WALLED OFF

RE-IMAGINING THE STANLEY PARK COASTLINE

by Ali Canning

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A Graduate Project submitted to the School of Architecture and Landscape Architecture, The University of British Columbia, in partial fulfillment of the requirements of the degree of

Master of Landscape Architecture

Faculty of Applied Science
School of Architecture and Landscape Architecture
University of British Columbia
Vancouver, BC

April, 2017

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ANALYSIS

Understanding Coastal Landscapes

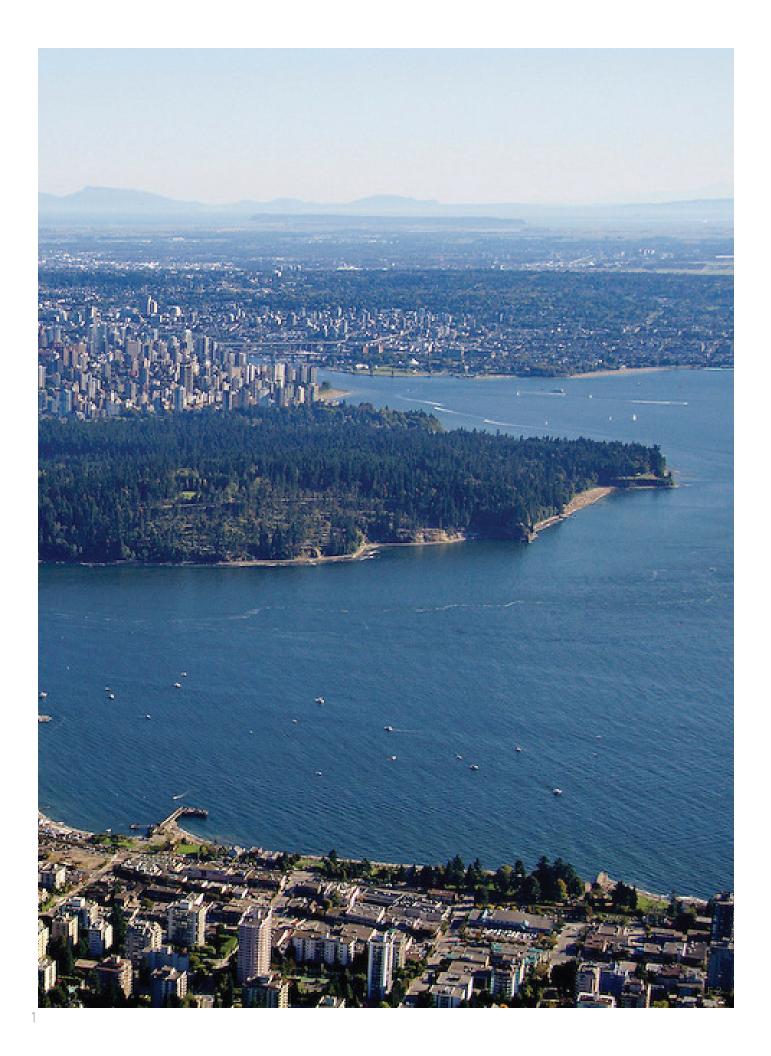
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With the need to adapt to changing climates and emphasis on protecting valuable coastal habitats, this thesis researches ways in which Vancouver can reimagine its connection to the marine environment. Intertidal landscapes provide disproportionately high levels of ecosystem services, making coastal and estuarine landscapes some of the most valuable on earth. However, our city is currently divided from its aquatic habitats with the beloved, but environmentally damaging seawall. Created to protect Stanley Park from erosion, the seawall is an iconic symbol of Vancouver with millions of people coming to visit it each year. However, rising tides and increasingly frequent storm events threaten its integrity and require constant maintenance and repair. With environmental pressures growing and future predictions calling for a new coastal adaption strategy, there is an opportunity to reimagine the interface between land and sea and increase resiliency within the park. Using design solutions based in both ecology and social awareness, landscape architecture can be used to redesign shoreline areas into multifunctional landscapes that restore marine habitat, are resilient to future change, and provide a place for people to reconnect with our oceans.



WALLED OFF

RE-IMAGINING THE STANLEY PARK COASTLINE

Vancouver needs to rethink the way we interact with our shoreline. Intertidal habitats provide disproportionately high levels of ecosystem services, making coastal and estuarine ecosystems some of the most valuable on earth (Ridge, J.T. et al. 2015). However, Vancouver has divided itself from the marine environment by building up a hardedge, which in turns degrades the functioning of intertidal areas (NRC, 2007). Although we are striving to be a 'Green City,' our care for our green space has lead us to forget about the importance of blue space and our dependence on the oceans wellbeing for survival.

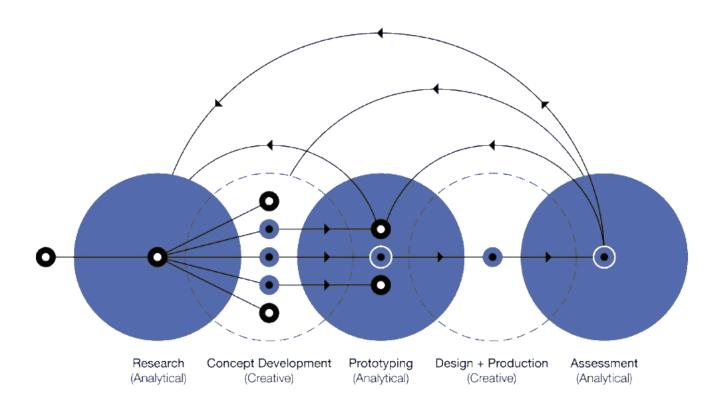
Restoration efforts along our coastlines have been conducted for many years, however this thesis argues there is an additional cause for continued decline in marine habitat- a lack of awareness and connection to marine environments due to the general populations disconnect with the health of our oceans. It is here that I believe landscape architects can make an impact that could not be achieved with solely ecological restoration projects. Using design solutions based in both ecology and social awareness, landscape architecture can be used to redesign shoreline areas that both increase marine habitat, adapt us to changing climates, and provide a place for people to reconnect with our oceans.

Vancouver is famous for being where land meets sea, its seawall allows citizens to enjoy the views and expanse of Burrard Inlet, however, this enjoyment comes at a cost to intertidal and foreshore habitats that have been replaced by concrete walls. Stanley Park, Vancouver's largest urban park, tourist attraction and city's treasure, is visited by over 8 million people a year and has dozens of people working to manage and maintain its 'natural' terrestrial beauty (SPES, 2012). Yet, the entire park is walled off, crippling the functioning of intertidal ecosystems, reducing habitat value and preventing the natural shoreline protection that could aid in Vancouver's resiliency to climate change and rising sea levels (Meidinger, Clark, & Adamoski, 2014).

By studying coastal processes, examining the foreshore typologies, and understanding the opportunities and constraints these each have for enhancement, this thesis argues that Stanley Park has the potential to increase social and ecological resiliency by expanding into the marine environment, and creating places where the boundary between land and sea is removed. This design will aim to create functioning intertidal areas that highlight ecosystem types, enhance social learning potential, increase marine biodiversity, and are resilient to future climate changes. With environmental pressures increasing and future predictions calling for a new coastal adaption strategy, there is an opportunity to reimagine how Vancouver meets the sea and allow citizens to once again become engaged with its continued health.

METHODOLOGY

APPROACH TO THESIS



Design visual showing the cyclical process of thesis design, blending creative and analytical worlds. Image Inspired by http://bhyousefi.com/wp-content/uploads/2012/09/20120914-091048.jpg, http://bhyousefi.com/?p=105

PROJECT GOALS

GOALS & OUESTIONS CONSIDERED

GOAL 1. Redesign Stanley park shoreline to restore ecosystem functioning to improve coastal habitat and promote species diversity

GOAL 2. Increase resiliency of shoreline to future climate change impacts

GOAL 3. Promote cultural connections to marine health through social learning and recreation

What are the processes that affect coastal ecosystems?

What is threatening coastal ecosystems now?

What are the benefits of restoring these ecosystems? Why should it be done?

What species would be present in a functioning ecosystem?

What did the shoreline look like before seawall development?

What are the alternatives to a seawall?

What are the ecosystem services provided by these systems?

How does landscape architecture play a role verses a biologist or engineer? How will climate change affect shorelines in the future?

What are the benefits for designing for this now?

What are the current or new methods for shorelines adaption? How can these be used in Vancouver?

What design strategies aren't just useful now, but will be necessary in the future?

What is currently being done in Vancouver, it it successful? How could it be improved?

What are Vancouver's goals for addressing climate change in the future? What does the coastline mean to people?

What does the seawall and Stanley Park mean to people?

Why do people visit the seawall?

Can a landscape be used to inspire social awareness in marine conservation? Should it?

What are the opportunities for education and social learning in a landscape? How can a landscape be designed to ecologically function and still maintain the social and recreation benefits that exist in the seawall now? Or how can these be enhanced?

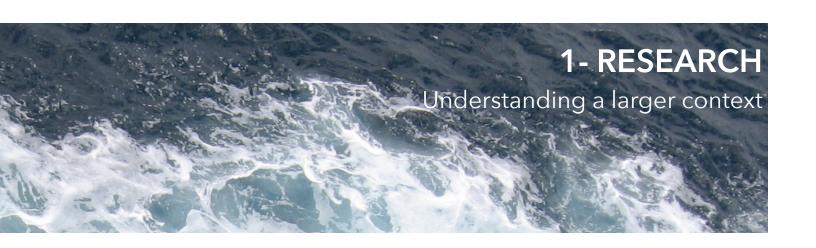
SCOPE

This project is looking into the redesign of the coastal areas of Stanley Park, specifically the western shorelines. This project will start by exploring the broad topics of coastal design and what the future of this might look like in Vancouver. In order to understand how coastal design can be used, this project will research the coastal processes that affect shorelines and analyze the landscape typologies within Burrard Inlet. This thesis will then research new methods and strategies that have been used globally to address coastal design in a matter that fits the goals of this project.

This thesis acknowledges the fact that Vancouver sits upon the unceded traditional territories of Musqueam, Squamish and Tsleil-Waututh First Nations communities, and that these communities have sacred lands within Stanley Park. This thesis will not be addressing the redesign of these areas, or the redesign of the entire park and the amenities within in. This project will aim to be able to connect with the current amenities and connectivity of Stanley Park to the city.

Vancouver will need to rethink the entirety of its shoreline in years to come, however, this thesis will zoom in to a specific area within Stanley Park where new approaches can be applied in hopes to increase awareness and social connection to the marine environment and so that learnings from this project may be applied to future design around Burrard Inlet.





THE SALISH SEA

OUR COASTAL WATERS THREATENED

The problems facing Vancouver are part of a much larger context that concerns that health of our oceans. The Salish Sea spans the coasts of two nations, is comprised of hundreds of islands, basins, bays, and open straits, creating a unique ecosystem mixing fresh and salt water, adding to one of the world's largest coastal seas (Environment Canada and EPA, 2013). It houses thousands of species of plants and animals, and its coastal environments are home to over

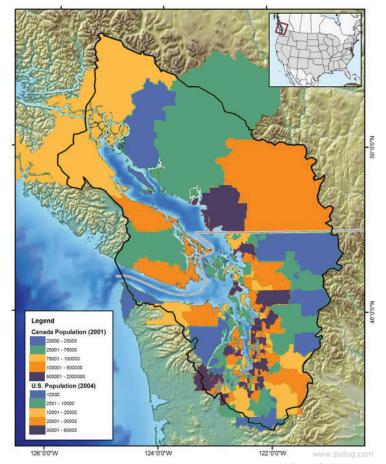
8 million residents within the populated regions of Victoria, Vancouver and Seattle (PSF, 2016). Due to its population, and highly used waters for ports and harbors, the Salish Sea's ecological integrity is threatened (US EPA, 2016). The basis for this marine conservation based thesis was found in a report of the transboundary ecosystem indicators (Environment Canada and EPA, 2013), with results showing us that over 113 marine species in the region are



highly at risk. Threats to these species are due to the fragility of the ecosystem and are highly impacted by the loss of biodiversity throughout the food chain. Reasons behind these declines can be linked to climate change and altered water conditions, anthropogenic pollutants, over fishing, and most importantly, the loss or degradation of habitat (Environment Canada and EPA, 2013).

It is estimated that by the year 2025, the human population will increase to expand to over 9 million residents (Environment Canada and EPA, 2013). With this increasing pressure on coastal areas, both the government of Canada and the United States have worked together to identify goals for the future. In a Joint Statement of Cooperation, the government organizations recognized that cross border dialogue and cooperation would be needed to continue to sustainably manage the Salish Sea (Environment Canada and EPA, 2013). For the sake of this thesis, the declining trends indicated within the report were used to highlight where design solutions could be used for future change.

Many populations of marine species of birds, mammals, reptiles, fish and invertebrates have experienced serious declines and have been identified as at risk. From 2008-2011 there was a doubling of species listed as at risk within the Salish Sea (Environment Canada & EPA, 2013). It is expected that the list of 113 threatened species will continue to grow with continued habitat modifications from population growth and climate change. Within Canada, the Government of BC and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) each assess species at risk in the Salish Sea and rank them for level of concern. Threatened invertebrates include species such as the native olympia oyster, and pinto abalone; keystone salmon species such as populations of coho, chum,



chinook and sockeye as well as populations of other traditionally important species such as eulachon, Pacific herring and steelhead trout (Gaydos & Brown, 2011). There are 45 avian species of concern within the BC rankings, with 12 red listed species, such as the American avocet, common murre and western grebe, which indicate the highest level of vulnerability to extinction (Gaydos & Brown, 2011). Finally, there are 12 mammal species identified by the provincial government, including both resident and transient killer whale populations and our northern sea otter (Gaydos & Brown, 2011).

All listed species depend on the Salish Sea ecosystem for varying parts of their life history such as reproduction, migration, molting, foraging or over wintering habitat (Environment Canada and EPA, 2013). The indicator report has stated that without strong efforts to improve habitat, these populations will continue to decrease and many face vulnerability of extinction (Environment Canada and EPA, 2013).

Urban densities within the Salish Sea. The Lower Mainland is one of the most dense areas with high pressures on coastal areas leading to habitat loss and degradation.

Design PrincipleCreate landscapes that provide and

A SHIFTING WORLD

ADAPTING TO SEA LEVEL RISE



Design PrincipleLandscapes must
be adaptable to
future climate
change

Littoral - locations proximate to the seashore (Brand, 2007)

Design Principle Maintain intertidal habitat as key landscape for biodiversity Coastal areas around the world are increasingly realizing the immensely damaging impacts of climate change and sea level rise (Bilkovic & Mitchell, 2013). Global sea level is affected by melting glaciers and ice caps, and by thermal expansion of the upper ocean (Gov BC, 2016). Rising sea level and global climate change will bring larger storm events with more frequent and extreme high water levels (Gov BC, 2016). This will lead to increased erosion and flooding along coastal areas, risking infrastructure and requiring costly maintenance and repair to protect these shoreline zones (Gov BC, 2016). Coastal ecosystems, including intertidal habitat, which is already severely reduced in populated areas, will be threatened as waters rise and its environmental gradients aren't able to shift (Sharma et al., 2015). Coastal areas contain high levels of biodiversity and the loss of habitat can already be linked to decreased biodiversity worldwide (Sharma et al., 2015). To mitigate these damaging consequences, there has been a shift in coastal design to adapt new approaches to coastal defense (Bilkovic & Mitchell, 2013, Sharma et al., 2015).

Traditionally, shoreline protection strategies have involved the construction of hardened built structures such as bulkheads,

revetments, groins, and seawalls (Sharma et al., 2015). Armouring shorelines to prevent erosion is a long standing global practice, however, it is increasingly apparent that the negative effects of these on coastal habitats and processes can not be ignored (see following page) (Bilkovic & Mitchell, 2013). The creation of hardened edges breaks up habitat leading to coastal fragmentation and reduction of species movement along shorelines (Sharma et al., 2015). Intertidal habitat already exists only within limited environmental and vertical gradients, and built structures usually remove or reduce these conditions often eliminating these ecosystems and the services they provide (Bilkovic & Mitchell, 2013). Sediment becomes permanently removed from the littoral system as it becomes disconnected, which in turn effects down current beaches and habitat (NRC, 2007). The most daunting feature of engineered structures is that they usually only have one layer of protection, meaning that if the structure fails, the results can be catastrophic (Board, 2007). Examples of failure can be seen globally, whether as the result from flash floods, storm events or extreme events like tsunamis. With locally changing environmental conditions, structures annually are needed to be maintained, repaired or increased in size, leading to extreme costs for coastal cities



(Bilkovic & Mitchell, 2013).

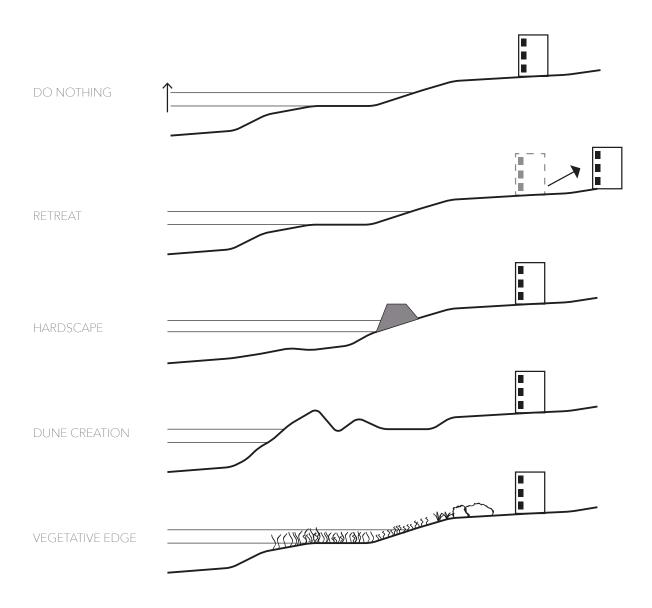
In recent years, coastal design tactics have begun to shift, with many areas adapting integrated management techniques which take a more holistic approach to coastal defense of sea level rise (Bilkovic & Mitchell, 2013). These often employ hybrid stabilization techniques or soft engineering methods as an alternative to the single engineered structure (CCRM, 2016). These methods look to natural design as the basis for resiliency solutions. The result is multifunctional landscape design that both adapts shorelines to sea level rise while increasing the natural functioning of these shorelines to maximize the ecosystem services they provide (Spalding et al., 2014). The concept of 'building with nature,' uses techniques that enhance natural buffers such as marshes, dunes and floodplains to combat changing water levels (Grossman, 2015). This allows landscapes natural ecosystem services such as water purification, habitat creation, carbon sequestration, and wave reduction to occur as part of a layered defense approach. Germany and the Netherlands are leaders in flood control strategies and have been gaining expertise in these integrated approaches in recent decades to fortify coastlines at lower financial and environmental costs (Grossman, 2015). The United States has recently sought to follow similar techniques after the devastating effects of Hurricane Sandy, with the US Department of Housing and Urban Development launching 'Rebuild by Design', a design competition aimed at creating resilient landscapes of the future (Rockefeller Foundation, 2016).

Moving forward, integrated management strategies will be come more common worldwide as a tool to combat the threats of rising waters, reducing the need for expensive engineered options and instead, creating functioning landscapes. Using techniques that utilize natural functioning allow for multiple solution options depending on landscape types and amount of shoreline vulnerability, which can create contextual approaches that can be cost saving (CCRM, 2016). The use of these approaches allows for the protection of shoreline communities without the degradation of coastal ecosystems and marks the future of coastal adaption planning (Spalding et al., 2014).

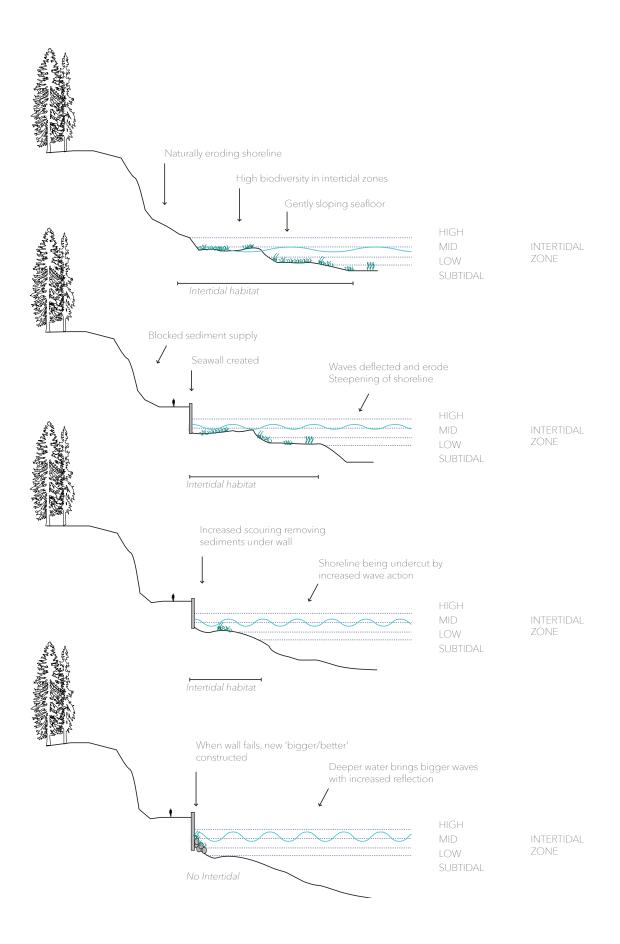
Design Principle
Use design
to maximize
landscape
ecosystem services
in multifunctional
landscapes

Design Principle

Use soft approaches over hardscapes where



Inspired by https:// en.wikipedia. org/wiki/Coastal_ management#/ media/ File:Fivepolicies.svg



VANCOUVER

STRIVING FOR SUSTAINABILITY

Quest to be a Green City

Vancouver is a city ready and striving for sustainable change. The city has identified itself as a global leader in sustainability, with the 2011 creation of the Greenest City Action Plan 2020, which strives to push for a sustainable future with goals in renewable energy, green technology, zero waste, and healthy ecosystems (City of Van., 2015). The city seeks to be a world leader in green technologies and sustainable living, pushing the development and design of new sustainability initiatives. Highlighting the importance of the 'natural' iconic image of the city, the Healthy City Strategy recognizes the significance of Vancouverites access to healthy environments, placing it as one of their targets for an integrated plan for healthier people, places and planet (City of Van. B., 2016). The government recognizes the value of natural infrastructure, and one of the targets within its Greenest City Action Plan is ensuring access to nature, noting the invaluable services provided by natural infrastructure such as clean air and water, enhancement of urban life, creation of habitat space, and lifted spirits for residents (City of Van., 2015).

Design Principle Create landscapes that maintain the 'natural beauty' of

Design Principle
Landscapes should
be accessible
and encourage
recreation

"The future of Vancouver's economy and livability will depend on our ability to confront and adapt to climate change"

> Mayor Gregor Robertson (City of Van., 2015, 2)

The continued health of our ecosystems is not just for the benefit of residents however, but is a driving force in our economy. The tourism industry is the second largest industry in the province, contributing approximately \$6.1 billion annually to the Metro Vancouver economy and providing over 66000 full time jobs (Tourism Vancouver, 2016). The tourism image bases itself on it's 'super, natural' qualities, stressing the access to our natural environment, and succeeding in bringing more than 9.3 million people annually to visit the city (Tourism Vancouver, 2016).

The access and importance of Vancouver's position on the coast however is threatened. The city is identified as the 15th most vulnerable port city to the effects of climate change, with its assets highly at risk to the effects of sea level rise (City of Van., 2012). The Vancouver Climate Change Adaption Strategy created in 2012, recognizes the changing climatic conditions Vancouver will receive in the future, such as increased precipitation, more severe storm events, and sea level rise, and creates a plan for the necessary steps the city must take to adapt and respond to the impacts of climate change (City of Van., 2012). Research shows that climatic changes will lead to an increase of overland and coastal flooding throughout the city and this document identifies and prioritizes the vulnerabilities and risks that the city will face. Within the last century, sea levels rose by 20cm, and the rate at which they have rose has doubled in the last three decades (City of Van., 2012). These accelerated rates are expected to continue and the city has recognized that increased shoreline erosion is a high priority as it affects infrastructure, natural environments and public amenities such as parks, trails and access to the water (City of Van., 2012).

Changing climates will increasingly isolate fragmented coastal habitats within the city, and the strategy stresses the importance in maintaining habitat and enhancing



"Despite our efforts to reduce carbon pollution, we need to ensure Vancouver is prepared for the impacts of a changing climate"

(City of Van., 2016, 1)

connectivity in the future. Parks and green space are additionally identified as being key areas within the city to help combat climate change, by decreasing the impacts of flooding from heavy rainfall and storm surges (City of Van., 2016).

Design PrincipleUse green space to help mitigate the affects of climate change

Within the cities goals for the future, the targets recognize not only the environmental impacts climate change will have, but how these changes will play a dramatic role in the functioning of the economy. The National Round Table on the Environment and the Economy (NRTEE) reported that by 2050, coastal flooding costs in BC alone could cost up to \$8 billion per year (City of Van., 2012). The NRTEE report stressed that ignoring climate change threats was not an option, and finding cost effective ways to alleviate the effects of climate change was a priority (City of Van., 2015).

Design PrincipleFind cost efficient ways to address climate change

This puts the City of Vancouver in a perfect position to lead Canada in the creation and use of leading coastal climate adaption strategies. The city has an opportunity to not only make the essential necessary responses to rising sea levels, but to do so in a manner that follows the goals of Vancouver to be a leader in new approaches and technologies, and to maintain and improve residents and tourists access to the natural environment on which it resides. The city has the complex task of assessing the high risk areas along the coast, and determining solutions that will minimize the financial, social and environmental impacts of inundation, while preserving near shore amenities, water access, and vistas.

VANCOUVER

LANDSCAPE OPPORTUNITIES

Social Learning

Bluespace

Design Principle

Create landscapes that are accessible to the public and encourage interaction with the environment for learning and experiential opportunities

Ecoliteracy

understanding the workings of physical systems

Environmental Literacy

understanding how humans interact with their surrounding ecosystems

Ecological Identity

understanding the workings of physical systems and how humans in society interact with the ecosystem and understanding your own perceived relationship to how you interact and are part of nature

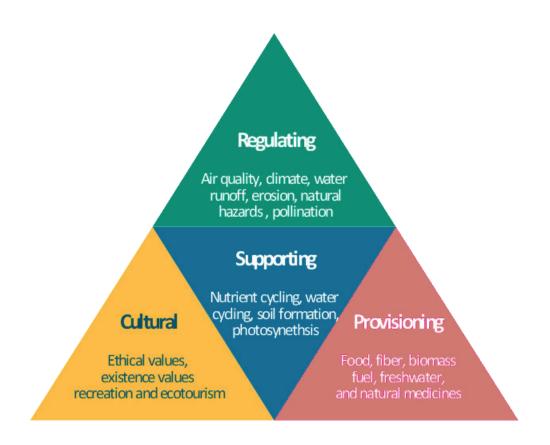
Design Principle

Redesign seawall to connect marine and terrestrial landscapes and restore coastal processes When approaching the idea of adaption to climate change and resiliency, it is essential to note not only the ecological and structural changes that will need to occur, but more so, the social changes that will ultimately affect the resiliency of Vancouver. In order to protect the shorelines, and ensure the ecological functioning of our coastal waters, Vancouverites will need to care about its continued health and integrity. Although much of the city will need to rethink protection strategies in years to come, this thesis will take the opportunity to exploit the landscapes that can have a social and ecological connection.

Goodwin (2016), argues that allowing people to build connections experiences to the natural world are essential components in maintaining its continued ecological integrity. To allow for this within Vancouver, people must have access and be able to witness the processes that affect the coastline to increase their ecoliteracy (Orr, 1991). Increasing environmental education through the gaining of outdoor experiences will allow the public, and especially youth, to then increase their ecological identity by gaining a personal connection to the environment and an understanding of how they are a part of a larger system (Goodwin, 2016). Focusing on a design that creates a public marine landscape, so that the functioning of our shorelines can be connected to, could allow for subsequent projects in the future to be more publically supported.

It has long been understood within city planning that urban green space, or vegetated public open space, is essential within a city to provide numerous social, psychological, and ecological benefits (Sander & Chang, 2014., Kaplan, 1995., Martinez & Rusch, 2014., Orr, 1991). The advantage that coastal cities have is the natural additional to these public spaces with the concept of bluespace. Urban water bodies provide similar social benefits to their terrestrial counterparts, providing environments for learning, social congregation areas, interactions zones with unique ecosystems, and areas for relaxation and recreation (Sander & Chang, 2014).

These spaces have become the backbone of many coastal cities, creating a thread of urban park that runs through or around a city (Brand, 2007). In Vancouver specifically, our largest public space is the linear seawall that connects our entire coastline, linking neighborhoods, parks and being the number one tourist destination in itself (Tourism Vancouver, 2016). The recreation and refuge benefits of the Vancouver seawall are immense, however what is lacking (in additional to ecological functioning), is the learning opportunities along our coast as the natural environment is essentially walled off. The majority of users of the seawall are moving through the space, using the ocean as a backdrop of expanse and it is here that a redesign can be used to maintain these social wellness qualities, but add additional layers of ecological functioning, education and protection (Martinez & Rusch, 2014).



Ecosystem Services

Ecosystem services are the benefits people obtain from the functioning environment. 2005, the Millennium Ecosystem Assessment categorized these benefits into provisioning services (ex. food, water, and timber), regulating services (ex. which affect climate, floods, disease, wastes and water quality), cultural services (which provide recreational, aesthetic and spiritual benefits), and supporting services (ex. nutrient cycling, soil formation and photosynthesis). These services can further be looked at by their organization, operation, and outflows that then are utilized by humans (Turner et al., 2008). These services are essential for human survival and are the framework upon which our society and economy builds (Philcox, 2007., Mooney, 2015., Turner et al., 2008).

The Millennium Ecosystem Assessment (2005), concluded that approximately 60% of the ecosystem services they identified were being degraded or used unsustainably. Coastal regions are made up of some of the worlds most productive ecosystems that provide a disproportionally high levels of ecosystem goods and services (Table 1), however, these areas, due to their increasing densification, are seeing a greater reduction in the benefits they provide at increasing rates (Martinez & Rusch, 2014). It is an aim within this thesis, to maintain or enhance the coastal ecosystem services provided by the foreshores of Vancouver, to ensure the landscape created is the most beneficial culturally, socially, economically ecologically.

Design PrincipleDesign landscapes that maximize ecosystem services

Table 1: Ecosystem functions, processes, goods & services of ocean and marine coastal resources in British Columbia

(Philcox, 2007)

Function	Ecosystem Processes and Components	Good and Services (examples)	
Regulatory Fund	ctions- Maintenance of essential ecological pro	ocesses and life support systems	
1. Gas Regulation	Role of oceans ecosystems in biogeochemical cycles	UVb protection by ozone, maintenance of air quality, influence on climate	
2. Climate Regulation	Influence of ocean area, coastal interface, and biological processes on climate	Maintenance of favorable climate for human habitation, health, cultivation etc.	
3. Disturbance Prevention	Influence of ecosystem structure on limiting environmental disturbances	Storm protection (ex. reefs, corals, coastal vegetation), Flood protection (ex. wetlands)	
4. Water Regulation	Role of coastal wetlands, estuaries, and deltas in regulating run off and river discharge	Regulation of global, regional, and local scale hydrology through currents and tides	
5. Water supply	Filtering, retention & storage of fresh water	Provision of water for consumption	
6. Soil Retention	Role of reefs, seagrass, & other vegetation in stabilizing in-shore coastal areas	Increase in water clarity, prevention of coastal erosion	
7. Soil Formation	Moving sediments from source areas & replenishing depositional areas	Contributes to coastal accretion	
8. Nutrient Cycling	Role of flora & fauna in the storage, internal cycling, processing, & acquisition of nutrients, nitrogen fixation, phosphorus cycles	Maintenance of healthy ecosystems	
9. Waste Treatment	The breakdown of excess xenic and toxic compounds	Pollution control, detoxification of waste	
10. Biological Control	Population control through trophic- dynamic relations	Control of pests & disease, maintenance of biodiversity	
Habitat Functio	ns- Providing habitat for wild flora and fauna		
11. Refugium function	Suitable living space for wild flora and fauna	Maintenance of biological & genetic diversity	
12. Nursery Function	Suitable reproductive & feeding habitat for resident & transient population	Feeding and nursery habitat for resident and transient populations of harvested species, maintenance of commercially harvested species	

Function	Ecosystem Processes and Components	Good and Services (examples)
Production Fun	ctions- Provision of natural resources	
13. Food	The portion of gross primary production which is extracted as food for humans	Subsistence harvest of pelagic & non pelagic species, small scale aquaculture
14. Raw Materials	The portion of gross primary production which is extracted as fuel/ building materials	Building & manufacturing for subsistence purposes, renewable energy, fertilizer
15. Genetic Resources	Genetic material & evolution in wild flora and fauna	Health care & other applications
16. Medicinal Resources	Variety in (bio)chemical substances & other medicinal uses of wild flora & fauna	Drugs & pharmaceuticals, chemical models & tools, test & assay organisms
17. Ornamenta Resources	Variety of flora & fauna in natural ecosystems with potential ornamental use	Resources for ceremonial, spiritual, fashion, handicraft, decoration & souvenirs
Information Fur	nctions- Providing opportunities for cognitive d	evelopment
18. Aesthetic Information	Attractive seascape features	Enjoyment of scenery (ocean views, beaches, cliffs etc)
19. Recreation	Variety in seascape with potential recreational use	Travel to natural ecosystems for eco-tourism, outdoor activities (boating, kayaking, fishing, whale & bird watching, wildlife viewing, beach and water related activities, scuba diving, sailing and power-boating activities
20. Cultural & Artistic	Variety in natural features with cultural and artistic value	Use of ocean & coastal features as symbols & sources of inspiration
21. Spiritual and Historic	Variety in natural features with spiritual & historic value	Use of nature for spiritual or historic purposes (ex. heritage value of natural ecosystems)
22. Science and Education	Variety in natural features with scientific & educational value	Use of natural systems for school, use of nature for scientific research

VANCOUVER

MULTIFUNCTIONAL COASTAL LANDSCAPE

The concept of multifunctional landscapes is to maximize and utilize a diverse set of ecosystem services within a landscape that are contextually relevant to its spatial, ecological and cultural conditions (O'Farrell & Pippin, 2010). The idea is that landscapes do not need to simply address a singular purpose or concern, but by careful design can tackle multiple problems by finding synergies instead of having a trade off. Within coastal landscape design, this principle can be used to highlight the need for protection, ecological functioning, cultural and society uses, and future resiliency. These landscapes must perform on multiple trajectories, with the natural and infrastructural systems integrated and working together (Naveh, 2001).

Design Principle Create a landscape that can synergize

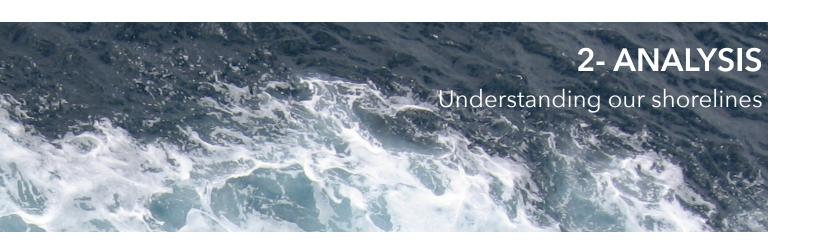
Being such a high density city, coastal design within Vancouver needs to be multifunctional. This project will have numerous goals in design and aims for long term trajectories, the challenge will be to design landscape that seamlessly links these objectives into one coherent landscape.

SITE CRITERIA

- ♦ Coastal Area within City of Vancouver- area that would benefit from coastal protection enhancement (ex. due to sea level rise, storm surges, high levels of erosion, flooding threats) and be supported by the goals and targets of the city.
- ♦ High Visibility/Use-near urban area to allow for recreation and education opportunities
- ♦ No high value development or residents on water edge- suitable to explore soft engineering approaches without building removal
- ♦ Environmentally degraded area- area that could benefit from ecological enhancement
- ◆ Potential for habitat connectivity- potential for connection to green spaces to allow for maximum habitat enhancement oppoutunities for biodiversity
- ◆ Sizable amount of public land- to allow for a creative design to be used by public (not within Port of Vancouver lands due to restrictions)

In order to better understand the ecological conditions of choosing a site, it is first necessary to understand the physical coastal processes that affect these sites.





COASTAL LANDSCAPES INTERTIDAL ECOSYTEMS

Intertidal Zones

The intertidal zone, or foreshore, is the area of interface between the marine and terrestrial realms within the littoral zone. It sits between the supratidal zone (riparian backshore above high tide line) and subtidal (always submerged) in the area of marine shoreline that is inundated with water during high tide and exposed during low tide (NOAA, 2008). The gravitational pull of the sun and moon results in the twice a day rise and fall of the ocean tides, creating a dynamic world of extremes (VNHS, 2009). Habitats within the intertidal zone can range from coastal bluffs, to sandy beaches, to vast mudflats, with conditions resulting from the constantly changing environmental gradients and exposure levels. Due to its mix of marine and terrestrial habitats, foreshore ecosystems are home to a unique blend of flora and fauna who have adapted to these blending conditions. These ecosystems inhabit the transition zone and therefore, are limited to landscapes that hold the appropriate environmental conditions. As such, intertidal habitats are limited and greatly effected by anthropogenic interactions such as foreshore development, urbanization, and shoreline armouring, which further reduce and alter the landscape (OST, 2016). However, despite its representatively thin linear like dispersion, functioning intertidal habitats contain rich species biodiversity and produce many ecosystem services that are beneficial to humans and fundamental to larger ecosystem functioning (NOAA, 2008).

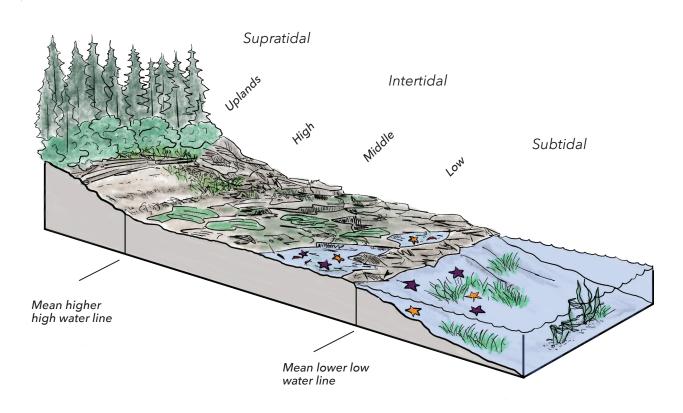
Design PrincipleMitigate
anthropogenic
influences on

Design Principle

Use appropriate ecosystem types for environmental gradients and forces

Intertidal ecosystems vary depending on their location within the landscape and the energy input they receive. High energy intertidal systems such as sea bluffs or rocky intertidal, may have high impact waves and currents, whereas low energy systems such as marshes and mudflats, may sit within protected pockets of shoreline or river estuaries. Substrate composition, whether it be consisted of rocks, sand, mud, or a mixture of all these sediments, will additionally determine which plant and animal communities populate these areas (VNHS, 2009).

As these associations are determined by the environmental gradients created by the tides rise and fall, a vertical stratification is created within the intertidal ecosystem, leading to the classification of the upper, mid, low and subtidal zones (MacKenzie, 2009). Each zone is exposed to varying degrees of wave action, changes in salinity, thermal stresses, exposure to winter ice and cold or periods of heat and drought, as well as varying periods of total submersion. Plants and animals that prefer similar environmental gradients tend to form communities, or biobands, horizontally along the shorelines (OST, 2016). Species in the upper and mid intertidal zones must adapt to prolonged periods of exposure, which brings risk of starvation as most only feed while submerged, as well risk of predation from land animals such as birds and raccoons (VNHS, 2009). Lower intertidal species diversity is often higher, leading to increased competition for space, as well as facing predation from marine organisms such as sea stars (CRD, 2016).



Intertidal Zones Inspired by (SCBC, 2003)



Intertidal ecosystem exposed during low tide in coastal BC

Ecological Importance

Habitat and Food Source

The intertidal zone plays an essential role in coastal riparian ecosystem functioning and is crucial to sea life and the survival of many land creatures (MacKenzie, 2009). The ecological complexity and value of foreshore environments cannot be overstated (SCBC, 2003).

Not only do unique plant and animal communities reside in these habitats, but they additionally are essential habitat and food sources for birds and wildlife. Terrestrial animals such as bears, wolves, deer, raccoons, mink and otter, as well as both resident and migrating bird species such as herons, eagles, and shorebirds, use this habitat for critical foraging grounds (CRD, 2016). Intertidal zones are keystone habitats for almost all fisheries within BC, especially as nursery, foraging, and refuge areas for salmonids (Mass. Gov., 2016). Marsh and estuary habitats provide the base of the aquatic food chain, and their continued health and production directly corresponds to larger species in the marine environment (Mass. Gov., 2016). Humans have also historically been very dependent on intertidal food sources, not only for their supplying of fisheries, but traditional food sources such as clams, oysters, and seaweed (CVD, 2016).

Design Principle
Ensure a mix
of landscape
elements to
maximize habitat
and food source
potentials







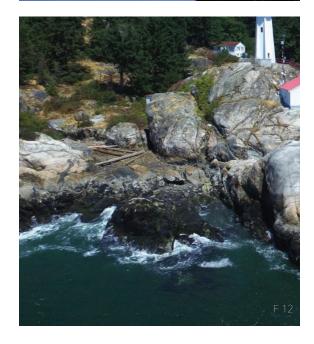


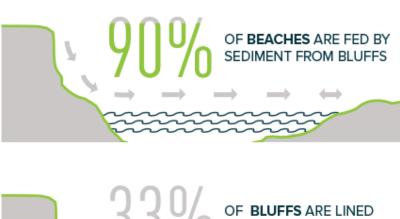
FI

Coastal Resiliency

Coastal zones are not just habitat transitions but act as physical buffer zones protecting land from erosion by ocean tides, waves from storm surges, and act as a filtering zones for terrestrial runoff back into the ocean (CCRM, 2016). Marsh, estuary and other gradual sloping shorelines reduce wave velocity, as do offshore islands and reef breaks, decreasing the affects of erosion along the coast. Intertidal and riparian vegetation reduce the affects of wind and wave sediment transfer. Estuaries and marshes act as carbon sinks as well as filter runoff to aid in improving both air and water quality (Bilkovic & Mitchell, 2013). Connectivity between terrestrial and aquatic ecosystems is essential to maintain sediment transfer between spheres. The natural processes of erosion and sedimentation of coastlines provide fluctuation capabilities which allow them to be resilient to changing sea levels (NRC, 2007).

Design Principle
Understand coastal
processes and
natural protection
landscapes to be
used within design





Social Importance

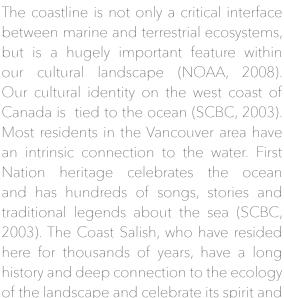
Cultural Identity

between marine and terrestrial ecosystems, but is a hugely important feature within our cultural landscape (NOAA, 2008). Our cultural identity on the west coast of Canada is tied to the ocean (SCBC, 2003). Most residents in the Vancouver area have an intrinsic connection to the water. First Nation heritage celebrates the ocean and has hundreds of songs, stories and traditional legends about the sea (SCBC, 2003). The Coast Salish, who have resided here for thousands of years, have a long history and deep connection to the ecology of the landscape and celebrate its spirit and energy (SPES, 2012).

Design Principle

Education and Research

Intertidal zones are fundamental interaction areas for humans. Unless one has access to a boat, the foreshore is the only area that allows humans to explore the marine landscape. The accessibility of intertidal zones makes them priceless educational areas for marine health and functioning, providing outdoor classrooms filled with rich species diversity (Mass. Gov., 2016).

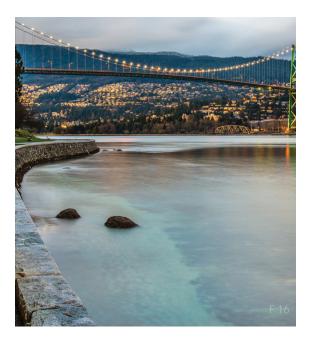








Design Principle Design landscapes that can be used for educational







Therapeutic Benefits

Vancouver's seawall is one of the most popular destinations within the city for tourists and locals alike (City of Van., 2016). The aesthetic and therapeutic values of walking along a coastline allow users to feel as though they are having an escape from the urban grid system. Viewpoints out over the ocean give users both physiological and psychological feelings of space, allowing these landscapes to become restorative (promoting mental and physical wellness) (Kaplan, 1995). Coastlines have this value round the world, and these values are reflected in the economy, with waterfront property or views being the most valued and sought after (SCBC, 2003).

Design PrincipleCoastal landscapes should allow for mental restoration

Tourism

'Super, Natural British Columbia' is the marketing slogan for our province and endorses its dramatic, physical terrain and significant species biodiversity (Davis, 2011). Vancouver is a city renown for its location between the coast and mountains, with the cities tourism being the second largest industry in the province bringing 9.3 million visitors a year (Bellet, 2015). Recreation opportunities along the coast such as fishing, kayaking, swimming, beach use, tidepool exploration and using the seawall bring thousands of people to our shoreline.

Design Principle Landscapes should contain recreation

COASTAL SHORE SYSTEMS

PHYSICAL PROCESSES



The creation of the coastal line we see today is from a mix of long term processes like continental drift, glaciation, climate, and changes in sea levels, as well as current forces such as wind, waves, tides.

Three natural process shape the physical characterization of our coast.

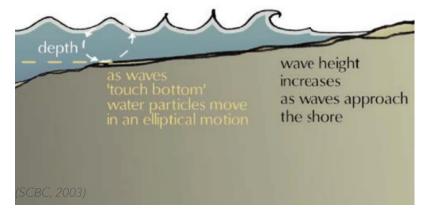
- ♦ *Waves* Wind waves are the primary force in the coastal zone, creating erosion, sediment transport, and deposition.
- ◆ Water Levels- Fluctuate with twice a day tides, surges caused by storms, and changes in sea level over long periods of time due to climate change.
- ◆ Sediment Movement- Sediment is constantly moving with the waves and currents and form the building blocks of the landscape.

Waves

The Primary energy source that shapes coasts. Wave force is determined by wave size, which is a product of the velocity of wind, the distance over which the wind blows (fetch) and the length of time the wind blows (duration).

Wave Base Depth

Wave Base Depth is the point where a wave first touches land. If there is sediment in this area and the wave carries enough energy, the sediment can be picked up and transported by currents. Wave base depth increases with wave height making this point dynamic with each landscape (SCBC, 2003).



Refraction

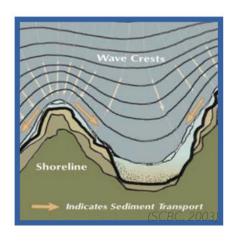
Refraction is the bending of waves as they approach the foreshore. Wave velocity decreases as waves enter shallow waters and hit wave base depth. If a wave approaches the shore at an angle, it refracts as the inner end of the the wave slows before the outer, resulting in waves crashing at similar times. This refraction is seen seen in certain land typologies, where wave energy is concentrated at first contact (headlands, seaward sides of islands) causing erosion, and sediment deposition occurs where energy is diffused (embayment, leeward side of islands) (SCBC, 2003).

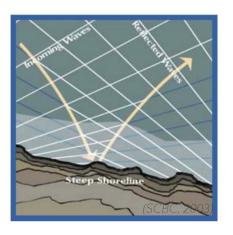
Reflection

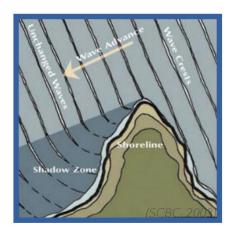
Reflection is the bounce back of waves off a solid object. When a wave approaches a steeply sloping bank, or hardened structure such as a seawall, the wave energy is echoed back instead of being dissipated along the coast. If a non breaking wave hits the wall, close to 100% of the energy is reflected, essentially doubling the wave height (NRC, 2007). The incoming and reflected waves interact creating large waves with strong bottom current which scour the seabed and will eventually cause the failing of the structure as its base is eroded (SCBC, 2003).

Diffraction

Diffraction is the diffusion of waves in the lee of an headland or island. These areas are blocked by protruding landforms or islands, however diffraction still brings dissipated waves to the protected shallow zones (SCBC, 2003).









Recommended Curve for Sea Level Rise Policy in BC Recommended Curve for Sea Level Rise Policy in BC Recommended Curve for Sea Level Rise Policy in BC Recommended Curve for Sea Level Rise Policy in BC Recommended Curve for Sea Level Rise Policy in BC Recommended Curve for Sea Level Rise Policy in BC Recommended Curve for Sea Level Rise Policy in BC Projections Recommended Curve for Sea Level Rise Policy in BC Projections Recommended Curve for Sea Level Rise Policy in BC Recommended Curve for Sea Level Rise Policy in BC Projections Recommended Curve for Sea Level Rise Policy in BC Projections Recommended Curve for Sea Level Rise Policy in BC Projections Recommended Curve for Sea Level Rise Policy in BC Projections Recommended Curve for Sea Level Rise Policy in BC Projections Recommended Curve for Sea Level Rise Policy in BC Projections Recommended Curve for Sea Level Rise Policy in BC Projections Recommended Curve for Sea Level Rise Policy in BC Recommended Curve for Sea Level Rise Polic

Predicted sea level rise within British Columbia. (Port of Vancouver, 2013)

Water Level

Inundation is the elevation of sea level above the fixed topography. Short term inundation leads to flooding by storm surges and heavy rains. Whereas long term inundation along the coast is caused by sea level rise (Thomson, 1981). Tide range in Vancouver is a maximum of 5.6m and averages at 3.3m in Burrard Inlet (Thomson, 1981). In the winter, low tides occur mainly at night, whereas in summer, low tides occur mainly during daylight. The highest and lowest tides occur during full and new moons (spring tides) during December and June. In BC the major storms that have caused damage in the past usually occur during a combination of winter high tide and storm surges. These surges occur when wind and pressure changes interact with water levels, leading to surges that cause flooding and shoreline erosion. Large storm surges on the BC coast can lead to a 1m sea level rise, especially when combined with spring tides and storm waves (SCB, 2003). This influx needs to be considered in shoreline design.

Climate Change

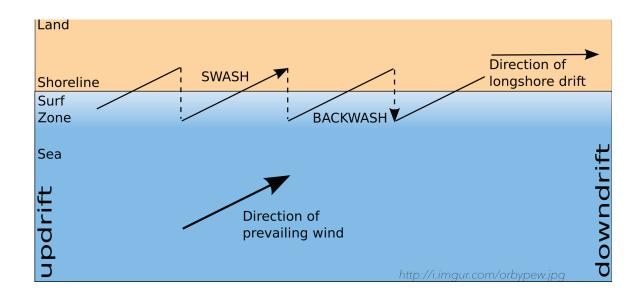
Climate change is causing global sea level rise each year from melting glaciers and warming of the upper ocean. On the BC coast, estimates of sea level rise by 2100 range from 80cm- 120cm (Gov BC, 2016). Impacts from rising waters include increased erosion of foreshore lands, more damaging storm and surge events, loss of intertidal habitat and diversity, and loss of cultural and historical sites (SCBC, 2003). The Provincial and Federal Governments have identified and listed sea level rise as a threat to future sustainability and have created multiple initiatives to research, manage and mitigate for these impacts (Gov BC, 2016).

Sediment Transport



Understanding erosion and sediment transport is based on a complicated system of both offshore and onshore processes. It is a function based upon the specific sediment characteristics (size, composition, sediment type) and the transport capacity and processes in the environment (NRC, 2007). Sediments do not proportionally move with currents and waves, but have an energy threshold that needs to be exceeded into order to dislodge and then be carried by these transport systems (NRC, 2007). Currents and waves can move vast amounts of sediment along shorelines as long as they maintain this energy sufficiency, once

it is lost, sediments are deposited along the coast. Interruptions to this system by blocking sediment sources (ex. hardening the shoreline), changing flow processes (ex. creation of groynes), or increasing energy levels (ex. offshore storm surges), can dramatically affect shoreline dynamics and potentially lead to permanent altering of the coastline (ex. the loss of a beach) (SCB, 2003).



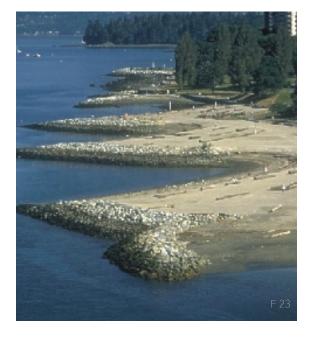
Longshore Drift

Longshore drift is the method by which sediment is transported along a coastline, determined by the prevailing wind and shoreline current. When waves approach the shore at an angle the sediment is carried up the beach at the same angle (swash), but when it retreads it does so at a right angle (backwash), resulting in a zig zag motion along the coastline (NRC, 2007). This grouping of sediment source, transport zone, and sediment deposition zone, make up a longshore drift cell. These cells repeat along the coast in varying sizes and layers and can be identified in landscape typologies with typical sources such as rivers and bluffs, and deposition sites like bays and spits (SCBC, 2003). Groynes are often build along beaches to reduce longshore drift, the results of this movement lead to a pile up of sediments on the updrift side, and visibility less sediments on the downdrift side (Revision World, 2016).

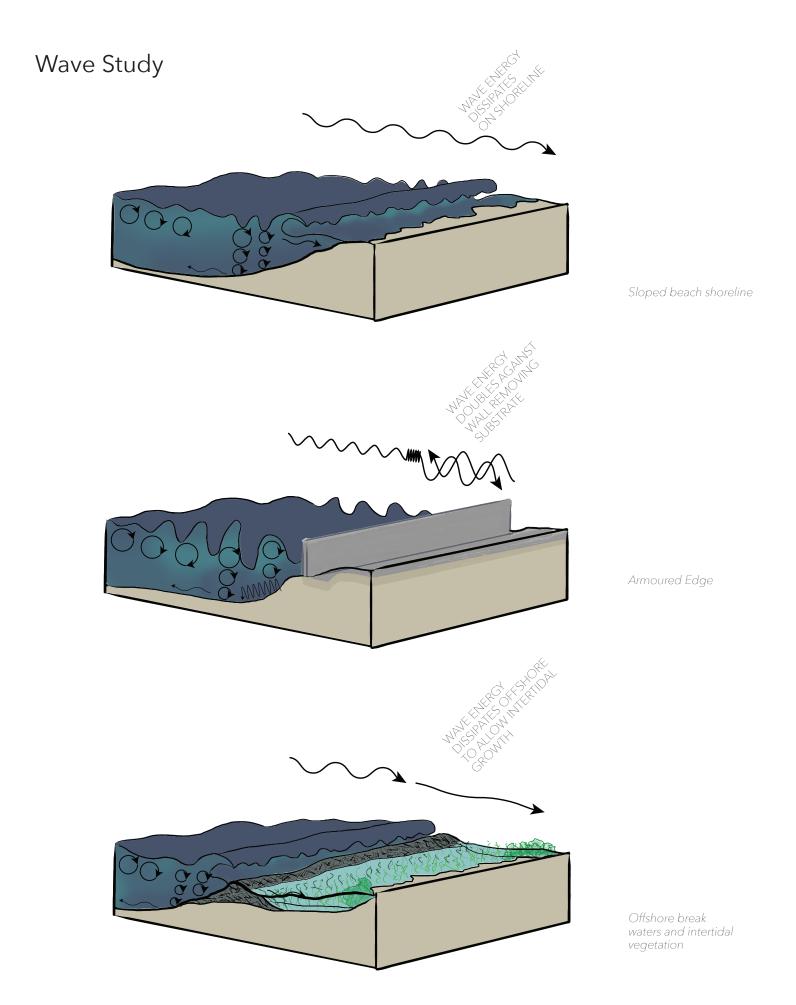
→ Predominent winds in the Straight of Georgia are storms and winter winds from the south and south east. In Burrard Inlet daily winds are usually easterly and the large damaging winter storms are westerly (Thomson 1981).

What direction is sediment moving?

Sediment transport changes throughout the year with varying wave, current and wind directions. However, the balance of sediment moved one direction along the coast versus another is calculated in the net sediment transport which is determined by the predominant wind direction. Sediment is constantly being moved in the landscape, but the net loss or gain decides if a shoreline is accreting (moving seaward) or eroding (retreating landward) (SCBC, 2003).



*When describing the wind direction, you use the direction it is blowing from, not to. (Revision World, 2016).



INTERTIDAL HABITAT

LANDSCAPE TYPOLOGIES IN BURRARD INLET

Rocky Shorelines

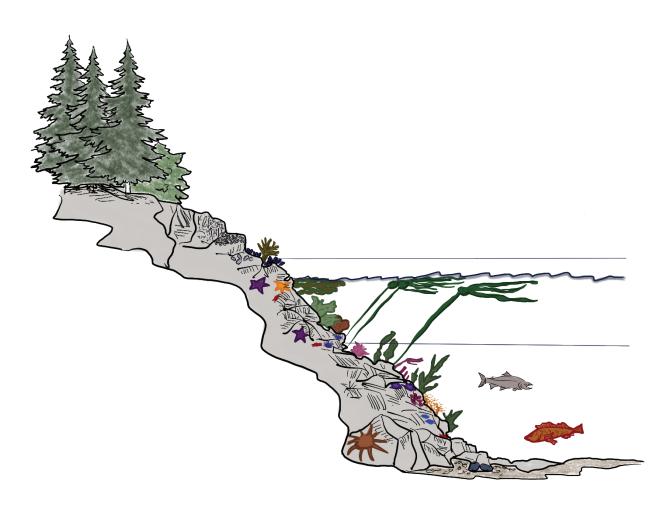


Image based on (SCBC, 2003).

This intertidal ecosystem sits at the marine zone where waves crash upon a rocky shoreline. Wave action and exposure gradients produce visible biobands along the steeper vertical edge with specific species at different inundation levels (SCBC, 2003). A unique feature of the rocky intertidal habitats are tidepools, pocket ecosystems created when the tide retreats and seawater is trapped in rock depressions. These shallow pools are often teeming with life and differ from surrounding plant and animal associations on the rock, as they fall into a lower tidal gradient (NOAA, 2008).

Substrate

◆ Hard surfaces with a mix of stones, boulders and bedrock. Low sediment transfer

Wave Energy

♦ Both low and high energy systems, but wave action determines which species are present

Key Species

◆ Barnacles, gastropods, algae, mussels, sea stars, sea urchins, scallops, prawn, rock crab, rock fish, and lingcod

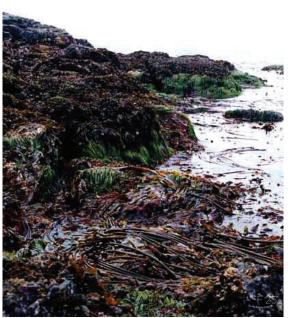
Key Functions

- ◆ Unique habitat to organisms at base of food chain, including foraging grounds (birds, wildlife, fish), and refuge areas
- ♦ Haul out landscape for seals
- ◆ Stabilization against erosion, wave action and rising sea levels
- ◆ Steep gradients provide popular vista points for people
- ♦ Most frequency visited by humans, as stable rock ground allows visitors to explore intertidal areas, making it accessible for recreation and research.
- ◆ Tidepools create mini classrooms that allow for marine education of species that would normally be inundated.

Threats

- ◆ Coastal development along the foreshore alters water quality with increased turbidity, urban run off and changes in flow, which can affect the species gradients.
- → Invasive species are often introduced via human activities associated with the ports, as well as marine recreational activities; these are a large threat as they can colonize biobands.
- → Due to their popularity with visitors, intertidal trampling and harvesting can occur when best management practices are unknown.
- ◆ Habitat loss due to shoreline stabilization, such as the seawall, reduces the necessary vertical gradients that enable the conditions for species diversity within this ecosystem.





Boulder Cobble Shores

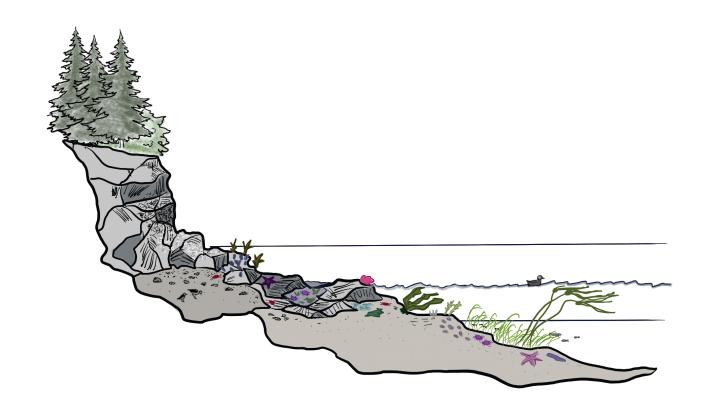


Image based on (SCBC, 2003).

Rock and large sediment shores are common in Vancouver and are found where there is a mix of large rock and loose sediment compositions. Sediments are the result of erosion and transfer from connected rock benches or cliffs. These habitats are often characterized by cobble/ boulder beaches with driftwood massing in the backshore regions (SCBC, 2003).

Substrate

◆ Rock and large sediments ranging from thin layers of cobbles or heavy gravel. Loose sediments overlay 10-40% of intertidal area (SCBC, 2003).

Wave Energy

♦ Both high and low energy systems

Key Species

♦ Mussels oysters, limpets, algae (especially kelp), shrubs and understory vegetation on slopes

Key Functions

- ♦ Key habitat areas for birds, especially raptors like eagles, who use perches and cavities for foraging and nesting.
- Important foraging area for shorebirds
- ◆ Unique crevice habitat and subtidal area can be colonized with eelgrass
- ◆ Stabilization against erosion, wave action and rising sea levels
- ◆ Popular beach type for human interactions and recreation

Threats

- ◆ Coastal development is frequent in these landscapes leading to habitat reduction, fragmentation, increased pollutants and changes in sedimentation.
- → Removal of coastal vegetation impacts sedimentation processes
- ◆ Development caused changes in elevation and seaward profile increasing wave erosion and reducing intertidal bands.
- ◆ Extremely long recovery time for pollutants and oil spills when it is trapped below rock substrate





Sand and Gravel Shores

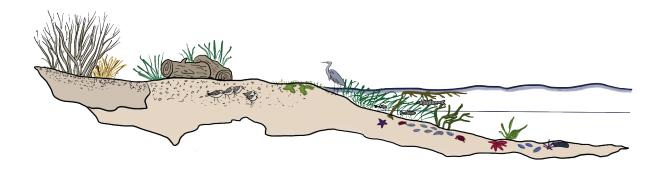


Image based on (SCBC, 2003).

Found on a variety of shoreline gradients, these shorelines are constantly changing and created through sedimentation transfer processes caused by wave, wind and current actions. Coastal bluffs and rivers are often a source of sediment and are transferred through longshore drift resulting in beaches, spirts and coastal lagoons.

Substrate

♦ Loose sand, gravel and small cobbles

Wave Energy

◆ Can be found in all energy systems, but intensity of wave action affects ratio of sediment composition. Finer sediment will accumulate in pocket beaches or sheltered areas, whereas gravel beaches can sustain greater wave action.

Key Species

→ Burrowing invertebrates (ex. worms and clams), mobile invertebrates (ex. sea stars), eelgrass, sea lettuce, dune grass, crabs, large concentrations of shorebirds

Key Functions

- ♦ Backshore vegetation forms unique dune habitat type with grasses and salt adapted plants and shrubs
- ♦ Intertidal habitat including low and subtidal eelgrass beds provide essential habitat for fisheries, and invertebrates, and foraging habitat for birds.
- ◆ Shorebirds reliant on beaches for foraging grounds
- ♦ Beach environment is highly utilized for coastal tourism and recreation

Threats

- → Highly affected by storm and tidal events, including boat wakes
- Prone to backshore flooding
- → Backshore clearing of these habitats removes grasses, sedges, shrubs and trees that would otherwise stabilize these landscapes, reducing their ability to absorb wave energy, reducing their habitat functions, and reducing biodiversity within the ecosystem.
- ◆ Adding sand to recreational beaches changes the sediment composition and can lead to increase in invasive species.
- ◆ Hardscape elements dramatically alter composition





Estuaries and Salt Marsh

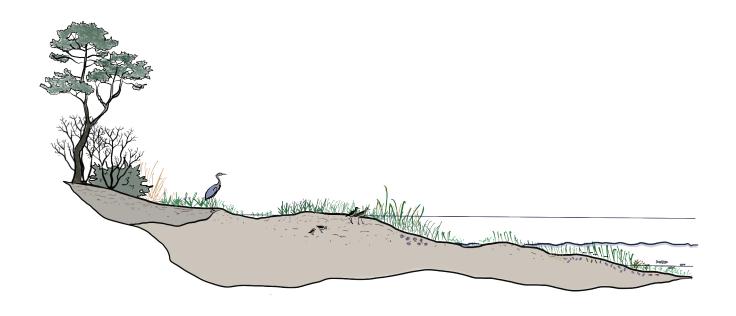


Image based on (SCBC, 2003).

Marshlands can be found where river outflow meets the ocean, and along coastlines in sheltered areas with fine sediment accumulation. Estuaries are located where fresh and salt water mix, whereas salt marshes contain salinity loving species in the high upper intertidal zones of frequency flooded coastal areas. Marsh habitat comes in many forms including large deltas, steep river mouths, fringe marshes and gradual shorelines.

Substrate

Can vary from fine sand and silt to coarser gravel and cobbles

Wave Energy

Found in low energy systems or protected areas

Key Species

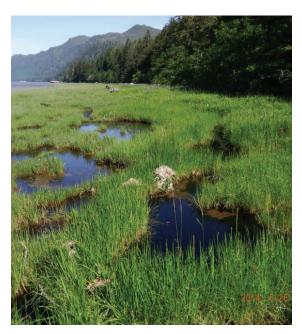
Marsh vegetative species range depending on salinity levels and energy inputs, eelgrass beds can form in subtidal, key areas for waterfowl, migrating birds, shorebirds, fish and invertebrate species

Key Functions

- ◆ One of the most valued ecosystem types
- ◆ Salt marshes and estuary vegetation provide unique habitats
- ♦ Key overwintering habitat for waterfowl, shorebirds and migrating species
- ◆ Essential rearing and feeding area for fish and invertebrates
- ◆ Foraging habitats for terrestrial species
- ◆ Carbon sequestration
- ◆ Detritus accumulation provides base of marine food web
- ◆ Flood absorption

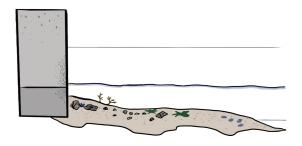
Threats

- ◆ Extremely sensitive to changes in water flow, sediment input, and longshore drift
- ♦ Slow recovery rate from disturbances
- ◆ Dredging of river outflow areas leads to habitat removal
- ◆ Sensitive to metal and organic contaminants from outflow areas and runoff
- → Human use and trampling in these areas can lead to decreased biodiversity and disturbance of the many wildlife species that use this habitat for foraging, refuge and breeding
- ◆ Disturbances encourages invasives like purple loosestrife and cordgrass





Altered Shores



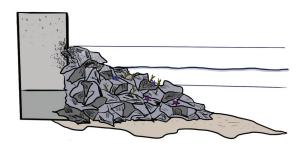


Image based on (SCBC, 2003).

Any shoreline or coastal region that has been altered by human activity. Traditionally the most common approach in urban areas to minimize coastal erosion forces (NRC, 2007). Ports and harbours cause severe alteration to natural shorelines due to hardening and structural developments such as seawalls, bulkheads, docks and riprap. Dredging often occurs to allow for docking which completely removes ecosystems sedimentation processes and eliminates benthic communities (SCBC, 2003). Hardened surfaces like walls and dikes accelerate erosion processes on seaward side, removing intertidal habitat. Altered

shorelines in estuaries and coastal wetlands remove water circulation and sedimentation processes leading to the elimination of these ecosystems. Cumulative impacts along shorelines include the permanent removal of sediment from the littoral system leading to steepening shores and loss of intertidal zones (NRC, 2007). Altered shorelines are the only type of shore that is increasing within the Anthropocene (SCBC, 2003).

Substrate

◆ Sediment composition varies but altered shorelines have added rocks (riprap), concrete, steel or wooden piles. These shorelines tend to be straight and impermeable and often have filling added behind to increase buildable area which buries natural substrate and biological communities.

Wave Energy

◆ All energy systems

Key Species

Minimal diversity is found in altered shorelines due to the negative consequences of their construction and reduction of ecosystem processes. Designed rip rap can mimic rocky intertidal zones with algae and invertebrate colonization, however they are unable to house the diversity of species found in natural edges, are are more susceptible to colonization from invasives (NOAA, 2008). Piling usually shades out marine plants, and added wave energy removes vegetation against constructed walls. Increasing shoreline alteration has been linked to global reduction in biodiversity in intertidal and benthic communities (Bilkovic & Mitchell, 2013).



Key Functions

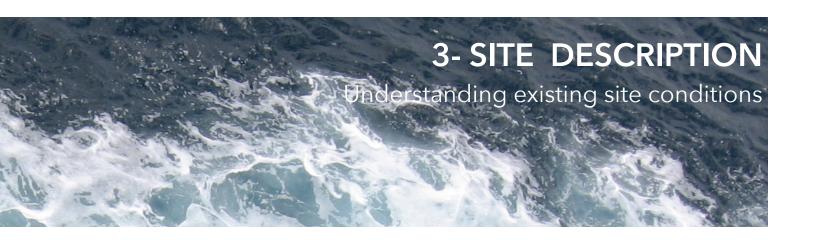
◆ Altered shorelines are constructed to stop the processes of coastal erosion and allow for development along seaside areas.

Threats

- ◆ Wave action and storms lead to failing of these built structures which can often have severe consequences for coastal communities
- ◆ Sea level rise threatens the sustainability of many static structures

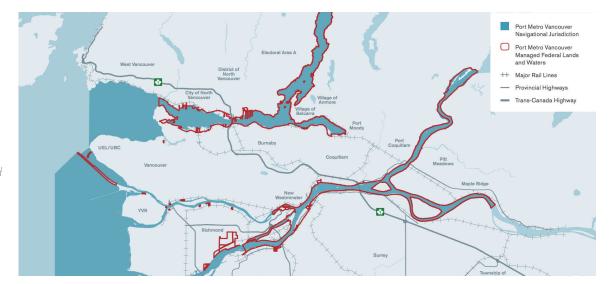






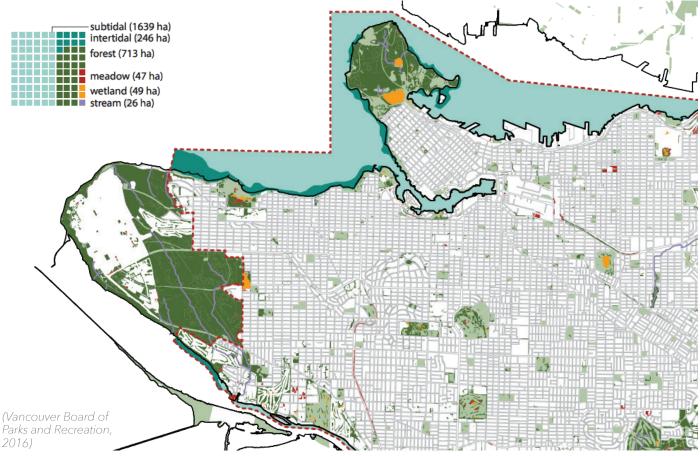
SITE SELECTION SITE CRITERIA

- ♦ Coastal Area within City of Vancouver- area that would benefit from coastal protection enhancement (ex. due to sea level rise, storm surges, high levels of erosion, flooding threats) and be supported by the goals and targets of the city.
- ♦ High Visibility/Use-near urban area to allow for recreation and education opportunities
- ◆ No high value development or residents on water edge- suitable to explore soft engineering approaches without building removal
- ♦ Environmentally degraded area- area that could benefit from ecological enhancement
- ◆ Potential for habitat connectivity- potential for connection to green spaces to allow for maximum habitat enhancement oppoutunities for biodiversity
- ♦ Sizable amount of public land- to allow for a creative design to be used by public (not within Port of Vancouver lands due to restrictions)

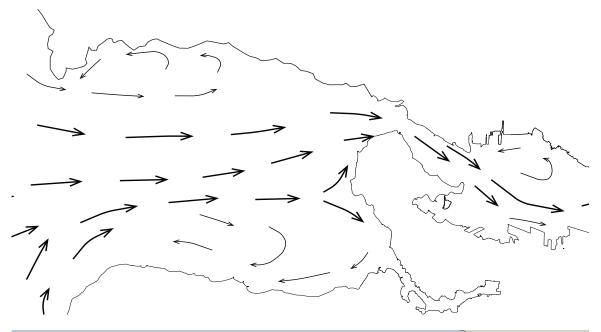


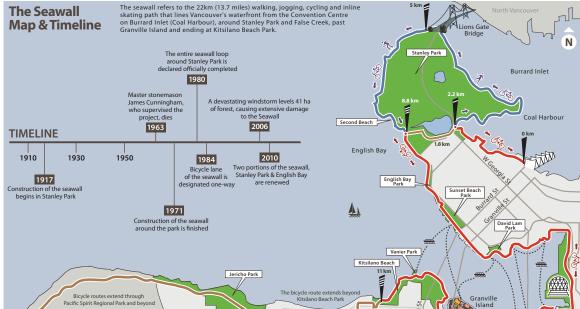
Port of Vancouver Lands (2014)- Used to understand where Port land ownership was within the city. This excluded the northern coast of the city.

Biodiveristy priority habitats mapping within the City of Vancouver was used to look at potential areas for ecosystem connectivity to terrestrial habitats as well as where exisiting intertidal zones are located.

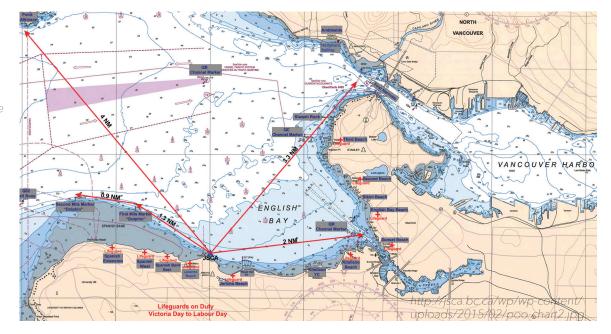


Current Maps were used to determine which areas were most subjected to tidal flux, storm surges, and coastal erosion. As shown by the figure, the western edge of Stanley Park receives the greatest of these impacts. Based on (DFO,

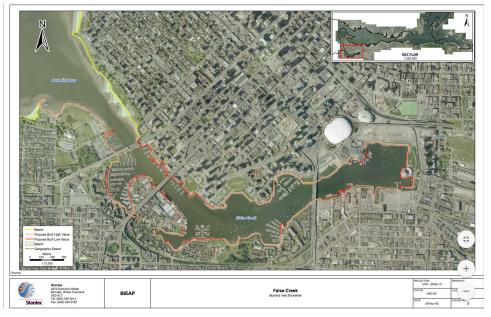




Seawall maps were used to determine placement of retaining walls, accessibility to intertidal areas, and connectivity to surrounding areas. (City of Vancouver, 2016)



Nautical Maps were used to determine shorelines depths, shipping routes, and marine markers. This map also highlights the different recreational beaches within the city. This map highlights the large distance of the Spanish Banks intertidal created by deposition.



BIEMP Mapping was used to determine the current conditions of Burrard Inlet coastline within the City of Vancouver (BIEMP FREMP, 2014)

False Creek contained a continuous build edge, with development surrounding the water edge. The only undeveloped areas were in North False Creek which is already under the process of being redesigned.



There is no BIEMP plan for the southern coast of BI so a personal site visit was conducted. The southern coasts of Bl contain a mix of recreational beaches and high value residential properties. There is opportunity here for enhancement within the public lands and connectivity to terrestrial habitat.



Stanley Park provides a unique coastline as it is completely developed high value with the seawall, yet directly connects to terrestrial habitat which is park land. It additionally contains some of the only intact natural rocky intertidal

SITE DESCRIPTION STANLEY PARK



Why Stanley Park?

The coastal edges, and specifically the western portion of Stanley Park from Ferguson Point to Second Beach was chosen for this thesis as a site location. As can be seen in the maps on the page before, Ferguson Point is most directly hit by tidal and weather conditions within Burrard Inlet making it vulnerable. As one of the most celebrated areas within the city, the redesign of the Stanley Park foreshore provides a challenging and unique opportunity to maximize recreational and learning opportunities, while restoring the ecological functioning of the intertidal zones. As a park, there is opportunity to reconnect the marine environment to the upland terrestrial ecosystems. Although considered high value developed lands, as result of the seawall, there are no coastal developments along the park foreshore, allowing for the potential use of soft engineered approaches to adapt coastal erosion and sea level rise. Furthermore, the City of Vancouver supports the continued protection and enhancement of the park and has multiple targets to improve its biodiversity strategies and enhancement for the future.

- ◆ Huge tourism draw, brings in money for the city
- ◆ Park area yet considered high purpose built shoreline due to the seawall. The terrestrial parts of the park are celebrated yet the marine landscape is cut off and almost ignored.
- ◆ City has goals for Stanley park biodiversity to be improved and has recognized the western shores as at highly at risk to sea level rise.
- ♦ Aquarium is a popular destination for visitors and educational purposes, yet is becoming an outdated institution. There is an opportunity to create a marine landscape that allows people to immerse themselves in the physical intertidal ecosystem and encourage learning here.
- ♦ Opportunity to create a multifunctional landscape here that is a functioning intertidal zone that highlights healthy ecosystems, enhances marine life, can adapt to climate changes and maintains its social and cultural senses of place.

STANLEY PARK

A Brief Park History

Stanley Park is a 1000 acre (405 hectare) forested peninsula that sits on the northwestern point of current downtown Vancouver. The history of social uses of the park date back before records as it was originally home to the Tsleil-Waututh, Musqueam, and Squamish First Nations peoples (City of Van., 2016). The park was home to indigenous populations for thousands of years before colonization by the British in the 1800's and this thesis recognizes that Vancouver remains on the unceded traditional territories of Musqueam, Squamish and Tsleil-Waututh First Nations communities (City of Van., 2016).

Following colonization, Stanley Park became home to both indigenous and European settlers, providing abundant natural resources for those that resided there. The land was established as a park in 1888 and named after Lord Stanley, the governor general at the time. Unlike most large urban parks of that time, Stanley Park did not have a lead Landscape Architect that created its design, instead the park was an evolution of forest and urban spaces resulting from the changing requirements of society throughout the years. Roads and trail networks were created throughout the park throughout the 1900's, and various athletic fields and pavilions were built to encourage recreational activities. Vessel waves were causing accelerated erosion to the shorelines of Stanley Park and as a solution seawall construction began in 1917 and would take sixty-three years to complete (City of Van., 2016). With the creation of the causeway and Lost Lagoon in 1926, the tidal flats of Coal Harbor were lost. Lions Gate Bridge was opened in 1938 and the connection to the north shore would make



Stanley Park Aerial 1926 (Vancouver Archives, 2016)



Stanley Park Residents 1860 (Vancouver Archives, 2016)



Siwash Rock 1890 (Vancouver Archives, 2016)

the Stanley Park causeway one of the most heavily used vehicular corridors in the future. During the World Wars, Stanley Park and specifically Third Beach became a military base. Following the end of the Second World War, Deadman's Island was transferred to the Department of National Defense as a naval reserve (City of Van., 2016). The park continued to create and promote varying recreational and educational amenities with the creation of the Vancouver Zoo and Aquarium in the 1950s, and the Miniature Railway in the 1960s. In 1988 Stanley Park was designated as a national historic site of Canada for it's "splendid setting and through the relationship between natural environment and its cultural elements developed over time" (City of Van., 2016). The park remains Vancouver's primary tourist attraction as the third largest urban park in North America (City of Van., 2016).



Second Beach 1900s (Vancouver Archives, 2016)



Second Beach 1910s (Vancouver Archives, 2016)



1940s (Vancouver Archives, 2016)



Second Beach 1900s (Vancouver Archives, 2016)



Stanley Park 1900s (Vancouver Archives, 2016)



Third Beach1890 (Vancouver Archives, 2016)

CURRENT CONDITIONS



(City of Vancouver, 2016)

The Park Today

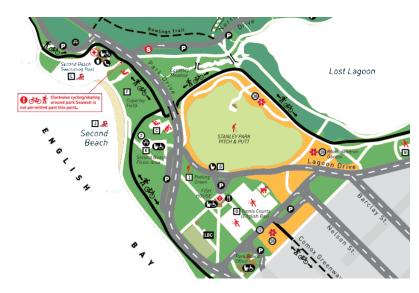
The park today draws over 8 million visitors a year, ranking the number one destination in Vancouver (Tourism Vancouver, 2016). Stanley Park provides visitors with a huge range of programming and amenities allowing all ages and user groups to utilize the park. There are countless outdoor recreation activities such as hiking, biking, swimming, tennis and golf, there are multiple restaurants, a splash park, guided tours, school trips, theatre productions, music venues, and seasonal events to keep visits unique with each trip to the park.

Experientially the park provides welcome relief to the urban grid of downtown Vancouver. The vistas along the seawall overlooking Burrard Inlet provide an expansive background that allows for feelings of space and freedom. Visitors can walk through ancient trees and feel as though they are a million miles away from a city. Whether you are exploring the park alone or with friends and family, whether it is your first visit or you have been coming since you were a child, Stanley Park truly holds a special place within Vancouver.

Second Beach

Located at the junction of Stanley Park Drive and North Lagoon Drive, Second Beach is one of the most popular areas within Stanley Park. This area has been chosen as part of the thesis site due to it's low lying gradient and vulnerability to sea level rise. High wave action targets Ferguson Point to its north and the erosion of the foreshore is evident along this coastline with sand having had to be added to the beach to prevent its continued erosion (SPES, 2016).

Second Beach is the easiest to walk to from the West End and therefore provides an opportunity for high user access within this site. Current programming of this area includes access to the seawall, a concession, washrooms, playground, baroques, picnic shelter, open meadow, playing field, recreational beach and an outdoor heated swimming pool.

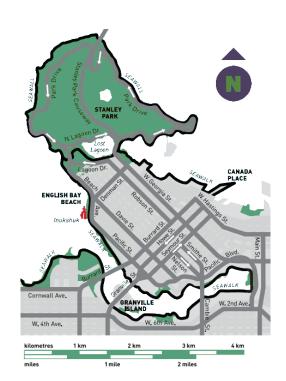




Circulation and Connectivity

Stanley Park is connected to Vancouver not only as a main destination, but as a through road for movement from downtown to the North Shore. The causeway is a three laned, heavily used traffic corridor, with connected bike and pedestrian lanes. Stanley Park Drive is one-way circular road around the park providing access to the multitude of park amenities.

Bike and pedestrian trails are equally influential throughout the park, with 9km of seawall and over 27km of networked trails.



(City of Vancouver, 2016)

EXPERIENTIAL



















PHYSICAL

Geological

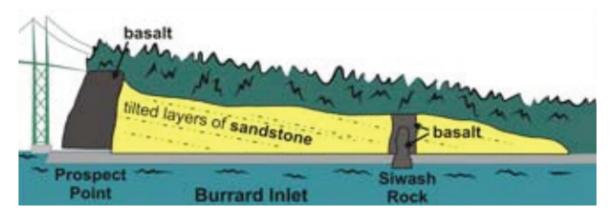


Image showing the sediment composition of Stanley Park (MineralsEd, 2011)

> It is important to understand the geological composition of Stanley Park to understand how physical processes, such as erosion, affect the site, and what the opportunities and constraints will be in the future. Sediment composition additionally determines the vegetation and habitat types that would naturally form in these conditions. Vancouver is underlain by three major geological materials- bedrock, Ice Age sediments (uplands) and modern sediments (lowlands), which erode along the shoreline into distinctive shoreline types including rugged rocky shores, sediment cliffs and beaches, and lowland sand, mud and gravel shores (MineralsEd, 2011).

> The beaches of Burrard Inlet, including Second Beach, Third Beach, and English Bay, are primarily composed of sand from

the Fraser River and the eroding sand cliffs at Point Grey. Due to dredging in the Fraser River, armoring of Point Grey, and increasing intensity of storm events, all these beaches are eroding and have depleting sand volumes (MineralsEd, 2011., City of Van., 2016)

The boulder patches found along the outside of the seawall are the result of erosion exposing the remaining large till accumulated by the scouring glaciers. Extending out from the seawall you can see tilted layers of sandstone, siltstone and shale that create rib like formations gently sloping into the water as a result of river deposition millions of years ago (MineralsEd, 2011). As the sandstone's fine mud and sand is eroded by each wave, the top layer of glacial till (ex. granite boulders) is all that remain as the sea cliffs retreat.

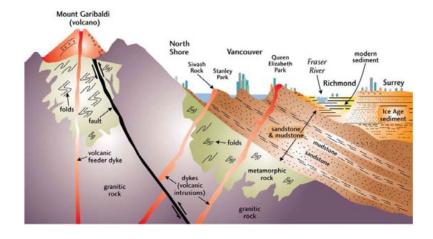
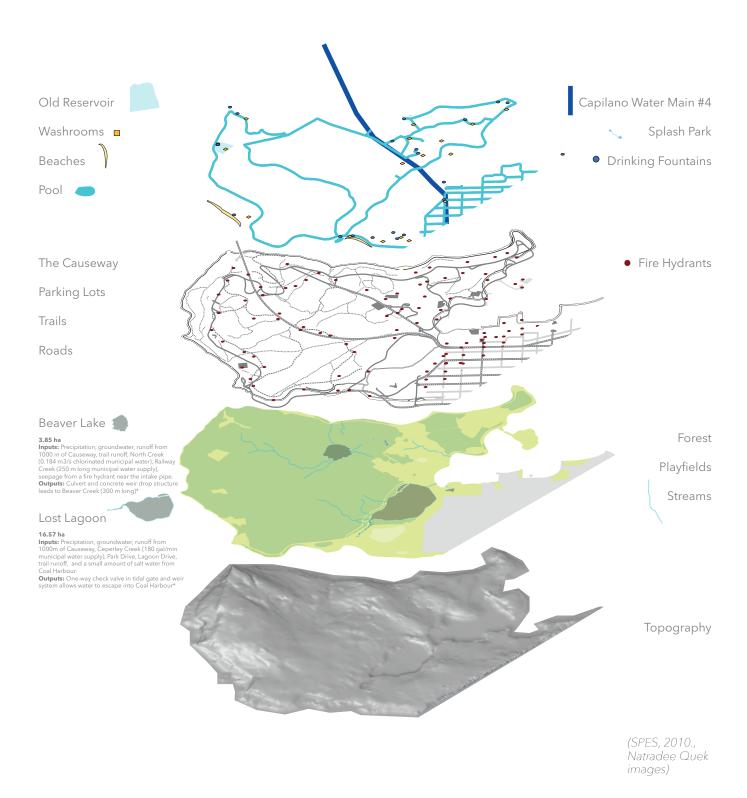
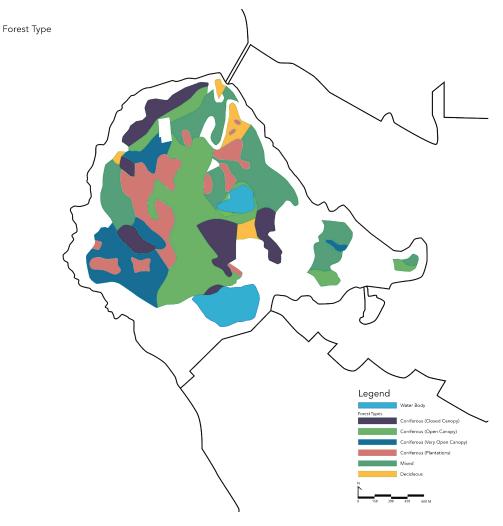


Image showing the geological formation of the Lower Mainland (MineralsEd, 2011)

Hydrology



Vegetation



Based off (SPES, 2010)

Part of Stanley Park's identity is it's 'natural' beauty, appearing as untouched landscape connected to downtown. The truth is that Stanley Park has had anthropogenic influences through the years by things like logging, the military, and now it is heavily maintained by the Park's Board and Ecological Society to maintain functioning, programming and safety (SPES, 2016). The protection of its existing vegetation is now a priority though, and the SPEC actively tries to conserve and enhance the habitat types (as seen above) throughout the park. The majority of the work conducted in Stanley Park is within its terrestrial world, and this thesis notes the lack of information available regarding the marine environment.

Habitat fragmentation has been recorded as a major influence on ecosystem function and biodiversity within Stanley Park (Vancouver Board of Parks and Recreation, 2011). Due to human use and the creation of roads, trails and the seawall, habitat has become fragmented into isolated patches. This can especially be seen with the creation of the seawall and the complete disconnect of marine and terrestrial ecosystems. Aquatic ecosystem habitats are ranked as poor quality in the State of the Park Report (SPES, 2010) and are identified as threatened due to erosion processes shrinking limited intertidal zones. It is noted within park studies that more research needs to be completed within the marine aquatic areas to assess the rate at which these environments are decreasing (SPES, 2010).

Foreshore Conditions













The Seawall

As described above, the Stanley Park seawall was first constructed in 1917 and was completed in 1980. Heavy ship traffic within Burrard Inlet caused increased wave height that accelerated shoreline erosion and the wall was commissioned to protect the sandstone cliffs. Since then the seawall is representative of the success of the park and of Vancouver, with its network expanding to 28km of uninterrupted seaside path around the city making it the largest in the world (SPEC, 2015). However, what was perhaps not known at its initial construction was the negative impacts the hardened shoreline would have on the intertidal communities. As previously described, research now shows that coastal retaining walls essentially end up removing all intertidal habitat through increased wave height and scouring, loss of connectivity and vegetation, and the removal of the natural sedimentation processes that would replenish the shoreline (Bilkovic & Mitchell, 2013, Sharma et al., 2015). Along the western portion of Stanley Park, there would have naturally been a mix of rocky, beach and gradual fine sediment ecosystems (BIEMP FREMP, 2014). With the seawall, all these ecosystems have essentially been removed, as the high tide line reaches the wall and degradation of habitat has left mostly dead zone areas of fine sediments and boulders without significant marine diversity.

The seawall's maintenance has increasingly become problematic in recent years with increasing storm events due to climate change. Larger storms with higher water levels have increased flooding and overtopping of the wall, leading to annual closures and repair costs. This problem is not likely to get better, and as the seawall is a singular protection defense, without raising its height the results of these storms will become worse (Bilkovic & Mitchell, 2013, Sharma et al., 2015).

Despite its negative ecological effects, the seawall is one of the most treasured aspects of the city with its extensive vistas and meandering ease. Ensuring that the experiential qualities of the seawall are maintained will be one of the most challenging parts of it's redesign.

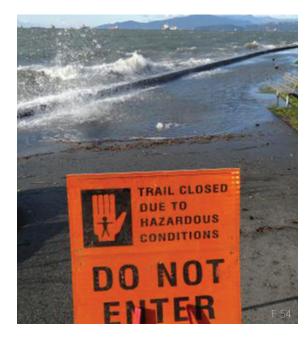














Environmentally Sensitive Areas



Invasive Species

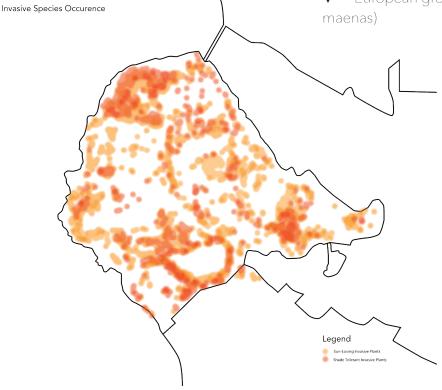
Invasive species are introduced species that are able to spread quickly, grow rapidly and thrive in environments often resulting in the outcompeting of native or other exotic species (SPES, 2013). Invasive species are one of the greatest threats to biodiversity in the world today, only second to the threats of habitat loss (Vancouver Board of Parks and Recreation, 2011). Invasive species can further exacerbate habitat loss, by overgrowing and colonizing areas thereby removing the habitat benefits provided by native or mixed plant communities. As noted above, the majority of the stewardship work done within Stanley Park is within the terrestrial landscape, so marine habitats are not as represented within the environmental management plans. Invasive species are mapped by SPES and there are programs for the removal and management of these species. The following are some of the species have been found in this thesis location (SPES, 2013).

Plant Species

- → English holly (Ilex aquifolium)
- ♦ English ivy (Hedera helix)
- → Japanese knotweed (Polygonum cuspidatum)
- → Himalayan blackberry (Rubus armeniacus)
- ♦ Scotch broom (Cytisus scoparius)
- ♦ Yellow flag iris (Iris pseudacorus)
- ◆ Spurge laurel (Daphne) (Daphne laureola)
- ◆ Purple loosestrife (Lythrum salicaria)
- ◆ Morning glory (Bindweed) (Convolvulus sepium)
- ◆ Climbing nightshade (Bittersweet) (Solanum dulcamara)

Wildlife Species

- ♦ Varnish clam (Nuttallia obscurata)
- ◆ European green crab (Carcinus maenas)



Invasive Species Occurrences and Hot spots. Based off (SPES, 2013).

POLITICAL

Key Players

Vancouver Board of Parks and Recreation

An elected government board that operates the 240 parks, destination gardens and community centers throughout the city. The park board is responsible for the creation and maintenance of parks, including trail and development strategies that facilitate user needs and ecological goals of the city for the future (City of Van., 2016).

Stanley Park Ecological Society

Founded in 1988, the Stanley Park Ecological Society (SPES) is a non profit that works alongside the Vancouver Board of Parks and Recreation to protect, manage and maintain Stanley Park (SPES, 2016). The non profit has a mix of employees and volunteers that help run the conversation and stewardship programs throughout the park. Together with the Vancouver Parks Board, stewardship programs focus on education, research, and conservation action (SPES, 2016).





BIEMP

The Burrard Inlet Environmental Action Program (BIEAP) and Fraser Environmental Management Program (FREMP) were established in 1991 to create an intergovernmental model of coordinated environmental management. BIEAP worked to create a framework to gather research and create a management program to improve the environmental quality of the Burrard Inlet ecosystem (BIEAP, 2008). The goal was to bring together the many agencies responsible or influencing the health of Burrard Inlet such as BC Ministry

of Environment, Environmental Canada, Fisheries and Ocean Canada, Metro Vancouver and the Port Authority, as well as local communities bordering the inlet (BIEAP, 2008). Due to legislation changes, the BIEAP and FREMP offices closed in 2013 (BIEAP FREMP, 2014).

Regulations

Applicable Laws

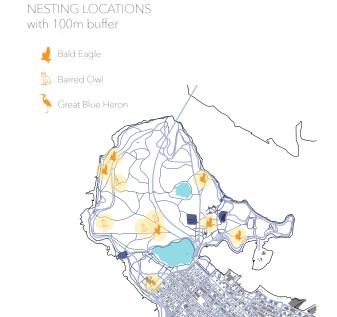
- ♦ BC Provincial Wildlife Act
- ◆ Species at Risk Act
- ♦ Migratory Birds Convention Act
- ♦ Federal Fisheries Act
- ◆ BC Provincial Water Act
- ♦ Vancouver Board of Parks and Recreation- Park By-laws

There are several species that reside within Stanley park that are protected under law and/ or because of their ecological importance in Stanley Park's natural heritage (Vancouver Board of Parks and Recreation, 2011). For example, salmon habitat, the great blue heron colony, bald eagle and owl nests, migrating birds, breeding birds and any species at risk are protected under law. The governing of the park has understood there are many additional species that are vital to the functioning of the park and have created programs to highlight some of these umbrella species. Protection of keystone and/or locally declining species with stewardship programs like Co-Existing with Coyotes program and Salmonids in the Park, have brought awareness to conservation concerns (SPES, 2012).

Burrard Inlet is internationally recognized as an Important Bird Area (IBA) that contains essential habitat for Canadian and migrating birds.

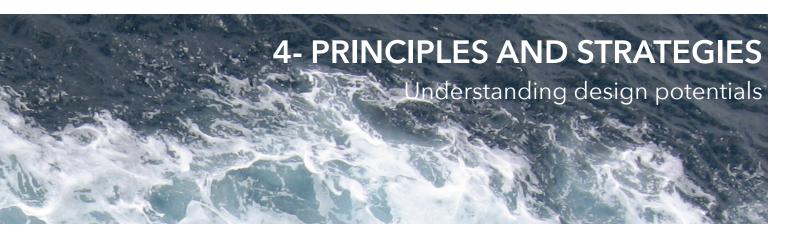
Applicable BMPs

- ◆ BMPs for the Protection of Amphibians and Reptiles
- ♦ BMPs of Raptors
- ♦ Standards and BMPs for Instream Works



Based off (SPES, 2012)





PRINCIPLES

A SUMMARY OF PRINCIPLES GAINED

GOAL 1. Redesign Stanley park shoreline to restore ecosystem functioning to improve coastal habitat and promote species diversity

Design PrincipleCreate landscapes that provide and enhance habitat

Design PrincipleMaintain intertidal
habitat as key
landscape for
biodiversity

Design Principle
Use design
to maximize
landscape
ecosystem services
in multifunctional
landscapes

GOAL 2. Increase resiliency of shoreline to future climate change impacts

Design PrincipleLandscapes must
be adaptable to
future climate
change

Design PrincipleUse green space to help mitigate the affects of climate change

Design PrincipleFind cost efficient
ways to address
climate change

GOAL 3. Promote cultural connections to marine health through social learning and recreation

Design Principle Create landscapes that maintain the 'natural beauty' of the coast Design Principle
Landscapes should
be accessible
and encourage
recreation

Design Principle
Create landscapes
that are accessible
to the public
and encourage
interaction with
the environment
for learning and
experiential
opportunities

Design Principle

Redesign seawall to connect marine and terrestrial landscapes and restore coastal processes

Design Principle

Ensure a mix of landscape elements to maximize habitat and food source potentials

Design Principle

Design landscapes that maximize ecosystem services

Design Principle

Use appropriate ecosystem types for environmental gradients and forces

Design Principle

Understand coastal processes and natural protection landscapes to be used within design

Design Principle

Create a landscape that can synergize multiple targets into one landscape

Design Principle

Mitigate
anthropogenic
influences on
intertidal zones

Design Principle

Use soft approaches over hardscapes where possible

Design Principle

Ensure cultural connection to landscape is maintained

Design Principle

Design landscapes that can be used for educational purposes

Design Principle

Coastal landscapes should allow for mental restoration

Design Principle

Landscapes should contain recreation potential

PRECEDENTS LARGE SCALE

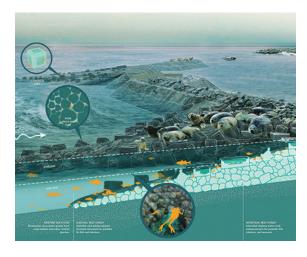
Living Breakwaters

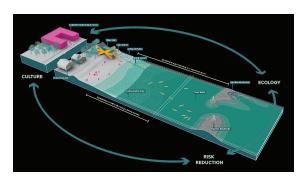


(SCAPE, 2016)

Part of Rebuild by Design Competition for New York and New Jersey in response to the effects of Hurricane Sandy, this project aimed to connect physical, social and ecological resiliency by the creation of offshore breakwaters that reduce risk while stimulating ecological growth, and creating recreation and educational opportunities along Staten Island's southeast shoreline. Staten Island sits in a funnel shape bay that is at risk location for waves, storm surges and sea level rise with a mix of highly densified areas and natural shorelines along this coast. This project had similar goals to this thesis, and the approach they used, as well as the documents produced were all used as inspiration. This project was a large stimulus for this thesis and below are some of takeaways that will be used to help further this project's design.

Developed by: SCAPE/LANDSCAPE ARCHITECTURE with Parsons Brinckerhoff, Dr. Philip Orton / Stevens Institute of Technology, Ocean & Coastal Consultants, SeArc Ecological Consulting, LOT-EK, MTWTF, the Harbor School and Paul Greenberg







- ◆ Goal of the design was to not only design a piece of protection infrastructure, but the creation of a place that would enhance life quality for both humans and wildlife in the area.
- New approach to design: not only looking at an economic/ cost based, but understanding the value of the ecosystem services provided, including environmental, social and community benefits.
- ◆ Creation of a multilayered protection approach along shoreline edges (tidal flats, marshes, dunes, upland vegetation).
- → Approach was to study the landscape typology characteristics of shallow water zones to understand the different protective benefits (ex. salt marsh, dune, mudflat, beach, reef). These were then combined into hydrodynamic modeling to better understand their potential uses as ecological infrastructure on the coastline.
- ◆ Discovered the potential of the combination of offshore living reefs and shorelines to create multifunctional landscapes.
- ◆ Use of oyster reefs and wetlands as an ecological way to reduce flooding.
- ◆ Research on reef shape and structure that would best protective shorelines without causing problems of sedimentation transfer and enable marine growth on structures.
- ◆ Using these coastal areas as recreational and educational zones through activity hubs. The added protection of the offshore reef breaks allowed for increased aquatic recreation potential along the coast.

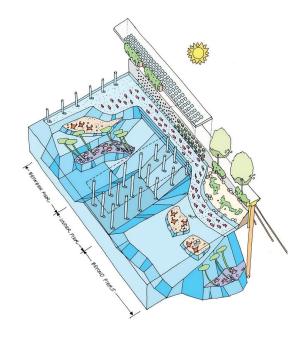
PRECEDENTS LARGE SCALE

Seattle Central Waterfront

JAMES CORNER/ FIELD OPERATIONS

(James Corner Field Operations, 2014) A comprehensive framework plan for the urban waterfront of downtown Seattle Washington. This thesis was particularly interested in the redesign of the Elliot Bay Seawall. Situated along a busy urban artery, this reconstruction is aimed to increase ecological functioning while maintaining its protective and structural functions to an urban area. Seattle has a similar ecological context to Vancouver, and Elliot Bay was previously a bluff-backed beach that contained marshes and intertidal flats home to many bird, fish, and invertebrate species that have been reduced with urban densification.

- ◆ New way to approach seawall design when removal is not an option in an urban context.
- ◆ Seawall design enhances marine life, with special interest in the enhancement of salmon migration corridors and refuge habitat.
- ◆ Uses a cantilevered seawall sidewalk which includes glass panels to allow for 20% of light to pass through and stimulate aquatic vegetation.
- ◆ Goal is to create a new boardwalk experience with both social and ecological benefits.
- ◆ Creation of shallow salmon passage waters with habitat benches along the bases of the walls which will link to other parts of the coastline.
- ◆ The wall is designed with textured panels to encourage algae and aquatic growth to create rich habitat.









MALMÖ Marine Education Centre

NORD Architects

The design of the Malmo Marine Education Centre hopes to blur the lines of architecture and landscape to create a place that helps people gain a deeper connection and education of marine life in the coastal city. The driving forces behind the project are similar to this thesis, and include the urgency for people to understand marine environments and the dramatic influence they have on our lives with changing climate, rising oceans and increasingly severe storm events.

(NORD Architects, 2014)



- ◆ Creation of a learning landscape centered around marine life.
- Programming of floating laboratories that will include teaching signs and underwater binoculars.
- ◆ Programming includes activities to varying age groups and user bases.
- ◆ Exposure of the systems that run the building, including energy consumption, water management and ventilation, so that people can understand how the it interacts with the environment.
- ◆ Hand on learning experiences and a learning landscape where everything could be an education tool.
- ◆ Many viewing areas so people can see and interact with underwater processes.



PRECEDENTS LOCAL

Being a high density coastal city, Vancouver has had many marine and coastal enhancement projects over the years. From government led initiatives, to non profit organizations, the protection of our shorelines has always had support. Below are brief summaries of a few of the past, present and current methods and strategies that have been found successful within the region.



A new island with adjacent intertidal habitat was created in South East False Creek as part of the Olympic Village development. The design included the creation of new rocky intertidal and shoreline forest zone, and is a successful example of habitat creation within an urban context. The project is partially attributed to the returning of herring spawning within the area (Vancouver Board of Parks and Recreation, 2016).

Jericho Park Shorelines Restoration

Jericho Beach Park restoration included a 185m section of foreshore that was enhanced by wharf removal and the creation of a new recreation beach, restored intertidal habitats focusing on fisheries habitat, and planted beach meadows and upland forest. It is a highly successful restoration project that has seen returns if surf smelt and spawning fish (Vancouver Board of Parks and Recreation, 2016).





Final Proposed Design Concept





₽ 60



Squamish Stream Keepers Herring piling Wrapping Project

Thousands of tons of herring used to spawn in the Mamquam Blind Channel in the 1960's, however with the industrial development that occurred and many of the docking structures that were placed were killing the herring eggs with the creosote on the pilings (Squamish Terminals, 2012). Finding a simple solution of wrapping these pilings and adding additional net pens to provide more surface area for spawning has allowed millions of herring to return to the area, bringing with them the return of larger fauna like salmon, dolphins and orcas (Squamish Terminals, 2012). This practice was additionally applied to the development of Southeast False Creek with positive results.

Robert Bank and Boundary Bay Salt Marsh

The restoration of five salt marsh sites in Delta was completed in 2014. The removal of excessive woody debris and litter was completed to allow for vegetation growth, along with the targeted recolonization of species like saltgrass, pickleweed, dunegrass and other salt tolerant herbaceous species (Port of Vancouver, 2014). Wildlife snags were installed to provide perch and roosting habitat.

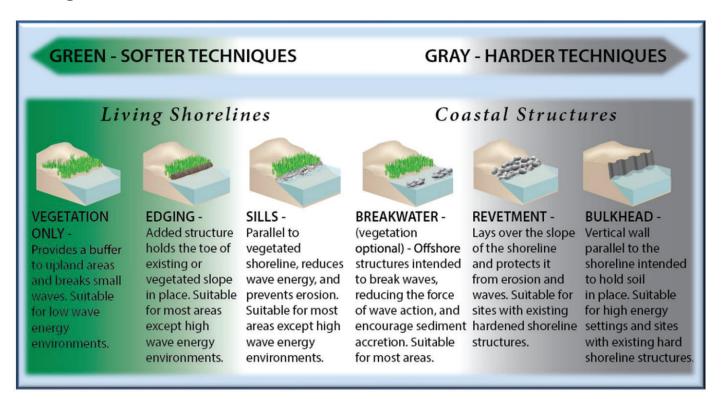
Tsawwassen Eel Grass Project

Creation of high value eel grass beds in currently degraded lower value subtidal areas. Construction of rock containment berms to create structure for the placement of substrate (sand and silt) and planting of eelgrass (Port of Vancouver, 2014).

STRATEGIES

INTEGRATED APPROACHES

Living Shorelines



Continuum showing shoreline stabilizing techniques. Living shorelines include vegetation only, edging, sills, and breakwaters (NOAA, 2015). New adaptive strategies in coastal design are circling around the concept of living shorelines. A broad term that encompasses a range of shorelines stabilization techniques along coastlines. These multilayered approaches to shorelines design do not include structures that cut off natural processes and instead promote connectivity from upland to aquatic ecosystems (CCRM, 2016). Shorelines techniques can range from green (natural materials only) to green/gray (hybrid) to gray (all built materials) depending on the shorelines environmental conditions such as wave energy, and targets of the project (NOAA, 2015).

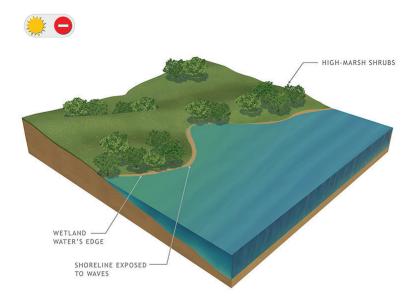
Living shorelines treatments address erosion through the placement of landscape elements like plants, stone, sand fill, and other structural or organic materials (CCRM, 2016). Designing or enhancing natural shoreline protection habitats such as marshes, beaches, and dunes is utilized to create marine and intertidal habitat that maximizes species diversity potential while providing shoreline resiliency and stabilization. The services provided by these living shores vary depending on the location, but can include water quality improvement through filtration, erosion reduction, habitat formation, and creating landscapes with high levels of aesthetic and recreational value.

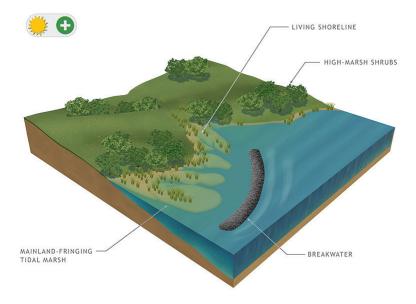
As living shorelines are not engineered feats, costs are usually lower that the construction of defenses like revetments and bulkheads (NOAA, 2008., CCRM, 2016). Furthermore, unlike engineered structures, living shorelines actually become more stable in time as plants, roots, and oyster's reefs grow (NOAA, 2015). Accretion of sediment

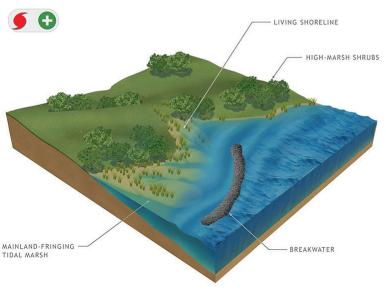
occurs behind reef structures and is trapped in habitats like marshes. This increases surface elevation through production of below-ground biomass, which make these landscapes more adaptive to sea level rise (Bilkovic & Mitchell, 2013). Although living shorelines might not be appropriate for extremely high energy coasts, research shows that living shorelines have outperformed hardened shorelines during storm events like Category 1 Hurricane Irene in Carolina (NOAA, 2015).

Key Services

- ♦ Risk Reduction and Increased Resiliency
- ♦ Shoreline Stabilization
- ♦ Habitat Creation
- ♦ Water Quality Improvement
- ♦ Water Filtration
- ◆ Cultural Services
- ♦ Recreational Opportunities
- ◆ Food Production
- ◆ Carbon Sequestration







Living Shorelines Diagrams showing different wave energy inputs and the benefits of breakwaters (http://www.nad.usace.army.mil/Portals/40/siteimages/NACCS/16.jpg)

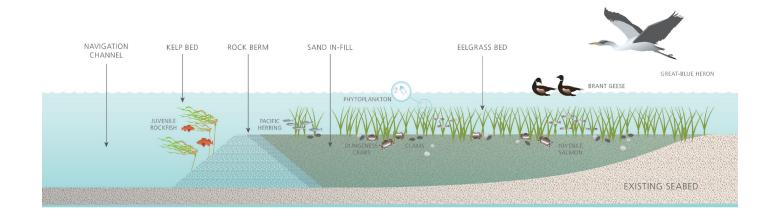
STRATEGIES INTEGRATED APPROACHES

Composite Systems

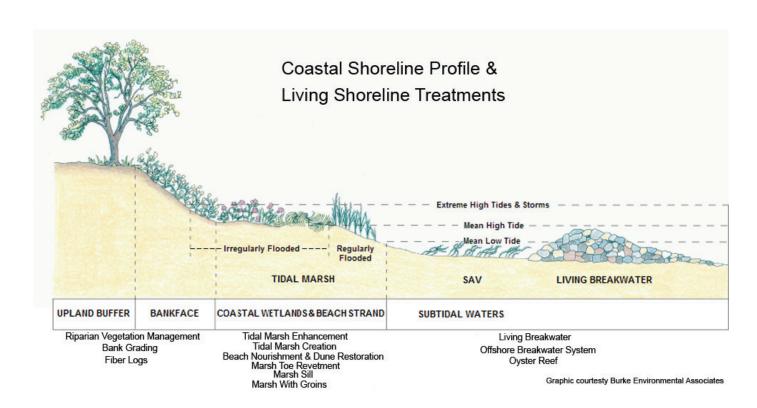
Due to Stanley Park's connection to open water and fairly high fetch (100km from the west), a hybrid approach of techniques would need to be developed. Composite systems, or hybrid stabilization techniques, use a mixture of complimentary methods to provide long term shoreline protection in higher energy coastlines and to create a layered support approach (Bilkovic & Mitchell, 2013., NRC, 2007). This includes techniques that use a blend of methods so that shorelines are protected in all levels of climatic conditions and climate changes. The eastern coast of the United States has been a leader in using these composite

systems to protect from hurricanes and common combinations include breakwaters, marshland and upland vegetation to create a living, adaptive barrier (NRC, 2007). Design for future coastlines will need to not only consider the stresses of storm surges today, but those of future sea levels and altered climates.

The following pages describe some of the landscape elements and habitat types that could be combined to create a diverse, functioning, and resilient landscape that could provide the social benefits needed within Stanley Park.



Cross section of a constructed eel grass bed with rock berm. (Port of Vancouver, 2014).



Living Shorelines Diagram (CCRM, 2016).

STRATEGIES INTEGRATED APPROACHES

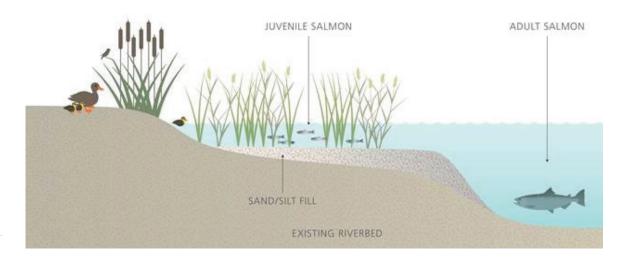
Methods: Habitat and Landscape Elements

Tidal Marsh

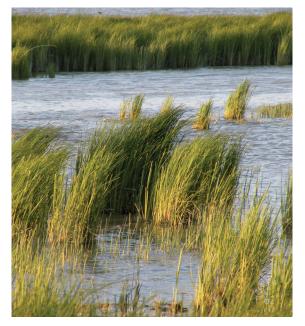
A coastal marsh found along shorelines and in estuaries, usually with a combination of fresh and salt water. Tidal marshes are key habitat for fisheries including salmon rearing and feeding, waterfowl, migrating birds, invertebrates and other wildlife (NRC, 2007). Marsh habitats aid in wave reduction and sediment accumulation.

Salt Marsh

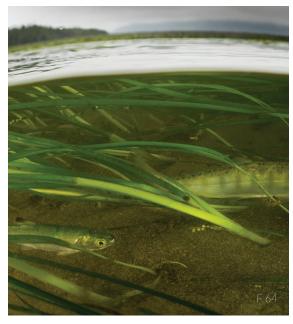
An intertidal marsh found in coastal areas where tidal fluxes control the inundation levels. Salt marshes are important sources of primary production, creating nutrients and organic matter for the food web of fish, birds and wildlife. Includes species such as eelgrass, pickleweed, and dunegrass (Port of Vancouver, 2014). Marsh habitats aid in wave reduction and sediment accumulation.

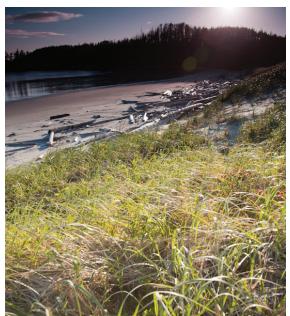


Cross section of constructed tidal marsh (Port of Vancouver, 2014)











Sea Grass Beds

Sea grass is submerged vegetation that stabilizes sediment, reduce wave height and provides aquatic habitat (NRC, 2007). Eelgrass is a perennial flowering plant which forms underwater beds off the coasts of Vancouver, providing important ecological functioning like nutrient cycling, storm protection, exporting organic matter, and is a key habitat for many marine species such as fish, waterfowl and invertebrates. These beds provide shelter habitat for juvenile salmon, Pacific herring, Dungeness crab, migrating brant geese, clams, shrimp and starfish (Port of Vancouver, 2014). Planting is determined by sediment composure, wave exposure, current velocity and light availability (NRC, 2007).

Vegetated Dunes and Beaches

Vegetated dunes on the upland side of beach environments will encourage beach integrity by increasing nourishment sources (NRC, 2007). Planting dune grasses on the backshore of a beach will naturally aid in the creation of these dunes which provide additional protection and unique habitat (NRC, 2007).

Marine Refuge Areas

Refuge habitat is a necessary element in most marine species survival. Creating additional infrastructure can act as refuge areas and provide habitat for marine life. Caissons are hollow concrete structures used to build marine terminals and docks and have been used with success in the Vancouver area (Port of Vancouver, 2014). Using this material with added holes creates 'caisson refugia, or 'reef balls,' allowing fish, crabs, shrimp, amphipods, sea stars, and other marine organisms to have refuge from waves and predators.

STRATEGIESINTEGRATED APPROACHES

Methods: Habitat and Landscape Elements

Habitat Benches

Built at various elevations, habitat benches are large underwater benches or shoreline layers that create the necessary conditions for a range of vegetation to grow. The benches built underwater can be filled in behind to create layered levels of elevation, which then naturally colonize with marine species. The resulting vegetation provides habitat for fish and invertebrates, and shelter for other marine species. Habitat benches are currently found in Roberts Bank.

Habitat and Barrier Islands

Off shore islands are the first line of defense that naturally occur in many coastal areas, but more frequency these habitats are being created within shoreline design. Islands reduce the affects of wind and waves, absorbing storm energy, and create added shoreline and uplands habitat for fish, birds and other wildlife. These islands can be separated from shorelines or joined during low tides creating varying intertidal habitats (NOAA, 2015).







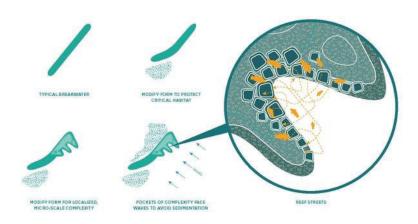


Living Reefs and Breakwaters

Constructed reefs can be both artificial or support natural reef forming species like oysters and mussels. Research shows that fish are found in more abundance where there are changing levels of sea floor, so constructing reef structures increases fisheries biodiversity, while additionally reducing the impacts of waves and tidal flux (Maglio, 2001). Artificial reefs can increase production by increasing habitat areas, including food and refuge habitat, as well as accreting substrate, and thereby countering affects of erosion (NRC, 2007). Seaward growth of the shoreline can occur in the lay of the breakwaters and this outcome can be amplified with the additional of fill (NRC, 2007). Material to make reefs must be heavy enough to resist movement from storm surges and changing sea level. More complex reefs



DESIGNING FOR HABITAT



structures contain higher levels of species diversity (Maglio, 2001). The shape and size of the reef structures is determined by carrying capacity of the base upon which it sits, and the environmental conditions such as currents and tidal change. Placing a reef structure behind the path of the current displaces the current depending on the porosity of the structure, which can create shielded areas where fish aggregations can occur (Maglio, 2001). Research shows that larger reefs structures attract larger groups of fish populations whereas smaller reefs usually have more diversity within species (Maglio, 2001). The key factors to consider in biomass production on reefs is current, sedimentation, temperature, depth and turbidity.





FUTURE DESIGN PROGRAMMING USER GROUPS

Anticipated Needs in Activities and Experiences

RESIDENTS

Seniors

Interacting with friends and family, people and wildlife watching, enjoyment of scenery, ease of access, gentle outdoor recreation, quiet relaxation, participatory and volunteer opportunities

Adults

Interacting with friends and family, people and wildlife watching, enjoyment of scenery, diverse outdoor recreation opportunities, socializing spaces, quiet relaxation spaces, connectivity to extended trail network

Teens

Socializing space, people and wildlife watching, safe environments, ease of wayfinding, participatory and volunteer opportunities, exploring and learning landscapes

Children

Active and passive play, watching boats, people, wildlife, multi sensory experiences, risky play environments, tactile interaction, picnicking, strolling, safe environments, exploring and learning landscapes





TOURISTS

If tourists in Vancouver are visiting the Stanley Park and specifically the seawall, it is usually to explore the beautiful coastline of the city. Tourists are often either walking or biking through the park to enjoy the natural scenic values of the park and Burrard Inlet. To maintain these functions, the redesign will need to maintain the image of the natural beauty of the park, the vistas provided by the trails, the easy circulation and wayfinding, and the 'wow' factor provided by the shoreline.

ENVIRONMENTAL SERVICES

Target services from the landscape

SOCIAL

- ◆ Enjoyment of scenery
- **♦** Ecotourism
- ◆ Outdoor recreation aquatic (kayaking, SUP, fishing, wildlife watching, scuba diving, boating, swimming, beach and intertidal exploration etc)
- ◆ Outdoor recreation terrestrial (walking, running, roller blading, biking etc)
- ♦ Social Spaces
- ♦ Educational and research landscapes
- ♦ Spiritual and cultural connections
- ◆ Landscapes that support mental wellness

ECOLOGICAL

- ♦ Storm and flood protection
- ♦ Water filtration
- ♦ Shorelines stabilization
- ♦ Increase coastal accretion
- ♦ Maintenance of biological diversity
- ◆ Provide feeding, nursery, refuge habitat
- ◆ Improve aquatic conditions to increase aquaculture populations
- ◆ Provide habitat diversity to increase biodiversity
- ♦ Adaptive to change



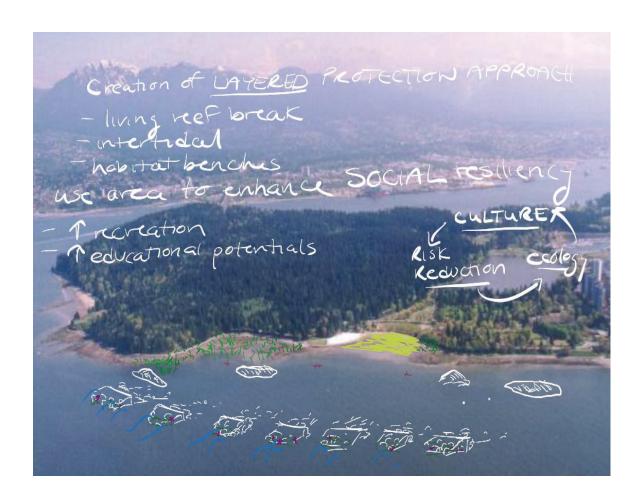
PROGRAM SUMMARY

Idea's for the future

This thesis project aims to restore and enhance the shoreline of Stanley Park from Ferguson point to Second Beach. The design will explore removing the existing seawall and replacing it with a living shoreline hybrid approach which maximizes landscape potential through achieved ecosystem services. Coastal protection will be explored through off shore living breakwaters and habitat islands, creating areas for pocket salt marshes and beach ecosystems that will be better adapt to future climate changes.

Circulation of the main seawall path will be maintained, with the exploration of alternative path types that allow for continued ecosystem functioning. Social spaces and refuge points will be essential to ensure user needs are met within the site. Vista's and natural heritage of the site will be maintained and enhanced where possible to preserve and enrich the park's natural iconic appearance. Programming will allow for the continued bike and walking path network, as well as outdoor recreational needs, including increasing the opportunities for learning within the landscape.

This design will produce a multifunctional landscape that balances the social, environmental and economic needs of the project. The idea will be to create a naturally functioning, biodiverse shoreline where people can explore the intertidal environment with friends and family while enjoying the stunning shoreline of Burrard Inlet. This landscape will have immense outdoor recreational potential and allow users to create an intrinsic connection with our coast while gaining tactile experiences to further increase their understanding of a healthy intertidal ecosystem.

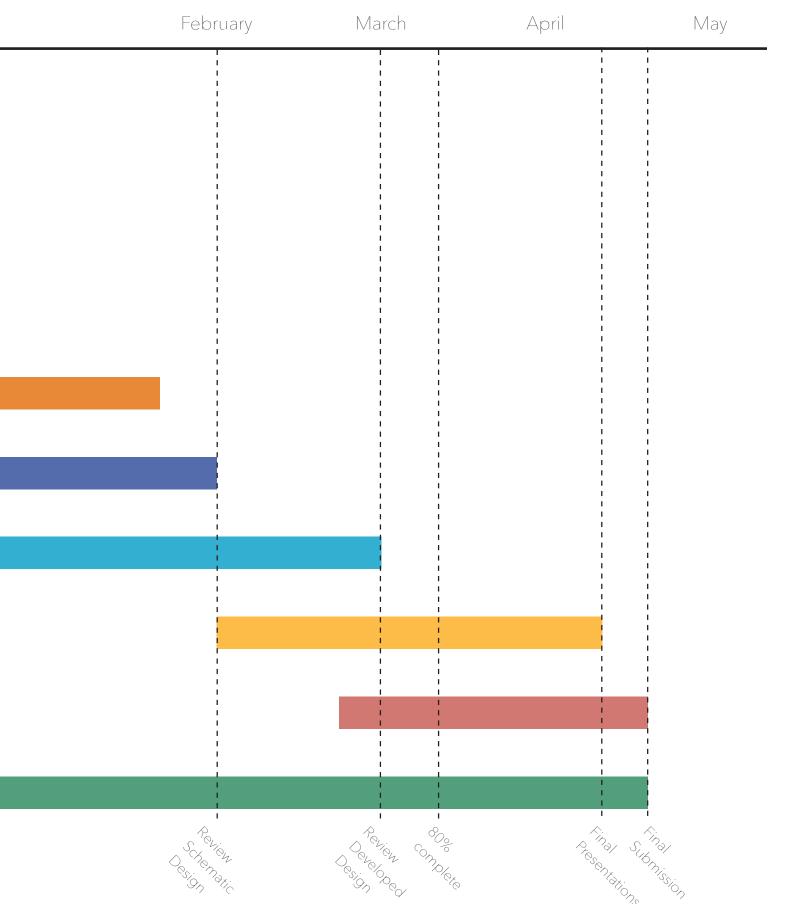




Initial concept based schematic drawings of potential strategies for the redesign of shoreline. Images Google Earth.

TIME LINE OF WORK



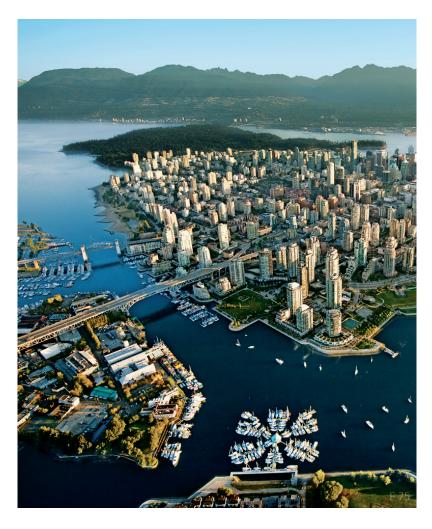






DESIGN DEVELOPMENT

UNDERSTANDING STANLEY PARK

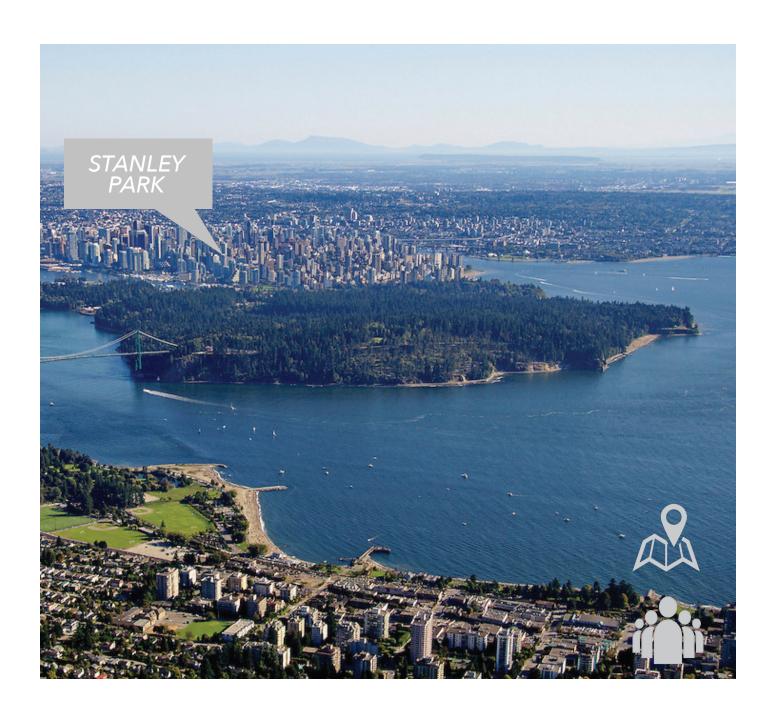


When beginning to move forward with the design stage of this thesis I had to come back to the initial investigation of the why I was choosing Stanley Park. An icon within the city, this park's coastal landscape is one of the most famous places in Vancouver. The design of the seawall began in 1917, and hasn't evolved since then. Although famed and loved for it's recreational purposes, the seawall is that of a wall, creating a physical barrier that disconnects us from the environment and cripples its natural functioning. This provided an opportunity to take a landscape that is already loved and reshape it to fit the current world and ensure it will be protected in the future.







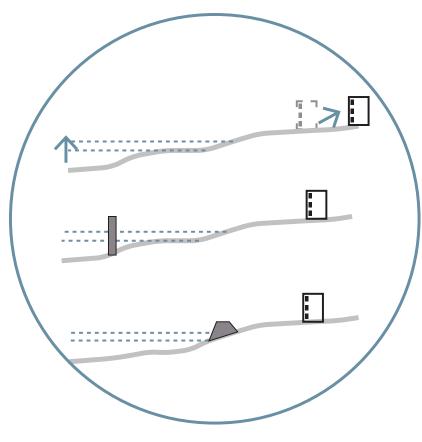


#1 Tourist Destination

Over 8 Million Visitors Annually

COASTAL DESIGN

A SHIFT FROM TRADITIONAL APPROACHES



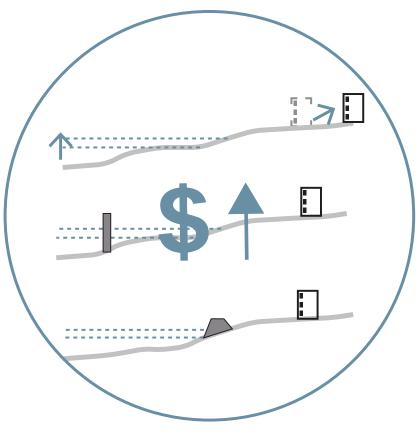
The current global standard of coastal design is structurally engineered hardscape elements. Traditionally the views of coastal design have been to keep the water out through the use of structures like bulkheads, dikes, groins and walls.







Changes in global climate and increasing understanding of the ecological and social importance of coastal landscapes is shifting this paradigm. Hardscape structures are needing annual repairs and continual maintenance from increased storm events and rising sea levels, making these structures less sustainable and more costly.



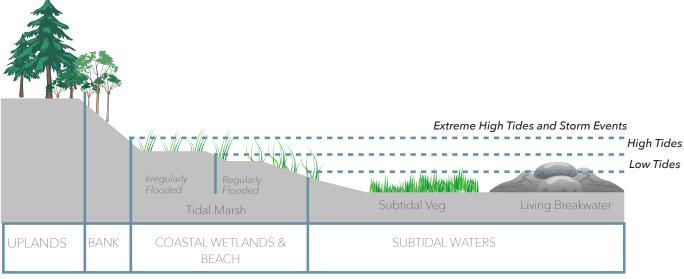






LIVING SHORELINES



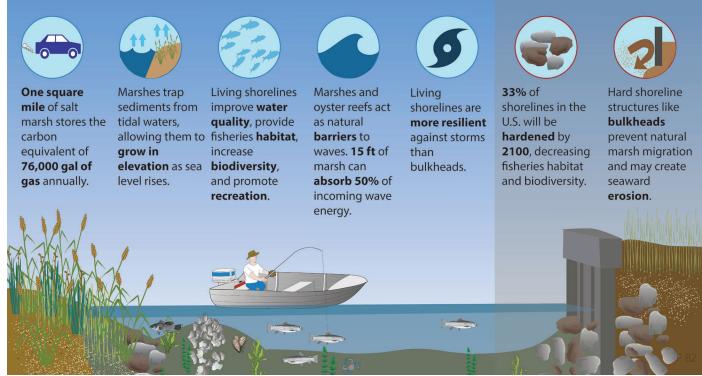


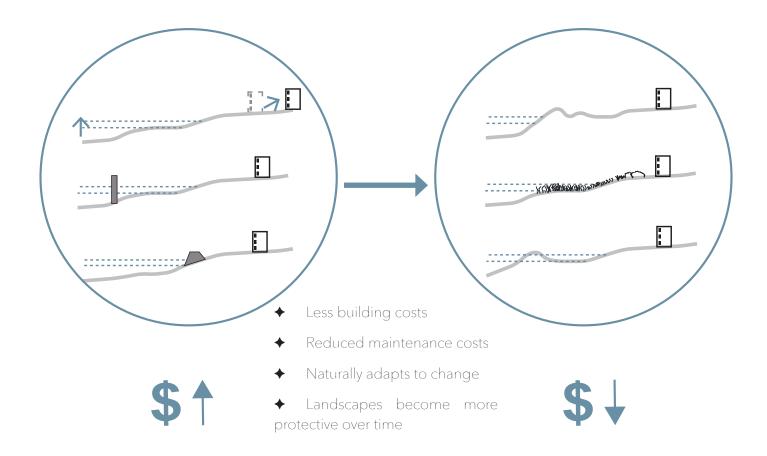
- ◆ Riparian Vegetation
- ♦ Bank Grading
- ▶ Tidal Marsh Enhancement ◆
- Tidal Marsh Creation
- ♦ Beach Nourishment
- ♦ Dune Creation
- ♦ Marsh Sill

- Living Breakwaters
- ► Offshore Breakwater Systems
- ◆ Oyster Reefs



NOAA Living Shorelines Graphic





Living shorelines take a holistic approach to coastal design, understanding the importance of these areas as protective buffers with immense ecological and social importance. Removing the sole reliance on engineered structures, these created landscapes reinstate functioning ecosystems that use natural processes to maximize ecosystem services. Shifts are beginning to occur in coastal design to use these soft engineering responses where possible as they are more cost effect and have produce multiple benefits.



Ensuring the new Stanley Park coastline followed the theory of a multifunctional landscape was vital to moving forward for the design of this project. The planning of this site needed to incorporate so many different functions within it to make this project successful. Not only did I want to ensure this site would exceed expectations on experiential qualities, but through it's success as a place, I wanted to safeguard the protection of habitat and landscape for the future.

Identifying the key problems within Burrard Inlet is what shaped the direction of this design. Vancouver is the 15th most vulnerable port city to the effects of sea level rise and it is estimated that by the year 2050, the provincial government will spend over \$8 billion dollars in coastal flood damage repair. The City of Vancouver is aware of

these threats and includes many targets to address issues of climate change in their city goals. As a highly densified port city, the majority of the shorelines within Burrard Inlet, and especially within the City, are altered. Hardened edges are created for urbanization and port activities, however, this has lead to a severe decrease in shorelines habitat quality. Furthermore, the hardening of shorelines removes people from accessing this transitional, area and understanding its importance. I believe because people are walled off from this environment, the understanding of how the marine world acts as a system is removed, and instead the majority of people use the water as an aesthetic. Without an understanding of it's functioning, the public won't feel the need to protect this system and I want to address this disconnect within my project.



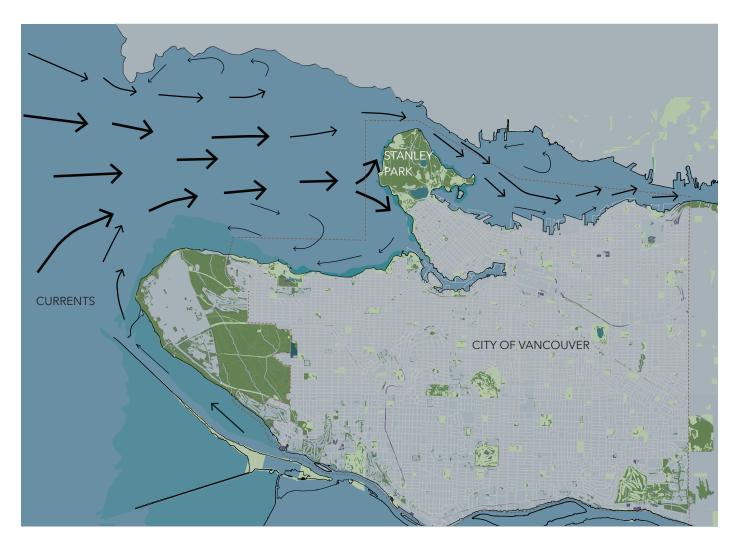
#15 most vulnerable coastal city to the effects of sea level rise

KEY PROBLEMS IN BURRARD INLET



CURRENTS AND FLOODING

A VULNERABLE COAST



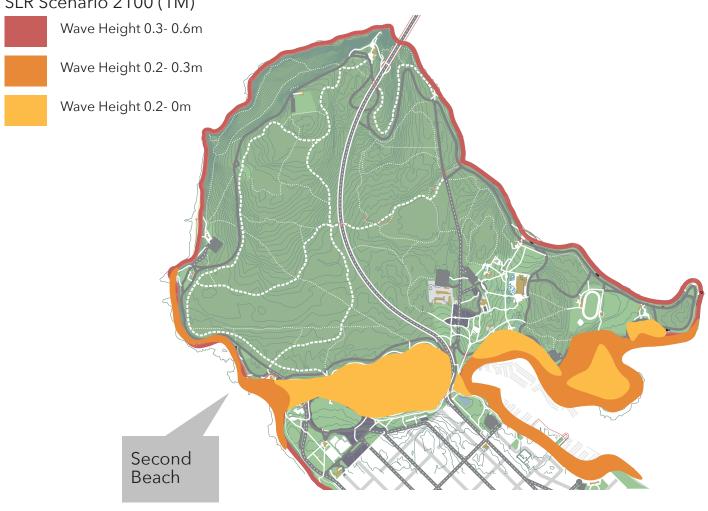
The main currents coming into Burrard Inlet hit land on the western side of Stanley Park at Ferguson Point. Winter westerly storms cause annual damage to this region and the seawall failure is becoming more frequent.

The flooding map information comes from reports from the Port of Vancouver and the City, determining the most vulnerable areas within the Vancouver. With a 1m sea level rise the entire coastline of Stanley Park will be affected, however it is the southern portion of the park at Second Beach that is categorized as a high risk area due to the inland coastal flooding that will occur.

Due to the storm damage and high risk flooding potential of these sites, the area from Ferguson Point to Second Beach was chosen as my thesis site.

FLOODING

SLR Scenario 2100 (1M)





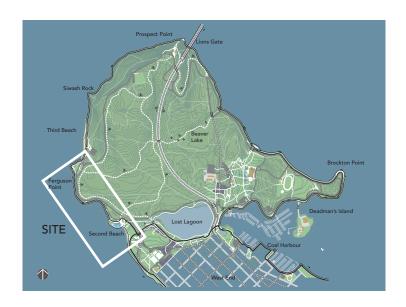


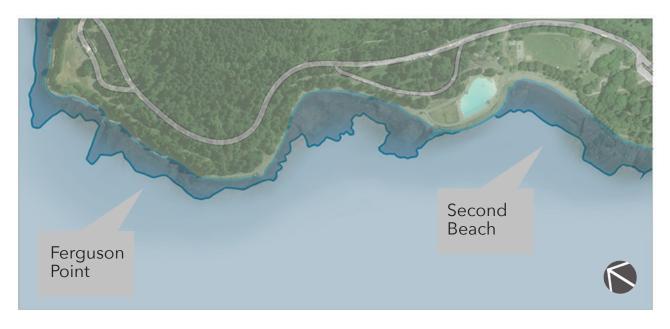


DETERMINING EXISTING SITE CONDITIONS

Beginning the detailed analysis of this site design was difficult as though Stanley Park is extremely well documented, the shoreline of it is not. There was little information of what existed apart from trail maps and an overall ecology report of the site, which included some invasive and endangered intertidal species (as talked about in previous sections). There were no maps of the current infrastructure or the contours going past the Om into the water. As my site was about this crucial area, I did many site visits and had

to draw my own maps for design purposes. Site visits were completed to understand the experiential qualities of the site, as well as doing a biological inventory and spot mapping. I determined what coastal processes were occurring at different areas of the site to understand what strategies would be appropriate moving forward.











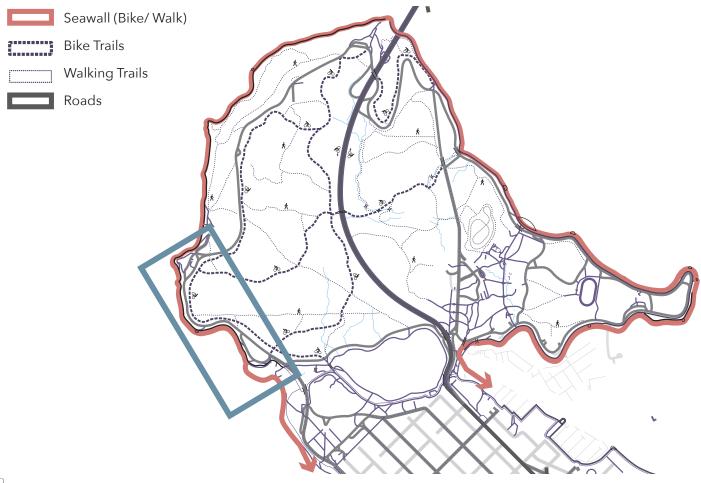


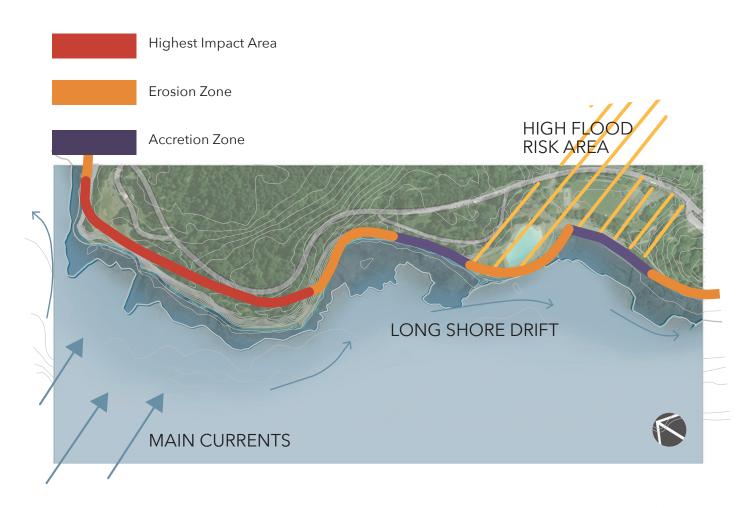
Experiential Notes

- ◆ The busyness of the seawall and need for alternative path options
- ◆ When it is a low tide and there is access, people love to explore this intertidal zone
- ◆ There are always people enjoying the beach and open field area
- ◆ People enjoy sitting on the logs on the beach
- ◆ There is a lack of secluded paces for people to pull off the trail and sit

- ◆ People tend to climb and sit on the larger stones
- ♦ Although during this thesis research the pool was closed, I know from past experience this is a very popular area for families
- ♦ The second beach washrooms are busy
- ♦ Biking along the seawall can become uncomfortable when busy as it is so narrow
- ◆ There should be more access paths to come off the seawall
- ◆ The events field gets very muddy with rain

SITE CONNECTIVITY





Coastal processes map made from site visits and investigation

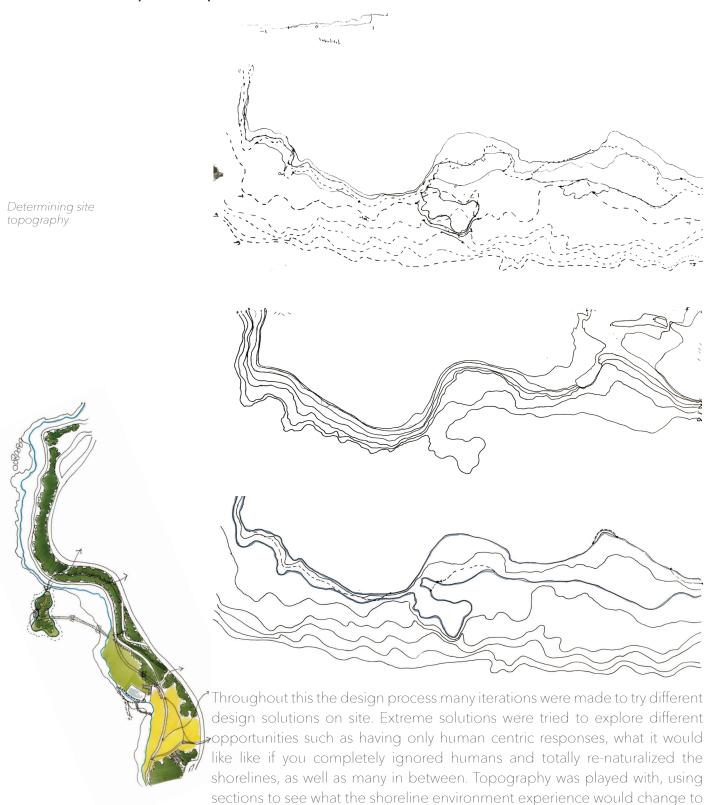
Local coastal processes were determined by field visits and marine mapping. As mentioned above, determining the existing grading of the intertidal and subtidal areas was difficult. Mapping only existed with the 0m meter and -10m contour lines, so I had to determine the others from spot locations and nautical guides. Areas of accretion and erosion were easy to determine on site and added to the understanding of longshore drift processes.

Once existing topography was determined I was able to begin to regrade the site to design for protection against sea level rise and storm events. Challenges were grading topography for expanding the intertidal area and therefore pulling out the shoreline into a more gradual slope, yet also raising areas to protect for SLR and ensure there would be intertidal areas in the future. Furthermore, ensuring these newly graded areas would align to existing infrastructure for site connectivity was important.

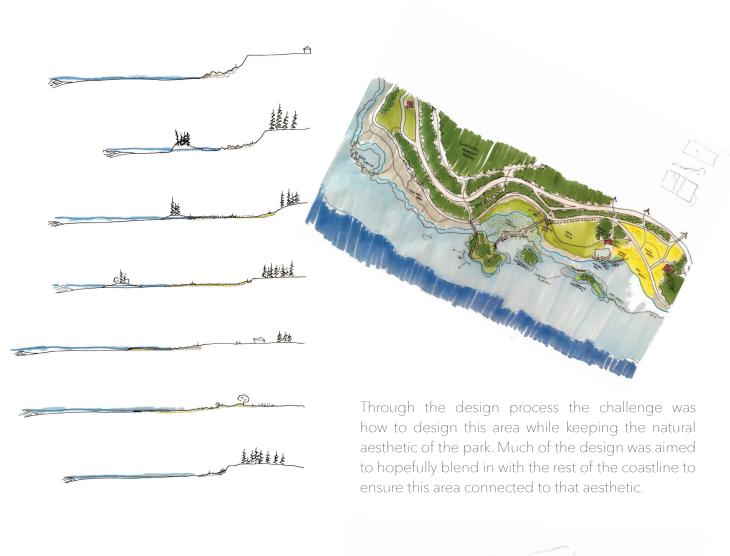
INITIAL DESIGN

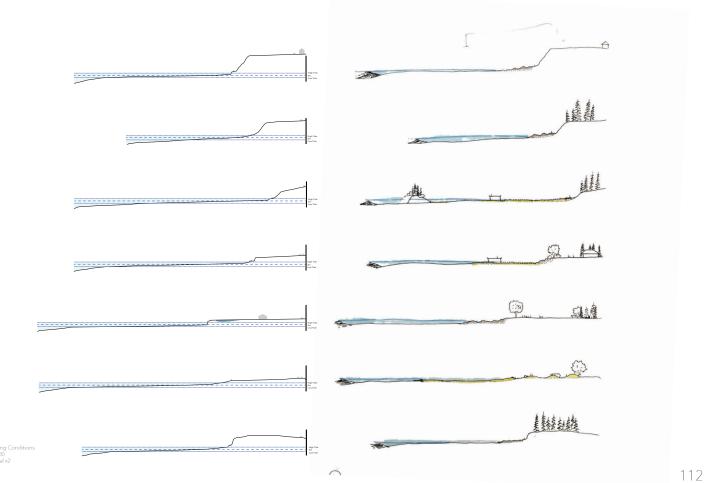
EXPLORING IDEAS

A small sample of process work

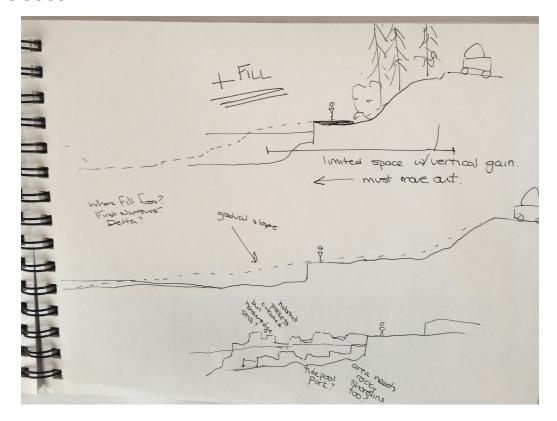


through different design methods.

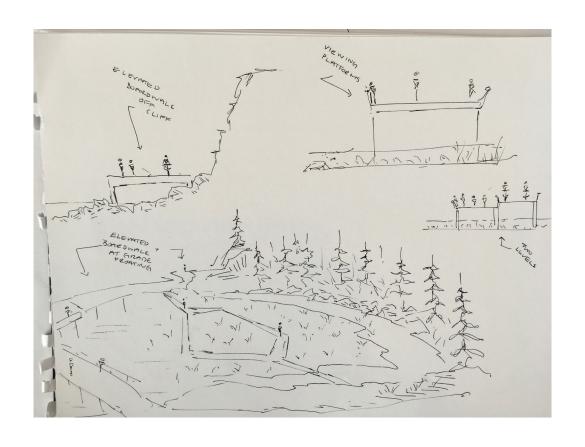


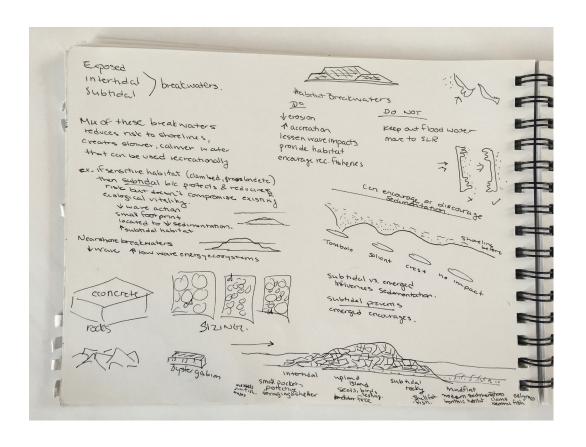


Work Process



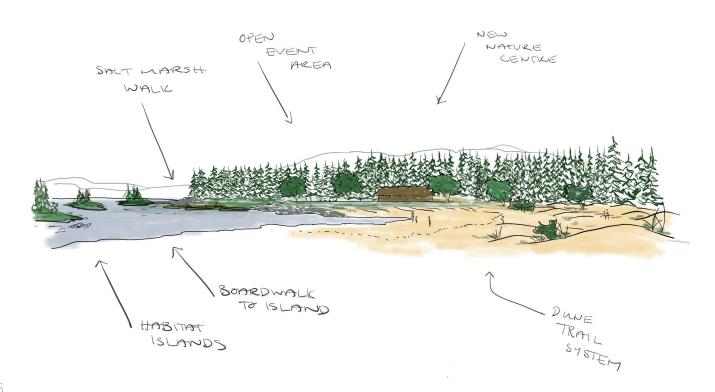


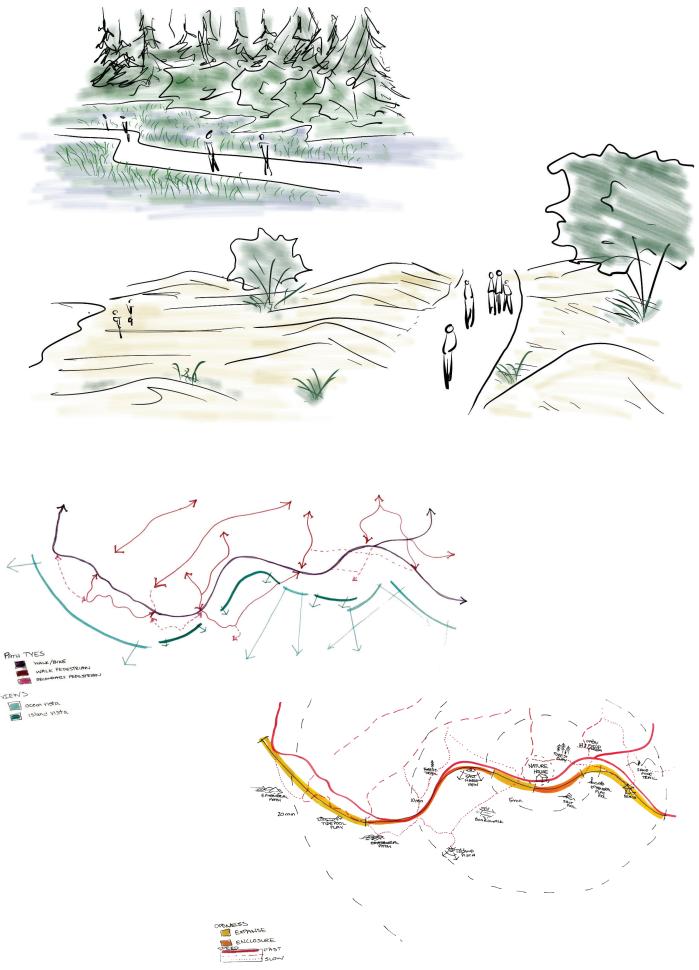




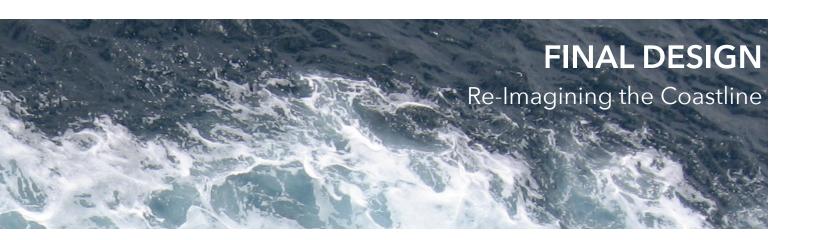
Experience











PROJECT GOALS DESIGN THEMES

Overview

Protect

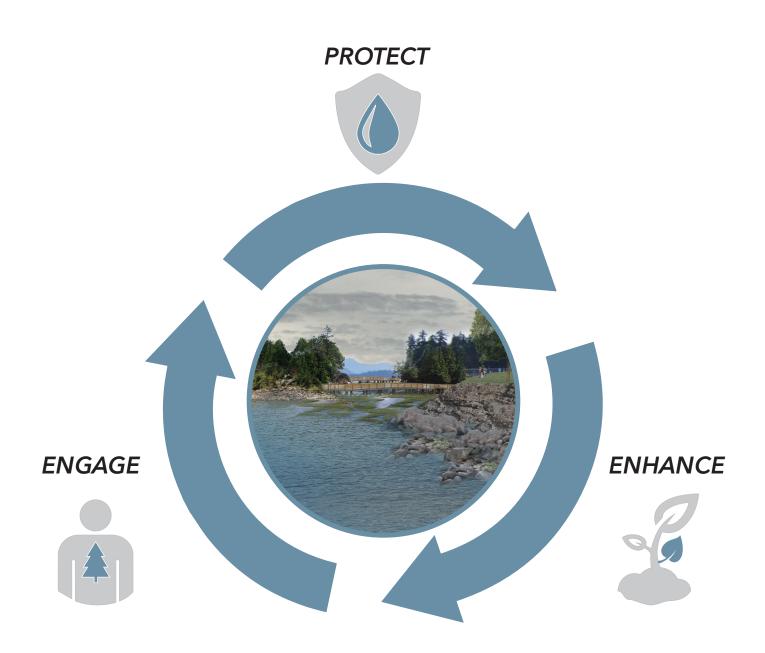
- ◆ Protect for future storm events
- ♦ Prepare and protect for SLR

Enhance

- ♦ Reestablish intertidal zone
- ♦ Reconnect terrestrial and aquatic habitats

Engage

- ♦ Reconnect people to the intertidal landscape
- ◆ Provide new unique experiences along the coastline
- ◆ Engage people to the marine world



PROJECT GOALS

DESIGN THEMES

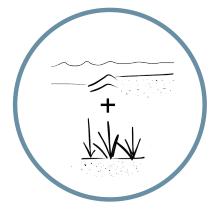
Main Moves

PROTECT

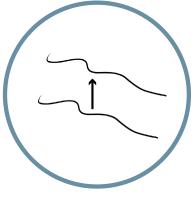




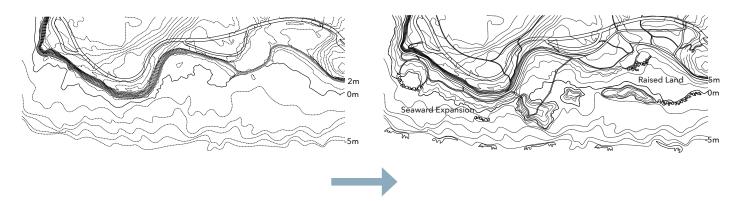
→ OFFSHORE BREAKWATERS AND HABITAT ISLANDS



→ SEAWARD ACCRETION AND GRADUAL SHORELINE



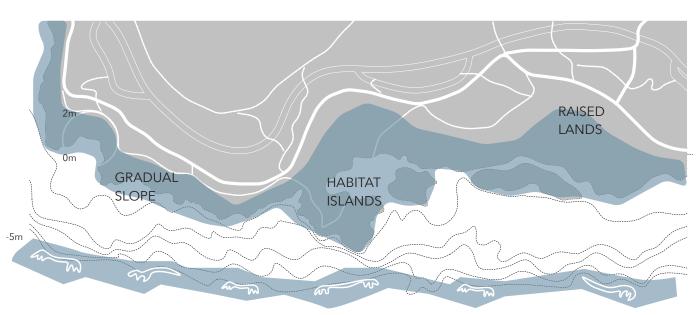
→ ELEVATE SHORELINE



An offshore breakwater system was designed as a first layer of defence for incoming storm events and wave action. As a second line of defence habitat islands and subtidal marine refuge were placed to additionally absorb wave and storm impacts. Due to the placement of the breakwaters and islands, natural shoreline processes and sediment movement would be affected and would allow for accretion, or shoreline sediment built up occur. Creating a more gradually sloped shoreline reduces wave height and velocity and reintroduces the intertidal zone. Finally, low lying areas especially around second beach have re-graded to protect against sea level rise and maintain connection with the existing infrastructure. Dredge from the First Narrows and Fraser River could be used for fill in this design to maintain the use of sediments already found in this system.







OFFSHORE BREAKWATER SYSTEM

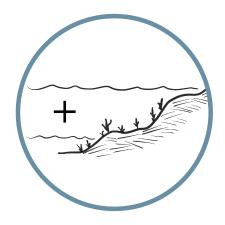
PROJECT GOALS

DESIGN THEMES

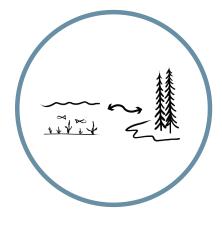
Main Moves

ENHANCE

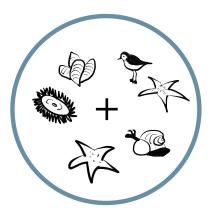




→ RE-ESTABLISH INTERTIDAL ZONE AND HABITATS



→ RE-CONNECT TERRESTRIAL AND AQUATIC HABITATS



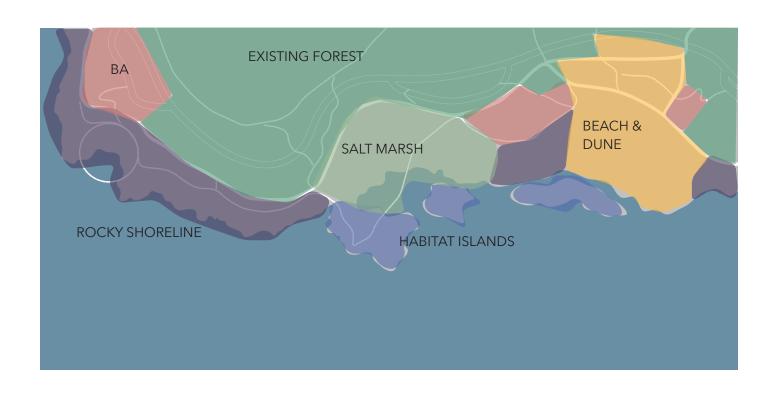
→ ADD ECOSYSTEM COMPLEXITY AND INCREASE BIODIVERSITY

To enhance the ecological conditions of this site main goals where to establish the intertidal zone and the connection between terrestrial and aquatic habitats and add complexity to the site to increase biodiversity. By re-grading the shoreline to re-establish the intertidal zone, it allows for the creation of coastal habitats reconnecting the land and sea. With the added protection of the breakwaters and islands new habitats can be established. In this project the altered shoreline and rec beach will be replaced with a rocky shoreline, salt marsh and dune ecosystem.

Below are the details of what each ecosystem would look like. Key species that would reside in each habitat are used to represent some of the increased biodiversity. Each habitat type has inherent protection qualities to ensure these landscapes are still adaptive for future changes.

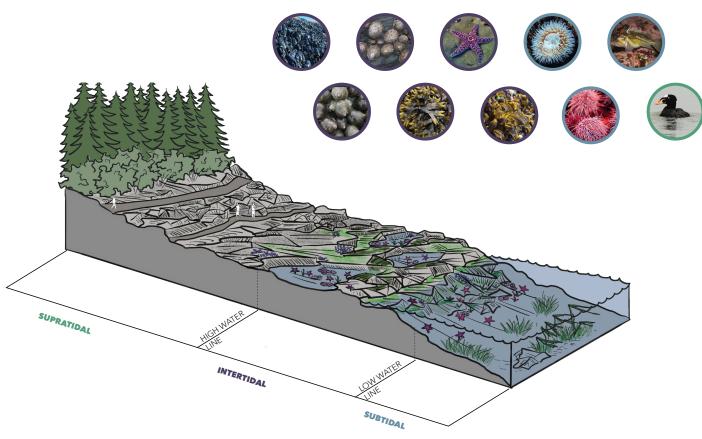




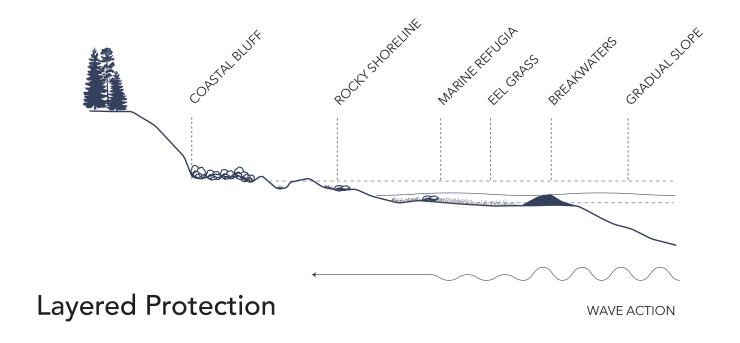


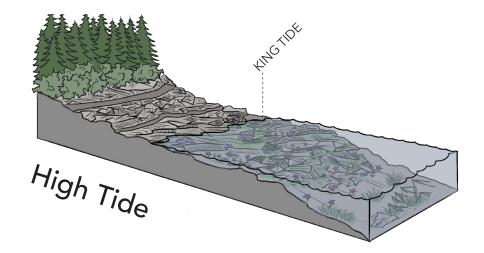
ROCKY SHORELINE

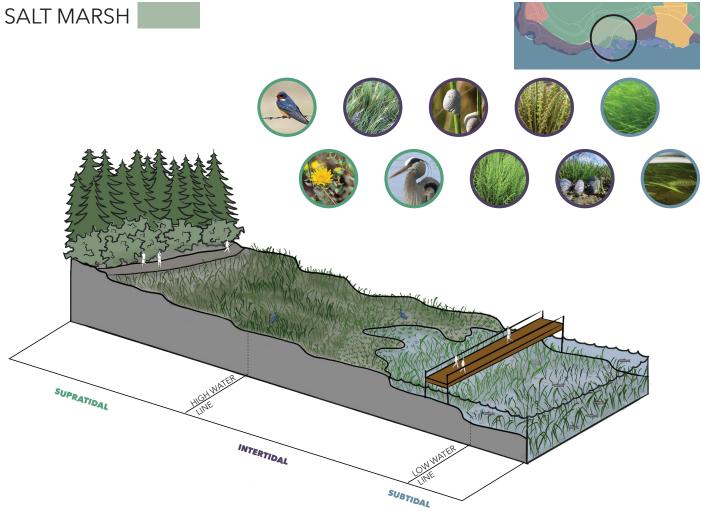




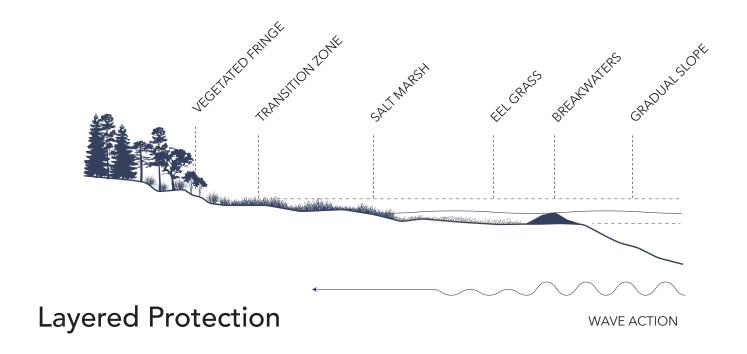
- ♦ Natural shoreline types that would exist in this area
- ♦ Appropriate for high energy systems
- ♦ Unique species form biobands along environmental gradients
- ♦ Key foraging area for both terrestrial and aquatic species
- ◆ Accessible to humans
- ♦ Tide pool provide window to underwater world
- ◆ Multilayered protection provided for king tides

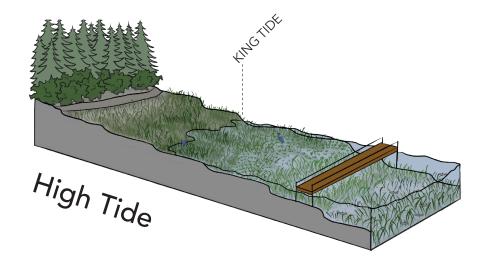






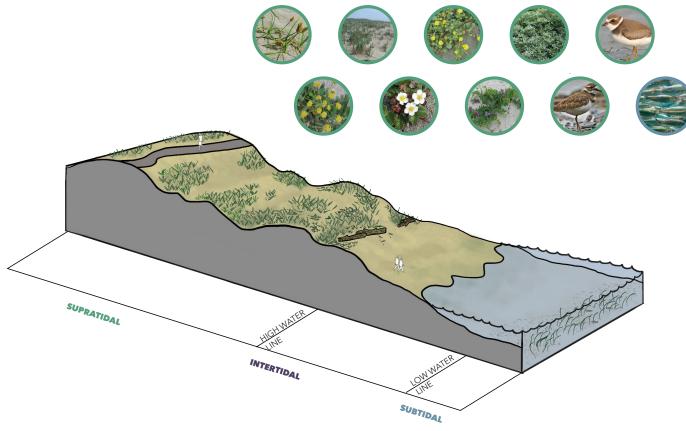
- Salt Marsh created in the more protected areas behind the habitat islands
- One of the most valuable ecosystem types due to the high level of ecosystem services
- Key area for bird, fish and invertebrates
- Detritus accumulation forms the basis of the food chain
- Contain inherent protective capacities with flood absorption
- Sediment accumulation adds to shoreline protection



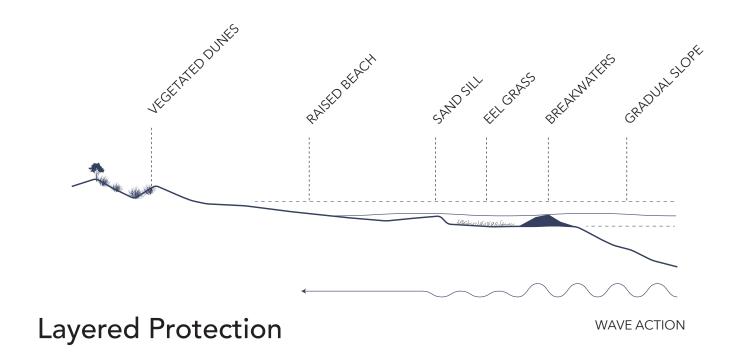


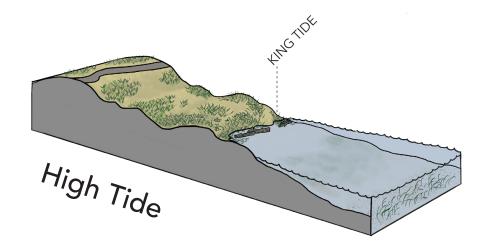
BEACH AND DUNE



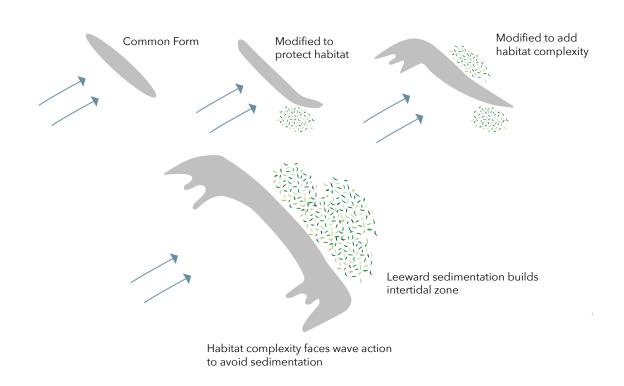


- ♦ Beach and dune ecosystem created to allow for continued beach access
- ♦ Creation of rare coastal ecosystem in BC
- ♦ Key intertidal area for fisheries and invertebrates
- ♦ Vegetated dunes provide unique habitat for rare species while providing additional protection for storm events and SLR

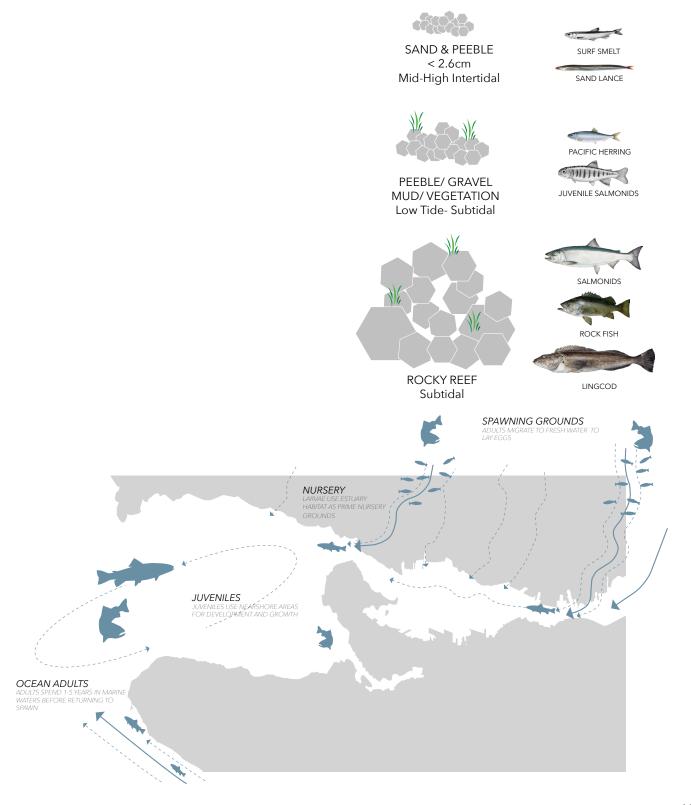




SUBTIDAL



- Breakwaters designed to maximize protection and habitat complexity
- ♦ Leeward sedimentation build up can add to the expanded intertidal zones
- $lack \$ Intertidal and subtidal design was aimed at certain fishery species
- ♦ All five salmon species use Burrard Inlet as a nursery ground- these are a very culturally important species and are protected in BC
- ♦ Design of the salt marsh and intertidal refuge to accommodate juveniles
- ♦ Intertidal rocks size is designed to target low trophic species in hopes to build the strength of the food chain



PROJECT GOALS

DESIGN THEMES

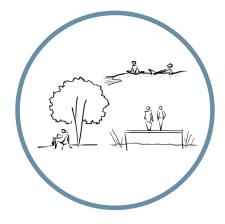
Main Moves

ENGAGE





→ DIVERSITY OF LANDSCAPE EXPERIENCES AND ACTIVITIES



→ ADD DYNAMIC PATHWAYS AND VIEWS

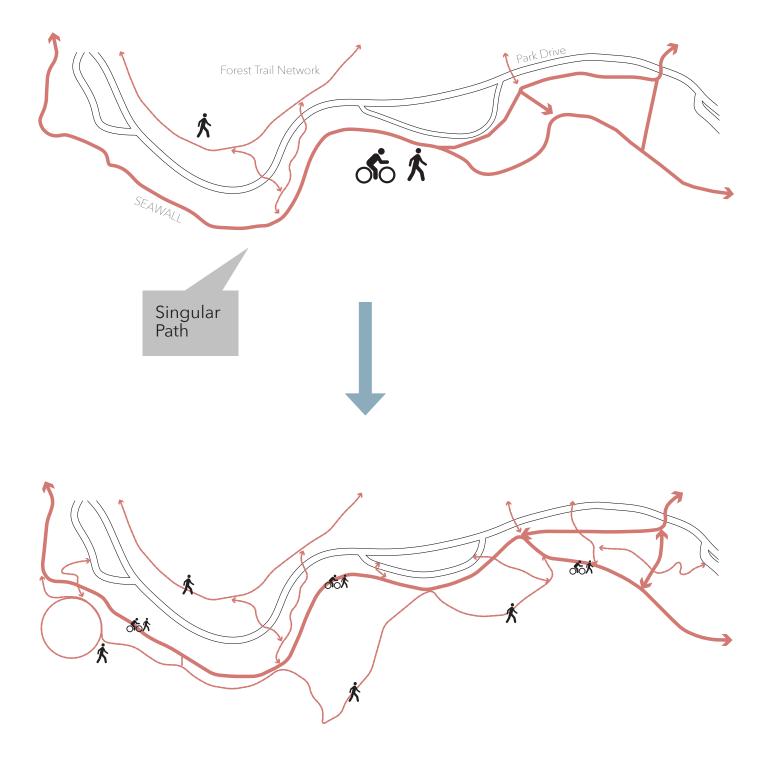


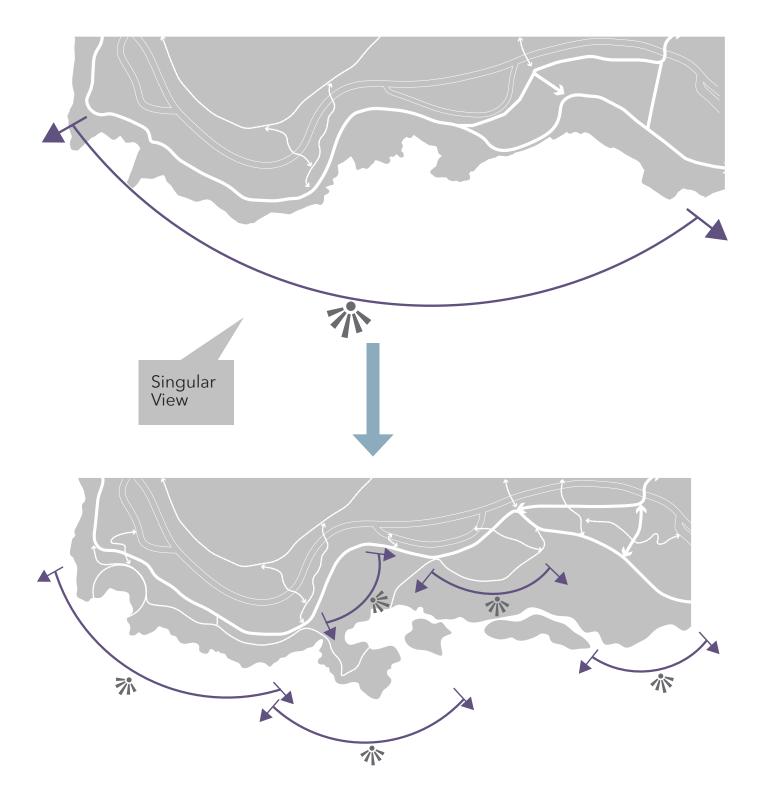
→ CREATE TANGIBLE AND EXPLORATORY LANDSCAPES

The most important aspect of this site design is the engagement of users in the site. Stanley Park is a loved area and the goal of this project was to create a new unique experience to reconnect people to the coastal landscape. With the diversity of landscapes created it gives people a diversity of experiences and activities. By adding additional pathways and looping systems it provides options to explore the shoreline. Finally, these landscapes are designed to promote exploration so participants can create a connection and gain an understanding of the functioning of the dynamic coastal area.

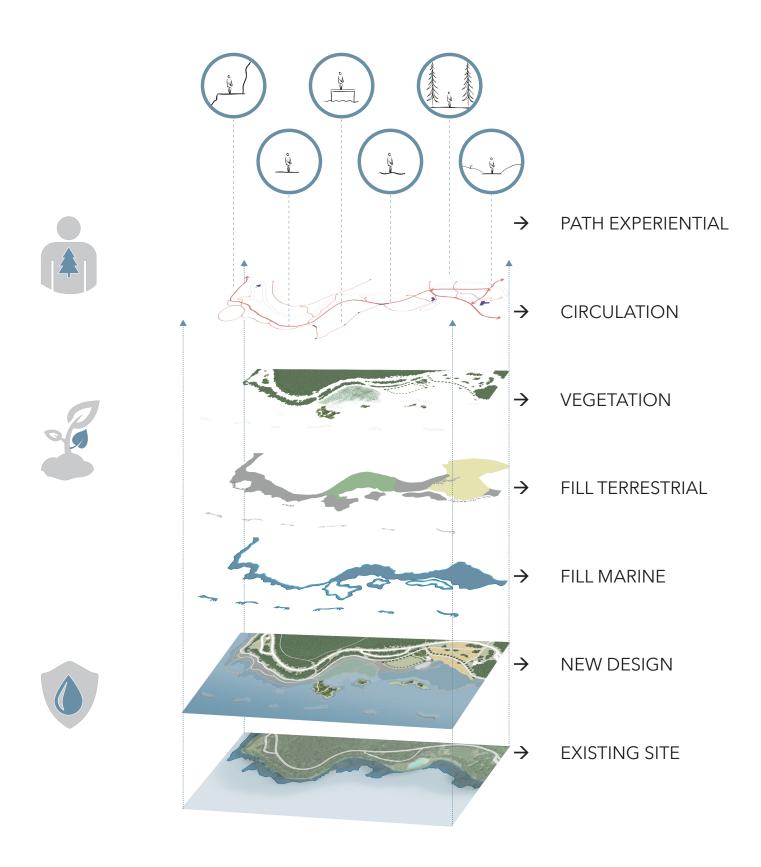
Existing circulation consists of the multipurpose seawall path that runs through the site. This pathway provides a singular view of BI as you pass through the park. By creating a new multipurpose path that connects to the existing seawall the recreational benefits are maintained however it is protected for SLR and widened to decrease congestion. Additional secondary paths are added to create a universally accessible looping trail system with various lengths and path experience types. Furthermore, the new shoreline and habitat types provide diversity of views as you move through the site.







DESIGN LAYERING



FINAL DESIGN

PLAN

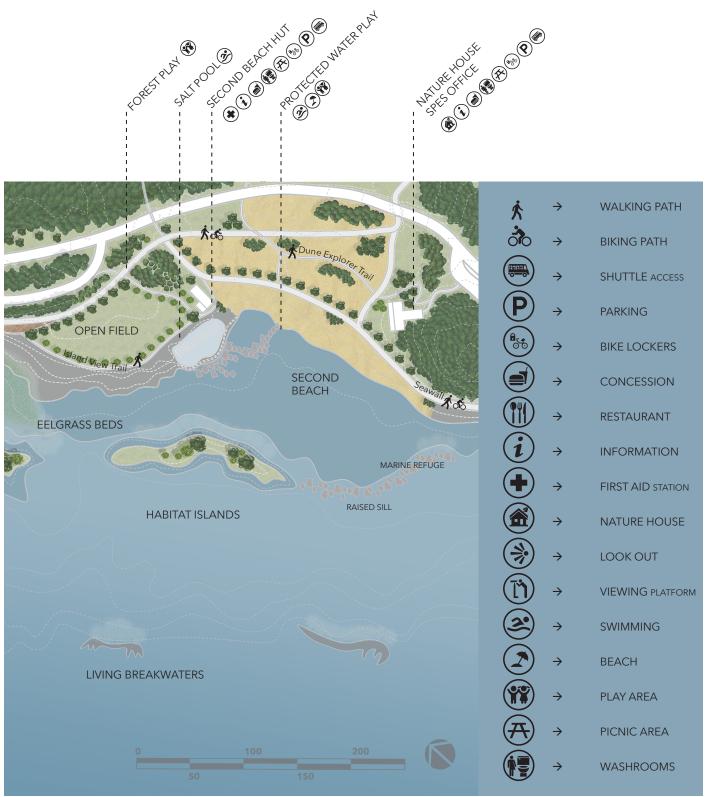
The final design of the Stanley Park site enhances the natural heritage of the site for which the park is famous for. This design creates a multifunctional landscape with a biodiverse shoreline with immense outdoor recreational and learning opportunities.



SECOND BEACH

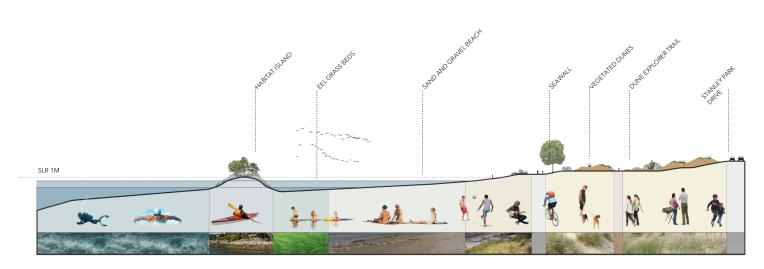
- ♦ Nature Ecology House designed on site to house educational and learning spaces and places for community involvement programs. Outdoor space has places for gatherings.
- ♦ Open events field designed to allow for continued park events
- ♦ Built in natural salt pool designed to match the natural aesthetic of the park
- ◆ Protected water play area designed to encourage parents and their kids to play in the ocean instead of the pool





SECOND BEACH

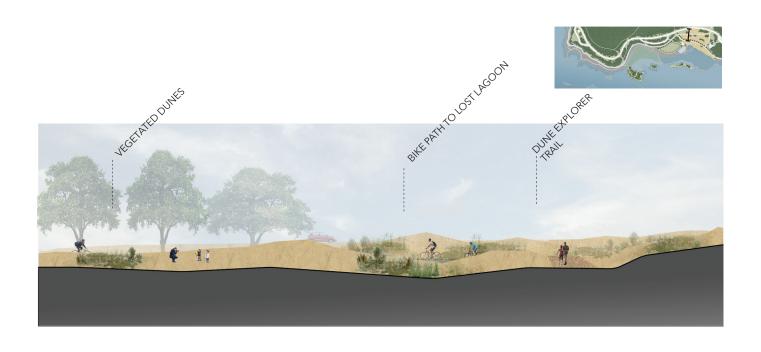


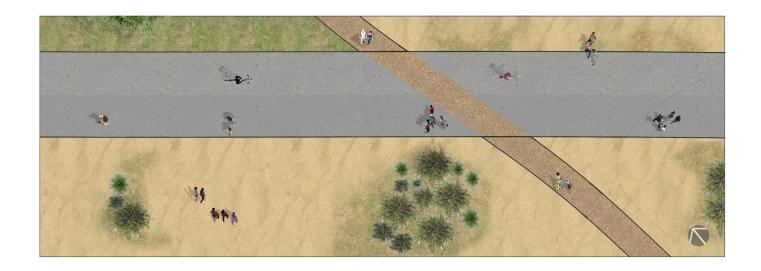




DUNES



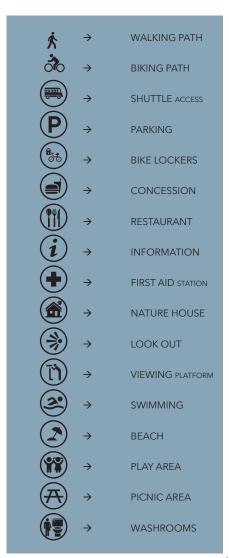




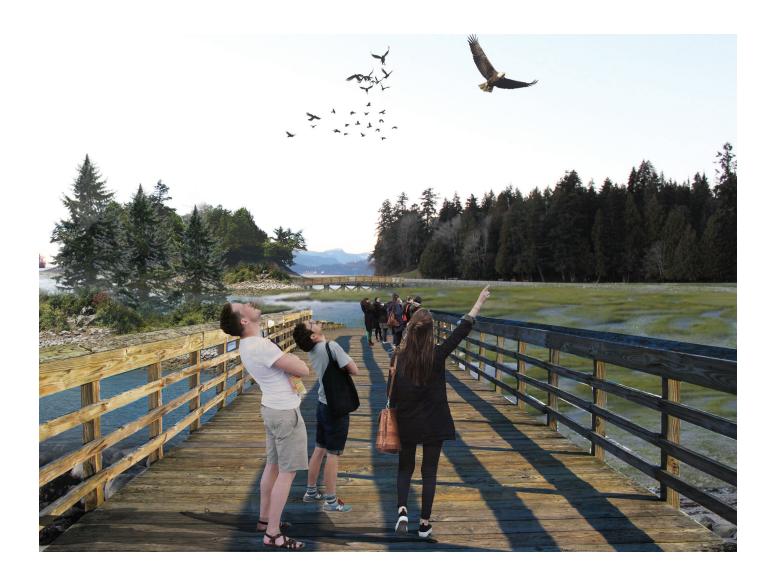
SALT MARSH AND FERGUSON POINT



- ♦ A network of boardwalks and viewing platforms are designed within the salt marsh
- ◆ Marsh Island Explorer Trail gives access to the islands and marsh landscapes providing a unique over water path experience
- ♦ Boardwalks allow people to to look out and view the marsh or choose to walk down into it and explore
- ◆ Salt marsh habitat provides unique wildlife viewing opportunities
- ◆ The islands create additional intertidal habitat designed to increase biodiversity through spawning areas and eelgrass beds
- ♦ Ferguson Point allows for people to access the rocky shoreline habitat through the Tide Pool Exploration Trail
- ♦ The ephemeral rock circle path provides a pathway that highlights the dynamic aspects of these coastal environments

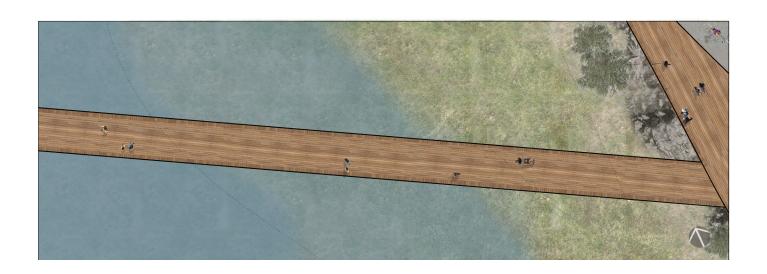


SALT MARSH



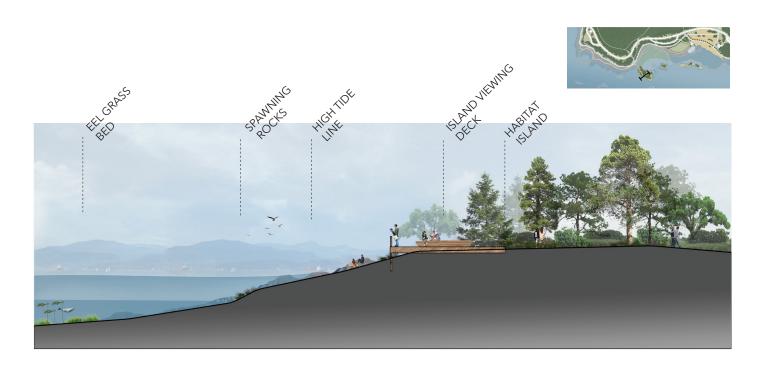


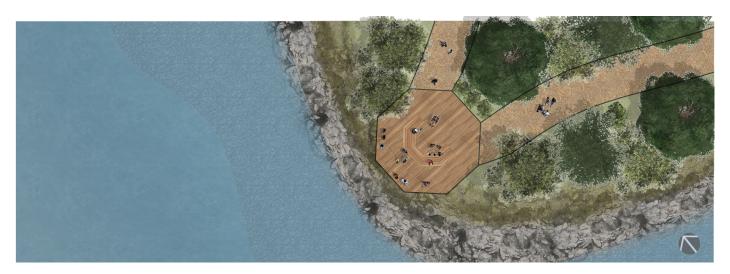




HABITAT ISLAND

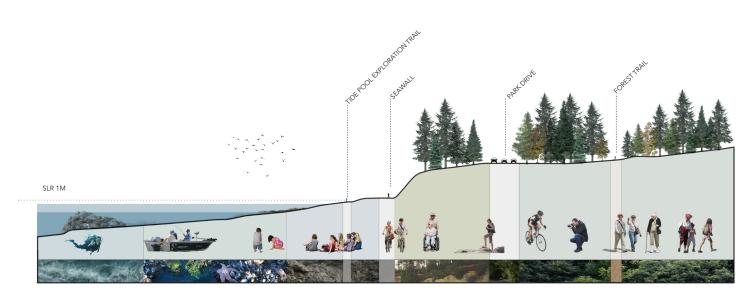


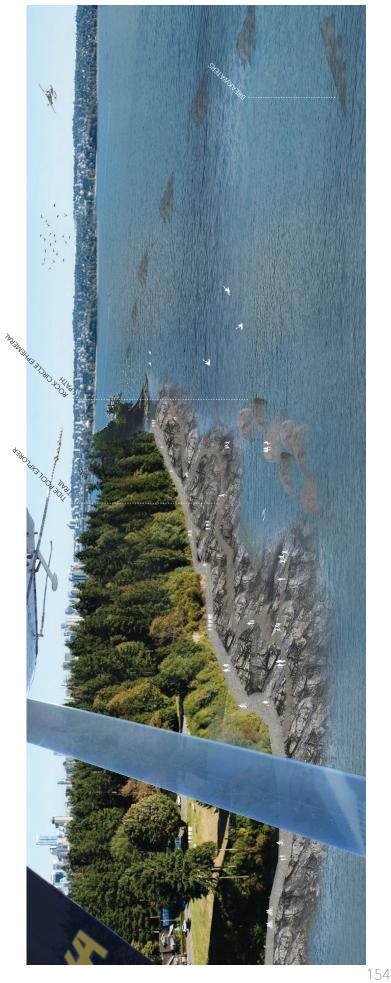




FERGUSON POINT

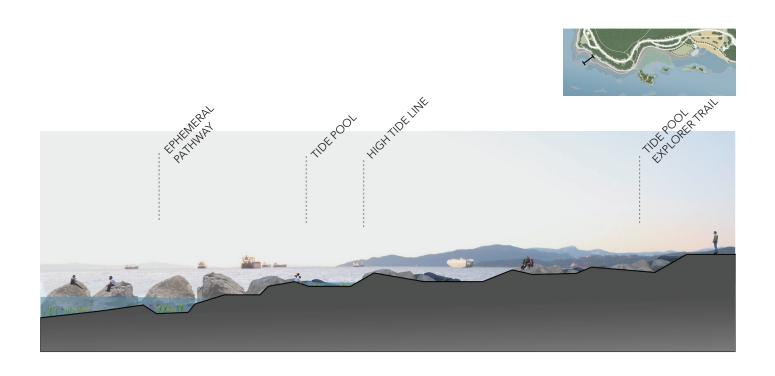






ROCKY SHORELINE



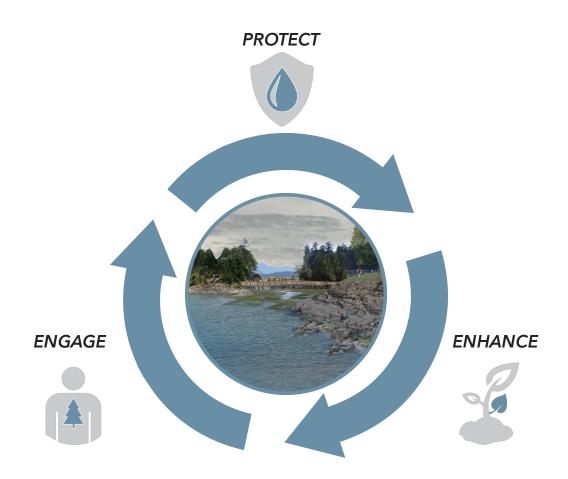




MAKING CONNECTIONS

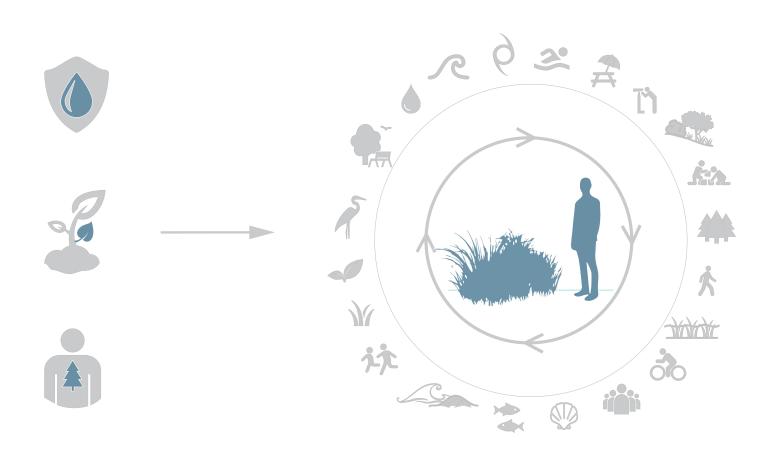
FUTURE DESIGN

A Repeatable Design with Multiple Benefits



What was discovered in this project is that each of my design moves affect and cascade upon another. The synergies between each of my themes is what makes this landscape so multifunctional. The creation of a habitat island provides protection, this area then enhances the intertidal habitat, which provides new experiential opportunities to engage users in a new way. To complete the circle- it is only with people building these connections to the landscape will they want to then protect it in the future.

Through each of these design moves the landscape additionally achieves so many other benefits and environmental services. The idea with this thesis is that it can be a repeatable prototype that can inspire other projects with lessons for future coastal design.











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ASSOCIATIONS

Island Trust
Habitat Conservation Trust
Pacific Salmon Commission
Pacific Salmon Foundation
Puget Sound Restoration Fund
Salish Sea Marine Survival Project
Squamish Streamkeepers
Stanley Park Ecological Society

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