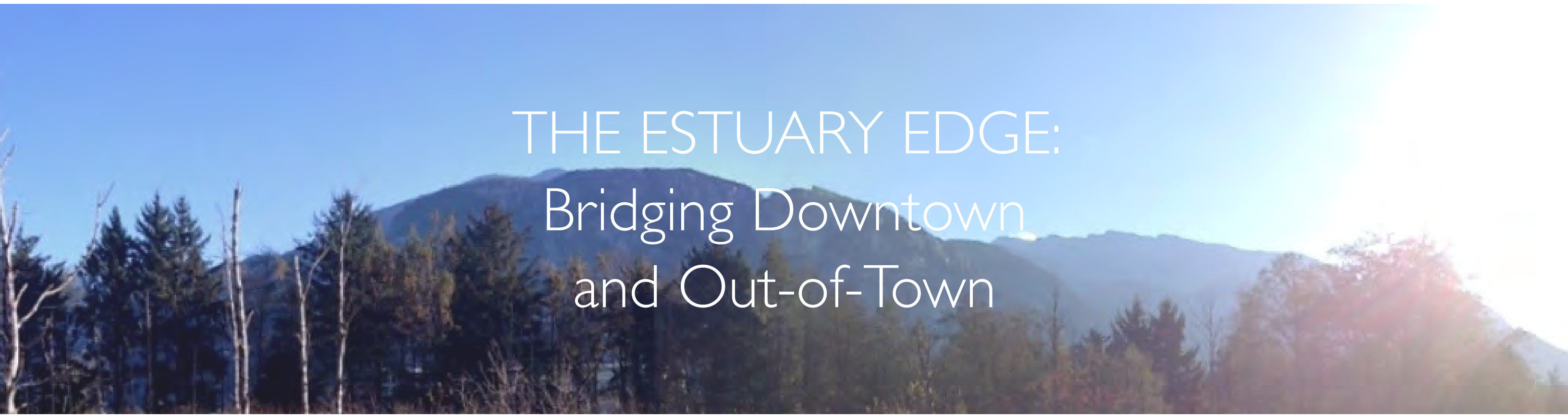

THE ESTUARY EDGE: Bridging Downtown and Out-of-Town

Michele Campbell
May 1, 2013

Submitted in partial fulfillment for the
Master of Lanscape Architecture,
Landscape Architecture Program,
University of British Columbia

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Landscape Architecture Program
School of Architecture and Landscape Architecture
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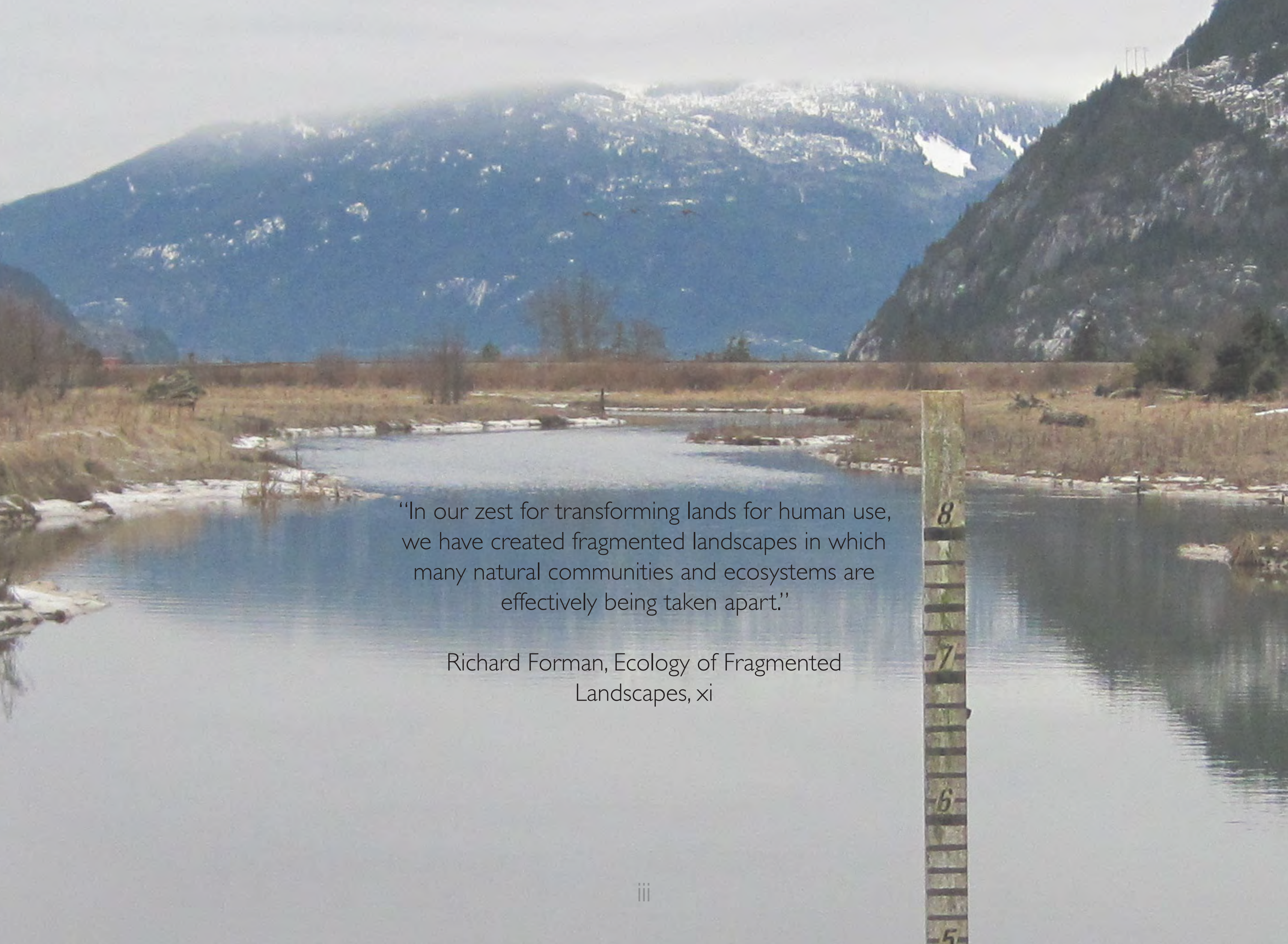
ABSTRACT

The District of Squamish is located in a breathtaking site, in the shadow of the Chief and at the confluence of five major rivers. Downtown Squamish sits precariously in the floodplain, where the mouth of the Squamish River meets the head of Howe Sound. The meeting of fresh and saltwater has created a dynamic estuary environment that was ignored when the town was initially developed (see the image of the 1913 Subdivision Plan on page 5). What was constructed required fortification, and a system of dikes was constructed that divide the downtown from the estuary. The Estuary Edge dismantles the original town dike to create a new estuary edge, where human and natural systems meet to define the western limit of downtown Squamish.



"In our zest for transforming lands for human use, we have created fragmented landscapes in which many natural communities and ecosystems are effectively being taken apart."

Richard Forman, Ecology of Fragmented Landscapes, xi

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NOTE: All photos in document taken by myself or Pietra Basiliji

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GRADUATE DESIGN PROPOSAL: The Site

"To think about landscape is to think about site" (Czerniak 107).

While design methodology is a subjective process, landscape designers share similar problems and hence, similar methods. My personal approach to this project has grown from a popular idea in landscape architecture: landscape design is site specific. For me and many other landscape designers, landscape and site are inextricably entangled. One cannot have good landscape design without considering the site. Although this seems rather obvious, it is not always at the foreground in design because sites are often burdened by complexity. As Julia Czerniak explains, sites are often defined by property ownership rather than by the complex network of "processes that operate at diverse spatial and temporal scales" to create the site (107). Due to the complex and inherently unique nature of sites it is nearly impossible to define what makes a site. Czerniak narrows the notion of site within landscape urbanism to, landscape performance and appearance, embedded in this is an incorporation of both cultural and ecological processes (108). I am thus, interested in the landscape performance and appearance of my site. Design for site specificity can begin by determining a problem that is relevant to the site and its performance. For this reason, the problem and goals I have outlined for this project emerged from constantly returning to the question, "What is the relevant problem for this specific site?" I identified one conextual problem and five design problems that address the contextual problem.

THE PROBLEM

The contextual problem that I recognized is that there is a disconnect between human systems and natural systems. This project will reconnect the human and natural systems to create a landscape of infrastructure and conservation. The subdivision plan from 1913 (shown on page 5) reveals how the development of downtown Squamish proceeded in dischord with the context. An urban grid was superimposed in the middle of the Squamish River and directly on top of a tidal channel, today known as Cattermole Creek. The placement of the downtown lead to the development of what is today the old town dike, which runs along the eastern edge of Cattermole Creek, and forms the western edge of downtown Squamish, physically dividing downtown from estuary. The BC rail embankement has been acting as the sea dike since the culverts were filled in 1985, rendering the old town dike unnecessary as a sea dike and creating an opportunity to dismantle the old town dike to mend the divide between estuary and downtown in Squamish (Squamish Sea Dike Upgrade Assessment, 1). More details about the site are explored in the following site description.

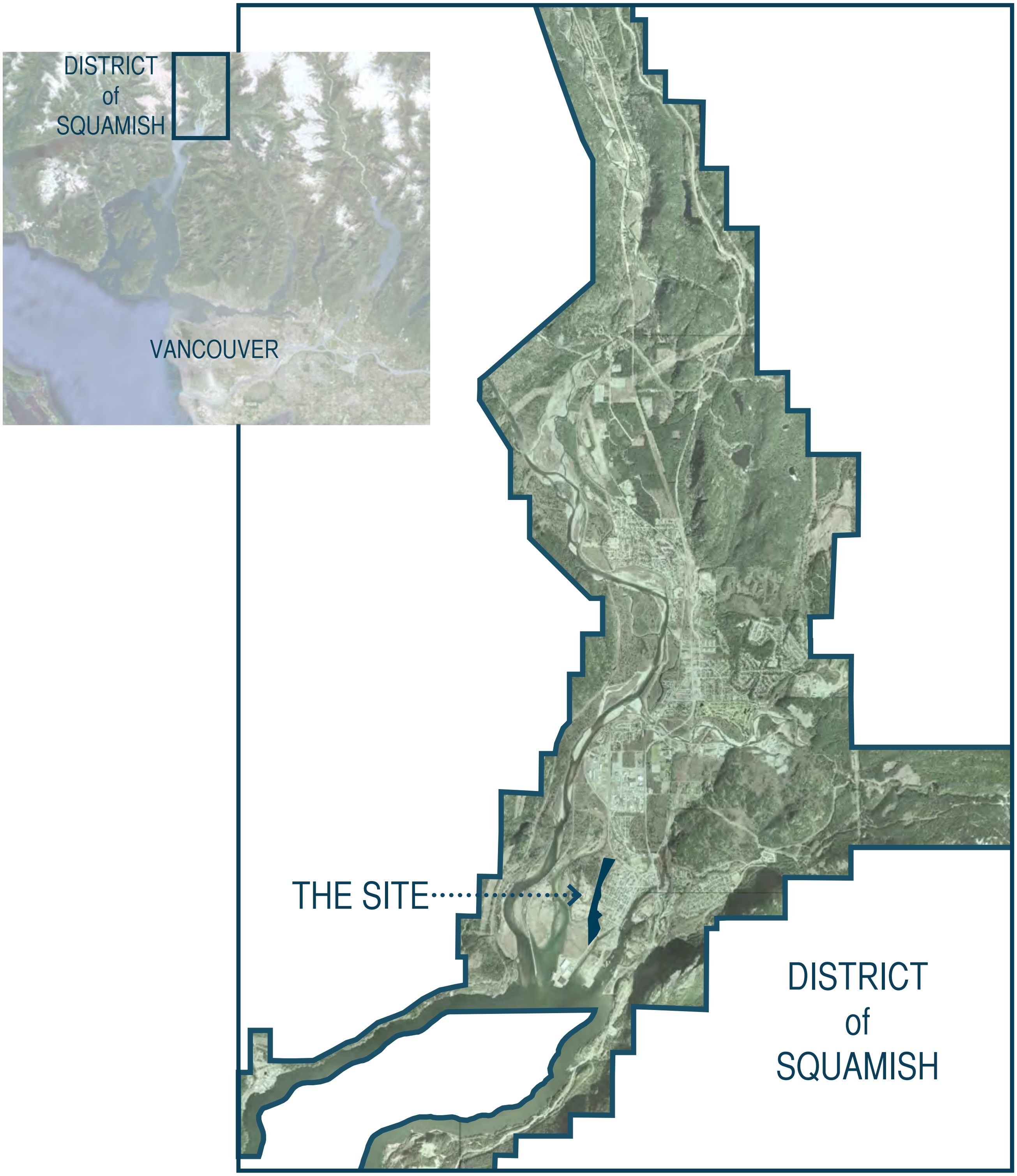


Figure 1
Disctict of Squamish in relation to Vancouver

THE SITE:
The interface between the Skewlwil'em Squamish estuary and downtown

The District of Squamish is located between Whistler and Vancouver on the Sea to Sky Highway in the Coast Mountain range. Bounded by Mount Tantalus to the west and Mount Garibaldi and the Chief to the east, the District of Squamish forms a floodplain draining the surrounding forests and five major rivers, including the Squamish River, which empties into the Howe Sound. Freshwater from the Squamish River flows south while saltwater from the ocean moves north, the meeting of these water bodies creates an ecologically rich fjord estuary, but also exposes downtown Squamish to flood hazards. Downtown Squamish sits entirely within this floodplain and is consequently exposed to the risk of flooding from multiple sources; high tides, storm surges, and spring thaw, all contribute to a make Squamish a very wet environment. The response to this problem of flooding has been to construct an approximately 17km long network of dikes. These dikes are aging and coupled with increased flood risk due to climate change, there is a 20% chance that these dikes will be overtopped in the event of a 1/200 year flood event (On Risky Ground 196). These dikes have dramatically altered the water regime of the estuary and as the Distinct of Squamish begins to upgrade these dikes there is a design opportunity remove or upgrade certain dikes to improve flood protection and simultaneously restore fresh and saltwater flow through the estuary.

The project site is a linear corridor stretching north to south between the western edge of downtown Squamish and the WMA. The WMA, protected by provincial legislation, provides critical flood protection to the downtown, but has been significantly altered by deposits of fill to construct dikes, railway corridors, and industrial platforms (BCMoE). The training dike, divides the estuary in two and cuts off the flow of freshwater, from the Squamish River, into the eastern portion of the estuary and the downtown. 10 culverts have been installed along the training dike but they are marginally effective at restoring the freshwater flows needed to keep an estuary active (Levings 111). The training dike has significantly altered the flow of the Squamish River: "Prior to the dyke, the main river flow actually ran through the current port facility location and, prior to 1921, actually flowed through what is now termed the Mamquam Blind Channel" (Squamish Prodelta Experiment 2011). The Mamquam Blind Channel is located east of the downtown. Studying historic maps of the Squamish River it becomes clear that freshwater from the river once spilled over the entire downtown area, mixing with saltwater and creating an estuary much larger than what exists today as the WMA. If freshwater and saltwater are not mixing there is no longer an estuary. The Squamish River has been disconnected from much of the estuary and the downtown.

Although the training dike is outside of the study site, understanding it's function as a river dike allowed me to conclude that the old town dike is no longer functioning as a river dike because the training dike is the primary line of defence against river flooding.

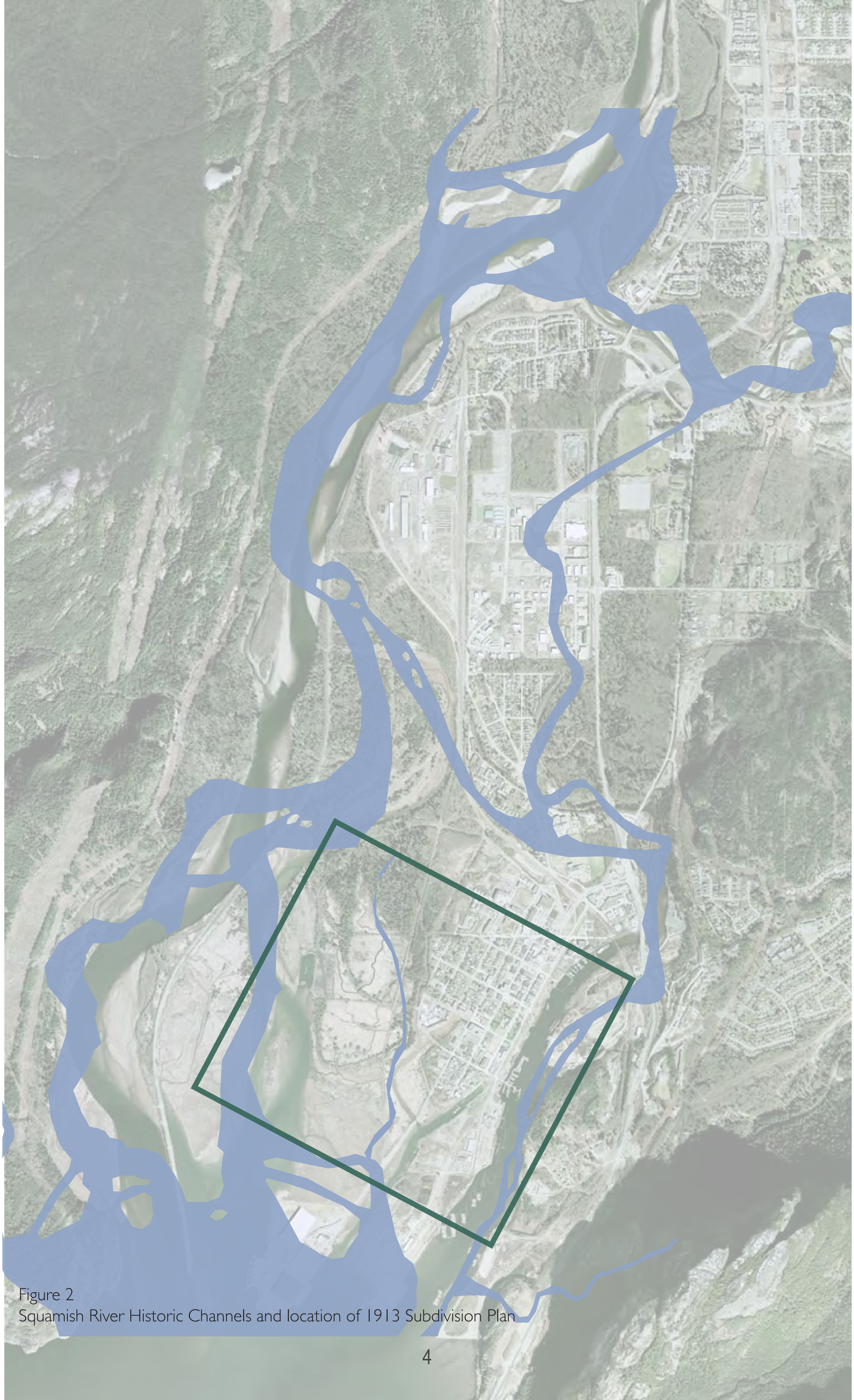


Figure 2
Squamish River Historic Channels and location of 1913 Subdivision Plan

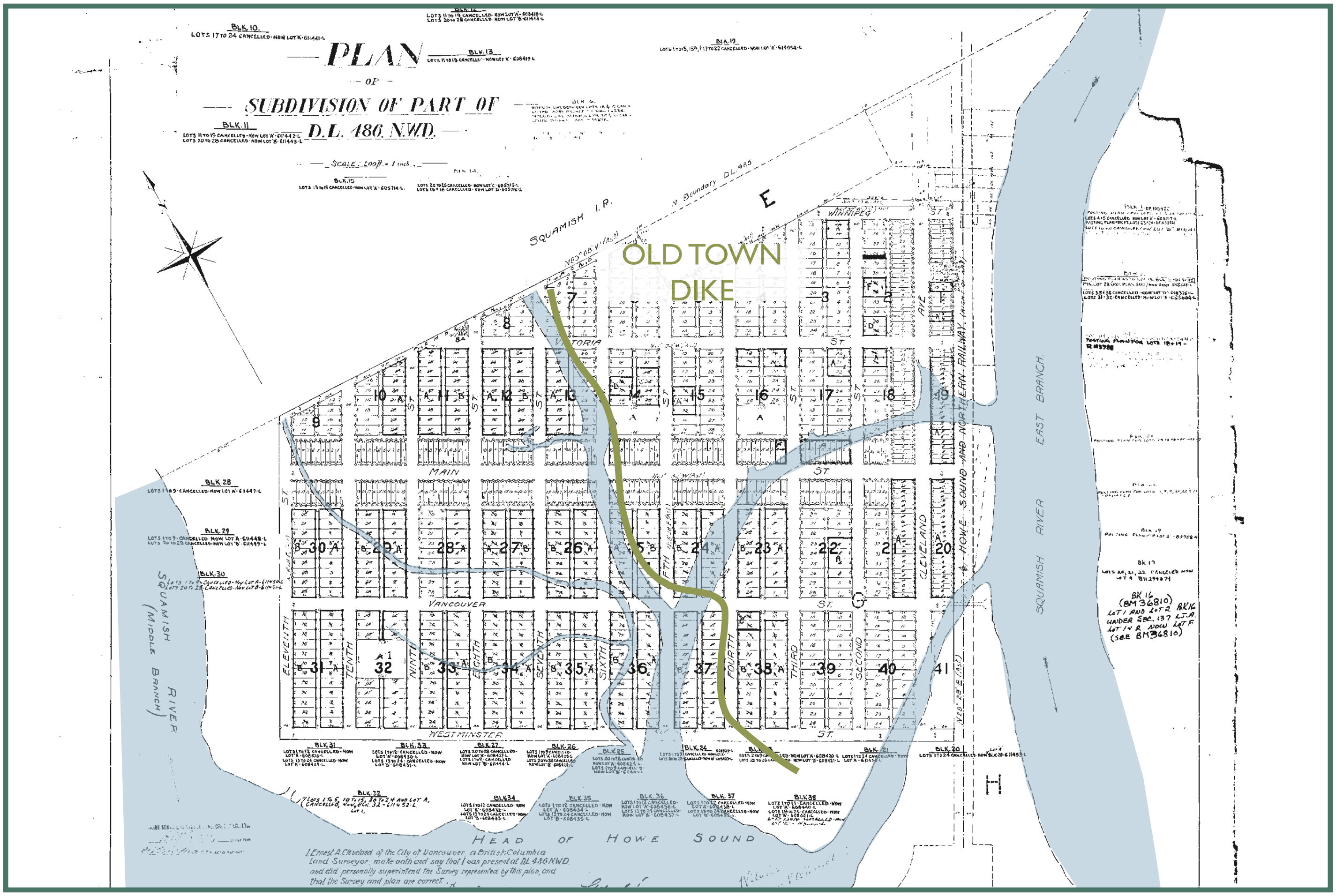


Figure 3
1913 Subdivision Plan

Figure 4
Squamish River New and Hisctoric Channels and Squamish River Training Dike

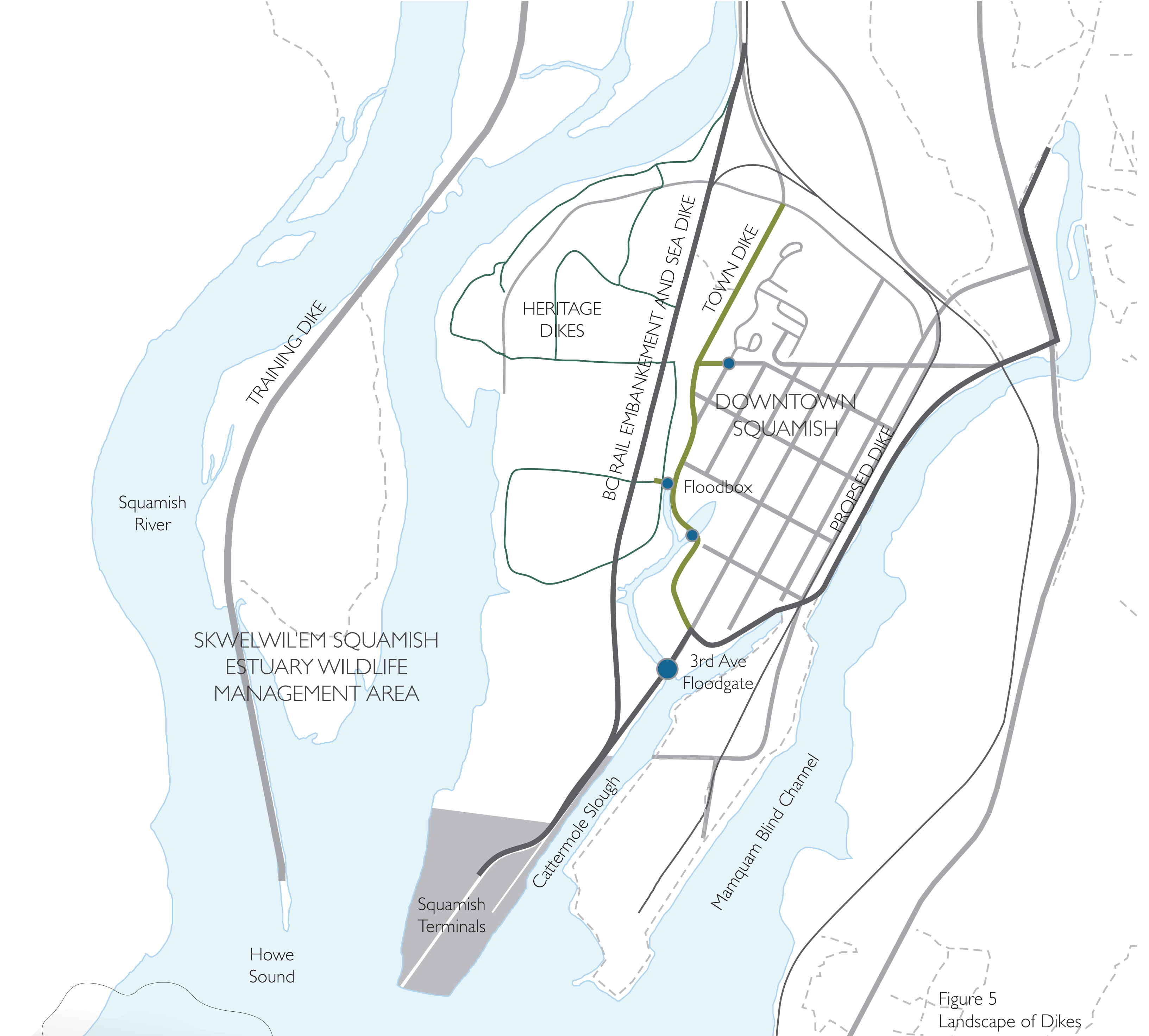
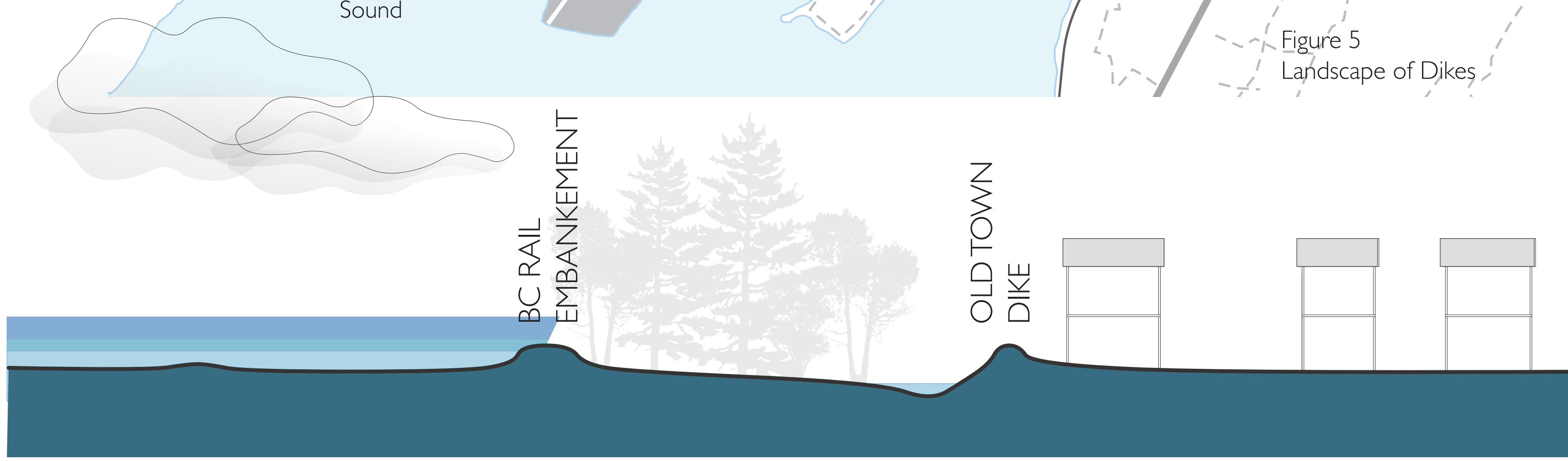


Figure 5
Landscape of Dikes



OCEAN FLOODING 4.5m

High tide = 2.7m
Storm surge = 0.6m
Sea-level rise in 100 years = 1.2m

ASSUMPTION:

The BC Rail Embankement will continue to protect downtown Squamish from flooding from both the Squamish River and Howe Sound. This will require an upgrade.

What is an Estuary?

An estuary is a transition zone where freshwater from a river meets and mixes with saltwater from the ocean. The word estuary comes from the Latin "aestus" meaning tide or "a tounge of the sea reaching inland" (Hardisty 3). Due to continuous fluctuations in river flow, tides, and sediment distribution, estuaries are constantly changing. Their physical position between the dynamic forces of river and ocean mean that in geological time they are relatively short-lived:

Estuaries are formed in the narrow boundary zone between the sea and the land and their life is generally short. Their form and extent is being constantly altered by erosion and deposition of sediment and drastic effects are caused by a small raising or lowering of sea level (Dyer 1-2).

Estuaries, inherently vulnerable landscapes, are sensitive to changes in sea-level and are thus threatened by sea-level rise from climate change. But estuaries are incredibly important for humankind. They provide a source of food and water, transportation links via water, and the topography is relatively flat, creating opportunities for architecture and agriculture; "hence the most densely populated areas of the world are situated in coastal areas near estuaries" (Savenije 3). Humans have consequently located themselves in the most ecologically rich environments, and also, the most vulnerable landscapes. Squamish is an example of a community located on a vulnerable estuary landscape.

The Squamish estuary is a fjord-head estuary. Fjord-head estuaries were formed by Pleistocene ice sheets that widened pre-existing river valleys through mountainous terrain forming deep troughs (Dyer 5). Fjords are characterized by a sill and basin. Sills can be quite high, limiting the inflow of saltwater into the estuary. Fjord inlets in British Columbia tend to have deeper sills than other fjords and the Squamish estuary is a macrotidal fjord meaning there is a tidal range greater than 4m (Squamish Prodelta Experiment 2011). Even when sills are deep, they create a highly stratified estuary, because the cold salt water enters the deep basin while the warmer freshwater floats on top, therefore river flows predominate (Dyer 5 and 8).

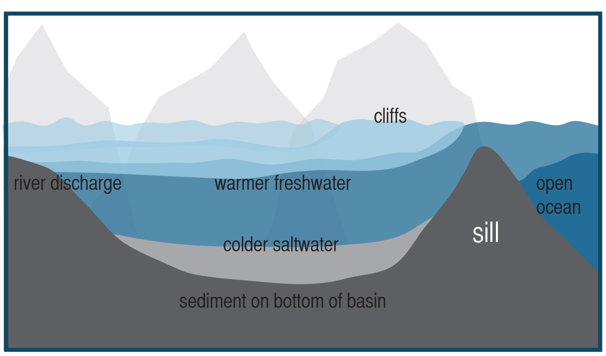


Figure 6
Diagram of a Fjord Type Estuary

THE SITE:
Continued

The training dike is not the only barrier to water flow on this site; in the eastern portion of the WMA, the BC Rail embankment acts like a dike that divides most of the WMA from Cattermole Creek and the downtown. According to the 1999 "Squamish Sea Dike Upgrade Assessment" by Bland Engineering Ltd., "The BC Rail embankment has acted as the sea dike since 1985 and can continue to do so subject to a geotechnical assessment"(1). The BC Rail embankment, constructed between 1968 and 1973, began to function as a sea dike in 1985 when the culverts running underneath it were closed and the 3rd Avenue floodgate was built on the mouth of the Cattermole Creek. No geotechnical assessment has been done, making it difficult to determine conclusively if the Rail embankment makes a reliable dike and, because the District of Squamish does not own the BC Rail embankment, management of the Rail embankment as a flood control structure is not probable. It does, however, create an interesting design challenge, with the possibility of proposing that the BC Rail embankement be upgraded to serve as a sea dike.

There are more dikes; there is a network of historic dikes, currently forming elevated trails, in the eastern part of the WMA. Chinese labourers built these heritage dikes in the 1890s in order to establish hay fields (Invasive Species and Trails 106). Along the western edge of downtown Squamish there is a sea dike, separating the downtown from Cattermole Creek, referred to as the "town dike". The town dike is 1020 m in length and dates back to the early 1990s. Although the town dike is set back from the Howe Sound, "flood and erosion damage is possible during high tide and surge periods" (Flood Damage Recovery 8-1). And, the Flood Management Plan for Squamish identified a potential flood hazard for downtown Squamish from Howe Sound high tides (Smart Growth on the Ground 3). Provincial Floodplain Maps for Squamish put the Howe Sound coastal flood level at 4.1m, including freeboard, and the town dike sits at roughly 3m, creating a 1.1m deficiency (Flood Damage Recovery 8-1). Cattermole creek, on the west side of the town dike, drains into the tidal dominated Cattermole Slough, but is restricted by an automated floodgate along another informal dike referred to as the "3rd Avenue dike". This totals to 4 barriers separating the Squamish River from downtown Squamish, and 2 separating the western edge of downtown from the sea. According to the "Public Works Asset Management Plan" from January 2011, the estimated cost of replace the aging town dike is 2.4 million, to replace the 2 outfalls is 82 thousand and to replace the 3rd Avenue floodgate is 637,500. With so many barriers, there seems to be a redundancy unaccounted for that could be incorporated into a design solution that is more cost effective and less invasive to the estuary.

Measuring Water Flux

WATER FLUX	TIME FRAME	OSCILLATION
Tide	Daily	Max tidal range for Squamish is 4.92m. (Tide Forecast). The vertical distance between high and low tide is amplified in Squamish by the tides moving through the Straight of Georgia and Howe Sound (Coastal Shore Stewardship 10). Howe Sound is a macrotidal fjord (Squamish Prodelta Experiment 2011).
Tide	Monthly	The lowest and highest tides occur during full and new moons (Coastal Shore Stewardship 10).
Tide	Annually	The lowest and highest tides occur in December and June (Coastal Shore Stewardship 10).
Tide	Seasonally	Last spring high tide in Squamish was on Mon Dec 31 at 4.77m (Tide Forecast).
Precipitation	Monthly	Average monthly precipitation is 203mm (The Weather Network).
Precipitation	Annually	November has the highest amount of precipitation at 435mm and August has the lowest amount of precipitation at 37mm (The Weather Network).
Estuary	Daily	272 m3/s mean daily discharge (Ascaphus Consulting 6).
Freshet	Annually	Discharge of > 500m3/s is maintained for more than 4 months, with some peak discharge events of over 1000m3/s (Squamish Prodelta Experiment 2011).
Storm surge	10-20 years	1m high in Straight of Georgia (Coastal Shore Stewardship 10).
Flooding	200 year flood	For Cattermole Creek area it is approximately 2-3m (BC Provincial Government).
Sea-level rise	100 years	1m (Ausenco Sandwell)
Sea-level rise	200 years	2m (Ausenco Sandwell)

Figure 7
Table of Water Flux

THE SITE:
Continued

In addition to the ecological lack of connection between water flux and downtown Squamish, there is a cultural lack of connection. This is made evident by the District of Squamish policy regarding flood management. For one, there is very little policy formally documented in Squamish, because responses to problems have evolved over time that require a large amount of human input. The Flood Management Plan dates back to 1994 and needs to be updated. Having spoken to a number of District staff, when a flood event occurs, their job is to get on site and do whatever they can to mitigate the impact of flooding, include manually operating equipment. The Squamish Official Community Plan includes very little on the issue of flooding with the exception of the following:

Within Squamish, nearly all of the commercial and industrial lands are located in areas subject to flood hazards. Protection from flooding is provided by approximately 17km of dikes. Despite development pressures, growth within areas with a high risk of hazards should not occur (111).

Meanwhile, one of the key goals in the Downtown Neighbourhood Plan, a schedule of the OCP, is "To ensure that downtown functions as the heart of the entire District of Squamish," and this includes accommodating residential and commercial development (25). This contradictory policy is evidence of an almost complete denial of the environmental constraints of living within a floodplain. If the downtown is to become the heart of the district, adaptations to the serious risk of flooding and sea-level rise need to be implemented.

The area between the downtown and WMA, the site of this project, is currently behaving as a large stormwater drainage ditch for the downtown, detaining a large amount of stagnant water. The whole of downtown Squamish drains into two points along the sea dike, that empty into the Cattermole Creek, and eventually, through the 3rd Avenue floodgate. The floodgate only opens when tides are low to release freshwater into Cattermole Slough, exchange of saltwater is limited. If this stormwater were cleansed properly, possibly in the riparian edge, it could be released slowly through the WMA, helping to restore the freshwater flows that have been cut off by the training dike. Restoring the riparian edge to treat stormwater is another design opportunity that requires altering the dikes. There is also lack of policy on this issue as there is currently no stormwater management plan. Formulating policy on other issues like water distribution is of a greater priority for the District and a stormwater management plan will most likely not be pursued for another 20 years, even though the stormwater infrastructure in the downtown is nearing the end of its lifespan. This is an excellent opportunity to provide the District with some innovate stormwater management strategies that they could implement quickly and cost effectively.

Site Sections

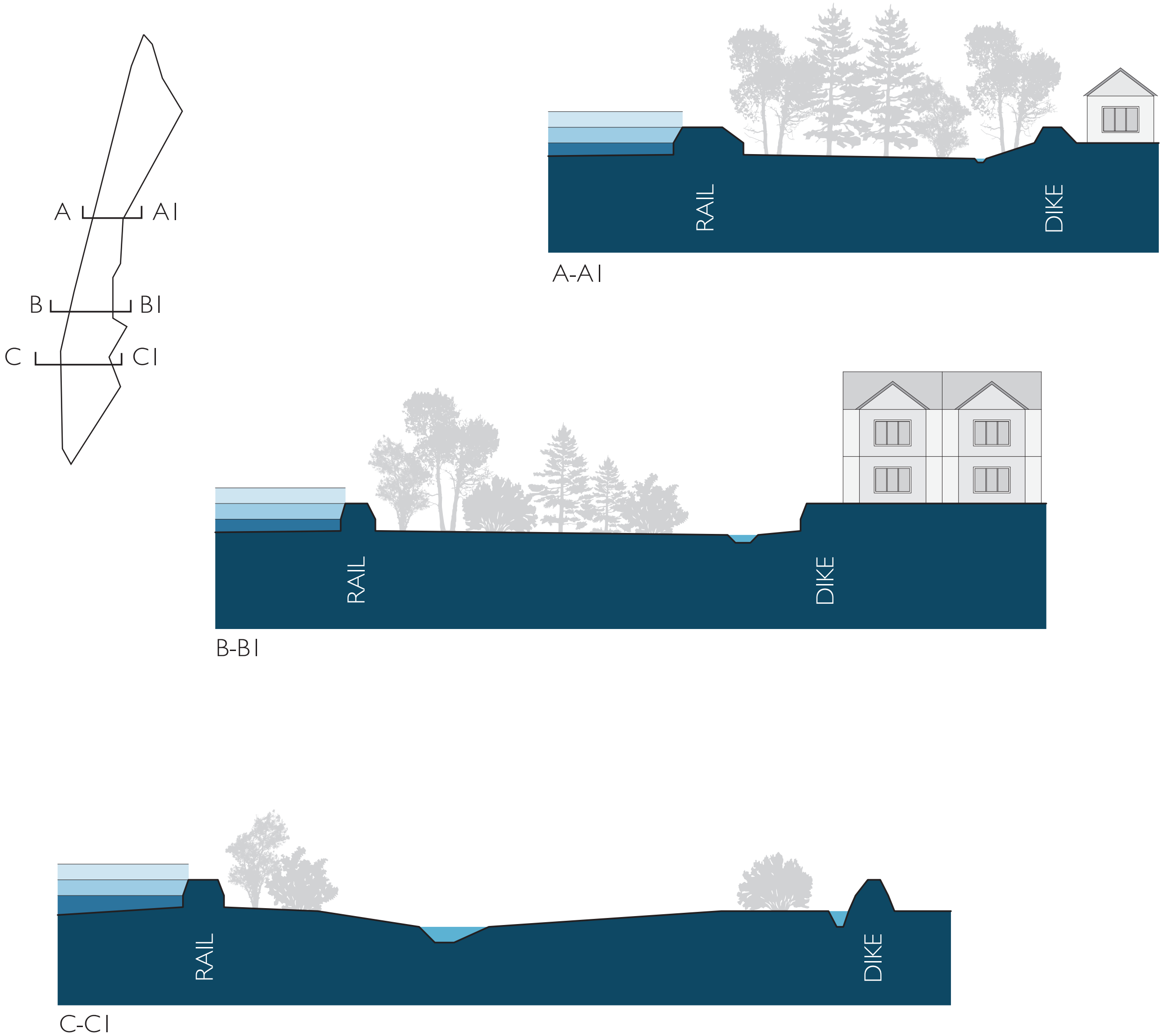


Figure 8
Site sections with 5x vertical exaggeration and a 3m sealeve rise from the seaward side of the rail corridor.

THE SITE:
Continued

Another cultural lack of connection exists between downtown Squamish and the WMA in the form of unpleasant, limited, and even dangerous circulation patterns, particularly along the sea dike trail that runs on top of the town dike. The crest width of the town dike ranges from approximately 2 to 3m wide and the sides of the dike are very steep, reaching a 1.5:1, horizontal to vertical, in some places (Flood Damage Recovery 8-1). This steep elevation prevents human access to Cattermole Creek on the west side of the dike. Along the trail signs are posted that read, "Warning: Trail Unsafe Use at Own Risk." This is certainly a problem and improving the sea dike trail experience will lead to a greater connection between downtown Squamish and the Estuary. As the downtown continues to grow, more people will be using this dike trail, and the experience they have along this trail will shape their perception of the WMA.

This is a very complex site. Additional knowledge about the site will be incorporated as I continue to study place throughout the month of January. An increasingly deeper understanding of site will continue to reframe the problem and remake the design solution.

ECOLOGY AND DESIGN

At the heart of this project lies a motivation to blend ecology and design successfully. The gap between ecology and design in landscape architecture has already been well documented as a theoretical challenge for the profession. In "The Expanded Field of Landscape Architecture" Elizabeth Meyers questions the pervasive role dialects has played in composing landscape architectures identity. She argues that common dialectics employed in the field of landsape architecture such as, human and nature, culture and nature, and architecture and landscape, position landscape as "other", reflecting cultural biases that undervalue landscape. She writes:

I wish to argue for a definition of landscape architecture as a hybrid activity that is not easily described using binary pairs as opposing conditions. Reliance on these outmoded ways of thinking and speaking limits out ability to see, listen, and create. If we think of continuums of hybrids-of-spaces in between-instead of opposing dualities, we do not have "others." If we do not have "others," we do not inherently value one term over another (50).

Ecology and design is a pervasive dialectic in landscape architecture, and divisions on the landscape still reflect this outmoded way of thinking. Transforming spaces that are "other" into "hybrids-of-spaces" can be achieved by bridging ecology and design, human and nature, and for this project, downtown and estuary. Bridging the gap between ecology and design is a challenge, but quite possible the seed of a much needed unifying and guiding theory in landscape architecture. In landscape architecture, to sacrifice ecology for design is a failure, and to sacrifice design for ecology is a failure, incorporating both is the central challenge.

SYSTEMS

Why think systemically? Fritjof Capra, physicist, systems theorist, and founding director or the Center for Ecoliteracy, writes that, "the most useful framework for understanding ecology today is the theory of living systems" (Speaking Nature's Language, 35). Although systems thinking is quite possibly a very ancient way of understanding the world, used by our ancestors to make legible the natural world, it has not taken root in mainstream culture (Speaking Nature's Language, 36). The modern day version of systems thinking emerged in multiple disciplines simultaneously in the 1920s (The Web of Life, 17). The essential point of debate between mechanistic points of view that predominate modern science and systems theories is an emphasis on the parts versus the whole (The Web of Life, 17). Thinking systemically shifts the focus away from the parts and instead emphasizes the relationship between the parts and how the parts operate as a whole. Systems thinking is a holistic way of understanding the world in the same way that ecology is holistic. Lawrence Henderson, a biochemist, applied systems thinking to social systems and since then "system has come to mean an integrated whole whose essential properties arise from the relationship between its parts" (The Web of Life, 27). Since its modern day origin, systems thinking has been applied to both human and natural systems.

Fritjof Capra writes that there are six shifts in perception that need to take place to think systemically:

From the parts to the whole.
From objects to relationships.
From objective knowledge to contextual knowledge.
From quantity to quality.
From structure to process.
From contents to patterns.
(Speaking Nature's Language, 36 to 37).

This shift in perception from studying the parts to the whole and patterns is an opportunity for ecologist and designers to work together, because designers have the skills required to recognize pattern on the landscape. Thinking systemically in design has the potential to be very rewarding for two important reasons. Firstly, once a particular systems is defined and understood it's structure is repeatable, but each time it is repeated it is unique because the relationship between it's parts is adaptable. This can be a very powerful alternative to modular designs that have gained popularity in the design world because they are easy to mass produce. In systemic design, rather than each component being identical, each component is unique. An analogy applying systems thinking to architecture sheds light on the relationship between systems thinking and design; two buildings are composed of the same parts, walls, windows, and roof, but the relationship between the parts makes each of the buildings unique. The second reason that systems thinking is useful in design is that it is applicable to both nature and humans, offering a theoretical window through which to bridge the natural and human world. The theory of living systems can help us build a better relationship between people and nature.

LANDSCAPE ECOLOGY

Theoretical boundaries can manifest into physical boundaries on the landscape. In Placing Nature: Culture and Landscape Ecology, Joan Nassuer writes about how landscape ecology interprets both physical and theoretical boundaries as an opportunity for connection:

"Landscape Ecology insistently confronts us with the complexities of connection. Rather than establishing boundaries to separate ecosystems or disciplines, it repeatedly points out their connectedness" (Placing Nature 165).

Human created divisions on the landscape, sometimes created to simplify our understanding of landscape, are at odds with the natural flows that permeate these divides. Landscape ecology offers a more holistic understanding of landscape, by considering how fluxes between distinct geographical areas create constantly shifting boundaries. Transcending disciplinary boundaries creates opportunities for landscape architects to create new theoretical approaches to landscape design. As Nassuer writes, any project that crosses boundaries to redeem ecological pattern contributes to the theoretical body of landscape ecology and builds landscape ecological pattern (Placing Nature 168).

Landscape ecology, as the name suggests, is a landscape-based approach to ecology that focuses on the spatial attributes of landscape rather than on individual species. In a foundational paper from 1983 entitled "Landscape Ecology: Direction and Approaches," 25 key thinkers from this field collectively created a definition of the field. They agreed that "Landscape ecology focuses explicitly upon spatial pattern" and has three main areas of focus:

1. spatially heterogeneous geographic areas
2. fluxes or redistribution among landscape elements
3. human actions as responses to, and their reciprocal influences on, ecological process (Risser et al. 255)

The focus on spatial distribution and flux, from an ecological perspective, can be used to inform the spatial pattern of landscape design. A brief application of this definition of landscape ecology to this research project demonstrates the relevance of landscape ecology to the spatial problem of connection; the WMA, Cattermole Creek, and downtown form spatially heterogeneous areas, water is the flux across these landscape areas, and the dike system represents a human response to this landscape with the resulting impact of fragmentation.

An important concept from landscape ecology that will be explored in this project is fragmentation. In Ecology of Fragmented Landscapes, Sharon K. Collinge, defines fragmentation as "breaking a whole into smaller pieces while controlling for changes in the amount of habitat" (3-5). This is a useful definition, however, the word habitat is misleading because habitat refers to both biotic and abiotic components and this project will focus on the abiotic water processes required to support habitat and ecological function. Fragmentation may result from natural or anthropogenic forces, although often the degree of disconnection caused by human-induced fragmentation is magnified. Natural fragmentation can have drastically different effects than anthropogenic fragmentation, one of these is described by Urban, O'Neill, and Shugar's notion of hierarchical space-time patterns:

[...] human activities rescale natural regions by imposing barriers—such as roads, pipelines, buildings, and dams—that retard the flow of species, disturbances, nutrients, or materials across landscapes. These newly bounded habitat fragments may therefore be too small to encompass natural disturbance regimes or dispersal patterns, thereby reducing habitat suitability for some species. (Collinge 10).

A common natural disturbance regime in marine systems, for example, is tidal inundation, which is currently controlled on the study site by a railway, dike, and floodgate. Efforts will be taken to understand the relationship between anthropogenic and natural fragmentation.

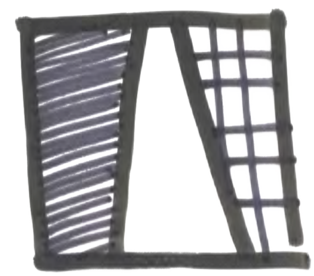
Although landscape ecologists understand the geophysical relationship between water and land their focus is more typically on terrestrial landscapes rather than aquatic environments. In 1996, Robert Naiman wrote a paper entitled, "Water, Society and Landscape Ecology" that called upon landscape ecologist to turn their focus to water and its role in establishing cultural and environmental integrity (193). He pin pointed water as an excellent research opportunity for landscape ecology, a field interested in the integration of society and landscape. Naiman drew attention to the social importance of water. Water is not only vital to human survival but it shapes patterns of human settlement; a spatial idea with both social and ecological implications. Landscape ecologists can transform information about aquatic processes on the landscape into applicable knowledge for protecting those resources. Naiman concluded with four reasons why landscape ecologists should pursue research in water: their products are visual, they can provide alternative scenarios, they provide a holistic perspective, and without them, socioenviromental issues will accelerate (196). I argue that this is still not a fully developed topic within landscape ecology, that the problems have accelerated, and that Naiman's four reasons for calling on landscape ecologists ring true, even louder, for landscape architects. By the end of this project I hope to have applied a landscape ecology approach to connect people with the unique estuary environment in which Squamish is located.

LANDSCAPE ECOLOGY PRINCIPLES

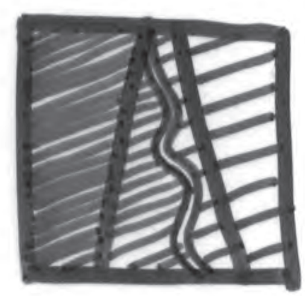
6 principles that apply to the site

(adapted from Landscape Ecological Principles in Landscape Architecture and Land-Use Planning)

roads and other trough corridors:
This principle helps to explain why human made corridors cause fragmentation on the landscape by acting as barriers to. Trough corridors are corridors that are straight, continuous lines, with regular human disturbance. Two of the types of trough corridors present on my site are a railroad and dikes. The effect of a trough corridor is exacerbated by the raised elevation of the corridors. Trough corridors restrict movement through the site.

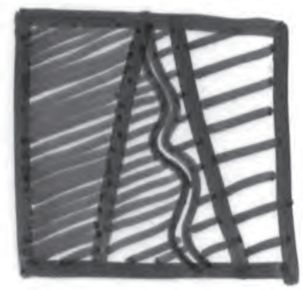


corridor width for stream:
Cattermole creek, used for stormwater management, is bounded by the railroad to the east and the town dike to the west. Restoration of water flow through this creek should be coupled with restoring proper corridor width. Riparian edges are important because they dissolve substances from water entering the stream and provide habitat for floodplain species. They can also create a more pleasing gradation in slope than dikes.

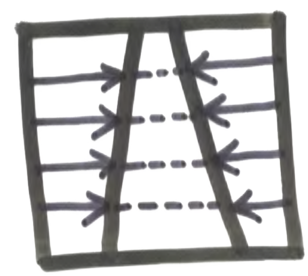


barrier to disturbance:
This may be a difficult principle to reconcile in this project. While barriers can create fragmentation of landscapes, they can also create a barrier to disturbance. If the railroad and dike are creating a barrier to the disturbance of floodwater, how can this function be maintained while addressing the lack of connection between the downtown and WMA? And, how can water enter the area between these barriers without causing disturbance?

administrative and natural ecological boundary:
Both of these boundaries exist on this site however there seems to be an abundance of administrative boundaries that do not necessarily correspond to natural boundaries. For example, the WMA ends at the railroad and does not include Cattermole creek although this site is an adjacent piece of estuary. Between the edge of the town, formed by the town dike, and the WMA is an indistinct buffer.



edge as filter:
Patch edges filter out the influences from surrounding patches. This is relevant to the site because there is potential for this principle to be applied more successfully to this site. Currently stormwater from the downtown passes into Cattermole creek through two culverts. This edge could act more like a filter if there were more opportunities for water to pass through the edge, being cleansed as it is slowly released into the creek and the sea.



edge abruptness:
Trough corridors create very abrupt edges that funnel movement along the edge rather than across it. This principle can be applied to the movement of water, small ditches of water run along the edges of the railroad and the town dike in various places. This principle can also be applied to the movement of people. Currently people use the railroad as a walking trail and this is dangerous, it would be safer if people had opportunities to cross quickly..

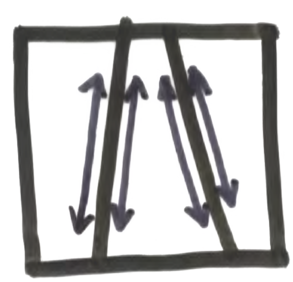


Figure 9
Landscape Ecology Diagrams

PANARCHY: An Evolution of Resilience Theory

In 1973 C.S. Holling introduced the concept of resilience in his paper, "Resilience and Stability of Ecological Systems". In this paper, Holling defined ecological resilience as "the amount of disturbance a system can take before its controls shift to another set of variables and relationship that dominate another stability region" ("The Evolution of an Idea" 426). In the book Panarchy: Understanding Transformations in Human and Natural Systems, Holling and Gunderson critique some views of nature, including "nature resilient":

It is a view of multiple stable states in ecosystems, economies, and societies and of policies and management approaches that are adaptive. But this view presumes a stationary stability landscape—stationary underlying forces that shape events. [...] This "resilient worlder" view is not wrong—just incomplete" (13).

In essence, the view of nature resilient assumes that ecosystems return to the same stable state, rather than evolving into a different stable state. Nature resilient assumes that time is static, that the forces that shape landscape are paused after a disturbance, while the ecosystem recovers. My main impetus for moving beyond resilience to try and incorporate ideas from Panarchy is this somewhat critical reflection of resilience by Holling, even though he pioneered the concept of resilience. With Panarchy, Holling is striving for a more complete view of nature and I would like to attempt to do the same.

ideas from Panarchy is this somewhat critical reflection of resilience by Holling, even though he pioneered the concept of resilience. With Panarchy, Holling is striving for a more complete view of nature and I would like to attempt to do the same.

The most simplified definition of Panarchy, written by Gunderson, Holling, and Allen, that I have found to date, comes from a book entitled Foundations of Ecological Resilience:

"Panarchy (derived from the Greek god of nature, Pan, combined with archy, from the Greek for 'rules' --hence 'rules of nature') is a term used to describe how variables at different scales interact to control the dynamics and trajectories of change in ecological and social-ecological systems" ("The Evolution of an Idea" 431).

For the sake of clarity, the key take away from this definition of Panarchy is the emphasis on understanding natural and human systems by examining different scales and tracking the change across time. The notion of space/time hierarchies refers to a very specific definition of hierarchy, as semi-autonomous levels determined by variables that adapt at similar speeds and share spatial attributes ("Understanding Complex Systems" 392). The term Panarchy was coined by Holling and Gunderson as an antithesis to the heavily laden, top-down concept of "hierarchy" while still retaining the notion of adaptive cycles across scales.

COMPLEX ADAPTIVE SYSTEMS

The natural and cultural world is increasingly complex; understanding this complexity as efficiently as possible is key if we are to adapt to our dynamic world. Holling and Gunderson write that the "complexity of living systems of people and nature emerges not from a random association of a large number of interacting factors rather from a smaller number of controlling processes" ("Understanding the Complexity" 391). Latent in this definition of complexity is a key idea that complexity can be reduced to a small set of variables. Complexity is not chaos, it is an amalgamation of interrelated processes. In addition to efficiently communicating the problem, systemic sustainability must be dynamic and prescriptive, and embrace uncertainty and unpredictability, because change is inevitable ("Understanding the Complexity" 391). The four stages of complex adaptive cycles: exploitation, conservation, release, and reorganization, are described below, and have been synthesized from multiple sources. These stages can be applied to both natural systems and human systems.

EXPLOITATION

The exploitation, or growth phase, is a period where ecosystem or social capital is slowly accumulated. Accumulated capital is sequestered to support the growth of new, emerging ecosystems or societies. Potential is high but internal connectivity is low as multiple species or social groups attempt to establish themselves.

CONSERVATION

Accumulated capital becomes efficiently used by well adapted, specialists that can outcompete newcomers. Efficient use of resources leads to a high degree of connectedness. Resilience decreases as the cycle moves towards the conservation phase. This is because the level of internal connectedness becomes so high that the system becomes rigid. The system is vulnerable to a disturbance.

RELEASE

This phase is initiated by a disturbance that causes the system to collapse. The sequestered capital is released and internal connectedness is lost. A chaotic phase of disorder with little potential for growth occurs.

REORGANIZATION

Resilience increases as the cycle moves back towards reorganization because the system is highly flexible and low in connectedness. Low connectedness allows for novel combinations and experimentations to emerge if some capital remains. The future after this phase is highly uncertain, it can either be a time of opportunity if systems reestablish in exciting new ways or it can be a time of despair if degraded systems are irrecoverable.

DESIGN SOLUTION: The Estuary Edge

There is a disconnect between human systems and natural systems. This project will reconnect the human and natural systems to create a landscape of infrastructure and conservation.

The disconnect between downtown Squamish and the adjacent estuary is in part due to the old town dike along the western edge of downtown Squamish. The Dike, an aging piece of flood protection infrastructure is no longer needed thanks to the BC Rail Embankement to the west, creating an opportunity to remove sections of the old town dike to reconnect downtown with estuary. By removing sections of the dike new saltwater wetlands can be created to form "The Estuary Edge". The old town dike is one of four design problems I identified that address the larger contextual problem of disconnect between human and natural systems. The following 4 Design problems are addressed in the design solution:

1. Old Town Dike
2. Conservation Priorities
3. Stormwater Capacity
4. Flood Construction Levels

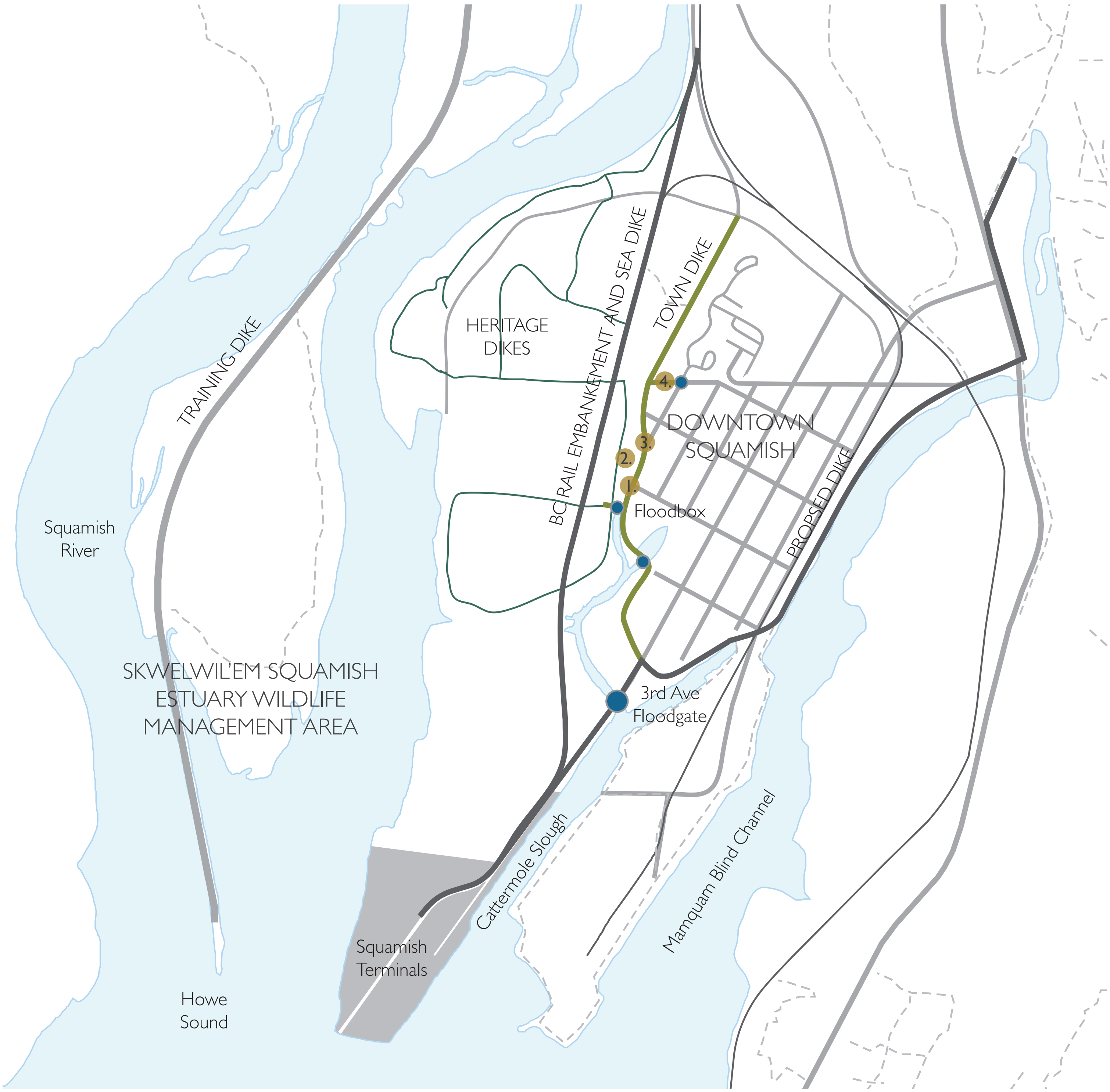


Figure 5
Landscape of Dikes


1.


2.


3.

4.

OLD TOWN DIKE

The old town dike, built in the early 1990s when the town was in the early stages of development, is a non-standard informal dike extending 1,020m along the western edge of downtown Squamish. The old town dike is no longer needed for flood protection, because, according to the Squamish Sea Dike Upgrade Assessment, "The BC Rail embankment has acted as the sea dike since 1985 and can continue to do so subject to to a geotechnical assessment" (1). This creates an opportunity to improve the pedestrian experience along the old town dike. Currently this heavily used pedestrian corridor is uninviting, smelly, along street ends, and dangerous.

ASSUMPTION:

The BC Rail Embankement will continue to protect downtown Squamish from flooding from both the Squamish River and Howe Sound. This will require an upgrade.

4 DESIGN PROBLEMS

1. Old Town Dike
2. Conservation Priorities
3. Stormwater Capacity
4. Flood Construction Levels

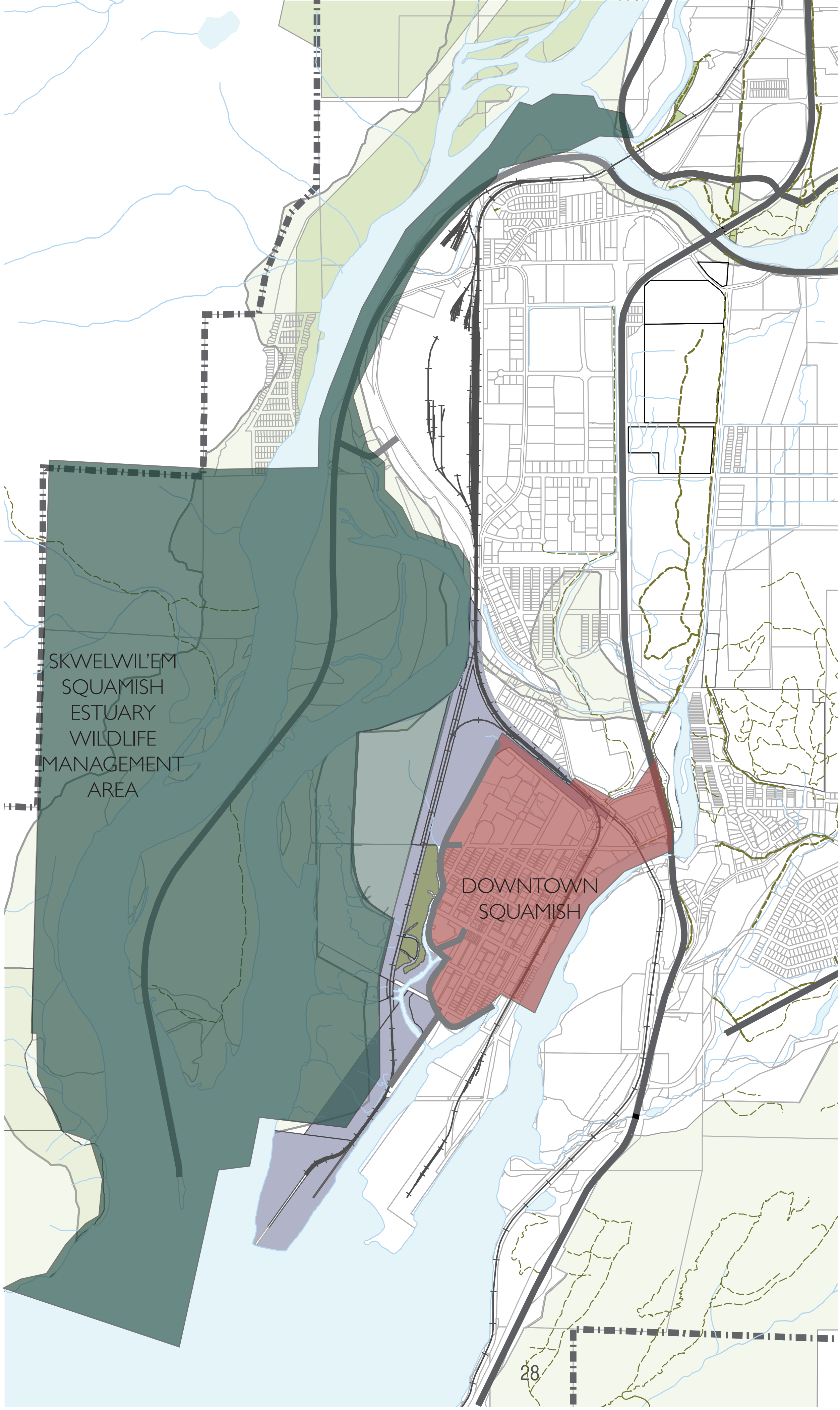
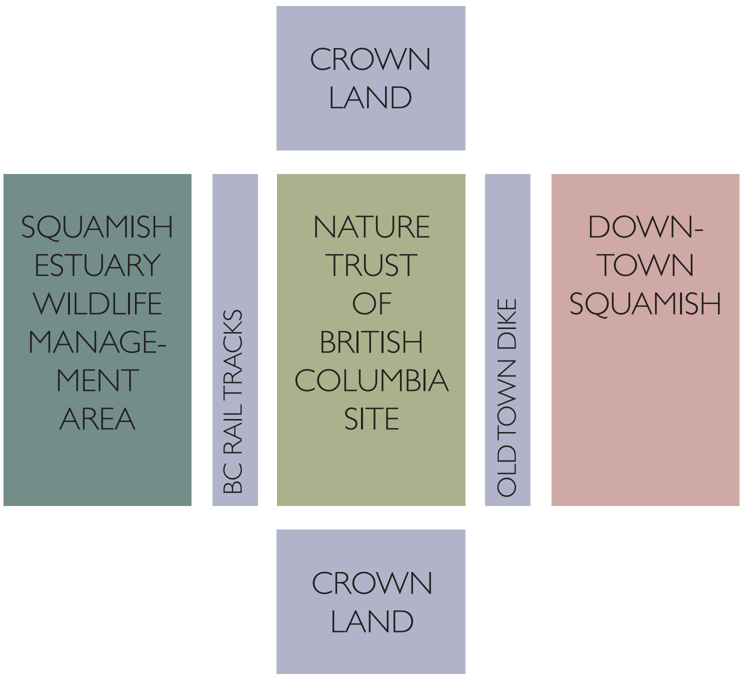


Figure 10
Conservation Lands



CONSERVATION PRIORITIES

According to conversations with Carl MacNaughton, the Conservation Land Manager of The Nature Trust of British Columbia, the priority for this site is conservation. The Nature Trust would like to see this 5.3 hectare site become part of the Skwelwil'em Squamish Estuary Wildlife Managment Area, also a conservation area, and will be working a lease agreement with the Province Summer 2013. Although this may be a challenge to do the seperation of the BC Nature Trust site and the WMA by the BC rail embankment, there is substantial reason for this site to become provincial protected because it hosts the largest diversity of birds in the estuary, due to nutrient loading from stormwater and the 50:50 ratio of land to water (Ascaphus Consulting, 15). By breaking up the old town dike, salt water is allowed to penetrate the dike, increasing the range of estuary plant communities and bird habitat, into downtown Squamish.

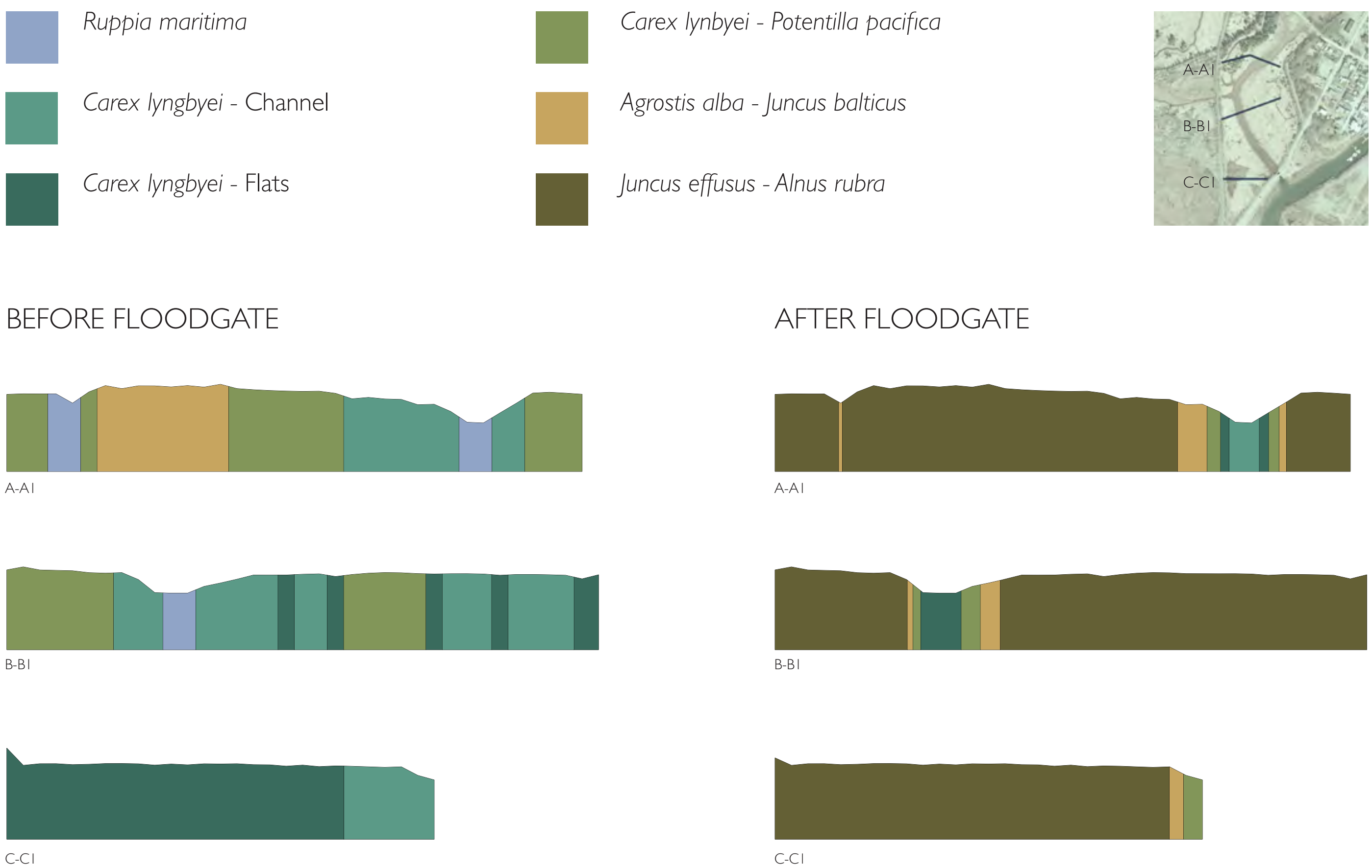
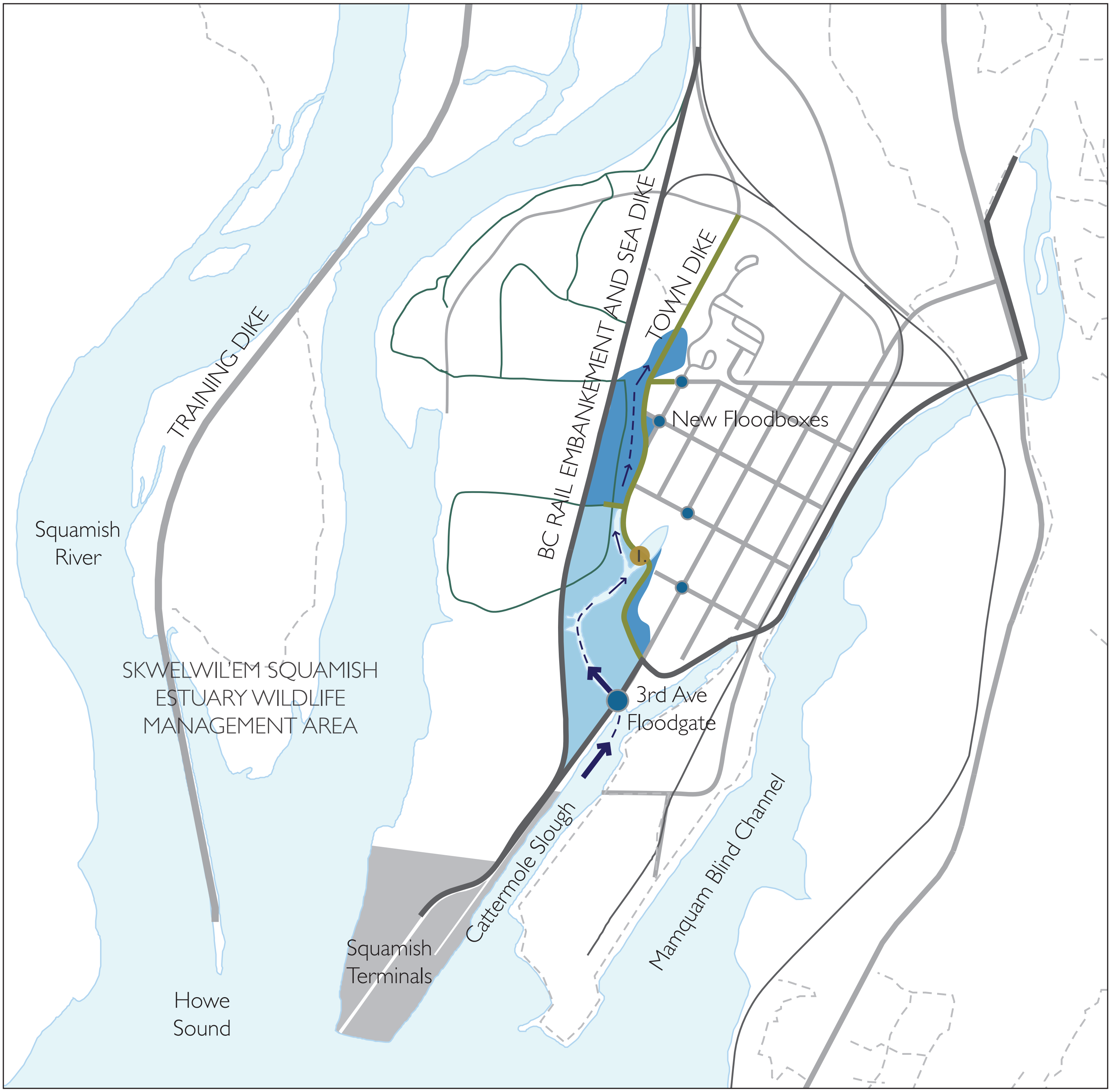


Figure 11 - Vegetation Study Before and After 3rd Ave Floodgate

ENDANGERED BIRD	STATUS	HABITAT	FOOD	NESTING	BEHAVIOUR
Asio flammeus Short Eared Owl	Blue listed	Grassland	Mammals	Nests on the ground in tall grasses or marshes.	Soaring
Botaurus lentigoinosus American Bittern	Blue listed	Marsh	Fish	Foundation of emergent vegetation like reeds, sedges, or cattails.	Stalking
Brachyramphus marmoratus Marbled Murrelet	Red listed	Ocean	Fish	Moss in Old Growth Trees	Stalking
Butorides cirescens Green Heron	Blue listed	Marsh	Fish	Basket of stick in small trees, usually over water. Small loose colonies.	Stalking
Eleoocharis parvula Great Blue Heron	Blue listed	Marsh	Fish	Herony colony in trees.	Stalking
Falco peregrinus Peregrine Falcon	Red listed	Mountains	Birds	Cliffs	Aerial dive
Hirundo rustica Barn swallow	Blue listed	Town	Insects	Buildings	Aerial Foreager
Megascops kennicottii Western Screech Owl	Blue listed	Open Woodland	Mammals	Nests in tree cavities with no additional material.	Stalking
Melanitta perspicaillata Surf Scoter	Blue listed	Ocean	Insects	Hollow in ground near water, lined with vegetative debris and down.	Surface diving
Patagioenas fasciata Band-tailed Pigeon	Blue listed	Forest	Seeds	Flat or saucer-shaped platform of intertwined twigs built in a sturdy tree.	Foliage Gleaner
Strix occidentalis Spotted Owl	Red listed	Forest	Mammals	Nests in tree cavities, broken-topped trees, and platforms, such as old raptor or squirrel nests.	Aerial dive

Figure 12 - Endangered Birds Observed on Site According to Edith Tobe



NEW TIDAL REACH

Figure 13
New Tidal Reach


1.


3rd Ave Floodgate


3rd Ave Floodgate

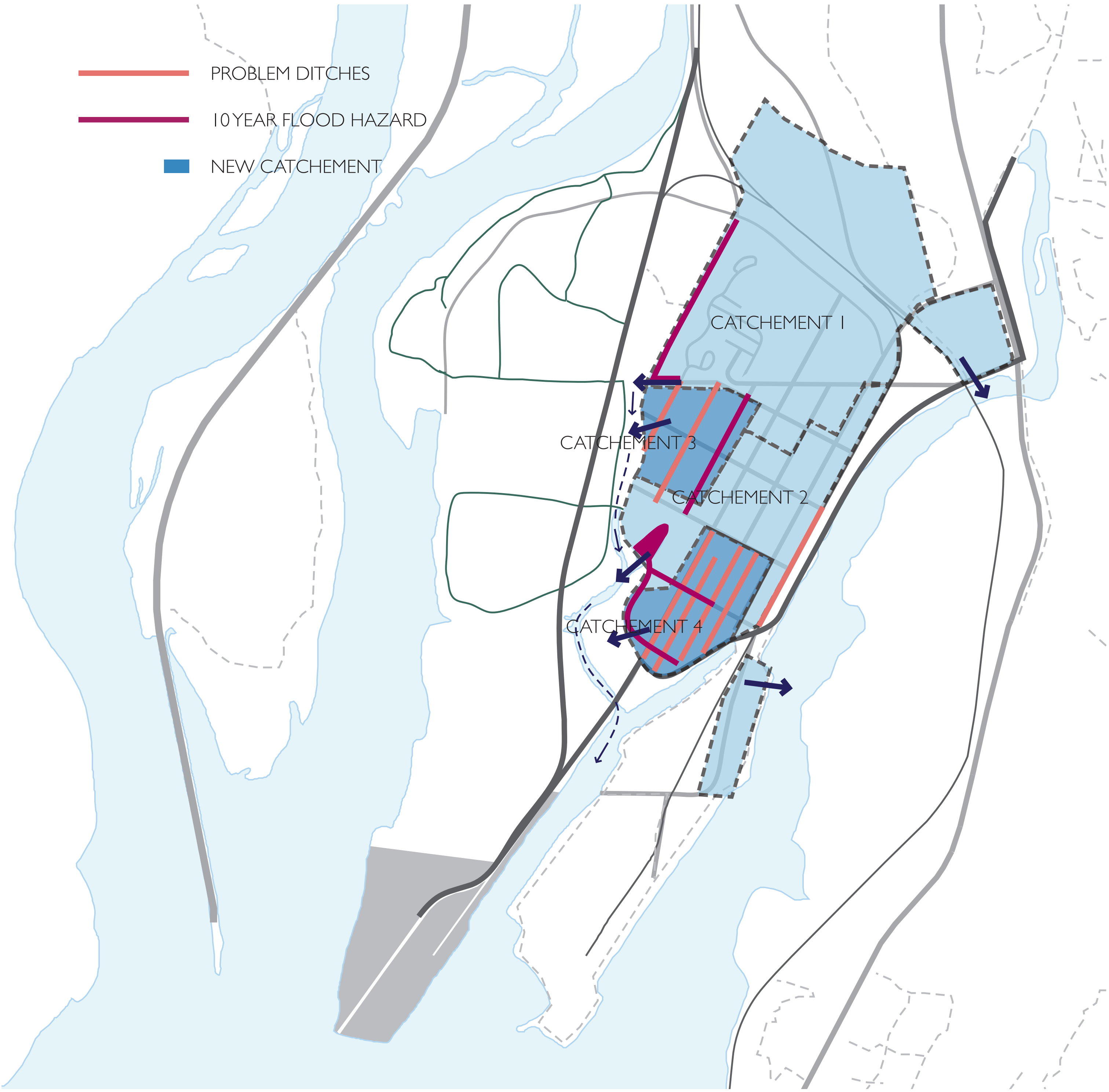


Figure 14
New Stormwater Catchements

STORMWATER CAPACITY

Currently there are only two pipesheds (Catchement 1 and 2) in downtown Squamish and all of the stormwater empties into the Cattermole Creek and the BC Nature Trust site unfiltered. This pipe system is aging and by regrading the ditches that are currently problematic and in need to regrading to create two new catchement areas, pressure is taken off the existing pipeshed and stormwater in conveyed at grade. Two new catchements are formed (Catchement 3 and 4). These four stormwater exits into Cattermole Creek can then become sites for stormwater filtration using constructed wetlands, which also increase the capacity of stormwater. According to the Downtown Drainage Study, an additional area of 30, 000 m2 is needed for stormwater storage during a 10 year event (9). By creating new wetlands, keeping the 3rd Ave floodgate closed during peak storm season, and digging new tidal channels, additional stormwater capacity can be created while also improving wildlife habitat and aesthetic experience.

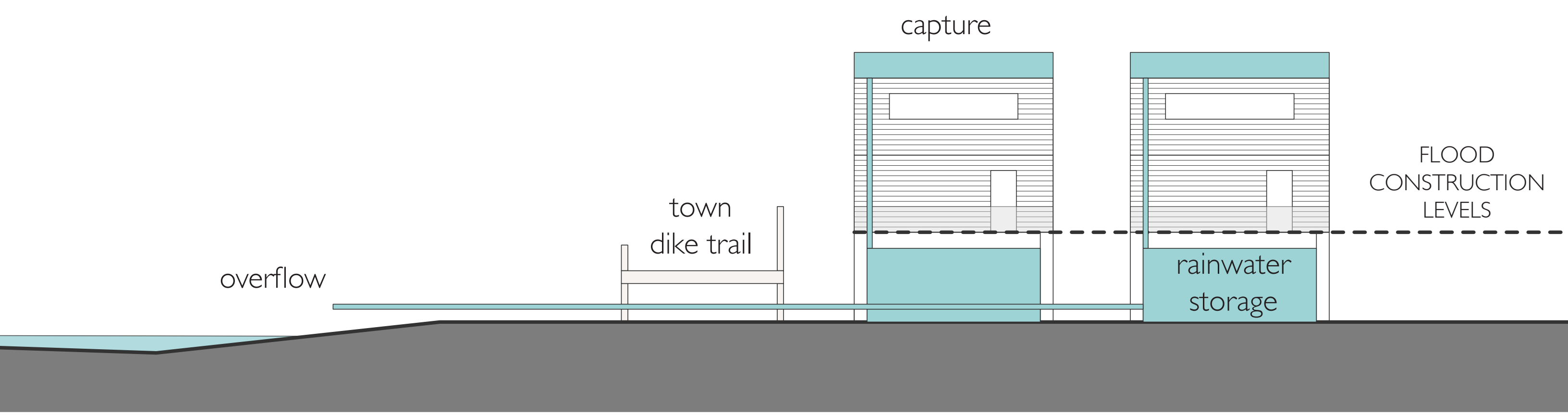


Figure 15
Rain Water Harvesting under Flood Construction Levels

FLOOD CONSTRUCTION LEVELS

According to the Provincial Floodplain maps the flood construction levels for downtown Squamish range from 4.1 to 5m. This means that on average the finished floor levels of buildings will be approximately 2.6 to 3.5m above existing grade. This creates a vertical disconnect in Squamish between the ground and the buildings. In addition to this only certain programs are allowed below flood construction levels: "Permitted uses below FCLs should be clearly defined and limited to garages, carports, accessory buildings, crawl spaces (under 1.5m in height) and entrance foyers. Relaxation of these provisions could only occur if approved by the Ministry of Environment, Lands & Parks" (Flood Hazard Management Plan, 12). This creates an opportunity for rainwater storage below flood construction levels, taking pressure off the stormwater system and connecting people and water. The old town dike is also used to physically connect people from grade to finished floor levels.

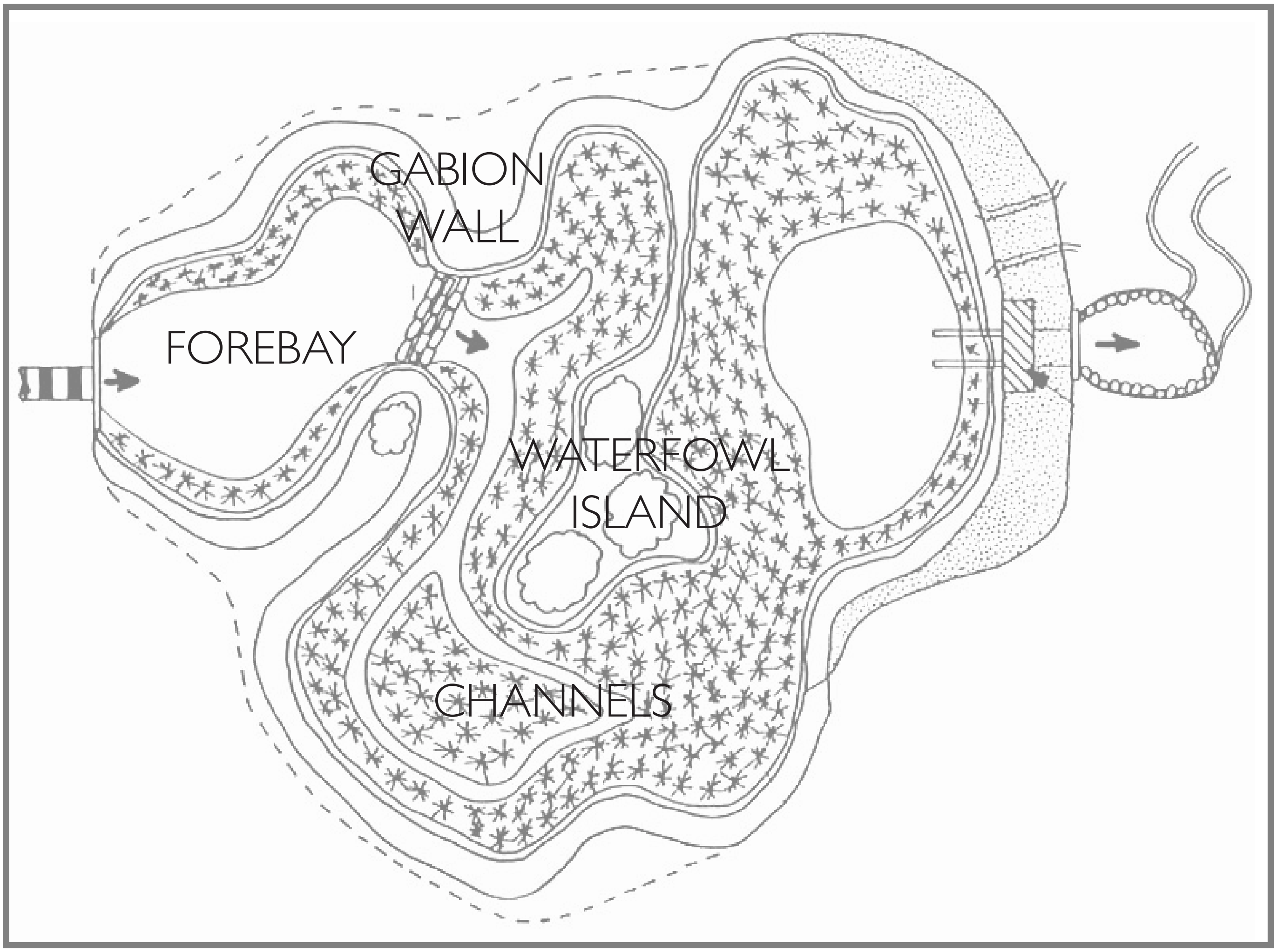


Figure 16
Shallow Water Wetland System Diagram from
Minnesota Urban Small Site BMP Manual.

SHALLOW WATER WETLAND SYSTEM BENEFITS

Reduce Runoff Volume
Pollutant Removal
- Suspended Sediment
- Phosphorus
- Nitrogen
- Heavy Metals
- Oil and Grease
- Fecal Coliform

Increased Bird Habitat
- Waterfowl Island
- Deep Water Cells attract Birds
- Increase Native Vegetation
- Link to Stream Corridor

Aesthetic Enhancement

Wetland/Watershed Ration .02
(Minnesota Urban Small Site BMP Manual)

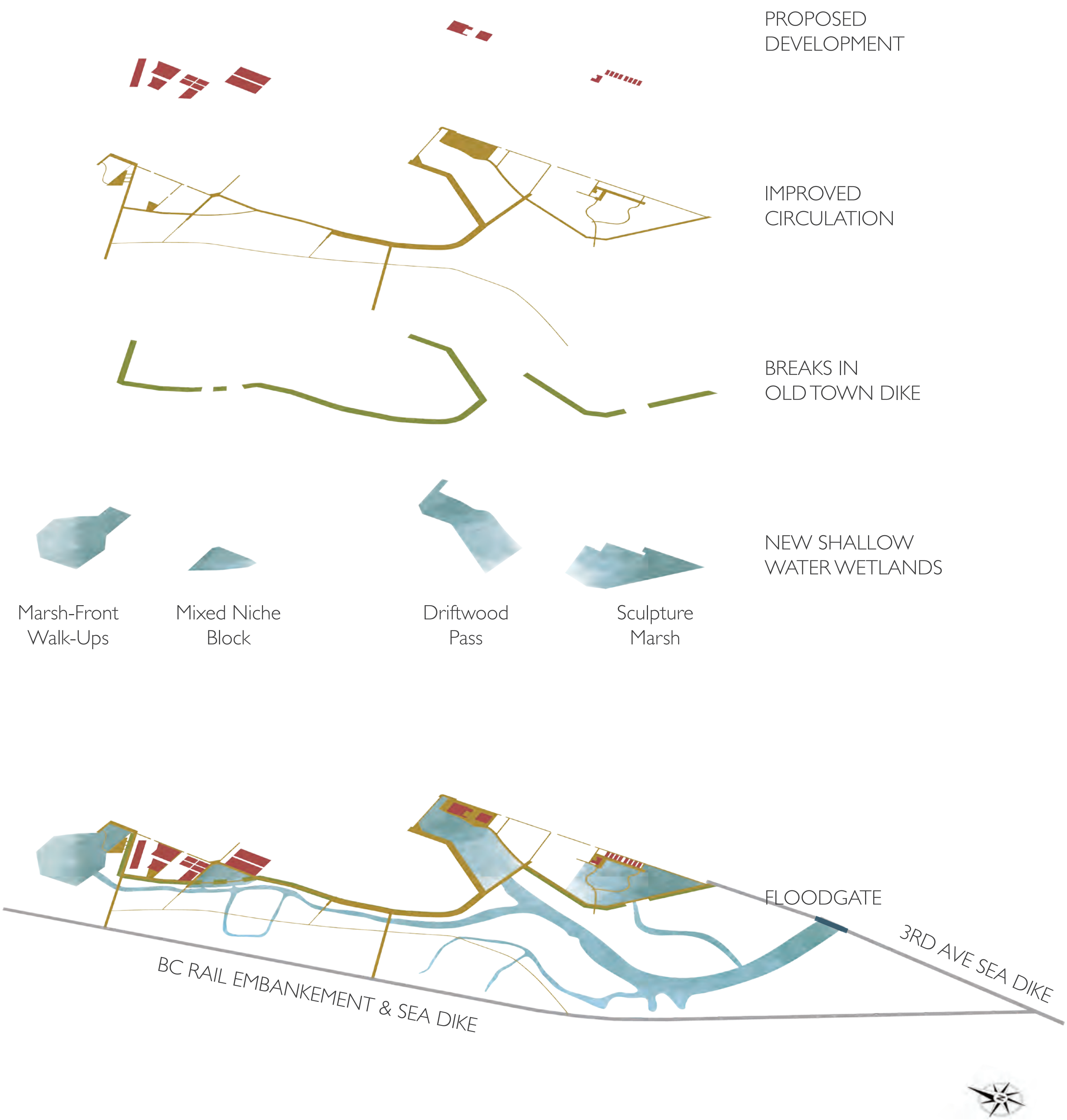


Figure 17
New Design Layers Diagram

Figure 18
Schematic Plan

Figure 19 - VIEW 1

SCULPTURE MARSH

Artist Live/Work Studios
Art Gallery with Storage above the FCLs
Sculpture Walk with Art Platforms above the FCLs

BEFORE: Private Ownership, Vacant Lot.

Figure 20 - VIEW 2: New Start to the Cattermole Creek Trail along the Old Town Dike

Figure 18
Schematic Plan

Figure 21 - VIEW 3

DRIFTWOOD PASS

Library with Reading Rooms and Wine Bar
Seasonal-Use Kiosks built into Library
Dance Studio with Indoor/Outdoor Stage
Gabion Weir Walkway

BEFORE: Private and Municiple Ownership, Vacant Lot.

Figure 22 - Entry to Driftwood Pass at the Corner of Main St and 3rd Ave. Forebay of Shallow Water Wetland.

Figure 18
Schematic Plan

Figure 23 - Mixed Niche Block Plan

MIXED NICHE BLOCK

Mixed-Use Buildings and Satelittle Offices
Habitat Hotel Eco-Hotel
Patios built into Forebay Walls
Boardwalk along the old town dike

Figure 18
Schematic Plan

Figure 24 - VIEW 5

MIXED NICHE BLOCK

Mixed-Use Buildings and Satelittle Offices
Habitat Hotel Eco-Hotel
Patios built into Forebay Walls
Boardwalk along the old town dike


BEFORE: Private Ownership, Single Family Homes


Figure 25 - VIEW 6: Forebay of Shallow Water Wetland System and New Mixed-Use from Old Town Dike Trail.

DETAILS
Three Walls

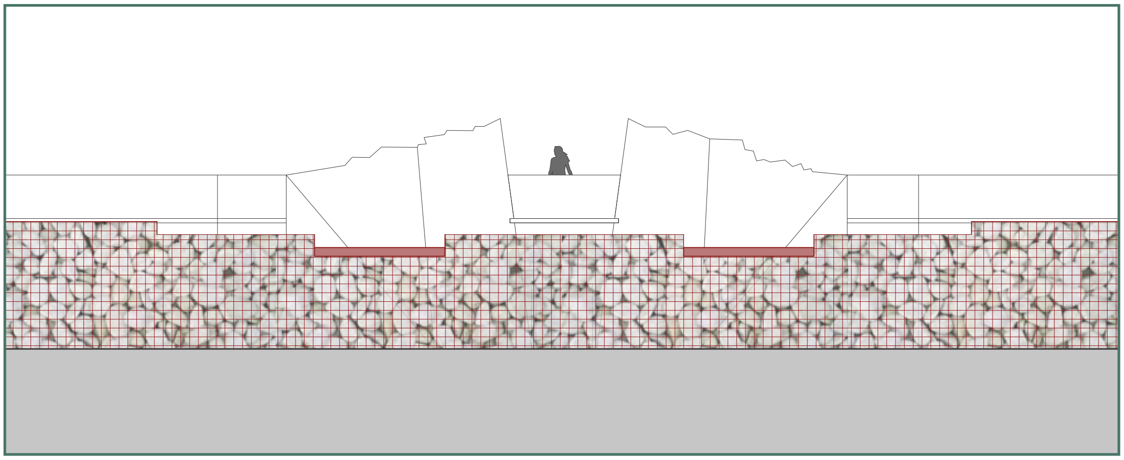
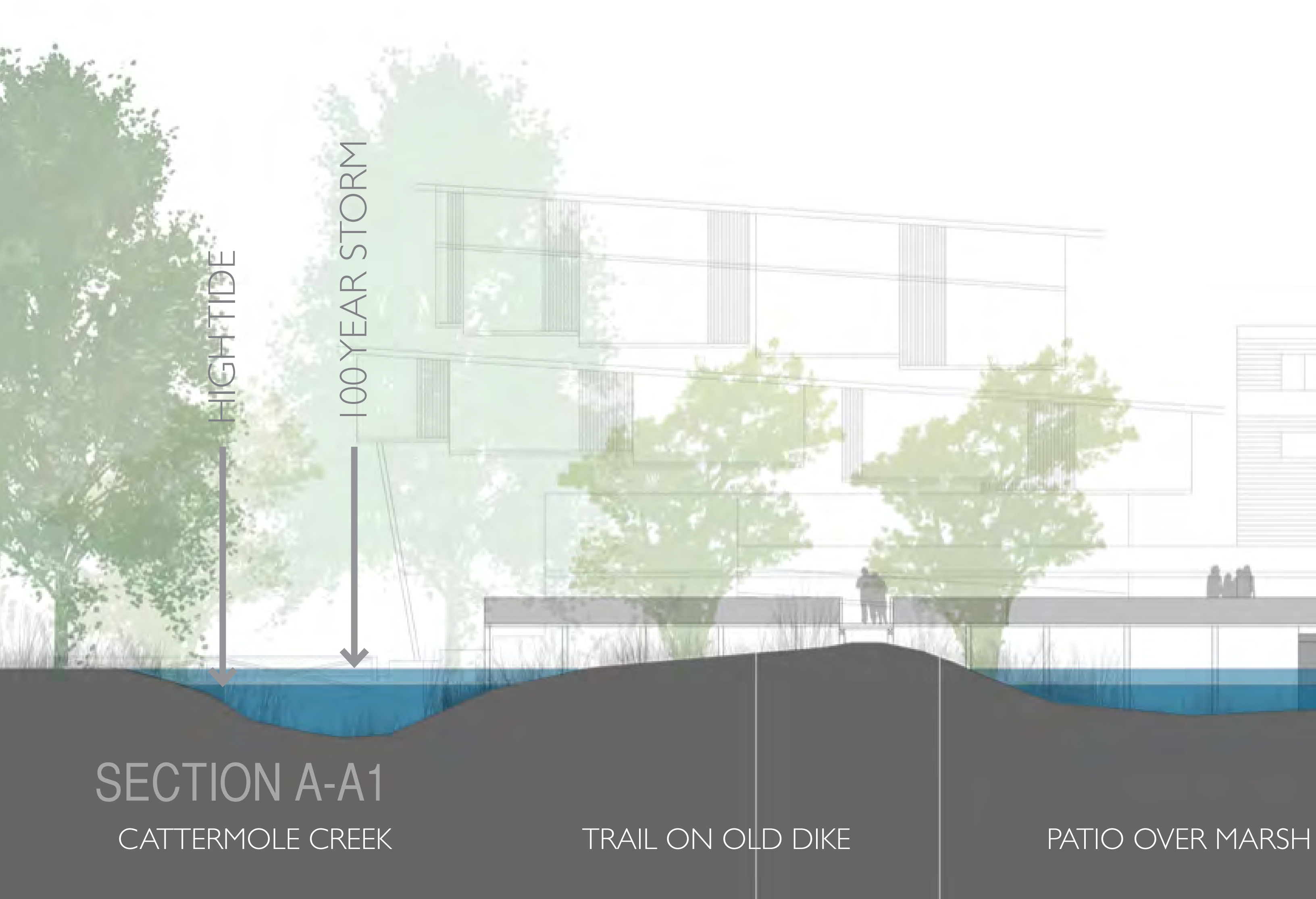


Figure 26
Gabion Weir Wall



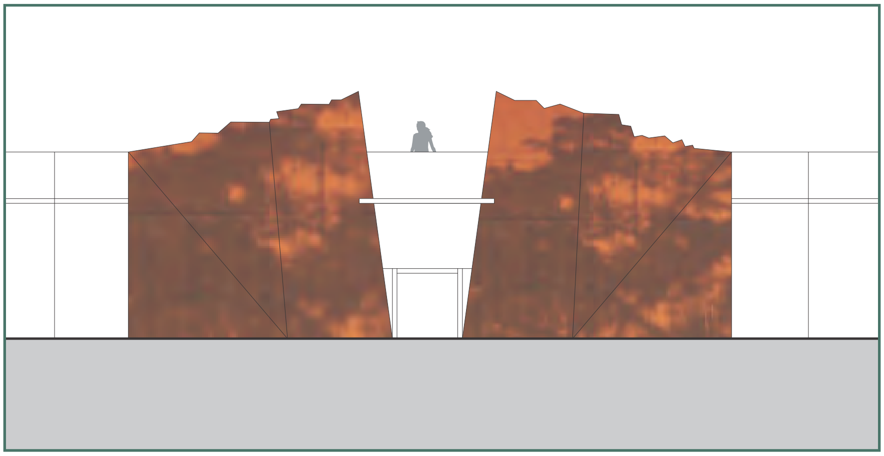


Figure 27
Sculpture Forebay Wall and Floodbox

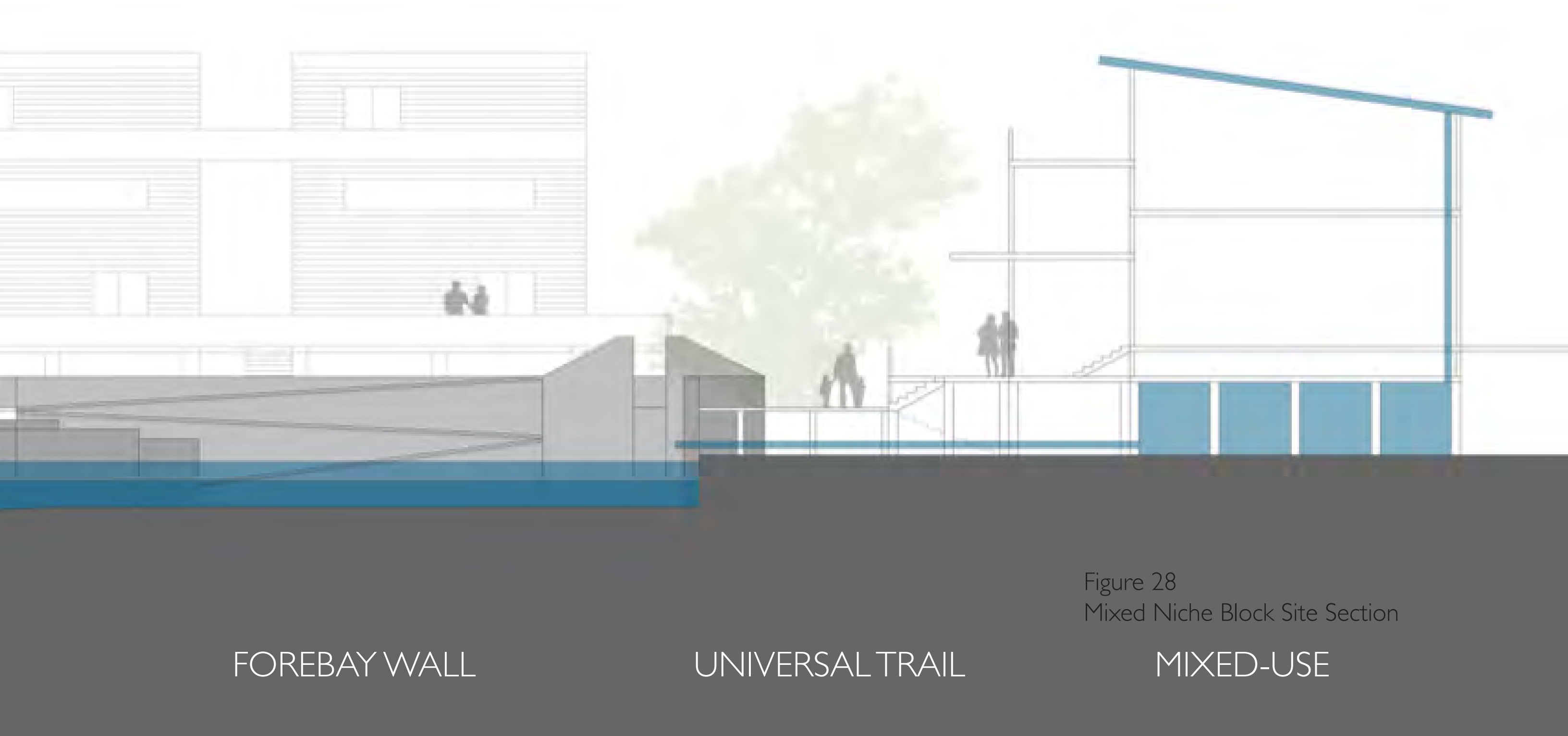


Figure 28
Mixed Niche Block Site Section

DETAILS
Three Walls

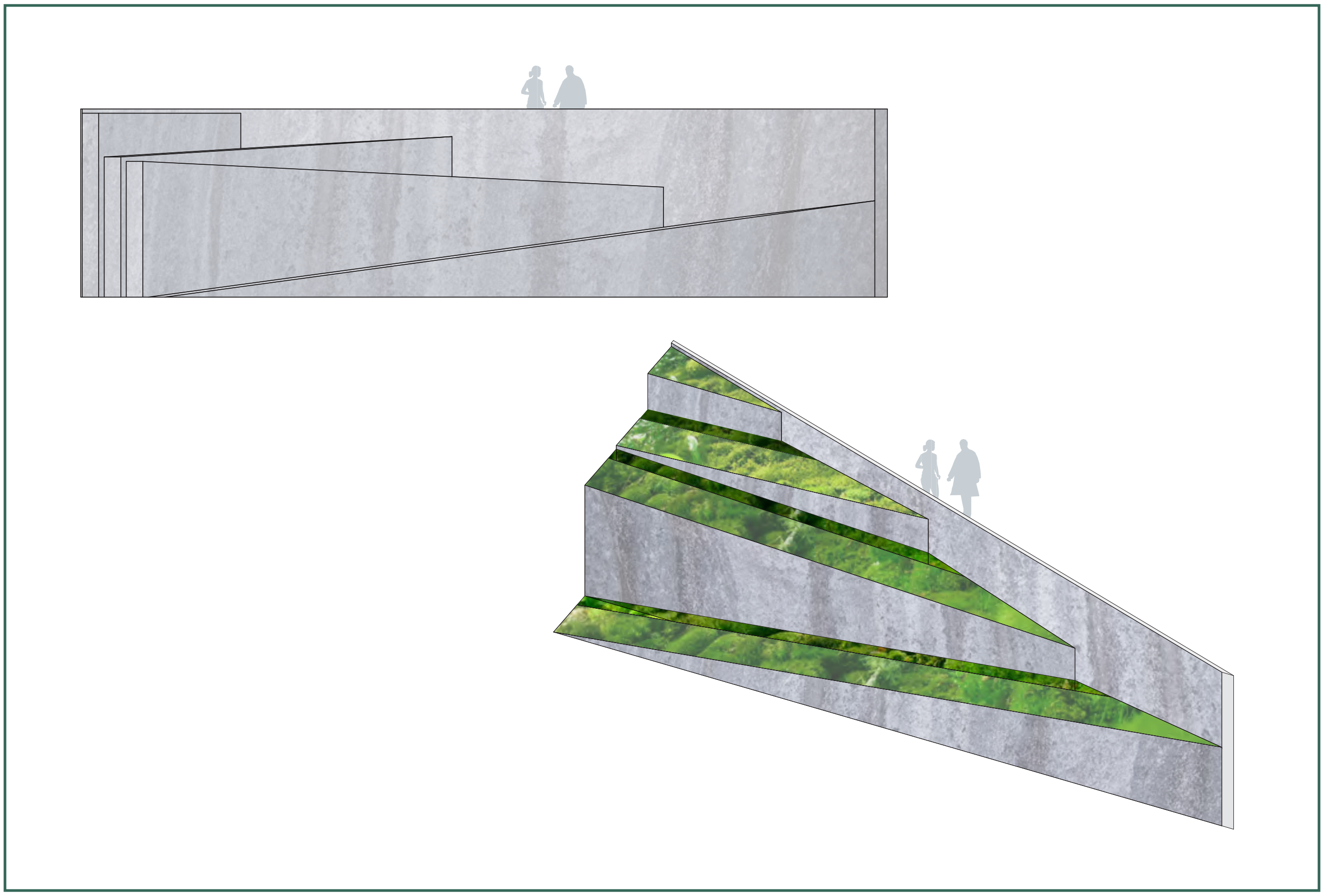


Figure 29
Granite Forebay Wall with Plants

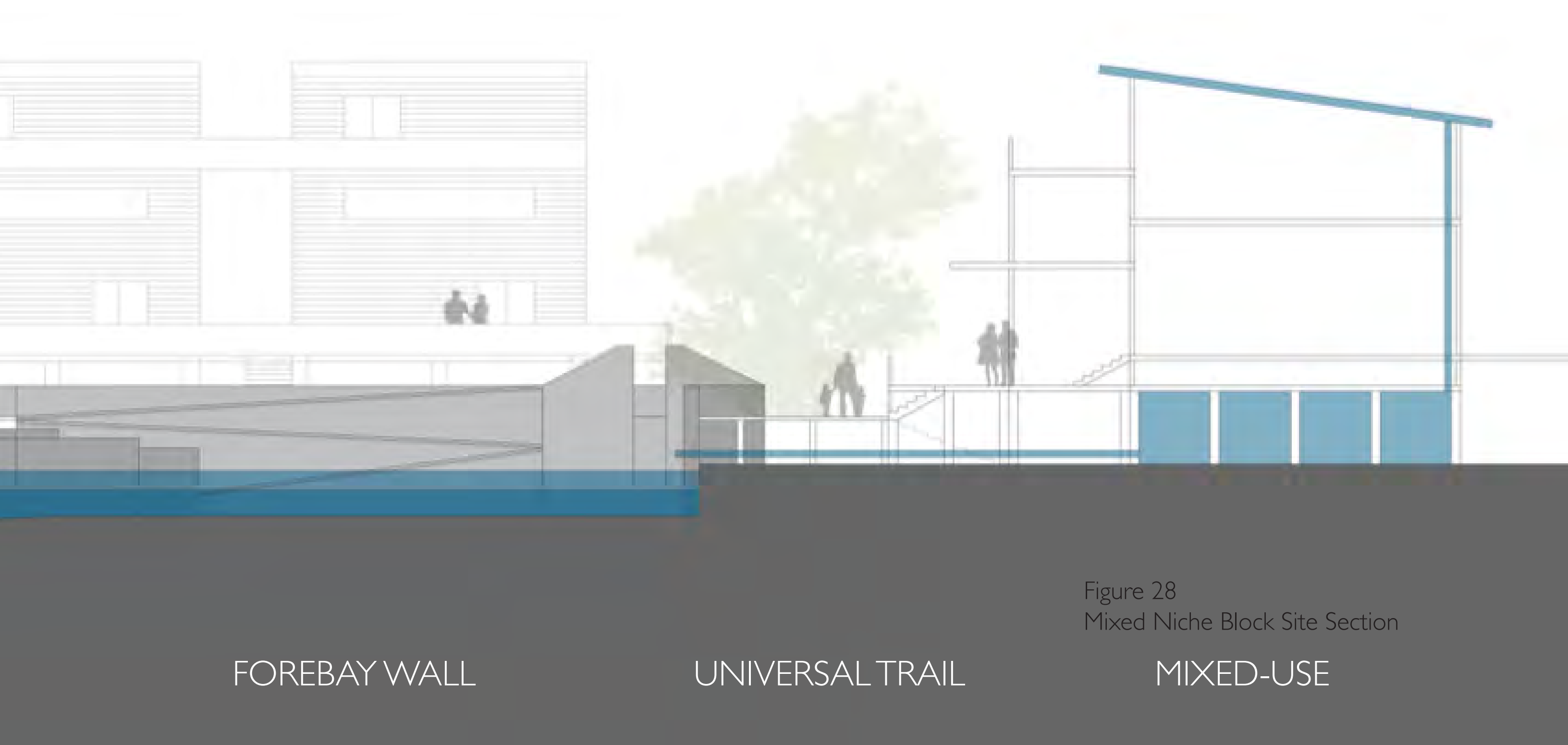


Figure 28
Mixed Niche Block Site Section

FOREBAY WALL UNIVERSAL TRAIL MIXED-USE

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the end!