Mind the Meander: A Water-First Approach to Architectural Design Method

by

Erin MacKenzie

Submitted in partial fulfilment of the requirements
for the degree of Master of Architecture

at

Dalhousie University
Halifax, Nova Scotia
June 2023

Dalhousie University is located in Mi'kmaq'i,
the ancestral and unceded territory of the Mi'kmaq.
We are all Treaty people.

Contents

Abstract

Learning from water's properties and its natural, life-sustaining processes, this thesis aims to return agency to water, shifting the narrative from water as a resource to water as a partner in design of public parks. To test this approach, I propose the restoration of the Town of Truro Reservoir within Victoria Park, restoring the rivers banks and allowing water to flow, while maintaining infrastructure capabilities. Three scientific monitoring stations and an elevated walking trail for visitors extend the park experience, prioritizing healing of the watershed over geopolitical boundaries. The architecture provides a perspective on our place among other species within the larger ecosystem, emphasizing reciprocity and the mutual respect of water. The design parameters work with three key water course characteristics: physical formation, vegetation, and aquatic biota. The design aspires to improve water quality while fostering stewardship and respect within visitors to the park.

Acknowledgements

Thank you to my family and friends for your patience and support over the past year. I thank my supervisor Sarah Bonnemaison for nudging me along with creativity and kindness, and my advisor Corey Dawson for exposing me to the world of fluvial geomorphology.

Chapter 1: Introduction

> Water exists, then, in a closed system called the hydrosphere, and contemplating the hydrosphere and the hydrologic cycle is almost enough to make a sceptic believe in the omni-existent Gaia. The system is so intricate, so so complex, so interdependent, so all-pervading, and so astonishingly stable that it seems purpose-built for regulating life. (de Villiers 1999)

Human behaviour was once intimately tied to water's behaviour. We ebbed and flowed with water's natural processes, seeking it out in times of drought, and turning our backs to it in search of higher ground in times of flooding. The human process was water's process. Through the gradual disassociation from nature, we strayed far from water's processes, imposing our own fracturing set of processes onto a system that was once experienced as a whole. New ways of representing, designing, and building placed the human experience as separate from that of the landscape and its natural phenomena, and reduced water's complex processes to a scientific observation.

In a world of hyper-engineering and over-simplification, there is a need to reflect on the phenomenology of our natural systems, returning agency to water by immersing ourselves in its complexities and setting aside "scientific explanations of perception in order to investigate the pre-scientific experience" (Diprose and Reynolds 2014, 21). Only then, when we trust our own experiences and rely on science to support our perceptions, will we truly be able to design with nature. Phenomenology does not reject scientific claims, but rather it insists that it is the experience that is either "directly or indirectly the foundation for all legitimate scientific claims" (Diprose and Reynolds 2014, 22).

We have grown to rely on scientific claims so much that we have come to reject our own experience, developing a deep disconnection between the body and subject. In other words, we have disassociated ourselves from our landscapes and the complex natural processes that we forget that we rely on; a disassociation that has led to the commodification and degradation of our watercourses. To restore nature, architectural design and methods must be rooted in phenomenology, creating spatial experiences that engage us in the complex systems in which we exist.

This thesis explores the restoration of an existing stream in Truro, Nova Scotia, and the subsequent re-design of a water treatment system and its associated infrastructure. Research is done through an equally balanced experiential and scientific approach, resulting in architecture that is doubly engaging, and revealing of natural complexities; complexities that, when experienced through the space, become accepted as vital to nature and our place among it.

1.1 Thesis Question

How can a phenomenological approach to architectureal design enable reciprocity between the built and natural environments, returning agency to water in architectural processes?

1.2 Approaching this Thesis

Somewhere along this process I fully and whole heartedly embraced water as my guiding light. I allowed water to inform the research and design processes and granted myself permission to ebb and flow in my explorations, picking up and dropping off pieces along the way. Some pieces proved as breeding grounds for further research and experimentation, while others were mere nuggets of information, adding to the larger picture. I began to see water around me every day, everywhere I went, consumed by its omni-presence. Even in urban environments I became accustomed to identifying its natural propensity to meander and grew increasingly irritated with contemporary attempts to straighten and smooth its naturally complex course. A complexity, I came to learn, that is so imperative to life on earth that made me wonder where we went wrong. When did we lose appreciation for this nearly divine system? A thesis that began has a straightforward design project, one that would improve upon park architecture, evolved into a quest, a rooting out of the cause of this great loss of appreciation for life's most precious provider. By distilling down a design method that is deeply rooted in respect for water, by understanding it at its various temporal and spatial scales, the hope is that the method can be applied when designing for other natural elements and phenomena, creating a world in which we design *with* nature in all of its forms.

Chapter 2: Why Water?

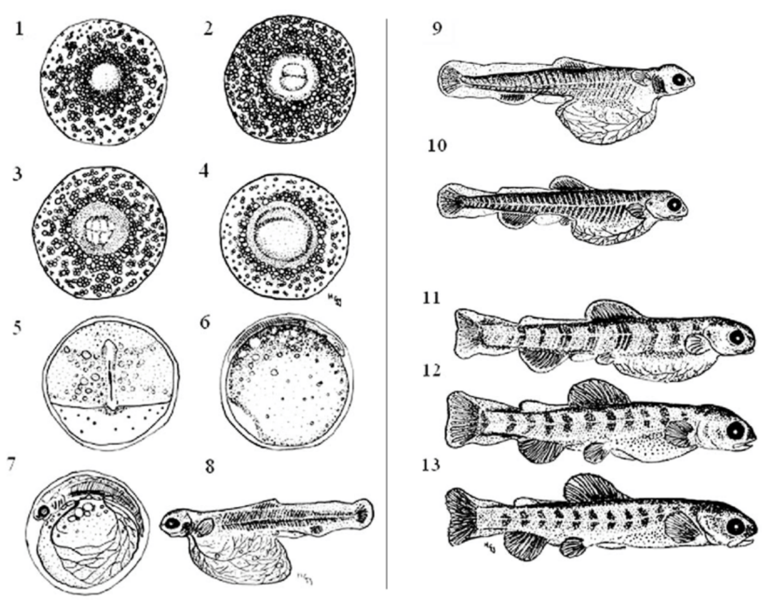
2.1 Understanding Water as Life

To understand how we can protect and maintain natural phenomenon, we must first begin by defining the natural and cultural systems in which they operate, providing us with the starting point of the project.

Most simply defined, the watershed is “an area or ridge of land that separates waters flowing to different rivers, basins, or seas” (Oxford Dictionary). Within large watersheds, smaller ones exist, and even smaller ones exist within those. More broadly speaking, the watershed as a natural phenomenon is a complex system through which rainwater is filtered and recycled again, providing all life-forms with the means to live. Rainwater runs through the landscape, getting filtered along the way through the various layers of rock and soil, nourishing the earth’s terranean layers and gradually trickling downward, replenishing the subterranean water stores that provide over half the global population with drinking water. The remaining half source their drinking water through surficial means, i.e., lakes, streams, and rivers; all points along the watershed cycle (Smith et al. 2016). In other words, watershed health and the maintenance of this finite source of life is vital to human survival.

2.1.1 Understanding the Nutrient Cycle

Humans are, of course, one species among many that rely on, and are shaped by, water’s nutrient cycle. Hills and mountain ridges separate the movement of water, often defining the speed at which water moves. Waters at the highest elevations receive rainwater first, some of which is immediately used by plants, some is absorbed into groundwater stores, and some will quickly run down the nearest watercourse before reaching gentler slopes. These headwaters are characteristically clean as little nutrients (tree fall, eroded minerals, and other flora and fauna) have yet to enter the cycle (Montgomery and Buffington 1997). In turn, species that inhabit these waters are small and rely on treefall from dense forest covers (McCabe 2010). Headwater streams are often sheltered from light and larger species, creating prime spawning conditions (McCabe 2010). As water moves down the river, nutrients are carried with it, broken down by the various sedimentary formations and the digestive tracks of larger species. Food chains, like maturing roe, become more complex and, by the time water makes its way to the end of its terrestrial highway, it is strife with nutrients, ranging from large predatorial species to small suspended particles (Creed et al. 2015; McCabe 2010).



Progressing complexity in brook trout development; illustration by György Hoitsy (FAO 2012, 16)

2.1.2 Understanding the Meander

The characteristic sinusoidal curve of a stream or river is no coincidence. This formation is the result of a perfectly balanced self-sustaining mechanism intended to manage sediment load, and reflects the riverbed's response to changes in concentration and dissipation of energy, and the associated transfer and storage of sediment (Fuller, Reid and Brierly 2013). When experiencing higher loads of water at higher velocities than is typical for a given area, the riverbed adjusts to accommodate the increase in load. The surge in energy (water velocity) erodes the riverbed until its form is able to accommodate the increase in water volume (Fuller, Reid and Brierly 2013).

As water moves along its course, it pushes and pulls sediment below, taking and depositing, forming, and reforming the riverbed. As it speeds up around a corner, it carves out the bank, slowing down as it pushes sediment into the next curve. Larger pieces of sediment fan out, creating riffles, while finer sediments are carried further downstream, collecting to create sandbars. Together, these elements create the mesmerizing meander we associate with natural streams and rivers. Changes in the meander reflect changes upstream, and are often evidence of a disruption to the equilibrium (Fuller, Reid and Brierly 2013).

As water carves out riverbeds, pushing and pulling sediment, the resulting formations, in conjunction with geological formations below, work to slow water, allowing it time to seep into the ground or stay in one place long enough to feed surrounding habitats.

We can think of watercourses as highways, delivering nutrients to every corner of the earth, either directly, by means of streams, rivers, and groundwater stores, or indirectly through the food chain. Water needs time to break down and distribute nutrients, allowing for particulate nutrients to sink to the bottom or collect along riverbeds, feeding surrounding habitats. Without the meander, rainwaters would barrel through the landscape, short circuiting the food chain while they head directly for lower lands.

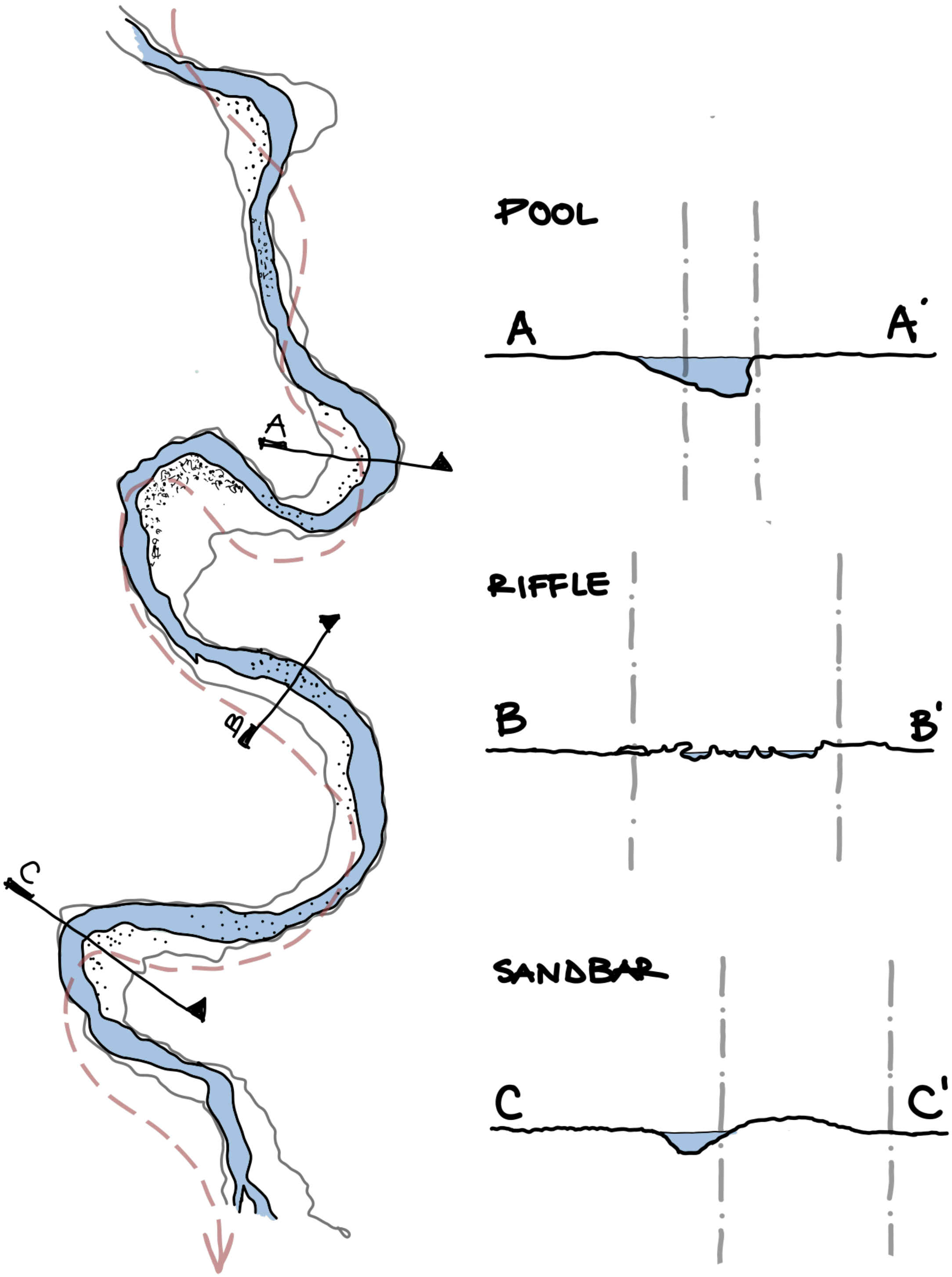
2.1.2.1 Experiencing the Meander

Individual geomorphological features found within the meander provide a diverse range of conditions for various species to inhabit. What we understand as pools, riffles, and sandbars, each provide a unique relation to the water, increasing access to, and reliance on, water and its processes.

Settlement followed shifting sandbars along the riverbed

Deep pools etched out by fast flowing water are particularly important for larger species to hide out in, while mounds of finer particles along the banks provide water access for non-aquatic and amphibious organisms. Larger sediment particles that fan out across the riverbed oxygenate water as it flows over, providing air for water-born insects and aquatic life (McCabe 2010).

Humans were, at one point, not unique in their relationship to the river's processes. Like other non-aquatic organisms, glistening riffles served as natural bridges, while sandbars served as respite spots, and pools as sources of food. Humans would ebb and flow with eroding sediment, following sandbars as they shift from season to season. Movement was dependant on water's natural rhythm, and humans listened for, and followed, signals from within the watershed system. Water's influence was ubiquitous with human existence.



Creation of pools, riffles, and sandbars

To read the water is to read where one is within the landscape, experiencing complexity with our senses and translating it so that we can identify ourselves within the landscape.

2.2 From Life Source to Resource

Humans are a unique species in that our relationship to water has shifted over the years from one of respect and reciprocity to one of fear and control. This shift was enabled through the disassociation of water as the source of life, and a new perception of water as a resource, one that can be controlled, contained, and distrubuted at a human rate (De Villiers1999).

2.2.1 Disassociation of Water

A disassociation from water began when humans became static. Humans planted literal roots, anchoring them geographically and forever changing their relationship to water. For most species, the perception of landscape is rooted in water; its presence or lack thereof guiding the mind. Their sense of self preservation is entwined with the preservation of water; two concepts that are one of the same, dependent, reciprocal. With static human settlement, came a shift in human perception. The omnipresence of water shifted to an ever-presence. Water was no longer gathered for immediate use but stored for future use, removing the ebb of the ebb and flow.

While human settlement allowed society to proliferate and cultures to blossom, it also enabled a loss of knowledge once engrained in our species. Humans no longer listened to water, moving alongside its shifting riverbed. We began moving water to us because in order to sustain static humans, water needed to become static as well.

As static settlement evolved and technology advanced, the disassociation of water grew. With the rise in popularity of wells, it was no longer necessary that humans settle near major rivers to access predictable and plentiful waters. For the first time humans were able to literally tap into other sources, drilling deep into the once precious and untouched aquifers that lie below (De Villiers 1999). Part of the hydrologic cycle that typically moves slowly, refilling and replenishing grounds above at a trickle pace was now being drained at unnaturally quick rates in an effort to keep up with growing populations above. This enabled the human population to spread further inland while driving our disassociation further… out of site, out of mind (Fang and Jawitz 2019).

The desire for predictable water sources followed as humans spread and settled even further from source waters and for some, far from precious groundwater stores. The damming of major rivers enabled predictability of freshwater in these unlikely locations. Water became a resource to be diverted and the landscape became the drawing board.

Over time natural water courses became smoother and simpler, made possible by embankments, culverts, and dredging; rerouting and straightening the meander in order to divert as much water away from human inhabitation as possible. While these diversion efforts enabled the funnelling of massive amounts of water to far away cities and reservoirs, the subsequent straightening of the meander removed nature's ability to slow and mantain water levels for itself and decreased natural flood mitigation measures (De Wolff, López-Calvo, and Faletti 2021).

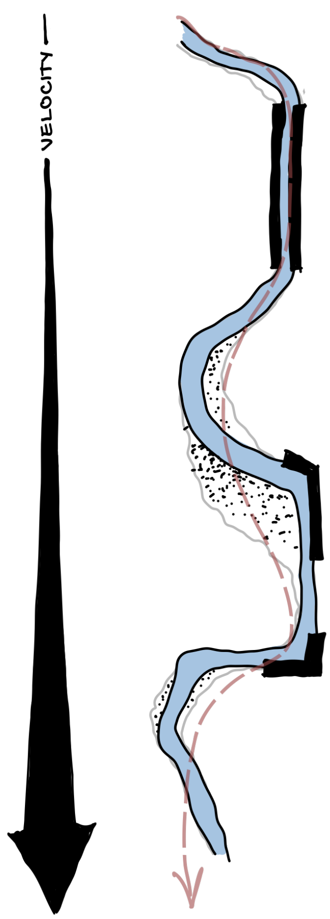


Diagram demonstrating effects of channelization

2.3 Map as Enabler

The verb to map is not so easily separated from its physical representation, the map. This is likely why then, when searched, Imago Mundi and the Babylonian city of Nippur etched onto clay are identified as some of the earliest maps. These maps are indisputable feats of modern geographical surveying, recording nearly accurate physical representations of the landscape: coastlines, mountain ranges, and waterbodies. When examined more closely, however, clues to the origins of these maps can be found in the non-natural features: administrative centres, orientation, and the mysterious lines not to be found in reality, borders (Wood 1993; Hann 1998). These maps have shaped our definition of mapping and shaped our collective map of the world.

A less common but arguably more intuitive definition describes the act of mapping as “to be assigned in a relation or connection” (Merriam Webster). By this definition, humans have been mapping for as long as humans have existed. The way in which humans have mapped has changed over the years, but to map is an innate skill. One that, at its core, means to place oneself within the landscape. A shift in the way in which humans mapped occurred simultaneous with the onset of static settlement. Prior to this, humans moved with the landscape and mapping reflected this dynamic nature, expressing relationships between humans and the landscape as a way to navigate the changing landscape. These expressions involved depictions of other species, landscape features, and the human translations of such, in the form of sensory and emotional experiences.

Contemporary mapping of static life changed the way in which the human species related to the landscape by asserting an unnatural rigidity on a dynamic and constantly shifting landscape. The way in which humans traversed and interpreted the landscape became differentiated from the way in which other species moved. Humans moved in straight lines, others moved erratically, unpredictably. Further to this, the way humans communicated our relationship to the landscape changed. Diction evolved to describe the landscape in relation to other humans, replacing land-based terminology with human-made markers. 'Downstream' became 'down the road'. 'Across the stream' became 'across the bridge'. Landscape became property (Hann 1998).

Dennis Wood, in his book The Power of Maps, argues that society has equated map data with reality because were it not reality, then it would be opinion… "somebody's idea of where your property began and ended, a good guess at where the border was, a notion of the location of the hundred-year food line, but not the flood line itself" (Wood 1992, 19). Wood goes on to argue that "as long as the map is accepted as a window on the world, these lines must be accepted as representing things in it with the ontological status of streams and hills. But no sooner are maps acknowledged as social constructions than their contingent, their conditional, their… arbitrary character is unveiled" (Wood 1992, 19). With this unveiling of arbitrary character, comes an unnerving realization that lines on a map can be debated and discussed, and suddenly "the interest in them of owner, state, insurance company is made apparent. Once it is acknowledged that the map creates these boundaries, it can no longer be accepted as representing these realities" (Wood 1992, 19).

Beyond the subliminal and subtle messages that maps inevitably convey, what are we seeking? Like other species, humans are constantly attempting to place ourselves within our landscape; garner a sense of time or space relative to our current spatial existence. Humans are the only species that rely on physical maps, yet every other species possesses the innate ability to map (Langston et al. 2010; Griffin 1985). Some, like the bumblebee, are even able to convey this information to other bumblebees (through dance) (Wood 1992). How is it that other species are able to gain this knowledge? How would humans place themselves without maps? Like other species we would engage with our environment, listen to the landscape, and trust our body's senses, weighing one experience against the other to place ourselves along a string of sensory experiences.

2.3.1 Mapping Water

Conventional mapping has simplified the human relationship to the landscape, codifying natural features so that they can be easily understood by, for many people, sight alone. The result is the simplification of otherwise complex and dynamics processes and the separation of parts, categorizing one part from another and dividing up a complete system. Water's complex forms and processes have been reduced to a single line on a page, one line in a series labeled streams. In fact, the two-dimensional recording of water has, in many cases, completely omitted the non-human experience of water. Bathymetric maps are an entirely separate class of maps altogether, leaving water to be represented as an opaque, deceivingly healthy blue, devoid of life below the surface.

The simplification of water has made it easy to both justify and disassociate us from its manipulation. Water was now simply a line on a map that could be redrawn. If humans needed to bring water to them, they would simply drawn a line between humans and water source, and construction would follow. Any potential up or downstream affects were replaced by concerns of geopolitical relationships; downstream became the town over (De Wolff, López-Calvo, and Faletti 2021).

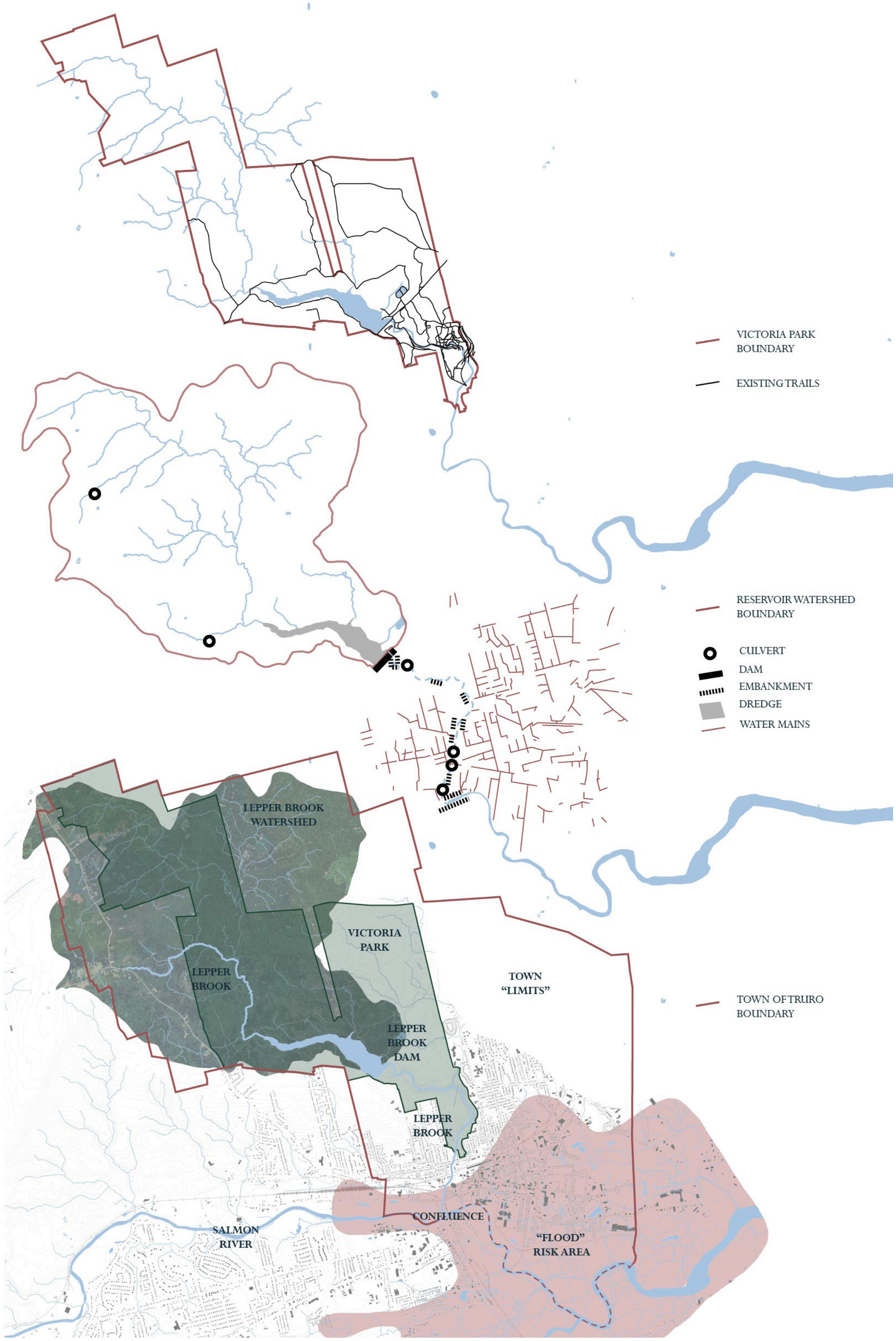
Chapter 3: Mapping the Park

This project aims to restore an existing stream to its natural state. Lepper Brook, a stream that runs through Victoria Park in Truro, Nova Scotia, serves as a representation of human influence on, and the disassociation from, water.

Lepper Brook begins in the pristine headwaters of “Upper” Truro, flowing through Victoria Park, a Victorian Era Park created by the donation of land by wealthy owners. The brook was dammed in the early 1800s to provide a growing population with a static drinking water supply (Town of Truro). Prior to the damming of the brook, the stream meanderedbeyond Victoria Park boundaries through what is now the Town of Truro before its confluence with Salmon River. Today, the brook continues to flow, though at a rate dictated by the Town of Truro’s engineering department, and is directed through a series of culverts and channels before reaching its confluence.

Lepper Brook, although dammed, remains part of a larger, natural system comprised of headwaters, streams, and flood plain land where the brook meets its host river. Neither the Victoria Park visitor’s map nor a map depicting the Town of Truro’s drinking water supply system encompasses the brook’s complexities and interrelations.

Considering what an existing map tells us about the watercourse and weighing it against background research is critical to gaining a complete context for any design effort. Experiencing the stream fills in the gaps that a site map may have. In the case of Lepper Brook, as is true with the way we represent most water courses, the universally blue line depicts a uniform set of conditions, when in reality, the



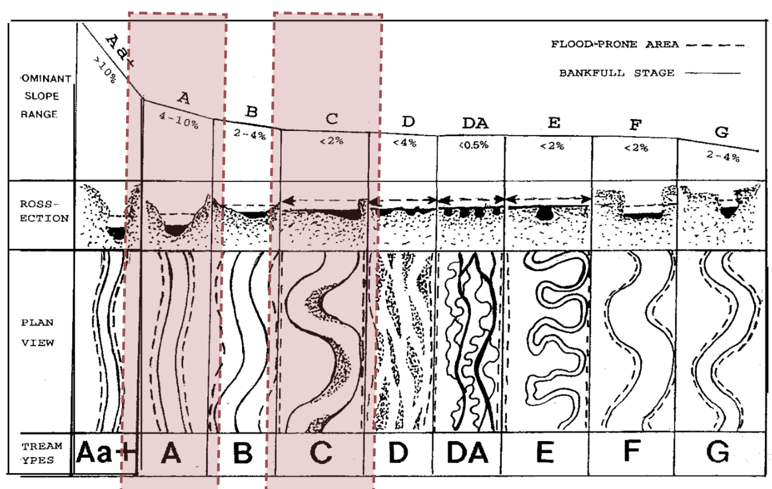
Existing site map showing various boundary conditions (data from Town of Truro 2019; Town of Truro 2019a; Town of Truro 2019b; Town of Truro 2019c; Town of Truro 2019d; TTPD 2022; TTPD 2022a; and TTPD 2022b) watercourse experiences a variety of relationships with its surrounding landscape.

3.1 Lepper Brook, Existing

Lepper Brook is 14 km long and flows through a near-complete spectrum of stream conditions; from natural, through semi-natural park conditions, to downtown where urban water management efforts are evident, directing the stream through a series of culverts, bridges, and embankments.

3.1.1 Stream Classification

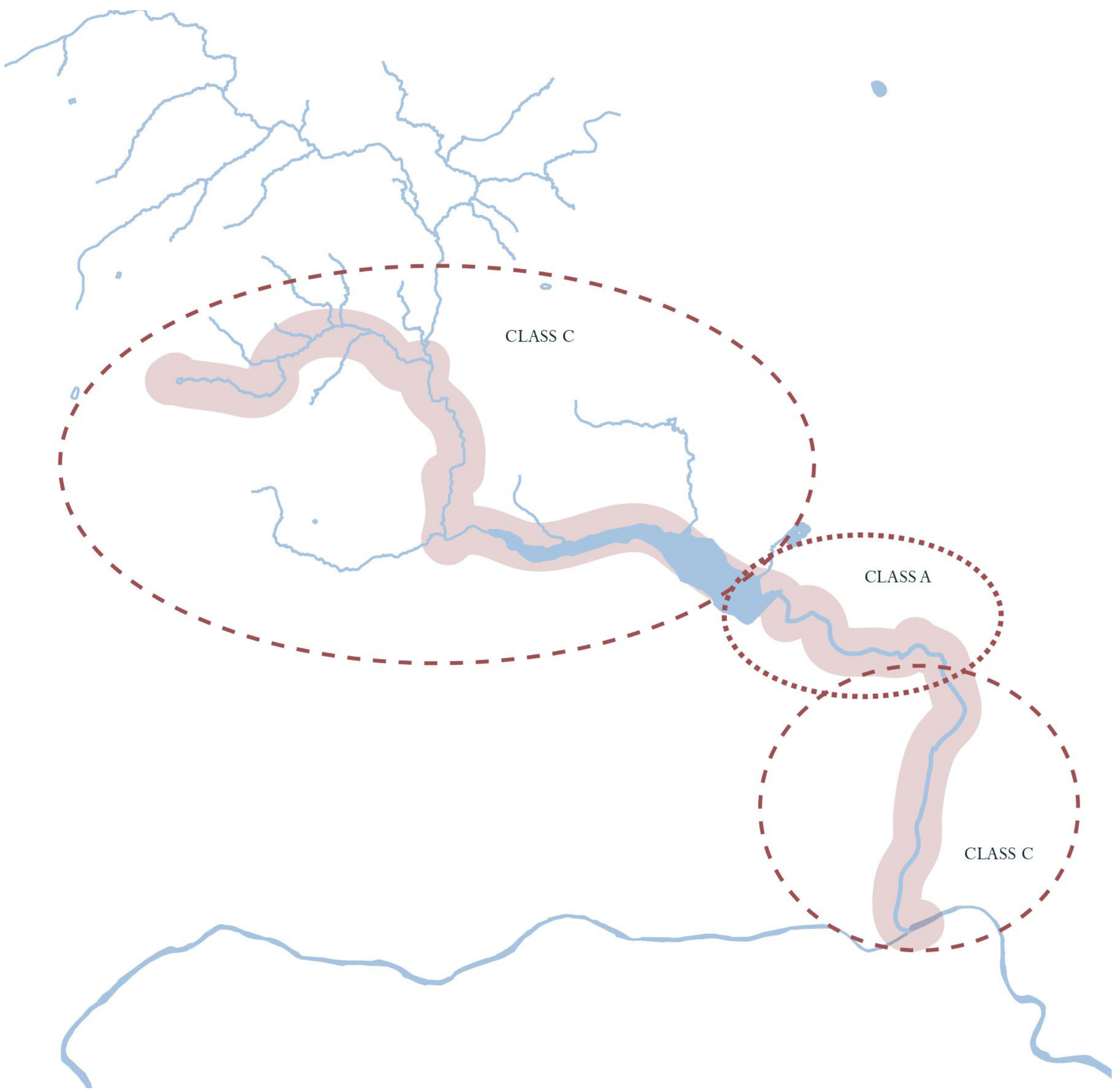
Lepper Brook flows through a variety of landscape conditions, ranging from gentle to high gradient. Streams within low-slope landscapes tend to consist mainly of riffle/pool formations, where higher slope landscapes consist of high debris transport streams and waterfalls (Rosgen 1994). Based on the Rosgen method of stream classification, Lepper Brook's dominant conditions classify the stream as Class C, characterized by "Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains" (Rosgen 1994, 176).



Longitudinal, cross-sectional and plan views of major stream types, as per the Rosgen classification method (Rosgen 1994, 174)

Streams are classified by their dominant slope range, as slope determines flow velocity and subsequent erosion of sediment within the steam bed. Faster moving waters are characteristic of straighter stream channels since sediment is eroded more consistently.

Restoring a stream's riverbed formation to its natural classification ensures that any restoration of streambed formations is in line with natural processes, avoiding premature erosion or build up of sediment (Rosgen 1994).



Classification of Lepper Brook, as per the Rosgen method (data from TTPD 2022a)

Chapter 4: Restoring the Map

A Western approach to architectural site selection and analysis typically begins by defining the study "site". Base plans are produced and confine the project to its geo-political boundaries, thus setting the spatial agenda for the design process. Conventional siting exercises typically constrain a project's potential for discovering and interpreting relations beyond geo-political boundaries, resulting in projects that reflect an isolated position. Conventional western methods of mapping most often "record the surface of the earth as direct impressions, [therefore] one can put one's finger on a map and trace out a particular route or itinerary. [...] Because of this directness, maps are taken to be 'true' and 'objective' measures of the world and are accorded a kind of benign neutrality" (Corner 1999, 215). A project's site map, in this instance, therefore gains more agency than its real-world counterpart, as it holds the power of exclusion and prioritizes the contents of the map. We interpret boundaries on a map as the end of the information, therefore we limit a site's relations to those laid out before us. By broadening the definition of site we understand more of a site's relations, extending beyond human relations (i.e., "neighbours"), to natural and environmental relations as well, extending the concept of "neighbours" to beyond physical adjacencies.

For this project "site", the map must extend to include the natural system in its entirety, thus including all adjacencies and considering all that are dependent on the brook. When a map excludes elements or gives the perception of isolation, then designing from that map risks isolation as well (Abrams and Hall 2006). In order to consider additional relationships, one must experience them first; go beyond the technical mapping exercise and into the physical space to experience the mapped area beyond its paper representation.

4.1 Lepper Brook, Reimagined

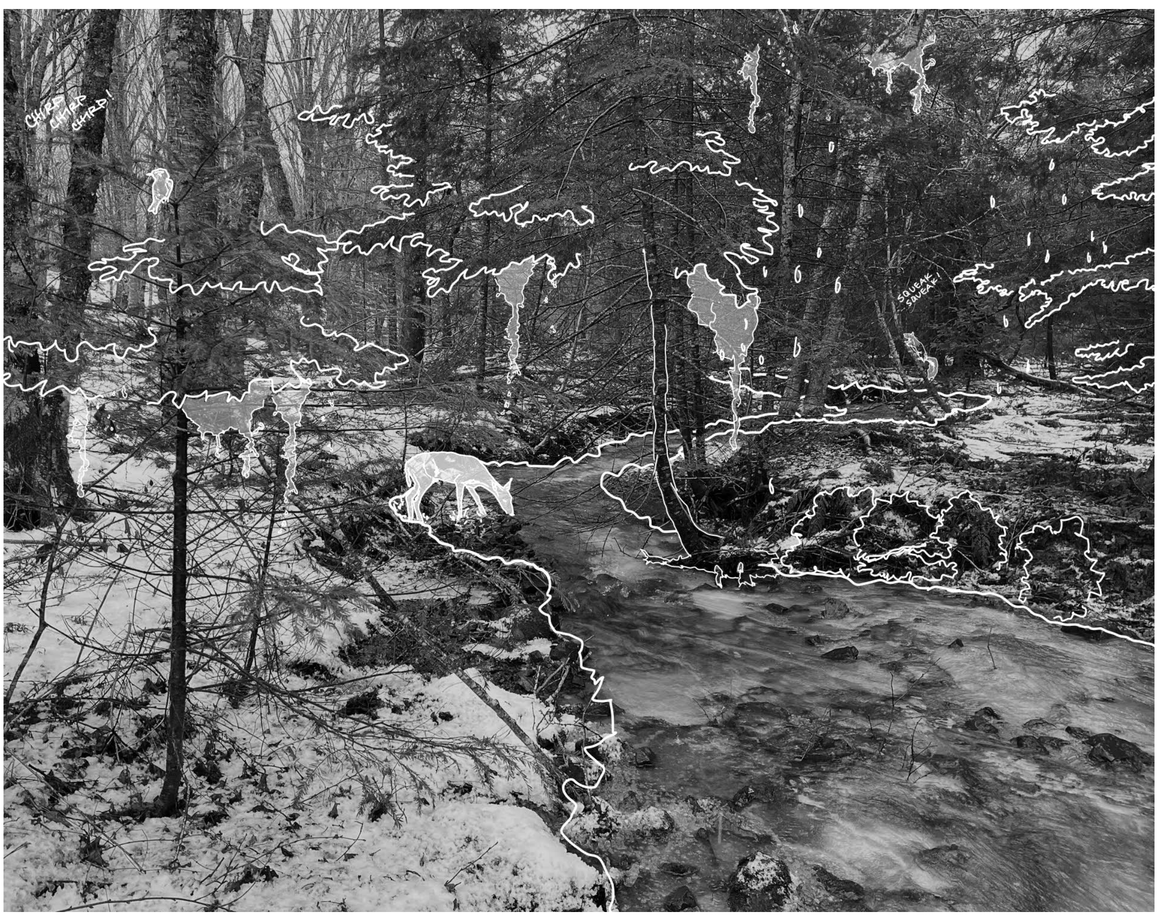
> The map exists in the space created between mind, memory and the daily occupation of and movement through territory. (Ryan 2017, 66)

Our perception has been formed by the way we represent our landscapes, but when we take a moment to immerse ourselves in, and engage with, the landscape, we begin to identify overlapping phenomena that are hidden from the representations we face every day. These experiences, developed through our senses and that only happen when we are physically present, reveal complexities, relationships between objects and forces that are not possibly represented in two dimensions. When we reveal, and experience, complexities, perceiving ourselves as only part of a complex and highly sophisticated natural process, then we can design for these complexities in ways far deeper than a conventional site plan would ever allow (Merleau-Ponty and Landes 2012; Ibrahimi and Nepravishta 2021).

4.1.1 An Experiential Account

The map makes it look so simple, I thought; the thin blue line that traces Lepper Brook from the Salmon River to its origins above Victoria Park. I had poured over these maps, studying the features of the stream, but I knew this wasn't the whole picture. I've visited Victoria Park more times than I can count, walking, biking, and skiing the trails. I went to the treatment plant as a child, a place that felt very alien in the landscape. I knew there was more going on than the map could tell, so I went. I committed to exploring the run of Lepper Brook from headwaters to confluence.

It was a rainy day last fall. Starting in the upper reaches of the stream, I entered the woods. The dampness was consuming. Every branch was sopping, the ground completely saturated. This was not a rainy day in the woods, this was a day in a truly wet landscape. The stream was omnipresent, it was hard to distinguish the stream from the forest floor amongst the wet. The forest was gnarly; the dense underbrush was strewn with downed trees that were slippery underfoot. I did not make it through this tangled landscape unscathed, shredding my rain pants before emerging from the brush bumped and bruised. Squeezing through a tight stand of trees, I found myself looking out over a dreary body of water: the reservoir. Bumping into



Headwaters of Lepper Brook, reimagined in its undisturbed natural state the reservoir did not surprise me, it is out of place in this landscape and so the landscape rejects it.

I paused to collect myself, taking stock of my shredded clothing and bruised legs, then of the experience I had just had. The gnarly, woven waters ended. Abruptly. Like I had done, they simply bumped into the reservoir. I had a new appreciation for the water that comes out of the tap, the same water that exists within the stream I had just traversed. Cold and hungry, I left the reservoir imagining what it might look like if it reflected the waters that feed it.

Dammed reservoir, reimagined in its undisturbed natural state

I returned to the reservoir with a new appreciation, but also with new intention. I began to think about what the park would look like in a more natural state. I followed Lepper Brook from the dam, walking through tall stands of spruce, pine, and hemlock. The established trails in the park would bump into the stream here and there, with containment devices straightening and channeling the stream to avoid damaging the trails. In this semi-natural environment, these concrete and metal obstructions felt invasive. “Why can’t the stream just flow?” I thought. The steep banks and retaining walls made it near impossible for me to access the stream, and certainly didn’t invite animals who rely on it. I walked past culverts and over bridges, imagining what it would look like in a more natural state. Would animals have more presence if the landscape was more conducive to their needs?

Lepper Brook through Victoria Park, reimagined in its undisturbed natural state

My journey continued, out of the park and into the urban environment of downtown Truro. There is no path that follows the stream in this area. Fences, steep embankments, and roadways block access to the water’s edge. The stream had no space here, no room to meander or express its complexity. Within the constraints of the built environment, I tried to imagine what it would look like if we gave Lepper Brook just a little more space.

I arrived at the confluence with the Salmon River early in the afternoon, the late fall sun warm on my face. I've always known this area to flood, an observant read of the landscape would tell you as much. I took a moment watching the waters of Lepper Brook and Salmon River swirl together on their way to the Bay of Fundy, thinking how best to capture the entirety of the system and my experience in it. I want others to feel these sensations, to appreciate the water for its human uses but also for the way it supports entire ecosystems. I realized that to experience water is to appreciate water, and architecture can help me share that.

Lepper Brook's confluence with Salmon River, reimagined in its undisturbed natural state

4.2 Lepper Brook, Restored

Restoring Lepper Brook to its reimagined natural conditions requires a restoration process that acknowledges its natural transition from densely covered headwaters down through sun-rich floodplains and its associated natural processes, while also accounting for its existing natural to urban transition. Restoring natural phenomenon must take into consideration the various spatial and temporal scales, ecosystems, and geological conditions; all of which operate dependently and create conditions necessary for natural systems to continually operate.

Conventional approaches to restoration focus on one area within a longer watercourse and fail to see the stream in its entirety. Where conventional restoration efforts may have short term benefits for localizaed areas, failing to address the watercourse in its entirety will result in downstream effects.

In the case of Lepper Brook, restoring one culvert or embankment will only partially restore the stream, clustering opportunities for natural ecosystem formation whereas in a natural state it would be spread out along the entire stream length. Clustering of restored conditions can lead to higher failure rates, as compared to a systemic approach which builds in resiliency across various scales (Beechie and Bolton 1999).

4.2.1 A Process-Based Approach

Process-based restoration of streams and rivers is an approach that aims to re-establish natural elements by considering processes critical to the sustainability of river and floodplain ecosystems, including its physical, chemical, and biological processes (Beechie et al. 2010). In contrast to other restoration efforts that include channel stability as an indicator of success, process-based restoration encourages erosion and the re-establishment of the meander, acknowledging river dynamics as integral to river health, and pushes back against approaches that attempt to control processes and dynamics by creating artificial and unnaturally static habitats (Beechie and Bolton 1999). Process-based restoration prioritizes riverine health at the system scale, addressing the physical (geomorphological), vegetative, and aquatic processes that operate co-dependently. Each of these processes operate at various time and spatial scales and changes to one can affect the others and vice versa. Restoring streams at the systemic scale addresses the stream's propensity to meander and change, whereas conventional approaches assume conditions remain constant. Process-based restoration assumes that riverbed conditions will change, and builds in a tolerance for such changes in ecosystems and vegetation conditions by establishing a *meander belt.* The meander belt ensures that enough protected space is granted for future changes by assessing existing and former topography to determine the natural path of water and ensuring that the stream can flow anywhere within that path. All edge conditions within the meander belt are restored to include vegetation that allows for water to flow through and around it, and naturally occuring sediment is in place of embankments or artificially placed stones, and is intended to erode and settle based on the restored water flow, which will inevitably lead to movement within the stream path. This approach is in contrast to conventional approaches where the stream has a pre-determined path set by either form-based measures or riparian buffers (Beechie et al. 2010).

Process-based restoration attempts to address an inherent distrust of natural processes and a natural tendency to rely on engineered approaches to water *management* by identifying measurable indicators of success and outlining a monitoring process that will enable the collection of data over time and space. Process-based restoration restores and then monitors natural processes and dynamics, watching for changes at the watershed and local scales. Conventional approaches to renaturalization and form-based water management (i.e., engineered embankments) both typically rely on temporally and spatially static data, in contrast to a process-based approach which re-introduces complexity (Beechie et al. 2010).

In their article, *Process-based Principles for Restoring River Ecosystems*, Beechie et al. (2010) identify four principles of process-based restoration:

1. Restoration actions should address the root causes of degradation,
2. actions must be consistent with the physical and biological potential of the site,
3. actions should be at a scale commensurate with environmental problems, and
4. actions should have clearly articulated expected outcomes for ecosystem dynamics (209).

Adressing the root causes of degradation and assessing physical and biological potential will be especially applicable to Lepper Brook as it runs through various conditions, ranging from natural and urban.

4.2.1.1 The Reference Reach

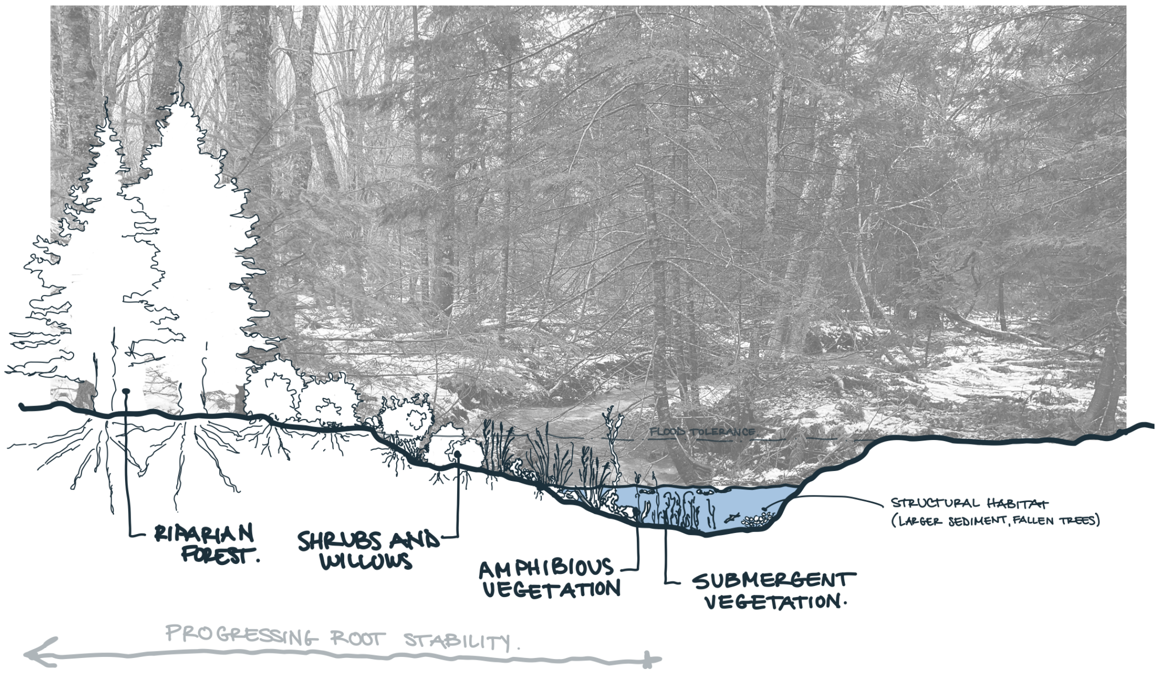
Process-based restoration typically relies on data from a relatively undisturbed portion of the stream, known as a *reference reach*. A reference reach allows for restoration efforts to be rooted in existing natural conditions, and enables a comparison (Beechie et al. 2010).

The portion on Lepper Brook that is located topographically above the Town's reservoir is highly protected from development and provides nearly untouched conditions. This portion of Lepper Brook will be used as a reference for the restoration of downstream portions.

4.2.2 Restoration Results

Using the headwater portion of Lepper Brook as a reference reach, the remainder of the stream will be restored through a process-based approach, focusing on four main areas:

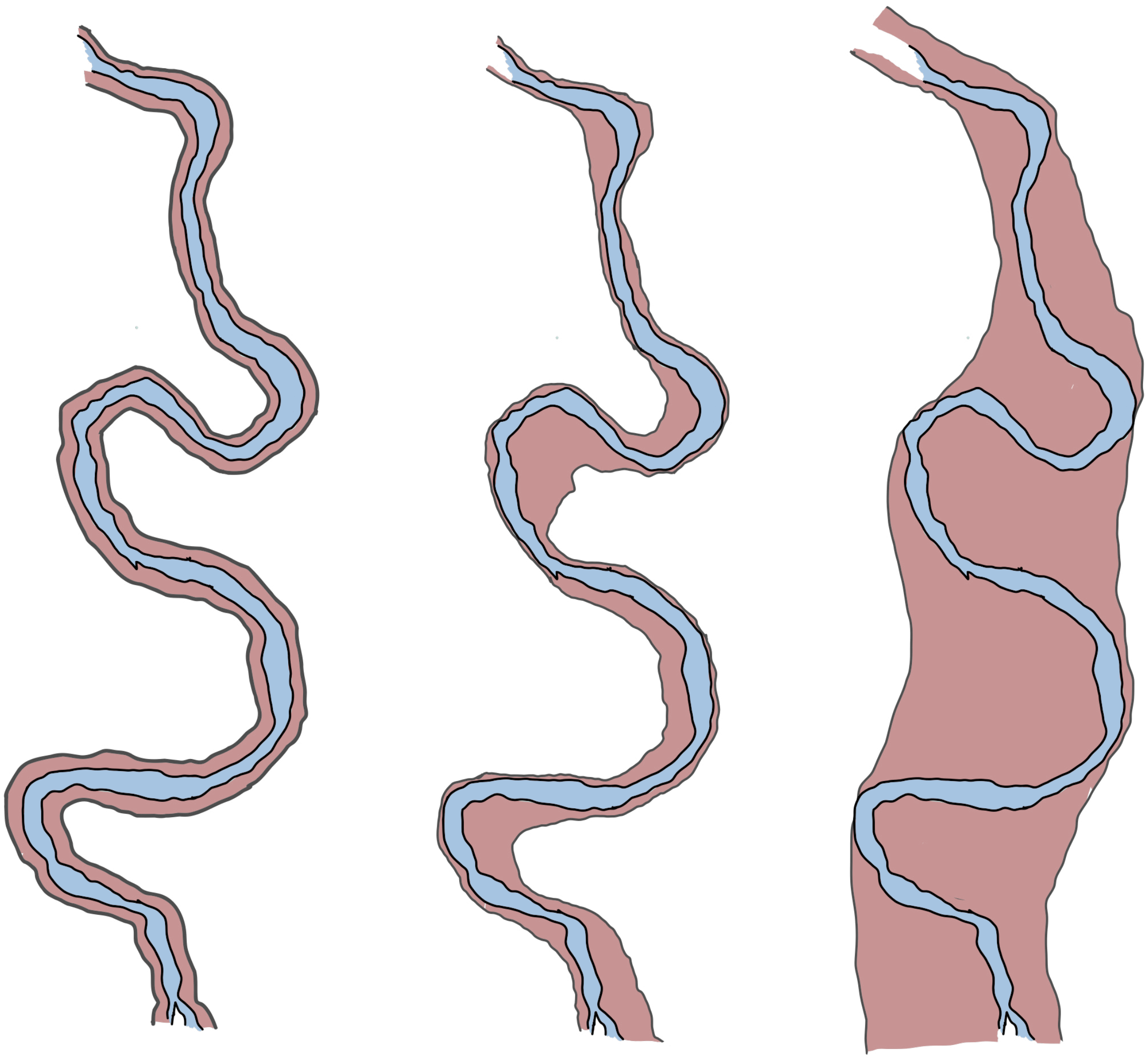
1. Lepper Brook dam and reservoir
2. Stream portion within the existing Victoria Park boundary, typical embankment
3. Stream portion within downtown Truro, typical culvert
4. Stream confluence with Salmon River



Existing section drawing of Lepper Brook at headwaters, typical natural state

In contrast to conventional riparian buffers which aim to prohibit development adjacent to streams, a meander belt will be determined base off of existing topography and implemented as a means of protecting future changes in the stream's processes. The meander belt removes the human-centric nature of the riparian buffer by prioritizing the stream's development rather than maximizing human development.

In addition to establishing a protected meander belt, special consideration will be taken when restoring the three portions of the stream which were most heavily affected by form-based structures. The natural meander path must be re-established in order to determine appropriate edge conditions and enable natural water flow rates (Beechie et al. 2010).



Conventional riparian buffer, meander path changing over time, and the established meander belt

4.2.2.1 Lepper Brook Dam and Reservoir

Lepper Brook was dammed to create an unnaturally static water supply. Despite its human benefits, damming imposes significant changes in natural flow and sediment regimes downstream (Li et al. 2019), and almost always results in unnatural shoreline development (Baxter 1977). The Lepper Brook reservoir was created by damming a stream that would otherwise be confined between two high banks, resulting in a long and narrow lake that is deepest just upstream from the dam (Baxter 1977). Shoreline conditions of the reservoir are underdeveloped compared to natural lakes because “the annual drawdown exposes a larger area to the effects of shore processes” (Baxter 1977, 258), and sediment that has eroded from the banks of the reservoir are deposited within it, rather than downstream, reducing the potential for downstream sandbars and riffles, and the associated habitat creation (Baxter 1977; Li et al. 2019). Water released from the reservoir into the stream system below travels through a concrete-clad human-made shoot, increasing the flow rate of water and eliminating any natural edge conditions.

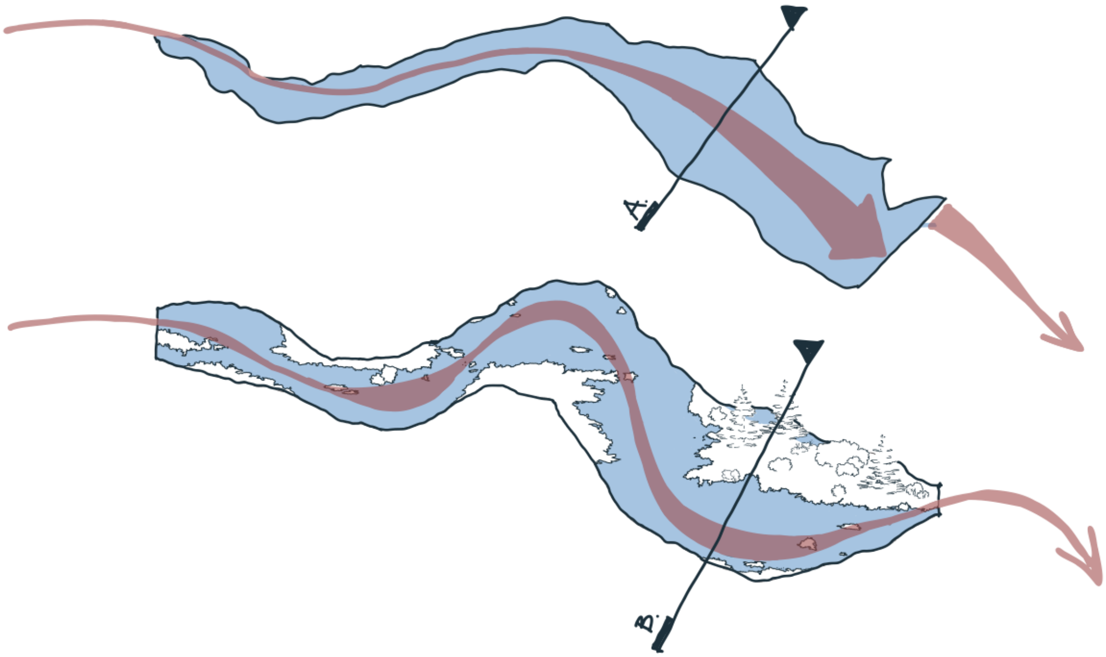
To restore the reservoir, the grade of the basin should be evened out to remove the unnaturally deep portion just upstream from the dam. The natural meander from upstream headwaters should continue through the former reservoir basin, reestablishing the natural sinusoidal pattern to slow water and create more natural pooling and edge conditions.

Natural Filtration

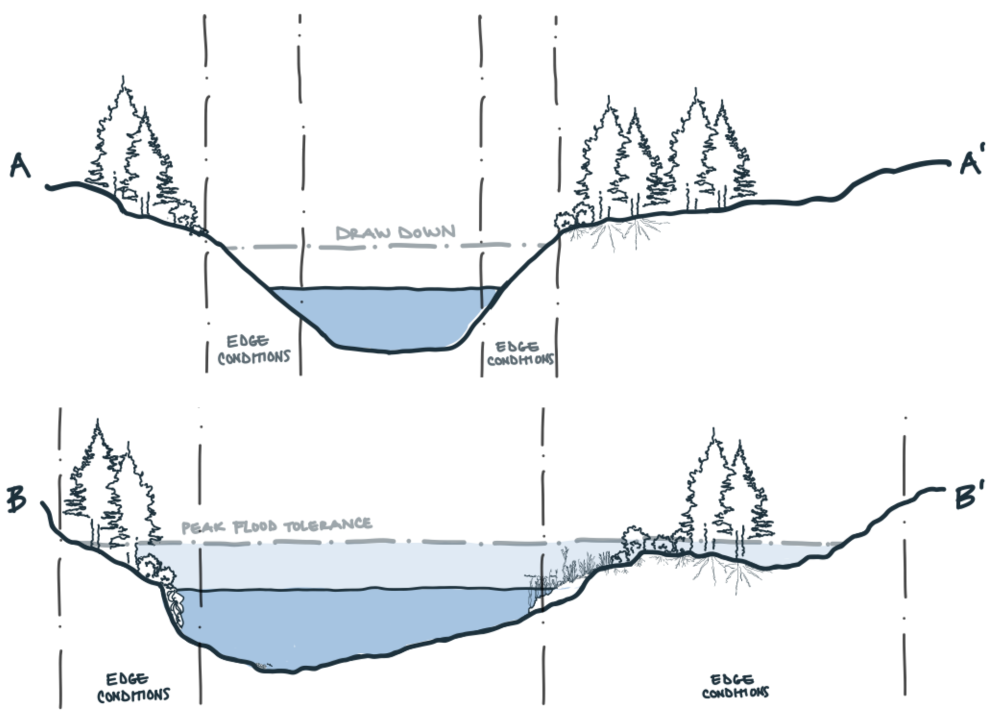
Natural watercourses do not need to be completely altered in order to meet human needs. Water is naturally filtered through layers of sediment and vegetation (Dobson and

Gilpin Beck 1999). By slowing water down naturally, pooled water has a chance to trickle down through layers of progressively larger sediment particles. Vegetation, soils and microbes work to remove any pollutants while larger sediments remove particle matter before water is fed into the drinking supply system below.

Water that does not pool long enough to trickle downward flow downstream, continuing the natural flow rate and removing the stark physical contrast between infrastructure and its natural system. In its existing state, the portions of the Lepper Brook system that are located downstream from the dam are dependent on human-made decisions of water release and retention, causing an otherwise organic and meandering process to become extreme in order to meet human demands of water supply (Schumm 2022).



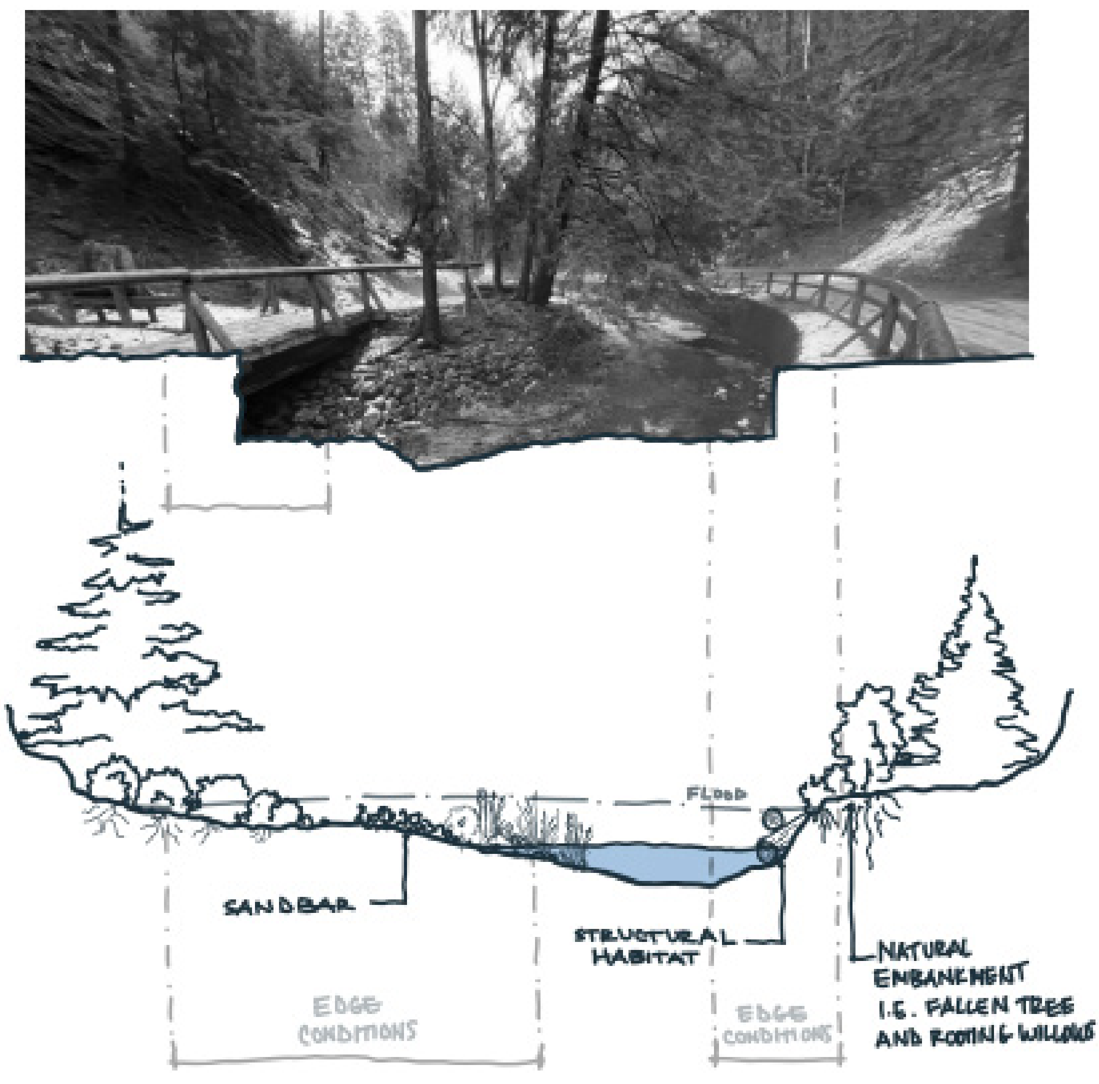
Existing and Proposed plan drawing of restored wetland (former reservoir), showing restored water flow and meander pattern



Existing and Proposed section drawing of restored wetland (former reservoir), showing restored edge conditions and flood tolerance

4.2.2.2 Victoria Park, Typical Embankment

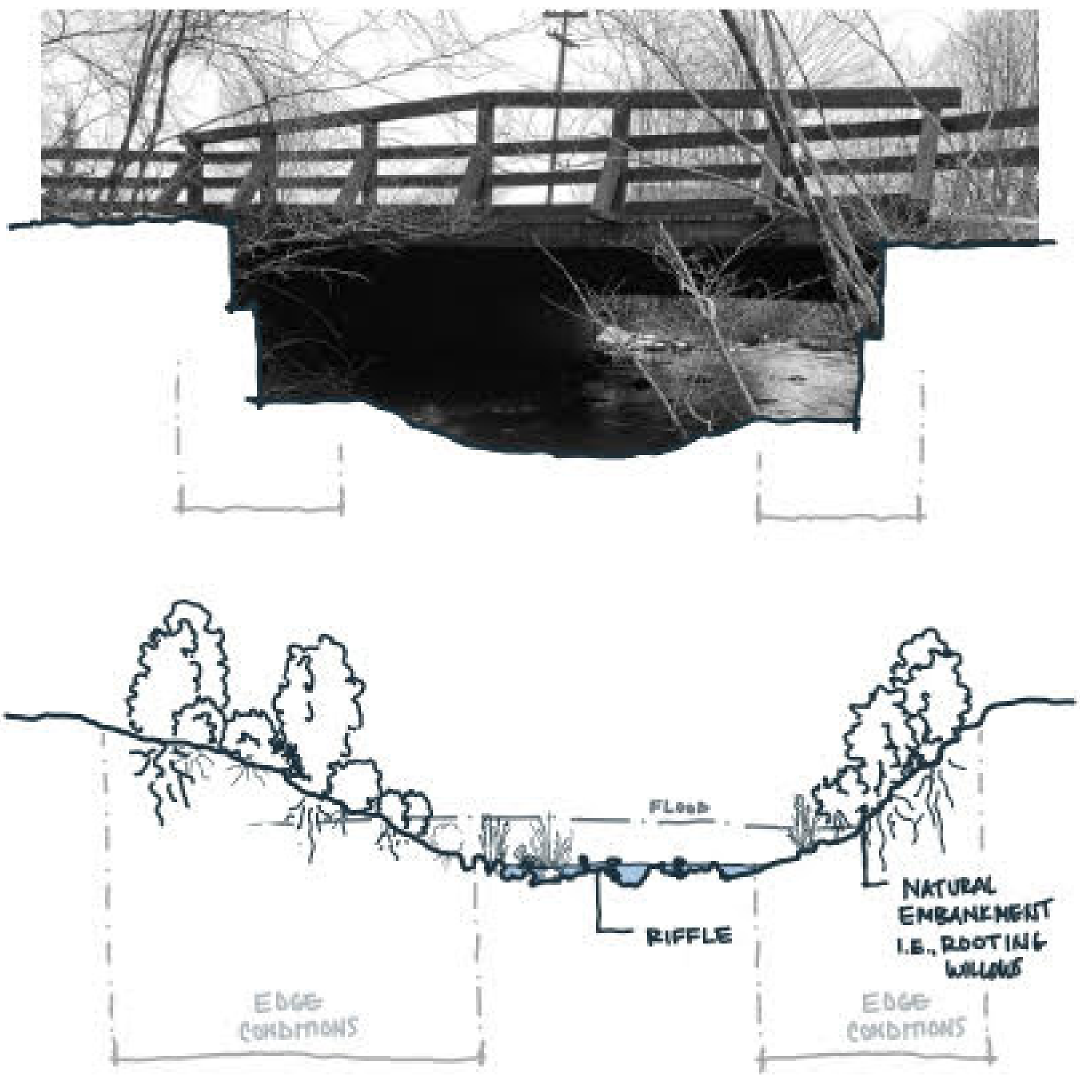
Where the stream bed is steeper and waters are flowing faster, embankments have been built in an attempt to keep water within its prescribed course. These embankments remove important edge habitat conditions and increase the speed of water flow further, resulting in downstream erosion. These embankments should be removed and replaced with natural edge conditions native to these steeper conditions (Mosley 1998).



Before and after section drawing of Lepper Brook in existing Victoria Park, typical former embankment

4.2.2.3 Downtown Truro, Typical Overpass

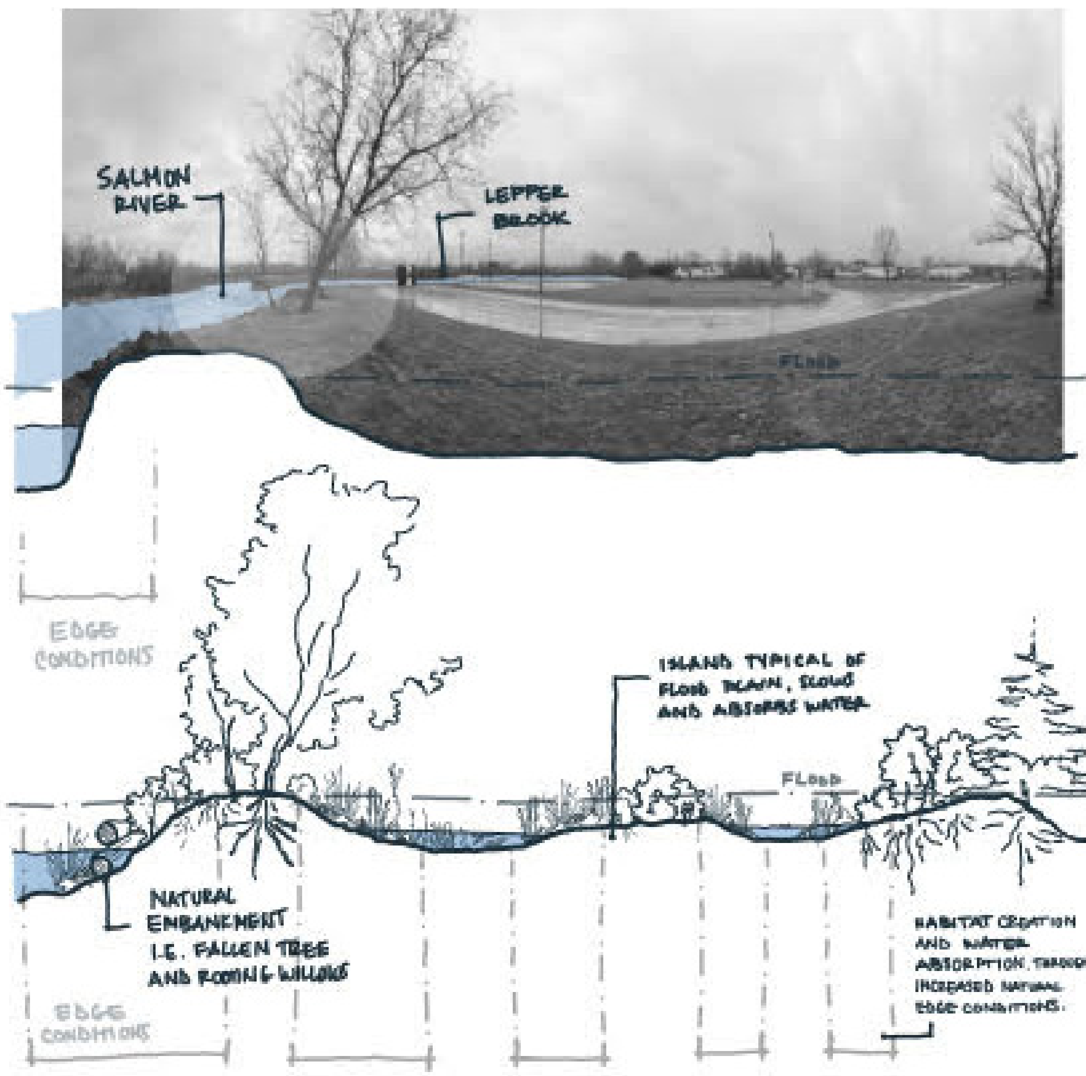
Human-made sream crossing structures such as roads, culverts and bridge buttresses block stream access for aquatic species, interrupting habitats and migration routes (Beechie et al. 2010, 219). The stream's bed and edge conditions should be restored and crossing structures should be raised, giving ample room for stream processes below. Vegetation at the edge help to filter pollutants from runoff from surrounding urban conditions.



Before and after section drawing of Lepper Brook in downtown Truro, typical former culvert

4.2.2.4 Stream Confluence

The confluence of Lepper Brook is currently adjacent to a grassed ball park and Salmon River is currently bermed in order to reduce flood risk. In the case of flooding, however, the berm and grassed lawn actually keep water from reabsorbing into the ground and rejoining Salmon River. The ball park should be restored to natural wetland conditions and berm removed and replaced with natural edge conditions in order to naturally anchor edge sediment and absorb flood waters, better protecting surrounding communities while restoring natural stream processes.



Before and after section of Lepper Brook confluence with Salmon River

Chapter 5: Creating the Map

The successful restoration of Lepper Brook will require the long-term buy-in of multiple stakeholders: the engineers, biologists, geologists, and landscape architects who will be responsible for monitoring the continual restoration processes, as well as the visitors who interact with the brook every day as part of their leisure activities.

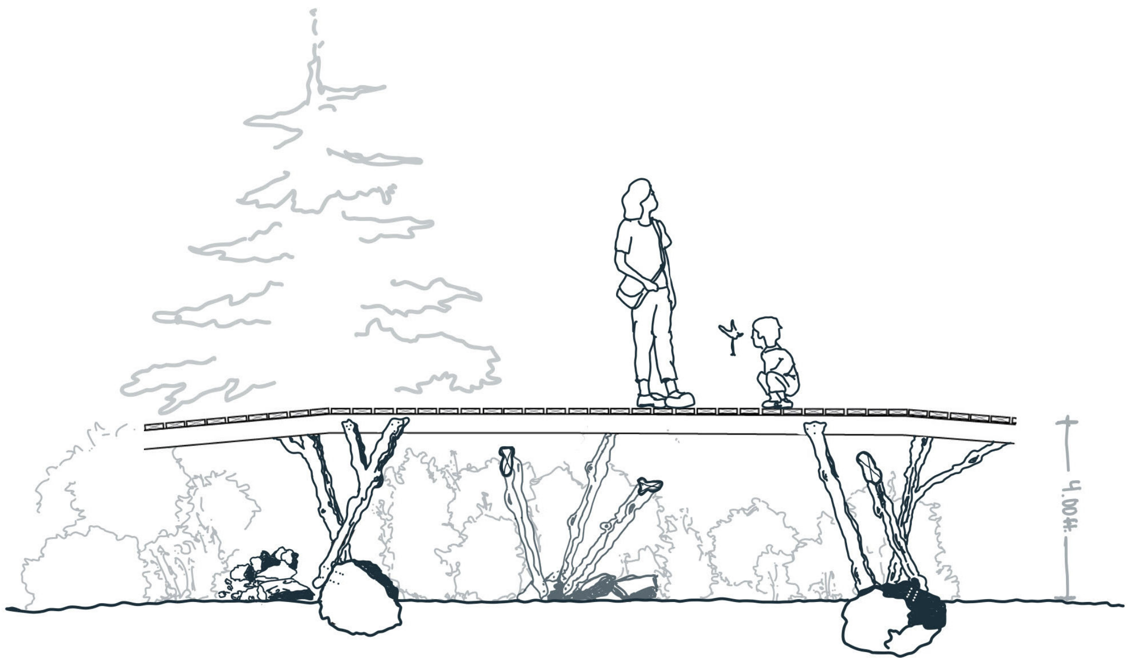
Part of the reason why our natural landscapes are facing degradation is a disconnect between those who experience the landscape as a resource and those who experience the landscape as leisure. Stream restoration and the associated architectural interventions that are rooted in mass consumption aim to satisfy needs that are shallow or impermenent (Machemehl, Sirost and Ducrotoy 2021). Process-based restoration is rooted first in the natural processes that are associated with the dynamic and long-term existence of the stream, and any subsequent architectural elements should reflect this process-based approach, building in spatial and temporal buffers that enable nature's processes to continue in perpetuity.

By ensuring that the park experience provides opportunities for both scientists and visitors to engage with, and develop an appreciation for, the complex processes involved in the restoration of the brook, the inherent value of the brook in its natural state becomes higher.

5.1 Engaging through Leisure

To provide visitors to the park with an understanding of stream processes, a boardwalk is proposed that follows the entire length of Lepper Brook, from the headwaters down to the confluence with Salmon River. The length is intended to reflect the completeness of the restored brook, and take visitors through its various natural transitions.

The form of the boardwalk will ebb and flow with the meandering stream, creating moments along the way that engage visitors with its natural processes. The connection to the landscape will be light and unintrusive, with organically formed supports that appear as natural wooden roots.



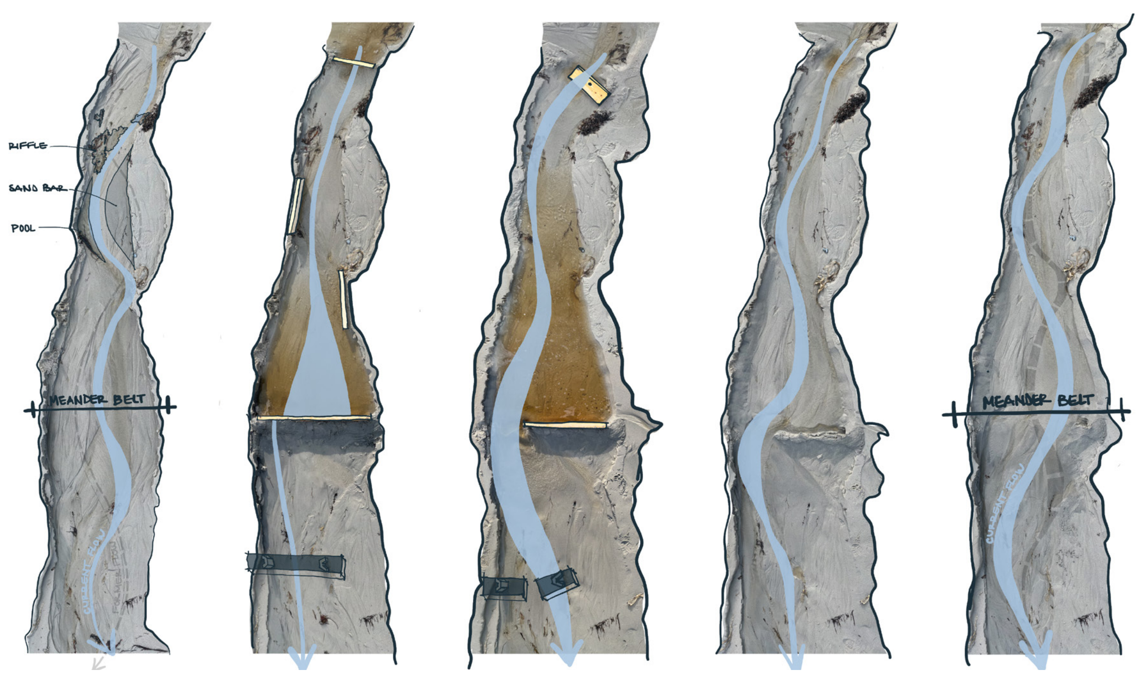
Boardwalk section showing supports and ground connection

5.1.1 Modelling Processes: Flow and Form

Water's natural processes are happening around us every day. In order to design with these processes we must observe and engage, learning from our chance encounters. While at the beach one day, I observed a meander pattern within a small stream and was able to identify typical stream bed formations, watching as sand eroded, being carried downstream and then resettled. To model the damage caused by the engineering of our stream beds, I returned to the beach and watched as the stream flow eventually overpowered the miniature embankments, culvert, and dam. Over time, and with engineered elements gone, the stream reestablished its equilibrium, the meander, and began eroding and redistributing sand once again to create pools, riffles, and sandbars.

With this knowledge of stream bed formations, I modelled the resulting forms, using clay to represent shifting sediment. I began by tracing the existing stream, following contours to identify the ebb and flow of the meander and to determine where sediment would be eroded and redistributed.

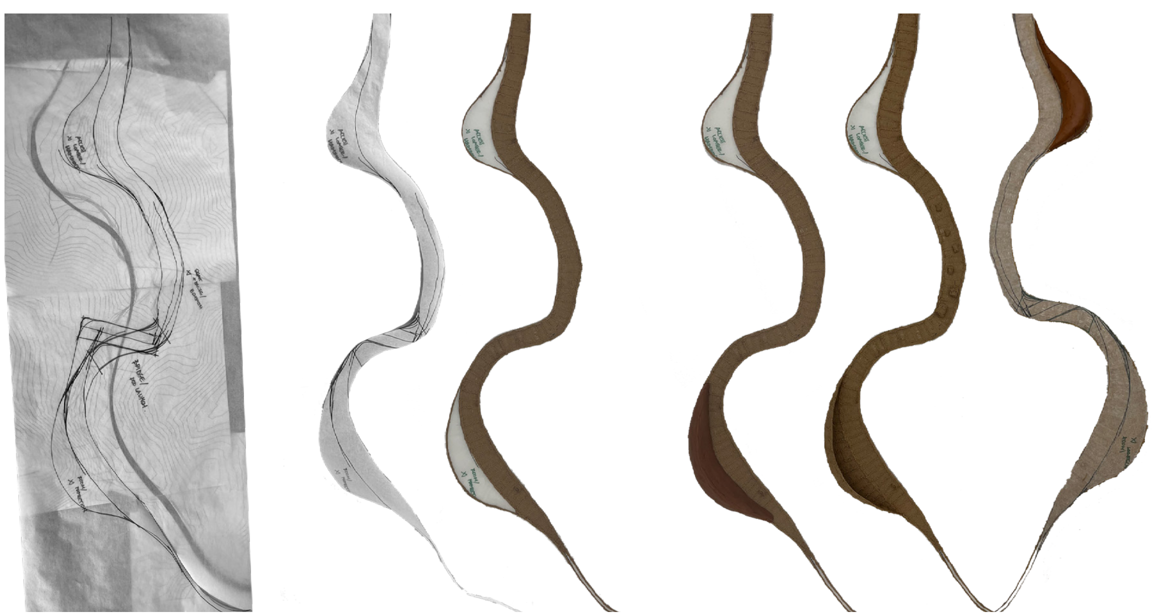
Modelling this process creates a tactile connection between the process being modelled and its resulting form. The physical nature of modelling by hand, as opposed to computer drawings, produces instant feedback as the model interacts with dynamic forces, much like the subject being modelled (Mills 2011). By rooting the modelling process in existing topographic data, resulting forms can be directly



Experiencing the menader through observation and engagement translated to the site, creating experiential spaces that are reflective of existing conditions. By moving clay “sediment” down the two-dimensional stream, shifting and reforming with my hands, I grew more familiar with the concept of sediment redistribution and developed visual cues, making it easier to identify stream bed forms in nature.

5.1.2 Human Translation: Experiential Boardwalk

Resulting forms are directly translated into human programs through a series of moments. Adjacent to portions of the stream where water carves out the bank and creates deep protective pools where fish group and rest, the boardwalk forms a protective wall where humans can group, rest and be protected from the elements. This space serves as a casual outdoor classroom, physically immersing individuals in the natural subject. Where sediment is fanned out and oxygenates the water, the boardwalk bumps and mottles, creating space where people can stop and take a breath on long straights. Finally, where sediment collects, deposited



Discovering form through modelling of sediment flow within the stream bed from upstream currents, the boardwalk curls downward, providing visitors access to the landscape.

5.2 Engaging through Science

In contrast to conventional stream restoration methods which prioritize stabilization and the creation of static habitat conditions, process-based restoration requires monitoring over space and time due to its dynamic nature and its tolerance for a stream's constantly changing conditions (Beechie et al. 2010).

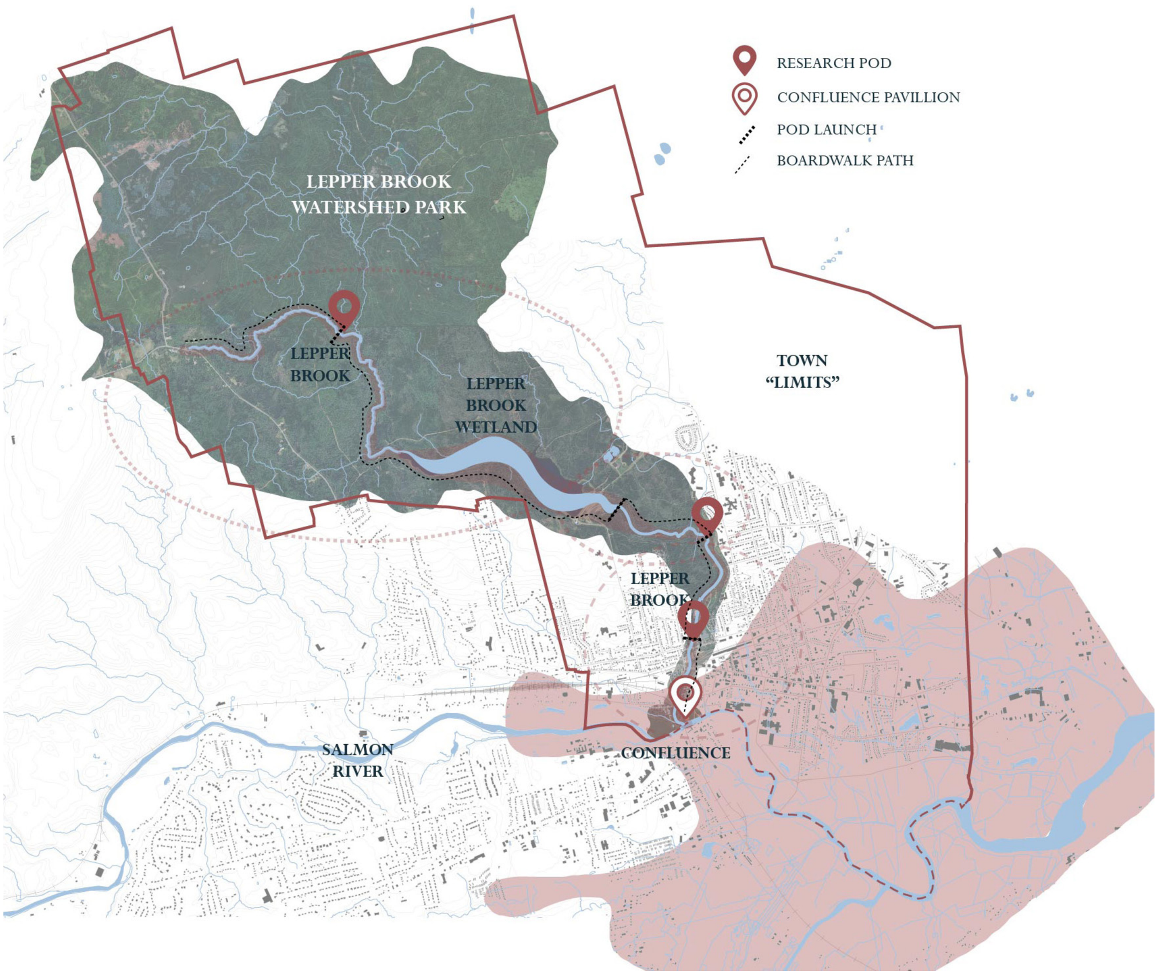
Architecture that houses research right now identifies with the institutions which they represent, not the subjects of research, leading us as spatial inhabiters to identify with the institution, rather than any natural phenomena. It is no wonder that we often hear ourselves describing academic environments as institutional, universally bleak and confining, rather than by their interesting and complex topics of study.

In contrast to conventional water treatment plants, the restored Lepper Brook will house three research pods, located at the various transitions points within the brook system. Decentralizing our infrastructure better reflects the omnipresent nature of our water systems, and provides more opportunities for perpetual monitoring and engagement. Monitoring plants are typically located away from natural watercourses to reduce the risk of damage in the case of failing engineering-based structures, i.e., dams. These pods will be suspended above the brook, allowing research to take place directly within the watercourse and without disturbing it. Bringing the research pods close to the water signifies our trust in nature and direct engagement with it.

Pods will be located in the following locations:

1. Headwaters, to monitor natural reference reach conditions
2. Existing Victoria Park portion of Lepper Brook, to monitor the removal and restoration of embankments
3. Downtown Truro portion of Lepper Brook, to monitor the removal and restoration of culverts

The pods will have the capacity to hover above each study reach, shifting within the range via a series of cables anchored just outside of the stream's meander belt. The access point for the pods will be located where the experiential boardwalk crosses the stream, providing a launch platform.



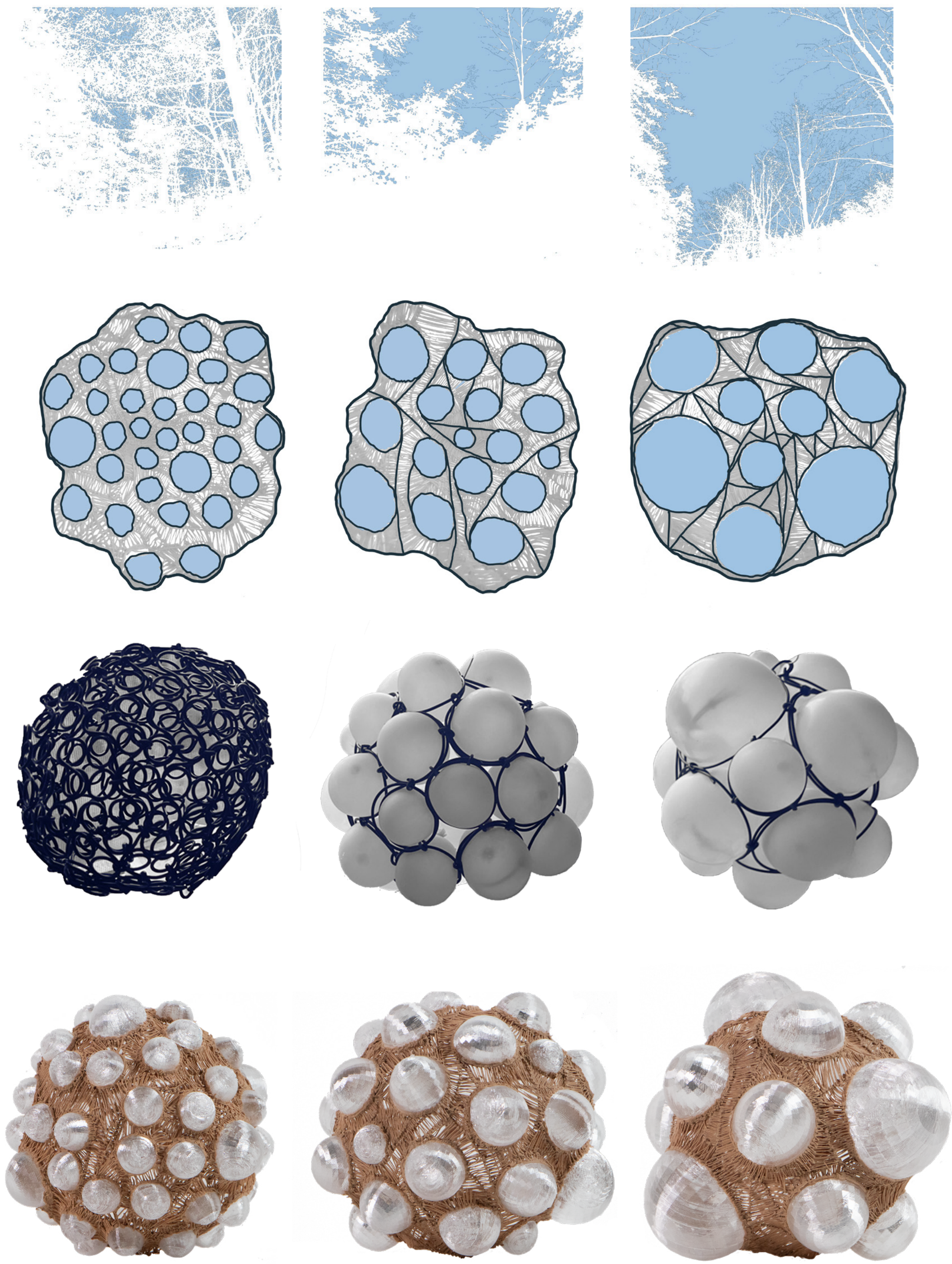
Site plan showing monitoring pod locations, boardwalk path, and pod launches at crossings (data from Town of Truro 2019; Town of Truro 2019a; Town of Truro 2019b; TTPD 2022; TTPD 2022a; and TTPD 2022b)

5.2.1 Modelling Processes: Building Complexity

The pods are tools for monitoring the complexity of the restored natural system of Lepper Brook. The experience of the pods, then, needs to reflect the complexity of the system in which they are located: the headwaters, the park, and the town. Each of these locations features its own unique intersection of nutrient complexity, forest density, and light transmission, to which the pods must respond. The pods integrate these features through a dialogue between light transmission and structural complexity, expressed through the act of creating physical models.

Creating physical models provides explicit feedback that would not be present in drawing or digital modeling. The modeling of the pods began with addressing the forest density and light availability at each reach, following the changes from dense headwater forest to open floodplain. The size and number of flotation bubbles mirrored the changing light availability, as larger bubbles would allow more light transmittance than smaller ones. This relationship is made explicit in the diagram on the following page.

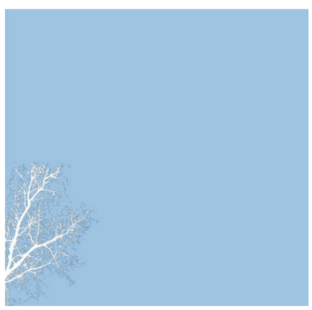
The differing structural complexity emerged as a consequence of the bubble size and distribution. Small bubbles allowed for short spans of material to create the structure of the pod, while larger bubbles required additional supports that added complexity. The increase in structural complexity expressed through modeling mirrors that of the natural systems, in which nutrient complexity increases as you move downstream from headwaters to confluence through the opening forest and floodplain. I was able to integrate science and experience through the modeling process, creating tactile feedback that furthered my understanding of how to convey complex natural systems through architecture.



Modelling complexity, demonstrating progressing light transfusion and structural complexity

5.2.2 Human Translation: Experiential Research Pods

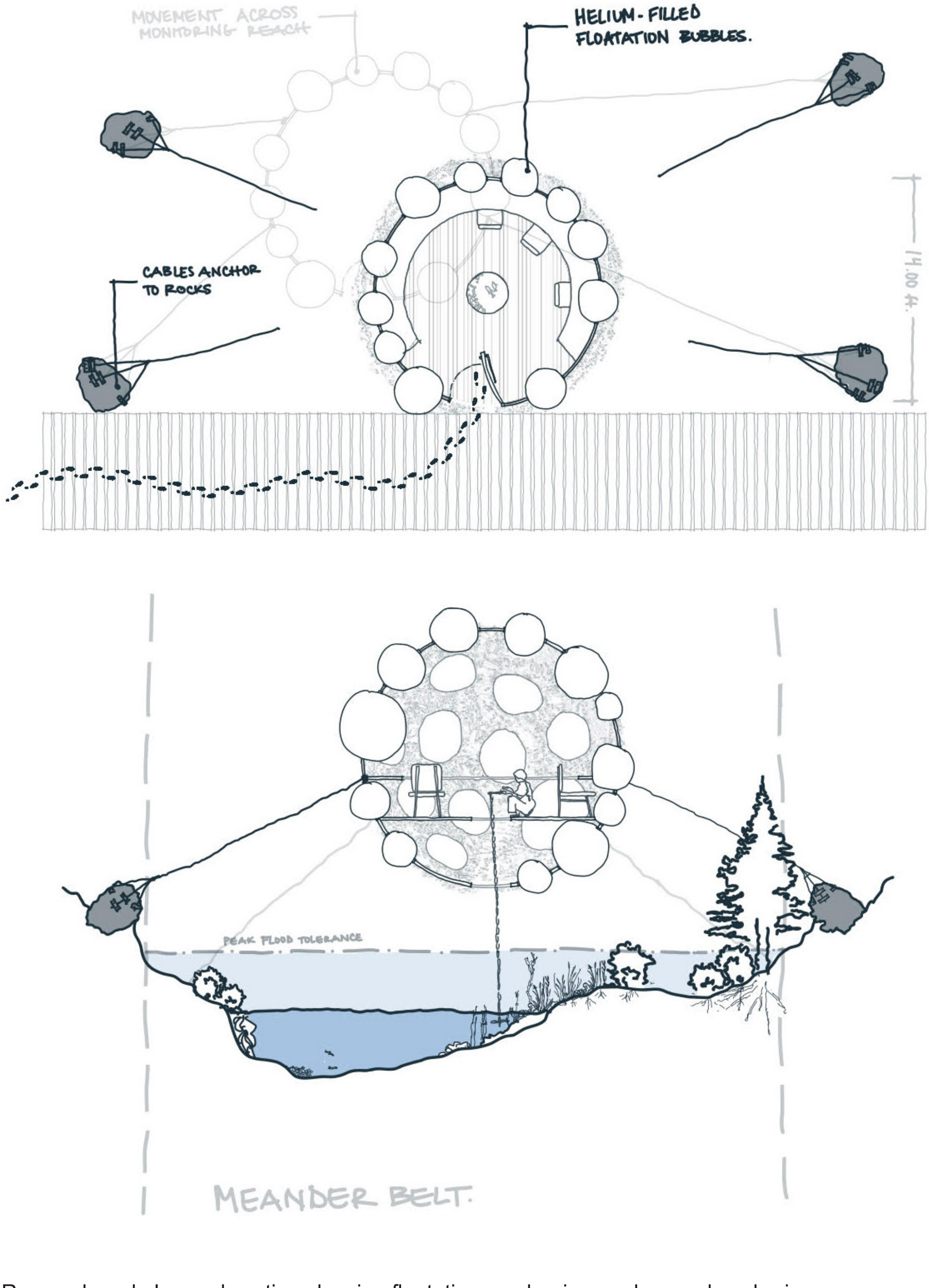
The resulting forms of the pods translate the complexity of the natural system to their users and visitors. They reflect the environmental conditions in which they exist to the inhabitants, deepening the understanding through a phenomenal experience: the bubbles transmit light equivalent to that of the forest, while the structural complexity reminds the user of the complexity of the system they are monitoring. Visitors are drawn to the pods, prompted to ask questions about their appearance and purpose, connecting the infrastructure that delivers their drinking water to their experience in the park.



Boardwalk and Pod language come together at Confluence Pavillion

5.2.2.1 Merging Leisure and Science

The integration of infrastructure and experience culminates at the confluence. A pavilion combines the strategies of creating the boardwalk with those of the pods. The boardwalk seamlessly connects with the pavilion as Lepper Brook connects with Salmon River. The pavilion's roof allows full light transmittance, matching the expansive blue sky that sits over the floodplain at the confluence. The bubbly roof form is supported by the structure of the boardwalk, directly connecting the two approaches in modeling. The pavilion is meant as a gathering point, where leisure and science meet to deliver their united message of interconnection and reciprocity to visitors and scientists alike.



Research pod plan and section showing floatation mechanism and ground anchoring

Chapter 6: Experiencing the Map

As Merleau-Ponty (2012) points out, phenomenology is perpetual, an unfinished practice that is lived rather than studied and only complete when taken up by the individual; a constant revealing of complexities and interrelations that we, as humans, exist within.

To re-consider “the essence of being by looking back to the realm of perceptual experiences allows the real power of architecture to come into presence; its experiential power” (Yorgancioglu 2007, 1). Our spatial experiences should not be reduced to the causal mechanisms described in science, nor to a single activity of consciousness, but rather a “doubly interesting” experience, combining both into a transcendental experience. Making this shift to the “transcendental attitude is a rediscovery, then, of the meaningful, structural relations formed between the perceiving subject and the perceived world, relations of intentionality rather than causailty” (Diprose and Reynolds 2014, 20). The architect’s task, then, is to evaluate the physical, cultural, and historical references of the site and program in order to determine “an order, a field of inquiry, a limited principle” (Holl 1989, 10) for each architectural design process, therefore rooting the spatial experience in the subject so intentionally that the individual is able to experience hidden complexities, identifying themself as part of the system (Holl 1989).

6.1 An Experiential Account

It is a park she had visited many times before; as a child on a school trip to the treatment plant, throughout her teens with friends. She had explored the many trails and seen the signs warning her not to swim in the reservoir. Despite these encounters, she never gained an appreciation for the intimate connection between the water as a feature of the park and the water as a lifeline for the town.

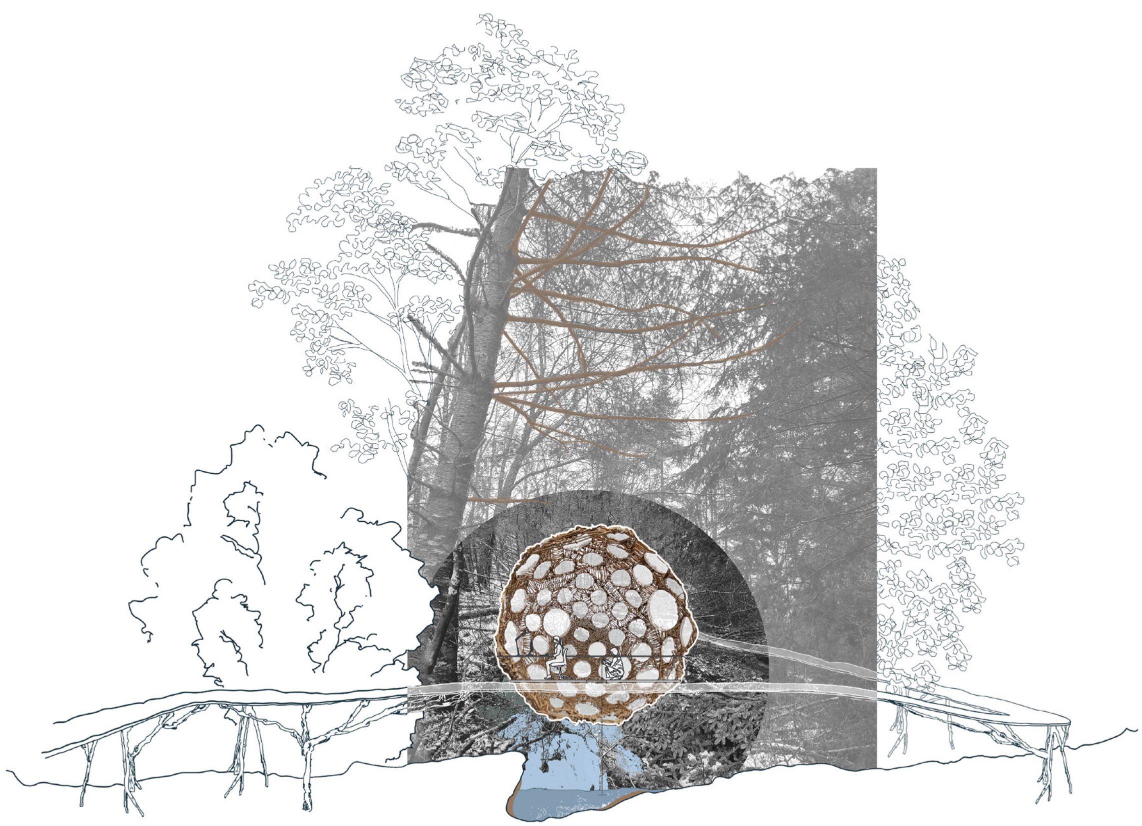
It was an exciting day, the park had undergone some major changes. The dreary, lifeless reservoir had been converted to a reconstructed wetland, while the trails she knew had been reconsidered for their relationship to the water. This was the word around town anyway, so she decided to check it out for herself. It wasn't the nicest day, June in Nova Scotia has a tendency to throw some curveballs at the idea of summer, but she decided to head out anyway. The hype around the redrawn borders of the park sparked her to start her journey in the headwaters of Lepper Brook. A boardwalk had been built to connect the watershed from headwaters to confluence, and since it's easier to walk downhill, she figured it only made sense to start up there.

A light drizzle began as she walked along the wooden slats that elevated her stride above the surface of the ground. Great care had been taken to not disturb the natural ecosystem when building the walkway. The path weaved through the dense forest of the headwaters, the trees holding the drizzle like a sponge, transferring the dampness to her jacket as she brushed the branches.

"This is truly a wet landscape" she thought to herself, the line between stream and forest becoming lost in the dampness. As she rounded a bend a light came glowing through the mist. A pod of sorts appears amongst the dense canopy. It was floating above the stream with an almost magical lightness. Getting closer, she peered inside. A young technician was within the pod surrounded by notepads and equipment she had never seen. Their relaxed demeanor invited her inside.

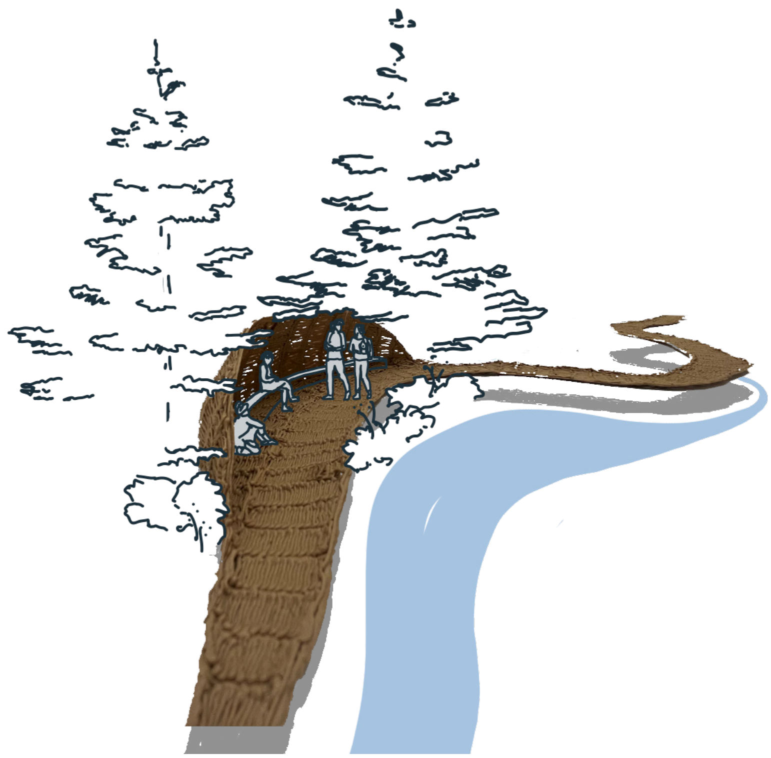
“What are you doing here?” she asked. “This is one of the new monitoring pods, I’m collecting reference data for the restoration downstream” they replied. The diffuse light seemed to come from everywhere and nowhere, it felt a lot like walking through the forest. “What a lovely place to work! Is this part of the new drinking water supply?” she inquired. “Yes it is! This pod is part of a network that monitors the health of the stream not only for drinking water but also for the other kinds of life it supports!” After remarking at the wonder of the pod, she continued her journey.

A brisk north wind had picked up while she was in the pod. She needed a place to get some shelter to put on another layer from her backpack. A shelter emerged from the boardwalk as she rounded the corner by a bend in the stream. It was positioned perfectly to block the cold wind driven rain, and



Inhabited pod, reference reach

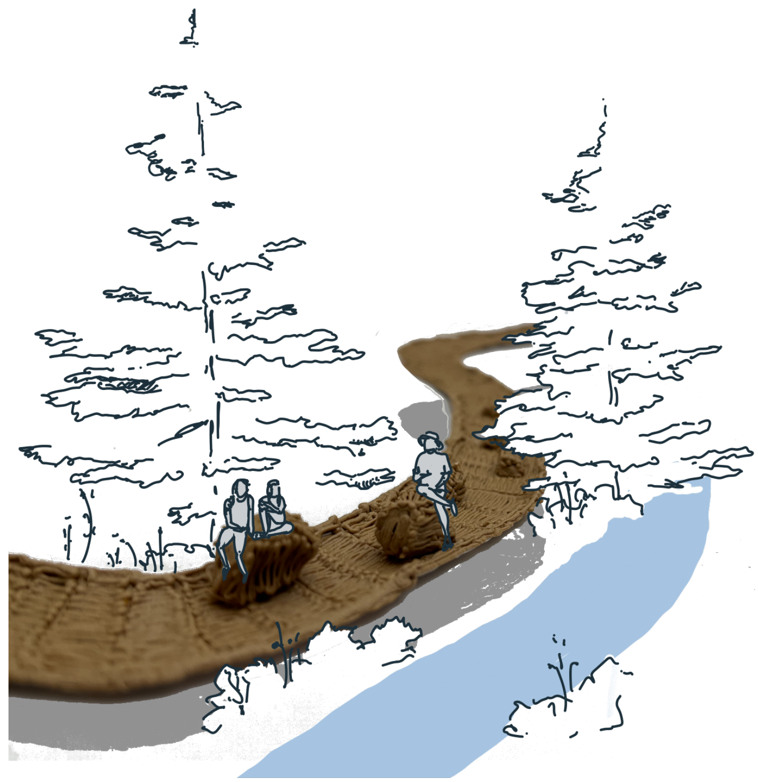
had attracted other visitors to the park as a result. There was ample room, yet the occupants congregated at the deepest point of the curve. Huddled, they remarked at the journey they were on and how it was giving them a new appreciation for the ecosystem in which they found themselves. Putting on more layers, she carried on down the path.



Inhabited boardwalk, protective “pool”

There appeared to be some kind of clearing ahead, or at least a parting in the density of the forest. “The reservoir!” she exclaimed. At least, it was where the reservoir used to be. Replaced by a reconstructed wetland, the reservoir was teeming with life. No longer a barren body of water, the wetland was full of activity and lush with plants that provided habitat for animals from fish to birds. She could hear birds chirping and frogs croaking, it was an orchestra of sound. To think all this life can exist while water is being filtered.

The rain had stopped and a bright June sun was piercing through the clouds. It was just after noon, or so she figured, so it was a good time to stop for lunch. A series of benches rose out of the boardwalk as though the whole thing had been draped over the landscape with rocks pushing through the even slats. She took the opportunity to pause and rest, breathing in the fresh air that lingers after rain. Other visitors sat nearby, but no one spoke. It was a space for breath.

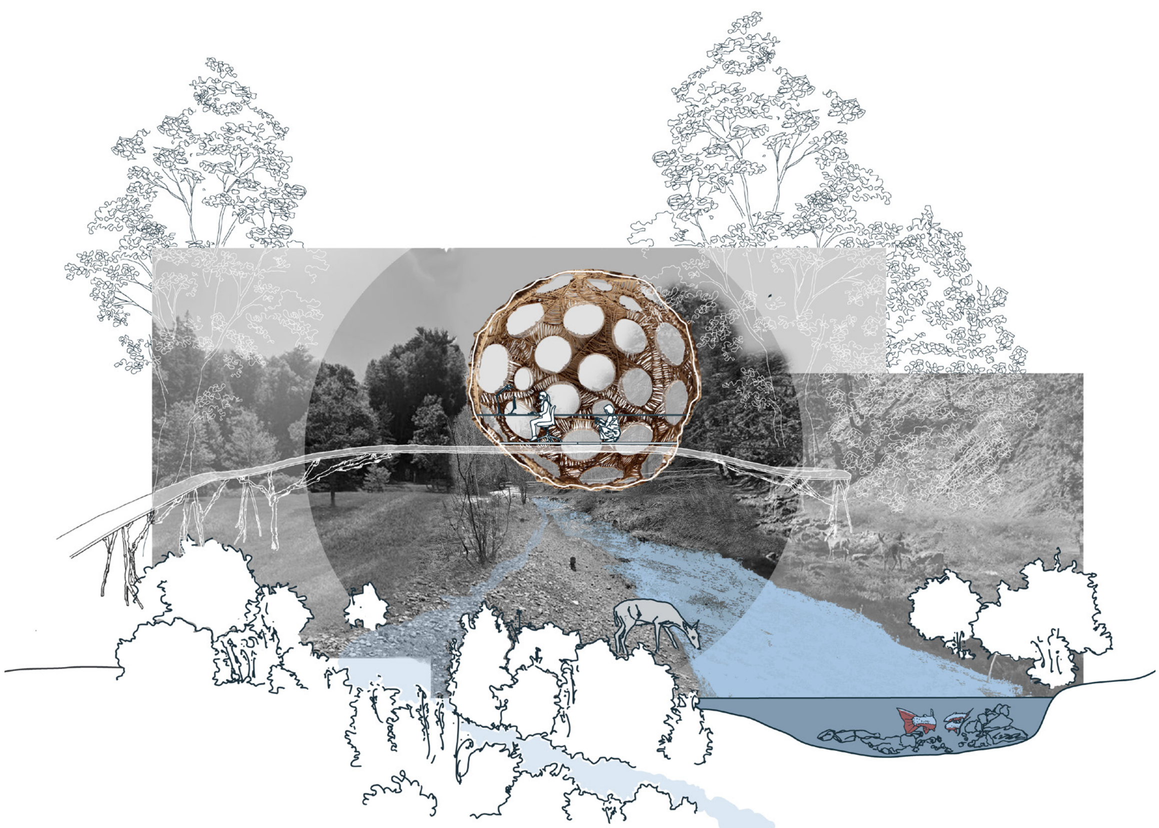


Inhabited boardwalk, “oxygenating” seats

After lunch she continued through a familiar landscape, it was the park, she knew that for sure, yet it felt different. The banks of Lepper Brook were less rigid, the hard edges that limited the meander were gone. In their place was, well, nothing. A seemingly edge-less condition that blurred the line between water and landscape. Sandbars formed on the inside edge of the bend, while erosion was free to take sediment from a steep bank up stream. It all felt… natural. Just below the sandbar, a hammock was slung off the side of the boardwalk. She climbed in to take in the warm afternoon sun. She noted the sounds of animals once again, though this time she could hear the critters among the underbrush. The hammock brought her into their realm, yet hovered just above it. The long grasses and low bushes that lined the river brushed up against her as she stared up at the blue sky. She must have dozed off, or at least been very quiet as she rested, as a deer had emerged from the forest onto the sandbar. It had come to take a drink and warm itself in the sun, using the sandbar to access the stream.

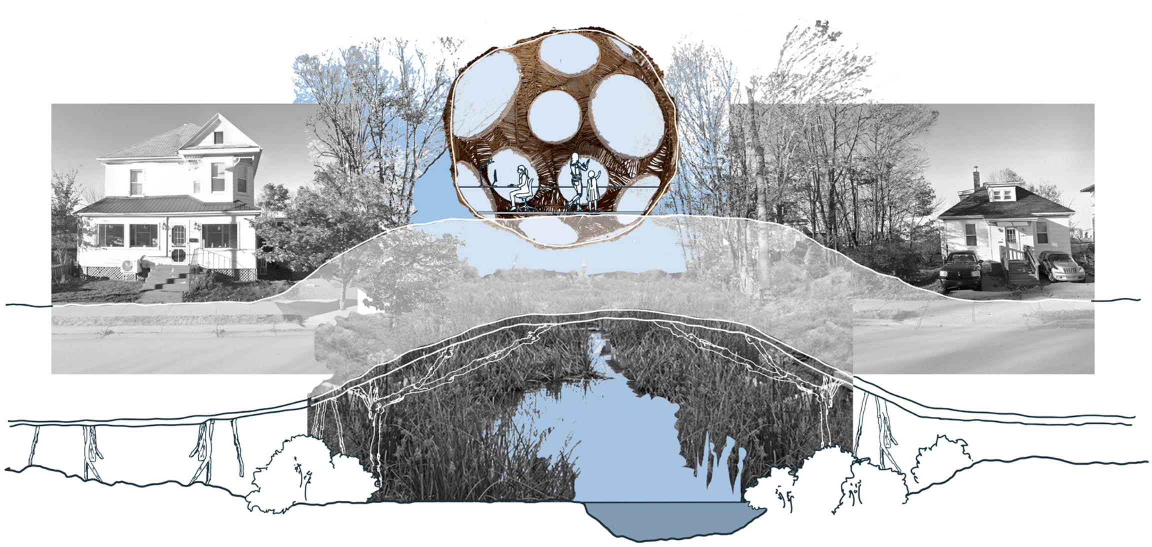
Inhabited boardwalk, “sandbar” hammock

The sounds of children soon filled the air, she got up to see where it was coming from. Another pod was just around the corner and a group of students were admiring its striking form. As she joined the group, the pod floated back to the boardwalk where it crossed the stream. A scientist popped their head out to talk to the students, explaining that this was the second of three pods in the system. This pod was monitoring the water health, comparing it to the reference reach in the headwaters. Glimpsing inside, she noted that this pod felt different to the one in the headwaters. It was brighter inside, with larger levitation bubbles allowing more direct light to flood inside.



Inhabited pod, park reach

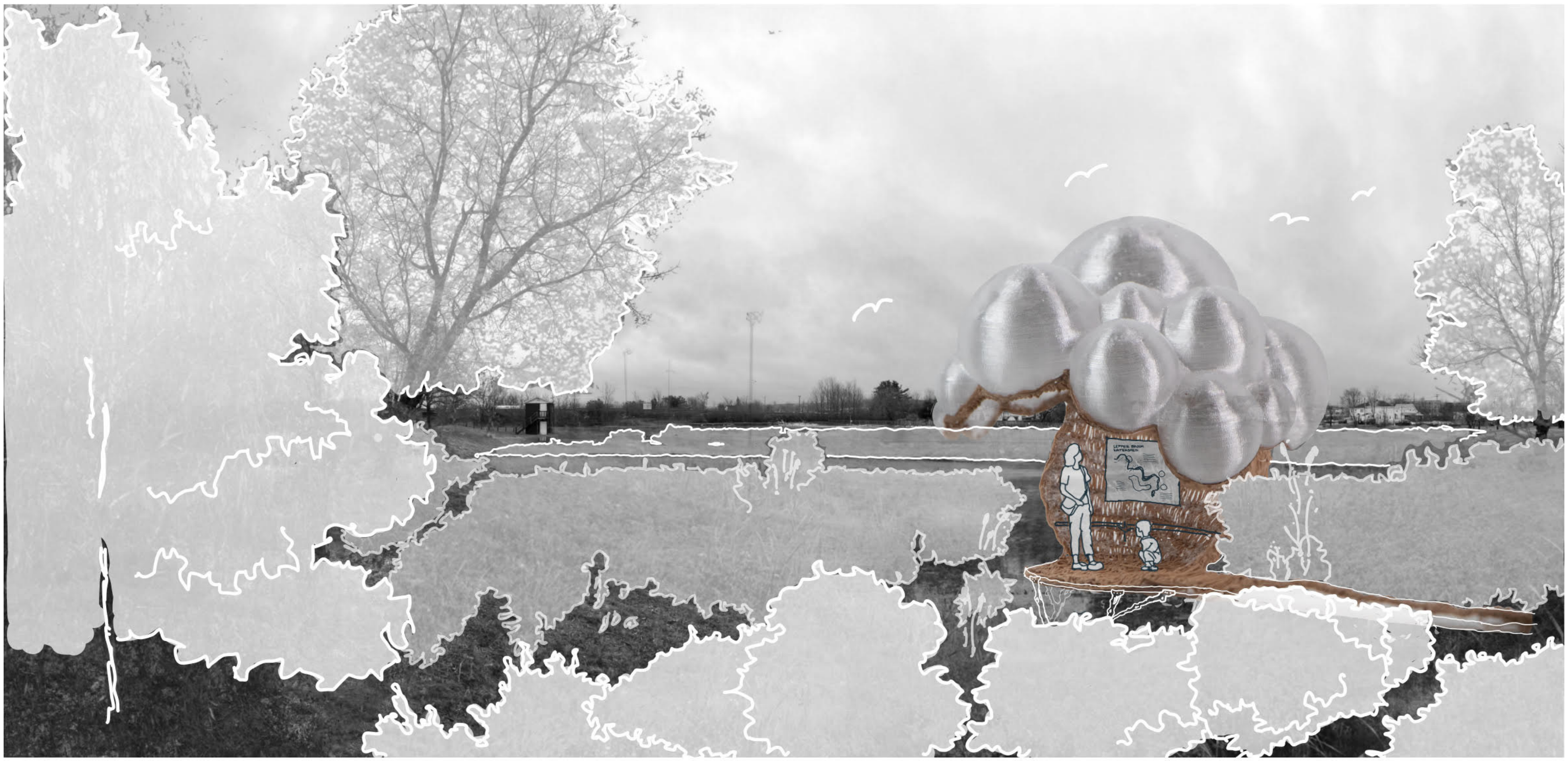
Leaving the group and the scientist behind, she continued her meander downstream. The stream had more curves than she remembered, yet the boardwalk seemed to know exactly where the stream would go. The hills on the sides had receded, giving way to the expansive floodplain. The forest was less dense, with meadows soaking up the available sunlight. She could see the third pod just ahead of her, nestled among homes that were built before renaturalization. Even from this distance she could tell this pod was different yet again. The bubbles were the largest yet, protruding from the light frame. There was no one in this pod at the moment, they must have gone on break, but the door had been propped open. She stepped inside. "Impressive," she thought, the arrangement of equipment clearly visible as the afternoon light flooded the pod. The large bubbles allowed ample light to fill the space, matching the light that sustained the meadow and provided the nutrients for the stream. She noted the probes that were ready and waiting to take measurements from the stream. It felt much more appropriate than the sterile rooms in the



Inhabited pod, urban reach

treatment plant she had entered years earlier. She couldn’t help but feel more connected to the water, the same water that came out of her tap.

It was getting later in the day as she finally made her way to the confluence. The evening sun glimmered off of the new pavilion that marked the end of the boardwalk. A family had gathered under its protective dome for a picnic dinner, weary of the lingering sun showers. The dome was reminiscent of the pods upstream, undulating as if made up of the same bubbles. The family was reading about the changes to the park on the panels in the pavilion. It explained the importance of restoring the stream to its natural state and allowing the stream to meander. It explained the link between drinking water for humans and the life sustaining ecosystem that the stream supported for other living beings. As the family discussed the panels and shared their meal, she reflected on her experience in the park. The information on the panels was important, but it didn’t convey the sensations she felt over her journey. The light, sounds, and tactile experiences that had made her feel connected to the water as a crucial part of a healthy environment. The family agreed, making plans to follow the boardwalk the next day, to experience the ecosystem that filled their cups and washed their hands.



Inhabited boardwalk at confluence pavillion

Chapter 7: Conclusion

Water has been an excellent guide. It has taken me on a journey that I never would have expected. It has been the subject of my research, pouring out of books and articles, it has filled my bottle keeping me hydrated through processes of designing, modeling, and writing. My appreciation for the complexity of water has evolved with my awareness of its omni-presense, observing the varied ways that water is considered in the built and natural environments. I learned to trust the meandering path of discovery that gave space for this thesis to emerge.

I embraced a phenomenological approach to design, immersing myself in water's existence and processes to better understand its agency. I worked with my experience and the agency of water to create architecture that immerses its users in a phenomenal existence, while restoring Lepper Brook to run a more natural course. The design process pursued these goals simultaneously to ensure integration between the restoration process and the experience and monitoring of that process. Designing in this way enabled me to remain focused on the re-associative nature of this thesis, so that others could develop the respect and understanding that I had gained during my experience following the flow of Lepper Brook.

I see this work as laying the groundwork for a reconsideration of how we define site and landscape in architecture. It calls into question our relationship to the natural processes that surround and sustain us, arguing for an approach that recognizes and celebrates the complexity of these processes. Working with a tolerance for the necessary changes in natural systems, like the meander belt, designers can create spaces that reinforce our connection to these systems rather than further our disassociation.

References

Abrams, Janet, and Peter Hall. 2006. *Else/where: Mapping New Cartographies of Networks and Territories*. Minneapolis: University of Minnesota Design Institute.

Baxter, R. M. 1977. “Environmental Effects of Dams and Impoundments.” *Annual Review of Ecology and Systematics* 8, no. 1: 255-283.

Beechie, Timothy J., David A. Sear, Julian D. Olden, George R. Pess, John M. Buffington, Hamish Moir, Philip Roni, and Michael M. Pollock. 2010. “Process-based Principles for Restoring River Ecosystems.” *BioScience* 60, no.3: 209-222.

Beechie, Timothy J., and Susan Bolton. 1999. “An Approach to Restoring Salmonid Habitat-forming Processes in Pacific Northwest Watersheds.” *Fisheries* 24, no. 4: 6-15.

Corner, James. 1999. “The Agency of Mapping: Speculation, Critique and Invention,” in *Mapping*, edited by Denis Cosgrove, 213-252. London: Reaktion.

Creed, Irena, Diane M. McKnight, Brian A. Pellerin, Mark B. Green, Brian A. Bergamaschi, George R. Aiken, Douglas A. Burns, Stuart E. G. Findlay, Jamie B. Shanley, and Rob G. Striegl. 2015. “The river as a chemostat: fresh perspectives on dissolved organic matter flowing down the river continuum.” *Canadian Journal of Fisheries & Aquatic Sciences* 72, no. 8: 1272-1285.

De Villiers, Marq. 1999. *Water*. Toronto: Stoddart.

De Wolff, Kim, Ignacio López-Calvo, and Rina C. Faletti, eds. 2021. *Hydrohumanities*. Oakland: University of California Press.

Diprose, Rosalyn, and Jack Reynolds. 2014. *Merleau-Ponty: Key Concepts*. London: Routledge.

Dobson, Clive, and Gregor Gilpin Beck. 1999. *Watersheds: A Practical Handbook for Healthy Water*. Richmond Hill: Firefly Books Ltd.

Fang, Yu, and James W. Jawitz. 2019. “The Evolution of Human Population Distance to Water in the USA from 1790 to 2010.” *Nature Communications* 10: 430.

FAO Regional Office for Europe and Central Asia. 2012. “Guide to the Small Scale Artificial Propagation of Trout.” György Hoitsy, András Woynarovich, and Thomas Moth-Poulen. Budapest, Hungary.

Fuller, I. C., H. E. Reid, and G. J. Brierly. 2013. “Methods in Geomorphology: Investigating River Channel Form.” In *Treatise on Geomprphology*, edited by John F. Schroder, 73-91. San Diego: Academic Press.

Griffin, Donald R. 1985. “Animal conciousness.” *Neuroscience & Biobehavioral Reviews* 9, no. 4: 615-622.

Hann, C. M. 1998. *Property Relations: Renewing the Anthropological Tradition*. Cambridge, UK: Cambridge University Press.

Holl, Steven. 1989. *Anchoring: Selected Projects, 1975-1991*. 3rd ed. New York, NY: Princeton Architectural Press.

Ibrahimi, Nada, and Florian Nepravishta. 2021. “Theories and Concretizations of Existentialist Phenomenology: The Neuroscientific Peak of Design Processes.” *International Journal of Ecosystems and Ecology Science* 11, no. 3: 529-536.

Langston, Rosamund F., James A. Ainge, Jonathan J. Couey, Cathrin B. Canto, Tale L. Bjerknes, Menno P. Witter, Edvard I. Moser, and May-Britt Moser. 2010. “Development of the Spatial Representation System in the Rat.” *Science* 328, no. 5985: 1576-1580.

Li, Dongfeng, Xi Xi Lu, Li Chen, and R. J. Wasson. 2019. “Downstream geomorphic impact of the Three Gorges Dam: With special reference to the channel bars in the Middle Yangtze River.” *Earth Surface Processes and Landforms* 44, no. 13: 2660-2670.

Machemehl, Charly, Olivier Sirost, and Jean-Paul Ducrotoy. 2021. *Reclaiming and Rewilding River Cities for Outdoor Recreation*. Cham: Springer International Publishing.

McCabe, Declan J. 2010. “Rivers and Streams: Life in Flowing Water.” *Nature Education Knowledge* 1, no. 12: 4.

Merleau-Ponty, Maurice, and Donald A. Landes. 2012. *Phenomenology of Perception*. Abingdon, Oxon: Routledge.

Mills, Chris. 2011. *Designing with Models: a Studio Guide to Architectural Process Models*. Hoboken, NJ: Wiley.

Montgomery, David R., and John M. Buffington. 1997. “Channel-reach Morphology in Mountain Drainage Basins.” *GSA Bulletin* 109, no. 5: 596-611.

Mosley, M. P. 1998. “Channelization and Bank Stabilization,” in *Encyclopedia of Hydrology and Lakes*, edited by Reginald W. Herschy and Rhodes W. Fairbridge. Dordrecht: Springer Netherlands.

Rosgen, David L. 1994. “A Classification of Natural Rivers.” *CATENA* 22, no. 3: 169-199.

Schumm, Stanley A. 2022. “Rivers and Humans – Unintended Consequences,” in *Large Rivers: Geomorphology and Management,* edited by Avijit Gupta. Hoboken, NJ: Wiley.

Smith, Mark, Katherine Cross, Mary Paden, and Peter Laban. 2016. *Spring: Managing Groundwater Sustainably*. Gland: International Union for Conservation of Nature and Natural Resources.

Town of Truro. 2019. *Road Network*. Town of Truro Maps, Apps and Open Data. Map from GIS data, using ArcGIS. https://interactive-truro-townoftruro.hub.arcgis.com/maps/townoftruro::recreational-spaces-1/about

Town of Truro. 2019a. *Town of Truro Boundary*. Town of Truro Maps, Apps and Open Data. Map from GIS data, using ArcGIS. https://interactive-truro-townoftruro.hub.arcgis.com/maps/townoftruro::recreational-spaces-1/about

Town of Truro. 2019b. *Truro Buildings*. Town of Truro Maps, Apps and Open Data. Map from GIS data, using ArcGIS. https://interactive-truro-townoftruro.hub.arcgis.com/maps/townoftruro::recreational-spaces-1/about

Town of Truro. 2019c. *Victoria Park Boundary*. Town of Truro Maps, Apps and Open Data. Map from GIS data, using ArcGIS. https://interactive-truro-townoftruro.hub.arcgis.com/maps/townoftruro::recreational-spaces-1/about

Town of Truro. 2019d. *Victoria Park Trails*. Town of Truro Maps, Apps and Open Data. Map from GIS data, using ArcGIS. https://interactive-truro-townoftruro.hub.arcgis.com/maps/townoftruro::recreational-spaces-1/about

TTPD (Town of Truro Planning Department). 2022. *Flood Risk Area*. Map from GIS data, using ArcView GIS. Truro, NS: Town of Truro Planning Department.

TTPD (Town of Truro Planning Department). 2022a. *Water Lines*. Map from GIS data, using ArcView GIS. Truro, NS: Town of Truro Planning Department.

TTPD (Town of Truro Planning Department). 2022b. *Water Mains*. Map from GIS data, using ArcView GIS. Truro, NS: Town of Truro Planning Department.

Wood, Denis, and John Fels. 1993. *The Power of Maps*. London: Routledge.

Yorgancioglu, Derya. 2007. “Steven Holl: A Translation of Phenomenological Philosophy into the Realm of Architecture.” Paper presented at *The First International Architecture and Phenomenology Conference*. Haifa, Israel.