Fields and Flows: Harmonizing Township Development with Riverine Health Through the Local Industrial Use and Cycling of Sedimentary Materials

by

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

Contents

Abstract

As hydrosocial creatures, rivers and streams are intimately connected to our existence and are strongly influenced by fragmentation and flow disruption. Across the globe, waterways are depleting at alarming rates; since the Eighteenth Century, our species has increased its use of freshwater over thirty-five-fold, with much of the disruption occurring over the last 50 years.

This proposal, centered on the eighteenth century Shubenacadie Canal network in Nova Scotia, Canada, demonstrates responsible water infrastructure design through modern sensibilities toward material use, environmental impact, and human habitation. It uses sedimentation as a generator of industry, and canals as points of application, providing the rationale for a distributed infrastructure tied to a local material culture. Integrating components of an industrial process helps improve fragmentation, provides better local and regional cohesiveness for inhabitants, and ultimately protects our critical waterways by improving the landscape through an ecologically centered design approach.

Acknowledgements

I would first like to extend a debt of gratitude to all those that have helped me along my journey. The numbers are too great to list here but just know you have had a tremendous impact on me.

Next, I could not have envisioned this project without the wisdom and guidance of my supervisor Brian Lilley. His eagerness to explore and positive attitude made every tutoring session a real joy. I shall treasure our time spent on the Shubenacadie and look forward to what future adventures await.

Thank you to the family of John D. Watson whose financial support helped fund the research expedition through which this entire project is possible.

Thank you to Robert France for his support and guidance as part of my thesis committee. His courses on Ecohydrology were of immense value to my project and I look forward to hopefully crossing paths on a river sometime.

A special thank you to Dr. Linda Campbell who, despite my flakiness, remained engaged and interested in my thesis work. Her insight and recommendations helped ground my research in a scientific foundation.

Finally, to Rhea. I cannot begin to express how grateful I am to the unwavering support you have given to me. Your strength is beyond measure and a true inspiration to me.

Chapter 1: Introduction

Preamble

In 2015, Terje Tvedt, a Professor of Geography from the University of Bergen, wrote a book titled *Water and Society: Changing Perceptions of Societal and Historical Development,* where he put out a call to reorient the way we think about the development of society. He lays out the foundation for a new "water-systems" approach that considers water in the context of a particular time and place, and as an "autonomous actor" within our societies, he writes:

> Only by looking at water in society and nature in this broad, inclusive way, can the role and impact of water be properly analysed and understood, and the actual history of the growing influence of the hydrosocial cycle and rearrangement be reconstructed. Water is eternal in nature and in society, but it is also always changing in nature and society. (Tvedt 2015, 5)

At our core, we are a hydrosocial animal; a creature that has developed its entire social order from the experience of being on, around, or in search of water. Every society lives within a waterscape that both creates and destroys life; too much water, or too little, and we perish. As a hydrosocial society, it is imperative that we negate the abstract notion that humans hold dominion over nature and accept the reality that we are not separate from, but are merely one component of the natural order. We tend to frame nature as something other than ourselves - something out there in the jungles, and aquariums, a place filled with birds and bugs and strange mushrooms. We define nature as mysterious and cunning, purposeless yet deterministic, and we often see nature as something to be conquered. As C.S. Lewis states, "we are always conquering Nature, because 'Nature' is the name for what we have, to some extent, conquered"

(Lewis 1944, 71). The idea that nature is something to be conquered is precisely the mindset responsible for the great challenges that beset us today; low water, soil, and resource availability, poor food production, low air and water quality, rapidly depleting biodiversity, economic instability, political unrest, and fragmented communities are challenges that we all face. By viewing the world in terms of us and nature, we further the discontinuity between humans and their context; instead, we should consider nature not as something outside of us, but something within for it is ultimately the source of our shared story as a species, binding us together at multiple scales and forming the heart of our very being. Water is not merely a resource to be utilized, but a fundamental building block of civilization, and the birthplace of culture and society (Tvedt 2015, 77). Placing water at the core of this thesis allows an exploration into the role and power waterscapes have in shaping the stories we tell, the relationships we make, and the systems we influence.

Thesis Question

This thesis uses storytelling, systems-thinking explorations, and materiality to investigate the potential for water and architecture to harmonize and generate community. Ultimately, this thesis is fundamentally rooted in a pro-human perspective, one that positions us as contributors to the success of our environment through emphasizing the need for stewardship, integration, and thoughtful engagement *within* the natural world.

Chapter 2: Research through Storytelling

Personal and directed experience form the basis for the narrative that shapes this investigation. A series of rivers are described through various stories that are intimately tied to the community that relies on the water. This broader narrative has developed from three locations - in Newfoundland, in Great Britain, and finally in Nova Scotia.

Mishta-shipu ("Grand River" or Churchill River)

In 1891, the American explorer Henry Grier Bryant, upon reading accounts of the beauty and majesty of Pat-ses-che-wan - (Innu for "The Narrow Place Where the Water Falls") would organize an expedition westward up the Mishta-Shipu ("Grand River" or Churchill River today), documenting the journey for the Royal Geographical Society of America (Bryant 1894, 38).

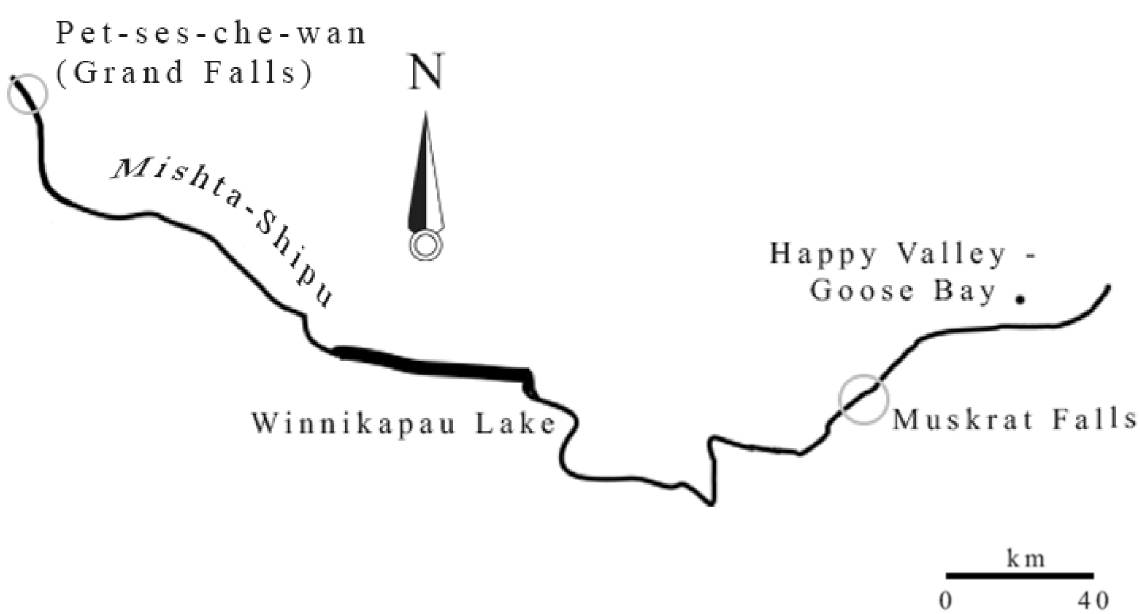


Figure 1: Simplified map of the Mishta-Shipu showing approximate location of Pet-ses-che-wan. Today it is the location of the Churchill Falls Hydroelectric Power Generating Facility.

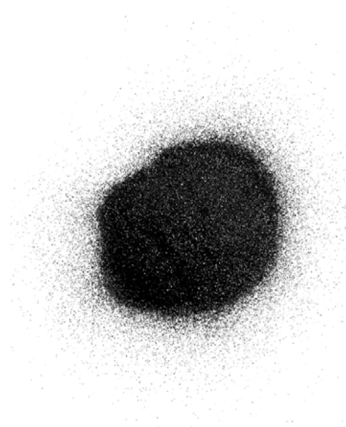


Figure 2: Sample of sand taken from a sandy beach outcrop on the eastern tail of Winnikapau Lake. This sand can be characterized by its striking black basaltic sand interspersed with quartz granules.

Pat-ses-che-wan, also called “Grand Falls” today, sits at the head of the Mishta-Shipu, but was never visited by the local Indigenous peoples for fear of the legend of two Innu woman who, enticed by the beauty of the falls, ventured too close and were pulled in by an evil spirit that dwelled in the mist. It was this story that attracted Bryant to the falls where he remarked at the time that a woman could still be seen with “trailing white hair and outstretched shrivelled arms”, eager to lock eyes with anyone that dares approach her resting place (Bryant 1894, 38).

During the summer of 2017, some 126 years after Henry Bryant’s expedition, myself and a crew of five others set out to retrace the 320km return journey from Pat-ses-che-wan through Mishta-shipu before exiting at Muskrat Falls. This river was once used as an important transportation route for Innu, Inuit, and Metis trappers, who would paddle upstream, make camp, and trap over the winter before leaving in the spring to trade meat and fur to the Hudson’s Bay Company in Rigolet, Labrador (Mitchell 2011, 6). This five-day journey proved to be an interesting and exhilarating experience; black skies and black flies welcomed us as old friends as we paddled our way through the rarely seen Labrador interior. On day three of our journey, following a pleasant morning out from the 42km long Lake Winnikapau, our company came upon what is known to locals as the *Devil’s Hole*; a large whirlpool in the middle of a set of rapids that - depending on water levels - is either stationary, or silently drifting across the river. My boatmate and I made our way to shore, ensured our belongings were lashed and began our approach. Entering into river rapids with a fully loaded canoe is challenging on the best of days, but a set of rapids containing an unknown, capsizing force - madness.

Turning starboard and facing upstream, we dug in; the hard current pushed us along our intended vector as we shot around a sharp bend in the river. Bull riding our way over the waves we lost sight of our target and were forced to rely on an instinct we had not yet developed, an instinct that is well and fully ensconced over the thousands of years long history of Indigenous living. Suddenly we caught sight of the whirlpool, and after pulling hard and driving through we managed to slip the bow to the right - but it was not enough; our stern was caught and we began to rotate. Two full turns later and the Devil shot us out broadside into the rapids, where we immediately capsized. Then, as if with “outstretched shrivelled arms” a force pulled us under, tossing the canoe into the darkness below and relinquishing us of any control we thought we possessed. As luck would have it, our lashings wore loose and the clumsy barrels that we had brought with us became the respite we needed to break free from the river’s grasp and swim to shore.

We were the last group so see the river as Henry Bryant and his company would have seen it in 1891, or indeed as the original inhabitants of the land would have seen it. A few weeks after our journey ended, the river was forever changed. The new Muskrat Falls Hydroelectric Project would write a new chapter of Pet-ses-che-wan, beginning with draining much of the river and rerouting it for man-made reservoirs. We experienced the water mere moments before the central power of industry inserted itself into this system – forever altering the waterscape and the social structures that rely upon it. Those that experienced the river in all its forms are bound together forever, for these experiences enable the telling of stories, the sharing of lessons, and the growing of communities.

As Tim Ingold writes;

> ...experiences ...contribute to the shaping of a person's own sense of self, and of their attitudes and orientations towards the world. ...experience is intrinsic to the generative process wherein persons – both human and other-than-human – come into being and pursue the goal of life, each within the field of their relations with others. (Ingold 2000, 90)

Experience is not static; it flows through us like rivers flow through land, meandering around obstacles, and carving new routes. Experience ultimately shapes who we are, setting the stage for life, and hopefully giving us purpose and meaning.

Figure 3: The natural and pre-industrial beauty of the Mishta-shipu. These three images represent an experience of the river not unlike that of life, shifting from anticipation to excitation before finally settling on a state of reflection. Each experience leaves a mark on the soul, reinforcing the mind-body connection of place.

River Lea (Lee)

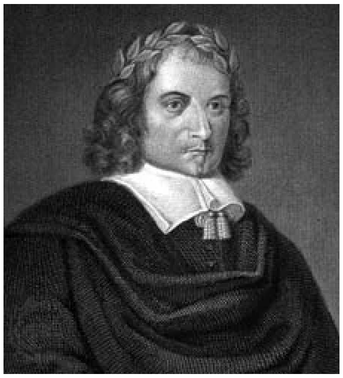


Figure 4: Portrait of Thomas Middleton, a prolific playwright and widely acknowledged Shakespeare collaborator (Luebering 2021).

Whereas the Mishta-shipu can be looked at as a system in its industrial infancy, the River Lea represents the opposite end of the industrial spectrum; a post-industrial water system being used by a pre-industrial society. Unlike the Mishta-shipu that sat unaltered for millennia, the canalized River Lea in England is a wholly constructed system that was brought into existence alongside a natural waterway through the gritty and backbreaking efforts of human labour. Standing on the banks of the Lea some 30km north of London, and with a dozen or so labourers around, Thomas Middleton recited a small poem to signify the end of a long and arduous construction project:

> Long have we labored, long desired and prayed. This great works perfection, now by the aid of heaven and mens good work, tis at length, happily conquered - by cost, wit, and strength. (Bergeron 2014, 68)

The year was 1613, and the newly canalized River Lea would provide the foundation by which England would embark on rapid and relentless industrialization; mill owners, barge keepers, distillers, blacksmiths, and coopers all flocked to the new system because of the potential the waterway possessed.

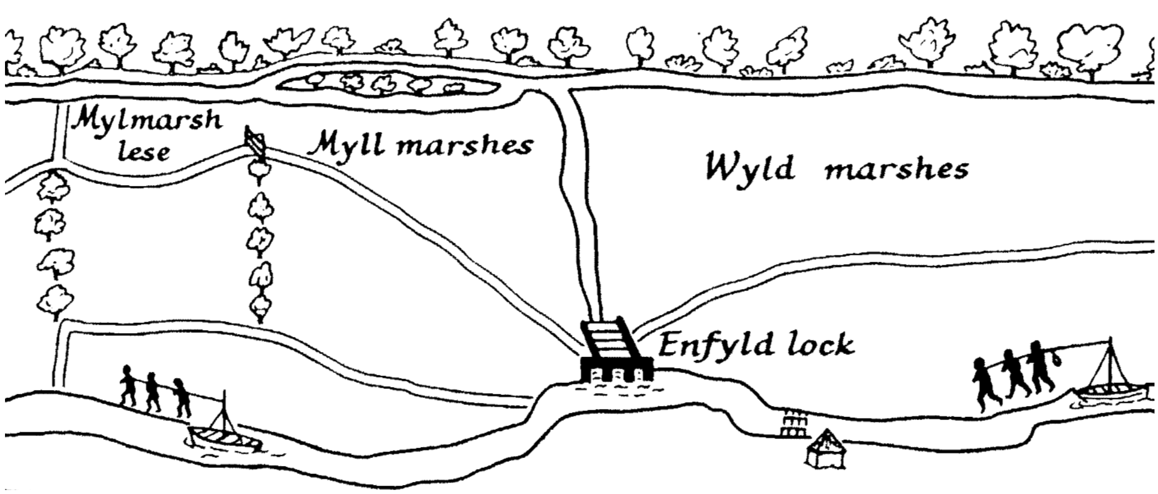


Figure 5: Early map (c. 1594) of the natural river Lea waterway (Bull 1958, 375).

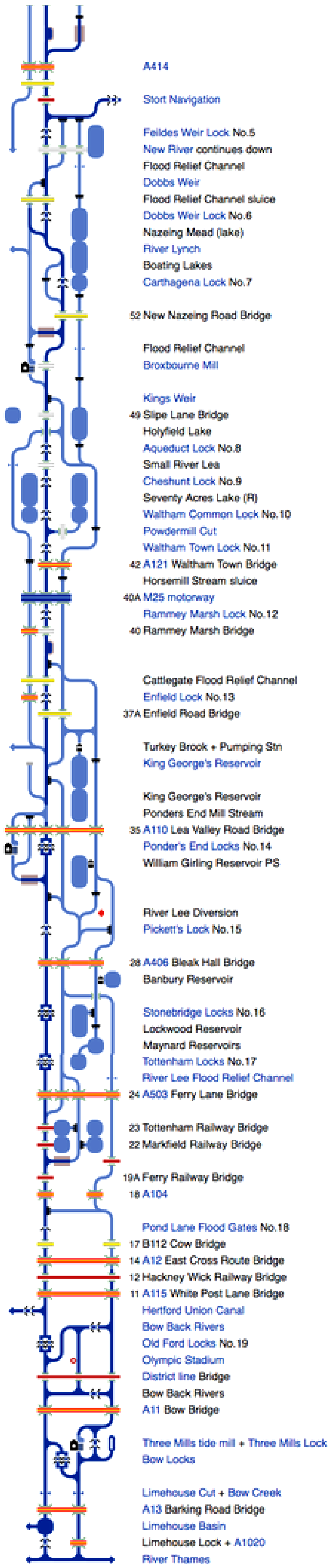


Figure 6: Systems map of the River Lea (Wikipedia 2021).

The Lea proved to be an indispensable resource for centuries, seeing it move from a place for profitable and independent business, to a network transporting coal, ammunition, beer, barley and wood, until finally metastasizing into an aesthetic system of dwelling for the boaters of today.

The importance of this waterway cannot be understated, for it is this system that jump started industrialization not only in England, but throughout the world. By providing a network for the transportation of goods and services, people, products, and power all coexisted within a framework mediated by the canal and enacted through the particular societal conditions nested on its walls. Unfortunately, because the underlying society remains fundamentally pre-industrial, the River Lea is now over-developed, and exists today as a highly polluted and degraded waterway system, and one that has ultimately driven industry away. Today, the River Lea is used primarily by the narrowboat community who live on the river, and by tourists and nearby townsfolk who travel the along the canal's walkways and ancient towpaths. It is a system no longer tied to its industrial heritage and remains an under-utilized resource that could be used to improve industry, the environment, and everyday life.

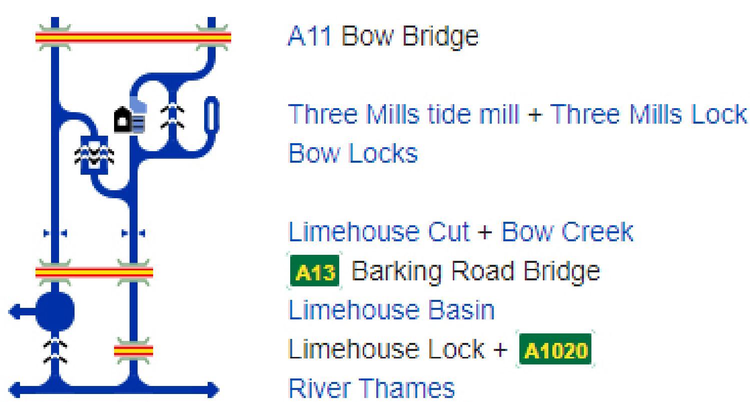


Figure 7: Close-up of the systems map of the River Lea showing detail relationships (Wikipedia 2021).

Figure 8: The post-industrial backdrop of old working London. Empty and desolate...haunting yet bucolic. (Google Maps n.d.).

Sipekne’katik (“Where the Wild Potatoes Grow” or Shubenacadie)

The Shubenacadie (*Sipekne’katik*) canals were designed to connect a series of lakes that dot the landscape between Dartmouth Cove and Cobequid Bay so that colonial settlers of the nineteenth century could allow goods to travel unimpeded across Nova Scotia by way of water. These challenging canals were built on top of traditional and long-standing portage routes used by the First Nations peoples for as long as they have roamed the land. What remains today is a patchwork of disconnected infrastructure; a relic of a bygone era; a palimpsest that hides the ancient wanderers’ path, waiting to be rediscovered (Lewis 2006).

During the summer of 2021, the explorer’s itch set in again and myself along with five others set out from Dartmouth, Nova Scotia to travel the old lakes and waterways of the Shubenacadie Canal System. The objective here was to document the journey by monitoring, measuring, and reporting on various water quality metrics throughout the entire system. Additionally, a series of sediment samples were collected at various points of interest. This type of engagement is called “Citizen Science”; a type of scientific endeavour conducted by the general public which gives the community an active and important role in monitoring the health of our surrounding ecosystems. During this expedition, our team was able to borrow environmental monitoring equipment through a local environmental group called the Atlantic Water Network. This allowed us to make connections with researchers and experts in environmental monitoring, and provided an avenue for depositing data. Through our journey, we collected air and water temperature readings, measured pH and conductivity, dredged sediment from the river bed, and documented any unusual observations. This data was then uploaded to an online database, feeding into the collective monitoring system, enhancing and providing feedback from a grassroots level.

This journey was part of a research expedition investigating the potential use of river sediment in construction. Wherever water flows – dams, canals, weirs, pipes, hills, etc. – small particles are transported, collected, and piled up, contributing to the degradation of natural and anthropogenic water infrastructure. Sediment buildup is the largest cause of maintenance costs to a water system, requiring specialized equipment, labour, and time to extract and dispose of dredged sediment (Jaikaew et. al. 2015). Additionally, sediment often becomes the place of toxic algae growth which can cause major problems for wildlife and humans who rely on the water system for survival. This research considered the use of river sediment in the formation of building materials through a process known as MICP (microbially induced calcite precipitation). MICP has been traditionally used in soil engineering and is just starting to be widely explored as a technique for "growing" building materials (Dosier 2014). Simply put, calcium carbonate (the material that shells, corals, and limestone are made of) forms as a result of the interaction between waste by-products and calcium ions in a microenvironment.

One of the more interesting findings was the relationship between sediment and location. Each sample contained a simple array of colours and textures, each carrying the signature of its origin; darker, concrete-coloured sediment in urban zones, and reddish, sandy sediment in rural farmland zones.

Citizen science is an important tool in not only educating the public about the natural world and getting them involved with actively managing their communities, but it is very important in watershed management in general (France 2005). It is important to gather as much baseline data as possible in order for decision-makers to be in a good position to make appropriate and context-dependent decisions (Pinkham 2000).

Finally, while many environmental challenges face us today, they can provide opportunities to think outside our traditional modes of operation and employ meaningful techniques that lead to local and novel adaptations. In doing so, we establish the worth of personal experience, broadening the narrative to engagement, right through to citizen science and active community engagement.

Figure 9: Part of the research expedition involved the generation of a report for the John D. Watson family who sponsored the research and really enabled much of what came out of it.

Figure 10: These photographs highlight the important changing characteristics of the Shubenacadie system. Shifting between rural and urban with mixed uses shows the potential of each lock to become an anchor point for development and a place to gather.

Summary

From the lived experiences in Newfoundland and Nova Scotia, to the recorded history of the River Lea in London, each place highlights the potential to consider rivers as a type of inhabited infrastructure. The Muskrat Falls project highlights the river as a source of immense power, but approached from an environmentally unconscious space; the River Lea, a model for successive inhabitations; and the Shubenacadie as an under-utilized system industrially, environmentally, and societally. It is here on the Shubenacadie River that a finely tuned approach to environmental regeneration is tested with the integration of industry into the community.

Chapter 3: Local Context

Geology

The underlying geology of any place provides the foundation for a dynamic interplay between all of earth's systems in much the same way the foundation of a house provides a base for not just architectural elements, but for an engaged life itself. Fields of stone guide flows of water as it meanders, carves, and deposits material throughout the landscape. Geologic formations affect the availability of ground and surface water, impact the presence and biodiversity of fauna and flora, and ultimate influences the very extent of human settlement (Masoud 2021, 32).

Nova Scotia is bifurcated by the east-west fault line known as the Cobequid-Chedabucto Fault Zone (CCFZ). This zone separates the region into two major geological formations: the Avalon Terrane to the north, and the Meguma Terrane to the south. The entire Shubenacadie waterway from Dartmouth Cove to the Bay of Fundy, is located south of the CCFZ and intersects most of the geological groups identified within the Meguma Terrane.

Figure 11: Gypsum mining on the banks of the Shubenacadie (Nova Scotia Information Service 1965).

The roughly 50km northern portion of the Shubenacadie River, between its outlet at the Bay of Fundy and Grand Lake, can be largely characterized by the 350 million years old Early Carboniferous sedimentary formations of red sandstone, limestone, and shale, with mineral deposits of gypsum, anhydrite, and halite interspersed between the sediment layers. National Gypsum Canada operates a large gypsum/anhydrite mine just off the eastern bank of the Shubenacadie River in the town of East Milford, 35km south of the Bay of Fundy outlet. This region is also dominated by shallow undulations in the landscape and expansive flat regions which provide the conditions necessary for deposition of fluvial and alluvial soils, making this region an important agricultural area.

The southern Meguma Terrane is Early Cambrian geology from Grand Lake through Central Nova Scotia to Dartmouth Cove and is a largely homogenous group of slates that range in colour from black and greenish-grey to rust-brown with granite outcrops and periodic inclusions of siltstone, and fine-grained sandstone (Department of Natural Resources 1996). Gentle undulations and shallow folds create large, wide depressions where water collects and remains relatively stable in the form of a series of freshwater lakes which contributed to the rise of a rich and ancient history of water travel.

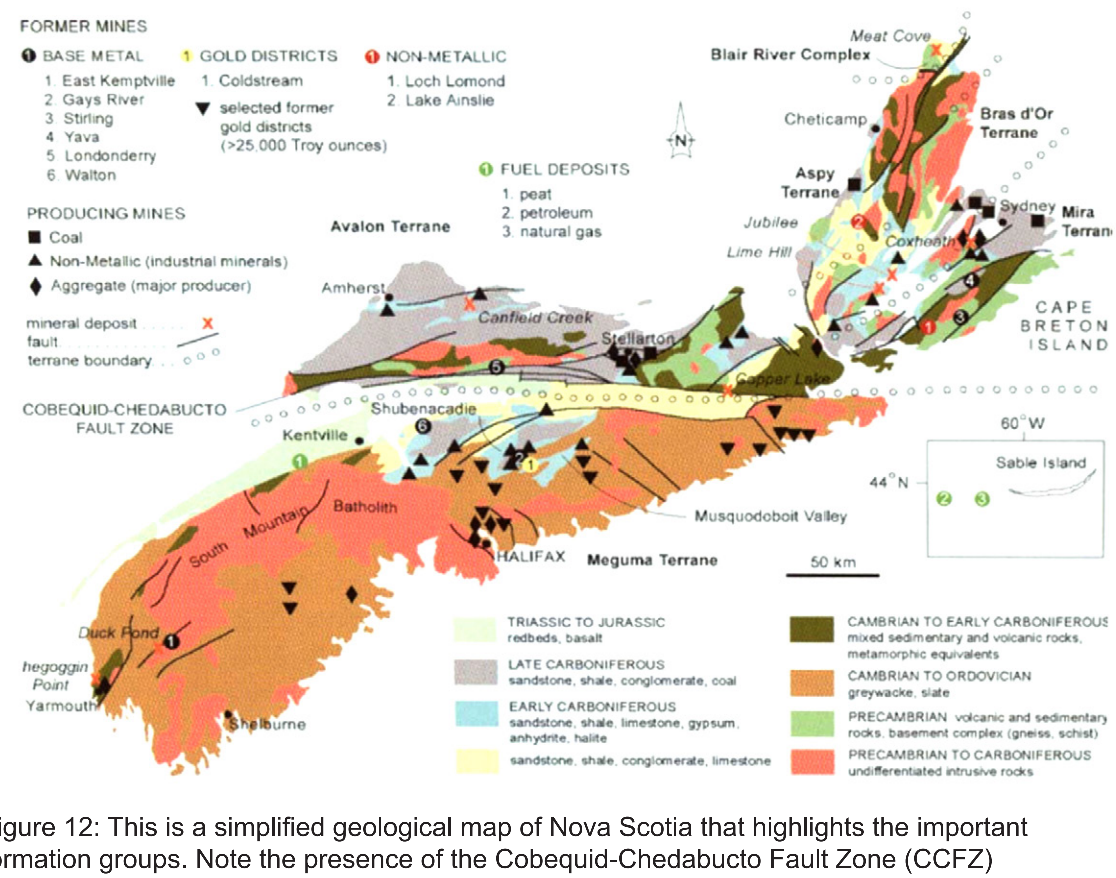


Figure 12: This is a simplified geological map of Nova Scotia that highlights the important formation groups. Note the presence of the Cobequid-Chedabucto Fault Zone (CCFZ) (Department of Natural Resources 1996).

Geology is an important foundational element in society; it determines what food is available, how the water flows over land, and organizes our building culture by responding to what is locally available. Regions with strong, robust geologic formations often use stone as a primary building source, while others may resort to a wood-dominated building strategy. In each case, utilizing the resources in your immediate vicinity is not just practical, it also enables the sustainable growth of communities grounded in a local material culture.

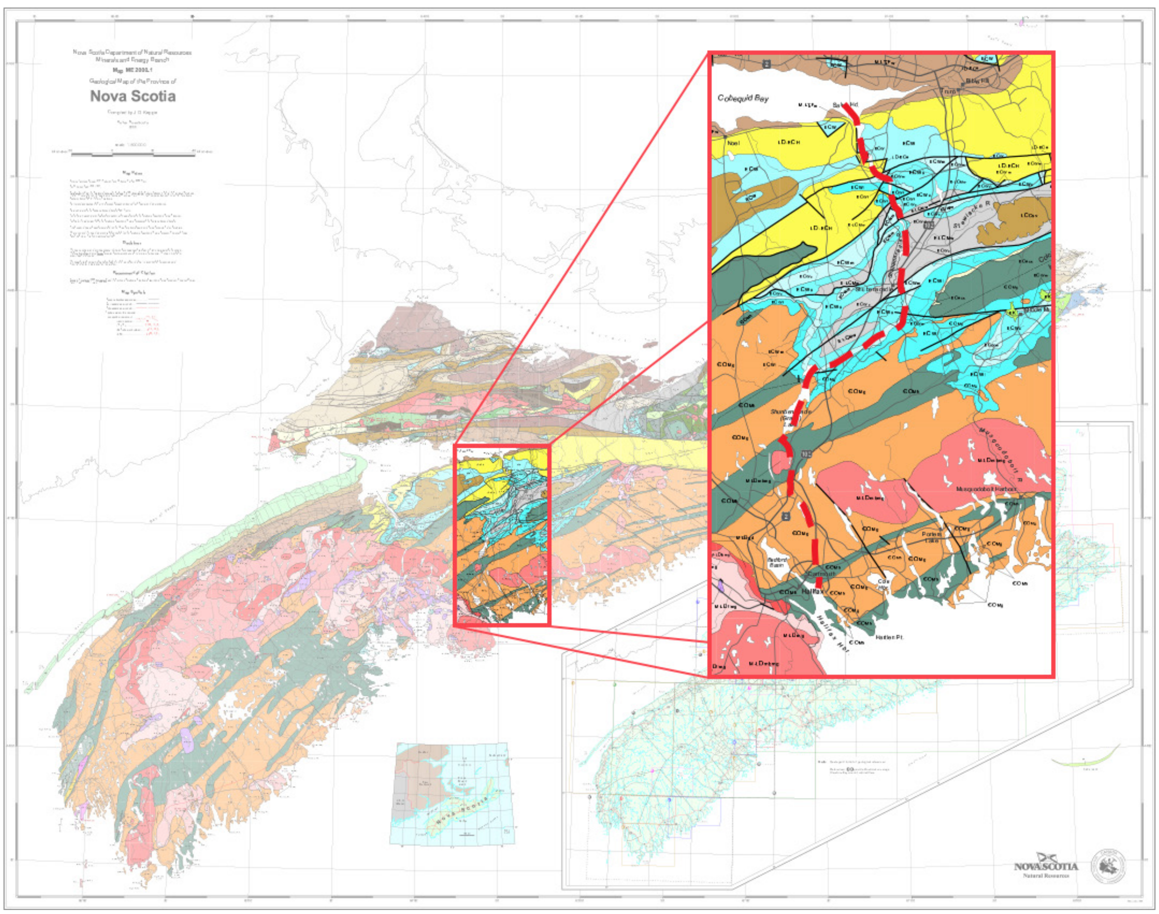


Figure 13: General path of the Shubenacadie waterway. This is important for understanding the baseline morphology of the region and gives clues as to what can be expected in terms of drainage potential and sediment loads (Base map adapted from White 2014).

Hydrology

Water is at the heart of many spiritual, mythic, and religious practices (Noah's Ark, Taj Mahal, Delphi, Glooscap, etc.) and we feel a deep sense of loss at its degradation (France 2003, 7). Therefore, it is imperative that when considering any design we consider the larger watershed boundary in order to bring a measure of clarity to a highly complex system and attempt to ensure that our interventions harmonize with the larger hydrological reality (France 2008a).

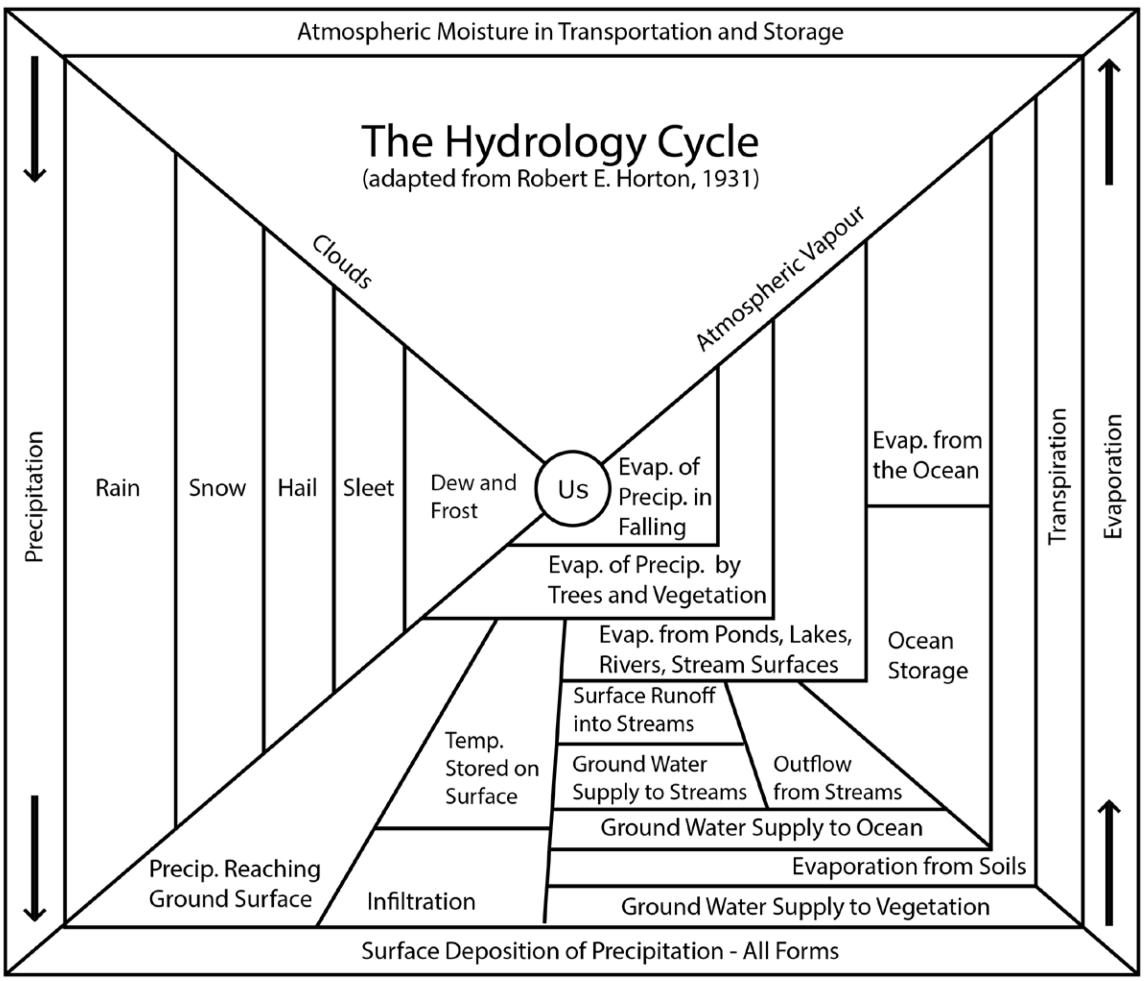


Figure 14: This hydrological cycle is adapted from Robert Horton's diagram first presented in 1931. Here I chose to include "us" in the middle for the simple fact that we are uniquely positioned to affect this cycle (for good or bad) more than any other creature.

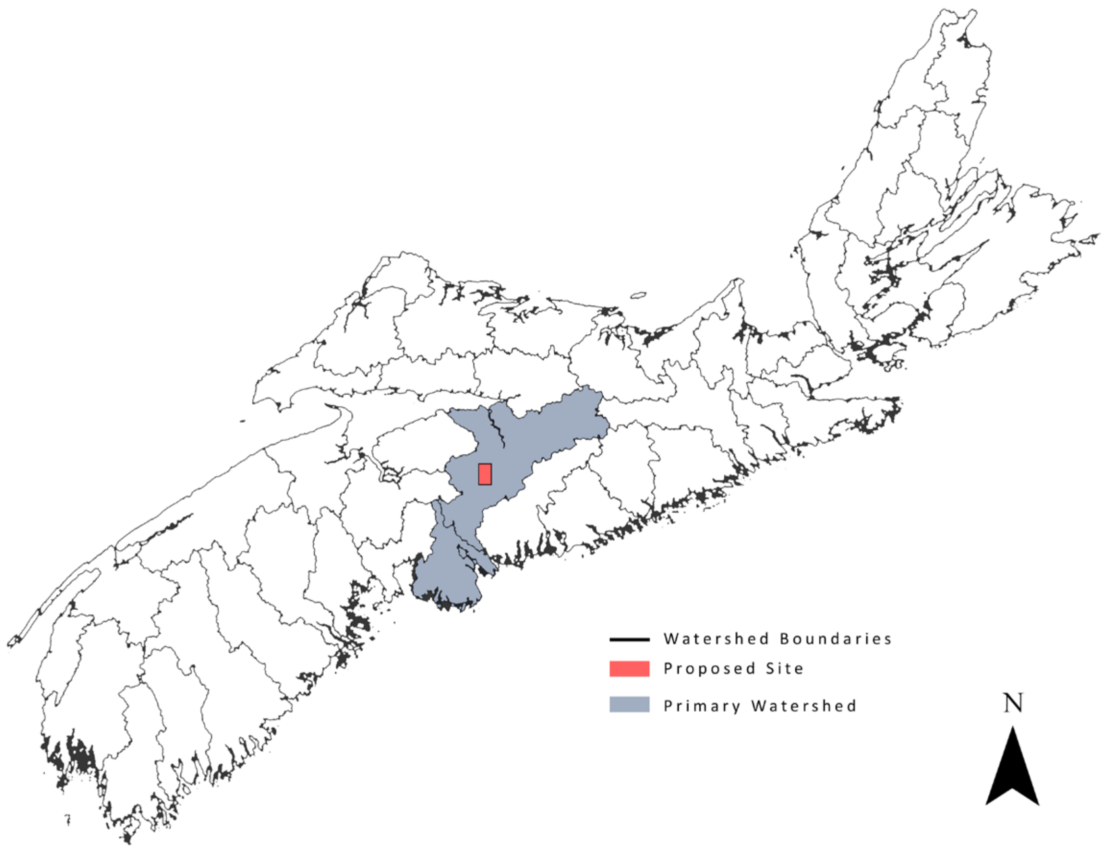


Figure 15: The approximate location of the proposed site in relation to the broader watershed boundaries of Nova Scotia (Base map adapted from Nova Scotia Environment 2011).

Nova Scotia sits at the eastern edge of Canada, with no one person more than 50km from the coast. It contains a vast array of bays, inlets, and coastal undulations as well as a large number of freshwater lakes and streams. The province contains 46 primary watersheds; areas of land that see all water flowing to the lowest point by way of rivers, streams, lakes, or underground. The lakes and rivers found in a watershed are primarily characterized by the underlying geology and geomorphology of the region but are also influenced by human activity.

The proposed site sits within the primary boundary of the Shubenacadie Watershed (seen in figure 15), which includes a portion of Dartmouth, East Hants, Milford, and up to the

Bay of Fundy region. A large portion of the neighbouring communities receive their freshwater from the series of lakes dotting the landscape near the Shubenacadie system, with Soldier Lake supplying reserve capacity for Dartmouth and Halifax. This puts added pressure on the water sources that drain in and out of the lakes and highlights the importance of ensuring that the streams connected to these water sources are of sufficient quantity and quality.

The watershed is interspersed with fields of forest that contain a mix of vegetation like spruce, pine, and fir (known locally as the Acadian Forest). Granite outcrops poke through from years of erosion and the region contains sand and siltstone of varying colour. There is also a mix of residential and commercial development, with residential dominating the main development type (Department of Natural Resources 2015). A major series highway and rail network also traverses through this watershed and frequently crosses over the main Shubenacadie waterway.

While every natural water system degrades and undergoes eutrophication – the mineral and nutrient enrichment of a system – not all degradation is naturally occurring. Human activity can have a tremendous effect on a system, overthrowing the harmonic balance of nutrient-load response, leading to an accelerated decline without any compensatory reaction; pushing the system beyond its natural management capacity and upsetting the natural “wildness” (France 2003, 36).

Hydrology of the region is a critical component of this thesis. The architectural exploration looks at ways of improving flow regulation through shielding, redirecting, and harvesting water toward improving environmental systems.

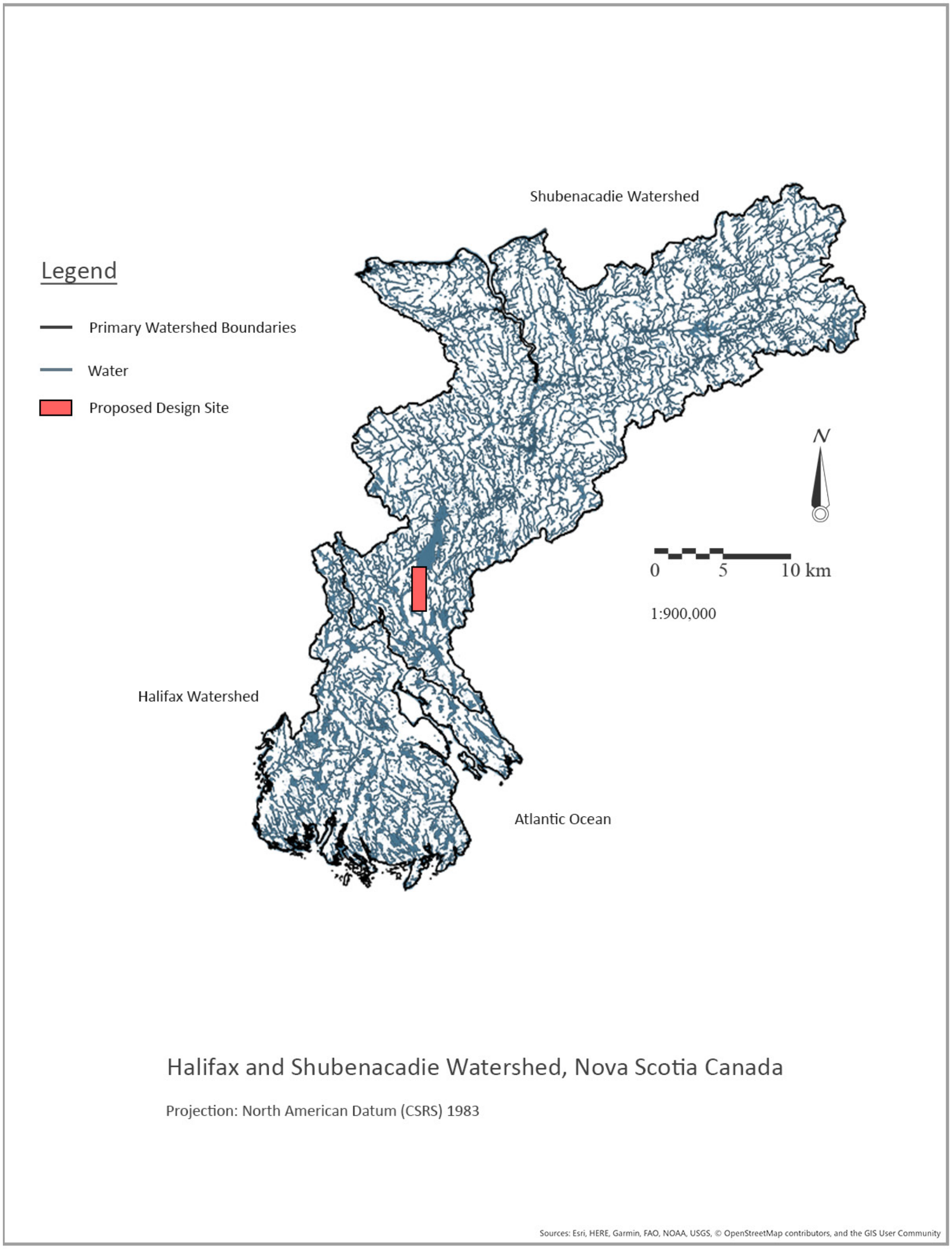


Figure 16: Location of proposed design site in relation to the two primary watershed boundaries of the entire Shubenacadie system - the Halifax and Shubenacadie Watershed. What becomes plainly obvious with this map is the extent to which the landscape is really a waterscape with a tremendous number of interconnected waterways moving precious liquid across the land (Base map by ESRI Openstreets, created using ArcGIS Pro).

Climate

Nova Scotia’s climate is largely mediated by its proximity to the Atlantic Ocean with areas further inland moderated by a more temperate, continental influence. Formally, the province is classified as Humid Continental - Dfb on the Köppen-Geiger system - with places like Vermont, US, and Sapporo, Japan sharing the same type of climate. Prevailing winds for the region range from south/southwest during spring and fall, and west/northwest the rest of the year. Winters in this area will experience storms called Nor’easters, which bring harsh winds and precipitation from the northeast. Less frequent are the warmer month storms like hurricanes and tropical storms, though according to the most recent report by the IPCC, hurricane/tropical storm intensity is likely to increase, highlighting the importance of protecting our natural systems from extreme weather inundation (Seneviratne et. al. 2021). Summer temperatures have been increasing in recent years and threaten the shallow lakes and streams that rely on cooler temperatures which prevent water quantity disturbances from evaporation. This is especially important in urban areas where ambient air temperatures are rising on average, in addition to streamside vegetation being removed for development, further increasing the temperature of the immediate area, and significantly contributing to the eutrophication of the system.

Future trends for the area indicate an increase in temperature and a slight increase in rainfall. This has the potential to add more stress to buildings which in turn demands more robust materials and architectural organization. We must adapt to the changing circumstances and in doing so, hope to achieve harmony with our environment.

Very Hot Days

*Temperatures in excess of 35 degrees Celsius

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (days)	0	0.1	0.3	0.9

Very Cold Days

*Temperatures in less than -20 degrees Celsius

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (days)	0	0	0	0

Hot Days

*Days max temperature exceeds 30 degrees Celsius

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (days)	2.4	5.2	9.7	16.1

Cold Days

*Days max temperature is less than -10 degrees Celsius

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (days)	4.6	3.6	2.2	1.4

Temperature

*Mean of monthly minimum and maximum temperatures in degrees Celsius

Season	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Winter	-4.1	-2.9	-1.5	-0.2
Spring	4.2	5.1	6.2	7.4
Summer	16.9	17.9	19	20.1
Autumn	8.8	9.8	11	12.2
Annual	6.4	7.5	8.7	9.9

Water Deficit

*Amount of available water that fails to meet the demand computed by subtracting potential evapotranspiration from actual evapotranspiration.

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (mm)	36	40	48.8	57.9

Figure 17: Climate data generated by the Meteorological Service of Canada at Environment Canada using the CGCM1 (Canadian Global Climate Model) (www.climatechange.novascotia.ca)

Days with Snow

*Days of snow on a monthly basis averaged over 30-year period

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (days)	44.8	52.4	45.3	38.5

Days with Rain

*Days of rain on a monthly basis averaged over 30-year period

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (days)	131.6	142.4	146.5	150.3

Freeze Free Season

*Days when daily mean temperature is above 0 degrees Celsius

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (days)	200.2	222.2	242.2	259

Growing Season Length

*Days between dates where daily mean temperature exceeds 5 degrees Celsius

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (days)	179.9	192.2	209.2	226.1

Precipitation

*Average accumulation on a seasonal and yearly basis in mm (includes all forms of precipitation)

Season	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Winter	382.1	398.4	407.7	428.1
Spring	327.4	337.8	343.1	356.3
Summer	277.4	282	280.1	280.4
Autumn	365	368.1	367	374.2
Annual	1351.8	1385.2	1396	1435.3

Change in Intensity for Short Period Rain

*Percentage change in 20-year period of 24-hour precipitation currently used in building design.

	Historical 1980s	Projected 2020s	Projected 2050s	Projected 2080s
Annual (percent)	0	5	9	16

Figure 18: Climate data generated by the Meteorological Service of Canada at Environment Canada using the CGCM1 (Canadian Global Climate Model) (www.climatechange.novascotia.ca)

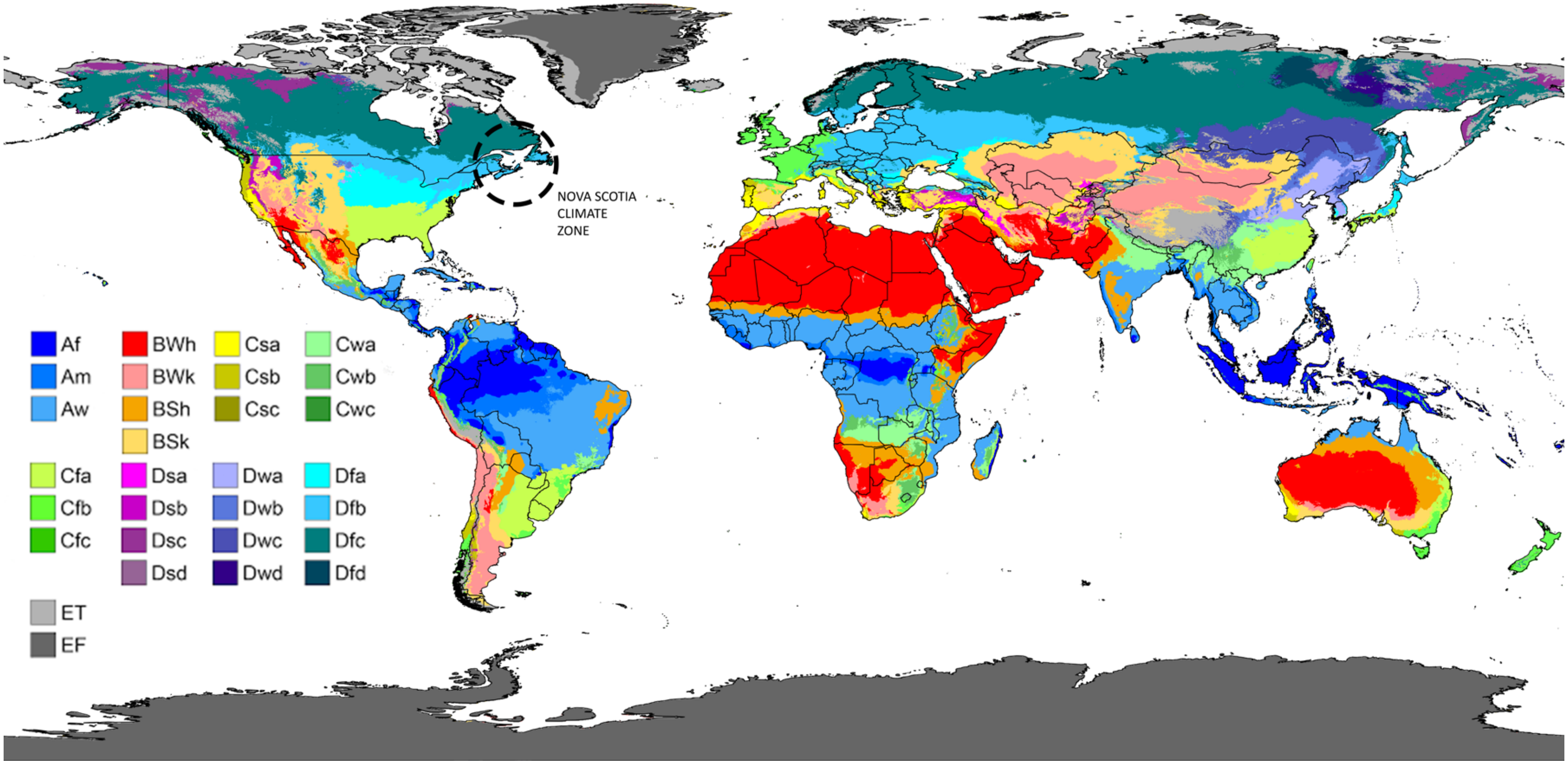


Figure 19: Köppen-Geiger Climate Classification Map (Wikipedia 2018).

Industry

Through the spirit of Ian McHarg, I find myself asking – what does the future look like? (McHarg 2006, 28). The Shubenacadie River valley is a rich, fertile resource and could be utilized toward a positive, pro-human future for Nova Scotia; a future that does not just pit one side of society as for something and the other side as against, but in a cooperative engagement that advances the life of all society. We are all inheritors of the place we call home, and as such have a duty to not merely preserve what is already here, but to correct any wrongs and attempt to leave a better place for the future (McHarg 2006, 31).

In 1942, Peter Drucker wrote an essay called “The Future of Industrial Man”, which highlights a great many insights into the realities of the second world war and of the times, but most importantly emphasized a major shift in the organization of society, one that would see us as a “subsidiary source of power” to industry (Drucker 1995). Society in nineteenth and twentieth century Britain and her Commonwealth nations, although firmly rooted in the industrial age, were still organized under pre-industrial ideals; society was organized around mercantilism, with manufacturing and energy production kept hidden from everyday life often in the way and to the detriment of the local Indigenous populations.

Under pre-industrial frameworks industry is outsourced away from our everyday lives by greater and more efficient systems; systems developed by corporations that generate social agendas designed solely for maximizing profit. A community prospers under pre-industrial frameworks insofar as the benefit generates profit, and positive community development is ultimately contingent on its ability to generate wealth. This is the modern manifestation of corporate capitalism, one that is unconcerned with the spiritual effects industry could have on the development of communities. As Marx writes:

> We can see how the history of industry and the objectively developed existence of industry are the opened book of human capacities, which is human psychology sensuously considered. Up to now industry has not been regarded in connection with the essence of man but has always been regarded only in terms of external relations of utility. (Marx 1844, 47)

The reintroduction of canal infrastructure in Fall River provides an opportunity to re-engage the industrial mindset; to accept that in order to prosper we must alter our land and waterscapes, but in a way that is hydrologically sensitive and responsible to the local community. Here, industry is viewed not merely for its utilitarian purpose but as a necessary act of living in a community where its success is tied to the degree to which industry is integrated into the surrounding environment. No longer is industry outsourced, but is instead brought into the home for all to see.

It is tempting to consider this project a type of “restoration” but to do so would be a categorical mistake for to restore would be to return to the very conditions that set us on our path of destruction and neglect; we must regenerate the systems of our land and waterscapes, and in doing so hope to regenerate ourselves too (France 2008b, 62).

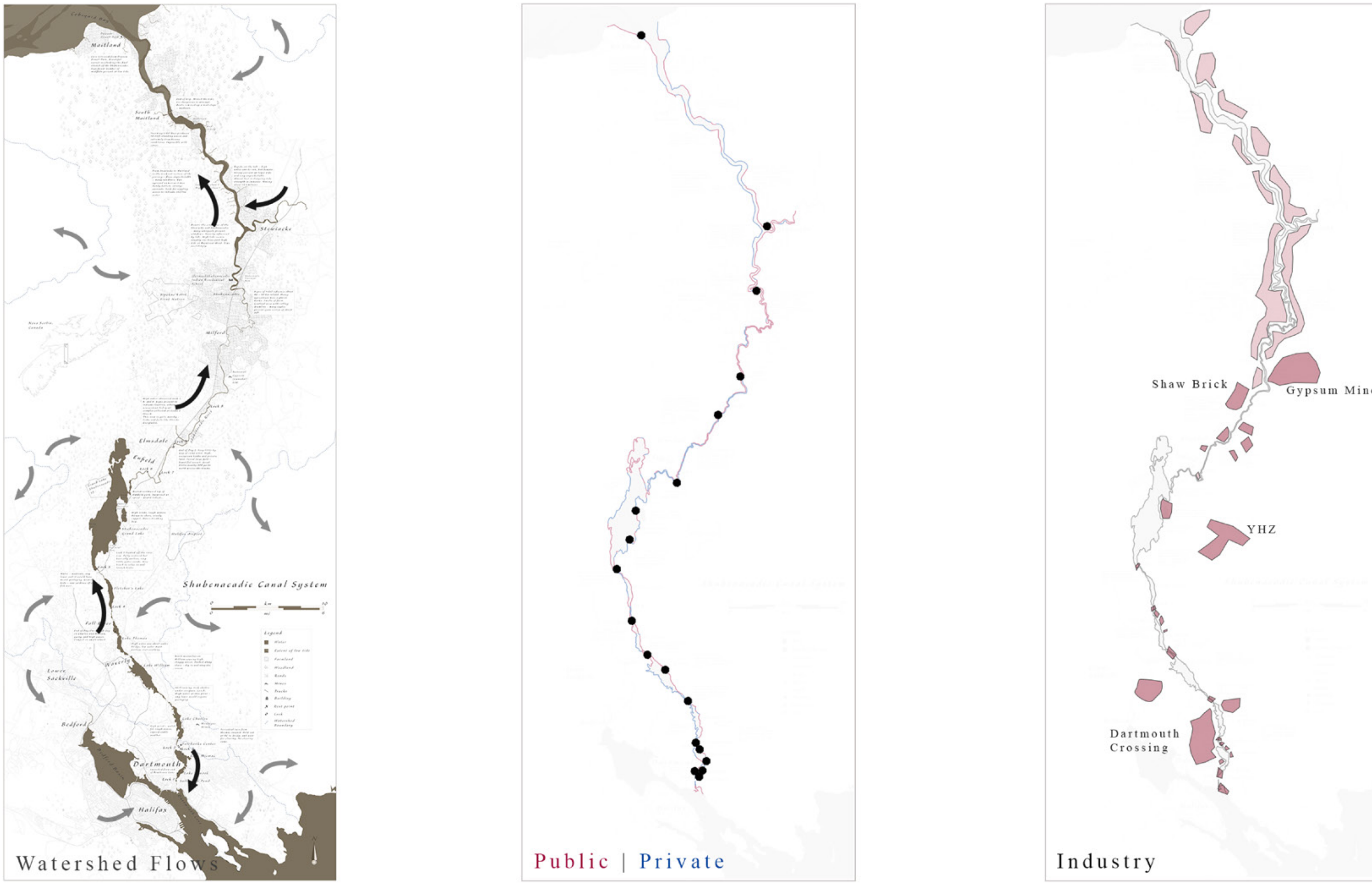


Figure 20: A series of maps developed from the journey through the Shubenacadie River system. They highlight the interconnectedness of our systems and ways of life; public and private realms are woven through a patchwork of industry, while the environment around us fills in the gaps.

Canal Development

Figure 21: Early depiction of the seal used by the Shubenacadie Canal Company in 1826 (Shubenacadie Canal Commission 2019).

The history of the Shubenacadie Canal system is an interesting story related to the economic and environmental inevitabilities associated with such a large and expansive project. The original plans called for 19 locks with 7 locks occurring before Lake Banook, some few kilometers from Dartmouth Cove. Additionally, the challenging winter freeze-thaw cycles complicated construction and the spring Freshets frequently caused work to halt, and in some cases required reconstruction of entire lock sections (Shubenacadie Canal Commission 2019). To make matters worse, the canal began construction at precisely the same moment that the railway system was being planned and developed, which would quickly supplant the need for an inland waterway. By 1858 the railway had already solved much of the logistical challenges of cross-province travel with a journey from Dartmouth to Windsor that would take approximately two and a half hours - a canal journey that would take roughly 8 days, three years later. Additionally, the railway absorbed most of the skilled labour and high-quality timber necessary for successful canal construction, making the project that much more impossible. After three generations of family struggle, the Fairbanks' dream of a complete and operable Shubenacadie Canal was laid to rest.


Figure 22: Section of Lock 2 of the Shubenacadie Canals seen in 2020.

The story of the Shubenacadie is interesting because it highlights the desire for an integrated and functional canal system, but without the true need for a definitively resourceful one. By reintroducing a portion of the canals, as opposed to a full-scale network, we improve the odds that the system will be absorbed and integrated into the surrounding community. The infrastructure remains in place, partially preserved, but continuing to degrade; by building on the past, the community feels an immediate connection to the infrastructure, and the system is therefore more likely to be maintained and remain functional into the future.

Figure 23: Early map by Hall of the Shubenacadie River showing the challenging changes in elevation (Nova Scotia Archives 1848).

1796	Province approves a feasibility study for a canal system moving from Dartmouth to Maitland.
1798	Feasibility study debated but ultimately shelved.
1824	New feasibility study ordered by the Province led by Francis Hall. New plans included 19 locks.
1826	June 1st, Shubenaccadie Canal Company is formed led by Michael Wallace as president, Francis Hall as Chief Engineer, and Charles Rufus Fairbanks as secretary and primary financier.
1826	July 25th, work begins on the canal with a ceremony in what is now Shubie Park.
1828	Project severely overbudget due to unpredictability of Nova Scotia freeze-thaw cycles affecting masonry.
1829	Charles Rufus Fairbanks sails to England to secure more funding by mortgaging the canals future profits.
1831	Problems ranging from poor weather, poor work, and design failures began to seriously affect canal construction.
1832	England appoints Royal Engineers to inspect the canal project and report major deficiencies and incredible cost overruns.
1841	Charles Rufus Fairbanks dies.
1845	England forecloses on its mortgage and the project is stopped.
1854	Charles William Fairbanks, son of Charles Rufus Fairbanks is appointed Chief Engineer by the newly formed Inland Navigation Company and construction resumes on the canal.
1857	The steamship Avery launched and later in the year the Portobello marine railway began operating.
1858	Charles William Fairbanks resigns as Chief Engineer.
1858	The Avery completes a full run of the entire system taking a full 8 days.
1865	Position of Lock Keeper is removed owing to financial problems.
1870	Lewis Fairbanks, son of Charles William Fairbanks buys the canal from the company. Shortly after the purchase, the canal collects its last toll from a lumber shipment.
1905	Lewis Fairbanks dies, and with him the multi-generational dream of a complete Shubenacadie Canal system. It would not be revived until well past the middle of the 20th Century with the formation of the Shubenacadie Canal Association in 1964.

Figure 24: Timeline of major events during the development of the Shubenacadie Canals.

Cartographic Analysis

What's in a Name

Cartography is an ancient art that is heavily steeped in the political and territorial ambitions of those that seek to understand the land and water they explore. Not unlike architecture, cartography begins with the drawing of lines as the mapmaker attempts to define space, capture physical realities, and hide or reveal certain 'truths' (Wilmott 2020, 14). Early cartographic representations of places often began with the drawing of boundaries between major physical land and waterscape features; rivers, mountains, and forests are separated into fields where hard boundaries can be drawn, often ignoring the ecological, cultural, and indeed spiritual realities of a place (Wilmott 2020, 80). This is particularly evident in the names used by western explorers who would name "new" places according to people or things of prominence from their own cultures, often without realizing the origins of their own names and simply imposing them onto others. What is lost through imposed place names are the stories and experience of a particular place that leads to a deeper understanding of our origins.

We should endeavour to recognize that maps signify meaning which is often tied to the lived experience of the people that dwell in a particular place; they hold truths and reveal intentions which can be a powerful reminder of what binds us together - our experiences (Wilmott 2020, 72).

Mapping Fields and Flows

Upon completion of the three-day canoe journey through the Shubenacadie River, an annotated and hand drawn map of the entire system was made. This map shows the locations of canal infrastructure, watershed boundaries, neighbouring communities, farmland, forested regions, and major building structures. The map is also annotated with small notes reflecting on moments of particular interest from that days' journey. By retracing lines drawn by our canoes, the map becomes a reference to history, to experience, and most importantly, to the water. The water in this context is used as a source of recreation, and specifically as an "agent of postmodern connectivity" (France, 2003, 3). We no longer rely on the waterway as a matter of livelihood, or as a necessary object of industrialization; we instead move through the system as mere spectators, eager to reach back and connect with those that have felt its current before. The map also has another use, one of increased awareness to the cultural and ecological importance of such a system. As France writes:

> ...the process of conceptually and physically revitalizing water must develop through an increased awareness of its presence in our environments and in our lives. This is critical, for one does not protect what one does not love and respect, and one does not love and respect what one does not first recognize. (France 2003, 100)

The completion of this map also helped push the fields of understanding further by developing a new water-system diagram for the entire network. Taking inspiration from the systems map developed for the River Lea, this map was then used to further analyze interactions between road, rail, bridge, and trail infrastructure interfacing with the Shubenacadie system. Sections are called out according to their dominant context, (Lake, Urban, etc.) revealing overlapping fields that provide opportunities for architectural intervention.

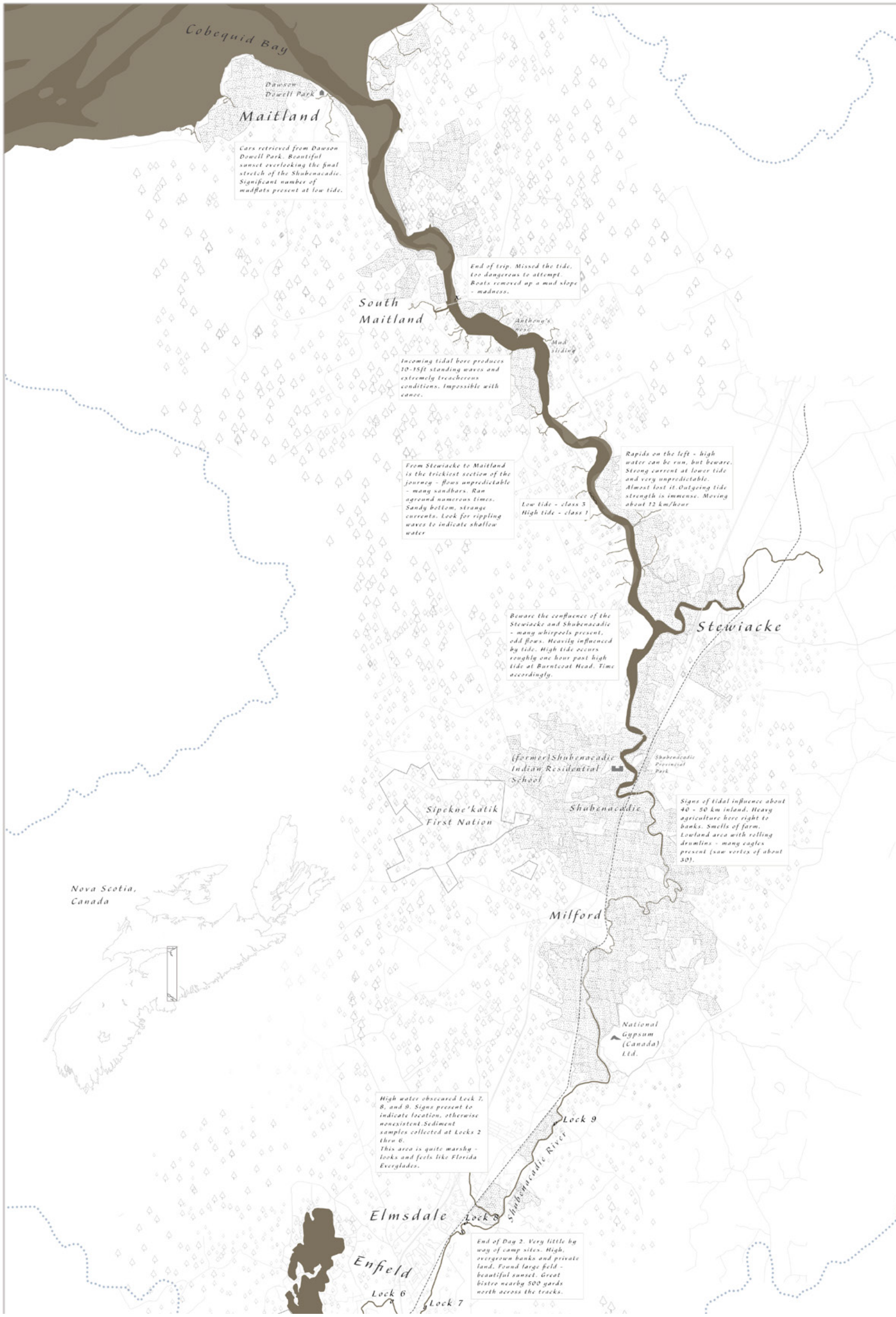


Figure 25: Top-half of an annotated and hand-drawn map of the Shubenacadie waterway.

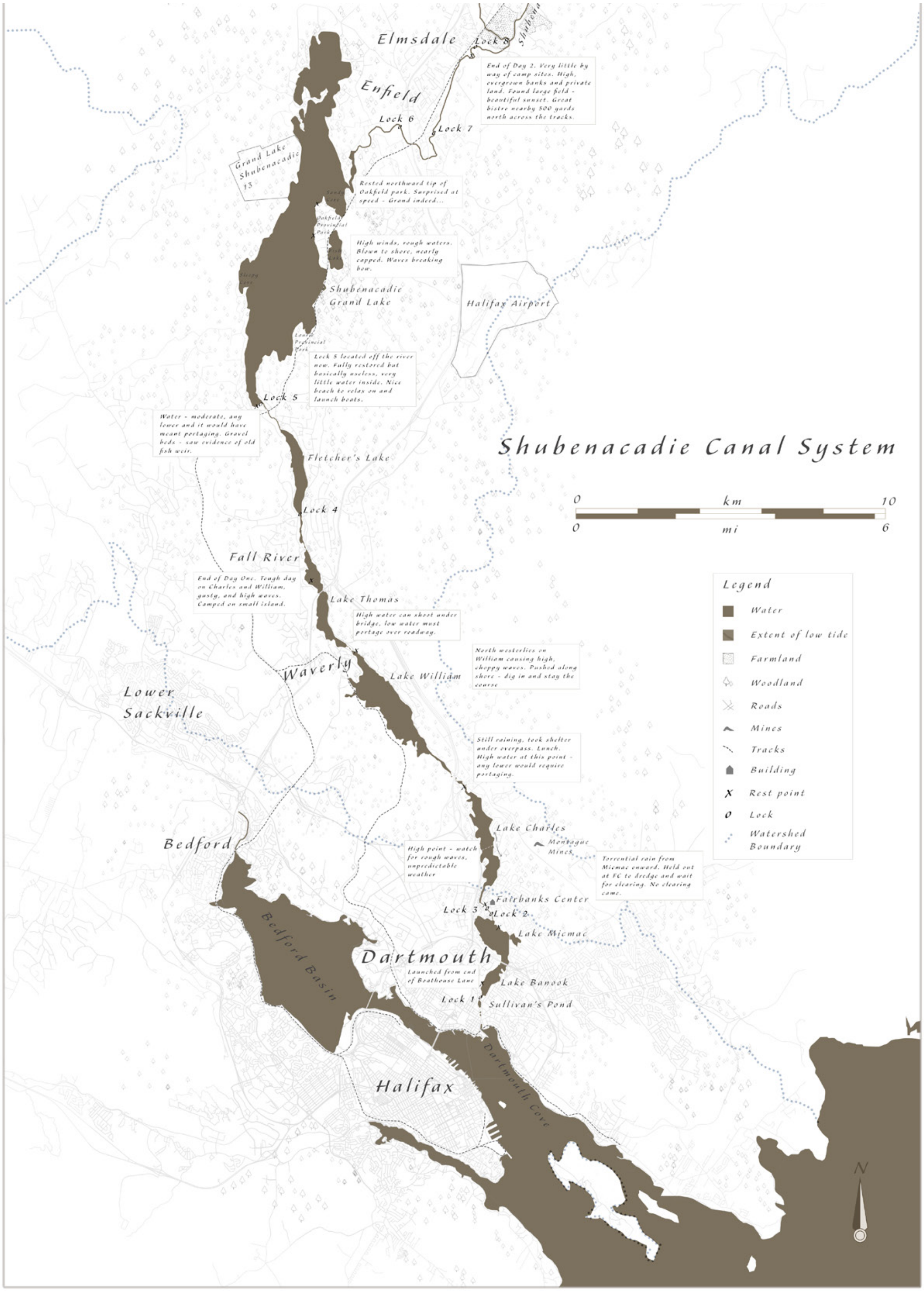


Figure 26: Bottom-half of an annotated and hand-drawn map of the Shubenacadie waterway.

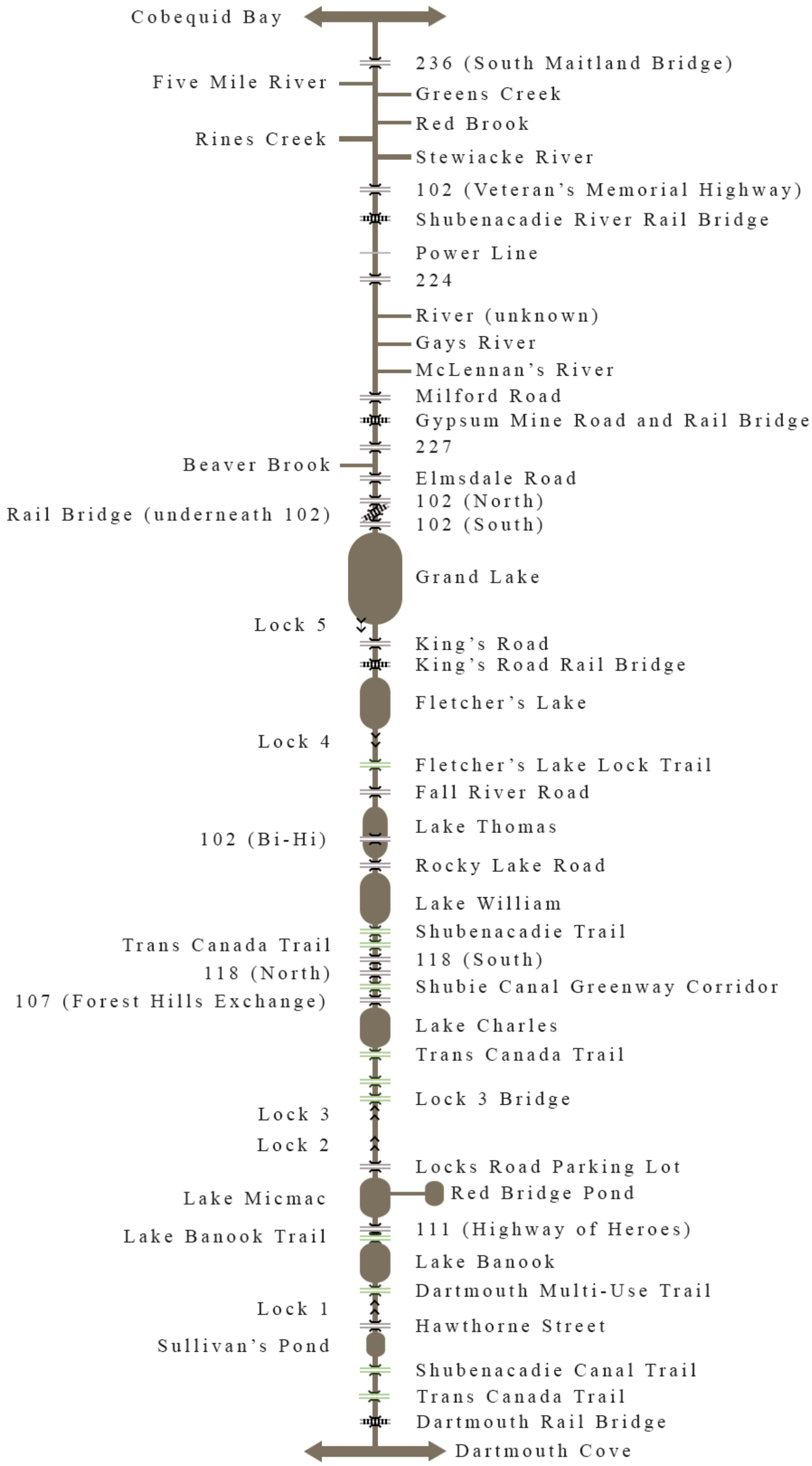


Figure 27: Systems map of the Shubenacadie waterway from Dartmouth Cove through to Cobequid Bay in the Bay of Fundy. Inspired by the River Lea systems map.

Mapping Cultural, Social, and Environmental Significance

Complimenting the hand drawn map of the Shubenacadie River system is a map developed from the results of online and in-person surveys conducted throughout the region. The surveys were conducted by the Halifax Green Network Plan which used 39 metrics associated with social and culturally important items: things like ecological diversity, archaeological significance, historical significance, natural reserves and much more. The more overlapping items in a particular area, the darker the colour. As can be seen from the map, the proposed design site reveals significant overlap indicating a socially, culturally, and environmentally important location. In fact, if we look throughout the map, we can see that the areas with the most overlapping interests are nearly all surrounding water. This mapping exercise strongly emphasizes the true extent of our hydrosocial condition and provides opportunities to position architecture and design within a framework that is both ecologically sound, and in the service of the ordinary citizenry.

The modern function of cartography is to represent the interests of not just the mapmaker, but of the mapped themselves. From a map developed from lived experience, to a hyper-virtual representation of human interests, mapping a place encourages one to understand the needs of the local community. Through mapping the experience of the Shubenacadie River, an embodied understanding of the system is attained and the lack of supporting community infrastructure like poor access to the water, and inadequate public facilities is made evident. The map then becomes more than just a record of conditions, it becomes a tool for improving lives.

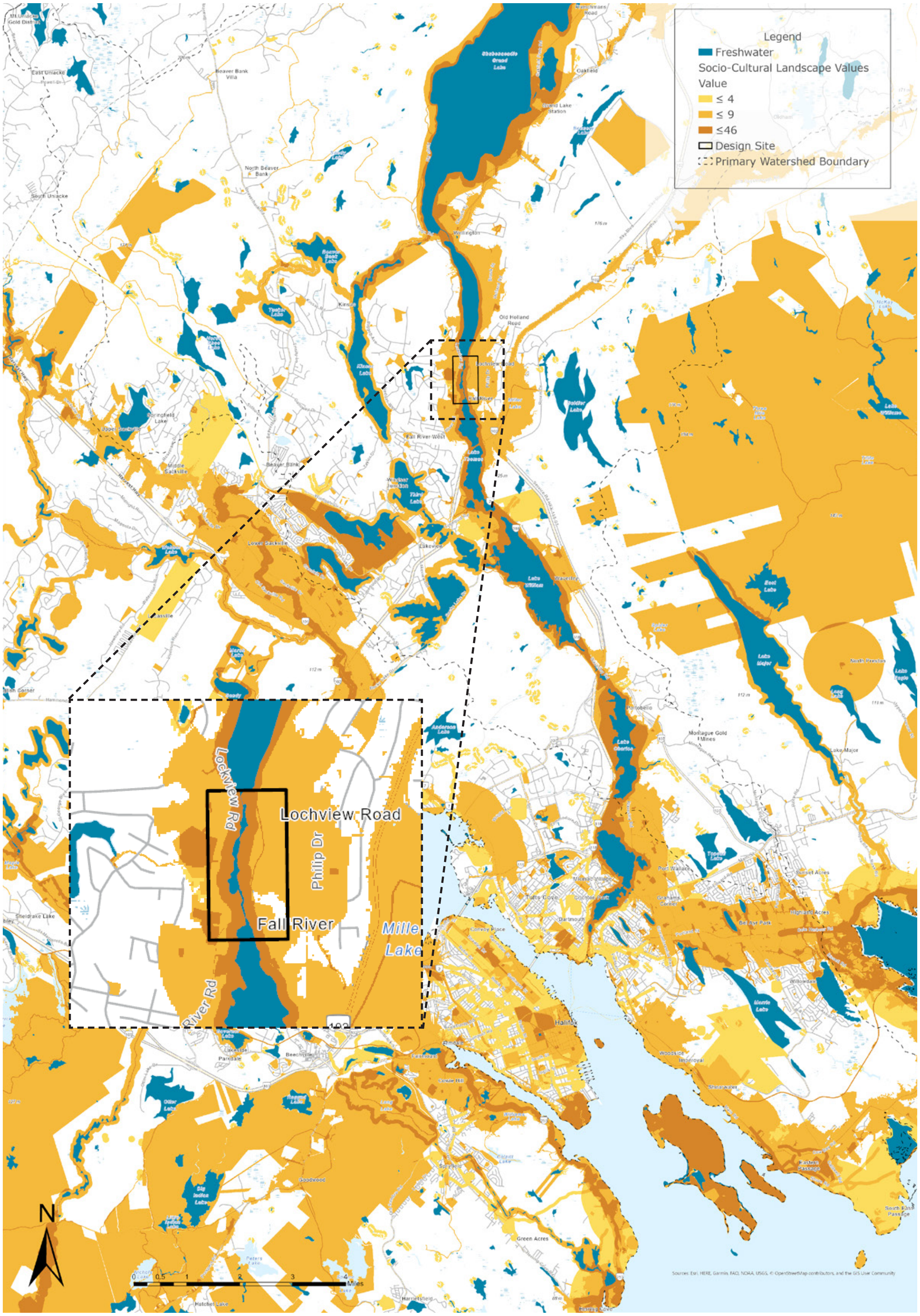


Figure 28: The socio-cultural landscape in relationship to environmental values. Map generated in ArcGIS.

Chapter 4: Design

Proposal

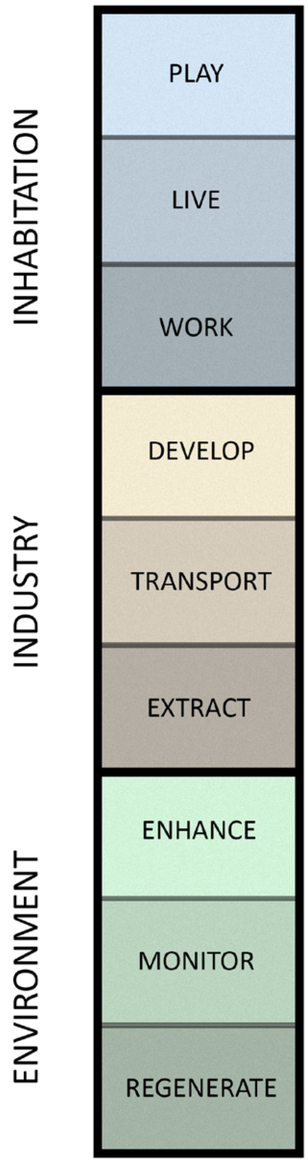


Figure 29: Program diagram

This thesis proposes a type of township development that integrates industry with water-based communities toward the promotion of healthy natural systems. The proposed site is centered on a kilometre long section of a sediment filled, shallow river that was once part of a canal network in the rural community of Fall River, Nova Scotia. Surrounded by dense woodlands, and nestled between two freshwater lakes, this site is explored through the lens of three tenets: *industry*, *inhabitation*, and *environment.* Utilizing past physical and academic research, each tenet is looked at in the context of the broader Shubenacadie canal network and seeks to demonstrate how we might mediate the water/society relationship through the introduction of industry as a byproduct of environmental management.

Materiality in this thesis is context-driven, and is explored from the macro application of rammed earth to the micro creation of glass. Products of erosion are recompressed into a multiscale framework of architecture. Architectural development is done through cartographic site analyses and by investigating discrete fields of activity overlaid by continuous flows of people, material, and natural systems. The industrial use of sediment is then tested at the architectural scale, making room for inhabitation, and supporting various environmental and community-based needs.

Site Analysis and Selection

The design site is located in Fall River, Nova Scotia; a small suburban community of about 2500 people and approximately 15 square kilometers in size. The town was founded in the late 1700's as a small outpost community in support of the interior development of the province. The town is situated between two large lake reservoirs - Lake Thomas to the south, and Lake Fletcher to the north - with a degraded and infilled canal system moving between reservoirs. The river empties into Lake Fletcher through a small set of rapids and the location of Lock 4 of the Shubenacadie Canal system is offset from the main run, acting as an overflow weir in times of high water. The lock was constructed using large ashlar stone masonry that is cut and neatly fit with wood piles providing internal support to act as bracing against frost heave. Here, the dilapidated canal is re-established, which generates a need for systems of management. Canal locks are built and a system of maintenance by way of canal dredging is established. Canal dredging is a necessary maintenance act which generates sediment as a waste-by-product, making way for local materials to become a catalyst for industry.

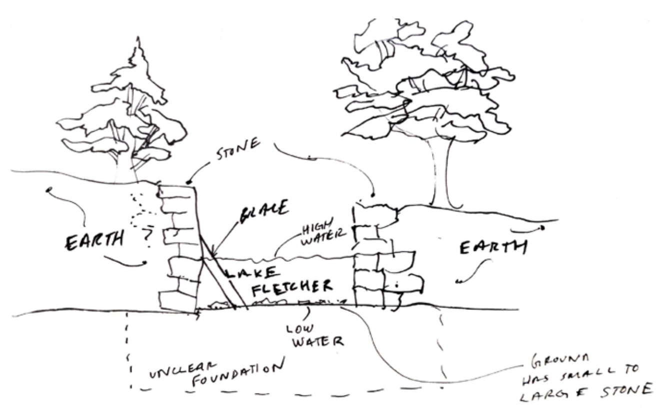


Figure 30: Section sketch of Lock 4. The river has been altered to run through a set of shallow rapids to the West of the lock. However, lock 4 is still used in the winter months as an overflow weir channel.

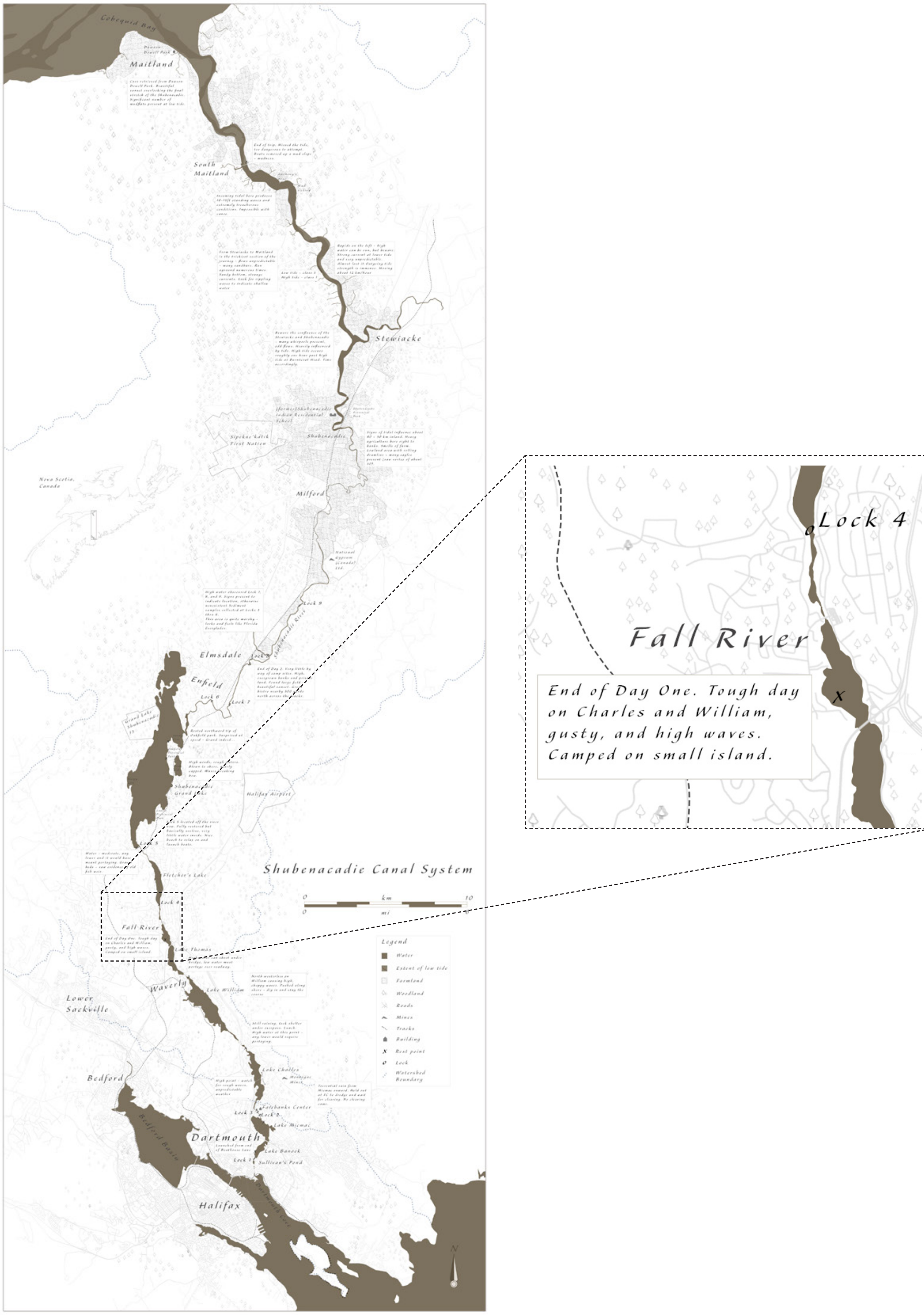


Figure 31: Location of proposed design site.

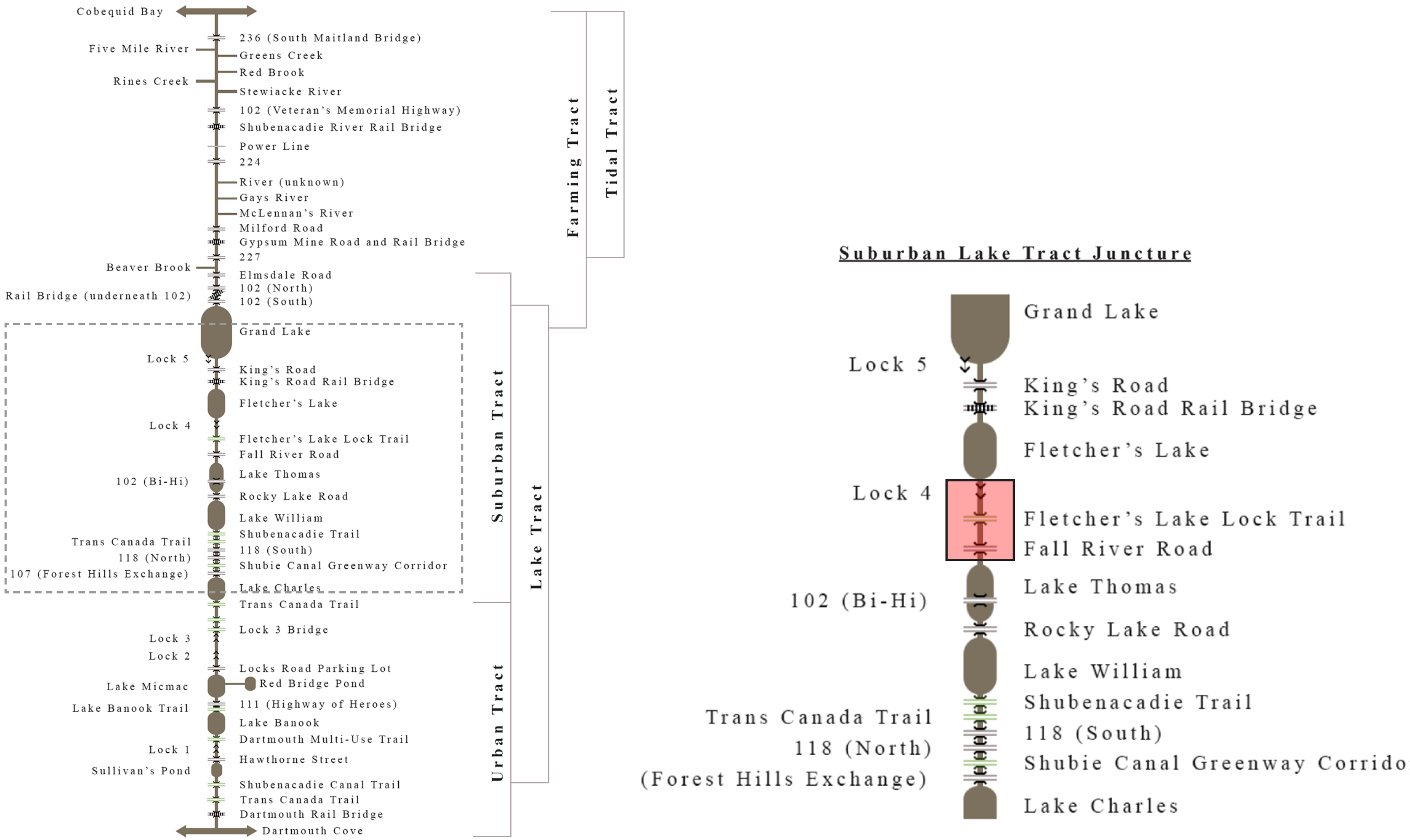


Figure 32: The systems map here shows the location of the proposed design site (in red) in relation to the overall context of the system. Additionally you can see the approximate locations where the dominant underlying cultural context shifts to better align with the community. For example, the "Lake Tract" area is a dominated by several boathouses with extensive boating communities that live, work, and play on the lakes.

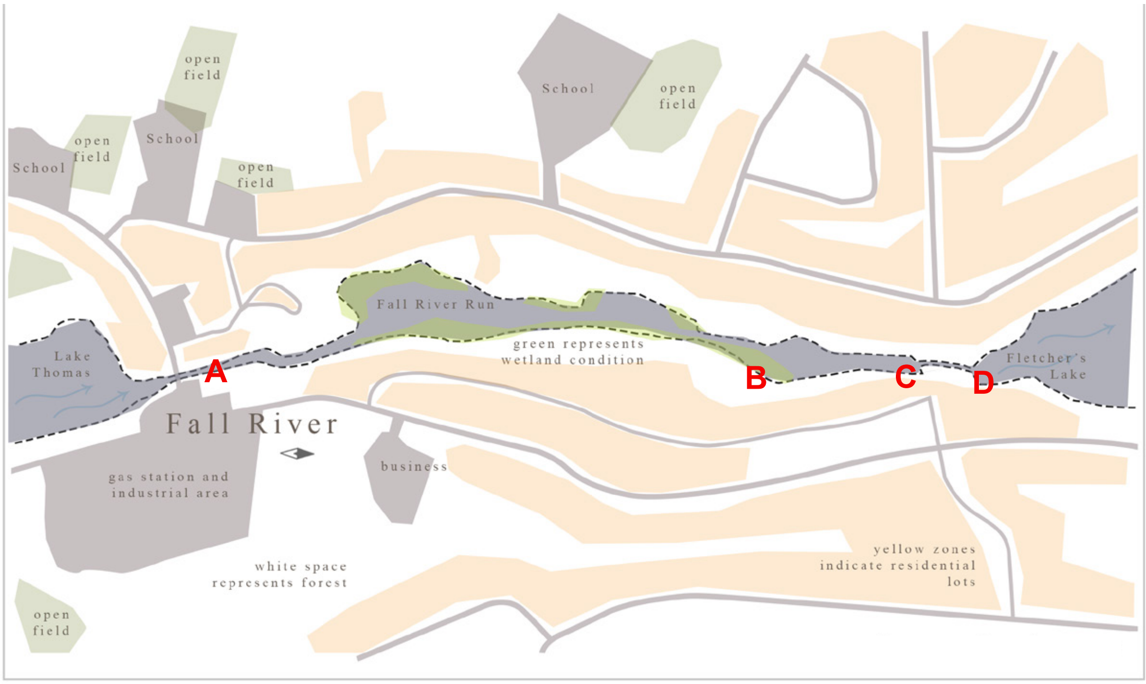


Figure 33: Overall site plan for proposed design. This is important for understanding the baseline morphology and ecology of the region.

Figure 34: Location A - Bridge showing high water

Figure 35: Location B - Flooded forest

Figure 36: Location C - Submerged dock

Figure 37: Location D - Lock 4 overflow

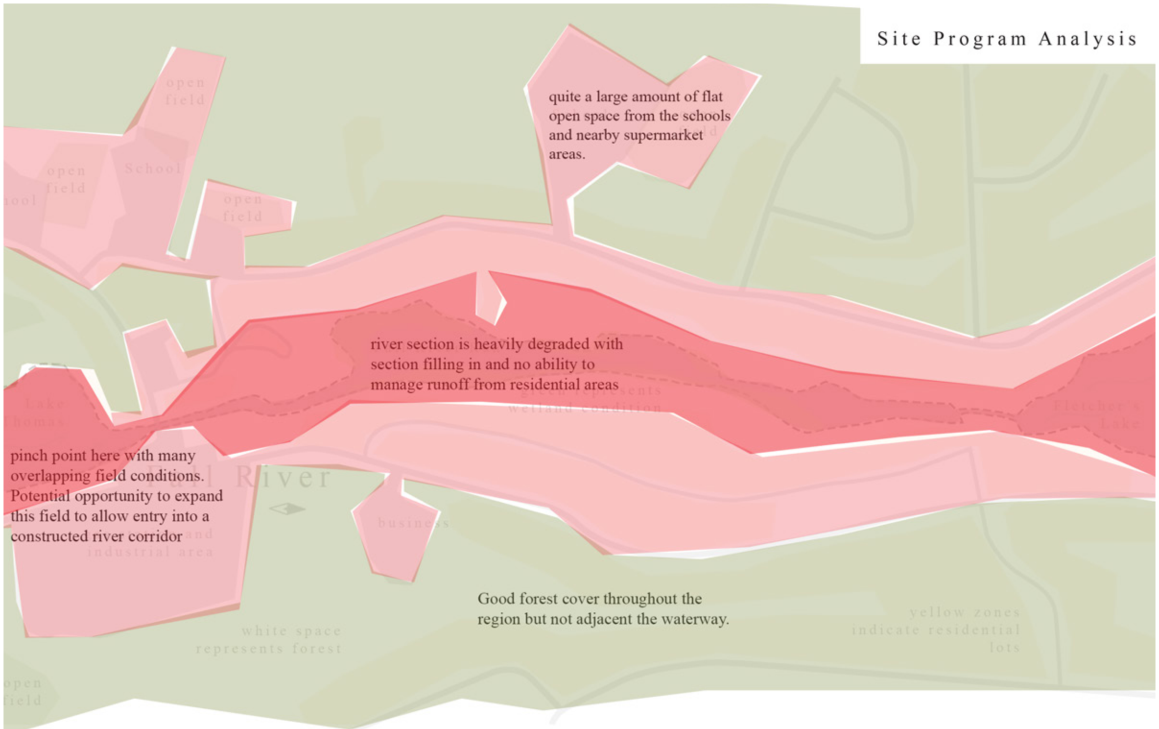


Figure 38: Investigating delineating factors and organizing sections into fields of interpretation.

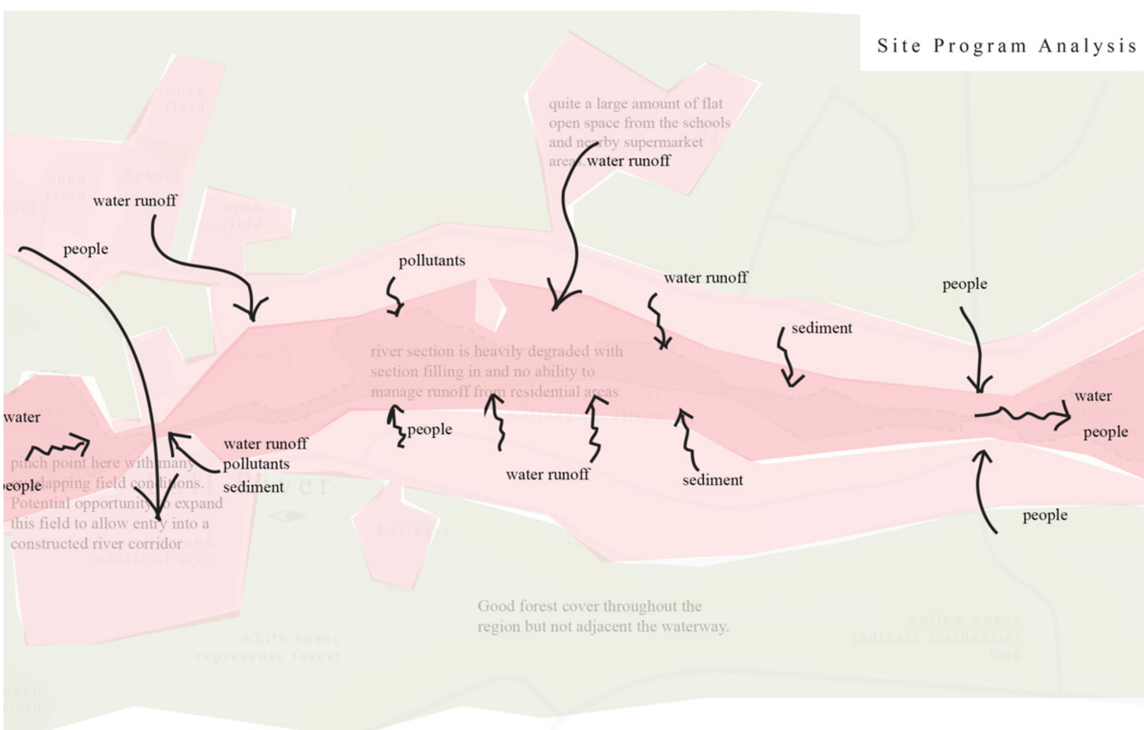


Figure 39: Overlaying flows to determine intersecting priorities used to identify potential sites of architectural intervention.

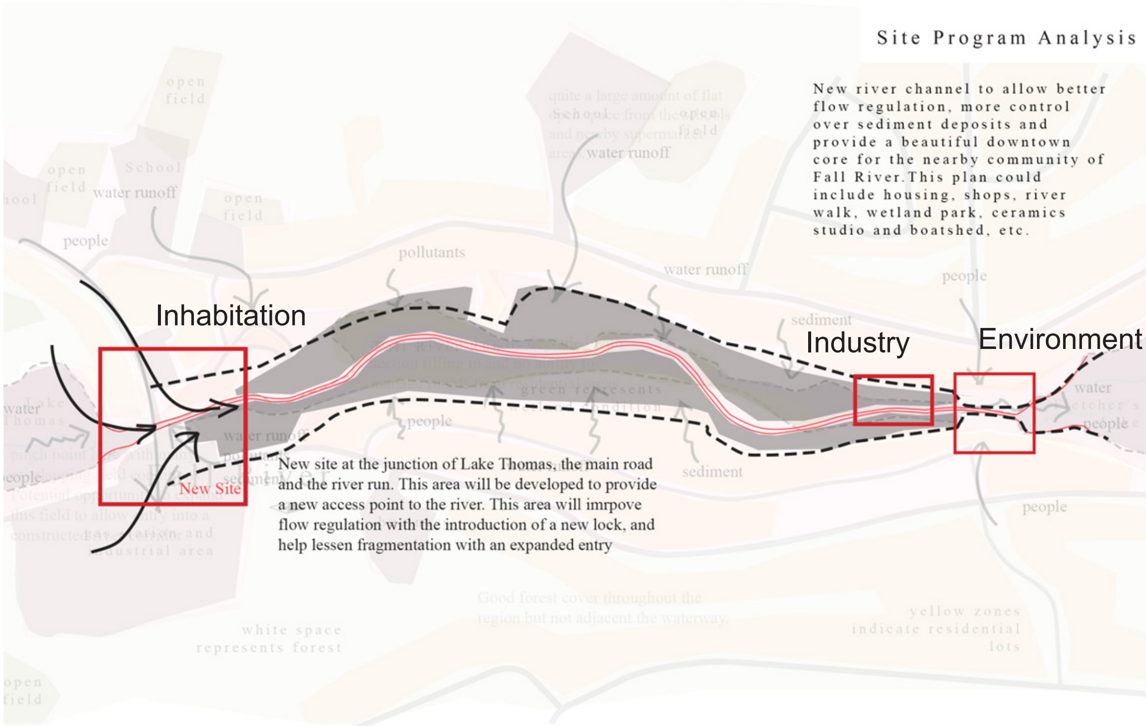


Figure 40: Overlapping areas of fields and flows highlight potential sites within the broader system.

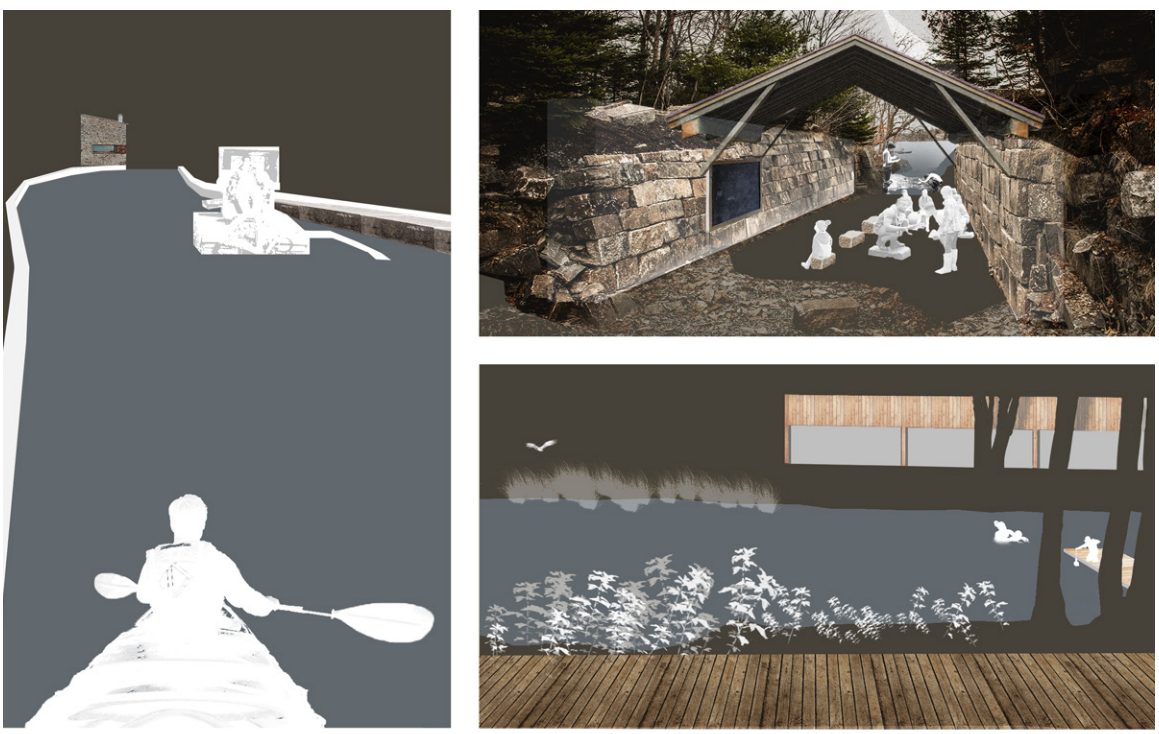


Figure 41: Collage showing potential program ideas based on site selection.

Industry - The Lock House (#13)

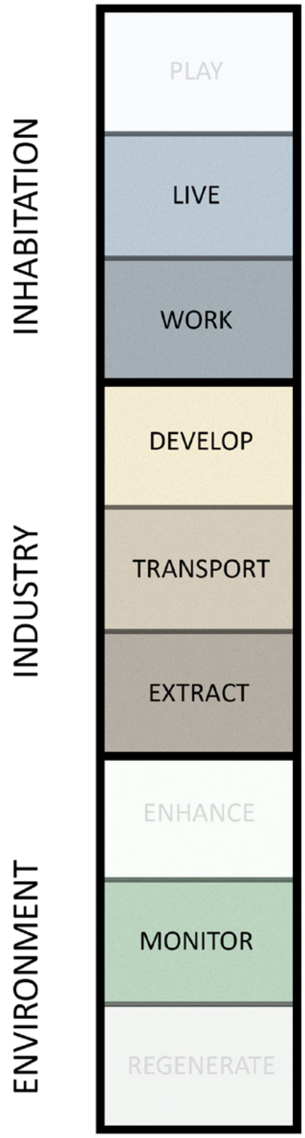


Figure 42: Lock House program diagram

In this system, the Lock House is where the process of industrialization begins. A regenerated canal is introduced with neatly dressed granite blocks lining the banks, and a small format canal lock helping to manage water levels within the system. This is ultimately the home of the Lock Keeper, who has the responsibility of operating, monitoring, and maintaining the Fall River Canal infrastructure.

A small shed houses the canal dredger which is used by the Lock Keeper to traverse the canal, harvesting and extracting sediment buildup throughout. They then transport the harvest back to the site where it can be processed and developed into various forms in the Lock Studio.

This studio is used for the testing and creation of various wares; ceramic pots, shelves, counter tops, glass items, and building components are developed here, each containing a unique colour signature, marking the origins of their journey.

The sediment collected ultimately forms the basis by which the rest of the program can be enacted. Here, and throughout the rest of the site, sediment is reconstituted into building materials through the use of rammed earth technology. Through the act of layering material, a stable foundation provides for the development of the town.

Finally, the Lock Keeper rests in the Lock House; a two-story rammed earth structure made using the very sediment collected throughout the system. The house contains all the comforts and amenities necessary for today's world and is capped off with a green roof terrace to help provide a vantage point for the Lock Keeper so they may monitor and reflect on their place in this system.

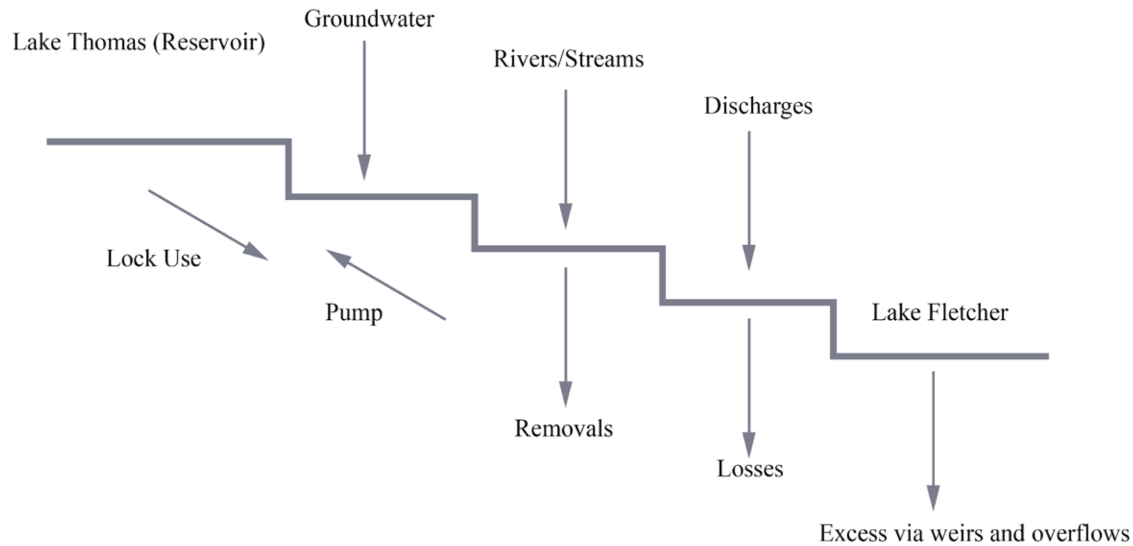


Figure 43: Simplified diagram showing the general movement of flows in the canal system.

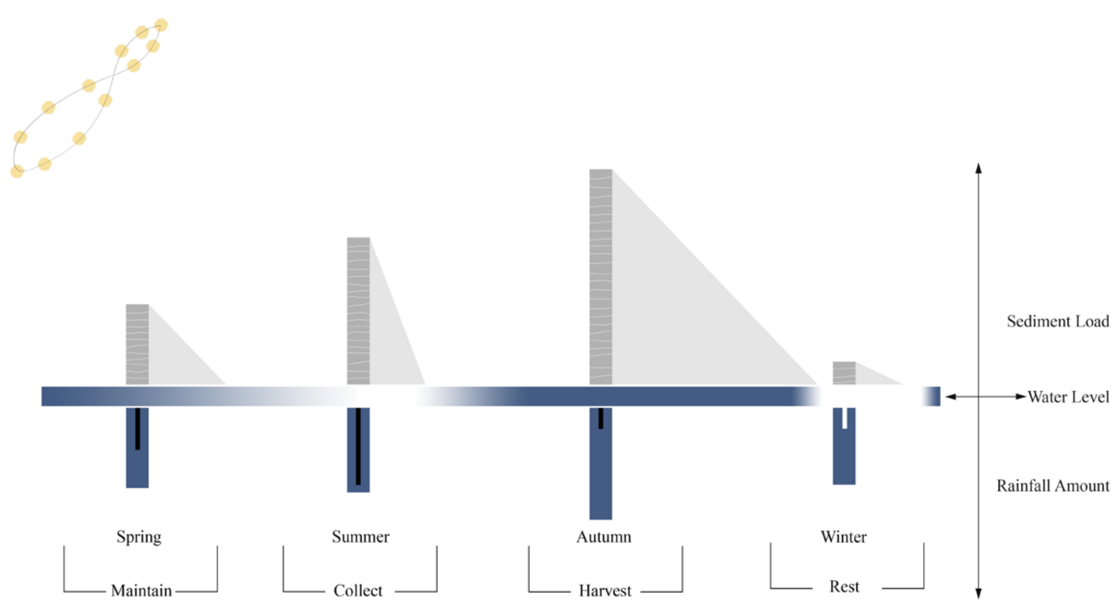


Figure 44: Canal operations linked with environmental systems to form a context-based cycle of regenerative industrialism.

Figure 45: Material harvested through manual dredging operations during a canoe trip through the Shubenacadie Canals.

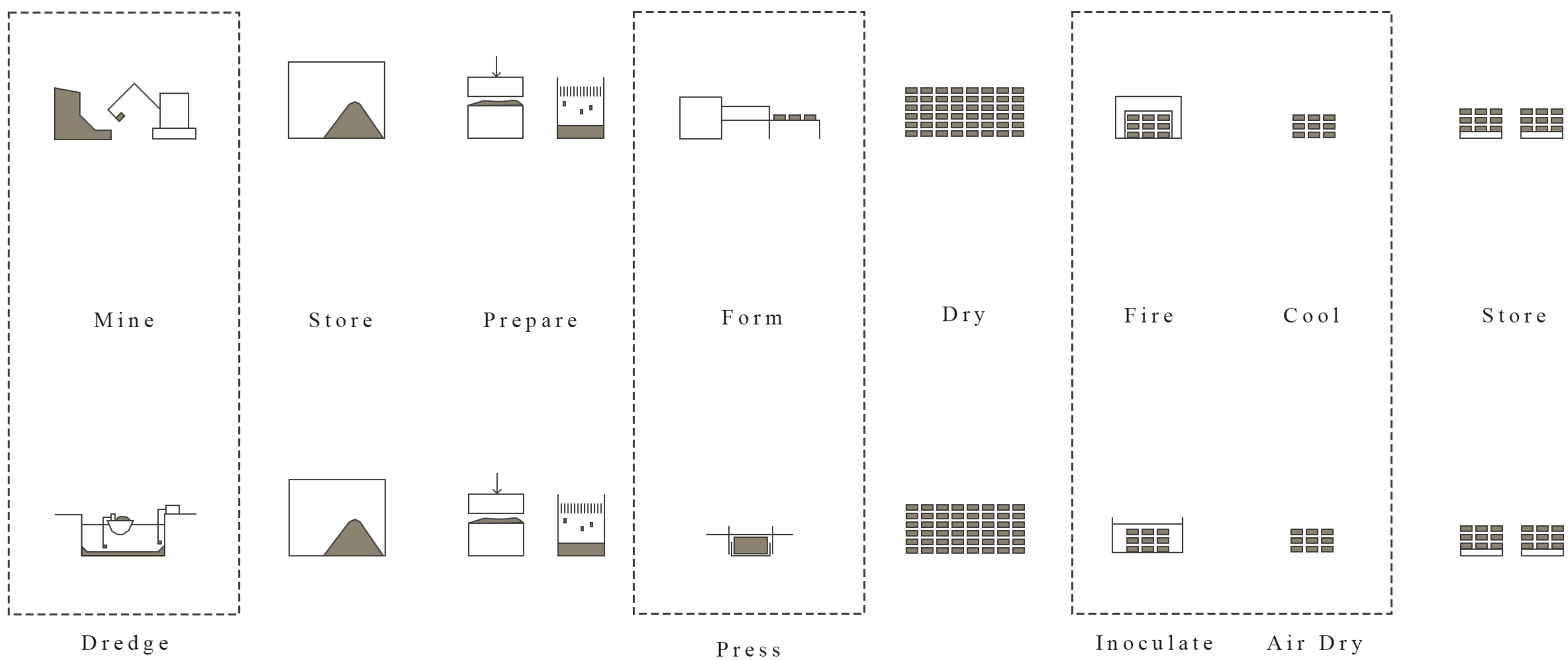


Figure 46: Proposed new sediment industrial process replicating a traditional brick making process. The new process for converting sediment into usable building components cuts out the entire heat cycle from brick making and instead utilizes the MICP process for reconstituting the sediment back into stone.

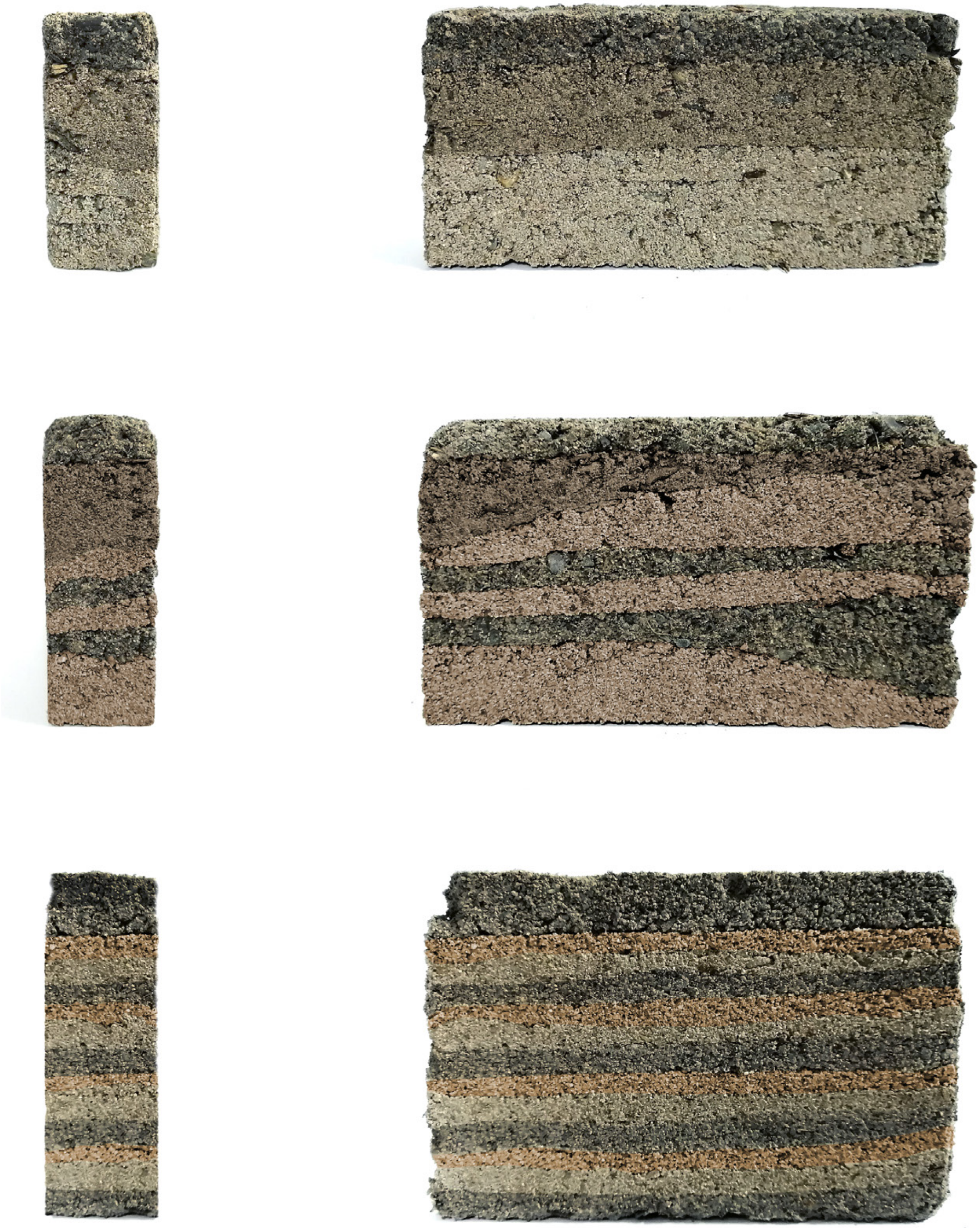


Figure 47: Sediment collected and recombined to test rammed earth potentialities. Test walls approximately six inches in height.

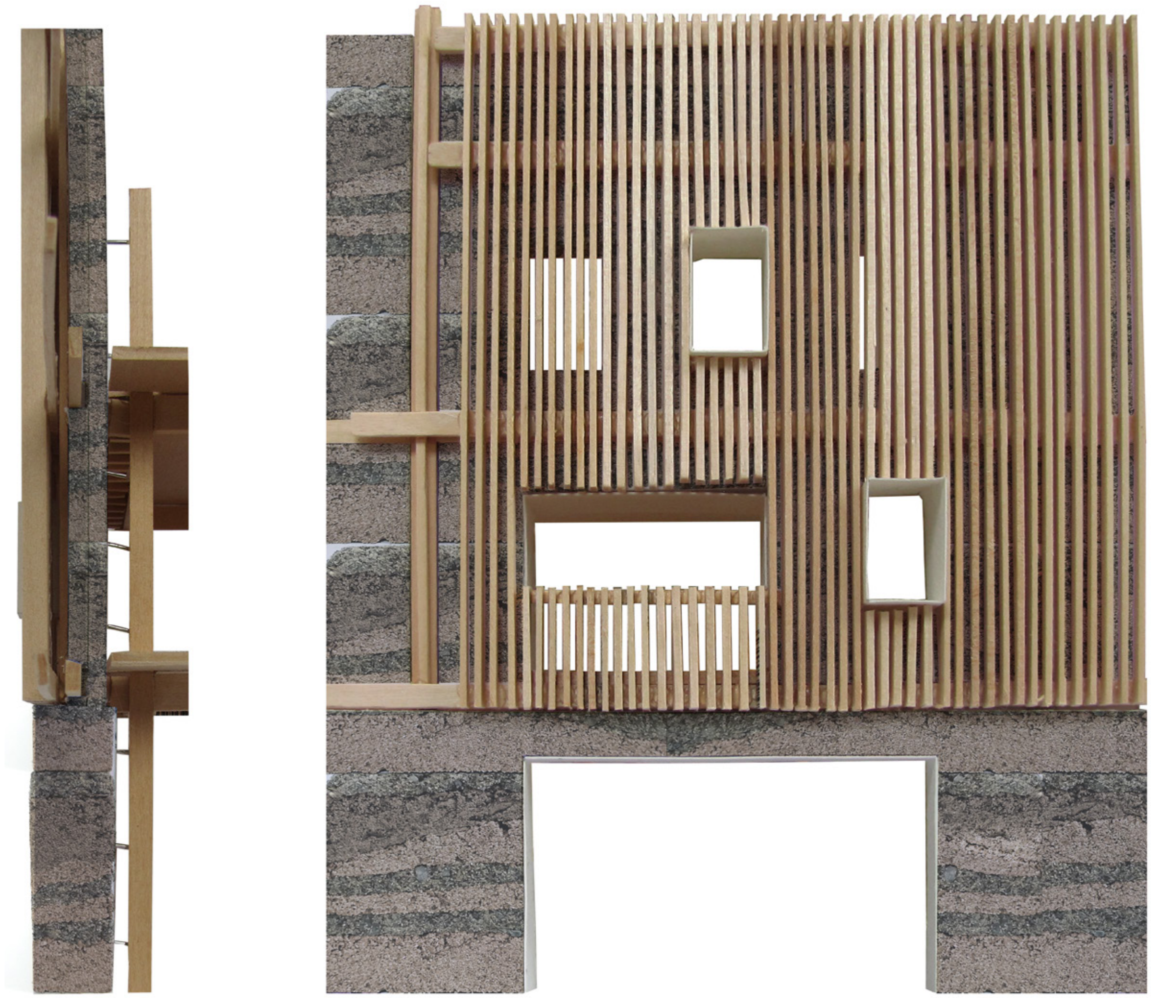


Figure 48: Exploring rammed earth technologies using sediment harvest.

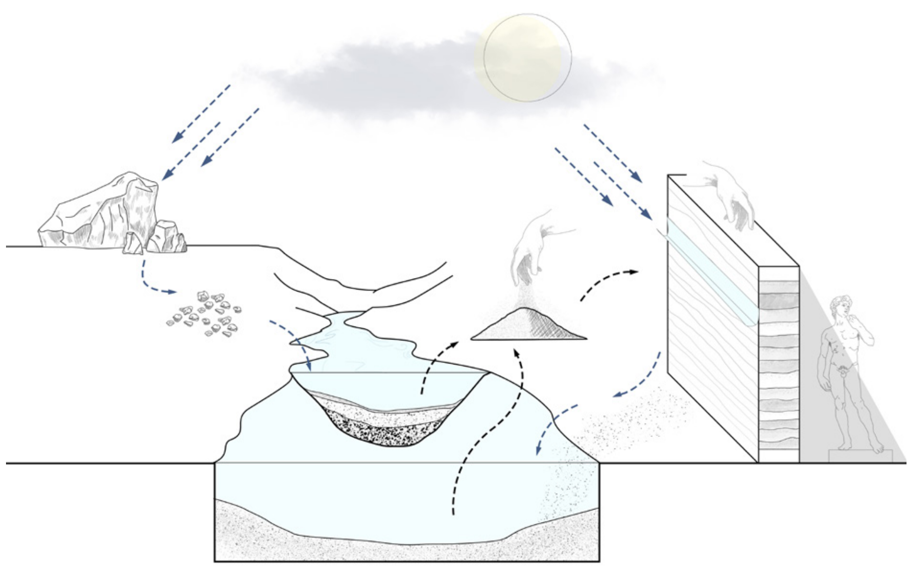


Figure 49: Conceptual diagram showing the circularity of material processes.

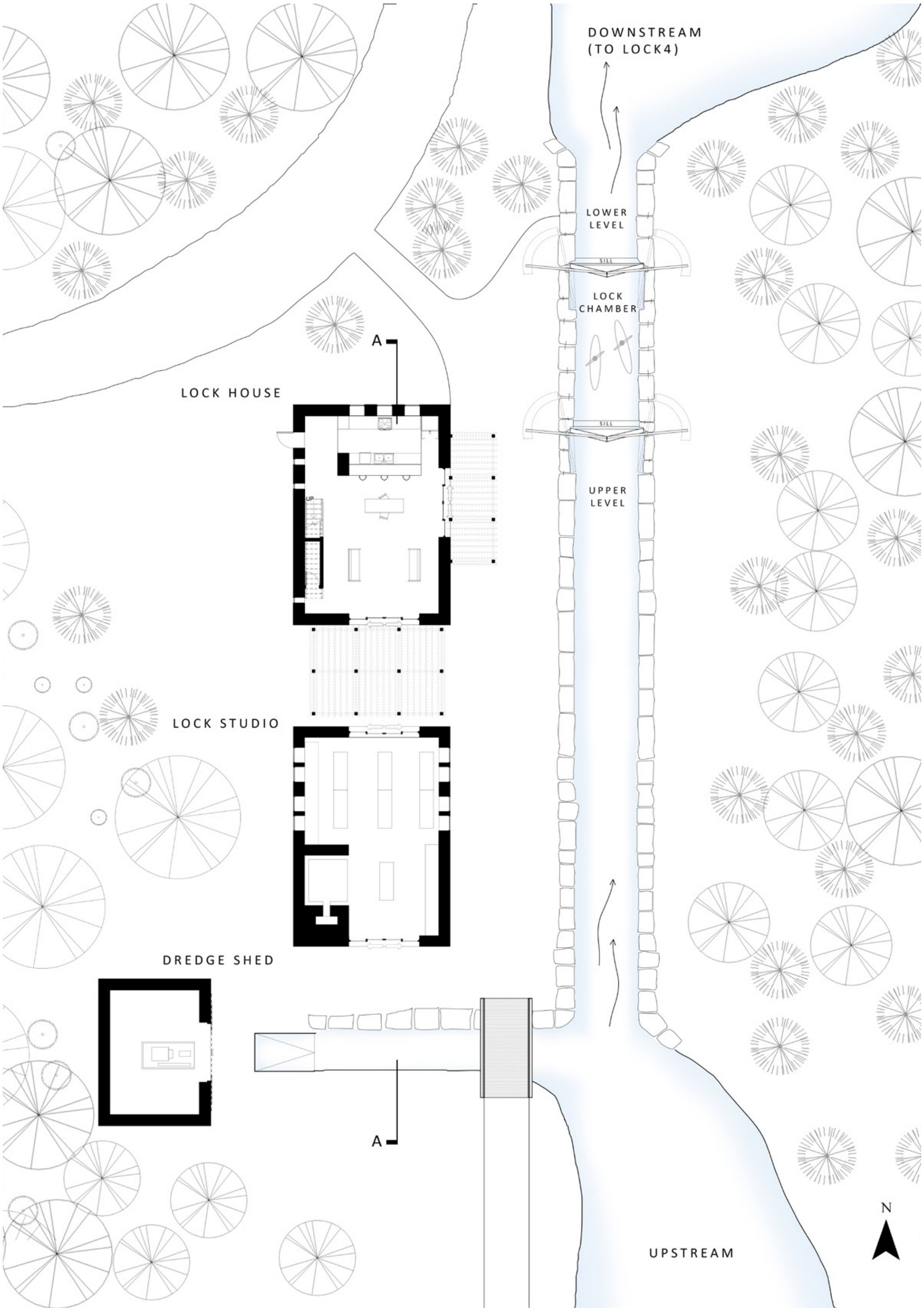


Figure 50: Ground floor plan of Lock Keepers facilities.

Figure 51: Section A - A through Lock Keeper's facilities.

Inhabitation - Town Core (#3)

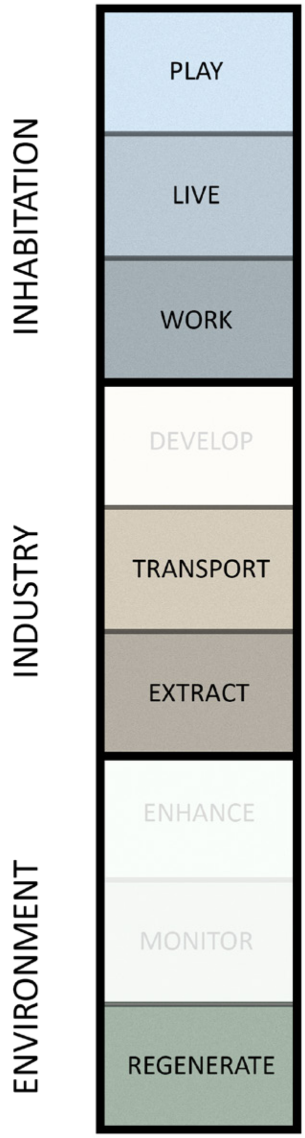


Figure 52: Town Core program diagram

As water from Lake Thomas funnels through the newly created King's Lock, people are brought into the bustling heart of this new system. The new lock provides a point of sediment harvesting for the Lock Keeper as they routinely return to provide maintenance.

The Town Core utilizes the newly developed rammed earth technology to create a three-story building. On the ground level, shops and cafes bring joy and life to the area, while studio apartments punctuate the upper floors. Rammed earth is carried from ground level through to the roof, providing relieve from harsh winter winds, and shielding against the intense summer sun. The upper levels utilize a wood rainscreen that collects and traps precipitation, allowing it to drain onto the permeable paving below.

The site is approach from various directions, but perhaps most prominently from the main road down a grande, monolithic rammed earth staircase. These stairs act as a meeting point for people who are entering or exiting the canal system.

Trees line the walkway in front of the main building providing a canopy to the public, and a bioswale is integrated between the main building and the canal, providing a collection point for rain and stormwater, ultimately helping to aid in the regeneration of the water system.

Finally, as you move north along the canal, a small canoe/ kayak rental shop can be seen under a sloped grassed walkway that extends gently over the canal, where one can stop and reflect.

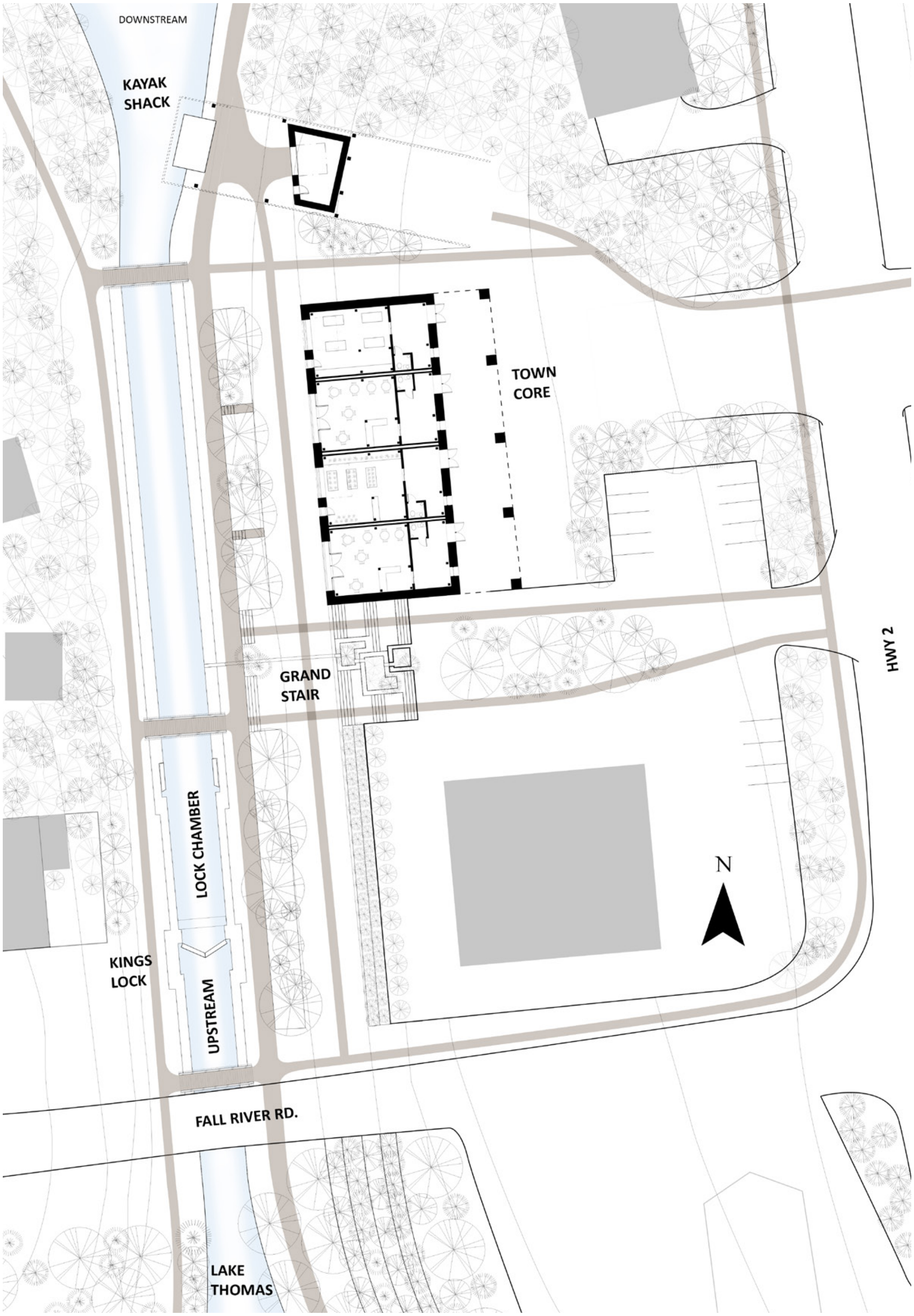
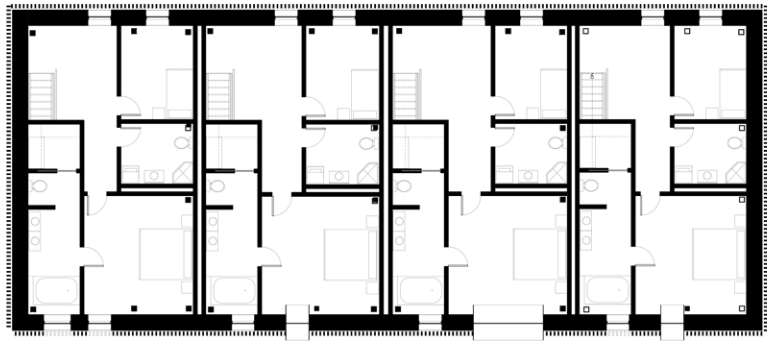
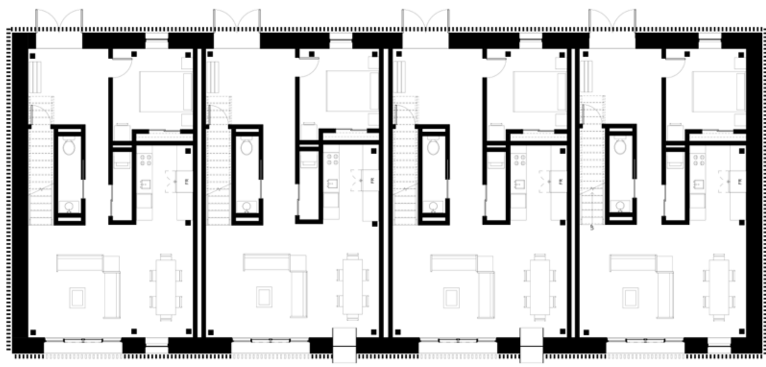


Figure 53: Ground floor plan of Town Core

Third Floor



Second Floor



Ground Floor

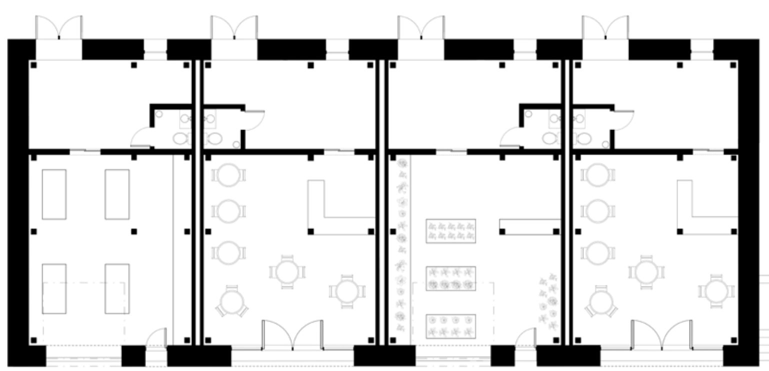


Figure 54: Main Town Core building floor plans.

Figure 55: Section through newly introduced canal and lock system.

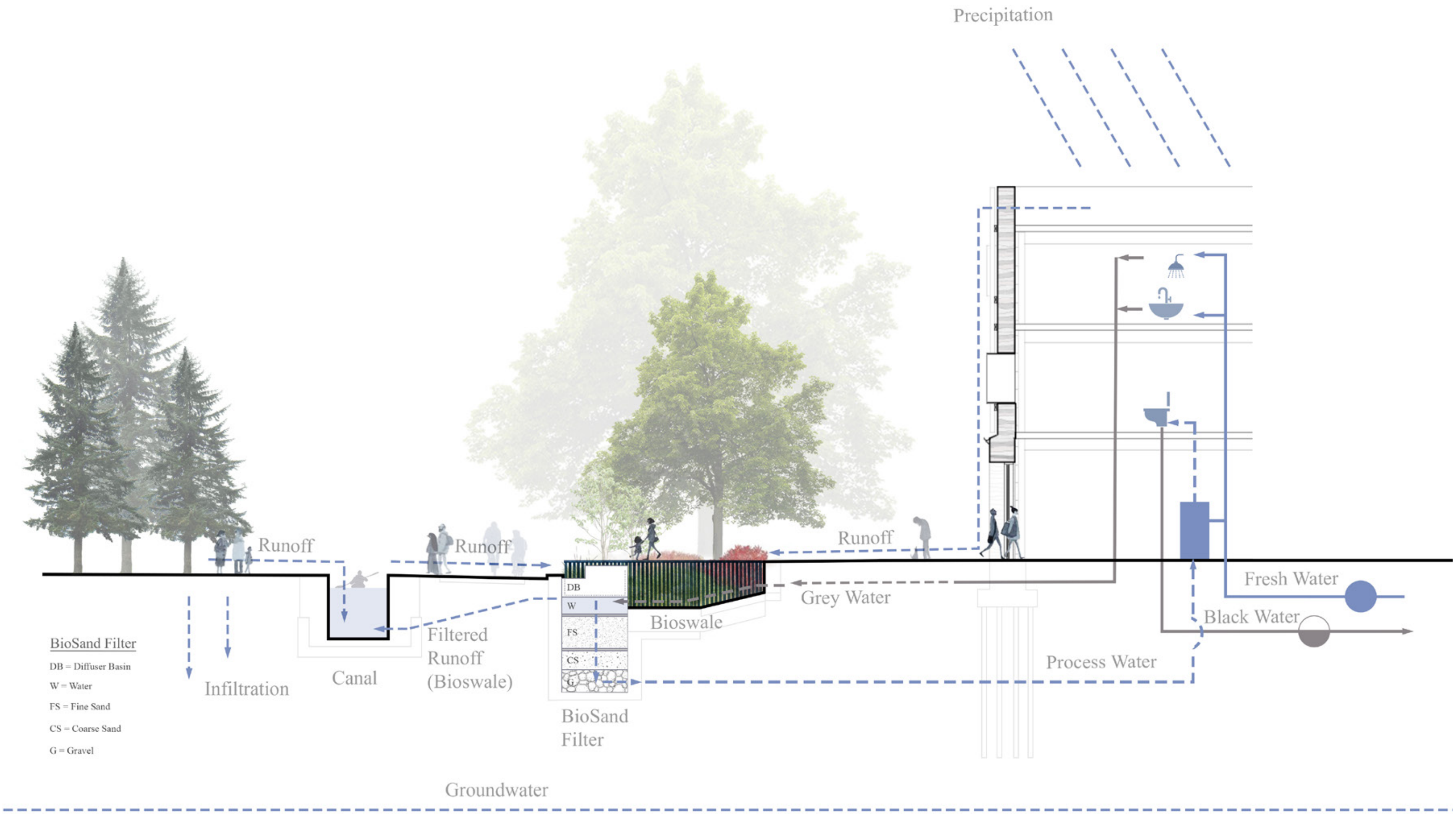


Figure 56: Building section showing the implementation of water infrastructure on the site and within the architecture.

Figure 57: Elevation rendered to show the relationship between layers of rammed earth and massing.

Figure 58: Render showing the main avenue along the front of the building and the massing relationship with the stairs.

Environment - The Learning Lock (#15)

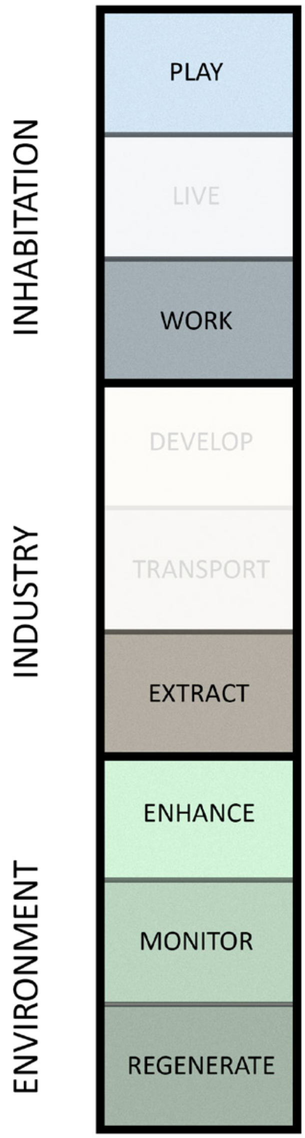


Figure 59: The Learning Lock program diagram

The final point of contact when exiting the Fall River Canal system is The Learning Lock; an outdoor classroom designed to provide an interface between the water system and the many students that call Fall River home. The abandoned Lock 4 is re-established, with new granite blocks inserted to replace missing and damaged ones, and new wood columns to brace against frost heave. Extending up from the west side of the lock, a semi-enclosed rammed earth structure is seen integrating into the landscape and providing refuge for the delivery of class lessons. The floor is raised to allow water to flow across the site, unimpeded by solid foundations. The roof is sloped back toward the trail where it helps slow bank erosion on all sides of the building.

This design is similar to the other but is deliberately toned down to emphasize the potential sediment has in providing a building material that can so easily delineate space for activity in a variety of ways. Rammed earth is not only used to provide a robust foundation, but also as a system of outdoor furniture in the form of student benches. Most of the structure is left open to frame the surrounding landscape and to ensure adequate ventilation, while the north wall facing Lake Fletcher provides shielding from lake effect wind and precipitation.

Finally, the environment is given precedent; architectural intervention is minimal and designed to enhance the natural beauty of its surroundings. Students are engaged in citizen science from an early age and the local ecology is monitored through daily classroom activities. A constant stream of data helps provide the necessary information for appropriate environmental regeneration.

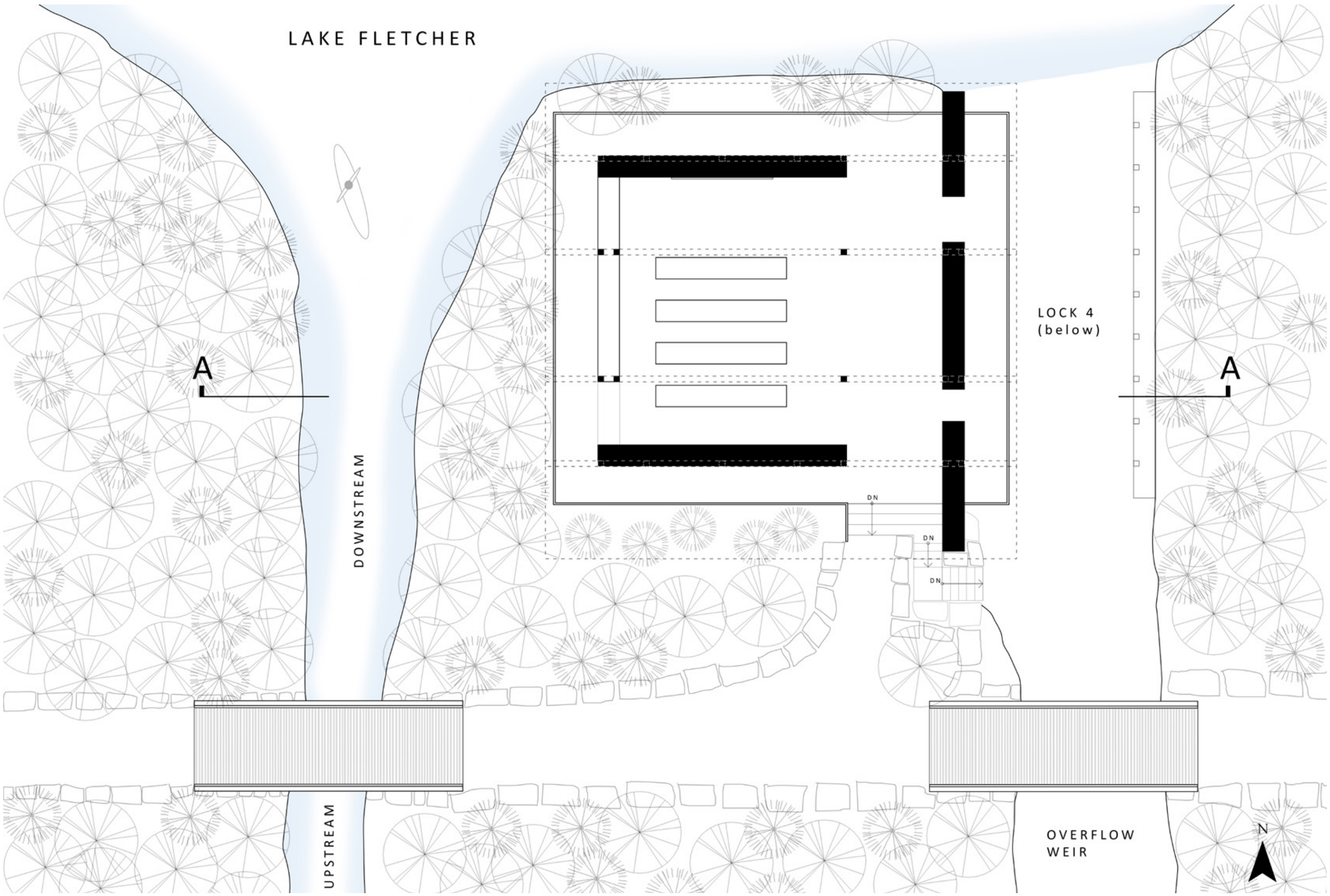


Figure 60: Ground floor plan of The Learning Lock outdoor classroom.

Figure 61: Section A - A through The Learning Lock classroom.

Figure 62: Collage displaying the walking trails through the system enroute to the Learning Lock. A parent can be seen bringing their child to class.

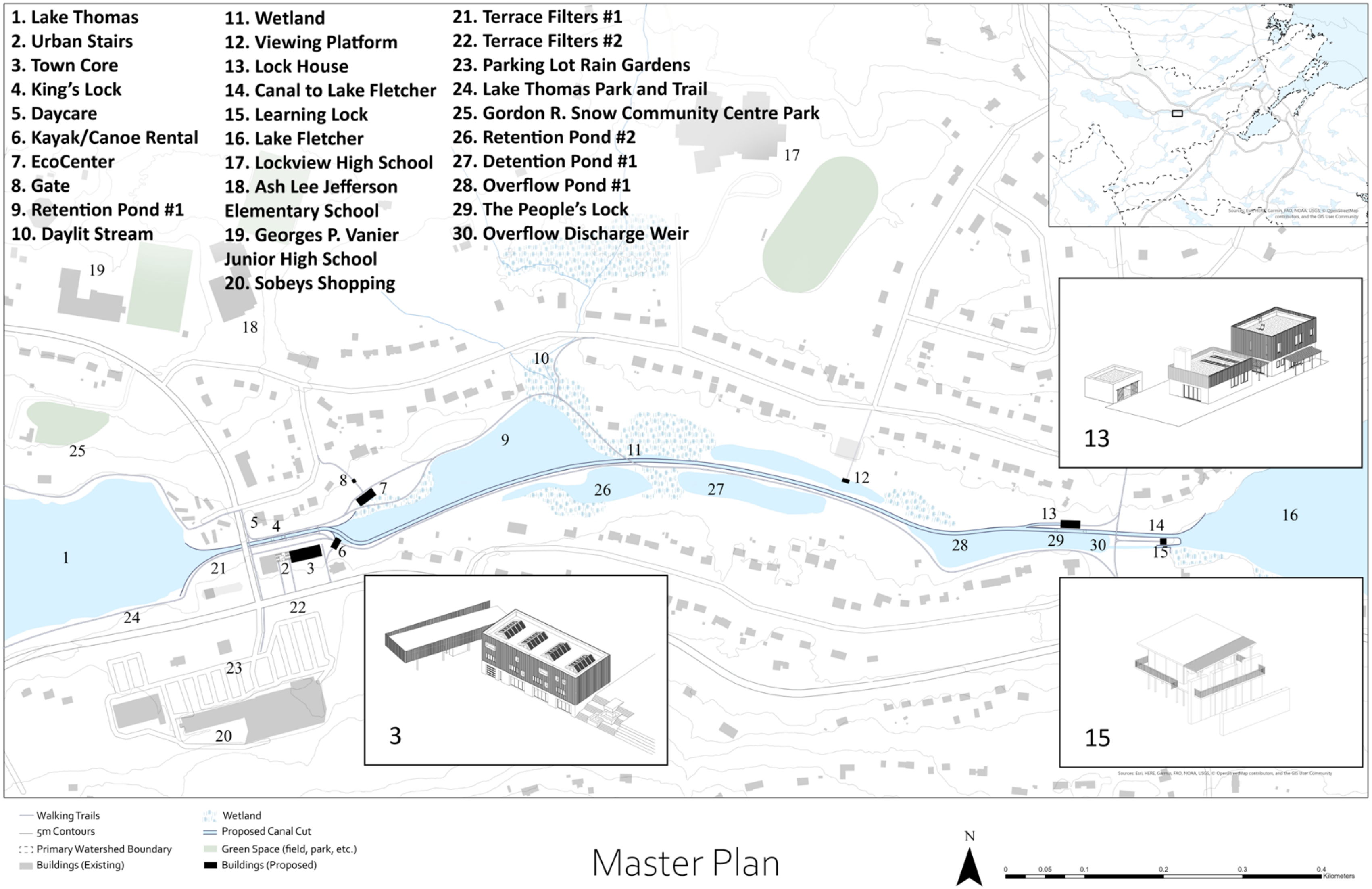


Figure 63: Overall Fall River Canals - Master Site Plan

Chapter 5: Conclusion

The challenge presented through this thesis is no small task; re-orient the way we think as a society, and in doing so re-orient the way we live. What has been proposed is ultimately a process for thinking about design in the context of a local material, and ecologically sensitive framework. By engaging industry head-on, this thesis seeks to position industrial man not as a boogeyman hiding in our closets, but as an integral and potentially positive force in our way of life.

The scheme is focused on a local Nova Scotia river and seeks to generate industry as a by-product of environmental management. The catalyst is the re-introduction of a canal system in a small, dilapidated river that runs between two large, freshwater lakes. Fields and flows are analyzed, and intersecting points reveal opportunities for architectural interventions that are fundamentally context-driven. Material is collected at various points throughout the water system and tied to the larger cycle of seasonality. By linking the industrial process to the broader hydrological cycle, a natural ebb and flow is developed where material availability is limited, freeing us from the endless pursuit of more.

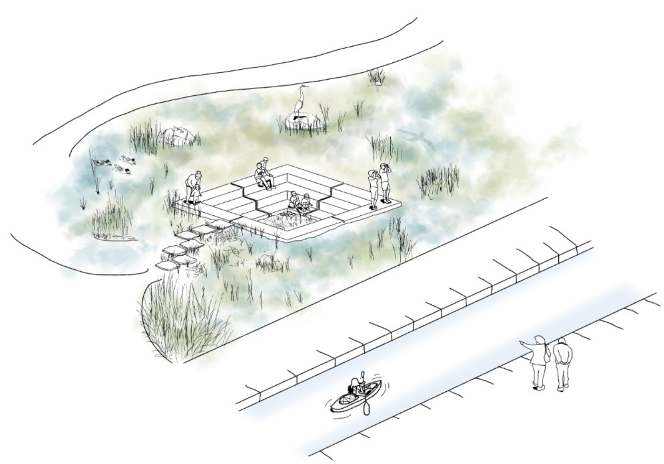


Figure 64: Potential Water-Society relationship.

Processes of material extraction then make way for the development of supporting infrastructure. Here, architectural moves are made in support of the development of a town core; a place that brings the community together and harmonizes with the surrounding ecosystem. Colours and textures provide warmth and comfort; vegetation flourishes throughout by way of an integrated water management framework, and reflection and engagement are encouraged. The town core supports growth, and makes room for people to live, work, and play.

Central to the development of the town is the need for responsible water systems management. Natural systems always tend toward degradation unless processes of renewal are integrated into them. Local material extraction coupled with an engaged citizenry combine to monitor, maintain, and regenerate the world around them.

Though this thesis explores the connections between industry, inhabitation, and the environment, this is not an exclusive intersection and future work on the role industrial processes have in our everyday lives would reveal many areas worth investigating. Additionally, this thesis proposes a design that fits within a particular time and place; how might the outcome differ were we to apply the process to another location along the river - say at the mouth of the Bay of Fundy? What materials would be available and what type of town would they generate? How might the outcome change if the surrounding environment required a different system of management? Different country? The queries are endless, but the use of positioning architecture as a way of integrating environmental management with our everyday lives, is worth exploring.

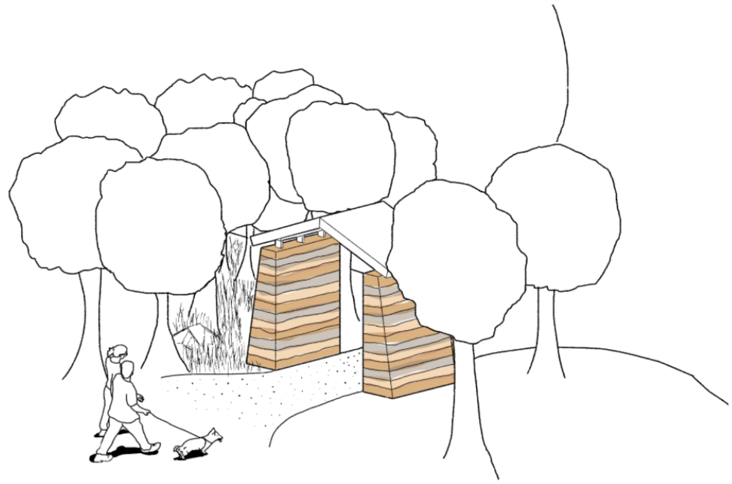


Figure 65: What forms could we generate when tying industrial processes to other forms of environmental management?

As our lives become ever more fragmented from the realities of our condition, it is important to remember our shared origins. By re-orienting the way we think about the water-society relationship, we can harmonize township development with industrial processes in support of our surrounding land and waterscapes. In doing so we re-engage our ancient heritage, connecting back to our roots, and enriching our minds and souls along the way.

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