Migrating with the Salt Marsh

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Graduate Thesis Book

A thesis submitted in partial fulfillment of the requirements for the Master of Landscape Architecture Degree in the Department of Landscape Architecture of the Rhode Island School of Design, Providence, Rhode Island.

By Yiming Lei
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Lara Davis, Thesis committee

Ann Kearsley, Tertiary Advisor

Migrating with the Salt Marsh

Full moon,
spring tide,
spawning fish,
chasing the hometown that
they once belonged.
Underneath the salty water that
polished by the moonlight,
the marsh hay feels like a gentle bed,
generously invites the fish,
to rest and bid farewell.

Half moon,
neap tide,
wading birds,
stranded fish,
hunting is too easy,
so they celebrate the receding,
by flying,
by cutting the sky with their wingtips.

Ebbs and flows,
inhales and exhales,
the marsh explains its breath with the moon.

Stretching roots,
pilling barks,
newborn buds.
the eternal parts of the marsh.

And it will remain eternal,
even when its rising,
And the swamp white oaks are born then die.
Expecting bird nests,
whose flock will one day leave,
and cordgrass taking root only to drown.

You know how the salt marsh migrates,
then you can migrate with it.

Table of contents

With global warming and rapidly rising sea levels, drowning marshes have become a global issue. Due to the critical ecological value of marshes, the phenomena of marsh migration (a horizontal shift in the salt marsh to the neighboring inland habitat)[1] has attracted increased attention across different fields.

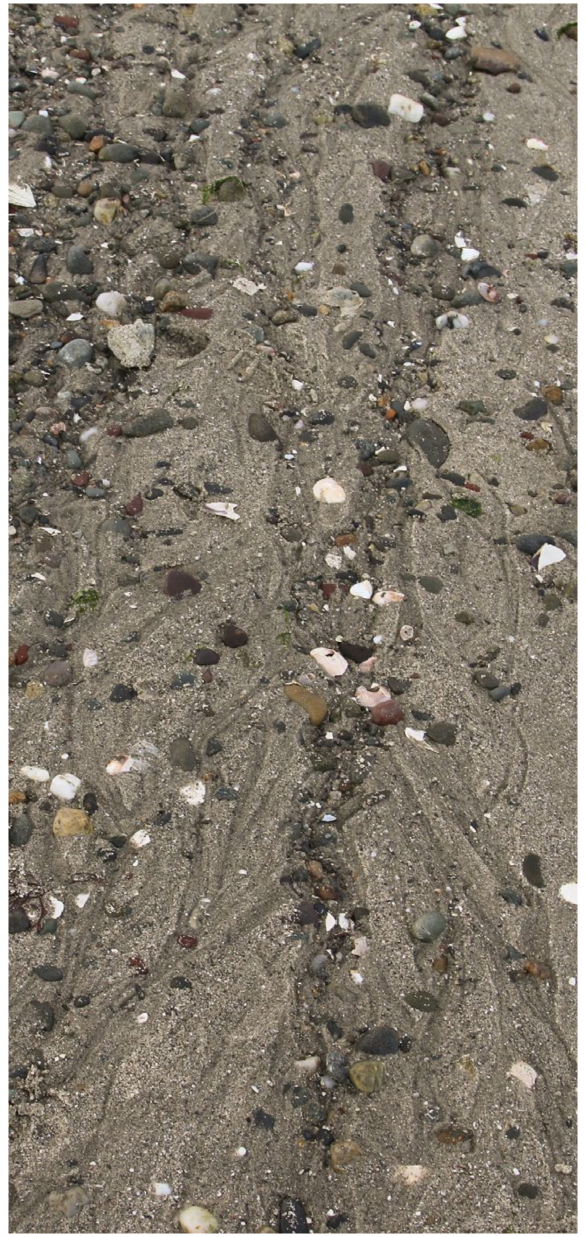
With its long coastal lines, the state of Rhode Island, in particular, has been supporting marsh migration for the past decades. Successful methods include but are not limited to Thin Layer Placement (TLP), marsh replanting, impermeable surface removal, fence building, and channel digging.

In Rhode Island, marsh migration has been supported mostly by methods related to water filtering and management, sediment building, land forming, and the creation of porous conditions. Based on the studies and integration of these effective methods, the straw clay technique was chosen as the primary construction method for the design exploration due to its flexibility and ability to achieve a large range of permeability. The flexible and porous nature of straw clay can flexibly inhibit tidal flux, allowing the marsh peat to grow progressively upland, making it a suitable building method to support marsh migration. What's more, the building materials that are required for straw clay can all be sourced locally, which can reduce the carbon footprint of material transportation, making the whole construction process more sustainable.

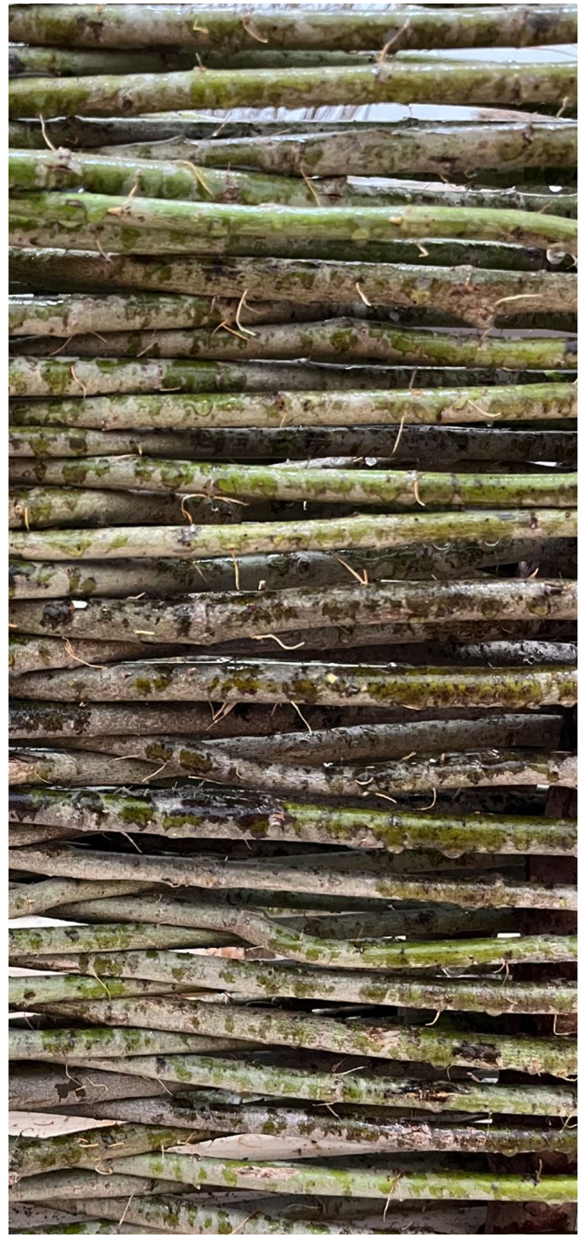
Using a combination of straw clay with wattle frames, and dug channels as the main design language, this thesis investigates its application in Tillinghast Place, a coastal system in Barrington, Rhode Island, that shows a typical drowning marsh with a surrounding forest fringe.

The work investigates ways to enhance marsh migration by exploring design methods with site-specific issues and opportunities. It proposes a holistic and sustainable design system that can be applied to other drowning marshes in New England.

[1] Goetz, Emily. "Marsh Migration Mania!" (2021).





02

Introduction

2.1 Sea Level Rise & Marsh Migration

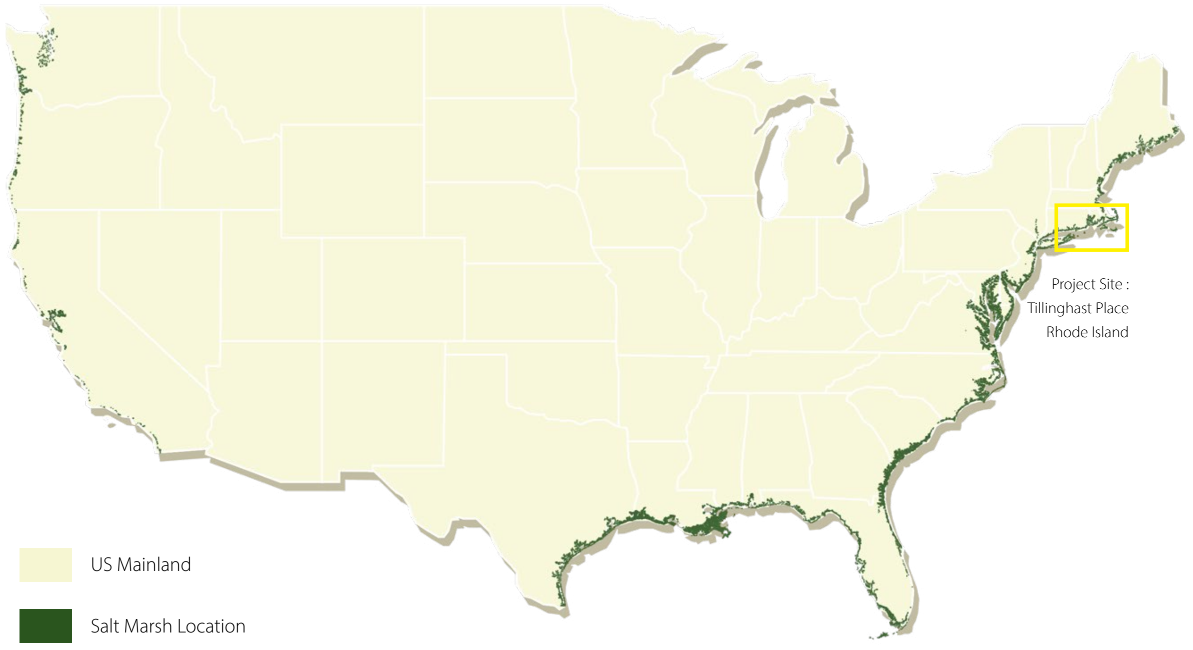
Salt marshes are coastal wetlands that are flooded and drained by tides on a daily basis. They are precious ecological buffer zones that provide irreplaceable habitats for coastal species such as birds, fish, and insects[1], making them ecological refugees during the Anthropocene. The richness and dynamics of salt marshes have also made them the heaven for art and literature. What's more, salt marshes also reduce the wave energy from the ocean, therefore protecting coastal human communities from various natural disasters. The intersection between nature and culture in salt marshes has proved their great value to both humans and nature.

Salt marshes are highly dynamic and sensitive systems due to the fact that they need specific conditions to form and grow, namely low wave energy environments, stable sea level rise rates, and so on. And with global warming and rapidly rising sea levels, drowning marshes have become a global issue. In 2100, a 1-meter rise in sea levels will result in the loss of 68% of the existing coastal wetlands worldwide [2]. Hence, marsh migration - a horizontal shift in salt marsh into the inland habitat that neighbors it (often forest) [3]has gained attention in different fields.

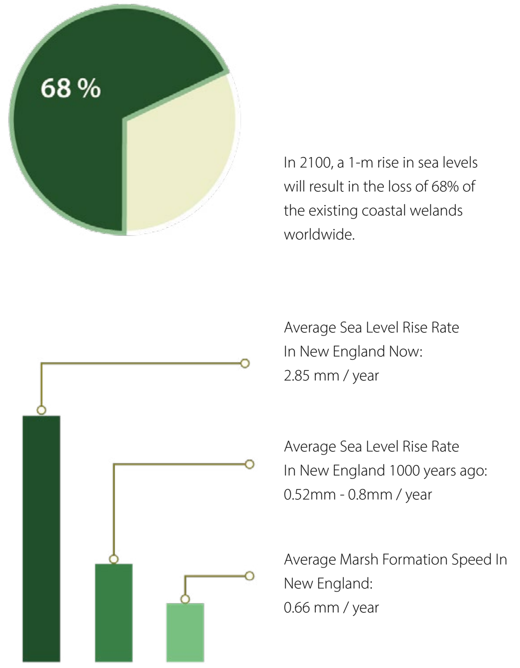
1-[2]FitzGerald, Duncan M., and Zoe J. Hughes, eds. "Salt Marshes: Function, Dynamics, and Stresses." (2021).

2-[3]Blankespoor, Brian, Susmita Dasgupta, and Benoit Laplante. "Sea-level rise and coastal wetlands." Ambio 43 (2014): 996-1005.

3-[4]Goetz, Emily. "Marsh Migration Mania!." (2021).



Salt Marsh Distribution in the USA

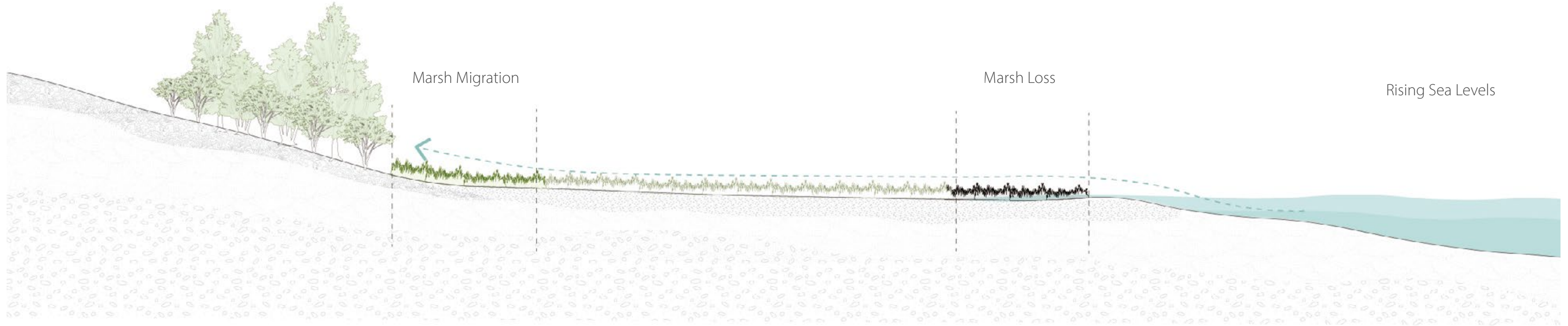


Marsh Drowning Due to Sea Level Rise

Scientific studies have shown that there are two types of pressures that the salt marshes face during their migrations: drowning lower marshes due to sea level rise and the barriers adjacent to the higher marshes that prevent them from migrating up.[1]

The work studies these two issues the salt marshes are facing, with a specific focus on the salt marshes in Rhode Island.

1-[5]FitzGerald, Duncan M., and Zoe J. Hughes, eds. "Salt Marshes: Function, Dynamics, and Stresses." (2021).



Marsh Migration Model

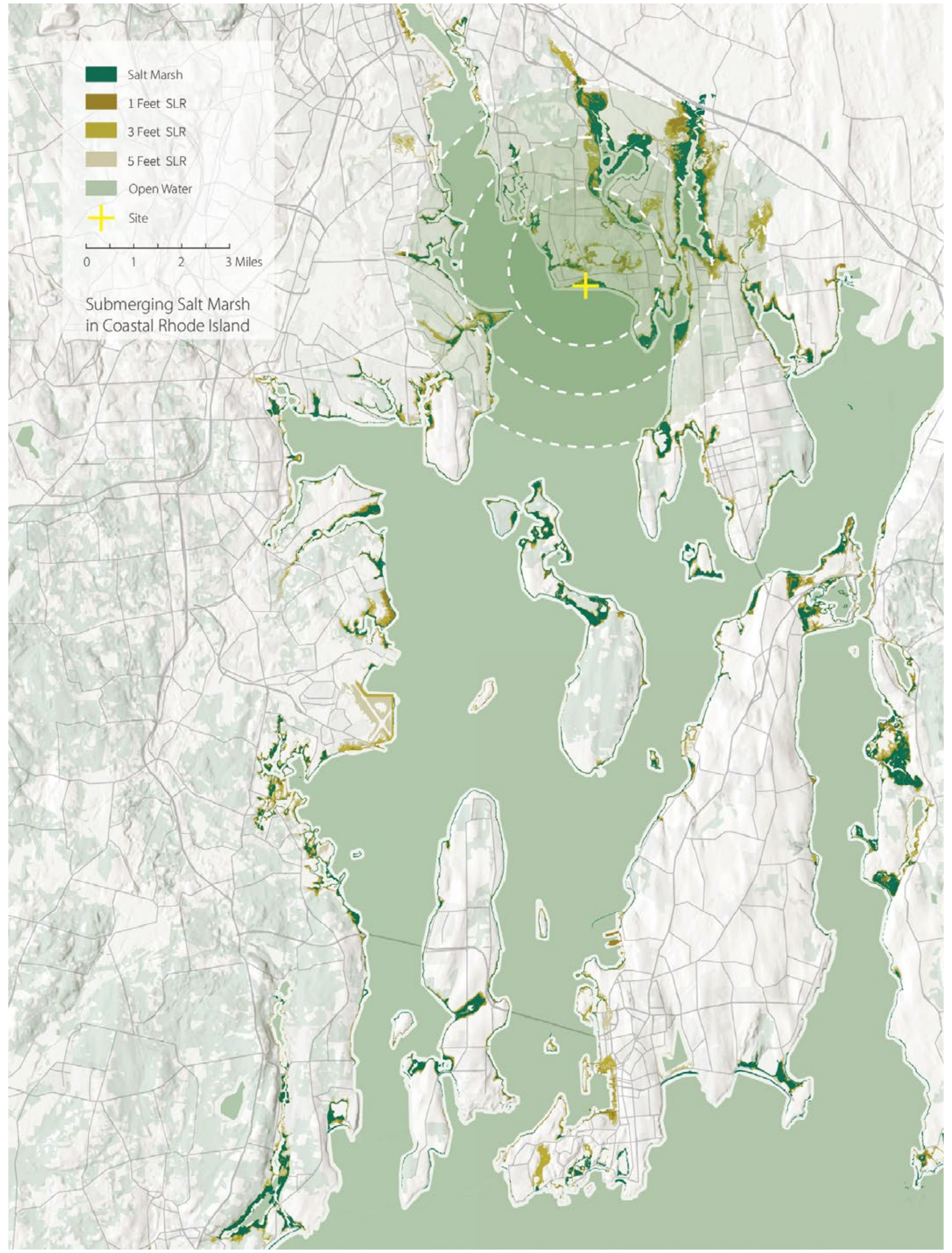
2.2 Marsh Migration in Rhode Island

Due to the long coastal line in Rhode Island, as well as its high coast/area ratio, attention has been paid to marsh migration in the state from different fields of expertise. What's more, the average sea level rise rate in New England is about 2.85 mm/yr, according to NOAA tides data, which is much faster than the average 1-2 mm yearly world rate.[1]

The average marsh formation speed in New England is 0.66mm/yr, which is similar to the average sea level rise rate in New England 1000 years ago: 0.52 - 0.8mm/yr. However, with the current accelerated sea level rise rate (2.85 mm/yr), the salt marshes will be unable to accumulate sediment and build peat to keep up with the rising sea levels.[2]

Hence, this thesis studies the effective local methods that support marsh migration, summarizes and takes inspiration from these methods, and eventually proposes the design of a holistic system that can be applied to the drowning marshes in Rhode Island.

1-[6]Rubinoff, Pam, and Don Robadue. "The Rhode Island Sea Level Affecting Marshes Model (SLAMM) Project: Summary report."
2-[7]FitzGerald, Duncan M., and Zoe J. Hughes, eds. "Salt Marshes: Function, Dynamics, and Stresses." (2021).

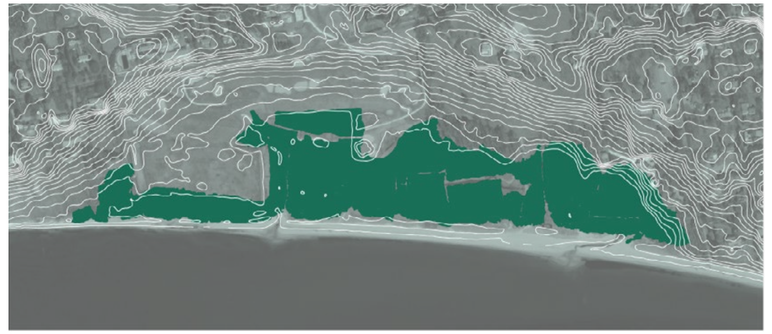


2.3 Site Introduction

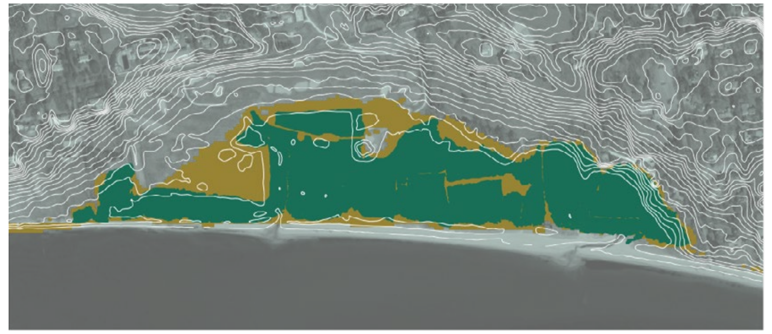
Tillinghast Farm in Barrington, Rhode Island, dates back to the 1700s. In 1929, Charlotte L. Tillinghast left the farm to family members and others who set up the Nayatt Folk School, originally the American Folk College, a charitable corporation headed by James A. Tillinghast, chairman and treasurer. The Nayatt Folk School, through James A. Tillinghast, deeded the farm to RISD on June 11, 1948. The court decree stated that the land was to be "held and used by it [RISD] in perpetuity for recreational, recuperative, educational, inspirational or charitable activities." RISD's records describe the property as 33 acres (26 tillable and seven marshlands) managed by a farmer's family for the previous two decades.[1]

1-[8]https://alumni.risd.edu/tillinghast-place

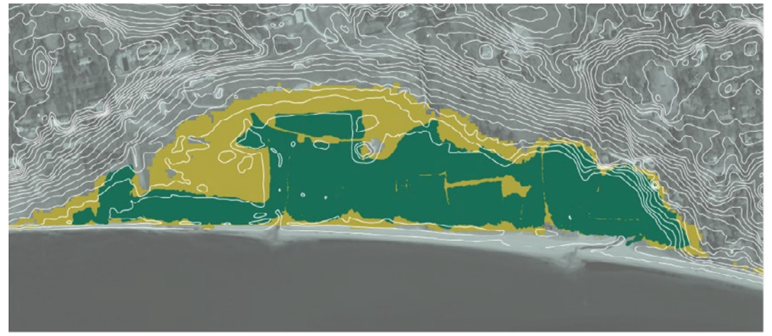
Tillinghast Farm is chosen as the study site due to its typical degrading and drowning marsh, as well as the clear upper land forest fringe and steep slopes, which make Tillinghast Farm a suitable study site.



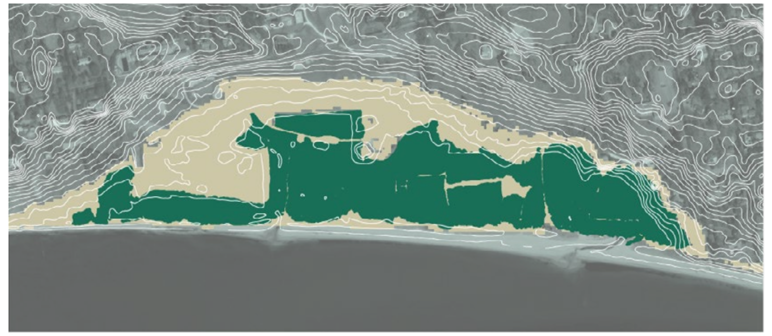
Salt Marsh



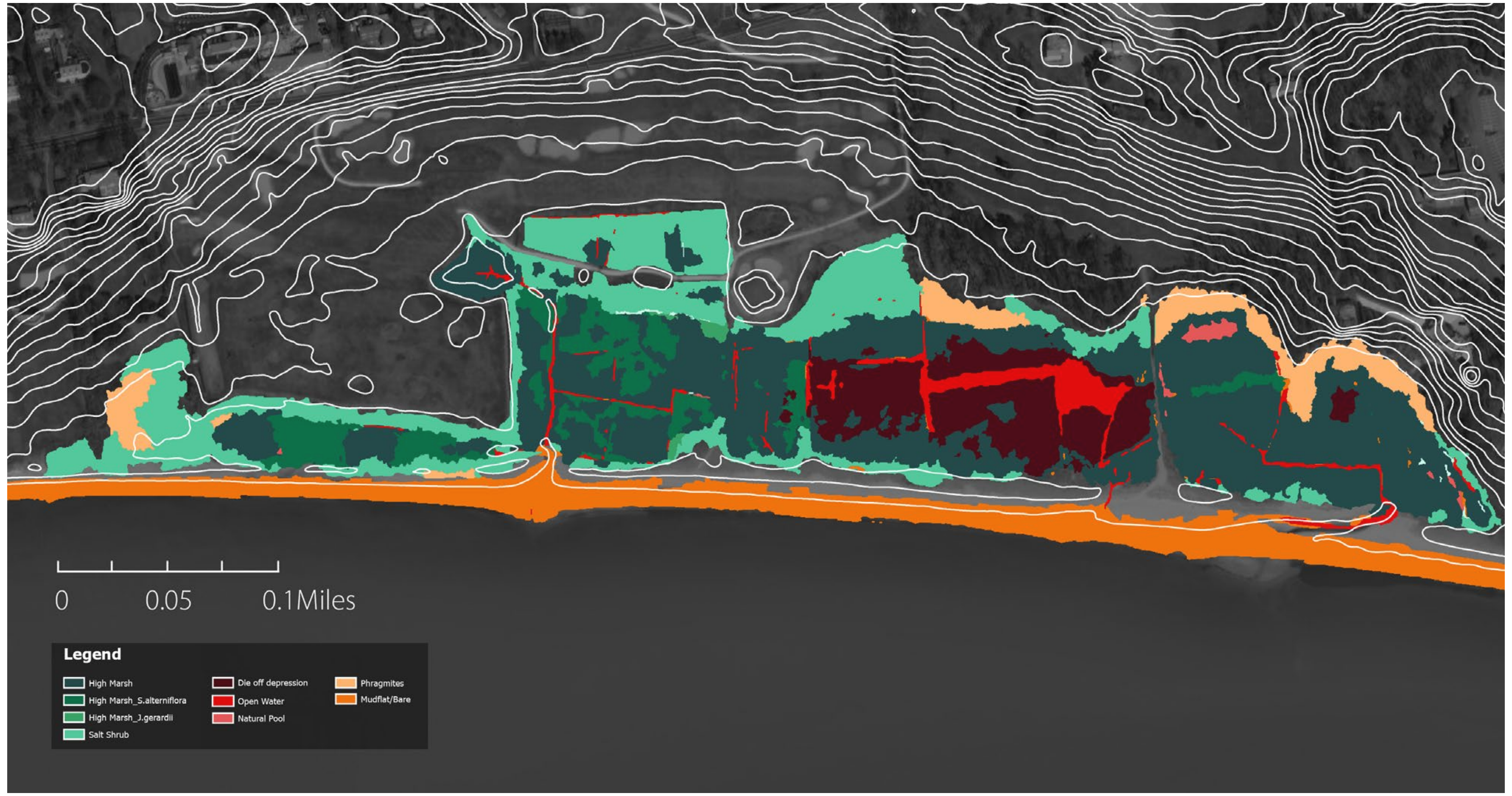
Submerging Salt Marsh - SLR 1 ft



Salt Marsh - Submerging Salt Marsh - SLR 3 ft



Submerging Salt Marsh - SLR 5 ft


0
0.05
0.1Miles
Legend
High Marsh
High Marsh_S.alterniflora
High Marsh_J.gerardii
Salt Shrub
Die off depression
Open Water
Natural Pool
Phragmites
Mudflat/Bare

2.4 Site-Specific Issues Related to Marsh Migration

2.4.1 Overgrowing Phragmites

Between the salt marsh and the upper land forest area, there is a continuous field of overgrowing phragmites, which is preventing the young marsh from migrating due to its dense rhizome system.

2.4.2 Existing Causeways

There are two existing causeways on the site that were built across the salt marsh, initially constructed to provide easy access to the beach from the upperland area of Tillinghast Farm. Due to the impermeability of these causeways, the salt marsh is facing serious drainage issues.

2.4.3 Eroding Marsh

Due to the marsh ditches that were initially proposed for mosquito control in the 1930s, as well as the rapidly rising sea levels, the marsh in Tillinghast Farm is showing signs of erosion, especially in the area that i's ditched.

2.4.4 Ghost Forest

With climate change, the phenomenon of ghost forests dying due to rising sea levels is also happening on Tillinghast Farm. The majority species of the dying forest is the swamp white oak, which has its limitation of saltwater tolerance.

2.5 Thesis Question

How can we support marsh migration in Tillinghast Place through sustainable design strategies and the utilization of local materials?

03

Rhode Island Local Case Studies

3.1 Ninigret Pond, Charlestown, RI

In Ninigret Pond, a technique called Thin Layer Deposition is used to prepare suitable conditions for marsh migration.

The sand was dredged from the Ninigret Pond breachway, and pumped onto the marsh surface. The sediment was distributed onto the marsh with low-ground pressure equipment to the target elevation.

Apart from Thin Layer Deposition, native marsh vegetation re-planting and shallow ditches are also applied to the marsh in Ninigret Pond, to stabilize the marsh sediment and also help enhance drainage in some low areas of the elevation-restored marsh, thereby promoting the survival of marsh plants.[1]

1-[9]https://www.edc.uri.edu/apps/c016136e821747a09ccf88e0b0a15450/explore

Figure. 1 Thin Layer Deposition

Figure. 2 Marsh Replanting

Figure. 3 Marsh Replanting

Figure. 4 Marsh Replanting

3.2 Walker's Farm, Barrington, RI

In Walker's Farm, Barrington, RI, marsh migration is being supported by low-tech and community-based methods, which also provide opportunities for natural education.

The previous concrete paving is removed and replaced with permeable materials, providing future upperland space for the young salt marsh to migrate up.

Wooden fences are built along the edge of the young salt marsh to indicate limited disturbance and interaction.

According to the volunteer website of Save The Bay[1], the public will only be allowed to walk onto the young marsh area to remove the trash and plant native marsh vegetation at specific times of the year.

1-[10]https://volunteer.savebay.org/need/detail/?need_id=804178

3.3 Sowams Meadows Preserve, Warren, RI

In Sowams Meadows Preserve, Warren, RI, marsh migration is mainly supported by channel digging.

A series of shallow channels are dug to help with water management and phragmites control due to the fact that the overgrowing of phragmites is a common issue in the salt marshes in Rhode Island.

These channels can partially transport the water from the upperland forest area directly into the salt marsh, which reduces the freshwater gaining of the phragmites field and, therefore, slows the growth of phragmites down to give more space for the young marsh to migrate.

Figure. 7 Channels Digging

Figure. 5 Channels Digging

Figure. 6 Channels Digging

Figure. 8 Channels Digging

3.4 Conclusion for Case Studies

From these three case studies, different effective methods are summarized as a tool kit, which includes but is not limited to water filtering and management, sediment building, land forming, and the creation of porous conditions.

To combine these methods together holistically as a system, straw clay with wattle frames is chosen as the fundamental construction technique due to its flexibility in form-making, as well as the range of permeability it can achieve. The materials used for this building technique can also be found locally, such as clay, soil, wood, and fiber. These materials are all highly sustainable and safe to work with, providing great potential for community engagement and natural education.

Tillinghast Place, a coastal system in Barrington, Rhode Island, that shows a typical drowning marsh, will be used as a study site due to its challenges and potential for marsh migration. Based on the case studies, dug channels with straw clay in wattle frames will be used as the primary design language, and further design strategies and material exploration will reflect on this primary design language.

04

Design Principles

4.1 Utilize Local and Waste Materials

Using the straw-clay with wattle frame technique as the primary sustainable construction method, the work proposes a framework that depends on local and waste materials.

With the utilization of local and waste materials, this thesis proposes a sustainable way to support marsh migration with a lower carbon footprint. Due to the low-tech building process of straw-clay in wattle frame, the proposed design strategies will require low energy consumption and reduce construction waste.

4.2 Limited Interaction & Disturbance to the Site

The salt marshes are productive but highly sensitive ecological and geological contact zones, especially the drowning marsh and the young marsh, which are experiencing rapid changes due to climate change and human activities. This thesis mainly focuses on the site's drowning marsh and young marsh area.

Due to the sensitive nature of salt marshes, this thesis proposes passive design strategies that only create limited interaction and disturbance to the site. With the wattle and daub technique, the proposed built-up elements on the site will eventually decay and become part of the landscape. These wattle and daub-based elements are temporary and can be removed when the ecosystem becomes self-sustaining with the maturity of soil conditions and vegetation.

This thesis suggests low-impact design strategies that support marsh migration, such as porous fence building, native marsh vegetation replanting, and freshwater reguiding. These strategies will require human labor and physical interaction with the site, but the ultimate goal is to establish suitable conditions for the marsh to migrate. Thus, the work builds up a dynamic methodology for natural restoration - that the moment the landscape becomes mature and independent, it is the moment that humans step away from the landscape.

4.3 An Evolving & Growing System

With the rising sea levels, other climate uncertainties, and the highly dynamic nature of salt marsh, the work takes advantage of the flexibility of the wattle and daub technique, proposes a system that's constantly evolving and growing and can respond to the changing conditions of the site, such as sea level, existing vegetation, marsh edge.

This system takes the local ecologies into consideration and proposes a sustainable low-tech design attitude that challenges conventional civil construction-based solutions, such as sea defense, impermeable causeways, and concrete water channels. Unlike conventional conservation projects with static boundaries, this thesis proposes a series of dynamic boundaries supporting marsh migration, such as retaining walls, water filters, and porous fences. These boundaries will be mainly made out of wattle and daub, and they can migrate with the marsh and forest in response to the rising sea level and other climate uncertainties.

Figure. 9 RESTORATION OF 'SALINES DE LA TANCADA' by EMF

Figure. 10 RESTORATION OF 'SALINES DE LA TANCADA' by EMF

4.4 Natural Building as Opportunities for Community Engagement & Natural Play

Due to the accessibility and cleanliness of the wattle and daub technique, the whole building process (material sourcing, building, repairing, demolishing) will be designed to provide opportunities for community engagement and natural play.

Taking Ise Grand Shrine as a case study, which is rebuilt every 20 years as a part of the Shinto belief in tokowaka (常若), meaning renewing objects to maintain a strong sense of divine prestige in pursuit of eternity, and as a way of passing building techniques from one generation to the next[1]. The work builds a framework to work with the young generation to pass the traditional raw earth-building techniques through the building and annual repair of the wattle and daub-based elements on site.

Due to the holistic relationship between the site and its material source, the young generation will be able to learn about the local ecologies and material cultures through material sourcing and raw earth-building.
Since the wattle and daub technique requires direct contact between humans and the raw earth, it also give opportunities to eliminate the bias towards the raw earth and push the binary understanding between humans and nature.

1-[11]https://en.wikipedia.org/wiki/Ise_Grand_Shrine#:~:text=The%20shrine%20buildings%20at%20Naik%C5%AB,one%20generation%20to%20the%20next.

Figure. 11 Ise Grand Shrine

Figure. 12 Rebuilding of Ise Grand Shrine

Figure. 13 Ritual of Ise Grand Shrine

05

Design Strategies

5.1 Dug Channels with Straw Clay in Wattle Frames

5.1.1 The Multi-functional Dug Channels

Straw clay in wattle frames is used as a supportive and water-filtering system along the edge of these dug channels. With the different ratios of fibers that are mixed in the straw clay, these wattle frames will have different permeability, which allows them to guide, collect, filter, and distribute water in various situations.

The straw clay in wattle frames will function primarily as a supportive system for channel erosion control, with other functions including but not limited to site barriers, check dams, water filters, and retaining walls.

Designed as a temporary system, these wattle frames with straw clay can be repaired annually depending on the need, and it's a decaying system that will be blended into the landscape with the maturing of planted vegetation's root systems and soil condition.

This temporary system challenges the conventional static landscapes because it's a dynamic system that sustainably supports the marsh landscape and makes it self-sustaining.

Figure. 14 Digital Sketch Based on Image by Save The Bay

Multi-functional Dug Channels

01 Freshwater Guiding

The channels can partially guide the stormwater directly from the upper land forest area into the salt marsh. By doing so, the gaining of fresh water in the existing phragmites field will be limited, which slows the growth of phragmites down. The control of the phragmites field will provide more root space for the native marsh plants to grow and allow the young marsh to start colonizing the overgrowing phragmites field. Eventually, these channels will support the growth of a young marsh habitat, which is the pioneer zone for marsh migration.

02 Freshwater Gathering

Water gathering is another function. With the combination of the channels and check dams, rainwater can be collected and distributed intentionally, creating a humid environment for the pioneer species so that the young forest can grow and migrate with rising sea levels. The upper land forest has its unique ecological function and value, and it also protects the salt marsh as a buffer zone. Thus, forest migration will also be one of the areas of focus.

03 Sediment Building

The designed channels can send decomposed organic matter from the upper land forest to the degrading marsh area to help it build thicker sediment layers. Taking The Sediment Budget[1] - the gaining and loss of marsh sediment as a design tool, this thesis will explore the contribution the channels can make in the building of marsh sediment, with a specific focus on the sediment from the upper land forest area.

1-[12]FitzGerald, Duncan M., and Zoe J. Hughes, eds. "Salt Marshes: Function, Dynamics, and Stresses." (2021).

04 Supporting Seawater Flow

The dug channels can allow more salt water to flow into the ghost forest to build sediment, which can prepare the ghost forest area to be ready to be transformed into a young salt marsh. What's more, the receiving of salt water from the ocean can also support phragmites control, due to the fact that phragmites is species that's less saltwater tolerant than the marsh plants such as spartinas.

5.1.2 Straw Clay in Wattle Frames

Straw clay in wattle frames is used as a supportive and water-filtering system along the edge of these dug channels. With the different ratios of fibers that are mixed in the straw clay, these wattle frames will have different permeability, which allows them to guide, collect, filter, and distribute water in various situations.

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This temporary system challenges the conventional static landscapes because it's a dynamic system that sustainably supports the marsh landscape and makes it self-sustaining.

5.2 Cultivated Plantings

Plants will be cultivated according to various site ecological and hydrological conditions, including but not limited to the humidity of the soil, the salt content of the water, and the existing vegetation root systems. The cultivation of plants can initiate pioneer species for succession forests and help stabilize the eroding marsh edge.

Specific species of plants will be chosen to meet different soil conditions and also provide unique functions. For example, in the young forest area, the plants will be mainly willow and dogwood due to the fact that they are fast-growing pioneer species that can help stabilize the soil and also provide building materials for the wattle frames with their flexible whips.

5.3 Removal of Existing Causeways

The two existing causeways will be removed in stages, with different phases of marsh vegetation replanting. The materials from the demolishing of the causeways, mainly sand and gravel, will be repurposed as the base materials of the proposed channels.

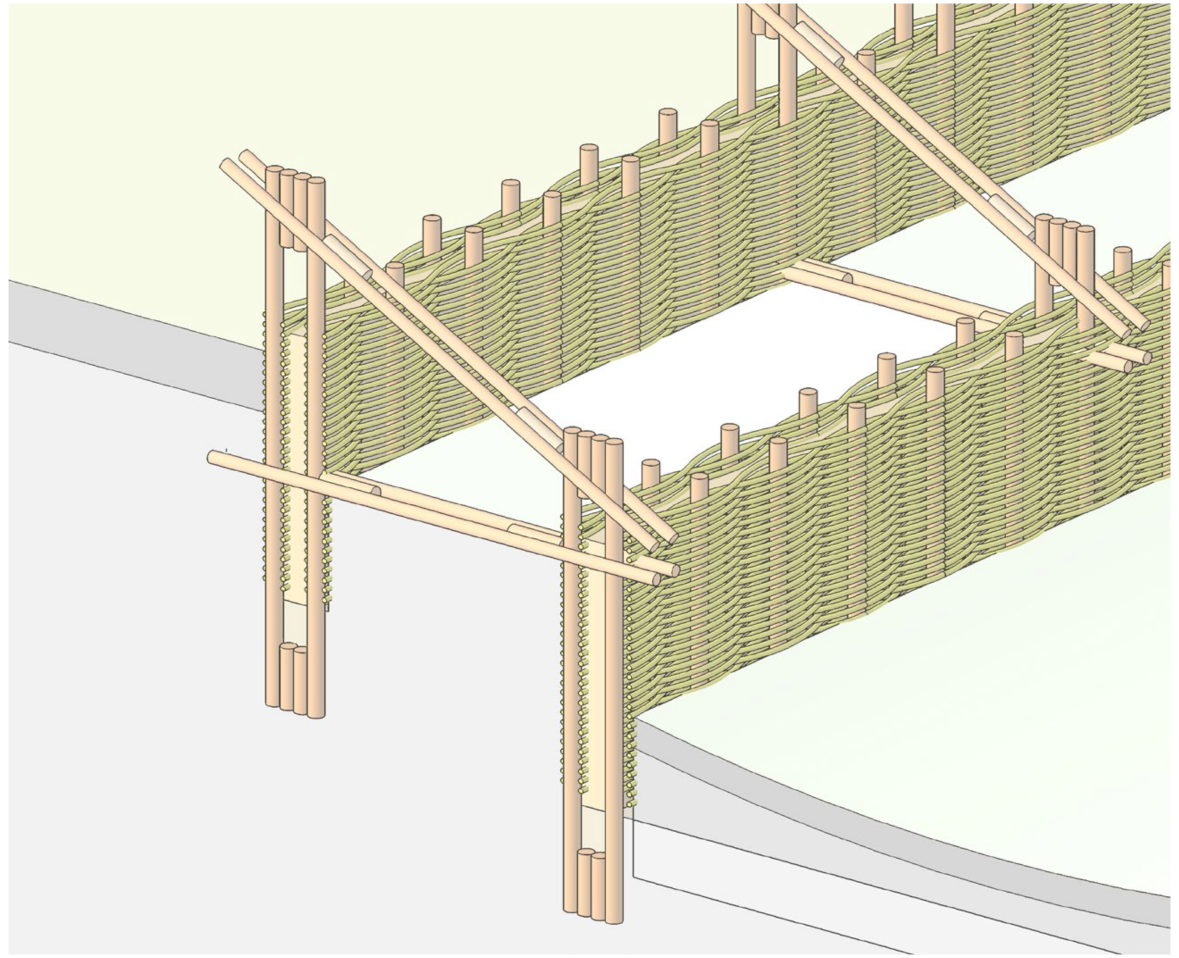
With the removal of the two causeways, a new path along the channel between the forest and the phragmites field will be built to redirect people to walk to the beach, this new proposed path is not only an enjoyable leisure path but also a statement that people should appreciate the beauty of salt marsh in a distance to limit the disturbance.

06

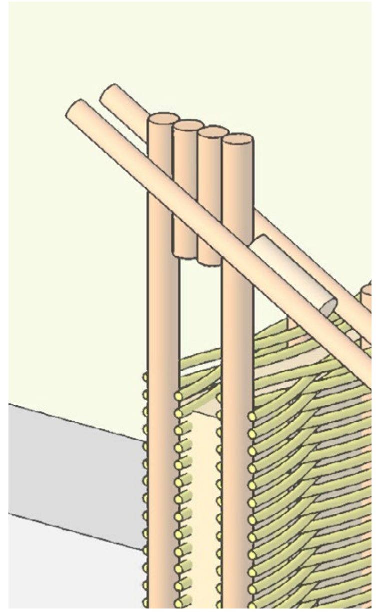
Design Outcomes

6.1 Prototype Design

The design of the prototype was developed together with the design of the channels. The primary prototype was designed to function as retaining walls that can achieve a large range of permeabilities, with a double-sided wattle as the frame, straw clay as filling, and the wooden structure as the skeleton, making the walls a self-supporting system.



With different ratios of fiber input for the straw clay filling, the retaining walls can meet different needs for water management and sediment building. Moreover, the changes in height and the thickness of the walls can adapt themselves to different site threshold elements, which include and are not limited to fences, retaining walls, bird blinders, and check dams.



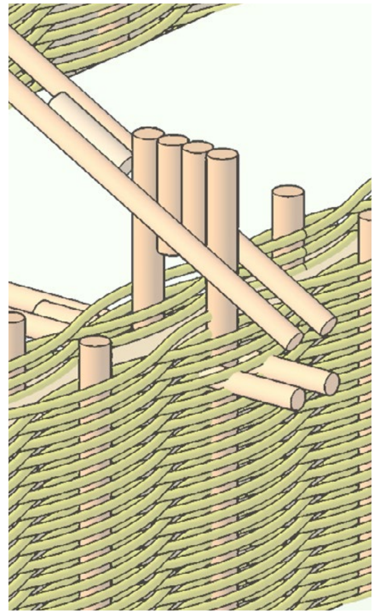


Figure. 15 Wooden Structure Reference - Handmade School by Anna Heringer + Eike Roswag

6.2 Plan Design

6.2.1 Master Plan

The site master plan is designed to meet various needs in different site conditions, with the dug channels and straw clay in the wattle frame as the main design language. The two existing causeways are removed to enhance marsh migration, and a new beach access that is along the edge of the young marsh is proposed in the master plan.

In each section, the proposed prototypes have unique functions:
#1 Young Forest - Water Harvesting
#2 Upland Forest - Organic Sediment Collection
#3 Ghost forest & Phragmites Field - Fresh Water Management
#4 Salt Marsh - Marsh Sediment Building
#5 Sand Dune - Degrading Sand Dune Retaining

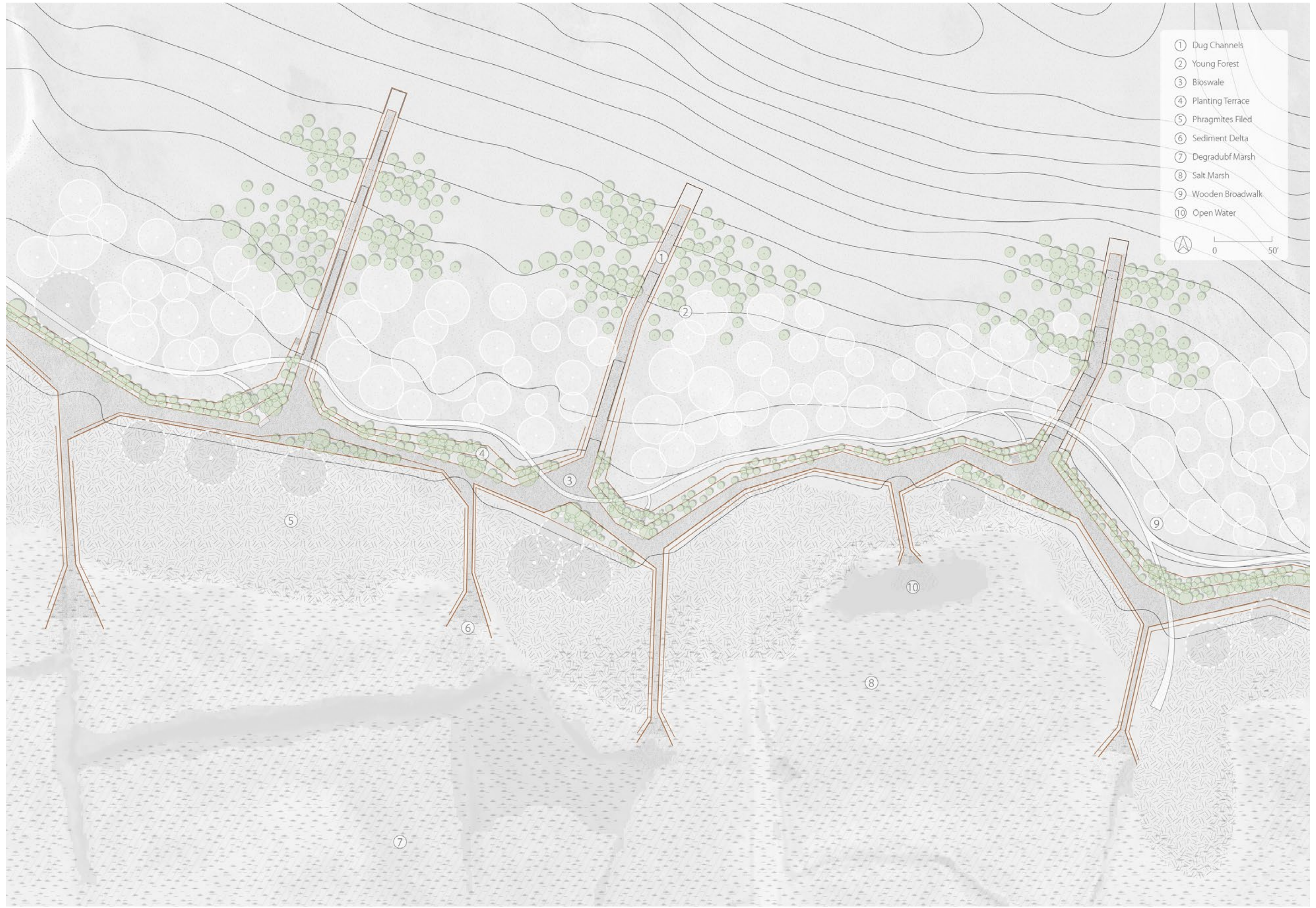
A portion of the master plan is chosen to be developed into a detailed plan, which integrates with the four major site conditions: young forest, upland forest, young marsh, and salt marsh.

In the detailed plan, grading is conducted to reduce the slope ratio of the existing phragmites field to support marsh migration and to help manage the flow of the freshwater.

As shown on the plan, the proposed channels with retaining walls are represented as white lines, and the areas between the retaining walls will become planting areas that will be planted with various native forest and marsh vegetation.

Apart from the dug channels, a wooden boardwalk is proposed to redirect people to the beach without stepping onto the salt marsh. In some areas of the plan, the visitors will be able to observe the salt marsh ecology from a distance, which provides opportunities for natural education and play with limited site interaction and disturbance.

6.2.2 Proposed Plan



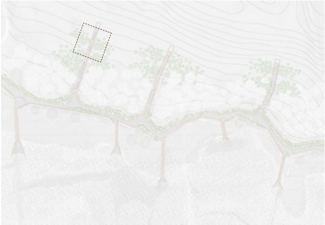
6.3 Section Design

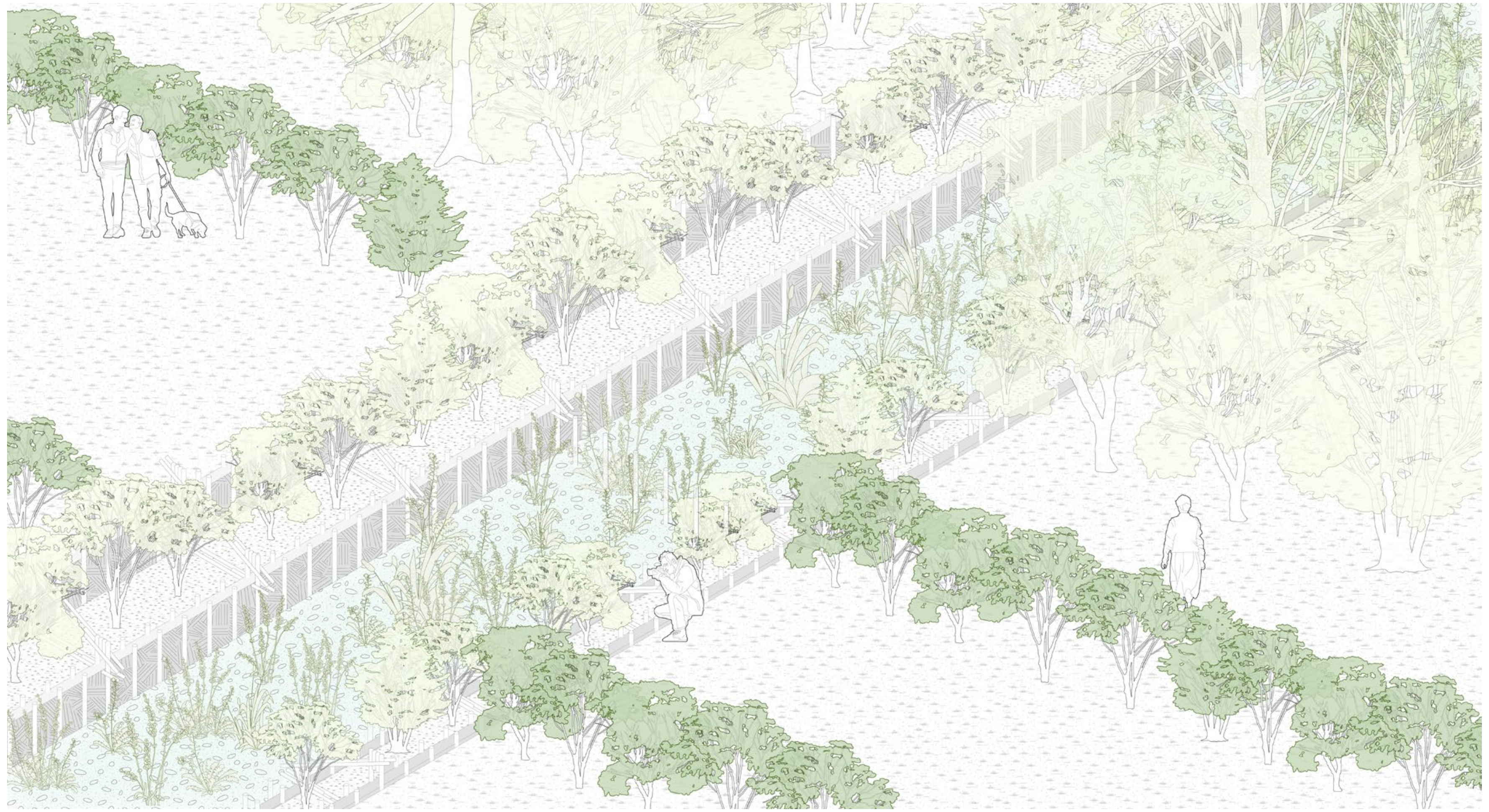
6.3.1 Young Forest Expansion

In the young forest area, the dug channels will function as a water harvesting system for forest expansion. Check dams built with wattles will be constructed in the channels, to slow down the speed of freshwater flow. The horizontal extension of the check dams will be built with living stakes, which will be the starting gesture of forest expansion.

The retaining walls on both sides of the channel can help with erosion control, and also provide spaces with different humidity levels for planting. Various water-loving plants will be planted in the middle of the channels, and the channels will also function as bioswales that can bring organic sediment to the degrading salt marsh.

On the two platforms along the channels, plants such as willow and dogwood will be planted to help stabilize the soil, and the whips of these plants can also be cut annually to support the repair of the wattle frames.





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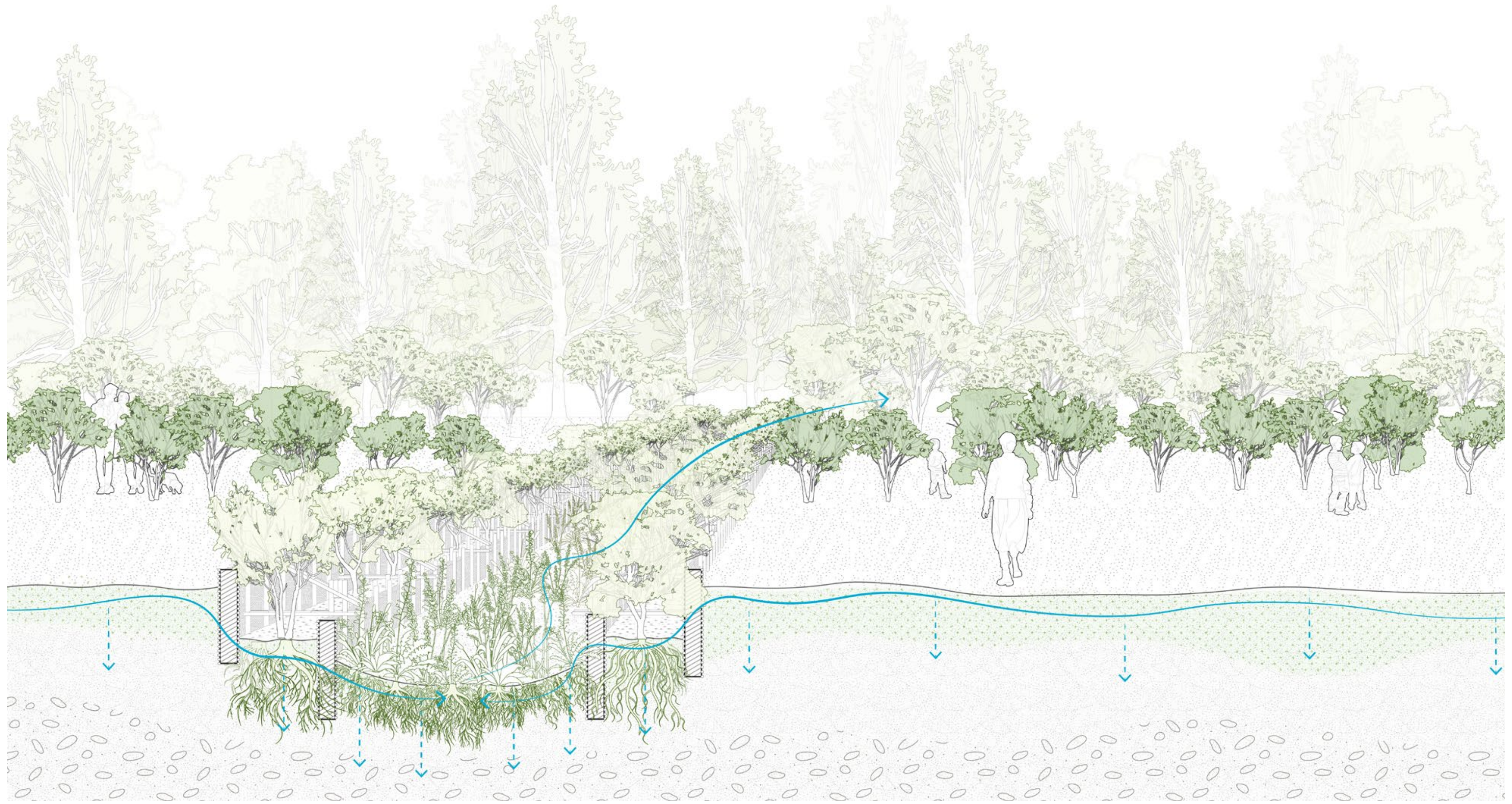
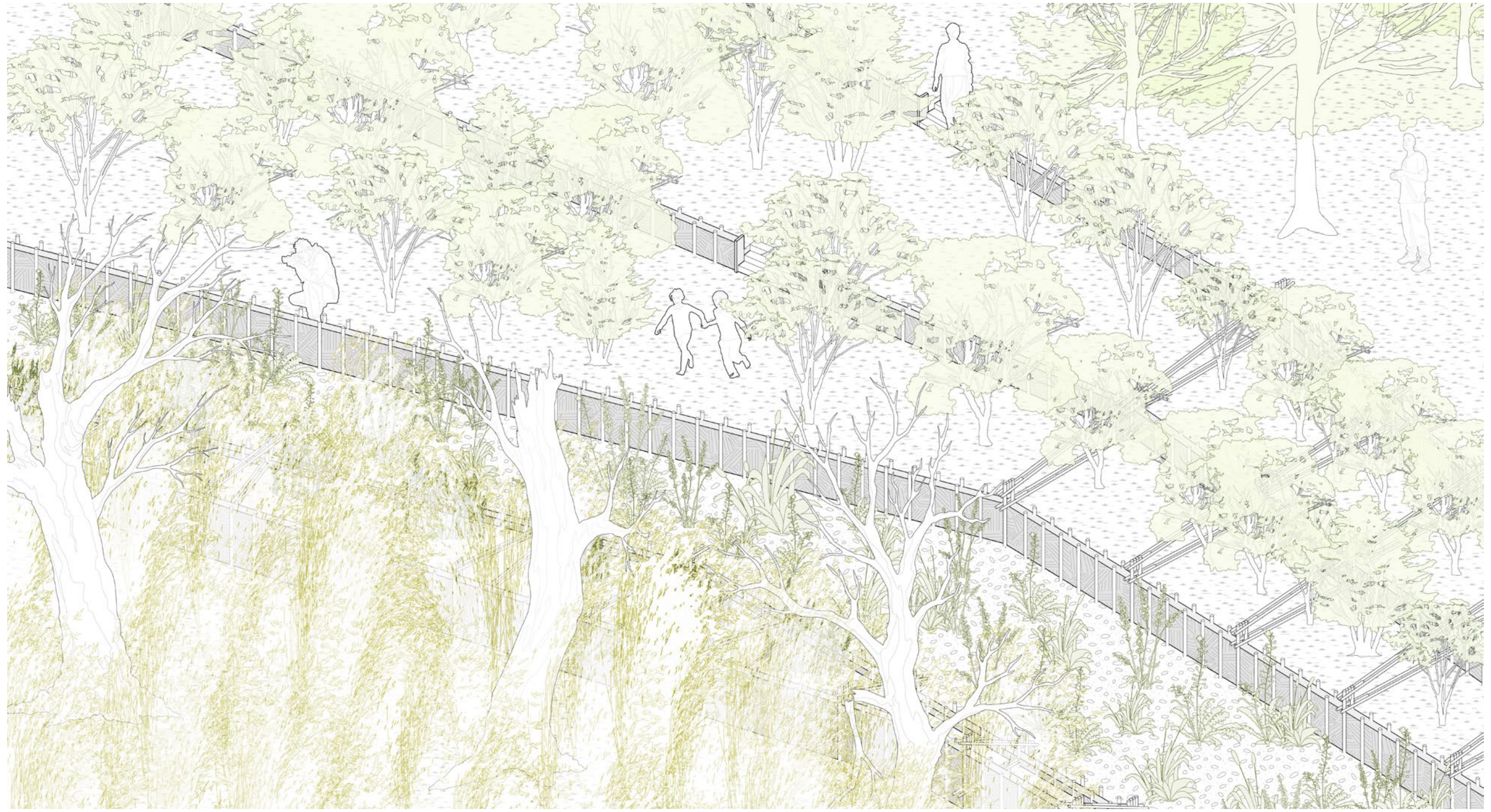


6.3.2 The Threshold of Forest & Phragmites Field

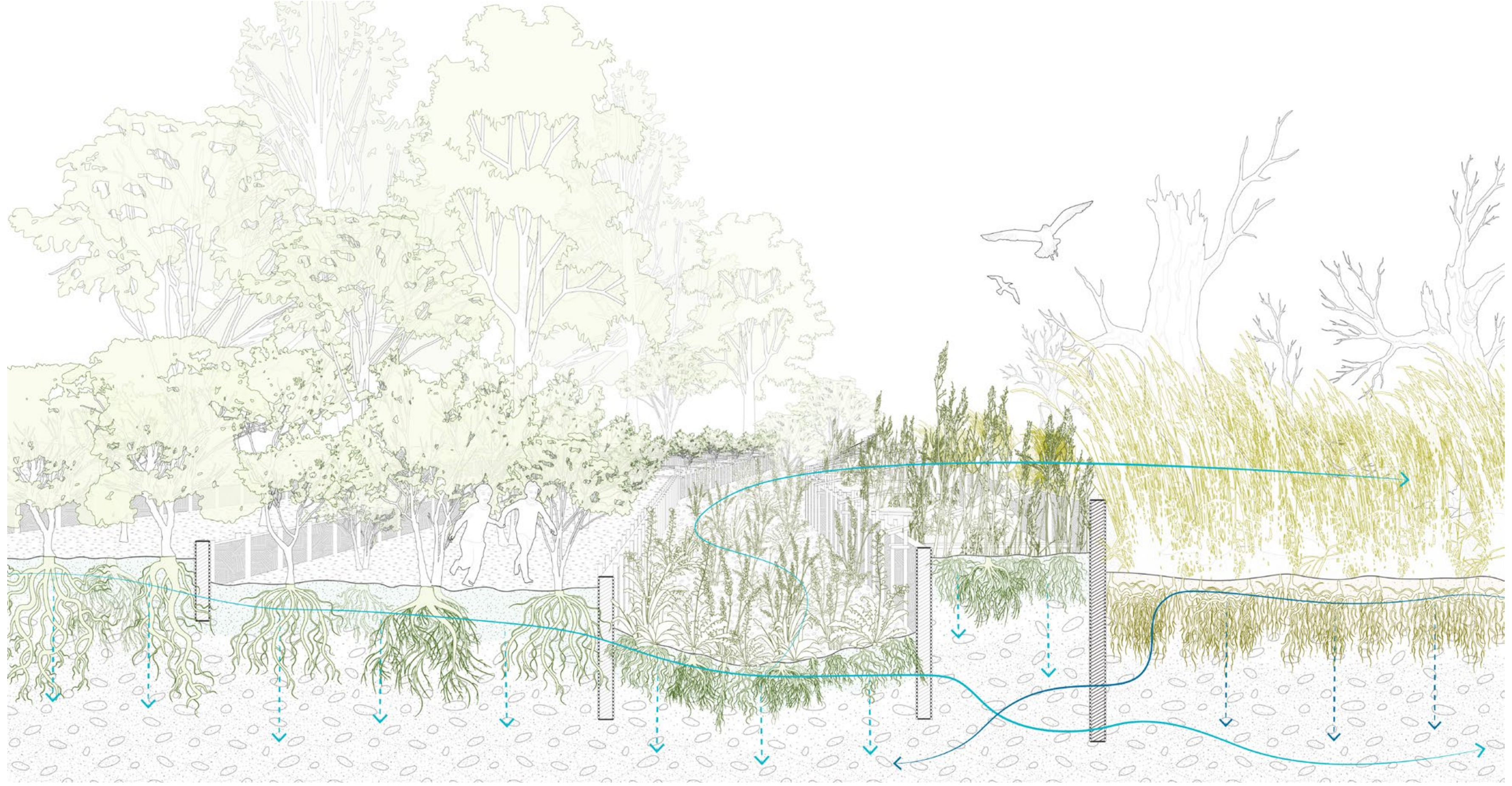
Along the threshold of the forest and the phragmites field, a continuous channel will be built to limit the freshwater receiving of the phragmites field.

The retaining walls on each side of the channel will have different permeability - the walls that are next to the phragmites field will be impermeable, which stops the phragmites from receiving freshwater and slows their growth, providing more root space for marsh migration. The walls adjacent to the existing forest will be porous, allowing freshwater to go through the planting terrace and creating suitable soil conditions for freshwater plants to grow and compete with the phragmites.
In some of the freshwater plant terraces, visitors will be able to walk down and observe the phragmites field, the ghost forest, and the young marsh within a distance.



Earth to Fiber - 1:8

Earth to Fiber - 1:4

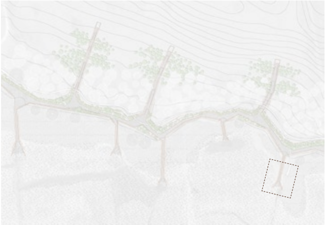


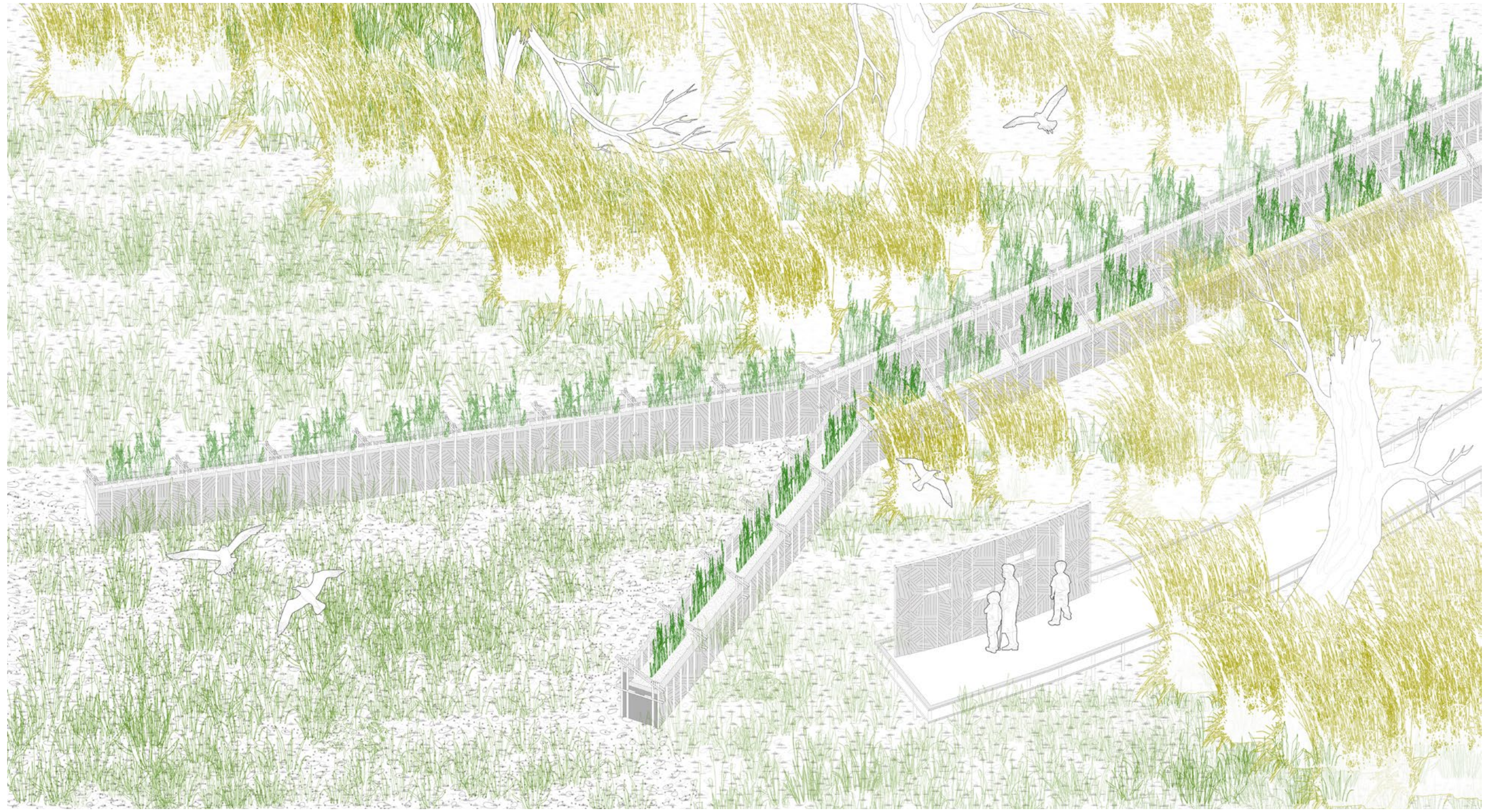
6.3.3 Marsh Sediment Building Delta

On the phragmites field, the channels are designed to send the freshwater and the organic sediment from the forest area to the degrading marsh with a delta-like opening.

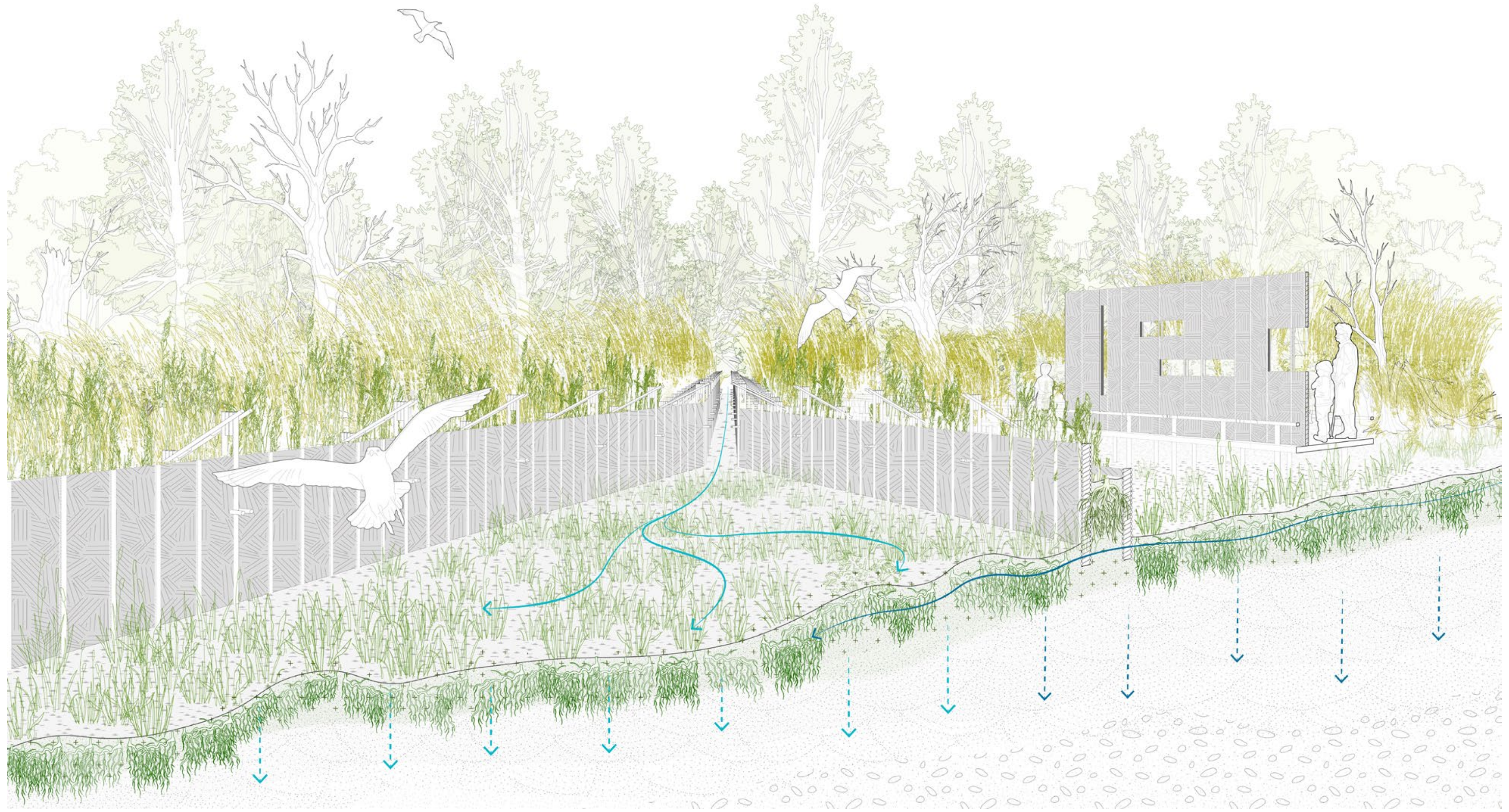
The channels will be impermeable from the inside, which stops the phragmites from getting freshwater, and will be porous from the outside, which creates a salty environment in the terraces for the high marsh plants to grow and compete with the phragmites.

The boardwalk will be extended into some areas of the phragmites field, providing access to the annual phragmites harvesting. The extended boardwalk will function as a bird-watching space in the non-harvesting season, with the tall wattle frames as bird blinders.





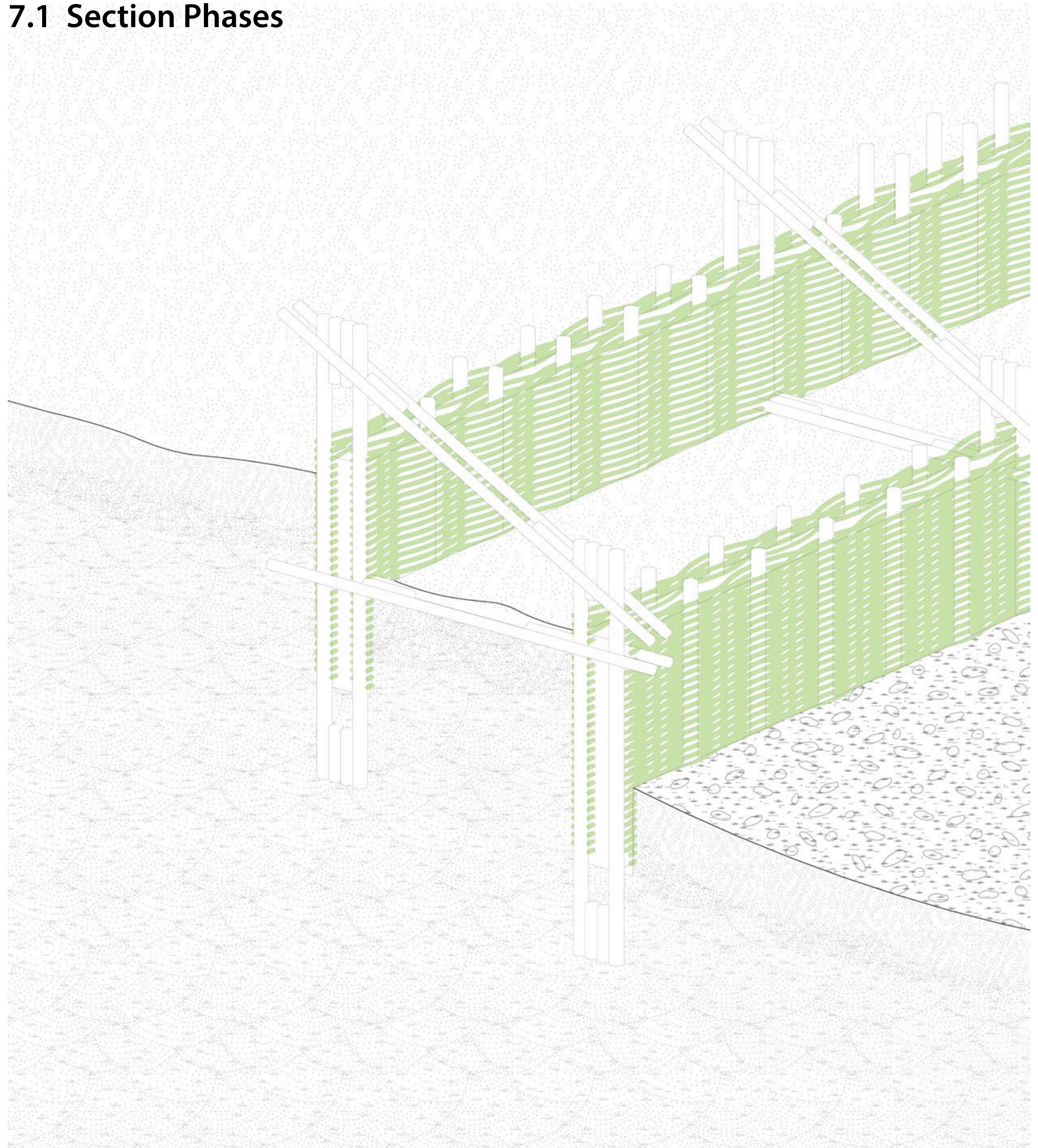
Earth to Fiber - 1:6



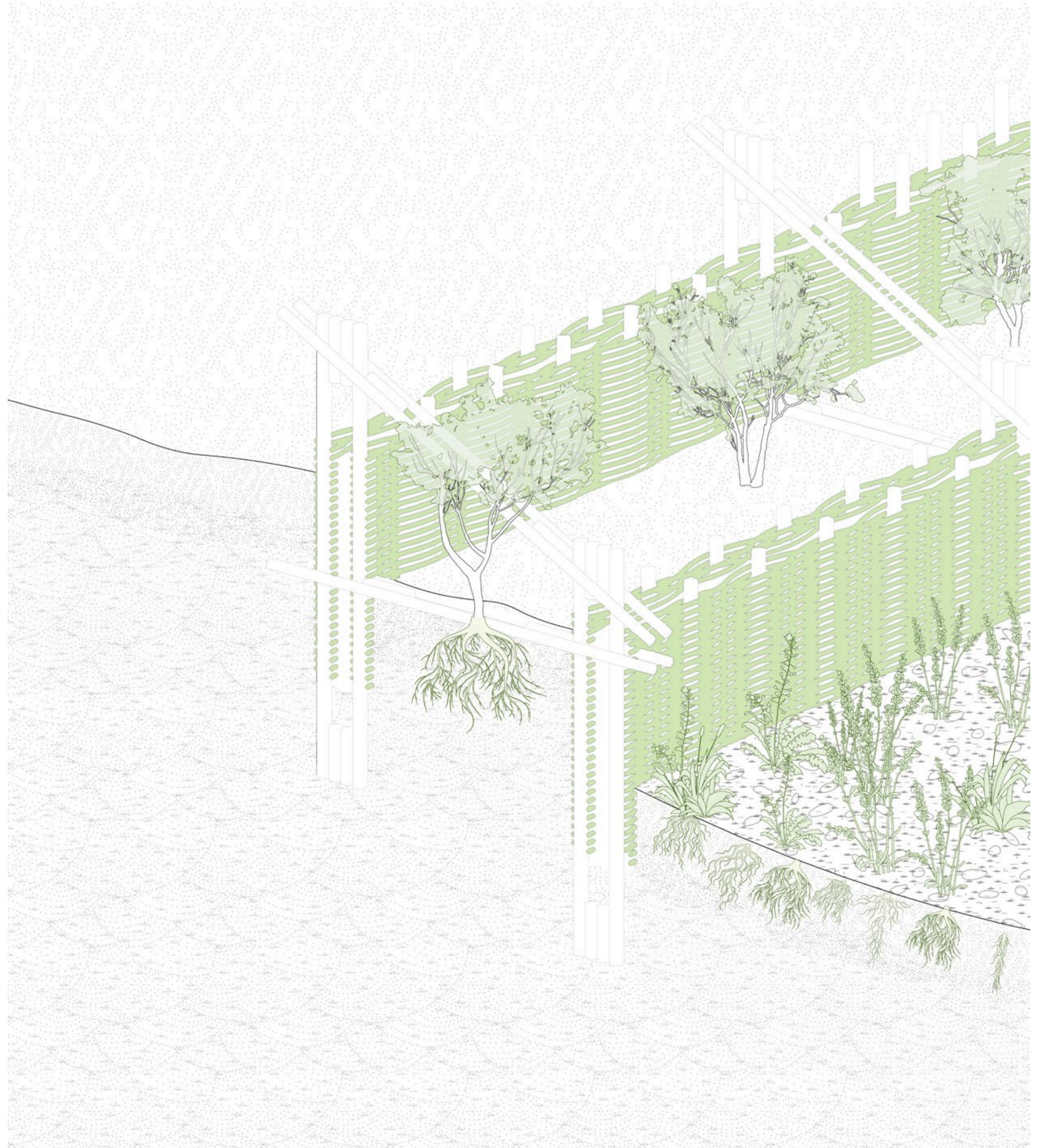
07

Design Phases

7.1 Section Phases



Year 0



Year 5

Year 10

Built with living stakes and straw clay filling, the system will grow and decay at the same time, and eventually blend into the ecosystem. Annual repairs will be conducted on specific areas of the site to achieve different ecological and functional needs.

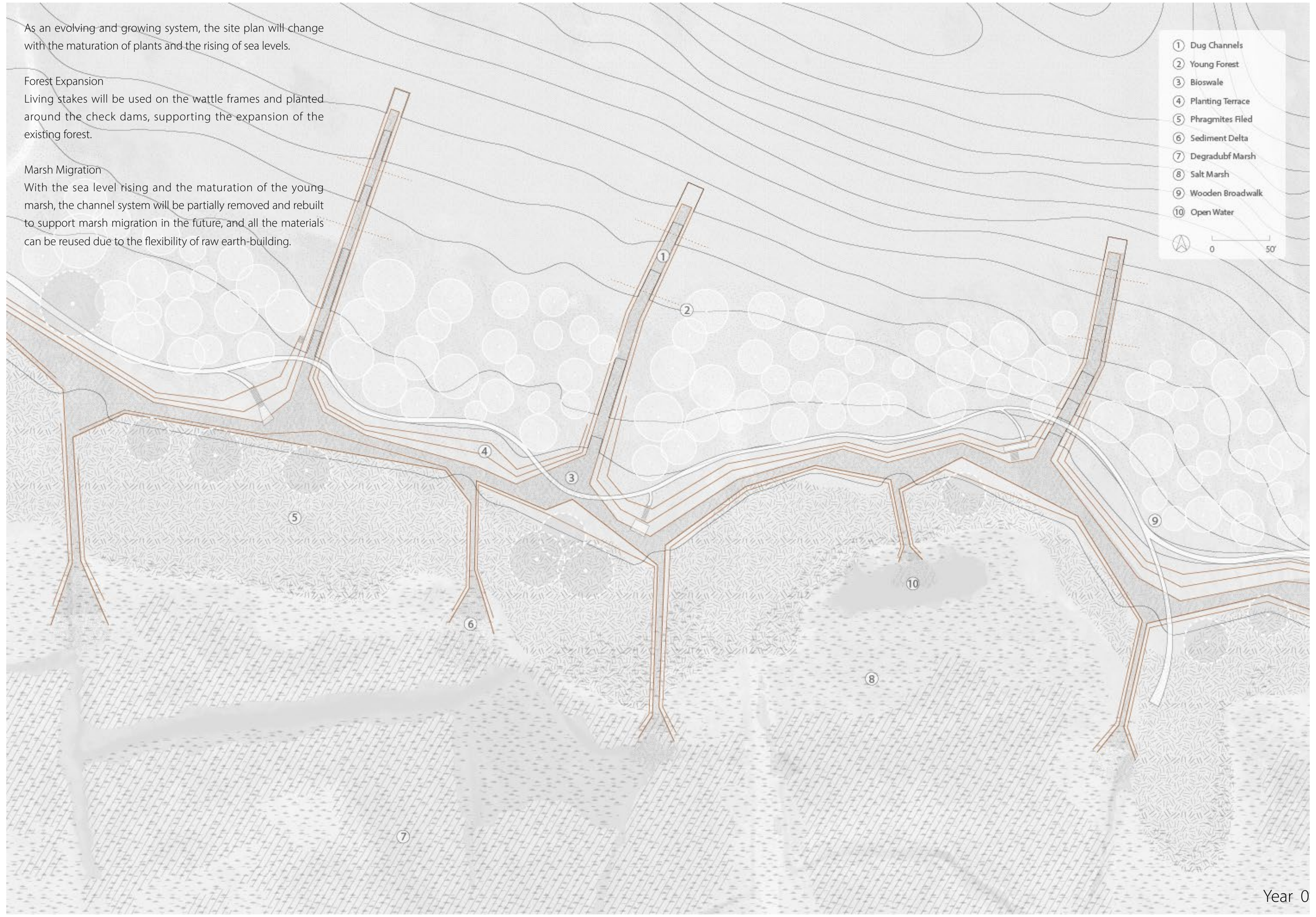
Year 15

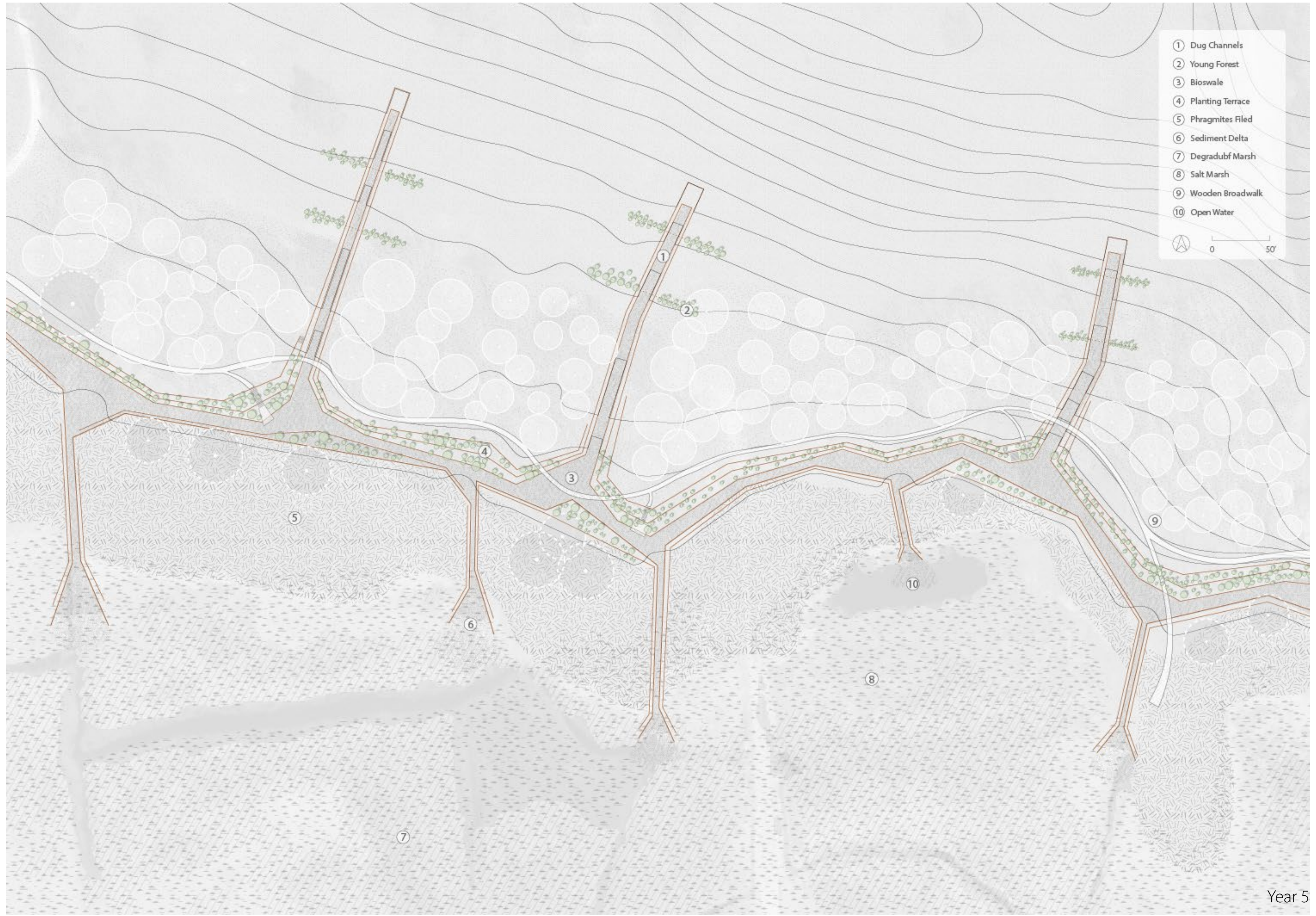
7.2 Plan Phases

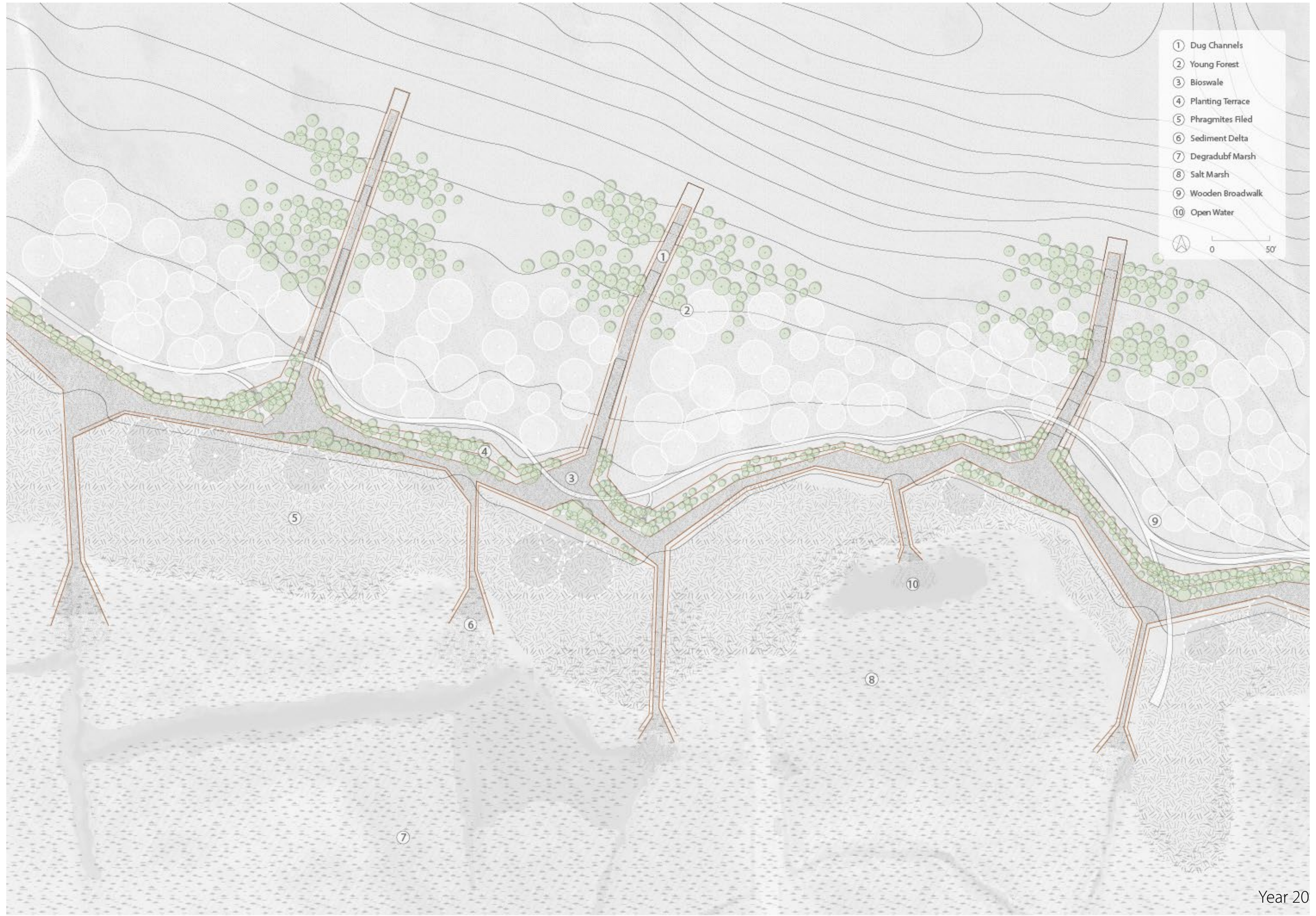
As an evolving and growing system, the site plan will change with the maturation of plants and the rising of sea levels.

Forest Expansion
Living stakes will be used on the wattle frames and planted around the check dams, supporting the expansion of the existing forest.

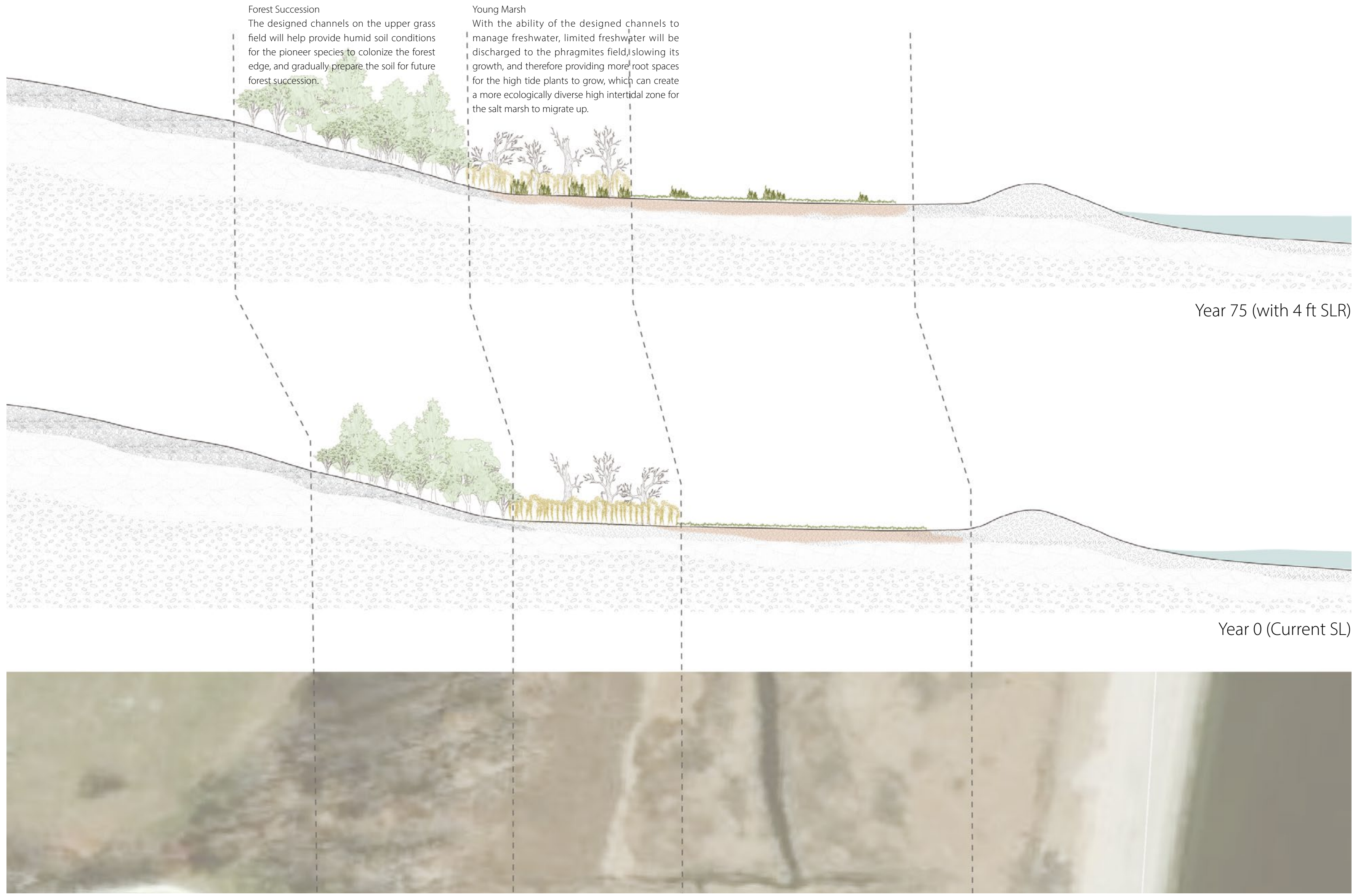
Marsh Migration
With the sea level rising and the maturation of the young marsh, the channel system will be partially removed and rebuilt to support marsh migration in the future, and all the materials can be reused due to the flexibility of raw earth-building.







7.3 Vegetation Phases



Year 75 (with 4 ft SLR)

Year 0 (Current SL)

Existing Site Plan

08

Material Explorations

8.1 Wattle and Daub Workshop

8.1.1 Wattle and Daub Workshop with Maddelena Achenza

On April 11th, 2024, a group workshop was organized to learn about the wattle and daub building technique with Maddelena Achenza, a professor from the University of Cagliari who specializes in earth architecture.

During the workshop, the soil from Tillinghast Place was tested and used to build wattle and daub. The lack of cohesiveness indicates the lack of clay in the site's soil, which provided valuable information for the future material exploration.

Figure.16 Different Fiber Inputs

In the building process of the wattle and daub frame with site soil, specific instructions were given to enhance the stability of the wattle and daub frame, such as: attaching the mixture of soil and fiber from the bottom of the frame to up; mixing clay and soil before adding fibers; limiting the usage of water to keep the mix humid enough to work with but not running. The suggestions given by Professor Achenza proved to be highly valuable and were used for future full-scale prototype building.

Figure.17 Wattle and Daub Detail

8.1.2 Reflection on the Workshop

After the workshop, the wattle and daub technique was chosen as the primary construction method for this thesis due to its flexibility in form-making, the variety of permeability it can achieve depending on the fiber's input, as well as the abundance of materials it requires. These conditions make the wattle and daub a sustainable and suitable building technique to support marsh migration.

Due to the limitation of wattle and daub – it can not be self-sustaining as a single wall structure, and the finishing layer needs to be weathering-proof – a system formed by straw clay in wattle frames was developed. The straw-clay is supported by a double wattle screen on both sides, and the wattle frames are connected to each other with wooden structures to make the system more self-sustaining.

8.2 Local Material Sourcing and Treatment

The straw-clay building in the wattle frame system requires four primary materials: soil, clay, fiber, and wood, all of which can be sourced locally. Taking Tillinghast Place as the study site, the local material sourcing and treatment were conducted on-site to prove the feasibility of the proposed design strategies.

8.2.1 Soil

The soil was sourced on-site from the upper forest area, which is highly abundant and can be sourced easily with shovels.

During the sourcing process, the topsoil (around 1.5 feet thick) was dug out and put back. This is because the organic topsoil is ecologically valuable and unsuitable for building. After digging out the topsoil, the subsoil was then sourced and later sieved in the Sustainability Design Lab after the drying process.

The sieved soil is a combination of sand and clay, which is suitable for earthbuilding.

8.2.2 Clay

During the sourcing process, not enough clay was found in four different locations in Tillinghast Place due to the ridge adjacent to the site, which limits the clay accumulation on the site. However, Rhode Island is abundant in clay due to its geographical history, which still supports the sustainable building process of the work for its clay sourcing.

Under the guidance of Professor Lara Davis, kaolin was chosen as the substitute for clay for the studio material exploration.

8.2.3 Fiber

The phragmites are chosen as the source of fiber due to their abundance on site as well as their doability in straw-clay construction.

On Tillinghast Place, there is a continuous field of overgrowing phragmites, which is preventing the growth of young marsh due to its dense rhizome system. Hence, the sourcing of phragmites for fibers is not only sustainable, but it can also help to control the growth of phragmites, therefore providing the required space for the young marsh to migrate.

The sourcing of phragmites is mainly done by hand with cutting knives, and the suitable season for phragmites sourcing is December to April annually due to the fact that this is the period when the dried phragmites stems are still standing on the ground and already dehydrated, with no further dehydration needed.

The fiber treatment process is further done in the Sustainability Design Lab using cutting knives and scissors. The processed phragmites fibers are soaked in the water to give them more flexibility before the mixing process.

8.2.4 Wood

The wood for the wattle frames is sourced from the garden waste from Tillinghast Place.

The structural wood is mainly from oak trees and thicker dogwood garden waste, and the weaving whips are sourced from thinner dogwood garden waste.

The on-site wood-treating process is done by hand with a hacksaw. The primary garden waste was cut into smaller pieces, making it easier to be transported back to the studio.

Further treatment happens in the RISD CIT woodshop, where a bandsaw is used to treat the wood efficiently. The treated thinner dogwood whips are stored in a water bucket to keep the moisture in the wood and provide flexibility for the wattle frame weaving.

After the sourcing and treating of wood, dogwood, and willow are chosen as the pioneer species for site design. These two plants are low maintenance, provide wood for structure and weaving, and can also compete with the phragmites to form a more diverse vegetation matrix on site.

8.3 Straw Clay with Wattle Frames Prototyping

8.3.1 The Ratio of Kaolin to Soil

Wattle Structure Building

Wattle Weaving

Mixture Ratio Testing (Left to right, Kaolin to Soil)
4:2 3:3 2:4 1:5

Different ratios of kaolin to sieved soi are tested to find the most cohesive mixture.

The 1:3 ratio was eventually chosen due to its cohesiveness and consultation with Professor Lara Davis.

8.3.2 The Ratio of Fiber

With the previous 1:2 kaolin to soil ratio, different ratios of earth to fiber are tested to study their cohesiveness and variety of permeability.

1 : 1

1 : 2

1 : 3

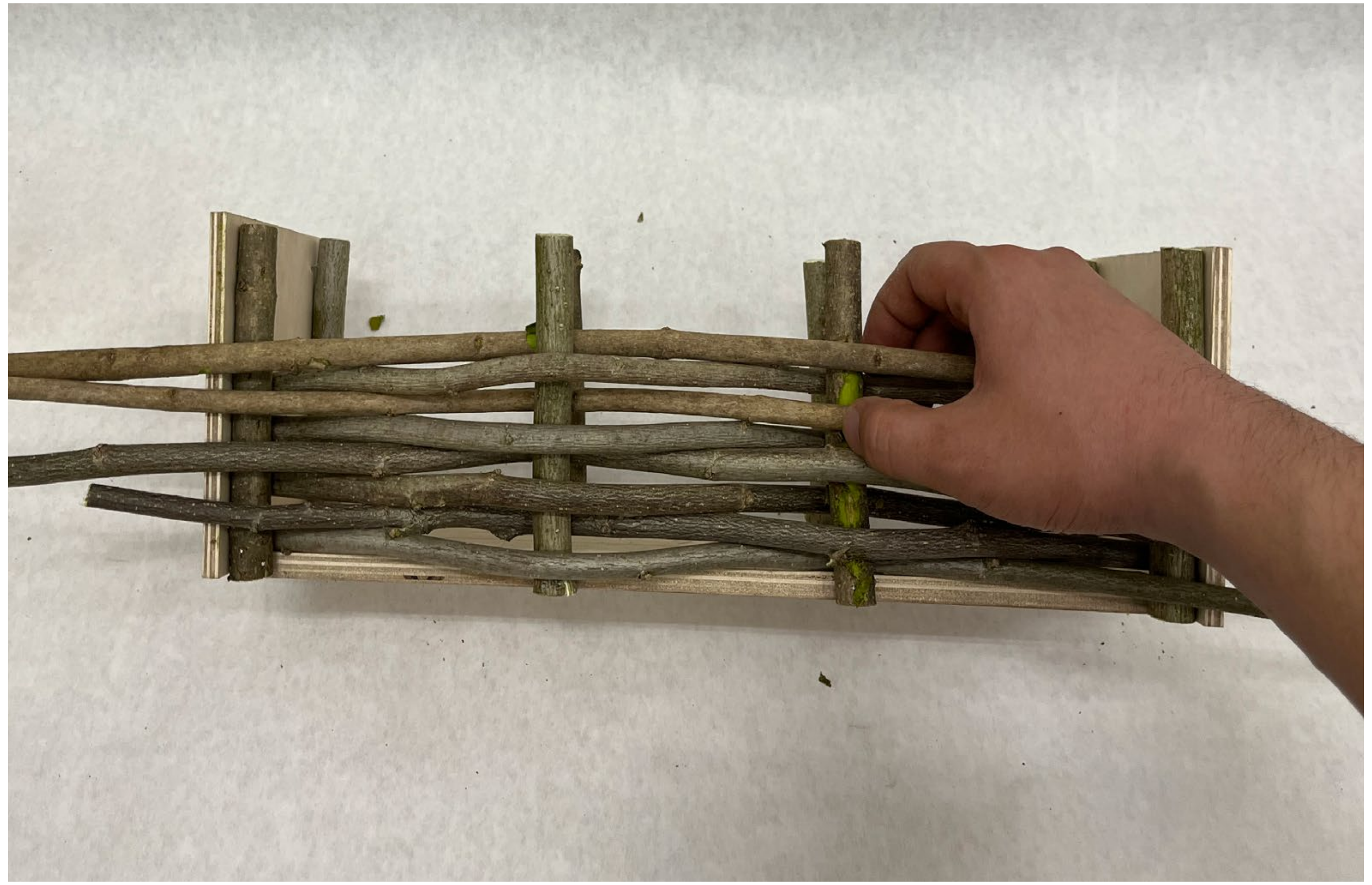
1 : 4

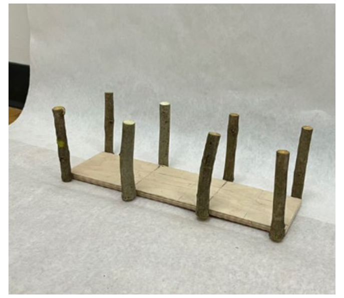
1 : 6

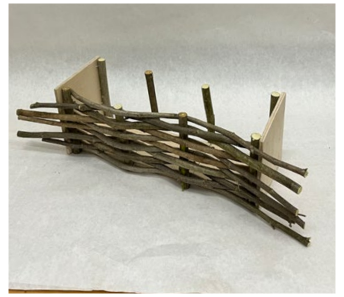
1 : 8

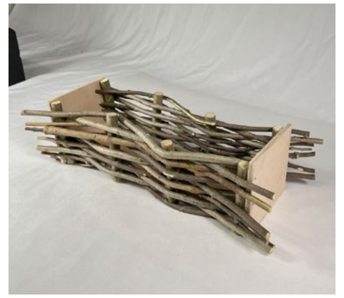
(Earth to Phragmites Fiber)

8.3.3 Small Mock-ups









The 1:1, 1:3, and 1:6 earth-to-fiber ratios are chosen to use as the input of the three small mock-up wattle frames, these three mock-ups are built to test the permeability of the frames for water management in different site situations.

1 : 1

1 : 4

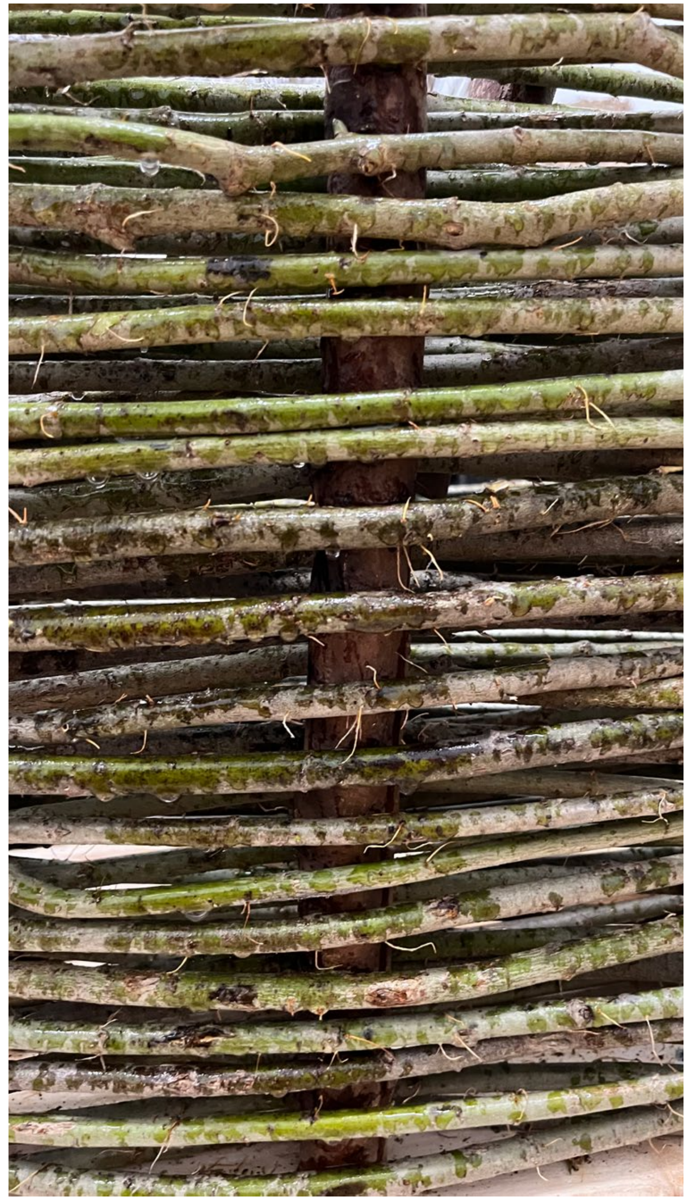
1 :6

(Earth to Phragmites Fiber)

8.3.4 Full-Scale Prototype

In the full-scale prototyping process, a wooden base is built to provide the foundation for the wooden sticks, which mimics the relationship between the soil and the wooden sticks. During the building of the wooden structure, the architect Anna Heringer's work METI Handmade School is referenced for the structural details, and further adjustment is applied to provide more space for the straw clay input.

Streamco Willow whips are chosen for the weaving of the wattle frames due to their flexibility and ability to grow as living stakes. The wooden sticks are placed at a 1-foot distance to ensure the strength of the wattle frames.



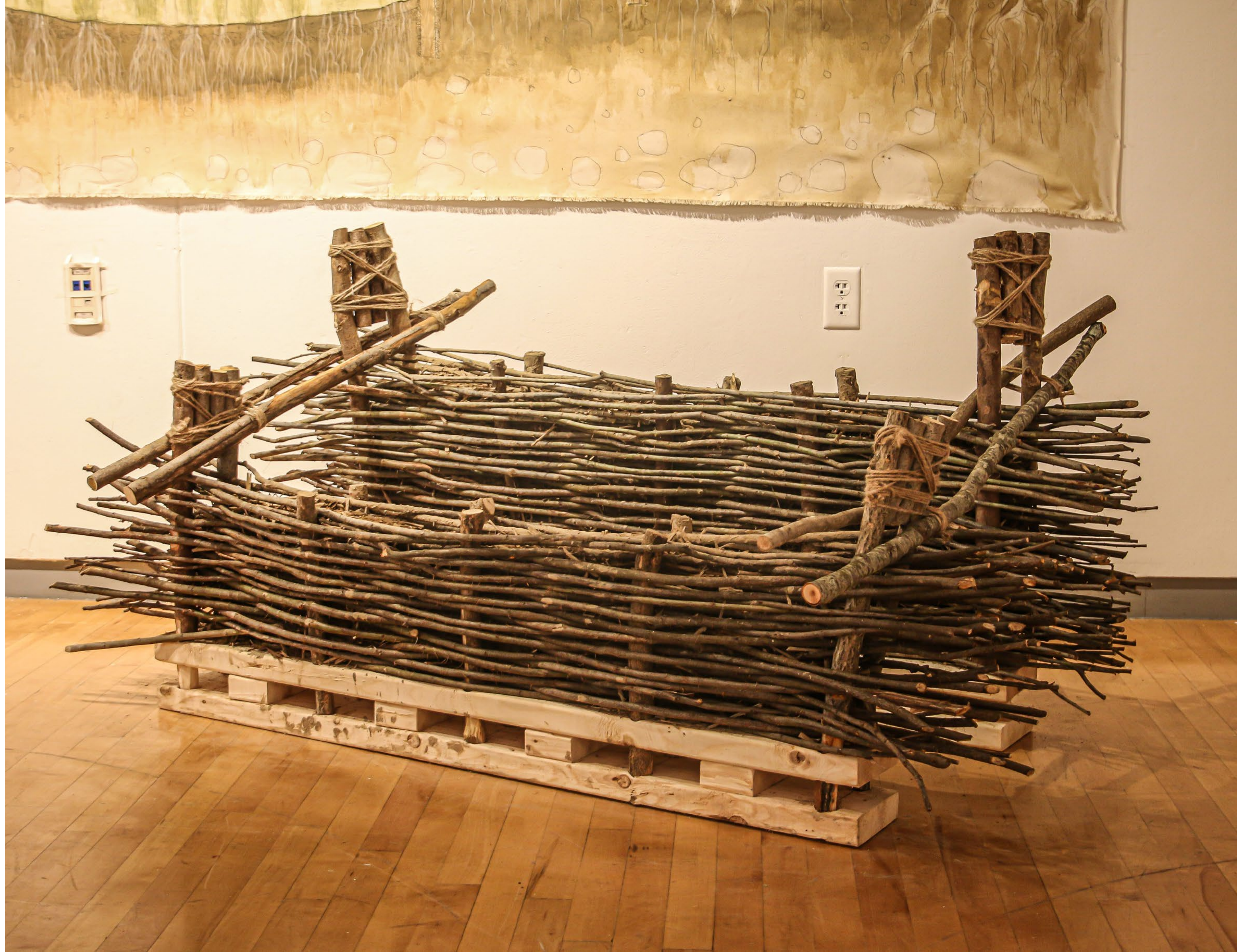
Weaving Process

The 1:6 (earth to fiber) mixing ratio is chosen for the straw clay input, which was proven to be structurally stable and also porous from the previous prototyping process.

After the building process, the Streamco willow whips start to take root and germinate, which proves the possibility of the straw clay in wattle frames to be a living and evolving system.

8.4 Exihibition Design

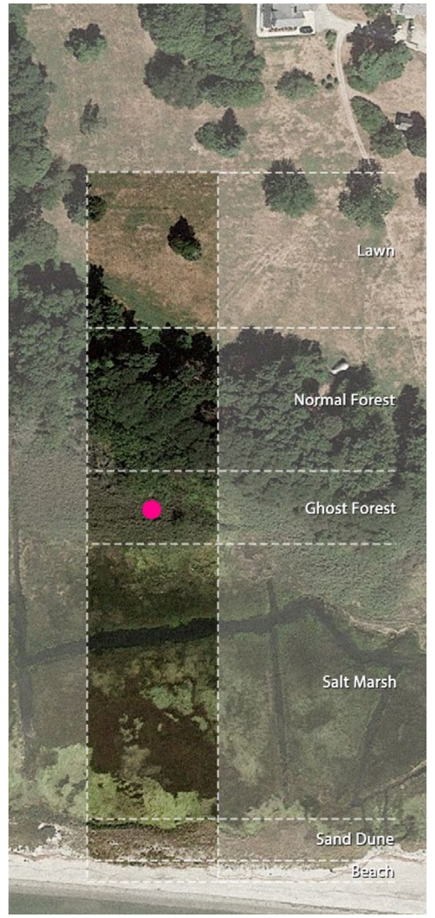
Sol Koffler Graduate Student Gallery
RISD, Providence, RI , USA
2024 May 24th - June 1st



8.5 Previous Material Explorations

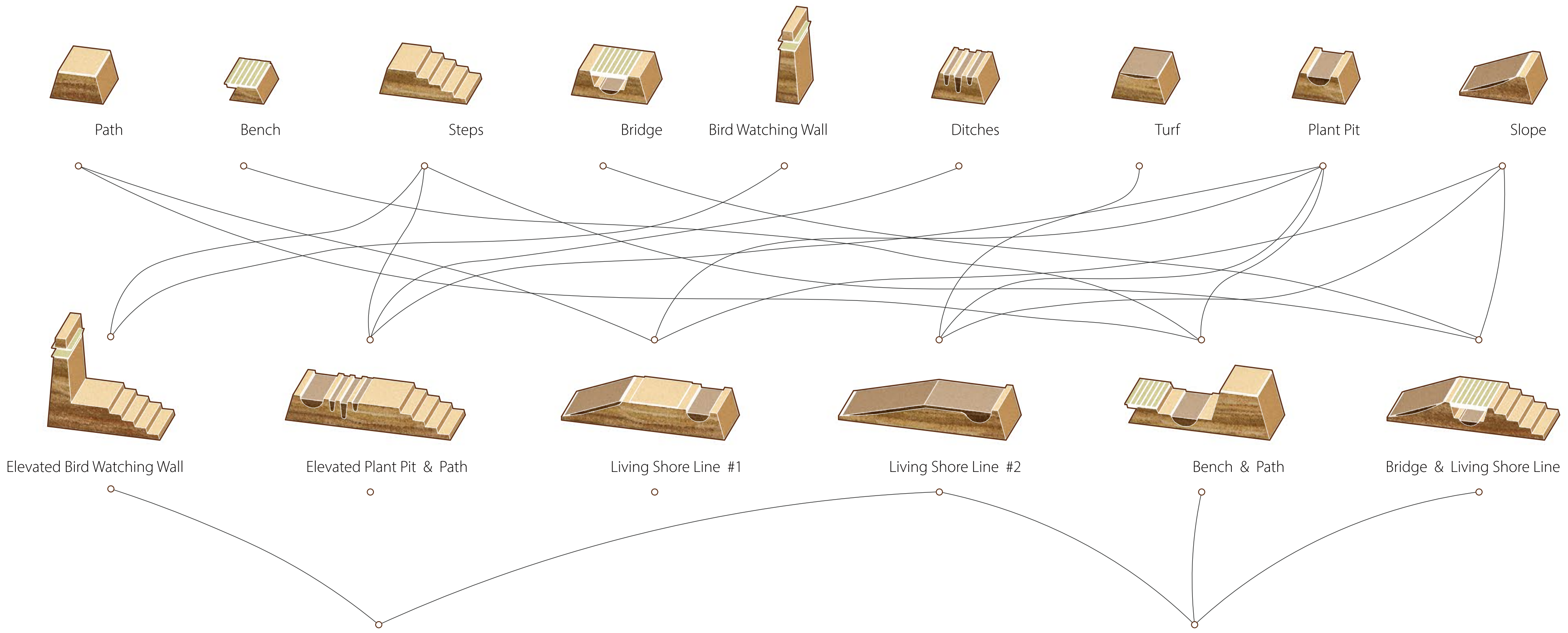
8.5.1 Rammed Earth

During the first semester, the initial design strategy was using rammed earth walls to help establish a series of low-energy environments for the young marsh to grow. The rammed earth was chosen due to its flexibility in forms, and the accessibility of the materials it requires to work with.



Site Location

Site Threshold

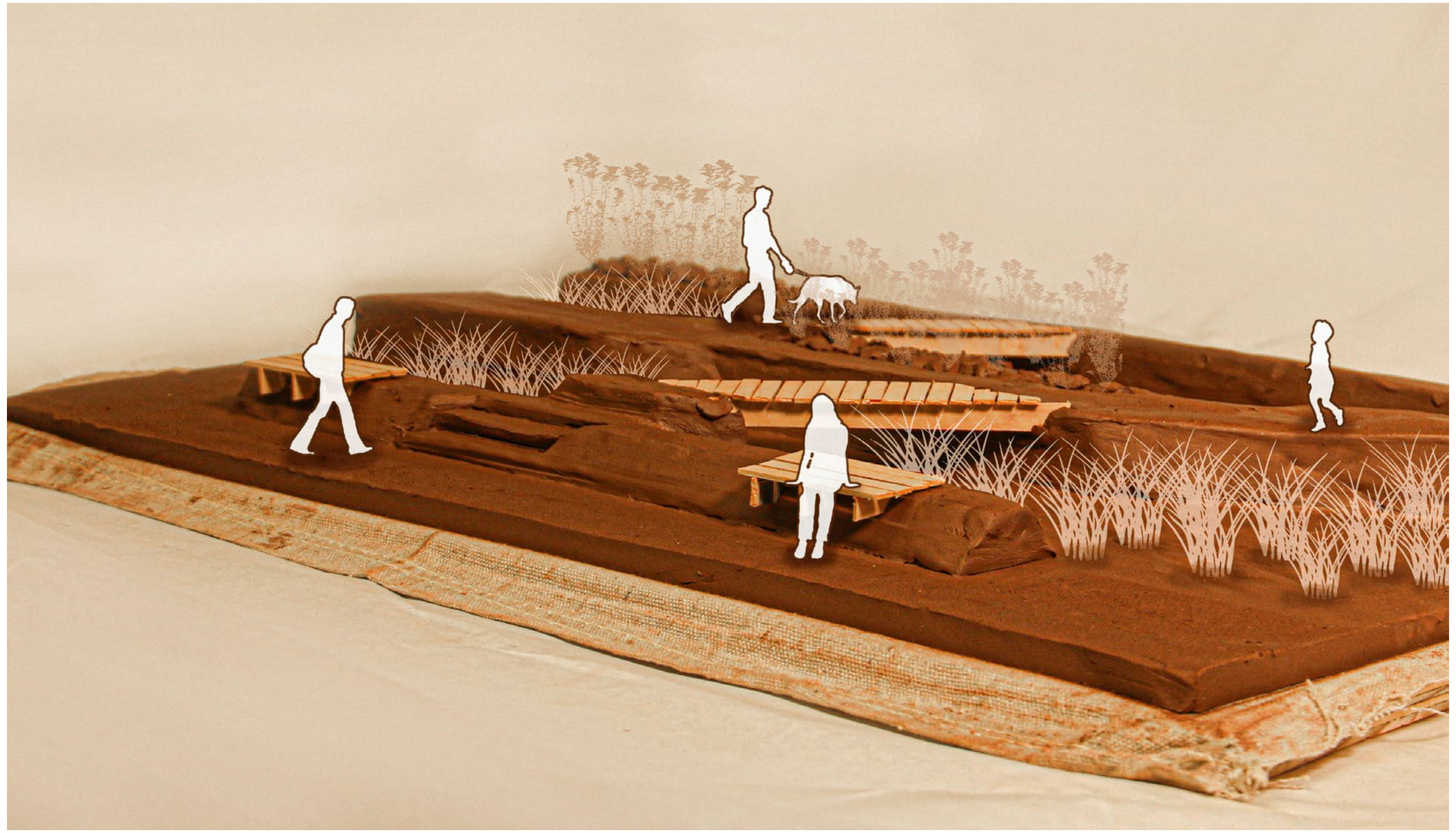


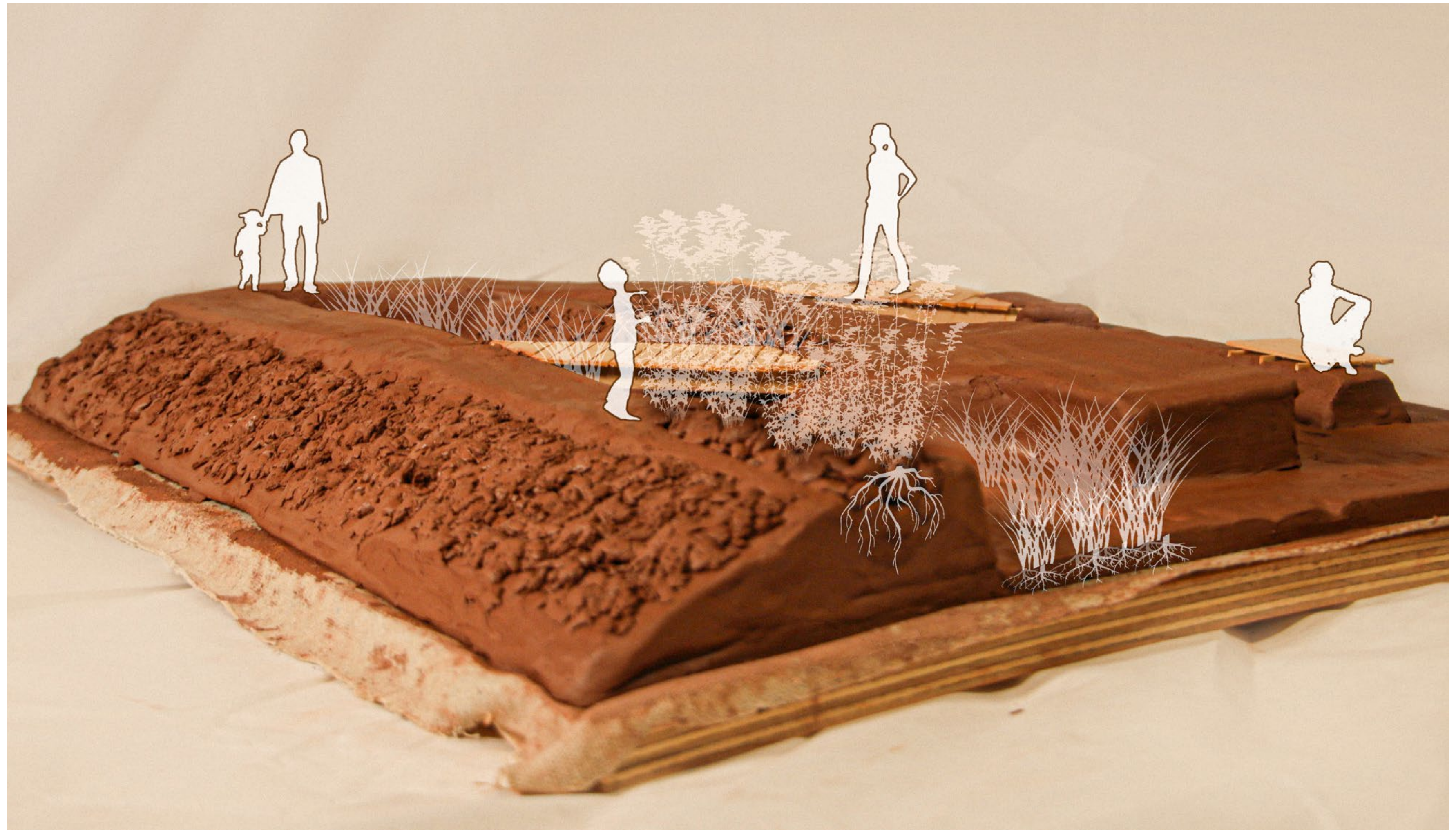
Prototype Test #1
Bird Watching Walls & Living Shoreline & Steps

Prototype Test #2
Walking Path & Benches & Living Shoreline

Unit Models

Prototype #1
Bird Watching Walls & Living Shoreline & Steps





Prototype #2
Walking Path & Benches & Living Shoreline

During the final review in the first semester, suggestions given by the critics indicated that rammed earth is not a suitable construction method for a regularly flooded area, and the narrow focus on the young marsh was also questioned, due to the fact that the salt marsh is a holistic ecological system.

The suggestions from the review were taken, which are reflected in the works in the next section.

Design Models

1:1 Scale Landscape Prototype Drawing
Tempera on Canvas 3.0 m x 1.8m

8.5.2 Cob

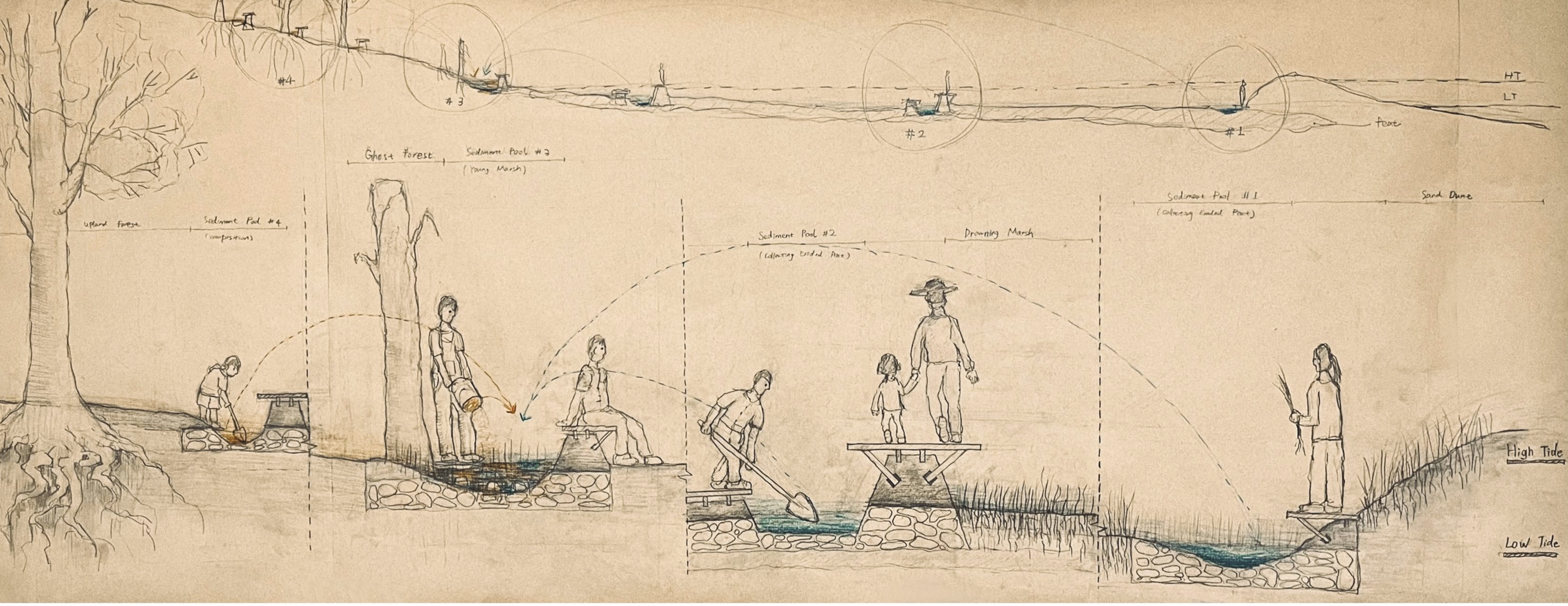
During the second semester, a holistic understanding of the salt marsh ecosystem was gained through academic readings. The refined design strategy used the Marsh Sediment Budget (the gaining and loss of marsh sediments) as a tool kit to help with site design and material exploration.

Cob was chosen as the construction method due to its resistance to constant flooding and the abundance of construction materials it requires on-site.

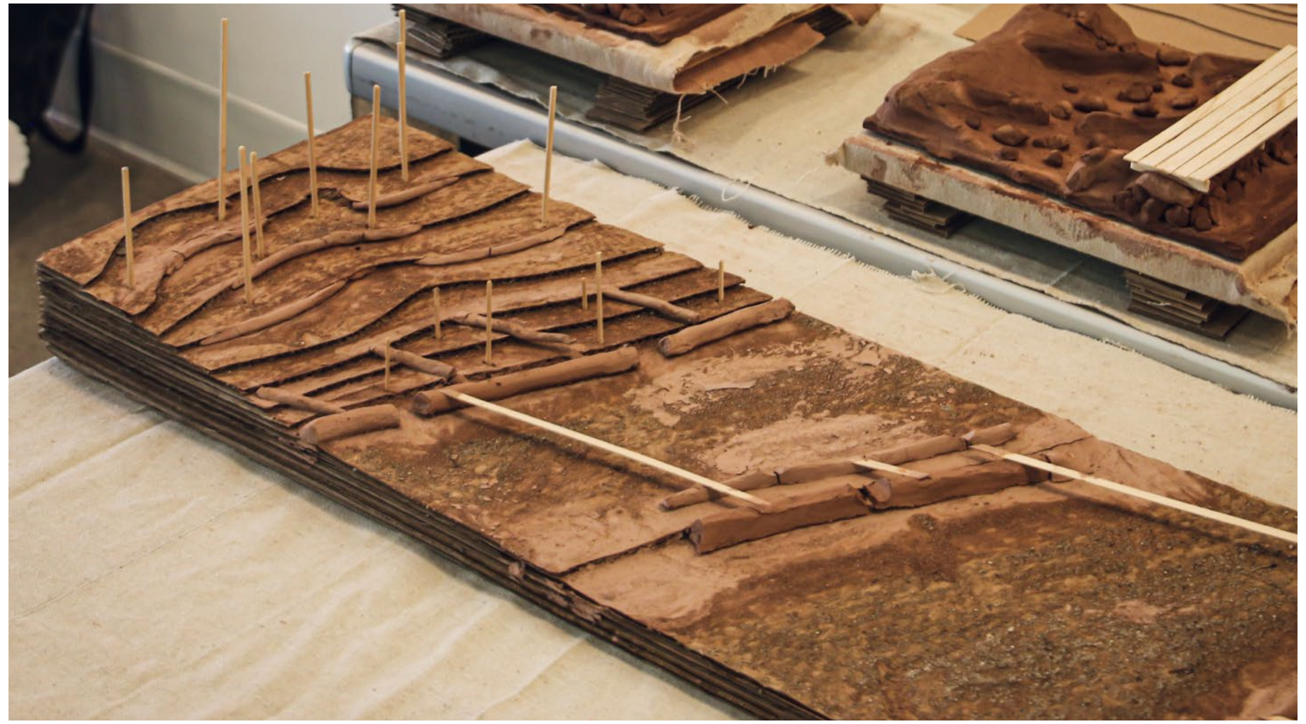
During the mid-term review, the critics agreed to the use of the Sediment Budget as a design tool, as well as the utilization of site-specific construction materials. However, the feedback suggested that the impermeability of rammed earth is in contrast with the fluid nature of salt marsh, which led to the choice of straw clay with wattle frames as the final construction method for this project.

Exhibition Design

Carazas Testing



HT
LT
#4
#3
#2
#1
Peat
Ghost Forest
Sediment Pool #3
(Young Marsh)
Upland Forest
Sediment Pool #4
(composition)
Sediment Pool #2
(Collecting Eroded Peat)
Drowning Marsh
Sediment Pool #1
(Collecting Eroded Peat)
Sand Dune
High Tide
Low Tide



Section Model

Section Model

Clay + Sand + Phragmites Fiber

Clay + Sand + Spartina Fiber

Clay + Sand + Beach Grass Fiber

Cob Bricks Making

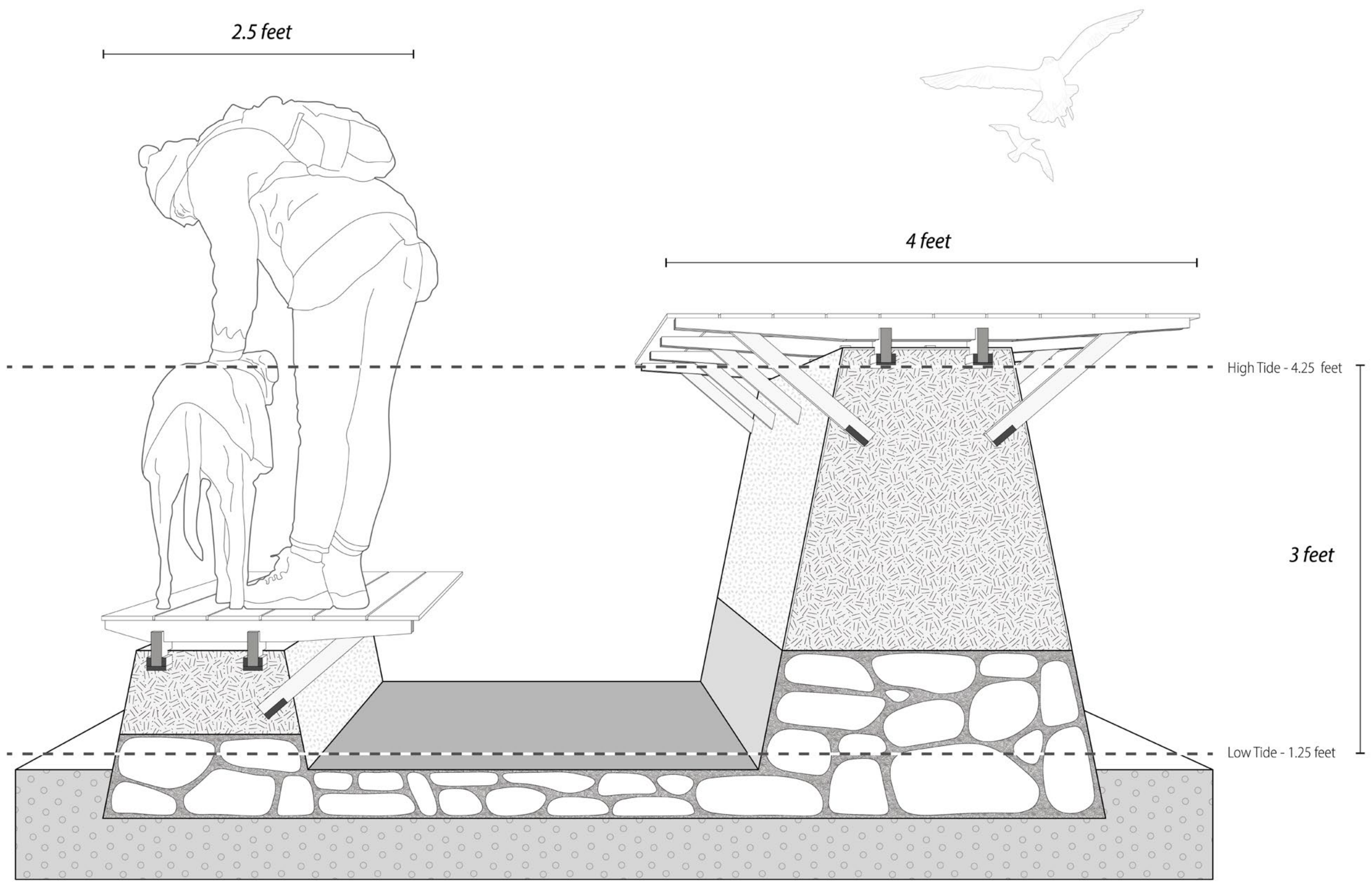
Without Fiber

With Phragmites Fiber

With Spartina Fiber

With Beach Grass Fiber

Dropping Test / Strength Test

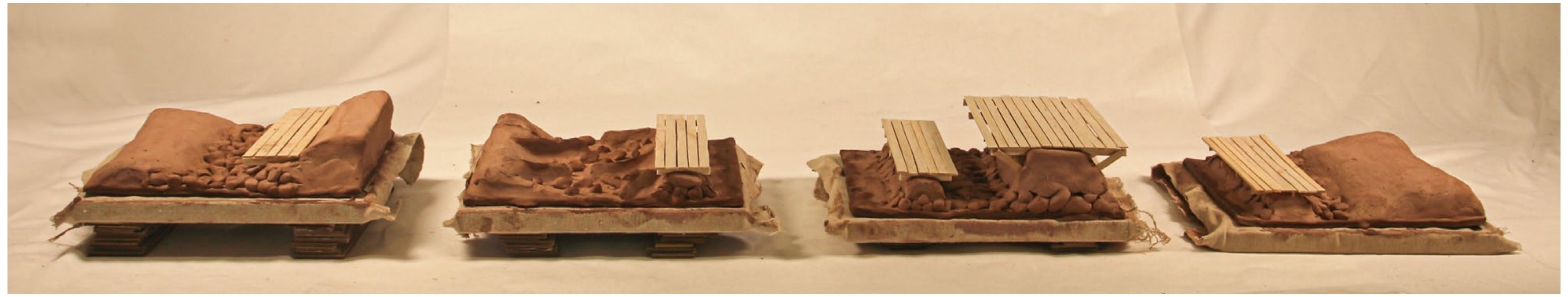


Prototype Design

8.5.4 Reflection on Previous Material Explorations

The previous material explorations happened synchronously with the knowledge gained of marsh ecology, which reinforced the understanding of sustainability for this thesis - that the chosen construction method has to co-exist harmoniously with the marsh ecology in order to support marsh migration.

The salt marsh is a fluid and porous system, which needs a porous material system to work with. Thus, the straw clay with wattle frames technique was chosen as the final construction method.



Prototype Models

09

Conclusion

Through the one-year-long research and material exploration-based design process, this thesis comes to the conclusion that the success of marsh migration requires not only the technical engineering that helps prepare the suitable ecological conditions, but also social awareness, community engagement, and public education to ensure the whole ecological restoration process is sustainable.

Marsh migration is a highly complex and dynamic ecological process, and it is impossible to take control of it as a whole in precise ways. Hence, redundancy and phasing have to be reinforced in the design of the landscape, and such redundancy and phases can not be achieved by a singular design method and material, but by a collective evolving system.

With a series of design errors and trials, the straw clay in wattle frames technique has proven to be sustainable not only because of its materiality, but also the various educational and community engagement opportunities that can be provided during its material sourcing and building processes. These processes require direct body contact with raw earth and other natural materials, which can help eliminate the bias of the raw earth being unclean, creating an embodied understanding of ecology for the participants, and therefore challenging the binary understanding of humans versus nature in the model construction industry.

Sustainability in landscape architecture is not only the mindful use of building materials, but also the continuity in the whole building and aftercare process. With the proposed straw clay in wattle frames technique, knowledge of ecology and earth building can be shared and generated in the whole building process. Through building, repairing, and playing in the landscape, the generated knowledge can be passed on to and used by the younger generation, which is key to sustainability.

10 Appendix

Bibliography

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[4]Goetz, Emily. "Marsh Migration Mania!." (2021).

[5]FitzGerald, Duncan M., and Zoe J. Hughes, eds. "Salt Marshes: Function, Dynamics, and Stresses." (2021).

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[9]https://www.edc.uri.edu/apps/c016136e821747a09ccf88e0b0a15450/explore

[10]https://volunteer.savebay.org/need/detail/?need_id=804178

[11]https://en.wikipedia.org/wiki/Ise_Grand_Shrine#:~:text=The%20shrine%20buildings%20at%20Naik%C5%AB,one%20generation%20to%20the%20next.

[12]FitzGerald, Duncan M., and Zoe J. Hughes, eds. "Salt Marshes: Function, Dynamics, and Stresses." (2021).

Image Citations

Cover Image: Renata Berta

Figure. 1 Thin Layer Deposition
https://www.semanticscholar.org/paper/Thin-Layer-Placement-of-Dredged-Material-on-Coastal-Ray/502e18da5b06b37cd46e2e62d98478b095114573

Figure. 2,3,4 Marsh Replanting
http://www.crmc.ri.gov/habitatrestoration/npsaltmarsh.html

Figure. 5,6,7,8 Channels Digging
by Save the Bay & Warren Land Conservation Trust

Figure. 9,10 RESTORATION OF 'SALINES DE LA TANCADA'
by Estudi Martí Franch
http://www.emf.cat/en/projects/l/292-life-project-restoration-of-salines-de-la-tan.html

Figure. 11 Ise Grand Shrine
https://scottfstudio.com/2014/06/20/ise-grand-shrine-linking-generations-through-construction/

Figure. 12 Rebuilding of Ise Grand Shrine
http://www.isejingu.or.jp/about/architecture/index.html

Figure. 13 Ritual of Ise Grand Shrine
http://www.isejingu.or.jp/index.html

Figure. 14 Digital Sketch
Based on Image by Save The Bay & Warren Land Conservation Trust

Figure. 15 Wooden Structure Reference - Handmade School by Anna Heringer + Eike Roswag
https://www.archdaily.com/office/anna-heringer

Figure.16 Different Fiber Inputs
by Tiago Torres-Campos

Figure.17 Wattle and Daub Detail
by Tiago Torres-Campos

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The journey with the RISD Sustainability Design Lab has ended, but the journey of exploring sustainability through design has just begun.

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