H A B I T A T S

Footholds for Nature in Industrial Waterways: Bulkhead Adaptation Design Guide

Introduction

Riverkeeper and the Newtown Creek Alliance teamed up to take on one of the original Vision Plan ideas, Adapted Bulkheads, creating a pilot project for footholds for nature throughout the canal, focusing on mussels.

Design

The project tackled one of the central questions of adaptive bulkhead design in the Creek: how to attach an ecosystem structure to the smooth, angled surface of the bulkhead without altering functionality.

Community Build

A network of partners and volunteers organized by Riverkeeper and NCA built the structures during a community build day. Billion Oyster Project provided build space and habitat design knowledge.

Trials and Redesign

Design trials tested durability and attachment methods to maximize habitat area within project constraints, accounting for canal use, extreme weather, and bulkhead shape. Redesigns refined for maximum habitat area.

Final Installation

NCA's years of experience boating and navigating the Creek provided the knowledge and resources needed for the installation of these heavy habitats in a difficult to access area of the Creek.

Conclusions

The project was a resounding success and the Newtown Creek Alliance and Riverkeeper will continue to monitor the habitats for signs of life. Future iterations will build on the experience gained and look to engineering firms and policy makers to rethink use of bulkheads.

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There were a number of constraints affecting this Newtown Creek Vision Plan idea and one primary goal, creating footholds for nature. Mussels proved to be the path of least resistance.

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After an initial test installation, the team developed a design rework to maximize the space and potential results.

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Final Installation

Keen awareness of the vessels and planning is critical to navigating Newtown Creek and work from water tends to be strenuous.

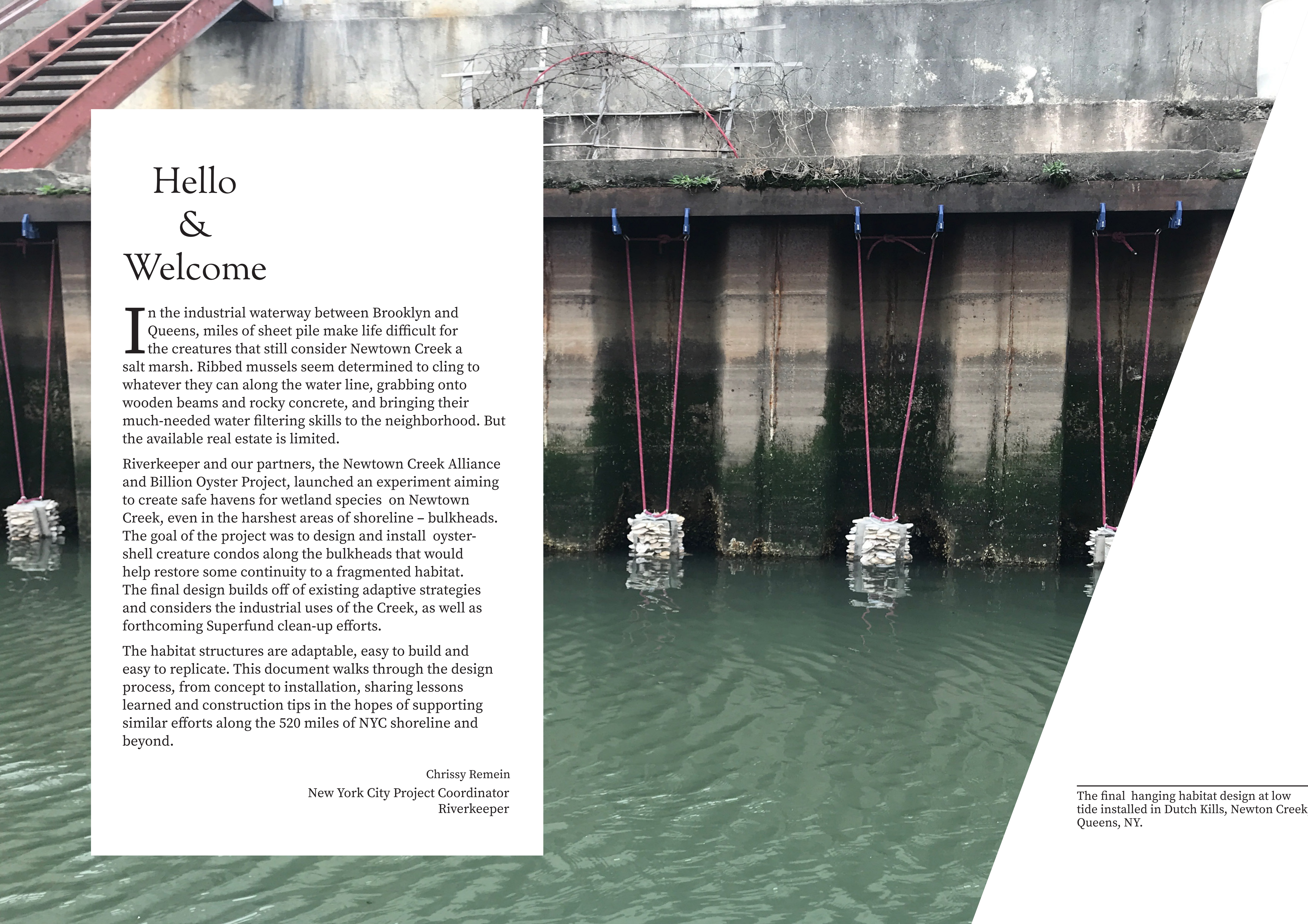
Hello & Welcome

In the industrial waterway between Brooklyn and Queens, miles of sheet pile make life difficult for the creatures that still consider Newtown Creek a salt marsh. Ribbed mussels seem determined to cling to whatever they can along the water line, grabbing onto wooden beams and rocky concrete, and bringing their much-needed water filtering skills to the neighborhood. But the available real estate is limited.

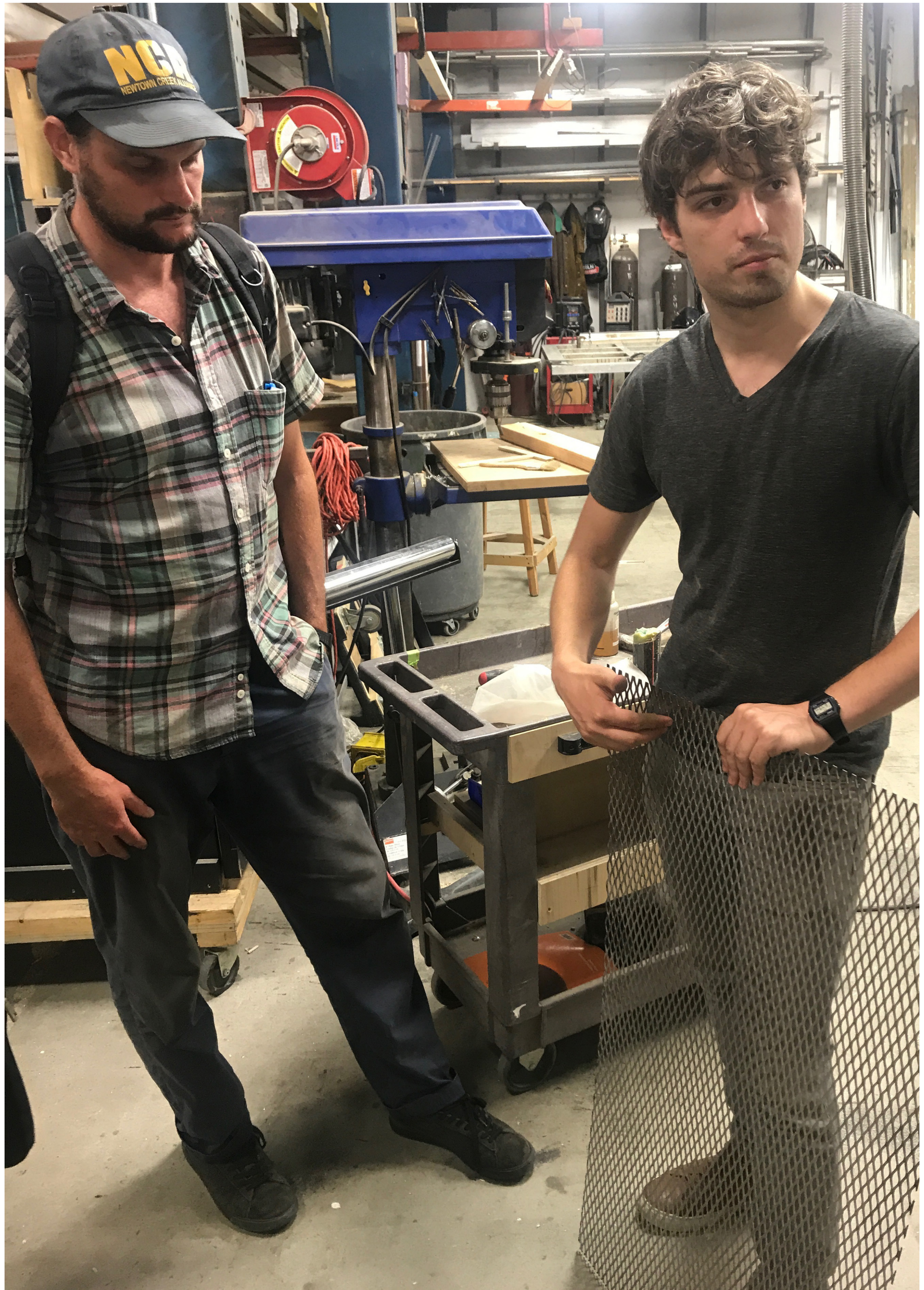
Riverkeeper and our partners, the Newtown Creek Alliance and Billion Oyster Project, launched an experiment aiming to create safe havens for wetland species on Newtown Creek, even in the harshest areas of shoreline – bulkheads. The goal of the project was to design and install oyster-shell creature condos along the bulkheads that would help restore some continuity to a fragmented habitat. The final design builds off of existing adaptive strategies and considers the industrial uses of the Creek, as well as forthcoming Superfund clean-up efforts.

The habitat structures are adaptable, easy to build and easy to replicate. This document walks through the design process, from concept to installation, sharing lessons learned and construction tips in the hopes of supporting similar efforts along the 520 miles of NYC shoreline and beyond.

Chrissy Remein
New York City Project Coordinator
Riverkeeper



The final hanging habitat design at low tide installed in Dutch Kills, Newton Creek, Queens, NY.



SITU and NCA consider build materials.

DESIGN PHASE

Project Constraints - Habitat Design - Habitat Mold - Materials - Supplies

Riverkeeper, Newtown Creek Alliance and Billion Oyster Project (BOP) embarked on this project in order to fill a critical gap in wetland restoration along Newtown Creek. BOP restores millions of oysters to New York City's harbor to enhance water quality and attenuate wave power. However, Newtown Creek is ineligible for restored oyster beds. Since the Creek is heavily polluted with legacy contamination and oysters carry those pathogens and pollutants, restored beds could prove to be a liability to anyone who might consume them.

With oysters off the table, ribbed mussels were the answer. Ribbed mussels improve water quality, are not consumed by humans, create habitats for other wetland species and already flourish in Newtown Creek. They also filter out bacteria at a higher rate than oysters.

Ribbed mussels were once so abundant in the Creek that there was a mass of them called Mussel Island, which was destroyed for navigation in the early 1900s. Despite the destruction of most of their habitat, ribbed mussels continue to colonize the shorelines of the Creek and its tributaries. Newtown Creek Alliance conducted a mussel survey and found over 200,000 ribbed mussels throughout the Creek. Riverkeeper and our partners decided to focus on how to help these water filterers thrive.

BOP's experiential and institutional knowledge was integral to developing a design. BOP, NCA, and Riverkeeper also developed a partnership with volunteer designers from a fabrication and design firm in Brooklyn, SITU, to bring expertise to a new concept. The team consulted with an engineering firm, to develop safety parameters for the installation that would ensure the structural integrity of the bulkhead.

Riverkeeper coordinated a series of planning and design meetings with NCA, SITU and BOP. The design process began by establishing the best location for the mussel habitats. NCA's analysis of surfaces and locations where mussels were found within their survey showed what conditions mussels favored and BOP's institutional knowledge of how structures withstand particular conditions helped to establish the initial design.

DESIGN PHASE

NCA's study found that mussels favored rocky concrete surfaces and wood. Mussels were most found in areas exposed at low tide and submerged at high tide. Though mussels in a natural or wild salt marsh would be found on salt marsh grasses exposed during low tide and covered at high tide, these observed examples of potential habitats in the absence of such conditions were critical.

After determining the ecological requirements for the mussel structures, we turned our attention to the industrial requirements of the bulkheads. The goal was to restore mussels through adaptive bulkhead design that would cause no harm to the functionality of the bulkheads, and to help restore continuity to a fragmented habitat, while Superfund efforts to address centuries' worth of oil and sewage contamination move ahead slowly. Achieving this goal also required an analysis of existing conditions and the best structure for those conditions.

Corrugated bulkheads are found throughout the Creek. The bulkheads are smooth and are not a place that life can cling to, but the corrugated spaces offered an area in which a mussel habitat could fit, while also remaining flush with the wall as not to be in the way of passing or docked barges. We sought out an ideal location for an installation on a stable piece of inactive shoreline so we could easily observe and service the habitats.

The materials used for the habitats needed to withstand the Creek's environmental conditions, including brackish water, extreme temperatures and potentially freezing water. We also wanted the design and materials to have as little impact on the environment as possible.

Since the mussel habitats are intended to be replicable, easy to build and transferable throughout Newtown Creek and similar industrial waterways, the structures be made from accessible materials. The design also needed to be easily removable for forthcoming Superfund remedial efforts, landowner needs, and State requirements.

The constraints that the natural and built environment placed on this project's design required several concept iter-ations. Finding the solution to the industrial and ecological needs of the Creek proved to be extremely complicated.

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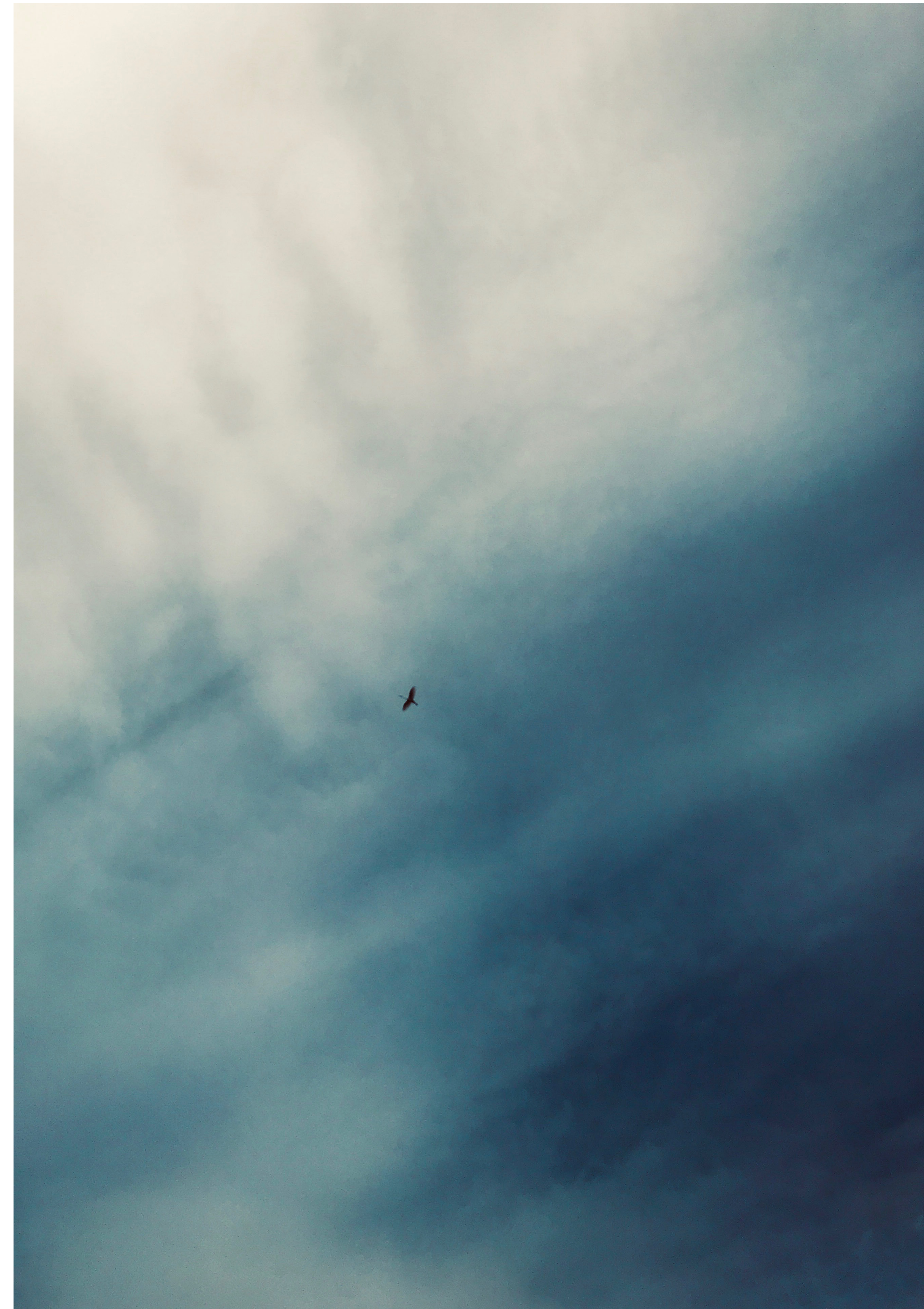
A Snowy Egret flies over Dutch Kills. Wading birds, Spartina, and ribbed mussels are pillars of a salt marsh. ecosystem.



The corrugated shape of the bulkhead offers up a unique space to create habitat without interfering with functionality of the hard edge.

Dutch Kills, located in Queens, juts into Long Island City and is in the backyard of LaGuardia Community College.

Mussels cling to a wooden edge in Newtown Creek.

PROJECT CONSTRAINTS

The design must fit into each bulkhead. The bulkhead selected was 18 inches by 21 inches at its narrowest to 28 inches at the mouth. There are no edges or pieces to connect to, except for an overhead lip. The habitat must stay flush to the wall. The bulkhead cannot be drilled into and the habitat cannot affect its structural integrity. It must be removable and must have a low environmental impact.

PROJECT SITE

The final project installation site is in Dutch Kills. The site was chosen because the property owner is amenable, the site is accessible by small vessel to check progress, the shoreline is a corrugated bulkhead, the bulkhead is stable, and the tributary is inaccessible by barge.

PROJECT GOALS

Habitats should attract mussels and other marine life, such as barnacles, sea squirts and grass shrimp, and act as a foothold for nature, creating habitat continuity throughout the Creek. The habitats should also be easily replicable, observable, and visually appealing.

PLANNING MEETINGS

A series of meetings provided the platform to discuss goals, constraints, potential materials and methods to manipulate and construct the materials into spaces that would be attractive to mussels and other marine wildlife.

NCA and Riverkeeper with SITU volunteers at their offices in the Navy Yard, Brooklyn.

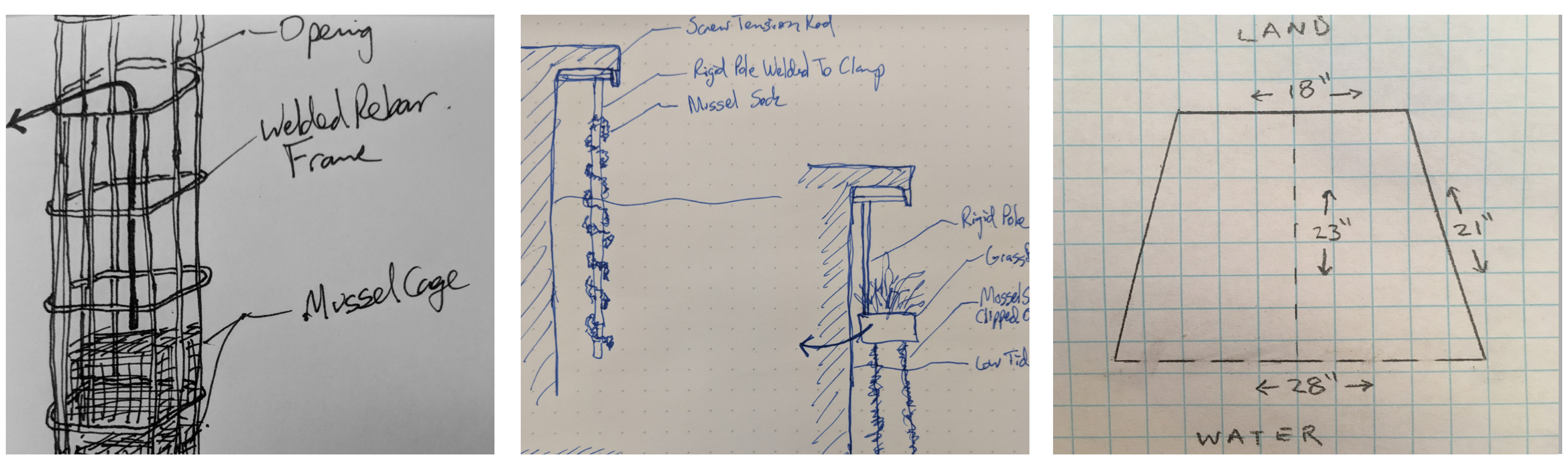
SITE VISIT

Visiting the site was critical to design. On the site visit the team noticed that the lip of the bulkhead stretched the length of the wall. With drilling into the bulkhead out of the question tension would be the primary method of affixing the habitats. The site visit also showed the low and high tide mark on the bulkhead at each specific installation site.

Willis Elkins of NCA making measurements on site.

DRAFT DESIGNS

The draft design process considered an array of materials—including rope, cages and wood— in various iterations. Reluctantly, we accepted that a complicated habitat with marsh grasses and a connection to land was impossible for the scale of the project and the shape of the bulkhead.



Original habitat draft designs and specs.

SITU volunteers explaning the design

Draft design in mold

Draft design

DESIGN 1.0

The initial design was a challenge, particularly because the bulkhead could not be altered.

The team had difficulty finding a temporary design that would be stable in the water and flush with the bulkhead.

Though cages work well for oysters when they are fixed and attached to stable surfaces, there wasn't a clear and replicable way to affix a cage into the bulkhead crevice that was removable and did not rely on drilling into the sheet pile.

The preferred design was a structure that could hang from a fixed system utilizing tension to attach to the bulkhead. The habitat structure would need to be dense enough and heavy enough to avoid floating in the water and rely on a textured and creviced surface appropriate for mussels.

The design Riverkeeper, BOP, NCA and SITU developed utilizes a quick drying concrete, embedded with oyster shells and studded with stainless steel eyes on each end. Three simple materials that could hang from the bulkhead, lie flush against the wall, and sink into the water at high tide.

The habitat would hang from a rope or chain attached to the bulkhead via a tension mechanism.

*See habitat image and mold above.

Billion Oyster Project provided the oysters for the habitats, seen here. Oyster shells donated by restaurants are scrubbed and cleaned by BOP volunteers then utilized to form the basis of their own oyster cages that they seed and deploy throughout the New York Harbor. They make for excellent surfaces to which bivalves can cling and make home.

HABITAT & MOLD MATERIALS

Easy to find and easy to build.

The habitat is made in a very simple mold. Following original project goals, the mold is made from easily accessible materials like fiberboard and cardboard shipping tubes. The fiberboard is cut so that the shipping tube, cut and halved into foot long sections, will fit into the two fiberboard ends. A key is cut out of the wooden ends that slides in and out, like a 3D puzzle piece.

Before the molds are filled with concrete, stainless steel eyes with nuts measuring 2.5 inches from the screw are placed under the key so that they are stable at each end. Tension ropes are used to hold the mold in place. Some masking tape and/or hot glue is used to hold the wooden keys that hold the stainless steel eyes in place. Three dowel rods are placed along the mold to help stabilize the oyster shells in the concrete, also affixed with hot glue and/or masking tape.

Once the mold is secure, concrete is carefully poured into the mold and oyster shells are placed. Re-purposed cooking oil is applied to the mold prior to filling with concrete to make removing the habitat from the mold easier. The concrete is quick-drying, durable, and weather resistant – not to be confused with the "quick-drying" only product that is also available.

For safety purposes while constructing, safety goggles, nitrile gloves, and face masks for those mixing the concrete, should be used.

Although the mold must be crafted and requires some work tools, the basic concept is easily adaptable and materials easily acquired. Some of the molds and materials can also be reused and repurposed.

Volunteers after a successful days work on Governor's Island.

COMMUNITY BUILD DAY

'Many hands make light work!' Utilizing volunteers to build the habitats was both an opportunity to empower and educate and the most efficient way for us to build the habitats.

What better place to do the work than Governor's Island?

Governor's Island is headquarters for both Billion Oyster Project, and the Harbor School. Homebase for students, teachers, scientists, and the workshops and spaces used to bring a Billion Oysters back to the New York City Harbor.

BOP offered their work space, staff, and volunteers to build the habitats. The beautiful location provided the basic resources required: Flat surfaces, indoor and outdoor workspaces, and a small cement mixer. We broke the work down into five key steps:

1. Construct the molds, fitting the wood ends, adding the tension rope and adding the dowel rods.
2. At the same time, a group works on mixing concrete.
3. Fill the molds as the concrete is prepared.
4. Volunteers remove some of the air in the concrete, carefully pounding the molds.
5. Oyster shells are studded into the concrete.

Volunteers of all ages participated.

Volunteers oil the molds so that the habitats can be easily removed when dry.

Throughout the day the team and volunteers problem solved and developed solutions. We removed air bubbles from the concrete by carefully pounding the mold on a table before inserting the oysters. The nut on the stainless steel eye was repositioned so that it was the preferred distance from the end of the concrete. While most of the labor was unskilled, we recommend having someone familiar with mixing concrete.

Thirty volunteers worked for about three hours to build thirty-five molds. At the end of the day, BOP staff gave volunteers an overview of the health of the NYC harbor estuary. The talk provided an opportunity to reinforce the lessons learned throughout the volunteer day and create new stewards of the harbor.

The day was very successful and and would be an ideal way to build the habitats in the future.

TRIAL INSTALLATION

In-water and on-site the test installation enabled the team to observe performance over time.

The test installation in Dutch Kills with three attachment methods.

The habitats were moved to a flat area so that they could slowly dry, helping to increase their strength. Once completely dry, BOP students loaded them onto their boat to be delivered by to Newtown Creek Alliance's office. Given the project location, the boat was best able to move the habitats as close as possible to the installation site, limiting the number of times the habitat structures, weighing about 18 lbs each, would need to be transported.

Before installing all of the habitats, the team did a test installation, testing materials to hang the structures with andtension attachment methods, and observing the performance of the habitats. The attachment methods included two c-clamp styles and a steel tension rod. The tension rod was modified by drilling a hole

Observing the rope, and the habitats in water on install day. The sand shrimp, as pictured below, can be seen on the habitat upon close inspection.

into the rod so that a steel carabiner could be fitted through and the rope attached. None of the methods altered the bulkhead in a permanent way. Each method attached firmly and securely allowing the habitat to hang in place in the water.

Installing the structures from the water and in a boat was challenging, though the difficulty did not impede the team from completing the test installation. Experience using basic hand tools and the ability to lift 50lbs with ease is required to complete the task.

Within minutes of securing the structures to the bulkhead, sand shrimp swam by the structures and peeked around the crevices, resting on them and seemingly at home. Though not a scientific observation, it was affirming and a potentially good sign for the coming seasons.

The team decided it would be best to allow about two months to observe the structures. We would focus on the rope, chain, tension attachment methods, and stability of the concrete. Mussels would most likely be observed in late summer, however it may be required to wait two to three seasons before drawing conclusions about the habitat's success.

The team tested three different attachment methods, for strength and use of space.

Tension rods, doubled up and used with rope, best met the project goals.

Three habitats could be joined together with zip ties on each end to form a beautiful Borromean ring structure.

LESSONS LEARNED

Of the three attachment methods tested, only the tension enabled the habitat to hang completely flush with the bulkhead. The chain, one of the methods tested to hang the habitat, did not function any differently than the climbing rope. The habitats were a little low within the tide lines, and a single habitat did not take up much space in the bulkhead.

DESIGN EDITS

Using these lessons, the team chose tension rods as the attachment method and climbing rope to hang the habitat. Hanging flush with the wall was a key goal of the project and the rope, which allowed that to happen, is less expensive than the chain. We also sought to utilize more space within the crevice of the bulkhead, maximizing surface area and habitat space. The cement, oyster shell, and steel eye habitats required no structural edits.

DESIGN 2.0

The final design utilizes two tension rods for strength and stability and combines three habitats into one, connected together with extra strong weather resistant zip ties on each end. The new 3D structures look like Borromean rings and provide more than three times the surface area. They are also aesthetically pleasing, weighing around 50 to 60 lbs and hang completely flush with the wall.

FINAL INSTALLATION

Feats of strength could be a better title for the final installation. The molds are heavy yet fragile and required patience

On the Brooklyn side of Newtown Creek behind NCA's offices in the Kingsland Wildflowers building, the habitats rest, waiting to be hoisted down 10 feet below into NCA's wooden boat. Rapidly growing Long Island City is in the background.

The final installation proved challenging. Prior to transporting the habitats to the installation site the team prepared the materials—drilling holes for carabiners, removing plastic from tension rods, cutting rope to appropriate lengths, and connecting the structures with the zip ties.The most difficult aspect of prep work was combining the three habitats. It's tricky work with heavy concrete and fragile shells. A foam pad or soft material helped prevent breakage.

At least two people are needed to complete the installation. Because each adapted 3D structure weighed 50 to 60 pounds, the team chose to use two tension rods per habitat structure. While each tension rod can hold over 100 pounds, the two rods provided extra stability in the case of waves or any other disturbance.

Prior to arriving on site, the team had to transfer the habitats to Newtown Creek Alliance's wooden boat. Without accessible water level access, we chose to hoist the habitats over a 12ft ledge to the boat in the water.

The process required able bodied people who are accustomed to the complications of working on an industrial waterway. Lifting the habitats while they were fastened, and tightening the tension rods from the water was strenuous work. In future installations it would be helpful to have extra people that could help to install the structures from land as well as on water.

Success for this project can be measured in many ways. The original project goal was to adapt bulkheads to provide a foodhold for nature. Riverkeeper and NCA accomplished this goal, creating a hanging habitat with materials easily sourced and easily replicable.

Though the team would be thrilled to find mussels on the habitat, it's entirely possible that relying on nature to find its way back to the reaches of Dutch Kills could take longer than one or two seasons.

Chrissy Remein, of Riverkeeper, on installation day.

Willis Elkins, of NCA, with the habitats in the Creek.

A section of the final installation in Dutch Kills.

CONCLUSIONS

Newtown Creek Alliance and Riverkeeper are very pleased with the end result of this project. We will continue to monitor progress of the habitats. Though the structures might seem small, the objective of this project was met—to begin the process of establishing habitat continuity on the Creek, and creating footholds for nature.

Volunteers were critical to the success of the project. They enabled the team to build all the habitats relatively quickly and provided critical design consultation. In the future, this is the kind of design work that all in-water design firms should be taking on—thinking about how to adapt bulkheads, developing a suite of options, and including options with recessed bulkheads. Furthermore, firms have the ability to determine scenarios where bulkheads aren't required at all. Opportunities to replace bulkheads are rare and engineering firms have a unique opportunity to shape waterways, encouraging all landowners to consider a bulkhead near water as the absolute last option, and acknowledging the resilience and cost benefits of softer shorelines.

If the team went back to the drawing board today, we would again try to find a method with cages and tension rods that maximizes the entirety of the crevice and creates maximum surface area. Since flat, parallel surfaces are required for the tension rods, they can only be installed at the top, not throughout the crevice. Perhaps a device adapted to make up for the angled walls could be created for future projects.

This project was supported by a grant from the Doris Duke Charitable Foundation. Many thanks to the volunteers, particularly the designers from SITU that offered up their time, creativity, and resources to support this project. Thank you also to Billion Oyster Project and The Harbor School for providing insight, workspace, and habitat design experience. The Newtown Creek Alliance is the critical voice for Newtown Creek and we look forward to working together on the rest of the 85 project ideas developed in the Vision Plan and creating a lasting imprint on the Creek as Superfund continues. This work, that accounts for the needs of the community and the water, is the way of the future.

Volunteers, including Riverkeeper's Mike Dulong, prepping habitat molds at the habitat build day on Governor's Island.