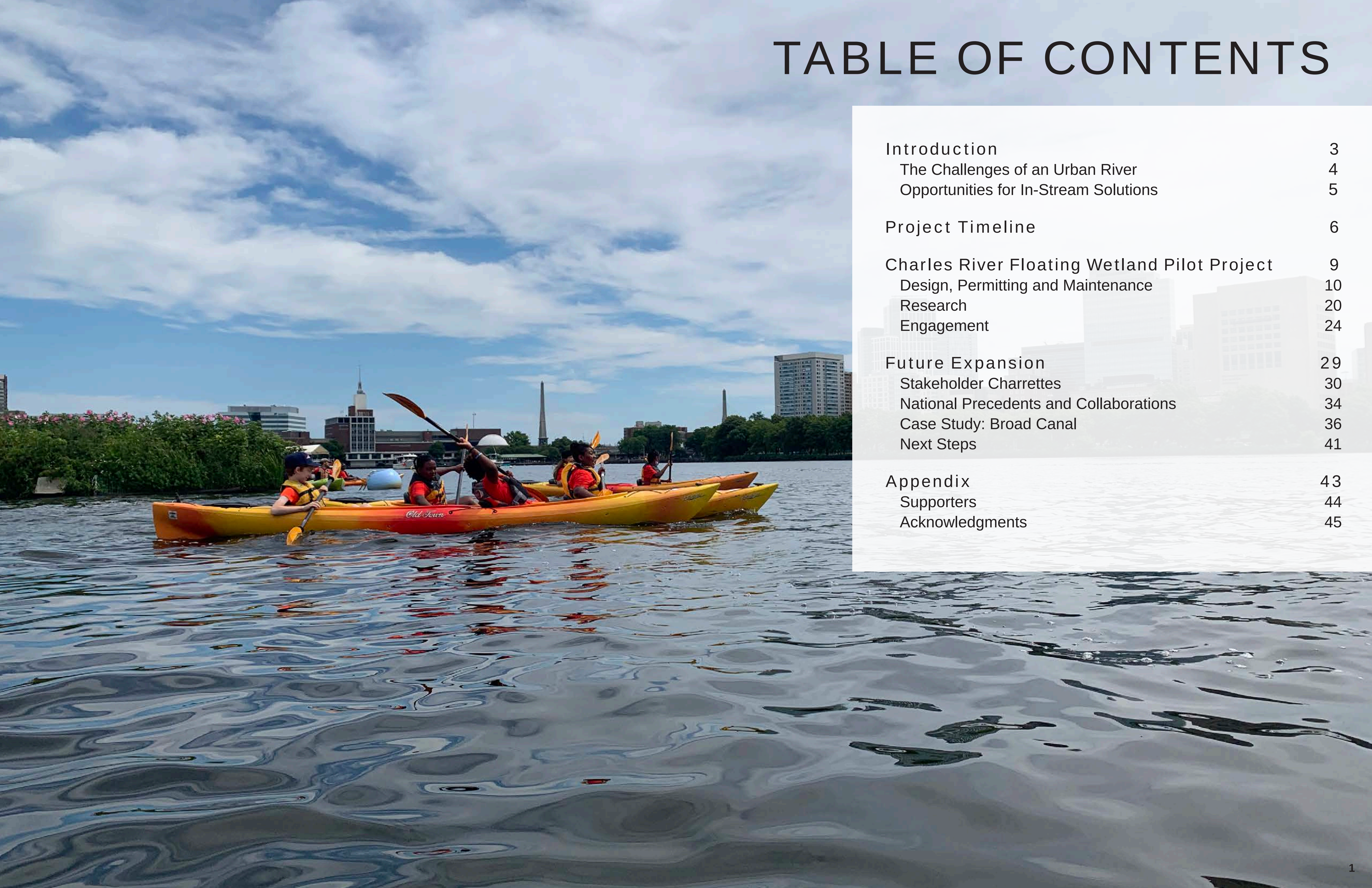
Lessons Learned from the Charles River's First Floating Wetland

Prepared by Charles River Conservancy
Spring 2023

TABLE OF CONTENTS



"Around the globe, urban waters are both uniquely valuable and uniquely challenged. For cities, urban waters provide essential ecosystem services including flood control and cooling. For native and migratory species, they provide a critical toehold and refuge in an urbanized environment. For human residents, urban waters provide space to meet the natural world, they support health and increase well-being. For water bodies though, urbanization alters their physical, chemical, and hydrologic conditions, fueling algal blooms, introducing bacterial contamination, and degrading biodiversity and ecological function."

– *Rome, McNamara Buck. Water Quality to River Health. 2022. Northeastern U, PhD Dissertation. xv.*

INTRODUCTION

The Charles River Reservation is a vital network of open space for Greater Boston. For the last several miles before the Charles River reaches its destination of Boston Harbor, the Lower Basin of the river widens and slows, providing an iconic backdrop, as well as a critical network of paths and parks for the neighboring cities. These parks are within walking distance of more than 300,000 urban residents and more than one million people visit this urban green space annually. The Charles River serves as a neighborhood resource, a regional destination, and a unique ecosystem, requiring careful support to ensure it can meet the needs of a broad and diverse human, plant and animal community.

At the Charles River Conservancy (CRC), a Cambridge, Massachusetts-based nonprofit, we work to ensure the river and parks are environmentally healthy and vibrant spaces and to provide access to this important resource so that all communities can benefit from the physical, mental, cultural and social health opportunities that nature affords. The CRC engages in ecological initiatives that support the river's health, provides educational programs for communities to increase their understanding and knowledge of the river's ecosystem, creates recreational opportunities to support fun and emotional connections with the Charles, and breaks down physical barriers to welcome everyone to "touch the water."

The Charles River Floating Wetland initiative embodies the CRC's mission, boldly introducing ecological and community resources that will transform the river's future and people's connection to it. The CRC is excited to share the experience of bringing floating wetlands to the Charles River. We hope you enjoy reading our story, and we invite you to reach out to us if you are curious to know more.

Laura Jasinski
Executive Director
Charles River Conservancy

CRC Mission and Vision

We strive to make the Charles River and its parks a well-maintained network of natural urban places that invite and engage all in their use and stewardship.

The Charles River Conservancy lies at the center of the Charles River, its parks, and the park's users. We similarly envision a future in which the Charles River and its parks are celebrated, well-utilized, and connected centers of public life.

The Challenges of an Urban River

In 1995, the EPA launched the Clean Charles River Initiative to address historic, post-industrial pollution with the goal of making the Charles fishable and swimmable. As a result of subsequent legal action and major infrastructure investments, the Charles went from being graded a D by the EPA to a B/A- in recent years. While that progress is impressive, the Lower Basin of the Charles remains closed to swimming and is impaired by frequent harmful algal blooms of potentially toxic cyanobacteria.

The Charles River Conservancy sees a swimmable Charles as a sign of a fully accessible, healthy river—one that can continue to support and adapt with its communities and climate. To advance this goal, the CRC partnered with Northeastern University in 2017 and 2018 to gather daily water quality information for two summers. The research confirmed that bacterial conditions are greatly improved from 1995 levels, with downstream locations meeting bacterial standards for swimming >95% of the time. However, the study highlighted another obstacle to restored swimming that has become a familiar headline for many other water bodies nationwide: cyanobacteria blooms. Cyanobacterial blooms are a symptom of human activity that has transformed the lower Charles from a free flowing tidal estuary into a warm slow-moving urban basin. Land use changes around the river result in excess loading of nutrients, particularly phosphorus, a process known as cultural eutrophication. Eutrophic water bodies tend to have low clarity as a result of excess algal growth (e.g., cyanobacteria) which creates conditions that are harmful for many native species.

There is still much to be learned about the forces that determine a eutrophic state and that shape cyanobacteria blooms. But it is understood that two drivers contribute to cyanobacteria blooms: (1) nutrient pollution like phosphorus (which is washed into the river by stormwater) and (2) warmer water temperatures. These blooms impair the ecosystem as a whole and create potentially toxic conditions for humans and animals. These two contributing factors on the Charles River are determined by both local and global circumstances.

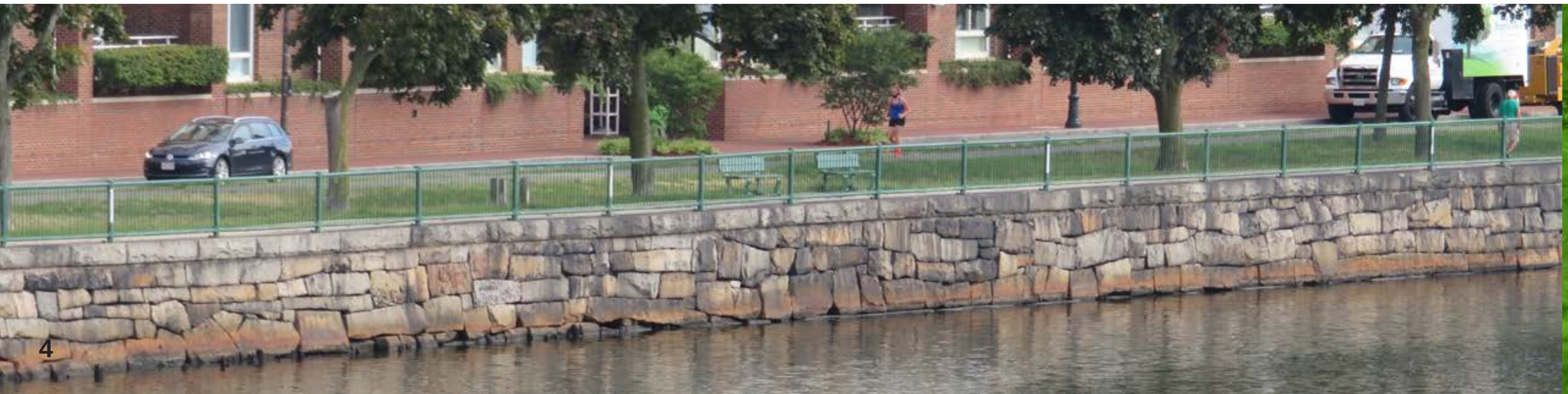
The nature of the Lower Charles River has been fundamentally changed by human development: rather than the free-flowing tidal basin it once was, urban development filled in its mud flats, replaced natural edges with sea walls and hardscaped once porous ground. At the same time, climate change brings more intense rain events and increased temperatures. The combination of these circumstances amplifies each other. The developed urban landscape means that water from these intense rainfalls picks up pollutants that cannot be absorbed or filtered adequately and transports them directly into the river. In addition, the slower moving water is more susceptible to rising temperatures.

Opportunities for In-Stream Solutions

The main approach to address eutrophication is to reduce the nutrient pollution in the river. In 2007 the Massachusetts Department of Environmental Protection set a Total Maximum Daily Load (TMDL) for nutrients in the river. Nutrient sources include both natural sources (like leaves) as well as human sources (like vehicle exhaust particulates). The purpose of the TMDL is to set a budget for phosphorus loading that would prevent cyanobacteria blooms and support the river's recovery.

A variety of approaches in different settings are needed to achieve this goal. Stopping pollution at its source (such as a reduction in fertilizer use) is crucial but not always fully possible. Improvements to infrastructure (like stormwater, sewer and outfall systems) can improve the capacity to handle major rain events and reduce run-off from entering the river. Other upland approaches include green infrastructure that re-introduce natural filtration systems into hardscaped areas to filter out some of the pollutants before that water reaches the river (like adding rain gardens to a parking lot). These upland approaches to pollution control have led to significant progress and major decreases in phosphorus concentrations. Despite this progress, the river remains impaired with frequent algal blooms. For this reason, there is a need to investigate complementary approaches to pollution reduction that might achieve restoration goals by creating improved habitat within the river. Floating wetlands are emerging as a new tool to address water quality, climate resiliency, and green goals.

Floating wetlands are a way to reintroduce wetlands, transforming a hard, urban edge into a rich habitat and supporting improved human connection to the life of the river. A **floating wetland** is an artificial, self-buoyant island that provides a surface for plants to grow on and allows their roots to grow into the water. Tackling pollutants before they reach the river should be the primary objective, but floating wetlands provide a means to ameliorate water quality issues when that has not happened. Where space for upland solutions is limited, having in-stream solutions is particularly important. Cities from Chicago to Paris to London have added floating wetlands. Since the technology is still new, there is opportunity to learn from each installation—about how to implement them, how they affect the local ecology, and how they can be designed to meet the needs of the surrounding human community.



Cyanobacteria bloom in the Charles
Northeastern University Floating Wetland Research Team

PROJECT TIMELINE

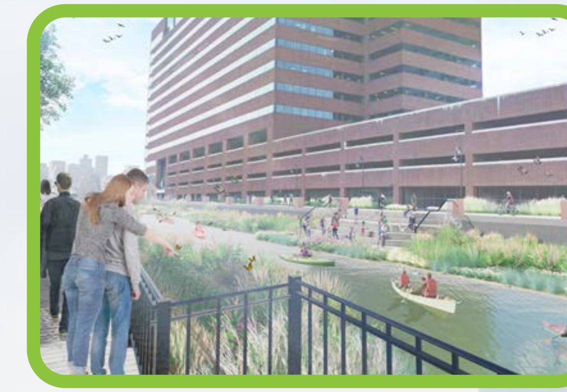
Design Initiated

Technical Charettes

170 STEAM Kits Deployed

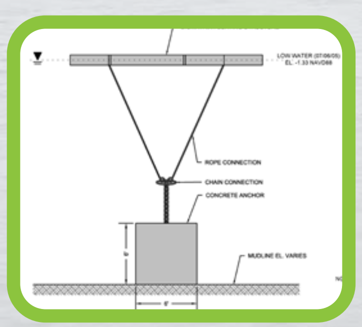
Research Dissertation Defense

Expansion Planning



2017 2018 2019 2020 2021 2022 2023 2024

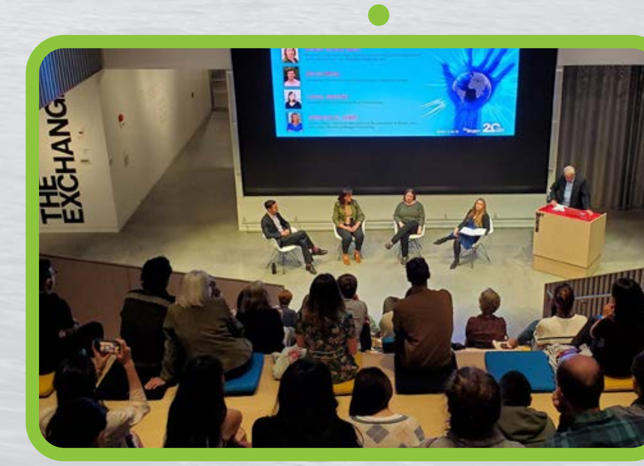
Daily Water Quality Sampling



Permitting

Floating Wetland Installation

City Parks Alliance Conference Presentation



Pilot Presentation & Celebration at MIT Museum

CHARLES RIVER FLOATING WETLAND PILOT PROJECT

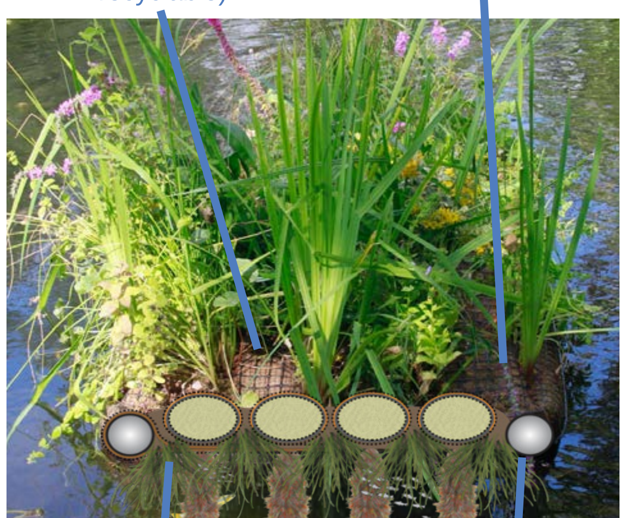
In 2018, the Charles River Conservancy began a pilot project to explore the ecological and community benefits that floating wetlands could provide in the Charles River basin. This would be the first such island in the Charles River and one of very few in the region. The intent was to understand how floating wetlands can ameliorate issues with pollution that impair water quality, support a healthy and biodiverse environment, and create new physical and programmatic paths for river access. Designed to maximize the impact of this innovative project, the multidisciplinary goals included:

1. **creating a visually impactful installation;**
2. **quantifying its effects on the local ecology and water quality; and**
3. **utilizing the floating wetland as a platform for education and engagement.**

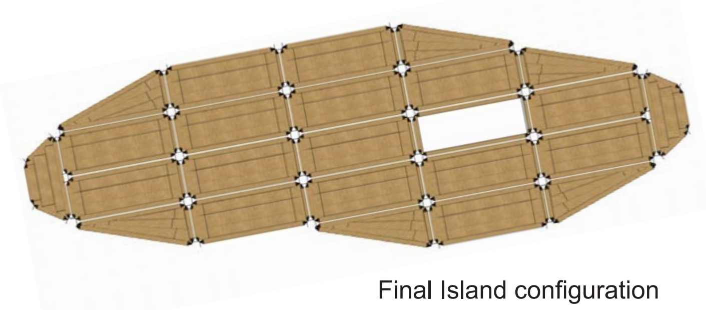
The CRC led the project, but the overall project success would not have been possible without the many contributions of partners and supporters. Most notable, Max Rome, Ph.D. (2022) in the Department of Civil and Environmental Engineering at Northeastern University, was a vital and hands-on research and thought partner throughout the project. For a full list of collaborators, see Appendix: Acknowledgements.

Design, Permitting and Maintenance: Creating a Visually Impactful Installation

Planning, design and permitting of the wetland took roughly 20 months, from late 2018 to June 2020. From the beginning, the project was envisioned as a temporary, multi-year installation. The path from the idea to the wetland's final design and installation was an iterative process: permitting impacted design, materials influenced engineering, installation logistics and cost drove scale. Ultimately, the Charles River Conservancy succeeded in finding a feasible means to accomplish the project goals.



Wetland Structure
CRC re-creation of diagram by Biomatrix Water

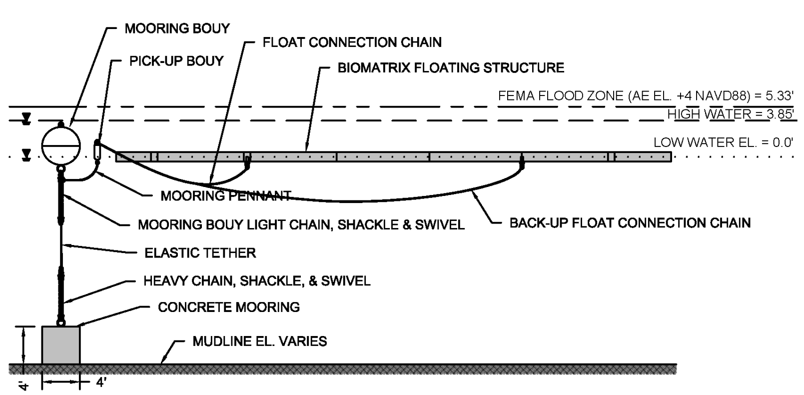


Final Island configuration
Biomatrix Water

Structure, Engineering and Sizing

An important item to understand early in the planning process was the materials and suppliers that existed for creating a floating wetland. The CRC hoped to use an "off the shelf" product that had been rigorously tested so that both the CRC and permitting agencies could feel confident installing it in the river. After researching a few options on the market, we chose BioMatrix Water's floating wetland matrix because they offered a durable, low-maintenance product with load-rated joints and multiple size and configuration options that could be assembled and installed by a small team.

Designs of different scale and complexity were explored. The CRC benefitted from and is extremely grateful for the pro bono support of marine engineering partner, Foth. Foth determined the anchoring system required for each design option and how those systems, the size of the wetland, and other related features would trigger different permitting requirements and timelines. The project team ultimately settled on a ~700 SF island with a small opening in the center, which required one large bottom anchor. Although the team was interested in more complex designs, it was optimal to go for a design that required a single anchor (for cost and permitting feasibility) and that did not have inlets (which could collect unwanted debris).



Anchor profile
Foth

Design Residency

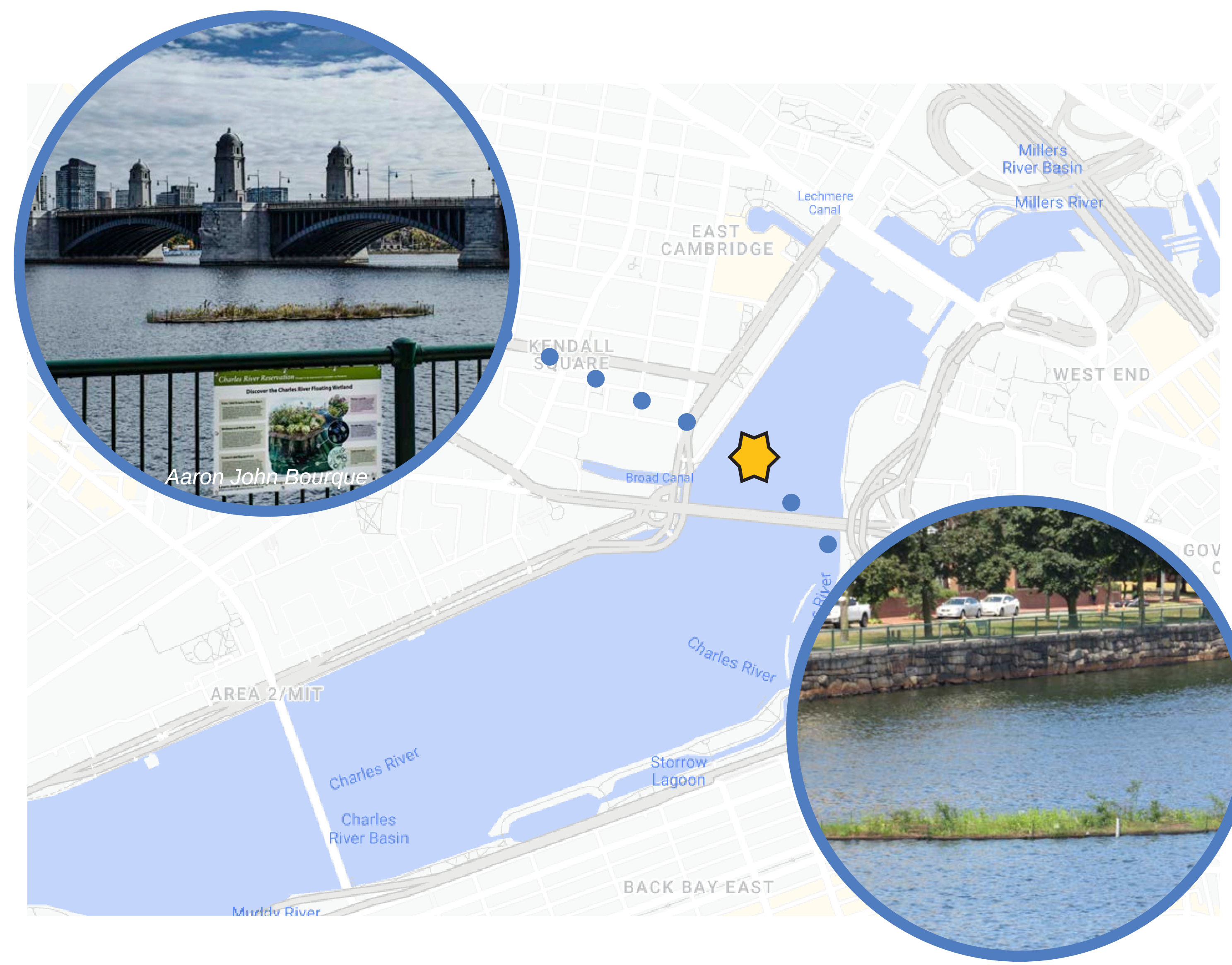
The CRC's floating wetland pilot project was fortunate to be included in the Sasaki Foundation's inaugural design award class. In addition to financial support, the team received expertise from several of the firm's accomplished design professionals.

Location

Given the goals for the project, the CRC sought a location that

1. routinely experienced cyanobacteria blooms,
2. was accessible for the research team,
3. had high visibility to support public engagement, and
4. did not create a hazard for river navigation.

After evaluating several spots in the Lower Basin of the Charles, a location just downriver of the Longfellow Bridge, along Cambridge Parkway in Cambridge was selected that met these criteria.



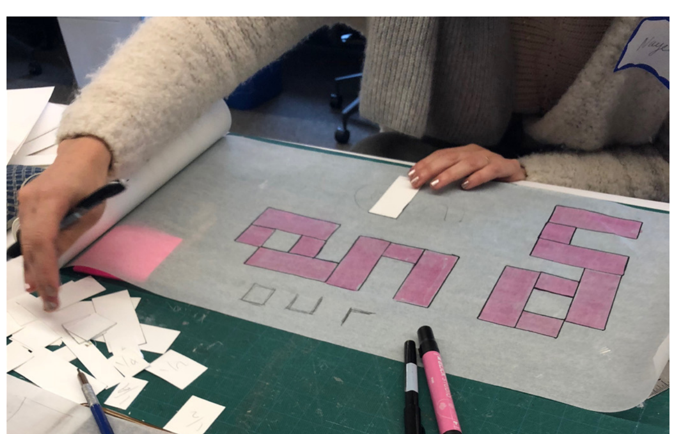
Permitting

The current permitting framework is designed to be arduous in order to prevent intrusion and harm to water bodies. An unfortunate consequence is that nature-based solutions that are intended to provide net benefits are also more challenging to execute within the same framework. The floating wetland project was no exception, making the permitting phase a significant part of the overall effort. The CRC found it extremely helpful to engage key stakeholders early, particularly permitting agencies, for support in navigating the processes.

The pilot went through several approvals and received

1. a Construction Access Permit and a Research Permit from DCR,
2. an Order of Conditions under the Wetlands Protection Act from the Cambridge Conservation Commission,
3. a Test Project Permit under Chapter 91 from MassDEP, and
4. a Self-Verification Form review by the Army Corps of Engineers.

These permits often required review by other agencies, with either a formal sign-off coordinated by the CRC as the applicant or as part of the permitting agency's internal process. A more detailed overview of permitting requirements and considerations that influenced the final project can be found in a white paper available on the CRC's website. Below are a few highlights from our permitting journey.



Permitting Agency: DCR

Because the Charles River is state land overseen by the Massachusetts Department of Conservation and Recreation (DCR), working closely with DCR was a crucial first step towards all subsequent approvals. Consent and signature of the landowner was needed for permits by other agencies (like the filing of a Notice of Intent under the Wetlands Protection Act), and DCR itself required a permit both for the installation (a one-time Construction Access Permit) and the subsequent water sampling (a renewable annual Research Permit). The CRC discussed the project with DCR early in the planning process, had a coordination meeting with several DCR departments as design and location were being finalized, and has kept them informed about project developments and research findings.

Stakeholders

There may be many stakeholders with direct or indirect jurisdiction over a project like our floating wetland. Here is a general overview of those groups that should be considered in outreach and permit planning:

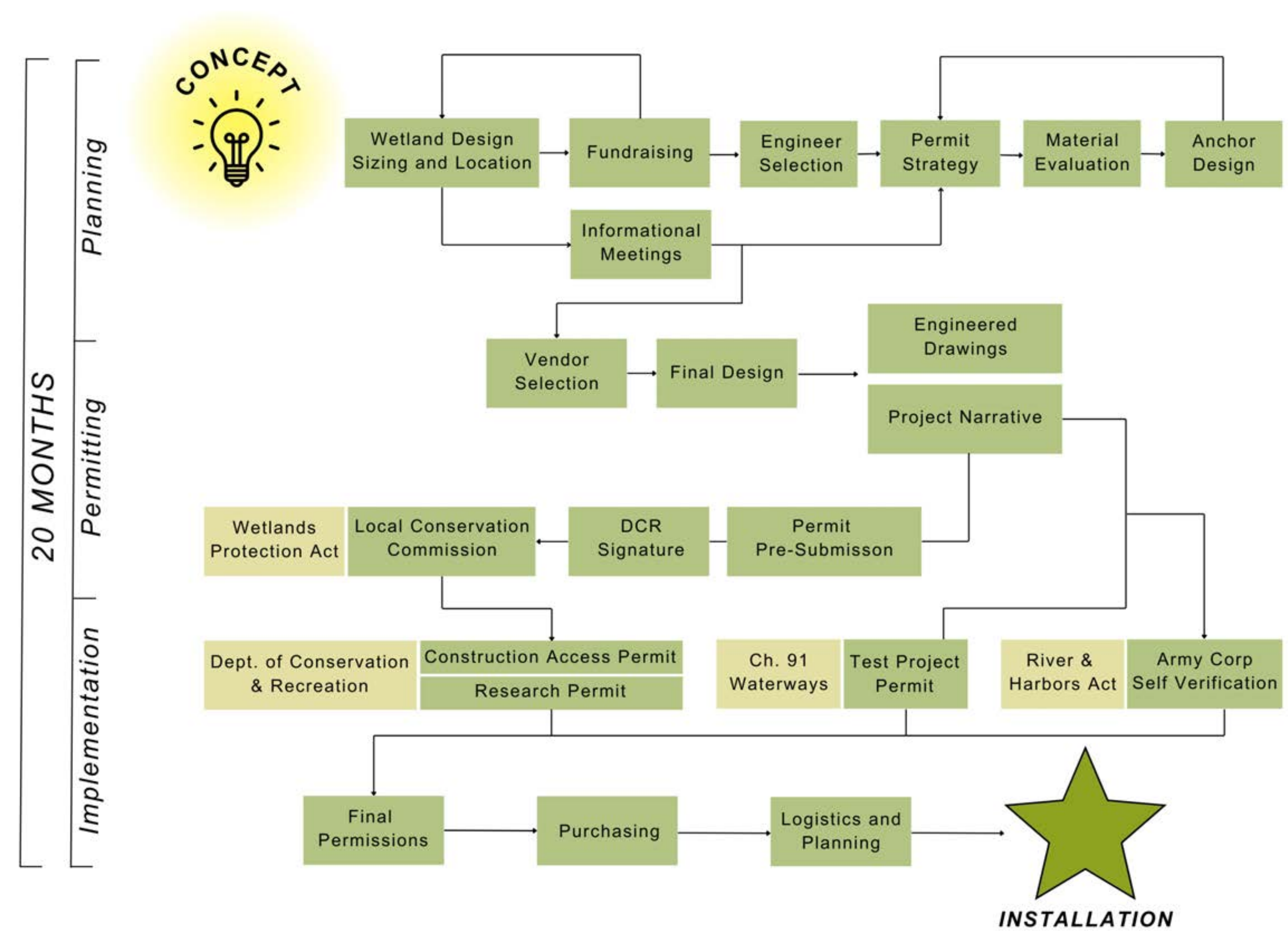
- **Landowners** – if project is being proposed by someone other than landowner
- **Municipalities** – approval of conservation commission, parks department, or zoning board may be required
- **State agencies** – some may have direct permitting authority over project, while others will be given notice of permit application and have ability to provide comments
- **Federal regulators** – may have direct or indirect authority
- **Abutters** – may receive notice of one or more permit applications
- **Community at Large** – should have a voice to ensure their needs are met
- **Other Advocates** – can provide valuable knowledge, expertise and support

Permitting Agency: City of Cambridge

In Massachusetts, the Wetlands Protection Act requires projects impacting waterways, including wetlands, riverfronts and land under waterways, to file a Notice of Intent in order to protect the public's interest in the ecological value of these resources. The Department of Environmental Protection (MassDEP) administers the law on the state level, and municipal conservation commissions oversee the process for local projects, issuing an Order of Conditions if the project is allowed to proceed. For the floating wetland pilot project, the Cambridge Conservation Commission administered the law, and the CRC is very grateful for the Commission's support, which included pre-permit meetings and guidance.

Permitting Agency: Department of Environmental Protection

To protect the public's long-standing rights in the Commonwealth's waterways, Massachusetts enacted the Public Waterfronts Act, generally known as Chapter 91. It regulates private uses and projects on many water bodies, including the Charles River. Local harbormasters are given authority under section 10A of the law to grant permission for seasonal moorings such as floats or rafts, which is how the project team had expected to permit the project. However, since the City of Cambridge does not have a harbormaster, the CRC applied with MassDEP for a Chapter 91 "test projects" permit, which provides an avenue for an annual, renewable permit.



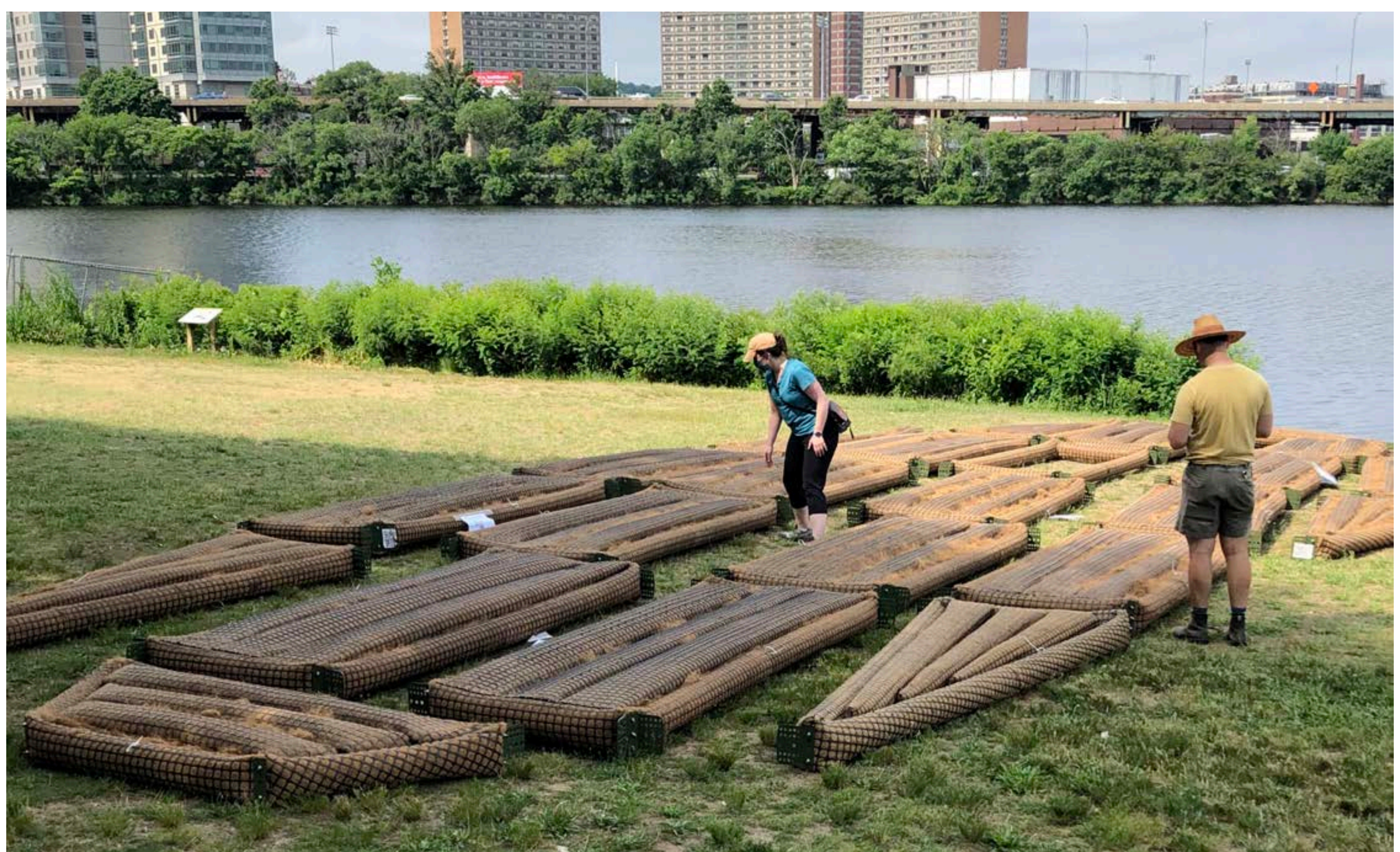
Installation

In late June 2020 over the course of two days, the CRC gathered a small group at Magazine Beach in Cambridge to assemble the wetland structure, plant it with native wetland species, and bring it into the water to be towed downriver. Magazine Beach was selected as the construction site because it contains a large open area with direct bank access to the river, making it feasible to accomplish the installation without heavy equipment. In contrast, constructing the wetland next to the mooring site would have required a crane to hoist the assembled matrix over fencing and down the seawall.

A small team was on site to meet the deliveries of the wetland matrix (composed of 24 separate pieces) and the wetland plants (roughly 3,000 plugs representing 19 species). Over the course of 6 hours, wetland pieces were arranged and bolted together as outlined in the manufacturer's plans. By working in small sections (usually 4 pieces in a horizontal row), a group of 6-8 people was able to lift each row and bring it into the river.

Once the rows were in the river, they were bolted together by a few individuals, while the rest of the team continued to plant the remaining rows and bring those to the river. The fully assembled wetland had light bird fencing put around its perimeter, primarily to deter geese whose presence would likely damage fragile, young plants. Four navigation lights were fastened to the wetland based on the input of the US Coast Guard. Signage was also placed on the wetland for general, permitting and safety information. Altogether, planting and assembly took about 13 hours.

Once assembly was complete, a hired marine contractor towed the island from Magazine Beach to just downriver of the Longfellow Bridge, adjacent to Cambridge Parkway, where the anchor and buoy had previously been installed.



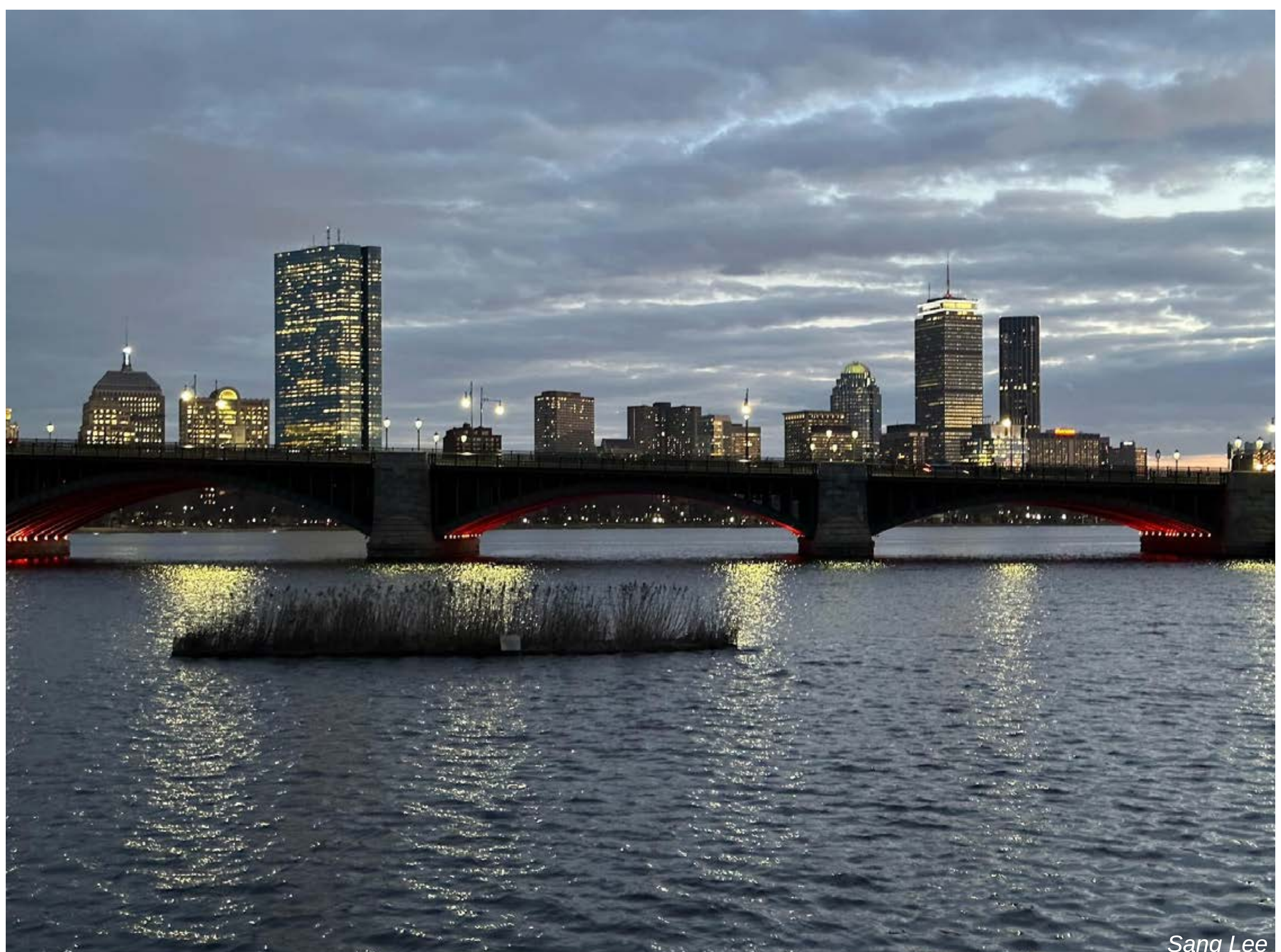
Top and middle photos by Rebecca Kopycinski

Aleks Zosuls

Maintenance and Winterization

Although the wetland is designed to be structurally sound and plants were selected for suitability to the conditions, the island requires oversight and periodic maintenance to ensure its integrity and plant health (described more later). Working in conjunction with the wetland manufacturer and the marine engineer, the project team developed an inspection checklist to ensure early identification of any issues, such as gauging buoyancy and periodically auditing bolt connections. Overall, the wetland has held up well and the list has been adjusted based on the performance of the island. The only notable issue has been the bird fencing. This fencing was damaged during installation and further compromised by wave action as the wetland flexed around the forward pivot connection during Summer 2020.

As a pilot project, it was optimal to avoid winter ice loads and move the wetland to a protected location. Thanks to a generous partnership with MIT Sailing, the CRC was able to move the wetland next to their dock for the winter months, where water circulators are used to prevent ice from forming. For three winters, a marine contractor moved the wetland to MIT Sailing in mid-November and back to the mooring location by mid-March. A winter maintenance checklist was developed and utilized to ensure the wetland fared well during the colder months. This included monitoring the buoyancy gauge (inset photo on right) after snow storms to determine how the wetland was responding to additional weight.



Sang Lee

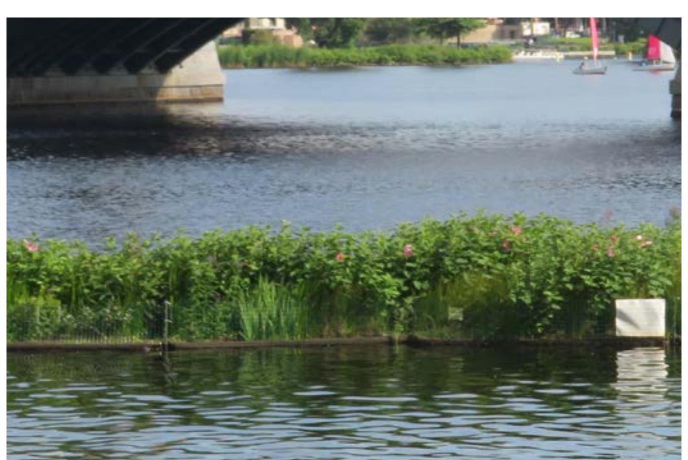
Plants

Plant selection was an important element of a successful installation, as choosing the correct species was vital in creating both a visually interesting island and one that would support the research goals. The island's location is a unique environment with strong exposure to both wind and sun. Species selection criteria included prioritizing those that were native, salt-tolerant (as that section of the Charles River can experience an increase in salinity during the summer months due to higher traffic in and out at the Charles River Dam locks), would provide a diversity of root and vegetation types, and would have visual interest throughout the seasons. Nineteen species were selected that met the criteria.

The pilot provided an opportunity to study which plants can be most successful under these conditions. Since the wetland was installed in the heat of summer, growth was varied in 2020, as expected, with some species showing robust growth (e.g. Swamp Mallow, Lurid Sedge) and others showing limited growth (e.g. Monkey flower, Iris, Sweet flag); many species flowered and produced seed.

In 2021, growth was much improved, despite an early setback when a goose made a nest and laid a clutch of 9 eggs on the wetland. After the goslings hatched and left the wetland, some native plugs and larger plants were added to fill in bare spots from the goose's grazing, as well as some relatively minor patches from plants that did not overwinter well. It was also reseeded with a native mix and additional mulch was added. These interventions led to a lush, green wetland that hosted wildlife from ducks to monarch caterpillars.

First summer, 2020



Second summer, 2021

Plant Selection Criteria

- ✓ **Native wetland species**
- ✓ Diversity of root and vegetation types
- ✓ Visual interest of species throughout the seasons
- ✓ Salt tolerance to succeed in **brackish water**
- ✓ **Availability of mature wetland plugs**
- ✓ **Experience from other floating wetland projects**

PLANT PROFILE

Blue Vervain
Plant Survival: Abundant; very successful

Swamp Rose Mallow
Plant Survival: Abundant; very successful

Swamp Rose
Plant Survival: Abundant; very successful

Seaside Goldenrod
Plant Survival: Established

Swamp Milkweed
Plant Survival: Established

Blue Flag Iris
Plant Survival: Present but poorly established

Very Successful
Sweet flag
Lurid sedge
Soft Rush
Hard-stem Bulrush
Soft-stem Bulrush
Elderberry
Green Arrow arum
Buttonbush
Swamp rose
Blue Vervain
Jewelweed
Chairmaker's Bulrush
Swamp Rose Mallow
Mountain Holly
Devil's beggar-ticks*
Fireweed*
Bugleweed*

Established
Swamp Milkweed
New York Ironweed
Seaside Goldenrod
Swamp Aster
Fox Sedge
Lurid Sedge
Blunt Broom Sedge
Fowl Bluegrass
Hop Sedge
Green Bulrush
Creeping Spike Rush
Fringed Sedge
Soft Rush
Woolgrass
Bur-reed
Red-osier Dogwood
Sweetgale

Poorly Established
Joe-Pye Weed
Crimsoneyed Rosemallow
Blue Flag Iris
Cardinal Flower
Shadbush
Common Boneset
Monkey Flower
Spotted Joe-Pye Weed
Rattlesnake Grass

No Longer Present
Pickerelweed
Thread-leaved Tickseed
Common Aerohead

*denotes "volunteer," a species that was not planted

Adapted from Rome, Table C.1, 139.

Research: Quantifying the Floating Wetland's Effect on the Local Ecology and Water Quality

As described previously in this report, the CRC embarked on a multi-year research program with Northeastern University in 2017 to obtain granular information on the state of the Charles River's water quality during the active summer season. Results of that initial two-year research led to a focus on floating wetlands as a potential intervention that could address the river's eutrophic state and increase its adaptive capacity to urban and climate pressures. Max Rome, lead researcher, was a partner throughout the planning and installation of the floating wetland and kicked-off a three-year research program as soon as it was in the water.

Rome's research resulted in a dissertation, part of which focused on how floating wetlands can benefit impaired water bodies, specifically (i) quantifying the amount of phosphorus that can be removed by the floating wetland through uptake by the plants' roots, (ii) examining the local ecological changes in and around the floating wetland, and (iii) comparing floating wetlands to other green stormwater solutions. For detailed information about methodologies, supporting research, results and limitations for each of these areas, please see *From Water Quality to River Health* (2022) by McNamara Buck Rome.

Phosphorus Removal

Floating wetland plants grow hydroponically, with the roots of the plants suspended in the water body. Nutrients required for plant growth are absorbed from nutrients in the river. By harvesting that plant material and quantifying the amount of nutrients in the plants, researchers can determine how much nutrients are taken out of the water by that vegetation. Harvesting that vegetation annually is therefore a potential means of removing nutrient pollution, notably phosphorus, from that ecosystem.

Rome harvested plants from the Charles River Floating Wetland in 2021 and 2022 and was able to combine his data with that collected at similar floating wetland projects in Baltimore and Chicago. While recognizing the variability of phosphorus loading in a particular water body as well as some variation in the amount of removal based on the plant species, the research showed that floating wetland plants do create a viable means of removing phosphorus from eutrophic water bodies.

"By seasonally harvesting wetland vegetation [floating wetlands] can achieve phosphorus reduction at a rate of ~2 g m-2 year-1. Harvested material can be composted offsite and then used as a beneficial soil amendment. One hectare of [floating wetland vegetation] can offset the phosphorus export of 7-15 hectares of dense urban development." Rome, 99.

> "This work argues for the importance of adding ecological interventions alongside pollution reduction efforts; and lays a foundation for monitoring and restoration work that moves from a narrow focus on water quality to a broader focus on river health."
>
> – Rome, 4.

Local Ecological Changes and Benefits

In addition to absorbing and removing phosphorus from the river, the study also examined whether floating wetlands led to other changes in the local ecology that might improve overall function and water quality. Across the three study sites (Boston, Baltimore and Chicago), there was evidence that floating wetlands created important new habitats and supported a variety of insect, fish and bird life in urban water bodies that are largely devoid of native surface plants or aquatic refuge. Presence and size of certain zooplankton and fish also suggest that larger scale floating wetland installations could further address eutrophic issues with "top-down" control, meaning the aquatic life higher up on the food chain, like zooplankton, could eat and control the cyanobacteria population.

"Results from the pilot scale projects suggest that [floating] wetlands are capable of locally modulating biotic assemblages compared to reference locations. Locally, [floating] wetlands may be associated with a reduction in pelagic zooplankton, increases in native minnows, and changes in the abundance of benthic and sessile invertebrates. Observed changes in abundance and size of large-bodied zooplankton suggest a possible contribution to top-down control of harmful algal blooms and raise the possibility that [floating wetlands] can be used to provide islands of refuge for stressed organisms in covering water bodies. Additional research is needed to investigate whether larger scale installations can produce durable reductions in algal growth and contribute to recovery of native species." Rome, 86.

Northeastern University Floating Wetland Research Team

Monarch Caterpillar

Great Blue Heron

Comparison to Other Green Stormwater Solutions

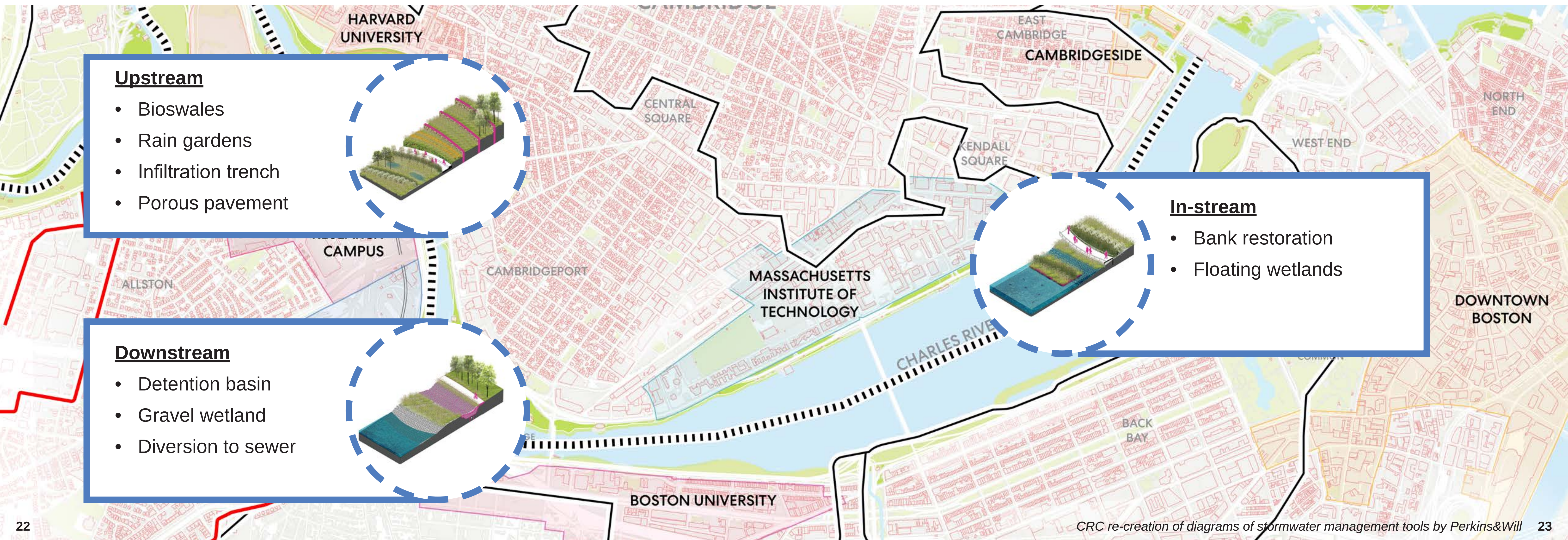
Given a floating wetland's ability to remove phosphorus from a water body through vegetation growth and harvesting, it was important to assess how its ability to reduce nutrient pollution compared to other accepted green solutions to reduce nutrient runoff, known Best Management Practices (BMPs, see inset).

Direct comparisons of BMPs are difficult because different solutions rely on different mechanisms of reduction and site restrictions can greatly affect viable tools and options. For example, a green roof will absorb a vast amount of rainfall and allow it to evaporate, reducing the amount of runoff that would otherwise carry pollutants from ever reaching the water body. In contrast, a floating wetland will not prevent polluted runoff, but does offer an in-stream solution where the capacity for upland solutions is limited. Rome found that floating wetlands are comparable in their impact on phosphorus to other relevant BMPs. Importantly, floating wetlands also provide important co-benefits discussed above, such as habitat for native species and green space for humans, pointing to their overall viability as an additional tool for the urban resilience toolbox.

"Compared to common stormwater best management processes, [floating wetlands] remove nutrients at a similar rate to rain gardens/biofiltration and more efficiently than stormwater detention ponds or green roofs while providing unique co-benefits." Rome, 99.

Best Management Practices

Advancing the application of [floating wetlands] for the improvement of urban waters requires crediting their contribution to nutrient reduction under existing regulations. In the United States the control of nutrient pollution from municipal storm water is regulated by the Environmental Protection Agencies' (EPA) as part National Pollution Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) Storm Water Management Program. Under this program, specific targets for nutrient loading called "Total Maximum Daily Loads" (TMDLs) are set to protect impaired water bodies (Listed by states under the Clean Water Act section 303-d). To meet these targets, communities implement [Best Management Practices (BMPs)] and are credited for certain load reductions based on the BMP selection, sizing, and design parameters... In Massachusetts, eligible stormwater BMPs are evaluated by the Department of Environmental Protection (MassDEP) for inclusion in their Stormwater Handbook. Treatment BMPs include rain gardens, wet basins, and constructed stormwater wetlands... [Floating wetlands] have not been evaluated for consideration as a treatment BMP in Massachusetts… [but] are credited toward nutrient removal in at least eight US states." Rome, 91.



CRC re-creation of diagrams of stormwater management tools by Perkins&Will

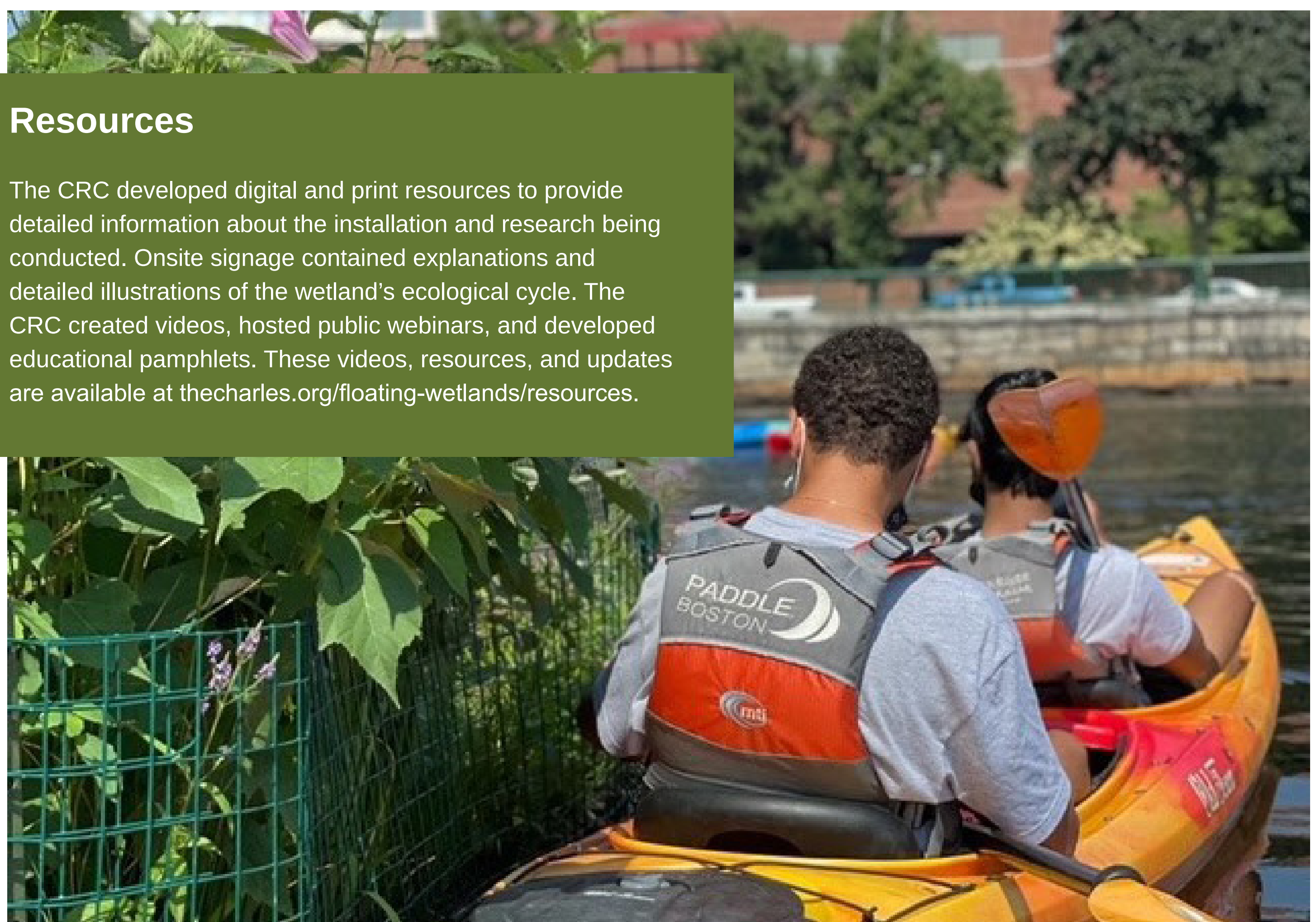
Engagement: Utilizing the Floating Wetland as a Platform for Education and Engagement

A goal of equal importance to the installation and the research has been the Charles River Conservancy's utilization of the pilot installation as a platform for environmental education and community outreach. Throughout the pilot phase, the CRC has prioritized partnerships to extend the reach of the floating wetland beyond its mooring and make wetland educational materials readily available and easily accessible for the community.

While the wetland was still in the design phase and for each season since its installation, the CRC has intentionally sought to connect with the community virtually, in classrooms, on field trips, on the water and at public tabling events, conferences and panels. The community audience brings a vital perspective; by spending time in a variety of settings, the CRC has sought to gather and incorporate that community perspective into the project. By prioritizing learning both inside and outside of educational facilities, the CRC has increased opportunities for community interaction with floating wetland concepts and removed barriers to STEAM knowledge. Below are more details about three of these educational engagement avenues.

Resources

The CRC developed digital and print resources to provide detailed information about the installation and research being conducted. Onsite signage contained explanations and detailed illustrations of the wetland's ecological cycle. The CRC created videos, hosted public webinars, and developed educational pamphlets. These videos, resources, and updates are available at thecharles.org/floating-wetlands/resources.



> "Our students (and teachers) learned so much during this project! The brochure and materials were such high quality... We so appreciate our partnership with you all and look forward to where it takes us in the future!!!"
>
> – Cambridge Public Schools Science Curriculum Coordinator

STEAM Kits

The floating wetland provided an opportunity to introduce nearby classrooms to their local ecology and to connect students with real-world science happening in their community. With partner MIT Sea Grant, the Charles River Conservancy brought the full-size wetland research into school classrooms with a "build your own floating wetland" kit. The kit consisted of a small tray, a grow mat and wheatgrass seeds and a detailed booklet to guide students in their exploration of the same ecological concepts researched at the full-size floating wetland. Students built their own wetland, hatched zooplankton, observed the growth and vitality of the plants, learned about food systems, gained understanding of the impact of pollution, and compared what happens in their kit to a larger ecosystem like the Charles River.

The kits were initially piloted in two virtual classrooms in Cambridge Public Schools (CPS) and Prospect Hill Academy. Based on the success of these trials, CPS expanded the program and deployed 170 kits in Spring 2022 to their 6th grade classrooms as part of their *River to the Sea* curriculum. In an ongoing effort to increase learning opportunities and outreach beyond the classroom, the CRC will deploy the kits again and develop translated educational resources that will support and encourage family engagement with student's STEAM education.

Youth Design Sessions

The floating wetland is not only a great real-world example of scientific research, it is a project centered on design and placemaking with the potential to meet wider public and green space needs of the community. Therefore, the floating wetland provided a natural means to give youth a glimpse into the environmental and landscape design professions and experience with gathering community feedback. The Charles River Conservancy partnered with the Cambridge Mayor's Summer Youth Program in 2021 and 2022 and Cambridge Youth Programs (CYP) interns in 2022. Both groups learned about the floating wetland, envisioned wetland expansion and identified community voices that should be represented during project development. The CYP internship included a visit to architects and designers at Perkins&Will to learn about the importance of community engagement and equitable design processes, inspiring the students to build a survey about the floating wetland. Feedback from 55 community voices was collected to inform their work–and future wetland installations!

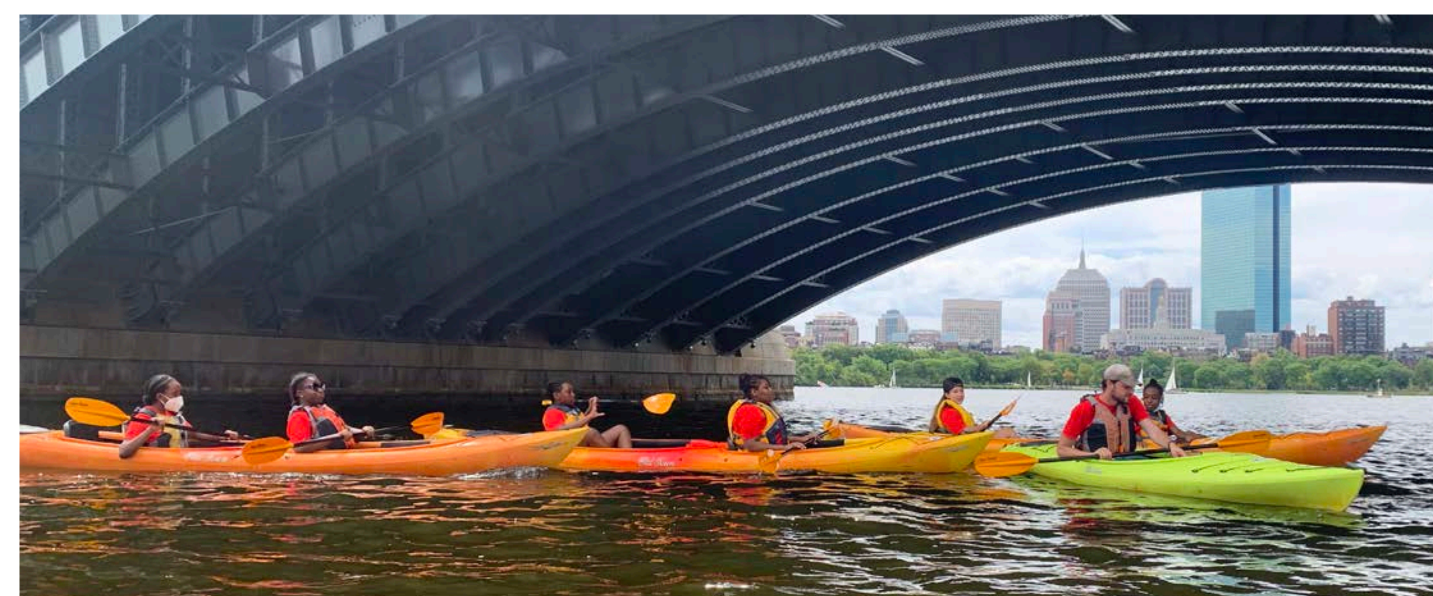
Student models of the floating wetland

Kayak Tours

The installation was intended to be eye-catching and to engender questions and conversations. While many people pass by it, the Charles River Conservancy has also created opportunities to view the floating wetland up close. In 2022, 85 youth from 8 community groups kayaked to the wetland with the CRC for a hands-on learning experience, including touching the underwater roots!
For many of the youth, it was their first time experiencing the Charles River by boat, thereby providing a new means of accessing and experiencing the river. Met with awesome curiosity, energy and insightful questions, the tours have been a wild success.

Program Partners

- MIT Sea Grant
- Cambridge Youth Programs, Frisoli Center
- Prospect Hill Academy STEAM it UP
- Cambridge Community Television
- Cambridgeport Elementary
- buildOn
- Youth Enrichment Services
- Green Cambridge
- High School Extension Program, Cambridge
- MIT Open Space Programming
- Cambridge Mayor's Summer Youth Employment Program
- Cambridge Public Schools, 6th grade classrooms
- Museum of Science
- Mass Audubon
- Cambridge Community Learning Center
- Norman B. Leventhal Map and Education Center at the Boston Public Library
- Biodiversity Builders
- CitySprouts
- RECESS Summer Program
- The American City Coalition
- Atrium School Watertown



FUTURE EXPANSION

Installing the first artificial wetland in the Charles River was a major accomplishment and an important step in realizing innovative approaches to a healthier, more resilient Charles River. In order to have a meaningful impact on the river's ecology, however, the project needs to be expanded in scale. With this understanding, the Charles River Conservancy began exploring opportunities and criteria for a larger installation shortly after the pilot was launched.

Conceptual rendering by Perkins&Will

Stakeholder Charrettes

Recognizing that expansion would require thorough feedback from many stakeholders, the Charles River Conservancy kicked off the discussion through a series of workshops in 2021 with representatives from city and state agencies–many of which were familiar with the project from the permitting process–scientists, environmental advocates and more. Over three, 90-minute sessions, the group met to discuss many practical considerations that need to be incorporated into the design for the expansion to be feasible. With their help, important planning criteria were outlined and four conditions were articulated where floating wetland installations would be a beneficial tool for improving river health, resilience and biodiversity:

1. **along linear seawalls,**
2. **within canals and lagoons,**
3. **as remediation in major infrastructure projects, and**
4. **where key park and path connections are missing along and across the river.**

Charrette Goals

GOAL 1

Deepen the community's connection to the Charles River

GOAL 2

Engage stakeholders in shaping the vision for expanded floating wetlands in the Charles River

GOAL 3

Inform next steps for floating wetland expansion in the Charles River

SESSION 1

Baseline Setting and Criteria Brainstorm

After the CRC provided an overview presentation of the floating wetland project to date, participants joined breakout rooms to brainstorm an initial list of design criteria.

SESSION 2

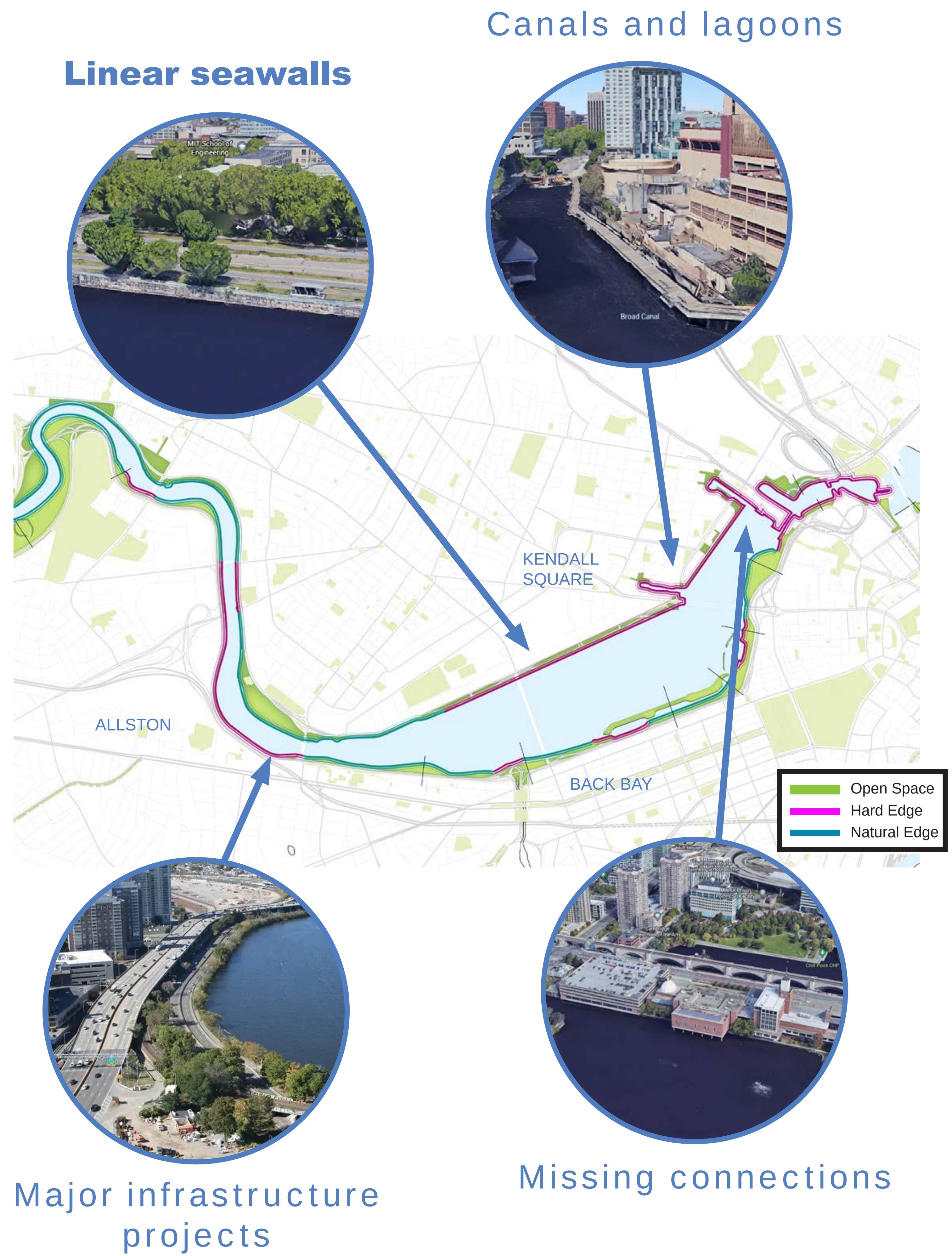
Criteria Development

The group reconvened one month later to review a comprehensive list of criteria developed in the first workshop. Through a robust discussion, the group further refined and developed the criteria under broad themes of "people," "place," and "science."

SESSION 3

Applying Criteria to Locations

In the third and final workshop, participants applied criteria to several locations identified in the Charles River Lower Basin. Stakeholders were also invited to elaborate on pros and cons associated with each location.



CRC re-creation of diagrams by Perkins&Will

APPLYING CRITERIA FOR LOCATION AND DESIGN

Criteria 1: Science

Be capable of advancing the water quality research program and serve other environmental goals

1. Size to create a measurable change in local water quality, considering
   - bloom prevalence
   - water depth/flow rate
   - outfall locations
2. Design and locate to support biodiversity, including
   - planting native species, particularly in areas lacking greenery
   - avoiding areas with regular herbicide runoff
   - understanding implications to fish habitat
3. Design to avoid negative impacts on sedimentation and promote shoreline stability

Criteria 2: Place

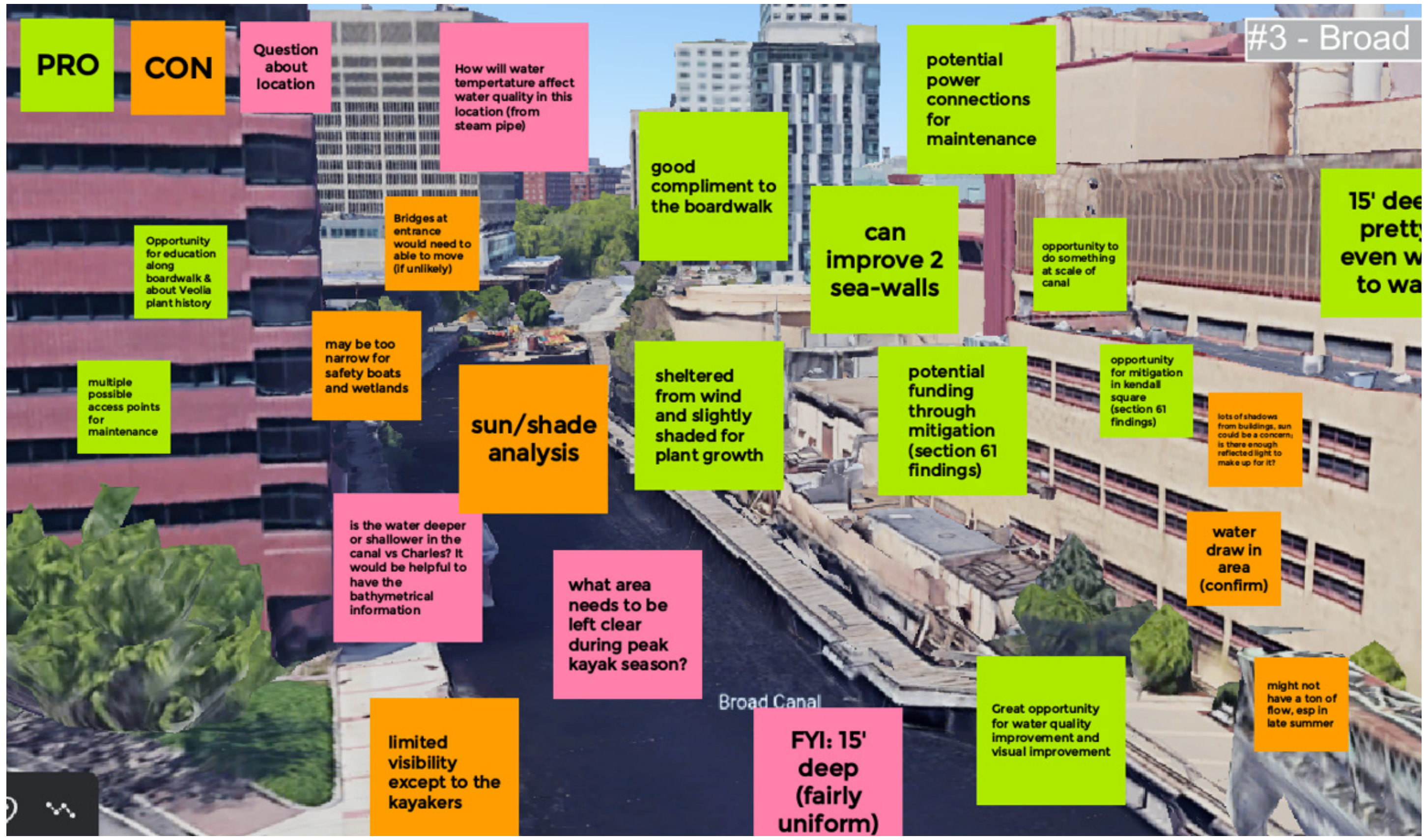
Be feasible from a permitting, engineering and maintenance standpoint

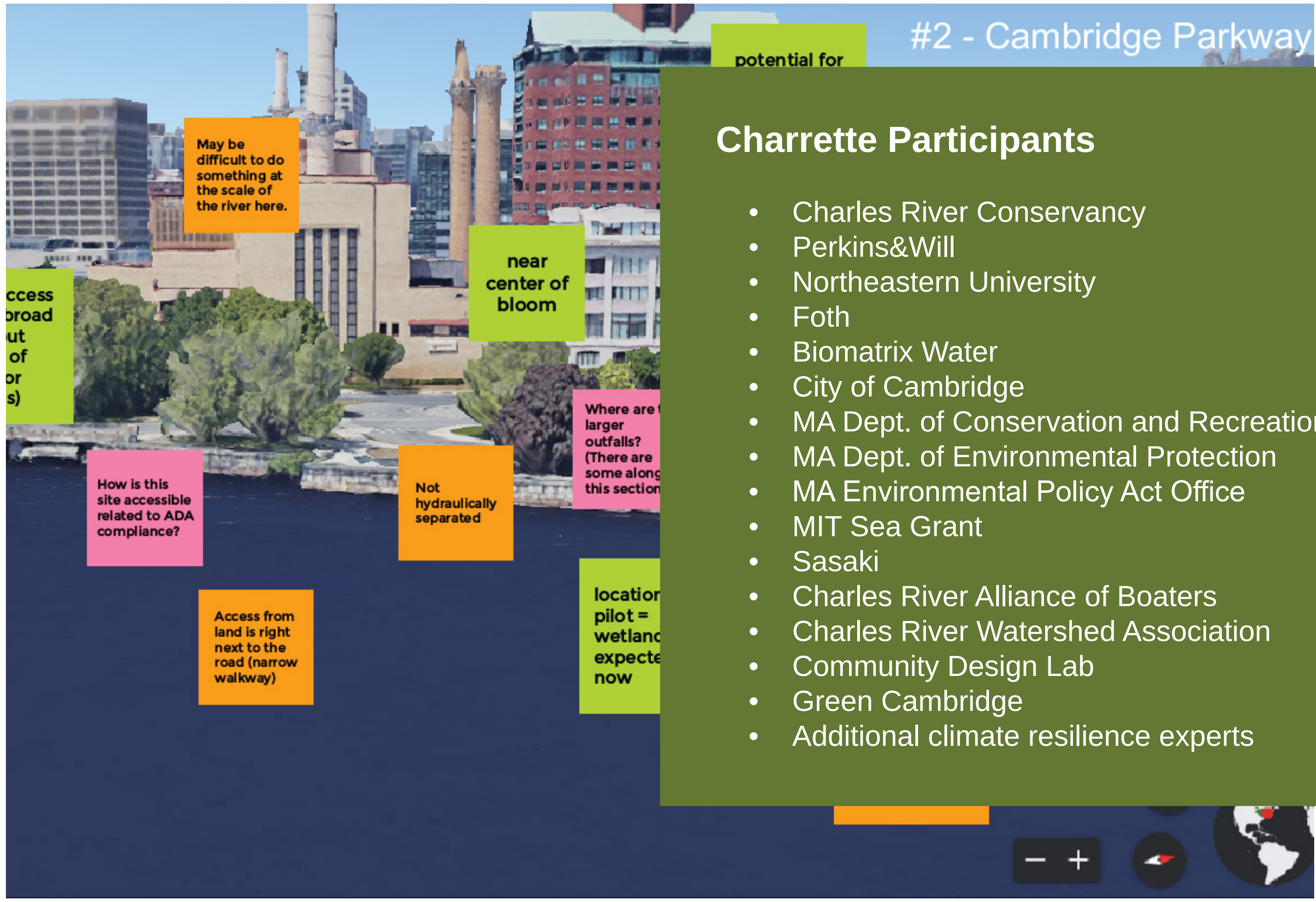
1. Respect navigation, both high use and emergency routes
2. Site to respect and augment other infrastructure or cultural resources
3. Locate in a place that can support annual maintenance needs
4. Design for year-round placement
5. Fit within applicable permitting schemas
6. Create new connections to the river

Criteria 3: People

Be designed for community benefits

1. From land,
   - be accessible, in terms of ADA compliance and transit/walking access
   - take advantage of existing or planned visits, such as those included in DCR's Charles River Vegetation Management Plan, and
   - create new access points to be closer to the river
2. By boat,
   - provide opportunities/interests in what can be viewed up close, and
   - locate near other amenities (Duck Boats, kayak launch/rental)
3. Create places from land where wetland can serve educational purposes, such as field lab opportunities for the community





Charrette Participants

- Charles River Conservancy
- Perkins&Will
- Northeastern University
- Foth
- Biomatrix Water
- City of Cambridge
- MA Dept. of Conservation and Recreation
- MA Dept. of Environmental Protection
- MA Environmental Policy Act Office
- MIT Sea Grant
- Sasaki
- Charles River Alliance of Boaters
- Charles River Watershed Association
- Community Design Lab
- Green Cambridge
- Additional climate resilience experts

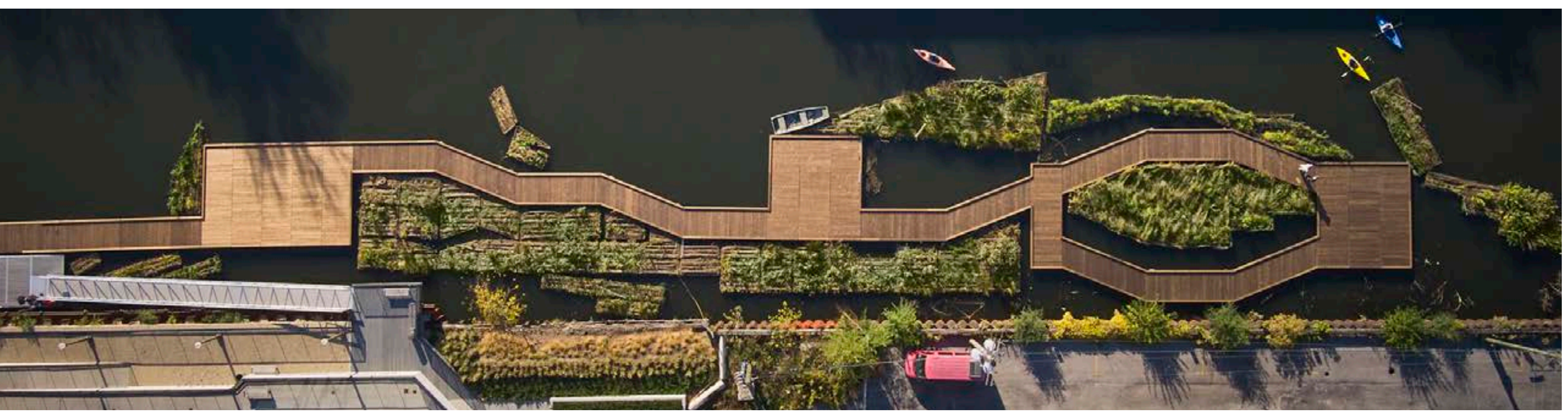
Charrette participants used electronic boards to brainstorm criteria and apply it to locations

National Precedents and Collaborations

Floating wetland technology is becoming an increasingly popular tool in cities–nationally and globally–that aims to reclaim polluted urban waterways, restore biodiversity, and engage communities with education and restoration activities. As the Charles River Conservancy pursues an expanded floating wetland installation, it has been incredibly valuable to learn from similar projects across the country. The CRC has been fortunate to collaborate with organizations in Chicago and Baltimore on both research and expansion efforts.

The Wild Mile, Chicago

Urban Rivers, a Chicago-based nonprofit focused on transforming urban waterways into wildlife sanctuaries, is working to install a mile-long floating eco-park in the north branch of the Chicago River. By converting an old industrial canal into an ecologically-focused park, the Wild Mile provides a place for research, recreation, and education in the heart of Chicago.



Top and bottom images of the Wild Mile by Dave Burke SOM

Floating Wetland Waterfront Campus, Baltimore

The National Aquarium is in the process of introducing 15,000 SF of floating wetland technology to Baltimore's highly urbanized Inner Harbor. The effort that began in 2010 has led to the design of a custom prototype, equipped with aeration, shallow water habitat, and adjustable buoyancy. This prototype explores how the technology encourages healthy waters, provides urban wildlife habitat, and restores a sense of place to Baltimore's waterfront.

Rendering of the Floating Wetland Waterfront Campus by Ayers Saint Gross

Through site visits and periodic meetings, this multi-city working group has been able to compare best practices and lessons learned for efficient design and installation, compare and align research initiatives in support of establishing floating wetlands as accepted best management practices in multiple state, and share resources for expanding environmental access and literacy through education and volunteer programs. Together, these projects have the potential to address a variety of water quality and climate challenges in each city while also increasing the impact of this resiliency tool overall.

Collaboration Spotlight: City Parks Alliance Conference

In June of 2022, representatives from the Charles River Conservancy, Urban Rivers, and the National Aquarium brought floating wetland technology to the national stage at the bi-annual City Parks Alliance Conference in Philadelphia. Each panelist spoke about the opportunities, barriers, successes and logistics of floating wetland initiatives, providing tangible models for strengthening the ecology of urban waterways and their connection to urban residents to a room full of park professionals, urban planners, city officials and advocates.

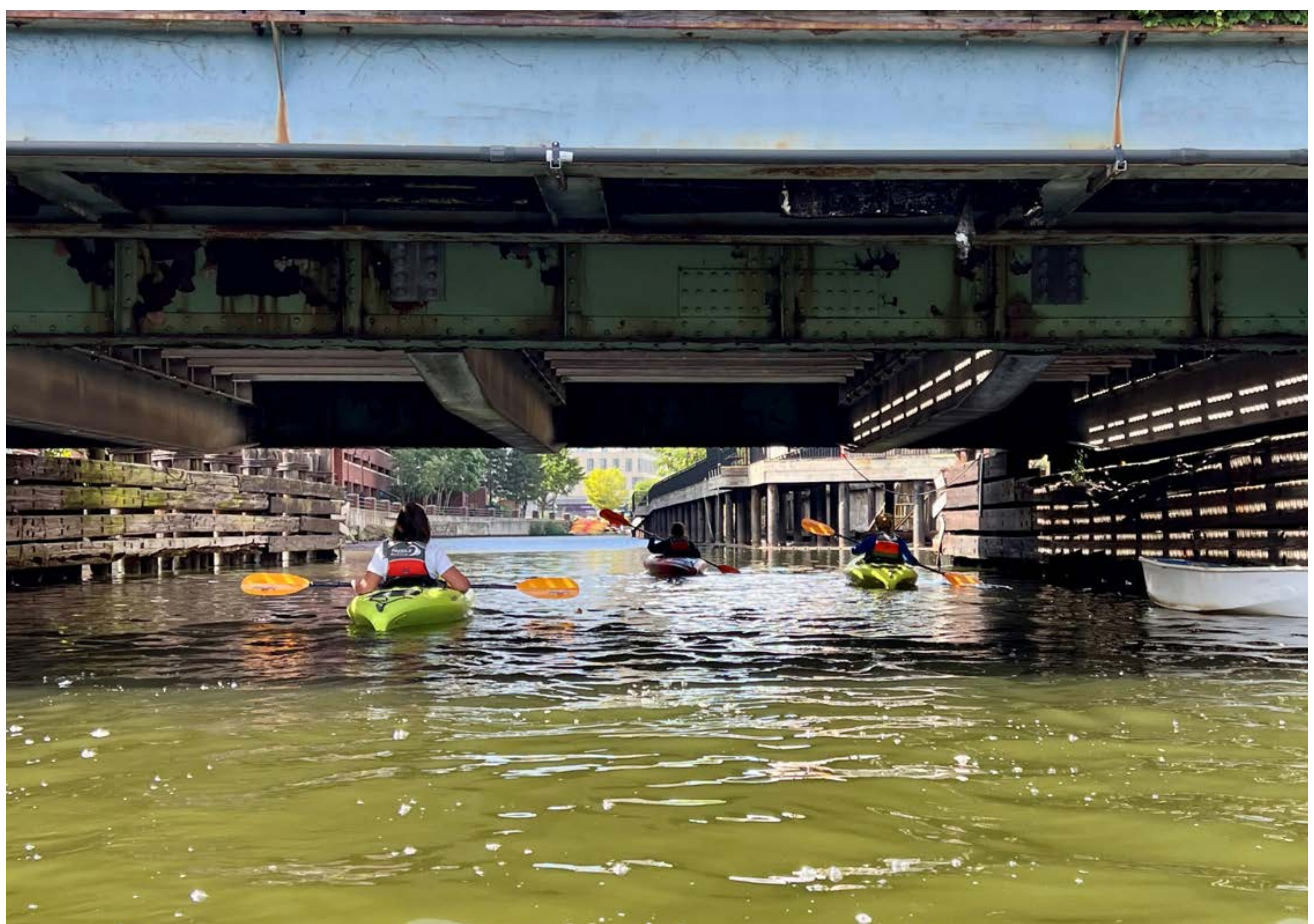
Case Study: Broad Canal

Based on research from Max Rome's dissertation, *From Water Quality to River Health*, the criteria developed in the stakeholder charrettes, feedback from youth and community engagement, and best practices gleaned from national peer projects, the Charles River Conservancy has identified the Broad Canal in Kendall Square as a promising location for the next phase of floating wetland expansion in the Charles River.

Criteria 1: "Science"

✓ bloom prevalence ✓ **flow rate** ✓ outfall location ✓ area lacking greenery

The Broad Canal in Cambridge is an isolated lagoon branching off the Charles River in East Cambridge. The often stagnant canal receives nutrient-polluted stormwater runoff directly from a storm drain located at the end of the canal during rain events. Because of these conditions, the canal is often among the first locations where visible cyanobacteria blooms form. Additionally, the canal is armored by a seawall and surrounded by the densely urbanized Kendall Square with limited biodiversity and spatial constraints for land-based green infrastructure. This makes it an ideal location for an in-stream stormwater management intervention that will offset nutrient loading while also providing native planting and habitat value to humans and wildlife.



Entrance to the Broad Canal from the Charles River

While a design for a floating wetland installation in the Broad Canal is yet to be determined, the conceptual plan shown below illustrates ~1 acre (about ¾ of a football field) installation for evaluation and discussion purposes. Based on the results from the 3-year Charles River Floating Wetland pilot study, this installation would provide a significant opportunity for achieving the 2007 TMDL phosphorus removal requirements. Figure 1 shows a "drainage" area for which 100% (left) and 65% (right) of phosphorus loading is offset by the conceptual Broad Canal floating wetland design. These sites were picked at random and for illustration purposes only.

Additionally, the recent EPA decision to assume "Residual Designation Authority" (RDA) will result in further regulation of stormwater pollution originating from built parcels with an area ≥1 acre. While the exact requirements under the RDA are not yet known, it is reasonable to expect that some dense parcels will be looking for creative ways to achieve pollution reductions. While stormwater should be managed within the same site as much as possible, for dense parcels, site constraints may necessitate locating green stormwater infrastructure outside of their own property boundaries.

Conceptual rendering by Perkins&Will

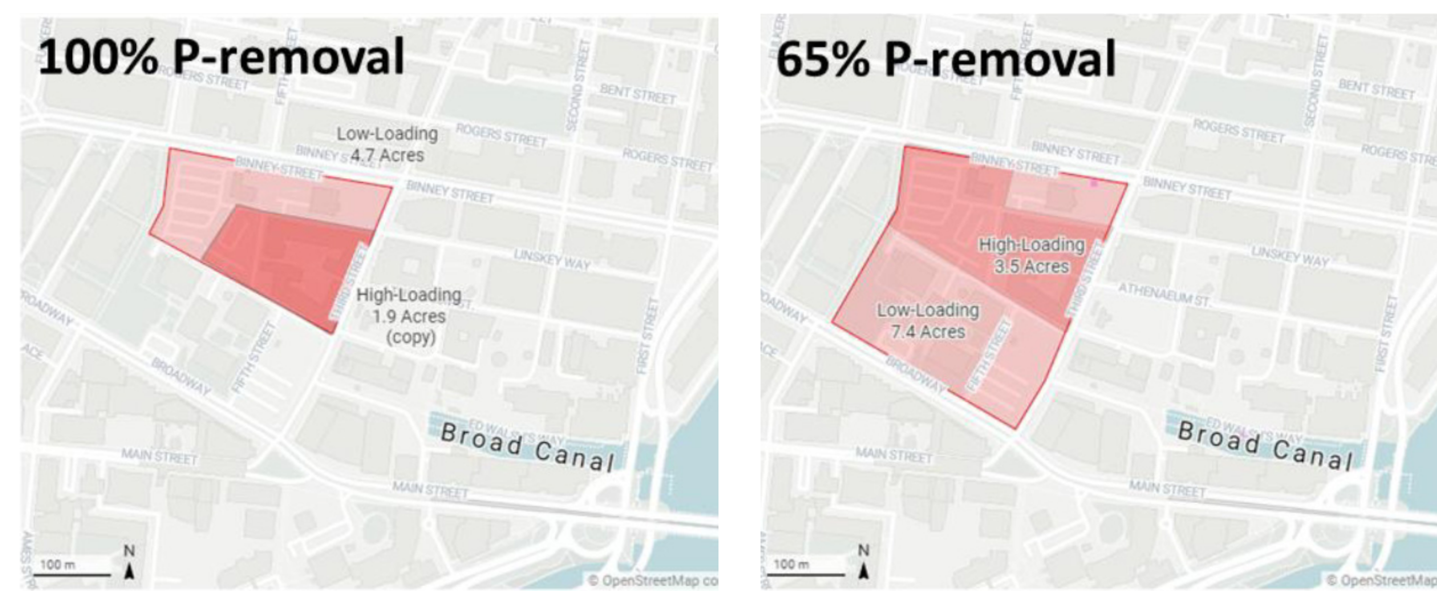
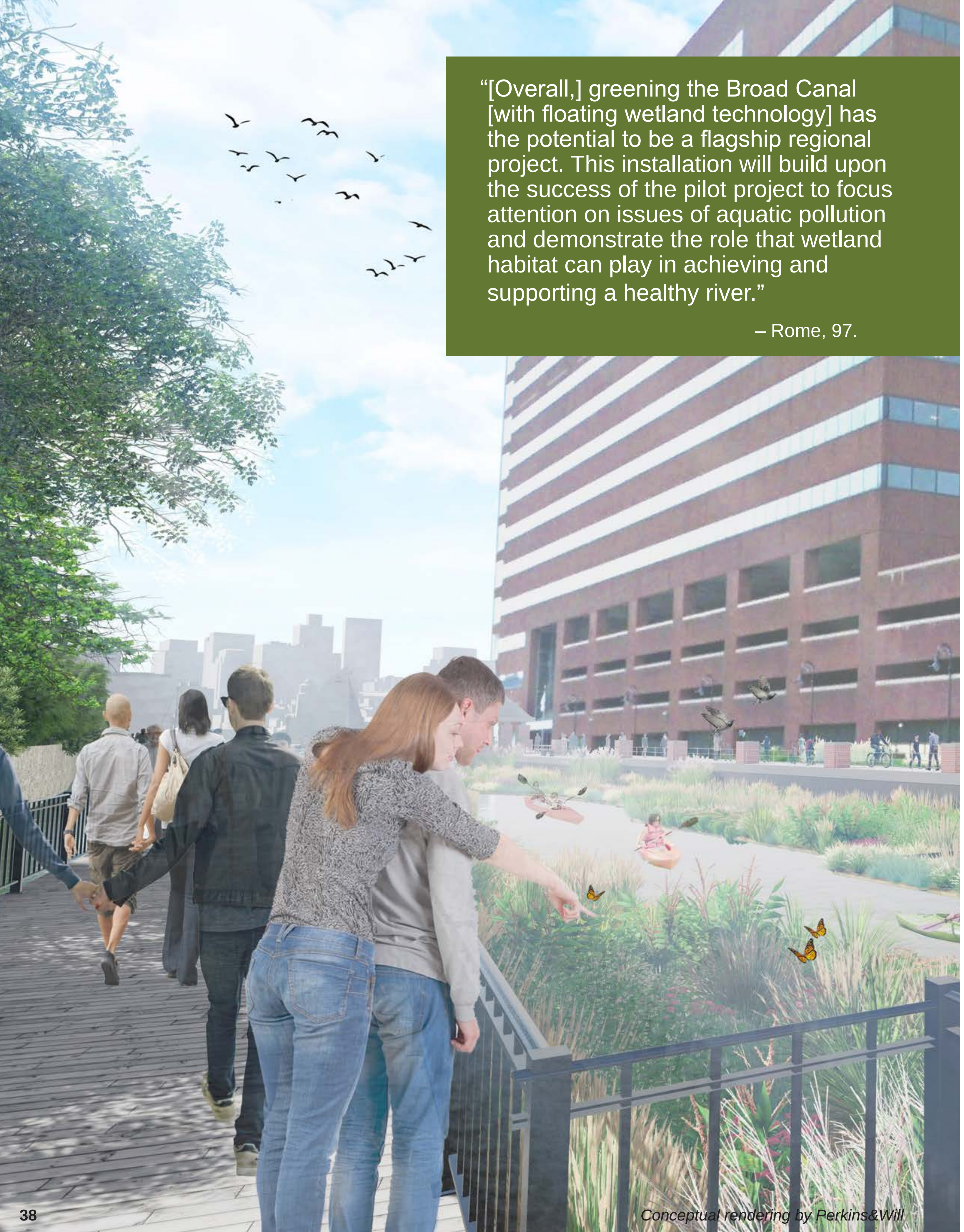


Figure 1: Taken from Rome, Figure 5.2, 95. "The space required for this offset is comparable to spatial requirements of other treatment BMPs and would have numerous co-benefits for human and non-human residents and visitors... [G]iven the relative size of the installation and canal, [it] might have a measurable impact on key water quality parameters including bacterial contaminants, dissolved oxygen, total suspended solids, and chlorophyll concentration." Rome, 97.

> “[Overall,] greening the Broad Canal [with floating wetland technology] has the potential to be a flagship regional project. This installation will build upon the success of the pilot project to focus attention on issues of aquatic pollution and demonstrate the role that wetland habitat can play in achieving and supporting a healthy river.”
>
> – Rome, 97.



Conceptual rendering by Perkins&Will

Criteria 2: Place

- ✓ respect navigation
- ✓ augment other infrastructure
- ✓ located to support annual maintenance
- ✓ designed for year-round placement

From a feasibility standpoint, the Broad Canal also has several advantages. There is a dock at the inner end of the canal that has a non-motorized boat rental facility. Therefore, the vast majority of boating activity in the canal is by kayak, canoe and paddle board, which limits potential conflicts with wetland infrastructure and provides an overall benefit to the navigation experience. The scheme above includes a channel with a minimum width of 23’ for emergency and other small motorized boats, but this design could also be easily adapted to meet any specific needs of kayak operations, particularly the high volume of vessel turnover that occurs in peak season near the dock. From the engineering and maintenance perspectives, the surrounding seawall can be an asset–both as an anchoring foundation and as a means to provide multiple access ladders for maintenance and trash removal. Finally, the canal rarely freezes or generates potentially-damaging ice sheets upon thaw. This makes the Broad Canal an attractive location for year-round installation.

Criteria 3: People

- ✓ accessible to transit
- ✓ ADA accessible
- ✓ located near other amenities
- ✓ provide educational opportunities

The Broad Canal also offers an opportunity to enlist the co-benefits of floating wetlands to create needed (floating) park space in East Cambridge/Kendall, a neighborhood of Cambridge in need of additional green space. An expanded installation would be close to the red subway line as well as several bus routes. As mentioned above, a robust floating wetland shoreline would add significant interest to the already-popular kayak rental operation. While space may be limited in the canal itself, it is a great launch location for adaptive boating and education programs. Inclusion of additional amenities nearby, such as a learning platform, could also be studied in the final design process.

Conceptual rendering by Perkins&Will

Next Steps

The CRC is currently working with public and private partners to realize a floating wetland expansion in the Broad Canal, as well as other feasible locations in the Charles River basin. As with all aspects of the project to date, centering community engagement, feedback and access will remain a priority to ensure that a larger installation–or "floating park"--on the Charles meets the needs of river science, place, and people.

Key next steps and considerations for the project include:

- **Final design:** The Broad Canal site plan shown above was developed to estimate the overall water quality benefit of a significantly larger installation. Moving forward would require a final design process to more carefully consider kayak operations, anchor points, utility locations, community feedback and more.
- **Permitting:** While the CRC and Rome have outlined anticipated permitting next steps in a white paper–which includes more rigorous permitting from the Massachusetts Environmental Policy Act (MEPA) and the Army Corps of Engineers in addition to approvals from the agencies that permitted the pilot–the final permitting path would be influenced by the final design (and vice versa).
- **Maintenance planning:** Maintenance is a key component of any stormwater or park system. In order to realize the full phosphorus removal benefits of a larger floating wetland installation, this will need to include the seasonal harvesting of vegetation. Regular inspections, weeding to control invasive species, and replanting to offset damage from nesting geese should also be expected.
- **Program development:** A larger installation also provides an opportunity for ongoing and expanded educational, recreational and research programs. These should be considered early in the final design process, to ensure that the "floating park" can maximize access and benefit for all.

The Charles River Floating Wetland is a "living" project, not only because of the plants that grow on it and the life those plants support, but because it can evolve with the needs of the surrounding community and landscape. It is the CRC's hope to continue to bring the many stakeholders–including residents, businesses, advocates and municipalities–together in public-private partnerships to fully realize the benefits that a larger floating wetland can provide to our diverse river community and ecology.

We encourage you to follow the CRC in our e-newsletter and on social media and to visit our website, thecharles.org/floatingwetlands, which has additional resources about the topics explored in this report and continues to be updated with new information.

- The Charles River Floating Wetland Team

APPENDIX

Supporters

This project would not have been possible without the generous support of individuals, foundations, corporations and government agencies. Securing funding over the course of a capital project is crucial. The CRC expresses its gratitude to the following donors who enabled this project at all phases, from planning to installation, and from research to community engagement. Thank you!

Heather and Robert Keane Family Foundation
Takeda
Metropolitan Area Planning Council
William Procter Scientific Innovation Fund
The Boston Foundation
Foth
Horne Family Foundation
McKenzie Family Charitable Trust
The Sasaki Foundation
Cell Signaling Technology, Inc.
CHT Foundation
Biomatrix Water
BSA Foundation
MathWorks
Paddle Boston
City of Cambridge
Reach Out for Schools

A special thank you to individuals who provided financial support for the project and all the CRC supporters who give to The River Bank, the annual fund that supports our operations, projects and programming.

Acknowledgments

Our thanks go out to the Charles River Conservancy's Board of Directors, whose belief and willingness to support new strategies for the river's health allowed the pilot project to grow and thrive.

Developing and nurturing partnerships has been crucial to the success of the Charles River Floating Wetland from its inception, allowing the CRC to bring valuable expertise, experience and perspectives that informed the project, expanded its impact in the community (and beyond!), and helped to lay the foundation for a larger, more impactful installation. We are grateful for the many people who have contributed their time to this project's success.

The American City Coalition
Atrium School, Watertown
Biodiversity Builders
Biomatrix Water
buildOn
Charlesgate Yacht Club
Charles River Alliance of Boaters
Charles River Watershed Association
City of Boston
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Cambridge Youth Programs, Frisoli Center
Charles Riverboat Company
Coalition for a Resilient and Inclusive Waterfront
Community Design Lab
Duck Boats
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East Cambridge Planning Team
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MIT Sailing
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