engaging cultural + environmental ecologies on the Elizabeth River
ARCH 702/802
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Most current environmental education is web based or communicated through classroom teaching. When students do venture out of the classroom, environmental education centers are typically located in relatively pristine "natural environments." The extreme impact and complex relationship between human settlement and the natural world is frequently not investigated in any serious way. Also, the architectural design of the center itself is rarely conceived of as a crucial part of the curriculum. In an environment like the Hampton Roads region, including the cities of Norfolk, Portsmouth, Chesapeake and Virginia Beach, the heavily industrialized Elizabeth River is an important generator of livelihoods and learning. Most K-12 school children have little opportunity to experience the river firsthand, especially to go out on the water and investigate. In collaboration with the Elizabeth River Project and other partners, this studio designed a floating environmental education field station to engage urban kids in hands-on exploration and learning about the Elizabeth.
Learning Barge
+ 9 Sites Out Of Mind

**Research 1: Identifying Issues**
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- r1.2: Human Culture + Settlement
- r1.3: Contamination + Restoration / Conservation Efforts
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LEARNING BARGE
+ 9 SITES OUT OF MIND

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RESEARCH I: identifying issues
The Elizabeth River is an estuary that drains into the James River, one of the eight major tributaries of the Chesapeake Bay. The Norfolk International Terminal, one of the busiest and fastest-growing ports in the United States, lies on the Elizabeth. The Southern Branch is the most heavily industrialized of the river’s three branches. It is flanked by the cities of Norfolk, Portsmouth and Chesapeake. The Elizabeth River watershed includes the brackish Lake Drummond, as well as rainwater runoff from the surrounding urban areas.

An estuary is defined as a semi-coastal body of water that has a measurable salinity gradient from its freshwater drainage to its ocean entrance. By its nature, it is a tidal entity, governed by the rhythms of the moon. The brackish quality of an estuary varies according to its sources, its proximity to the ocean, and to the seasons. Both the Elizabeth River and the Chesapeake Bay are estuaries, but their different scales and shoreline topographies distinguish them.

The ecology of an estuary changes constantly. Besides twice-daily shifting of the tides, there is a sectional layering of the water. Due to the higher density of salt water, salinity is generally higher at greater depths. The river is therefore the least saline at its source, and as the salinity gradient shifts between here and its mouth, the communities of plants and animals found in the waters and wetlands change accordingly.

There are five major Chesapeake Bay communities. Wetland types are defined by the primary plant communities of which they are comprised. Marshes can exist as freshwater, brackish, or saltwater and are dominated by grasses and reeds. Swamps tend to exist further inland and further along the chain of succession. One finds in them shrubs and trees as well as forbs, as these plants gradually replace the emergent marsh grasses. Submersed grassbeds consist of only about ten major species, commonly known collectively as SAV, or submersed aquatic vegetation. Of crucial importance to the food chain are plankton. These organisms float near the surface of the water and include zooplankton (copepods), bacteria and jellyfish. Nekton are free-swimming aquatic creatures such as fish, crustaceans and other invertebrates. Residing in the bottom sediments, the benthos group includes algae, bacteria and ciliates.

Wetland areas in the Elizabeth River region are generally brackish marshes. Cordgrass, narrow-leaved cattail, switchgrass and common reed are their dominant vegetation.

Two factors are of prime importance in determining the populace of a given area of the river. One is the dynamic and harsh environment produced by its salinity. Few creatures are adapted to permanent residency in the bay or the river. Those few, such as oysters, flourish in the bay. A second factor is the abundance of nutrients and sediment suspended here, which make it an ideal nursery for juvenile ocean fishes. These in turn attract predators, so the bay and the river are home to an extremely wide variety of transient species.

There are three categories of endemic species in the bay and the river. Native species such as the grass shrimp and the to its oceanic indigenous to the bay and spend their whole lives in its brackish waters. There are three subcategories of visiting species. Anadromous species such as herring and shad migrate from the ocean to breed. The young remain to feed. Semi-anadromous species such as the striped bass spawn in brackish water. Marine species such as the menhaden and croaker spawn in the ocean but carry their eggs to brackish water to hatch. These species attract other fish as well as water birds as predators. Migrating birds also take advantage of the resources of the river.

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According to Christopher White’s Chesapeake Bay: Nature of the Estuary (Centreville, MD: Tidewater Publishers, 5th ed., 1997) the following are a selected list of endemic species to the Elizabeth River.

**freshwater wetlands and waters:**
- broad-leaved cattail
- river bulrush
- tall grasses: wild rice, Washer’s millet
- smartweeds, tbrt thumbs
- at the edge, red maple, common alder (transition and succession)
- sometimes at high tide, minnows
- amphibians and reptiles: various frogs (Northern spring peeper, upland chorus frog, Northern cricket frog, green frog, southern leopard frog), Northern water snake
- birds: great blue heron, great egret, marsh ducks, rails, coots, sandpipers and allies, other birds
- mammals: raccoon, voles, muskrat

**fresh water:**
- invertebrates: grass shrimp, river snail, fingernail clam, freshwater mussels
- fishes: American eel, yellow perch

**brackish marsh:**
- plants: big cordgrass, narrow-leaved cattail, oligo three square, tall grasses (switchgrass and common reed), shorter grasses, herbaceous plants, shrubs, sedges
- reptiles and amphibians: frogs and toads (green treefrog), turtles (common snapping), water snakes (Northern water snake)
- birds: herons and egrets (great blue), swans, geese, ducks (tundra swan, Canada goose, snow goose, many kinds of ducks, other birds
- mammals: raccoon, marsh rice rat, muskrat

**salt marsh:**
- invertebrates: common clam worm, seaweed snail, brackish-water clam, blue crabs
- plants: only two species are predominant: saltmarsh cordgrass and saltmeadow cordgrass
- invertebrates: marsh insects (mosquito, deerfly), crustaceans and mollusks (marsh crab, saltmarsh snails, Atlantic ribbed mussel)
- reptiles (few can tolerate): northern diamondback terrapin, northern water snake
- birds: herons and egrets, ibises, gulls and terns, rails, sandpipers and allies, plovers, birds of prey, passerine birds
- mammals: raccoon, red fox, meadow voles, marsh rice rat, muskrat

**salt shallows:**
- plant communities: phytoplankton, benthic algae, and submerged aquatic vegetation (wild celery, common waterweed, pondweed, eelgrass, sea lettuce)
- aquatic invertebrates: univalves, crustaceans (common grass shrimp), barnacles, other epifauna of pier pilings (whelm mud worm), plankton, bivalves (clams and oysters)
- fishes: bay anchovy, killfishes (mummichog), juvenile fishes (sandbar shark, black sea bass, bluefish, silver perch, spotted seatrout, Atlantic croaker, summer flounder), other foragers (Atlantic needlefish, lined seahorse, northern pipefish)
- waders and water birds: double-crested cormorant, snowy egret, common tern, pied-billed grebe, American coot, American blackduck

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*From top to bottom: transverse sections looking north of the Southern Branch of the Elizabeth River at Nauticus, Money Point, and through the Upper Reach, in approach to the Great Bridge Lock.*
Population + Settlement

Six time periods were chosen to represent important moments in the settlement history of the Norfolk/Portsmouth area.

1608 - Native American Settlement
1663 - Civil War + Naval Production
1903 - Growth of Coal Exportation
1944 - World War II
1944 - Highway System
1994 - Present Growth
Early Settlement

Native American History

1580's - The Chesepian Indians lived in the area that is now Norfolk, Portsmouth, Chesapeake and Virginia Beach when Raleigh's expedition arrived in Virginia in the 1580's. Their name came from the nearby Chesapeake Bay, meaning "Mother of the Waters."

They had a few urban settlements, including Skicoak (the largest town), Apasus and Chesepiac. These towns were all enclosed by wooden palisades. Archaeologists believe that Skicoak was located between modern-day Fort Norfolk and the Lambert's Point coal piers. The Chesepian cultivated corn, beans, squash and tobacco. Houses were made from saplings and wood by women. Women also farmed, collected firewood, and made pots, while men hunted and fished.

1590's - The Chesepian were massacred by Powhatan a few years before the British established a colony at Jamestown in 1607. The Powhatan Confederacy, of the Algonquin ethnic group, lived throughout the Tidewater and Chesapeake bay region. Wahunsonacock (called Powhatan by the British) ruled over more than 30 different groups in this region, living throughout 200 settlements. Powhatan sent warriors to the Elizabeth River region to secure the area after the Chesepian were massacred.

European Impact

Colonialism and Slavery

1607 – Europeans come ashore at Cape Henry in April. One states, "Heaven and Earth never agreed better to frame a place for man's habitations than Virginia."

Early 1600's - The 25 square mile Hampton Roadstead, at the confluence of the Chesapeake Bay and the Elizabeth, James and Nansemond Rivers, is named for Henry Wriothesley, 3rd Earl of Southampton. The OED defines roadstead as "a place where ships may conveniently or safely lie at anchor near the shore."

1775 – Norfolk is Virginia's most prosperous town, because of its deep water harbor and transatlantic trade routes. In the 1600's, much of the trade consisted of slaves brought to Norfolk from the West Indies, and by 1700 the trade in enslaved people originated mainly from Africa. Many of the slaves were forced to cultivate tobacco, which was then exported to Europe.

1624 – King James I makes first land grant to colonists on the site that will become Norfolk.

1776 – Norfolk is Virginia's most prosperous town, because of its deep water harbor and transatlantic trade routes. In the 1600's, much of the trade consisted of slaves brought to Norfolk from the West Indies, and by 1700 the trade in enslaved people originated mainly from Africa. Many of the slaves were forced to cultivate tobacco, which was then exported to Europe.

Most enslaved Africans who came to Virginia and Maryland were originally from Western or Central Africa. Many were skilled boatmen, fishermen, and boatbuilders. In the maritime communities of the Chesapeake Bay, African boat-building and boathandling skills were in great demand.

A notice from the Virginia Gazette in 1772 describes a runaway slave: "He calls himself Bonna, and says he came from a Place of that name in the Ibo Country, in Africa, where he served in the Capacity of a Canoe Man." (http://www.mariner.org/waters/slavery/slavery03.htm)
Norfolk

Building and Rebuilding

1776 - British attack Norfolk. Government of Virginia orders colonists to burn the city. The city is razed by February.

Fort Norfolk is constructed, and Fort Nelson is built in Portsmouth. When invasion was imminent, soldiers would run a huge chain between the two forts across the Elizabeth River to trap the encroaching ships.

After the Revolutionary War, Norfolk rebuilds and once again becomes a major Atlantic port.

1785 - A new fort is built in Norfolk by congressional decree.

1810 - Brick buildings constructed at Fort Norfolk.

1845 - Norfolk incorporated as a city.

1855 - Yellow fever epidemic. Nearly every person in Norfolk becomes ill, and 2000 people, 1/3 of the populace, die. The single ship allowed in the harbor carries coffins. 1000 die in Portsmouth.

1907 - "World Fair" Jamestown tercentennial exposition held in Norfolk. Substantial architectural additions made to the city. Site is later included in 474 acre parcel government buys to construct Norfolk Naval Base in 1917.

Shipbuilding on the Elizabeth

1767 - Gosport Shipyard established under private ownership in Portsmouth on Elizabeth River. Norfolk Naval Shipyard established.

1779 - Shipyard burned by British.

1794 - Shipyard leased by federal government, which it then purchased in 1801 for $12,000.

1833 - First drydock in Western hemisphere opens at shipyard. Dry dock 1, a national historic landmark, is still in operation.

1851 - Confederate army takes control of Shipyard, burns and rebuilds it. Burns it again when they depart in 1862.

1862 - Name changed to Norfolk Naval Shipyard.

WWI + II: During both world wars the naval Yards undergoes a huge expansion.
Shipping coal to the Elizabeth
1883 – First coal arrives by rail in Norfolk, soon replaces cotton as primary export.

Most of the coal at Lambert’s Point Coal Terminal is mined in West Virginia, Virginia, and Kentucky and brought in by rail.

The largest coal-transloading terminal in the Northern Hemisphere, it has an annual capacity of 48 million tons.

Population growth in the region
1917–1945 - Population of Norfolk increases dramatically during the First and Second World Wars. The port becomes critical because of its ability to expand and handle additional capacity.

1919 – Thousands of workers enter the Hampton Roads region in order to meet the demand for military supplies. The workforce at the Norfolk Naval Yard increases by 400 percent over the course of the war. The Norfolk Naval Base is rapidly constructed.

1939 – Three military bases are constructed in the region during WWII. The Norfolk Naval Yard adds 1,000 employees a month during the war, and doubles the size of its operation to 746 acres.

The influx of population strains the housing and civic resources of the area; housing stock is rapidly built by federal and local government, the navy, and private developers.

Postwar – The towns of Chesapeake and Virginia Beach were created in the 1960s through the merger of counties and cities. This was followed by a period of urban renewal.

Today the Hampton Roads area is the 27th most populous metropolitan areas in the US, and the largest metro area between D.C. and Atlanta. It ranks behind Northern Virginia as the fastest growing region in the state.
Pollution and Remediation

Coexistence of polarities

The Elizabeth River is one of the most polluted bodies of water on the Chesapeake Bay. This is due to several factors, including its role as a primary shipping port of the east coast, the shipbuilding and related activities of the United States Navy, and over a century of manufacturing that included trade in chemicals.

The pollution of river sediments with metals and chemicals is exacerbated by the low flush rate of the river which tends to keep contaminants in place rather than diluting them in ocean water. While positive for the bodies of water connected to the Elizabeth, this has compounded problems locally, particularly with the South Branch. Industry, including the Navy, continues to operate along the river. Numerous areas of “legacy” contamination are situated in the immediate region, including four Superfund sites.

Currently, water quality of the Elizabeth is polluted by non-point sources coming from the urban fabric more than point release from specific factories. Stormwater from the 300 square mile watershed is the number one source of new pollutants in the Elizabeth.

Non-point pollution comes from water related activities as well. A primary concern with water quality is the chemical Tri-Butyl-Tin (TBT), used as an anti-foulant in marine paints. The paint rubs off the ship hull and persists for two years in the anaerobic conditions of the water. While the paint is banned on small ships it is still widely used on large ones. TBT is a suspected carcinogen.

Money Point

The river bed sediments offshore of Money Point have been the focus of a coordinated regeneration effort led by the Elizabeth River Project (ERP). Historically, industries at Money Point included (1921):

- Robertson Fertilizer Co.
- Gulf Refining Co.
- Norfolk Creosoting Co.
- U.S. Wood Preserving
- Swift & Co. Fertilizer Company

These industries created a community of chemical facilities at Money Point. In 1969, a fire at Eppinger & Russell released thousands of gallons of creosote into the soil and water at Money Point. Creosote was a product used for wood preserving that contains chemicals known as Polycyclic Aromatic Hydrocarbons (PAHs). Derived from carbon sources such as wood, coal and oil, PAHs are organic chemicals that rank in the top quarter of most toxic chemicals. Reproductive disorders and cancer are suspected to result from contact with PAHs.

Money Point is significant because it is an instance of a widespread issue: “The most significant problem within the system is related to elevated levels of organics (primarily PAHs) and metals in the bed sediments of certain areas…” 1983, DEQ Report

Benthic Integrity

Most PAHs stick to solid particles and settle to the bottoms of rivers or lakes. The river bottom, or benthic zone, is home to diverse organisms that are key to the food chain. The mummichog minnow was selected as the indicator species for the Elizabeth River’s benthic health because it stays local throughout its life cycle, and spends winter burrowed in the river bottom. High rates of cancer have been found in this fish at Money Point.

This map of the South Branch shows contemporary industries (yellow), Superfund sites (green), and the urban fabric of adjacent cities.

It also shows potential docking sites and the regeneration efforts, led by the Elizabeth River Project, that include wetland restoration and the construction of oyster reefs.

Composite watershed map

Currently, water quality of the Elizabeth is polluted by non-point sources coming from the urban fabric more than point release from specific factories. Stormwater from the 300 square mile watershed is the number one source of new pollutants in the Elizabeth.

Oil and trace metals from roads and parking lots flow to the river when rain falls. High nutrient levels, bacteriological contamination and sediments (turbidity) also affect water quality.

Non-point pollution comes from water related activities as well. A primary concern with water quality is the chemical Tri-Butyl-Tin (TBT), used as an anti-foulant in marine paints. The paint rubs off the ship hull and persists for two years in the anaerobic conditions of the water. While the paint is banned on small ships it is still widely used on large ones. TBT is a suspected carcinogen.

Composite watershed map

Map of Money Point with overlay of river area contaminated with PAHs.
The Toxic Release Inventory was launched in 1986 by the EPA to create public knowledge of toxins released into the environment by industry.

The map above, from 2003 data, shows that the industries reporting releases of listed toxins are concentrated along the South Branch of the Elizabeth River.

The map also underlays, in pale green, four Superfund sites on the western side of the South branch.

Toxins are released to soil, to water, and to air. Alternatively, they are transferred off site for licensed waste disposal or processing.

The diameter of the circles above are keyed to quantities of chemicals released. The map shows that the greatest quantity of toxins are released to the air.

Once aloft, toxins migrate from local to regional to global scales. Pollution to air challenges the drawing of geographic boundaries around sites of industrial production.

This map shows the different types of chemicals released to the air by South Branch industries.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrochloric Acid</td>
<td>2,000,000 lbs</td>
</tr>
<tr>
<td>N-Hexane</td>
<td>370,000</td>
</tr>
<tr>
<td>Zinc</td>
<td>340,000</td>
</tr>
<tr>
<td>Hydrogen Fluoride</td>
<td>240,000</td>
</tr>
<tr>
<td>Xylene</td>
<td>183,000</td>
</tr>
<tr>
<td>Sulfuric Acid</td>
<td>180,000</td>
</tr>
<tr>
<td>Hydrochloric Acid</td>
<td>170,000</td>
</tr>
<tr>
<td>N-Butyl Alcohol</td>
<td>142,000</td>
</tr>
<tr>
<td>Glycol Ethers</td>
<td>100,000</td>
</tr>
<tr>
<td>1,2,4-Trimethylbenzene</td>
<td>51,000</td>
</tr>
</tbody>
</table>

Regeneration Efforts

River Stars

The Elizabeth River Project’s River Star Program recognizes local industries and organizations for their efforts to contribute to the clean-up of the river. The program recognizes regeneration activities as well as pollution prevention efforts, but a combination of the two is recognized with the highest level of “Riverstar Model”. Many local industries and schools have joined this group which mixes public activism with environmental consciousness.

Species diversity and numbers of pollution-phobic species are lower than target levels. ERP has focused on wetland restoration and oyster seeding, with twelve oyster reefs now installed.

Oyster Reefs

TBT causes infertility in oyster and mollusk populations leading to species extinction. TBT is the primary reason for the decimation of the oyster populations in the bay. ERP is undertaking a number of oyster reef reconstruction projects to build up the populations in the river. Oysters are significant to the ecosystem as a whole because they filter water, producing a cleaner environment for less tolerant species.

Volunteers planting a wetland at the former Peck Iron & Metal

SAIC has prepared a series of options for capping sediments at Money Point. Work is expected to begin in 2007.

Species diversity and numbers of pollution-phobic species are lower than target levels. ERP has focused on wetland restoration and oyster seeding, with twelve oyster reefs now installed.
**Potential Sites:**
1. Scott's Creek
2. Portsmouth City Park
3. Elizabeth River Project
4. Paradise Creek
5. Money Point
6. Scuffletown Creek
7. Harbor Park
8. Nauticus

**Existing Bridges:**
1. Churchland Fixed Bridge
   - 38 ft.
2. Fixed Bridge
   - 45 ft.
3. N&PBL RR Lift Bridge
   - Down 61 ft., Up 142 ft.
4. Jordon Lift Bridge
   - Down 15 ft., Up 145 ft.
5. OVHD Power Cab
   - Up 42 ft.
6. N&W Ry Lift Bridge
   - Down 10 ft., Up 135 ft.

**Docking Site Evaluations**

Evaluation was conducted by identifying pertinent issues affecting a site and then assigning a numeric grade (1-5, 1=good, 5=bad) to each issue as it related to each site. The criteria for grading a category often involved considering subcategories. For instance, grading “Car Access” consisted of evaluating both the ability of a car to access the site as well as ease of finding a site by car. The chart (left) maps our findings, with the larger dots representing a higher grade and smaller dots representing a lower grade.
Sites Navigation Evaluation

**Portsmouth City Park, Western Branch**
good access by water & land, no industrial or remediating sites, cemetery as threshold

**Elizabeth River Project Info Center**
central location, long term docking possibilities, good water and land access, connection to ERP

**Paradise Creek, Portsmouth**
good industrial/environmental combination, ambiguous docking/anchoring possibility, shallow depths, land site undetermined

**Money Point, Chesapeake**
good remediation proximity, bad land access, bridge sensitive water access, good industrial/environmental combination

**Scuffletown Creek / Elizabeth River Park**
good industrial/environmental combination, good land access, bridge sensitive water access

**Harbor Park**
good land and water access, central location, no industrial/remediation

**Nauticus, Downtown Norfolk**
good land and water access, central location, teaching/museum proximity, visibility, no industrial/remediation

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**LEARNING BARGE**

**Portsmouth City Park, Western Branch**
good access by water & land, no industrial or remediating sites, cemetery as threshold
Barge Types

**Hopper Barge**
- double-hulled walls and deck
- open interior free from structural interference
- designed to haul solid cargo
- can be covered with retractable roof to cover cargo

New barge:
- Dimension: 146' x 38' x 17'
- Gross tonnage: 885
- Capacity: 800 tons
- Cost: $2 / cubic foot

**Flat Deck Barge**
- single-hull with flat deck
- contains any number of water-tight bulkheads
- bulkheads are bisected by a water-rib along the center

New barge:
- Dimension: 120' x 30' x 7'
- Lightweight tonnage: 100 tons
- Draft (empty): 16” – 18”
- Draft (weight/feet): 80 tons / 1 ft
- Cost: $1 / pound
- 1/4” steel plate bulkheads
- 3/8” steel plate hull

Hopper Barge:
- structure is contained within the double hull
- because the deck is at the base of the barge, more steel is required to clad the interior walls, making these barges more expensive than flat deck barges
- special care is required when modifying the deck because, when loaded, the deck sits below the water line

Flat Deck Barge:
- structure spans from the hull to the deck
- a series of steel trusses run along the barge
- steel angles sit atop these trusses to support the welded steel deck
- modification of flat deck barges is possible, as long as lateral support and water-tight integrity of the unaffected bulkheads is maintained
- an advantage to this type of barge is that the deck is well above the water line, thus enhancing safety and visibility

Spuds
- Spuds are a means of anchoring a barge by dropping a series of weighted piles into the land surface below the water.
- On an existing barge it is most economical to install spuds at raked ends, allowing all installation to be performed "dry", or without having to operate on parts of the barge that are submerged.
- Spud pole depths to be determined by channel depths at points of docking.

Conclusions
After considering issues surrounding the floating field station idea, the barge is the more appropriate choice of vessel. The barge will stay in each place for extended periods of time, de-emphasizing the need for frequent mobility. Furthermore, tug service has been donated for the times the barge does change location. The barge allows for a significant increase in usable educational space for the ERP, a primary goal of the organization. The abundant space results in the greatest possibility for educational exploration, allowing both shelter and immediate access to the outdoors and water. With a more robust on-board educational program, the barge differentiates the ERP from similar programs in the area, such as the Chesapeake Baywatcher.

Tug Boats
- A 90’x30’ barge would require a small tug-boat to move it. Most tugs in the Elizabeth River are A T/B, or "Articulated Tug Barge," which means they push the barge, giving greater control in tight spaces.
- Spuds poles are a means of anchoring a barge by dropping a series of weighted piles into land surface below the water.
- A 90’x30’ barge has been loaded with (3)15’x25’x10’ volumes. The accumulated mass takes up about half of the deck, leaving significant surface area for outdoor program. The self-propelled vessel, modeled after the dimensions of the Chesapeake Baywatcher, holds one of the volumes with a small amount of leftover outdoor space. The advantage of the barge is the amount of space it affords.

Specs for a tug pushing 90’x30’ barge:
- 300-500 Horsepower
- approximately 55’ x 25’
- this tug has approximately 7-8 ft. draft.
- tug cabin must be taller than height of barge structure to allow for unobstructed sight when moving.

(info provided by C&P Tug and Barge, Portsmouth, VA)
curricular goals:
• Maritime History and Culture
• Weather
• River Ecology

EE activities:
Self-tour of Battleship Wisconsin
Navigation Games
Tornado in a Tube
Pressure cups activity
Water testing
River Eco Expeditions

EPA
Environmental Protection Agency

CBF
Chesapeake Bay Foundation

curricular goals:
• Increase public awareness and knowledge of environmental issues and challenges.
• Help people gain an understanding of how their individual actions affect the environment, and acquire skills that they can use to weigh various sides of issues, and become better equipped to make informed decisions.

EE activities:
Quizzes, puzzles

curricular goals:
• Improve water quality in the Chesapeake Bay by revealing the relationship between people, land, and water.

EE activities:
Investigate local waterways.
Observe, collect data, analyze, and synthesize information through field study.

curricular goals:
• Maritime Heritage
• River Ecology

EE activities:
Self-tour of Battleship Wisconsin
Navigation Games
Tornado in a Tube
Pressure cups activity
Water testing
River Eco Expeditions

curricular goals:
• To improve water quality in the Chesapeake Bay by revealing the relationship between people, land, and water.

EE activities:
Investigate local waterways.
Observe, collect data, analyze, and synthesize information through field study.

Collaborators
Nauticus & NOAA @ Nauticus
Virginia Naturally
Virginia Aquarium
ERP - Elizabeth River Project

curricular goals:
• To connect students with Virginia's environmental education resources.

EE activities:
Web based activity sheet, workbooks, games

curricular goals:
• To increase the public’s knowledge and appreciation of Virginia’s marine environment and inspire commitment to preserve its existence.

EE activities:
Touch tanks
Terrarium

curricular goals:
• To educate schoolchildren and the public on river ecology and the Elizabeth River's key challenges.

EE activities:
Princess Elizabeth’s visits
River is alive - bottom grabs
Visits to restored wetlands

r1.5: ENVIRONMENTAL EDUCATION IN THE REGION
It is important to understand the Learning Barge within its environmental education context. Mapping the location of other sites for experiencing the Chesapeake Bay and Elizabeth River by boat helps to identify what services are missing, and ways that the barge can stand out from the other options.

One unique feature of the barge is its size. The majority of boating opportunities are on small boats, such as canoes (blue dots). The flexibility of activities on the barge far exceed those on smaller boats. Boats, like the Victory Rover and The Battleship Wisconsin at Nauticus, do not focus on Environmental Education, but on military and maritime history. The Baywatcher, run by the Chesapeake Bay Foundation, is the only vessel that goes into the Elizabeth River, and it only goes as far south as the Elizabeth River Project Headquarters. The barge will visit areas of the river and her tributary creeks not visited by the other educational boats in the region.

The existing educational boat trips through ERP’s collaborators are successful and are consistently booked by school groups. It is expected that the Learning Barge will enjoy the same popularity, if not more.
Science
As a result of science instruction, students will be able to achieve the following objectives:
1. Design and use an experimental design in scientific inquiry.
2. Use the language of science to communicate understanding.
3. Investigate phenomena, using technology.
4. Apply scientific concepts, skills, and processes to experiences.
5. Experience the richness and excitement of scientific discovery of the natural world through the collaborative quest for knowledge and understanding.
6. Make informed decisions regarding contemporary issues, taking into account the following:
   o public policy and legislation;
   o economic costs/benefits;
   o validation from scientific data and the use of scientific reasoning and logic;
   o respect for living things;
   o personal responsibility; and
   o history of scientific discovery.
7. Develop scientific dispositions and habits of mind including:
   o curiosity;
   o demand for verification;
   o respect for logic and rational thinking;
   o consideration of premises and consequences;
   o respect for historical contributions;
   o attention to accuracy and precision; and
   o patience and persistence.
8. Explore science-related careers and interests.

Specific
Elementary Science
Throughout a student's science schooling from kindergarten through grade six, specific content topics, are included:
- Scientific Investigation, Reasoning, and Logic;
- Force, Motion, and Energy;
- Matter;
- Life Processes;
- Living Systems;
- Interrelationships in Earth Space Systems;
- Earth Patterns, Cycles, and Change; and
- Resources.

3rd, 4th & 6th Grades
SOLs in these three grades specifically address issues relevant to the Learning Barge:
- 3rd Grade - water related environments, soil, water cycle, life cycle, human effect on habitat, renewable and non-renewable energy.
- 4th Grade - plant anatomy and life cycle, watershed, ecosystems, habitat and niches, weather.
- 6th Grade - health of ecosystems and watersheds, rivers and streams, wetlands, estuaries, water health and conservation issues, water quality monitoring, resource management.

Math
The content of the mathematics standards is intended to support the following 5 goals for students: becoming mathematical problem solvers, communicating mathematically, reasoning mathematically, making mathematical connections, and using mathematical representations to model and interpret practical situations.

1st, 2nd, 3rd, 4th, 5th, 6th
High School
High school science goals are divided up into category by subject. The subjects are
- Life Science
- Physical Science
- Earth Science
- Biology
- Chemistry
- Physics

English
From kindergarten through twelfth grade, students become increasingly aware of the structure of language and the writing process. Improvement in written communication is achieved through frequent opportunities to apply narrative, persuasive, expository, and technical skills.

High School SOLs that specifically address issues relevant to the Learning Barge:
- Maps and mapping
- Virginia energy resources, renewable and non-renewable
- Weather, data collection, weather patterns
- Ground water, water quality issues, freshwater and saltwater environments
- Ecosystem equilibrium
- Virginia flora and fauna
- Virginia ecosystems
- Fluid properties including buoyancy
- Hydrologic cycle

Social Science
History-Students will understand chronological thinking and the connections between causes and effects and between continuity and change.

- Geography-Geographic skills include the ability to use maps, globes, and aerial imagery; to interpret graphs, tables, diagrams, and pictures; to observe and record information; and to assess information from sources.

- Civics-Civics instruction should provide regular opportunities at each grade level for students to develop a basic understanding of politics and government and to practice good citizenship.

High School
High School SOLs that specifically address issues relevant to the Learning Barge:
- Maps and mapping
- Virginia energy resources, renewable and non-renewable
- Weather, data collection, weather patterns
- Ground water, water quality issues, freshwater and saltwater environments
- Ecosystem equilibrium
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- 6th Grade - health of ecosystems and watersheds, rivers and streams, wetlands, estuaries, water health and conservation issues, water quality monitoring, resource management.
DESIGN I: eleven individual explorations
Hybrid Space

The barge is a vehicle to experience the Elizabeth River as a hybrid landscape, where large scale ecologic and industrial processes occur.

The form of the structure references the scale of its surroundings. While the structure has the ability to create some degree of enclosure, it is built to allow the natural elements to permeate the barge.

A sectional strategy is employed to allow access to the water, and to reveal the processes and life of the benthic layer.

Strategies employed in the wetlands will allow visitors to become involved in ecological processes at a tangible scale, whether through harvesting decaying plants or providing a native plants nursery for the shores of the Elizabeth River.

One element of the sectional strategy is the construction of a stair/aquarium from Plexiglas which will contain submerged aquatic vegetation and estuarine life.

Opposite the stair/aquarium will be a window into the water of the Elizabeth, allowing students to see her murky color, and understand its relationship to the tannins in the Great Dismal Swamp.

The Elizabeth River is a dialectic - a landscape created by the intersections between Chesapeake Bay and Great Dismal Swamp, salt and freshwater, between land and sea, between ecology and industry.

The form and educational strategies of the barge will embody this dialectic, allowing students to open to the multiple processes which occur on the river.

- Laura Bandara
The Learning Barge is didactic architecture that functions at multiple scales; most clearly, it must have meanings at the scale of the river and the visitor. Creating narratives that describe how the barge is to be understood is an important first step in determining its physical form. By programming narratives rather than spaces, the barge becomes part of its educational goal, not just the site for it. These narratives include, the barge as a:

• **lens** making large things small and small things large. The barge is a mediating device that brings global issues to the size of the students and exposes hidden life within the river. The same place can be understood in dramatically different ways depending on the lens that is used.

• **display.** Against the backdrop of the city, it is a marker of the work being done to clean up the river; within reach of curious hands, it is a place that has three dimensional value and interest.

• **threshold.** Providing transitions through path, light and sound that remove visitors from the environment of the everyday in order to re-present it to them.

• **filter.** That sorts through the muddled relationship of industry, culture and nature. Both the physical filtering of water and the conceptual filtering of information can break down opaque wholes into their usable parts – revealing hidden processes.

The parameters that clarify the function of the barge and unify its many lessons have physical parallels in a strong structural armature that is a framework to serve multiple functions. Rather than a series of discreet objects or spaces, singular interventions on the barge can be at the scale of industrial and maritime technologies and still allow for flexibility within them.
Project Intentions
To represent the ground / background / field / site of the Learning Barge in such a way that the figure of the barge is transformed by this context.

The barge is a work of environmental design that engages, amplifies and reveals the historical and present ecology of the Elizabeth River.

Two crucial aspects of this story are the "legacy" contamination in the soils of the river, and the current regeneration efforts achieved by the efforts of volunteers.

Use the barge as a transformative space for children’s environmental ethics.

The barge design, fabrication materials and operation should clearly embody an attitude towards material production, using renewable resources for its energy needs.

Spatial / Program Ideas
Spatial issues operating on the barge:

Facilitating contact with the water.
Transitioning from the barge surface, at minimum six feet above water, to a contact zone one foot above water.

Using the "river as sink," a traditional pollution model, as a formal element.

Interfacing solid forms with fluid, such as is evident on the river bank.

Exploring the spatial compression and multi-tooling typical of boats/houseboats/nomadic structures.

Using the darkness below deck as an asset, perhaps as a "lab" for science on materials pulled from the river.

Wind power on the barge seen in light of tanks containing carbon based energy.

Sediment contamination at Money Point.

The barge at the Elizabeth River Project docking site. Proposed wetland on board represented alongside volunteer efforts re-vegetating Paradise Creek shoreline.
The studies explore the Learning Barge as movable as both an object and a collection of objects or onboard components. Adaptable architecture has the ability to alter itself to suit the diverse needs of its users, in this case the need for a place that supports education, wetland planting operations, conferences and even fundraising events. The barge must also adapt to the sun and changing tidal conditions. As a collection of objects it must have the ability to be both open and closed to a spectrum of activities and conditions. These models explore these ideas in a multitude of ways.

Sliding walls and movable storage partitions create adaptable space, while solar panels with a tracking system allow the barge to settle into its site. Operable floor grates allow use of the space above the greywater garden, while facilitating the opportunity to descend into the garden for “bottom grabs”. The garden may be extruded above deck to allow views of the rich benthic zone.

Access to the water is studied in both inboard and outboard solutions, such as cutting the deck and lowering a mobile gangplank to the water’s surface for educational activities as well as easy access from boats. Natural ventilation is studied as the primary means of cooling the spaces utilizing the breeze off the river’s surface.

Layers of Interior/Exterior space wrap around a central service core, with storage above and mechanical below. The permeable border between interior and exterior space promotes ventilation, while a solar roof provides power for the barge and shelter from the sun. Eaves overhang a stair to the lower deck where an enclosed space can be used for secure storage of electronic equipment and batteries for the solar power system. There is the possibility of an additional learning environment below deck. An open deck facilitates experiential learning on the barge facilities.

Two gardens have very precise functions, one purifying greywater and the other growing plants harvested annually for methane production to heat the barge in the cold winter months. A ramp allows access to the lower level where visitors can witness the abundant life hidden below the surface of the water garden. An open steel grate system covers the wetland allowing full occupation of the deck, as the gardens still perform the filtration function required of them. These gardens do not represent the natural environs but recreate the functions that these environs perform for us.

- Adam Donovan
Visiting the Elizabeth River, we experienced a palpable disconnection between the waterfront and the land. Security and environmental concerns combine to create a fragmented landscape. I see one mission of the barge design to connect the land, water and shore. As a framework for thinking about methods of accomplishing this, I looked for the elements that tied together the “natural” and “man-made” and found it impossible to avoid seeing them as interconnected cycles. A normal wetland or river circulates nutrients and is a balanced system. Industry is a cyclical process as well, however imbalanced it may be.

What are the reasons for and consequences of environmental and industrial imbalances? How can the Learning Barge express the mechanisms of these coexisting cycles while contributing to an awareness of the essential phenomenological conditions of water, shore, and land?

The incorporation of a wetland into the design of the barge is important. No attempt should be made to replicate a fragment of an actual wetland, but the barge wetland should function as a water treatment mechanism. The idea would be to show the cyclical nature of production, consumption, waste and transformation. This should be accompanied with some element of interaction with actual wetland areas, possibly through participation in restoration.

The barge should be as self-sufficient as possible, harvesting rainwater and sun, and wasting as little as possible. Enclosure should be kept to a minimum. Perceptual connection to the water and land would be on more than one level, but sectional manipulation would be minimized to maintain the expansive sensation offered by the barge deck. This would also help to control costs. The industrial character of the landscape and culture would be acknowledged in a way that makes clear the interconnectedness of constructed and naturally-occurring processes.
The Elizabeth River is water in process. Tidal flow, temperature, salinity, imports, exports, each changes hourly, daily, yearly. These explorations look at one or a combination of those processes and make them manifest. The architectural interventions become forces and movements frozen in time, or lenses and keys that make those processes visible.

What if all five sites could be condensed? As the barge moves, students realign elements to call out the sun at noon, the north star, the rising of the moon. A giant solar clock tracks the sun as it passes each hour. A cut through the barge reflects the sky above, as a tower projects from the depths. Spaces are created to learn how to navigate on earth with what is above. At night, the structures themselves become sextant and astrolabe.

What if the barge plugged into something else and became new? If the barge had a presence on the land, it could become the generator of process, rather than merely an observer. When the barge changes site, its wetland attaches to one on land, taking on stormwater runoff that is treated and held. Pneumatic panels in the ground translate the energy of hopping children into air pressure, driving pumps that carry clean water back on to the land. The barge becomes a battery, storing energy needed elsewhere, and releasing it at just the right moment.
What if everything the barge needed could be held in one box? As elements are needed, they are pulled or folded out from the central box. The conference table slides over a hole in the barge and unfolds, becoming a water testing laboratory. Windows slide outwards and become interactive maps. Floors unwrap, exposing structure and water below. The movement itself is used to power process. Certain elements generate the pressure needed to move water, create enclosure; nothing exists in isolation.

Solar, pneumatic, hydrodynamic, vegetal, heat, are all types of energy in different states. Plants can be considered organic translations of energy from the sun, from the ground, from water. The energy needed to drive a tugboat is energy from the sun turned to food, turned to animal, compressed and turned to oil. Each manifestation is one moment in this process.

What if other ships could read the barge as they passed? This exploration combines the previous. There is a tower that unfolds to the sun and stars, and a box that explodes into student activity stations. But now, as each piece changes, it becomes a signal representing what occurs within. Areas of the barge flood and dry as the tide ebbs and flows. Window panels are historic photographs aligned with locations on the shore. As each piece is moved, the enclosure is rapidly eroded until the box is less building and more ruin.

- Matt Hural
My goals combined a practical solution to fitting possible program elements within the structural constraints of the barge bulkheads, while at the same time emphasizing the sectional experience by excavating below deck and constructing on top of it. The experience of the path was intended to take advantage of these sectional qualities, allowing for visual connections to the various systems at work on the barge and in the adjacent landscapes. Material changes are used to emphasize different types of intervention on the barge. Given its mass and opacity, steel plate would become oppressive as an additive material above deck. To maintain a sense of the deck’s vastness, some transparency should be achieved so as not to clutter the barge’s surface. Due to the rigid, rectilinear quality of the barge’s shape and internal structure, an intervention above the deck might break from that orthogonality by moving in ways oblique or even curvilinear to the structure of the barge itself.

The Hopper barge (above right) allows for greater sectional flexibility without compromising structure.

The deck barge (far right) requires more careful modifications to achieve sectional experiences that penetrate below the surface of the deck.

Emphasizing Sectional Experience

The most promising source of electric power for the barge is to harness both solar and wind energy. These two power sources work well in tandem since neither will reach their optimum performance in the Elizabeth River area. For instance, on hot, sunny days, winds tend to be calm while wind speeds increase during storms and at night. This variability makes solar and wind power a complementary and effective way to produce energy for the barge. Combining these two sources can provide a more consistent and reliable power supply for the barge’s various systems.

Wind Power Exploration - Matthew McClellan
This scheme explores the connection between the barge and the land. It operates from the idea that there is inherent reciprocity between our own constructions and ones found in nature. Ideally, these are harmonious situations that coexist, both as nature. This scheme anchors the barge into its surroundings with a literal connection from its deck to the ground of the shore. The model, loosely based on conditions at Money Point, shows a ramp leading from the barge to the ground, over the water between them. There is also an “arm” or small ramp structure that protrudes from the opposite side of the barge, over the River, to afford the opportunity for children and other visitors to get very close to the water while being as removed as possible from where they have come.

This scheme suggests that the program allows students to cross this edge between water and land, recognizing that the two depend upon one another seamlessly, each permeating the other. More specifically, this would include the literal transport of young plants from a barge nursery to land, so that students may contribute to the regeneration of conditions in the landscape that may have been erased. This new vegetation would contribute to the efforts of many to restore habitats and bring to the River more closeness between man’s building and the building of nature.

- Katherine Pabody
This exploration takes advantage of the subtractive and additive barge section to allow people to experience didactic elements in a sectional and processional way. One enters the barge at deck level and then ascends via ramp, passing platforms/containers of: filtering oyster beds, wetlands, green roof, recycled/re-used roof/floor material, solar water heaters, and photovoltaic panels. As one descends, the lower portions of the wetland, green roof, and oyster beds are visually accessible and a sheltered space is available for gathering or inhabiting. As the “terraces” ascend, the progression from ground/water to sky occurs abstractly along the procession.

Surface / Ground
Section
Didactic Procession
Open View
Ramp / Accessible
Compartmentalization
Gather
Path
Explored Surface
Oysters: filtering
Wetland: filtering
Green Roof: thermal, inhabitable
Recycled Materials
Cistern
Photovoltaics

This idea also relates to interlocking/compact space by allowing people to experience didactic elements in a sectional way. The roof becomes a main element. The two sections of green roof and photovoltaic panels slope toward a channel, collecting and conveying rainwater into a “water channel” on one side. In this, gray water is collected and filtered with wetland plants. Relating to this space is a sunken classroom with amphitheater, accessed by a ramp, where the students can see light-filtering panels above, water channel to one side, and the river to the other side. The deck level along the edge opposite the water channel is a place for students to stand next to the water and experience the edge of the barge looking out to the Elizabeth River.

Surface / Ground
Section
Structure / Enclosure
Open View
Ramp / Accessible
Compartmentalization
Gather
Path
Amphitheater
Water Channel / Wetland
Photovoltaics
Green Roof
Taking inspiration from the numerous cranes and loading docks of the port, the challenge was how to transform the flat deck of a barge into a dynamic surface with a sense of motion reminiscent of the busy Elizabeth River.

- Jayme Schwartzberg
This initial barge design is informed by ideas of Balance, in both a literal and philosophical sense. Concepts of balance pervade many aspects of the project, from the equilibrium of water and the physical balance required of a barge, to the theoretical balance of an educational program. Perhaps most importantly, the idea of balance is at the heart of a healthy, functioning natural environment, and is the fundamental goal of ecologically sensitive initiatives such as recycling; the same initiatives and processes about which the students will be educated. This design is based on a 32’ x 94’ barge with a uniform, unchangeable central spine. Formal Classrooms, one enclosed and one covered, are placed on either end of the barge and linked by perimeter paths. The configuration accommodates two, 25-person classes that rotate between the two rooms. The perimeter paths also function as entry points onto the barge. One path ramps down 3.5 feet to provide low-level access to the barge from a boat. The outdoor classroom consists of 2 16’x24’ spaces, one of which is a terraced seating area sloping down to meet the level of the ramp landing. The enclosed space is approximately 32’x20’. The overall spatial idea was to provide several learning “environments” while promoting even circulation throughout the barge, seeking physical and spatial balance.

Conceptual The barge organization has a didactic purpose in terms of how it structures the learning process. If we see the educational agenda of the learning barge as a balance between observation and participation, the design must reflect this balance. The enclosed classroom will house the observation component, in which displays, charts, and other “flat” material is exhibited. The outdoor classroom will hold the more participatory components, where students will become physically involved in the processes and get their hands dirty. Furthermore, the central area enclosed by the classrooms and perimeter paths will function as a learning garden of native ecological activity, or a microcosm of the larger surrounding environment. Thus the perimeter spaces on the barge provide students the opportunity to look outward and observe the existing conditions, while the central space with its reduced scale allows for more immediate participation with the elements that comprise the larger environment. By reducing the scale, the systems at play will become more comprehensible to the students. The central space will contain several native wetland planted areas, a living oyster bed, and a thru-hole to the river for bottom grabs and crab traps.

-Clark Tate
RESEARCH 2: integrating environment and architecture
Land-Based & Water-Based Regulations

Which Code Regulations Apply?


ABYC – American Boat and Yacht Counsel Regulations website - https://www.abyc.com/

VUSBC – Virginia Uniform Statewide Building Code

ADA – American Disabilities Act

Any other regulations specific to Chesapeake Bay region

Boat-Based Review

Professional Opinion #1:

Key Factors:

- Are there people on the barge when it is moving?
- Building from scratch, or refurbishing an existing barge?
- Getting a new construction/certification package?

Professional Opinion #2:

Contacts

LTJG Arthur F Loughran, USCG

Eric Matheme, Matheme Marine Design

Land-Based Review, using IBC

Use group:

The project could fall under two of the outlined use groups:

- A-3 – assembly without fixed seating, ex: Lecture Hall, Community Room of E – educational

Types:

The type of the building is determined by the fire resistance properties of the structural and non-structural materials in the building:

Type I and II – non combustible materials exterior and interior

Type III – non combustible exterior any other allowed material interior

Type IV – Heavy Timber

Type V – Any other kind of building

The project could fall under two of the outlined use groups:

- Use group A and E

Occupancy:

The code specifies a square footage required per occupant based on use group, activity within the space, and configuration of interior elements:

- Assembly:
  - Concentrated (fixed seats or chairs) – 12 sf/occupant
  - Un-concentrated (non-fixed tables & chairs) – 7 sf/occupant

Egress:

The proposed building will not have sprinklers, therefore the required egress for the building is:

- Stair – 32 sf/occupant
- Other forms of egress - 22 sf/occupant

Occupancy:

- Learning Barge

- Lecture Hall, Community Room

- A-3 – assembly without fixed seating, ex: Lecture Hall, Community Room of E – educational

Egress:

The proposed building will not have sprinklers, therefore the required egress for the building is:

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- Other forms of egress - 22 sf/occupant
Salt Marsh

Development and form

Salt marshes are created by the process of sedimentation and erosion. As sediment increases in locations with a degree of protection from wave energy, marsh plants become established. The sediment continues to accrete as these plants grow, because the root mass of marsh grasses provides an armature for the soil. On shores with steep slopes, salt marshes are sometimes only a few meters wide. They are usually much larger in the Chesapeake Bay where land is very flat.

Determinants for the development and extent of salt marsh wetlands are:

- Tides
- Sediments
- Freshwater inputs
- Shoreline Structure

Salt Marsh

Process and Productivity

Ecological process in the salt marsh is dynamic, because the daily tides scour the marsh, and storm events can uproot them entirely. Marsh development occurs through a process of accretion and submergence.

Salt marshes are among the most productive ecosystems in the world.
Dominant plant species

Growth is irregular with early plant colonization, while the marsh becomes more stable as vegetation becomes established.

At maturity, Spartina alterniflora (Saltmarsh cordgrass) dominates the low marsh.

The dominants of the high marsh community are: short S. alterniflora, Salicornia spp., (glasswort) Distichlis spicata (Saltgrass) and Juncus roemerianus (Black needle-rush).

As the marsh ages, the high marsh species begin to dominate, and sedimentation and surface flows become more important for determining community composition. If this occurs, then fresh marsh and terrestrial plant species begin to invade.

Salt Marsh

Tidal creeks

Because water flow is bi-directional, tidal channels do not meander as much as rivers. The pattern created by tidal movement through the marsh is, in some ways, more interesting than its section.

Salt pannes are barren salt patches in the sand that are inundated during high tide and become covered with blue-green algae. Mud flats retain water in low tide, and sometimes contain widgeon grass (Ruppia spp.).

Recommendations:

Include more than one type of wetland plant community on the barge. Identify ways for people to participate in wetland processes. Shoe dynamism of the ecologic process.
Methane

A source of power and an environmental dilemma

Methane CH₄ is produced abundantly in the anaerobic decomposition of wetland organic material. One square meter of wetland can produce up to 213 grams of methane in a single year (climatechange.ca.gov). Methane is considered to be a greenhouse gas; one molecule of CH₄ traps 21 times as much heat as a single molecule of CO₂ (EPA). Methane, an odorless gas is the primary ingredient of natural gas.

CH₄ + 2O₂ → CO₂ + 2H₂O + 891 KJ

This equation shows the chemical reaction of the combustion of methane. It shows that burning one mole of methane releases one mole of carbon dioxide as well as two moles of water and energy.

213 g × 1 Mol. × 891,000 Joules × 2.78 × 10⁻⁷ KWH

1 m²/yr. 16.04246 g Mole. 1 Joule

\[ = 3.28 \text{ KWH/M²/YR} \]

This equation derives the amount of energy available from a square meter of wetland. Assuming 30% efficiency in the conversion of gas to energy 0.9867 KWH/M²/YR is a reasonable expected energy supply. In a Berkeley study, 6769 KWH/YR was the average annual consumption of the ten homes studied.

Methane is harvested from mines and landfills, but little research is available about collecting from distributed sources such as wetlands. Landfill collection is perhaps the most relevant to our process. The limitation is how to create the double layer of low-permeability required to provide anaerobic digestion and ready collection of the pure gas. Perhaps water could provide this barrier as it does naturally in wetlands, but the problem then becomes how to collect an effervescing gas from a liquid.

This is the schematic design of a wetland methane collection system: untested. This system based on the previous landfill diagram could collect methane from the intact wetland. There would most likely be a significant loss factor of CH₄ not recovered. Perhaps a solution to this problem is to harvest the wetland grasses before they begin to decay, as an educational activity that allows children to participate in the system-reinforcing the idea that humans are a part of natural systems, not extraneous to them.

The collected litter could then be utilized in a biogas plant as shown below.

The treated effluent from the plant could be used as fertilizer for the next crop of wetland and the methane could be used either to create steam (possible heat source) that would then turn a turbine to generate power, or it could be used directly in a generator to create electricity. The former, while less efficient, has greater educational opportunity as the phases of traditional power production are utilized. This solution has significant educational potential and connects the learning barge to the industrial landscape through its processes.

LEARNING BARGE
Habitat

Two primary resources for this section were the Elizabeth River Project’s Habitat Guide, and Chesapeake Bay: A Field Guide by Christopher White. Both are invaluable texts for understanding the ecology of the Elizabeth River. The source of the drawings and diagrams is Chesapeake Bay: A Field Guide.

The Elizabeth River has a predominately high salinity gradient when compared to other Chesapeake Bay tributaries. Due to this gradient, it offers primarily saltwater habitat. Virtually its entire shoreline has been disturbed by the activity of human industry; were this not the case, the river would be bound by salt marshes on both shores for the majority of its length. Unfortunately this does not represent what actual ecological conditions comprise the river currently, though many are working to re-vegetate its shores. The wetlands on either side of the river, for the most part, sit beneath the constructions of industry, the boundary of which is usually the water’s edge.

Even without the disturbance of human activity, the Elizabeth River is a harsh habitat for endemic species. Few species are permanent residents, both due to this harshness, as well as that the populations of some are in decline due to disturbances beyond the eco-system. The shallow natural basin of the estuary leaves it very vulnerable to the effects of temperature and wind fluctuations. Thus it is a habitat of extremes: its waters are colder in winter and warmer in summer than in the open ocean. The Elizabeth River is also a difficult habitat because of its salinity gradient. These salinity levels offer extremely narrow ranges within which organisms can survive, and many actually test these limits by venturing into transition zones within the gradient. River salinity varies from extremely saline at its mouth to completely fresh near its source, but the gradation between these extremes happens sporadically and the line of this gradation is never constant. The confluence of these two conditions provides a specific habitat where selected species may reside permanently; these species flourish here and are better suited to this environment than anywhere else in the world. Otherwise, species visit according to patterns of reproduction, feeding, hibernation and other rhythms of survival.

The five communities of the Chesapeake Bay include organisms from all of the animal kingdoms as well as a large variety of plants. These communities are: benthos, submerged aquatic vegetation (SAV), plankton, nekton and wetlands. These communities populate the three salinity conditions of the Bay, freshwater, brackish water and salt water. Though technically the water of the Elizabeth River is brackish, this study focuses on species whose residence is primarily salt water habitat, because of its high salinity.

Oysters are one example of species that naturally flourish in the Elizabeth River; they belong to the benthos community. Benthos inhabit bottom sediments in both shallow and deep water, and includes algae, bacteria, and ciliates (protozoa). Ciliates also belong to the plankton community, though its habitat is the benthic layer. The benthic layer is a crucial part of energy transfer from the base of the food chain to its top. Fishes and other nekton feed upon the benthos, and in turn feed larger organisms such as birds and turtles that inhabit the river’s wetlands.

LEARNING BARGE + 9 sites out of mind
When the survival of benthos and its habitat is jeopardized, an extensive system is disrupted. Water runoff from neighboring human developments is also detrimental to the health of the benthic layer. The high nutrient content in this runoff, from sources such as fertilizer, waste treatment plants, animal farms and remnants of chemical products made for cleaning and other uses, enters the river system from its watershed.

These nutrients launch intense algae blooms, blocking light that would otherwise penetrate beneath the water's surface and sustain the growth of submerged aquatic vegetation. The decomposition of these algae consumes oxygen from the river water, which sustains fish, benthos and other aquatic life.

Historically oysters have been an abundant and critical component in the Chesapeake Bay structure. Their population dramatically declined after the turn of the century due to over harvesting and disease. The irony of the effects of this declination now, amidst numerous ecological concerns for the health of the Elizabeth River, is that oysters are the estuary's natural cleaning system via their behavioral filter feeding. Prior to its decline, the Chesapeake Bay's oyster population could clean its waters in just a few days.

The blue crab, another permanent resident of the Elizabeth River but in decline, is a shellfish that depends upon certain oxygen levels for survival. Its habitat is submerged aquatic vegetation.

Plankton are free-floating or non-swimming organisms whose habitat is upon, or near the surface of the water. Phytoplankton (diatoms, algae, dinoflagellates) are planktonic plants. Zooplankton (water fleas, copepods) are tiny planktonic animals. Macrozooplankton (jellyfish) are larger, relatively mobile species of zooplankton and can be seen more easily with the naked eye.

Nekton are free-swimming aquatic organisms, such as fish, whose habitat beneath the water surface can be very shallow, very deep, and all depths in between. The blue crab is nekton, as are the hundreds of species of fish that reside in the Chesapeake Bay. Fishes who inhabit the mostly saline and shallow waters of the Elizabeth River often like to hide in its submerged aquatic vegetation. Predominantly, this population is juvenile fishes, most of whose adult lives are spent in deeper waters.

Wetlands mark the emergence of land from beneath the water. Marshes typically line the shores of the river and transition into swamps as one moves away from it. Marshes are characterized by low-lying grassy vegetation while in swamps, though still very wet areas, one finds predominantly woody vegetation. The salt water marsh is home to many plants, insects, birds, reptiles, and mammals. Its vegetation is characterized by the predominance of Spartina, or cordgrass. Many other plants also attract and feed butterflies and birds of all kinds. Many of these birds are migratory and the wetland habitat provides what sustenance they need for their seasonal journeys. There is marked activity in the wetland always: a few of its plants persist in fruiting and blooming through the winter, sustaining selected species.

One of the rare permanent residents of the Elizabeth River salt marshes is the diamondback terrapin turtle; it is the only species of turtle that is native to the saline wetlands of the East coast.

When the survival of benthos and its habitat is jeopardized, an extensive system is disrupted. Water runoff from neighboring human developments is also detrimental to the health of the benthic layer. The high nutrient content in this runoff, from sources such as fertilizer, waste treatment plants, animal farms and remnants of chemical products made for cleaning and other uses, enters the river system from its watershed.

These nutrients launch intense algae blooms, blocking light that would otherwise penetrate beneath the water’s surface and sustain the growth of submerged aquatic vegetation. The decomposition of these algae consumes oxygen from the river water, which sustains fish, benthos and other aquatic life.

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Wind Turbines

Options and Area Information

Option 1

Bergey BWC XL.1
24 VDC Only
Bergey Wind Power

Power: Rated 1 KwH
Rotor size: 8.4' diameter
Cut in speed: 5.6 mph

Price:
- Turbine: 2,400
- Anti-corrosion: 400
- 7 Circuit DC power: 600
- Battery string: 4,860
- Sine wave inverter: 4,495
- Tower (80'): 2,050
- Tower raising kit: 355
TOTAL = $15,160

Pro
- Provides enough power
- Powerful spatial organizer
- Hinged tower (easy fold-up + maint.)

Con
- Guyed wires
- Might require alternate structure
- Potential height restrictions in area

Option 2

Air-X
Southwest Windpower, AZ.

Power: Rated 400 KwH
Size: 4' diameter
Cut in speed:
Weight: 13 lbs.

Price:
- Turbine: $580
- Anti-corrosion: 0
- 7 Circuit battery string: 4,860
- Tower (80'): 2,050
- Tower raising kit: 355
TOTAL = $7,845

Pro
- Light weight, easy to install
- Low price
- Can have multiples on barge

Con
- Possibly insufficient power output
- Having multiples increases maintenance needs

Option 3

Vertical Axis Wind Turbines (VAWT)

Power: Variable, 10w - KWHs
Cut in speed: Very low

Pro
- Works in turbulent conditions
- Mountable on buildings or low to the ground
- Potential do-it-yourself project

Con
- Commercial viability is unproven
- Poorly established market
- Although the technology is old, many products are still in prototype stage
- Potentially heavy

Average Wind Speeds

Wind turbines work most efficiently in areas where winds blow not only at higher speeds but at consistent speeds.

As the map below indicates, the Elizabeth River averages Class II winds (11.2-12.3 mph).
Photovoltaic Panels
What they are and how they work

Photovoltaic panels, commonly known as PVs, consist of a layer of silicon cells usually sandwiched between two layers of glass. Impurities in the cell create a condition in which the electrons on the two sides of the cells are imbalanced, creating a flow toward the side lacking in electrons. Energy created by this process can be collected and used as electricity.

A collection of PV panels is called an array. These arrays can be mounted on roofs or incorporated into the building skin so that the building produces all or part of the energy it consumes. Combined with wind power and a storage battery, a PV system will be a crucial component of the Learning Barge.

Photovoltaics are available in several types, each of which has a distinct appearance. Polycrystalline cells are usually blue. Thin-film cells are usually brown, and can be flexible. New cells are being developed that are gold, violet, or green in color.

In addition to the panels themselves, ‘balance of systems’ (BOS) equipment is required. Batteries are needed to store excess energy so that it can be used on cloudy days and at night. Electrical equipment such as a charge controller, inverter to convert current from DC to AC, switches, fuses, and wiring are also needed. These components will occupy about twenty square feet on the barge.

Equipment

Batteries are temperature sensitive. For maximum efficiency, they should be kept as close to 77 degrees as possible.

They must be kept dry, and because they produce hydrogen gas, their housing must be ventilated.

Depending on the placement of the program elements, the battery compartment could be located above or below the barge deck.
Orientation and tilt

In theory, maximum energy collection occurs when the PV panels are oriented as nearly perpendicular to the sun. Variations in the location of the barge, as well as in seasonal and daily rhythms, must be considered. Orientations and tilts that are less than ideal still yield energy gains that do not differ significantly from the maximum.

The effectiveness of specific lateral orientation relies on the direct quality of the light. In the Elizabeth River area, humidity and occasional cloud cover means that 50 to 80 percent of the light received is diffuse. Thus the difference in gain from the east and west sides to the south side is not as great as might be expected.

Although potential solar gain is higher in dry climates, the proportion lost due to less-than-optimal orientation is reduced in a humid climate where much of the light is diffuse.

The ideal tilt of solar panels is more crucial for solar hot water collectors than for PV panels. In designing the angles of roof and wall structures, it will be necessary to know how and when the barge will be used. For maximum annual solar gain, the optimal tilt corresponds to latitude. For the Elizabeth River area, this would be 36.5 degrees above the horizon. If more solar gain is needed in the summer months, the panels should be tilted to latitude minus 15 degrees to take advantage of the higher angle of the sun. Maximum gain in the winter would occur at latitude plus 15 degrees.

If feasible, the panels on the barge should be adjustable so that they face as close to true south as possible at each location. The angle of the panels should ideally be adjustable according to season. If movement in only one plane is possible, roof panels should be allowed to tilt, while wall panels are placed on faces that are most likely to face south.

That said, even with no adjustability at all, panels can be placed on the roof in such a way that significant gains will occur.
Sizing the array

The substantial investment required for a solar collection system, along with the fact that excess power cannot be stored beyond the capacity of the batteries means that careful calculations of power needs is essential. Once the program and design of the barge are established, the wattage of each piece of equipment and the number of hours in use will determine more precisely the size of the array. The following figures estimate the nature and quantity of appliances and their usage hours, as well as comparisons with electrical usage in small residential spaces.

The cost of the system will depend on factors including the program of the barge, the amount of enclosed space, and types of equipment chosen.

Determined the electrical load of the barge

<table>
<thead>
<tr>
<th>Appliances</th>
<th>Watts</th>
<th>Number of hours used per day</th>
<th>Watt-hours used per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lights</td>
<td>240 (40 watts each)</td>
<td>3</td>
<td>720</td>
</tr>
<tr>
<td>Refrigerator</td>
<td>200 (high efficiency)</td>
<td>6</td>
<td>1200</td>
</tr>
<tr>
<td>Fans for heating and cooling</td>
<td>500</td>
<td>6</td>
<td>3000</td>
</tr>
<tr>
<td>Science equipment</td>
<td>100</td>
<td>3</td>
<td>900</td>
</tr>
<tr>
<td>Pumps</td>
<td>27-57 (5 to 5.5 gals per minute)</td>
<td>6</td>
<td>334</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>2000</td>
<td>6</td>
<td>12000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18,000 (45 kw/day x 40 days)</td>
</tr>
</tbody>
</table>

*Rough estimates

(A small apartment with gas heat and hot water requires between 85 and 250 Kw/month. Those figures are assuming that heat is provided by passive solar methods.)

Photovoltaic Panels

Approximate summer and winter solar gain ranges with various possible orientations of the barge.
Recycled Materials

Closing The Loop

STEEL: Pros: standard steel contains 50% recycled metal and can be recycled. Cons: condensation and thermal conduction issues, high embodied energy.

CONCRETE: Ground up and reused as aggregate. May also incorporate the industrial by-product fill materials below.

Cenospheres: Additives similar to coal fly ash and ground granulated blast furnace slag. Cenospheres occur naturally in fly ash, the largest byproduct of coal-fired power plants. They are microscopic spheres made of silica and alumina and are filled with air or other gases.

Coal fly ash: A byproduct of coal burning at electric utility plants. It is called “fly” ash because it is transported from the combustion chamber by exhaust gases.

APSHALT: Ground up and reused.

Foundry sand: Clean, high-quality silica sand or lake sand from both ferrous and nonferrous metal castings makes a good fill material.

PAINT: Consolidated paint: Postconsumer latex paint with similar characteristics (such as type, color family, and finish) that is consolidated at the point of collection. The postconsumer paints are blended and repackaged, usually with few or no new ingredients added to improve the performance of the resulting paint.

Reprocessed paint: Postconsumer latex paint that has been sorted by a variety of characteristics that are dictated by the recycler. In general, the paint is sorted by type (i.e., interior versus exterior), by light and dark colors, and by finish (i.e., high-gloss versus flat). The reprocessor adds raw materials to meet the performance and color requirements expected or required by the end user.

GLASS: Crushed as aggregate for fill, mulch, or as rocks. Recycled into tile.

PLASTIC LUMBER: Uses recycled materials in varying degrees of post-consumer content. Important not to get the toxic variety or minimal recycled content type. Not optimal for structural strength.

RUBBER: Recycled from tires and suitable for interior and exterior use.

ALUMINUM: Recycled aluminum uses 95% less energy than newly processed. Consider Galvalume as a roofing material and aluminum tile.

WOOD:

I-Joists: The vertical member or “web” of the “I” is usually made from OSB or plywood, while the top and bottom flanges are made from solid sawn, fingerjointed, or engineered lumber. Stronger structurally with less material than wood.

Oriented Strand Board (OSB): A plywood-like material composed of small wood chips derived from young, fast growing trees instead of larger pine, spruce, fir, etc.

Laminated Veneer & Strand Lumber: Efficiently uses lumber by combining small pieces from second and third growth trees to create defect free structural lumber.

Laminated Strand Lumber: 12” wood fiber strips oriented lengthwise.

Glue-Laminated Lumber: Creates large beams or structural posts from smaller pieces of standard-size lumber.

GYPUSM, FIBERBOARD, & PARTICLEBOARD:

Paper-Faced Wallboard: Can claim 10% recycled content from recycled paper.

Wallboard: 50% recycled content from recycled wallboard.

Fiberboard & Particleboard: Utilizes smallest size lumber by-product. New kinds use phenolic resin & don’t offgas formaldehyde like their predecessors.

INSULATION:


Cellulose Insulation: Made from post consumer recycled wood fiber in the form of newspapers or telephone books, which are ground, shredded and processed. 75-80 % recycled content by weight. R value 3.2 - 3.7 per inch. Dry-blown or poured in a loose-fill application. Fire-resistance a concern - requires boron, a non-renewable resource in limited supply and longevity because it is water soluble.
Salvaged Materials

Structural Steel
Structural steel re-used in its existing form requires little additional energy input. Sometimes must be tested to make sure it will support the required load.

Shipping Containers
The U.S. currently imports more than it exports, which has resulted in an excess of shipping containers in our ports. They are commonly 8’ wide, 8.5’ or 9.5’ tall, and 20’ or 40’ long.

Other Steel
There are many other interesting forms of steel that might be creatively salvaged such as rebar, street signs and manufacturing offcuts.

Brick / Concrete
Brick, concrete, ceramic and porcelain can all be salvaged. Crushing them for use as aggregate does not require high energy input and keeps these materials out of landfills.

Wood
Wood is salvaged from numerous sources and can be an ecological way to make use of rare woods such as teak, mahogany, oak or heart pine.

Other
Additional materials are salvaged, such as: textiles, clothing, plastic, rubber, used plumbing fixtures, doors, windows, lighting fixtures, household appliances, and auto parts.
DESIGN 2: four schematic designs
Hopper Barge

Using a hopper barge, this scheme creates an experience of the river both above and below the waterline.

The upper deck is envisioned as an outdoor classroom, a place to experience the horizontal expanse of the river. Rainwater falls between wooden slats of the deck, and is funneled to a filtration tank for use on the barge. PV panels are angled to direct rainwater into a water wall that extends to the space below. The lower level of the barge becomes a hybrid space: classroom, amphitheater, exhibition hall. The experience is built around the concept of exploring the sectional changes of the Elizabeth River, from the sediment of the benthos to the plants and animals of the marsh, represented in the water wall. Opposite, the wood wall provides an armature for power systems, furniture, etc.

Laura Bandara Matt McClain
Katherine Pabody Phoebe Richbourg
**Flat Deck Barge**

The surface of the flat deck barge becomes a metaphor for exploration, as layers are peeled and punctured, and infrastructure is uncovered to reveal the functions and structure of the barge.

The barge's structural module establishes chambers that contain infrastructural elements such as wetland plants which filter grey water and batteries used to store energy generated by PVs.

The translucent PVs are inserted into an armature, and provide a canopy for the sheltered classroom while also meeting the electricity needs of the barge.

As the armature rises from the deck, amphitheater seating is built in, and wetland plants puncture these seats in places, providing a rare experience of immersion in wetland grasses.

A retractable shade cloth sits underneath the armature, making the enclosure a sort of nomadic tent during the hot summer months.

Along one side, a ramp permits access at different levels, and allows visitors to experience the water more closely.

Laura Bandara    Katherine Pabody
Matt McClellan    Phoebe Richbourg
The barge is imagined as a lens that focuses the student’s attention towards the river. Multiple spaces on the barge allow for different learning environments. The deck ramps toward the river, allowing greater engagement with the water. The barge has an upper deck and a lower deck 4 feet below. The lower deck includes a 575 square foot enclosed room, a hole cut to the river below, and “amphitheater” seating steps for 28 children.

An armature that holds the energy and curricular systems of the barge is built to reflect the many trestles and cranes in the region.

An expanse of uncovered deck acts as a void and counterpoint to the enclosure on the barge, promoting an unmediated experience of the sky, (eco/industrial) shoreline, and winds.

Along one side of the barge, an armature engages students with the renewable energy systems and curriculum of the barge. Water storage and distribution, including solar hot water panels and a planting, is at one end, and the other end holds energy generation such as PV’s. Curriculum in the form of large maps of the watershed, and an archive of student drawings, crafts and writing is held within the armature, backlit by the river.
The Components Diagram at right is a visual encyclopedia of the component parts of the barge. Each image represents a line of research to determine the most suitable system or manufacturer.

The sketch below depicts the water cycle on the barge. A sloped roof conducts rain into a suspended cistern that stores the water for hand washing, and plantings are irrigated with any excess. Grey water from the sink flows to the plantings, seeps through the planting soil matrix, and exits through the hole cut in the barge to the river below.

The Gathering/Enclosure Diagram shows a range of onboard spaces from fully to partially enclosed. A Circulation Diagram represents how docking on the barge occurs at the 8 foot or 4 foot level. This set of diagrams analyzes and explains the performance of the barge from several points of view, including technological and in terms of human occupation.
An enclosed, climate-controlled space is, by nature, not site-specific. A temperature and humidity controlled room is intended to be the same in the desert as it is on a river. The outside may be one condition, but once an enclosed space is entered, only the view is different. This project conceives of the entire barge as classroom that is transformed by its inhabitants rather than prescribed in advance.

Rather than typical walls, there are two cabinets: one devoted to enclosure and one to display. As the enclosure cabinet is opened, it begins to alter the space of the barge. Cabinet doors pull out to become walls that frame views and hint at the separation between barge and river. Moving a cabinet also unfolds the roof, and as the door opens, the sky is screened out. Tables fold down from the interior of the cabinet, creating space for lab experiments. It is an omni-customizable ‘magic box.’ All the boundary you need, ready to be unfurled.

A transparent display cabinet faces this ‘enclosure cabinet’ and modulates views without closing them entirely, allowing stored maps and aquaria to become part of the view and the lesson. The display cabinet contains built-in activity stations and seating that unfolds as needed. When students are finished, their newly created and found artifacts become treasures stored in the cabinet as well. The lesson builds with time, each group of students adding a trace of their experience to the barge so that it becomes richer and more complex with each visit.
In this way, the barge becomes the lesson. Small changes in enclosure, whether a space is in shade or sheltered from the wind, will have great consequences for the quality of the surroundings. This is tied to the notion of the interconnectedness of river, sky, and inhabitant. When the deck is at its most open, the cabinets are closed and inaccessible, and when the deck is most enclosed, all of the cabinets become available for use. Open and closed have inverted their normal relation.

This is tied to the wetland as well. When moored, the interior of the barge is flooded, settling it in the water. Cuts through the sides of the barge allow water to flood through the wetland, reconnecting it to the river. The wetland is less something contained, than the filter that permits river water to pass through the barge. The river has as great a role to play in the barge’s occupation, as the students do in creating the enclosure.

Rather than a place to simply sit and be lectured to about the river, the Learning Barge is a mutable object to be engaged with wonder. Like the river, it is intimately tied in to its surroundings, responding to every change in pressure, light, and wind. Also like the river, the inhabitants provide the final piece, imbuing the surface of the barge with meaning through transformation. It is less a place and more an experience.
DESIGN 3: two final iterations
A fusion of successful elements

A regular steel armature is the physical structure as well as the link between all the barge elements. The Armature creates a spatial promenade, serves as a teaching device, and physically supports the building systems make the barge work. It unites the open wetland of the barge with the more enclosed spaces, as well as the two extroverted spaces that occupy the raked ends. In the wetland amphitheatre, shadecloth is unfurled from the armature and pulled across the terraced steps to create a protective covering overhead. A four-foot deep interstitial space is created within the armature. This space contains cabinetry and houses the environmental system components attached to the armature structure. The systems include water and power collection, as well as water purification in the form of native plant filtration and release back into the river. Wind turbines and solar arrays are integrated into the armature for power production. The fore and aft decks, as well as the processional space through the armature, are built up two feet from the original deck of the barge, with a particular focus on the treatment of the deck and barge surface.
Systems: Water flow and activity
The wetland plan is intended to recall the meander of a tidal creek, while allowing water to flow through the barge according to the tidal currents. An amphitheater allows the wetland plants to be used as a teaching tool, while providing a degree of access for students and visitors.
This iteration of the barge builds upon the idea of the barge as a lens. The housing of this lens is conceived as multivalent and adaptable, with varying degrees of enclosure made possible through layered wall systems, sectional manipulations, and direct physical connections to river and shore. Stitching together diverse elements, an armature contains the infrastructure necessary for making the barge as self-sufficient as possible.

Approaching the barge from land, site is filtered phenomenologically as well as physically. Working with the Money Point site as a starting point, we considered ways of extending an Arm that would allow tactile and visual experiences of the industrial and ecological systems. By inhabiting the margin where land and water converge, analogies are formed between newly regenerated wetland habitat, transformed river, and curricular intentions of the Learning Barge.

Occupying the barge involves shifting experiences as seasons change. Visitors arrive at a place where water and structure converge as the river flows into a constructed onboard wetland. Besides providing a transition from land conditions to barge, there is an opportunity for close interaction with plants and microhabitats without disturbing the endangered river shoreline. Native plants provide a backdrop or foreground for two stages: one directly connected to a gathering place called the Storytelling Stairs, and one occupying the transitional space of enclosure. As the wetland changes over the course of the year, so will the activities in this area, as children plant, harvest, and observe at an intimate scale.

Two open decks of differing sizes are connected by a long space under the Armature. Partially enclosable through shade fabric, this space faces the expanse of the river and addresses the opposite shore. Here students might sketch and write about their surroundings. This space also allows a close look at the solar photovoltaic and hot-water systems, and at the water collection and filtration system. Large windows connect this space to the classroom.
Gathering on the small deck, one glimpses the Artifact Wall that stores objects students have found on their travels or made on their visit to the Barge. Accessible from two sides, this wall creates another condition of permeability.

Proceeding down the shore-side ramp, the visitor is once again visually joined with the wetland. Depending on the season, the classroom wall on this side will be open or closed. Because the roof structure is cantilevered from the Armature, columns are not necessary on this wall. Entering the space one is protected from wind and sun, but a sense of openness is preserved. Still intimately connected to the river through sight, sound and smell, children can gather around fold-down tables to process what they’ve learned through making and group discussion. Stored inside the walls are microscopes, paintbrushes and paper, buckets, maps and modeling clay.

As the students leave the barge, they will have a new sense of their role within the river ecosystem. Depending on their age and curricular needs, they may have concentrated on ecological awareness, the history of the shipping port, or the role of industrial processes in contemporary life. Visiting the Learning Barge, they will have experienced a unique educational event that will enhance their sense of the river as a crucial element of a set of interconnected systems, one for which we must provide stewardship for as well as ethically inhabit.
Framing the Approach

The barge is a semi-nomadic field station: it stops on the river according to certain criteria that oscillate between what is best for the curriculum and what is practically achievable in terms of students embarking and debarking from the barge.

How do students and educators access the barge? This first piece of our site research looked at a “typology of landings.” This drawing is a way of categorizing how the barge would engage the river and be accessed by visitors. Three principle types were classified: Barge as Extension, Barge as Island, and Barge as Adjacency. These are presented with their pros and cons on the facing page.

An important issue concerns the curricular opportunities in the barge approach sequence. Is the barge expected to do “all the work” of the curriculum, or do students often arrive having been immersed in the landscape of their curriculum? In other words, are the students learning as they approach, or do they learn only once they have arrived and stop learning once they leave? This informs in a related way the relationship of the barge as figure to its context or ground. Is it detached or engaged?

The barge was originally intended as a way of occupying the river without using the highly privatized shoreline. Limiting the barge to the river is a missed opportunity to engage more actively in the regeneration of the river and its shore. Stormwater from the urban fabric of the watershed is the primary contemporary pollutant, and people of the region have little experience of the waterfront. This regeneration is as much about bringing people back to the waterfront as it is about ecology. In this scenario, the barge becomes an agent of colonization. We researched the shoreline of the South Branch, looking for parcels that are likely to change ownership or are owned by “RiverStar” industries. The barge anchors off these shores and begins to claim them for public use. The claim operates along a gradient from conceptual to actual; the students may arrive to the barge by boat and then occupy the shoreline briefly, perhaps planting while they are there, or they may arrive at the barge by land.
Site: Money Point

We chose a site off Money Point as a case study. Our proposal is grounded in the work of Crisman + Petrus Architects’ Money Point Revitalization Plan, and in our own appraisal of the qualities of the site. The barge would be anchored at a site offshore of a vegetated area on the northern edge of Money Point. This position allows river views up to the Jordan Bridge and across to Blows Creek. The vegetated condition suggested that it is a property that is in transition of use.

The Revitalization Plan calls for a bioswale and possible stormwater bioretention pond in a proposed Citgo (a Riverstar industry) conservation area at the site we have identified. We use the bioswale as a path, connecting Freeman Avenue with the shore line. The school bus would park on Freeman Avenue in the remnant residential neighborhood. The phenomena of impervious surfaces and urban runoff would be discussed. Turning to follow the bioswale to the shoreline, the function of plants in relation to water quality, as well as the function of the Citgo storage tanks, would be clarified. Students arriving at the barge would have visceral exposure to factors that affect the health of the Elizabeth. The onboard wetland and sustainable energy systems of the barge are discussed in context of what students have seen on their approach.

LEARNING BARGE

where: Map of Money Point with river depths and urban fabric
below: Proposed revitalization projects at Money Point. Crisman + Petrus Architects’
above: Map of Money Point with river depths and urban fabric
below: Proposed revitalization projects at Money Point. Crisman + Petrus Architects’
above: The barge with connecting arm leading to onboard wetland.
below: Aerial photo of Money Point with barge moored, bioswale and other proposed trails.
RESEARCH 3: focusing on material and detail
STEEL: Pros & Cons

PROS
- Structural variety
- Lasts just as long as the barge, being the same material
- Very strong in tension and compression
- Contextually makes sense in an industrial area
- Uniformity of material with the barge – avoid thermal coefficient differences, longer lifespan, easier to attach steel to steel
- Greater attachment flexibility: welding, fastening
- Steel structure could be erected in place at the shipyard
- Easier to involve the technical education community in erection and welding process
- Durable in general and in several stress conditions, shear, tension, and compression
- Standardized, readily available components
- Good for pinned connections, allowing movement
- Enclosure systems can be easily hung from above

CONS
- Thermal conductivity
- Corrosiveness of environment
- Potential maintenance needs
- Toxic chemicals sometimes used for coatings
- Galvanization changes shape and structural integrity
- Coatings and galvanization must be factory applied
- Coatings requires pre-drilling (tolerance could become big issue)
- Welding breaks the weather seal on coatings. That area is field painted with Thenece and maintained twice a year.
- Structure and enclosure transition
- Limited student welding experience
- Higher shipping costs b/c of weight makes offsite steel fabrication questionable
- Tie to barge maintenance – i.e., can’t sandblast barge to paint it without ruining coating on structural steel
- Corrosion could hinder movement of panels, etc.

STAINLESS STEEL PROS
- Higher corrosive protection
- Nautical precedent (not barge precedent)

STAINLESS STEEL CONS
- More expensive
- Not as contextual aesthetically
- Still has some maintenance requirements
- Not as standardized or readily-available

WEATHERING PROS
- Pre-weathered
- Aesthetically appealing
- Works well as a cladding

WEATHERING CONS
- You can’t bolt or screw (ie puncture) but you can weld and clip before weathering
- Runoff discoloration
- Can’t puncture it.
- Problematic with rain washing

ENVIRONMENTAL PROS
- Easy to separate from other wastes in recycling process
- Small amount can do large job, reducing the energy and pollution
- Industry has made efforts to reduce emissions

ENVIRONMENTAL CONS
- One of the most energy intensive materials per weight, manufacturing a major source of pollution
- Many alloy additives like chromium and nickel are toxic
- Liquid wastes from washing, pickling, and oils can be toxic to fish
- Energy saving in recycling not as great as for aluminum

ZINC/GALVANIZING ENVIRONMENTAL PROS:
- Toxicity of zinc is low for humans but higher for other species, especially aquatics (fish)
- Can reclaim zinc coating in recycling steel

ZINC/GALVANIZING ENVIRONMENTAL CONS:
- Leachates from mining can be toxic - i.e copper and lead
- Processing uses many toxic chemicals
- Wastewater can contain heavy metals
- Galvanizing steel produces similar wastewater and sludge to the original processing of zinc
- Nonrenewable
Different carbon and alloy contents effect weatherability and strength

**GALVANIZED (zinc):**
- can connect to wood, concrete, mortar, lead, tin, zinc, and aluminum (not red cedar or redwood), any other metal needs protection to prevent corrosion
- when not galvanized, needs to be protected in connection with other metals to prevent electrolytic action (corrosion)
- good fire resistance
- not good for large painted surface areas

**BITUMINOUS:**
- can connect to anything

**CORRUGATED SHEET:**
- 18, 20, 22, 24 gauge
- 7, 8, 10, 12 ft lengths 26 in wide
- industrial 27.5 in and 33 in 5 ft to 12 ft in 2 in increments

**GALVANIZED CORRUGATED PIPE:**
- spans from 18 in to 20 ft with differing radii
- make sure liquid is non-corrosive

**GALVANIZED SHEET:**
- roofing, siding, decking
- fencing, partitions, grilles, insect screens, lath

**STEEL MESH AND WIRE CLOTH:**
- fencing, partitions, grilles, insect screens, lath

**STEEL SHEET, STRIP (less than 12 in. in width), & PLATE:**
- Hot-rolled - generally shouldn’t be used exposed
- Cold-rolled - okay for exposure

**STEEL, information**

**Protection - galvanized; electrolytically galvanized:**
- vinyl, alkyd, acrylic, polyester, and paint coatings; ferritic stainless steel coatings, porcelan enamel
- Fabricated from steels that meet special requirements for boats

**METAL DECK:**
- Standard attachment to steel system to create flooring with concrete
- Could be means of making thermal mass for passive and/or solar water radiant heat

**STEEL CABLE:**
- Can be used in conjunction with column (and/or beams) for tensile structure

**STRUCTURAL STEEL:**
- Beams: S shape, W shape, C shape, Structural tubing
- Span: 9.5 to 22 in depth for classroom
- Columns: W shape, Round pipe, rectangular or square tubing, welded plates, cruciform (4 angles)
- 4x4 steel tube supports the same as W6x6 wideflange section
- I-beams: 36 in to 5 or 4 in
- Channels: Steel Unequal Angles, Steel Structural Tees

**OPEN WEB STEEL JOISTS:**
- Span: 8 to 16 in, depth for classroom
- Can’t cantilever
- Open web accepts pipes, wires, etc.

**SPACE-FRAME CONSTRUCTION:**
- Best to have square supporting bay since it acts as a two way structure

**STAINLESS STEEL:**
- scratch sensitive, lighter members for same structural strength
- grade 304 is acceptable in marine conditions when washed regularly with fresh water
- grade 316, stronger, more corrosive resistant is good for decks, corrodes in t greater than 95 f.
- Higher grade can be completely submerged
- Cable

**EPoxy COATING:**
- non-slip coating, painted on
- RECOMMENDED for 50 year lifespan
- Near White Blast (NWB) steel
- Acid dip for cleaning
- Galvanization and/or Primer Coat of Epoxy
- 2 coat finish
- Polyanalite

**LEARNING BARGE**
### Off the shelf & Miscellaneous

#### Armature Structure

**Structural Pipe Scaffolding**
- **Pros**: ease of construction, no welding, lightweight members, re-configurable, strong, ease of transport
- **Cons**: difficulty of cantilever, emphasizes joints, not members, potentially weakens impact of armature

**Marine Grade Aluminum**
- **Pros**: 40-70% lighter than steel, requires no painting, higher embodied energy than steel
- **Cons**: difficulty of cantilever, emphasizes joints, not members, potentially weakens impact of armature

**Combination**
- **Pros**: maximize properties of each material, minimize strength of armature as organizational piece
- **Cons**:

#### Roofs

**Fabric**
- Pros: can be designed to withstand heavy winds, lightweight, good light transmission, dynamic form, can be layered so each layer serves one function
- Cons: thermal properties close to glass, nautical associations, complicated drainage, full enclosure complicated, chemical content

**Polycarbonate / Fiberglass**
- Pros: absorbs very little moisture, no chance of degradation due to salt water, chemicals or oils, used in many marine applications
- Cons: rigid, lightweight, good light transmission, can be insulated

**Truck tops**
- Pros: lightweight, good light transmission, chemical content
- Cons: thermal properties unknown, non-architecture industry may make coordination difficult

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**Learning Barge**

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**r3.1: ARMATURE MATERIAL EXPLORATIONS**
Rainwater Collection

The first step in designing a rainwater collection system is to determine the amount of water that can be collected off available surfaces. This is based on the area of the surfaces and the amount of rain in the region:

- one cubic foot = 7.481 gallons
- maximum precipitation on a given day is 7.83". This is extreme, a normal rainfall would be more approximately 1-2". The average daily total for the year is 0.13".
- The roof of the barge is currently about 48'x16'=768 square feet of collection area.

If we assume we only collect from the roof surface, we have:

- 768 sf X .0108333=8.32 cf per day
- 8.32 X 7.481 cf/gal=62.24 gallons per day

To rinse off the roof, it is recommended to capture and discard the first 10 to 20 gallons of rainwater per 1000 sf during each storm. This can be done with a simple PVC stand pipe system. 8 inches of 6 inch pipe will collect 1 gallon of water.

If space permits, the system can be designed to work by gravity alone. In order to ensure an adequate supply of water, gallons-per-minute flow would be regulated. At 1gpm, 240 10-second handwashings would require 40 gallons of water.

The best roof surface for collection is a metal roof with coatings that contain no heavy metals.

First-Flush Diverters

The simplest first-flush diverter is a 6- or 8-inch PVC standpipe (Figure 2-2). The diverter fills with water first, backs up, and then allows water to flow into the main collection piping. These standpipes usually have a cleanout fitting at the bottom, and must be emptied and cleaned out after each rainfall event. The water from the standpipe may be routed to a planted area. A pinhole drilled at the bottom of the pipe or a hose bibb fixture left slightly open (shown) allows water to gradually leak out.

If you are using 3" diameter PVC or similar pipe, allow 33" length of pipe per gallon; 4" diameter pipe needs only 18" of length per gallon; and a little over 8" of 6" diameter pipe is needed to catch a gallon of water.

The standpipe with ball valve is a variation of the standpipe filter. The cutaway drawing (Figure 2-3) shows the ball valve. As the chamber fills, the ball floats up and seals on the seat, trapping first-flush water and routing the balance of the water to the tank.

This Pump/Disinfection/Filtration Board is all that would be required to fully treat the water between storage and delivery of collected water. This unit contains a UV filter (optional), a 5-micron sediment and 3-micron sediment charcoal filter, and a pump that is approved for use with rain water.

If filtering is necessary to remove particulate matter several basic systems are available. One is a simple system of sand filtration which can be made with a 55 gallon drum. A small constructed wetland can easily utilize and filter greywater with or without pre-filtration.

To fully treat the water between storage and delivery of collected water, a UV filter (optional), a 5-micron sediment and 3-micron sediment charcoal filter, and a pump that is approved for use with rain water would be required. This narrow tank holds 400 gallons of water, which would mean a full tank could supply the barge for nearly 12 peak-occupancy days without rain. It would require 53.41 cf or 2.25" of rainfall to fill the tank to capacity.

If no filtering is necessary to remove particulate matter, several basic systems are available. One is a simple system of sand filtration which can be made with a 55 gallon drum. A small constructed wetland can easily utilize and filter greywater with or without pre-filtration.
r3.2: ARMATURE: SYSTEMS

Waterflow Diagram

The proposed scheme for directing the rainwater flow on the barge deck takes advantage of runoff to flush salt buildup that may occur in the wetland basin. Inlets into the plant beds adjacent to the upper deck are fed by a channel created through creasing the steel surface, creating a modified curb and gutter system. Overflow during storm events is channeled through a large outlet into the river.

Barge Deck Rainwater Flow Diagram
**Heating**

Active Solar Heating Systems

Energy efficient heating can be achieved through the use of solar power. To do this water is circulated through tubes that are exposed to the sun’s energy. The water is then circulated through the barge classroom floor to heat the space. There are many methods of using this energy, but the learning barge will use a closed direct system that cycles water repeatedly through the system. Anti-freezes can be used, but this system will be emptied to minimize mistakes. This module the system will be emptied to prevent freezing while avoiding the use of toxic fluid.

![Solar Water Heating System](image)

In order to provide the 3200 watts of power required to maintain a consistent temperature, the barge will require a solar collection array of 180 square feet; this is based on an efficiency of 60% with an insolation of 315 watt-hours/square meter and a temperature difference of 22°F. These collectors will heat the water which will act as the heat source in the barge itself. Water has excellent thermal retention properties and is ideal for this type of application.

**Storage**

Water is pumped from the solar panels into a storage tank. The water will need to be circulated at a rate of 5-15 gallons per minute in order to maintain the efficiency of the system. This can be accommodated by a number of DC rated pumps available from marine power distributors. The system will require a total of 1 gallon of water per square foot of solar collector. The storage tank will need to be sized so that on very cold nights the solar panels can be emptied to prevent freezing and thus damage to the system. Rectangular tanks designed for RV and boat use will minimize loss of space due to the inefficient circular shape of typical water tanks.

![Capture](image)

**Transmission**

Piping from the storage tank will join with piping leading to the radiant floor in a manifold. In conjunction with the manifold assembly, a second pump will circulate water from the tank to the flooring. This assembly will allow transmission from one system of pipes to the next, preventing the need to run one set of pipes from the solar collectors all the way through the floor and back.

![Learning Barge](image)

In order to maintain the desired room temperature, the radiant floor must account for all temperature 160° above that of the space. This accounts for the thermal loss of the four walls and roof. Plastic tubing is coiled throughout the floor and solar-heated water is pumped through it. This piping can be laid either directly in a concrete slab or through a network of wooden “sleepers”. A concrete mass will allow greater transmission of heat than wood due to the materials’ respective thermal properties. Insulation must be laid below this system in order to prevent heating the barge deck.
Passive Cooling Systems

Passive cooling for a climate like the Elizabeth River’s is a challenge because of the combination of humidity and intense summer heat. This eliminates some conventional passive cooling options like radiant cooling and solar evaporative cooling.

Because the barge is not land based, ground source cooling and heating are not an option. Using the temperature of the river water for cooling was found to be problematic because of the piping issue, the exposure of the thermally conducting barge deck to the sun (counteracting the exposure to water on the bottom side). Another difficulty is the potential shallowness of docking sites - places where the sun could heat the river and cancel out its cooling potential.

Ventilation will be the main cooling strategy. Ways to encourage airflow include sizing openings strategically, placing openings at opposite walls, and creating a draw on the stilliest days with a solar chimney. The implications for the barge include flexibility of openings in each wall (because of the variability of prevailing wind), a double layered roof or roof openings, solar-powered fans, and possibly some evaporative cooling. Evaporative cooling could be easily achieved in the open wetland area through pools of water and/or misting.

These diagrams show potential ventilation strategies for the classroom. In all cases, cross ventilation and air movement are the desired effects.

Greater specificity of ventilation strategies will occur in the detailing phase and should necessarily include site possibilities.
Lighting

Lighting on the barge is essential to maintain on-board safety and productivity. While the barge will utilize natural lighting as much as possible, there are conditions where artificial light is necessary.

Given its classification as a marine vessel, running lights are required at the stern, port, and starboard at all times. These lights will require their own designated power supply, but since they are LED lights they draw very little electrical power.

On overcast days, or an event where natural light is inadequate for indoor activities, interior lighting will ensure that students and teachers can proceed with their desired activities. Compact fluorescent bulbs would provide the best low voltage lighting for that space.

For outdoor applications, two lighting types will be necessary. For safety, low level lights will be spaced along barge walkways at foot level, to ensure that visitors can clearly see their way around the barge. In the event of evening functions, these lights will have the added effect of highlighting the modularity of the barge’s structural elements. In addition to safety lights for outdoor applications, strategically placed flood lights will emphasize important locations on the barge, such as the wetland and story-telling steps.

### Curricula

**Floodlight:**
- **FL 48-48 LED**
- 12VDC Floodlight
- 4 luminaires
- .25 amps

**Running Lights:**
- **LX2-PT/ST/ST**
- 12VDC
- 3 luminaires
- .17 amps

**Interior Lights:**
- **Solsum 11W 12VDC Compact Fluorescent**
- 10 luminaires
- .9 amps

**Safety Lights:**
- **MC1050 LED Step Light**
- 23 luminaires
- .08 amp
### Plant Name | Salt Tolerance | Tidal Zone | Height | Image
--- | --- | --- | --- | ---
**Salt grass**
Distichlis spicata
0-50 parts per thousand
Above mean high tide to spring tide
6’-1’6”
**Black needle rush**
Juncus Roemerianus
0-25 ppt
Above mean high tide to spring tide
1’-4”
**Salt marsh cordgrass**
Spartina alterniflora
0-35 ppt
Mid-tide to mean high tide
2’-7”
**Salt meadow hay**
Spartina patens
0-35 ppt
Irregularly flooded high marsh at or above high tide
1’-3”
**Pickelweed**
Salicornia virginica
0-32 ppt
Tolerates alkaline, salty soil, no drainage and seasonal flooding
1’-2”

### Plant Name | Salt Tolerance | Tidal Zone | Height | Image
--- | --- | --- | --- | ---
**Salt marsh elder**
Baccharis halimifolia
0-15 ppt
Above mean high tide to uplands
5’-12”
**High tide bush**
Iva frutescens
0-15 ppt
Above mean high tide to uplands
2’-10”
**Wax myrtle**
Myrica cerifera
0-15 ppt
Above mean high tide to uplands
6’-15”
**Salt meadow hay**
Solidago sempervirens
0-15 ppt
Coastal dunes
1’-6’6”

**Rejected plants:**
- *Ammophila breviligulata*: coastal dune grass, sandy soil
- *Panicum amarum*: coastal dune grass, sandy soil
- *Ruppia maritima*: submerged aquatic vegetation, no place for it
- *Zostera marina*: submerged aquatic vegetation, no place for it
- *Scirps robustus*: not salt tolerant enough
Bio-Filtration: how it works

Greywater, sometimes referred to as sullage, consists of all non-toilet household wastewater. It includes wastewater from showers, baths, spas, hand basins, washing machines, laundry troughs, dishwashers and kitchen sinks.

Aerobic Pre-treatment: suitable for showers, hand-washing and laundry. The aim of this stretch filter treatment technique is simply the removal of large particles and fibers to protect the subsequent infiltration pipes from clogging and transferring it as soon as possible for treatment into a biologically active, aerobic soil-zone environment where both macro- and microorganisms can thrive. Stretch-filters are made to retain fibers and large particles and allow the rest of the organic material to travel on to the next stage of processing. This filter is suitable for public facilities where the principal source of greywater is hand-washing and showers, not food waste.

Plant soil box design:

Soilboxes have been used for greywater purification since 1975 with excellent results.

Bio-filtration: ecologists advice

Notes from Biohabitats meeting (http://www.biohabitats.com)

April 6, 2006

Biohabitats coastal wetland ecologists: Joe Berg, Ed Mongrelth, Peter May
Barge wetland design team members: Laura Bandara, Jayme Schwartzberg

Greywater system:

- The amount of water generated by hand washing will likely be small enough to be dispersed through plant uptake and evapotranspiration.
- Make it an enclosed system (i.e. do not discharge filtered greywater to river)

Hydraulic issues (with inundation scheme):

- Water on the barge creates a barrier to flow of river water into the barge
- Low velocity may create problem
- Because barge is moored, there are no tidal dynamics to support inflow
- “Shore” scheme will not work without a tidal condition
- Pumping water from the river may be preferable to allowing it to inundate barge (check water ram system)

Define goals of the treatment system:

- Reduction of turbidity/suspended solids (can be demonstrated by shining a light through a tube)
- Increasing oxygen content in water
- Nutrient content of water
- Demonstrating reduction in toxins (note: PAH detection is expensive).

Physical features necessary to improve water treatment:

- Deliver water
- Move water through a growing media
- River water flows through root material, then through soil into next bed
- Time and distance relationship for effective filtration: less distance water has to flow, longer holder time is required and vice versa
- Gravity flow to force water through the system and to create subsurface flow (i.e. through gravel bed) – analogous to a step/pool fluvial morphology

River Treatment system – plant and soil issues:

- Need to have mature plants to treat effectively
- Plant stems slow water flow, allowing sediments to fall out
- Porous soil material also filters
- Soil choice is key because it is doing the majority of the filtration

Bio-filtration: ecologists advice

Greywater systems:

- Surface water should not create a problem in terms of either plants or soil becoming toxic
- Greatest concern with soil is that it will become too saline because of evaporation – use plants which can tolerate a high salinity
- As plants mature, soil and organisms will develop to assist in cleaning water: invest in soil testing at points to determine impact and health – this would demonstrate the processes of the benthic layer

Plant species suggestions:

- Spartina alterniflora
- Spartina patens
- Zostera spp.

Management considerations:

- Most likely the wetland plant beds will need to be thinned, rather than replanted– possible to transplant to shore wetlands
- Acknowledge that system will need to be tweaked at points: have some back-up species
- Do a test patch of application of compost from composting toilet
- Rain events should not create a problem as long as there is sufficient flow through (fresh water may help decrease high salinity of the soil)

Suggestions:

- Hang seed oysters in beds off the side of the barge
- Number of oyster beds would enable you to calculate the amount of water being filtered
- Oysters require a lot of water flow to have sufficient food, they would be unable to obtain enough within the water on the barge
- Make a portion of the wetland into a plant nursery
- Information sources:
  - Pinelands Nursery: http://www.pinelandsnursery.com
  - Environmental Concern: http://www.wetland.org/educat.htm

LEARNING BARGE... THE CORE OF THE SYSTEM

Learning Barge: Bio-filtration: how it works

- Source: http://www.greywater.com/
DESIGN 4: one refined design
Enclosure Designs

Things We Like From Our Explorations:

Artifact wall:
- reflect module of wetland construction
- register the change in deck level, through shadow or bench
- stop short of armature wall to allow walls to read separately
- allow openings for ventilation
- bring wall to ceiling to show expansion upward

Seat wall / Window wall:
- flexible ventilation, multiple openings
- provide seating
- relate to artifact wall, perhaps with storage
- use eight foot rhythm of structure
- maximize transparency

Opening wall:
- maximize connection with wetland
- reinforce longitudinal axis of the barge
- do not block water system or movement on deck

The translucent artifact wall was chosen for the final design, as was the flip-up opening wall design.

This flexible window configuration will be part of the final design.
Structure Designs: 6 options

Things We Like From Our Explorations:
- steel verticals
- not tube steel
- primacy of center columns
- existence of armature structure over line of classroom
- minimize beam transverse to structure at cantilevered side
- roof cant opening inward
- lower classroom floor (less feel lower than armature deck between columns)
- steel deck exposed on upper area (armature portion between columns)
- logically sized structural members
- frame of structure with systems insertions between armature, potentially a second skin making the enclosure
- opaque roof with potential openings for light and air

- main vertical structure sits outside of enclosure
- separability of structure from inside & inside
- cantilevered roof to articulate gutter
- separation of PV roof from enclosure roof
- design armature wall to hold other elements

- double column structure to allow reading of armature from both interior and exterior
- push-up interior floor for possible change of parti
- separation of interior zone between columns that allow for systems inside and gutter
- water draining to channel to facilitate collection
- translucent roofing material emphasizes the lightness of the enclosure
- columns are back-to-back channels that allow beam to slide between them
- cantilevered in tension with steel cables
- openings in armature wall allow for seating and possible passage from armature to interior room
- translucent roofing material emphasizes the lightness of the enclosure

Learning Barge
Structure Designs

Understanding the visual articulation of the armature structure and enclosure systems became an important detail to resolve. These model studies were used to examine how to both express the structure of the armature and also provide a weather tight enclosure for the classroom.
Ecology and human activity

Hybrid systems which combine designed solutions with natural systems – or the cultivation of ecologic processes – brings restoration efforts and human activities together.

The wetland system on the barge demonstrates how these hybrid strategies might be employed at a small scale.

Principles for design

- Living with and participating in ecologic processes
  - wetland should educate
- Ability to access and be in wetland space
- Ability to touch water and touch plants
- Teach plant identification with plant beds
- Wetland should be defined as a volumetric and articulated space
- Integrate spaces with plants and water
- Consider edges and adjacencies and detail them carefully
- Create a nursery bed for Spartina alterniflora to be used in shore restoration projects

George Trakas, Berth Haven
Filtration and Dissolved Oxygen

The wetland allows visitors to see both the natural filtration function of plants and soil, and the engineered components of scuppers with a roughened surface, which increases the dissolved oxygen level in the water.

The barge wetland acts as a pilot project to demonstrate strategies that can be employed along the river at different scales and in different forms.

The wetland design integrates ecologic systems by making process visible and participatory.

Visitors experience wetland plants in ways that they might not otherwise be able along the shore, and see that plants function to clean, filter and slow water.

This iteration of the design process explored different strategies for inhabiting the wetland, making process tangible and visible, and creating an experience of delight for the visitor.
The Arm

There is great potential for the curricular and phenomenal experience of the barge, in its connection to the shores of the river. The "arm" is a simple, narrow bridge that affords passage between the barge and the shore.

The evolution of the arm stemmed from the belief that the curriculum could reflect a reciprocity between the water of the river and the land it permeates. The physical anchoring of the barge, to land that emerges from beneath the water, makes apparent the relationship between the river and constructions upon it that have significantly altered its disposition in the last century.

The arm is part of the structure of the barge, housed at its side and deployed in certain conditions. The barge may moor where occupation of the shore is both permitted and feasible for The ERP and visitors to the barge, in which case this passage and occupation can become part of the barge curriculum.

Once deployed, the arm becomes a stable structure that is moored at both of its ends with "spuds", one of these being the very spud that moors the barge itself. This arrangement allows the barge to pivot around this spud, gently rotating as it is swayed by prevailing currents of the river and winds. This phenomenon is one of several afforded by the arm that presents a visceral moment of learning for students of the river's ecology.
LEARNING BARGE: final design

DETAILS CURRICULUM SITES MODEL DIAGRAMS

PERSPECTIVES MEASURED DRAWINGS

Barge Systems:
- Filtered water is gravity fed to bathroom sink and outdoor utility sink
- Rainwater is collected in basin at the end of building
- Warm water is pumped through manifold which connects piping from systems

Armature Wall:
- Bathroom is accessed from exterior armature path
- Story-telling stairs (9' x 17')
- Observation Deck (19' x 32')

Gathering Spaces
- Murphy tables fold down from the wall allowing for adaptability of space
- Large windows allow view to outdoor path activity as well as observation of interior and exterior
- Open shelves with adjustable translucent sliding panels are stacked vertically
- Wall is pulled back slightly from interior columns so as to isolate and emphasize armature structure

Barge Elements:
- 1. Upper deck
- 2. Cablever sor sun-shade
- 3. Window-wall support
- 4. Exterior steel column
- 5. Interior steel column
- 6. Window-wall support
- 7. Armature beam (supporting roof)
- 8. Lower deck

Information gathered. Students show samples collected during the day. Develop a common map defined by the various types of sediment and vegetative layers discussed on the barge, by ERP managers. ERP gives basic introduction to the cultivation tasks for the barge wetland. (i.e. its various layers and buffers, endemic plant and water regeneration, including constructed wetland ecology.)

Where does that water go? Discuss together and develop into natural and man-made sites? How much surface on the land? Discuss together and develop into natural and man-made sites? How much surface on the land?

Small group activity: Each group, on the barge develops a common class map on the barge surface (with chalk). Where does that water go? Discuss together and develop into natural and man-made sites? How much surface on the land?

Student participation in building osprey nests or an activity oyster reef at Paradise Creek. Discuss the Atlantic flyway/oysters' natural ability to cleanse the river, present the cultivation tasks for the barge wetland.

There are a number of possibilities for the students' arrival site from a point further upstream. A third would be for case of a summer camp group, would be to canoe to the site.

Paradise Creek

10:10
10:00
9:20
9:00

1:15  mapping the land

9:00  walking the land

8:30  moving plants along the arm

5:30  planting the wetland

2:00  conversation about renewable energy

12:30  planting the wetland

Volunteer Wetland Workers - 15 adults

SOLs:
9:00  walking the land
10:10  conversation about renewable energy
10:30  planting the wetland
9:45  moving plants along the arm

Communities Work:
Regenerating Wetland
"At Home" Projects

Bird Sanctuary
Butterfly Sanctuary
Oyster Nursery

Partners
Community Groups
River Stars
Public Institutions

Representative of company. Discuss Giant Cement's role in local economy, industry/politics, weather, buoyancy, and perspectives.

Students arrive at Giant Cement and meet with ERP project managers. ERP gives basic introduction to the regeneration efforts. The volunteers are engaged in planting the wetland just off edge of landing. Water, Arm: Volunteers carry wetland plants down arm and planted, where and how. Volunteers given room to put on the Elizabeth River increases, along with community regeneration efforts. Discussion also of local community projects and development.

This day looks at the barge's potential as the base of what will be accomplished the next day, as well as reports/artifacts from the day placed in artifact wall before reboarding boat to return home. Waders and hip boots are required.

Begin afternoon planting with renewed vigor. See artifacts held in wall from class visits and other ERP volunteer work. See student participation in projects. Water, Arm: Volunteers carry wetland plants down arm and planted, where and how. Volunteers given room to put on the Elizabeth River increases, along with community regeneration efforts. Discussion also of local community projects and development.

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Students arrive at Giant Cement and meet with ERP project managers. ERP gives basic introduction to the regeneration efforts. The volunteers are engaged in planting the wetland just off edge of landing. Water, Arm: Volunteers carry wetland plants down arm and planted, where and how. Volunteers given room to put on the Elizabeth River increases, along with community regeneration efforts. Discussion also of local community projects and development.

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There are a number of possibilities for the students' arrival site from a point further upstream. A third would be for case of a summer camp group, would be to canoe to the site.

Paradise Creek

10:10
10:00
9:20
9:00

1:15  mapping the land

9:00  walking the land

8:30  moving plants along the arm

5:30  planting the wetland

2:00  conversation about renewable energy

12:30  planting the wetland

Volunteer Wetland Workers - 15 adults

SOLs:
9:00  walking the land
10:10  conversation about renewable energy
10:30  planting the wetland
9:45  moving plants along the arm

Communities Work:
Regenerating Wetland
"At Home" Projects

Bird Sanctuary
Butterfly Sanctuary
Oyster Nursery

Partners
Community Groups
River Stars
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The primary purpose of the Learning Barge is to educate the community of Tidewater Virginia about the cultural and ecological landscape of the Elizabeth River, to serve as an outreach vessel for the Elizabeth River Project and their sediment, wetland and oyster regeneration projects, and to enable the regeneration of the river's ecology after a century of impact by heavy industry.

The barge's general site agenda is two-fold: First, it seeks out marginal and compromised sites - sites out of mind - and identifies them. Second, it aims to engage the civic realm. Anchoring the barge becomes an act of place making. Unique to the Elizabeth River Project's efforts is the "One Creek at a Time" strategy that avoids a single, big budget remediation effort in favor of multiple, smaller projects that proceed over time as funding becomes available. This approach, which relies on community support and consensus building, is a model of national significance for addressing environmental degradation and contamination at the scale of the region.

The sitelessness and buoyancy of the barge is a great asset within this decentralized context. As ERP cleans the Elizabeth on a project by project basis, the Learning Barge moves to the work site and serves as both a place of observation and as a place for staging the operation, serving as the project's temporary headquarters. The barge is both nomadic and consistent; it gives a material presence to the common purpose that links together the disparate sites. Students respond to the regeneration projects by writing, drawing, or collecting, and embedding the records of these activities into the artifact wall. Student responses are complemented by photographs and maps that documents each regeneration project. Over time, the artifact wall becomes an archive of the Elizabeth River Project's river clean-up, the place where one goes to see the work of the organization.
final design: SITES

• Money Point
• Paradise Creek
• Scott's Creek - Hospital Point
• Scuffletown Creek
• Birdsong Wetland
• Oil Slip
The sites, in addition to addressing specific projects, will act as prompts for teaching from a modular curriculum. The modules include but are not limited to:

- Navigation and Shipping
- RiverStar efforts
- Cultural History of the River
- Renewable Energy and Weather
- Wetland Ecology
- Pollution Prevention and Remediation
- Oyster Restoration

Our strategy is to situate these modules in the spatial and temporal context of the Elizabeth River. A module on the role of oysters in the river, for example, would ideally be taught at sites where a constructed oyster reef is visible. The Learning Barge educator and visiting teacher would discuss together the curriculum for each visit based on class needs and the "formula":

Curriculum = Site + Module + Sequence

The educational mission of the Learning Barge is its primary focus, including school children in Kindergarten through twelfth grade. The barge will be occupied by many types of constituents, including project facilitators and volunteers in the staging of regeneration projects, the Elizabeth River Project Board of Directors, adult education classes, summer camp field trips, or any "Walk-on" public agenda.

We propose a flexible curriculum for the school groups that draws on the unique qualities and events of specific sites. The site includes everything that can be seen or perceived from the barge, as well as land conditions that are accessed by the barge's gangway and extended approach sequences via watercraft, such as the Chesapeake Bay Foundation’s Baywatcher or the barge’s own outboard watercraft.

The ‘Navigation Drawing’ shown on the preceding pages is our attempt to register and construct a possible macro-sequence for moving the barge over a three year period. A climate and events timeline, including regeneration projects, runs along the top of the drawing. The barge is moved opportunistically to take advantage of these events. Placed below the timeline are several informant conditions about the sites themselves: a description of the strategic and curricular opportunities of each given site, a typology of its accessibility and the anchoring conditions it offers, its spatial condition, and a “benthic layer” that evokes the material and phenomenal qualities of the site. A sequencing of the Learning Barge’s sitting based upon these rhythms and characteristics will help to reveal a more complete understanding of the river’s ecological complexity.
Learning Barge
March 21st
10th Grade Earth Science - 24 students
SOLs:
- Geography (map making, recording information)
- Earth science (weather, hydrologic cycle, ecosystem, flora/fauna identification)
- Physics (fluid properties, buoyancy)
- Civics

9:00 There are a number of possibilities for the students’ arrival to the site. One would be to arrive via boat and walk onshore from an existing dock. Another, perhaps in the case of a summer camp group, would be to canoe to the site from a point further upstream. A third would be for the students to arrive from land; their buses could park at varying possible distances from Giant Cement, with each distance affording them a different sort of approach to the site.

9:20 Students arrive at Giant Cement and meet with a company representative. Discuss Giant Cement’s presence in the area and walk along shoreline. What is the environmental impact of cement making? What does it mean to be a River Star and in what projects do they engage?

10:00 Students guided to landing arm and board the barge.

10:10 Armature: Conversation about sustainable power generation, tied to notions expressed by Giant Cement (i.e. lesser environmental footprint, resource conservation, land use and groundwater infiltration, conversion of natural energy). Discuss the U.S. Naval Yard Superfund Site and Landfill.

10:30 Small group activity: Each group on the barge develops a speculative map of the Chesapeake Bay watershed, after short discussion of how the creek plays a role within this boundary. Further discussions: How does water infiltrate into natural and man-made sites? How much surface on the drive over was paved, how much was permeable? Where does that water go? Discuss together and develop a common class map on the barge surface with chalk.

11:30 Lunch on barge at story telling stairs facing wetland.

12:00 Wetland and ecosystems: Discuss engineered solutions to water regeneration, including constructed wetland ecology. Discuss local ecosystem, including focus upon the process of a wetland “waking up” from its winter dormancy. Discuss how one recognizes the different parts of the shoreline (i.e. its various layers and buffers, endemic plant and animal species, etc.). Possibility of student participation in cultivation tasks for the barge wetland.

12:40 Habitat/endemic species: oyster reefs and life cycles, oysters’ natural ability to cleanse the river, present the oyster reef at Paradise Creek. Discuss the Atlantic flyway and fall migrations, osprey nesting. Present other native species. Discuss plants being the most important element of maintaining healthy wildlife habitat. Possibility of student participation in building osprey nests or an activity that could contribute to oyster regeneration efforts.

1:15 Students given sketchy maps of the area and divided into teams. Each chooses a tool (i.e. core sampler, etc.) to map the character of a part of the shoreline. Where are the sediment and vegetative layers discussed on the barge, what is the profile of the land at the site, how does one represent this? How has local industry affected the profile of the land?

1:50 Develop a common map defined by the various types of information gathered. Students show samples collected during their shore trip and explain what these say about the shoreline. Discuss the geography of the Chesapeake Bay area, Portsmouth, and how the scale of the creek shore relates to larger geographical frames. Collective map stored in artifact wall for later students to see and compare to their own.

2:30 Leave by bus (with copy of map for in-class use).
This day looks at the barge’s potential as the base of operations for a wetland regeneration partnership between ERP and local community members. This day is a catalyst for more regenerative work along the Elizabeth River. As community volunteers experience the barge and the replanting process, awareness of issues along the Elizabeth River increases, along with community-sponsored regeneration efforts. The volunteers arrive by boat, but as with the 10th grade earth science class, it is also possible for volunteers to arrive on land and use the arm to enter the barge.

### Scotts Creek
**September 22nd**
**Volunteer Wetland Workers - 15 adults**

**Community Work:** Regenerating Wetland
*At Home* Projects (Bird Sanctuary, Butterfly Sanctuary, Oyster Nursery)
Partners (Community Groups, River Stars, Public Institutions)

9:00 volunteers arrive by boat

8:30 ERP project managers arrive, prepare barge for volunteers by letting out landing arm and opening up classroom doors. Plants and supplies should have arrived the previous night and been stored on the upper deck. Plants prepared and laid out for volunteers.

9:00 Upper deck: Volunteers arrive by boat and are greeted by ERP managers. ERP gives basic introduction to the wetland regeneration effort and shows the plants that have been stored and prepared for planting.

9:15 Classroom: Begin to discuss planting of wetland. Requires maps of what has been accomplished and future work, including work for that day. What needs to be planted, where and how. Volunteers given room to put on waders, hip boots, prepare for work.

9:45 moving plants along the arm

9:45 Arm: Volunteers carry wetland plants down arm and begin regeneration project just off edge of landing. Water, plants, and supplies are placed on the end of the folded arm for easy access.

10:00 planting the wetland

10:30 Lunch, rest. Volunteers learn about artifact wall and see the project status of other wetlands in the area. They see artifacts held in wall from class visits and other ERP regeneration efforts. Discussion also of local community wetlands (Birdsong, etc.) and what kinds of work can be done at home (i.e., building migratory bird/butterfly sanctuary, oyster farming, etc.).

12:00 planting again

2:00 Arm: Volunteers carry wetland plants down arm and begin regeneration project just off edge of landing. Water, plants, and supplies are placed on the end of the folded arm for easy access.

2:00 planting again

5:00 Volunteers gather on barge to prepare to leave. Project reports/artifacts from the day are placed in the artifact wall before reboarding the boat to return home. Waders and hip boots are removed and stored in classroom wall. Short discussion of what will be accomplished the next day, as well as possibilities for future community partnership.

6:00 ERP project managers lock up classroom, put remaining plants to bed for the night, and depart.
The learning barge was conceived as an integrated experience, where the goals of the Elizabeth River Project are advanced by the physical spaces dedicated to them. The indoor and outdoor rooms are stages, staging areas and laboratories used to facilitate and explain ERP’s work “one creek at a time”.

The barge mediates the vast scale differences that define the Elizabeth River. The higher deck focuses views and activities outward to the industrial and natural landscape; the lower deck supports internal activities that focus on the water, plants and habitats. This narrative for the design creates multiple areas for activities and organizes the use of the barge while still allowing for flexibility based on different sites and groups on board.
1. Classroom roof collects water.
2. Photovoltaic panels produce electricity.
3. Solar hot water panels heat water for radiant heating system.

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**Barge Plan**

1. Upper deck
2. Armature gallery
3. Artifact deck
4. Ramp
5. Classroom
6. Toilet
7. Wetland
8. Storytelling stairs
final design: MEASURED DRAWINGS

Longitudinal Sections

Section cut through armature gallery

Section cut through ramp and lower deck
Longitudinal Sections

Section cut through classroom, planted filtration basin and story telling stairs
final design: MEASURED DRAWINGS

Cross Sections

Section cut through classroom looking towards artifact wall

Section cut through classroom looking towards planted basin

Section cut through armature gallery and planted filtration basin (next page)
As the barge takes up residence at a remediation site, it reaches out to connect to the land. This connection becomes the approach to the barge and a threshold between the existing land and visiting land of the barge. Along this approach the barge landscape is seen in contrast with the river. Discussions along this route explore the connection between what happens on land and the health of the river.

Arriving at the barge, visitors can gather on the lower deck, or move up from water level to expand their view of the site. Ascending, the top deck is the most open space on the barge; this deck allows an uninterrupted 270° view of each site. As the most open space, the flexibility of uses here include: map making for school groups, staging area for planting days, or gathering space for fundraising events.

Continuing to navigate the barge, visitors move through the armature. This is the exo-skeleton of the barge; it organizes all the systems on board and supports the materials that create enclosure. Running completely off the power grid, the systems of the barge are models for sustainable infrastructure. These mechanical systems are exposed to provide a counterbalance to a discussion of natural systems that are at work in the river.

Moving from the upper deck down, the outside of the artifact wall catalogs ERP’s projects and displays treasures that have marked milestones in their work.
The seating steps provide an area for focused learning, such as lectures or story telling, and casual interactions as students take lunch breaks or volunteers work. Presentations here have the native plants of the water filtration basins as a stage set.

Moving within the filtration basins, and over the water collection pool there are opportunities to work within the filtration system. Water samples taken here show how plants in a wetland work to filter contaminants in the river water. The filtered water also nourishes the on board nursery in which native plants are grown to populate the banks of the river. These plants are moved from the barge to the land at each site.

The filtration basins are used to connect the outdoor rooms of the barge with the most enclosed space on board. This classroom and laboratory maintains a connection with the site through highly operable windows and fully openable walls. In the classroom, fold down tables and flexible storage areas allow the room to work during the day as a classroom, or in the evening for board meetings and community barge-parties.

Work done on the barge can be displayed in the artifact wall so that a piece of the barge grows and changes with time as the river restoration proceeds.

Moving back out of the classroom, visitors look back to the land and consider how what has been learned on the barge can be applied to each visitor’s daily life on the land.
Learning Barge

+9 sites out of mind

System: run the barge entirely off the energy grid, minimize the power needs of the barge using passive strategies

**ELECTRICITY:**

- **solar**
  - PV panels
  - Batteries in 2hr fire rated enclosure
  - Inverter: 14”x24”x36”
  - Electrical panel

- **wind**
  - Turbine
  - Pole
  - Batteries in 2hr fire rated enclosure
  - Inverter: 14”x24”x36”
  - Electrical panel

**WATER:**

- Collect and use rainwater that falls on the barge for hand washing, cleaning, and possibly watering plants

- **rainwater collection**
  - Metal roof surface
  - Collection tank: 400 gal, gravity fed
  - Sediment charcoal filter
  - Bathroom sink for hand washing
  - Classroom sink for experiments
  - Outside sink in wetland
  - Spigots for deck washing

- **waste:**
  - Manage all waste on the barge

- **greywater treatment**
  - Manual pump
  - DC pump: automatic backup
  - Holding tanks
  - Planted filtration basins

- **composting toilet**
  - Self-contained toilet unit
  - Wind powered fan

**HEATING:**

- Use heated water from solar hot water collectors to radiantly heat enclosed classroom, block wind for added comfort inside and outside, provide opportunities for passive solar heating.

- **radiant floor**
  - Continuous plastic piping in floor
  - Two pumps: DC rated
  - Manifold: 36”x36”
  - Storage tank: 180 gal
  - Solar hot water collectors: 180 sf

- **wind block**
  - Moveable elements to block wind
  - Rolling shutters for hurricane lockdown on classroom window wall

- **passive solar**
  - Exposure to sun
  - Select appropriate building material to reflect, absorb or retain heat

**COOLING:**

- Design barge to promote natural ventilation and evaporative cooling.

- **natural ventilation**
  - Cross ventilation via operable windows on all walls
  - Stack effect
  - Windows act as wind scoops

- **evaporative cooling**
  - Air is cooled as it blows across the wetland’s planted filtration basins and water collection pool

**SAFETY:**

- Provide a safe learning environment on the Elizabeth River through careful design and incorporation of safety features.

- 42” high guardrails at perimeter
- Life vests for all occupants
- Fire extinguishers
- First aid kits

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*What goes in the armature?*
As a platform for ecological education it is vitally important that the barge itself exemplify environmental responsibility in both its construction and operation. To this end the barge will employ heating, energy collection, water collection, and water filtration systems that utilize the abundant natural resources of the region. The systems, while minimizing the environmental impact of the barge, will be clearly visible to the students and embody educational opportunities, allowing for close observation of the various processes.

Wetland: river filtration (1)
- Water is manually pumped from river into collection basins
- River water flows through tiered plant basins
- During 24 hour residence in filtration basins, water is oxygenated, sediment drops out, and minute toxins are consumed by plantings
- Naturally filtered river water flows to collection pool
- Collection pool feeds nursery beds with filtered water and overflows to river

Water: rainwater collection / filtration (2)
- Rainwater falls on sloped roof
- Rainwater is directed towards large gutter running the length of the building
- Rainwater is collected in basin at the end of building
- Rainwater is gravity-fed across the bathroom to water filtration unit
- Filtered water is gravity fed to bathroom sink and outdoor utility sink
- Greywater is deposited into planted filtration bed

Energy: photovoltaics / wind turbine (3)
- Photovoltaic panels collect sun energy
- 2 wind turbines rotate with wind movement and generate wind energy
- Both energy sources connect to battery cabinet
- 5 12V DC batteries collect and store all energy received
- Usable electricity is channel through an electrical box
- Electricity is disseminated to various parts of the barge

Heat: solar hot water / radiant floor (4)
- Water is circulated through tubes exposed to the sunlight, warming it
- Warm water is pumped to storage tank equal to capacity of solar array
- Warm water is pumped through manifold which connects piping from storage to piping for sub-floor circulation
- Warm water is circulated through coils embedded in flooring, radiating heat
- Expended water is pumped back up to the solar array of tubes in a closed loop
final design: DIAGRAMS: GATHERING / CIRCULATION / STRUCTURE

Gathering Spaces

1. Observation Deck (19’ x 32’)
2. Story-telling stairs (9’ x 17’)
3. Wetland and work area (46’ x 24’)
4. Armature Path (8’ x 120’)
5. Systems Wall (3’ x 32’)
6. Classroom (35’ x 14’)
7. Regeneration Deck (11’ x 32’)

Circulation

1. High entry access (+/- 4’ above water)
2. Armature Path
3. Ramp
4. Low entry access (+/- 2’ above water)

Structure

1. Upper deck
2. Cantilever for sun-shade
3. Armature beam (supporting systems)
4. Exterior steel column
5. Interior steel column
6. Window-wall support
7. Armature beam (supporting roof)
8. Lower deck
**Exterior Articulation:**

- Water, heat, and energy system components are located on the exterior wall and visible along the armature path.
- System components are color coded to emphasize their interconnectedness and indicate which barge elements are served by which systems.
- Large windows are placed to reveal vertical columns of the interior space, emphasizing the armature structure.
- Smaller box windows protrude into system wall, displaying relevant artifacts, viewable from interior or exterior.
- Bathroom is accessed from exterior armature path.

**Interior Articulation:**

- Low cabinets run the length of the wall below datum line created by the level of the upper barge deck.
- Wall is pulled back slightly from interior columns so as to isolate and emphasize armature structure.
- Open shelves with adjustable translucent sliding panels are stacked vertically for more accessible storage and placement of found artifacts.
- Irregularly placed apertures within the shelves allow for displays visible from both interior and exterior.
- Large windows allow view to outdoor path activity, as well as observation of color coded systems conduits.
- Murphy tables fold down from the wall allowing for adaptability of space.
The Arm: a landing device

The Learning Barge arrives at site and is pushed into place by a tug operator. One person then goes to the arm/barge spud and sinks it by releasing the winch. They then walk along the length of the barge, unhooking the locking mechanisms for the arm, which could be small and simple. At this point, another person could help by getting into the ERP skiff and towing the arm out until it’s about perpendicular to the barge, but it’s more a convenience than a necessity to have more than one person. Once the arm is towed out, the arm’s spud needs to be dropped just as the barge’s spud was by released the winch. At this point, one can then throw out the folding section of the arm (by opening the trapdoor at the edge of the barge and resting it against the guardrail, then pulling the gangway out of the cavity in the deck and pushing it up and over the edge; at this point, the second piece can then be unlocked and also pushed over), or it can be left in until actually needed, or for security reasons. The whole process should take no longer than 15 minutes, and each of the pieces is designed in such a way as to make it a much easier process (there are handles in the folding gangway door to make it easier to grip, the gangway itself is counter-weighted to make it easier to move, etc.) There is no part of the process that requires more than one person, though obviously it’s easier if one operates the boat and the other operates the various pieces of the arm itself.
**Water Filtration Basin: native plants & prototype system**

- Visitors are able to learn about and experience native salt marsh plants up close.
- The cascading system of basins teaches about the filtration process, so that the benefits of wetlands are visible and measurable.
- The windows let students view benthic layers and see how water infiltrates and flows through the root system.
- The rough surface of the scuppers aerate the water, increasing dissolved oxygen content.
- Plants in the nursery receive cleansed, oxygenated water.
- Filtered water is returned to the river.
- Plants will need to be thinned once they mature, but will require minimal maintenance.
- Basin can be drained in winter.

**Artifact Wall: display & timeline**

- The artifact wall displays elements that visitors to the barge have found or made during their visit to the barge.
- The display on the artifact wall creates a visual history of the barge, and links it to the people who inhabit it.
- The wall is a timeline of the barge’s progress, and allows visitors to participate in the life of the barge even after they have left it.