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
- Durability 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 Trimet and maintained twice a year.
- Structure and enclosure transition
- Limited student welding experience
- Higher shipping costs b/c of weight makes offshore steel fabrication questionable
- Tied 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 (i.e. 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
STEEL_information

Different carbon and alloy contents affect 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

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

Protection- galvanized; electrolytically galvanized; vinyl, alkyd, acrylic, polyester, and paint coatings; ferritic stainless steel coatings, porcelain 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

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 temperature over 86 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
• Galvanize and/or Primer Coat of Epoxy
• 2 coat finish
• Polyanaite
### Off the shelf & Miscellaneous

#### Armature Structure

<table>
<thead>
<tr>
<th>Material</th>
<th>Pros</th>
<th>Cons</th>
</tr>
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</table>
| Structural Pipe Scaffolding | - ease of construction  
- no welding  
- lightweight members  
- re-configurable  
- strong  
- ease of transport | - difficulty of cantilever  
- emphasizes joints  
- non members  
- potentially weakens impact of armature |
| Marine Grade Aluminum | - 40-70% lighter than steel  
- requires no painting | - higher embodied energy than steel |
| Combination | - maximize properties of each material | - minimize strength of armature as organizational piece |

#### Fabric

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| Marine Grade Aluminum | - maintenance free with corrosion resistance  
- can be mechanically joined or welded | - requires no protective coatings |
| Polycarbonate / Fiberglass | - absorbs very little moisture  
- no chance of degradation due to salt water, chemicals or oils | - higher impact stress, low thermal expansion |

#### Roofs

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| Fabric | - can be designed to withstand heavy winds  
- dynamic form  
- can be layered so each layer serves one function | - lightweight  
- good light transmission  
- dynamic form  
- can be layered so each layer serves one function  
- rigid  
- lightweight  
- good light transmission  
- can be insulated |
| Polycarbonate / Fiberglass | - translucent insulated panels  
- high impact stress, low thermal expansion | - comes in one piece  
- order to size and attach with typical fasteners  
- industrial vocabulary  
- thermal properties unknown  
- non-architecture industry may make coordination difficult |

#### Truck Tops

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#### LEARNING BARGE

**126 Learning Barge**

+ 9 sites out of mind

**127 off the shelf & miscellaneous**

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**Roofs**

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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:
- 768sf x 0.0083333=6.32 cf per day
- 6.32 x 7.481 cf/gal=46.24 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.

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

3.2. ARMATURE: SYSTEMS

Rainwater Collection

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 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.

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.
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.
Complete systems include tank, single wall heat exchanger, evacuated tube collectors, pump, and tanks are lined with seamless EDPM have a 20 year warranty against leaking. These tanks have an each tank comes standard with one heat exchanger for domestic hot water pre-heat. Any number of heater back-up is recommended but not required for SRCC and tax credits.

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 watts/hour/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 gpm 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.

In order to maintain the desired room temperature, the radiant floor must account for all temperature 16° 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.

<table>
<thead>
<tr>
<th>Pipe (gal)</th>
<th>A-Frame</th>
<th>AP-30</th>
<th>1/8 (in) of</th>
<th>Fin</th>
<th>7'-3”</th>
<th>Heat</th>
<th>(in)</th>
<th>MSRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS-300-5-30-PC</td>
<td>290</td>
<td>54</td>
<td>38</td>
<td>52</td>
<td>(5) AP-30</td>
<td>$17681</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS-200-3-30-PC</td>
<td>192</td>
<td>38</td>
<td>38</td>
<td>52</td>
<td>(3) AP-30</td>
<td>$12,431</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS-150-2-22-PC</td>
<td>145</td>
<td>38</td>
<td>30</td>
<td>52</td>
<td>(2) AP-22</td>
<td>$8,775</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TS-100-1-30-PC</td>
<td>109</td>
<td>30</td>
<td>30</td>
<td>52</td>
<td>(1) AP-30</td>
<td>$7,085</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(The above chart is included in the document for reference.)
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 stillest 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.

DC powered ceiling fan:
42” diameter, hangs 12” down from flat ceiling, variable height from sloped ceiling, approx. 12 lb

DC powered attic fan:
12” or 16” square, operates automatically between 90F and 110F (temperatures hotter near roof)

Evaporative cooler:
22 amps at 18 volt DC
27”W x 25”H x 20”D, 35 lb dry
1 gallon water/hour

Solar evaporative cooler:
22 amps at 18 volt DC
27”W x 25”H x 20”D, 35 lb dry
1 gallon water/hour

Radiator barrier:
with or without insulation; reflects radiant heat, typically used in roofs or attics

Desiccant cooling:
interesting but not such an option, absorbs moisture out of air - then needs to be reheated to lose moisture, nasty chemicals

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

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

<table>
<thead>
<tr>
<th><strong>Floodlight:</strong></th>
<th>FL-48-48 LED</th>
<th>12VDC Floodlight</th>
<th>4 luminaires</th>
<th>.25 amps</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Running Lights:</strong></td>
<td>LX2-PT/SB/ST</td>
<td>12VDC</td>
<td>3 luminaires</td>
<td>.17 amps</td>
</tr>
<tr>
<td><strong>Interior Lights:</strong></td>
<td>Solsum 11W 12VDC</td>
<td>Compact Fluorescent</td>
<td>10 luminaires</td>
<td>.9 amps</td>
</tr>
<tr>
<td><strong>Safety Lights:</strong></td>
<td>MC1030 LED Step Light</td>
<td>23 luminaires</td>
<td>.08 amp</td>
<td></td>
</tr>
</tbody>
</table>
### Plant selection: native marsh plants

<table>
<thead>
<tr>
<th>Plant Name</th>
<th>Salt Tolerance</th>
<th>Tidal Zone</th>
<th>Height</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saltgrass</td>
<td>Distichlis spicata</td>
<td>0-50 parts per thousand</td>
<td>Above mean high tide to spring tide</td>
<td>6&quot; - 1.5'</td>
</tr>
<tr>
<td>Black needle rush</td>
<td>Juncus Roemerianus</td>
<td>0-25 ppt</td>
<td>Above mean high tide to spring tide</td>
<td>1'- 4'</td>
</tr>
<tr>
<td>Saltmarsh cordgrass</td>
<td>Spartina alterniflora</td>
<td>0-35 ppt</td>
<td>Mid-tide to mean high tide</td>
<td>2'- 7'</td>
</tr>
<tr>
<td>Salt meadow hay</td>
<td>Spartina patens</td>
<td>0-35 ppt</td>
<td>Irregularly flooded high marsh at or above high tide</td>
<td>1'- 3'</td>
</tr>
<tr>
<td>Pickelweed</td>
<td>Salicornia virginica</td>
<td>0-32 ppt</td>
<td>Tolerates alkaline, salty soil, no drainage and seasonal flooding</td>
<td>1'- 2'</td>
</tr>
<tr>
<td>Salt marsh elder</td>
<td>Baccharis halimifolii</td>
<td>0-15 ppt</td>
<td>Above mean high tide to uplands</td>
<td>5'- 12'</td>
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<tr>
<td>High tide bush</td>
<td>Iva frutescens</td>
<td>0-15 ppt</td>
<td>Above mean high tide to uplands</td>
<td>2'-10'</td>
</tr>
<tr>
<td>Wax myrtle</td>
<td>Myrica cerifera</td>
<td>0-15 ppt</td>
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</tr>
<tr>
<td>Salt meadow hay</td>
<td>Solidago sempervirens</td>
<td>0-15 ppt</td>
<td>Coastal dunes</td>
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### Plant selection: graywater filtration

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Rejected plants:
- Ammophila breviligulata: coastal dune grass, sandy soil
- Panicum amarum: coastal dune grass, sandy soil
- Ruppia merina: submerged aquatic vegetation, no place for it
- Zostera marina: submerged aquatic vegetation, no place for it
- Scirpus 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 plant fibres 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 wastewater. It includes wastewater from showers, baths, spas, hand basins, washing machines, laundry troughs, dishwashers and kitchen sinks.

Soilbox design:

Soilboxes have been used for greywater purification since 1975 with excellent results. The planter bed has to be well drained to prevent the formation of a water-logged 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.

Planter soil box design:

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Greywater system:

Bio-Filtration: ecologists advice

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

April 6, 2006

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