MONITORING PLAN

PROJECT NO. LA-05 FLOATING MARSH CREATION DEMONSTRATION PROJECT

DATE: June 13, 2005

<u>Project Description</u>

The Floating Marsh Creation Demonstration Project (LA-05) is authorized by the Coastal Wetlands Planning Protection and Restoration Act of 1990 (PLO 101-646, Title III). The initial development of this project will take place in control settings at LSU and UNO. Currently no field location has been determined, but it is envisioned that the field deployment will be on Mandalay National Wildlife Refuge. Components of this project include development of structures to establish *Panicum hemitomon* marsh in areas that have converted to open water and monitoring the structural and biotic integrity of the created structures.

Land loss in coastal Louisiana has been well documented and related to a variety of causes (Craig et al. 1979, Gagliano et al. 1981, Sasser et al. 1986, Evers et al. 1992, Britsch and Dunbar 1993). This loss covers all marsh types, including freshwater floating marshes. Even though the remaining marshes in the upper part of the coast have remained fresh since they were first mapped by O'Neil (1949), significant areas of marsh have converted to open water, and vegetation associations have changed from thick-mat maidencane (*Panicum hemitomon*) dominated marsh to thin-mat spikerush (*Eleocharis baldwinii*) dominated marsh (Visser et al. 1999). Visser et al. (1999) identified the following potential causes for the dramatic change in fresh marsh vegetation and land loss: grazing by nutria, increased water levels, hydrologic modifications, and eutrophication. Sasser et al. (2004) show that grazing by nutria may be the most important of these factors in freshwater marshes. Although the effect of nutria grazing on maidencane marshes has not yet been documented, nutria grazing helps prevent the re-establishment of maidencane in spikerush marshes (Visser et al. 2001). In addition, recent research has shown that maidencane grows well in the spikerush floating marsh with or without nutrient enhancement when protected from grazing (Sasser et al. 2004). This indicates that no nutrient limitation exists in the maidencane marsh areas that have converted to spikerush marsh and open water.

The belowground structure of *Panicum hemitomon* is characterized by extensive root and rhizome allocation that results in an organic root mat that is very fibrous and buoyant. *Panicum hemitomon's* extensive network of fibrous roots and rhizomes is crucial for forming well-integrated floating marsh mats. The ability of other co-dominant or subordinate species (e.g., *Sagittaria lancifolia*, *Eleocharis baldwinii*) to form this type of highly-buoyant floating root mat in the absence of *Panicum hemitomon* seems improbable based on their respective belowground morphologies and general architecture. Therefore, *Panicum hemitomon* probably plays a key role in the successful formation and sustainability of healthy (thick mat) freshwater floating marshes (Sasser 1994, Holm et al. 2000), and will be the primary plant species utilized in this project.

Wetland plant species typically display aerenchyma (tissue air space) development in their tissues, which facilitates oxygen diffusion to the roots and may also reduce the amount of living, respiring tissue in roots relative to root volume (Armstrong 1979, Jackson et al. 1985, Schussler and Longstreth 1996). Although wetland plants generally form aerenchymatous tissues during their normal development, aerenchyma can also be induced in many wetland plants when subjected to waterlogged or hypoxic conditions (Schat 1984, Burdick 1989, Schussler and Longstreth 1996). Formation of adventitious roots is widespread in grass species regardless of soil conditions, but also occurs in plants subjected to conditions in which the primary root cannot function properly, such as in waterlogged conditions where soil oxygen levels are depleted to the point of inhibiting aerobic metabolism (Jackson and Drew 1984). Flood-induced adventitious roots are typically very porous due to the prevalence of aerenchymatous tissue, which facilitates the diffusion of gases, such as oxygen from shoots to roots, thereby enabling many plants to grow in hypoxic or anoxic soils (reduced soils) that typically form under flooded conditions (Armstrong 1979, Dacey 1980, Jackson et al. 1985; Drew 1992; Naidoo et al. 1992). Therefore, the induction of aerenchyma and the formation of adventitious roots are viewed as mechanisms of facilitating aerobic root respiration under flooded soil conditions and would likely have tremendous implication for root production and mat buoyancy in floating marshes.

The first phase of this demonstration is the development of artificial floating-marsh systems (AFS) and has two components. The first component is development of a floating system which provides the structure that keeps the substrate in place and provides the buoyancy during the period in which *Panicum hemitomon* plants establish. Each structure will include nutria exclusion measures that protect plants during the establishment phase. For this component eight structures using a variety of mat materials and support structures will be evaluated (Appendix A). The second component consists of efforts to understand the plant response to environmental effects (nutrients, flooding, and substrate) in order to develop methods to maximize the establishment and growth of *P. hemitomon* in an AFS. This second component has several subcomponents. The first subcomponent evaluates the effect of nutrients (nitrogen and phosphorus) on *Panicum hemitomon* growth. The second subcomponent evaluates the effect of substrate material (peat, bagasse, sugarcane leaf strippings, and two commercially available types of mulch.) on *Panicum hemitomon* growth. The third subcomponent evaluates the effect of containment material (coconut mat, birch mat, bagasse, straw, and coconut with latex) on *Panicum hemitomon* growth. The fourth subcomponent evaluates the effect of edge expansion species on *Panicum hemitomon* spread. The last subcomponent evaluates the possibility of *Panicum hemitomon* establishment from seed. Based on the information gathered during the development phase (year 1), three designs will be selected based on maintenance of structural integrity and buoyancy as well as the potential for maximizing *P. hemitomon* growth and tested under field conditions.

Phase 1,Component 1: Design of Floating Marsh Systems

We will develop eight AFSs that will be tested in an outdoor laboratory setting with *P. hemitomon* established from nursery stock and/or plugs harvested from healthy marshes (Appendix A, Figure 1). Dimensions will range from 1-10.4 m^2 (10.8 to 112 ft^2), with five replicates of each. These designs will be adapted (e.g. cross braces added) based on performance in the initial stages with the goal to support the substrate in the range of flooding conditions that are optimal for *P. hemitomon* growth. Construction will be designed such that each AFS can be relatively easy to put together in the field. Each design will incorporate an anchoring system to minimize horizontal movement, while not hindering vertical movement of the AFS, and a light weight fence consisting of poultry wire will be attached to deter grazing by nutria during the plant establishment phase. We will use biodegradable materials where feasible and use non-degradable materials in such a way that they can be easily removed at the appropriate time (i.e. when the plants are sufficiently established to provide buoyancy and structural integrity; this is estimated to occur 1 to 2 years after deployment). The attachment will be made with materials that can be cut (e.g. rope, wire ties, or mat material). Any wood used will be untreated (to minimize introduction of treatment chemicals to the environment) and as buoyant as possible (e.g. white pine). The AFSs are designed to maintain sufficient structural integrity until the established *P. hemitomon* mat becomes self sustainable. The fabrication of each design will be such that multiple units can be attached to one another to create larger areas of floating *P. hemitomon* marsh for field testing.

The site selected for the outdoor laboratory setting consists of several ponds at the LSU Agricultural Center's Aquaculture Research Station on Ben Hur Road in Baton Rouge. At this site, three 0.14 ha (0.3 acre) experimental ponds will be utilized where water levels can be controlled from 0 to 1.8 m (6 ft) in depth with an adjustable riser, using freshwater from a well. This outside laboratory setting provides water depths that are comparable to those found in the coastal marsh areas targeted for restoration with this project. The targeted restoration areas are former *P. hemitomon* marshes that have converted to open water and thin-mat flotant. Data on the water-level movement and water-quality from these areas have been documented (Sasser et al. 1995, Sasser et al. 1996, Sasser et al. 2004).

Phase 1, Component 2: Optimization of Plant Responses

Effects of elevated nutrient availability and flooding: This subcomponent will focus on the role of nutrient loading and mat flooding depth on aboveground and belowground plant allocation and overall mat productivity and buoyancy. Both whole plant responses and measures of plant tissue specific gravity (as an indicator for buoyancy potential buoyancy) will be measured. This subcomponent will be a 3 x 3 x 2 (3^2 x 2) factorial with 5 replications (n = 90). The factorial treatment arrangement will consist of 3 levels of nitrate loading (oligotrophic, mesotrophic, and high) completely cross-classified with 3 levels of phosphate loading (oligotrophic, mesotrophic, and high) and 2 levels of flooding (flooded to the mat surface and flooded to 15 cm above the mat surface). Rubbermaid containers (68-liter capacity) will serve as experimental mesocosm units that will contain the vegetated mats. A standardized, double-layer coconut fiber mat will be used in all the experimental units for uniformity of substrate material.

Preliminary evaluation of containment and substrate materials: This subcomponent will focus on the assessment of a wide range of potential containment materials and configurations. We will asses 5 main types of mat material (coconut, coconut with latex, bagasse, birch, and straw) that will be configured as two-layer sandwiches that will contain one of the substrate materials between the two layers of fiber mat. The various substrate materials to be assessed will include peat, bagasse, sugarcane leaf strippings, and two commercially-available types of mulch. This subcomponent will be conducted in two parts: one that focuses on evaluating the containment material utilizing two standard substrate materials (peat and bagasse; 5 x 2 factorial design with

5 replicates; n=50) and the other that focuses on assessing the various substrate materials within a standard containment material (5 substrate treatments and 5 replicates; n=25). Both of these parts will be conducted outdoors (to maximize sunlight and better emulate environmental conditions) in experimental mesocosm vessels located on the UNO campus. An additional setup in 2005 will then fine-tune and optimize various configurations based on the 2004 results.

Evaluation of edge-expansion species: This subcomponent will assess the potential value of including additional plant species, other than solely *P. hemitomon*, in the vegetated mats. The overall goal is to determine if plant species such as *Ludwigia peploides, Alternanthera philoxeroides*, *Hydrocotyle ranunculoides* or *Paspalum vaginatum*, can be established as "edge expansion species" to facilitate the outward, lateral expansion of the vegetated mats. These edge expansion species may help stabilize or lock separate mats together, as well as provide an additional organic rooting matrix outside of the originally deployed mats that *P. hemitomon* can colonize, thereby facilitating lateral expansion of this key species. Coconut fiber mats (1 m^2) will be utilized and deployed in 40 shallow pools (all independent experimental units). Four vegetative conditions will be assessed under oligotrophic and nutrient-augmented conditions (4 x 2 factorial design with 5 replicates = 40 mats). Each mat will be planted with *P. hemitomon* in the center and one edge species.

Fine-scale optimization of mat configurations and protocols: Based on the results of the first year, a second-year greenhouse study will be conducted to "fine tune" and optimize the mat configurations and environmental conditions. A clipping regime as a plant cultivation enhancement technique will be incorporated to evaluate plant productivity and vegetative spread.

Assessment of Panicum hemitomon seed production and viability: A preliminary assessment of *P. hemitomon* seed productivity and seed viability (germination) will be conducted. This species is known as "maidencane" because of its reputation for not producing viable seeds. However, Louisiana *P. hemitomon* has not been specifically investigated to our knowledge, and may show promise for sufficient production of viable seeds that can be utilized in future floating marsh restoration/creation projects. We propose to collect 50 inflorescences (flowering seed heads) from plants from at least two locations during the early summer of 2005 and conduct an initial assessment of average number of seeds produced per culm. If sufficient seed is available (>100 seeds) the seed will be after ripened and germination potential determined in the spring of 2006.

Phase 2: Field Testing of Selected Artificial Floating Systems

Selection of Artificial Floating Systems: Components 1 and 2 in year 1 should provide sufficient information to select up to three AFS for deployment in the field. There is the potential to recombine materials used in year 1 into one or more new systems (using one of the existing structural designs) for field deployment. Design flaws should become apparent during the initial deployment in the ponds. This information will be used to improve the designs and possibly add additional designs for testing under the controlled conditions. The following criteria will be used to select the best AFS and the best components for creating new AFS based on the year 1 designs:

1. Structural integrity of the AFS after 9 month of deployment under controlled conditions.
    - Is the shape maintained?

- Do the fasteners show signs of wear and tear?
- Is the AFS floating at or near the water surface?
- Is the substrate contained?

2. Performance of the components after 9 month of deployment under controlled conditions.
    - Which structural material (wood, pvc pipe, foam billet) provides the best (nearest to the water surface) buoyancy. Take into account the type of AFS (different weight) that the structural material is supporting. If two or more structural materials provide similar buoyancy, which material is the most cost effective?
    - How well does the containment material (i.e. different mats) maintain its strength? Which containment material (mat) provides better growth conditions (based on green house study)? If two or more provide similar strength and growth conditions, which material is the most cost effective?
    - Which substrate material provides the best growing conditions (green house results)? If two or more substrates provide similar growth conditions, which material is the most cost effective?

Selection of Field Sites: A minimum of two[1] field sites for testing the creation of floating marshes will be selected from former *P. hemitomon* marsh areas that have converted to open water. The selected sites will consist of shallow (approximately 2 - 4 ft deep) water with flanking fresh marsh (in most areas this is most likely thin-mat spikerush marsh). Field sites will be selected based on the following criteria:

1. landowner permission
2. accessibility
3. nutria control (area is leased to trappers or other management practice)

It is envisioned that these field sites will be located on Mandalay National Wildlife Refuge.

Within each site, areas will be located that are relatively sheltered from waves (sheltered treatment) and sites that are open to wave action (exposed treatment). Sheltered areas will have a maximum of 200 m (656 ft) of fetch in all directions from the deployed AFSs, while the exposed treatments will have fetch exceeding 200 m (656 ft) in at least one direction. Up to five replicates of the three selected AFS will be randomly placed in each wave environment. Slow release fertilizer will be applied to the structures if appropriate based on nutrient availability in the water and the monitoring results from the plant response tests performed during the development phase.

<u>Project Objective</u>

The objective of this demonstration is to develop methods for restoration of open areas within thin and deteriorated mats that once supported thick-mat maidencane marsh and other fresh water areas where establishment of maidencane marsh is desired. This will be accomplished in two phases. The first phase is a development phase consisting of two components. The first

[1] The number of replicates and field sites is contingent on the budget for labor and materials. The statistical sufficiency of the number of replicates can not be determined at this time, since this project involves new materials and construction techniques both with unknown variability.

development component is the development of structures that provide a floating substrate in which *Panicum hemitomon* can establish. The second development component is optimizing plant responses to accelerate the development of floating marsh. The information from this first phase will be used to design three artificial floating systems for field testing.

Specific Goals

1. *Phase 1, Component 1*: Development of structures
   a. Determine which AFS designs provide structural integrity (including structure and the artificial mat) of sufficient duration to allow the establishment of a floating marsh mat.
   b. Determine which AFS designs provide buoyancy of sufficient duration to allow the establishment of a floating marsh mat.
2. *Phase 1, Component 2:* Optimizing plant responses
   a. Determine the combination of flooding, nitrogen level, and phosphorus level that optimizes the above and belowground production of *Panicum hemitomon* biomass.
   b. Determine which substrate material optimizes the above and belowground production of *Panicum hemitomon* biomass.
   c. Determine which containment (mat) material optimizes the above and belowground production of *Panicum hemitomon* biomass.
   d. Determine which of four edge expansion species (*Ludwigia peploides, Althernanthera philoxeroides, Hydrocotyle ranunculoides*, and *Paspalum vaginatum*) provides for the maximum lateral expansion of *Panicum hemitomon*.
   e. Provide a preliminary assessment of the possibility for establishing *Panicum hemitomon* from seed.
3. *Phase 2:* Field deployment
   a. Determine which of the three selected AFS designs provides the best establishment of *Panicum hemitomon* under exposed and under sheltered field conditions.
   b. Determine which of the three tested AFS designs provides the most cost effective method for floating marsh creation under exposed and under sheltered field conditions.

Monitoring Elements

The following monitoring elements will provide the information necessary to evaluate the specific goals listed above.

1. Vegetation

Phase 1, Component 1: Percentage cover of plant material will be assessed ocularly to the nearest 5% and number of live *P. hemitomon* stems will be noted weekly after all 8 AFS structures are deployed in the controlled setting. *Phase 1, Component 2*: Stem counts and stem heights (for cumulative stem height as a surrogate for biomass) data will be collected at regular intervals. At harvest the following variables will be measured: stem counts and heights, total plant biomass (wet), and biomass partitioned into dry live and dead aboveground and belowground. Root and rhizome tissue specific

gravity will be determined on fresh tissues samples collected from the nutrient addition and flooding experiment according to the modified pycnometer method described by Burdick (1989) and employed by Sorrell et al. (2000). Where appropriate, lateral spread from the edge of each mat will be determined to the nearest cm perpendicular to each mat edge. To assess *P. hemitomon* seed production, we will collect 50 inflorescences (flowering seed heads) from plants from at least two locations during the early summer of 2005 and conduct an initial assessment of average number of seeds produced per culm. If sufficient seed is available (>100 seeds) the seed will be after ripened and germination potential determined in the spring of 2006.
Phase 2: Vegetation species composition and cover on the AFS will be assessed ocularly to the nearest 5%. Maximum lateral spread of *P. hemitomon* away from the AFS structure in each perpendicular direction will be measured to the nearest centimeter. In addition, the presence of submerged and free-floating aquatic vegetation near each AFS will be noted. These measurements will be made quarterly (July, October, January, and April) in the first two years after deployment (starting July 2005) and in October and April the remaining years (starting October 2007).

2. Mat Characteristics

Phase 1, Component 1: Mat thickness and strength will be determined for each AFS that maintains structural integrity after 9 months under controlled conditions (April 2005). Mat thickness will be measured to the nearest cm by cutting 5 sections and measuring the distance from mat surface to the bottom of the mat. Mat strength will be assessed using the Torvane Soil Strength tester (McGinnis, 1997) or similar method.
Phase 2: Mat thickness will be determined to the nearest cm annually in October of all years. This will be accomplished by inserting a ruler through the the mat and leveling it with the bottom of the mat. Mat strength will be determined in the last fall of field deployment (October 2008) using the Torvane Soil Strength tester (McGinnis, 1997) or similar method.

3. Buoyancy

Phase 1, Component 1: Buoyancy of each structure will be classified weekly after all 8 AFS structures have been deployed. Three buoyancy classes will be used: 1. floating at or above the water surface, 2. submerged floating (0 - 15 cm below the water surface), and 3. sunk (structure at bottom of the pond). When the structure is tilted (i.e. with one side of the structure floating and the other side submerged), the buoyancy class of the majority of the structure's surface will be assigned.
Phase 1, Component 2: Root mat buoyancy will be measured on the layered fiber mats at the time of harvest. Buoyancy will be measured by applying a uniform, downward force until the surface of the mat is submerged below the water surface (either with a modified Pesola scale or a set of weights); the greater the force required, the greater the buoyancy (Fisher and Hester unpublished data). Buoyancy will be expressed on an area basis. If mats are not yet fully buoyant at the end of the evaluation period, the depth of flood water over a suspended, neutrally-buoyant mat surface will be used as an

indicator of buoyancy (see Hester and Fisher 2003).
Phase 2: Buoyancy classifications will be made quarterly quarterly (July, October, January, and April) in the first two years after deployment (starting July 2005) and in October and April the remaining years (starting October 2007). Three buoyancy classes will be used as described above. Root mat buoyancy will be measured as described in Phase 1, Component 2 above at the end of field deployment (April 2009).

4. Structural Integrity — *Phase 1, Component 1*: The structural integrity of each AFS will be classified based on visual observations weekly after all 8 AFS structures have been deployed. Using yes or no answers to the following three questions. Is the shape maintained? Do the fasteners show signs of wear and tear? Does the containment fabric show signs of wear and tear? Where possible the source of wear and tear will be identified. For example, if wear and tear is the result of animal activity.
Phase 2: The above questions will be answered quarterly (July, October, January, and April) in the first two years after deployment (starting July 2005) and in October and April the remaining years (starting October 2007).

5. Nutrients — *Phase 1, Component 1:* Nutrient concentrations in the two ponds will be assessed after deployment of the structures. Nutrient samples will be processed using the Coastal Ecology Institute's standard operating procedures for nutrient sampling, which consist of EPA method 353.2 for Nitrate-Nitrite, EPA method 350.1 for Ammonia, and EPA method 365.2 for Phosphorus.
Phase 2: Nutrient concentrations in the areas of field deployment will be assessed at the time of deployment of the structures. Nutrient samples will be processed using the Coastal Ecology Institute's standard operating procedures for nutrient sampling. Nutrients included will be Phosphate, Ammonia, and Nitrate-Nitrite.

<u>Anticipated Hypotheses and Statistical Analyses</u>

The following hypotheses correspond with the monitoring elements and will be used to evaluate the accomplishment of the project goals. All hypotheses will be tested using Analysis of Variance (ANOVA).

Goal 1a: Determine which AFS designs provide structural integrity (including structure and the artificial mat) of sufficient duration to allow the establishment of a floating marsh mat.

Hypothesis: H_o:All of the AFS designs provide the same duration of structural integrity
H_a:Some of the AFS designs provide structural integrity for a longer duration.

- ► If H_o is accepted, this indicates that all of the designs are similarly effective.

- ► If H_a is chosen then tests will be performed that select the most effective designs.

Goal 1b: Determine which AFS designs provide buoyancy of sufficient duration to allow the establishment of a floating marsh mat.

Hypothesis: H_o:All of the AFS designs provide the same buoyancy duration
H_a:Some of the AFS designs provide longer buoyancy duration

- ► If H_o is accepted, this indicates that all of the designs are similarly effective.
- ► If H_a is chosen then tests will be performed that rank the designs based on their effectiveness.

Goal 2a: Determine the combination of flooding, nitrogen level, and phosphorus level that optimizes the above and belowground production of *Panicum hemitomon* biomass.

Factors to be assessed:	Treatment Levels:
Flooding	Saturated, 15 cm water above substrate
Nitrogen	oligotrophic, mesotrophic, high
Phosphorus	oligotrophic, mesotrophic, high

Hypothesis: H_o:All factors do not have any main or interaction effects on production
H_a: Some of the factors have main or interaction effects on production

- ► If H_o is accepted, this indicates that none of the factors have a significant effect on production.
- ► If H_a is chosen then tests will be performed to determine which factor or combination of factors has a significant effect.

a. H_o: Flooding has no effect
H_a: Flooding has a significant effect
b. H_o: Nitrogen has no effect
H_a: Nitrogen has a significant effect
c. H_o: Phosphorus has no effect
H_a: Phosphorus has a significant effect
d. H_o: Interaction of flooding and nitrogen has no effect
H_a: Interaction of flooding and nitrogen has a significant effect
e. H_o: Interaction of flooding and phosphorus has no effect
H_a: Interaction of flooding and phosphorus has a significant effect
f. H_o: Interaction of nitrogen and phosphorus has no effect
H_a: Interaction of nitrogen and phosphorus has a significant effect
g. H_o: Interaction of flooding, nitrogen, and phosphorus has no effect
H_a: Interaction of flooding, nitrogen, and phosphorus has a significant effect

Goal 2b: Determine which substrate material optimizes the above and belowground production of *Panicum hemitomon* biomass.

Hypothesis: H_o:All of the substrate materials provide the same production of biomass
H_a:Some of the substrate materials provide different production of biomass

- If H_o is accepted, this indicates that all of the substrates are similarly effective.
- If H_a is chosen then tests will be performed that select the most effective substrate(s).

Goal 2c: Determine which containment material optimizes the above and belowground production of *Panicum hemitomon* biomass.

Hypothesis: H_o:All of the containment materials provide the same production of biomass
H_a:Some of the containment materials provide different production of biomass

- If H_o is accepted, this indicates that all of the containment materials are similarly effective.
- If H_a is chosen then tests will be performed that select the most effective containment material(s).

Goal 2d: Determine which of four edge expansion species provides for the maximum lateral expansion of *Panicum hemitomon*.

Hypothesis: H_o:All of the species result in the same expansion
H_a:Some of the species result in different expansion

- If H_o is accepted, this indicates that all of the species are similarly effective.
- If H_a is chosen then tests will be performed that select the most effective species.

Goal 2e: Provide a preliminary assessment of the possibility for establishing *Panicum hemitomon* from seed.

Hypothesis: H_o: *Panicum hemitomon* does not have viable seed
H_a: *Panicum hemitomon* has viable seed

- If H_o is accepted, this indicates that no viable seed was found.
- If H_a is chosen then determination will be made to find the percentage of viable seeds.

Goal 3a: Determine which of the three tested AFS designs provides the best establishment of *Panicum hemitomon* under exposed and under sheltered field conditions.

Factors to be assessed:	Treatment Levels:
Design	3 different designs
Exposure	sheltered vs. open

Hypothesis: H_o:All factors do not have any main or interaction effects on establishment
H_a: Some of the factors have main or interaction effects on establishment

- ► If H_o is accepted, this indicates that none of the factors have a significant effect on establishment.
- ► If H_a is chosen then tests will be performed to determine which factor or combination of factors has a significant effect.

a. H_o: Design has no effect
H_a: Design has a significant effect
b. H_o: Exposure has no effect
H_a: Exposure has a significant effect
c. H_o: Interaction of design and exposure has no effect
H_a: Interaction of design and exposure has a significant effect

Goal 3b: Determine which of the three tested AFS designs provides the most cost effective method for floating marsh creation under exposed and under sheltered field conditions.

Factors to be assessed:	Treatment Levels:
Design	3 different designs
Exposure	sheltered vs. open

Hypothesis: H_o:All factors do not have any main or interaction effects on cost effectiveness
H_a: Some of the factors have main or interaction effects on cost effectiveness

- ► If H_o is accepted, this indicates that none of the factors have a significant effect on cost effectiveness.
- ► If H_a is chosen then tests will be performed to determine which factor or combination of factors has a significant effect.

a. H_o: Design has no effect
H_a: Design has a significant effect
b. H_o: Exposure has no effect
H_a: Exposure has a significant effect
c. H_o: Interaction of design and exposure has no effect
H_a: Interaction of design and exposure has a significant effect

Notes

1. Data on factors that may affect creation success such as water depth, water quality (available nitrogen and phosphorus), as well as the distance to the nearest marsh will be measured at the time of field deployment. Slow release fertilizer will be applied to the structures if appropriate based on nutrient availability in the water and the results from component 2.
2. None of the specific goals require a comparison to a reference site. However, at the end of the demonstration vegetation composition and mat thickness of the structures will be compared to CRMS sites as well as published literature.

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Appendix A

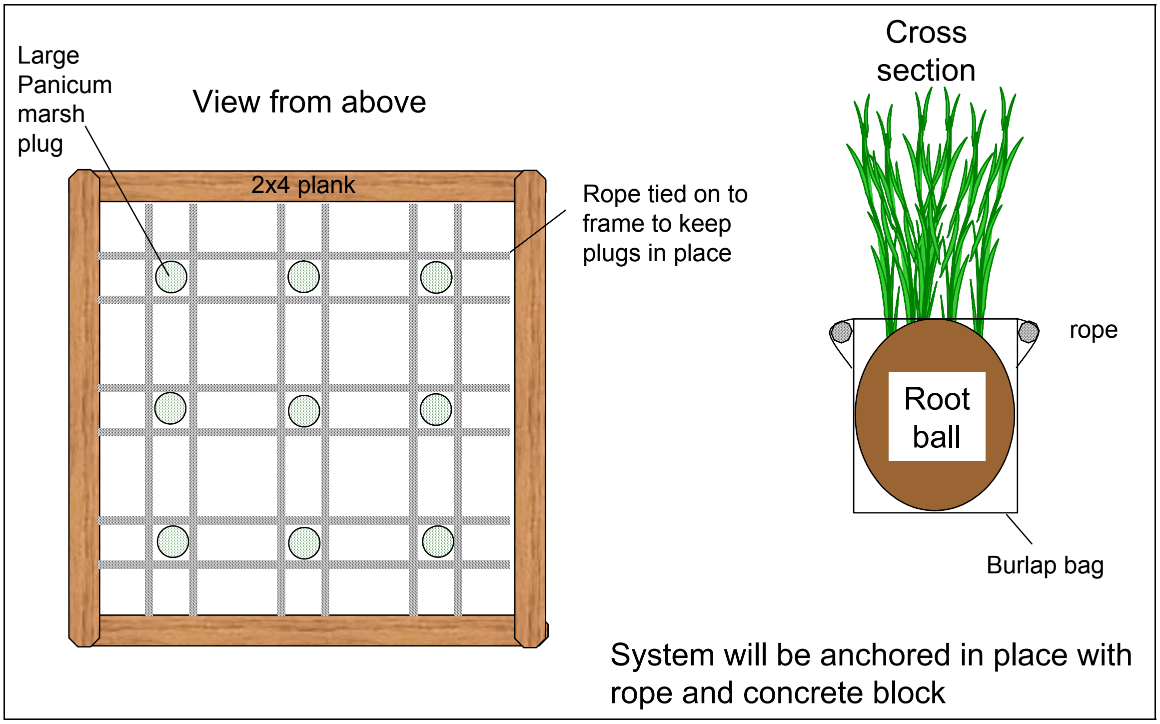

Figure 1a. Design for artificial floating system 1: large plugs. This design will have approximate dimensions of 9.3 m^2 (100 ft^2).

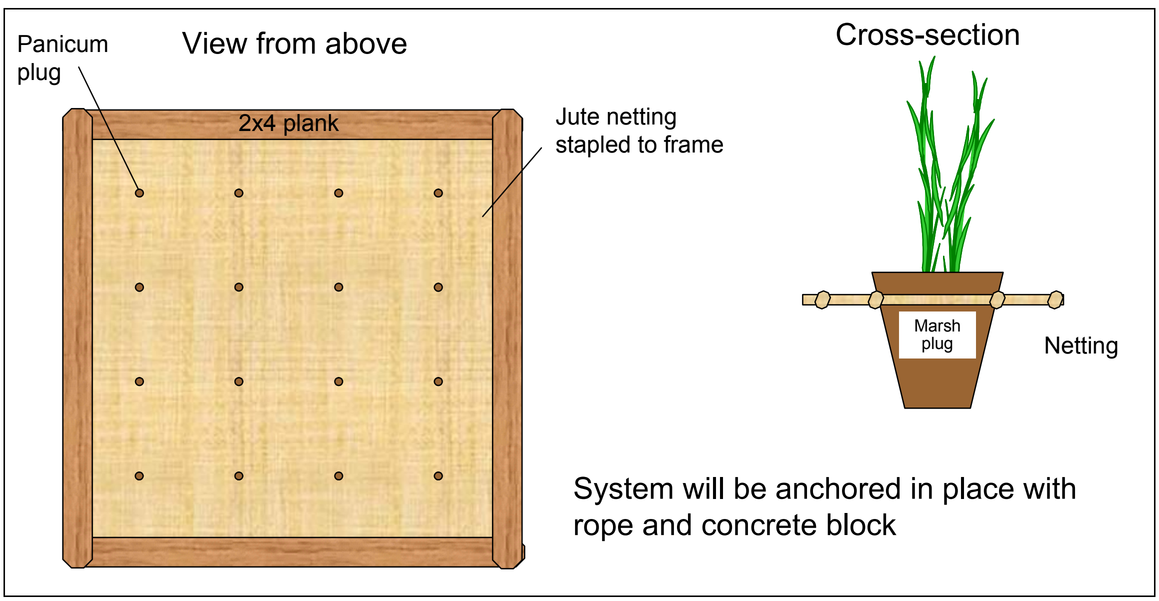

Figure 1b. Design for artificial floating system 2: small plugs. This design will have approximate dimensions of 9.3 m^2 (100 ft^2) and additional bracing of the netting will be applied if necessary.

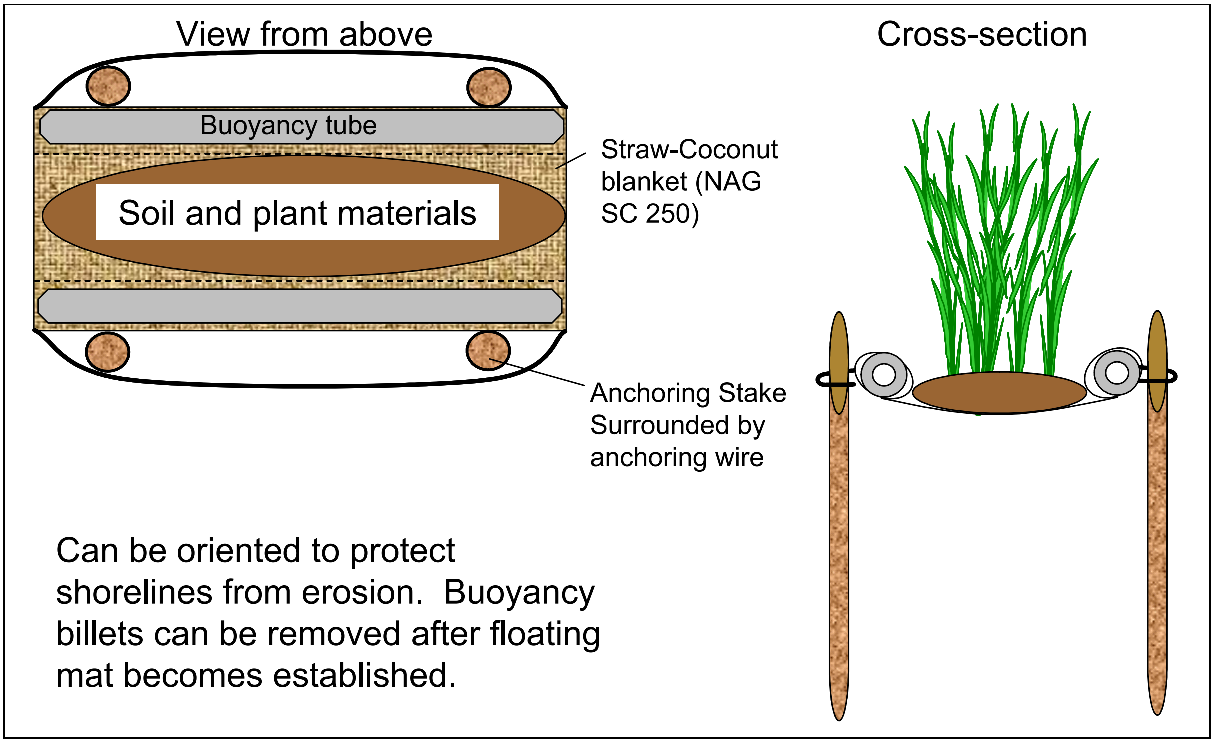

Figure 1c. Design for artificial floating system 3: floating terrace. This design will have approximate dimensions of 2.8 m^2 (30 ft^2). Additional bracing of the blanket will be applied if necessary.

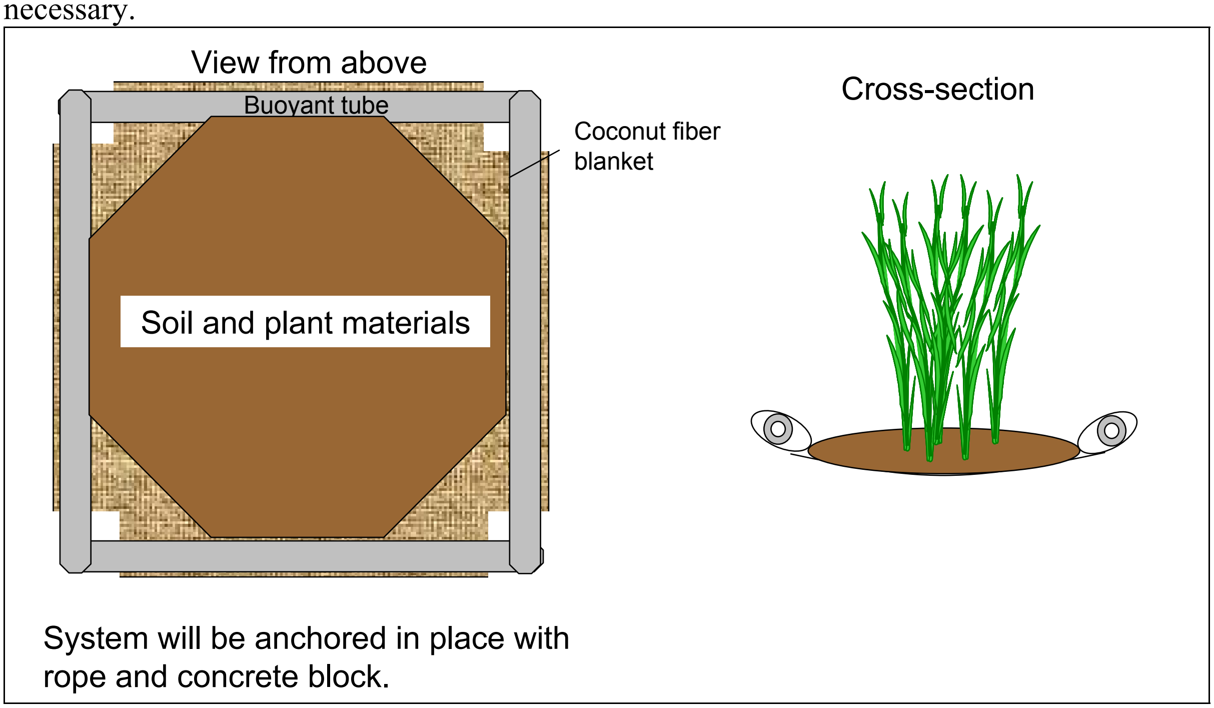

Figure 1d. Design for artificial floating system 4: floating island 1. This design will have approximate dimensions of 9.3 m^2 (100 ft^2). Additional bracing of the coconut blanket will be applied if necessary.

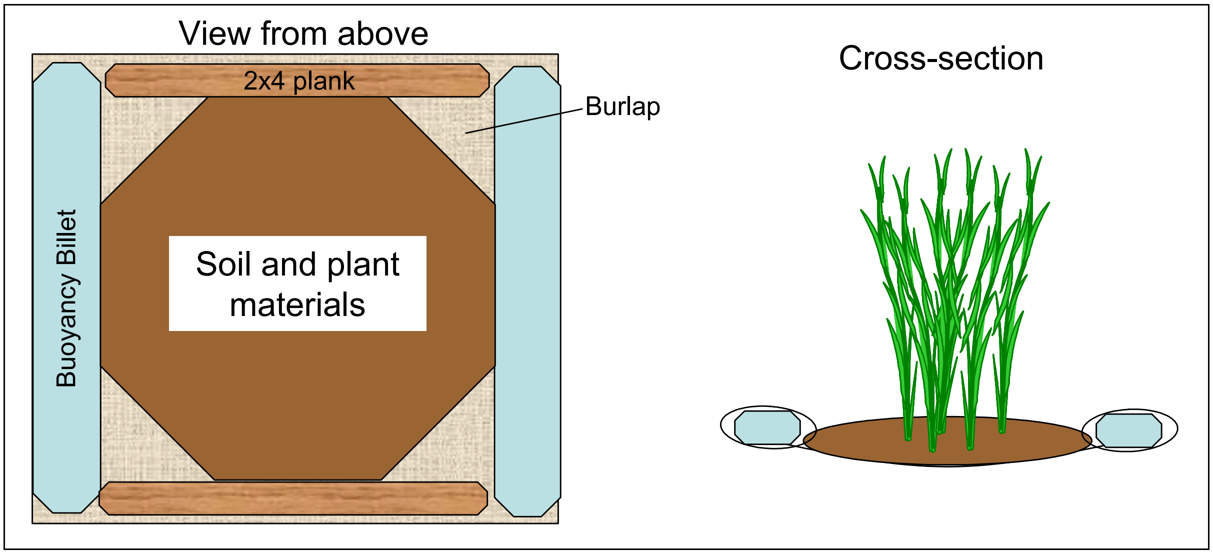

Figure 1e. Design for artificial floating system 5: floating island 2. This design will have approximate dimensions of 7.4 m^2 (80 ft^2). Additional bracing of the burlap will be applied if necessary.

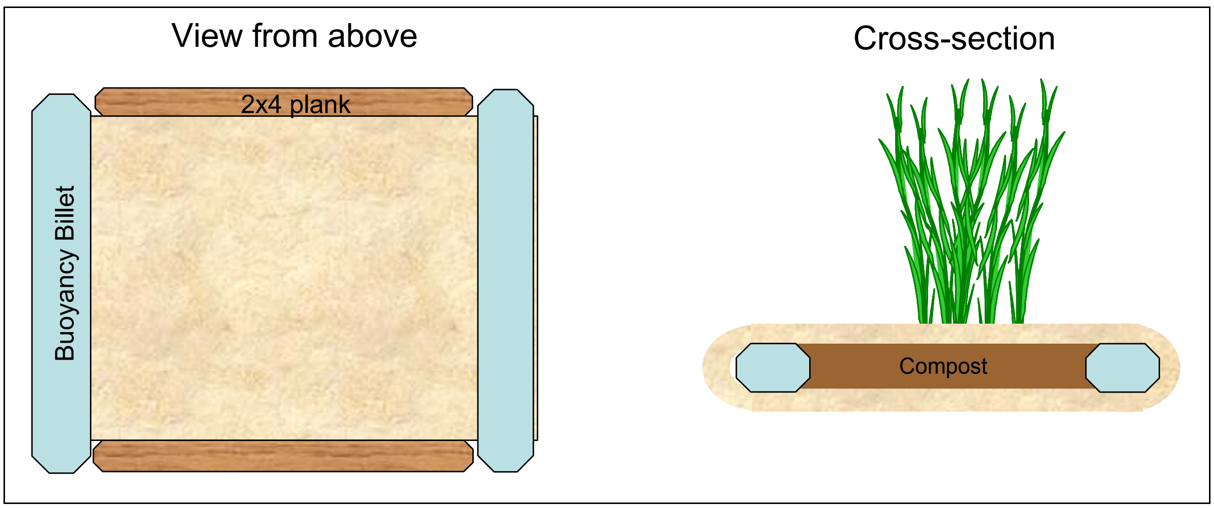

Figure 1f. Design for artificial floating systems 6 and 7: floating mattresses. This design will be tested with two different erosion control blankets. The dimensions of both systems will be approximately 1 m^2 (10.8 ft^2) and the fabrication will be such that multiple units can be attached to one another to create larger areas of floating *P. hemitomon* marsh for field testing.

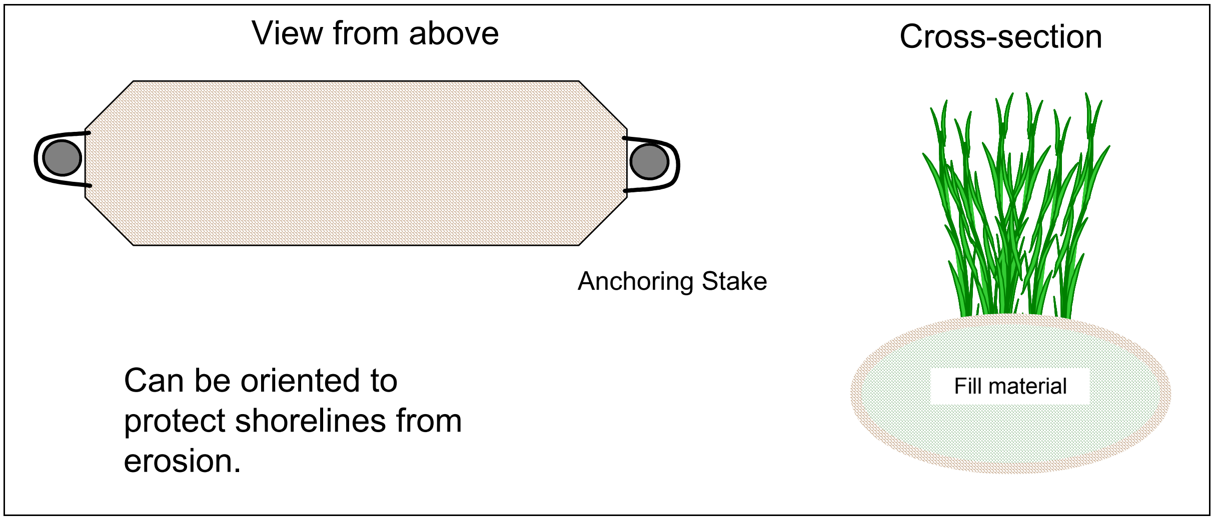

Figure 1g. Design for artificial floating system 8: floating bag. This design will have approximate dimensions of 7.4 m^2 (80 ft^2).