Appendix S
MsCIP Monitoring and Adaptive Management Plan

MISSISSIPPI COASTAL IMPROVEMENTS PROGRAM

Comprehensive Barrier Island Restoration

Monitoring and Adaptive Management Plan

January 6, 2016

MsCIP

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1.0 Introduction

The Mississippi barrier islands are dynamic coastal landforms that are the first line of defense between the Gulf of Mexico and the Mississippi mainland coast. The Mississippi barrier islands are experiencing changes in island landform (land area and habitat) and processes (erosion and accretion) due to frequent intense storms, relative rise in sea level, changes in sediment supply associated with inlet hydraulics, channel configuration, and shoal dynamics (Byrnes *et al.*, 2012). Long-term loss of these barrier islands threatens the highly productive Mississippi Sound estuarine ecosystem and exposes mainland Mississippi Gulf Coast and its associated wetland habitats to increasing saltwater intrusion and damage from future tropical storms.

In 2005, Hurricane Katrina caused widespread damage along the Mississippi Gulf Coast. Soon after Hurricane Katrina, the notion became widely accepted by the public that if the Mississippi barrier islands had been in a "pre-Hurricane Camille" condition, there would have been much less storm damage from Hurricane Katrina. Hurricane Camille (1969) caused extensive land loss on the barrier islands, and little natural recovery has occurred since then. In 2009, in response to the Department of Defense Appropriation Act of 2006 (P.L. 109-148) the Mississippi Coastal Improvement Program (MsCIP) was developed by the U.S. Army Corps of Engineers (USACE), Mobile District in conjunction with other Federal and State agencies, to help reduce future storm damage along the Mississippi Gulf Coast. As part of a Comprehensive Plan, the Mississippi barrier island system was evaluated with the overall goal of restoring the natural ability of the barrier island system to reduce the impact of hurricanes traversing the Mississippi Gulf coast. The USACE, Mobile District, proposes restoration of sediment to the system to preserve and protect the Mississippi barrier islands and in turn the Mississippi Sound and the Mississippi mainland.

Since the proposed restoration of a portion of the Mississippi barrier islands and change in placement of dredged-material disposal at Horn Island Pass may influence regional conditions, a Monitoring and Adaptive Management (MAM) Program will be implemented before, during, and after project construction. Such monitoring will allow the USACE, Mobile District to assess restoration progress relative to short- and long-term effects to the barrier island system. Furthermore, the monitoring will provide the necessary information to adjust project performance through adaptive management (AM), if necessary and possible, to better meet project goals and objectives, and will ultimately provide information to better design and maintain coastal resources in the future.

This MAM Plan describes the monitoring design proposed to evaluate progress towards meeting project goals and objectives, describes the organizational structure for the MAM process, identifies key uncertainties, provides potential AM actions, and provides time and cost estimates that will be used to guide project planning, implementation, and performance. Many factors such as ecosystem dynamics, engineering applications, institutional requirements, and other key uncertainties can change and/or evolve over a project's life. The MAM Plan is a living document and will be regularly updated to reflect monitoring-acquired and other new information as well as resolution of and progress on resolving and/or discovery of key uncertainties and lessons learned to help with management of coastal resources.

1.1 Introduction to Monitoring and Adaptive Management

Adaptive management is distinguished from traditional long-term monitoring in part through implementation of an organized, coherent, and documented decision process. Important aspects of the AM process lie in exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on the current state of knowledge, implementing one or more alternatives, and establishing a feedback mechanism whereby monitored conditions may be used to update the knowledge base and adjust management actions to refine and/or better achieve project goals and objectives. The definition of AM used for the MsCIP program is adopted from the National Research Council, Adaptive Management for Water Resources Project Planning, 2004:

> *"Adaptive management promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a "trial and error" process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders."*

Learning from the AM experience is certainly not a new idea; but the purposeful and systematic pursuit of knowledge to address identified uncertainties has rarely been practiced. Adaptive management acknowledges the uncertainty about how ecological systems function and how they may respond to management actions. Nevertheless, AM is not a random trial-and-error process; it is not ad-hoc or simply reactionary. An essential element of AM is the development and execution of a monitoring and assessment program to analyze and understand responses of the system to implementation of the project.

The MsCIP MAM program will be developed and used to:

- Allow scientists and managers to collaboratively design plans for managing complex and partially understood ecological systems.
- Reduce uncertainty over time.
  - Acknowledgement, identification, and characterization of risks and uncertainties.
  - Uncertainty can be analyzed and exploited to identify key gaps in information and understanding.
- Implement systematic monitoring of outcomes and impacts.
  - Scientific information obtained through continued monitoring is used to evaluate and manage uncertainties to achieve desired goals and objectives.
  - Explicitly stated goals and measurable indicators of progress toward those goals.
  - Demonstrate to others that the project is meeting or exceeding performance goals and achieves "ecological success" as required by USACE (See Section 1.2).
  - Detect beneficial and detrimental system responses as early as possible to quantify the effects of these responses.
  - Evaluate hypotheses and performance measures and revise conceptual ecological models as appropriate.
- Incorporate an iterative approach to decision-making.
  - The monitoring data is used to influence future management decisions.
  - Feedback loops are developed so that monitoring and assessment produce continuous and systematic learning that in turn is incorporated into subsequent decision-making.
  - Management flexibility is incorporated in the design and implementation of programs or projects.

  - Projects and programs can be implemented in phases to allow for course corrections based on new information.
- Provide a basis for identifying options for improvements in the design, construction and/or operation of MsCIP projects and components through AM.
- Develop reports on the status and progress of the MsCIP Barrier Island Restoration for the agencies involved, the public, Congress, and stakeholders.
- Enhance predictive capability through improvements in simulation models before and after project construction.
- Provide information to summarize and develop lessons learned to optimize barrier island restoration strategies in the future; "lessons learned".
- Ensure interagency collaboration and productive stakeholder participation. AM encourages defining agency objectives for stakeholder involvement, deciding upon a strategy for stakeholder involvement, clearly communicating this to the public, and maintaining long-term collaboration among stakeholders. Continued communication with key stakeholders helps identify and reduce socio-economic uncertainties, measure project progress towards objectives, and adaptively manage projects (Knight *et al*., 2008, Smith *et al*., 2009, Nkhata and Breen 2010).

Monitoring and Adaptive Management Process

The developed MAM program and process is complimentary to the USACE Project Life Cycle (planning, design, construction and operation and maintenance). The MAM process is not elaborate or duplicative and enhances activities that already take place. The basic process of MAM for USACE projects (Figure 1), was adapted from the DRAFT USACE Adaptive Management Technical Guide (USACE 2011) and includes:

Planning a program or project

Designing the corresponding project

Building the project (construction and implementation)

Operating and maintaining the project and

Monitoring and **assessing** the project performance

Continue project implementation as originally designed or

Adjust the project if goals and objectives are not being achieved

Complete project if goals and objectives and **success** criteria are achieved, or it is determined the project has **success**fully produced the desired outcomes

Project **Termination** is possible if project goals and objectives are not being achieved and the decision is made not to adjust the project or no adjustments are possible

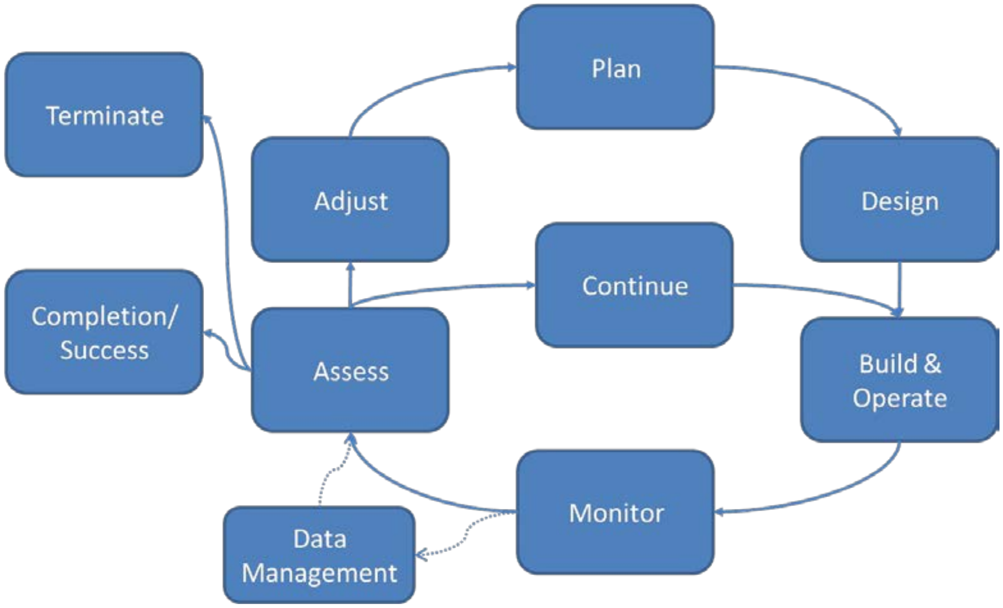

Figure 1. Monitoring and Adaptive Management process for the USACE Civil Works.

1.2 Authorization for Monitoring and Adaptive Management

Section 2039 of the Water Resources Development Act (WRDA) of 2007 and Implementation guidance for Section 2039, in the form of a CECW-PB Memo dated 31 August 2009, require ecosystem restoration projects to develop a plan for monitoring the success of the ecosystem restoration and to develop an AM Plan (contingency plan). See Appendix B.

1.2.1 Monitoring Plan

- The plan must specify nature, duration, and periodicity of monitoring, disposition of monitoring and analysis, costs, and responsibilities.
- Scope and duration should include the minimum monitoring actions necessary to evaluate success.
- Success is determined by an evaluation of predicted outcomes compared to actual results.
- Monitoring plan has been reviewed during Agency Technical Review (ATR).
- Monitoring will be continued until "ecological success" is documented by the USACE in consultation with Federal and state resource agencies.
- Monitoring costs must be included as part of the project cost and cannot increase the Federal cost beyond the authorized dollar limit. Monitoring can end sooner if success is determined.
- Funding for monitoring beyond 10 years post construction is a 100% non-MsCIP responsibility.

1.2.2 Adaptive Management/Contingency Plan

- Adaptive management plan must be appropriately scoped to project scale.
- The rationale and cost of AM and anticipated adjustments will be reviewed as part of the decision document.
- Significant changes needed to achieve ecological success that can't be addressed through operational changes or the AM plan may be examined under other authorities.
- Costly AM plans may lead to re-evaluation of the project.

1.3 Program Structure for Implementation of Monitoring & Adaptive Management

A program implementation structure has been identified (Figure 2) to execute a MAM program for MsCIP. The structure establishes lines of communication that facilitates coordination between Program Management, Adaptive Management and Monitoring Oversight Committee, Technical Advisory Group, Data Management and stakeholders.

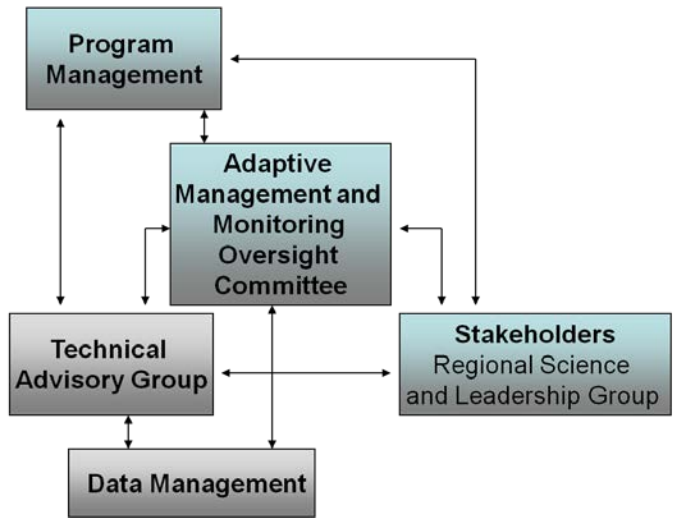

Figure 2. Program Structure for MsCIP Monitoring and Adaptive Management.

1.3.1 Program Management Team

The MsCIP Program Management Team consists of senior leaders from the USACE, Mobile District, the Mississippi Departments of Marine Resources (MDMR) and Environmental Quality (MDEQ), and the National Park Service (NPS) (Appendix C). The Program Management Team will vet MAM program issues, and consider recommendations for AM or monitoring actions from the Adaptive Management and Monitoring Program Oversight Committee, the Technical Advisory Group (TAG), the Data Management Team and the Regional Science and Leadership Group (RSLG). The Program Management Team will make determinations of whether monitoring or AM actions are required. In accordance with Section 2039 of the 2007 Water Resources Development Act, the Program Management team will coordinate with the USACE Mobile District Commander and the South Atlantic Division (SAD) Commander once a determination has been made that operational and/or structural changes (AM) may be needed to ensure that the ecosystem restoration project meets specified success criteria. Likewise, the Program Management Team will coordinate with the USACE District Commander and the SAD Commander for final determination that project success has been achieved and to cease monitoring efforts.

1.3.2 Adaptive Management and Monitoring Program Oversight Committee

The Adaptive Management and Monitoring Program Oversight Committee will report to the MsCIP Program Management team, and provide progress reports as necessary on the status of monitoring efforts and project results. A list of these team members is provided in Appendix C. The Committee will:

- provide recommendations regarding the need for AM actions to better meet expected restoration goals and objectives.

- identify additional monitoring or AM program requirements and set priorities for the TAG, as needed.
- work with the TAG to establish the MAM program and to develop and coordinate the individual MAM plans.
- be responsible for administrating the implementation of AM, monitoring and assessment processes detailed in the MAM plans.
- ensure that the monitoring data and assessments being produced are properly used to determine project success and to inform future decision-making.
- lead the effort to compile lessons learned from the MAM program and to assist the Program Management Team in making the best possible decisions regarding future design and implementation strategies.
- coordinate with other Gulf of Mexico/regional restoration efforts including but not limited to Revived Economies of the Gulf Coast States Act (RESTORE Act), Natural Resource Damage Assessment (NRDA), Louisiana Coastal Area (LCA), and Alabama and Louisiana State Planning Efforts.

1.3.3 Technical Advisory Group

The TAG will be involved in the pre-construction, during-construction, and post-construction MAM activities. The purpose of the TAG is to bring together the necessary technical experts to develop monitoring and assessment protocols required to determine whether performance measures have been met and ecological success has been achieved. During pre-construction, the TAG will:

- document the methods, procedures, and monitoring sampling design necessary to evaluate ecological success.
- develop the potential AM processes that could be implemented if the project is not performing as expected.
- coordinate with and leverage other monitoring efforts where possible (i.e. US Geological Survey [USGS] Barrier Island Evolution Research [BIER] Project) to reduce MsCIP monitoring costs and design an approach consistent with other ongoing monitoring efforts.
- develop a conceptual ecological model (CEM) for the Barrier Island Ecosystem (using existing information where possible) including development of performance measures, success criteria and triggers which will be used to evaluate project performance. The developed CEM is further described in Section 2.1.1 and presented in Appendix F. Success criteria and triggers have been identified and included in Section 3 and 6.
- develop the specific details of the protocols for processing, analyzing, and summarizing the data collected through the MAM Plan.
- develop the methodology for assessments to evaluate project restoration progress and to determine if AM is needed; including identification of potential AM actions should a contingency plan be needed.

In addition to the pre-construction planning activities, the TAG will:

- be involved during and post construction, as the MAM plans are implemented and the project is monitored and assessed to understand the responses of the system to project implementation and relative to the established performance measures.
- work with the Oversight Committee to ensure that all monitoring data collection, processing, and analysis are consistent and in accordance with protocols developed in the MAM Plan.

More specifically, the TAG will be responsible for actual project performance assessment and interpreting that performance based on data analyses.

- produce periodic reports that measure progress towards project goals and objectives and make recommendations to the Oversight Committee and Program Team to improve MAM Plan performance.

Technical Advisory Group Members

The TAG is divided into Official and Reach-back members. The Official TAG members will be responsible for producing the MAM plan. A subset of the Official Team is a core team that will be responsible for initially drafting work products and sending draft products to the rest of the Official Team for review, as well as providing comments and additional input as necessary. Reach-back members are a potential technical expert resource that may be needed and will be brought in as necessary to support Core and Official team members. A list of TAG members is provided in Appendix C.

At this time TAG members have been identified for involvement in the necessary pre-construction planning activities. Additional members may be brought in to supplement the existing TAG once the project moves into the implementation/construction phase.

1.3.4 Data Management Team

A Data Management Team has been developed to facilitate the management of data and information available for the MsCIP program. This includes data collected directly for the MsCIP program and by outside agencies and organizations in support of the program, includes historical datasets, ongoing monitoring collections and new data collections generated from the MAM program. The Data Management Team has representation on the TAG and will develop the data standards for inclusion in the MAM Plan (Section 4.0). The Data Management Team will:

- develop and provide the decision-support tools necessary to compare historical trends and management strategies with MsCIP project restoration.
- incorporate transparency into data and information delivery and visualizations, and this will facilitate determinations of restoration progress, adjustments to restoration strategies as needed, and demonstrations of lessons learned.

A list of Data Management Team members is provided in Appendix C.

1.3.5 Regional Science and Leadership Group

The RSLG is a multi-agency and multi-disciplinary group of Federal and state resource agencies and stakeholders who are involved in the MsCIP program. In addition to those listed below, the members of the Program Management, Oversight Committee, TAG, and Data Management Team will also participate on the RSLG which will:

- provide peer review on the project monitoring results.
- review MAM deliverables produced by the Oversight Committee, TAG and Data Management Team.

The broad membership of the RSLG aims to facilitate coordination with other regional restoration efforts (such as Resources and Ecosystems Sustainability, Tourist Opportunities and RESTORE Act, NRDA, etc). A list of RSLG members is provided in Appendix C.

2.0 Monitoring and Adaptive Management Planning

An interagency team with members from the USACE, Mobile District, NPS, MDEQ, MDMR, US Fish and Wildlife Service (USFWS), USGS, and Applied Coastal Research and Engineering developed the MAM plan for the comprehensive barrier island restoration component of MsCIP. The actual scope of the MsCIP MAM Plan is based on project complexity, project uncertainties, flexibility in potential management options, and the stage of project development. The MAM Plan will be implemented during pre-construction, project-construction, and post-construction phases and will be updated regularly to reflect new information, including significant progress or resolution of recognized uncertainties, as well as any new uncertainties that might emerge during and following project construction.

2.1 Monitoring and Adaptive Management Program Set-up Phase

The MAM Program includes a Set-up Phase (Figure 3) and an Implementation Phase (Section 2.2). The Set-up Phase proceeds concurrently with the planning process. While planners are identifying problems and opportunities, inventorying and forecasting resource conditions, evaluating and comparing alternative formulations, and selecting a plan, the MAM Plan for the project will be developed. In addition to items developed during the planning process, a CEM will be developed; uncertainties will be identified; and performance measures, targets, and decision criteria (triggers) will be established.

Engagement with stakeholders throughout project planning and implementation phases is critical to developing and maintaining common understandings of the goals and objectives, expectations of results, and potential commitment of resources. All phases of the MAM process must be open, transparent, and accessible to stakeholders. Such interaction fosters the mutual understanding of events and appreciation of the time and patience required to fully realize the benefits of restoration projects and to manage unrealized expectations. A strong effort must be made to identify and engage all appropriate stakeholders. Project teams should continually seek to identify governmental and non-governmental organizations, groups and other interested parties who could affect, be affected by, and/or be able to contribute knowledge, data, and/or resources to project-related activities (e.g., planning, design, implementation, and monitoring).

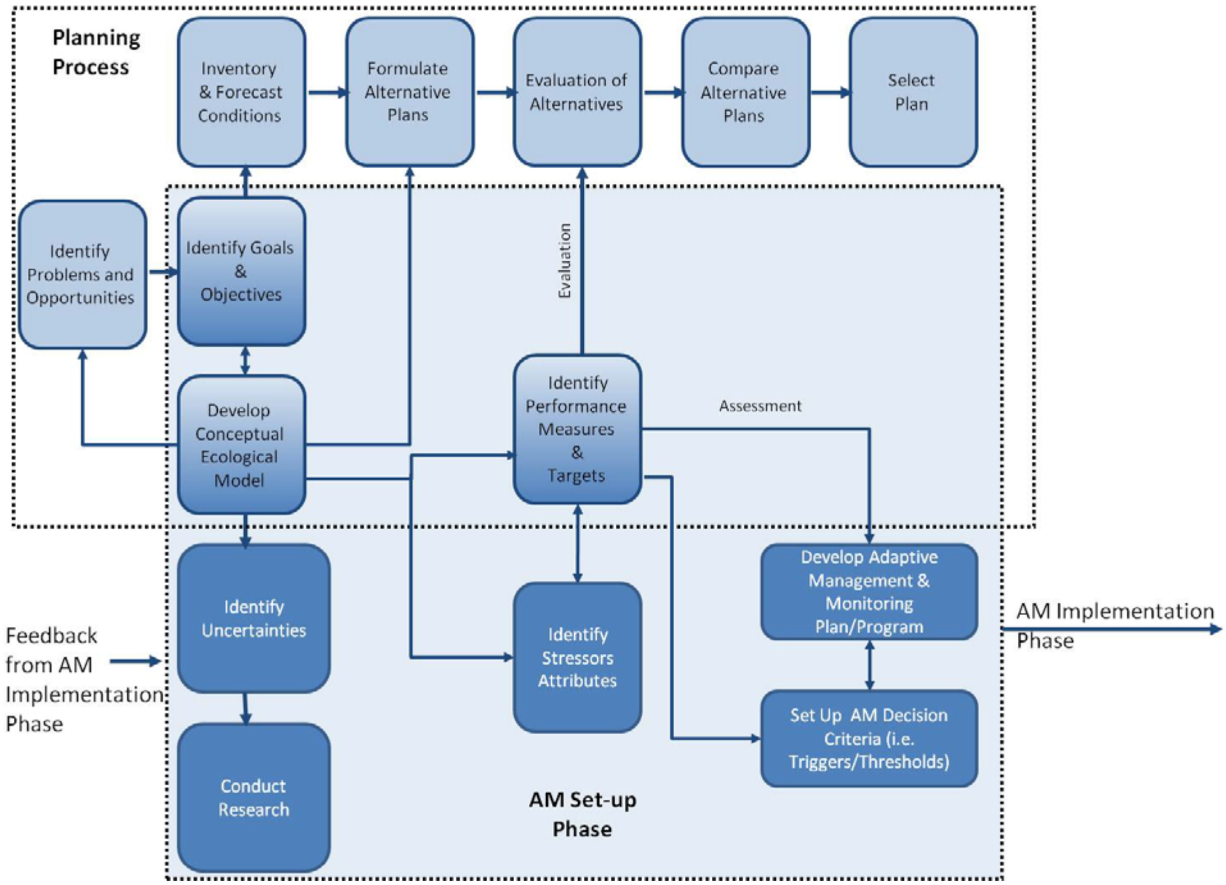

Figure 3. Monitoring and Adaptive Management Program Set-up Phase.

2.1.1 Conceptual Ecological Model

As part of the monitoring and AM planning process, a CEM (Appendix F) was developed to help explain the general functional relationships among the essential components of the barrier island ecosystem. CEMs are a means of:

(1) simplifying complex ecological relationships by organizing information and clearly depicting system components and interactions;
(2) integrating to more comprehensively implicit ecosystem dynamics;
(3) identifying which attributes will show ecosystem response;
(4) interpreting and tracking changes in restoration/management targets; and
(5) communicating these findings in multiple formats.

This CEM assists with identifying those aspects where the project can effect change. Specifically, the CEM identifies those major stressors, ecosystem drivers, and critical thresholds of ecological processes and attributes of the natural system likely to respond to restoration features. The barrier island CEM, together with a structured decision analysis process described in Section 6, will be used to help confirm objectives, identify problems, opportunities, uncertainties, and select those attributes to be used as performance measures for monitoring. The CEM represents the current understanding of these factors and will be updated and modified, as necessary, as new information becomes available to assist with developing monitoring and AM during project planning and implementation.

Factors identified for the MsCIP Barrier Island project are listed below and further detailed in Appendix F.

Drivers

- D1: Coastal Processes
- D2: Acute Events
- D3: Anthropogenic Activities

Stressors

- ES1: Littoral Sediment Transport
- ES2: Relative Sea Level
- ES3: Current and Tides
- ES4: Winds and Waves
- ES5: Storms
- ES6: Restoration
- ES7: Oil Spills
- ES8: Channel Dredging/Placement
- ES9: Human Use
- ES10: Cultural Resources

Effects

- ES1: Land Loss/Gain
- ES2: Biological Composition (community or species change)
- ES3: Elevation Change
- ES4: Habitat Alteration
- ES5: Altered Sediment Transport
- ES6: Altered Circulation

Attribute

- A1: Habitat Cover of Emergent and Submerged Land
- A2: Habitat Diversity of Emergent and Submerged Land
- A3: Species of Concern
- A4: Island Morphology
- A5: Water Quality
- A6: Cultural Resources

Performance Measures

- PM1: Shoreline/Island Response (Aerial and Subaerial)
- PM 2: Water Circulation
- PM 3: Habitat Composition and Utilization
- PM 4: Sedimentation/Shoaling
- PM 5: Species Diversity, Abundance and Distribution
- PM 6: Salinity, Turbidity, Dissolved Oxygen

2.1.2 Goals and Objectives

In accordance with specific authorizations, prior reports, and collaborative interactions with stakeholders, the USACE, Mobile District defines restoration goals to achieve or resolve the identified problems, needs, opportunities, and agreed upon desired future conditions. The goals and objectives developed for project planning play a crucial role after project implementation in evaluating constructed project performance, reducing uncertainty, improving AM actions, and determining project success. Therefore, it is important to have clear, measurable, and agreed upon goals and objectives at the outset. To be useful for the MAM Program, a guide for project assessment and decision making, and consistent with Engineering Regulation 1105-2-100, Planning Guidance Notebook, objectives should be specific, measureable, and applicable over a specific time frame.

The overarching goal of barrier island restoration for MsCIP is environmental sustainability. This includes sustaining cultural resources and estuarine habitat in the Mississippi Sound by restoring barrier island habitat and augmenting natural sediment transport quantities prior to breaching and inlet formation along Ship Island.

The objectives for barrier island restoration for MsCIP are to:

- Maintain the estuarine ecosystem and resources of the Mississippi Sound.
- Preserve the natural and cultural resources of the Mississippi barrier islands.
- Restore the barrier islands structure to reduce storm damage impacts on the mainland coast of Mississippi.
- Enhance the long-term littoral drift system for the Mississippi barrier islands.

2.1.3 Restoration Actions

From west to east, the islands of the Mississippi Barrier Island system are Cat Island, West Ship Island, East Ship Island, Horn Island, Petit Bois Island, and Dauphin Island (Figure 4). Sand Island (Disposal Area 10) was artificially created from dredged material placement of littoral sand removed from Horn Island Pass. Major inlets within the island system are Ship Island Pass, Little Dog Keys Pass, Dog Keys Pass, Horn Island Pass, and Petit Bois Pass.

The USACE, Mobile District proposes to restore a portion of the Mississippi barrier islands through placement of sand at and adjacent to Camille Cut to connect East and West Ship Islands and augment sediment to the updrift system along East Ship Island. Additional sand has been placed on the northern shore of West Ship Island around Fort Massachusetts and beach restoration is planned for Cat Island. Additionally, future placement of dredged material adjacent to Horn Island Pass will be in a manner that will enhance the natural transport of dredged material to Horn Island.

Figure 4. Project Area Map

Ship Island Restoration

The Ship Island restoration component would be constructed in five phases. Four of the phases would consist of dredging and placement activities and the fifth phase would consist of dune planting on the newly restored Ship Island. Phases 3, 4, and 5 would be constructed concurrently. Work being performed under Phases 3 and 4 would be completed at different locations (i.e., Camille Cut and East Ship Island). Work completed under Phases 3 and 5 would occur in the same location (i.e. Camille Cut), but Phase 5 would begin approximately 2 months after Phase 3 begins, to allow for the Phase 5 effort to occur on the portion of the Phase 3 work that would have already been completed. It is estimated that the five phases would be completed over a period of 2.5 years. Each phase is detailed below:

- Phase 1 calls for approximately 6.0 million cubic yards (mcy) of sand for construction of the initial berm across Camille Cut and approximately 0.8 mcy for construction of a portion of the berm on East Ship Island. The East Ship Island berm would be constructed adjacent to the Camille Cut berm along the west end of the southern shoreline of East Ship Island. It would serve as a feeder source for Camille Cut until the remaining portion of the East Ship Island berm is constructed under Phase 3. It is estimated that Phase 1 would be completed over a period of 15 months.
- Phase 2 calls for approximately 5.0 mcy of additional sand to raise and widen the template at Camille Cut. Work under Phase 2 is expected to begin immediately upon completion of Phase 1, and is estimated to take approximately ten months to complete.
- Phase 3 consists of restoring the southern shoreline of East Ship Island. Approximately 4.2 mcy of sand would be placed to extend and expand the initial East Ship Island berm constructed in Phase 1 and complete the restoration of the southern shoreline of East Ship Island. It is estimated that Phase 3 would be completed over a period of 7 months.

- Phase 4 consists of placing approximately 1.1 mcy of sand in the interior portion of the Camille Cut berm. The work is estimated to take approximately five months to complete. Due to its finer grain size, material from the Ship Island borrow area will be used as a cap on the Camille Cut fill section to facilitate establishment of dune vegetation.
- Phase 5 consists of planting the Camille Cut restoration berm with native dune vegetation. The newly created island segment would be planted with native dune vegetation, including sea oats (*Uniola paniculata*), gulf bluestem (*Schizachyrium maritimum*), and or other grasses and forbs, to restore stable dune habitat. Planting would include vegetation similar to that found in the existing coastal habitats. It is estimated that Phase 5 would be completed over a period of 7 months.

<u>Cat Island Restoration</u>

Restoration work at Cat Island would be conducted in one phase, over approximately 6 months. Cat Island restoration consists of placement of an estimated 2 mcy of sand along the eastern shoreline. The material would be pumped onto the beach and shaped using land-based equipment. The construction profile is expected to adjust rapidly through the erosion of the upper profile, and mimic the natural nearshore profile once it reaches equilibrium. The total equilibrated fill area encompasses approximately 305 acres. Following placement, the area would be vegetated with native dune vegetation.

The portion of Cat Island to be restored was acquired by BP following the Deepwater Horizon incident to allow for the ease of clean-up. The restoration will not begin until the property is under public ownership.

Restoration work at Cat Island would be accomplished under a separate contract, but the timing of the construction could occur concurrently with the Ship Island Restoration efforts.

2.1.4 Uncertainties

A fundamental tenet underlying AM is decision-making and achieving desired project outcomes in the face of uncertainties. The MAM Program provides a framework for identifying, analyzing, and managing uncertainties for the MsCIP Barrier Island Restoration program. Scientific uncertainties and technological challenges are inherent with any large-scale restoration project with the principal sources of uncertainty typically including (1) incomplete description and understanding of relevant ecosystem structure and function, (2) imprecise relationships between project management actions and corresponding outcomes, (3) engineering challenges in implementing project alternatives, and (4) ambiguous management and decision-making processes. It is important to determine the type of risk each uncertainty comprises and to discern what constitutes sufficient knowledge to proceed considering those risks.

Identified uncertainties associated with the restoration of the Mississippi barrier islands include:

- Natural variability in ecological and physical processes. Geomorphic variability and barrier island evolution.
- Life expectancy of the barrier island system without restoration.
- The long-term fate of placed material.
- Climate change variability, such as tropical cyclone frequency, intensity, and timing.
- Climate change effects in redistributing sand placed as part of the project.

- Future rate of relative sea level rise (subsidence plus eustatic variability), how much sea level will rise at the barrier islands, whether the rate of rise will be relatively constant or accelerate and the island's response.
- Gulf sturgeon population utilization of adjacent passes after closure of Camille Cut.
- Bird species utilization of existing low lying spits on the west and east tips for feeding, resting, and roosting after fill placement at Camille Cut and East Ship Island.
- Projected recovery time and recruitment for benthic invertebrates.
- Effectiveness of protection of existing submerged aquatic vegetation (SAV) and wetland habitat in the lee East Ship and Camille Cut after restoration.
- Water quality variability (e.g., salinity) in the lee East Ship and Camille Cut after restoration.
- Sediment utilization if impacts occur to historic and cultural resources from storms.
- Borrow area impacts to sediment transport processes.
- The hydrology of West and East Ship islands, potential effects on wetlands, and island hydrology from the placement of sediment.

Ultimately, identifying and analyzing uncertainties and their associated risks allows the project team to discern what constitutes sufficient knowledge to proceed with a proposed course of action or how best to adaptively manage. The project team has evaluated these uncertainties and the risks and determined they are outweighed by the potential benefits of moving ahead. As additional information is received and existing uncertainties and risks are minimized or new uncertainties arise, this list will be updated and the project re-evaluated based on the revised uncertainty list.

2.1.5 Performance Measures, Decision Criteria, Success Criteria and Adaptive Management Triggers

Performance measures (PM) are indicators of progress toward a goal, objective, or target and the desired outcomes of program and project implementation (Fischenich et al., 2012). Selection of performance measures is based on project goals, objectives, and the CEM which identifies potential stressors and drivers, providing a context for monitoring or tracking them as funds allow. In most AM frameworks, performance measures are utilized to assess project outcomes, and modify project performance. PMs should:

(1) be measurable;

(2) have a relatively strong degree of predictability (*i.e*., targets specified by predictive models or by best professional judgment);

(3) be sensitive enough to change in response to project implementation; and

(4) verify progress and evaluate hypotheses through monitoring and assessment (Fischenich *et al*., 2012).

See Section 3.1 for the performance measures developed through the MAM planning process including the justifications for their selection.

Restoration targets for each performance measure are used to develop thresholds that serve as **Decision Criteria** to determine whether restoration success has been met (see “Success Criteria” description) or adjustments are needed (see “AM triggers” description). Decision Criteria are specific values of monitored parameters used in evaluating program and project performance. These criteria can be based on reference sites, predicted values, or comparison to historical conditions. They can be qualitative or quantitative based on the nature of the performance measure and the level of information necessary to make a decision. The management options in response to the criteria can be adjusted over time as resource conditions change and understanding evolves.

- **AM triggers** are thresholds that are used to determine the need for a corrective action. These criteria are used to determine if monitoring results support continued implementation of the project as designed or if AM actions should be undertaken. AM triggers should be developed for performance measures, so that performance hypotheses about project outcomes can be evaluated to determine if adjustments are needed in management measures (Fischenich *et al*., 2012).

- **Success Criteria** are used to assess project performance and the trajectory of ecological progress. Ultimately, success criteria will be used to help determine when ecological success has been achieved and determine whether monitoring may cease prior to the 10 year post construction monitoring period. Project success criteria have been identified based on the project objectives and performance measures and are included in Section 3.0 of this plan.

  Interim Targets were developed concurrently with development of the success criteria and are included in Section 3. Interim targets are a means for evaluating progress towards meeting the success criteria on a shorter time scale. A time period less than the 10 year post construction monitoring period is identified to determine with trend of restoration progress; e.g. what would be expected at year 3 or 5 if restoration is progressing as planned. AM actions could be needed to adjust the project if an interim target is not met.

2.2 Monitoring and Adaptive Management Program Implementation Phase

While the AM Set-up phase includes planning, the implementation phase puts the MAM Plans into action (Figure 5). Projects will be designed, constructed, monitored, and assessed relative to stated hypotheses and evaluated relative to established performance measures, decision criteria, targets, and triggers. The Program Team will decide whether to alter the project and implement AM actions to improve plan performance based on assessment results.

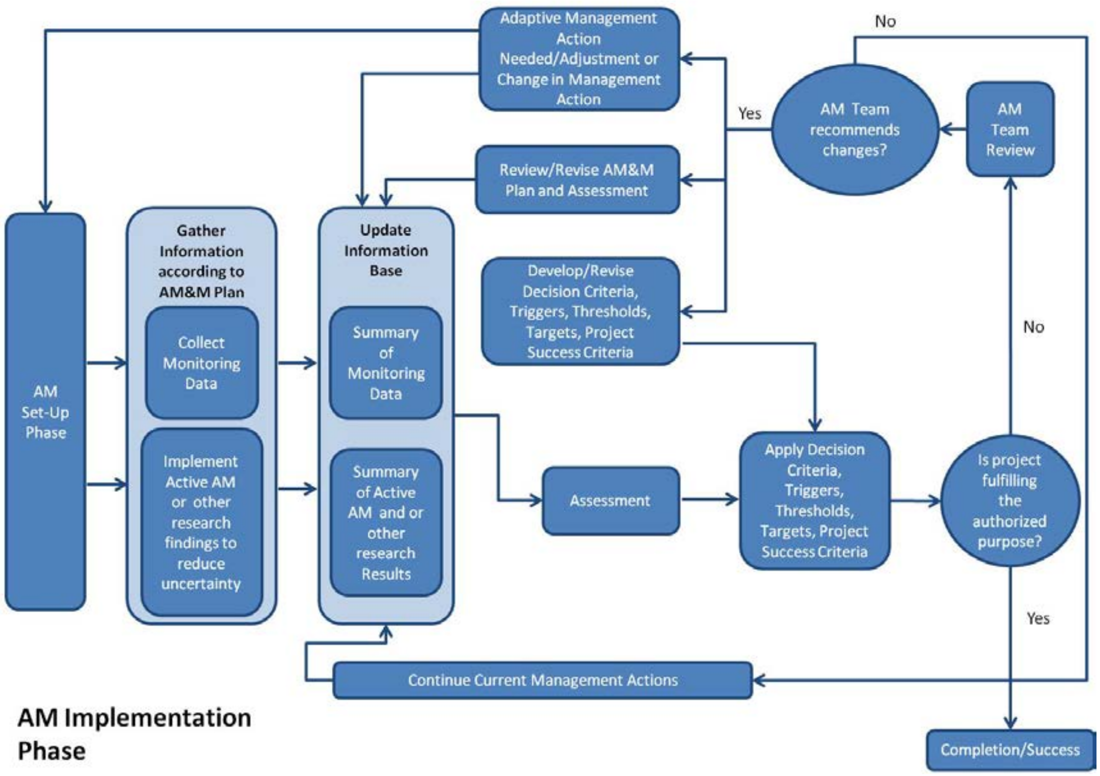

Figure 5. Implementation Phase of the Adaptive Management Framework.

Baseline monitoring should begin during or proceeding the design phase, prior to project construction. Monitoring will also be conducted during construction. Unexpected detrimental events may alter the project site, requiring consideration of corrective measures. For example, a tropical cyclone impacting a project site or invasion of an exotic species may necessitate management actions. A decision will be required on how to address changes in conditions. In addition, projects that are phased-in over a long period of time present a greater potential for changing baseline conditions due to construction methods, deviations from selected methods, or development of new information. Using an AM strategy in this situation may increase the chances of overall project success. Design changes during construction may require changes to the MAM Plan.

After construction, the project will enter the iterative cycle of AM where monitoring data is used to assess impacts and gain an understanding of project performance. The results from the monitoring assessment will guide decision-making (Figure 1). The Operation and Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) manuals should clearly communicate the MAM Plans and process including: monitoring parameters, frequency and duration of monitoring and assessment, decision criteria, and options for adjustment (if necessary) to increase project success.

The results of the monitoring program will be used to assess system responses for evaluation of overall project performance, and assemble Assessment Reports and project Report Cards as outlined in the MAM Plans (Section 5).

2.3 Rationale for Monitoring & AM- Risk and Uncertainty Management

The primary reason for implementing AM is to increase the likelihood of achieving desired project outcomes given the uncertainties identified in Section 2.1.4. Adaptive management works best when it is tailored to the specific problem(s), designed to ensure accountability and enforceability, used to promote useful learning, and supported by sufficient funding (Doremus et al., 2011). Although all restoration projects are required to consider AM, there may be some projects or increments of project for which AM may not be applicable. AM is warranted when there are consequential decisions to be made, when there is an opportunity to apply learning, when the objectives of management are clear, when the value of reducing uncertainty is high, and when a monitoring design can be put in place to reduce uncertainty (Williams et al., 2007, Williams et al., 2009). Adaptive management should not be used where or when there is a lack of flexibility in project designs and mistakes may be irreversible, when learning is unlikely on the relevant time scale, or where no opportunity exists to revise or reevaluate decisions (Doremus et al., 2011).

The MsCIP Barrier Island Restoration Project was evaluated to determine if AM was applicable and would better enable the project to meet stated goals and objectives. Several questions were considered to determine if AM could be applied to the project or a portion of the project:

1) Are the ecosystems to be restored sufficiently understood in terms of hydrology and ecology, and can project outcomes be accurately predicted given recognized natural and anthropogenic stressors?

   A: Partially. There has been extensive data collection, analyses, and numerical modeling conducted as part of the MsCIP Barrier Island Program, and additional existing information has been used to support engineering and design of the restoration project. Data analyses and numerical modeling provide information needed to better understand coastal processes, geomorphology, and ecology for the area to make estimates of project performance. Physical data collection, analyses, and predictive modeling under the MsCIP Barrier Island Program included geophysical and geotechnical investigations; bathymetric and sediment budget assessments; wave, current, circulation, sediment transport and water quality modeling. Baseline ecological data collection and analyses include submerged aquatic vegetation, benthic sampling, gulf sturgeon, shorebird, raptor, and sea turtle nesting assessments. However limited information exists on beach invertebrate communities and hydrology of wetlands on East and West Ship Island.

   There will always remain uncertainties related to climate change and sea level rise and the associated response of the barrier islands.

2) Can the most effective project design and operation for achieving project goals and objectives be readily identified?

   A: Yes. The design and optimization process relied on extensive data collection, analyses, and numerical modeling. Furthermore, the Main Report/Supplementary Environmental Impact Statement (SEIS), and all appendices and supporting documentation, are subject to ATR conducted by a regional and national team of experts. Post construction, the MAM process will be used to measure restoration progress towards meeting the goals and objectives over time.

As evidenced by a recently completed project within Gulf Islands National Seashore (i.e., 2012 West Ship Island, north shore sand replenishment project), achieving desired conditions will vary over time due to the dynamic nature of these systems.

3) Are the measures for this restoration project performance well understood and agreed upon by all parties?

A: Yes, the ultimate goal to restore compatible sand to Ship Island and augment the existing sand transport system is well understood and agreed upon by all parties. It is also understood that the direct sand supply to the islands once placed should be allowed to move naturally by coastal processes and its performance measured as part of the MAM Program.

Specific performance measures and desired outcomes to measure restoration progress are being drafted as part of the MAM Plan by the interagency TAG based on the overall goals and objectives of the MsCIP Barrier Island Restoration Program and the stressors and attributes identified in the CEM. Performance measures and success criteria will be coordinated and vetted through the MAM process by members of the TAG, Oversight Committee, Program Management Team, and the RSLG.

4) Can project management actions be adjusted in relation to monitoring results?

A: Yes, however, there is limited flexibility for AM and adjustment in relation to monitoring results once construction has started given design criteria, logistics associated with dredging operations, and timing for placement of sand. The project design was developed to meet certain criteria (i.e. design life, sand compatibility, minimal impacts to Gulfport Navigation Channel, etc.). Components that are not flexible include the upper amounts of fill quantities, costs, and modifications to a contract once awarded. However, construction will be conducted in phases with separate construction contracts allowing for small modifications between phases. Any proposed changes in relation to monitoring results to borrow sites, placement areas, etc., would need to be implemented on short notice in order to limit potential delays that could impact project success. Potential AM triggers and actions under the MsCIP and recommendations that can be made to other programs and or agencies are further described in Sections 5 and 6.

A lack of complete understanding in response to question 1, 2 or 3 and a "YES" answer to question 4 qualifies the project as a candidate that could benefit from AM. Based on the TAG and Oversight Committee discussions and the identified project uncertainties, needs, and opportunities, the MsCIP MAM program was developed to:

- reduce uncertainty over time
- implement monitoring to determine progress towards meeting ecological success
- determine long-term cumulative impacts of restoration actions
- develop feedback loops so that monitoring and assessment produce continuous and systematic learning that in turn is incorporated into subsequent rounds of decision-making through AM
- develop reports on the status and progress of the restoration for the agencies involved, the public, Congress, and stakeholders
- enhance predictive capability through improvements in simulation models before and after project construction

- provide information to summarize and develop lessons learned to optimize barrier island restoration strategies in the future; "lessons learned"

3.0 Monitoring Plan

An effective monitoring program is required to determine if project outcomes are consistent with original project goals and objectives. The strength of a monitoring program developed to support AM lies in the establishment of feedback between continued project monitoring and corresponding project management. Consistent with the USACE Civil Works (CECW-PB) Memo dated 31 August 2009, the monitoring plan: *"…includes the systemic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether Adaptive Management may be needed to attain project benefits."*

Pre-construction/baseline data, during construction, and post-construction monitoring will be utilized to determine barrier island restoration success and avoid impacts to threatened and endangered (T&E) species. This plan includes the monitoring actions necessary to evaluate success within the project area and also includes the monitoring necessary for T&E species compliance as required in the Biological Opinions (BO) issued for the project. Additional monitoring will be collected during construction by the contractor as required by project plans and specifications that may support the monitoring proposed in the MAM Plan (i.e. turbidity monitoring and grain size testing); detailed procedures are not included within the MAM Plan.

Post construction monitoring is scheduled to begin after completion of Ship Island sand placement construction phases 1, 2, 3 and 4 including Cat Island sand placement upon completion as described in Section 2.1.3. Although Section 2039 of WRDA 2007 allows for a ten year cost-shared monitoring plan post construction, ten years of monitoring may not be required. Monitoring will continue until the trajectory of ecological change and/or other measures of project success are determined as defined by project-specific objectives. Once ecological success has been achieved, a determination would be made as to whether further monitoring would be required. Any additional monitoring required past the 10 years will be a non-MsCIP responsibility.

The MAM Plan is a living document and the proposed monitoring elements are based on currently available information and will be updated to reflect monitoring-acquired and/or other new information as well as resolution of and progress on resolving and/or discovery of key uncertainties and lessons learned.

Currently, the MAM plan focuses on the MsCIP Barrier Island restoration actions at Ship Island and Cat Island (described in Section 2.1.3) but will be modified as necessary to include data collection for other future project components.

Data collected by MsCIP partners, not necessarily under MsCIP funding, will be leveraged wherever possible. Additional data will be collected as part of MsCIP (1) if required, or (2) only if scientifically defensible to achieve a complete dataset in which to compare post-restoration success and avoid impacts to T&E species. Appendix E presents the supplementary datasets that have been compiled for baseline information and will be used in conjunction with the monitoring proposed under the MAM plan.

Other monitoring and programs that we will coordinate with include the:

- USGS BIER Project
- Louisiana Barrier Island Comprehensive Monitoring (BICM) Program
- USGS Mississippi Water Science Center Data Collection

- NPS Inventory and Monitoring Program at Gulf Islands National Seashore
- Baseline samples collected under various oil spill response programs (e.g. NRDA, Pollution Removal Funding Authorizations [PRFA]) related to the Deepwater Horizon spill of April 20, 2010 will be used to augment baseline data and monitoring efforts funded under the MsCIP program.
- NFWF Gulf Environmental Benefit Fund, Alabama Barrier Island Restoration Assessment.

3.1 Objectives, Performance Measures, Desired Outcomes, and Monitoring Designs

In accordance with the MAM planning approach outline in Section 2.0, this section identifies the performance measures and desired outcomes needed to evaluate whether or not we are meeting the desired project objectives. The performance measure includes specific feature(s) to be monitored to determine project performance. A monitoring design was established to determine if the success criteria are met. Additional details regarding the proposed monitoring designs are provided in Appendix D. Details regarding how the monitoring data will be used to influence future management decisions including triggers and potential adaptive management actions are included in Section 6 and Table 1. Success criteria and interim targets have been developed for the performance measures and are included under each of the objectives below.

Objective 1- Maintain the estuarine ecosystem and resources of the Mississippi Sound.

a. **Performance Measure- Flow patterns at Ship Island Pass, Little Dog Keys Pass and Dog Keys Pass:** East and West Ship Islands, separated by Camille Cut, are flanked by Ship Island Pass to the west and Little Dog Keys Pass and Dog Keys Pass to the east. Current flows through these passes and through Camille Cut affect the estuarine ecosystem and resources of Mississippi Sound. This estuarine ecosystem is expected to adjust to changing flow patterns once Camille Cut is closed. It is anticipated that minimal flow pattern changes will occur after closure of Camille Cut within Ship Island Pass, Little Dog Keys Pass and Dog Keys Pass.

   Monitoring Purpose: Record flow patterns at Ship Island Pass, Little Dog Keys Pass and Dog Keys Pass to evaluate overall circulation changes after closure of Camille Cut. The monitoring is being conducted for the Ship Island Restoration component and will provide the supporting information required to measure progress against success criteria.

   Monitoring Design Summary: To document changes and assess whether closure of Camille Cut impacts overall circulation in the sound adjacent to the island, Acoustic Doppler Current Profiler (ADCP) transects should be monitored at each pass – one prior to the closure of Camille Cut and one after closure of Camille Cut. Current measurements at each transect should be measured for at least one tidal cycle. Pre- and post-closure data should be collected at the same time of year for similar tidal conditions. Additional details regarding the monitoring procedure can be found in Appendix D2.

   Desired Outcome: Minimal changes to overall circulation patterns in the Mississippi Sound due to sediment placement along Ship Island and filling of Camille Cut.

   Success Criteria: An assessment of changes in currents through Ship Island and Dog Keys Pass will be made within one year of post construction. Changes in flows measured from the pre and one year post construction surveys through the three passes are within the range of simulated change.

Interim Target: N/A

b. **Performance Measure- Water Quality:** East and West Ship Islands, separated by Camille Cut, are flanked by Ship Island Pass to the west and Little Dog Keys Pass and Dog Keys Pass to the east. Current flows through these passes and through Camille Cut affect circulation patterns and water quality in the Mississippi Sound. It is anticipated that minimal changes in water quality in the system will occur after implementation of the Ship Island component and closure of Camille Cut.

Monitoring Purpose: To monitor water quality parameters, as long term indicators of change due to the Ship Island Restoration Component and closure of Camille cut. The long term responses will be used to perform a strength of evidence approach to evaluate project success. The monitoring will provide the supporting information required to measure progress against success criteria and understand the other biological responses including Gulf sturgeon and SAV.

Monitoring Design Summary: Before, during, and after Ship Island construction measurements at 5 water quality stations located north, south, east and west of Ship Island and 3 reference water quality stations within Mississippi Sound. Primary water quality parameters will be continuously monitored at the East Ship Island Light monitoring station and monitored during 8 discrete sampling events per year for a period of up to 2 years post construction. Additional details regarding the monitoring procedure can be found in Appendix D2.

As part of construction for both the Ship Island and Cat Island restoration components, turbidity curtains will be installed and turbidity measurements will be collected within seagrass beds located north of East and West Ship Islands and around Cat Island during critical construction periods.

Desired Outcome: Maintain current estuarine conditions in Mississippi Sound for primary water quality parameters (e.g., salinity, light within seagrass beds leeward of West and East Ship Island, turbidity, dissolved oxygen and temperature).

Success Criteria: Post construction salinity level changes measured for a period of up to 2 years post construction are within the range of historic variability and compare to changes observed at control stations.

Interim Target: Salinity levels measured over a year post construction are within the range of the historic variability and compare to changes observed at control stations.

c. **Performance Measure- Submerged Aquatic Vegetation Coverage:** Seagrasses and SAV provide critical spawning, nursery, refuge, and feeding habitat for recreational and commercial marine species. Aerial coverage and distribution of SAV around the barrier islands has declined significantly since 1969 (Moncreiff 2007), with a high of approximately 13,000 acres to its 2010 coverage of 3,614 acres (USACE 2014; Appendix H). There is the potential for temporary impacts to SAV during construction but it is anticipated there would be an increase in SAV after closure of Camille Cut.

Monitoring Purpose: Document SAV distribution, acreage and condition over time at Cat Island and Ship Island and to evaluate effects of changing circulation and sedimentation patterns on and around Ship Island.

Monitoring Design Summary: Aerial imagery mapping of SAV will be conducted within the technical framework established by the National Oceanic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP) and following methods described in Appendix H of the 2014 Draft Supplemental Environmental Impact Statement (USACE 2014). Aerial imagery will be collected in the summer before and after project construction, and two additional surveys before the end of the 10-year monitoring. Digital orthophotographs will be created, boundaries of SAV signatures digitized, and classifications field verified.

SAV condition indicators, percent cover, species composition and canopy height, and stressors (water transparency, depth, temperature, salinity, DO, and pH) will be measured within 0.25 m^2 quadrats following Tier II rapid assessment methodologies adapted from Dunton *et al.* (2010) and Neckles *et al.* (2012) and used by the NPS Gulf Islands National Seashore (GUIS) in surveys conducted in 2011, 2012, and 2013. Existing GUIS Ship Island ground surveys will be extended into potential SAV areas on the north side of Camille Cut by including 5-7 additional sampling locations to the existing 18 station repeated measures design. These surveys will be conducted in conjunction with GUIS annual surveys for a period of up to 5 years. Additional details regarding the monitoring procedure can be found in Appendix D3.

Additional turbidity monitoring will be collected as part of the construction activities that will be used to support the monitoring proposed in this MAM plan. Additional monitoring will be collected during construction by the contractor as required by project plans and specifications that may support the monitoring proposed in the MAM Plan (i.e. turbidity monitoring and grain size testing); detailed procedures are not included within the MAM.

Desired Outcome: Increase in total acreage of SAV on Ship Island as compared to the pre-construction period 2010-2014.

Success Criteria: 10 years post construction total SAV acreage, distribution, condition and species composition on Ship Island are similar as compared to the pre-construction period 2010-2014.

Interim Target: 1 year post construction, maintain 2014 pre-construction SAV distribution.

d. **Performance Measure- Benthic and Infaunal Species:** The sediment and sand bottom present in the tidal passes and beaches of the barrier islands and shallow waters adjacent to the barrier islands provides habitat for multiple species of benthic and infaunal species that are important food sources for shorebirds and Gulf sturgeon. Previous benthic macroinfauna community studies found that taxa richness and densities varied significantly by location due to the dynamic nature of these systems and exposure to frequent disturbances (e.g., sediment disposal, storm action, and maritime activity), and species tended to be either tolerant of disruption or capable of rapidly recolonizing disturbed areas (USACE 2009; Rakocinski et al., 1990, 1993, 1998, Wilber et al 2007). It is anticipated that benthic and infaunal communities will be displaced in the short-term due to dredging and placement of dredged material.

Monitoring Purpose: Document benthic and infaunal communities (density and diversity) on and around Ship Island and Cat Island prior to and after construction to evaluate the reestablishment of benthic populations post construction at placement and borrow sites and to determine the suitability of placement areas for feeding habitat for the Gulf sturgeon and shorebirds. The monitoring will provide supplementary information needed for Gulf sturgeon and shorebirds compliance monitoring as required in the BOs issued for the project.

Monitoring Design Summary: Benthic macroinfauna community sampling will follow methods described in Appendix I of the 2014 Draft Supplemental Environmental Impact Statement (USACE 2014). Pre-construction baseline benthic community surveys were collected in the 2010 (Summer and Fall) and 2011 (Spring) at borrow and placement sites and reference sites. In late 2011 (Fall) additional sites were surveyed to support Gulf sturgeon monitoring and in 2015 (Winter) sites were added for shorebird monitoring. Post construction sampling will be conducted at the sites previously surveyed in 2010, 2011, and 2015 and potential new locations where sturgeon and shorebird feeding would occur after closure of Camille Cut. Sand placement and borrow sites will be surveyed approximately 3 years after project construction. Benthic surveys for shorebird feeding sites will be conducted in the Winter approximately 3 years after project equilibration has occurred. Post construction benthic sampling for sturgeon feeding sites are scheduled to be sampled in the Fall and Spring beginning 6 months after completion of phase 4 construction. Additional details regarding the monitoring procedure can be found in Appendix D3 in the Benthic and Infaunal species, Gulf sturgeon, and Shorebirds sections.

Additional monitoring related to grain size testing will be collected as part of the construction activities and will be used to support the benthic monitoring proposed in this MAM plan. This additional monitoring being during construction will be detailed as part of the Plans and Specifications and detailed procedures are not included within this MAM.

Desired Outcome: Re-establish benthic and infaunal species population densities and diversity to pre-construction baseline levels post-construction for borrow, placement, shorebird and sturgeon feeding sites.

Success Criteria: The re-establishment of benthic and infaunal species post-construction will occur when the average biomass level within the project area is at least 70 percent of the pre-project average biomass level. This success criteria will be evaluated approximately 3 years post construction.

Interim Target: A short term evaluation of benthic and infaunal species re-establishment will be collected 6 months post construction as part of the Gulf sturgeon benthic prey assessment.

e. **Performance Measure- Gulf Sturgeon:** The Gulf sturgeon, *Acipenser o. desotoi*, occurs in Gulf of Mexico drainages from Tampa Bay westward to the Mississippi River. This subspecies is listed as threatened under the Endangered Species Act and is also state listed as endangered in Mississippi, with the principal reasons for population declines being habitat loss due to dams, commercial fishing, and general water quality deterioration (USFWS and Gulf States Marine Fisheries Commission 1995). In Mississippi, the Gulf sturgeon historically occurred in the Pascagoula, Pearl, and Mississippi Rivers. Critical habitat for Gulf sturgeon was designated in 2003, and within the western Gulf of Mexico includes the entire Mississippi Sound to one mile south of the Mississippi barrier islands. Several studies have noted the occurrence of Gulf sturgeon in barrier island passes (Rogillio et al. 2007, Ross et al. 2009) and with the closure of Camille Cut, it is anticipated that Gulf sturgeon will redistribute and utilize adjacent passes.

Monitoring Purpose: Compliance monitoring to document Gulf sturgeon critical habitat utilization over time at Ship and Dog Keys Pass and determine whether Ship Island restoration and filling Camille Cut has an impact on Gulf sturgeon utilization of these habitat features.

Monitoring Design Summary: To assess habitat utilization, monitoring of Gulf sturgeon will be conducted at Ship Island and Dog Keys Pass using acoustical tagging techniques before (baseline), during construction after the filling of Camille Cut (post-fill) and post construction (after completion of all phases of construction). The approach will be evaluated at multiple levels: (1) an initial assessment to determine the relative occurrence of Gulf sturgeon within the project area (e.g., specific zones; seasonal timing); (2) a secondary assessment will address occupancy patterns of Gulf sturgeon within identified project areas to evaluate potential changes in occupancy patterns between years and project zones; and a (3) benthic assessment to develop a relationship between Gulf sturgeon and benthos. Data collection started in 2011 and be conducted during construction and after construction. Monitoring for Gulf Sturgeon also will be evaluated in conjunction with benthic and infaunal species sampling described within PM 1d to develop a surrogate to predict favorable Gulf sturgeon habitat. Additional details regarding the monitoring procedure can be found in Appendix D3.

Desired Outcome: Maintain suitable Gulf sturgeon habitat in the vicinity of Ship and Horn Islands.

Success Criteria: 2 years post-construction occupancy values fall within 2 standard deviations of pre-construction values
AND
No significant change in post-construction benthos community assessments as compared to the pre-construction assessment.

Interim Target: Immediately post construction track potential movement of gulf sturgeon shift to other surrounding habitat zones.

<u>Objective 2- Preserve the natural and cultural resources of the Mississippi barrier islands.</u>

a. **Performance Measure- Habitat Composition:** The Mississippi barrier islands contain over 50 unique categories of terrestrial and aquatic habitats that have been previously classified under the National Wetlands Inventory (NWI). Changes in terrestrial and submerged vegetation communities and geomorphic features such as tidal flats, beaches, and bars occur naturally over time, but large events such as Hurricane Katrina and restoration efforts such as MsCIP can greatly change the island morphology and the habitats they support.

   Monitoring Purpose: Document changes in habitat diversity and acreage of emergent/submerged habitats over time and use these data with supporting datasets (bathymetry and topography, shorebird and sea turtle nesting, Gulf sturgeon distribution, benthic/infaunal density, and SAV cover) to develop relationships between emergent and submerged habitat types and habitat utilization on Ship Island and Cat Island. This monitoring will be used to measure project performance as a success criterion.

Monitoring Design Summary: High resolution aerial photography will be used to map emergent and submerged habitats on Ship and Cat Islands using the technical framework established by the USFWS National Wetlands Inventory (NWI) Classification of Wetlands and Deepwater Habitats (Cowardin *et al.* 1979). Aerial photography will be collected annually before, during, and for two years post-construction. Aerial photography acquired during Light Detection and Ranging (LiDAR) missions will also be analyzed and mapped as part of this monitoring effort. Field investigations will be conducted to ground-truth various geomorphic and vegetation habitats in the field with corresponding signatures on aerial photography. Additionally, moderate resolution Landsat Multi-Spectral Scanner and Thematic Mapper satellite imagery will be used to increase the number of datasets available to assess historic and 10-year post-construction geomorphic landform evolution and land area change trends and to help discern normal environmental variability present at the time of acquisition of the aerial photography. Additional details regarding the monitoring procedure can be found in Appendix D3.

Desired Outcome: Increase the habitat diversity and acreage of emergent and submerged habitats over time including beach and dune, intertidal flats, wetlands, and upland/scrub shrub.

Success Criteria: Less than 23% of emergent habitat is lost within 10 years post construction relative to project-completion acreage. Acreage will be determined from the habitat mapping effort conducted immediately after project completion.
AND
Maintain habitat diversity of emergent and submerged habitats over time including beach and dune, intertidal flats, wetlands, and upland/scrub shrub.

Interim Target: Habitat mapping is scheduled to be conducted at regular intervals post construction and success criteria can be assessed at each interval. (Collection is expected annually up to 2 years post construction, Year 5 and Year 10)

b. **Performance Measure- T&E Shorebirds:** The Mississippi barrier island beaches are listed as critical habitat for the threatened Piping plover (*Charadrius melodus*) and is important habitat for the Red knot (*Calidris canutus*). These species are protected pursuant to the Endangered Species Act (ESA) and Migratory Bird Treaty Act, and therefore potential impacts must be avoided associated with barrier island construction activities.

Monitoring Purpose: Compliance monitoring to document the number of T&E shorebirds using Ship and Cat Islands to determine any impacts pursuant to the ESA.

Monitoring Design Summary: Trained bird monitors (observers) will be used to conduct bird identification, counts, habitat use, behavior observations, and locational assessments of Piping Plover and Red Knot following U.S. Fish and Wildlife Service, Ecological Services Office, Jackson Mississippi, Non-breeding season survey guidelines. Monitoring will be conducted weekly on Ship Island (East and West) and Cat Island to cover migration/mid-winter seasons and will be conducted before, during, and 2 years post construction after project equilibrium.

Post construction monitoring will occur every other week. In addition to Piping Plover and Red Knot, all observed solitary and colonial nesters, and other winter migrants will be included in the shorebird surveys. Long-term shorebird monitoring data that is collected by the NPS on GUIS, Mississippi, will be utilized, as appropriate, upon availability. Additional details regarding the monitoring procedure can be found in Appendix D3.

The benthic sampling being conducted under performance measure 1d will be used to correlate T&E Shorebirds and benthic prey species at shorebird feeding sites previously surveyed in 2010, 2011, and 2015 and new locations where feeding would occur after closure of Camille Cut.

Desired Outcome: Maintain T&E shorebirds habitat Ship Island and Cat Island post construction as compared to the pre-construction baseline.

Success Criteria: 10 years post construction maintain or increase the pre-construction acreage of suitable shorebird foraging habitat as evaluated by habitat mapping.
AND
Provide suitable benthic habitat 5 years post construction.

Interim Target: Maintain suitable shorebird foraging habitat acreage 5 years post construction. Specific acres will be determined by habitat mapping conducted on baseline conditions.

c. **Performance Measure- Nesting Birds:** The Mississippi barrier islands and shorelines provide feeding, nesting, resting, and wintering habitat for numerous resident and migratory bird species (MDMR 2010). The project area serves as an important migration corridor and stopover habitat for birds migrating to and from tropical wintering areas. It is anticipated that the project will enhance island morphology and diversity of habitats supporting solitary and colonial nesters and winter migrants.

Monitoring Purpose: Assess utilization of newly created beach and shoreline habitats by nesting shorebirds. This monitoring will be used to measure project performance as a success criterion.

Monitoring Design Summary: Trained bird monitors (observers) will conduct bird identification, counts, habitat use, behavior observations, and locational assessments of all observed solitary and colonial nesters, and winter migrants following the USFWS, Ecological Services Office, Jackson, Mississippi, Non-breeding season survey guidelines. Monitoring will be conducted daily during construction activities on Ship Island (East and West) and Cat Island during March through September to cover nesting seasons. Long-term shorebird monitoring data that is collected by the NPS on GUIS, Mississippi, will be utilized, as appropriate, upon availability. Tracking of emergent and submerged habitat types over the 10 year post-construction monitoring period will be used with any available NPS data to help access nesting potential over time. Additional details regarding the monitoring procedure can be found in Appendix D3.

Desired Outcome: Post-construction improve nesting potential in newly created habitats

Success Criteria: 10 years post construction maintain or increase suitable acres of nesting habitat as compared to the pre-construction acreage. This will be evaluated by habitat mapping.

Interim Target: 5 years post construction maintain suitable acres of nesting habitat as evaluated by habitat mapping efforts.

d. **Performance Measure- Sea Turtles:** The Mississippi barrier island beaches are sometimes used for nesting by 5 species of endangered and threatened sea turtles: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), and Kemp's Ridley (*Lepidochelys kempii*). These species are protected pursuant to the ESA and therefore, potential impacts must be avoided associated with barrier island construction activities.

Monitoring Purpose: Compliance monitoring to document the number of sea turtle nests on Ship and Cat Island and determine any impacts pursuant to the ESA.

Monitoring Design Summary: Sea turtle monitors (observers) will be used to conduct sea turtle identification, counts, and locational assessments and identification of turtle crawls and nest sites, marking of nests, and Global Positioning System (GPS) locations on beaches of Ship and Cat Island following U.S. Fish and Wildlife Service, Ecological Services Office survey guidelines. Monitoring will be conducted from April 15 to November 30 both during and 2 years after construction. No pre-project surveys will be required if project construction activities are initiated between November 30 and April 15. If the project construction is initiated between April 15 and November 30, daily pre-project surveys will begin at least 100 days prior to the project starting or by April 15, whichever is later. Post Construction weekly sea turtle monitoring shall continue for 2 full nesting and hatching seasons (April 15th thru November 30th) once the project reaches equilibrium, approximately one to two years after the end of construction. In addition, the shear resistance of the beach sediments at Ship Island and Cat Island, Mississippi will be measured pre and post construction using a dynamic cone penetrometer testing (DCP) apparatus, since sediment shear resistance is an important factor in sea turtle nesting. Further details regarding the monitoring procedure can be found in Appendix D3.

Desired Outcome: Establish suitable habitat for sea turtles post construction.

Success Criteria: 10 years post construction maintain or increase suitable acres of sea turtle habitat as compared to the pre-construction acreage. Sea turtle habitat is defined as upper beach habitat at 3 feet or higher. Specific acres will be determined by habitat mapping conducted on baseline conditions.
AND
Successful compaction test to indicate suitable turtle hatching requirements.

Interim Target: 5 years post construction maintain suitable acres of turtle habitat as evaluated by habitat mapping efforts.

e. **Performance Measure- Cultural Resources:** Cultural resources are archeological and architectural resources known to occur within the project area and are listed in, eligible, or potentially eligible for listing in the National Register of Historic Places (NRHP). They are important historical and cultural aspects of the country's national heritage. Construction will be conducted to avoid impacts to cultural resources, and subsequent monitoring will document the land surrounding the resources.

Monitoring Purpose: Document areal island extent surrounding cultural resources eligible or potentially eligible for nomination to the National Register of Historic Places and coordinate any needed actions based on monitoring results. The monitoring will provide supporting information to assess potential exposure of cultural resources to erosive forces as Ship Island and Cat Island evolves over time.

Monitoring Design Summary: Monitoring will ensure that all previously identified eligible or potentially cultural resources are avoided. Additionally, a monitor trained in recognizing cultural material that may be inadvertently discovered during construction can prevent further destruction to the cultural resource so that the material/site can be evaluated before construction resumes. Continued post construction monitoring by NPS archaeologists will assess erosion to sites.

Desired Outcome: Emergent land continues to surround cultural resources.

Success Criteria: 10 years post construction no appreciable loss of listed, eligible, or potentially eligible cultural resources due to erosion or construction based on aerial mapping and baseline conditions.

Interim Target: Five years post construction no appreciable loss of listed, eligible, or potentially eligible cultural resources due to erosion or construction based on aerial mapping and baseline conditions.

<u>Objective 3- Restore the barrier islands structure to reduce storm damage impacts on the mainland coast of Mississippi.</u>

a. **Performance Measure- Island morphology and shoreline change:** The ability of the Mississippi barrier island system to limit storm impacts to mainland beaches depends upon the islands' ability to maintain sufficient width and elevation. Beach erosion and overtopping along East Ship Island and changes in inlet shoal and channel morphology within Little Dog Keys and Dog Keys Passes endanger the longevity of East Ship Island, which could result in complete degradation of the island within the next 10 to 20 years (Byrnes *et al.*, 2012). Restoration along Camille Cut and East Ship Island will include increased island width and elevation to augment natural sediment transport quantities prior to breaching and inlet formation along Ship Island. Once island restoration design templates are complete, it is anticipated that adjustments in shoreline change and subaerial island morphology will occur.

Monitoring Purpose: Document island elevations, shoreline change rates, and aerial island extents of Ship and Cat islands. The monitoring at Ship Island will be used to measure project performance against success criteria and be used to identify breaches that would be used as AM decision criteria under the AM Plan (Section 6). The monitoring will also provide supplementary information to better understand the responses of other biological and physical performance measures, for example, circulation and habitat availability.

Monitoring Design Summary: To capture changes, simultaneous near-vertical aerial imagery and LiDAR surveys will be acquired before and after construction and three additional times during the 10-year monitoring effort. To evaluate the effectiveness of the restoration design, measurements will be compared with previous measurements of historic shoreline change rates, foreshore slopes, elevations and volumetric changes within the system when combined with bathymetric surveys. Additional details regarding the monitoring procedure can be found in D1.

Desired Outcome: Net loss of original Ship Island restoration surface area should be less than an average of 3% per year over the 10-year monitoring period.

Success Criteria: Net loss of original island restoration surface area is not greater than an average of 3% per year over the 10-year monitoring period.

Interim Target: Net loss of original island restoration surface area should be less than an average of 15% per year over the 5-year monitoring period.

b. **Performance Measure- Wave Reduction Leeward of Ship Island:** One of the expected benefits of filling Camille Cut is to reduce Gulf of Mexico wave energy impacting mainland beaches in Harrison County, Mississippi. Wave measurements at locations seaward and soundward of Camille Cut are required to directly measure the extent of wave energy attenuation from the Gulf of Mexico after Camille Cut has been closed. Additionally, wave measurements will provide a valuable data set for verifying wave prediction models used for the nearshore and estuarine system surrounding Ship Island.

Monitoring Purpose: Assess wave attenuation in the lee of Ship Island. The monitoring will provide the information required to measure progress against success criteria.

Monitoring Design Summary: Deployment of three wave gages prior to and for a period up to 2 years after construction to measure wave height, period, direction, and water level seaward and soundward will provide quantitative data to evaluate the degree to which Camille Cut closure reduced wave energy leeward of Ship Island. Additional details regarding the monitoring procedure can be found in Appendix D1.

Desired Outcome: Reduce wave heights in the lee of Ship Island.

Success Criteria: Reduced wave height leeward of Ship Island relative to pre construction baseline conditions during the 5 years post construction monitoring period.

Interim Target: None

<u>Objective 4 - Enhance the long-term littoral drift system for the Mississippi barrier islands.</u>

a. **Performance Measure- Restore Sediment to the Barrier Island System**: Based on littoral sand transport estimates along East and West Ship Island and long-term sediment budget estimates for the Mississippi barrier islands (Byrnes *et al.*, 2013), Dog Keys Pass and Little Dog Keys Pass have been a sand sink throughout the historical record, resulting in limited sand movement from Horn Island to East Ship Island. The result has been rapid shoreline recession and chronic beach erosion along East Ship Island, resulting in significant island area losses and habitat degradation. Presently, the island is in a highly degraded state and is expected to become a shoal within the next decade if island restoration is not considered. If the island is left to naturally degrade, valuable wetlands, sea turtle nesting habitat, and shorebird foraging and nesting habitat will be lost and wave and current energy from the Gulf of Mexico are expected to impact estuarine habitats in the lee of the island, water quality, and mainland beach sustainability. As such, island restoration with sand outside the Ship Island littoral transport system has been designed to augment the natural littoral transport system and create subaerial and subaqueous habitat within the barrier island system.

Monitoring Purpose: Verify sand restoration volumes are adequate for enhancing sand supply to the littoral transport system to help maintain Ship Island. The monitoring will provide the information required to measure progress against success criteria.

Monitoring Design Summary: Measurements of the subaerial and subaqueous portions of the beach should be conducted to track sand movement and monitor island elevation changes throughout the monitoring effort. Simultaneous near-vertical aerial imagery and LiDAR surveys should be collected before and after construction and two times during the 10-year monitoring effort to verify restored sand volumes were adequate to maintain Ship Island. Bathymetric surveys of the nearshore should be collected at similar time intervals to track the subaqueous movement of sand transported from the subaerial beach during initial beach adjustments toward dynamic equilibrium and in response to storm events. Additional details regarding the monitoring procedure can be found in Appendix D1.

Desired Outcome: Increase sediment availability for littoral transport along the barrier islands.

Success Criteria: Increase sediment availability for littoral transport along the barrier islands measured over a 5 and 10 year period.

Interim Target: Increase sediment availability for littoral transport along the barrier islands measured over a 5 year period.

b. **Performance Measure- Sedimentation/Shoaling:** Ship Island Pass exists along the western end of Ship Island and encompasses the federally maintained Gulfport Ship Channel. Water depths within the channel are generally 40 ft or less. Long-term dredging records show large variability in maintenance dredging quantities on an annual basis. However, long-term annualized dredging requirements for Ship Island Pass are on the order of 156,000 yd^3/yr. Analysis indicates that the restoration of the littoral sediment transport system and changes to local currents resulting from the closing of Camille Cut could potentially result in increase sedimentation in the Ship Island Pass in particular during hurricane events. However, increased sedimentation over what would naturally occur with the westward growth of Ship Island is expected to be minimal.

Monitoring Purpose: Verify sedimentation and shoaling that could impact dredging operations and maintenance costs. The monitoring will provide the information required to access meetings the success criteria.

Monitoring Design Summary: Bathymetric surveys of the Gulfport Ship Channel (Ship Island Pass) will be collected and evaluated to verify whether or not sedimentation and shoaling rates increase on average more than the historical variability in average annual maintenance dredging per year.

NOTE: Surveys will continue to be collected by the USACE O&M program. The TAG will assess the shoaling rates and compare to historical rates as well as other nearshore bathymetric surveys collected as part of the restoration of sediment to the barrier island system performance measure to determine if an increase in channel shoaling/sedimentation is associated with the Camille Cut and East Ship Island restoration.

Desired Outcome: Minimal impact to navigation channel dredging operations and maintenance at Ship Island Pass.

Success Criteria: No increase over natural variability in average annual maintenance dredging during the 5 and 10 year periods with Ship Island Pass.

Interim Target: Shoaling rates in the Ship Island Pass navigation channel increase on average by more than the variability in average annual maintenance dredging per year over a 5 year period.

c. **Performance Measure- Dredged material placement within Horn Island littoral system:** Horn Island Pass is approximately 3.5 miles wide, encompasses the Pascagoula Ship Channel, and is located between Horn Island to the west and Petit Bois Island to the east. Dredging activities within Horn Island Pass have intercepted west-directed littoral sand transport, some of which has not been placed in the littoral zone west of the channel (Byrnes *et al.*, 2013). Although a substantial portion of maintenance dredging sand has been placed in the littoral zone in an area known as Disposal Area 10 (DA-10), this disposal area is not located too far north on the shoal complex where there is limited wave breaking to drive sediment to the west, thereby limiting transport to eastern Horn Island.

Based on sediment transport and budget information developed as part of the MsCIP, proposed modifications to maintenance dredging practices are being implemented to redirect placement of maintenance dredging sand to a more active portion of the littoral drift system west of the channel. Modification of USACE dredged material placement practice is expected to improve current beneficial use practices and enhance the natural sand transport system.

Monitoring Purpose: Verify sand placement west of Horn Island Pass has been relocated to a more active portion of the littoral transport system for bypassing material downdrift to Horn Island. The monitoring will provide the information required to measure progress against success criteria.

Monitoring Design Summary: To ensure modified maintenance dredging placement practice is achieving its desired outcome, bathymetric surveys will be conducted before and after sand is relocated to the new dredged material placement site adjacent to Horn Island. In addition, at least two extended surveys within Horn Island Pass will be conducted during the 10-year monitoring period. A sand transport study is also being conducted using sand tracer technology and subsequent monitoring to provide insight into the fate of dredged material placed within the Horn Island and DA-10 Littoral Zone Placement site to assist in verifying the optimum placement zone for future dredging/placement operations. Additional details regarding the monitoring procedure can be found in Appendix D1.

Desired Outcome: Effective placement of dredged material from Horn Island Pass to downdrift beaches of Horn Island.

Success Criteria: Increase sediment availability for littoral transport along the barrier islands measured over a 5 and 10 year period at Horn Island Pass.

Interim Target: Increase sediment availability for littoral transport along the barrier islands measured over a 5 year period at Horn Island Pass.

4.0 Data Management

Data management is a vital component of any long-term monitoring plan and the overall AM process. To maintain hydrological, biological, and physical data, the data must be stored, organized, and archived in an efficient and intuitive structure. The data management role will be shared by USACE, Mobile District and USGS, forming the MsCIP Data Management Team. All data collected will be analyzed for sensitivity and protected accordingly. Using a public and/or password protected web interface, spatial and temporal aspects of applicable data types will be available for accessing restoration project progress and for use in AM decision-making. Each distinct data type collected must comply with its specific data format, delivery, and metadata standard. These standards will be prescribed by the Data Management Team and managed by the Adaptive Management and Monitoring Program Oversight Committee. Over-arching MsCIP data management concepts and data type details can be found outlined in the MsCIP Data Management Plan (Appendix E).

Topics included in the data management plan include:

- Applicability
- Public Release
- Coordination
- Standardization

- Provider
- Data Access
- Data Format
- Metadata
- Archival
- Transparency

5.0 Assessment

The assessment phase of the implementation framework (Figure 5) compares the results of the monitoring efforts to the MsCIP barrier island performance measures that reflect the goals and objectives of the restoration action.

This assessment process measures the progress of barrier island restoration in relation to the stated project goals and objectives. The assessments will continue through the life of the project or until it is decided that the project has successfully achieved (or cannot achieve) its goals and objectives.

The CEM (Section 2.1.1; Appendix F) helps describe the linkages between stressors and performance measures and may be used to further define management actions based on the monitored results. The assessments will help determine if the observed responses are:

1) attributable to sediment placement by MsCIP; and 2) undesirable (e.g., are moving away from restoration goals) vs. in accordance with specified success criteria. If performance measures are not responding as desired or the stressor has not changed enough in the desired direction (for example, there is an increase in wave heights in the lee of Ship Island), then recommendations should be made for modifications to the project (both within the authority of MsCIP and outside of MsCIP) See section 5.2. If the stressor has changed as expected/desired and the performance measure has not, additional research may be necessary to understand why.

5.1 Variance

The TAG will refer to a combination of formal predictive models along with their own professional judgment when comparing the values of the performance measures detected by monitoring with the corresponding pre-defined decision criteria (performance measures, success criteria, triggers and thresholds). This group will collaborate with project managers and decision-makers to define magnitudes of difference (e.g., statistical differences, significance levels) between the values of monitored performance measures and the desired values (i.e., decision criterion) that will constitute variances from the desired outcomes. Comparisons between monitoring results and project performance will require characterization of historical and current spatial-temporal variability that define baseline conditions. Variances (or their absence) will be used to recommend one the following actions:

1. continuation of the project without modification
2. determine that more data are required and continue (or modify) monitoring
3. identify and implement active design or a remedial AM action through the MsCIP
4. identify and recommended remedial AM action outside of the MsCIP
5. modify project goals and objectives (this option would only be considered as a last resort and upon careful consideration by and consensus of the Program Management Team).
6. successful close-out of the barrier island restoration project and lessons learned.

Appropriate statistical comparisons (e.g., hypothesis testing, ANOVA, multivariate methods, etc.) will be used to summarize monitoring data and compare these data with the decision criteria. These continued assessments will be documented as part of the project reporting and data management protocols

5.2 Frequency of Assessments

An initial project assessment will be completed using pre-construction baseline data. There will be post-construction project assessments during the post-construction period; however the level of detail will depend on the timescale of expected responses, and frequency of data collection. At this time it is proposed that assessments will occur every three years and after acute events as necessary. Ultimately the determination of the frequency of assessment will be based on:

- relevant temporal scales of the performance measures
- time required to obtain sufficient monitoring results and analysis for meaningful comparisons with the decision criteria
- consequences (ecological, socioeconomic, political, stakeholder) of variances with decision criteria
- logistical requirements to perform the assessment
- availability of the AM personnel
- funding
- occurrence of acute events

5.3 Reporting

The TAG will document each of the performed assessments and communicate the results of its deliberations to the RSLG, Oversight Committee managers and Program Management Team. The TAG will produce periodic reports that will measure progress towards project goals and objectives as characterized by the selected performance measures and decision criteria. The reporting of monitoring results and AM evaluations will be in the form of both Assessment Reports to include a high level of detail and science and management friendly summary Report Cards.

6.0 Adaptive Management and Decision Making Processes

Scientific, technological, socio-economic, engineering, and institutional uncertainties are challenges inherent with any large-scale ecosystem restoration project. Because of inherent uncertainty and the inability to develop courses of actions optimal to all possible future scenarios, the USACE and other natural resource management agencies have increasingly committed to address uncertainties using AM (NRC 2004, Convertino *et al.*, 2013, Rist *et al*., 2013). The monitoring design (previously described Section 3) provides feedback necessary to not only determine progress towards achieving project goals and objectives but address uncertainty and inform iterative decisions about future project adjustments that may be needed through AM.

A distinction is often made between "passive" and "active" adaptive management and although there is considerable variability in the use of these terms, the main difference between passive and active adaptive management is the degree to which management objectives treat uncertainty and learning and how decisions are formalized (Fischenich *et al.,* 2012, Williams *et al.*, 2012). Active adaptive management formally pursues the reduction of uncertainty and learning to determine the cause-and-effect relationships between management actions and environmental responses. In active AM a range of management choices are explored at decision points and the best alternative is applied (NRC 2004). AM can also be passive, in which case uncertainty is recognized and selected performance measures are monitored but the project is implemented and focused on evaluating outcomes rather than resolving uncertainties, in these cases learning is a byproduct (NRC 2004; Fischenich *et al.*, 2012, Williams *et al.*, 2012). Traditionally passive AM has been planned and implemented for restoration projects. Whether passive or active, AM is an evolving process involving learning (the accumulation of understanding over time) and adaptation (the adjustment of management over time) that lead to a better understanding of the resource system, and better management based on that understanding (Williams et al., 2012).

The development of the AM program for the MsCIP program included both traditional passive AM planning and identification of corrective actions that could be implemented post-construction should monitoring data indicate the project is not performing as expected (Section 6.1) and also implementation of a more active formal AM program through the incorporation of Structured Decision Making (SDM, Section 6.2). Since the barrier island restoration is being implemented (previously described in Section 2.1.3) in a highly dynamic system, a formal decision analysis tool was developed to provide a framework to guide AM decisions that could arise at critical decision points during construction.

6.1 Adaptive Management Actions

As previously indicated in Section 2.3 there is limited flexibility for traditional AM post-construction since the MsCIP barrier island restoration once implemented is not planned to be modified or renourished. The adaptive management (contingency/corrective) actions identified in Table 1 are proposed to be implemented if the success criteria (presented in Section 3.1) are not met within the specified timeframe. It should be noted that in some cases due to the limited authority of the MsCIP barrier island restoration and the design criteria, some corrective actions may be implemented under the MsCIP and in other cases the MsCIP would make recommendations for an action that would have to be implemented by other programs and/or agencies.

Table 1.Potential Adaptive Management Response Options

Performance Measure Indicator	**Success Criteria**	**Trigger**	**Potential Response Option**	**Responsibility (MsCIP or outside agency)**
Flow patterns at Ship Island Pass, Little Dog Keys pass and Dog Keys Pass	Changes in flows measured from the pre and one year post construction surveys through the 3 passes are within the range of simulated changes.	Flows having similar tidal, river and wind conditions exceed predicted values through Ship Island Pass, Little Dog Keys Pass and Dog Keys Pass.	N/A	N/A
Water Quality	Salinity level changes measured for a period of up to 2 years post construction are within the range of historic variability and compare to changes observed at control stations.	Salinity levels exceed predicted values and are outside of the range of historic variability.	N/A	N/A
Submerged Aquatic Vegetation (SAV) coverage	10 years post construction total SAV acreage, distribution, condition and species composition on Ship Island is similar to the pre-construction period 2010-2014.	Reduction in SAV cover and condition 2 years post construction on Ship Island associated the closure of Camille cut.	Restore seagrass habitat in suitable areas. Potential methods include plantings in areas conducive for SAV establishment.	If determined to be associated with the construction of Ship Island a MsCIP action may be required.
Benthic and Infaunal Species	The re-establishment of benthic and infaunal species post-construction will occur when the average biomass is within the project area is at least 70 percent of the pre-project average biomass level. (applies to shorebird and sturgeon feeding sites and borrow and placement sites)	Success criteria not met by 5 years	Should prey biomass not meet the success criteria, then additional benthic surveys will be conducted until the success criterion is met.	MsCIP would conduct additional benthic surveys needed to meet success criterion.

Performance Measure Indicator	**Success Criteria**	**Trigger**	**Potential Response Option**	**Responsibility (MsCIP or outside agency)**
Gulf sturgeon	2 years post-construction occupancy values fall within 2 standard deviations of pre-construction values. AND No significant change in Fall and Spring post-construction benthos community assessments as compared to the pre-construction assessment.	Reduction in Gulf sturgeon habitat usage and occupancy patterns within the Ship and Horn Island System.	Additional gulf sturgeon monitoring will be implemented until success criteria are met (See scenarios A-D in Appendix D3i)	MsCIP would conduct additional gulf sturgeon monitoring until success criteria are met.
Habitat Composition	Less than 23% of emergent habitat is lost within 10 years post construction relative to project-completion acreage. (determine acreage from habitat mapping effort conducted immediately after project completion) AND Maintain habitat diversity of emergent and submerged habitats over time including beach and dune, intertidal flats, wetlands, and upland/scrub shrub.	Loss of more than 23% emergent habitat within 10 years. .... 10 years post construction an increase in the reduction in acreage of wetlands on Ship Island due to overwash and sand burial based on historical data	Additional sand placement on the island to restore emergent land. .... Restore wetlands lost from overwash or sand burial.	Not within the current MsCIP Authorization, if implemented action would be required by outside agency or additional authorization .... Not within the current MsCIP Authorization, if implemented action would be required by outside agency or additional authorization.
T&E Shorebirds	A) 10 years post construction maintain or increase the pre-construction acreage of suitable shorebird foraging habitat as evaluated by habitat mapping efforts. Specific acres will be determined by	N/A	If closing of Camille Cut adversely affects the low lying spits on the west and east tips of the island that provide sufficient habitat for key indicator bird species, recommendations to construct lower lying areas within the restoration template in the lee or at the ends of	MSCIP would re-consult with the USFWS to determine if further actions are necessary.

Performance Measure Indicator	Success Criteria	Trigger	Potential Response Option	Responsibility (MsCIP or outside agency)
	habitat mapping conducted on baseline conditions. AND B)Suitable Benthic by at least 5 yrs (benthic habitat success criteria must also be met)		the project during one of the later project construction phases may be made.	
Nesting Birds	10 years post construction maintain or increase suitable acres of nesting as compared to the pre-construction acreage as evaluated by habitat mapping efforts. Specific acres will be determined by habitat mapping conducted on baseline conditions.	Loss of nesting habitat (acres) for solitary and colonial nesting shorebirds as evaluated by habitat mapping efforts. Specific acres will be determined by habitat mapping conducted on baseline conditions.	Additional sand placement on the island to create suitable nesting habitat.	Not within the current MsCIP Authorization, if implemented action would be required by outside agency or additional authorization
Sea Turtles	A) Successful compaction test to indicate suitable turtle hatching requirements. AND B) 10 years post construction maintain or increase suitable acres of sea turtle habitat as compared to the pre-construction acreage. Sea turtle habitat is upper beach habitat @ 3 ft or higher. Specific acres will be determined by habitat mapping conducted on baseline conditions	Compaction tests do not meet requirements for suitable turtle hatching. .... Loss of habitat (acres) for sea turtle as evaluated by habitat mapping efforts. Specific acres will be determined by habitat mapping conducted on baseline conditions.	Tilling will occur as required by the Biological Opinion. .... Creation of additional suitable habitat.	MSCIP would re-consult with the USFWS to determine if further actions are necessary. .... MSCIP would re-consult with the USFWS to determine if further actions are necessary

Performance Measure Indicator	Success Criteria	Trigger	Potential Response Option	Responsibility (MsCIP or outside agency)
Cultural Resources	Success is defined as identifying cultural resources and making effects determinations regarding those cultural resources prior to construction activities, ultimately resulting in their avoidance of cultural resources with the desired outcome of having No Effect to cultural resources deemed eligible or potentially eligible for the NRHP.	An inadvertent discovery made during construction Or Increase exposure or disturbance to resources eligible for nomination to the National Register of Historic Places.	The purpose of this monitoring is for compliance with Section 106 of the National Historic Preservation Act of 1966. During construction any actions would fall within these requirements along with the Inadvertent Discoveries Plan.	MsCIP Actions are required during the construction period only. No actions will be conducted under the MsCIP program post construction.
Island morphology and shoreline change	Net loss of original island restoration surface area is not greater than an average of 3% per year over the 10-year monitoring period.	Net loss of original island restoration surface area is greater than an average of 3% per year over the 10-year monitoring period.	Additional sand placement on the island.	Not within the current MsCIP Authorization, if implemented action would be required by outside agency or additional authorization
		Land loss along Ship Island exceeds 50% of the original restoration area over the 10-year monitoring period.	Additional sand placement on the island.	Not within the current MsCIP Authorization, if implemented action would be required by outside agency or additional authorization
		A storm(s) significantly impacts the project before and/or during construction	If a storm(s) significantly impacts the project before and/or during construction and requires additional sand fill, additional construction actions may be necessary to maintain island integrity and meet the project objectives.	MsCIP Action. See Section 6.2 for recommended actions; SDM was specifically used to evaluate decisions on how to respond to

Performance Measure Indicator	**Success Criteria**	**Trigger**	**Potential Response Option**	**Responsibility (MsCIP or outside agency)**
				potential storm-induced damages.
Wave Reduction Leeward of Ship Island	Reduced wave height leeward of Ship Island relative to pre construction baseline conditions during the 5 years post construction monitoring period.	No reduced wave attenuation north of Ship Island after closure of Camille Cut to limit mainland beach damages.	N/A	N/A
Restore Sediment to the Barrier Island System	Increase sediment availability for littoral transport along the barrier islands measured over a 5 and 10 year period.	During construction material at Ship Island placement in the initial phases reveals higher longshore transport rates than expected	If material at Ship Island placement in the initial phases reveals higher longshore transport rates, then additional sand could be placed updrift in later construction phases. These revisions would be limited to the coordinated template and additional coordination would be required.	MsCIP Action. See Section 6.2 for recommended actions; SDM was specifically used to evaluate decisions on how to respond to increased longshore transport rates.

Performance Measure Indicator	**Success Criteria**	**Trigger**	**Potential Response Option**	**Responsibility (MsCIP or outside agency)**
Dredged Material Placement within Horn Island littoral system.	Increase sediment availability for littoral transport along the barrier islands measured over a 5 and 10 year period at Horn Island Pass.	No improved sediment transport of placed dredged material from Horn Island Pass toward Horn Island. Sediment flux is not increased to Horn Island.	If dredged material removed from Horn Island Pass and placed west of the channel is not migrating toward Horn Island at rates higher than disposal quantities and/or is migrating back toward the channel, recommendations outside of the MsCIP for revisions to future placements may be made.	Not within the current MsCIP Authorization. MsCIP could recommendation revisions to future Horn Island placements
Sedimentation/ Shoaling	No increase over natural variability in average annual maintenance dredging during the 5 and 10 year periods with Ship Island Pass.	Shoaling rates in the navigation channel increase on average by more than the variability in average annual maintenance dredging per year over the10-year monitoring period.	Recommendation to limit sediment from depositing in the Ship Island Pass navigation channel may be investigated (i.e. groins, sediment basins, backpassing sediment to nearshore etc.). or If suitable sand is available to be dredged from the Ship Island Pass navigation channel, MsCIP could recommend the future back passing to benefit the overall Ship Island system, if such action would not adversely impact the existing navigation project	Not within the current MsCIP Authorization, if implemented action would be required by outside agency

6.2 Structured Decision Making

Many AM programs employed in large restoration projects include a formal monitoring program, but lack formalized decision structures to integrate learning about effectiveness of management actions and system dynamics and often utilize a "trial and error" approach to implementing corrective actions (NRC 2004; Rist et al., 2013). Formal AM, on the other hand, necessitates decision analytic models that explicitly address uncertainties to inform the iterative adjustment of actions through time. Structured Decision Making (SDM) is a collaborative process that includes stakeholders and scientists to define management objectives, alternative actions, external drivers, predictive models, and quantitative methods for optimization and tradeoff analysis to identify optimal decisions and key uncertainties to be addressed through further gathering of information (Conroy and Peterson 2012 and Gregory et al., 2012). This process has been used effectively to develop decision analytic models that can then be used to inform AM programs (Nichols et al., 2007, Conroy and Peterson, 2012, Moore et al., 2013). Under the MsCIP program, SDM was applied to the Barrier Island Restoration on Ship Island to provide a formal, transparent and replicable process for analyzing decisions about repairing storm-related damages that may arise during island construction.

Typically the design template for barrier island restoration is based on a number of assumptions that if met should provide a specified island structure and longevity. This however does not take into account possible alternations that could arise during construction in these highly dynamic systems. In developing the AM plan for the MsCIP project we looked to directly incorporate the scientific uncertainties and technological challenges inherent with large-scale barrier island restoration into the AM planning through the use of SDM and create an AM decision framework that could be used to actively guide construction decisions for barrier island restoration on Ship Islands (East and West) and help determine the relationships between environmental conditions and management actions.

6.2.1 Decision Model Development Summary - PrOACT Process

SDM was applied to four phases of Barrier Island Restoration at Ship Island to set up a decision process that could be quickly and effectively implemented during project construction to make decisions should the restored berm incur damages or environmental dynamics change. SDM was conducted through a collaborative decision analysis with a diverse team of stakeholders representing multidisciplinary expertise in barrier island ecosystems. Participants represented subject-matter experts, decision makers, and stakeholders who preserve, manage, or restore barrier islands across the Gulf of Mexico region (Appendix C). Specifically, we followed a SDM framework that includes an assessment of Problems, Objectives, Alternatives, Consequences, and Tradeoffs (PrOACT) (Hammond et al 1999; Runge et al 2011) and through a series of webinars and rapid-prototyping workshops used expert judgment to identify and link objectives, performance measures, consequences, trade-offs and uncertainties associated with the construction of the Barrier Island Restoration at Ship Island. This formal process analyzed decisions at key decision points by breaking the problems, potential scenarios and solutions into components that were weighed through a transparent and replicable process. Expert elicitations, predictive models, and quantitative analysis were incorporated into a Bayesian decision network model (decision support tool) to represent the probabilistic relationships between storm impacts on the constructed island footprint (i.e., breaching, narrowing, and/or lowering) and consequences for restoration objectives including mitigation of shoaling; wave attenuation; avoiding loss of habitat for sea turtles, shorebirds, and Gulf sturgeon; maintaining salinity levels in Mississippi Sound; and preserving funds for subsequent MsCIP restoration projects.

The initial prototype decision (Prototype 1) framework was developed at a workshop in November 2013. Results from this workshop were then used in a subsequent series of webinars and workshops through June 2014, to refine the decision questions and consider additional objectives for Ship Island construction and restoration, which were included in Prototype 2. The results of the SDM effort and the decision tool are the product of this iterative process and illustrate the crucial uncertainties affecting the optimal choices for the construction and performance of the MsCIP Barrier Island Restoration Project. A summary of the process and results are presented in this Chapter.

Problem Definition

The group developed decision questions, including the spatial and temporal dimensions of the problem and any relevant legal or regulatory issues. These elements formed the conceptual foundation for SDM application. The decisions questions that were developed for the project were:

<u>Prototype 1</u>

How can MSCIP partners optimize decision making relative to Ship Island restoration and the benefits, including the use of monitoring & AM practices during construction given the uncertainties in budgets, storm impacts, & system response? If a storm impacts the constructed berm or longshore sediment transport is greater than expected, should the MSCIP partners repair a major breach in the berm or address increased longshore sediment transport by offsetting sediment placement given the funding and sand limitations?

<u>Prototype 2</u>

When should MSCIP partners repair weakening events (i.e., lowering or minor puncturing of the fill), if needed, within the Ship Island template to maximize the benefits, including the use of monitoring & adaptive management practices during construction, given the uncertainties in storm impacts and system response? How would potential minor mid-construction damage be handled?

Objectives

The next step was to identify a set of fundamental objectives to guide decision-making. The fundamental objectives that were selected were:

- Gulfport Harbor Channel Shoaling
    - Do not exceed historic shoaling rates of the Gulfport Harbor navigation channel

- Wave Attenuation
    - Increase wave height attenuation between Gulf of Mexico & Mississippi Sound

- Ecological integrity of Mississippi Sound
    - Maximize shallow sandy acreage for Gulf sturgeon feeding habitat
    - Maintain normal salinity levels in Mississippi Sound

- Ecological integrity of Shoreline
    - Minimize loss of upper beach habitat for sea turtles
    - Maximize swash zone habitat for shorebird feeding

- Maximize leftover funding for other high priority MsCIP projects
    - The MsCIP Management Team identified several high priority MsCIP projects that it would like to implement if funding were available after the implementation of the Barrier Island Restoration Project. Approximately $39,000,000 would be needed to

implement these high priority projects, so this minimum cost was included as a consideration in the decision model in cases where decisions would reduce available funding.

Alternative strategies

Once the objectives were identified, the next step was to identify alternative management actions that could be combined into strategies for achieving the fundamental objectives. The participants identified alternative management actions and alternative strategies for sediment placement decisions during each phase of Ship Island construction. Implementation of any given alternative strategy was dependent on the drivers including the longshore transport rate (LST) (included only in Prototype 1), storm inundation, available sediment, and remaining funding. The alternative management strategies identified were as follows:

Prototype 1

- Phases 1-4: If there is a major breach to the Camille Cut berm after initial construction and strengthening in Phases 1 and 2 should it be repaired?
- Phase 3: If longshore sediment transport is greater than expected should sediment placement be offset with additional sand placement to account for the increased rate?

Prototype 2

- Phase 1: If there are minor damages (lowering and/or narrowing) to the Camille Cut berm behind construction during Phase 1, should they be repaired at the end of Phase 1 (Sooner option) or during Phase 2 (Later option)?
- Phase 2 decision: If there are minor damages (lowering and/or narrowing) to the Camille Cut berm behind construction during Phase 2, should they be repaired at the end of Phase 2 (Sooner option) or during Phase 4 (Later option)?
- Phase 3 decision: If the nourished area of East Ship Island is lowered to less than 3-foot elevation over at least 50% of its surface area, then should this be repaired at the end of Phase 3 (Repair option), or not repaired at all (No Repair option)?
- Phase 4 decision: If the Camille Cut berm is lowered behind construction during Phase 4, should this be repaired at the end of Phase 4 (Repair) or not (No Repair)? If the decision is to repair, should those repairs be made with coarser sand (more expensive) or finer sand (less expensive)?

Consequences

In order to predict and evaluate consequences of alternative management strategies, the SDM team began by using influence diagrams to link the strategies to each of the fundamental objectives, while explicitly considering the external effects. The influence diagrams developed are presented in Figures 6-8. For prototype 1 which focused on whether or not to fix a major breach and or offset increased longshore transport, the diagram aggregated the fundamental objectives into Mississippi Sound conditions, near-shore conditions and island habitat. These fundamental objectives represent biophysical processes and functions of the Barrier Island restoration on Ship Island project. Some of the management actions that could be taken to influence the fundamental actions are shown in the hexagon in Figure 6 and are associated with how to manage sediment within the designed construction template of Ship Island. Each of the actions would require a decision that is dependent upon available sediment quantity and quality, available budget, and consideration of storm impacts during construction. Availability of suitable sediment, storms and budget were identified as important drivers to include in the decision frameworks that would impact the success of the fundamental objectives.

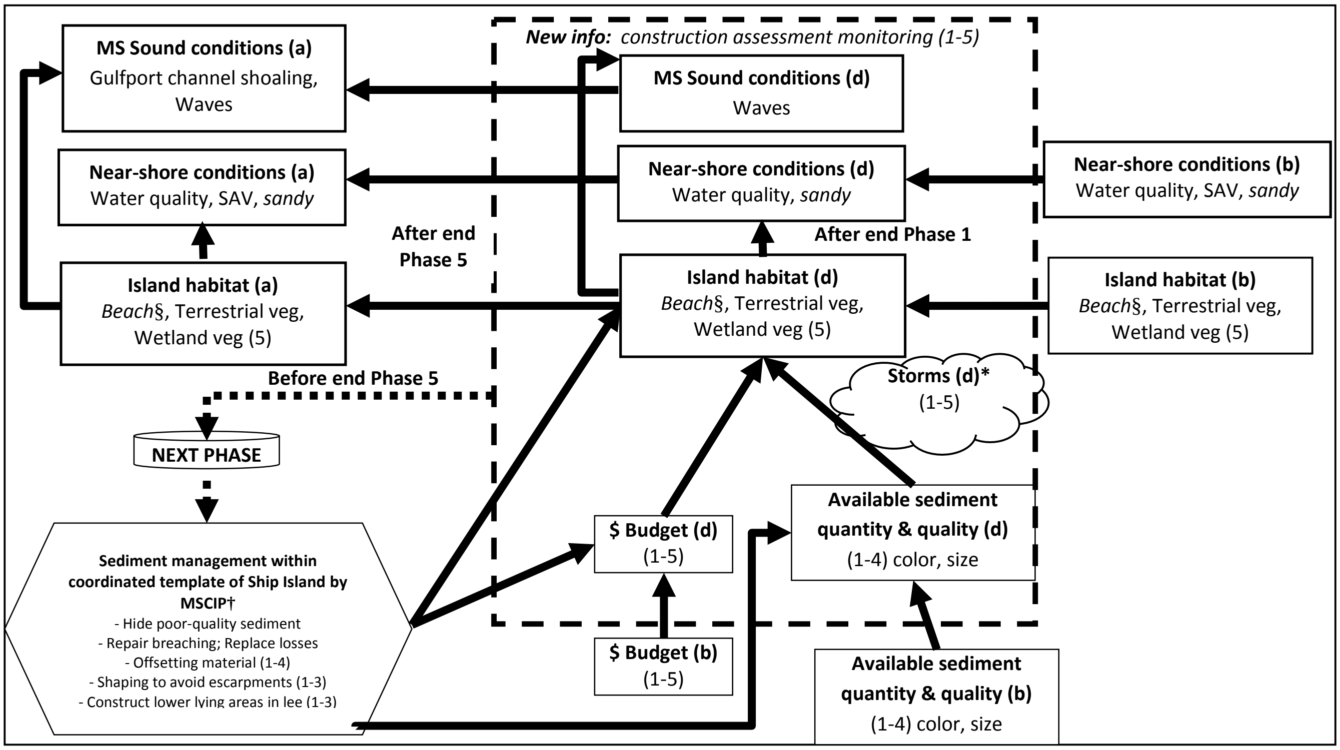

Figure 6. Prototype 1 Influence diagram representing timing of external drivers, constraints, and ultimate outcomes regarding linked decisions related to sediment placement within the coordinated template of Ship Island under authority of the Barrier Island Restoration Project administered by the USACE MsCIP. Hexagons represent decisions and rectangles represent objectives. Numbers in parentheses represent phases of construction; letters in parentheses represent before (b) or during (d) construction. †Actions will avoid exceeding allowed take of threatened and endangered species (i.e., Gulf coast sturgeon and sea turtles). *Storms impact every objective. SAV = submerged aquatic vegetation.

For Prototype 2, the influence diagrams were developed further to include a temporal component and the phases on construction and include a broader range of decisions to be made regarding potential damages (lowering, narrowing and minor breaching). Each of the actions would require a decision that is dependent upon storm impacts during construction, costs to fix damages, available sediment quantity, available budget, and sediment quality.

Damages in early phases could be repaired immediately or they could be repaired during subsequent phases as part of scheduled sand placement in the future phases. The decision to make immediate repairs would require additional cost for remobilization, while leaving the berm damaged and weakened until future phase repair increased the risk of additional damage, potentially increasing future costs. For damage in Phase 4, there was also the choice to use finer or coarser sand. The finer grain material is less stable but more readily available at a reduced cost. The condition of Ship Island restoration at the end of the phase depends on the occurrence of storms or unrepaired damage in prior phases and possible repair (at a sand and money cost) of narrowing, lowering, or breaching. The availability of suitable sediment, storms and budget were identified as important drivers to include in the decision frameworks that would impact the success of the fundamental objectives.

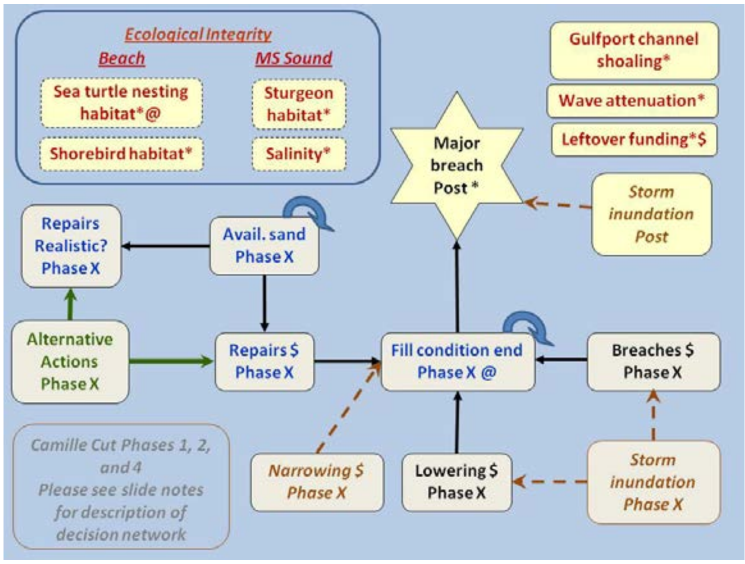

Figure 7. Prototype 2 Influence Diagram-Phases 1, 2, 4. Phase X refers to Phases 1,2, and 4, except “Avail. sand”, which is relevant for only Phases 2, and 4. Circular arrows indicate that these factors are contingent on their levels during the previous phase, which is only pertinent to Phases 2 and 4. Gray boxes are factors occurring during construction, and yellow boxes are happening post-construction. Red text indicates fundamental objectives, Brown text and dashed arrows indicate external drivers. Blue text indicates intermediate drivers not needing to be informed with elicited probabilities. Black text indicates intermediate drivers that would need to be informed by elicited probabilities. In some cases, linkages between factors are indicated with symbols: asterisk (*), “at” (@), and dollar ($).

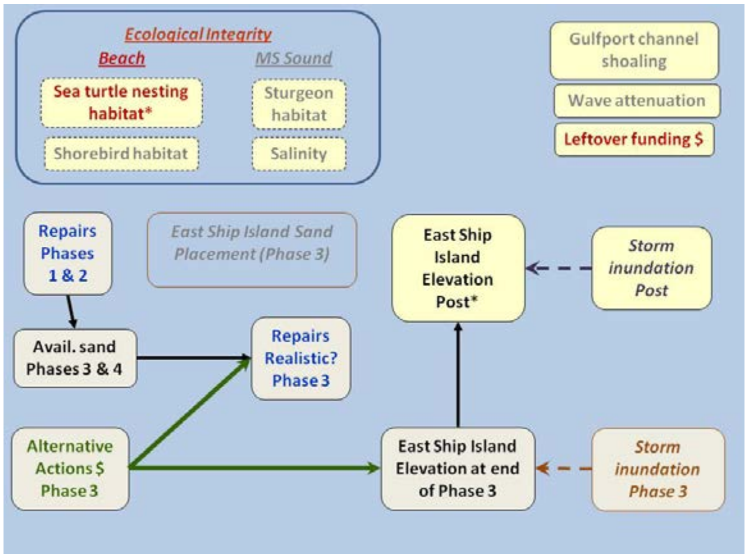

Figure 8. Prototype 2 Influence Diagram-Phase 3. Gray boxes are factors occurring during construction, and yellow boxes are post-construction. Red text indicates fundamental objectives, Brown text and dashed arrows indicate external drivers. Blue text indicates intermediate drivers not needing to be informed with elicited probabilities. Black text indicates intermediate drivers that would need to be informed by elicited probabilities. In some cases, linkages between factors are indicated with symbols: asterisk (*) and dollar ($).

The developed influence diagrams subsequently were converted to Bayesian Decision Network (BDN) models using the Netica software program (Norsys Software Corp: Vancouver BC, Canada) to represent probabilistic relationships. In general the BDN is organized as a collection of linked nodes that take one of 3 forms: 1) decision nodes that distinguish among alternative management strategies; 2) stochastic nodes that quantify intermediate outcomes (i.e., means objectives) and ultimate outcomes (i.e., fundamental objectives) along with external drivers; and 3) a utility node that represents how managers and decision makers value all possible outcomes in terms of the fundamental objectives. The BDN is particularly valuable for predicting the consequences of alternative management strategies, because uncertainties (e.g., sediment availability, budget, and storm impacts) are propagated explicitly through the model.

To parameterize the BDN model and assign probabilities in Netica, the group assigned measureable attributes to the objectives and used quantitative methods for making predictions about the effects of management actions on the objectives. When literature-based predictions, existing data and or predictive modeling results were unavailable, the group used rapid expert elicitation approaches to parameterize the BDNs during the workshops (Kuhnert et al. 2010). During the elicitation, decision makers, stakeholders and workshop participants were asked to quantify their values regarding the possible outcomes of the fundamental objectives on a 0-100 scale, with 0 being the worst possible outcome and 100 being the best possible outcome, providing their expert judgment and supporting rationale (based on data, experience and values). The resulting BDN models developed decision frameworks that tied various potential future scenarios to management actions and the resulting effects on the fundamental objectives.

Optimization, Tradeoffs and the Identification of optimal management strategies

As the final step in the PrOACT sequence, a tradeoff and sensitivity analysis was conducted on resulting BDNs for Prototypes 1 and 2. Often a decision maker would like to know whether an optimal decision would change if assumptions within the decision model are changed or if new information is discovered. Sensitivity analyses were conducted to evaluate the robustness of an optimal decision (expected utility), i.e. whether it changes when assumptions are altered regarding external drivers, predicted consequences, and/or trade-offs between objectives. Netica allowed the team to conduct the multi-attribute perturbation analyses to identify which of the stochastic nodes or combinations of nodes were driving optimal decision-making.

Summary and Conclusions

Under the SDM process the team developed two prototypes through an iterative process to formalize AM decisions that may be needed during construction to better ensure the project meets the objectives and success criteria. The first prototype addressed decisions regarding whether or not to repair a major breach and or offset long shore transport and the second model further addressed determining the decisions regarding minor breaches, lowering and or narrowing that could occur in each phase and tracking of sand and expenditures through the phases and decisions. Using expert elicitation from the team we identified the expected consequences and tradeoffs of potential actions (repairs, offsetting future placement to adjust for LST) that could be needed to ensure the integrity of the constructed Ship Island template while minimizing impacts on the fundamental objectives (mitigation of shoaling; wave attenuation; avoiding loss of habitat for sea turtles, shorebirds, and Gulf sturgeon; maintaining salinity levels in Mississippi Sound; and preserving funds for subsequent MsCIP restoration projects). Overall the results from the BDN models determined that sand could be a limiting factor in making optimal decisions but the available budget was not. From the scenarios examined there was enough funding available but there may not be enough sand if multiple repairs are required since the maximum amount of sand that can be placed is limited by the project's authorization.

The optimal decision identified from the BDN in Prototype 1 was to always repair a major breach if there was available sand. Under scenarios with limited funding and sand the optimal decision was to repair the breach but not offset material in future phases to account for increased LST. In a scenario with plenty of funding and sand the optimal decision was to fix the major breach and offset material to address LST but the benefit of this strategy was only slightly more beneficial (<2%) than not offsetting to address LST. A sensitivity analysis was run to evaluate the strategy optimality to uncertainty about predicted outcomes of the fundamental objectives and selected drivers. The uncertainties in Gulfport Harbor navigation channel, shoaling, Gulf sturgeon habitat, upper beach habitat, salinity in Mississippi Sound, storm inundation, major breaching post construction and funding for phase 5 plantings did not change the optimal decision. The only fundamental objective that was slightly affected was wave attenuation. When the likelihood of wave attenuation decreasing was adjusted the expected utility outcome was increased by <1%; this was not a large enough difference to change the optimal decision but does illustrate the importance of including monitoring for wave attenuation in the MAM plan.

The Prototype 2 framework helped determine optimal decisions related to repair of minor damages and identification of scenarios that might result in a shortage of sand in later phases. Furthermore Prototype 2 further helps guide decisions that would allow MsCIP to reserve funding to implement subsequent high priority MsCIP projects without impacting the fundamental objectives or integrity of the constructed Barrier Island Restoration project at Ship Island. The model showed that the optimal decisions for Phases 1 & 2 are to repair minor damages at end of each phase rather than waiting until the next phase. A bigger breach was determined to be up to 3 times as likely if the damages were not repaired at the end of Phase 1 but were delayed until Phase 2. Similarly, according to the decision model a major breach has no chance of occurring if minor damages are repaired in Phase 2, and a bigger breach is up to 43 times as likely to occur in later phases if the repairs are not made in Phase 2. The optimal decision during Phase 3 depended on two primary factors: whether the available sand limit has been exceeded, and whether the threshold of funding needed to implement subsequent high priority MsCIP projects had been reached. When sand is available to repair damages to Phase 3 but doing so would not leave enough funds to implement the high priority projects, the optimal decision was to consider not repairing the lowered sections, since the BDN model did not show negative impacts to the fundamental objectives. Most of the fundamental objectives were predicted to have similar outcomes regardless of whether a repair was made in phase 3. The only fundamental objective that was shown to be potentially impacted was the sea-turtle nesting habitat where the model showed that there was up to a 0.05 greater probability of losing sea-turtle nesting habitat if the minor damages were not repaired. Based on the loss of ability to pay for additional MsCIP projects resulting from performing the repairs, it was determined that the potentially minor impacts to the sea turtle fundamental objective habitat did not outweigh the benefits of implementing the additional MSCIP projects. The phase 4 decision also took the cost of using fine vs. coarse grain sand into consideration; in this scenario fine grain sand is the least costly. Consistent with the results from the previous phases it was determined that a major breach is >20 times as likely to form if damages are left unrepaired than if they are repaired depending on the type and extent of damage. The optimal decision was to complete repairs with coarser sand, if funding was available. If the cost of repairing with courser sands would not leave enough funding left for additional MsCIP projects, finer sand would be considered. When the cost-savings threshold would be crossed by the coarser-sand but not the finer-sand repair, then the recommendation for the optimal decision is to conduct the finer-sand repair. In cases where the use of finer sand it not suitable a decision would need to be made to determine if the repair is needed. In cases where the fundamental objectives are not impacted (as shown by some scenarios in the BDN) the optimal decision may be to consider not repairing because of the negligible impacts on the fundamental objectives.

Tables 2-5 summarize the recommended actions based on the BDN.

Table 2. Phase 1 Example Scenarios

Major Breach (> 670 KCY) during Phase 1	Narrowing or lowering < 90 KCY during Phase 1	Bigger breach (> 90 KCY) during Phase 1	Is sand still available within the 22 MCY limit for the entire project?	Recommended Action
Yes	--	--	Yes	Repair damages in Phase 1
--	--	Yes	Yes	Repair damages in Phase 1
--	Yes	--	Yes	repair damages in Phase 1
Yes	--	--	No	Do not repair
--	--	Yes	No	Do not repair
--	Yes	--	No	Do not repair

Table 3. Phase 2 Example Scenarios

Major Breach (> 670 KCY) during Phase 2	Narrowing or lowering < 90 KCY during Phase 2	Bigger breach (> 90 KCY) during Phase 2	Is sand still available within the 22 MCY limit for the entire project?	Recommended Action
Yes	--	--	Yes	Repair damages in Phase 2
--	Yes	--	Yes	Repair damages in Phase 2
--	--	Yes	Yes	Repair damages in Phase 2
Yes	--	--	No	Do not repair
--	Yes	--	No	Do not repair
--	--	Yes	No	Do not repair

Table 4. Phase 3 Example Scenarios

Major Breach (> 670 KCY) during Phase 3	More than or equal to 50% of the Berm is lowered to 3ft or less	Was more than $39M available for other MsCIP projects before damages discovered?	Is sand still available within 22 MCY limit for the entire project?	Would at least $39M be available for other MsCIP projects if repair done?	Recommended Action
Yes	--	--	Yes	Yes or No	Repair in Phase 3
Yes	--	--	No	--	Do not repair
--	Yes	No	Yes	--	Repair lowered
--	Yes	Yes	Yes	Yes	Repair lowered
--	Yes	Yes	Yes	No	Consider not repairing (fundamental objectives are expected not to be significantly impacted)
--	Yes	--	No	--	Do not repair
--	No	--	--	--	Do not repair

Table 5. Phase 4 Example Scenarios

Major Breach (> 670 KCY) during Phase 4	Narrowing or lowering < 90 KCY during Phase 4	Bigger breach (> 90 KCY) during Phase 4	Is sand still available within 22 MCY limit for the entire project?	> $39M available for other MsCIP projects before damages discovered	≥ $39M be available for other MsCIP projects if repair done with coarse sand	Berm is lowered to ≤ 6ft or less & narrowed to ≤200ft	Berm is lowered to 4ft or less & narrowed to 500ft or less	≥$39M be available for other MsCIP projects if repair done with fine sand?	Recommended Action
Yes	--	--	Yes	--	--	--	--	--	Repair damages in Phase 4
Yes	--	--	No	--	--	--	--	--	Do not Repair
--	Yes	--	Yes	No	--	--	--	--	Repair with Coarse Sand
--	--	Yes	Yes	Yes	Yes	--	--	--	Repair with Coarse Sand
--	Yes	--	Yes	Yes	Yes	--	--	--	Repair with Coarse Sand
--	Yes	--	Yes	Yes	No	--	--	Yes	Repair damages in Phase 4 with Fine sand
--	Yes	--	Yes	Yes	No	Yes	No	No	Repair damages in Phase 4 with Coarse Sand
--	Yes	--	Yes	Yes	No	No	No	No	Consider not repairing (fundamental objectives are not expected to be significantly impacted)
--	Yes	--	Yes	No	--	--	--	--	Repair with Coarse Sand
--	Yes	--	Yes	Yes	No		Yes	No	Repair with Coarse Sand
--	--	Yes	No	--	--	--	--	--	Do not Repair
--	Yes	--	No	--	--	--	--	--	Do not Repair
--	Yes	--	Yes	--	Yes	--	--	--	Repair with Coarse Sand

6.3 Adaptive Management Decision Making Process

For both the AM actions outlined in Section 6.1 and the optimal decisions determined by the SDM framework in Section 6.2 a formal process will be followed for recommendation and implementation of an AM action. The MAM program structure (Section 1.3, Figure 2) establishes lines of communication that facilitates coordination between Program Management, Adaptive Management and Monitoring Oversight Committee, TAG, and the RSLG. Based on during construction data, MAM plan monitoring results, Assessment Reports and outlined AM actions and SDM framework the TAG will submit specific AM recommendations to the Oversight Committee. The TAG will investigate and further refine any recommended AM action for Oversight Committee presentation to the Program Management Team. During project implementation and operation, it will ultimately be up to the District Commander in coordination with the NPS and other agencies to make a change under AM for the MsCIP Program or to make a recommendation to an outside agency or program to improve performance.

7.0 Lessons Learned

Although there will be limited opportunities for AM actions through the MsCIP, the MAM program will allow for lessons learned and provide information and or recommendations to other programs and or future projects. Monitoring results from the project will help refine modeling, design, and predictions of physical and ecological processes that will in turn inform design of future restoration projects. The barrier island prototype decision framework developed as part of the SDM process (Section 6) will also provide collaborative problem solving and stakeholder engagement tools that will be used to adjust future adaptive management decisions.

The Adaptive Management and Monitoring Oversight Committee will develop and compile lessons learned, best practices and experiences relevant to implementation of barrier island restoration, technical and organizational challenges, and monitoring and adaptive management approaches. Lessons and experiences will be clearly documented with recommendations so that they can be easily applied to future barrier island and ecosystem restoration programs and projects. Documenting the lessons learned ultimately aims to reduce recurring, technical or programmatic issues that negatively impact cost, schedule, restoration project performance and success.

Future potential projects that may benefit from lessons learned include O&M of Gulfport and Pascagoula Harbor Federal Navigation Channels, future local plans for restoring Dauphin Island in Alabama, potential expansion proposed by the Port for Gulfport, and other state and local planning initiatives including the planning efforts in the State of Alabama.

8.0 Costs

Costs associated with implementing this MAM Program were estimated based on available data and may be revised as additional information becomes available. Section 2039 of the WRDA 2007 allows monitoring for up to ten years post-construction. For cost estimating purposes, this ten-year monitoring timeframe was assumed for all performance measures. The need for additional monitoring to determine the project’s ecological success would be assessed at the end of the 10-year cost-shared period, and any additional monitoring would be a 100-percent non-MsCIP responsibility.

The MAM program establishes a feedback mechanism whereby monitored conditions will be used to adjust or refine construction and or maintenance actions to better achieve project goals and objectives.

As previously indicated there will be limited opportunities for AM actions through the MsCIP. At this time it is not recommended that separate funding for AM contingency actions be included for the activities described in Section 6.1 as these potential AM actions are already expected to be covered in the construction or O&M costs if needed. AM program, planning and management costs have been estimated.

Table 6 presents the breakdown of the estimated project costs for MAM between pre-construction, during construction and post construction. These costs include planning and management costs, data collection, T&E species compliance monitoring, data assessment and evaluation, data management and adaptive management program costs. These proposed MAM Plan elements and associated costs will continue to be evaluated to ensure they include the minimum elements necessary to evaluated project success, meet required compliance monitoring and conduct adaptive management actions.

Table 6- Estimated MAM Costs for the MsCIP Barrier Island Restoration

	Pre-Construction	During Construction	Post Construction
Planning and Management	$1,030,000.00	$720,000.00	$1,680,000.00
Currents/Waves	$970,000.00	$150,000.00	$0.00
Habitat Classifications/ Land:Water	$140,000.00	$70,000.00	$210,000.00
Surveys	$450,000.00	$260,000.00	$550,000.00
Water Quality	$190,000.00	$280,000.00	$150,000.00
Submerged Aquatic Vegetation	$130,000.00	$100,000.00	$210,000.00
Compliance: Shorebirds	$290,000.00	$1,000,000.00*	$730,000.00*
Compliance: Sea Turtles	$60,000	$220,000.00*	$160,000.00*
Compliance: Sturgeon	$1,530,000.00	$1,260,000.00	$430,000.00
Compliance: Benthic	$850,000.00	-----	$170,000.00
Data Management	$520,000.00	$530,000.00	$870,000.00
Assessment and Reporting	$440,000.00	$820,000.00	$1,730,000.00
Post storm surveys (Contingency)	------	------	$230,000.00

*monitoring will be included in construction contract

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10.0 Appendices

A. Acronym List

B. Implementation Guidance for Section 2039 of WRDA 2007

C. Monitoring & Adaptive Monitoring Program and Structured Decision Making Team Members

D. Monitoring Procedures

1. Physical –Survey Data
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   - ii. Water Quality
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   - ii. Shorebirds
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   - vi. Submerged Aquatic Vegetation
4. Cultural

E. Data Management Plan

F. Conceptual Ecological Model

Appendix A. Acronym List

Appendix A- Acronym List

ADCP	Acoustic Doppler Current Profile
AM	Adaptive Management
ATR	Agency Technical Review
AWAC	Acoustic Wave and Current profilers
BDN	Bayesian Decision Network
CEM	Conceptual Ecological Model
CIR	Color-infrared
DA-10	Disposal Area #10/Sand Island
DEM	Digital Elevation model
DMC	Digital Mapping Camera
DO	Dissolved Oxygen
EM	Engineering Manual
ER	Engineering Regulation
GIS	Geographic Information Systems
GPS	Global Positioning System
GUIS	National Park Service Gulf Islands National Seashore
HQUSACE	Headquarters United States Army Corps of Engineers
IEPR	Independent External Peer Review
LCA	Louisiana Coastal Area
LiDAR	Light Detection and Ranging
MAM	Monitoring & Adaptive Management

Mcy	Million Cubic Yards
MsCIP	Mississippi Coastal Improvements Project
MDEQ	Mississippi Department of Environmental Quality
MDMR	Mississippi Department of Marine Resources
mNDWI	Normalized Difference Water Index
NEPA	National Environmental Policy Act
NPS	National Park Service
NRDA	National Resources Damage Assessment
NRHP	National Register of Historic Places
NWI	National Wetlands Inventory
O&M	Operation and Maintenance
PAR	Photosynthetically Active Radiation
PM	Performance Measure
PPA	Project Partnership Agreement
PPCP	Primary Project Control Points
RSLG	Regional Science and Leadership Group
RSME	Root Mean Square Error
SAV	Submerged Aquatic Vegetation
SDM	Structured Decision Making
TAG	Technical Advisory Group
T&E	Threatened and Endangered Species
TM	Thematic Mapper
TOC	Total Organic Carbon

USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
WRDA	Water Resources Development Act

Appendix B. Implementation Guidance for Section 2039 of WRDA 2007

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET NW
WASHINGTON, D.C. 20314-1000

CECW-PB

31 AUG 2009

MEMORANDUM FOR COMMANDERS, MAJOR SUBORDINATE COMMANDS

SUBJECT: Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007) – Monitoring Ecosystem Restoration

1. Section 2039 of WRDA 2007 directs the Secretary to ensure that when conducting a feasibility study for a project (or component of a project) for ecosystem restoration that the recommended project includes a plan for monitoring the success of the ecosystem restoration. The monitoring plan shall include a description of the monitoring activities, the criteria for success, and the estimated cost and duration of the monitoring as well as specify that monitoring will continue until such time as the Secretary determines that the success criteria have been met. Within a period of ten years from completion of construction of an ecosystem restoration project, monitoring shall be a cost-shared project cost. Any additional monitoring required beyond ten years will be a non-Federal responsibility. A copy of Section 2039 is enclosed.

2. Applicability. This guidance applies to specifically authorized projects or components of projects as well as to those ecosystem restoration projects initiated under the Continuing Authority Program (CAP) or other programmatic authorities.

3. Guidance.

a. Monitoring includes the systematic collection and analysis of data that provides information useful for assessing project performance, determining whether ecological success has been achieved, or whether adaptive management may be needed to attain project benefits. Development of a monitoring plan will be initiated during the plan formulation process for ecosystem restoration projects or component of a project and should focus on key indicators of project performance.

b. The monitoring plan must be described in the decision document and must include the rationale for monitoring, including key project specific parameters to be measured and how the parameters relate to achieving the desired outcomes or making a decision about the next phase of the project, the intended use(s) of the information obtained and the nature of the monitoring including duration and/or periodicity, and the disposition of the information and analysis as well as the cost of the monitoring plan, the party responsible for carrying out the monitoring plan and a project closeout plan. Monitoring plans need not be complex but the scope and duration should include the minimum monitoring actions necessary to evaluate success. The appropriateness of a monitoring plan will be reviewed as part of the decision document review including agency technical review (ATR) and independent external peer review (IEPR), as necessary. The estimated cost of the proposed monitoring program will be included in the project cost estimate and cost-shared accordingly.

c. Upon completion of the construction of the ecosystem restoration project (or component of a project), monitoring for ecological success will be initiated. Monitoring will be continued until ecological success is determined. Once ecological success has been documented by the District Engineer in consultation with the Federal and State resources agencies, and a determination has been made by the Division Commander that ecological success has been achieved (may be less than ten years), no further monitoring will be required. Ecological success will be documented through an evaluation of the predicted outcomes as measured against the actual results. The law allows for but does not require a 10 year cost shared monitoring plan. Necessary monitoring for a period not to exceed 10 years will be considered a project cost and will be cost shared as a project construction cost and funded under Construction. Costs for monitoring beyond a 10 year period will be a non-Federal responsibility. Financial and implementation responsibilities for the monitoring plan will be identified in the Project Partnership Agreement. For CAP projects, or for those projects that may be authorized with an explicit dollar cap, any cost shared monitoring costs cannot increase the Federal cost beyond the authorized project limit of the CAP or other authority under which the project is being considered.

d. Contingency Plan (Adaptive Management). An adaptive management plan (i.e., a contingency plan) will be developed for all ecosystem restoration projects. The adaptive management plan must be appropriately scoped to the scale of the project. If the need for a specified adjustment is anticipated due to high uncertainty in achieving the desired outputs/results, the nature and cost of such actions should be explicitly described in the decision document for the project. The reasonableness and the cost of the adaptive management plan will be reviewed as part of the decision document. Costly adaptive management plans may indicate the need to reevaluate the formulation of the ecosystem restoration project. The information generated by the monitoring plan will be used by the District in consultation with the Federal and State resources agencies and the MSC to guide decisions on operational or structural changes (adaptive management) that may be needed to ensure that the ecosystem restoration project meets the success criteria. The adaptive management plan cost should be shown in the 06 feature code of the cost estimate.

If the results of the monitoring program support the need for physical modifications to the project, the cost of the changes will be cost shared with the non-Federal sponsor and must be concurred in by the non-Federal sponsor. The appropriate HQUSACE RIT should be advised at such time that it is determined a modification to a project is required. Any changes to the adaptive management plan approved in the decision document must be coordinated with HQUSACE at the earliest possible opportunity. If a needed change is not part of the approved adaptive management plan and is determined by HQUSACE to be a deficiency correction the annual budget guidance to initiate a study for such corrections should be followed. Significant changes to the project required to achieve ecological success and which cannot be appropriately addressed through operational changes or through the approved adaptive management plan may need to be examined under other authorities, such as Section 216, River and Harbor and Flood Control Act of 1970.

4. This guidance is effective immediately and will be incorporated into ER 1105-2-100 upon the next revision.

FOR THE COMMANDER:

Encl

THEODORE BROWN, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

DISTRIBUTION:
COMMANDER, GREAT LAKES AND OHIO RIVER DIVISION
COMMANDER, MISSISSIPPI VALLEY DIVISION
COMMANDER, NORTH ATLANTIC DIVISION
COMMANDER, NORTHWESTERN DIVISION
COMMANDER, PACIFIC OCEAN DIVISION
COMMANDER, SOUTH ATLANTIC DIVISION
COMMANDER, SOUTH PACIFIC DIVISION
COMMANDER, SOUTHWESTERN DIVISION
CECW-LRD
CECW-MVD
CECW-NWD
CECW-SAD
CECW-NAD
CECW-SAD
CECW-POD
CECW-SPD
CECW-NWD
CECC-G

SEC. 2039. MONITORING ECOSYSTEM RESTORATION.

(a) In General- In conducting a feasibility study for a project (or a component of a project) for ecosystem restoration, the Secretary shall ensure that the recommended project includes, as an integral part of the project, a plan for monitoring the success of the ecosystem restoration.

(b) Monitoring Plan- The monitoring plan shall--

(1) include a description of the monitoring activities to be carried out, the criteria for ecosystem restoration success, and the estimated cost and duration of the monitoring; and

(2) specify that the monitoring shall continue until such time as the Secretary determines that the criteria for ecosystem restoration success will be met.

(c) Cost Share- For a period of 10 years from completion of construction of a project (or a component of a project) for ecosystem restoration, the Secretary shall consider the cost of carrying out the monitoring as a project cost. If the monitoring plan under subsection (b) requires monitoring beyond the 10-year period, the cost of monitoring shall be a non-Federal responsibility.

Appendix C. Monitoring & AM Program and Structured Decision Making Team Members

MSCIP Monitoring and Adaptive Management Teams	
Name	**Agency**
Program Management Team	
Susan Rees	USACE
Tom Smith	USACE
Gary Rikard	MDEQ
Jamie Miller	MDMR
Dan Brown	NPS
Sherri Fields	NPS
Adaptive Management and Monitoring Oversight Committee	
Justin McDonald	USACE
Linda Barnett	USACE
Greg Steyer	USGS
Cassity Bromley	NPS
Jennifer Jacobson	USACE
Technical Advisory Group	
Official Team Members (Core Members are in Bold)	
Michelle Meyers	**USGS**
Linda Barnett	**USACE**
Mark Byrnes	Consultant
Soupy Dalyander	**USGS**
Elizabeth Godsey	**USACE**
Cheryl Bosley	USACE
Jeff Clark	MSDMR
Allen Wilson	USACE- Cultural
Matthew Hicks	USGS/MSWSC
Gary Hopkins	NPS
Christina Hunnicutt	USGS
Mike Miner	BOEM
Paul Necaise	FWS
Martha Segura	NPS
Additional technical experts that contacted as needed are listed below	
Ray Chapman	ERDC- Water Quality
Andy Coleman	Turtles-IMMS
Jim Flocks	USGS-Geomorphology
Nicholas Enwright	USGS-Habitat Mapping
Kristen Hart	Turtles-USGS
Hardin Waddle	Birds/Benthic-USGS
Nate Lovelace	Project Management Navigation-USACE
Scott Mize	USGS-Benthics
Mark Peterson	Sturgeon-USM
Deborah Shafer	SAV-ERDC

Todd Slack	Sturgeon-ERDC
Steve Underwood	Consultant
Ty Wamsley	USACE-Geomorphology
Jacqueline Whittmann	USACE
Nick Winstead	MMNS
Mark Woodrey	Birds -Grand Bay NERR
Barry Vittor	Consultant

Data Management Team	
Clint Padgett	USACE
Craig Conzelmann	USGS
Cheryl Bosley	USACE
Christina Hunnicutt	USGS
Dave Hill	USACE
Christopher Barrow	NPS
Joesph Givhan	USACE-OC
Reach back as needed with other regional data management systems	

Regional Science and Leadership Group	
David Barnes	MDEQ
Linda Barnett	USACE
Cheryl Bosley	USACE
Christopher Barrow	NPS
Cassity Bromley	NPS
Dan Brown	NPS
Mark Byrnes	Applied Coastal
Ray Chapman	ERDC- Water Quality
Jeff Clark	MSDMR
Andy Coleman	Turtles-IMMS
Melissa Collins	Birds/Benthic-USGS
Craig Conzelmann	USGS
John Cornelison	NPS
Soupy Dalyander	USGS
Nicholas Enwright	USGS
Michelle Fischer	USGS/NWRC
Mike Federoff	USACE
Sherri Fields	NPS
Mike FitzHarris	MSCIP
Jim Flocks	USGS
Mark Ford	NPS
Joesph Givhan	USACE
Elizabeth Godsey	USACE
Kristen Hart	USGS
Ryan Hendren	NMFS
Matthew Hicks	USGS/MSWSC
Dave Hill	USACE
Gary Hopkins	NPS

Christina Hunnicutt	USGS
Jennifer Jacobson	USACE
Ntale Kajumba	EPA
Jack Kindinger	USGS
Barb Kleiss	USACE
Darin Lee	LA CPRA
Nate Lovelace	USACE
Chris Macon	USACE
Justin McDonald	USACE
Michelle Meyers	USGS/NWRC
Jamie Miller	MDMR
Mike Miner	BOEM
Paul Necaise	FWS
Clint Padgett	USACE
Larry Parson	USACE
Mark Peterson	USM
George Ramseur	DMR
Richard Rebich	USGS
Susan Rees	USACE
Gary Rikard	MDEQ
Julie Rosati	USACE
Martha Segura	NPS
Deborah Shafer	ERDC
Todd Slack	ERDC
Tom Smith	USACE
Brian Spears	USFWS
Greg Steyer	USGS/NWRC
Dottie Tillman	ERDC
John Tirpak	GCPO LCC
Steve Underwood	Applied Coastal
Barry Vittor	Consultant
Ty Wamsley	USACE
Jacqueline Wittmann	USACE
Jolene Williams	NPS/GUIS
Allen Wilson	USACE
Nick Winstead	MMNS
Mark Woodrey	Grand Bay NERR
Jennifer Wozencraft	USACE
Steve Wright	NPS
Heather Young	NMFS
Linda York	NPS

Structured Decision Making (SDM) Core Team		
Greg Steyer	USGS	Team Coordinator/Project Management
Mark Byrnes	Applied Coastal	Scientist
P. Soupy Dalyander	USGS	Scientist
Mark Ford	NPS	Scientist
Elizabeth Godsey	USACE	MSCIP Decision Maker/Technical advisor
Elise Irwin	USGS	SDM Co-Coach
Ayse Karanci	North Carolina State University	SDM Coaching Apprentice
Linda Barnett	USACE	MSCIP Technical
Darin Lee	CPRA	LCA OM&M Decision Maker, In-Kind
Nate Lovelace	USACE	MSCIP Decision Maker
Brady Mattsson	BOKU Institute of Zoology	SDM coaching, Technical
Justin McDonald	USACE	MSCIP Decision Maker/Technical, In-Kind
Michelle Meyers	USGS	Adaptive Management Liaison/Technical/Project Management

Appendix D. Monitoring Procedures

D. Monitoring Procedures

1. Physical –Survey Data
2. Hydrological Data
   i. Wave, Currents, Circulation
   ii. Water Quality
3. Biological
   i. Gulf Sturgeon
   ii. Shorebirds
   iii. Habitat Composition/Habitat Mapping
   iv. Sea Turtles
   v. Benthic and Infaunal species
   vi. Submerged Aquatic Vegetation
4. Cultural

APPENDIX D - MONITORING PROCEDURES

The following monitoring procedures will provide information necessary to evaluate project objectives for the MsCIP Barrier Island Restoration project. This plan proposes and builds upon existing data to establish a detailed baseline condition. This monitoring will continue during and post-construction to evaluate short-term and long-term response to the proposed restoration. These procedures will be updated as required to provide the necessary information to evaluate ecological success and inform the adaptive management program.

1 PHYSICAL- SURVEY DATA

A combination of bathymetric and LiDAR surveys will be used to determine the cross-shore profile, shoreline position, and sand volumes for East and West Ship Islands and Cat Island. One pre-construction LiDAR and bathymetric survey will be conducted, as the standards for future changes in island dimensions along with historical topographic, bathymetric, and shoreline data compiled in Byrnes et al. (2012). Four post-construction LiDAR surveys and two bathymetric surveys will be conducted within the first 10 years in the vicinity of Ship Island and Ship Island Pass to develop elevation models for comparison of subaerial and subaqueous elevation and to quantify volumetric changes. Similar data will be collected at Cat Island. Additionally, two bathymetric surveys will be conducted within the first 10 years within Horn Island Pass to compare subaqueous volumetric changes and movement of dredged material placed in the littoral zone west of the Pascagoula Federal Navigation Channel.

LiDAR surveys will be conducted as per methods detailed by Heidemann *et al*. (2012) and in compliance with USACE EM-1110-1-1000 for Photogrammetric Mapping, USACE EM -1110-1-1002 Survey Markers and Monumentation, USACE EM -1110-1-1003 NAVSTAR Global Positioning System Surveying, USACE EM -1110-1-1004 Deformation Monitoring and Control Surveying, USACE EM -1110-1-1005 Topographic Surveying, USACE EM -1110-2-1003 Hydrographic Surveying, and USACE EM -1110-1-2909 Geospatial Data and System, Tri-Services A/E/C CADD Standards, Tri-Services Spatial Data Standards, and Related Spatial Data Products. LiDAR surveys will cover the complete island shoreline and extend inland approximately 1 km to cover the whole island including the shallow shoals to the north. The resulting data will provide a density of approximately 1 elevation point per square meter accurate to approximately +/- 15 cm (RMSE) vertical elevation and +/- 1.5m (RSME) horizontal position.

Bathymetric survey methodology should include a combination of single-beam and swath or multi-beam sensors (for the rest of the discussion the term swath refers to either swath or multi-beam sensors). Within the project areas, bathymetric coverage should be extensive enough to capture the area of active littoral transport under normal oceanographic conditions (non-storm processes). To capture the area of active littoral transport on the Gulf and Sound sides of placement areas, bathymetric surveys should extend to water depths identified as the long-term seaward limit for significant sand transport in the MsCIP sediment budget (Byrnes et al., 2013). This distance can be defined through the examination of previously collected geophysical data. Real Time Kinematic (RTK) shall be utilized for horizontal and vertical positioning of all hydrographic data acquisition. All project surveying and mapping shall be in strict compliance with EM 1110-2-6056, Standards and Procedures for Referencing Project Elevation Grades to Nationwide Vertical Datums. Specifically, all Primary Project Control Points (PPCP) and all project survey mapping shall be referenced to NAVD88. In addition, all PPCP shall be tied to the National Spatial Reference System.

For single beam coverage shore perpendicular tracklines should be spaced 1 km apart across the study areas which extend to water depths identified as the long-term seaward limit for significant sand transport in the MsCIP sediment budget (Byrnes et al., 2013). The use of single beam systems for shore-perpendicular transects will be used to ensure reproducibility in different oceanographic conditions. Two shore-parallel single-beam tie-lines should be obtained across the shore-perpendicular transects on both the Gulf and Sound sides to provide cross-track error estimates. Water depths less than one meter should be measured using single beam systems. A survey grid should be designed to cover the study area with trackline spacing not to exceed 328 feet where possible. Trackline spacing in areas of significant elevation change should be reduced as much as possible to ensure data represent the bathymetry accurately. The seaward portion of the study area, defined by the1 m water depth contour should be measured by near-total swath or multibeam coverage. Near-total coverage can be defined as measurements covering a minimum of 80% of the study area. Project design and construction surveyed points (including, easting, northing, and elevation for each point) will be collected along cross-section lines within the fill portion of Camille Cut and the nearshore area of East Ship Island with shore-perpendicular spacing not to exceed 200 feet within the immediate fill template and 500 feet elsewhere. In addition cross-lines shall be run every 1,000 to 2,000 feet. The easting and northing values will be relative to the State Plane Coordinate System, Mississippi East zone, NAD 1983 in U.S. survey feet. This data will supplement bathymetric data collected as part of the MAM.

In addition, District bathymetric surveys are routinely conducted for the navigation channels (including the Pascagoula and Gulfport channels) by the USACE, Operations Division. These surveys will supplement bathymetric data collected as part of the MAM to assess channel shoaling rates to infer transport rates from the west end of Ship Island.

PASCAGOULA HARBOR – DISPOSAL AREA 10 LITTORAL ZONE PLACEMENT

SAND TRANSPORT STUDY

DESCRIPTION

The scope of work for this task is for the completion of a sand transport study for the Pascagoula Harbor – Disposal Area 10 Littoral Zone Placement Site (see Figure 1) using sand tracer technology and monitoring. The current Disposal Area 10 Littoral Zone Placement was identified through review of historical bathymetric changes and dredging operations and costs. The objective of the proposed study is to provide insight into the fate of dredged material placed within the Disposal Area 10 Littoral Zone Placement site to assist in verifying the optimum placement zone for future dredging/placement operations. Specific objectives of this study include:

1. Identifying if sand within the placement site is transported toward Horn Island and if so at what size fractions and at what rates (for normal tidal and storm conditions).

2. Identifying if sand within the placement site is transported back toward the Pascagoula Harbor Federal navigation channel and if so at what size fractions and at what rates (for normal tidal and storm conditions).
3. Identifying if sand within the placement site is transported offshore of the placement site and if so at what size fractions and at what rates (for normal tidal and storm conditions).

The Mobile District will provide two field personnel to assist with the background sampling, mixing, and release of the sand tracer. Additional before and after dredge placement surveys will also be provided.

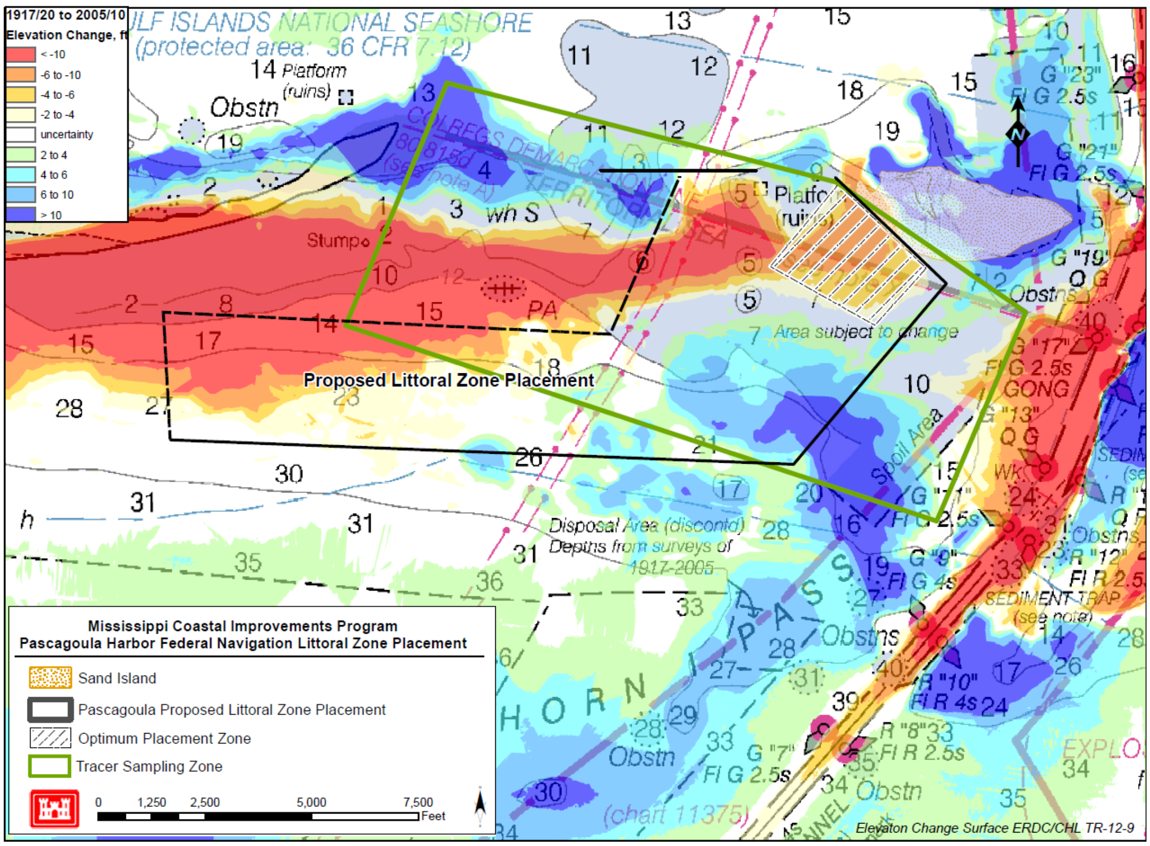

Figure 1: Pascagoula Harbor – Disposal Area 10 Littoral Zone Placement Site

Task 1: Approval/Permits for the Tracer Release:

Obtain all necessary approval/permits for the tracer release prior to mobilizing to the site for background sampling collection and placement. This includes but is not limited to a Special Use Permit from the United States National Park Service.

Task 2: Sand Tracer Background Collection, Manufacturing and Release:

i. Tracer Manufacturing: Provide an artificial fluorescent tracer that mimics the physical properties of sand from the Pascagoula Harbor Navigation Chanel placed at the Disposal Area 10 Littoral Zone Placement Site. Specifically the tracer particle shall be a Barium sulphate filled polymer to adjust the density to SG 2.65, such as EcoTrace or equivalent. Sufficient tracer as approved by the Contracting Officer shall be manufactured to allow sediment tracing for 12-18 months (as required).

ii. Background Sampling: Collect background samples from an agreed sampling area (approximately 30 samples). The locations of the samples will be determined through coordination with the Mobile District Coastal Engineer POC and PAE.

iii. Tracer Release: Mix one color of tracer with native sediment and release via dissolving bags within the Disposal Area 10 Littoral Zone Optimized Placement Site (see Figure 1) post dredged material placement within the site. A second color tracer shall be released via dissolving bags in the southeast portion of the Disposal Area 10 Littoral Zone Placement Site to compare the dispersal and deposition of material from the different locations within the site. The tracer shall be earth tone in color (i.e black, green and/or blue) and the quantity shall be limited to no greater than 3.5 cubic feet per site unless otherwise approved by the USACE. The locations for the placement of tracer shall be fully coordinated with the Mobile District Coastal Engineer POC and PAE prior to deployment. The current operation and maintenance dredge cycle for the Pascagoula Harbor Entrance channel is scheduled for January 2016.

Task 2: Sand Tracer Sampling and Evaluation:

i. Standard Operating Procedure: Develop a Standard Operating Procedures for tracer sampling and sub-sampling. The sampling procedure shall be submitted the Mobile District Coastal Engineer POC for approval prior to the collection of any samples. Grab sampling shall be conducted with a spring-loaded grab (similar to a Shipek grab) such that consistent samples can be taken. Vessels utilized to release samples shall be equipped with davit, Hiab, A-frame or similar and with a hydraulic winch strong enough to operate the grab. The vessel shall also be equipped with a navigational positioning system and have sufficient draft, capacity, and deck space to deploy the sand tracer.

Ensure proper field and office quality control procedures are implemented and monitored, including adherence to accuracy standards and compliance with minimum technical standards.

ii. Sampling Location: Collect tracer samples from an agreed sampling area (approximately 75-80 samples over a sampling area of roughly 3.5 square miles). To provide more accurate data in areas of specific interest, such as close to the release site, the navigation channel, and eastern tip of Horn Island, initial sampling shall be weighted to the tracer release site(s) since there may be limited transport in the first few months after placement. Additionally, in order to be able to accurately conduct a mass balance calculation in the areas of specific interest more samples shall be concentrated in these areas. In the wider area sampling zone, samples shall be collected over a wider grid area. Refinement determined through coordination with the Mobile District Coastal Engineer POC) of each sampling zone shall be made based on results from earlier sampling events prior to the next.

iii. Tracer Sampling Timing: Conduct sampling over a 12-18 month period generally as follows:

Sampling Event 1: 1-2 months after release, ideally after a period of quiescent conditions tidal currents only or ahead of first storm whichever is the sooner

Sampling Event 2: After localized small storm with seas, as determined through coordination with the Mobile District Coastal Engineer POC

Sampling Event 3: After a larger storm with swells, as determined through coordination Mobile District Coastal Engineer POC

iv. Tracer sampling Evaluation: Analyze, interpret, and report the tracer data along with any locally available **oceanographic and meteorological** data. Available data sources include but are not limited to USACE-Mobile District, NOAA, and the National Weather Service. Integrate relevant **oceanographic and meteorological** data and information into the evaluation.

Task 3. Meetings and Final Report. The results of all tasks within this SOW will be summarized into a final report and presented the Mobile District Mississippi Coastal Improvements project delivery team. Three hard copies and an electronic copy of the report shall be provided.

Work performed will conform to the additional criteria and data listed below. Addresses are specified below for those documents which are available electronically.

a. Engineer Regulation 1110-2-1150, “Engineering and Design for Civil Works Projects”, U.S. Army Corps of Engineers, August 1999 (Internet address http://140.194.76.129/publications/eng-regs/er1110-2-1150/toc.htm).
b. Engineering Regulation 1110-2-1403, “Engineering and Design - Studies by Coastal, Hydraulic, and Hydrologic Facilities and Others,” U.S. Army Corps of Engineers, January, 1998 (Internet address http://140.194.76.129/publications/eng-regs/er1110-2-1403/toc.htm).
c. Engineering Regulation 1110-2-1407, “Engineering and Design - Hydraulic Design for Coastal Shore Protection Projects”, 30 November 1997. (Internet address http://140.194.76.129/publications/eng-regs/er1110-2-1407/toc.htm).

d. Engineering Manual 1110-2-1100, “Coastal Engineering Manual - Part I - IV”, 30 April 2002 (Internet address http://140.194.76.129/publications/eng-manuals/).
e. Engineer Circular 1110-2-6065 “Comprehensive Evaluation Of Project Datums,” 1 December 2007. (Internet address http://www.mvn.usace.army.mil/ENG/EC%201110-2-6065.pdf).

In the event of any conflict between this SOW and the above criteria, the SOW will govern.

APPENDIX D - MONITORING PROCEDURES

The following monitoring procedures will provide information necessary to evaluate project objectives for the MsCIP Barrier Island Restoration project. This plan proposes and builds upon existing data to establish a detailed baseline condition. This monitoring will continue during and post-construction to evaluate short-term and long-term response to the proposed restoration. These procedures will be updated as required to provide the necessary information to evaluate ecological success and inform the adaptive management program.

2 HYDROLOGICAL DATA

i. Wave, Currents, Circulation

Wave and current data, should be collected by self-contained wave and current systems in trawler resistant mounts deployed at three locations north and south of Camille cut prior to and up to 2 years after project construction. In-situ current sensors should be acoustic type with Acoustic Wave and Current profilers (AWAC) preferred for deployment at depths greater than 10 feet. Data will be retrieved and downloaded every 90 days.

Wave data will be analyzed and made available within 30 days of data retrieval, and annual reports will contain processed spectral wave heights, periods, and direction. Collection of these data will provide site-specific wave data for quantifying wave attenuation results before and after Camille Cut closure and provide data for further validation of wave prediction models.

Additionally, Acoustic Doppler Current Profile (ADCP) transects should be conducted to get a horizontal/vertical profile across Ship Island Pass, Little Dog Key Pass, and Dog Keys Pass during maximum spring-neap tide. Two transect data sets should be collected – one prior to the closure of Camille Cut and one six months after closure of Camille Cut. Current measurements at each transect should be measured for at least one full tidal cycle. Pre- and post-closure data should be collected at the same time of year for similar tidal conditions.

Data from the AWACs will be available within 90 days of data retrieval and annual reports will contain processed velocity and current profile measurements. In addition, current profile measurement after each ADCP survey will be available within 60 days of data retrieval. These data will allow for direct comparisons of flow through each pass and at two points within the sound before and after Camille Cut closure, and provide data for further validation of hydrodynamic models.

APPENDIX D - MONITORING PROCEDURES

2 HYDROLOGICAL DATA

ii. Water Quality

To document changes and assess whether closure of Camille Cut results in significant changes in water quality, time-series data will be collected at two sites, and discrete data will be collected at 6 to 8 sites. Data will be collected before, during and two years post-construction.

Time series water-quality data; include temperature, specific conductance, dissolved oxygen and turbidity, collected at a minimum of one-hour intervals at two locations. The first location will be near the proposed work area, and the second at a control location proximate to the first to allow the determination of natural or background water quality variations. Discrete water-quality sampling will be collected at five (5) sites in the vicinity of Ship Island, three (3) control sites in the lee of Cat, Horn and Petit Bois islands, and at two (2) time series data sites. Depending on the location some sites may serve to meet two of the criteria reducing the total number of sites required.

Sites will be sampled every 6 to 8 weeks, for a total of 8 samples per year pre-construction and up to 2 years post-construction. Major environmental events such as extreme drought, hurricanes, or opening the Bonnet Carre' Spillway for flood control purposes may alter the fixed schedule by requiring additional sample collection. Field measurements, collected at the water surface and at 5 foot increments, will profile water temperature, specific conductance, pH, dissolved oxygen, and turbidity to document any water column stratification, particularly of salinity and/or dissolved oxygen.

In addition to these insitu water column measurements, water samples will be collected at mid depth and will be analyzed for : Total Organic Carbon, Dissolved Organic Carbon, Nitrate, Ammonia, Total Kjeldahl Nitrogen, Dissolved Kjeldahl Nitrogen, Total Phosphorus, Dissolved Inorganic Phosphorus, Total Organic Phosphorus, Dissolved Organic Phosphorus, Total Suspended Solids, and Chlorophyll. These data will allow comparison with previous modeling results which indicate that closure of Camille Cut is expected to have minimal impact on overall water quality in the Sound. Data is also expected to provide a unique data set for validating water quality models that can be applied to future coastal restoration and navigation dredging activities adjacent to the project site.

Processed water quality data will be available every 2 months. Annual reports will be prepared, which provide a clear comparison of water quality constituents against control sites, existing background data and CE-QUAL-ICM model runs. Should an identified concern in water quality be observed that cannot be explained with existing data, additional water quality modeling simulations may be necessary to aid in data interpretation.

APPENDIX D - MONITORING PROCEDURES

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3 BIOLOGICAL

i. *Gulf Sturgeon*

Gulf Sturgeon monitoring focuses on three different evaluations: (1) an initial assessment to determine the relative occurrence of Gulf sturgeon within the project area (e.g., specific zones; seasonal timing); (2) a secondary assessment will address occupancy patterns of Gulf sturgeon within identified project areas to evaluate potential changes in occupancy patterns between years and project zones; and a (3) benthic assessment to develop a relationship between Gulf Sturgeon and benthos.

The initial assessment will utilize an automated acoustic telemetry array to monitor Gulf Sturgeon presence within the project area including 39 telemetry receivers deployed during the pre- fill assessment period, during the construction and post-fill periods. Automated VR2W telemetry receivers (Vemco; Nova Scotia, Canada) will be used for the acoustic array. Receivers will be positioned at the surface in a top down orientation deployed from a large polyform buoy and marked with signage (Sulak et al. 2009). Concrete blocks (68 kg or larger) will be used to anchor receivers in locations where passage at project sites are expected. Data acquired during this phase will provide information on the relative use of Camille Cut by acoustically tagged Gulf Sturgeon in comparison to the passes located at the east and west ends of Ship Island, and will provide a comparative perspective of habitat utilization of the passes within (E, W and Camille Cut) and among years (pre-construction, during construction post-fill, and post-construction).

In addition, broad-scale aquatic habitat features for Ship Island will be mapped using aerial imagery and LIDAR and overlaid with resulting acoustic telemetry data to evaluate additional Gulf Sturgeon habitat utilization patterns.

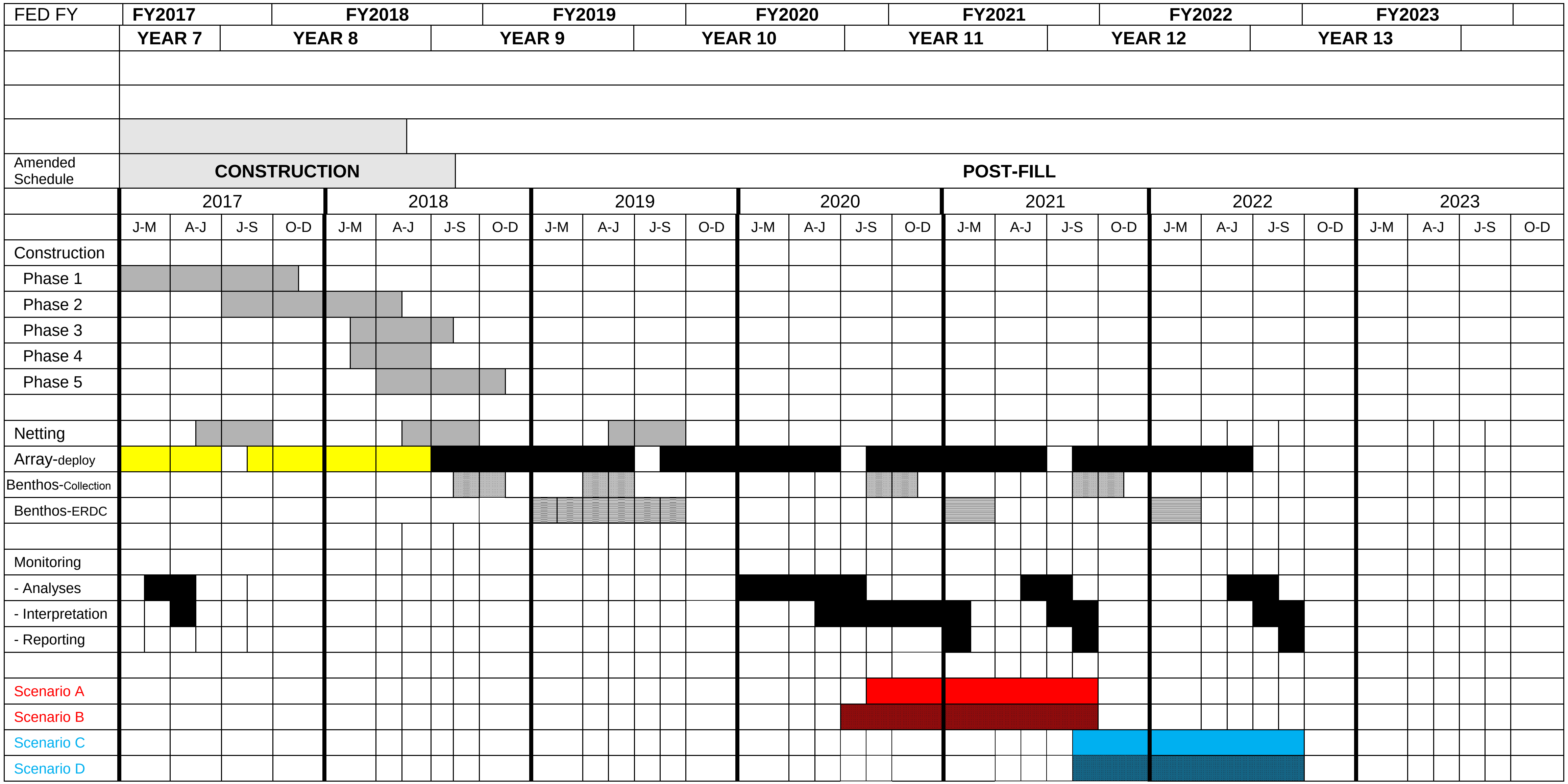
An assessment of occupancy patterns in specific zones within the telemetry array will provide a means to quantify changes in Gulf sturgeon occurrence patterns between designated zones and years following a method outlined by Peterson et al. (2013). These analytical efforts will allow us to evaluate potential shifts among habitat zones during the noted project periods (i.e., pre-construction, during construction post-fill, and post-construction). Netting within riverine habitats and tagging will follow the methodology outlined in Heise et al. (2004, 2005) and Havrylkoff (2010).

In addition to the habitat occupancy patterns, monitoring for Gulf Sturgeon also will be evaluated in conjunction with benthic and infaunal species sampling to develop a relationship between Gulf sturgeon and benthic habitat. Benthic data for the project area was acquired and processed in 2011 for a pre-fill assessment and will also be conducted post construction. Integration of those data will provide a crucial data layer for assessment of Gulf sturgeon habitat and foraging within the project area. Data will be utilized to infer potential use of the specified habitat (e.g, presumed feeding). The benthic data will be categorized based on the occurrence of constituent taxonomic groups that are known prey resources (family-level identification) for all reported Gulf Sturgeon diets (Peterson et al. 2013) to determine relative prey availability among the benthic samples and sites. Additionally, physical factors such as sediment texture, percentage, organic matter content and depth collected during the benthic macroinfaunal sampling may also be correlated with benthic macrofaunal composition, Gulf Sturgeon activity patterns, and determining favorable Gulf Sturgeon habitat.

The resulting data from these approaches will allow project managers to better evaluate the uniqueness of these specific habitats to Gulf Sturgeon. Specifically, whether reducing barrier island pass habitat by filling Camille Cut will or will not have an impact on Gulf Sturgeon populations. The proposed multi-year monitoring program includes pre-construction baseline assessments followed by during construction post fill and post-construction assessments.

Table 1. Conducted activities and tentative timetable for major tasks associated with Ship Island Camille Cut Gulf sturgeon monitoring project (Netting = Gulf sturgeon river netting effort; Array = deployment periods for Gulf sturgeon acoustic telemetry array denoted with black shading and non-deployment periods during periods of active construction are noted with yellow shading; Benthos Data Collection = acquisition and identification of benthic samples; Benthos-ERDC = analysis, interpretation and reporting of benthos samples; Monitoring = subtasks associated with analyses, interpretation and reporting of Gulf sturgeon activity patterns depicted on deployed telemetry array). ADCP efforts were conducted during YEAR 1 but were discontinued in future years due to uninformative data. Year designation (1-13) corresponds to the annual telemetry deployment period. Scenarios A-D are optional and may be determined to be needed based on results. Changes in the construction schedule may change the activties outlined in this table.

Federal Fiscal Year				FY2011				FY2012				FY2013				FY2014				FY2015				FY2016				
			YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5				YEAR 6				YR 7	
Amended Schedule	PRE-FILL								PRE-FILL								PRE-FILL										CONSTRUCTION	
	2010				2011				2012				2013				2014				2015				2016			
	J-M	A-J	J-S	O-D	J-M	A-J	J-S	O-D	J-M	A-J	J-S	O-D	J-M	A-J	J-S	O-D	J-M	A-J	J-S	O-D	J-M	A-J	J-S	O-D	J-M	A-J	J-S	O-D
Construction																												
Phase 1																												
Phase 2																												
Phase 3																												
Phase 4																												
Phase 5																												
Netting																												
Array-deploy																												
Benthos-Collection																												
Benthos-ERDC																												
Monitoring																												
- Analyses																												
- Interpretation																												
- Reporting																												
ADCP																												


FED FY
FY2017
FY2018
FY2019
FY2020
FY2021
FY2022
FY2023
YEAR 7
YEAR 8
YEAR 9
YEAR 10
YEAR 11
YEAR 12
YEAR 13
Amended Schedule
CONSTRUCTION
POST-FILL
2017
2018
2019
2020
2021
2022
2023
J-M
A-J
J-S
O-D
Construction
Phase 1
Phase 2
Phase 3
Phase 4
Phase 5
Netting
Array-deploy
Benthos-Collection
Benthos-ERDC
Monitoring
- Analyses
- Interpretation
- Reporting
Scenario A
Scenario B
Scenario C
Scenario D

APPENDIX D - MONITORING PROCEDURES

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3 Biological

ii. Shorebirds, Secretive Marsh Birds, and Associated Benthos

Threatened and endangered species, critical habitat, and nesting shorebirds must be monitored for this project to determine impacts pursuant to the Endangered Species Act and the Migratory Bird Treaty Act. This project is located within the boundaries of Gulf Islands National Seashore, whose barrier island beaches are listed as critical habitat for the Threatened Piping Plover and contains suitable habitat for the Threatened Red Knot. The U.S. Army Corps of Engineers (USACE) (and its Contractor and/or subtractor) shall keep construction activities under surveillance, management, and control to prevent impacts to shorebirds and/or their nests. The Piping plover is a federally protected species that occurs in the construction area. The USACE and its Contractor may be held responsible for harming or harassing the birds, their eggs or their nests as a result of the construction. Eggs and chicks of beach-nesting birds blend in with their surroundings and are nearly invisible on the ground, making it easy for people and equipment to accidentally crush the eggs or kill young chicks; young chicks can get stuck in deep tire ruts, etc.

Monitoring includes bird identification, counts, habitat use, behavior observed, and GPS locations of the main groups of birds using the beach areas on West Ship Island and East Ship Island, and Cat Island. The three main groups of birds are solitary nesters, colonial nesters, and winter migrants (including threatened Piping Plover and the threatened Red Knot). Species identification information will be provided by the U.S, Fish and Wildlife Service, (USFWS), Jackson, Mississippi. An NPS Biologist will be available for assistance if needed during all periods of the monitoring.

Specific time frames for monitoring will vary with the avian season, weather, and actual construction logistics. As the project moves from place to place, the Bird Monitor will also have to be able to move with the project and/or with the birds.

There are two avian seasons:
-Migration/Mid-Winter from July 15 to May 30. During this time, the Bird Monitor will focus on migratory shorebirds including Piping Plover and Red Knot, but should also report on other birds like osprey and eagle.

-Nesting from March to end of September. Monitoring for nesting birds is only required during construction.

There are three monitoring periods: **pre construction, during construction and post construction.**

Monitoring for nesting shorebirds (during construction) will focus on colonial and solitary shorebird species but will also report on other birds like osprey and eagle. Species documented to nest on the Mississippi barrier islands include solitary nesting species such as: Wilson's Plover, Snowy Plover, Semi-palmated Plover, Willet and American Oystercatcher. Documented colonial species include: Least Tern, Gullbilled Tern, Royal Tern, Sandwich Tern, Common Tern and Black Skimmer.

1. Monitoring Periods:

a. Pre Construction:

The one-year requirement for pre-construction shorebird monitoring activities for West and East Ship Island was completed, with the exception of the following 2 weekly migration period surveys in 2013: (Aug 19-23); (Aug 26-30) that were missed due to contractual issues. These weekly surveys were subsequently collected in 2014.

Similarly, pre-construction monitoring for Cat Island will be conducted 1 year prior to construction. Data collection began March 2015.

(1) Migration/Mid-Winter: Monitoring should take place on a weekly basis at Cat Island, except in the event of adverse weather conditions.

(2) Nesting Shorebirds: No requirement for preconstruction.

(3) Benthic Monitoring: Benthic monitoring along beach transects on East, West Ship Islands, and Cat Island will be performed in accordance with the shorebird benthic sampling protocol, located at the end of this portion, Appendix D 3 ii.

b. During Construction:

The Contractor shall start this frequency of monitoring activity for a period of 2 weeks prior to work commencement and continue with this frequency until completion of the construction and the current bird season ends. A site survey should be conducted before the resumption of any break in activity.

(1) Migration/Mid-Winter Shorebirds: Monitoring frequency a minimum of weekly throughout entire project area where sand will be placed on East and West Ship Islands, and Cat Island except in the event of adverse weather conditions.

(2) Nesting Shorebirds: Monitoring frequency daily during active construction except in the event of adverse weather conditions. However, nesting surveys only need to take place within the project area where activities are ongoing or will be within 90 days prior to active construction in order to prevent impacts to nests/nesting activities. If a nest is found to impede construction work, the USACE must contact USFWS as soon as possible.

c. Post Construction:

The Contractor shall start post construction monitoring activities once the project equilibrates, approximately one to two years after the end of construction and continue for two years. If the second year of post construction surveys need to be delayed due to weather, etc., further coordination will occur with FWS. The second year of surveys should overlap with benthic collection which may require a delay in the timing of the second year of bird monitoring.

(1) Migration/Mid-Winter Shorebirds: Monitoring will occur every other week, throughout the entire project areas of East and West Ship Islands and Cat Island, except in the event of adverse weather conditions.

(2) Nesting Shorebirds: No requirement for post construction.

(3) **Benthic Monitoring**: Benthic monitoring along beach transects on East and West Ship Island will be performed 3 years after construction based on optimal conditions, i.e. lack of sand shifting, hurricane events, etc, during the December – January timeframe in accordance with the shorebird benthic sampling protocol, located at the end of this monitoring plan and Appendix D3v.

2. Visual Surveys and Survey Protocols:

Shorebird monitoring is dependent upon the avian season, shall include species, observed breeding behavior, nest location, chicks observed, and location of recently fledged chicks. Surveys shall be conducted during the dawn or dusk time frames by a trained or experienced Bird Monitor contractor, approved by the USACE/FWS. Bird monitoring should not take place immediately following turtle monitoring where birds have been disturbed by the use of ATVs.

Surveys should be conducted by traversing the length of the project/construction area and visually inspecting, using binoculars or spotting scope, for the presence of shorebirds exhibiting courtship or nesting behavior. The preferred method for monitoring is by foot patrol. During the construction phase, if an ATV or other vehicle is needed to cover large project areas, the vehicle must be operated at a speed <6 mph, shall be run at or below the high-tide line, and the Bird Monitor will stop at no greater than 200 meter intervals to visually inspect for nesting activity. An ATV will be used only on the unvegetated beach face of the new beach, not on the natural beach face of East Ship or West Ship Islands. Even with the use of an ATV, the Bird Monitor will use a drive and walk technique coupled with scanning ahead to detect secretive solitary nesting species. During post construction monitoring, an ATV will not be used, surveys will be conducted by foot or boat.

Surveys shall be conducted using survey protocols outlined here and the form provided.

(1) **<u>During Construction (Nesting):</u>** A daily report of nesting shorebird monitoring and nest activity shall be kept by the contractor's Bird Monitor. Daily logs shall summarize each shorebird species observed (adults and chicks/fledglings) and provide a rough estimate of numbers of each species, the location of species (GPS coordinates preferred), leg bands (if applicable), and their activity (e.g. foraging, resting, nesting, courtship behavior, feeding chicks). In addition, daily logs shall summarize upon locating a dead or injured bird that may have resulted from direct or indirect results of the project, the USACE shall notify the USFWS as soon as possible (Paul Necaise: 228-493-6631, or paul_necaise@fws.gov). Care shall be taken in handling an injured bird, contact a local permitted wildlife rehabilitation center to ensure treatment or disposition of the dead bird. Banded birds should also be noted and recorded (color of bands and location on bird, i.e. one red band on lower right leg and one green band on upper right leg). All activity will be submitted in a report format, and provided within one week of data collection during

construction. Contractor will also enter all data into the USACE Mobile District's database for MSCIP on a weekly basis.

Nesting season surveys for detecting new nesting activity will be completed prior to movement of equipment, operation of vehicles, or other activities that could potentially disrupt nesting behavior or cause harm to the birds or their eggs or young (see aforementioned 90 day requirement). Once nesting activity is confirmed by the presence of a scrape, eggs, or young, the USACE will notify the USFWS as soon as possible. This is only required when there is "new" nesting activity (this is defined as a new species seen and/or new area). Bird Monitor will install red wire flags in area identifying location until buffer zone is established (see number 3 below).

(2) **During Construction, and Post Construction (Migration/Mid-Winter)**: Monitoring will be done on a weekly basis during construction and bi-weekly for post construction. The areas to be monitored should include the east tip of West Ship Island, specifically from the vegetation line to the water's edge and East Ship Island, specifically the from the edge of the forested area to the water's edge and covering the east tip, the south shore, and west tip. When construction timeframes are identified, the east shoreline of Cat Island from the vegetation line to the water's edge shall be monitored. Reports shall be submitted once a month during the construction time frames. Contractor will also enter all data into the USACE Mobile District's database for MSCIP on a monthly basis.

The following data shall be included in the surveys:

a) Negative and positive survey data;
b) Piping Plover and Red Knot locations with a Global Position System (GPS-decimal degrees, preferred);
c) Habitat features used by Piping Plovers and Red Knots when seen (i.e. intertidal, fresh wrack, old wrack, dune, mid-beach, vegetation, other);
d) Landscape features where Piping Plovers or Red Knots are located (i.e. Gulf of Mexico shoreline, bayside shorelines, inlet spit, tidal creek, shoals, lagoon shoreline, lakeside sand flats, ephemeral pools, etc.);
e) Substrate used by Piping Plovers and Red Knots (i.e. sand, mud/sand, mud, algal mat, etc.);
f) Behavior of Piping Plovers or Red Knots (i.e. foraging, roosting, preening, bathing, flying, aggression, walking);
g) Color-bands seen on Piping Plovers or Red Knots;
h) All other shorebirds/waterbirds seen within the survey area.

Any bands/flags seen on piping plovers and red knots shall also be carefully documented, and should also be reported according to the information found at the following websites. Information regarding piping plover band/flag observations can be found at:
http://www.fishwild.vt.edu/piping_plover/Protocols_final_draft.pdf,
http://www.waterbirds.umn.edu/Piping_Plovers/piping2.htm, and
http://www.fws.gov/northeast/pipingplover/pdf/BahamasBandReporting2010.pdf.
Information regarding red knot band/flag observations can be found at:
http://www.bandedbirds.org/Reporting.html,

http://www.flshorebirdalliance.org/resources-pages/bands.html, and http://www.pwrc.usgs.gov/bbl/.

3. **Buffer Zones:** A temporary, 300-foot buffer zone, or as approved by the USFWS, shall be created around any nesting or courtship behavior, or around areas where Piping Plovers, Red Knots, or winter migrants congregate in significant numbers. Designated buffer zones must be posted with clearly marked "Area Closed" signs around the perimeter and left undisturbed until nesting is completed or terminated, and the chicks fledge. No access to the nesting sites by humans, equipment under control of the Contractor (except limited access when approved by USFWS and accompanied by the Bird Monitor). Construction activities, movement of vehicles, or stockpiling of equipment are prohibited in the buffer zone. Buffer zones shall be increased if birds appear agitated or disturbed by construction or other activities in the adjacent area. Disturbed adult birds will attempt to drive a predator away by calling out, dive bombing, or dropping feces on the predators. Other times adult birds will pretend to have a broken wing to lure a predator away from their young.

4. **Equipment:** Travel corridors and staging areas outside of buffer zones near nesting sites shall be coordinated with the USFWS, Jackson, Mississippi Field Office (Mr. Paul Necaise at 228-493-6631), and these areas shall be designated and marked outside the buffer areas. Heavy equipment, other vehicles or pedestrians may transit past nesting areas in the corridors.

5. **Shorebird Signs:** If nesting occurs within the construction area, the Contractor shall place and maintain a bulletin board in the contracting shed with the location map of the construction site showing the bird nesting areas and a warning, clearly visible, stating that "BIRD NESTING AREAS ARE PROTECTED BY THE MIGRATORY BIRD TREATY ACT."

6. **Report Submission:** The results of the daily shorebird monitoring and nest activities report shall be forwarded weekly or monthly (depending on the time of surveys) to the USFWS and USACE. Following completion of the project, a summary report of the shorebird monitoring and nesting activities shall be forwarded within 30-days to USFWS (Attn: Mr. Paul Necaise (228-493-6631) at paul_necaise@fws.gov, 6578 Dogwood View Pkwy, Jackson, MS 39213), NPS (Mr. Gary Hopkins, 3500 Park Road, Ocean Springs, MS 39564 or email: gary_hopkins@nps.gov), and USACE.

7. Shorebird Benthic Sampling Protocol

Purpose: To perform biological surveys required to collect surface sediment samples, sort and identify benthic macroinfauna organisms on beaches located on East and West Ship Island, Cat Island, and Horn Island as associated with Piping Plover and Red Knot foraging areas to support the Mississippi Coastal Improvements Program (MsCIP) barrier island restoration project.

Objective:

- To establish a pre-construction baseline of macroinfaunal taxonomy and abundance within future project influenced and reference beaches on East and West Ship Islands, Cat Island, and Horn Island.

Sampling and Analysis Plan: The protocol is to determine the characterization of benthic communities at the tips of Eastern and Western Ship Islands near Camille Cut and the eastern shoreline of Cat Island, and appropriate reference areas, and includes the sorting, identification, and enumeration of benthic macroinvertebrate organisms collected in each area. Sediment texture and organic content will be determined at each location where benthic macroinfaunal samples are collected. Hydrographic measurements will also be taken at each sampling location. Benthic community studies will be conducted during the November/December timeframe prior to construction activities and post construction. This winter benthic community survey is for determination of the pre-construction and post construction habitat characteristics and macroinfaunal assemblages on beaches used by Piping Plover and Red Knot.

Benthic Sample Locations and Schedule: Benthic community samples will be collected along beach transects on East and West Ship Islands, Cat Island, and Horn Island associated with Piping Plover and Red Knot foraging areas. Sample locations will include sites in which Piping plover are actively foraging on the tips and pre-sand placement and reference sites. The sample locations are anticipated to include:

- 3 beach transects on west tip of East Ship Island (including 1 through tidal pool area, one on northern shoreline area, one on the southern area of tip).
- 3 beach transects on east tip of West Ship Island (including 1 through tidal pool area, one on northern shoreline area, one on the southern area of tip).
- 1 transect on Gulf front shoreline of East Ship Island (pre-placement location).
- 1 transect on Gulf front shoreline of West Ship Island (reference for pre-placement location).
- 4 beach transects on eastern shoreline of Cat Island (including 1 on north tip, 2 on south tip, and 1 through tidal inlet area).
- 3 beach transects on west tip of Horn Island as reference (including 1 through tidal pool area, one on northern shoreline area, one on the southern area of tip).

Two sampling stations will be arrayed along each transect at mean lower low water and mean high tide line to capture tidally exposed flats and wet sand samples. Both wet sand and high tide line intertidal samples will be collected within a 1 square-meter sampling zone in homogenous beach or flat environment.

Benthic Sample Replication: Adequate replication of benthic sampling is necessary to provide statistical power for comparisons of pre-construction and post-construction data. Based upon earlier USACE benthic community studies, four (4) replicate samples per sample station are estimated to be required to represent over 75% of the taxa present at the sample sites. Both wet sand and high tide line intertidal samples will be collected within a 1 square-meter sampling zone in homogenous beach or flat environment.

Benthic Sample Collection Methods: Beach/subtidal samples will be collected with a 3" hand core (to a depth of 6") which samples an area approximately $0.0044m^2$. The samples may be rinsed in the field through a 0.5-mm mesh screen if silty sediments are encountered; sand sediments generally will not be rinsed in the field. All cores will be preserved with 10% buffered formalin.

At each station, standard hydrographic measurements will be taken at mean lower low water surface, depths prior to benthic sampling. A YSI® Model 600XL Datasonde or equivalent will be used to measure temperature, conductivity, salinity, pH, and dissolved oxygen (DO) concentration. **Table 1** provides a summary of the benthic macroinfaunal and sediment texture/TOC sampling program.

Table 1. Summary of benthic community characterization sampling, pre-construction

STATIONS/SURVEY	
STUDY AREA	**Winter**
Beach/Intertidal Benthos	
Project	12
Reference	3
Total Stations *(2 per transect)*	30
Replicates	4
Total Samples	120
Sediment Texture	30
Sediment TOC	30

Laboratory Analyses: *Infauna:* In the laboratory, benthic samples will be inventoried, rinsed through a 0.5–mm mesh sieve to remove preservatives and sediment, stained with Rose Bengal, and stored in 70% isopropanol solution until processing. Sample material will be sorted and all macroinvertebrates will be removed and placed in labeled glass vials containing 70% isopropanol, with each vial representing a major taxonomic group (*e.g.* Oligochaeta, Mollusca, Arthropoda). Oligochaetes will be individually mounted and cleared on microscope slides prior to identification. All sorted macroinvertebrates will be identified to the lowest practical identification level (LPIL), which in most cases will be to species level unless the specimen is a juvenile, damaged, or otherwise unidentifiable. The number of individuals of each taxon, excluding fragments, will be recorded. A voucher collection will be prepared, composed of representative individuals of each species not previously encountered in samples from the region. Additionally each sample will be analyzed for wet-weight biomass (g/m^2) of the major taxonomic groups identified, to facilitate evaluation of Piping Plover and Red Knot feeding habitat.

Sediment Grain Size Analysis and Sediment Total Organic Carbon (TOC): One sample will be collected at each station for sediment grain size analysis. Each sample will be washed with deionized water, dried, and weighed. The coarse and fine fractions (sand/silt) will be separated by sieving through a U.S. Standard Sieve Mesh #230 (62.5 µm). Median grain size and percentages of gravel, sand, silt, and clay will be calculated for each sample.

A subsample of each sediment sample will be analyzed for total organic carbon (TOC). Sediment TOC analyses will be performed according to the guidelines in EPA-600/4-79-020, 1983, Method 415.1 for determination of total organic carbon in sediment and soils.

Data Analyses: The number of replicate samples taken with the 3” hand core will be sufficient to permit statistical comparisons of pre- and post- placement data. The macroinfaunal data will be analyzed using univariate and multivariate approaches to identify any differences in community structure between project and reference station groups.

The following numerical indices will be calculated for each sample:

1) Infaunal abundance (total number of individuals per station);
2) Infaunal density (total number of individuals per square meter);
3) Species richness (total number of taxa represented in a given station and by Margalef’s D);
4) Taxa diversity (Pielou’s Index H`); and

5) Evenness (Pielou's Index J`).

An appropriate test of significance will be performed on the univariate indices to determine significant differences between groups (stations). Multivariate analyses will be used consisting of ordination of station species abundance data by multi-dimensional scaling using the Bray-Curtis similarity coefficient, displayed in two dimensions. Classification analyses will be used including the Bray-Curtis similarity measure and hierarchical clustering of similarity values using the group-average sorting strategy. A test of the significance of dissimilarities determined by the ordination will be conducted using a non-parametric permutation procedure on the ordination similarity matrix. The Analysis of Similarities (ANOSIM) module in the Primer statistics program or an analogous routine will be acceptable. A species analysis will be done to determine the contribution of taxa to the average dissimilarity between groups. The SIMPER module of the Primer statistical package or an analogous routine will be acceptable.

Macroinfaunal Data Interpretation: Data interpretation will consist of habitat characterization (water depth, salinity, sediment texture) and benthic community characterization including faunal composition, abundance, and community structure, numerical classification analysis and taxa assemblages. A discussion should also include a comparison of relevant samples collected as part of previous surveys.

Macroinfaunal and sediment data will be used to evaluate the suitability of the sediment for feeding habitat for the Piping Plover and Red Knot. Potential prey species will be identified and an interpretive report will be prepared to describe use of the study area by Piping Plover and Red Knot.

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3 BIOLOGICAL

iii. Habitat Composition/Habitat Mapping

Near-vertical color-infrared (CIR) digital aerial photography will be the primary data source for information on wetland and associated environments. These data will be collected annually in conjunction with LiDAR missions and under separate acquisition in non-LiDAR years through one year post construction (currently estimated at 2018). Photointerpreters will use stereo heads-up-display to determine habitat classification, including the location and extents of wetlands, upland, and seagrass habitats from the imagery. Habitat categories will consist of a combination of NWI and Anderson Land Use/Land Cover Classification Systems, as well as special modifiers to characterize critical habitat for the identified species of interest. Historically, 15 NWI habitat classes comprise the majority of the Mississippi barrier island land area. With respect to aquatic habitat, intertidal, tidal flats, beaches and bars will be mapped. Those habitats will be classified then further collapsed into a subset of classes for use by the MsCIP program.

In addition to annual near-vertical high resolution aerial imagery, moderate resolution (5-30m) Landsat Multi-Spectral Scanner and Thematic Mapper (TM) satellite imagery will be used to increase the number of datasets available to assess land area change and to help discern normal environmental variability present at the time of acquisition of the aerial photography.

All habitat photointerpretation will follow protocols and standards described in Cowardin et al. (1979). Uplands are derived from a land use and land cover classification system for use with remote sensor data (Anderson *et al.*, 1976). The digital mosaic of the high resolution color infrared aerial photography project area is brought into ArcMap Software where photointerpretation begins. Habitat types are delineated by overlaying project area boundaries onto the imagery and editing features. Ancillary data sets from 1998 through 2012, with similar resolutions, are utilized to help classify areas that may be difficult to identify. Imagery of the project area is also viewed on screen in stereo which helps determine vegetation height and proper habitat classification. Where available, LIDAR data is utilized for elevation information that help discern habitats from one another especially where floating aquatics may be present. A field verification process will be conducted using photosignature verification of cover types and checking problematic areas by field personnel at the request of the photointerpreters during the quality control phase of the mapping. After completion of habitat classifications, the photointerpreter will perform a Quality Assurance self-check. In addition, a second photointerpreter will perform a final in-house Quality Control, assuring accuracy and data integrity.

Land/water classification is typically conducted using a series of spectral bands and indices which are particularly sensitive to and indicative of the presence of water. The most notable of these being the variable reflectance of land and water targets by infrared and visible wavelengths of light. One index which has been developed to exploit these differences is the modified Normalized Difference Water Index (mNDWI). The mNDWI has been shown to be capable of revealing subtle features of water more efficiently than other bands and indices. Therefore, the hyper-temporal land/water classifications will rely upon a threshold of the mNDWI. The resulting datasets will be summarized for each barrier island within the study area and trends will be assessed. Land area change trends will be a component of the final report. These trends will assist in understanding the development of geomorphic features and trajectory of change on these islands. Field investigations (ground-truthing) will be conducted to compare various geomorphic and vegetation habitats in the field with corresponding "signatures" on aerial imagery. Accuracy assessments will then be conducted using field data (not used as initiation data) and user-specified "truth" at randomly selected points.

Habitat and land:water classification data will be made available within 12 months of acquisition of digital aerial photography and satellite imagery. These data will be used with the LIDAR data to discriminate geomorphic and vegetated features and with the shorebird, sea turtle, and Gulf sturgeon data to investigate habitat utilization.

APPENDIX D - MONITORING PROCEDURES

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3 BIOLOGICAL

iv. Sea Turtles

Threatened and endangered species, critical habitat, nesting shorebirds, and sea turtles must be monitored for this project to determine impacts pursuant to the Endangered Species Act and the Migratory Bird Treaty Act. This project is located within the boundaries of Gulf Islands National Seashore, whose barrier island beaches are used by nesting endangered and threatened sea turtles. The U.S. Army Corps of Engineers (USACE), to also include its Contractor/Subcontractor, shall keep construction activities under surveillance, management, and control to prevent impacts to sea turtles, their nests and hatchling sea turtles. The USACE may be held responsible for harming or harassing sea turtles, their eggs or their nests as a result of the construction. Sea turtle nests are easily missed by those unaware, making it easy for people and equipment to accidentally crush the eggs; young sea turtle hatchlings can get stuck in deep tire ruts; bright construction lights at night can disorientate adults and hatchlings causing them to migrate in the wrong direction away from the ocean which almost assures the hatchlings' death.

Sea turtle monitoring includes documenting defined parameters of sea turtle nesting activity including species, abundance, locating crawls, marking nests and relocating vulnerable nests (see FWS/NPS monitoring protocol). Monitoring will be conducted on the project beaches of Cat Island, West Ship Island, and East Ship Island. In order to prevent disturbance to nesting shorebirds, monitoring of sea turtles should be done in the morning prior to the required shorebird monitoring.

There are 5 species of sea turtles: loggerhead (*Caretta caretta*), green (*Chelonia mydas*), leatherback (*Dermochelys coriacea*), hawksbill (*Eretmochelys imbricata*), Kemp's Ridley (*Lepidochelys kempii*), that may be found in the Gulf of Mexico. Green, Loggerhead and Kemp's Ridley sea turtles are regularly documented in the waters surrounding the barrier islands of Gulf Islands National Seashore. Of these, loggerhead and green sea turtles have been documented nesting on the barrier islands in the Mississippi Sound. Though never documented, Kemp's Ridley sea turtles are likely to nest on the Mississippi islands and nests have been documented on Santa Rosa Island in the Florida District of the Seashore.

Sea turtle nesting and hatching season for Mississippi starts around April 15 and ends around November 30. Incubation for the loggerhead sea turtle ranges from about 45 to 95 days and incubation for the green sea turtle ranges from about 45 to 75 days.

Potential hatching dates will be determined for each crawl documented and monitored for nesting success 95 days beyond the crawl date.

MONITORING PERIODS:

There are three monitoring periods: **pre construction, during construction, and post construction.** An NPS Biologist will be available for assistance if needed during all periods of the monitoring.

A. Pre Construction:

If project activities are initiated between Nov 30 and April 15, then no pre-project surveys will be required. If the project will be initiated between April 15 and Nov 30, daily pre-project surveys should begin at least 100 days in the immediate vicinity of work as well as in the area where work will be occurring within the next 100 days, weather permitting.

B. During Construction:

Nesting surveys, marking, and potential relocation activities must be conducted daily, weather permitting, while construction activities are on-going during nesting and hatching season, April 15-Nov. 30 in work areas.

C. Post Construction:

Weekly sea turtle monitoring shall be conducted and include 2 full nesting and hatching seasons (April 15th thru November 30th) once the project reaches equilibrium, approximately one to two years after the end of construction. The goal of the post construction monitoring is to ensure that suitable habitat for sea turtles is established.

MONITORING PROTOCOLS:

SURVEY METHODS:

1. For sea turtle nesting surveys during construction, a meeting between representatives of the contractor, the COE, the Service, the NPS, the Service permitted sea turtle surveyor, and other species surveyors, as appropriate, must be held prior to the commencement of work. This meeting will be held approximately 10 days prior to commencement of surveys as required by the Biological Opinion. The meeting will provide an opportunity for explanation and/or clarification of the sea turtle protection measures, as well as additional guidelines when construction occurs during the sea turtle nesting season, such as storing equipment, minimizing driving, and reporting within the work area, as well as follow-up meetings during construction. At that meeting the COE will provide the USFWS and the NPS with specific information on the actual project that is going to proceed (form on the following web link: http://www.fws.gov/northflorida/SeaTurtles/Docs/Corp%20of%20Engineers%20Sea%20Turtle%20Permit%20Information.pdf) and emailed to the Service at seaturtle@fws.gov.

2. On native beaches, surveys will be conducted first thing in the morning by All-Terrain Vehicles (ATV/UTV), foot or boat. The ATV will be operated at <6 mph, to provide adequate opportunity to view the beach, to avoid obstacles and hazards, and to visually investigate all possible turtle crawls. **The ATV will be operated low on the beach, on the unvegetated dune face, at or below the last high tide line.** This will allow even the shortest turtle crawls to be

located and minimize impacts to bird nests. **Be careful not to drive through a bird nesting area.** Back track on foot if necessary to survey the area not accessible by ATV.

If it is high tide during your survey, do not attempt to drive the ATV through water. Also, do not drive the vehicle over dunes and vegetation. If there is a path wide enough for the ATV to drive through without impacting vegetation, use the path to circumvent the area where there is no beach. **Be careful not to drive through a bird nesting area.** Back track on foot if necessary to survey the area that was missed.

3. During the survey, be alert for tracks, stranded turtles, nests uncovered by predators, hatchlings, etc. or any evidence of a sea turtle incident. Check any marked nests found during previous surveys.

Investigating Nesting Activities:

1. If a turtle crawl is discovered, stop and evaluate the incident as thoroughly as possible. A completed "Sea Turtle Monitoring" form is required for all incidents, false crawl or nest. Identify the species of the turtle crawl. Record the GPS location. Take photos of the turtle crawl.

2. Mark the turtle crawl to prevent double-counting and/or a nest associated with the crawl. Look for evidence of a body pit. A body pit will look like a roughly circular area of disturbed sand which may or may not be slightly lower than surrounding areas. If there is not a body pit discovered, the crawl will be assumed to be a false crawl. False crawls will be recorded on a report form. If a conspicuous area of disturbed sand is found (body pit), assume that a nesting event has occurred. Look for signs of animal depredation or human tampering.

3. Measure the crawl at three different locations and taking an average of the three. Straight-line measurements should be taken from the tip of the flipper mark on one side to the tip of the flipper mark on the other. With loggerheads, since the flipper marks alternate, the measurements should be from flipper mark on one side to an extended straight line from the flipper mark on the other side.

4. If the incident was a nest, record the distance from the water to the nest site. This does not need to be exact (water level fluctuates with each wave) but it should be fairly accurate. Also, note if the nest is above or below the rack line (highest debris line on the beach).

5. Estimating egg cavity location. Determine the direction of travel along the crawl, locate a body pit, and locate an escarpment in the shape of an arc at the front of the pit. Typically the female faces away from the water during nesting, although this is not always the case. The escarpment is the result of the turtle using her front flippers to cover the nest with sand when she is done laying. The egg cavity is usually centered behind this escarpment, approximately 3-5 feet back. It may be further back, if the turtle was moving forward while covering the nest site.

6. Occasionally, a nest may be uncovered by predators or beach erosion. If you find a nest where eggs or the remains of eggs are visible, the incident will be reported as a nest. If the nest was predated, the nest must be checked for viable eggs. Do not assume the nest has been totally predated.

   If a nest is partially depredated, the remaining eggs can be reburied with the necessary precautions. Eggs must be rinsed off with freshwater to remove all albumen and other fluids that came from the damaged eggs. Rough handling and turning of the eggs should be avoided. The nest cavity, if still intact, should be emptied out down to clean sand before the eggs are replaced. Do not dig too deep. Occasionally, most eggs can be left in place and only the top few need to be removed, cleaned and returned to the nest. The nest should then be filled with moist sand. Compress the sand with your hands using slight to moderate pressure. Damaged eggs and shells should be removed from the area.

If the nest was totally depredated, fill in the hole and clean up the area. If you find an area where eggs are strewn about and there is a hole in the sand, but no crawl, this is an old nest that has been depredated. Fill in a nest report (photo and GPS).

MARKING NESTS FOR PRE AND DURING CONSTRUCTION:

Equipment for nest perimeter buffer zone marking:

1. 4 wooden perimeter buffer zone stakes. Dimensions 1" x 2", 4 feet long.
2. 1 roll of 3/16" fluorescent orange flagging tape

Marking Nest Sites to Protect Buried Eggs from Hazardous Activities

The goal of this marking method is to clearly identify the nest area and protect it from human activities such as vehicular traffic or other disturbances.

A series of stakes and highly visible survey ribbon or string shall be installed to establish a 10-foot radius around the nest (see photo below). No activity shall occur within this area nor will any activity occur that could result in impacts to the nest. Nest sites shall be inspected daily to assure nest markers remain in place and that the nest has not been disturbed by the project activity. The stakes should extend more than 36" above the sand. To further identify the nest site, surveyor's ribbon can be tied from the top of one stake to another to create a perimeter around the nest site. Additionally, a nest sign can be attached to one of the stakes used to create the perimeter. A nest-identifying number and the date the eggs were laid should be placed on at least one of the nest perimeter stakes. At least one additional stake should be placed a measured distance from the clutch location at the base of the dune or seawall to ensure that future location of the nest is possible should the nest perimeter stakes be lost.

Signs should have the following information:

SEA TURTLE NEST - DO NOT REMOVE

VIOLATORS SUBJECT TO FINES AND IMPRISONMENT

U.S. Endangered Species Act of 1973: No person may take, harass, harm, pursue, hunt, shoot, wound, kill, trap, or capture any sea turtle, turtle nest, and/or eggs, or attempt to engage in any such conduct. Any person who knowingly violates any provision of this Act may be assessed a civil penalty up to $25,000 or a criminal penalty up to $100,000 and up to one year imprisonment.

SHOULD YOU WITNESS A VIOLATION OR OBSERVE AN INJURED OR STRANDED TURTLE OR DISORIENTED HATCHLINGS, PLEASE CONTACT:

Mr. Paul Necaise, USFWS (228) 493-6631.

Nests Relocation Protocol:

After a nest is identified, three circumstances would warrant nest relocation:

(1) If eggs have been exposed as a result of erosion,
(2) If you observe a nest, due to its location on the beach, is in danger of being inundated by daily tides or lost through erosion, or
(3) The nest is within active construction zone or any zone that will be active within 95 days from the date of discovery.

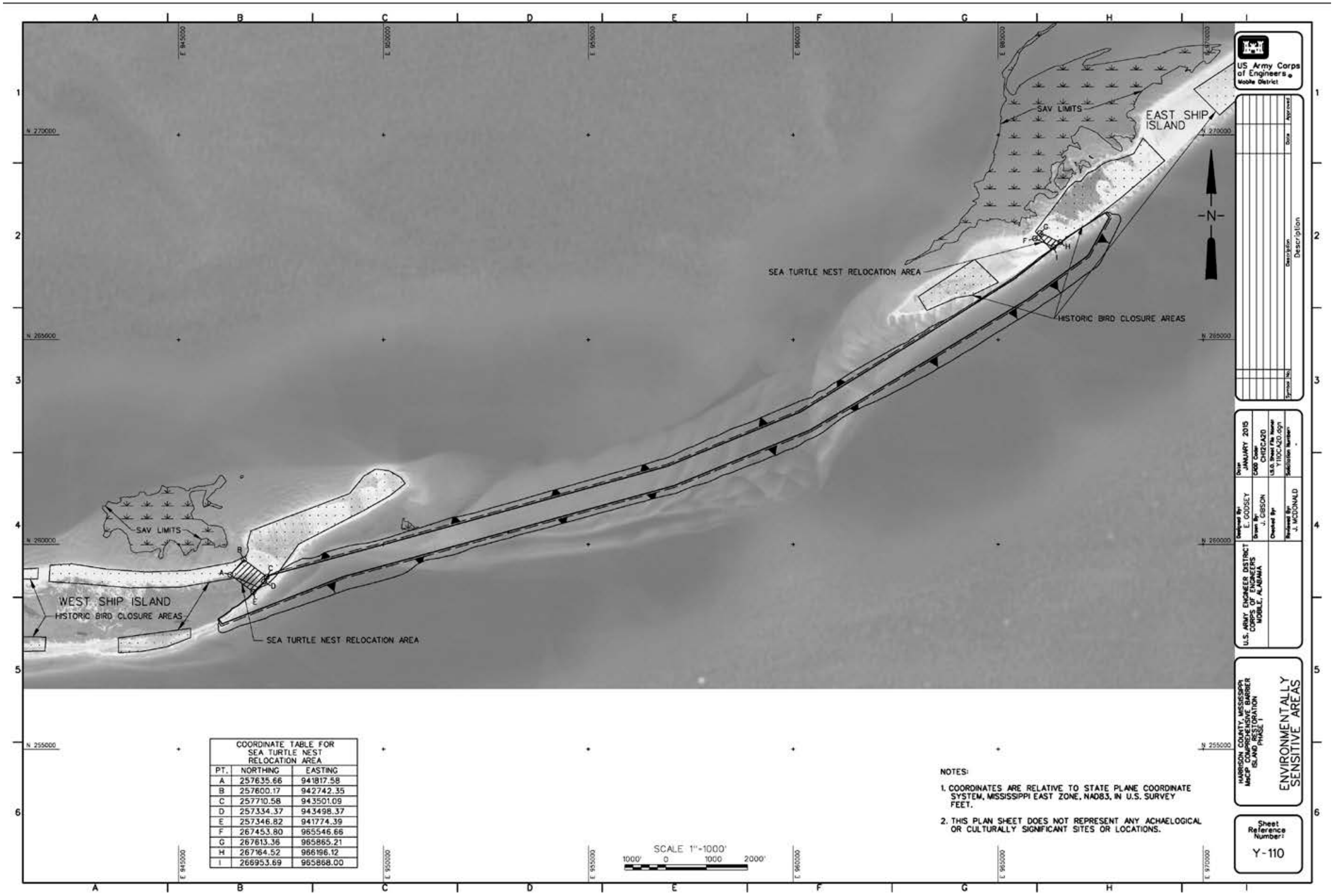
Do not move the nest unless you are completely confident the nest will be lost.

If the nest requires relocation, then call the designated person(s) permitted to relocate nest and contact Paul Necaise (FWS: 228-493-6631) as soon as possible.

Gary Hopkins (NPS) will provide input on where relocation should occur. Suitable sea turtle nesting habitat above the average high tide line as appropriate within the areas indicated on the relocation zone map should be used for relocating sea turtle nests. The relocation zone maps for East and West Ship and Cat Islands are included at the end of this section as Figures 1 and 2. Relocation areas should not include newly constructed areas due to sand compaction being unsuitable.

Nests requiring relocation must be completely moved no later than 9 a.m. the morning following deposition to a nearby self-release beach site in a secure setting where artificial lighting will not interfere with hatchling orientation. The specific site for nest relocation will be determined in coordination with FWS and NPS. Relocated nests must not be placed in organized groupings. Relocated nests must be randomly staggered along the length and width of the beach in settings that are not expected to experience daily inundation by high tides or known to routinely experience severe erosion and egg loss, or subject to artificial lighting. Relocated nests should have a predator proof screen/cage as outlined in the nest marking protocols where raccoons are a problem. Nest relocations in association with construction activities must cease when construction activities no longer threaten nests.

A new nest location can be excavated above the high tide line, but not above the dune line in an area that is not impacted by construction The top of the new nest, or egg cavity should be located approximately 10-12 inches below the level of the sand. The bottom of the new cavity should be about 22 inches deep. The nest cavity should be in the shape of a vase with a round bottom and long neck. Dig the new nest cavity before you begin to move the eggs. Move the eggs with care but in a timely manner. Move them one by one to the container. **Handle the eggs with care.** Use the supply container to store the eggs, or a cooler if one is available. Fill the bottom with some sand from the nest area to prevent the eggs from rolling in the container. The sand will also cushion the eggs. Use the lid to shade the eggs. Large temperature changes need to be avoided. After all the eggs have been deposited (not dropped) carefully in the new nest cavity one at a time, fill cavity with moist sand using the sand from the original nest site. Then use surrounding sand as needed. Compress the sand with your hands with slight to moderate pressure. Mark these nests in accordance with the general guidelines for a positive nest.



COORDINATE TABLE FOR SEA TURTLE NEST RELOCATION AREA

PT.	NORTHING	EASTING
A	257635.66	941817.58
B	257600.17	942742.35
C	257710.58	943501.09
D	257334.37	943498.37
E	257346.82	941774.39
F	267453.80	965546.66
G	267613.36	965865.21
H	267164.52	966196.12
I	266953.69	965868.00

Figure 1: Ship Island Turtle Relocation Zone Map

Figure 2: Cat Island Turtle Relocation Zone Map

Recording Data:

Completely fill in the FWS form provided for all nests and false crawls. Be as accurate as possible. Pay particular attention to describing the location of the nest and how the nest was marked. Use the back of the sheets for additional information or maps/diagrams. Use a separate data sheet for each nest.

Routine Monitoring of all existing Nest Sites:

1. All sea turtle nests will be monitored throughout the incubation period. This monitoring is for the purpose of determining the duration of incubation, and identifying the incidence of depredation, damage from beach erosion, or disturbance by human activities.

2. Make sure all the stakes are readable and in good condition. If a stake or sign is missing, replace it and note the replacement in the log book and on the nest sheet.

Sites will be evaluated for evidence of disturbance including tracks, digging, ghost crab holes, tire tracks, beach erosion or wash-overs, or any other indication of nest disturbance. Photographs and observations of any disturbance should be recorded and provided in the report.

Monitoring at Expected Time of Hatching

1. Beginning at the 50^{th} day from initial discovery, each nest will be monitored more closely. This intensive regime of monitoring will be conducted to determine the precise duration of incubation, and to gather data on hatchling emergence, depredation, and disorientation.

2. Nest sites will be evaluated to determine if hatching has occurred by looking for tracks of hatched turtles which have left the nest. In general, the majority of hatchlings will leave the nest as a group during the night. Their tracks will appear as a clutter of small, approximately 2” wide tracks which radiate out from the nest. The area where the eggs are located will usually appear collapsed.

3. Look for evidence of depredation such as ghost crab or bird and any indication of turtle remains. Look for evidence of hatchling disorientation. Note any tracks which deviate from a straight course to the water and attempt to follow any tracks which have headed in the wrong direction. If disoriented hatchlings have been located, contact Paul Necaise (FWS, 228-493-6631) and Gary Hopkins (NPS: 228-230-4104) as soon as possible.

4. Record all observations made at the site on the specific FWS form developed for that nest. Please be as complete as possible. Any information which can be learned about the fate of the hatchlings after they emerged from the nest is of value.

Final Nest Assessment and Excavation:

1. All nests will be assessed at the conclusion of the nesting process to gather data on overall nesting success.

2. In general, the final assessment will be conducted 3 days after hatchlings have been documented as emerging from the nest or 80 days after initial discovery of a nest if no evidence of hatching has been recorded. (This is dependent upon the identified species).

3. When excavated, the sites are evaluated to determine the fate of the nest. The data collected includes, at minimum, the total number of eggs found (both hatched and unhatched), the presence of any hatchlings inside the nest, the number of unhatched eggs with embryonic development, the number of eggs without embryonic development, and any evidence regarding factors which may have affected the nest, such as ghost crab burrows, vegetation roots, etc.

4. Results will be recorded on the FWS form and all protective material including screens and stakes will be removed from the nest location.

Construction protection measures to be monitored (compliance/noncompliance observations should be included in weekly report):

1. During turtle nesting and hatching season, staging areas for construction equipment must not be located in the natural dunes and vegetation on the island. In project areas on natural beaches, construction pipes will be as short in length as possible to allow nesting sea turtles use of the natural beach and limit trapping of nesting sea turtles behind the construction/dredge pipes. In addition, all construction pipes placed on the beach must be located as far landward as possible without compromising the integrity of the dune system. Pipes placed parallel to the dune must be 5 to 10 feet away from the toe of the dune if the width of the beach allows. Temporary storage of pipes must be off the beach to the maximum extent possible. If the pipes are stored on the beach, they must be placed in a manner that will minimize the impact to nesting habitat and must not compromise the integrity of the dune systems.

2. To minimize possible boat impact to nesting sea turtles feeding and loafing in the surf off the outer bar of the south beach support vessels should observe a no wake zone 300 yards from the south shoreline.

3. Direct lighting of the beach and nearshore waters must be limited to the immediate construction area during the nest laying season through end of hatching season (April 15 – November 30) and must comply with safety requirements. Lighting on all equipment must be minimized through reduction, shielding, lowering, and appropriate placement to avoid excessive illumination of the water's surface and nesting beach while meeting all Coast Guard, Corps EM 385-1-1, and OSHA requirements. Light intensity of lighting equipment must be reduced to the minimum standard required by OSHA for General Construction areas, in order to not misdirect sea turtles.

4. Sea Turtle Signs: If nesting occurs within the construction area, the nest should be relocated, and the construction contractor shall place and maintain a bulletin board in the contracting shed with the location map of the construction site showing the sea turtle nesting areas and a warning, clearly

visible, stating that "SEA TURTLE NESTING AREAS ARE PROTECTED BY THE THREATENED AND ENDANGERED SPECIES ACT".

5. Beach Rutting: Ruts created by heavy equipment located along the beach face between the nest and the water will be smoothed to avoid trapping of hatchlings as they move down the beach face to feed.

Reporting:

1. Report any activity as soon as possible, including nesting, false crawls, (can be in form of an email). The logs shall summarize sea turtle species observed (adults and hatchlings), the location of turtle crawls and/ or nests (GPS coordinates), and construction compliance/noncompliance observations. In addition logs shall summarize upon locating a dead or injured sea turtle that may have resulted from direct or indirect results of the project. Nests with estimated hatch dates should be supplied with the submitted logs. If an injured or dead sea turtle is discovered, contact Paul Necaise (FWS), and Gary Hopkins (NPS) immediately to ensure treatment or disposition of the dead sea turtle. A NOAA Sea Turtle Stranding and Salvage Network – Stranding Report should be completed and filed with NOAA, and provide a copy to NPS (Gary Hopkins 228-230-4104).

2. Report Submission: A monitoring report should be submitted weekly to FWS and NPS (including logs and all data forms/sheets). All data must be entered into a web-based form provide by the Corps.

3. Following completion of the project, a summary report of the monitoring and nesting activities shall be forwarded within 30-days to USFWS and NPS.

Requirements for monitor:

Monitoring will be conducted by trained individuals with proven sea turtle experience and identification skills. Credentials of the Sea Turtle Monitor will be submitted to the USFWS and NPS Biologists for review and approval. Not every monitor will require relocation experience and permits, however at least two individuals approved for relocation should be available to allow one person to monitor the construction site every day during the nesting season when there are active construction activities occurring. An NPS Biologist will be available if needed during all periods of the monitoring.

MDWFP, USFWS, NPS, and anyone permitted by MDWFP or USFWS shall be allowed on work site during construction as needed, to assist with sea turtle monitoring and nest search or to post nest buffers when needed with the approval of the USACE on-site inspector in order to comply with safety regulations.

CONTACT LIST:
FWS: Mr. Paul Necaise at 228-493-6631;FWS: Mr. David Felder at 601-321-1131, 6578 Dogwood View Pkwy, Jackson, MS 39213 ;NPS: Mr. Gary Hopkins, at 228-230-4104, Gulf Islands National Seashore, 3500 Park Road, Ocean Springs, MS 39564 or
USACE: Ms. Jennifer Jacobson, 251-690-2724.

SHEAR RESISTANCE TESTING

Purpose:

The purpose of this supplemental information is to outline procedures for the establishment of a baseline shear resistance condition of the beach sediments at Ship Island and Cat Island, Mississippi using a dynamic cone penetrometer testing apparatus. It is believed that beach sediment shear resistance is an important factor in sea turtle nesting and constructed beach management.

Dynamic Cone Penetrometer Apparatus

The dynamic cone penetrometer (DCP) is a test apparatus that may be used for field soil testing to estimate the in place (in situ) strength characteristics of undisturbed soils or compacted materials. The shear strength and thickness of strata can be estimated by monitoring the penetration rate of the cone into the soil and correlating the penetration rate to the pounds per square inch (psi) of strength and bearing capacity via the California Bearing Ratio. The DCP is typically used for material assessments to a depth of thirty-six inches (36").

Complete operating instructions for the dynamic cone penetrometer apparatus utilized for testing, as well as further details regarding its application, may be requested from the Mobile District MsCIP team. Point of contact for the MsCIP team is Justin McDonald, email address: Justin.S.McDonald@usace.army.mil.

Shear Resistance Testing Locations and Configuration

Shear resistance testing stations should be established along transects that extend from the seaward base of the dune to the swash zone. A transect is defined as a straight line that runs shore normal from the dune to the water's edge of the island, along which observations and measurements will be taken. There will be two test stations located on each of the transect lines. A station is defined as the place specified for the DCP shear resistance measurements or sampling to occur. Three spatially independent DCP measurements will be taken to a depth of twenty-four inches (24") at each station.

Test Station Location

One test station is to be located at the seaward edge of the dune and one station must be in the dry berm midway between the dune line and the high water line (normal wrack line). At each station, the dynamic cone penetrometer (DCP) test will be applied to a cluster of three replicated test spots. The three DCP measurement locations within each station will be configured in a triangular pattern with the vertices being spaced twenty-four inches (24") apart.

Transect Intervals

DCP measurements should be conducted on no less than thirty (30) transects per island. The alongshore distance between the transects should be established such that the intervals will allow AT LEAST thirty (30) testing stations to be located midway between the wrack line and the dune and AT LEAST thirty (30) stations along the seaward edge of the dune. The testing station intervals should be no greater than five-hundred (500) feet apart. The purpose of the thirty (30) station minimum is to collect enough data to perform statistical hypothesis testing on the results obtained from the DCP testing (n >/= 30).

Samples for Validation

It is suggested that sediment samples be procured from the existing island sediments for the purpose of validating the data obtained from the DCP measurements. The samples will be used to determine characteristics (such as classification and unit weight) of the sediments.

A series of soil samples should be collected along transects located at the center and each of the distal tips of the island so that at least three transects will be physically sampled on each island. The series should consist of soil samples collected at the 18 and 36-inch depths (below the surface) at one spot at each station located along a transect. The locations of collected samples may vary with the specific site conditions of each barrier island and it may be necessary to collect additional samples if the island sediments are highly stratified or exhibit a large range of variability among the transects.

See Figure 1 for a layout of the DCP testing scheme described in this document.

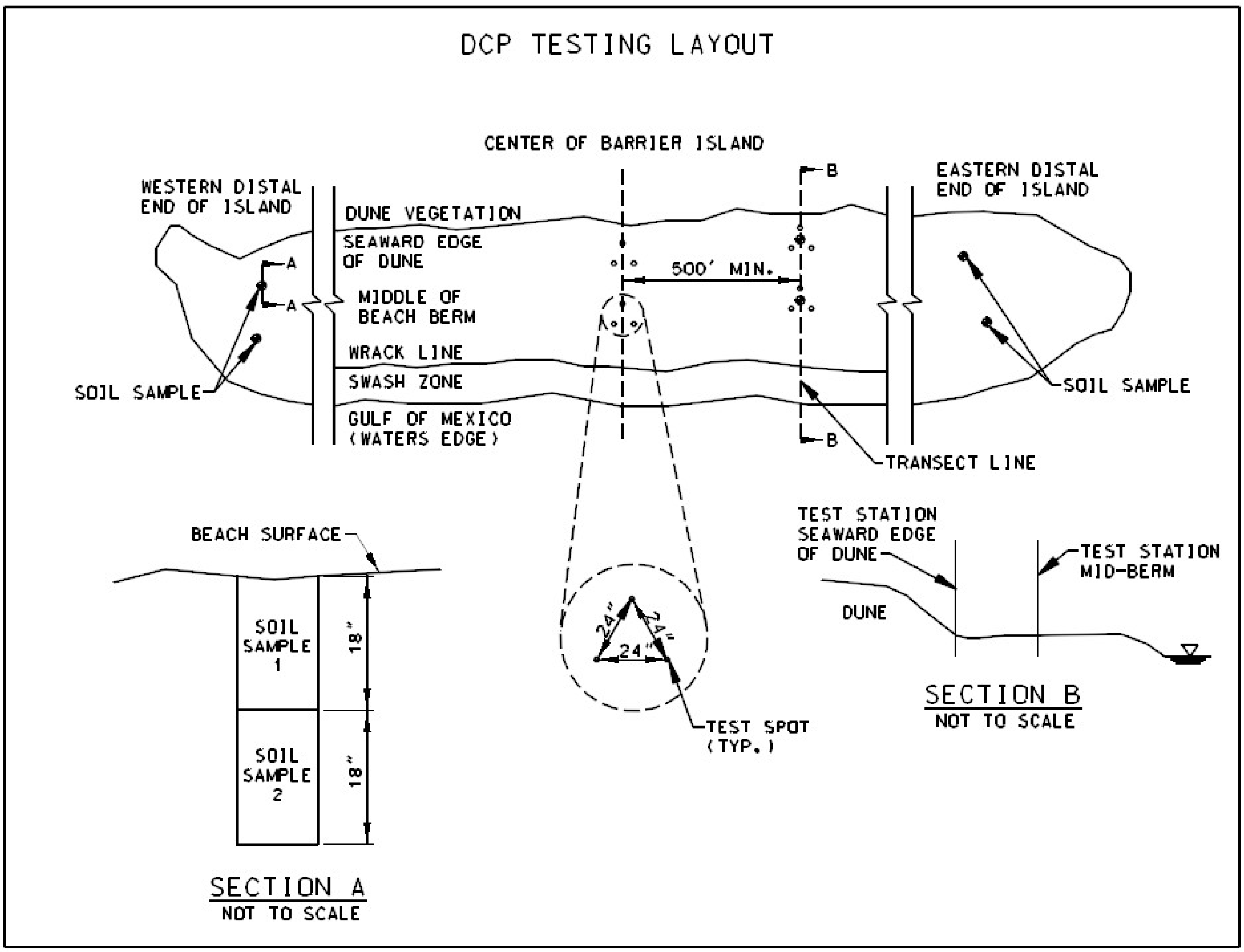


Figure 1: Typical DCP testing layout and details.

Dynamic Cone Penetrometer (DCP) Pre-Construction Values

The three replicate DCP shear resistance values for each station will be averaged to produce a final value for statistical hypothesis testing. Submitted reports will include all measured values for each transect line, as well as the final averaged shear resistance values. The shear resistance values should be correlated to the bearing capacity of the soil being tested and reported in pounds per square inch (psi).

The pre-construction shear strength of the specified Mississippi barrier islands (East and West Ship Island, and Cat Island) shall be established based upon these testing methods. These same testing methods are to be applied after the restoration projects at the islands are completed. Data from the pre-construction and the post-project conditions will be analyzed and compared using the appropriate statistical analysis. The statistical significance of the differences between the two conditions will be reported.

Statistical Hypothesis Testing

DCP data will be collected in a standardized digital format and exported to MS Excel for statistical analysis using before and after nourishment data. DCP data will be analyzed with One-way Analysis of Variance (ANOVA) to test equality of mean penetration measurements. The F-test, Duncan's Multiple Range Tests or Student-Neuman-Kuels t-tests will be used to test differences in penetration measurements and beaches. Values will be considered statistically similar where $P=0.01$. The null hypotheses that will be tested presume no differences in DCP values between the pre and post construction beaches.

Constructed Project Comparisons to Pre-Construction Values

Statistical hypothesis testing will be conducted to determine whether or not the sediment shear resistance of the existing island is statistically significantly different from that of the post-construction restoration project. Results obtained from stations along the seaward edge of the existing dune will be compared to those that are similarly located along the seaward edge of the constructed dune of the completed project. Likewise, results obtained from the stations located midway between the dune and the high water line will be compared to those that are similarly located on the completed project. A report on the baseline and post construction results of the shear resistance condition of the beach sediments will be submitted to the Fish and Wildlife Service. Consultation regarding tilling will occur with the Fish and Wildlife Service if the post-project conditions are statistically significantly different from those of the established pre-construction baseline.

APPENDIX D - MONITORING PROCEDURES

The following monitoring procedures will provide information necessary to evaluate project objectives for the MsCIP Barrier Island Restoration project. This plan proposes and builds upon existing data to establish a detailed baseline condition. This monitoring will continue during and post-construction to evaluate short-term and long-term response to the proposed restoration. These procedures will be updated as required to provide the necessary information to evaluate ecological success and inform the adaptive management program.

3 BIOLOGICAL

v. Benthic and Infaunal species

Benthic macroinfauna community sampling will follow methods described in Appendix I of the 2014 Draft Supplemental Environmental Impact Statement (USACE 2014). Pre-construction baseline benthic community surveys were collected in the 2010 (Summer and Fall) and 2011 (Spring) at borrow and placement sites and reference sites. In late 2011 (Fall) additional sites were surveyed to support Gulf Sturgeon monitoring and in 2015 (Winter) sites were added for shorebird monitoring. Post construction sampling will be conducted at the sites previously surveyed in 2010, 2011, and 2015 and potential new locations where sturgeon and shorebird feeding would occur after closure of Camille Cut. Sand placement and borrow sites will be surveyed approximately 3 years after project construction. Benthic surveys for shorebird feeding sites will be conducted in the Winter approximately 3 years after project equilibration has occurred. Post construction benthic sampling for sturgeon feeding sites are scheduled to be sampled in the Fall and Spring beginning 6 months after completion of phase 4 construction. Additional details regarding the monitoring procedure can be found in Appendix D3 Gulf Sturgeon and Shorebirds sections. Sampling sites are planned in the following locations:

1) Reference sites unlikely to be unaffected by construction,
2) Sand placement and borrow sites after completion of construction.
3) Additional sitesto complement the Gulf sturgeon and shorebird monitoring.

In the laboratory, benthic samples will be inventoried, rinsed through a 0.5–mm mesh sieve to remove preservatives and sediment, stained with Rose Bengal, and stored in 70% isopropanol solution. Sample material will be sorted and all macroinvertebrates will be removed and placed in labeled glass vials containing 70% isopropanol, with each vial representing a major taxonomic group (e.g. Oligochaeta, Mollusca, Arthropoda). Oligochaetes will be individually mounted and cleared on microscope slides prior to identification. All sorted macroinvertebrates will be identified to the lowest practical identification level (LPIL), which in most cases the species level unless the specimen is a juvenile, damaged, or otherwise unidentifiable. The number of individuals of each taxon, excluding fragments, will be recorded. A voucher collection will prepared, composed of representative individuals of each species not previously encountered in samples from the region. Additionally each sample will be analyzed for wet-weight biomass (g/m2) of the major taxonomic groups identified, to facilitate evaluation of potential feeding habitat for gulf sturgeon and shorebirds. Numerical indices will be calculated for each sample, including: (1) Infaunal abundance (total number of individuals per station); (2) Infaunal density (total number of individuals per square meter); (3) Species richness (total number of taxa represented in a given station and by Margalef's D); (4) Taxa diversity (Pielou's Index H`); and (5) Evenness (Pielou's Index J`).

In addition to the benthic samples, one sample will be collected at each station for sediment grain size analysis. Each sample will be washed with deionized water, dried, and weighed. The coarse and fine fractions (sand/silt) will be separated by sieving through a U.S. Standard Sieve Mesh #230 (62.5 μm). Median grain size and percentages of gravel, sand, silt, and clay will be calculated for each sample. A subsample of each sediment sample will be analyzed for total organic carbon (TOC). Sediment TOC analyses will be performed according to the guidelines in EPA-600/4-79-020, 1983, Method 415.1 for determination of total organic carbon in sediment and soils.

Once all data are collected and processed, interpretation will consist of habitat characterization (water depth, salinity, sediment texture) and benthic community characterization including faunal composition, abundance, and community structure, numerical classification analysis and taxa assemblages. A discussion will include a comparison of relevant samples collected as part of previous surveys. Macroinfaunal and sediment data will be used to evaluate the suitability of the sediment placement areas for feeding habitat for the Gulf Sturgeon and Shorebirds. Potential prey species will be identified and an interpretive report prepared to describe potential use of the study area by Gulf Sturgeon and Shorebirds. The physical parameters collected during the sampling and habitat characterization may also be correlated with benthic prey composition and determining favorable Gulf Sturgeon and Shorebird habitat.

APPENDIX D - MONITORING PROCEDURES

The following monitoring procedures will provide information necessary to evaluate project objectives for the MsCIP Barrier Island Restoration project. This plan proposes and builds upon existing data to establish a detailed baseline condition. This monitoring will continue during and post-construction to evaluate short-term and long-term response to the proposed restoration. These procedures will be updated as required to provide the necessary information to evaluate ecological success and inform the adaptive management program.

3 BIOLOGICAL

vi. Submerged Aquatic Vegetation

Submerged aquatic vegetation (SAV) data will be collected through aerial surveys to map coverage and in-situ ground condition assessments for examining health and vigor. Aerial imagery will be acquired with an Imaging Digital Mapping Camera (DMC) and orthoimagery will be produced for the mapping component. The orthorectification process will use the digital aerial imagery, ground control/aerotrangulation, and a digital elevation model (DEM). The DMC will utilize a minimum of four panchromatic and one each red, blue, green and near infrared bands controlled with airborne Global Positioning System (GPS). Three dimensional position and rotation will be determined for each exposure. A 1-meter native pixel resolution is required for the entire study area. Digital orthophotos will produced as individual rectified images and will be projected to the North American Datum of 1983, Universal Transverse Mercator (UTM) Zone Number 16 North. Aerial imagery will cover the barrier island system: Cat Island, E. Ship Island, W. Ship Island, Horn Island and Petit Bois Island.

SAV boundaries from the orthoimagery will be digitally delineated with a minimum mapping unit of 0.03 hectares. Polygons will be assessed for vegetation density and categorized as continuous (>50% coverage) or patchy (<50% coverage). Field surveys will be conducted within 2 months of acquisition to verify photographic signatures, with data collected at a minimum of 15 locations on the north side of Ship Island.

Annual SAV condition assessments will be conducted in mid to late summer during peak seagrass standing crop for up to five years post construction. Fixed stations established under the NPS GUIS surveys will be sampled as well as new fixed stations established north of Camille Cut. Four replicate $0.25m^2$ quadrat samples will be taken per station using an underwater digital camera (or through direct observation in shallow waters) and by visually estimating seagrass cover and canopy height. If water visibility is poor, one 15.2 cm inner diameter core to a depth of 15 cm will be taken at each sampling station, maximum leaf length of each shoot as well as overall canopy height based on 80% of leaf material. Information on water depth and transparency, water temperature, salinity dissolved oxygen, and photosynthetically active radiation (PAR) will also be collected at each station.

SAV aerial survey mapping and ground condition assessment data will be made available within 12 months of surveys. A report will be prepared which compares SAV coverage extent, health, and vigor with existing background data to document observed changes following closure of Camille Cut and restoration of the Cat Island component.

APPENDIX D - MONITORING PROCEDURES

The following monitoring procedures will provide information necessary to evaluate project objectives for the MsCIP Barrier Island Restoration project. This plan proposes and builds upon existing data to establish a detailed baseline condition. This monitoring will continue during and post-construction to evaluate short-term and long-term response to the proposed restoration. These procedures will be updated as required.

4 CULTURAL

The RECENTPAST Geographic Information Systems (GIS) tool is being developed by the Cultural Resources staff of the Planning and Environmental Inland Environment Team as part of management and compliance for the Cultural Resources Program at the USACE Mobile District. This tool was developed to evaluate the cultural resources objectives applicable to management of archaeological sites within the Mobile District and aid in compliance responsibilities under Section 106 of the National Historic Preservation Act.

The purpose of this tool is the creation of a real-time remote accessed map showing culturally sensitive areas and the effects of USACE Mobile water and land management practices. Additionally, email alerts can be configured to notify USACE Mobile District Archaeologists when factors of negative site impacts are present. The tool will track erosion data and archaeological site boundaries to monitor the impacts of the restoration on cultural resources. The USACE Geo-portal website is the portal for real-time end user view. Furthermore, this sensitive information can be restricted and permission accessed as needed.

Appendix E. Data Management Plan

VERSION 1.5

DECEMBER 28, 2015

DATA MANAGEMENT PLAN

MISSISSIPPI COASTAL IMPROVEMENTS PROGRAM

PRESENTED BY:

U. S. Army Corps of Engineers, Mobile District, Operations
Division, Spatial Data Branch

U. S. Geological Survey, National Wetlands Research Center, Advanced Applications Team

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1 PROGRAM OVERVIEW

The US Army Corps of Engineers, Mobile District (USACE), intends to restore the Mississippi Barrier Islands as part of the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Plan, which was authorized by Congress in the Department of Defense Appropriations Act, 2006 (Public Law 109-359) 30 December 2005. The restoration of the Mississippi Barrier islands and ecosystem restoration components of the MsCIP were authorized and funded in Public Law 111-32 in June 2009.

The Comprehensive Barrier Island Restoration Plan contains detailed supporting data and technical information on the various options proposed to meet the goals of the MsCIP Comprehensive Plan. Coordination with the National Park Service (NPS) which has ownership of most of the islands, and other agencies has resulted in a plan that will provide continuing existence for the islands. The plan includes direct sand placement in the breach of Ship Island with plantings of dune grasses, additional sand placement along the southern shoreline of East Ship Island, changes in the dredged material placement practices for the Pascagoula Federal Navigation Channel, restoration of the northern shoreline of West Ship Island, and restoration of the eastern shoreline of Cat Island. The program also has the potential to make beneficial use of dredged material that has been deposited in both inland and offshore areas if quality objectives are clearly demonstrated.

In light of the fact that restoration of the Mississippi barrier islands is a large-scale project that may influence regional conditions, a monitoring program was proposed to be implemented before, during, and after construction. Such monitoring during and following the implementation of barrier island restoration actions will allow the USACE to assess the progress of restoration and both short- and long-term impacts to the barrier island system including natural cultural resources. **Data** collected as a part of this monitoring program will allow the success of this restoration effort to be evaluated, and will be used to provide the necessary information to guide Adaptive Management (AM) and future decision-making, and will provide the NPS with information they can use to better manage their coastal resources.

2 DATA MANAGEMENT PLAN REVISIONS

This Data Management Plan is a dynamic document that will be updated as needed. Table 1 provides a history regarding modifications and/or additions to the plan.

Date	Version	Comments
10/22/13	1.0	Initial Draft
06/19/14	1.1	Added appendix: Benthic
10/24/14	1.2	Added appendices: ADCP, SAV, Borrow Area
01/21/15	1.3	Added appendix: Shoreline
02/20/15	1.4	Added appendices: Turtles, Birds 2015
12/28/15	1.5	Added data inventory entries

TABLE 1 **DATA MANAGEMENT PLAN REVISIONS**

3 DATA MANAGEMENT PLAN OVERVIEW

3.1 DATA MANAGEMENT PLAN PURPOSE

The MsCIP barrier island restoration project will contain an extensive monitoring and adaptive management program producing a large amount of varying types of data as well as utilizing legacy data for analysis purposes. This document outlines a plan for the lifecycle of data types included in this project. This plan also promotes standardized approaches to data acquisition, submission, and dissemination. This document will also serve as a record of what data has been collected and archived as part of the barrier island restoration effort. Standards developed during this effort may also be leveraged to manage data acquired for future MsCIP projects.

3.2 MONITORING AND ADAPTIVE MANAGEMENT (MAM) PLAN GUIDANCE

The MsCIP Monitoring and Adaptive Management (MAM) plan will outline the types of data to be monitored before, during, and after construction needed to produce a beneficial monitoring program or network. Additionally, the MAM plan will provide details describing desired locations and frequency of data collection for each named data type. This Data Management Plan (DMP) was developed in conjunction with the MAM plan; all data types within the MAM Plan will be covered by this DMP. The level of detail in this DMP is based on currently available data and information developed during MAM planning to date. Once monitoring data types are outlined and finalized within the MAM Plan and the data type does not appear within this DMP, a new version of the DMP containing the new data type as an appendix will be created and released.

3.3 DATA MANAGEMENT PLAN STRUCTURE

Over-arching data management details are described within the main sections of this plan. Data-specific details for each type of data being collected as part of the MsCIP barrier island restoration effort are located in the corresponding appendix for that data type. Information including data format attributes, delivery method, storage, and visualization details will be outlined within the corresponding data appendix.

Data-specific appendices have been developed for the following data types to date:

- Appendix A .... Shorebirds 2013
- Appendix B .... Gulf Sturgeon
- Appendix C .... Benthic
- Appendix D .... ADCP
- Appendix E .... SAV
- Appendix F .... Borrow Area
- Appendix G .... Shoreline
- Appendix H .... Turtles
- Appendix I .... Shorebirds 2015

3.4 AUDIENCE

The intended audiences of this Data Management Plan are:

- MsCIP Program Management
- MsCIP Project Team
- All people involved in data collection for the MsCIP program
- All stakeholders and cooperators utilizing MsCIP collected data
- Public

3.5 DATA MANAGEMENT COORDINATION

Coordination and open communication is key to a successful Data Management Plan. A partnership between USACE Mobile District and USGS has been established to create the MsCIP data management team. For each defined data type to be monitored and managed within the MsCIP project, the data management team will require a data type point of contact (POC) to be named by the MsCIP Program Management Team with guidance from the MsCIP Technical Advisory Group. The data management team will reach out to the named POC and present a series of questions to answer regarding their specific data being collected/analyzed. Working with the POC and/or actual data collectors, data format and submission will be decided and documented within the appendices of this data management plan.

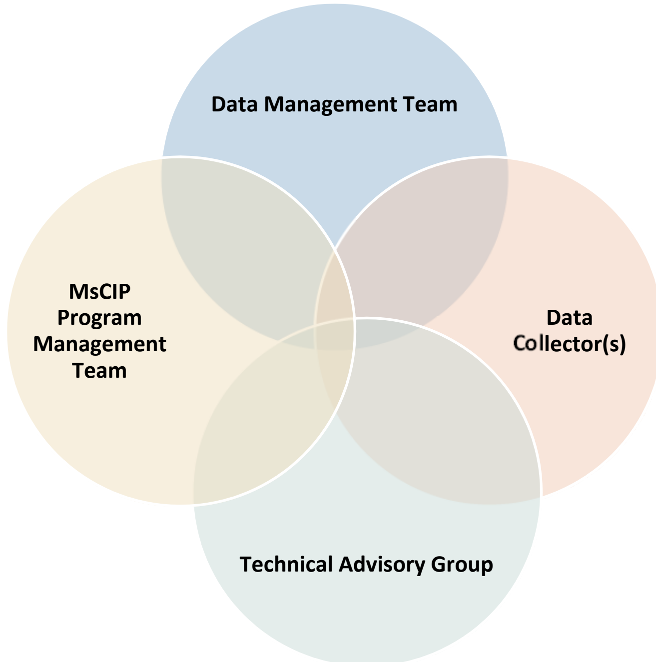

FIGURE 1 DATA MANAGEMENT COORDINATION

4 DATA TYPES COVERED BY THIS PLAN

4.1 DATA TYPE SUMMARY

The MsCIP effort will produce an abundant amount of data of varied data types. Example data products that will be managed include:

- Original monitoring data consisting of temporal observations
  - Field data sheets
- Verified monitoring data converted to tabular format
  - Electronic data sheets
  - Databases
- Analyzed data products
  - Summarized data/reports
  - Statistical result data/reports
- Documentation
  - Metadata
  - Data collection protocols
- GIS Data (Baseline/Supplemental Data)
  - Bathymetry
  - Lidar
  - Side scan sonar
  - Aerial photography
  - Location data (point/polygon)

- Attribute data

4.2 DATA TYPE CATEGORIES (GROUPS)

The following list provides anticipated baseline and monitoring data types to be collected by the MsCIP barrier island restoration project. Once a determination has been made regarding a new data type to be monitored, an appendix for that data type will be added to this plan.

- Physical
  - Aerial Imagery (AI)
  - Survey data (SD)
    - Bathymetry
    - LIDAR
    - Topography
- Hydrological
  - Waves (WS)
  - Water quality (WQ)
- Biological
  - Threatened and endangered species (TES)
    - Gulf Sturgeon
    - Shorebirds
      - Piping Plover
      - Red Knot
  - Habitat Composition (HC)
  - Sea turtles (ST)
  - Nesting shorebirds (NS)
  - Benthic and Infaunal species (BT)
  - Submerged Aquatic Vegetation (SAV)
- Chemical
  - Oil (present/not present)

5 DATA SUBMISSION STANDARDS

The Data Management Team will work with the various data collectors regarding data submission which may vary by data type. By following the submission standards, the data being submitted will integrate seamlessly into the appropriate database. The particular data submission method along with data format used will be documented in the corresponding data appendix.

6 DATA STORAGE AND PROTECTION

All electronic data submitted following the data-specific guidelines presented in the data appendices will be stored on a USACE data server.

This section lists data storage and protection details:

All Spatial data must be collected in the SDSFIE 3.1 (http://www.sdsfieonline.org/default.aspx) data standards; previously collected data will be converted to the SDSFIE 3.1 data standard by the Spatial Data Branch. The Spatial Data Branch is responsible for providing an SDSFIE 3.1 data schema for future collections and contracting for specific datasets.

MsCIP Program Management will request permission for the USACE, Mobile District Spatial Data Branch to load data to the USACE Enterprise database which also provides a public access point to the data. Collected data will be given to the Spatial Data Branch for uploading.

Users requesting access to password-protected data must complete an iPass request form. An iPass template form will be provided to the MsCIP Program Management Team to give to users requesting access to the password-protected site. Completed iPass forms will be submitted to the Army Corps of Engineers Information Technology (ACE-IT) group by the MsCIP Program Management Team.

A full backup of the USACE database is performed every Sunday, and incremental backups are performed every other day. Backups can also restore to a specific date/time. All backups are saved to disk and taken off site.

Data housed in the local SDE geodatabase will be replicated to the USACE Enterprise database to ensure up-to-date data.

7 DATA DOCUMENTATION

7.1 METADATA

If data is to maintain a long-term value, certain information about the data must be consistently documented. All data submitted by data collectors must have metadata delivered with it. It is the responsibility of the data collector to create the metadata for their submitted data. It is recommended that data collectors follow the ISO Metadata Standard 19115 (www.iso.org) when creating metadata.

8 DATA SHARING

8.1 DATA AVAILABILITY

The intent of the Data Management Team is to disseminate all data collected and delivered under the MAM plan. The MsCIP Program Management Team will inform the data management team regarding access levels of collected/delivered data since not all data types will have the same access. Data with access restrictions will be made available through a password protected interface. Data with no access restrictions will be made available through the MsCIP public web interface (TBD).

8.2 DATA SHARING PROTOCOLS

When data is loaded into the USACE Enterprise database, an ArcGIS rest service is created to allow users to download data. A MsCIP site will be created to host all MsCIP services. The services available to each user will be based on his/her profile.

8.3 DATA VISUALIZATION

The Data Management Team will work with the Program Management Team and Technical Advisory Group to design applicable visualization tools. Some tools may be used to gauge project progress, such as if restoration success has been achieved or if adaptive management needs to be implemented to adjust project performance. Discussions will occur regarding applicable datasets (baseline and/or monitoring) the tools should target as well as potential analysis operations that can be incorporated in tool development.

Overall, each data type will have a visualization component integrated within the data management visualization platform offering temporal and spatial information where applicable. The data management team will document the visualization strategy for each data type within the corresponding data appendix. A private and a public interface will be designed and implemented to comply with potential data access restrictions. Through the private password-protected interface, all data (i.e. locations and observational data) will be made available to the project team and those specific users defined by the MsCIP program management team. Based on guidance provided by the project team, summarized and/or partially obfuscated data where applicable will be made available through the MsCIP public interface along with all public data.

9 DATA MANAGEMENT POINTS OF CONTACT

Clint Padgett
Chief, Spatial Data Branch (CESAM-OP-J)
Operations Division
US Army Corps of Engineers, Mobile District
109 St. Joseph Street, Room 7029
Mobile, AL 36602

Craig Conzelmann
Physical Scientist
USGS - National Wetlands Research Center
700 Cajundome Blvd
Lafayette, LA 70506

10 APPENDIX A: BIRD MONITORING DATA (2013)

10.1 BIRD MONITORING ATTRIBUTES (2013)

MsCIP is to monitor certain bird species pre, post, and during the barrier island restoration construction. The table within this section gives the attributes expected to be recorded by any data collector. These attributes will be uploaded into the databases discussed in Section 6.

Attribute	Data Type	Size/format	Description
SPECIES	Text	200	Species name observed
LOCATION	Text	150	Descriptive location (i.e. West Ship Island)
DATE_	Date	mm/dd/yyyy	Observation date
BIRDS	Double		Number of birds observed
TIDE	Text	50	Low, Mid, or High Tide
WEATHER	Text	100	General weather description (i.e. Sunny)
TEMPERATUR	Text	50	General temperature description (i.e. Cool)
WIND	Text	50	General wind description (i.e. Low, Moderate, High)
HABITAT	Text	150	General habitat description (i.e. Sand Beach, Lagoon)
SIDE	Text	50	Side of island (i.e. Gulf Side, Bay Side)
VEGETATION	Text	50	General vegetation density description (i.e. Sparse)
SUBSTATE	Text	50	(i.e. Mud/Sand)
BEHAVIOR	Text	200	General bird behavior (i.e. Walking, Foraging, Roosting)
NESTS	Double		Number of observed nests
DISTURBANC	Text	250	Activities occurring nearby (i.e. BP Survey, planting…)
COMMENTS	Text	250	Species name when type “Other” is selected
OBSERVERS	Text	200	First and Last name of observer
TRANSPORAT	Text	50	Transportation being used when observing (i.e. Foot)
DOCUMENTS	Text	250	Pictures taken with GPS at time of data capture or additional links to documentation.
COLOR_BAND	Text	250	Description of any bands on bird if present

TABLE 2 BIRD MONITORING DATA ATTRIBUTES

10.2 BIRD MONITORING DATA DELIVERY PROCESS

Mobile District has implemented an upload solution for bird related data built upon ArcGIS Mobile. The data collector will be provided with a handheld Global Positioning

System (GPS) containing the aforementioned software and will be required to enter and sync the data to Mobile District where the data will be archived. All attributes seen in Table 2 will be included in submitted data.

10.3 BIRD MONITORING DATA STORAGE

The data collector will use a GPS with ArcGIS Mobile installed. When a data collector syncs the observation data, the data is ingested into the Spatial Data Branch SDE geodatabase. From there the data will be replicated up to USACE Enterprise database for visualization. The location data and attributes will be hosted through ArcGIS rest services for consumption.

10.4 BIRD MONITORING DATA VISUALIZATION/DESSIMINATION

All bird data including locations and attributes will be available through the password-protected private interface. Locations will be viewable within the web map along with the attributes from that particular data observation. Due to the threatened and endangered nature of the particular bird species being monitored, obfuscated bird data may be available within the public interface giving total number of birds seen during a time range but not bird siting locations.

11 APPENDIX B: GULF STURGEON MONITORING DATA

11.1 GULF STURGEON MONITORING ATTRIBUTES

MsCIP is to monitor gulf sturgeon pre, post, and during the barrier island restoration construction. The monitoring started in 2011 and is to continue through construction and for a number of years (TBD) post construction.

Table 3 contains attribute details for Gulf Sturgeon tags detected within the telemetry array over the course of the study period to date.

Attribute	Data Type	Size/format	Description
RIVER	Text	25	River where fish was tagged
TRANSMITTER	Text	25	Uniquely coded acoustic tag
DATE_TAGGED	Text	mm/dd/yyyy	Date tag placed
SIZE_CLASS	Text	5	Size class at tagging
FORK_LENGTH	Double		Fork length at tagging (cm)
WEIGHT	Double		Weight at tagging (Kg)

TABLE 3 GULF STURGEON TAG LIST ATTRIBUTES

Table 4 contains attribute details for the location of deployed stations/receivers.

Attribute	Data Type	Size/format	Description
STATION_NAME	Text	25	The name of each VR2W location, corresponds to the station name found in the data tabs
LATITUDE	Double		The GPS coordinate recorded for each station, in WGS 1984 Datum
LONGITUDE	Double		The GPS coordinate recorded for each station, in WGS 1984 Datum

TABLE 4 GULF STURGEON STATION LOCATION ATTRIBUTES

Table 5 contains attribute details for monitoring data collected.

Attribute	Data Type	Size/format	Description
DATE_TIME_UTC	Date	mm/dd/yy hh:mm:ss	Date and time of each tag relocation, recorded in UTC time
DATE_TIME_LOCAL	Date	mm/dd/yy hh:mm:ss	Date and time of each tag relocation, corrected for local CST & CDT time
RECEIVER	Text	25	The serial number for each VR2W

TRANSMITTER	Text	25	Uniquely coded acoustic tag of Gulf sturgeon detected on the array
STATION_NAME	Text	25	The name of each station in the array.
LATITUDE	Double		The GPS coordinate recorded for each station, in WGS 1984 Datum
LONGITUDE	Double		The GPS coordinate recorded for each station, in WGS 1984 Datum

TABLE 5 GULF STURGEON DATA ATTRIBUTES

11.2 GULF STURGEON MONITORING DATA DELIVERY PROCESS

The data collector will deliver data-corrected gulf sturgeon monitoring data to the MsCIP data management team by electronic data files in Microsoft Excel format. The data is to be organized based on the attribute information given in the tables above.

11.3 GULF STURGEON MONITORING DATA STORAGE

The gulf sturgeon data will be converted into SDSFIE 3.1 data standards by the Spatial Data Branch and replicated up to USACE Enterprise database for visualization. The location data and attributes will be hosted through ArcGIS rest services for consumption.

11.4 GULF STURGEON MONITORING DATA VISUALIZATION/DESSIMINATION

Gulf sturgeon data will be available through the password-protected MsCIP private web interface. Receiver locations by year will be viewable within the web map along with aggregated details of the actual monitoring data. The data will be password-protected until given further notice by the data collector and the Program Management Team.

12 APPENDIX C: BENTHIC MONITORING DATA

12.1 BENTHIC MONITORING ATTRIBUTES

Benthic community surveys will be collected in the spring and summer before and 1 year after project construction. Sampling will be conducted at sturgeon and shorebird feeding sites previously surveyed in 2010 and 2011 and potential new locations where feeding would occur after closure of Camille Cut. Sediment texture will also be determined at each location where benthic macroinfaunal samples are collected. Hydrographic measurements will also be taken at each sampling location.

The tables below outline the necessary attributes from benthic monitoring.

Attribute	Data Type	Size/format	Description
STATION	Text	25	Name/ID of benthic station
LATITUDE	Double		The GPS coordinate (decimal degrees) recorded for each station, in WGS 1984 Datum
LONGITUDE	Double		The GPS coordinate (decimal degrees) recorded for each station, in WGS 1984 Datum

TABLE 6 BENTHIC STATION LOCATION ATTRIBUTES

Attribute	Data Type	Size/format	Description
STATION	Text	25	Name/ID of benthic station
TAXA	Text	50	Macroinfaunal taxonomic group name
TOTALNOTAXA	Double		Total number of corresponding taxa at station
TOTALTAXA%	Double		Taxa percentage
TOTALNOINDIV	Double		Total number of individuals within taxa at station
TOTALNOINDIV%	Double		Total number of individuals percentage
DATE_	Date	mm/dd/yyyy	Observation Date/Datetime

TABLE 7 BENTHIC ABUNDANCE AND DIVERSITY SUMMARY ATTRIBUTES

Attribute	Data Type	Size/format	Description
STATION	Text	25	Name/ID of benthic station
DEPTHDESC	Text	50	Bottom, Mid-Depth, Surface
DATE_	Date	mm/dd/yyyy	Observation Date/Datetime
DEPTH	Double		Depth (ft)
TEMP	Double		Temperature (C)

SPCOND	Double		Specific Conductance (mS/cm)
SALINITY	Double		Salinity (ppt)
PH	Double		pH
ODO%	Double		Dissolved Oxygen (%)
ODOCONC	Double		Dissolved Oxygen Concentration (mg/L)

TABLE 8 WATER QUALITY ATTRIBUTES (SAMPLES AT BENTHIC STATIONS)

Attribute	Data Type	Size/format	Description
STATION	Text	25	Name/ID of benthic station
DATE_	Date	mm/dd/yyyy	Observation Date/Datetime
GRAVEL%	Double		Gravel percentage
SAND%	Double		Sand percentage
SILT%	Double		Silt percentage
CLAY%	Double		Clay percentage
SILTCLAY%	Double		Silt + Clay percentage
TOC%	Double		Total Organic Carbon percentage

TABLE 9 SEDIMENT ATTRIBUTES (SAMPLES AT BENTHIC STATIONS)

12.2 BENTHIC MONITORING DATA DELIVERY PROCESS

The data collector will deliver benthic data to the MsCIP data management team by electronic data files in Microsoft Excel format. A sample data file can be provided. The data is to be organized based on the attribute information given in the tables above. Additional data files, giving more detailed benthic information (additional taxa break-down, mean no. taxa, abundance, density, total taxa, total individuals, diversity, and evenness) is also still to be delivered in Excel but does not need to adhere to a specified format.

12.3 BENTHIC MONITORING DATA STORAGE

The benthic data will be converted into SDSFIE 3.1 data standards by the Spatial Data Branch and replicated up to USACE Enterprise database for visualization. The location data and attributes will be hosted through ArcGIS rest services for consumption.

12.4 BENTHIC MONITORING DATA VISUALIZATION/DESSIMINATION

The benthic data attributes given in the tables above, as well as the sediment and hydrological measurements taken at the benthic stations, will be available through the

MsCIP web mapping interface. Any additional data files giving additional diversity and/or abundance information may be available through download links.

13 APPENDIX D: ACOUSTIC DOPPLER CURRENT PROFILER (ADCP) DATA

13.1 ADCP DATA FILES AND ATTRIBUTES

To document changes and assess whether closure of Camille Cut impacts overall circulation in the sound adjacent to the islands, Acoustic Doppler Current Profiler (ADCP) transect data will be collected at each pass.

The data collector will deliver multiple files in regards to ADCP data. For each ADCP dataset, the data collector will deliver the raw WinRiver™ binary file, WinRiver™ classic Ascii-out file, and the ERDC .GIS file format to the MsCIP data management team. Associated metadata should also be delivered along with each dataset specifying projection, units, and reference information.

Delivered binary files may consist of the following:

***r.000	WinRiver™ raw binary data file
***n.000	WinRiver™ navigation file
***h.000	WinRiver™ header file

TABLE 10 WINRIVER™ BINARY FILES

Delivered ascii files may consist of the following:

***t.000	WinRiver™ 1 older text file format
***_ASC.TXT	WinRiver™ 2 ascii-out file
***.GIS	Cleaned up Ascii Text (***t.000 or ***_ASC.TXT) File

TABLE 11 ASCII FILES

An example WinRiver™ II Classic Ascii-out file appears below.

```
This is WinRiver II comment line #1
This is WinRiver II comment line #2
    50      25      40     124      1       9       1
11 6 21 13 15 9 62  1961      1     2.700    -3.700  313.120   28.740
-0.86     1.50    0.00    0.00     0.00    25.69     0.82     9.10    30.71
40.38    38.71    32.05
6.72         3.89         5.82        -3.36         6.72
29.99097562   -90.42193135    -0.86     1.50          6.7
212.6          32.9          64.7            0.0          75.0            0.0
75.0   4.07   25.39
124 ft GGA dB 0.42  0.065
  4.07      0.55    342.82   -0.2    0.5    1.3   -0.6    89.5   90.7   89.9
95.8  100      1.36
  5.71      1.46    149.66    0.7   -1.3    0.0    0.4    90.8   89.5   88.3
92.5  100      0.09
  7.35      0.95     91.13    0.9   -0.0    0.3   -0.2    92.2   88.8   88.0
89.7  100      8.92
  8.99      1.30    127.79    1.0   -0.8    0.0   -0.1    89.6   90.1   88.8
88.0  100      5.41
 10.63      2.61     71.05    2.5    0.8    0.4    0.7    86.7   88.0   87.6
88.0  100     28.27
```

FIGURE 2 **EXAMPLE WINRIVER CLASSIC ASCII-OUT FILE**

The above Ascii-out file values are described in detail below (extracted from the WinRiver™ II User Guide).

Classic ASCII Output Format

Each time *WinRiver II* opens a new ASCII-out data file, it first writes the following three lines.

Row	Field	Description
A	1	NOTE 1 – You can enter these lines by right-clicking **Transect** and selecting **Add Note** (see Add Note).
B	1	NOTE 2 – You can enter these lines by right-clicking **Transect** and selecting **Add Note** (see Add Note).
C	1	DEPTH CELL LENGTH (cm)
	2	BLANK AFTER TRANSMIT (cm)
	3	ADCP DEPTH FROM CONFIGURATION NODE (cm)
	4	NUMBER OF DEPTH CELLS
	5	NUMBER OF PINGS PER ENSEMBLE
	6	TIME PER ENSEMBLE (hundredths of seconds)
	7	PROFILING MODE

Whenever *WinRiver II* displays a new data segment (a raw or averaged data ensemble), it writes the following data to the ASCII-out file. The first six rows contain leader, scaling, navigation, and discharge information. Starting with row seven, *WinRiver II* writes information in columns based on the bin depth. When *WinRiver II* writes the information for all bins in the current ensemble, it goes to the next ensemble and repeats the cycle starting with row one. Fields are separated by one or more spaces. *WinRiver II* does not split ensembles between files. The file size automatically increases to fit at least one ensemble. Missing data (data not sent from ADCP) are not included (no dashes or fill values). "Bad data" values: velocity (–32768); discharge (2147483647); Latitude/Longitude (30000).

Row	Field	Description
1	1	ENSEMBLE TIME -Year (at start of ensemble)
	2	- Month
	3	- Day
	4	- Hour
	5	- Minute
	6	- Second
	7	- Hundredths of seconds
	8	ENSEMBLE NUMBER (or SEGMENT NUMBER for processed or averaged raw data)
	9	NUMBER OF ENSEMBLES IN SEGMENT (if averaging ON or processing data)
	10	PITCH – Average for this ensemble (degrees)
	11	ROLL – Average for this ensemble (degrees)
	12	**CORRECTED HEADING** - Average ADCP heading (corrected for one cycle error) + heading offset + magnetic variation
	13	ADCP TEMPERATURE - Average for this ensemble (°C)
2	1	**BOTTOM-TRACK VELOCITY** - East(+)/West(-); average for this ensemble (cm/s or ft/s)
	2	Reference = BTM - North(+)/South(-)
	3	- Vertical (up[+]/down[-])
	4	- Error
2	1	**BOTTOM-TRACK VELOCITY** - GPS (GGA or VTG) Velocity (calculated from GGA String) Reference = GGA East(+)/West (-1)
	2	Reference = VTG - GPS (GGA or VTG) North(+)/South(-) Velocity
	3	- BT (up[+]/down[-]) Velocity
	4	- BT Error
	5	**GPS/DEPTH SOUNDER** - corrected bottom depth from depth sounder (m or ft) as set by user (negative value if DBT value is invalid)
	6	- GGA altitude (m or ft)
	7	- GGA Δaltitude (max – min, in m or ft)
	8	- GGA HDOP x 10 + # satellites/100 (negative value if invalid for ensemble)
	9	**DEPTH READING** - Beam 1 average for this ensemble (m or ft, as set by user)
	10	(Use River Depth - Beam 2
	11	= Bottom Track) - Beam 3
	12	- Beam 4
	9	**DEPTH READING** - Depth Sounder depth
	10	(River Depth - Depth Sounder depth
	11	= Depth Sounder) - Depth Sounder depth
	12	- Depth Sounder depth
	9	**DEPTH READING** - Vertical Beam depth
	10	(River Depth - Vertical Beam depth
	11	= Vertical Beam) - Vertical Beam depth
	12	- Vertical Beam depth

FIGURE 3 **WINRIVER™ CLASSIC ASCII-OUT FILE FORMAT**

The .GIS file is created from custom software. It creates a "cleaned up" version of the WinRiver™ classic Ascii-out file. A subset of a .GIS file (one row of data) appears below.

```
11 6 21 13 15 9 62 3569344.194031 543357.940803 4.070000 0.550000 342.820000
-0.200000 0.500000 1.300000 -0.600000 89.500000 90.700000 89.900000 95.800000
```

FIGURE 4 **EXAMPLE .GIS FILE**

The above example .GIS file values are described in detail below.

1. Year
2. Month
3. Day
4. Hour
5. Min
6. Sec
7. Hundredth sec
8. State plane X
9. State plane Y
10. Depth (z) from water surface
11. Velocity Magnitude
12. Velocity Direction
13. East Velocity Component - East (+)/West(-)
14. North Velocity Component - North(+)/South(-)
15. Vertical Velocity Component - Up(+)/Down(-)
16. Error velocity
17. Backscatter beam 1
18. Backscatter beam 2
19. Backscatter beam 3
20. Backscatter beam 4

FIGURE 5 .GIS ASCII FILE FORMAT

13.2 ADCP DATA DELIVERY PROCESS

The ADCP data collection team will upload their data to their own project web site (TBD) as the SOW states and a notification will be sent to the MsCIP program management team that the data is now available. The data will be downloaded by the MsCIP data management team to be catalogued, processed, stored, and visualized.

13.3 ADCP DATA STORAGE

The ADCP transect and observational point data will be converted into SDSFIE 3.1 data standards by the Spatial Data Branch and replicated up to USACE Enterprise database for visualization. The data and attributes will be hosted through ArcGIS rest services for consumption.

13.4 ADCP DATA VISUALIZATION/DESSIMINATION

The ADCP data contains two separate visualization components - the transect data (line) and the individual observational point data (point) that can be displayed at a specified zoom level on the web map. The observational point data contains velocity observations at varying depths of the water column. These values can be plotted dynamically in a line or bar chart displaying on mouse-click of an observational point.

14 APPENDIX E: SUBMERGED AQUATIC VEGETATION (SAV) DATA

14.1 SAV MONITORING ATTRIBUTES

Submerged aquatic vegetation (SAV) data will be collected through both aerial surveys to map extent and ground condition assessments to examine health and vigor.

The table below outlines the SAV polygon monitoring attributes.

Attribute	Data Type	Size/format	Description
SPECIES	Text	20	Species type code (hw = Shoal grass (*Halodule wrightii*))
HABITAT	Text	20	SAV density (i.e. Patchy/Continuous *)
PERIMETER	Double		Perimeter measurement of SAV polygon feature
AREA	Double		Area measurement of SAV polygon feature
ACRES	Double		Acres within SAV polygon feature
ISLAND	Text	20	Nearest island where SAV polygon is located (W Ship, Cat, Horn, Petit Bois)

TABLE 12 **SAV MONITORING ATTRIBUTES**

* Patchy: <50% coverage; Continuous: >50% coverage

14.2 SAV MONITORING DATA DELIVERY PROCESS

The data collector will deliver SAV data to the MsCIP data management team by electronic data files in ArcGIS shapefile format. The shapefile should contain a polygon feature class containing the SAV determined areas/boundaries near the islands. The data is to be attributed based on the information given in the table above.

14.3 SAV MONITORING DATA STORAGE

The SAV data will be converted into SDSFIE 3.1 data standards by the Spatial Data Branch and replicated up to USACE Enterprise database for visualization. The location data and attributes will be hosted through ArcGIS rest services for consumption.

14.4 SAV MONITORING DATA VISUALIZATION/DESSIMINATION

The SAV polygon and attribute data given in the table above will be available through the MsCIP web mapping interface.

15 APPENDIX F: BORROW AREA DATA

15.1 BORROW AREA MONITORING ATTRIBUTES

The borrow area dataset designates where the approved material will be obtained for use in the closing of Camille Cut.

The table below outlines the borrow area polygon attributes.

Attribute	Data Type	Size/format	Description
DREDGE DEPTH	Double		Borrow dredge depth
ELEV_U_D	Text	16	Borrow dredge depth units
NAME	Text	30	Borrow Site Name
NARRATIVE	Text	240	General description of the borrow area
SUBTYPE_ID	Small Int		Type of borrow area (1 = Open Water Borrow Area)
LOCATION	Text	20	Nearest island where borrow is located (Ship Island, Cat Island, Horn Island, Petit Bois Island)

TABLE 13 BORROW AREA ATTRIBUTES

15.2 BORROW AREA DATA DELIVERY PROCESS

The data collector will deliver borrow area data to the MsCIP data management team by electronic data files in ArcGIS shapefile format. The shapefile should contain a polygon feature class containing the determined borrow areas/boundaries. The data is to be attributed based on the information given in the table above.

15.3 BORROW AREA DATA STORAGE

The borrow area data will be converted into SDSFIE 3.1 data standards by the Spatial Data Branch and replicated up to USACE Enterprise database for visualization. The location data and attributes will be hosted through ArcGIS rest services for consumption.

15.4 BORROW AREA DATA VISUALIZATION/DESSIMINATION

The borrow area polygon and attribute data given in the table above will be available through the MsCIP web mapping interface.

16 APPENDIX G: SHORELINE DATA

16.1 SHORELINE DATA ATTRIBUTES

The shoreline is the boundary where land meets the edge of a large body of fresh or salt water. The shoreline is the mean high water line between high and low tide.

Shoreline data will be collected through both aerial surveys to map extent and ground condition assessments to examine health and vigor.

The table below outlines the shoreline line monitoring attributes.

Attribute	Data Type	Size/format	Description
bankType	String	Domain (see BankType Domain Values table)	The type of bank the shoreline segment represents (correlates to a manmade shorelineType).
collectionDate	Date		Date the shoreline data was collected
heightAboveVerticalDatum	Decimal		The nominal height of the shoreline above the vertical datum provided by the geomtry of the shoreline.
heightAboveVerticalDatumUOM	String	Domain (see GSIP_LengthUOM Domain Values table)	The units of measure for the like-named value.
sdsFeatureDescription	String(Max)		A narrative describing the feature
sdsFeatureName	String	80	The common name of the feature
shorelineIDPK	String	20	Primary Key. A unique, user defined identifier for each record or instance of an entity.
shorelineTidalDatum	String	Domain (see VerticalDatumType Domain Values table)	In general, a datum is a base elevation used as a reference from which to reckon heights or depths. A tidal datum is a standard elevation defined by a certain phase of the tide. Tidal datums are used as references to measure local water levels and should not be extended into areas having differing oceanographic characteristics without substantiating measurements. In order that they may be recovered when needed, such datums are referenced to

			fixed points known as bench marks. Tidal datums are also the basis for establishing privately owned land, state owned land, territorial sea, exclusive economic zone, and high seas boundaries.
shorelineType	String	Domain (see ShorelineType Domain Values table)	Indicator of the type of shoreline, natural, manmade, or unknown.

TABLE 14 SHORELINE DATA ATTRIBUTES

Value	Description
ASPHALT	Asphalt
CEMENTD_STONE	Cemented stones
CONCRETE_LINED	Concrete lined
DUMP_BRICK_CONC	Dumped brick and concrete
DUMPED_ROCK	Dumped rocks
FORMEDLINING	Formed channel lining
GABIONS	Gabions
PILEDIKE	Pile dike
PLACED_STONE	Placed stone
SAND_CEMNBGRR	Sand cement/bag riprap
WILLOW_MAT	Willow Mat
NA	Not applicable
OTHER	Other
TBD	To be determined

TABLE 15 SHORELINE BANKTYPE DOMAIN VALUES

Value	Description
astronomicUnit	A conventional unit of measurement of length equal to 1.4959787 x 10^11 metres.
centimetre	A conventional unit of measurement of length equal to 0.01 metres.
dataMile	A conventional unit of measurement of length equal to 6,000 feet (1,828.8 metres). Used in the Joint Tactical Information Distribution

	System (JTIDS) and Variable Message Format (VMF).
decafoot	A conventional unit of measurement of length equal to 10 feet (3.048 metres).
decakilometre	A conventional unit of measurement of length equal to 10,000.0 metres.
decametre	A conventional unit of measurement of length equal to 10.0 metres.
decifoot	A conventional unit of measurement of length equal to one tenth of a foot (0.03048 metres).
decimetre	A conventional unit of measurement of length equal to 0.1 metres.
deciNauticalMile	A conventional unit of measurement of length equal to one tenth of a nautical mile or 185.2 metres.
fathom	A conventional unit of measurement of length equal to 6 feet (1.8288 metres).
foot	A conventional unit of measurement of length equal to 0.3048 metres.
halfFoot	A conventional unit of measurement of length equal to one half of a foot (0.1524 metres).
halfHectometre	A conventional unit of measurement of length equal to 50.0 metres.
halfMetre	A conventional unit of measurement of length equal to 0.5 metres.
hectofoot	A conventional unit of measurement of length equal to 100 feet (30.48 metres).
hectokilometre	A conventional unit of measurement of length equal to 100,000.0 metres.
hectometre	A conventional unit of measurement of length equal to 100.0 metres
Inch	A conventional unit of measurement of length equal to 0.0254 metres.
kilofoot	A conventional unit of measurement of length equal to 1000 feet (304.8 metres).
kilometre	A conventional unit of measurement of length equal to 1,000.0 metres.
kiloyard	A conventional unit of measurement of length equal to 1000 yards (914.4 metres)
metre	The base unit in SI for the physical quantity length, defined as the length of the path travelled by light in vacuum during a time interval of 1/299,792,458 of a second.
micrometre	A conventional unit of measurement of length equal to 0.000001 metres.
millimetre	A conventional unit of measurement of length equal to 0.001 metres.

nanometre	A conventional unit of measurement of length equal to 0.000000001 metres.
nauticalMile	A conventional unit of measurement of length equal to 1,852.0 metres.
picometre	A conventional unit of measurement of length equal to 0.000000000001 metres.
statuteMile	A conventional unit of measurement of length equal to 5,280 feet (1,609.344 metres).
usSurveyFoot	A conventional unit of measurement of length equal to 0.3048006 metres. Set by the U.S. Coast and Geodetic Survey as exactly 1200/3937 metres.
usSurveyMile	A conventional unit of measurement of length equal to 5,280 U.S. Survey Feet (1,609.347 metres).
Yard	A conventional unit of measurement of length equal to 0.9144 metres.
NA	Not applicable
TBD	To be determined

TABLE 16 SHORELINE GSIP_LENGTHUOM DOMAIN VALUES

Value	Description
ALWP	Average Low Water Plane
DHQ	Mean Diurnal High Water Inequality - The difference in height of the two high waters of each tidal day for a mixed or semidiurnal tide.
DLQ	Mean Diurnal Low Water Inequality - The difference in height of the two low waters of each tidal day for a mixed or semidiurnal tide.
DTL	Diurnal Tide Level - The arithmetic mean of mean higher high water and mean lower low water.
GT	Great Diurnal Range - The difference in height between mean higher high water and mean lower low water.
HWI	Greenwich High Water Interval - The average interval (in hours) between the transit of the moon over the Greenwich meridian and the following high water at a location.
LWI	Greenwich Low Water Interval - The average interval (in hours) between the transit of the moon over the Greenwich meridian and the following low water at a location.
LWRP	Low Water Reference Plane 1974
MHHW	Mean Higher High Water - The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch.

MHW	Mean High Water - The average of all the high water heights observed over the National Tidal Datum Epoch.
MLG	Mean Low Gulf
MLLW	Mean Lower Low Water - The average of the lower low water height of each tidal day observed over the National Tidal Datum Epoch.
MLW	Mean Low Water - The average of all the low water heights observed over the National Tidal Datum Epoch.
MN	Mean Range of Tide - The difference in height between mean high water and mean low water.
MSL	Mean Sea Level - The arithmetic mean of hourly heights observed over the National Tidal Datum Epoch. Shorter series are specified in the name; e.g., monthly mean sea level and yearly mean sea level.
MTL	Mean Tide Level - The arithmetic mean of mean high water and mean low water.
NAVD_88	North American Vertical Datum of 1988
NGVD_29	National Geodetic Vertical Datum of 1929
NTDE	National Tidal Datum Epoch - The specific 19-year period adopted by the National Ocean Service as the official time segment over which tide observations are taken and reduced to obtain mean values (e.g., mean lower low water, etc.) for tidal datums.
SD	Station Datum - A fixed base elevation at a tide station to which all water level measurements are referred. The datum is unique to each station and is established at a lower elevation than the water is ever expected to reach.
NA	Not applicable
OTHER	Other. Must be described in the sdsFeatureDescription attribute.
TBD	To be determined

TABLE 17 SHORELINE VERTICALDATUMTYPE DOMAIN VALUES

Value	Description
manmade	The shoreline is manmade
natural	The shoreline is naturally occurring
NA	Not applicable
Other	Other. Must be described in the sdsFeatureDescription attribute.
TBD	To be determined

TABLE 18 SHORELINE SHORELINETYPE DOMAIN VALUES

16.2 SHORELINE DATA DELIVERY PROCESS

The data collector will deliver shoreline data to the MsCIP data management team by electronic data files in file geodatabase format. The geodatabase should contain a line feature class containing the determined shoreline boundaries. The data is to be attributed based on the information given in the table above.

16.3 SHORELINE DATA STORAGE

The shoreline data will be replicated to USACE Enterprise database by the Spatial Data Branch once received. The location data and attributes will be hosted through ArcGIS rest services for consumption.

16.4 SHORELINE DATA VISUALIZATION/DESSIMINATION

The shoreline line and attribute data given in the table above will be available through the MsCIP web mapping interface

17 APPENDIX H: TURTLE DATA

17.1 TURTLE DATA ATTRIBUTES

The table below outlines the turtle monitoring attributes.

Attribute	Data Type	Size/format	Description
turtlePermitNo	String	50	Turtle Permit Holder (TP#)
contractNo	String	50	Contract Number
prinPermitHolder	String	50	Principal permit holder
organization	String	50	Data Collector Organization
address	String	150	Data Collector Address
telephoneDay	String	20	Data Collector daytime telephone #
telephoneNight	String	20	Data Collector evening telephone #

TABLE 19 DATA COLLECTOR ATTRIBUTES

Attribute	Data Type	Size/format	Description
beach	String	20	Beach name
obsStartDate	Date	mm/dd/yyyy	Initial observation date
obsStartTime	String	20	Initial observation time (00:00:00)
weather	String	25	Weather conditions
species	String		Species type (Loggerhead, Green, Leatherback, Kemp's Ridley, Unknown)
incidentType	String	25	Incident Type (nest/false crawl)
incidentID	String	25	Turtle Nest/Crawl ID ([IslandID_mmddyy] Island IDS: Cat Island = 1; Ship Island = 2; Horn Island = 3; Petit Bois Island = 4)
crawlMeasurement	Decimal		Crawl Measurement (width)
crawlDescription	Text	20	Crawl Description (alternating, symmetrical)
latitudeGPS	Decimal		Latitude in decimal degrees of nest/crawl location
longitudeGPS	Decimal		Longitude in decimal degrees of

			nest/crawl location
markers	Text	20	Markers around nest (signs, stakes)
nestPhotoID	String	150	File path/name of nest photo
siteDescription	String	150	Site Description
relocated	String	20	Is this a relocated nest? (yes, no)
relocatedReason	String	150	Reason why the nest was relocated. Value required if "relocated" attribute is yes.
previousNestID	String	20	Nest ID (incidentID) before relocation to track movement of nest. Relocated nest gets a new Nest ID.
clutchMeasurements	Decimal		Measurements from center of body pit/egg cavity to marker signs/stakes
clutchDeposited	String	20	Clutch deposited (yes, no, unknown)
totalClutchSize	String		(number of eggs)
clutchPhotoID	String	150	File path/name of clutch photo
inventoryDate	DateTime		Inventory date of hatchling data
emerged	String	20	Hatchlings emerged? (yes, no)
broken	Integer		How many broken?
stakes	String	20	Stakes? (yes, no)
hatched	Integer		Number of hatchlings
bufferStakes	String	20	Buffer stakes? (yes, no)
liveHatchlings	Integer		Number of live hatchings
deadHatchlings	Integer		Number of dead hatchlings
earlyStageMortality	String	20	Early stage mortality? (yes, no)
addled	String	20	Addled? (yes, no)
lateStageMortality	String	20	Late stage mortality (yes, no)
infertile	String	20	Infertile? (yes, no)
pippedDead	Integer		Number of pipped dead
pippedLive	Integer		Number of pipped live
hatchlingSuccess%	Decimal		Hatchling Success % (number of hatched shells/total clutch size X

			100)
emergingSuccess%	Decimal		Emerging Success % (no. hatched shells – {live + dead hatchlings}/total clutch size) X 100)
eggsAffectedBy	String	150	Describe if nest was affected by predators or inundation
Notes	String	250	Additional notes

TABLE 20 TURTLE MONITORING DATA ATTRIBUTES

17.2 TURTLE DATA DELIVERY PROCESS

The data collector will deliver turtle monitoring data to the MsCIP data management team by electronic data files in Excel file format. The data is to be attributed based on the information given in the table above.

17.3 TURTLE DATA STORAGE

The turtle monitoring data will be replicated to USACE Enterprise database by the Spatial Data Branch once received. The location data and attributes will be hosted through ArcGIS rest services for consumption.

17.4 TURTLE DATA VISUALIZATION/DESSIMINATION

The turtle monitoring given in the table above will be available through the MsCIP web mapping interface. Access restrictions to the data will be determined by the MsCIP program management team.

18 APPENDIX I: BIRD MONITORING DATA (2015)

18.1 BIRD MONITORING ATTRIBUTES (2015)

The MsCIP Data Management Team re-defined the required bird monitoring attributes to document more thoroughly the birds seen on the island and to comply with the required USACE data standard. The table within this section gives the attributes expected to be recorded by any data collector.

Attribute	Data Type	Size/format	Description
birdSpeciesIDPK	Text	20	Primary Key. A unique, user defined identifier for each record or instance of an entity.
birdSpeciesXID	Integer		Unique ID used for indexing and linking purposes.
sdsFeatureName	Text	150	Name of the observed bird species
sdsFeatureDescription	Text	Max	A narrative describing the feature
mediaIDFK	Text	20	Used to link the record to associated multimedia records the reference data such as imagery, video, audio, scanned documents, drawings, and other digital media. See you service implementation guidance for details as to the target of this foreign key.
projectID	Text	Max	A foreign key reference to a project identifier used by an external business system.
sdsID	GUID		A unique identifier for all features and objects in the SDSFIE
sdsMetadataID	Text	80	The foreign key to a metadata record
species	Text	80	Species of the observed bird
location	Text	150	Descriptive location (i.e. West Ship Island)
observationDate	Date		Observation date
observationCount	Double		Number of birds observed
tide	Text	50	Low, mid, or high tide
weather	Text	100	General weather description
temperature	Text	50	General temperature description (i.e. cool)
wind	Text	50	General wind description (i.e. Low, Moderate, High)

habitat	Text	150	General habitat description (i.e. Sand Beach, Lagoon)
side	Text	50	Side of Island (i.e. Gulf Side, Bay Side)
vegetation	Text	50	General vegetation density description (i.e. Sparse)
substrate	Text	50	Substrate (i.e. Mud, Sand)
behavior	Text	200	General Bird behavior (i.e. Walking, Foraging, Roosting)
nests	Double		Number of observed nests
disturbances	Text	250	Activities occurring nearby (i.e. BP Survey, planting…)
speciesRange_Comments	Text	255	Species name when type "Other" is observed
observers	Text	200	First and last name of observer
obsTransportation	Text	50	Transportation being used when observing (i.e. foot, boat,…)
hyperlinks	Text	250	Hyperlinks to pictures taken with GPS at time of data capture or additional documentation
notableCharacteristics	Text	250	Description of any bands on bird if present

TABLE 21 BIRD MONITORING DATA (2015) ATTRIBUTES

18.2 BIRD MONITORING DATA DELIVERY PROCESS

The Data is to be collected using an iPad app that will be discussed with the data collector. Data will be collected in the field using an iPad and synced with a master database once connectivity is regained. All attributes seen in Table 21 will be included in submitted data.

18.3 BIRD MONITORING DATA STORAGE

When a data collector syncs the observation data, the data will be ingested into an interim protected online GIS database. The data will be regularly transferred to the USACE Spatial Data Branch where it will be uploaded into an SDE geodatabase. From there the data will be replicated up to USACE Enterprise database for visualization. The location data and attributes will be hosted through ArcGIS rest services for consumption.

18.4 BIRD MONITORING DATA VISUALIZATION/DESSIMINATION

All bird data including locations and attributes will be available through the password-protected private interface. Locations will be viewable within the web map along with the attributes from that particular data observation. Due to the threatened and endangered nature of the particular bird species being monitored, obfuscated bird data may be available within the public interface giving total number of birds seen during a time range but not bird siting locations.

19 APPENDIX J: DATA INVENTORY

19.1 MONITORING DATA

Data Group	Date	Data Collector	Data Type	Data Format
TES*	2013	Tropical World	Bird	Database
TES	2011-2013	William T. Slack, ERDC Mark S. Peterson, USM - Gulf Coast Research Laboratory	Gulf Sturgeon	Excel
TES	2014 - Mar 2015	William T. Slack, ERDC Mark S. Peterson, USM - Gulf Coast Research Laboratory	Gulf Sturgeon	Excel
BT	June 2010 Sept 2010 Apr-May 2011	Barry A. Vittor & Associates, Inc.	Benthic (also includes sediment and hydrological measurements)	Excel
SAV	Aug - Oct. 2010	Barry A. Vittor & Associates, Inc.	Seagrass (Submerged Aquatic Vegetation)	Shapefile
AI	Jan 2015	USGS	Aerial Imagery	12 inch Stereo Orthoimagery
HC	Dec 2015 (based on aerial data from Jan 2015)	William Jones	Habitat Composition (Habitat Mapping)	Shapefile

TABLE 22 MONITORING DATA INVENTORY

*See Data Groups in Section 4.2 *Data Type Categories*

19.2 BASELINE DATA

Additional datasets besides those being collected under the MAM Plan have been compiled and are listed in the table within this section. These supplementary datasets provide baseline information to be used in conjunction with the proposed monitoring data for analysis purposes. The authoritative sources of these datasets will vary and will be noted when applicable. Depending on the dataset, its source, and its comparative potential regarding project progress, data accessibility may vary. Possible accessibility options include providing a download link to the original source, providing the actual data to be downloaded, and/or including the dataset within visualization tools to aid in project decision-making.

Data Group	Date	Collector	Data Type	Data Format	Data Link	Data Description
SD	2010	USGS	Side scan sonar; Bathymetry	shapefile; tif; txt; pdf	http://pubs.usgs.gov/ds/577/	Archive of Side Scan Sonar and Swath Bathymetry Data Collected During USGS Cruise 10CCT02 Offshore of Petit Bois Island Including Petit Bois Pass, Gulf Islands National Seashore, Mississippi, March 2010
SD	2010	USGS	Side scan sonar; Bathymetry; tracklines	shapefile; tif	http://pubs.usgs.gov/ds/739/Data_downloads_Cat.html	Bathymetry and Acoustic Backscatter Data Collected in 2010 from Cat Island, Mississippi
SD	2010	USGS	Side scan sonar; Bathymetry; tracklines	shapefile; tif; pdf	http://pubs.usgs.gov/ds/724/html/contents.html	Archive of Digital Chirp Subbottom Profile Data Collected During USGS Cruise 10BIM04 Offshore Cat Island, Mississippi, September 2010
SD	2010	USGS	Side scan sonar; Bathymetry; tracklines	shapefile; tif; png	http://pubs.usgs.gov/of/2010/1178/html/GIS_catalog.html	Geophysical Data from offshore of the Gulf Islands National Seashore, Cat Island to Western Horn Island, Mississippi
	1950	LSU	Shoreline	shapefile		1950-1957 high water line (HWL) shoreline survey of the Mississippi Gulf Coast. Data were digitized from NOS U.S. Coast and Geodectic T-Sheets by Louisiana State University. These shorelines represent reliable positions for use in analyzing rates of change and documenting

					the location of the shoreline.
1966	LSU	Shoreline	shapefile		1966 high water line (HWL) shoreline survey of the Mississippi Gulf Coast. Data were digitized from NOS U.S. Coast and Geodectic T-Sheets by Louisiana State University. These shorelines represent reliable positions for use in analyzing rates of change and documenting the location of the shoreline.
2002	MDEQ	Shoreline	shapefile		This data set was created by conflating multiple data sources onto the most up to date high water shoreline. The data can be used as an inventory of recent shoreline conditions.
2006	MARIS	Wells	shapefile		Oil and Gas Wells. Created by the MS Oil and Gas Board. The data are not survey products and not intended for legal use.
2007	USACE	Model Stations	shapefile		These points represent the "save points" or "output stations" for predicted storm surge or water levels from the Advanced CIRCulation (ADCIRC) model. The surge information is being used in the HEC-FDA modeling for the MsCIP.
2007	USACE	Boreholes	shapefile		To locate and display borehole locations in Mississippi.
2006	MARIS	Contours	shapefile		Mississippi 1:24,000 USGS topographic hypsography contours. Contour intervals are 5, 10 or 20 feet depending on the area of the state. Supplemental contours (where applicable) are 5 or 10 feet.
1850	USGS	Shoreline	shapefile		Historical shoreline change is considered to be a crucial element in studying the vulnerability of the national shoreline. These data are used in a shoreline change analysis for the USGS National Assessment Project.
1917	USGS	Shoreline	shapefile		Historical shoreline change is considered to be a crucial element in studying the vulnerability of the national shoreline. These data are used in a shoreline change analysis for the USGS National Assessment Project.
1986	USGS	Shoreline	shapefile		Historical shoreline change is considered to be a crucial element in studying the vulnerability of the national shoreline. These data are used in a shoreline change analysis for the USGS National

					Assessment Project.
2005	FEMA	Contours, Surge	shapefile		The Hurricane Katrina surge inundation contour shapefile represents the extent of land inundation by coastal storm surge as calculated by spatial analysis of collected high water marks.
2005	USACE	Track	shapefile		To display the Hurricane Katrina Track. This track was developed to help track damages from the hurricane.
1992	USGS	Seagrass	shapefile		This data set consists of digital data describing the submerged aquatic vegetation (seagrass) beds in the Pensacola Bay of Florida in 1992. The data set includes 12 7.5' quadrangles, which were digitized at the Mid-Continent Ecological Science Center from 1:24,000 scale hard copy maps developed by the U. S. Geological Survey, National Wetlands Research Center. The seagrass beds were classified according to a U. S. Geological Survey, National Wetlands search Center derived classification scheme based on the C-CAP Coastal Land Cover Classification system of NOAA Coastwatch Change Analysis Project.
1994	US Dept of Agriculture	NRCS General Soil Map	shapefile		This data set consists of general soil association units. It was developed by the National Cooperative Soil Survey and supersedes the State Soil Geographic (STATSGO). It consists of a broad based inventory of soils and nonsoil areas that occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped.
	US Dept of Agriculture	SSURGO Detailed Soil Survey	shapefile		SSURGO depicts information about the kinds and distribution of soils on the landscape. The soil map and data used in the SSURGO product were prepared by soil scientists as part of the National Cooperative Soil Survey.
	US Fish and Wildlife	National Wetlands Inventory	shapefile		This data set represents the extent, approximate location and type of wetlands and deepwater habitats in the conterminous United States.
		Pisces Species Pop	shapefile		Display, location, and analysis of pisces species population areas.

		Area			
2005	USACE	PMH Innundation Surge	shapefile		A data set used to display the maximum possible surge height from any storm along the Mississippi coast.
		Reptilian Species Population Area	shapefile		Display, location, and analysis of reptilian species population areas.
2007	USACE	Risk Zones	shapefile		This shapefile represents the Union of 5 return periods surge limits for a 1 in 25, 1 in 50, 1 in 100, 1 in 500, and 1 in 1000 annual chance surge surface limits. These show annual chance event surge-only inundation surface limits for coastal Mississippi.
		Gulf Sturgeon Critical Habitat	shapefile		This data represents the critical habitat for Gulf Sturgeon as designated by Federal Register Vol. 68, No. 53, Wednesday, March 19, 2003, Rules and Regulations.
1988	USGS	Habitats	shapefile		This data set consists of digital data describing wetland and upland habitats in the coastal Mobile Bay and nearby Gulf Coast areas of Alabama.
	NOAA	Aves Species Population Area	shapefile		Birds are divided into several species subgroups based on behavior and taxonomy. The species table lists all the birds included on the maps, sorted by subgroup. These species were included either because of their likelihood of impact by an oil spill or special protection status as threatened or endangered.
1917	Mississippi Office of Geology	Petit Bois Island USGS T-Map 1917	imagery		These maps are the earliest reliable indicators of shoreline position and shoreline type.
1917	Mississippi Office of Geology	Horn Island USGS T-Map 1917	imagery		These maps are the earliest reliable indicators of shoreline position and shoreline type.

	1917	Mississippi Office of Geology	Cat Island & Ship Island USGS T-Map 1917	imagery	These maps are the earliest reliable indicators of shoreline position and shoreline type.

TABLE 23 BASELINE DATA INVENTORY

20 APPENDIX K: DATA TYPE QUESTIONNAIRE

Whenever a new data type has been received that does not appear within this DMP as an appendix, the data collector for that data will be presented with the following data attribute questions regarding the data that has been or will be collected. The responses to these questions will be used to better understand the data being submitted and assist in creating appropriate data format, submission, and dissemination standards.

General Description of the Data to be Managed?

- Dataset Name
- Data Keywords
- Data Summary Description
- Temporal Extent of Data
- Geographic Extent of Data
- Data Type(s)
- Data Capture/Creation Method
- DMP Storage Location
- Data Volume
- PII or Restricted Info Included?

Points of Contact (Name, Title, Location, Mailing Address, Email Address, Phone)?

- Project Representative(s)
- Overall Project POC
- Responsible Party—Verification of Data Quality
- Responsible Party—Answering Data Collection Questions
- Responsible Party—Data Documentation & Metadata
- Responsible Party—Data Storage & Disaster Recovery
- Implementation/Adherence

Data Stewardship?

- Quality Control Procedures
- Overall Data Lifecycle (Collection-->Customer Availability)

Data Documentation/Metadata?

- Metadata Repository Catalog
- Additional Info (Besides Discovery-Level Metadata)
- Collection/Update Method for Metadata
- Additional Data Catalog

- Data/Metadata Standards

Data Sharing?

- Public Availability
- Date of First Public Availability
- One-Time or Ongoing Data Collection
- Hold/Delay between Data Collection & Publication
- If a Hold/Delay, How Long
- If no Public Availability, Why
- User Access Conditions/Restrictions
- Data Access Protocols Used for Data Sharing
- Registered in What Catalogs to be Discoverable

Initial Data Storage and Protection?

- Where/How Stored Before Storage in Long-Term Archive Facility
- Method of Data Protection from Accidental/Malicious Deletion (Data Backup, Disaster Recovery/Contingency Plan, Off-Site Storage)
- Data Access Limitations, How Protected from Unauthorized Access
- How Permissions Managed
- What Process Followed in Case of Unauthorized Access

Long-Term Archiving and Preservation

- Data Archive Location
- Has this Location been notified
- If no Data Archive Location Identified, what is Long-Term Strategy for Maintaining/Curating/Archiving Data
- Method of Providing/Maintaining Archiving Costs
- Transformations Required to Prepare Data for Archiving/Sharing
- Related Information Submitted to Archive to Enable Future Data Use/Understanding

Hardware/Software Requirements

- Storage Requirements
- Software Requirements
- Products

Appendix F. Conceptual Ecological Model

1.0 INTRODUCTION

1.1 Conceptual Ecological Model Definition

Although the term "conceptual ecological model" (CEM) may be applied to numerous disciplines, CEMs are generally simple, descriptive models, represented by a diagram, that describe general functional relationships among the essential components of an ecosystem. CEMs typically document and summarize current understanding of, and assumptions about, ecosystem function. When applied specifically to ecosystem restoration projects, CEMs also describe how restoration actions propose to alter ecosystem processes or components to improve system health (Fischenich 2008). To describe ecosystem function, a CEM usually diagrams relationships between major anthropogenic and natural stressors, biological indicators, and target ecosystem conditions.

1.2 Purpose and Functions of Conceptual Ecological Models

CEMs can be particularly helpful with the Mississippi Coastal Improvements Program (MsCIP) Comprehensive Barrier Island Restoration by providing assistance with four important tasks: ecosystem simplification; communication; plan formulation; and science, monitoring, and adaptive management.

1.2.1 Ecosystem Simplification

Because natural systems are inherently complex, resource managers must utilize tools that simplify ecosystem relationships and functions within the target ecosystem. An understanding of the target ecosystem is paramount to planning and constructing effective ecosystem restoration projects. During CEM development, known and unknown connections and causalities in ecosystems are identified and delineated (Fischenich 2008).

CEMs can promote ecosystem simplification by:

- Organizing existing scientific information;
- Clarifying system components and interactions;
- Promoting understanding of the ecosystem;
- Diagnosing underlying ecosystem problems;
- Isolating cause and effect relationships; and
- Identifying elements most likely to demonstrate an ecosystem response.

1.2.2 Communication

CEMs are an effective tool for the communication of complex ecosystem processes to a large diverse audience (Fischenich 2008). It is important for project teams understand ecosystem function in order to reliably predict accomplishments to be achieved by restoration projects. CEMs can facilitate effective communication among project team members regarding ecosystem function, processes, and problems, and can assist in reaching consensus within the project team on goals and objectives.

Because CEMs summarize relationships among the important attributes of complex ecosystems, they can serve as the basis for sound scientific debate. Stakeholder groups, agency functions (e.g., planning and operations), and technical disciplines typically relate to system resource use and management independently, but CEMs can be used to link these perspectives.

The process of model development is at least as valuable as the model itself and affords an opportunity to draw fresh insight as well as address unique concerns or characteristics for a given project. Workshops to construct CEMs facilitate brainstorming sessions that explore alternative ways to compress a complex system into a small set of variables and functions. This interactive process of system model construction facilitates communication among project team members and almost always identifies inadequately understood or controversial model components.

CEMs can promote communication by facilitating the following:

- Integrating input from multiple sources and informing groups of the ideas, interactions, and involvement of other groups (Fischenich 2008);
- Assembling project/study managers with the project team and stakeholders to discuss ecosystem condition, problems, and potential solutions;
- Synthesizing current understanding of ecosystem function;
- Developing consensus on a working set of hypotheses that explain habitat changes;
- Developing consensus on indicators that can reflect project specific ecological conditions; and
- Establishing a shared vocabulary among project participants.

1.2.3 Plan Formulation

Formulating a plan for an effective ecosystem restoration project requires an understanding of the following elements:

1. The underlying cause(s) of habitat degradation;
2. The manner in which causal mechanisms influence ecosystem components and dynamics; and
3. The manner in which intervening with a restoration project may reduce the effects of degradation.

These three elements should form the basis of any CEM applied to project formulation (Fischenich 2008).

CEMs can provide valuable assistance to the plan formulation process through the following:

- Supporting decision-making by assembling existing applicable science;
- Assisting with formulation of project goals and objectives, indicators, management strategies, and results;
- Providing a common framework among team members from which to develop alternatives;
- Supplementing numerical models to assess project benefits and impacts; and
- Identifying biological attributes or indicators that should be monitored to best interpret ecosystem conditions, changes, and trends.

1.2.4 Science, Monitoring, and Adaptive Management

By recognizing important physical, chemical, and biological processes in an ecosystem, CEMs identify aspects of the ecosystem that should be measured. Hypotheses about uncertain relationships or interactions between components may be tested and the model may be revised through research and/or an adaptive management process. Indicators for this process may occur at any level of organization, including the landscape, community, population, or genetic levels; and may be compositional (i.e., referring to the variety of elements in a system), structural (i.e., referring to the organization or pattern of the system), or functional (i.e., referring to ecological processes) in nature.

CEMs can be helpful in restoration science, monitoring, and adaptive management through the following:

- Making qualitative predictions of ecosystem response;
- Identifying possible system thresholds that can warn when ecological responses may diverge from the desired effect;
- Outlining further restoration and research and/or development needs;
- Identifying appropriate monitoring indicators and metrics;
- Providing a basis for implementing adaptive management strategies;
- Interpreting and tracking changes in project targets;
- Summarizing the most important ecosystem descriptors, spatial and temporal scales, and current and potential threats to the system;
- Facilitating open discussion and debate about the nature of the system and important management issues;
- Determining indicators for monitoring;
- Interpreting monitoring results and exploring alternative courses of management;
- Establishing institutional memory of the ideas that inspired the management and monitoring plan;
- Forecasting and evaluating effects on system integrity, stress, risks, and other changes;
- Identifying knowledge gaps and the prioritization of research;
- Interpreting and monitoring changes in target indicators; and
- Assisting in qualitative predictions and providing a key foundation for the development of benefits metrics, monitoring plans, and performance measures.

1.2.5 Limitations of Conceptual Ecological Models

CEMs cannot identify the most significant natural resources within a target ecosystem or prioritize project objectives. They do not directly contribute to negotiations and trade-offs common to ecosystem restoration projects. CEMs are not "*The truth*", but are simplified depictions of reality. They are not "*Final*", but rather provide a flexible framework that evolves as understanding of the ecosystem increases. CEMs are not "*Comprehensive*" because they focus only upon those components of an ecosystem deemed relevant while ignoring other important (but not immediately germane) elements. CEMs do not, in and of themselves, quantify restoration outcomes, but identify indicators that can be monitored to determine responses within the target ecosystem to restoration outputs.

Good conceptual models effectively communicate which aspects of the ecosystem are essential to the problem, and distinguish those outside the control of the implementing agency. The best conceptual models focus on key ecosystem attributes; are relevant, reliable, and practical for the problem considered; and communicate the message to a wide audience.

1.3 Types of Conceptual Ecological Models

CEMs can be classified according to their composition and presentation format. They can take the form of any combination of narratives, tables, matrices of factors, or box-and-arrow diagrams. The most common types of CEMs are narrative, tabular, matrix, and various forms of schematic representations. A comprehensive discussion of these types of CEMs is provided in Fischenich (2008). Despite the variety in types of CEMs, no single form will be useful in all circumstances (Fischenich 2008). Therefore, it is important to establish specific plan formulation needs to be addressed by the CEM, and develop the CEM accordingly because "[c]onceptual models . . . are most useful when they are adapted to solve specific problems" (Fischenich 2008).

1.3.1 Application of Conceptual Ecological Models to MsCIP Comprehensive Barrier Island Restoration

CEMs have been widely used in other regions of North America when planning large-scale restoration projects including the Louisiana Coastal Area Program and the Everglades Restoration Program (Barnes et al. 2005). The MsCIP Monitoring and Adaptive Management (MAM) Technical Advisory Group (TAG) has decided to utilize the Ogden model (Ogden and Davis 1999). The TAG recognizes that CEM development is likely to be an iterative process, and the CEM developed prior to construction may change during the phased construction or post-construction as data and supporting information are gathered.

1.3.2 Model Components

The CEM structure utilized for the MsCIP Comprehensive Barrier Island Restoration follows the top-down hierarchy using the components established by Ogden and Davis (1999). The schematic organization of the CEM is depicted in Figure 1 and includes the following components:

> *Drivers* - External driving forces that have large-scale influences on natural systems. Drivers may be natural (e.g., eustatic sea level rise) or anthropogenic (e.g., hydrologic alteration).

Stressors - Physical or chemical changes that occur within natural systems that are produced or affected by drivers and are directly responsible for significant changes in biological components, patterns, and relationships in natural systems.

Effects - Biological, physical, and chemical responses within a natural system that are produced or affected by stressors. CEMs propose linkages between one or more stressors and effects and attributes to explain changes that have occurred in ecosystems.

Attributes - Indicators or end points of a frugal subset of all potential elements or components of natural systems representative of overall ecological conditions. Attributes may include populations, species, communities, or chemical processes. Performance measures and restoration objectives are established for each attribute. Post-project status and trends among attributes are measured by a system-wide monitoring and assessment program as a means of determining success of a program in reducing or eliminating adverse effects of stressors.

Performance measures - Specific features of each attribute to be monitored to determine the degree to which an attribute is responding to projects designed to correct adverse effects of stressors (i.e., to determine success of the project).

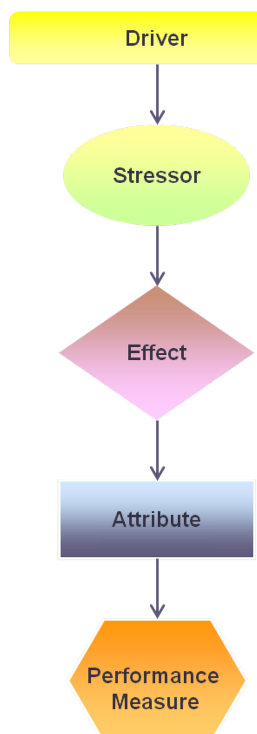

Figure 1. Conceptual Ecological Model Schematic Diagram.

This CEM does not attempt to explain all possible relationships or include all possible factors influencing the performance measure targets within natural systems in the study area. Rather, the model attempts to simplify ecosystem function by containing only information deemed most relevant to ecosystem monitoring goals.

2.0 CONCEPTUAL ECOLOGICAL MODEL DEVELOPMENT

2.1 Methodology

A CEM was developed for the MsCIP Comprehensive Barrier Island Restoration by members of the TAG through an interactive and iterative review process with technical experts and stakeholders. Prior to CEM development, existing information on the Mississippi barrier island ecosystem was assembled to identify and discuss causal hypotheses that best explain both natural and key anthropogenically-driven alterations in the study area. The CEM was then developed using this information while framed by the four project objectives listed below. A list of appropriate stressors and consequent effects in the study area ecosystem was discussed. Additionally, a series of attributes was identified that exhibited characteristics ideally suited to serve as key indicators of project success through measurement and analysis of assessment performance measures associated with these attributes. The project team used this information to develop an initial draft of the model and to prepare a supporting narrative document to explain the organization of the model and science supporting the hypotheses. Additional information about the components of this CEM is presented below.

2.2 Project Background

In 2005, Congress authorized the development of the Mississippi Coastal Improvement Plan (MsCIP) by the Mobile District, U.S. Army Corps of Engineers (USACE), in conjunction with other Federal and State agencies. The MsCIP goals were to support the long-term recovery of coastal Mississippi from the devastation caused by Hurricane Katrina and other Gulf of Mexico hurricanes in 2005, evaluate past navigational dredging activities that have altered sediment transport along the islands, and develop restoration projects and property acquisition strategies to make the coast more resilient against damage from future storms (USACE 2009).

As part of the MsCIP Comprehensive Plan, the Mississippi barrier island system was evaluated with the overall goal of restoring the natural ability of the system to reduce the impact of hurricanes traversing the Mississippi Gulf coast on mainland and Sound ecosystems (Figure 2). The Mobile District proposed restoration of the sediment transport system and augmentation of the sediment budget to preserve and protect the Mississippi barrier islands and in turn the Mississippi Sound and the Mississippi mainland.

2.2.1 Project Goals and Objectives

The overarching goal of barrier island restoration for MsCIP is environmental sustainability. This includes sustaining estuarine habitat in Mississippi Sound by restoring barrier island habitat and augmenting sediment availability to the natural sediment transport system of central and east Ship Island.

The objectives for barrier island restoration for MsCIP are to:

- Maintain the estuarine ecosystem and resources of the Mississippi Sound.
- Preserve the natural and cultural resources of the Mississippi barrier islands.
- Restore the barrier islands structure to reduce storm damage impacts on the mainland coast of Mississippi.
- Enhance the long-term littoral drift system for the Mississippi barrier islands.

2.2.2 Project Description

The restoration plan fulfills the goals identified in the MsCIP Programmatic Environmental Impact Statement (PEIS) for restoration of the Mississippi barrier islands as a first line of defense against storm impacts to estuarine and mainland ecosystems, resulting in a more resilient coast. This plan includes:

- Restoration of Ship Island, including sand placement in Camille Cut and along the Gulf boundary of East Ship Island;
- Sand placement along the Gulf-facing shoreline of Cat Island; and
- Management of maintenance dredging material from the Horn Island Pass segment of the Pascagoula Ship Channel.

The restoration of Ship Island work will be conducted in five phases:

1. The first phase consists of constructing an initial berm across Camille Cut. The sand for Phase 1 is approximately seven million cubic yards (mcy). The work is expected to take approximately one year to complete.
2. The second phase consists of restoring the southern shoreline of East Ship Island. It is estimated that approximately 6 mcy of sand will be required to complete this phase. Work is estimated to begin approximately six months after the commencement of Phase 1 and is expected to take approximately 16 months to complete.
3. The third phase consists of additional placement of approximately 8 mcy of sand in Camille Cut. Work under Phase 3 is expected to begin immediately upon completion of Phase 1 and is estimated to take approximately one year to complete.
4. The fourth phase is expected to commence after completion of Phase 3 and consists of placement of approximately one mcy of sand in the void left in the central portion of the Camille Cut berm. The work is estimated to take approximately three months to complete. Due to its finer grain size, material from the Ship Island borrow area will be used as a cap on the Camille Cut fill section to facilitate establishment of beach vegetation.
5. The fifth and final phase consists of planting the Camille Cut restoration berm with native dune vegetation. This work is expected to begin upon completion of Phase 4 and is estimated to take approximately one year to complete.

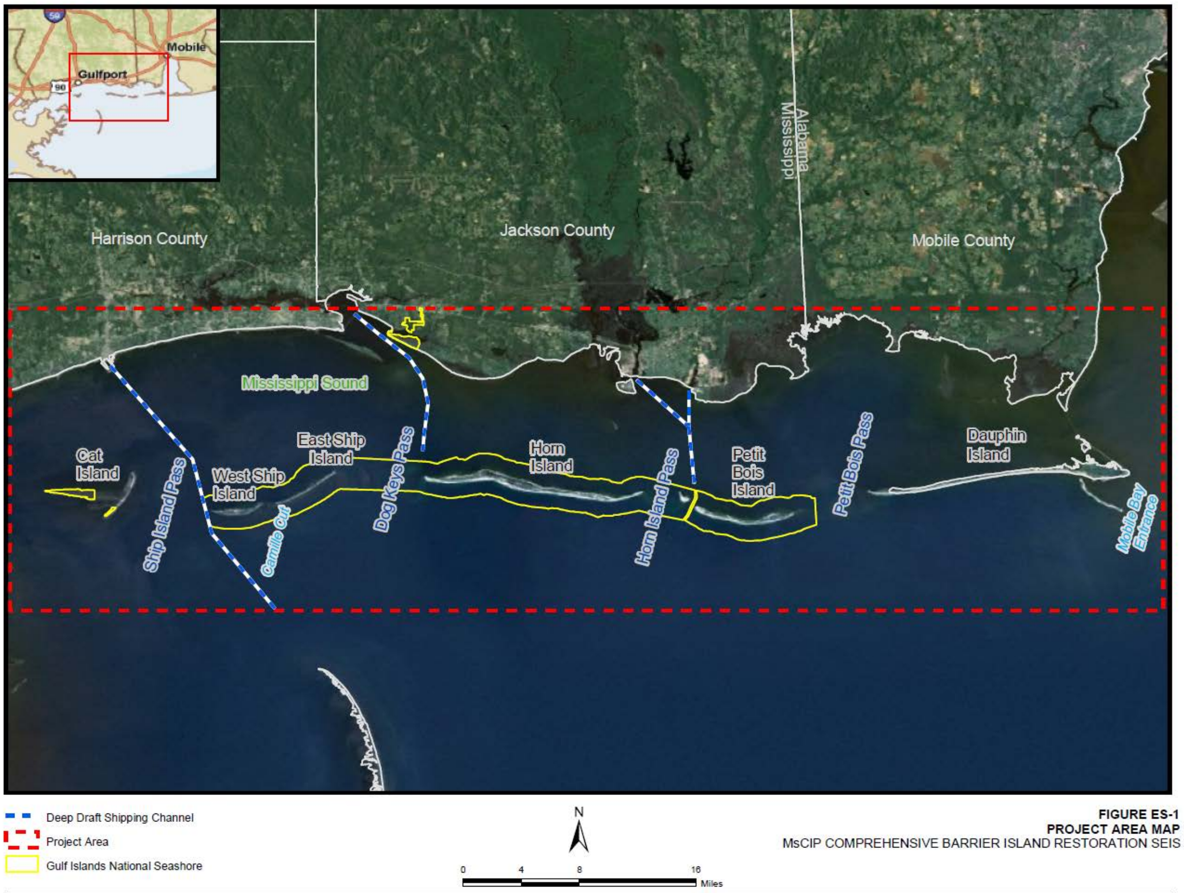

Figure 2. MsCIP Comprehensive Barrier Island Restoration Project Study Area

3.0 CONCEPTUAL ECOLOGICAL MODEL DISCUSSION

The CEM developed for the MsCIP Comprehensive Barrier Island Restoration Project is presented in Figure 3. Model components are identified and discussed in the following subsections, and references for additional information are noted. In some cases, information is incorporated from related section of the PEIS.

3.1 Drivers

The Mississippi barrier islands form the first line of defense for protecting coastal Mississippi from the direct effects of winds, waves, and storms. The barrier islands serve multiple purposes to: (1) reduce coastal flooding during periods of storm surge; (2) reduce wave intensity on mainland shorelines, which would accelerate rates of erosion and degradation of marshes and other wetlands; and (3) help maintain gradients between saline and freshwater, thereby preserving estuarine conditions in Mississippi Sound.

The major external driving forces that have large-scale influences on the Mississippi barrier islands are coastal processes, acute events and, anthropogenic activities. The continuous sand platform that underlies the Mississippi barrier islands was delivered primarily by erosion of ebb-

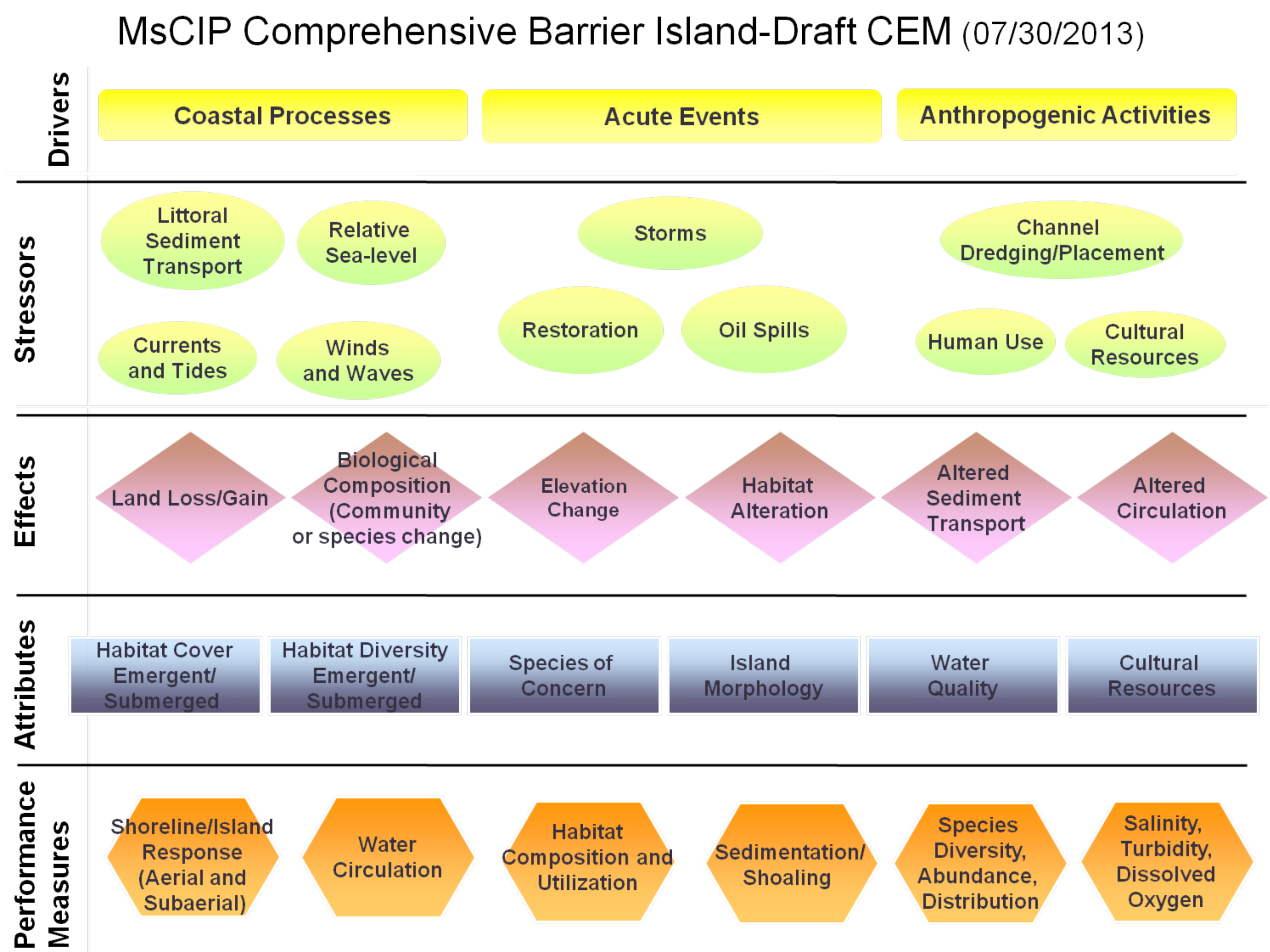

Figure 3. Conceptual ecological model for the Mississippi Coastal Improvements Program, Comprehensive Barrier Island Restoration Project.

delta shoals at the entrance of Mobile Bay, continental shelf sediments, and reworking within the sandy platform (Otvos 1979). Maintaining the morphology and integrity of the Mississippi barrier islands is related to sediment availability and transport and the physical processes operating on the coast of Mississippi. Primary coastal processes influencing the shape of the Mississippi barrier islands include currents and tides, winds and waves, and relative sea-level rise. These natural coastal processes are greatly affected by acute events such as storms, including both tropical (summer) and extratropical (winter) storms, oil spills, and restoration activities. Anthropogenic activities such as navigational channel dredging and placement can also affect the westward migration of barrier islands (Byrnes et al. 1991; Byrnes et al. 2010; Byrnes et al. 2012; Morton 2008). These drivers can affect cultural resources of national importance that exist on the islands and human uses that can affect biological community composition and integrity.

3.2 Stressors

3.2.1 Littoral Sediment Transport

Littoral sediments are transported in the nearshore zone by longshore currents. This process is a result of breaking and shoaling waves suspending sand from the bottom and the displacement of the sediment down-drift by the longshore current. The magnitude of the longshore current intensifies with increasing wave height and breaker angle, and the rate of transport is a function of barrier orientation, offshore shelf slope, local depth, normal wave and current conditions, and storm events. Byrnes et al. (2013) used historical shoreline and bathymetric survey data to construct net littoral sand transport pathways for the MS barrier islands and found an east to west sand flux of about 305,000 m^3/yr. Study results illustrated that ebb shoals at the entrances and west ends of the islands were net depositional (sediment sinks) and the east ends of the islands were net erosional (sediment sources). Ship Island, located at the end of the littoral transport system, and farthest from original sand sources, is most susceptible to erosion.

3.2.2 Relative Sea-level Rise

Relative sea-level rise (RSLR) consists of eustatic sea-level rise combined with subsidence. Eustatic sea-level rise is defined as the global increase in oceanic water levels primarily due to changes in the volume of major ice caps and glaciers, and expansion or contraction of seawater in response to temperature changes. Analysis of historical data suggests a relative sea-level rise of approximately 2 to 3 mm yr^{-1} along the Mississippi coast during the 20th century (Morton 2008).

Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century and possibly beyond, which will cause a continued or accelerated rise in global mean sea level. Based on the historical rate of sea-level rise taken from the NOAA tide station located at Dauphin Island, Alabama of approximately 3 mm/yr, sea level over the next 50 years is projected to rise approximately 0.12 m from present day. Accounting for potential accelerated rise in global mean sea level in the future, it is projected that sea level over the next 50 years could increase as much as 0.24 and 0.61 m based on the 1987 National Research Council's (NRC) low and high curves modified with the IPCC current estimate of historic global mean sea level change rate.

Barrier islands are among the most vulnerable areas to the consequences of climate change. In most cases, rising sea levels result in landward movement of the high-water shoreline, potentially causing the islands to migrate slowly inland, provided sufficient sediment supply is available and the rate of sea-level rise is such that the islands can keep pace. Losses could be accelerated due to a combination of other environmental and oceanographic changes such as an increase in the frequency of storms and/or changes in prevailing currents, both of which could lead to increased beach loss via erosion. This could translate into continued loss of valuable habitat along the Mississippi barrier islands, including sea turtle nesting habitat, shorebird foraging and roosting areas, dune habitat supporting various flora and fauna, and general island ecosystem functions. The MsCIP barriers island restoration seeks to minimize the impacts of RSLR and island land losses by placement of sand in the most crucial areas of the system.

3.2.3 Currents and Tides

Hydrologic characteristics of Mississippi Sound are strongly influenced by wind-driven currents in combination with tidal influences of the Gulf of Mexico. Tides within the Sound are diurnal, with an average range of up to approximately 0.6 m. The tides are strongly influenced by local bathymetry, local river discharges, and winds (Jarrell 1981). The relatively shallow depth and large area of Mississippi Sound can create strong currents in the tidal passes between the islands, both on flood and ebb tides (Foxworth et al. 1962). This can increase the exchange of water and sediment between the Gulf and Mississippi Sound and contribute to widening tidal inlets.

Normal tides are affected by seasonal weather patterns. During the winter months, prevailing winds are from the north and are associated with frontal systems (USEPA 1986). These frontal storm systems occur approximately weekly and have a substantial effect on Mississippi Sound. The resulting response of coastal waters is an initial increase in tidal amplitudes, which causes waves to break higher on the beach, overwashing low barrier islands. Elevated tides increase the flow of Gulf water into the bays and marsh systems behind the barrier islands. As floodwaters reside and exit the passes with passage of a front, abrupt changes in wind direction from southerly to northerly cause increased wave heights in the bays.

3.2.4 Winds and Waves

Wind can induce circulation in the form of set-up and set-down, seiche, and wind-waves. Similarly, the presence of front-like weather during the winter, and storms during hurricane season, enhances these processes by producing dynamic wind conditions. The speed and direction of winds shift abruptly, creating extreme water level fluctuations that are responsible for a significant amount of the erosion taking place along the Mississippi coast (Chaney and Stone 1996; Cipriani and Stone 2001).

The influence of winds on coastal currents and waves within the Sound and on the Gulf side of the barrier islands is well documented (Morton et al. 2004; Byrnes et al. 2013). Wind-driven waves and associated currents are the primary mechanisms for entraining and transporting nearshore sediments (Morton et al. 2004; Morton 2008; Byrnes et al. 2012). Wave energy is a key factor in sediment re-suspension and promotion of lateral transport through longshore water movements. Prior characterizations of wind conditions in the project area indicate that prevailing nearshore surface winds are from the south from March to July, gradually shifting to more easterly in August and September drive currents toward the west (Cipriani and Stone 2001). During winter months, prevailing winds are from the north and are associated with frontal systems (USEPA 1986). While much of the literature focuses on these east-to-west currents being major factors in influencing barrier island migration westward and to some degree landward, these same factors influence localized current speed and direction conditions on the Sound side of the islands.

3.2.5 Storms

The Gulf Coast region is affected by tropical and extra-tropical storms. These atmospherically driven storm events can directly and indirectly contribute to coastal land loss through a variety of processes: (1) erosion and breaches from increased wave energies; (2) removal and/or scouring of vegetation from storm surges; and (3) storm-induced saltwater intrusion into interior wetlands and Mississippi Sound. These destructive processes can result in the loss and degradation of large areas of coastal habitats in relatively short periods of time (days and weeks versus years). Tropical storms have made landfall along the Mississippi coast (Biloxi to Pascagoula) approximately every 10-12 years (Byrnes et al. 2012). In 2005, Hurricane Katrina devastated coastal Mississippi and impacted the entire barrier island chain, resulting in gulf shoreline erosion, overwash from beach/dune habitats to back-barrier habitats, land loss, and damage to infrastructure.

3.2.6 Restoration

Acute events, such as large-scale barrier island restoration projects, may immediately alter existing conditions and system dynamics of the islands and nearshore waters. The restoration of Mississippi barrier islands through placement of sand resources may alter bathymetry and topography, inundation patterns, sediment availability, littoral sediment transport and other hydrologic and coastal processes, wave and circulation patterns, and water quality regimes. Changes in the described conditions will affect biological resources including changes in habitat composition and utilization on the barrier islands and in Mississippi Sound.

3.2.7 Oil Spills

Impacts of oil spills, as well as the various emergency actions taken to address oil spill impacts (e.g., use of oil dispersants, use of Hesco baskets, rip-rap, sheet piling, and other actions), could impact the study area and USACE water resources projects and studies. Potential impacts may include factors such as changes to existing, future-without, and future-with-project conditions, as well as increased project costs and implementation delays. In the event of an oil spill, the USACE will continue to monitor and closely coordinate with other Federal and state resource agencies and local sponsors to determine how to best address any potential problems associated with an oil spill that may adversely impact project implementation.

3.2.8 Channel Dredging/Placement

Dredging of the Pascagoula and Gulfport Ship Channels facilitates the exchange of water and sediment between Mississippi Sound and the Gulf of Mexico, and can interrupt the westward transport of littoral sand. Maintenance dredging in Horn Island Pass and Ship Island Pass since initial authorization in the late 1800s has increased channel depths from approximately 7 to 9 m to 12 to 15 m (Byrnes et al. 2012). Placement of dredged material adjacent to Horn Island Pass from September 1917 to June 2009 and Ship Island Pass from September 1917 to November 2005 has been estimated at 352,700 cy/year and 265,200 cy/year, respectively (Byrnes et al. 2012).

3.2.9 Human Use

The Mississippi barrier islands are part of the Gulf Islands National Seashore, National Park Service (NPS). They are listed by the NPS as a national watchable wildlife area and include designated wilderness areas that afford a variety of recreational activities and other human uses. Human activities, such as visitor and recreational usage, park management actions, and resource extraction and consumption can stress biological resources and critical habitats, and alter coastal ecological processes.

3.2.10 Cultural Resources

Cultural resources eligible for nomination to the National Register of Historic Places, such as Fort Massachusetts are threatened by active shoreline processes, including erosion, migration and encroachment. The comprehensive barrier island restoration would add a greater land area between these resources and the Gulf waters. This increase in land area, while not totally diminishing the threat of erosion to the resource, will substantially reduce that threat.

3.3 Effects

3.3.1 Land Loss/Gain

For barrier island shorelines, complex interactions between storm events, longshore sediment supply, coastal structures, and inlet dynamics contribute to erosion and migration of beaches and islands. Barrier islands are important elements of the geomorphic framework of the estuary. Barrier islands separate the Gulf from back-barrier estuarine environments helping to maintain salinity gradients important to estuarine species. As islands erode and are breached, marine forces impact interior boundaries of the estuaries, thereby accelerating land loss. Barrier islands also serve as valuable storm buffers protecting communities, industry, and associated infrastructure from storm surge. Marine influences, particularly those associated with tropical storm events, gradually erode and rework the structure of islands until they eventually disappear. Barrier islands serve as natural storm protection buffers and limit erosion of Mississippi coastal wetlands, bays, and estuaries by reducing wave energies at the margins of coastal wetlands.

Large-scale conversion of barrier island habitat to open water can occur during hurricane events when breaches are formed and the island is overwashed exposing underlying soft muddy substrates.

3.3.2 Biological Composition (Community or Species Change)

The Mississippi barrier islands and Mississippi Sound support a diversity of habitats that provide essential services for plants and animals that live within these habitats. The Mississippi barrier islands and the adjacent shallow waters of Mississippi Sound include shallow open waters, tidal mud and sand flats and bars, tidal pools and creeks, inlets, submerged aquatic vegetation, beaches, dunes, marshes, and maritime forests. Diverse assemblages of terrestrial and aquatic species utilize these habitats for resting, foraging, breeding, and nursery habitat. Changes to or loss of these habitats may affect species utilization and may result in changes or shifts in biological communities and species specific abundance and diversity.

3.3.3 Elevation Change

Changes in sediment delivery, circulation, wave dynamics, and overwash regimes have significant effects on the elevation of the Mississippi barrier islands. Coupled with scouring caused by storms and relative sea level rise, the elevation and structural integrity of the barrier islands are negatively affected. Alternatively, restoration can enhance elevations of the barrier island footprint, providing greater stability and resilience to stressors.

3.3.4 Habitat Alteration

Barrier islands are an ever-changing and dynamic landscape that consists of many different habitats including shallow open waters, tidal mud and sand flats and bars, tidal pools and creeks, inlets, submerged aquatic vegetation, beaches, dunes, marshes, and maritime forests. Subaerial and subaqueous vegetated and un-vegetated habitats can be altered gradually in response to sea level rise and changes in littoral sediment transport, or they can be altered substantially in a short period of time due to acute events such as hurricanes and restoration activities that change the geomorphic profile and alter salinity and inundation regimes that are forcing functions in the distribution and diversity of coastal habitats. Alterations in the distribution and diversity of habitats could lead to increases in some critical habitat and decreases in others that would affect changes in biological community composition and utilization by species of concern.

3.3.5 Altered Sediment Transport

A majority of littoral sand supplied to downdrift beaches is derived from longshore transport during storm events (Byrnes et al. 2013). Longshore currents redistribute available sand westward from eroding beaches and headlands to the east, but it can be captured by shore-perpendicular navigation channels, potentially reducing sand transport to downdrift barrier islands. Additionally, properly sited dredged-material placement west of Horn Island Pass could facilitate natural sediment transport pathways to islands west of the channel, thereby emulating littoral sand transport in the absence of a dredged navigation channel. When sand is placed outside the littoral transport system, the natural littoral sediment budget is altered and dredged sand is no longer available to support maintenance of the barrier islands.

3.3.6 Altered Circulation

Kjerfve and Sneed (1984) described tidally based circulation in the eastern portion of the Sound as having a strong clockwise rotation. The western portions of the Sound are characterized by a weaker, counter-clockwise rotation. These circulation patterns may contribute to how the potential effects of barrier island restoration might be distributed within the Sound, depending on proximity of restoration activities to tidal inflow and outflow at passes. Closing of Camille Cut will alter circulation patterns around Ship Island potentially affecting updrift erosion and downdrift deposition associated with westward migration (Byrnes et al. 1991; Otvos 1979). The change in circulation patterns may have some localized effects on water quality and may influence Gulf sturgeon utilization of Ship Island and Dog Keys Passes.

3.4 Attributes and Performance Measures

3.4.1 Emergent/Submerged Habitat Cover and Diversity

Habitat and emergent/submerged land cover have been identified as key indicators of project success with respect to preventing habitat conversion and future land loss. Comparison of pre-project habitat characteristics with post-project habitat characteristics would serve to determine if the current trend in conversion of beach and marsh to open water within the study area has declined.

Shoreline and island response have been identified as assessment performance measures for evaluating habitat changes and extent for the proposed project. Spatial analysis may involve comparative analysis of pre- and post-project aerial or satellite imagery and may utilize thematic mapper analysis to determine relative changes in habitat within the study area.

Habitat composition and utilization also have been identified as potential performance measures for determining the response of habitat cover and diversity to the proposed project. Habitat and vegetation types will respond to changes in conditions (e.g., salinity and elevation) based on individual tolerances, and this change will be reflected in the distribution/abundance of habitat community composition and the species that use them. Changes in all submerged and emergent habitats will be captured.

3.4.2 Species of Concern

Habitat utilization has been identified as a key indicator of project success with respect to maintaining or increasing the availability of habitat for particular species of concern. The species of concern that will be addressed include: piping plover, red knot, Gulf sturgeon, and sea turtles. Criteria for habitats will be identified to reflect the opportunity to rest, forage, and/or breed, which is dependent on many factors.

Species diversity, abundance, and distribution, along with habitat composition and utilization, have been identified as potential performance measures for determining the response of species of concern to the restoration action. Additionally, tracking island elevation and land change response may allow refinement of habitat specific criteria and dependencies.

3.4.3 Island Morphology

Once sand is placed on Ship Island and in the littoral system, island morphology will change. Aerial extent has been identified as a key indicator of project success with respect to addressing barrier island longevity. Comparison of pre- and post-project island extent will serve to determine if current trends in barrier island loss have changed. Subaerial extent also will be tracked to determine changes in sedimentation/shoaling patterns.

Elevation has been identified as a key indicator of project success with respect to reducing or reversing land loss on barrier islands. Topographic and bathymetric surveys will be conducted in conjunction with other barrier island geomorphic profiles to (1) detect changes in overwash impacts to morphology; (2) document changes in island habitat (e.g., subtidal, intertidal, shoreface, beach, dune, forest, upland); and (3) relate changes in features to particular events or chronic changes.

3.4.4 Water Quality

Surface water quality in the study area has been identified as a key indicator of project success with respect to reducing hydrologic connectivity through Camille Cut and the interior estuarine ecosystem. Comparison of pre- and post-project water quality will serve to determine if there are any changes in salinity, turbidity, and dissolved oxygen within the study area, and whether water quality is maintained over time.

Evaluating flow and circulation patterns in the study area has been identified as a key indicator of project success with respect to reducing hydrologic connectivity between the Gulf of Mexico and the back-barrier bays and interior marshes. Comparison of pre- and post-project hydrography will be used to determine if closure of Camille Cut and restoration of Ship Island have reduced the duration of flooding and the tidal prism.

3.4.5 Cultural Resources

Erosion of Ship Island is leading to increased risk to cultural resources sites. Restoration of barrier island form and structure is expected to provide beneficial impacts to reduce threats to these cultural resources. Shoreline/island response, including aerial extent and surveys, will be used to measure project performance in maintaining a land area (buffer zone) around cultural resources.

3.3.6 Summary of Conceptual Model Components

Driver	Stressor	Effect	Level of Confidence That a Relationship Exists	Level of Predict-ability	References for More Information
Coastal Processes	Littoral Sediment Transport	Reduced littoral sediment transport has led to continued erosion of barrier islands.	High	High	Byrnes et al. 2012

Driver	Stressor	Effect	Level of Confidence That a Relationship Exists	Level of Predict-ability	References for More Information
Coastal Processes	Relative Sea-level Rise	Changes in inundation frequency and duration and wave dynamics associated with relative sea level rise affects the geomorphology of the island (erosion and accretion) and the habitats they can support.	High	Medium	Rosati and Stone 2009; Morton 2008; McBride et al. 1995
Coastal Processes	Currents and Tides	Altered sediment transport, circulation patterns, and water quality effects	High	Medium	See PDSIES Appendix D
Coastal Processes	Winds and Waves	Altered sediment transport due to changes in wind & wave dynamics affects sediment transport and deposition patterns.	High	Medium	Morton 2008; Otvos and Carter 2008; see PDSIES Appendix D
Acute Events	Storms	A change in storm regime affects acute erosion (loss of sediment due to shoreline change) and lowers elevation resulting in loss of total sediment volume, changes in overwash, inlet formation, dune morphology and affects supported habitats.	High	Low	Morton 2008; Otvos and Carter 2008; Shabica et al. 1984

Driver	Stressor	Effect	Level of Confidence That a Relationship Exists	Level of Predict-ability	References for More Information
Acute Events	Restoration	Restoration of barrier island footprints alter bathymetry and topography which influence island morphology, inundation patterns and salinity regimes which results in changes in habitat composition and utilization.	High	Medium	Otvos and Carter 2008
Acute Events	Oil Spills	Pollutant discharge and burial may affect existing and future barrier island and Mississippi Sound resources including sand used for restoration purposes	High	Low	Michel et al. 2013
Anthropogenic Activities	Channel Dredging /Placement	Maintenance of navigation channels affects sediment supply and transport. Placement location affects sediment transport within littoral zone.	High	High	Byrnes et al. 2012; Byrnes et al. 2010; Otvos and Carter 2008
Anthropogenic Activities	Human Use	recreation activities could alter habitat composition, and habitat usage by species of concern	High	Medium	Bonanno et al. 1998
Anthropogenic Activities	Cultural Resources	Maintenance of sand buffer around historic sites.	High	High	See PDSEIS Appendix D

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