



*Joseph H. Vicari, Director
Gary Quinn, Deputy Director
Barbara Jo Crea, Commissioner
Virginia E. Haines, Commissioner
John P. Kelly, Commissioner*

*Tristin J. Collins, Director, Management & Budget
Jennifer L. Bowens, Purchasing Agent*

*County of Ocean
Administration Building
101 Hooper Avenue
Toms River, NJ 08754*

***REQUEST FOR PROPOSALS
ENGINEERING DESIGN SERVICES FOR THE DESIGN AND PERMITTING
OF PAGE'S POINT, CATTUS ISLAND COUNTY PARK LIVING SHORELINE
RESTORATION PROJECT***

***ADVERTISEMENT DATE: March 2, 2023
OPENING: March 30, 2023, 4:00 pm***

REQUEST FOR PROPOSALS

The Ocean County Board of Commissioners is requesting proposals for the services of a firm licensed in the State of New Jersey to provide services for Engineering Design Services for the Design and Permitting of Page's Point, Cattus Island County Park Living Shoreline Restoration Project.

The Request for Proposal (RFP) is available on the [County's OpenGov Electronic Bid Portal \(https://procurement.opengov.com/portal/oceancounty/\)](https://procurement.opengov.com/portal/oceancounty/) or by contacting the Purchasing Department at (732) 929-2101.

All proposals must be received prior to 4:00 pm, prevailing time on Thursday, March 30, 2023.

The County will not be responsible for late submissions and no proposals will be accepted after the time stipulated on this notice.

By order of the Board of Commissioners of the County of Ocean.

Signed:

JOSEPH H. VICARI, Director

JENNIFER L. BOWENS, Purchasing Agent

INTRODUCTION TO PROPOSERS

Summary

The Ocean County Board of Commissioners is requesting proposals for the services of a firm licensed in the State of New Jersey to provide services for **Engineering Design Services for the Design and Permitting of Page's Point, Cattus Island County Park Living Shoreline Restoration Project.**

Contact Information

For further information regarding these specifications, contact

Jennifer Bowens

Purchasing Agent

Email: ocpurchasing@co.ocean.nj.us

Phone: [\(732\) 929-2101](tel:(732)929-2101)

Department:

Planning

Timeline

Advertising Date	March 2, 2023
Pre-Bid Meeting (Non-Mandatory)	March 13, 2023, 10:00am Cooper Environmental Center at Cattus Island County Park 1170 Cattus Island Boulevard Toms River, NJ 08753
Question Submission Deadline	March 14, 2023, 12:00pm
RFP Receipt Date	March 30, 2023, 4:00pm Administration Building, 101 Hooper Ave., Room 119, Toms River, NJ, 08753

INSTRUCTIONS TO PROPOSERS

INTRODUCTION

The County of Ocean is a County of Fifth Class as defined in N.J.S.A. 40A:6-1 et seq. Pursuant to N.J.S.A. 19:44A-20.4 et seq., the County of Ocean requests proposals from firms capable of providing Engineering Design Services until project completion.

The successful vendor(s) must have a minimum of five (5) years' experience in providing coastal engineering, permitting, and construction administrative services of living shoreline projects and at least two (2) successfully completed living shoreline projects with one (1) of those being in a high energy wave environment.

METHOD OF SUBMISSION

The County of Ocean is accepting **only electronic proposals** for this RFP. Submitting your proposal manually is cause for rejection.

You may only provide one (1) final submission which includes one (1) cost proposal and one (1) technical proposal. ***DO NOT*** submit a hard copy of your electronic submission.

NOTE: In order to access any DocuSign forms in this solicitation, you must first click "Draft Response".

Instructions on how to access the forms through DocuSign are available in the Attachments. Please note that in order to view the forms as a .pdf document, you must access DocuSign first. Once you access DocuSign, the option to download, save, print and complete the forms becomes available

IMPORTANT INSTRUCTIONS FOR ELECTRONIC SUBMITTAL

The County is accepting electronic submissions with ProcureNow by following these instructions:

Sign up for a FREE account at <https://secure.procurenow.com/signup>.

Once you have completed account registration, browse back to this page, [County's OpenGov Electronic Bid Portal \(https://procurement.opengov.com/portal/oceancounty/\)](https://procurement.opengov.com/portal/oceancounty/)

Click on the opportunity of interest, then click "Draft Response".

Follow the instructions to submit the electronic proposal.

It is important to note that this process should be completed well in advance of the proposal deadline / proposal opening. **DO NOT WAIT UNTIL THE LAST MINUTE.** The County's electronic submission system will not allow electronic proposals to be submitted once the deadline has passed, even if you've already started the process. The deadline is based on the countdown timer found on the ProcureNow submission page.

MANDATORY EQUAL EMPLOYMENT OPPORTUNITY

N.J.S.A. 10:5-31 et seq. (P.L. 1975, C. 127)

N.J.A.C. 17:27

GOODS, PROFESSIONAL SERVICE AND GENERAL SERVICE CONTRACTS

During the performance of this contract, the contractor agrees as follows:

The contractor or subcontractor, where applicable, will not discriminate against any employee or applicant for employment because of age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex. Except with respect to affectional or sexual orientation and gender identity or expression, the contractor will ensure that equal employment opportunity is afforded to such applicants in recruitment and employment, and that employees are treated during employment, without regard to their age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex. Such equal employment opportunity shall include, but not be limited to the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Public Agency Compliance Officer setting forth provisions of this nondiscrimination clause.

The contractor or subcontractor, where applicable will, in all solicitations or advertisements for employees placed by or on behalf of the contractor, state that all qualified applicants will receive consideration for employment without regard to age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex.

The contractor or subcontractor will send to each labor union, with which it has a collective bargaining agreement, a notice, to be provided by the agency contracting officer, advising the labor union of the contractor's commitments under this chapter and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

The contractor or subcontractor, where applicable, agrees to comply with any regulations promulgated by the Treasurer pursuant to N.J.S.A. 10:5-31 et seq., as amended and supplemented from time to time and the Americans with Disabilities Act.

The contractor or subcontractor agrees to make good faith efforts to meet targeted county employment goals established in accordance with N.J.A.C. 17:27-5.2.

The contractor or subcontractor agrees to inform in writing its appropriate recruitment agencies including, but not limited to, employment agencies, placement bureaus, colleges, universities, and labor unions, that it does not discriminate on the basis of age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex, and that it will discontinue the use of any recruitment agency which engages in direct or indirect discriminatory practices.

The contractor or subcontractor agrees to revise any of its testing procedures, if necessary, to assure that all personnel testing conforms with the principles of job-related testing, as established by the statutes and court decisions of the State of New Jersey and as established by applicable Federal law and applicable Federal court decisions.

In conforming with the targeted employment goals, the contractor or subcontractor agrees to review all procedures relating to transfer, upgrading, downgrading and layoff to ensure that all such actions are taken without regard to age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex, consistent with the statutes and court decisions of the State of New Jersey, and applicable Federal law and applicable Federal court decisions.

The contractor shall submit to the public agency, after notification of award but prior to execution of a goods and services contract, one of the following three documents:

- Letter of Federal Affirmative Action Plan Approval
- Certificate of Employee Information Report
- Employee Information Report Form AA302 (electronically provided by the Division and distributed to the public agency through the Division's website at www.state.nj.us/treasury/contract_compliance)

The contractor and its subcontractors shall furnish such reports or other documents to the Division of Purchase & Property, CCAU, EEO Monitoring Program as may be requested by the office from time to time in order to carry out the purposes of these regulations, and public agencies shall furnish such information as may be requested by the Division of Purchase & Property, CCAU, EEO Monitoring Program for conducting a compliance investigation pursuant to **Subchapter 10 of the Administrative Code at N.J.A.C. 17:27.**

AMERICANS WITH DISABILITIES ACT

Equal Opportunity For Individuals With Disabilities

The CONTRACTOR and the COUNTY do hereby agree that the provisions of title II of the Americans with Disabilities Act of 1990 (the "Act") (42 U.S.C. 12101 et seq.), which prohibits discrimination on the basis of disability by public entities in all services, programs and activities provided or made available by public entities, and the rules and regulations promulgated pursuant thereto, are made a part of this contract. In providing any aid, benefit, or service on behalf of the COUNTY pursuant to this contract, the CONTRACTOR agrees that the performance shall be in strict compliance with the Act. In the event that the CONTRACTOR, its agents, servants, employees, or subcontractors violate or are alleged to have violated the Act during the performance of this contract, the CONTRACTOR shall defend the COUNTY in any action or administrative proceeding commenced pursuant to this Act. The CONTRACTOR shall indemnify, protect and save harmless the COUNTY, its agents, servants and employees from and against any and all suits, claims, losses, demands, or damages of whatever kind or nature arising out of or claimed to arise out of the alleged violation. The CONTRACTOR shall, at its own expense, appear, defend and pay any and all charges for legal services and any and all costs and other expenses arising from such action or administrative proceeding or incurred in connection therewith. In any and all complaints brought pursuant to the COUNTY'S grievance procedure, the CONTRACTOR agrees to abide by any decision of the COUNTY which is rendered pursuant to said grievance procedure. If any action or administrative proceeding results in an award of damages against the COUNTY or if the COUNTY incurs any expense to cure a violation of the ADA which has been brought pursuant to its grievance procedure, the CONTRACTOR shall satisfy and discharge the same at its own expense.

The COUNTY shall, as soon as practicable after a claim has been made against it, give written notice thereof to the CONTRACTOR along with full and complete particulars of the claim. If any action or administrative proceeding is brought against the COUNTY or any of its agents, servants and employees, the COUNTY shall expeditiously forward or have forwarded to the CONTRACTOR every demand, complaint, notice, summons, pleading, or other process received by the COUNTY or its representatives.

It is expressly agreed and understood that any approval by the COUNTY of the services provided by the CONTRACTOR pursuant to this contract will not relieve the CONTRACTOR of the obligation to comply with the Act and to defend, indemnify, protect and save harmless the COUNTY pursuant to this paragraph.

It is further agreed and understood that the COUNTY assumes no obligation to indemnify or save harmless the CONTRACTOR, its agents, servants, employees and subcontractors for any claim which may arise out of their performance of this Agreement. Furthermore, the CONTRACTOR expressly understands and agrees that the provision of this indemnification clause shall in no way limit the CONTRACTOR'S obligations assumed in this Agreement, nor shall they be construed to relieve the CONTRACTOR from any liability, nor preclude the COUNTY from taking any other actions available to it under any other provisions of this Agreement or otherwise at law.

EVALUATION CRITERIA

No.	Evaluation Criteria	Scoring Method	Weight (Points)
1.	<p>Proposer’s Understanding of the Project</p> <p>1. Has the proposer demonstrated a thorough understanding of the purpose and scope of the project?</p> <p>2. How well has the proposer identified pertinent issues and potential problems related to the project?</p> <p>3. Has the proposer demonstrated that they understand the deliverables the County expects them to provide?</p> <p>4. Has the proposer fully responded to all the questions set forth herein?</p> <p>5. Does the proposal depict a logical approach to fulfilling the requirements of the RFP?</p> <p>6. Has the proposer visited the site?</p>	Points Based	35 <i>(35% of Total)</i>
2.	<p>Experience and Qualifications</p> <p>1. Does the Engineering Firm have a minimum of 5 years’ experience on projects as listed in Qualifications on Page 2?</p> <p>2. Do the Project Manager and key personnel assigned to the project have experience on similar projects?</p> <p>3. Are resumes complete and do they demonstrate backgrounds that would be desirable for individuals engaged in work this project requires?</p> <p>4. How extensive is the applicable education and experience of the personnel designated to work on the project?</p> <p>5. Has the proposer demonstrated experience in completing similar projects?</p> <p>6. How successful is the general history of the proposer regarding timely and successful completion of the projects?</p> <p>7. Has the proposer provided letters of reference from previous clients?</p>	Points Based	25 <i>(25% of Total)</i>
3.	<p>Innovative Living Shoreline Restoration Design</p> <p>1. Has the proposer given specific and detailed examples of previous living shoreline restoration design?</p> <p>2. Has the proposer presented any innovative design ideas specific to the site?</p>	Points Based	25 <i>(25% of Total)</i>

4.	<p>Contractual Conditions</p> <p>1. Has the proposer provided all documents required on the RFP document checklist?</p> <p>2. Has the proposer provided all other documentation required in the RFP?</p> <p>3. Does the proposal follow the Format and Content requirements outlined in the RFP?</p> <p>4. Has the proposer provided a sample Certificate of Insurance evidencing the required types and levels of insurance coverage?</p> <p>5. If the proposer requested any modifications to the Specifications, are they reasonable and acceptable to the County?</p>	Points Based	5 <i>(5% of Total)</i>
5.	<p>Cost</p> <p>Once the list of Proposers has been rated on the above scoring system, the cost proposals for the highest scoring vendors will be evaluated. The lowest cost proposal will receive the maximum number of points allocated to cost. The point allocations for cost on the other proposals will be determined through the method set forth below:</p> <p><u>(lowest cost proposal) x (max points) = points awarded</u> (amount of proposal being rated)</p>	Reward Low Cost	10 <i>(10% of Total)</i>

SCOPE OF WORK

SCOPE OF WORK

Please refer to the PDF under "Attachments - Project Documents" to view the downloadable RFP document and Scope of Work.

VENDOR QUESTIONNAIRE

DOCUMENTS TO BE EXECUTED*

Documents include:

- Signature Page
- Non Collusion Certification
- Affirmative Action Questionnaire
- **Statement of Ownership (N.J.S.A. 52:25-24.2) (Mandatory Document)**
- Prohibited Russia-Belarus Activities & Iran Investment Activities

FAILURE TO SUBMIT ANY OF THESE DOCUMENTS MAY BE CAUSE FOR REJECTION OF YOUR PROPOSAL.

All documents should be from this proposal package as forms change frequently and the most updated forms are provided in this specification. The forms must not be dated or executed prior to the date of advertising.

NOTE: For detailed instructions on how to complete the forms via DocuSign, please access the "Instructions for Completing Forms in DocuSign" document available in the Attachments.

Please note: The County's preferred method of submission is DocuSign.

[Click here to go to the form](#)

*Response required

Certificate of Employee Information Report

Within seven (7) days after receipt of the notification of intent to award the contract or receipt of the contract, whichever is sooner, a Contractor should present one of the following to the County of Ocean:

- (a) An existing federally approved or sanctioned affirmative action program.
- (b) A New Jersey Certificate of Employee Information Report Approval.
- (c) If the Contractor cannot present "a" or "b", the Contractor is required to submit a completed Employee Information Report (Form AA302). This form will be made available to the Contractor by the County of Ocean.**

QUESTIONS BELOW MUST BE ANSWERED BY ALL CONTRACTORS:

1. Do you have a Federally approved or sanctioned Affirmative Action Program?

If yes, please upload a photocopy of such approval.

2. Do you have a State of New Jersey "Certificate of Employee Information Report" approval?

If yes, please upload a photocopy of such certificate.

Please note, the only acceptable file forms are as follows:

Documents (doc, docx, rtf, txt, xls, xlsx, pdf)

Images (jpg, png, bmp, tif)

Copy of New Jersey Business Registration Certificate

A Valid BRC is required Prior to Award of Contract. Please upload your company's BRC.

Use the following link to check the status of your company's BRC:

https://www1.state.nj.us/TYTR_BRC/jsp/BRCLoginJsp.jsp

NOTE: a BRC is not required at the time of submission, only prior to award of the contract.

Please note, the only acceptable file forms are as follows:

Documents (doc, docx, rtf, txt, xls, xlsx, pdf)

Images (jpg, png, bmp, tif)

Mandatory Equal Employment Opportunity Statement*

Does the PROPOSER comply with the [#Mandatory Equal Employment Opportunity Statement?](#)

Yes

No

*Response required

Americans with Disabilities Act Provisions*

Does the PROPOSER comply with the [#Americans with Disabilities Act Provisions?](#)

Yes

No

*Response required

TECHNICAL PROPOSAL *

Please upload your technical proposal for Engineering Design Services for the Design and Permitting of Page's Point, Cattus Island County Park Living Shoreline Restoration Project.

- Technical proposal must include:
- Description of Experience and Qualifications
- Current List of Board of Directors
- Signed Cover Letter
- Organization Chart

Please note, the only acceptable file forms are as follows:

Documents (doc, docx, rtf, txt, xls, xlsx, pdf)

Images (jpg, png, bmp, tif)

*Response required

REFERENCES

Please upload your references for Engineering Design Services for the Design and Permitting of Page's Point, Cattus Island County Park Living Shoreline Restoration Project.

Please note, the only acceptable file forms are as follows:

Documents (doc, docx, rtf, txt, xls, xlsx, pdf)

Images (jpg, png, bmp, tif)

CERTIFICATE OF INSURANCE

Please upload your Certificate of Insurance for Engineering Design Services for the Design and Permitting of Page's Point, Cattus Island County Park Living Shoreline Restoration Project.

Please note, the only acceptable file forms are as follows:

Documents (doc, docx, rtf, txt, xls, xlsx, pdf)

Images (jpg, png, bmp, tif)

COST PROPOSAL*

Please upload your cost proposal for Engineering Design Services for the Design and Permitting of Page's Point, Cattus Island County Park Living Shoreline Restoration Project.

Please note, the only acceptable file forms are as follows:

Documents (doc, docx, rtf, txt, xls, xlsx, pdf)

Images (jpg, png, bmp, tif)

*Response required

ADDITIONAL VENDOR DOCUMENTATION

Please use this area to include additional paperwork you wish to be considered as part of this RFP.

Please note, the only acceptable file forms are as follows:

Documents (doc, docx, rtf, txt, xls, xlsx, pdf)

Images (jpg, png, bmp, tif)

PROPOSAL SUBMISSION ACKNOWLEDGMENT*

The County of Ocean is accepting only electronic proposals for this RFQ. Submitting your proposal manually is cause for rejection. You may only submit one (1) proposal. **DO NOT** submit a hard copy of your proposal. Please confirm that you understand that the method of submission for Labor Consultant Services is electronic **ONLY** and that submitting a proposal manually is automatic cause for rejection.

Please confirm

*Response required

SUBMISSION OF PROPOSAL FORMS*

Proposers shall complete all documents and acknowledge all terms included with this package. All documents should be from this proposal package as forms change frequently and the most updated forms are provided in this specification. The forms must not be dated or executed prior to the date of advertising. Failure to follow these instructions is cause for rejection.

Please confirm

*Response required



*Joseph H. Vicari, Director
Gary Quinn, Deputy Director
Barbara Jo Crea, Commissioner
Virginia E. Haines, Commissioner
John P. Kelly, Commissioner*

*Tristin J. Collins, Director, Management & Budget
Jennifer L. Bowens, Purchasing Agent*

**COUNTY OF OCEAN
ADMINISTRATION BUILDING
101 HOOPER AVENUE
TOMS RIVER, NEW JERSEY 08753**

REQUEST

FOR

PROPOSAL

FOR

**ENGINEERING DESIGN SERVICES FOR THE DESIGN AND PERMITTING
OF
PAGE'S POINT, CATTUS ISLAND COUNTY PARK
LIVING SHORELINE RESTORATION PROJECT**

Prepared by:
Ocean County Department of Planning
129 Hooper Avenue, P.O. Box 2191
Toms River, NJ 08754-2191
(732) 929-2054

INTRODUCTION

The County of Ocean is a County of Fifth Class as defined in N.J.S.A. 40A:6-1 et seq. Pursuant to N.J.S.A. 19:44A-20.4 et seq., the County of Ocean requests proposals from firms capable of providing Engineering Design Services until project completion.

The successful vendor(s) must have a minimum of five (5) years' experience in providing coastal engineering, permitting, and construction administrative services of living shoreline projects and at least two (2) successfully completed living shoreline projects with one (1) of those being in a high energy wave environment.

METHOD OF SUBMISSION

The County of Ocean is accepting **only** electronic proposals for this RFP. Submitting your proposal manually is cause for rejection.

DO NOT submit a hard copy of your electronic submission.

SCHEDULE

A *tentative* schedule has been established for respondent proposals, proposal review, contractor selection and project initiation. The dates established for procurement are:

March 2, 2023	Release of RFP via Ocean County Bid Portal
March 13, 2023	Bidders' Site Visit at 10:00 AM
March 14, 2023	Questions and Clarifications due by 12:00 PM
March 20, 2023	Final Interpretations and Addenda issued
March 30, 2023	Proposal due date
May 3, 2023	Commissioner Board Action to Award Contract
May 17, 2023	Contract Execution and Project Initiation
May 2023	Kick-off Meeting with Successful Consultant

SITE VISIT

A bidder's site visit will be held on March 13, 2023 at 10:00am at:

Cooper Environmental Center at Cattus Island County Park
1170 Cattus Island Boulevard
Toms River, NJ 08753

QUESTIONS AND CLARIFICATIONS

All questions or clarifications regarding this Request for Proposals must be submitted electronically by 12:00pm on March 14, 2023 through the OpenGov website. All responses, addenda, clarifications, or instructions, if issued, will be posted through the OpenGov website and shall be binding.

QUALIFICATIONS

All proposers are required to include the following in their proposals:

1. The Engineering Firm, Project Manager and key personnel shall provide proof of a minimum of 5 years' experience with the engineering, design, and permitting of constructed living shoreline projects, coastal ecological restoration, hydrologic and hydraulic modeling in tidal environments, environmental permitting, and project management. Please provide details of prior shoreline restoration projects, including costs, cost overruns, and deadlines exceeded description of management duties and contact information for property owner. A minimum of five (5) letters of recommendation must accompany all proposals.
2. Provide a list of all key personnel that will be working on this project, including a duty statement and brief resume of each key person, by name and title, including experience in pertinent fields, and hourly rate schedule, along with an organizational chart specific to those personnel assigned to the project.

The County Reserves the right to disqualify proposers based on experiences and/or references. Proposers must be prepared to present the County with suitable evidence of their financial standing upon request.

PROJECT DESCRIPTION

Cattus Island County Park (CICP) is located in Toms River, NJ along Barnegat Bay and Silver Bay, and is a part of the Ocean County Park System. The park preserves a significant portion of the natural ecosystem of the northern part of Barnegat Bay, encompassing 530 acres out of over 1,000 acres of preserved public property in the immediate vicinity. Additional public property includes the Ocean County Natural Lands Trust Fund (OCNLTF) Program's 65-acre Tilton Point preserve adjacent to the park as well as the New Jersey Natural Lands Trust's 251-acre Tilton Creek preserve. CICP is the most significant salt marsh and the largest breakwater in the northern portion of Barnegat Bay.

Cattus Island's shorelines have experienced significant erosion and retreat. Some areas of the park have lost more than 300 feet over the past 85 years. This erosion is likely to increase over time, especially if the northeast peninsula known as "Page's Point" is not stabilized. Page's Point itself serves as a wetland buffer and upland forest breakwater that protects surrounding marshland and areas from tidal flooding and erosion.

Upon receiving a grant from the NJDEP for living shoreline restoration, Ocean County has partnered with experts in coastal engineering from the Stevens Institute of Technology (Stevens). Stevens will be a grant partner throughout the project, from site assessment, conceptual design, monitoring, implementation, and final tasks. Site assessments have been performed to determine the best strategies to mitigate the marine conditions' contribution to the extreme erosion over the entire site. The site evaluations and the resulting recommended strategies have been developed into refined conceptual plans (Attachment 2), which will serve as the basis to develop final design, permitting, and construction plans in phases, based on the grant timeline and availability of funds.

The Cattus Island project site was split into six segments based on shoreline orientation, as shown in the map in Attachment 1, and will be bid separately. This RFP concerns Phase 1: Page's Point (Segment 3), which has been identified as a priority area as noted above.

PROJECT GOAL AND OBJECTIVES

The goal of this project is to protect and restore critical shoreline areas of Cattus Island County Park and to prevent future extreme wetlands loss in the Barnegat Bay.

The project objective is to utilize the conceptual designs prepared by Stevens, which were informed by the detailed site assessments, to develop detailed engineering plans for implementation to:

- Wherever possible, incorporate resilient and sustainable “living shoreline” practices and design elements that mimic natural features and processes that would also preserve the marsh and associated coastal and inland habitat areas on the site.
- Reducing the sediment load and resulting turbidity caused by erosion, thereby improving the water quality of Barnegat Bay.
- Halt the erosion and the resulting loss of habitat.
- Plans will include offshore strategies using attenuating structures, including sills and various designs, beneficial use of dredged materials, and other proven technologies, particularly as detailed in the Living Shorelines Engineering Guidelines document by Stevens.
<https://www.nj.gov/dep/cmp/docs/living-shorelines-engineering-guidelines-final.pdf>.
- Plans shall be developed for long term sustainability and resilience.
- Buffer the Park's recreational resources and marshland from destructive storm surges.
- Post-construction implementation evaluation will inform the next phases of this project.

SCOPE OF WORK

Proposals are being sought for engineering services for the design, permitting and construction plans of a shoreline restoration plan for Page's Point, Cattus Island County Park, Toms River Township, NJ. The Design Phase is a critical element in the successful implementation of this project.

Notes:

1. All supporting studies and/or surveys necessary to obtain all local, county, state, and federal permits which will be necessary to complete the improvements and utilities at the site (i.e. Threatened and Endangered Species Survey, geotechnical/subsurface investigations, Hydro-geologic studies, archeological surveys, topographic survey, etc.) shall be included in the proposal as separate line items.
2. All state and federal permits required; or potentially required; (i.e. stream encroachment, CAFRA, etc.) to complete the improvements at the site shall be included in the proposal as separate line items.
3. The County anticipates awarding the contract for the duration of the project. Ocean County reserves the right to reject any or all proposals.

A. PROJECT TASKS

Task 1: Project Management

Project Administration

1. The Ocean County Departments of Parks and Recreation and Planning will be jointly managing this project.
2. The Ocean County Department of Parks and Recreation will oversee the design process and coordination between the selected Consultant, County, Stevens, and stakeholders.
3. The Ocean County Department of Planning will manage the tasks associated with grant reporting and billing, including the processing of consultant invoices and the preparation and submission of the quarterly reports and any other documentation as required by the NJ Department of Environmental Protection per grant administration.
4. Stevens Institute of Technology (Stevens), specializing in the field of marine engineering and hydrodynamics, is a Project Partner. Stevens has conducted site assessments throughout the project site and has developed conceptual designs for Page's Point, which serve as the basis for the engineering drawings. Stevens will be providing expertise as a resource throughout the duration of the project.
5. Prior to construction, the County will be awarding a separate contract for a Construction Manager to oversee the Construction Phase of the Project. The successful Project Engineer will be required to coordinate with the Construction Manager.

Consultant Project Management Responsibilities

1. Consultant shall designate a Project Manager who will be responsible for managing the day-to-day activities of the consultant team and will serve as the primary point of contact with the County. To ensure continuity, any changes in Project Manager shall require approval by the County.
2. Consultant will be required to conduct biweekly meetings onsite or virtually as determined by the County to provide status updates on the project.
3. Consultant will be required to conduct quarterly, at a minimum, stakeholder progress meetings to update partners over the course of the project, and additional meetings as needed. Meetings may be virtual; however, at least one stakeholder meeting to be held on the project site.
4. Consultant shall also designate a Report Manager who shall be responsible for the preparation and submission of the quarterly progress reports and monthly invoicing.
5. A detailed project schedule (Gantt chart) shall be submitted prior to the kick-off meeting for County review and approval and reviewed regularly during the course of the work to ensure the timely completion of the project.
6. Consultant shall provide cost estimates for the construction of Phase 1, Page's Point. Preliminary cost estimates must also be provided after initial design and final estimates after preparation of final bid documents.

7. The Consultant shall develop an *Adaptive Management/Monitoring Plan* in consultation with Stevens. This will include monitoring at intervals to include before construction, during construction and post construction. Consultant shall establish baseline data and criteria for evaluation of progress. This *Plan* will include actionable steps for implementation if criteria are triggered or exceeded. Post construction evaluation will be explained in detail. More details in Attachment 4.

Deliverables for Task 1: Project Management:

1. *Detailed project schedule (Gantt chart)*
2. *Kick-off meeting*
3. *Biweekly status on-site or virtual meetings*
4. *Quarterly reports per Attachment 3 schedule and any other documentation required by the NJDEP. All reports are to be written within acceptable professional standards as approved by the County.*
5. *Quarterly Stakeholder meetings*
6. *Cost estimates for all phases of construction*
7. *Development of Adaptive Management Plan.*

Task 2: Site Evaluation and Field Surveying

1. Consultant shall review all available data of site conditions, including site assessments, testing, site evaluations and conceptual designs performed by Stevens, Ocean County Parks and other partners.
2. The Consultant shall perform an in-person site inspection to confirm previous assessments as to the current condition of the exposed shoreline at Page's Point and affected adjacent areas.
3. In-person site evaluations shall be performed throughout the work period as necessary for each phase of the project.
4. Assessments, including geotechnical investigations and nearshore test borings, shall be conducted to determine whether the sediments can support proposed breakwaters.
5. Consultant to provide summary review memo of collated site assessments of existing conditions.
6. Consultant shall complete field surveying in accordance with the specifications in Section B: SURVEY REQUIREMENTS AND STANDARDS.

Deliverables for Task 2: Site Evaluation and Field Surveying

1. *Consultant to provide summary memo of collated site assessments of existing conditions.*
2. *Two (2) hardcopies (paper 24" x 36") of existing conditions in accordance with required survey standards as listed in Section B.*
3. *Provide electronic copy in DWG and PDF formats.*

Task 3: Preliminary Design

1. Stevens Institute of Technology has developed conceptual designs, informed by detailed site assessments, attached herein as Attachment 2.
2. The Consultant shall coordinate with Stevens as a resource in the review and incorporation of the conceptual designs and all site assessments to develop preliminary engineering plans. These plans shall be designed to meet the project objectives as listed above, particularly utilizing “living shoreline” and sustainable strategies to remediate and prevent extreme erosion and habitat loss due to the marine conditions.

Deliverables for Task 3: Preliminary Design

1. *Pre-application consultation with NJDEP; federal and local agencies as needed.*
2. *Preliminary Design submission – Two (2) hardcopies (paper 24” x 36”) of proposed concept layout with existing conditions as basemap.*
3. *Provide electronic copy of the above sheets in DWG and PDF formats.*
4. *Feasibility assessment and cost estimate for each alternative design.*
5. *Presentation of preliminary designs at Stakeholder meeting.*

Task 4: Construction Plans and Specifications

1. The Consultant shall prepare final construction design plans developed to a level of detail required to submit application for regulatory approvals from Local, County, State and Federal agencies, as applicable.
2. Plans shall include detailed specifications drawings with clear description of acceptable materials.
3. Written specifications shall be provided by the consultant engineer.

Deliverables for Task 4: Construction Plans and Specifications

1. *All plans and specifications shall be prepared in accordance with the detailed Plan and Specification Requirements and Standards as listed in Section C. PLAN AND SPECIFICATION REQUIREMENTS AND STANDARDS.*
2. *Presentation of final construction plans at Stakeholder meeting.*
3. *Meetings with NJDEP grant managers as needed.*

Task 5: Permitting

1. The Consultant shall identify all federal, state, and local permits needed for this project.
2. The Consultant shall prepare plans, apply for, and obtain the various required permits.
3. Any and all application fees shall be paid for by consultant and reimbursed by the County.

Deliverables for Task 5: Permitting

1. *The Consultant shall prepare plans, apply for, and obtain the various required permits.*

Task 6: Bidding Services

1. Bidding will be completed through Ocean County’s ProcureNow portal.

2. The Consultant shall prepare the bid package documents for construction, perform bid review and participate in the Consultant Selection Review process to make recommendation of award to contractor who would best carry out the plans in accordance with project goals and objectives.
3. The Consultant shall develop a Construction Schedule in consultation with the County and in accordance with the grant schedule. The schedule shall include tentative working days for phases of the implementation, and will be included in the bid package for contractor.
4. The Consultant should be prepared to hold a Pre-Bid meeting on-site for prospective bidders, answer all inquiries, and issue addendums if necessary.

Deliverables for Task 6: Bidding Services for Contractor

1. *The Consultant shall prepare the bid package documents.*
2. *Conduct on-site onsite meeting for prospective bidders.*
3. *Provide expertise and recommendation to award bid.*

Task 7: Construction Support Services

1. Upon completion of the design phase, it will be necessary to continue the services of the design engineer to assist in the review of the shop drawings and other questions that may arise concerning the design for the duration of the project as outlined in the bid. The purpose is to provide continuity from design through implementation and post construction evaluation.
2. The Construction Manager will be the primary point of contact during the construction implementation phase for all requests for information (RFI). The Engineering Consultant shall respond within five (5) working days to all formal written requests for clarification and information (RFI) during the construction phase, particularly in respect to resolving technical questions, plans, drawings, specifications, and agreements, and as related to the *Adaptive Management / Monitoring Plan*.
3. The Consultant shall, in coordination with the Construction Manager, participate in onsite inspections for adherence to plans and specifications at a minimum of weekly while construction is taking place.
4. The Consultant shall submit weekly and final construction status reports.

Deliverables for Task 7: Construction Support Services

1. *Participate in bid process.*
2. *Participate in weekly site inspections during the construction phase to ensure that implementation is being carried out according to the plans and specifications.*
3. *Coordination with Construction Manager.*
4. *Submit weekly and final construction status reports.*

Task 8: Post Construction Evaluation

1. Development of *Adaptive Management Plan* :

- a. The Consultant shall follow post construction evaluation as outlined in the *Adaptive Management Plan*. Participate in the final inspection of the completed construction as needed to ensure that it is functioning as designed.
2. The Consultant shall contribute to the final reporting as needed.

Deliverables for Task 8: Post Construction Evaluation

1. *Participate in final inspections.*
2. *Participate in final reporting as needed.*

B. SURVEY REQUIREMENTS AND STANDARDS:

1. Consultant shall complete field surveying in accordance with the following:
 - a. Establish a Survey Traverse Line with Control Points set at a maximum interval of 500' along the entire length of the project area using GPS observations and conventional survey methods, when necessary. The Traverse Control Points need to be located a sufficient distance away from the shoreline so that they will not be destroyed or disturbed during future construction.
 - b. Reference ties for each Traverse Control Point shall be to a specific point (such as a PK Nail in a Utility Pole or a Cross Cut on a Manhole Rim) on or in a recoverable physical feature near the Control Point. A minimum of three (3) ties shall be provided for each point, and the tie distances must be measured to the nearest one-hundredth of a foot (0.01'). All ties must be field measured and cannot be inverted from located physical features. An approximate distance must be shown from the existing edge of pavement to the Control Point. These ties will be used to recover the Control Points and re-establish them if they are lost or destroyed.
 - c. Recover and locate existing property corners, Right-of-Way Monumentation and other survey control markers, including the PLS identification number or company name at the time of the survey utilizing current Tax Maps and/or County Roadway/right of way plans. All located Property corners, Right of Way Monumentation and other survey control markers must be labeled with stations and offsets, shown to the nearest one-hundredth of a foot (0.01'), relative to the project baseline. Coordinates should also be provided for all Property Corners and Right of Way Monumentation. A tabular format is acceptable for these locations. When preparing the mapping described below, the Lot and Block designations for the properties adjacent to area being surveyed must be labeled.
 - d. Make a third order digital level run or conventional three-wire level run, starting from either an existing Geodetic Monument near the Project or one of the GPS Traverse Points with good Vertical Components, over the entire project limits with benchmarks established at a maximum interval of 500 feet. These Benchmarks need to be positioned sufficiently off the shoreline so that they will not be lost prior to construction of this Project. They should be on solid, permanent objects such as Property Monuments and Corners, Fire Hydrants, Nails in Concrete Structures (Curb or Sidewalk).
 - e. All horizontal and vertical controls shall be NAD83/NAVD88. Vertical controls shall be established by a conventional bench run holding the elevation of the GPS point with the best height differential. All deliverables shall be determined using

ground coordinates with control points shown, on a map signed and sealed by a Professional Land Surveyor along with a minimum of three (3) ties to each control point including bench run elevations. Control point ties must be measured and shown to the nearest one-hundredth of a foot. Measurements cannot be inverted from located physical features.

- f. New Jersey State plane coordinate values must be shown for each traverse point along the survey Baseline along with a benchmark elevation on each point. Bearings and distance between survey traverse points must also be shown.
- g. Obtain all topographic features within the landward area of shoreline improvement. Features shall include but not be limited to: dune and slope; mean high water line; trails, driveways, fences, landscape areas, trees with caliper greater than six (6) inches, utility surface structures; poles; signs; overhead wires; drainage structures including inverts, pipe material and size, etc.
- h. The consultant will contact New Jersey One Call or obtain utility mark up plans from the individual utilities. Surveyor shall locate all underground utilities marked out at the time of survey. Consultant shall obtain rim, grate, sump, and invert elevations as well as pipe size, type, and direction of flow for the entire drainage system within the project limits. Survey costs to locate underground utilities and the drainage system shall be incidental to the other survey work associated with the contract. Locations of other structures such as utility poles, sanitary sewer structures, water valves, hydrants, gas valves, N.J.H.A. manholes, N.J. Bell Telephone manholes, etc., must also be located and shown on the plan.
- i. Sufficient survey data shall be collected at each drainage or utility structure to determine the proposed grade for any structure to be reset. A minimum of 2 shots at each structure is recommended.

C. PLAN AND SPECIFICATION REQUIREMENTS AND STANDARDS:

1. Anticipated plans sheets shall include:
 - a. Title
 - b. Estimate of Quantities
 - c. Standard Legend
 - d. General Notes
 - e. Soil Erosion Notes
 - f. Existing Conditions
 - g. Grading Plan
 - h. Construction
 - i. Cross Sections
 - j. Construction Details
2. One (1) set of paper plans and one (1) set in pdf format shall be included with the 30%, 60%, and 90% submission.
3. Prior to the 100% submission, Ocean County will submit the contract plans, project specifications, and engineers estimate to the NJDEP for their approval. The DEP submission shall consist of one (1) set of signed paper plans and one (1) set in pdf format and the signed Engineers Estimate. Any DEP comments shall be addressed in the final submission.

1. 30% Deliverable

- a. Construction Plans - 5 scale base maps showing existing conditions, topo, existing drainage, utilities, right-of-way, and property line information. Project limits should also be indicated.
- b. Grading Plans - 3 scale details indicating the existing grades and slopes.

2. 60% Deliverable

- a. Title Sheet, Estimate and Distribution of Quantities (EDQ) Sheet with preliminary pay items, Standard Legend, and General Notes Sheets.
- b. Tie Sheet
- c. Construction Plans - include preliminary pay items.
- d. Grading Plans - include proposed Grades and Slopes.

3. 90% Deliverable

- a. Title Sheet, EDQ Sheet with Final pay items, Standard Legend, and General Notes Sheets.
- b. Tie Sheet
- c. Typical Sections
- d. Construction Plans - include Final pay items and quantities.
- e. Grading Plans - include Final layout, grades, slopes, and control.
- f. Preliminary Engineers Estimate.

4. 100% Deliverable

- a. Two (2) set of paper and one (1) set of Mylar final plan sheets signed and sealed.
- b. Final Engineers Estimate signed.
- c. One (1) electronic copy of final signed plans in PDF format
- d. One (1) electronic copy of final plans and base files in Microstation compatible format. The electronic sheets shall have a base unit of U.S. Survey Foot and shall be unscaled.
- e. An ASCII Comma Separated Value (CSV) MS-DOS text file (PDF format) of all the coordinate data. Separate ASCII files must be included for both Grid Coordinate values, and Ground Adjusted Coordinate values.
- f. A complete copy of the electronic data collector file used in gathering the requested information and ASCII text mapping format using the feature/preference and control coding. Alternately, the original file as well as ASCII Comma Separated Value (CSV) MS-DOS text file which has been mapped to use Ocean County features and control coding. An ASCII Comma Separated Value (CSV) MS-DOS text file (PDF format) of the coordinate data containing all data collected field and of the points associated with the individual break lines/alignments collected and/or used in the field.
- g. Copy (PDF format) of Survey Field Notes
- h. If working in Non-Microstation CAD, the Consultant shall provide all line style, font and block resources files.

SELECTION CRITERIA

The Director of the Ocean County Department of Parks and Recreation shall designate a committee to review and rank all responses. The selection criteria to be used in awarding a contract for the services described herein, shall include:

35%	Proposer's Understanding of the Project
25%	Experience and Qualifications
25%	Innovative Living Shoreline Restoration Design
10%	Cost
5%	Contractual Conditions

Proposer's Understanding of the Project: Proposals will be evaluated against the questions set forth below:

1. Has the proposer demonstrated a thorough understanding of the purpose and scope of the project?
2. How well has the proposer identified pertinent issues and potential problems related to the project?
3. Has the proposer demonstrated that they understand the deliverables the County expects them to provide?
4. Has the proposer fully responded to all the questions set forth herein?
5. Does the proposal depict a logical approach to fulfilling the requirements of the RFP?
6. Has the proposer visited the site?

Experience and Qualifications: Proposals will be evaluated against the questions set forth below:

1. Does the Engineering Firm have a minimum of 5 years' experience on projects as listed in Qualifications on Page 2?
2. Do the Project Manager and key personnel assigned to the project have experience on similar projects?
3. Are resumes complete and do they demonstrate backgrounds that would be desirable for individuals engaged in work this project requires?
4. How extensive is the applicable education and experience of the personnel designated to work on the project?
5. Has the proposer demonstrated experience in completing similar projects?
6. How successful is the general history of the proposer regarding timely and successful completion of the projects?
7. Has the proposer provided letters of reference from previous clients?

Innovative Living Shoreline Restoration Design: Proposals will be evaluated against the questions set forth below:

1. Has the proposer given specific and detailed examples of previous living shoreline restoration design?
2. Has the proposer presented any innovative design ideas specific to the site?

Contractual Conditions: Proposals will be evaluated against the questions set forth below:

1. Has the proposer provided all documents required on the RFP document checklist?
2. Has the proposer provided all other documentation required in the RFP?
3. Does the proposal follow the Format and Content requirements outlined in the RFP?
4. Has the proposer provided a sample Certificate of Insurance evidencing the required types and levels of insurance coverage?
5. If the proposer requested any modifications to the Specifications, are they reasonable and acceptable to the County?

Cost: Once the list of Proposers has been rated on the above scoring system, the cost proposals for the highest scoring vendors will be evaluated. The lowest cost proposal will receive the maximum number of points allocated to cost. The point allocations for cost on the other proposals will be determined through the method set forth below:

$$\frac{(\text{lowest cost proposal}) \times (\text{max points})}{(\text{amount of proposal being rated})} = \text{points awarded}$$

COST PROPOSAL

1. Cost proposal must include all direct and indirect costs associated with the performance of this project.
2. Cost proposal shall be broken down by Task as designated in the Scope of Work.
3. Exception/Alternate Proposals: To be considered, proposers must follow the instructions outlined in this document. Any exceptions to the terms, conditions or other requirements in any part of the RFP must be clearly stated in the proposal. Otherwise, the County will consider that all proposals offered are in strict compliance with this RFP and the successful proposer will be responsible for compliance.
4. The contract shall remain in effect for the duration of the project.

PROPOSAL SUBMISSION REQUIREMENTS

All responses to the Request for Proposal (“RFP”):

1. Must be submitted electronically and must be received prior to 4:00PM, prevailing time on the date on which they are to be unsealed.
2. The County will not be responsible for late submissions and no responses to this RFP will be accepted by the County if received after the time stipulated above.
3. A statement acknowledging that the proposer shall comply with all conditions outlined. An Officer of the company empowered to bind the company must sign the proposal.
4. Failure to include required items as listed may cause the proposal to be determined as non-responsive and the proposal may be rejected.

AWARD

The County of Ocean shall award a contract to the vendor or vendors that best meet the needs and interests of Ocean County. The County reserves the right to negotiate the terms and conditions of

a contract with the successful vendor or vendors to obtain the most cost advantageous services for the County.

The County reserves the right to reject any or all proposals in accordance with N.J.S.A. 40A:11-13.2, or to waive any informalities and non-material defects in the proposals and to accept any proposal deemed in the best interest of the County.

It is to be understood by the proposer that their proposal is submitted on the basis of specifications prepared by the County and the fact that any proposer is not familiar with these specifications or conditions will not be accepted as an excuse.

INDEMNITY CLAUSE

The proposer, if awarded a contract, agrees to protect, defend and save harmless the County against any damage for payment for the use of any patented material process, article or device that may enter into the manufacture, construction or form a part of the work covered by either order or contract, and he further agrees to indemnify and save harmless the County from suits or actions of every nature and description brought against it, for, or on account of injuries or damages received or sustained by any party or parties by, or from any of the negligent acts of the contractor, his servants or agents.

INSURANCE REQUIREMENTS

The contractor shall maintain primary insurance to protect against all claims under Worker's Compensation, Comprehensive General Liability and Automobile. Except for Worker's Compensation, all coverage shall apply as primary coverage with respect to any other insurance or self-insurance program afforded to the County. There shall be no endorsement or modification of this coverage to make it excess over other available insurance/coverage; alternatively, if the CGL and umbrella, excess of reinsurance states that it is pro rata, it shall be endorsed to be primary with respect to the County. Primary coverage shall be subject to approval for adequacy of protection as per the following limits:

Worker's Compensation

1. Limits according to Worker's compensation Laws of the State of New Jersey.
2. Contractor's Liability not less than \$100,000.

Comprehensive General Liability

1. Bodily Injury - \$500,000 per person; \$1,000,000 per occurrence.
2. Property Damage - \$1,000,000 per occurrence.

Comprehensive General Liability shall include the following:

3. Coverage for explosion, collapse or underground hazards.
4. Occurrence basis coverage.
5. Broad form property damage coverage.
6. Coverage for personal injury sustained by any person as a result of an offense directly or indirectly related to the employment of such person by the insured.

Comprehensive Automobile Liability shall include the following:

Business auto liability insurance or its equivalent with a minimum limit of \$1,000,000 per accident and including coverage for all of the following:
the following:

- a. Liability arising out of the ownership, maintenance or use of any auto;
- b. Auto non-ownership and hired car coverage.
- c. Contractor's Worker's Compensation, Comprehensive General Liability and Comprehensive Automobile Liability arising out of subcontractor's operations shall be identical as that listed above.

Copies of each insurance certificate shall be furnished to the County with Proposal (when requested).

ADDITIONAL INFORMATION

It is to be understood by the proposer that their proposal is submitted on the basis of specifications prepared by the County and the fact that any proposer is not familiar with these specifications or conditions will not be accepted as an excuse.

Payments will be made upon the approval of vouchers submitted by the successful proposer in accordance with the requirements of the Board of Commissioners and subject to the Board of Commissioners customary procedures. The County will not pay interest or late fees regardless of language provided.

Ocean County Board of Commissioners will make award within sixty (60) days after receipt of proposals.

The County of Ocean is exempt from any State sales tax or Federal excise tax.

“All contractors must comply with the provisions of New Jersey Statute Title 40A:11-18, when applicable.”

PAY TO PLAY REQUIREMENTS

Starting in January 2007, all business entities are advised of their responsibility to file an annual disclosure statement of political contributions with the New Jersey Election Law Enforcement Commission (ELEC) pursuant to N.J.S.A. 19:44A-20.27 if they receive contracts in excess of \$50,000 from public entities in a calendar year. Business entities are responsible for determining if filing is necessary. Additional information on this requirement is available from ELEC at 888-313-3532 or at www.elec.state.nj.us.

CERTIFICATION OF NON-INVOLVEMENT IN PROHIBITED ACTIVITIES IN IRAN

Pursuant to N.J.S.A. 52:32-58, the proposer must certify that neither the proposer, nor one of its parents, subsidiaries, and/or affiliates (as defined in N.J.S.A. 52:32-56(e)(3)), is listed on the Department of the Treasury's List of Persons or Entities Engaging in Prohibited Investment Activities in Iran and that neither is involved in any of the investment activities set forth in N.J.S.A.

52:32-56(f). If the proposer is unable to so certify, the proposer shall provide a detailed and precise description of such activities. Prior to contract award or authorization, the contractor shall provide the Contracting Agency with a completed Certification on Non-Involvement in Prohibited Activities in Iran.

CERTIFICATION OF NON-INVOLVEMENT IN PROHIBITED ACTIVITIES IN RUSSIA OR BELARUS

Pursuant to N.J.S.A. 52:32-60.1, the “person or entity” (as defined in N.J.S.A. 52:32-60.1, et seq) seeking to enter into or renew a contract for the provision of goods or services or the purchase of bonds or other obligations shall certify that it is not “engaging in prohibited activities in Russia or Belarus” (as such term is defined in as defined in N.J.S.A. 52:32-60.1, et seq. If the person or entity is unable to certify, the person or entity shall provide a detailed and precise description of such activities. The N.J.S.A. 52:32-60.1 certification form must be completed prior to contract award and is provided in the specification documents (DocuSign).

Vendors may view the Precluded Entities List Here:

<https://www.nj.gov/treasury/administration/pdf/RussiaBelarusEntityList.pdf>

TRANSITIONAL PERIOD (excluding Professional Contracts)

In the event services are terminated by contract expiration or by voluntary termination by either the Contractor or the County of Ocean, the Contractor shall continue all terms and conditions of said contract for a period not to exceed one month, at the County’s request.

NEW JERSEY BUSINESS REGISTRATION CERTIFICATE

Pursuant to N.J.S.A. 52:32-44, Ocean County (“Contracting Agency”) is prohibited from entering into a contract with an entity unless the bidder/proposer/contractor, and each subcontractor that is required by law to be named in a bid/proposal/contract has a valid Business Registration Certificate on file with the Division of Revenue and Enterprise Services within the Department of the Treasury.

Prior to contract award or authorization, the contractor shall provide the Contracting Agency with its proof of business registration and that of any named subcontractor(s).

Subcontractors named in a bid or other proposal shall provide proof of business registration to the bidder, who in turn, shall provide it to the Contracting Agency prior to the time a contract, purchase order, or other contracting document is awarded or authorized.

During the course of contract performance:

- (1) the contractor shall not enter into a contract with a subcontractor unless the subcontractor first provides the contractor with a valid proof of business registration.
- (2) the contractor shall maintain and submit to the Contracting Agency a list of subcontractors and their addresses that may be updated from time to time.
- (3) the contractor and any subcontractor providing goods or performing services under the contract, and each of their affiliates, shall collect and remit to the Director of the Division of Taxation in the Department of the Treasury, the use tax due pursuant to the Sales and Use Tax Act, (N.J.S.A. 54:32B-1 et seq.) on all sales of tangible personal property delivered into the State. Any questions in this regard can be directed to the Division of

Taxation at (609)292-6400. Form NJ-REG can be filed online at www.state.nj.us/treasury/revenue/busregcert.shtml.

Before final payment is made under the contract, the contractor shall submit to the Contracting Agency a complete and accurate list of all subcontractors used and their addresses.

Pursuant to N.J.S.A. 54:49-4.1, a business organization that fails to provide a copy of a business registration as required, or that provides false business registration information, shall be liable for a penalty of \$25 for each day of violation, not to exceed \$50,000, for each proof of business registration not properly provided under a contract with a contracting agency.

COMPLETION OF DOCUMENTS

Proposer's shall complete all documents and acknowledge all terms included with this proposal package. All documents should be from this proposal package and must not be dated or executed prior to the date of advertising. Failure to follow these instructions is cause for rejection.

EXHIBIT A

MANDATORY EQUAL EMPLOYMENT OPPORTUNITY LANGUAGE N.J.S.A. 10:5-31 et seq. (P.L. 1975, C. 127) N.J.A.C. 17:27

GOODS, PROFESSIONAL SERVICE AND GENERAL SERVICE CONTRACTS

During the performance of this contract, the contractor agrees as follows:

The contractor or subcontractor, where applicable, will not discriminate against any employee or applicant for employment because of age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex. Except with respect to affectional or sexual orientation and gender identity or expression, the contractor will ensure that equal employment opportunity is afforded to such applicants in recruitment and employment, and that employees are treated during employment, without regard to their age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex. Such equal employment opportunity shall include, but not be limited to the following: employment, upgrading, demotion, or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship. The contractor agrees to post in conspicuous places, available to employees and applicants for employment, notices to be provided by the Public Agency Compliance Officer setting forth provisions of this nondiscrimination clause.

The contractor or subcontractor, where applicable will, in all solicitations or advertisements for employees placed by or on behalf of the contractor, state that all qualified applicants will receive consideration for employment without regard to age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex.

The contractor or subcontractor will send to each labor union, with which it has a collective bargaining agreement, a notice, to be provided by the agency contracting officer, advising the labor union of the contractor's commitments under this chapter and shall post copies of the notice in conspicuous places available to employees and applicants for employment.

The contractor or subcontractor, where applicable, agrees to comply with any regulations promulgated by the Treasurer pursuant to N.J.S.A. 10:5-31 et seq., as amended and supplemented from time to time and the Americans with Disabilities Act.

The contractor or subcontractor agrees to make good faith efforts to meet targeted county employment goals established in accordance with N.J.A.C. 17:27-5.2.

The contractor or subcontractor agrees to inform in writing its appropriate recruitment agencies including, but not limited to, employment agencies, placement bureaus, colleges, universities, and labor unions, that it does not discriminate on the basis of age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex, and that it will discontinue the use of any recruitment agency which engages in direct or indirect discriminatory practices.

The contractor or subcontractor agrees to revise any of its testing procedures, if necessary, to assure that all personnel testing conforms with the principles of job-related testing, as established by the statutes and court decisions of the State of New Jersey and as established by applicable Federal law and applicable Federal court decisions.

In conforming with the targeted employment goals, the contractor or subcontractor agrees to review all procedures relating to transfer, upgrading, downgrading and layoff to ensure that all such actions are taken without regard to age, race, creed, color, national origin, ancestry, marital status, affectional or sexual orientation, gender identity or expression, disability, nationality or sex, consistent with the statutes and court decisions of the State of New Jersey, and applicable Federal law and applicable Federal court decisions.

The contractor shall submit to the public agency, after notification of award but prior to execution of a goods and services contract, one of the following three documents:

1. Letter of Federal Affirmative Action Plan Approval
2. Certificate of Employee Information Report
3. Employee Information Report Form AA302 (electronically provided by the Division and distributed to the public agency through the Division's website at www.state.nj.us/treasury/contract_compliance)

The contractor and its subcontractors shall furnish such reports or other documents to the Division of Purchase & Property, CCAU, EEO Monitoring Program as may be requested by the office from time to time in order to carry out the purposes of these regulations, and public agencies shall furnish such information as may be requested by the Division of Purchase & Property, CCAU, EEO Monitoring Program for conducting a compliance investigation pursuant to **Subchapter 10 of the Administrative Code at N.J.A.C. 17:27.**

AMERICANS WITH DISABILITIES ACT

Equal Opportunity for Individuals with Disabilities

The CONTRACTOR and the COUNTY do hereby agree that the provisions of title II of the Americans with Disabilities Act of 1990 (the "Act") (42 U.S.C. 12101 et seq.), which prohibits discrimination on the basis of disability by public entities in all services, programs and activities provided or made available by public entities, and the rules and regulations promulgated pursuant thereto, are made a part of this contract. In providing any aid, benefit, or service on behalf of the COUNTY pursuant to this contract, the CONTRACTOR agrees that the performance shall be in strict compliance with the Act. In the event that the CONTRACTOR, its agents, servants, employees, or subcontractors violate or are alleged to have violated the Act during the performance of this contract, the CONTRACTOR shall defend the COUNTY in any action or administrative proceeding commenced pursuant to this Act. The CONTRACTOR shall indemnify, protect and save harmless the COUNTY, its agents, servants and employees from and against any and all suits, claims, losses, demands, or damages of whatever kind or nature arising out of or claimed to arise out of the alleged violation. The CONTRACTOR shall, at its own expense, appear, defend and pay any and all charges for legal services and any and all costs and other expenses arising from such action or administrative proceeding or incurred in connection therewith. In any and all complaints brought pursuant to the COUNTY'S grievance procedure, the CONTRACTOR agrees to abide by any decision of the COUNTY which is rendered pursuant to said grievance procedure. If any action or administrative proceeding results in an award of damages against the COUNTY or if the COUNTY incurs any expense to cure a violation of the ADA which has been brought pursuant to its grievance procedure, the CONTRACTOR shall satisfy and discharge the same at its own expense.

The COUNTY shall, as soon as practicable after a claim has been made against it, give written notice thereof to the CONTRACTOR along with full and complete particulars of the claim. If any action or administrative proceeding is brought against the COUNTY or any of its agents, servants and employees, the COUNTY shall expeditiously forward or have forwarded to the CONTRACTOR every demand, complaint, notice, summons, pleading, or other process received by the COUNTY or its representatives.

It is expressly agreed and understood that any approval by the COUNTY of the services provided by the CONTRACTOR pursuant to this contract will not relieve the CONTRACTOR of the obligation to comply with the Act and to defend, indemnify, protect and save harmless the COUNTY pursuant to this paragraph.

It is further agreed and understood that the COUNTY assumes no obligation to indemnify or save harmless the CONTRACTOR, its agents, servants, employees and subcontractors for any claim which may arise out of their performance of this Agreement. Furthermore, the CONTRACTOR expressly understands and agrees that the provision of this indemnification clause shall in no way limit the CONTRACTOR'S obligations assumed in this Agreement, nor shall they be construed to relieve the CONTRACTOR from any liability, nor preclude the COUNTY from taking any other actions available to it under any other provisions of this Agreement or otherwise at law.

Shoreline Segments

- Segment 1 – Yellow Bank
- Segment 2 – Pages Point West
- Segment 3 – Pages Point
- Segment 4 – Pages Point East
- Segment 5 – Applegate Cove
- Segment 6 – Shelter Cove North



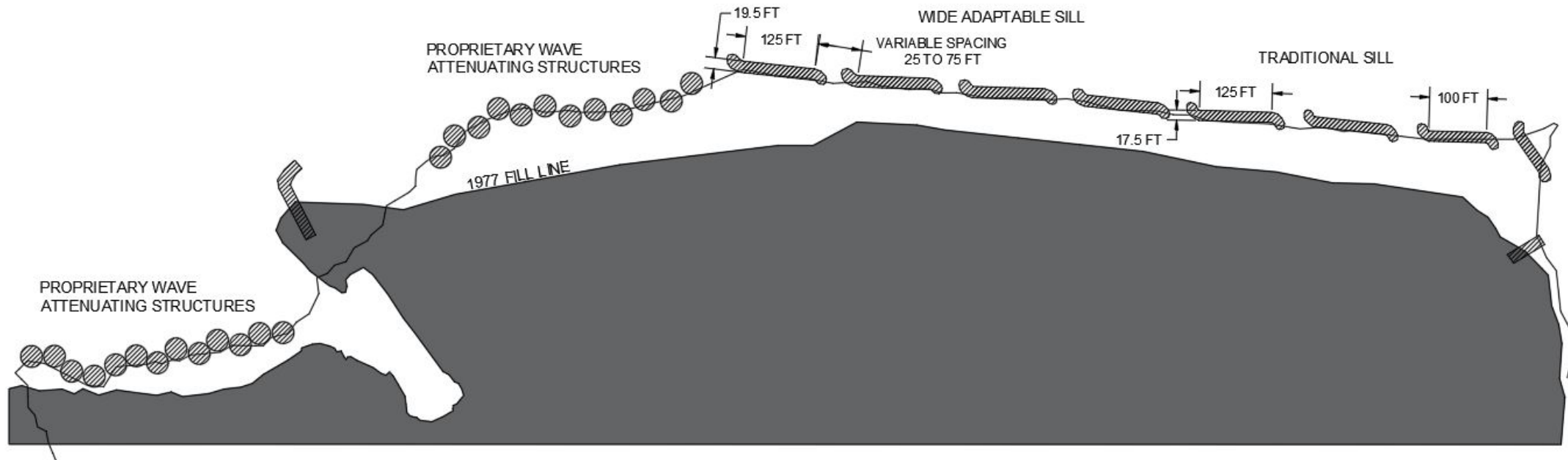
Cattus Island Concept Design



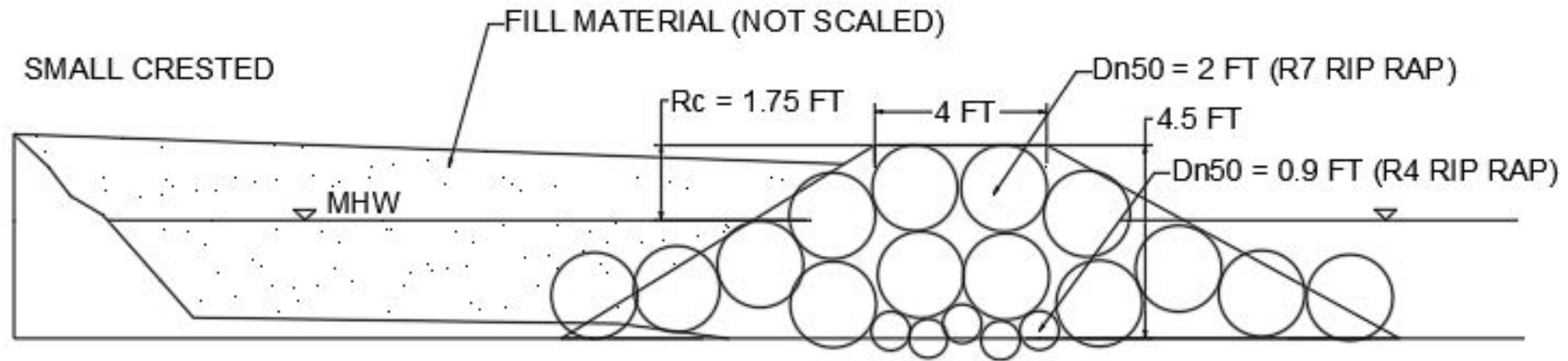
Yellow Bank Concept Design



Yellow Bank Plan View

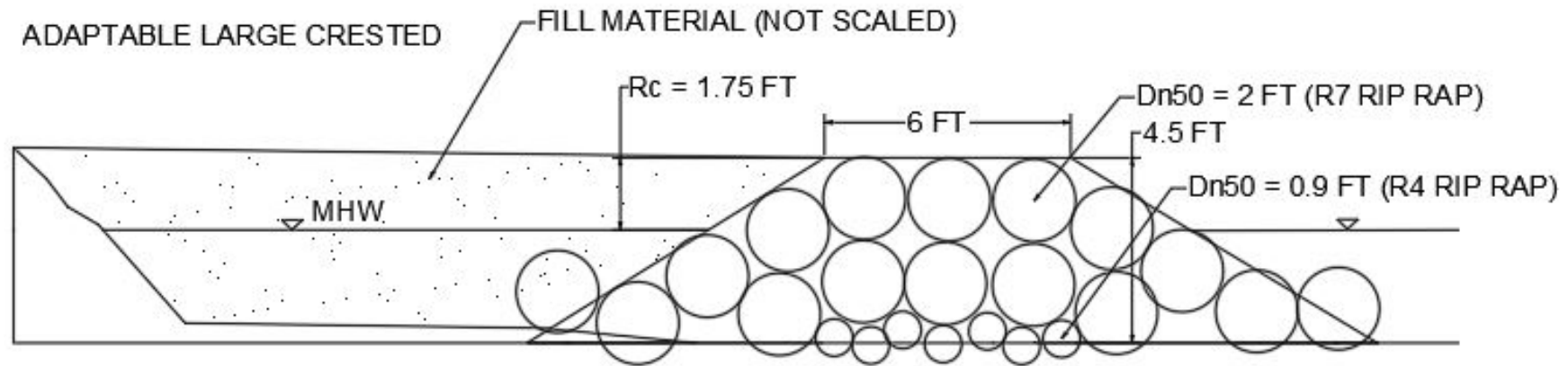


Yellow Bank-Traditional Sill Cross-Section

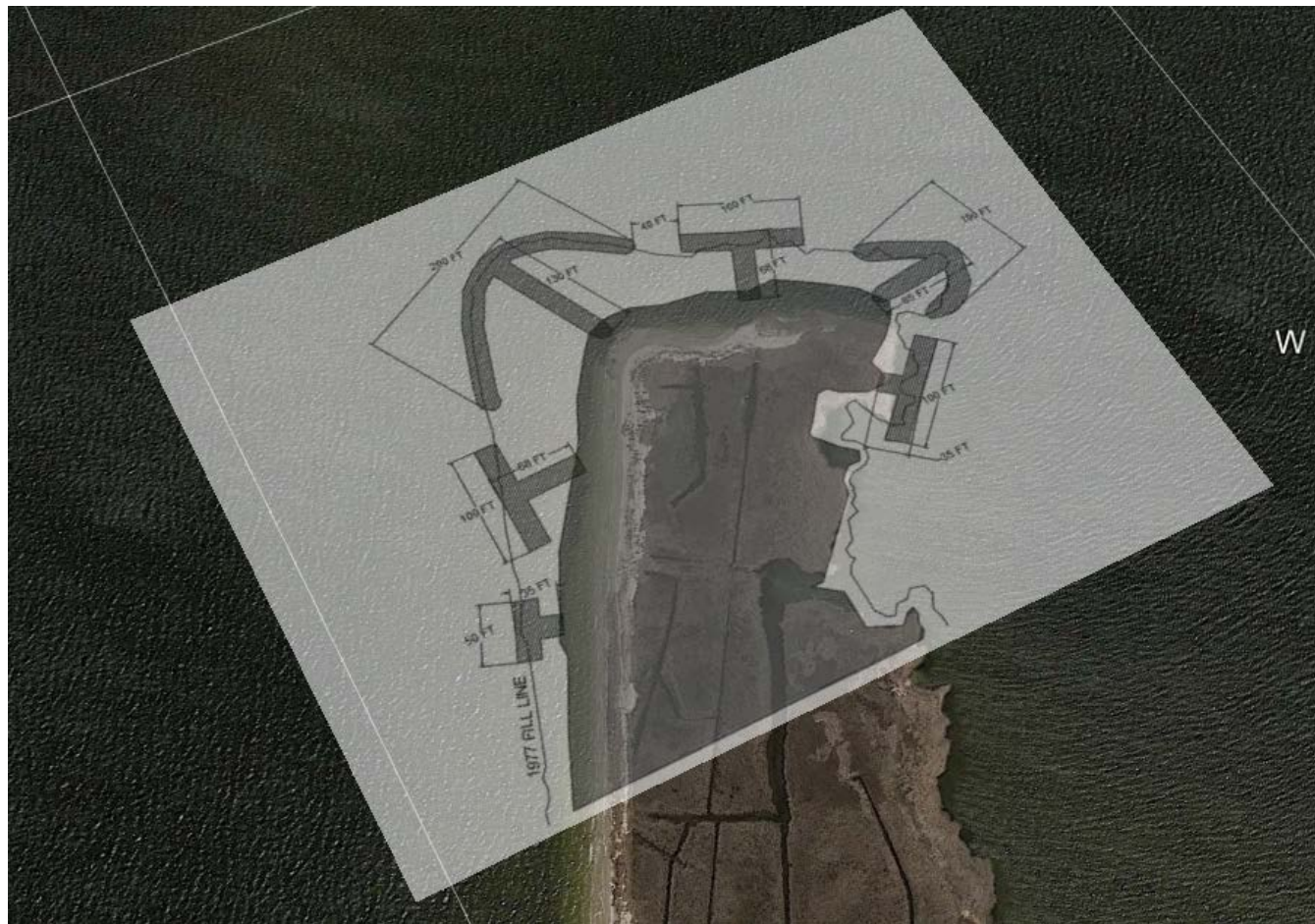




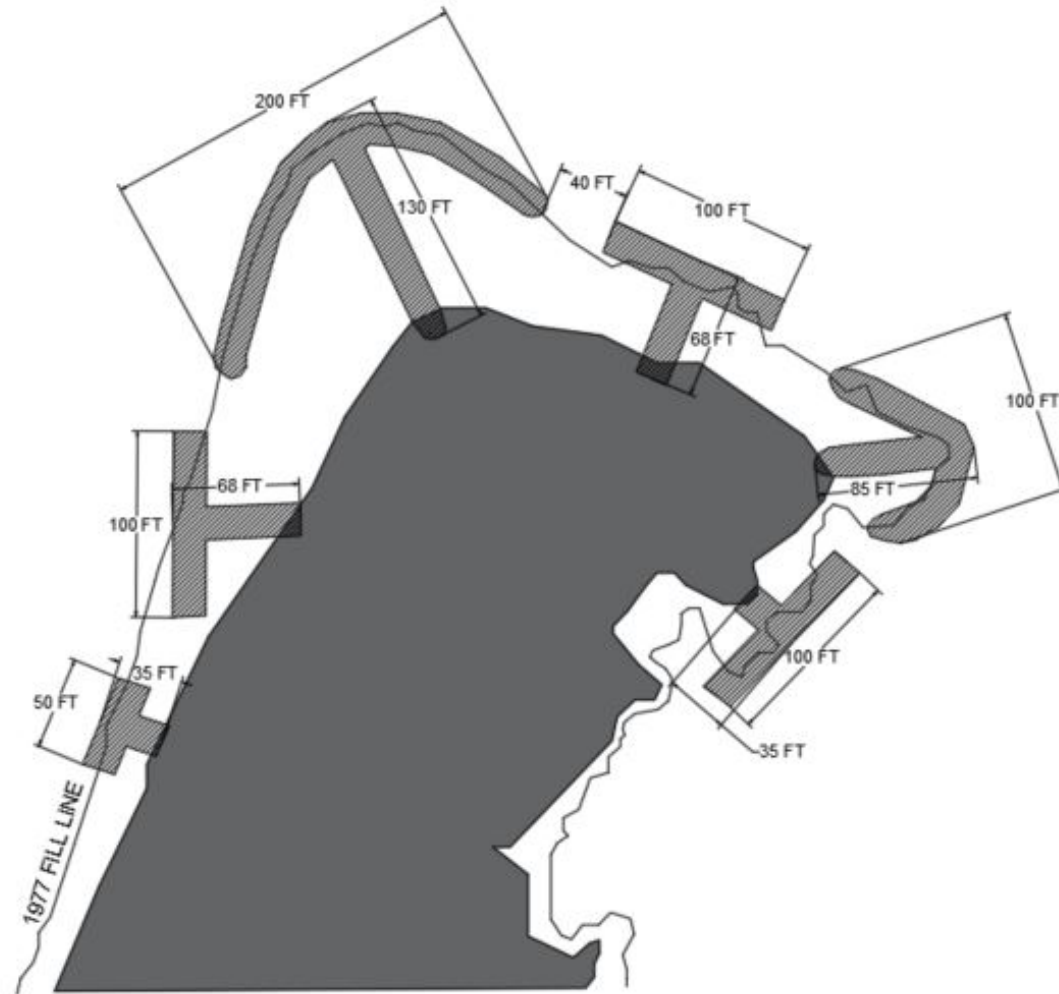
Yellow Bank-Wide Adaptable Sill Cross-Section



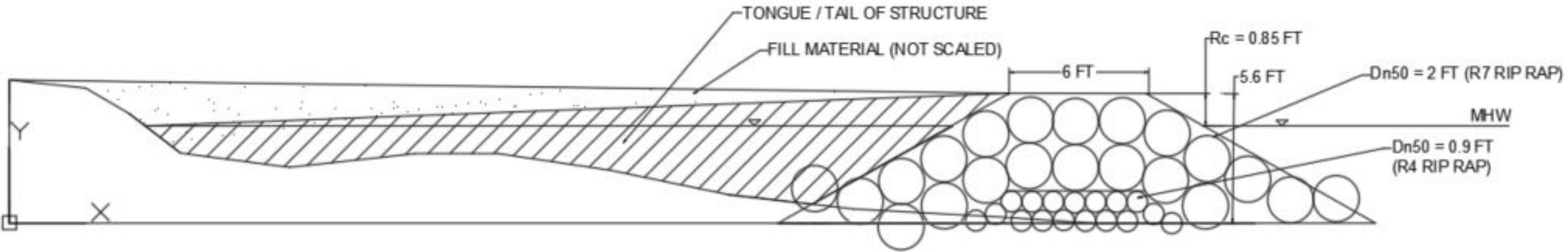
Pages Point Concept Design



Pages Point Plan View



Yellow Bank Whale's Tail Cross-Section





STEVENS
INSTITUTE *of* TECHNOLOGY
THE INNOVATION UNIVERSITY®

Cattus Island Living Shoreline

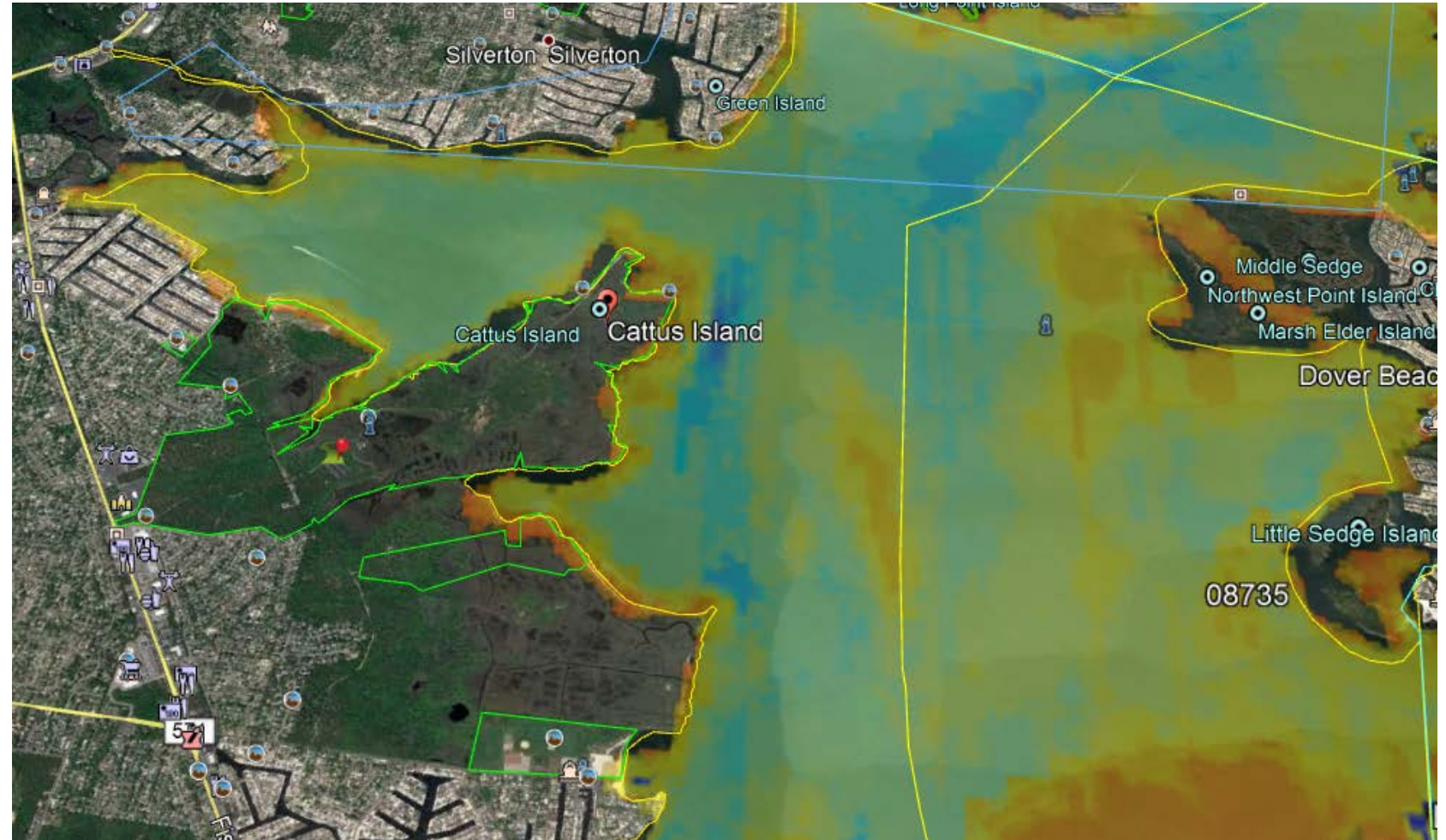
Project Update & Stakeholder Meeting

Jon K. Miller, PhD & Laura Kerr
Stevens Institute of Technology
Coastal Engineering Research Group
jmiller@stevens.edu | lkerr@stevens.edu



Site Overview

- North, south, and east facing shorelines
- Shoreline edge consists of marsh, beach, coastal bluff
- Large fetches in several directions
- Significant boat activity
- Relatively shallow (<6')
- Combination of sand/silt/organic soils
- Upland runoff
- Ditching
- Ice



New Jersey Living Shorelines Engineering Guidelines

- <https://www.nj.gov/dep/cmp/docs/living-shorelines-engineering-guidelines-final.pdf>
- <http://www.stevenscoastal.com/uploads/1/1/7/3/117304558/living-shorelines-engineering-guidelines-final.pdf>



Living Shorelines Engineering Guidelines

Prepared for:

New Jersey Department
of Environmental Protection

Prepared by:

Jon K. Miller, Andrew Rella, Amy Williams, and Erin Sproule

SIT-DL-14-9-2942

February 2015
Revised February 2016





Parameter Evaluation

System Parameters	Value
Erosion History	Varies
Relative Sea Level	0.35 in/yr
Tidal Range	~ 0.5 ft

Hydrodynamic Parameters	Value
Wind Waves	Varies
Wakes	Varies
Currents	n/a
Ice	Varies
Storm Surge	"4-5-7"

Terrestrial Parameters	Value
Upland Slope	Flat
Shoreline Slope	Varies
Width	Varies
Nearshore Slope	Flat
Offshore Depth	Varies<6'
Soil Bearing	???

Ecological Parameters	Value
Water Quality	Varies
Soil Type	Varies
Sunlight Exposure	Full

Additional Concerns

- Tidelands
- SAV



TNC Restoration Explorer

“Level 0” Analysis

Collaboration between:

- American Littoral Society
- Barnegat Bay Partnership
- NOAA Office for Coastal Management
- New Jersey Department of Environmental Protection
- Partnership for the Delaware Estuary
- Rutgers University – Center for Remote Sensing and Spatial Analysis
- Stevens Institute of Technology
- U.S. Geologic Survey

Living Reef Breakwater

Shoreline Change Rate: Yes - 1 feet/year

Tidal Range: Yes - 1.1 feet

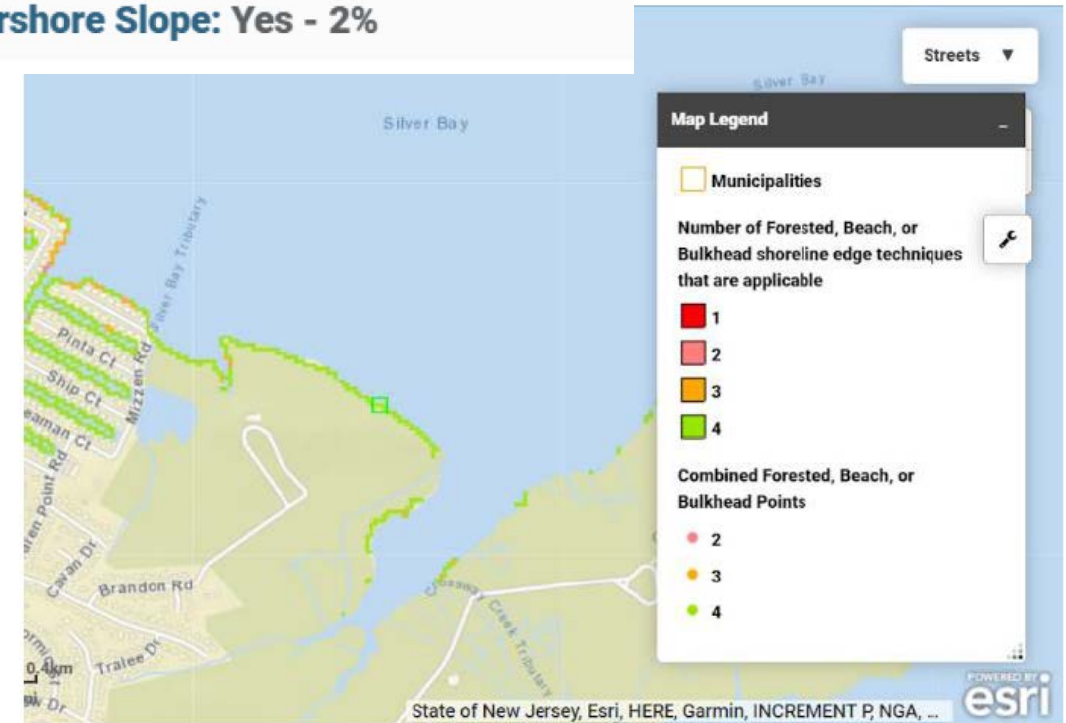
Salinity: Yes - 16.4 ppt

Wave Height: Yes - 1 feet

Ice Cover: No - Higher

Shoreline Slope: Yes - 6%

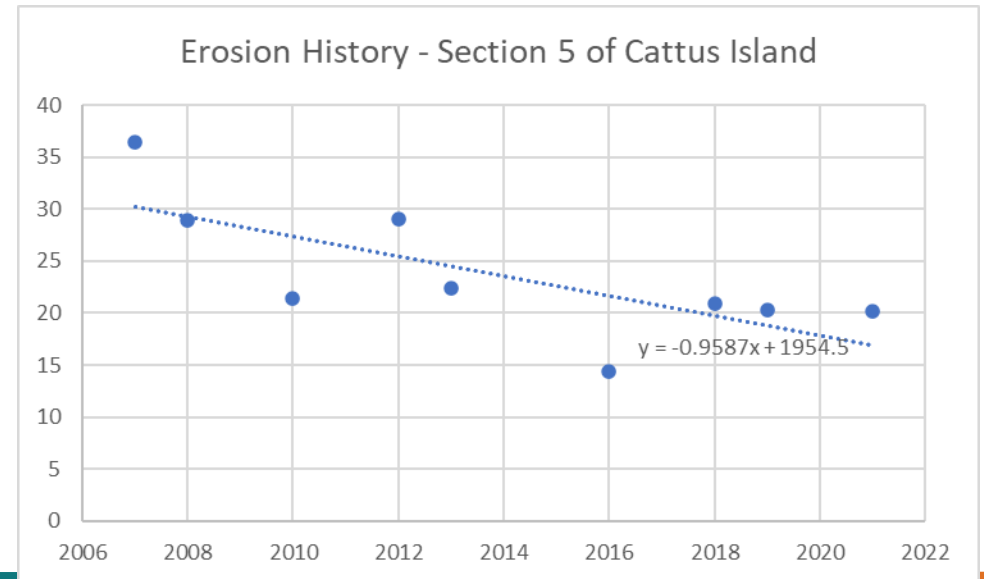
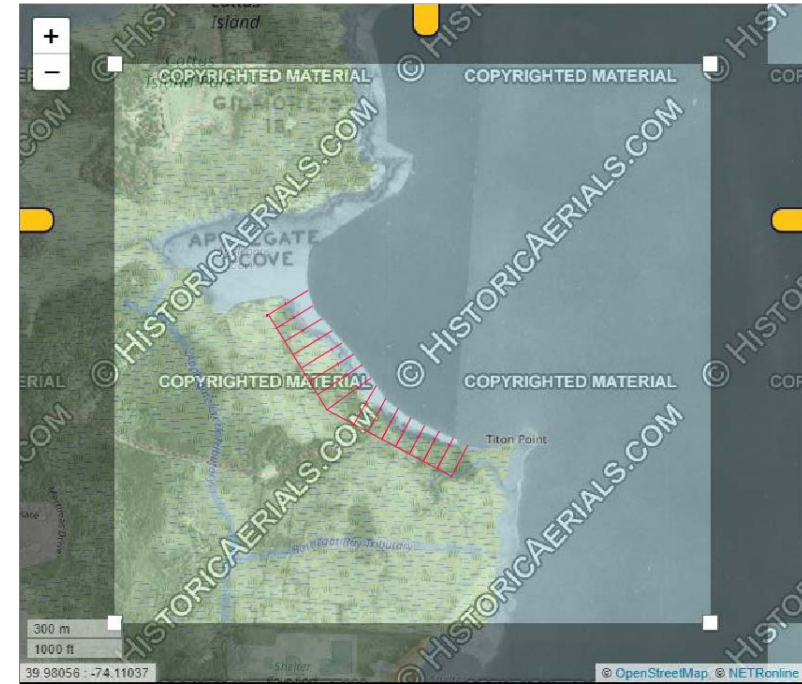
Nearshore Slope: Yes - 2%



<https://coastalresilience.org/project/new-jersey/>

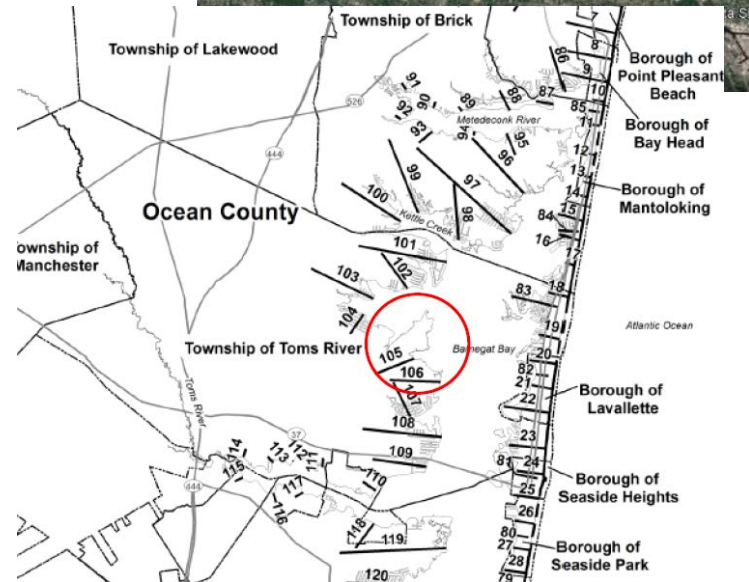
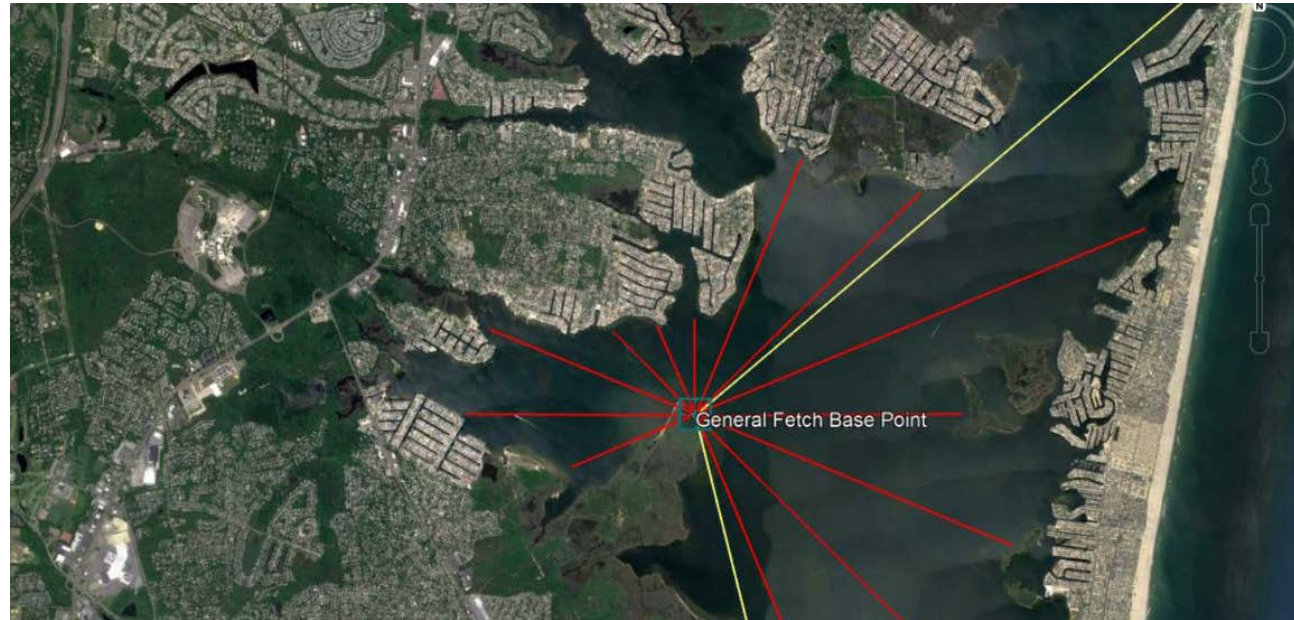
Erosion Rate

- Erosion rate is generally indicative of the magnitude of the erosional forces at the site
- Two general methods used:
 - Restoration Explorer (provides an end point shoreline change rate based on the shoreline location in 1977 and the mid-2010's)
 - Google Earth historical shoreline analysis (linear regression of many data points)



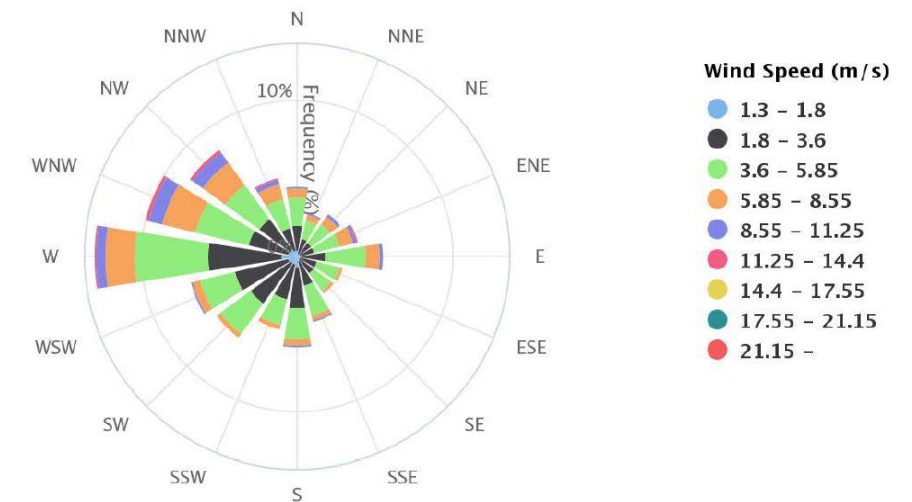
Waves

- Generally the most relevant parameter for shoreline and structure stability
- Several different wave height estimates captured including
 - Restoration Explorer
 - FIS Study (100-yr storm)
 - Fetch based empirical calculation



BELMAR ALLAIRE AP (NJ) Wind Rose

Dec. 1, 1999 - Feb. 21, 2021
Sub-Interval: Jan. 1 - Dec. 31, 0 - 23

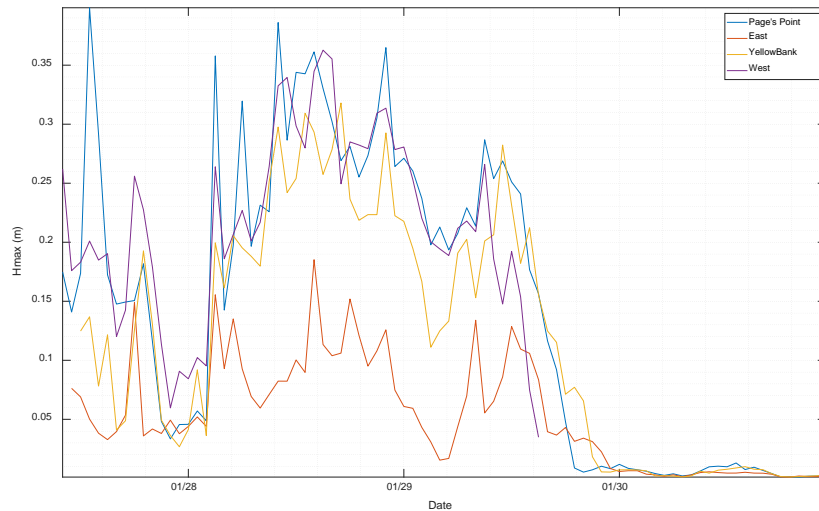


Waves

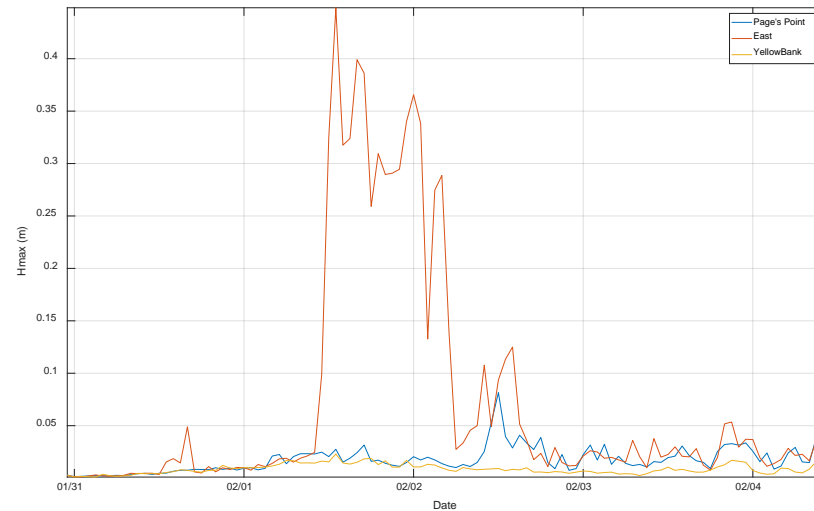
- Waves were measured at 4 locations between January 29th and February 4th, 2021 during two storm events
- Data collected during the first storm (NW) indicate wave heights were < 16”
- 3 of 4 gauges were impacted by ice between storms; however the gauge that remained upright indicated waves were <16” during the 2nd storm (NE)



Maximum Wave Height - Storm 1



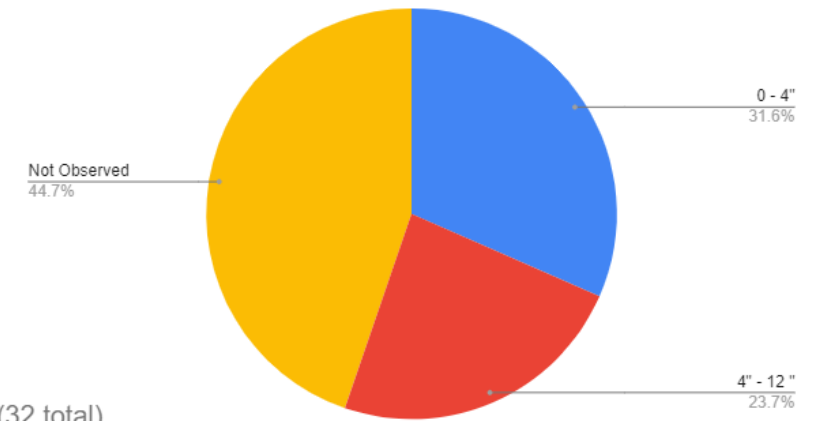
Maximum Wave Height - Storm 2



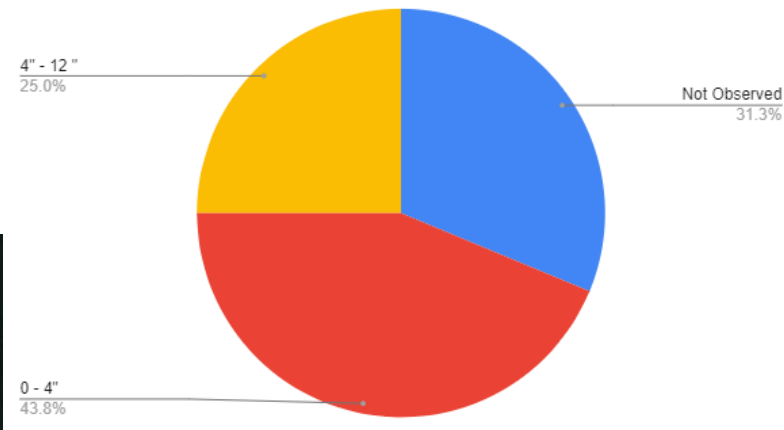
Wakes

- Field study Friday July 16th from 11:30-3:30 PM
- Visual observation + wave staff measurements at 4 locations
- Focused on Yellow Bank/Pages Point
- Gauge data still being processed

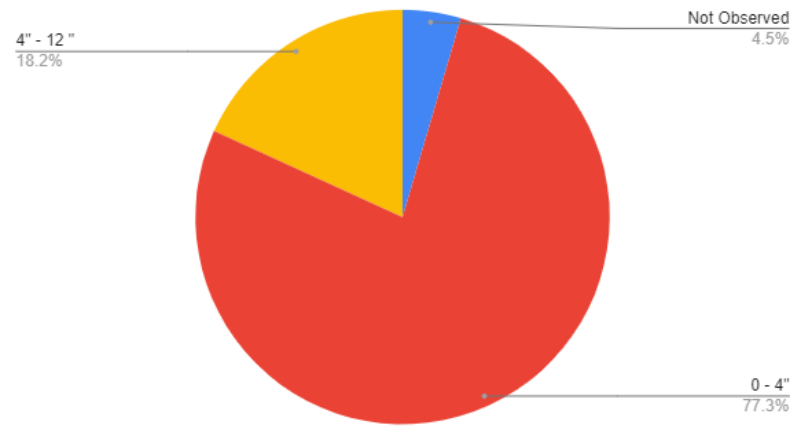
Distribution of Wake Size Pages Pt North (38 Total)



Distribution of Wake Size Pages Pt West (32 total)



Distribution of Wake Size Yellow Bank (22 Total)



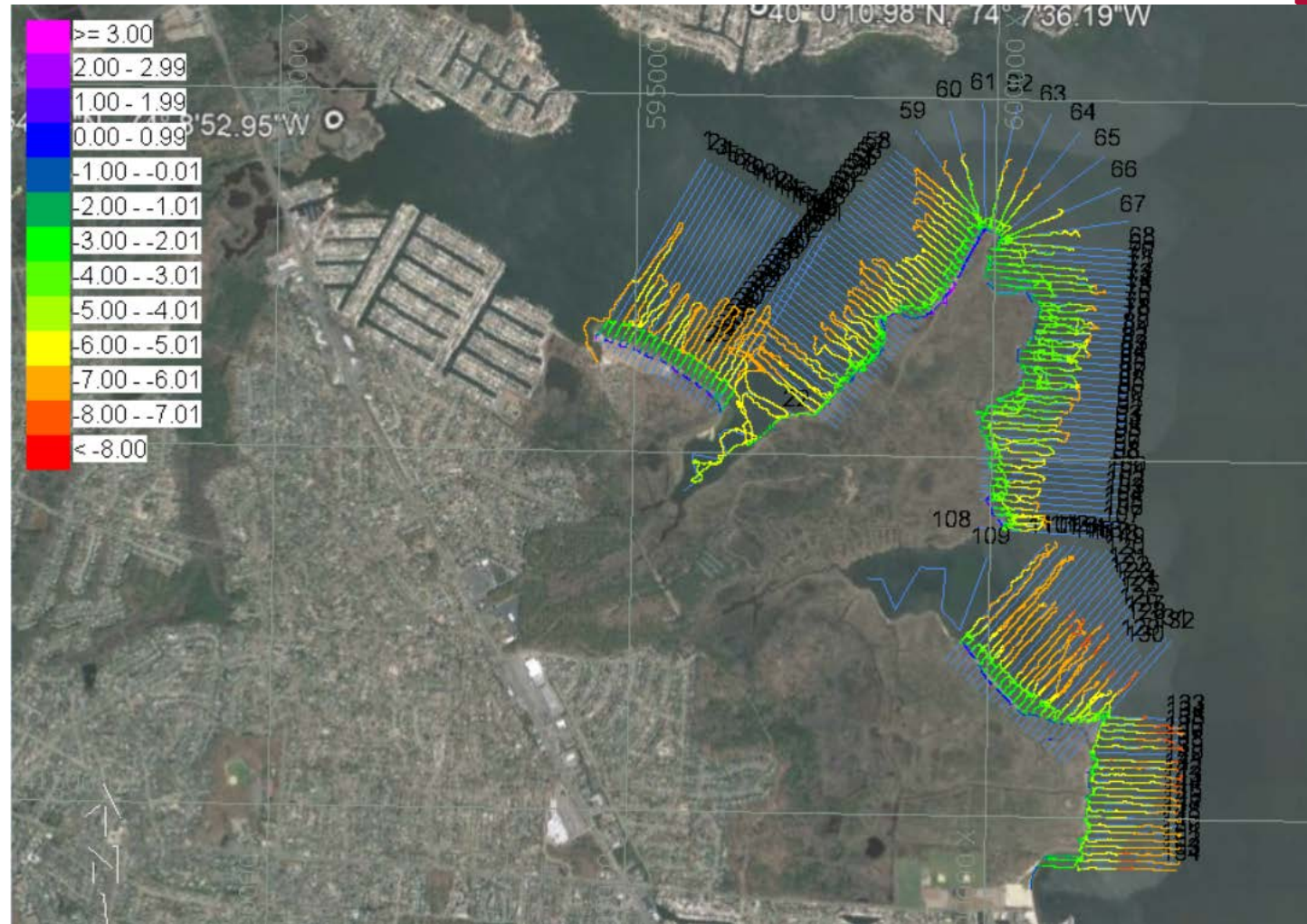
Ice

- During wave gauge retrieval, ice was present at Yellow Bank, Pages Point West, and Pages Point
- Ice at Yellow Bank and Pages Point West was at least 4" thick
- Ice knocked over wave gauges at 3 of the 4 deployment locations



Bathymetry

- Used to check the post Sandy topo-bathy Lidar
- Provides info on shoreline slope, nearshore slope, and depth
- Combination of RTK GPS wading & wave runner based survey
- Results indicate gentle offshore slopes with depths < 6 ft well past the 1977 tidelands line



Shoreline Segments

- Segment 1 – Yellow Bank
- Segment 2 – Pages Point West
- Segment 3 – Pages Point
- Segment 4 – Pages Point East
- Segment 5 – Applegate Cove
- Segment 6 – Shelter Cove North



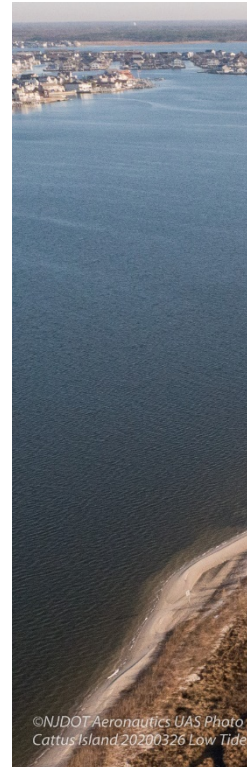
Segment 3 – Pages Point

Site Conditions

- Erosion: 2-4 ft/yr; moderate (highly variable)
- Wave: 1.5-2.5 ft; low-moderate
- Wakes: <4"; low-moderate
- Ice: Yes
- Bearing Capacity: poor**
- Water Quality: shellfish restricted/conditional
- Soil Type: PT
- Offshore Depth: 2-6'
- Shoreline Slope; mild (beach), some vertical (marsh)

*Wake gauge analysis pending

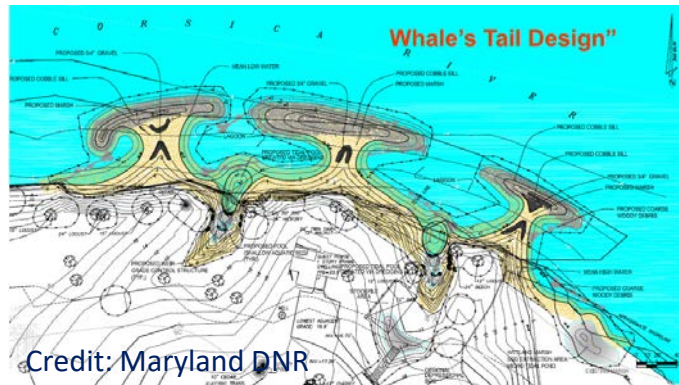
**Geotechnical investigation is recommended



Segment 3 – Pages Point

Alternatives/Concept Design

- Marsh sill, breakwater, living reef, and reef balls all potentially viable (of approaches considered in LSEG)
- Stability of Pages Point impacts Yellow Bank
- Point is the most eroded portion of Cattus
- Design Philosophy: stabilize the corners with “whales tail” design



Segment 1 – Yellow Bank

Conditions

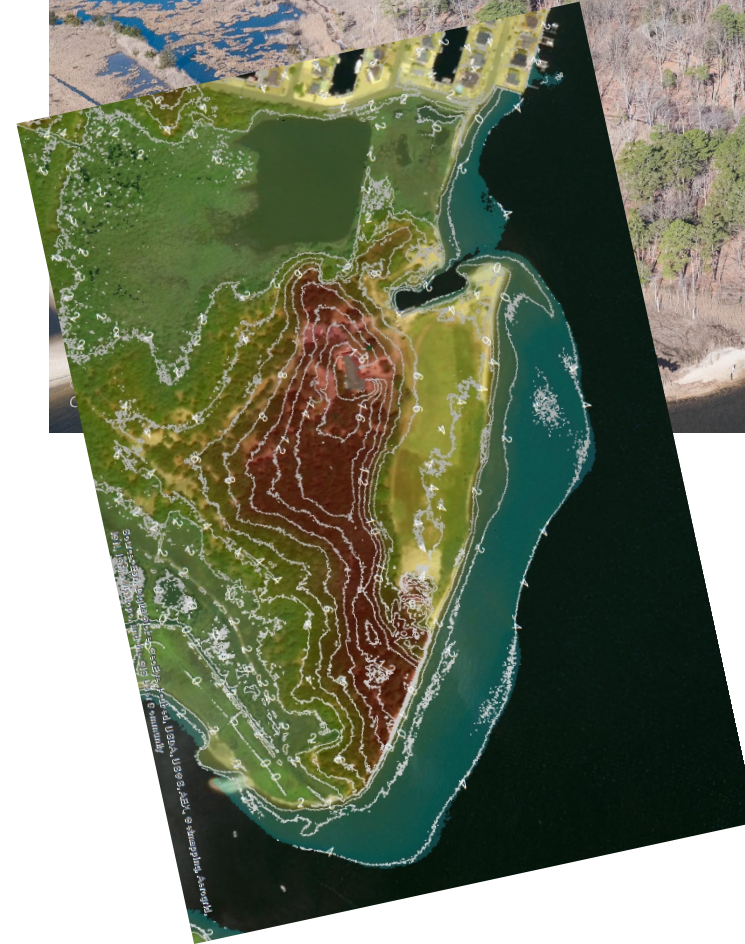
- Erosion: 1-4 ft/yr; low-moderate
- Wave: 1.5-2.5 ft; low-moderate
- Wakes: <4"*; low-moderate
- Ice: Yes - >4"
- Bearing Capacity: poor**
- Water Quality: shellfish restricted
- Soil Type: PT
- Offshore Depth: 2-4'
- Shoreline Slope; mild

*Wake gauge analysis pending

**Geotechnical investigation is recommended



Photo Credit: NJDOT Aeronautics UAS Photo



Segment 1 – Yellow Bank

Alternatives Analysis/Alternatives/Concept Design

- Marsh sill, breakwater, revetment & reef balls all potentially viable
- Stability of Pages Point impacts Yellow Bank
- Only site backed by erodible bluff
- Need to protect base
- Ice a concern for materials like coir/tree revetment
- Rainfall induced erosion also a concern
- Design Philosophy: perched beach, possibly with bluff protection



Segment 4 – Pages Point East

Conditions

- Erosion: 1-3 ft/yr; moderate
- Wave: 1-2 ft; low-moderate
- Wakes: <4''*; low-moderate
- Ice: no
- Bearing Capacity: poor**
- Water Quality: approved/conditional
- Offshore Depth: 4-6'
- Shoreline Slope; vertical (marsh)

*Wake gauge analysis pending

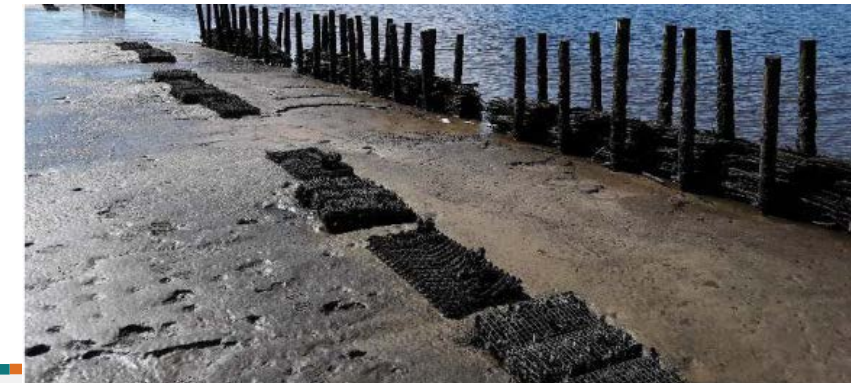
**Geotechnical investigation is recommended



Segment 4 – Pages Point East

Alternatives/Concept Design

- Marsh sill, breakwater, revetment & reef balls all potentially viable
- More of a pure marsh edge erosion problem
- Stabilize ditch mouth
- Design Philosophy: combination of sills (perhaps different type, layouts, etc.);





Segment 6 – Shelter Cove North

Conditions

- Erosion: 1-2.5 ft/yr; low-moderate
- Wave: 1-1.5 ft; low-moderate
- Wakes: < 4''*; low-moderate
- Ice: No
- Bearing Capacity: poor**
- Water Quality: approved
- Offshore Depth: 4-6'
- Shoreline Slope; mostly vertical & mild (d-d)

*Assumed

**Geotechnical investigation is recommended



Photo Credit: NJDOT Aeronautics UAS Photo

Segment 6 – Shelter Cove North

Alternatives/Concept Design

- Marsh sill, breakwater, revetment & reef balls all potentially viable (of approaches considered in LSEG)
- Design Philosophy: mimic what works best in section 3 (or vice versa)



Segment 2 – Pages Point West

Conditions

- Erosion: 1 ft/yr; low - moderate
- Wave: 1-1.5 ft; low-moderate
- Wakes: < 4"*; low-moderate
- Ice: Yes
- Bearing Capacity: poor**
- Water Quality: restricted
- Offshore Depth: 2-4'
- Shoreline Slope; vertical (marsh) & mild (beach)

*Wake gauge analysis pending

**Geotechnical investigation is recommended



Segment 2 – Pages Point West

Alternatives/Concept Design

- Marsh sill, breakwater, revetment & reef balls all potentially viable (of approaches considered in LSEG)
- Stability of Pages Point impacts this shoreline
- Ice a concern for materials like coir/tree revetment
- Design Philosophy: wait to see how the Pages Point project impacts this section (beach and marsh)



Segment 5 – Applegate Cove

Conditions

- Erosion: 1 ft/yr; low
- Waves: 1-2 ft; low-moderate
- Wakes: < 4"*; low-moderate
- Ice: Yes
- Bearing Capacity: poor**
- Water Quality: restricted
- Offshore Depth: 2-4'
- Shoreline Slope; mild, some vertical (east)

*Assumed

**Geotechnical investigation is recommended



©NJDOT Aeronautics UAS Photo
Cattus Island 20200326 Low Tide

Photo Credit: NJDOT Aeronautics UAS Photo

Segment 5 – Applegate Cove

Alternatives/Concept Design

- Lowest erosion rates of all sections considered
- Satellite images indicate the presence of ice
- Design Philosophy: potential “do-nothing” scenario; stabilize ditch mouth; beach nourishment/sills where necessary; possibly consider shore perpendicular structures and planting





STEVENS
INSTITUTE *of* TECHNOLOGY
THE INNOVATION UNIVERSITY®

stevens.edu

Jon Miller - Laura Kerr

jmiller@stevens.edu | lkerr@stevens.edu

A Framework for Developing Monitoring Plans for Coastal Wetland Restoration and Living Shoreline Projects in New Jersey

Recommended data collection and evaluation of project performance to facilitate adaptive management and improve future project designs

Version 1.2; Most recent update 12/12/2016

This document is the product of the New Jersey Measures and Monitoring Workgroup of the NJ Resilient Coastlines Initiative, whose members contributed extensively to the content, writing, and preparation of the report. The NJ Resilient Coastlines Initiative is a network of conservation, academic, state and federal partners supported by funding from the National Oceanic and Atmospheric Administration's Coastal Resilience (CRest) Grant program. The goal of the Initiative is to facilitate the use of nature-based solutions, such as living shorelines and marsh restoration, when responding to coastal hazards to help ensure a resilient New Jersey coastline. The workgroup would also like to acknowledge the contribution of concurrent work by the Delaware Living Shoreline Committee in developing the theoretical framework that formed the basis of this document.



New Jersey Measures and Monitoring Workgroup Members:

Metthea Yepsen, The Nature Conservancy (editor)
Joshua Moody, Partnership for the Delaware Estuary (editor)
Elizabeth Schuster, The Nature Conservancy (editor)
Carl Alderson, National Oceanic and Atmospheric Administration
William Crouch, U.S. Fish and Wildlife Service
Meredith Comi, New York/New Jersey Baykeeper
Patricia Doerr, The Nature Conservancy
Danielle Donkersloot, NJ Department of Environmental Protection
Darlene Finch, National Oceanic and Atmospheric Administration
Dorina Frizzera, NJ Department of Environmental Protection
LeeAnn Haaf, Partnership for the Delaware Estuary
Heidi Hanlon, U.S. Fish and Wildlife Service
Jackie Jahn, GreenVest
Danielle Kreeger, Partnership for the Delaware Estuary
Jenna Krug, American Littoral Society
Martha Maxwell-Doyle, Barnegat Bay Partnership
Gene McColligan, Dewberry
Jon Miller, Steven Institute of Technology
Capt. Al Modjeski, American Littoral Society
Erin Reilly, Barnegat Bay Partnership
Zack Royle, American Littoral Society
John Szczepanski, U.S. Fish and Wildlife Service
Michael Tolan, U.S. Fish and Wildlife Service
Amy Williams, Stevens Institute of Technology

Points of Contact for More Information:

Metthea Yepsen Coastal Projects Manager New Jersey Chapter The Nature Conservancy myepsen@tnc.org (609) 861-4138	Joshua Moody Restoration Coordinator Partnership for the Delaware Estuary jmoody@delawareestuary.org (302) 655-4990 Ext. 115	Elizabeth Schuster Environmental Economist New Jersey Chapter The Nature Conservancy eschuster@TNC.ORG (609) 861-4132
--	---	---

Recommended citation: Yepsen, M., Moody, J., Schuster, E., editors (2016). A Framework for developing monitoring plans for coastal wetland restoration and living shoreline projects in New Jersey. A report prepared by the New Jersey Measures and Monitoring Workgroup of the NJ Resilient Coastlines Initiative, with support from the NOAA National Oceanic and Atmospheric Administration (NOAA) Coastal Resilience (CRest) Grant program (NA14NOS4830006).

Executive Summary

Monitoring of coastal restoration projects is needed in order to assess project performance (both in the general effectiveness of the restoration technique and in regard to meeting project-specific ecological and/ or socioeconomic goals) and to inform adaptive management. This document provides guidance on how to select monitoring metrics and develop a monitoring plan for coastal wetland restoration and living shoreline projects in New Jersey. Because it is important for all projects to have some level of monitoring, this framework is intended to cover a variety of coastal wetland restoration and living shoreline techniques and be adaptable to the needs of users from a range of backgrounds - from those with little experience and small budgets, to experts with larger budgets who may plan to publish their findings and advance the understanding of living shoreline and wetland restoration activities.

The document was written by the NJ Measures and Monitoring Workgroup, whose membership included experts from ecological non-profits, universities, state and federal agencies, National Wildlife Refuges, and an environmental consulting firm. This is the first working draft of what we hope will be a living document that evolves with the field of restoration. The framework itself has been kept intentionally inclusive and concise so that it will be accessible to a wide range of users. The framework is meant to be applied after project goals have been selected and does not cover project design. We recommend consulting with restoration professional regarding method selection, data analysis, and result interpretation. **Although the document was written with NJ restoration projects in mind, the document does not have any regulatory implications for federal or state permitting requirements.**

The framework walks through the process of developing a monitoring plan for living shoreline and wetland restoration or enhancement projects. During this process, users select metrics that are relevant to their projects' goals and restoration type. The document then provides a list of common methods for collecting data on each metric. Finally, recommended components of a monitoring plan are suggested with a monitoring plan template that can be filled out for specific projects. Tables that facilitate the selection of metrics and methods, metric definitions and lists of resources are located in the appendices.

In addition to assisting in the development of monitoring plans for individual projects, this framework encourages the use of standardized metrics, common data collection methods, and sharing of data and lessons learned from projects. This will help to enhance local understanding of the ability of specific restoration techniques in meeting their goals and hopefully pave the way for increased implementation of appropriate natural and nature-based solutions. By assessing coastal restoration projects with a common set of metrics and sharing lessons learned, we can expect three major advantages: 1) improved technique selection and project design that better meets site-specific ecological and socioeconomic goals, 2) a better informed and interactive permitting process, and 3) increased funding and support for natural and nature-based solutions based upon the greater understanding of the ecological and socioeconomic benefits.

Table of Contents

Executive summary	2
I. Introduction	4
II. Objective and Scope.....	5
<i>OBJECTIVES</i>	<i>5</i>
<i>SCOPE.....</i>	<i>6</i>
III. How to Use This Framework.....	6
IV. Monitoring Plan Conceptualization.....	8
V. Project Type and Goals.....	9
<i>PROJECT TYPE</i>	<i>10</i>
<i>PROJECT GOALS.....</i>	<i>11</i>
VI. Metrics Selection	13
<i>RE-EVALUATING PROJECT GOALS.....</i>	<i>14</i>
<i>IDENTIFYING RESTORATION TARGETS.....</i>	<i>14</i>
VII. Methods Selection	15
<i>DOUBLING-UP ON METHODS</i>	<i>16</i>
<i>ADDITIONAL USER CONSIDERATIONS.....</i>	<i>16</i>
VIII. Monitoring Plan Development.....	19
IX. Summary and Next Steps	21
X. Cited Literature.....	23
Appendices	24
Appendix A. Metric Tables	25
Appendix B. Description of metrics.....	38
Appendix C. Sample Monitoring Outline.....	44
Appendix D. Citations for More Information on Monitoring Methods	45
Appendix E. Other Guidance Documents on Developing Monitoring Plans for Coastal Habitats.....	55
Appendix F. Metric Worksheet.....	56

I. Introduction

Coastal habitats, like wetlands and natural shorelines, provide a myriad of socioeconomic and ecological benefits that have been widely acknowledged. Beyond being a key part of the natural aesthetics of our coast, these vital habitats provide a variety of services including water filtration, carbon sequestration, reduced erosion and flooding, nursery habitat for recreational and commercial fisheries, nesting and foraging ground for important avian species, and they help boost the tourist economy through spending by visitors. In addition, wetlands and natural shorelines provide a smooth transition from water to land which is critical for wildlife and healthy ecosystems.

However, severe rates of coastal habitat degradation and loss, due to development, sea level rise, and increasing storm frequency and severity, translate into a loss of socioeconomic and ecological habitat benefits. In the Delaware Estuary, approximately an acre per day of coastal wetlands are vanishing and converting into mud flats and then open water (Partnership for the Delaware Estuary 2012). Recent data for New Jersey shows a loss of approximately 1,755 acres of wetlands per year between 1986 and 1995 (Balzano et al. 2002).

When natural habitats are restored or enhanced through a variety of methods to benefit both wildlife and human communities, we call it **natural and nature-based solutions (NNBS)**. Since Superstorm Sandy, there has been increased interest in using NNBS as a defense against coastal storms and sea level rise. These innovative coastal resilience techniques, such as living shorelines and tidal wetland restoration and enhancement¹, provide promising new approaches to shoreline protection and enhancement. Since 2007, partners have been developing NNBS for the Mid-Atlantic region and a handful of pilot projects have been installed.

NATURAL AND NATURE-BASED SOLUTIONS (NNBS)

Solutions to societal challenges (such as property loss due to coastal erosion, water quality degradation, or a decline in commercial fish species) that utilize natural features in a way that provides economic, social, and environmental benefits.

As additional coastal restoration and enhancement projects are planned and designed to meet ecological and socioeconomic goals, it has become more important to have a process to gauge project performance. Although many studies have demonstrated the benefits that NNBS provide, data gaps exist (Barbier 2013; Cunniff and Schwartz 2015). For instance, while it is known that salt marshes provide coastal resilience benefits to communities during storms, little is known about how those benefits vary during larger and smaller events; faster and slower moving events; and storm events of varying durations (Sutton-Grier, Wowk, and Bamford 2015). This framework provides that much-needed process for selecting and integrating ecological and socioeconomic metrics, and developing a monitoring plan for coastal wetland restoration and living shoreline projects. By following the process outlined in this framework, the data collected can be utilized to improve project design, site-specific technique selection, adaptive management, and fill data gaps on benefits provided by restored or enhanced coastal habitat.

This document provides guidance on developing monitoring plans for two types of NNBS projects that

¹ The terms restoration and enhancement are used interchangeably in this document because the same process for developing a monitoring plan and selecting metrics can be used on both types of projects.

are of particular interest in coastal New Jersey: living shorelines and tidal wetland restoration. **Living shorelines** are built or engineered structures that incorporate native flora and fauna to stem erosion and provide an ecological benefit to the surrounding habitat (i.e., ecological uplift). Techniques currently being investigated include: bio-based tactics, comprised solely of natural materials and native plants and animals; and hybrid tactics (e.g. marsh sills) which couple bio-based designs with harder structures that reduce wave energy and provide ecological enhancement. **Tidal wetland restoration and enhancement techniques** are varied and typically are larger scale than living shoreline projects. They can be used to: help marshes gain elevation, restore natural tidal hydrology, and/or maintain native wetland plant and animal communities. These restoration practices include, but are not limited to, beneficially reusing dredge material to increase marsh elevation or restore spatial extent, restoring hydrologic function to marshes previously altered for human purposes (e.g., mosquito ditching, diking, Open Marsh Water Management (OMWM), etc.), and rebuilding native plant communities.

The science and coastal management community has a shared interest in improving the design of NNBS projects. However, there has been little assessment of the performance of these projects under a wide range of conditions and limited analysis of the long-term viability of these practices. ***It is therefore vital that the performance of implemented projects be assessed with regard to 1) stem the loss of coastal habitats; 2) meet ecological and socioeconomic goals such as habitat enhancement, clean water, and flood reduction; and 3) hold up under increasingly severe environmental conditions and under daily stresses.*** This is best accomplished by having some level of monitoring on every project, increased standardization of monitoring used to assess project performance, and the sharing of data and lessons learned from local projects.

II. Objective and Scope

OBJECTIVES

This document is intended to be used as a framework to guide New Jersey coastal restoration practitioners, from a variety of backgrounds, in the development of a monitoring plan to assess their coastal restoration projects' performance (both in terms of the general effectiveness of the restoration technique and in terms of a project's ability to meet its specific ecological and/ or socioeconomic goals), and to inform adaptive management or maintenance actions. **The intended user groups of this document include, but are not limited to, academics, environmental non-profits, regulatory agencies, restoration professionals, community organizations, funding agencies, citizen science groups, and private landowners.** Because of the broad range of project sizes and user groups, an equally broad range of methods are offered - from those that are rigorous and might be expensive and/or time-consuming, to those that are less rigorous, and can be done on little to no monitoring budget and/or are less time-intensive.

Beyond improving individual projects, adoption of this framework by practitioners in New Jersey is intended to pave the way for increased implementation of NNBS projects. It promotes more consistent data collection and sharing of lessons learned from projects, which in turn can be used to: 1) improve restoration and living shoreline project designs in order to meet specific ecological and socioeconomic goals, 2) inform the permitting process, and 3) communicate the ecological and socioeconomic benefits

of coastal habitats to stakeholders and the general public, which in turn can lead to increased funding and support for NNBS and the conservation and restoration of coastal habitats.

SCOPE

This document is intended to walk the practitioner through the steps shown in Figure 1, which are necessary for developing a monitoring plan for a living shoreline or tidal wetland restoration project. More specifically, the document covers the following areas, *after* a project type and goal have been selected:

1. decide what aspects (referred to in this document as **metrics**) of the project to monitor based on the project's design and goals,
2. select methods for measuring each metric based on the user's skill, budget, and other considerations,
3. provide a process for integrating ecological and socioeconomic metrics and data collection when appropriate, and
4. write an executable monitoring plan that will help the practitioner to collect data, identify when maintenance is needed, and pass on lessons learned from the project to the local restoration community.

A monitoring plan developed using this document will be helpful in developing a Quality Assurance Project Plan (QAPP), which may be required if a project received federal funds.

This document is **not intended** to guide the practitioner in choosing a restoration technique for their project,² and it is also not intended to help the practitioner choose project goals – it is important that these be established while developing your project and before developing a monitoring plan. However, the user may find that reviewing the description of Project Goals (Section V) and the recommended metrics in the tables in Appendix A is useful for clarifying existing project goals and/or developing a monitoring budget.

Most importantly, **this framework is meant as a starting point**, and additional guidance may be needed to satisfy special requirements issued by funders or regulatory agencies. There are many existing, and more extensive, guidance documents available on monitoring for coastal systems (an incomplete list can be found in Appendix E). That being said, this framework is among the only existing frameworks that provides the user with such clear guidance on recommended ecological and socioeconomic metrics (found in Appendix A).

III. How to Use This Framework

This framework is built around a number of tables (located in Appendix A) that guide the user from the selection of metrics and methods based on their project design, goals, and other user considerations, to

² Developed as part of the Resilience Coastlines Initiative, the Restoration Explorer is an on-line tool that supports the initial step in identifying and planning potential shoreline enhancement projects to help stabilize and strengthen New Jersey's shorelines. <http://coastalresilience.org/project-areas/new-jersey-introduction/>

the development of a monitoring plan. There is one table for each project type (tidal wetland restoration and living shoreline) and one for each goal (the five goals covered by this document are discussed in the next section). The users select each table that is relevant to their projects and extract the metrics and methods appropriate for their projects from the tables.

There is a broad spectrum of monitoring options available to gauge the performance of wetland restoration and living shoreline projects. Decisions regarding which metrics and methods to implement are dependent on the project type, project goals, the end-uses of the data, and user constraints that may limit monitoring efforts, such as budget and expertise. These considerations are used to tailor the development of a project specific monitoring plan. Monitoring plan development follows a stepwise process (Figure 1) in which the user, in collaboration with the restoration project team:

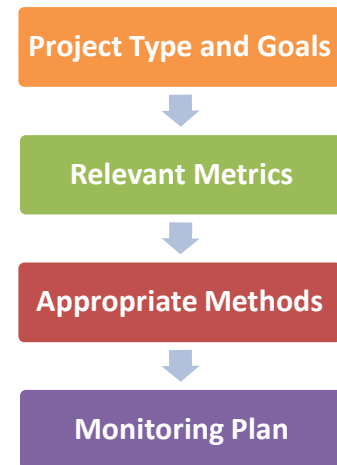


Figure 1. Stepwise progression of monitoring plan development

1. Identifies the project type and goal(s), including prioritization of goals if there are multiple;
2. Identifies relevant metrics for both the project type and goal(s);
3. Selects appropriate methods to measure the metrics based on user considerations and planned uses for the monitoring data; and
4. Develops a monitoring plan.

There are two **Project Type** tables: Living Shoreline and Tidal Wetland Restoration. Project type tables contain metrics regarding the basic structure and function of the project (e.g., is the wetland a functioning wetland or is the living shoreline maintaining its form and function).

There are five **Project Goal** tables. Project goal tables contain metrics used to evaluate whether or not a project-specific goal has been met (e.g., if the living shoreline has a goal of reducing erosion, tracking changes in shoreline position is important; if the wetland restoration project has a goal of increasing fish production, it is important to monitor fish in the project site). The five categories of goals covered by this document are:

- Erosion Control,
- Water Quality,
- Habitat Enhancement,
- Hydrologic Enhancement, and
- Socioeconomic Enhancement.

Monitoring Tip #1:

*A **metric worksheet** that can be filled out as the user goes through the document is located in Appendix F.*

Project goals are discussed further in Section V. Metrics selection is discussed further in Section VI. The metrics tables, located in Appendix A, provide a list of recommended metrics for each project type or goal, as well as a short list of the most likely socioeconomic metrics associated with a project type or goal. There are very few resources on monitoring of coastal restoration projects that provide such concise metric tables with specific recommended metrics; thus, the tables provided in Appendix A are a valuable resource for those who adopt this framework. The metric tables are organized as follows:

LAYOUT AND DEFINITIONS FOR METRIC TABLES

Class	Metric categories	Method options	Additional user considerations
-------	-------------------	----------------	--------------------------------

Class (Column 1): Differentiates core metrics from conditional metrics and identifies socioeconomic metrics that are likely to be applicable to the project type or projects with this goal. **Core** metrics should be collected on all projects of a given type or with a specific goal. **Conditional** metrics are those that will only apply to some projects, but that should be collected on all projects where the design or site specific conditions make the metric important. (See section V)

Metric (Column 2): **Metrics** are the actual parameters that are used to gauge whether a project has met its goals and design. Metrics are discussed in section VI. A description of each metric is provided in Appendix B. All core metrics and conditional metrics that are important to the project’s success should be included in the monitoring plan as well as socioeconomic metrics associated with socioeconomic goals of the project.

Method (Column 3): For each metric, a variety of common method options are listed. **Methods** are the way that data is collected for a metric. An attempt was made to provide methodological options for a variety of projects and user types. Method selection is discussed in section VII. Compiling a complete list of peer-reviewed detailed methods or Standard Operating Procedures (SOPs) for recommended methods was beyond the scope of this project, but links to some detailed methods are included in Appendix D.

User Considerations (Column 4): Next to each method option, the user consideration column lists some top attributes of a method that need to be taken into account by the user before selection of the method. The information in this column allows the user to rule out certain methods based on the skill level of the user, required equipment, time, or expense. User considerations are discussed in section VII.

IV. Monitoring Plan Conceptualization

Project performance is gauged by the evaluation of metrics related to the goals or design of a project. **Metrics** are measurable physical, chemical, biological, and/or socioeconomic aspects of a restoration project or the areas they impact. They are used to estimate and track the state of critical aspects of the project. **Monitoring plans** document when, where and how data will be collected for the evaluation of these metrics (i.e., **methods**). Development of a monitoring plan early in the project design process, provides the user *a priori* knowledge regarding potential spatial and/or temporal data gaps, and ensures that all relevant information is collected in a meaningful and coordinated way.

Components of a monitoring plan include project goals; metrics and detailed methods; target outcomes; spatial and temporal sampling design; and data management and analysis approach. More detail on each of these is provided in section VIII. These plans are most useful if they include these basic ingredients and are implemented before installing the project. By implementing a monitoring plan before project installation, the practitioner is able to gauge project performance through a series of

monitoring stages:

1. Baseline Monitoring
 2. As-Built Survey
 3. Performance Monitoring
- **Baseline monitoring:** monitoring and data collection conducted prior to installation that serves as the starting ecological and socioeconomic conditions of the site. Baseline monitoring documents the condition against which all future monitoring will be compared. This allows the practitioner to better make a causal linkage between actions and the changes that are observed. It can also suggest refinements to the restoration plan or changes to the metrics included in the monitoring plan (e.g., if one of the project goals is to improve water quality by reducing nitrate loads, but the baseline monitoring shows that nitrate levels are already below detectable levels, the user does not need to spend the resources to monitor nitrates or include it as a project goal).
 - **As-built survey:** monitoring conducted soon after construction, typically by the contractor who builds the project, to demonstrate that the project meets engineering and design specifications. While some of the metrics used for the as-built survey will be the same as those used to gauge project performance, some will be different. This document does not cover developing an as-built survey plan, but ideally the two types of data collection will be coordinated. NNBS projects are not always built exactly to design, so the as-built survey data is also important data to have when considering management decisions and assessing the performance of a project.
 - **Performance monitoring:** monitoring conducted periodically after installation that compares the condition of the site to the baseline and as-built conditions, or stated target outcomes, to document progress toward meeting project goals. Performance monitoring can also help inform the need for adaptive management or maintenance if the project is not performing as expected. For socioeconomic metrics, performance monitoring may take place at the project site, or may take place outside of the project site, as it is dependent upon where project beneficiaries are located.

Monitoring Tip #2

*To show a stronger causal link between the restoration project and an outcome, consider adding a control site for a full **BACI (Before, After, Control and Impact)** design. A **Control** site is an area that has the same baseline conditions as the **Impact** site where the project is installed, but that will not be affected by the restoration. By taking identical measurements at each site, both **Before** and **After** project implementation, the user can better evaluate the project's effect.*

V. Project Type and Goals

The first step in developing a monitoring plan involves identifying the project type and goals. Below are definitions of the project types and goals addressed within this framework.

PROJECT TYPE

This document can be used to develop monitoring plans for the following types of coastal restoration and enhancement projects:

1. *Living shorelines*, which include,
 - Natural living shorelines
 - Hybrid living shorelines
 - Structural living shorelines
2. *Tidal wetland restoration*, which include,
 - Elevation changes (i.e., proper positioning within local tidal range)
 - Rebuilding wetlands that have been lost due to excavation or erosion
 - Hydrologic changes (i.e., restoring optimal tidal flow)
 - Restoring native flora/fauna

A living shoreline is a method of shoreline stabilization that protects the coast from erosion while also preserving or improving environmental conditions (i.e., ecological uplift). Living shorelines are implemented in coastal areas that are tidally influenced, generally in the intertidal and shallow subtidal zones. Living shorelines represent a number of treatments and techniques that:

- Offer resilience to shorelines from acute or chronic wave energy and/or rises in sea level;
- Utilize predominantly natural materials and processes exclusively or in combination with a man-made structural component (hybrid); and
- Sustain, enhance, and/or restore ecological functions and connections between uplands and aquatic areas. A living shoreline must result in a net increase in ecological function (e.g., vegetation, substrate, water quality, wildlife utilization, etc.).

This is accomplished through the strategic placement of plants, stone, sand, or other structural and organic materials **that result in net ecological uplift**. There are three types of living shorelines:

1. **Natural living shorelines** include native vegetation, submerged aquatic vegetation, fill, and biodegradable organic materials.
2. **Hybrid living shorelines** incorporate native vegetation, submerged aquatic vegetation, fill, and/or biodegradable organic materials with low-profile rock structures such as segmented sills, stone containment, and/or living breakwaters seeded with native shellfish.
3. **Structural living shorelines** include, but are not limited to, revetments, breakwaters, and groins that have been designed to increase ecological function to adjacent areas (more so than a traditional hardened structure) and maintain the gradual transition from land to water.

Wetland restoration for the purposes of this document refers to practices that either restore or enhance one or more functions of tidal wetlands that have been degraded or are threatened by human activities or sea level rise. “**Wetland functions** are defined as a process or series of processes that take place within a wetland. These include the storage of water, transformation of nutrients, growth of living matter, and diversity of wetland plants, and they have value for the wetland itself, for surrounding ecosystems, and for people” (Novitzki et al. 1997). Wetland restoration and

enhancement methods include:

- Reintroducing or correcting tidal flow by breaching dykes, changing channel morphology, plugging or filling ditches, and other methods;
- Recreating marsh area that had been lost due to excavation or erosion;
- Changing the elevation of the marsh so that it receives optimal tidal flow by excavating fill or adding sediment to drowning marshes; and
- Managing flora and fauna; for example to remove nuisance or invasive species and re-establish native wetland species.

PROJECT GOALS

In order to evaluate the success of a living shoreline or wetland restoration project, the project must have well defined goals. The Society of Ecological Restoration defines ecological restoration goals as the desired “states and conditions that an ecological restoration effort attempts to achieve. Written expressions of goals provide the basis for all restoration activities, and later they become the basis for project evaluation” (Clewell et al. 2005). **Goals define the primary purposes of the project and should be specific, measurable, achievable, relevant, and time bound so that the user can select the appropriate metrics for evaluating whether or not the goal has been achieved.**³ Selecting metrics based on project goals will help ensure that data provide meaningful and useful results. As projects are likely to have multiple goals, it is important to prioritize those goals so that the number of metrics selected for the project is manageable. As the user refines the metrics, target outcomes and goals, they should continue to consider the interests of stakeholders and partners. Stakeholder engagement, which ideally began before setting goals for the project, is important for ensuring compatibility between goals and stakeholders’ values, and to increase stakeholder support for the project.⁴

We recommend convening an interdisciplinary work group to coordinate selection and collection of biophysical and socioeconomic data. Reiterating goals and agreeing on metrics and methods as a group will serve to improve coordination around data collection efforts, and identify linkages between the biophysical and socioeconomic metrics. In many cases, the analysis of a socioeconomic metric relies upon ecological data (e.g. the socioeconomic metric *Damage costs avoided to surrounding homes (\$)* may rely upon ecological metrics related to vegetation).

The following is a list of the restoration project goals that have been identified as most important for coastal restoration in New Jersey and are addressed in this framework:

- **Erosion Control:** The linear edge of many beaches, coastal wetlands, and developed shorelines is changing under the pressure from natural erosional forces including waves, storm surge, and tides, in concert with sea level rise, and possible human-related influences such as boat wakes. Projects with a primary goal of erosion control are designed to stabilize our coastlines, thus

³ For help setting goals for restoration projects, see Chapter 3 of *Returning the Tide* from the NOAA Restoration Center http://www.habitat.noaa.gov/toolkits/tidal_hydro/Chapter_3.pdf (NOAA Restoration Center & NOAA Coastal Services Center 2010)

⁴For more information on 1) identifying relevant ecosystem service benefits to people for an upcoming restoration project, 2) establishing socioeconomic goals and metrics, and 3) stakeholder engagement around coastal restoration projects, refer to *A user’s guide for incorporating economics into the planning process for coastal restoration projects* (Schuster and Doerr 2015). <http://www.nature.org/media/oceansandcoasts/ecosystem-service-valuation-coastal-restoration.pdf>

reducing the lateral landward migration of the land-water interface of coastlines and/or creating conditions for the facilitation of sediment accrual.

- **Water Quality:** Ensuring high water quality in New Jersey's coastal waters is critical to the functioning of our coastal ecosystems, which support valuable biodiversity and local communities. Projects with a goal to maintain or improve water quality are designed to either facilitate reductions in, or reduce the rate of input of, concentrations of nutrients, contaminants and/or suspended solids that can inhibit ecosystem functions.
- **Habitat:** New Jersey's coasts contain critical habitat for hundreds of ecologically important species, some of which are also important commercially, recreationally, or are threatened or endangered. Projects with a goal of habitat enhancement are designed to increase biodiversity and improve the habitat provision services of coastal lands and waters (e.g., food, shelter and nursery habitat). This can include projects that restore or recreate habitat such as reefs, beaches or marshes and/or projects that provide improvements to existing habitat for fish and wildlife.
- **Hydrological Enhancement:** Historically, coastal wetlands have been hydrologically altered through ditching and diking for agriculture, development, mosquito population management, etc. Hydrological alterations often prevent optimal tidal inundation, either isolating areas from receiving inputs of nutrients and sediments by decreasing inundation, or drowning vegetation with increased depth or duration of inundation. Projects with the primary goal of hydrological enhancement are designed to promote optimal hydrologic connectivity usually through the filling of ditches, breakdown of dikes or the (re)creation of historic or new tidal creeks and channels.
- **Socioeconomic Enhancement:** New Jersey coastal habitats, like beaches and coastal wetlands, have significant social and economic value, providing livelihoods for fisherman, positively impacting tourism and ecotourism-related industries, providing opportunities for recreation, supporting historic community character, and reducing the costs of damage to coastal communities from flooding and storms, among other benefits. Projects with a goal of economic and/or social (socioeconomic) enhancement are specifically designed to enhance aspects of the environment that contribute to one or more aspects of human wellbeing. The total value of the benefits derived by a community will depend upon the number of beneficiaries impacted. Meeting a socioeconomic goal will be based upon a change in human wellbeing as a result of ecological change. Even when the primary goal of the project is not economic or social, the economic or social co-benefits provided by the project may be of sufficient magnitude that they are worth measuring. If key project stakeholders are interested in the economic or social benefits provided by a project, it may be worth collecting appropriate baseline data for a future ecosystem service valuation or economic impact study. Interdisciplinary projects that integrate the biophysical parameters with socioeconomic parameters throughout the project are becoming more common, as continual integration can lead to more accurate and cost-effective measurement of performance, outcomes and benefits.

LINKING ECOSYSTEM SERVICES TO SOCIOECONOMIC ENHANCEMENTS

Ecosystem services are provided by a specific habitat type, either terrestrial or aquatic. The full list of ecosystem services provided by nature is broad in scope, but includes water filtration, flood attenuation, provision of food and water, and others. The type and quantity of ecosystem services provided by a coastal restoration project will vary depending upon a number of factors including habitat type and habitat attributes. The underlying premise is that the level of ecosystem services provided by a site will change as a result of a restoration or enhancement project.

Ecosystem service benefit is the term for the way in which ecosystem services support and contribute to human wellbeing. Examples of ecosystem service benefits provided by an ecological restoration project might include an increase in revenues to commercial fisherman from the increase in fisheries production, damage avoided to homeowners from the reduction of flooding, or an increase in the recreation opportunities to birders. The total value of ecosystem service benefits will depend upon the number of beneficiaries impacted.

VI. Metrics Selection

Once the project type and goal(s) are established, metrics are selected to measure a project's success. **Metrics are specific parameters used to assess project success and gauge attainment of project goals, whereas methods are the actual techniques that are used to measure the metrics.** This section focuses solely on relevant metric identification. Method selection will be discussed in section VII.

Two categories of metrics are addressed in this framework: project type metrics and goal based metrics. It is the collection of project type metrics and goal based metrics that make up the monitoring plan. As such, both types of metrics should be collected on all coastal restoration projects (see Figure 2).

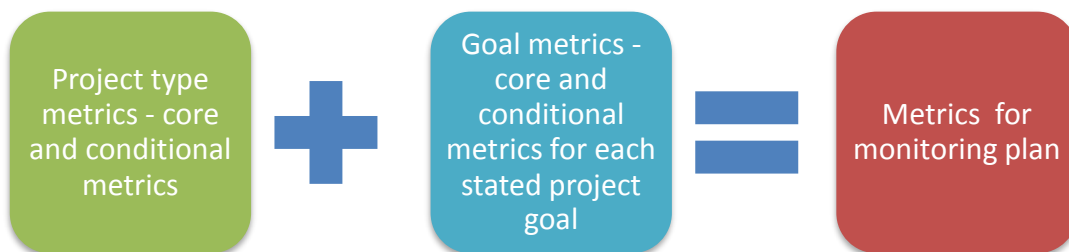


Figure 2. Selecting metrics for a monitoring plan based on project type and project goals.

Project Type Metrics are associated with each restoration project type (i.e., Living Shorelines and Tidal Wetlands Restoration). They serve to evaluate the general effectiveness of a restoration technique, inform adaptive management and address data/knowledge gaps. The project type metrics tables (located in Appendix A) identify a small number of **core metrics** that we recommend collecting on all projects of a specific *type*, as well as additional, **conditional metrics**, that we also recommend collecting for all projects when they apply to the specific project site or design. For example, oysters are not components of all living shoreline projects, but if the project design includes the use of oysters, like an

oyster reef breakwater, then it is recommended to monitor oysters.

Goal Based Metrics are associated with project specific goals. These metrics are recommended to determine if the specific goals of a project are being met and can help inform the need to adaptively manage a project in order to meet those goals. All relevant goal metrics (**core** and **conditional**) listed in the goal based metric tables (located in Appendix A) should be collected for each project goal. An example of a conditional goal based metric relates to the socioeconomic impact of wetland restoration. If the goal of the wetland restoration project is to improve habitat quality and biodiversity, then the selection of a specific socioeconomic metric dependent upon the local conditions, project attributes, and stakeholder interests may be relevant. However, there is more than one option for a socioeconomic metric (e.g., *change in spending by birders (\$)* and *change in revenues for commercial fisherman (\$)*), and the selection of a specific metric of interest will be highly dependent on the project. Some of the same metrics found in the project type tables will also be found in the goal based tables.

Monitoring Tip #3

Citizen Science and volunteer monitoring are cost effective, but not cost free options, and still involve a commitment of training volunteers, handing and care for equipment and communication between all partners including leads to the volunteer teams. Involving the local community member in these types of monitoring projects will raise the ecological awareness of the importance coastal wetlands and nature and natural-based restoration efforts.

RE-EVALUATING PROJECT GOALS

If the project has multiple goals, users should evaluate whether or not they have the resources to monitor all of the metrics recommended by this framework. It is worth noting that in some cases the same metric may be recommended by both a project type and a goal, and some methods of data collection may cover more than one metric (e.g., an RTK GPS survey can be used to document the position of a shoreline as well as the elevation). Conversely, one metric may require a great deal of resources and may preclude the user from assessing multiple goals. In this case, the user can either select less resource intensive methods or refine the stated project goals.

IDENTIFYING RESTORATION TARGETS

With both ecological and socioeconomic goals, the selected metrics will be used to evaluate whether goals were successfully met. Once metrics are identified, restoration targets are set for select metrics. **Restoration targets** indicate the changes the user expects to see over time in the restoration project; they are a restating of the goals in terms that directly relate to a metric and method. Targets may be expressed in terms of a set desired outcome, a change from baseline conditions, a difference from control site conditions, or even a desired trajectory. For new technologies and projects design types, the user may be uncertain of how the project will perform and the time frames within which results can be expected. For these newer restoration techniques, targets will be more general and will likely need to be evaluated and modified over time as data are evaluated. For example, a project using an established and well-understood technique with a goal of decreasing shoreline erosion may have the target outcome of a reduction in erosion to less than 5" per year by 2020, whereas the target outcome for a less established technique could be a simple decrease in erosion rate from baseline or control site conditions.

It is important to select restoration targets carefully so that the specificity and precision of the target properly reflects the current scientific knowledge regarding the technique and the ability of the user. The monitoring plan may have only one set of target outcomes for the end of the project that indicate whether or not the project has met its goals, or there may be interim targets at set intervals throughout the monitoring period that allow the project manager to address issues early on. Interim targets can be thresholds, or indicators, that trigger maintenance or adaptive management of the project. For example, if a wetland restoration project has an end target of 85% cover by vegetation by 2020, an interim target for 2018 could be set at 50%. If the vegetation monitoring in 2018 indicates less than 50% cover by vegetation, the project manager could decide to do some planting that would help ensure 85% cover will be reached by 2020.

For some environmental and socioeconomic metrics, the target outcomes for the project won't be achieved during the limited timeframe that monitoring funds are available. For example, some water quality parameters will require more than five to ten years to be able to quantify changes. In these cases a combination of options are available. One option is to find less expensive ways to continue monitoring the metric.

This may include using less rigorous methods, decreasing the frequency of monitoring, working with citizen scientists or existing volunteer monitoring organizations to conduct the monitoring, or establishing other creative partnerships such as working with local schools or borrowing equipment or lab space. Another option is to collect data frequently enough during the period where monitoring resources are available to establish that the metrics are on satisfactory trajectories toward meeting target outcomes. If this last option is selected, a satisfactory trajectory should be defined based on existing studies. Meeting your monitoring goals may include one or many of these suggested collaborative efforts.

Monitoring Tip #4

Not all projects will have large enough budgets or access to the expertise needed to do professional/scientific research level monitoring. However, in many cases less rigorous methods are sufficient to identify when maintenance is needed and assess whether the goals of the project have been met.

VII. Methods Selection

Once metrics and endpoints are selected based on the project type and project goals, monitoring methods can be selected for each metric. **Monitoring methods are the actual techniques that are used to collect data on a metric.** In order to make monitoring accessible to all coastal restoration projects, we have identified a variety of common methods for each monitoring metric that span a variety of resources and expertise. For socioeconomic methods, we include data collection and data analysis methods in the metrics tables. Method options are listed in the metrics tables in Appendix A.

The list of methods included in the metrics tables is far from comprehensive, but we attempted to have at least two common, peer-reviewed methods per metric and include a common standard operating procedure (SOPs) or other citation for those methods. This document includes citations of SOPs for some methods, but a fuller SOP directory is needed, perhaps as subsequent versions of this monitoring framework become available.

DOUBLING-UP ON METHODS

It may be practical for users to implement both intensive and less intensive methods at the start of a project. Cross-calibrating more intensive methods to less intensive methods during the initial phases of data collection may allow for continued long-term monitoring of a project using the less intensive methods after the close of a grant or depletion of monitoring funds. For example, shoreline position is a core metric for living shoreline projects. Shoreline position can be collected with high precision and rigor using an RTK-GPS, or with lower precision and rigor by measuring the change in the position of the shoreline over time from PVC poles. If both methods are employed during the first few years of the project when more funds are available for monitoring, the project will have high resolution data that is helpful for assessing initial trajectories and calibrating low resolution methods. Low resolution data that can be continued by citizen scientists or landowners past the initial few years of monitoring funding is important to track major changes and flag any issues that might arise.

ADDITIONAL USER CONSIDERATIONS

The **Additional User Considerations** column in the metrics tables is designed to help the user select the best method for their project. The expert working group that developed this document has begun to identify common methodological attributes. This list of attributes is not intended to be exhaustive, but to allow the user to narrow down the methodological options based on the needs and abilities of the user and project. **The presence of one of the considerations in the User Consideration column does NOT imply that the method is exclusive to those who either have a large amount of expertise, a large budget, or highly specialized equipment.** The user will need to look at detailed methodologies to determine which method will be best suited for the project. Monitoring may be conducted either by the user or other groups (e.g., citizen science groups or contractors). This section is only intended to highlight, and generally comment on, requirements of the user regarding some of the following considerations for each method:

- **Technical Expertise:** The degree of technical knowledge needed by the user to employ the method or data analysis varies. For example, measurements of elevation change using an RTK-GPS require survey and GIS training, whereas the installation of measuring posts with height demarcations does not. The same considerations apply to socioeconomic methods (e.g., surveys will require more expertise than interviews) and analysis (i.e., certain ecosystem service valuation methods require knowledge of specialized software). **The inclusion of this consideration informs the user that this method requires the user to have some degree of technical expertise and/or training.**
- **Temporal Requirements:** Time requirements for a metric or method vary either in the number of years needed to document a change or seasonal considerations for data collection. It is important to consider the timeframe of the project and funding when selecting metrics and methods. Some methods cannot be used to evaluate metrics in short timeframes (e.g., elevation processes via SETs), whereas others can (e.g., position of shoreline via RTK survey). Additionally, some metrics may require that data is collected in specific seasons (vegetation metrics need to be taken during the summer). Time-frames also apply to the collection of baseline data, where more time may be needed to reduce the error from abnormal variations that may have occurred in a single year. Time-frame considerations are also relevant for

socioeconomic metrics. Certain changes to human wellbeing as a result of biophysical changes will not be quantifiable for many years (e.g., if it takes 3-5 years for vegetation to fully establish after restoration and the resulting storm surge reduction services to be achieved). Seasonal considerations, like times of year for recreational birding or fishing, also vary depending upon the goal and which benefit is being measured. Developing a monitoring plan within a known time-frame required by the data or funding group will enable the user to select metrics and methods that are the most useful in evaluating progress toward meeting restoration targets and goals. **The inclusion of this consideration informs the user that this method has temporal requirements regarding sample collection.**

- **Collection Time Investment:** Different methodological techniques may require different time commitments in terms of data collection, sample processing, and analysis. For example, evaluating vegetation productivity is a time intensive metric because processing above-ground and below-ground biomass samples are both time intensive methods. Conversely, the measurement of accretion, whether using a ruler, marker horizon, or a RTK-GPS is a metric that can be collected more quickly. However, there can be tradeoffs between rapid and time intensive methods. For example, for the metric vegetation structure, stem counts are a more labor intensive method than horizontal vegetative obstruction, but may have differences in resolution or data transferability that are meaningful to the user. **The inclusion of this consideration informs the user that this method will require a relatively greater time investment than a rapid method; including, but not limited to, multiple measurements, and/or extended sensor collection/installation time.**
- **Cost:** Cost may increase based upon the relative expense of the method and/or the study design. Being aware of the range of costs associated with method options will help in deciding which method to adopt within the constraints of the monitoring budget. **The inclusion of this consideration informs the user that this method requires monetary investment in order to collect data, including, but not limited to, equipment costs, contracting costs, and/or processing costs.**
- **Permitting:** In some cases, permits or permission may be needed for a particular method. For example, shellfish harvesting or fish collection as part of monitoring may require a state or federal permit and flying a drone will require landowner and other agency permissions. Different states have different state, regional and local regulations so it is important to know what is needed at the local, regional, state, and national levels. Some permits can take a while to obtain and can be costly and these considerations should be built into the timeline and budget. **The inclusion of this consideration informs the user that this method may require a special permit or general permission of local officials. The requirements may differ by location, but the user will want to clarify this within their locality.**

If a method does not require that the user take any of the preceding considerations into account, the phrase "**Suited for all User Groups**" will appear in the Additional User Considerations column. This indicates that the method is accessible to users of all backgrounds. **It is recommended that the user reach out to the author of the associated SOP (or a local/regional group/agency that employs the**

method) for initial guidance in its usage. Orientation to the methodology by an appropriate group will ensure that the user understands the method precisely before employing it on their own.

Additionally, in many cases one monitoring method will provide data that can be used to assess a variety of metrics. A good example of this is an RTK-GPS survey which provides horizontal as well as vertical position. Horizontal position also may aid in assessing a socioeconomic metric such as *number of homes or structures benefitting*. It is therefore recommended that multi-metric methodologies are utilized when available.

The expert workgroup acknowledges that this list of user considerations is not comprehensive, but has identified these five attributes as being the most informative and applicable to a wide variety of users, goals and project types. Other considerations that may have value to the user when choosing a methodological option, but are not included in the tables, include:

- **Rigor/Confidence:** Does this methodological option provide data at an acceptable level of confidence (e.g. statistically, spatially, temporally, etc...) to show the results of the project in a way that is meaningful to stakeholders?
- **Scalability/Transferability of Data:** Ideally each method will enable comparison of metrics across projects of different scales, but this will not always be possible. Some methodologies may be widely used in a variety of contexts and therefore allow for easy transferability to other projects at multiple scales. Pay attention to the units of measure in which the data will be collected. Some units of measure are easily converted (e.g., inches to meters) while others are more difficult to compare (e.g., number of oysters per m² cannot be compared to number of oysters per reef ball).
- **Availability of Existing Data:** For some methods, existing data may be publically available and not need to be collected by the user. For example, geo-referenced aerial photography is widely available or in the case of property values, assessed or actual sale price of homes are also commonly available.⁵

Monitoring Tip #5

*Do not underestimate the contribution of citizen science to a project. Community members and citizen scientists can tend to the restoration site and collect data after the formal project has ended. The latest **estimated value of volunteer time is \$23.07 per hour.***

Citizen science and Community involvement: Successful restoration projects are tended to like productive gardens. They need to be frequently visited and monitored and one way to do this is through the involvement of local community groups, schools and citizen scientists. As mentioned in Section VI, volunteer monitoring is cost effective but not cost free, and the cultivation of these types of partnerships require community outreach, information sharing, training and resources. Once the

⁵ If the user is interested in finding out if there is existing ecological data on or near the site, they can check out the Water Quality Portal at <http://www.waterqualitydata.us/>. The Water Quality Portal (WQP) is a cooperative service sponsored by the United States Geological Survey (USGS), the Environmental Protection Agency (EPA) and the National Water Quality Monitoring Council (NWQMC) that integrates publicly available water quality data from the USGS National Water Information System (NWIS) the EPA STORage and RETrieval (STORET) Data Warehouse, and the USDA ARS Sustaining The Earth's Watersheds - Agricultural Research Database System (STEWARDS). The Portal is not just for water quality data and has been storing wetlands data in the Northwestern US and the Great Lakes. There data is available for download and is a searchable platform.

project/grant requirements are completed, the citizen scientists and community members can be the “eyes and ears” on the site.

VIII. Monitoring Plan Development

Once appropriate metrics and methods are chosen based on project type and goals, a monitoring plan should be developed that summarizes the strategy for gauging performance of the project. The plan should be developed and implemented prior to construction of the project. As depicted in Figure 1, the monitoring plan concisely summarizes the metrics and methods, as well as the project specific strategy for collecting data (e.g., sample timing, location, and number). Some monitoring plans may also clarify roles and responsibilities when projects are being assessed by teams of partners and staff with different skill sets. Depending on the size of the project or the funding agency, varying levels of details in the monitoring plan will be appropriate. For example, a detailed quality assurance/ quality control plan for digital data is likely not necessary for a small living shoreline project on private property installed by the landowner. Figure 3 provides a list of questions that may be useful in guiding the writing of a monitoring plan.

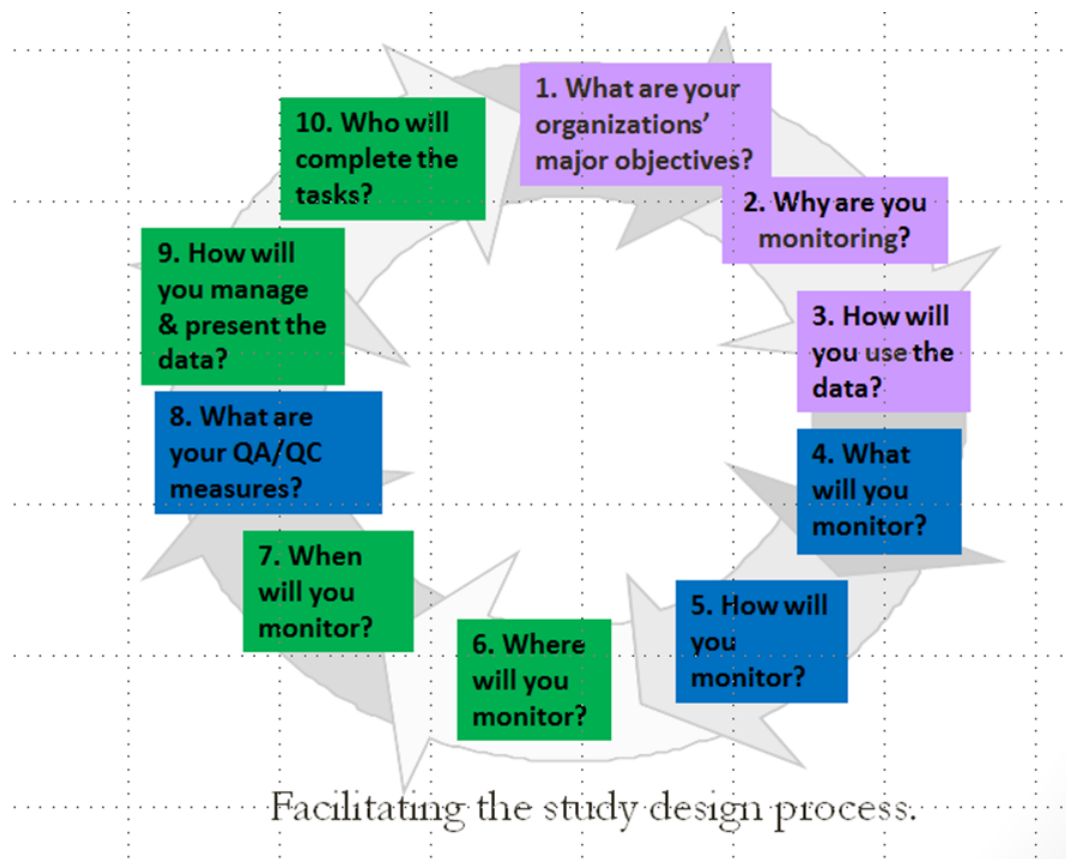


Figure 3. Questions to be answered in a project specific monitoring plan (Adapted from the Alliance for Aquatic Resource Monitoring (ALLARM), Dickinson College).⁶

⁶http://www.dickinson.edu/info/20173/alliance_for_aquatic_resource_monitoring_allarm/2911/volunteer_monitoring

The following are suggested content and considerations for developing the monitoring plan. A template for building a monitoring plan is included in Appendix C.

- *Project Overview:* A project overview should include a description of the restoration project design, location, partners, and project goals.
- *Monitoring Metrics:* List the monitoring metrics associated with the project as well as any interim targets and end targets that describe how the user expects the metric to change as a result of the project. For example, “50% cover by native plants by year 2020” may be listed as an interim target. If a project is not performing as expected or is not meeting its interim targets, then the project manager can decide whether or not maintenance or a corrective action may help the project meet its goals.
- *Monitoring Design:* For each metric, provide details on when and where the data will be collected. This should include the number or density of samples, where sampling occurs, when sampling occurs, as well as a justification for why these designs were selected. The number of samples needed will depend on the size of the project and the variability in the samples. The user will need enough samples to be able to evaluate the entire project and not just one small area. If the user is aiming for a high level of rigor, consultation with a statistician regarding the experimental design and statistical evaluation is recommended. There are a variety of ways to select sampling locations, and specific types of sampling may require certain time frames. For example, vegetation monitoring typically occurs at a time when the vegetation is in full growth (i.e. late summer). Therefore vegetation monitoring might occur during July and August in years 0, 1, and 5. Maps of sample locations should be included in an appendix. When collecting socioeconomic data, consider seasonality as well - for example, on tourism and recreation metrics, certain birds only come in spring (red knots) or fall. If the user is aiming for high level of rigor with regard to socioeconomic metrics, consultation with an experienced environmental economist or social scientist is recommended.
- *Detailed methods:* **Document step-by-step field and lab procedures so that they can be repeated consistently.** Where possible, use a common and established method that has been peer-reviewed.
- *Data management and Quality Assurance/Quality Control (QA/QC):* Document how data quality will be ensured on the project. This includes ensuring that data is collected in a standard way (QA), transferred to digital form accurately (QA/QC), and that the data is an accurate representation of the conditions observed (QC). The monitoring plan may also document how and where the data will be stored. We encourage projects to make their data publicly available. [The Water Quality Exchange \(WQX\)](#) is one public place to store data. It is less common to share socioeconomic data in public databases. In cases where socioeconomic data contains proprietary information on individuals, it is not advisable to post the data in a publicly accessible format.

- *Data analysis and reporting:* Describe how the monitoring data will be used, including detail on any statistical analyses that will be performed (e.g., equations or formulas used), and the relationships between data that will be explored. **We encourage everyone conducting monitoring on coastal restoration projects to have a way of sharing the results of their monitoring and general lessons learned with the informed public and partners so that this information can be used to improve the site selection and design of future projects.**
- *References:* List the monitoring method documents that the plans were based off of, where appropriate, and any other references cited in the plan.
- *Appendix:* An appendix can include standardized field and lab data sheets, maps of the project site, sampling locations, and more. For socioeconomic metrics, any survey or interview questions used, maps with locations of beneficiaries, or other relevant information should be included.

IX. Summary and Next Steps

Monitoring is essential for all coastal restoration and enhancement projects. Information collected can help practitioners improve living shoreline and wetland restoration techniques, indicate when maintenance or adaptive management is needed, document the benefits of these projects to coastal communities, and make the case for why these types of projects are needed. For the coastal restoration and enhancement techniques that are new to New Jersey, monitoring is especially important to vet their local applicability under a range of conditions.

There are monitoring methods to fit all scales of restoration projects, from photo documentation of a ten foot living shoreline installed on private property to LiDAR collected by airplane on a 500-acre salt marsh restoration on federal lands. This document helps the user identify what metrics to monitor on their project, provides an array of methods for each metric to fit projects of different scales, and details what needs to be included in a monitoring plan.

Developing a monitoring plan is just the first step in preparing to track the progress of a coastal restoration or enhancement project. The plan may need to be updated as methods are field tested or change to better fit the needs of the project. It is a good idea to field test methods and equipment before the first day of monitoring. Once data collection has begun, changes to the monitoring methods will make it more difficult to analyze –and to draw conclusions from. For instance, if one wants to show that a restoration led to an increase in ecotourism at the site, it is recommended to ask visitors the exact same set of questions before and after the restoration, and not change the set of questions, wording of questions, or sampling method during the process.

Using standardized field and lab datasheets promotes good data collection. Along with planned monitoring data, it can be helpful to take notes and photos of general observations that may explain findings or capture issues that the monitoring does not. Transcribing both data sheets and field notes soon after returning from the field also helps to ensure that data is entered accurately. For socioeconomic data, if surveys will be conducted, spending ample time doing background research and

interviewing relevant stakeholders will ensure that survey questions are relevant and easily understood by those being surveyed.

At set times throughout the life of the project, the monitoring data should be reviewed to evaluate progress towards the goals set for the project. If the project meets expectations then conclusions can be drawn about the success of the technique that may be used to improve future project selection and design. If the project is not meeting goals, then the monitoring data and other observations can help identify what is causing the impairment as well as actions that can be taken to correct the project's trajectory. **Lessons learned from techniques that do not meet goals are equally important to those that succeed.** For example, a living shoreline project built out of materials that worked well in the Gulf of Mexico may be found to fail in New Jersey when exposed to freezing and thawing.

Promotion and dissemination of the lessons learned and results from a project is important, whether in the form of a peer-reviewed journal article, a presentation during a community gathering, or a report to permitting agencies.

The goal of this framework is to provide enough information to empower coastal restoration practitioners to develop a monitoring plan. Please don't hesitate to reach out to us with questions or suggestions about how we can improve the guide.

X. Cited Literature

- Barbier, E.B. (2013). Valuing Ecosystem Services for Coastal Wetland Protection and Restoration: Progress And Challenges. *Resources*, 2: 213–230.
- Cunniff, S. , Schwartz, A. (2015). Performance of Natural Infrastructure and Nature-based Measures as Coastal Risk Reduction Features. A report prepared by the Environmental Defense Fund.
https://www.edf.org/sites/default/files/summary_ni_literature_compilation_0.pdf
- NOAA Restoration Center & NOAA Coastal Services Center. (2010). Returning the Tide, a Tidal Hydrology Restoration Guidance Manual for the Southeastern U.S. NOAA, Silver Spring, MD, USA.
http://www.habitat.noaa.gov/toolkits/tidal_hydro/tidal_hydro_full_document.pdf
- Clewell, A., Rieger, J., Munro, J. (2005). Guidelines for Developing and Managing Ecological Restoration Projects. Society for Ecological Restoration International. 2nd Edition.
https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwjF_3k0szJAhXljz4KHcCwAFEQFggdMAA&url=http%3A%2F%2Fwww.ser.org%2Fresources%2Fresources-detail-view%2Fguidelines-for-developing-and-managing-ecological-restoration-projects&usq=AFQjCNEEES0MOWCx7E9NmwwHTNutxVCIHg&sig2=RBT0mYtkJu0hhG3YYhyxWQ&cad=rja
- Novitzki, R. P., Smith, R. D., Fretwell, J. D. (1997). Restoration, Creation, and Recovery of Wetlands Wetland Functions, Values, and Assessment. United States Geological Survey Water Supply Paper 2425. <https://water.usgs.gov/nwsum/WSP2425/functions.html>
- Partnership for the Delaware Estuary. (2012). Technical Report for the Delaware Estuary and Basin. PDE Report No. 12-01. pps. 255.
www.delawareestuary.org/science_programs_state_of_the_estuary.asp.
- Schuster, E. and Doerr, P. (2015). A Guide for Incorporating Ecosystem Service Valuation into Coastal Restoration Projects. The Nature Conservancy, New Jersey Chapter. Delmont, NJ, USA.
https://www.conservaiongateway.org/ConservationPractices/Marine/crr/library/Documents/Ecosystem_service_valuation_coastal_restoration_Schuster_Doerr_-_2015.pdf
- Steven Balzano, S., Ertman, A., Brancheau, L., Smejkal, S. (2002). Creating Indicators of Wetland Status (Quantity and Quality): Freshwater Wetland Mitigation in New Jersey. New Jersey Division of Science, Research and Technology. <http://www.state.nj.us/dep/dsr/wetlands/final.pdf>
- Sutton-Grier, A., Wowk, K., Bamford, H. (2015). Future of our coasts: The potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems. *Environmental Science and Policy*, 51: 137-148.

Appendices

Appendix A. Metric Tables

Living Shoreline Metric Table			
Class	Metric categories	Method options	Additional user considerations
Core	Position of living shoreline structure AND Lateral Position of Shoreline (i.e., horizontal change, erosion)	RTK GPS (m/y)	Technical expertise; cost/expense; specialized equipment
		Aerial photograph (m/y)	Technical expertise; temporal requirements; cost/expense; specialized equipment
		Surveying Instrument (barcode leveling)	Technical expertise; cost/expense; specialized equipment
		Distance from installed post or perm structure	Suited for all user groups
		LiDAR	Technical expertise; cost/expense; specialized equipment
	Vegetation Structure	Horizontal vegetative obstruction	Temporal requirements; specialized equipment
		Vertical light attenuation	Temporal requirements; specialized equipment
		Cover per m2	Suited for all user groups; temporal requirements
		Number of stems per m2	Temporal requirements; collection time investment
	Structural integrity of materials (e.g. how well is the breakwater holding together)	Observation	Suited for all user groups
Photograph (fixed point)		Suited for all user groups	
Conditional	Sediment capture/ accretion	Sedimentation disc/tile/plate/ marker horizon	Cost/expense (for some methods); temporal requirements; specialized equipment (for some methods)
		Measuring stick	Suited for all user groups
	Wave energy or height and amplitude (wind/wake)	Gauges and Buoys (e.g., Acoustic Doppler Current Profilers)	Technical expertise; cost/expense; collection time investment; specialized equipment
		Water level loggers	Technical expertise; cost/expense; temporal requirements; specialized equipment
		Graduated rod	Temporal requirement; collection time investment
		Plaster or gypsum ball/ clod card dissolution	Technical expertise; temporal requirements; collection time investment; specialized equipment
	Vegetation Productivity	Biomass (above and/or belowground)	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
	Vegetation Community Composition	List of species found at site	Suited for all user groups; temporal requirements
	Nuisance species	Cover per m2, Stem counts per m2, or presence/absence	Suited for all user groups; temporal requirements

Living Shoreline Metric Table (continued)				
Conditional (continued)	Nuisance species (cont.)	Observation of grazing or other disturbance	Suited for all user groups	
	Debris	Observation	Suited for all user groups	
	Target species (e.g. Oysters...)	See habitat/ biodiversity goal table		
	Elevation (i.e. Vertical change): of the shoreline	RTK GPS (m/y)		Technical expertise; cost/expense; specialized equipment
		Lidar		Technical expertise; cost/expense; specialized equipment
		Laser level height relative to position on permanent post or other structure		Cost/expense; specialized equipment
		Thermal imaging		Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		Surveying Instrument (barcode leveling)		Technical expertise; cost/expense; specialized equipment
	Foreshore slope	RTK GPS (m/y)		Technical expertise; cost/expense; specialized equipment
		Lidar		Technical expertise; cost/expense; specialized equipment
		Laser level height relative to position on permanent post or other structure		Cost/expense; specialized equipment
		Thermal imaging		Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		Surveying Instrument (barcode leveling)		Technical expertise; cost/expense; specialized equipment
	Planted species (e.g. Mussels or vegetation)	Percent survival (of all if small area or quadrat samples if large area)		Suited for all user groups
	Socioeconomic	Difference in cost between hardened structure and a living shoreline (\$)	Data collection method: Project budgets and existing data sources; Analysis method: substitute cost method	Technical expertise and specialized software needed. <i>If using a BACI design</i> , may require a large collection time investment (need to wait several years to have enough weather events to compare changes in damage per storm over time).
Cost-effectiveness of structure for shoreline stabilization (rate of erosion reduction per unit cost)		Data collection method: Project budgets; Analysis method: Cost effectiveness analysis	Technical expertise and specialized software needed. <i>If using a BACI design</i> , may require a large collection time investment (need to wait several years to have enough weather events to compare changes in damage per storm over time).	
Number of homes or structures benefitting (#)		Data collection methods: visual assessment or GIS analysis	Some technical expertise needed; may require additional collection time.	
Public awareness of living shorelines		Data collection methods: Surveys; focus group meetings; Analysis methods: NA	Note that the value placed on individual experience represents the <i>social value</i> of the visitor experience, or the value <i>beyond</i> the actual amount spent. Some technical expertise needed; may require additional collection time.	

Tidal Wetland Restoration or Enhancement Metric Table			
Class	Metric categories	Method options	Additional user considerations
Core	Elevation	Rtk gps	Technical expertise; cost/expense; specialized equipment
		Surface elevation table	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		Surveying Instrument (barcode leveling)	Technical expertise; cost/expense; specialized equipment
		Lidar	Technical expertise; cost/expense; specialized equipment
		Laser level height relative to position on permanent post or other structure	Suited for all user groups
	Vegetation structure	Horizontal vegetative obstruction	Temporal requirements; specialized equipment
		Vertical light attenuation	Temporal requirements; specialized equipment
		Cover per m2	Suited for all user groups; Temporal Requirements
		Stem heights	Collection time investment; temporal requirements
		Number of stems per m2	Collection time investment; temporal requirements
		Habitat Type %, 50m Radius (e.g., High marsh, low marsh, invasives, pannes and pools etc.)	Collection time investment; temporal requirements
Vegetation community composition and diversity	List of species (plants)	Suited for all user groups, Temporal Requirements	
Conditional	Hydroperiod (i.e. Flood duration)	Water level loggers	Technical expertise; cost/expense; temporal requirements; specialized equipment
	Vegetation productivity	Biomass (above and/ or belowground)	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		Photograph (fixed point)	Suited for all user groups; Temporal Requirements
		Plant tissue nutrient analysis (C/N)	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
	Vegetation productivity (cont.)	LANDSAT/infrared imagery	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		Number of stems per m2 and stem height of dominant species	Suited for all user groups; Temporal Requirements; Collection Time Investment
	Sediment capture (e.g. Capture, accretion)	Sedimentation disc/tile/ feldspar marker horizon	Cost/Expense (for some methods); Temporal Requirements; Specialized Equipment (for some methods)
		Measuring stick	Suited for all user groups

Tidal Wetland Restoration or Enhancement Metric Table (continued)			
Conditional (continued)	Sediment supply (e.g. TSS)	Filtration	Technical expertise; cost/expense; temporal requirements; specialized equipment
		Turbidity meter	Cost/expense; specialized equipment
		Secchi disc	Suited for all user groups
	Erosion rate/ shoreline position	RTK GPS (m/y)	Technical expertise; cost/expense; specialized equipment
		Aerial photograph (m/y)	Technical expertise; temporal requirements; cost/expense; specialized equipment
		Surveying Instrument (barcode leveling)	Technical expertise; cost/expense; specialized equipment
		Distance from installed post or permanent structure to shoreline (m/y)	Suited for all user groups
		Lidar	Technical expertise; cost/expense; specialized equipment
		Aerial photographs (GIS analysis)	Technical expertise; temporal requirements; cost/expense; specialized equipment
	Foreshore slope	RTK GPS (m/y)	Technical expertise; cost/expense; specialized equipment
		Lidar	Technical expertise; cost/expense; specialized equipment
		Laser level height relative to position on permanent post or other structure	Cost/expense; specialized equipment
		Filtration	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		Surveying Instrument (barcode leveling)	Technical expertise; cost/expense; specialized equipment
	Drainage density/ position	Aerial photographs (GIS analysis)	Technical expertise; temporal requirements; cost/expense; specialized equipment
		Rtk gps	Technical expertise; cost/expense; specialized equipment
	Survival of planted species	Percent survival (all if small area or quadrat samples if large area)	Suited for all user groups
	Nuisance species (e.g. Invasives, herbivory)	Cover per m2, number of stems per m2, or presence/absence	Suited for all user groups; Temporal Requirements
		Observation of grazing and other disturbance	Suited for all user groups; Temporal Requirements
	Debris	Observation	Suited for all user groups
Target habitat: salinity	Refractometer	Specialized equipment	
	Meter (total dissolved solids)	Cost/expense/ specialized equipment	

Tidal Wetland Restoration or Enhancement Metric Table (continued)			
Socioeconomic	Damage costs avoided to surrounding homes (\$)	Data collection method: Surveys; existing data sources; Analysis method: Avoided cost method; HAZUS modeling or other modeling that simulates changes in flood levels	Technical expertise and specialized software needed. <i>If using a BACI design</i> , may require a large collection time investment (need to wait several years to have enough weather events to compare changes in damage per storm over time).
	Damage costs avoided to surrounding structures, roads or other public infrastructure (\$)	Data collection method: Surveys; existing data sources; Analysis method: Avoided cost method; HAZUS modeling or other modeling that simulates changes in flood levels	Technical expertise and specialized software needed. <i>If using a BACI design</i> , may require a large collection time investment (need to wait several years to have enough weather events to compare changes in damage per storm over time).
	Spending by birders (\$)	Data collection methods: surveys; existing data sources; Data analysis methods: Economic impact assessment	Some technical expertise needed; may require additional collection time.
	Value of visitors place on the improved water quality (boaters, anglers, beach visitors, etc.) (\$)	Data collection methods: surveys; existing data sources; Data analysis methods: Contingent valuation or choice experiment	Note that the value placed on individual experience represents the <i>social value</i> of the visitor experience, or the value <i>beyond</i> the actual amount spent. Some technical expertise needed; may require additional collection time.

Goal: Erosion Control Metrics Table			
Class	Metric categories	Method options	Additional User Considerations
Core	Lateral position or shoreline or Erosion (i.e., horizontal change) of the shoreline (m/year)	RTK GPS	Technical expertise; cost/expense; specialized equipment
		Aerial photograph	Technical expertise; cost/expense; specialized equipment
		Lidar	Technical expertise; cost/expense; specialized equipment
		Surveying Instrument (barcode leveling)	Technical expertise; cost/expense; specialized equipment
		Distance from permanent post of other structure to shoreline	Suited for all user groups
	Elevation of shoreline (m/year)	Rtk gps	Technical expertise; cost/expense; specialized equipment
		Lidar	Technical expertise; cost/expense; specialized equipment
		Surveying Instrument (barcode leveling)	Technical expertise; cost/expense; specialized equipment
		Laser level height relative to position on permanent post or other structure	Cost/expense; specialized equipment
	Foreshore slope	Rtk gps	Technical expertise; cost/expense; specialized equipment
Lidar		Technical expertise; cost/expense; specialized equipment	

Goal: Erosion Control Metrics Table (continued)			
Core (continued)	Foreshore slope (cont.)	Laser level height relative to position on permanent post or other structure	Cost/expense; specialized equipment
		Thermal imaging	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		Surveying Instrument (barcode leveling)	Technical expertise; cost/expense; specialized equipment
Conditional	Accretion (m/year)	Sedimentation disc/tile/plate/ marker horizon	Cost/Expense (for some methods); temporal requirements; specialized equipment (for some methods)
		Measuring stick	Suited for all user groups
	Wave energy or height and amplitude (wind/wake)	Gauges and buoys (e.g., acoustic doppler current profilers for wave energy and stream/ creek flow)	Technical expertise; cost/expense; collection time investment; specialized equipment
		Water level loggers	Technical expertise; cost/expense; temporal requirements; specialized equipment
		Graduated survey rod	Temporal requirement; collection time investment
		Plaster or gypsum ball/ clod card dissolution	Technical expertise; temporal requirements; collection time investment; specialized equipment
	Vegetation Structure	Horizontal vegetative obstruction	Temporal requirements; specialized equipment
		Vertical light attenuation	Temporal Requirements; Specialized Equipment
		Cover per m2	Suited for all user groups; Temporal Requirements
		Number of stems per m2	Temporal Requirements; Collection Time Investment
	Vegetation Productivity	Biomass (above and/ or belowground)	Technical Expertise; Temporal Requirements; Collection Time Investment; Cost/Expense; Specialized Equipment

Goal: Erosion Control Metrics Table (continued)			
Potential socioeconomic metrics	Change in property value due to reduction in rate of erosion (\$)	Data collection method: Existing data sources; Analysis method: Hedonic valuation	Technical expertise needed.
	Difference in cost between hardened structure (e.g. bulkhead) and a living shoreline (\$)	Data collection method: Project budgets and existing data sources; Analysis method: substitute cost method	Little technical expertise required; this method is suited for most user groups.
	Number of homes or structures benefitting (#)	Data collection methods: visual assessment or GIS analysis; Analysis method: NA	Suited for all user groups. Note that this metric only shows number, not the magnitude of the benefit.

Goal: Habitat/ Biodiversity Enhancement Metrics Table			
Class	Metric categories	Method options	Additional user considerations
Core	Vegetation community composition and diversity	List species found at site (plants)	Suited for all user groups; temporal requirements
	Vegetation Structure	Horizontal light obstruction	Temporal requirements; specialized equipment
		Vertical light attenuation	Temporal requirements; specialized equipment
		Cover per m2 (for each plant species or total cover by plant species)	Suited for all user groups; temporal requirements
		Stem heights of dominant species	Temporal requirements; collection time investment
		Number of stems per m2	Temporal requirements; collection time investment
		Habitat Type %, 50m Radius (e.g., High marsh, low marsh, invasives, pannes and pools etc.)	Temporal requirements; collection time investment
Photographs (fixed point)	Suited for all user groups; temporal requirements		
Conditional	Target species for restoration (e.g. black duck or oysters) or biodiversity	Observations (e.g., horseshoe crabs, terrapins)	Suited for all user groups; temporal requirements
		Biomass (wet weight or dry weight/ m2) (e.g., plants, nekton, mussels)	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment; permitting requirements
		Cover per m2 or # per m2 (e.g., percent cover of SAV, # of fiddler crab boroughs, # of fish in a sample, Ribbed mussel lip counts)	Suited for all user groups; temporal requirements

Goal: Habitat/ Biodiversity Enhancement Metrics Table (continued)			
Conditional (cont.)	Target species for restoration (e.g. black duck or oysters) or biodiversity (cont.)	Morphometric (e.g., length of nekton or oysters)	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment; permitting requirements
		Health (e.g., condition index, of bivalves)	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment; permitting requirements
		List of species found at site (e.g., nekton or benthic infauna)	Suited for all user groups; temporal requirements
		Recruitment (e.g., oysters)	Suited for all user groups; temporal requirements
		Feeding and breeding behavior (for avian target species)	Technical expertise; temporal requirements; collection time investment; permitting requirements
	Soil texture	Grain size and soil type analysis	Technical expertise; collection time investments; cost/expense; specialized equipment
	Belowground stability	Shear vane strength	Technical expertise; cost/expense; specialized equipment
		Bearing capacity	Specialized equipment
	Vegetation productivity	Photograph (fixed point)	Suited for all user groups; temporal requirements
		Plant tissue nutrient analysis (C/N)	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		LANDSAT/infrared imagery	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		Biomass (above and/or belowground)	Technical expertise; temporal requirements; collection time investment; cost/expense; specialized equipment
		Number of stems per m2 and stem height of dominant species	Collection time investment; temporal requirements
	Salinity	Refractometer	Specialized equipment
		Meter (total dissolved solids)	Cost/expense; specialized equipment
	Dissolved oxygen	Meter (total dissolved oxygen)	Cost/expense; specialized equipment
	Area of habitat	GPS	Cost/expense; specialized equipment
		Aerial photography	Technical expertise; temporal requirements; cost/expense; specialized equipment
	Nuisance species	Number of stems per m2	Collection time investment; temporal requirements
		Cover per m2	Suited for all user groups; Temporal Requirements
Presence/absence		Suited for all user groups; Temporal Requirements	

	Inhibition of fauna movement	Observations	Suited for all user groups; Temporal Requirements
Goal: Habitat/ Biodiversity Enhancement Metrics Table (continued)			
Potential socioeconomic metrics	Economic impact of ecotourism (\$)	Data collection methods: surveys; existing data sources; Data analysis methods: IMPLAN or other regional economic modeling, such as input/output models	Technical expertise and specialized software needed; only relevant for large enough projects to have a meaningful impact; if existing data sources are not available, may require additional collection time.
	Spending by birders (\$)	Data collection methods: surveys; existing data sources; Data analysis methods: Economic impact assessment	Some technical expertise needed; may require additional collection time.
	Revenues for commercial fisherman (\$)	Data collection methods: surveys; interviews; existing data sources; Data analysis methods: Partial budget analysis	Some technical expertise needed; only relevant for large enough projects to have a meaningful impact.
	Value visitors to the site place on their experience (\$)	Data collection methods: surveys; existing data sources; Data analysis methods: Contingent valuation or choice experiment	Note that the value placed on individual experience represents the <i>social value</i> of the visitor experience, or the value <i>beyond</i> the actual amount spent. Some technical expertise needed; may require additional collection time.
	Number of students benefiting from environmental education/research (#)	Data collection methods: Surveys; Focus group meetings; Tracking with a log; Data analysis methods: NA	Suited for all user groups.

Goal: Water Quality Metrics Table			
Class	Metrics: Target water quality parameter- select one or more based on project goals	Method options	Additional user considerations
Conditional	Dissolved Oxygen	Meter (DO)	Cost/expense; specialized equipment
		Titration kit	Cost/expense; specialized equipment
		Winkler titration	Technical expertise; cost/expense; temporal requirements; specialized equipment
	Turbidity	Meter (turbidity)	Cost/expense; specialized equipment
		Clarity tube	Suited for all user groups
		Secchi disc	Suited for all user groups
Sediment supply / total suspended solids	Filtration	Technical expertise; cost/expense; temporal requirements; specialized equipment	

	Nutrients nitrate, nitrite, ammonia	Filtration (lab tests TKN, etc.)	Technical expertise; cost/expense; temporal requirements; specialized equipment
Goal: Water Quality Metrics Table (continued)			
Conditional (continued)	Nutrients nitrate, nitrite, ammonia (cont.)	Laboratory Analysis	Technical expertise; cost/expense; temporal requirements; specialized equipment
		Colorimeter	Technical expertise; cost/expense; temporal requirements; specialized equipment
	Water - bacteria	Lab analysis (CFUs)	Technical expertise; cost/expense; temporal requirements; specialized equipment
	Nutrients: phosphates	Lab analysis	Technical expertise; cost/expense; temporal requirements; specialized equipment
	Ph	Titration kits	Cost/expense; specialized equipment
		Colorimeter	Cost/expense; specialized equipment
		Meter (pH)	Specialized equipment
	Salinity	Refractometer	Specialized equipment
		Meter (total dissolved solids)	Cost/expense; specialized equipment
	Algal bloom	Chl a tests (lab or sensor)	Technical expertise; cost/expense; temporal requirements; specialized equipment
	Water BOD	Dilution method EPA method 5210B	Technical expertise; cost/expense; temporal requirements; specialized equipment
Pollutants	Manometric method	Technical expertise; cost/expense; temporal requirements; specialized equipment	
Temperature	Meter	Cost/expense; specialized equipment	
	Thermometer	Suited for all user groups	
Potential socioeconomic metrics	Number of beach closing days (#)	Data collection method: existing data sources; analysis method: NA	Suited for all user groups.
	Value of visitors place on the improved water quality (boaters, anglers, beach visitors, etc.) (\$)	Data collection methods: surveys; existing data sources; data analysis methods: contingent valuation or choice experiment	The value placed on individual experience represents the <i>social value</i> of the visitor experience, or the value <i>beyond</i> the actual amount spent. Some technical expertise needed; may require additional collection time.
	Number of shellfisheries closing days (#)	Data collection method: existing data sources; analysis method: NA	Suited for all user groups.
	Delisting of a waterway from EPA 303d	Data collection method: existing data sources; analysis method: NA	Suited for all user groups. Note that this metric will only be relevant for large enough projects that would have a quantifiable impact on water quality.

Change in property value due to water clarity improvements (\$)	Data collection method: existing data sources; analysis method: hedonic valuation	Technical expertise needed. Note that this metric will only be relevant for large enough projects that would have a quantifiable impact on water quality.
---	---	---

Goal: Hydrological Enhancement Metrics Table

Class	Metrics	Method options	Additional user considerations	
Core	Stream flow	Flowmeter	Technical expertise; cost/expense; temporal requirements; specialized equipment	
		Gauges and Buoys (e.g., Acoustic Doppler Current Profilers)	Technical expertise; cost/expense; collection time investment; specialized equipment	
	Creek/channel morphometry	Aerial Photography or satellite imagery	Technical expertise; temporal requirements; cost/expense; specialized equipment	
		Survey instrument (barcode leveling)	Technical expertise; cost/expense; specialized equipment	
		RTK GPS transects	Technical expertise; cost/expense; specialized equipment	
Conditional	Hydroperiod	Water level loggers	Technical expertise; cost/expense; temporal requirements; specialized equipment	
	Sediment supply (e.g., TSS)	Meter (turbidity)	Cost/expense; specialized equipment	
		Secchi disc	Suited for all user groups	
		Filtration	Technical expertise; cost/expense; temporal requirements; specialized equipment	
	Sediment capture/ accretion	Sedimentation disc/tile/plate/ marker horizon	Cost/expense (for some methods); temporal requirements; specialized equipment (for some methods)	
		Measuring stick	Suited for all user groups	
	Salinity	Refractometer	Specialized equipment	
		Meter (total dissolved solids)	Cost/expense; specialized equipment	
	Dissolved oxygen	Meter (total dissolved solids)	Cost/expense; specialized equipment	
	Vegetation community composition	List of plant species in site	Suited for all user groups; temporal requirements	
	Vegetation structure	Horizontal vegetative obstruction	Horizontal vegetative obstruction	Temporal requirements; specialized equipment
			Vertical light attenuation	Temporal requirements; specialized equipment
		Cover per m2	Suited for all user groups; temporal requirements	
		Number of stems per m2	Collection time investment; temporal requirements	
		Stem heights	Collection time investment; temporal requirements	

		Habitat Type %, 50m radius (e.g., high marsh, low marsh, invasives, pannes & pools etc.)	Collection time investment; temporal requirements
Goal: Hydrological Enhancement Metrics Table (continued)			
Potential socioeconomic metrics	Damage costs avoided to surrounding structures, roads or other public infrastructure (\$)	Data collection method: Surveys; existing data sources; Analysis method: Avoided cost method; HAZUS modeling or other modeling that simulates changes in flood levels	Technical expertise and specialized software needed. <i>If using a BACI design</i> , may require a large collection time investment (need to wait several years to have enough weather events to compare changes in damage per storm over time).
	Number of homes or structures benefitting (#)	Data collection methods: visual assessment or GIS analysis	Suited for all user groups. Note that this metric only shows number, not the magnitude of the benefit.
	Number of days per month that road is flooded (#)	Data collection method: Surveys; existing data sources; Analysis method: Modeling that simulates changes in flood levels	Some technical expertise required. Note that this metrics shows only the number of days, not the number of people benefitting.
	Change in property value due to decrease in flood risk (\$)	Data collection method: Existing data sources; Analysis method: Hedonic valuation	Technical expertise needed.

Goal: Socioeconomic Metrics Table			
Class	Metric categories	Method options	Additional user considerations
Community resilience	Damage costs avoided to surrounding structures, roads or other public infrastructure (\$)	Data collection method: surveys; existing data sources; analysis method: avoided cost method; HAZUS modeling or other modeling that simulates changes in flood levels	Technical expertise and specialized software needed. <i>If using a BACI design</i> , may require a large collection time investment (need to wait several years to have enough weather events to compare changes in damage per storm over time).
	Damage costs avoided to surrounding homes (\$)	Data collection method: surveys; existing data sources; analysis method: avoided cost method; HAZUS modeling or other modeling that simulates changes in flood levels	Technical expertise and specialized software needed. <i>If using a BACI design</i> , may require a large collection time investment (need to wait several years to have enough weather events to compare changes in damage per storm over time).
	Value of time saved by individuals driving on a road where flooding is reduced (\$)	Data collection method: surveys; existing data sources; analysis method: avoided cost method	Technical expertise required; specialized software may be needed, depending upon if hydrological modeling is used to supplement the analysis.
	Change in property value due to decrease in flood risk (\$)	Data collection method: existing data sources; analysis method: hedonic valuation	Technical expertise needed.
	Difference in cost between hardened structure (e.g. bulkhead) and a living shoreline (\$)	Data collection method: project budgets and existing data sources; analysis method: substitute cost method	Little technical expertise required; this method is suited for most user groups.
	Number of homes or structures benefitting (#)	Data collection methods: visual assessment or GIS analysis	Suited for all user groups. Note that this metric only shows number, not the magnitude of the benefit.
	Change in property value due to reduction in rate of erosion (\$)	Data collection method: existing data sources; analysis method: hedonic valuation	Technical expertise needed.
Recreation and tourism	Spending by birders, boaters or anglers (\$)	Data collection methods: surveys; existing data sources; data analysis methods: economic impact assessment	Some technical expertise needed; may require additional collection time.
	Number of visitors to the restoration site (#)	Data collection methods: car counter; surveys; geospatially referenced social media methodology; analysis methods: NA	Suited for all user groups. Note that this metric only shows number, not the magnitude of the benefit.
Water quality	Number of shellfisheries closing days (#)	Data collection method: existing data sources; analysis method: NA	Suited for all user groups. Note that this metric will only be relevant for large enough projects that would have a quantifiable impact on water quality.

Appendix B. Description of metrics

Algal Bloom (Biological): Describes the presence or quantity of algal blooms. This metric can be used as a proxy indicator for nutrient enrichment in water.

Belowground stability (physical): Describes the below-ground stability of the wetland. The wetland substrate can become less firm due to natural and anthropogenic influences that decrease below-ground organic material and soil bearing capacity. Reduced below-ground organic material can be a good indicator of stress. Reduced belowground stability can make the marsh more susceptible to erosion.

Change in property value due to decrease in flood risk (\$) (Socioeconomic): Through a method called hedonic valuation, shows the portion of the property value that is influenced by flood risk and describes how that portion of the property value changes with a change in flood risk. This metric is more likely to be applicable if there are a sufficient number of homes within the zone influenced by the marsh.

Change in property value due to reduction in rate of erosion (\$) (Socioeconomic): Through a method called hedonic valuation, shows the portion of the property value that is influenced by rate of erosion at the parcel edge and describes how that portion of the property value changes with a change in erosion rate. This metric is more likely to be applicable if there are a sufficient number of homes benefitting from the erosion reduction benefits of the project.

Change in property value due to water clarity improvements (\$) (Socioeconomic): Through a method called hedonic valuation, shows the portion of the property value that is influenced by water clarity and describes how that portion of the property value changes with a change in water clarity. This metric is more likely to be applicable if there are a sufficient number of projects taking place in the bay that quantifiable changes in water clarity are likely to result and if there are a sufficient number of homes benefitting in the region surrounding the project site.

Cost-effectiveness of structure for shoreline stabilization (rate of erosion reduction per unit cost) (Socioeconomic): Cost-effectiveness is the calculation of the change in a benefit over the total project cost to give a benefit per unit cost. In this example, the benefit is the change in the rate of erosion, and cost-effectiveness may be compared to a hardened structure such as a bulkhead.

Creek/Channel Morphometry (Physical): Describes the shape and size of specific creeks and channels, including: slope from banks to trough center. This metric can be used to measure creek/channel changes in drainage capacity and creek erosion.

Currents (Physical): Describes properties related to the flow of water, including spatial and temporal variability related to direction, rate, and stratification.

Damage costs avoided to surrounding homes (\$) (Socioeconomic): Describes the change in damages costs to homes as a result of lower levels of flooding (and not due to raising homes or other structural changes), taking into consideration equivalent level weather variables (e.g. precipitation). This metric is more likely to be relevant when resources are available to conduct a more rigorous analysis and if there are a sufficient number of homes within the zone influenced by the marsh.

Damage costs avoided to surrounding structures, roads or other public infrastructure (\$) (Socioeconomic):

Describes the change in damages costs to structures, roads or other public infrastructure as a result of lower levels of flooding (and not due to raising homes or other structural changes), taking into consideration equivalent level weather variables (e.g. precipitation). This metric is more likely to be relevant when resources are available to conduct a more rigorous analysis and if there are a sufficient number of structures or other infrastructure within the zone influenced by the marsh

Debris (e.g. trash capture) (Physical): Describes the presence, change in density, or impact of debris and wrack on a restoration project. This metric can be used to determine whether management of debris in the project area is warranted.

Delisting of a waterway from EPA 303d (Socioeconomic): Describes the action of a waterway being delisted for a single pollutant due to the water quality of that waterway meeting or going below the EPA maximum amount. This metric is likely to be most relevant for larger-scale restoration projects, or a salt marsh restoration or living shoreline project that is in conjunction with a series of other actions to improve water quality in a bay or estuary.

Difference in cost between hardened structure (e.g. bulkhead) and a living shoreline (\$) (Socioeconomic): Using the substitute cost method, this metric shows the difference in cost between the living shoreline and a hardened alternative such as a bulkhead, assuming equivalent level of functionality for both options. Typically the calculation includes both construction and maintenance costs over the long-term (i.e. 25 or 50 years).

Drainage density/ position (Physical): Describes density of drainage creeks sometimes in relation to other features of interest, including upland habitats, main channel edge, and infrastructure. This metric can be used to evaluate larger scale marsh characteristics, including duration of flooding, changes in vegetated area, and sediment/nutrient inputs.

Economic impact of ecotourism (\$) (Socioeconomic): Describes the economic impact from increased spending by visitors in the ecotourism segment of the tourism market, as a result of ecological restoration project(s). This metric is more likely to be relevant for projects with a site access component, projects implemented in conjunction with an ecotourism strategy led by local partners, and/or for cases where projects are large enough to have a direct impact on ecotourism (for instance through the quantifiable increase in bird abundance or diversity).

Elevation (vertical change) (Physical): Describes the relative (e.g. tidal prism) or specific (e.g. datum) vertical position of a feature of interest (e.g., marsh platform, shoreline edge, shellfish). This metric can be used when project targets are elevation dependent.

Foreshore Slope (Physical): Describes the gradient of elevation running perpendicular to a living shoreline or wetland edge. This metric can be used to evaluate changes in the foreshore as a result of project implementation, or to assess the effects of different physical conditions on the success or persistence of a project type.

Hydroperiod (Physical): Describes the frequency and duration of flooding in a marsh or other area of interest. This metric can be used to evaluate habitat suitability or erosion/drowning potentials. Hydroperiod can be either relative to the tidal prism or specific to a tidal datum.

Inhibition of fauna movement: Describes the interruption of wildlife movement by materials used in a restoration project (e.g., rock sills may prevent the fish and crabs from swimming between water and land). This metric should be used at all projects that involve the addition of structural materials, including those used for construction of living shorelines and hardened structures, as well as temporary equipment used for monitoring measurements.

Lateral Position or Erosion (i.e., horizontal change) (Physical): Describes the latitudinal and longitudinal position of the shoreline (defined as either the water ward line of vegetation or the continuous defining edge feature ,e.g., front terrace, mussel line, etc.) or of a living shoreline structure (e.g., oyster reef breakwater. This metric can be used to measure the horizontal marsh movement rate (i.e. erosion or accretion).

Nutrients (Chemical): Describes the concentration of nutrients (e.g., Nitrate, nitrite, ammonia, phosphate) in soils, vegetation, or water. This metric can be used to evaluate changes in water/soil quality or the uptake/utilization by plants. It can also be used to evaluate the effect of a treatment type on point source pollution.

Number of beach closing days (#) (Socioeconomic): Describes the change in number of days in which beaches used for swimming are closed as a result of changes in water quality. This metric is likely to be most relevant for larger-scale restoration projects, or a salt marsh restoration or living shoreline project that is in conjunction with a series of other actions to improve water quality in a bay or estuary.

Number of days per month that road is flooded (#) (Socioeconomic): Describes the change in number of days per month that a road adjacent to a restored marsh is flooded as a result of lower levels of flooding, taking into consideration equivalent level precipitation and storm surge. This metric is more likely to be applicable if there are roads within the zone influenced by the marsh.

Number of homes or structures benefitting (#) (Socioeconomic): Describes the number of homes or structures that are located within the marsh-influenced zone and thus are benefitting from the marsh due to the flood reduction services provide from the restoration OR to the number of homes or structures directly benefitting from the erosion reduction benefits of a living shoreline project. This metric is only relevant to projects with expected flood reduction or erosion reduction benefits.

Number of shellfisheries closing days (#) (Socioeconomic): Describes the change in number of days in which shellfisheries (e.g. oyster fisheries) are closed as a result of changes in water quality. This metric is likely to be most relevant for larger-scale restoration projects, or a salt marsh restoration or living shoreline project that is in conjunction with a series of other actions to improve water quality in a bay or estuary.

Number of students benefiting from environmental education/research (#) (Socioeconomic): Describes the number of students directly benefitting from environmental education at the restoration site or involved in research directly linked to some aspect of the restoration project. This metric may apply to students of all ages and levels and is only applicable for projects where there exists a strong link to environmental education programs or research.

Number of visitors to the restoration site (#) (Socioeconomic): Describes the change in number of visitors to a restoration site due to the restoration project. The reason for the increase in visitation may be due to the improvement in aesthetics or site access, increase in the abundance or diversity of birds, improvement in water quality, and/or increase in number of fish caught; only applicable to projects with a public access point within or

in close proximity to the site.

Nuisance species (e.g. invasive, herbivory) (Biological): Describes the presence, change in density, or impact of nuisance species. This metric can be used determine whether management of invasive species like *Phragmites australis* or installation of goose fencing to prevent new plantings from being eaten is needed.

Other target pollutants (Chemical): Describes the concentrations of a specific pollutant in soils, vegetation, or water. This metric can be used to evaluate changes in concentration over time and can be used to evaluate the effect of a treatment type on point source pollution.

pH (Chemical): Describes the acidity or alkalinity in soils or water. This metric can be used to evaluate changes in overtime in relation to water/soil quality.

Planted species (e.g. mussels or vegetation) (Biological): Describes fate of planted/relocated species into a restoration site including, but not limited to, vegetation and shellfish. This metric can be used to describe survivorship of transplants.

Position of Structure (Physical): Describes the lateral and/or vertical position of structural materials used in the restoration project (e.g., biologs, breakwaters, shell bags, etc.). This metric is used to evaluate whether or not the structure is maintaining the shape and position needed to meet the project goals and can inform the need for maintenance.

Public awareness of living shorelines (Socioeconomic): Describes the level of public awareness of the term “living shorelines.” Typically, the awareness is gauged through administration of surveys, polls or through focus groups, and can include questions on perceived benefits and perceived effectiveness of living shorelines.

Revenues for commercial fisherman (\$) (Socioeconomic): Describes the change in revenues for commercial fisherman due to the increase in number or quality of fish harvested. Only applies to fish species which directly benefit from salt marshes (e.g. blue crabs), or who prey upon species directly benefiting from salt marshes.

Salinity (Chemical): Describes the concentration of dissolved salts in water. This metric can be used to evaluate changes in these levels over time in relation to water quality, habitat suitability, or saltwater intrusion. Salinity is typically measured in grams of salt per one kilogram of water.

Sediment capture/ accretion (Physical): Describes either the volume or depth of sediment deposited in the project site either naturally or as a result of a restoration action. This metric can be used measure changes in elevation due to the deposition of sediment on projects aiming to enhance elevation.

Sediment supply (e.g. TSS) (Physical): Describes the concentration of suspended material in the water column (mg/L). This metric can be used to evaluate water quality, habitat suitability, or material available to accrete naturally within project sites.

Shoreline slope (Physical): Describe the changes in elevation between the water bottom and the shoreline. This metric is useful for tracking changes to the shoreline caused by erosion and accretion.

Soil texture (physical): Describes the relative proportion of sand, silt, and clay sized particles present within a soil. Soil texture will affect how quickly a site drains, how easy it will be for vegetation to establish, and often the bearing capacity of the ground.

Stream flow (Physical): Describes the velocity of water movement within a stream or creek. This metric can be used to evaluate the transport ability of a drainage creek/stream.

Structural integrity of materials (Physical): Describes the ability of materials used for restoration to withstand environmental forces overtime. This metric should be used at all restoration sites that involve structural materials, including those used for construction of living shorelines and hardened structures. This metric is used to evaluate the ability of the material to function overtime and withstand environmental forces such as storms and icing, which can inform the need for maintenance.

Spending by birders, boaters or anglers (\$) (Socioeconomic): Describes the change in spending at restaurants, hotels, or other stores, from birders, boaters or anglers to the restoration site as a result of the restoration project. The reason for the increase in visitation may be due to the improvement in aesthetics or site access, increase in the abundance or diversity of birds, improvement in water quality, and/or increase in number of fish caught; only applicable to projects with a public access point within or in close proximity to the site.

Surrounding land use (Physical): Describes land use/land cover of areas neighboring or surrounding the restoration project. This metric is used to evaluate changes that coincide with the restoration.

Target habitat (Biological): Describes changes in the extent, type, or quality of a habitat as a result of a restoration. This metric can be used when a specific habitat is targeted for the restoration project, in some cases because the habitat provides food or shelter for a species of interest (target species).

Target species (Biological): Describes the change in number, spatial extent, natural recruitment, or health of a species in the restorations site. This metric can be used when enhancement of a specific species is a goal of the restoration project.

Temperature (Physical): Describes the temperature of water, air, soil, etc. This metric can be used to evaluate habitat suitability.

Value of time saved by individuals driving on a road where flooding is reduced (\$) (Socioeconomic): Describes the value placed by individuals on their time saved due to a reduction in flooding on a road due to a restoration project. This metric does not represent spending by individuals, but rather, the *value* that individual places on their time and/or wages that were lost on days in which the road was flooded prior to the restoration. This metric is more likely to be applicable if there are roads within the zone influenced by the marsh.

Value of visitors place on the improved water quality (boaters, anglers, beach visitors, etc.) (\$) (Socioeconomic): Describes the change in value that visitors to a site place on the experience as a result of the improved water quality. This value does not represent spending, but the value beyond the amount spent. This metric is likely to be most relevant for larger-scale restoration projects, or a salt marsh restoration or living shoreline project that is in conjunction with a series of other actions to improve water quality in a bay or estuary.

Value visitors to the site place on their experience (\$) (Socioeconomic): Describes the change in value that visitors to a site place on the experience as a result of the ecological restoration. This value does not represent spending, but the value beyond the amount spent; only applicable to projects with a public access point within or in close proximity to the site.

Vegetation community composition and diversity (Biological): Lists the plant species that make up the plant communities within a restoration project. This metric can be used to track changes plant native species diversity and habitat types. Plant communities can also be used as a proxy for tidal inundation. This describes what plants are there.

Vegetation Structure (Biological): Describes the relative abundance of plant species within a plant community as well as the vertical and/or horizontal structure of vegetation (either for all species or for each species). This metric can be used to characterize the density or robustness of vegetation at a restoration site. This describes how the plants cover the area - whether the vegetation cover is robust or sparse.

Vegetation Productivity (Biological): Describes the growth rate of vegetation, above and/or below ground biomass, overtime. This metric can be used a number of different ways – as a general indicator of health, lopsided ratios of above to belowground biomass can indicate excessive nutrient input, belowground biomass is important for soil stabilization and accretion, and above ground biomass is important for reducing wave energy. This describes what the vegetation is doing by providing a rate of plant production.

Water - Bacteria (Biological): Describes the presence or quantity of bacteria in the water. This is often used

Water Biological Oxygen Demand (Chemical): Describes the amount of dissolved oxygen needed to maintain decomposition processes without promoting hypoxic or anoxic conditions. This metric is used to assess water quality and habitat parameters necessary to sustain healthy waters.

Water Dissolved Oxygen (Chemical): Describes the amount of dissolved oxygen present in water. This metric is used to assess water quality and habitat suitability.

Wave energy or height and amplitude (wind/wake) (Physical): Describes physical characteristics of waves. This metric can be used when a reduction of wave energy is a restoration project goal.

Appendix C. Sample Monitoring Outline

Monitoring Plan Title

Project Lead

Date of last edit of the document

Monitoring Personnel

Names and contact information for those developing and executing the monitoring plan

Project Overview

Description of the restoration project design, project site, location, etc,

Project Goals and Objectives

List project goals and provide reasoning for why goals were selected (e.g.: erosion control as goal due to value of infrastructure behind shoreline or value of habitat, etc...).

Monitoring Metrics

- *List monitoring metrics for each project goals (e.g., vegetation percent cover)*
- *Interim targets and target outcomes for each metric (where appropriate)*

Monitoring Design

Spatial design for each metric

of samples will be taken

How sample locations will be chosen

Temporal design for each metric

When sampling will happen

Detailed methods

Field Methods

Data collection

Data management and QA/QC

Data storage

Data analysis

Provide detail on statistical analyses to be performed, any equations or formulas used, and the relationships that will be explored.

Reporting

References

Appendix

Standardized field and lab data sheets

Figures

Map of project site

Map of sampling locations

Appendix D. Citations for More Information on Monitoring Methods

The following are a list of resources for more information on methods listed in the Metrics Tables. This is far from complete. All methods will have to be adapted for each project and when samples will be sent to a lab for analysis, instructions from the lab should be followed rather than any protocols below. Despite these limitations, the resources below will help the user to get an idea of what is involved in collecting and processing data for each method and select the method that is the best fit for their project. Please scroll to the end of the list for resources related to socioeconomic methods.

Aerial photographs

- Smith, S. M. (2009). Multi-decadal Changes in Salt Marshes of Cape Cod, MA: Photographic Analyses of Vegetation Loss, Species Shifts, and Geomorphic Change. *NORTHEASTERN NATURALIST* 16(2):183–208. http://www.nps.gov/caco/learn/nature/upload/Northeastern-Naturalist-Smith-2009_compressed_version.pdf (accessed March 2016)
- TidalMarshMonitoring.org. Habitat: Aerial Photography and Remote Sensing <http://www.tidalmarshmonitoring.org/monitoring-methods-aerial-photography-remote-sensing.php> (accessed March 2016)

Bearing capacity

- Mid-Atlantic Tidal Wetland Rapid Assessment Method Version 3.0 (June 2010) Delaware Department of Natural Resources. http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/Tidal%20Rapid_Protocol%203.0%20Jun10.pdf (accessed March 2016)
- The Partnership for the Delaware Estuary has detailed methods upon request

Biomass

- The Partnership for the Delaware Estuary has detailed methods upon request for above and belowground plant biomass as well as shellfish biomass
- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)

Bivalve demographics, recruitment, health

- The Partnership for the Delaware Estuary has detailed methods upon request
- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring and Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)
- Burrows, F., Harding, J. M., Mann, R., Dame, R., Coen, L. (2005). Chapter 4, Restoration monitoring of oyster reefs, pages 4.2-4.73. In: Thayer, G. W., McTigue, T. A., Salz, R. J., Merkey, D. H., Burrows, F. M., Gayaldo, P. F. (Eds.), *Science-Based Restoration Monitoring of Coastal Habitats, Volume Two: Tools for Monitoring Coastal Habitats*. NOAA Coastal Ocean Program Decision Analysis Series No. 23. NOAA

National Centers for Coastal Ocean Science, Silver Spring, M.D. USA. <http://www.oyster-restoration.org/wp-content/uploads/2012/06/Volume2ch4oys.pdf> (accessed March 2016)

Chlorophyll a

- YSI Tech Note, The Basics of Chlorophyll Measurement
<https://www.yei.com/File%20Library/Documents/Technical%20Notes/T606-The-Basics-of-Chlorophyll-Measurement.pdf> (accessed March 2016)

Clarity tube

- Orhel, R. L., Register, K. M. (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA.
<https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)

Colorimeter

- Orhel, R. L., Register, K. M., (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA.
<https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)

Cover per m2 or # per m2 (e.g., percent cover of vegetation, # of fiddler crab boroughs, # of fish in a sample, ribbed mussel lip counts)

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring and Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)
- Neckles, H.A. and M.Dionne, (eds.) (2000). Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, ME. 21 p. plus appendices. <https://www.pwrc.usgs.gov/resshow/neckles/Gpac.pdf>. (accessed March 2016)
- Orhel, R. L., Register, K. M. (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA.
<https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)
- TidalMarshMonitoring.org has SOPs for monitoring tidal marsh flora and fauna.
<http://www.tidalmarshmonitoring.org/monitoring-methods.php> (accessed March 2016)

Dilution method EPA Method 5210B

- NEMI.gov is a great source for water quality monitoring protocols

Distance from installed post or permanent structure to shoreline (m/y)

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)
- The Partnership for the Delaware Estuary has detailed methods upon request

Feeding and breeding behavior (for avian target species)

- The SOP use by USFWS can be supplied upon request.
- Neckles, H.A. and M.Dionne, (eds.) (2000). Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, ME. 21 p. plus appendices. <https://www.pwrc.usgs.gov/resshow/neckles/Gpac.pdf>. (accessed March 2016)
- TidalMarshMonitoring.org Bird Monitoring Methods <http://www.tidalmarshmonitoring.org/monitoring-methods-birds.php> (accessed March 2016)

Filtration

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)
- The Partnership for the Delaware Estuary has detailed methods upon request

Flow meter

Graduated rod

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)
- Miller, J. K., Rella, A., Williams, A., Sproule, E. (2015). Living Shorelines Engineering Guidelines. Stevens Institute of Technology, Davidson Laboratory Technical Report SIT-DL-14-9-2942, Hoboken, NJ, USA, 101pp. <http://www.nj.gov/dep/cmp/docs/living-shorelines-engineering-guidelines-final.pdf> (accessed March 2016)

Grain size and soil type analysis

- Merkey, D., Burrows, F., McTigue, T., Foret, J. (2005). Chapter 10: Restoration Monitoring Of Coastal Marshes, pages 10.17-10.19. In: G.W., Thayer, T. A. McTigue, R. J. Salz, D. H. Merkey, F. M. Burrows, Gayaldo, P. F.(eds.), Science-Based Restoration Monitoring of Coastal Habitats, Volume Two: Tools for Monitoring Coastal Habitats. NOAA Coastal Ocean Program Decision Analysis Series No. 23. NOAA National Centers for Coastal Ocean Science, Silver Spring, MD, USA. <https://coastalscience.noaa.gov/research/docs/rmv2/Ch10Bundle.pdf> (accessed March 2016)

Gauges and Buoys (e.g., Acoustic Doppler Current Profilers for wave energy and stream/ creek flow)

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)

- Miller, J. K., Rella, A., Williams, A., Sproule, E. (2015). Living Shorelines Engineering Guidelines. Stevens Institute of Technology, Davidson Laboratory Technical Report SIT-DL-14-9-2942, Hoboken, NJ, USA, 101pp. <http://www.nj.gov/dep/cmp/docs/living-shorelines-engineering-guidelines-final.pdf> (accessed March 2016)
- TidalMarshMonitoring.org Hydrology: Flow and Hydrodynamics
<http://www.tidalmarshmonitoring.org/monitoring-methods-hydrology-hydrodynamics-adcp-profile.php> (accessed March 2016)

Habitat Type %, 50m Radius (e.g., High marsh, low marsh, invasives, pannes & pools etc.)

- The SOP used by USFWS can be supplied upon request.

Health

- The Partnership for the Delaware Estuary has detailed methods upon request
- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)
- Burrows, F., Harding, J. M., Mann, R., Dame, R., Coen, L. (2005). Chapter 4, Restoration monitoring of oyster reefs, pages 4.2-4.73. In: Thayer, G. W., McTigue, T. A. , Salz, R. J., Merkey, D. H., Burrows, F. M., Gayaldo, P. F. (eds.), Science-Based Restoration Monitoring of Coastal Habitats, Volume Two: Tools for Monitoring Coastal Habitats. NOAA Coastal Ocean Program Decision Analysis Series No. 23. NOAA National Centers for Coastal Ocean Science, Silver Spring, MD USA. <http://www.oyster-restoration.org/wp-content/uploads/2012/06/Volume2ch4oys.pdf> (accessed March 2016)

Horizontal vegetative obstruction

- Mid-Atlantic Tidal Wetland Rapid Assessment Method Version 3.0 (June 2010) Delaware Department of Natural Resources.
[http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/Tidal%20Rapid Protocol%203.0%20Jun10.pdf](http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/Tidal%20Rapid%20Protocol%203.0%20Jun10.pdf) (accessed March 2016)

Lab analysis (water quality)

Orhel, R. L., Register, K. M., (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA.
<https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)

LANDSAT/infrared imagery

Laser level height relative to position on permanent post or other structure

LiDAR

- TidalMarshMonitoring.org Elevation: Terrestrial and Aerial LiDAR
<http://www.tidalmarshmonitoring.org/monitoring-methods-terrestrial-aerial-lidar.php> (accessed March 2016)

List of species found at site (e.g., fish, plants, birds)

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)
- Neckles, H.A., Dionne, M. (eds.) (2000). Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, ME. 21 p. plus appendices. <https://www.pwrc.usgs.gov/resshow/neckles/Gpac.pdf>.(accessed March 2016)

Manometric method

Measuring stick (for measuring accretion)

- The Partnership for the Delaware Estuary has detailed methods upon request

Meter (e.g., total dissolved solids, dissolved oxygen, pH, etc.)

- Orhel, R. L., Register, K. M., (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA. <https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)
- TidalMarshMonitoring.org Hydrology: Discrete and Continuous Water Quality SOPs <http://www.tidalmarshmonitoring.org/monitoring-methods-hydrology.php> (accessed March 2016)

Morphometric (e.g., length of nekton or oysters)

Nekton (identity, density, length, biomass, species richness)

- The SOP use by USFWS can be supplied upon request

Number of stems per m²

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)
- Neckles, H.A. and M.Dionne, Editors. (2000). Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, ME. 21 p. plus appendices. <https://www.pwrc.usgs.gov/resshow/neckles/Gpac.pdf>.(accessed March 2016)

Observations (e.g., grazing or other disturbance)

- Neckles, H.A., Dionne, M. (eds.) (2000). Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells,

ME. 21 p. plus appendices. <https://www.pwrc.usgs.gov/resshow/neckles/Gpac.pdf> (accessed March 2016)

- Orhel, R. L., Register, K. M. (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA. <https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)

Percent survival of planted animals or plants (of all if small area or quadrat samples if large area)

Photograph (fixed point)

- Neckles, H.A., Dionne, M. (eds.) (2000). Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, ME. 21 p. plus appendices. <https://www.pwrc.usgs.gov/resshow/neckles/Gpac.pdf> (accessed March 2016)
- TidalMarshMonitoring.org Habitat: Photo-Points <http://www.tidalmarshmonitoring.org/monitoring-methods-photo-points.php>
- The Partnership for the Delaware Estuary has detailed methods upon request

Plant tissue nutrient analysis (C/N)

Plaster or gypsum ball/ clod card dissolution

Presence/ absence

- Mid-Atlantic Tidal Wetland Rapid Assessment Method Version 3.0 (June 2010) Delaware Department of Natural Resources. http://www.dnrec.delaware.gov/Admin/DelawareWetlands/Documents/Tidal%20Rapid_Protocol%203.0%20Jun10.pdf (accessed March 2016)

Recruitment

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)

Refractometer

- Orhel, R. L., Register, K. M. (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA. [http://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual](https://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual) (accessed March 2016)

RTK GPS

- TidalMarshMonitoring.org Elevation: Ground-based Topographic Mapping. [Elevation Topographic Mapping RTK GPS SOP http://www.tidalmarshmonitoring.org/monitoring-methods-ground-based-topographic-mapping.php](http://www.tidalmarshmonitoring.org/monitoring-methods-ground-based-topographic-mapping.php) (accessed March 2016)
- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring and Assessment Handbook. The Nature Conservancy,

Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)

Secchi disc

- Orhel, R. L., Register, K. M. (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA. <http://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)

Sedimentation disc/tile/plate/ marker horizon

- USGS Website: Surface Elevation Table (SET) <https://www.pwrc.usgs.gov/set/> (accessed March 2016)
- Lynch, J. C., P. Hensel, Cahoon, D. R., (2015). The Surface Elevation Table And Marker Horizon Technique: A Protocol For Monitoring Wetland Elevation Dynamics. Natural Resource Report NPS/NCBN/NRR—2015/1078. National Park Service, Fort Collins, Colorado. <https://irma.nps.gov/App/Reference/Profile/2225005> (accessed March 2016)

Shear vane strength

Stem heights

- Neckles, H.A. Dionne, M. (eds.) (2000). Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, ME. 21 p. plus appendices. <https://www.pwrc.usgs.gov/resshow/neckles/Gpac.pdf> (accessed March 2016)
- TidalMarshMonitoring.org Habitat: Vegetation <http://www.tidalmarshmonitoring.org/monitoring-methods-vegetation.php> (accessed March 2016)
- The Partnership for the Delaware Estuary has detailed methods upon request

Surface elevation table

- USGS Website Surface Elevation Table (SET) <https://www.pwrc.usgs.gov/set/> (accessed March 2016)
- Lynch, J. C., P. Hensel, Cahoon, D. R., (2015). The Surface Elevation Table and Marker Horizon Technique: A Protocol For Monitoring Wetland Elevation Dynamics. Natural Resource Report NPS/NCBN/NRR—2015/1078. National Park Service, Fort Collins, Colorado. <https://irma.nps.gov/App/Reference/Profile/2225005> (accessed March 2016)

Surveying Instrument (barcode leveling)

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)

Thermal imaging

Thermometer

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring and Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/> (accessed March 2016)
- Orhel, R. L., Register, K. M. (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA. <http://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)

Titration kits

- Orhel, R. L., Register, K. M. (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA. <http://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)

Turbidity meter

Vertical light attenuation

- The Partnership for the Delaware Estuary have detailed methods upon request

Water level loggers

- USFWS and The Partnership for the Delaware Estuary have detailed methods upon request

Winkler test

- Orhel, R. L., Register, K. M. (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA. <http://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual> (accessed March 2016)

The following are resources related to socioeconomic methods. All socioeconomic methods shown include both a data collection method and an analysis method.

Data collection method: Existing data sources; Analysis method: Hedonic valuation

- Gopalakrishnan, S., Smith, M. D., Slott, J. M., & Murray, A. B. (2011). The Value Of Disappearing Beaches: A Hedonic Pricing Model With Endogenous Beach Width. *Journal of Environmental Economics and Management*, 60(3): 297–310.
- Bin, O., Dumas, C., Pouter, B., Whitehead, J. (2007). Measuring the impacts of climate change on North Carolina coastal resources. Report prepared for National Commission on Energy Policy, Washington, DC, USA.
- Michael, H., Boyle, K., Bouchard, R. (2000). Does the Measurement of Environmental Quality Affect Implicit Prices Estimated from Hedonic Models? *Land Economics*, 76(2): 283-298.
- Walsh, P., Milon, J. (2015). Nutrient Standards, Water Quality Indicators, and Economic Benefits from Water Quality Regulations. *Environmental and Resource Economics*: 1-19.

Data collection method: Project budgets and existing data sources; Analysis method: substitute cost method, and also Analysis method: Cost effectiveness analysis

- Alleman, L., Carrera, J., Maxwell, E., Smith, E., Freed, A., Kaiser, C., Percifull, E., Thorbourne, C., Bassetti, L., Bayram, A., Bohn, B., Goldstick, J., Kealy, M., McConnell, K., Ostroff, G., Robinson, P., Weier, J., Wilson, M. (2015). Urban Coastal Resilience: Valuing Nature's Role. Case Study: Howard Beach, Queens, New York. New York. The Nature Conservancy, with technical support from CH2M Hill and Davey Resource Group.
<http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/newyork/climate-energy/natural-infrastructure-study-at-howard-beach.xml> (accessed March 2016)

Data collection method: Surveys; existing data sources; Analysis method: Avoided cost method; HAZUS modeling or other modeling that simulates changes in flood levels

- Federal Emergency Management Agency (2016). HAZUS software. <https://www.fema.gov/hazus-software> (accessed March 2016)

Data collection method: Surveys; existing data sources; Analysis method: Modeling that simulates changes in flood levels

Data collection methods: Car counter; Surveys; Geospatially referenced social media methodology; Analysis methods: NA

- Wood, S. A., Guerry, A. D., Silver, J. M., Lacayo, M. (2013). Using Social Media To Quantify Nature-Based Tourism And Recreation. *Scientific Reports*. 3(2976).

Data collection methods: surveys; existing data sources; Data analysis methods: Contingent valuation or choice experiment

- Haab, T., McConnell, K. (2002). Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation. *New Horizons in Environmental Economics*, Northampton, Massachusetts.
- Johnston, R.J., Whelchel, A.W., Makriyannis, C., & Yao, L. (2015a). Adapting to coastal storms and flooding: Report on a 2014 survey of Old Saybrook residents. Worcester, MA. George Perkins Marsh Institute, Clark University, and The Nature Conservancy, Connecticut Chapter.
- Johnston, R.J., Whelchel, A.W., Makriyannis, C., & Yao, L. (2015b). Adapting to coastal storms and flooding: Report on a 2014 survey of Waterford residents. Worcester, MA. George Perkins Marsh Institute, Clark University, and The Nature Conservancy, Connecticut Chapter.

Data collection methods: surveys; existing data sources; Data analysis methods: IMPLAN or other regional economic modeling, such as input/output models and also, Data analysis methods: Economic impact assessment

- Thompson, M., Wagenhals, E. (2002). Economic Impact Of Nature Tourism And Cultural Activities In Worcester County, Maryland.
<http://msa.maryland.gov/megafile/msa/speccol/sc5300/sc5339/000113/002000/002269/unrestricted/20063302e.pdf> (accessed March 2016)
- Carver, E., Caudill, J. (2013). Banking on Nature: The Economic Benefits to Local Communities of National Wildlife Refuge Visitation. Washington, D.C. Division of Economics, U.S. Fish and Wildlife Service.
- IMPLAN. (2016). <http://www.implan.com/> (accessed March 2016)

Data collection methods: Surveys; Focus group meetings; Tracking with a log; Data analysis methods: NA

Data collection methods: surveys; interviews; existing data sources; Data analysis methods: Partial budget analysis

Data collection methods: visual assessment or GIS analysis; Analysis method: NA

Appendix E. Other Guidance Documents on Developing Monitoring Plans for Coastal Habitats

- Baggett, L. P., S. P. Powers, Brumbaugh, R., Coen, L.D., DeAngelis, B., Greene, J., Hancock, B., Morlock, S. (2014). Oyster Habitat Restoration Monitoring And Assessment Handbook. The Nature Conservancy, Arlington, VA, USA., 96pp. <http://www.oyster-restoration.org/oyster-habitat-restoration-monitoring-and-assessment-handbook/>
- Neckles, H.A. and M.Dionne, (eds.) (2000). Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. Wells National Estuarine Research Reserve Technical Report, Wells, ME. 21 p. plus appendices. <https://www.pwrc.usgs.gov/resshow/neckles/Gpac.pdf>
- Thayer, G. W., McTigue, T. A., Bellmer, R. J., Burrows, F. M., Merkey, D. H., Nickens, N. A., Lozano, S. J., Gayaldo, P. F., Polmateer, P. J., Pinit, P. T. (2003). Science-Based Restoration Monitoring of Coastal Habitats, Volume One: A Framework for Monitoring Plans Under the Estuaries and Clean Waters Act of 2000 (Public Law 160-457). NOAA Coastal Ocean Program Decision Analysis Series No. 23, Volume 1. NOAA National Centers for Coastal Ocean Science, Silver Spring, MD. 35 pp. plus appendices. <http://coastalscience.noaa.gov/research/docs/rmv1/restorationmntg.pdf>
- Thayer, G. W., McTigue, T. A., Salz, R. J., Merkey, D. H., Burrows, F. M., Gayaldo, P. F. (eds.), (2005). Science-Based Restoration Monitoring of Coastal Habitats, Volume Two: Tools for Monitoring Coastal Habitats. NOAA Coastal Ocean Program Decision Analysis Series No. 23. NOAA National Centers for Coastal Ocean Science, Silver Spring, MD. 628 pp. plus appendices. <http://coastalscience.noaa.gov/research/docs/rmv2/WholeDocument.pdf>
- Orhel, R. L., Register, K. M., (eds.) (2006). Volunteer Estuary Monitoring: A Methods Manual. Second Edition, U.S. Environmental Protection Agency; Office of Water; Washington, DC, USA. <http://www.epa.gov/nep/volunteer-estuary-monitoring-methods-manual>
- Roman, C.T., James-Pirri, M., Heltshe, J.F. (2001). Monitoring Salt Marsh Vegetation: A Protocol for the Long at Cape Cod National Seashore. Long-term Coastal Ecosystem Monitoring Program, Cape Cod National Seashore Wellfleet, MA 02667

