Final Report of the Technical Review Working Group

Technical Review of the Waterfront Alliance's Waterfront Edge Design Guidelines Program

Convened by the Science and Resilience Institute at Jamaica Bay for the Waterfront Alliance

Supported by the Rockefeller Foundation

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Executive Summary

To further the technical development of the Waterfront Edge Design Guidelines (WEDG) – a certification program for waterfront design and development released in 2016 – the Science and Resilience Institute at Jamaica Bay (Institute) provided a technical review of the program for the Waterfront Alliance. The Institute convened a Technical Working Group (TWG) comprised of eight experts in a range of disciplines to evaluate the credit system's technical merits in the context of best available knowledge regarding resilience, public access, and urban coastal ecosystems. This report is intended to provide critical technical guidance to inform the next iteration and expansion of WEDG into a national program.

The TWG conducted its review over the from February through September of 2017. The recommendations presented are the culmination of individual review of WEDG categories and credits, lessons drawn from program precedents, feedback from the Advisory Committee and discussion amongst the TWG and between the Waterfront Alliance and TWG. The recommendations are grouped in three sections: Cross cutting themes, structure and format recommendations and category specific recommendations. Key findings include the following:

- Temporality and lifecycle are key components of resilience thinking. WEDG must be thoughtful about how credits define and addresses the life cycle of a project and what that means in terms of their short and long-term performance. While in its current formation, WEDG is constrained to individual sites, the program is well positioned to confront longer-term trends and planning-level strategies with its network of users.
- Applying "adaptive management" as an overarching concept can allow waterfront projects to continue to perform as originally designed as well as cope with uncertainty about future conditions. Linking together baseline conditions with performance targets, ongoing monitoring and adaptive actions will allow WEDG-certified sites to evolve over time.
- Performance-based requirements award project teams based on measured outcomes. Including performance-based rather than perspective credits in WEDG encourages teams to based designs around a comprehensive, whole-systems approach.
- Instead of providing a credit simply for meeting code or sufficient actions, WEDG should be aspirational, encouraging developers, waterfront residents, and communities to rethink the way that development is planned in coastal areas.
- While WEDG currently does not explicitly address the connections between waterfront development and human health, many credits are implicitly tied to health strategies and outcomes. Two areas where this could be further highlighted are in the ability of waterfront public spaces to (1) promote active living and (2) allow people to connect with nature.
- A new prerequisites category (Category 0) should be established with a set of process-based requirements that all WEDG-certified project must complete, such as establishing a multidisciplinary team, completing a site assessment, developing a community engagement plan, and planning for monitoring and adaptive management. In the long term, WEDG should consider a periodic recertification program.

- Overall, the structure of WEDG 1.0 can be improved by restructuring credits around outcomes, regrouping categories around key themes (e.g. edge design and natural resources), providing clear but separate design guidelines, and simplifying and clarifying the manual to be more user-friendly.
- While WEDG encourages use of local plant and construction materials, this represents an oversimplification that does not take into consideration the broader context of the regional ecology, climate or economy.
- In order for the innovation credits to encourage teams to surpass the mandated or typical practice, they must demonstrate how their design is "significantly" different from what is already out there, by contrasting their design solution to the usual or accepted practices. LEED is a useful model for how to document and reward innovation.
- Innovation is no good unless it spreads out from the innovators. Therefore, innovation credits should be awarded for documenting success, making designs and measured results available to a broader community, and sharing innovations in public fora. Collaborations with the academic and non-profit sector may be particularly beneficial.

Additionally, two "deep dives" were conducted into topic areas that were deemed important for further research. Deep Dive 1 focuses on the integration of performance goals and adaptive management into WEDG through the development of a table designed to help users to organize data to support initial assessment, ongoing performance and adaptive management planning. Deep Dive 2 presents a decision-support tool to assist with the selection of soft/hybrid shoreline strategies and materials for different shoreline conditions.

This work was made possible with the generous support of the Rockefeller Foundation. The eight members to the TWG (Anthony Dvarskas, Jessica Fain, Peter Groffman, Christina Kaunzinger, Walter Meyer, Jon Miller, Ashley Muse and Eric Sanderson) Adam Parris from the Science and Resilience Instiutute at Jamaica Bay, Alison Schlesinger, and participants in the WEDG Project Advisory Committee provided on-going support and invaluable contributions that form the basis of this report. Special thanks to Roland Lewis, Kate Boicourt and Sarah Dougtherty from the Waterfront Alliance for their strong partnership and collaboration.

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Purpose

Background

The Waterfront Alliance is a non-profit civic organization coalition of more than 950 organizations working together to restore and revitalize the New York Harbor and surrounding waterways. In 2015, the Waterfront Alliance developed the Waterfront Edge Design Guidelines (WEDG) as a tool to incentivize waterfront planning and design that increases public access to the waterfront, improves ecology, and strengthens resiliency amidst threats posed by climate change. The program is designed as a voluntary ratings system that aims to influence long-term, sustainable, and effective practice at the water's edge, and in so doing, change people's relationship with the water. Project developers, public entities or owners can apply to receive WEDG certification by demonstrating their achievement of a series of credits.

The Waterfront Alliance developed WEDG 1.0 with the input of a task force of engineers, designers, regulators, environmental scientists, and activists, collecting a set of best practices for multiple types of uses at the water's edge. As the program grows, the Waterfront Alliance seeks to strengthen the program's utility by producing a thorough review of the credits system, an investigation of incentives for adoption, and an expansion of applied uses in under-resourced waterfront communities and waterfronts nationwide.

To aid in these objectives, the Waterfront Alliance commissioned a technical review by the Science and Resilience Institute at Jamaica Bay (Institute), with support provided by the Rockefeller Foundation. Through the formation of a Technical Working Group, the Institute was tasked with reviewing the scientific basis and technical guidance in WEDG to inform the next iteration and expansion of WEDG 2.0.

The **Science and Resilience Institute at Jamaica Bay** supports a thriving urban watershed and estuary in Jamaica Bay for all its inhabitants and contributing to New York City's international reputation as a resilient and sustainable city. The institute is a partnership between the City of New York, the National Park Service, and eight research institutions led by the City University of New York – Brooklyn College. Partners include, New York Sea Grant, Cornell University, Rutgers University, Columbia University, Wildlife Conservation Society, Stevens Institute of Technology, and Stony Brook University. The Institute's mission is to produce integrated knowledge that can be used to increase biodiversity, well-being, and adaptive capacity in coastal communities and waters surrounding Jamaica Bay and New York City.

The Waterfront Alliance's mission is to protect, transform, and revitalize our harbors and waterfronts. They are the New York region's preeminent waterfront advocate for environmental restoration, waterfront access and transportation, and the working waterfront. Now in their ninth year and with more than 900 Alliance Partners, the Waterfront Alliance unites a diverse coalition of stakeholders working toward a powerful shared vision of a resilient New York Harbor and waterways alive with commerce and recreation.

The **Rockefeller Foundation's** mission is to promote the wellbeing of humanity throughout the world. The Rockefeller Foundation funded the Waterfront Alliance and the Institute to develop WEDG in pursuit of the Rockefeller Foundation's goal to build resilience by helping people, communities and institutions prepare for, withstand, and emerge stronger from acute shocks and chronic stresses.

Technical Working Group

The Technical Work Group (TWG) is comprised of eight experts with both research and practical experience in waterfront management, design and evaluation. In addition to their technical backgrounds, members were selected for being good communicators and collaborators.

Technical Work Group Members

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Jessica Fain
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Research Associate Professor, Coastal Engineering, Stevens Institute of Technology

Ashley Muse
Architect and Green Building Consultant

Eric Sanderson
Senior Conservation Ecologist, Wildlife Conservation Society

The Science and Resilience Institute at Jamaica Bay Program Director, Jessica Fain, was the primary project management contact for this review.

Scope of Review

The scope of the Technical Working Group review included conducting a technical review of the Waterfront Alliance's Waterfront Edge Design Guidelines to evaluate the credit system's technical merits in the context of best available science, design and engineering regarding resilience, public access, and urban coastal ecosystems.

This review does not assess the need for a waterfront design certification program. Instead the primary driver of this review was to assess the overall program and its component pieces, to answer the following questions: Are the WEDG qualifications supported by the most up-to-date scientific research? Is the structure of the credit system clear and consistent? Do the credits add up to the intended outcomes and goals for the overall rating system?

The review focused on the following components:

1. The appropriateness of WEDG categories and credits based on scientific merit,
2. The value of WEDG categories and credits toward achieving desired outcomes,
3. The requirements for documentation and process, and
4. Areas of further investigation (Deep Dives topics)

Review Process

This review occurred from February to September 2017. An eight-member multidisciplinary review committee was assembled with expertise in designing credit rating systems, conservation ecology, coastal resilience planning and policy, environmental economics, waterfront design, and coastal engineering.

All seven thematic categories were assessed by at least two Technical Working Group members for credibility, value, and process of credit assignment. Technical Working Group meetings were held to report on and discuss member topics. Six in-person meetings were held between March and September, as well as additional phone meetings. The group designed questionnaires to guide their review process and ensure consistency in analysis.

The questionnaire was divided into three parts: credit credibility, credit value, and process.
Part one, credit credibility, examined what was and was not supported by research and the relevance and reliability of sources and definitions.

Part two, credit value, examined WEDG principles and category goals, the benefit of credits, the most and least meaningful credits, missing credits, streamlining of credits, connection to outcomes, whether credits support or limit desirable strategies and outcomes, credit weighting, and economic and market transformation.

Part three, process, examined project process and documentation. (See Appendix 1 for full questionnaire.)

The TWG also examined what could be learned from other credit systems, which are summarized in the "Lessons from Program Precedents" section.

The Waterfront Alliance also convened an Advisory Committee to steer the revision of the guidelines and credit system. The Advisory Committee is a volunteer group with open membership comprised of waterfront design practitioners and agency representatives. The Technical Working Group interacted regularly with the Advisory Committee to ensure a coordinated process. Some key lessons from program precedents and other cross-cutting topics were discussed with the Advisory Committee at their June meeting (see Takeaways from Advisory Committee Breakout Group Discussions), and informed the recommendations that were formulated.

Lessons from Program Precedents

There are many existing examples of voluntary design guidelines, credit-based frameworks, and certification programs that WEDG can learn from. Many of them overlap in intent, format, and content. The following summary presents key lessons based on a review of several relevant program precedents including:

- Leadership in Energy and Environmental Design (LEED)
- Sustainable Sites Initiative (SITES)
- Blue Flag
- Active Design Guidelines

Table 1. Summary of Relevant Program Precedents

	LEED	SITES	Blue Flag	Active Design Guidelines
Organization	US Green Building Council (USGBC)	Sustainable Sites Initiative	Foundation for Environmental Education	Center for Active Design
Developed	1999	1999	1985	2010*
Territory	Written as a national US-based standard but has been applied and adapted globally.	Primarily US	Global	New York City
Program Goal	Driving market transformation to encourage building performance above and beyond code	To distinguish sustainable landscapes by measuring their performance and elevating their value.	Challenges local authorities and beach operators to achieve high standards.	Provides designers with a manual of strategies for creating healthier buildings, streets, and urban spaces, based on the latest academic research and best practices in the field.
Structure	Suite of credit-based rating systems. Each rating system follows a similar format & categories but specifically tailored to address differences in: scales (from cities/ neighborhoods to campuses to buildings); building types (commercial, healthcare, hospitality, schools, retail, and homes); owner types (master plan, full construction, core & shell, and interior fit-out); phase of project (planning, design & construction, operations and maintenance)	Credit-based rating system	Stringent criteria, most of which are imperative, i.e. must comply to be awarded Blue Flag accreditation. Guideline criteria is preferable, but not mandatory. Criteria for different applications: • Beaches • Marinas • Boating Tourism Operators • Boat Owner's Code of Conduct • Sail Training International Code of Conduct	Checklist of objectives and strategies. Different strategy sets for: • Buildings • Urban Design
Primary categories	1. Building Design & Construction: Process, Location & Transportation, Site Selection, Water Efficiency, Energy & Atmosphere, Indoor Environmental Quality, and Innovation 2. Neighborhood Development: Smart Location and Linkage, Neighborhood Pattern and Design,	Context, Pre-design, Water Soil/Vegetation, Materials, HHWB, Construction, Operations & Maintenance, Education, and Innovation	Water Quality, Environmental Management, Environmental Education and Safety.	Urban Design: Land Use Mix, Transit & Parking, Park, Open Spaces, & Recreational Facilities, Children's Play Areas, Public Plazas, Grocery Stores & Fresh Produce Access, Street Connectivity, Traffic Calming, Designing Pedestrian Pathways, Programming Streetscapes, Bicycle Network and

	LEED	SITES	Blue Flag	Active Design Guidelines
	Green Infrastructure & Buildings, and Innovation.			Connectivity, Bikeways, Bicycling Infrastructure
Certification	Third-party review administered by Green Business Certification Inc. (GBCI)	Third-party review administered by Green Business Certification Inc. (GBCI)	Third party evaluation from National and International Jury	None, self-applied checklist
Ongoing Performance	All project owners must agree to annual data sharing. Projects can elect to participate in the LEED for Existing Buildings Operations and Maintenance program, which is now evolving in partnership with the Arc Platform for benchmarking.		During the Blue Flag season the flag must fly at the beach. The flag is both a symbol of the program being run at the beach but also an indication of compliance. If a beach that has Blue Flag accreditation does not comply with the Blue Flag criteria, the flag may be permanently or temporarily withdrawn from the beach.	None

* Developed as a partnership between the NYC Departments of Design and Construction, Health and Mental Hygiene, Transportation, City Planning, and Office of Management and Budget, working with leading architectural and planning academics, and with help from the American Institute of Architects New York Chapter.

Key Lessons from Program Precedents

Ensuring Integrity

- Minimum requirements for size, program, use and/or ownership establish what types of projects are eligible for the program. Examples: LEED has Minimum Program Requirements, SITES explains Eligible Sites (i.e. when and where to use), and Blue Flag Criteria describes who can apply and minimum requirements for eligibility.
- One or more prerequisites per goal or category ensure minimum performance. Prerequisites are a standard way to establish that certified projects are at least a notch above business as usual in all the program categories. LEED, SITES, and Blue Flag all have prerequisites/mandates.
- Programs with a third party review process, like LEED, SITES, and Blue Flag, add a level of rigor and effectiveness over self-certifying programs, such as Active Design Guidelines. The party awarding certification is holding the project team accountable for what they say they have done and should not have a conflict of interest. Third-party verification is a standard requirement for many ISO standards.

Relevance & Ease of Use

- Most prerequisites are required by code in most cities and/or are standard best practice in the industry within the US, so rarely a barrier to entry.
- Certification levels in LEED and SITES encourage broader participation by maintaining a relatively low barrier to entry while still incentivizing high levels of achievement and distinguishing precedent-setting projects.
- Guidance on establishing key project parameters helps create consistency and clarity across the intial assessment, documentation, and review process. For example, LEED and SITES have guidance for how a project identifies the boundary between what is and is not being certified. LEED and SITES also have thorough guidance for establishing a baseline and performing calculations to help

standardize the way projects analyze and report performance. This guidance defines what area is in the project's control and provides a more consistent way to address tricky questions such as: which credits should include an adjacent parking lot used by occupants of the site but not owned by the WEDG project land owner be included in? When reviewing to verify credit compliance, it becomes important that site-related calculations across credits are using the same info for values, such as total square footage of the site, and what that translates into for items like pervious vs. non-pervious, amount of vegetation, habitat, open space, etc.

- Programs tailored for different project types (in LEED and Blue Flag) allow for broader participation by minimizing the need for the applicant to interpret how the standard applies to their niche.

Adapting & Evolving the Program

- In a response to feedback about the one-size fits all nature of LEED's early versions, LEED identified mechanisms for encouraging projects to focus on regionally specific approaches and priorities. When referencing national standard as a requirement or baseline, LEED adds the caveat "or local code, whichever is more stringent." Regional Priority credits award 'bonus' points for achieving credits deemed important by local chapters.
- Like WEDG, the number of points awarded to each credit vary in both LEED and SITES. Credit weighting plays an important role in establishing priorities within the credit-system. LEED and SITE publications include an explanation of the decision-making process used to determine credit weighting.
- Both LEED and SITES include processes for learning & improvement, such as credit interpretations, innovation & pilot credits, application guides, local chapter input
- Both LEED and SITES have established processes for ongoing updates and addenda allow for a predictable improvement process with opportunities for input.

Pre- and Post- Certification Processes

- Process-focused categories/credits support outcomes for results-oriented credits. Examples: LEED's Process category with an Integrative Design credit awarding early analysis. SITES Pre-Design, Construction, and Operations & Maintenance categories.
- Building/land owners sign agreement that includes willingness to provide some minimum data on ongoing performance. Example: LEED is aiming to require and/or incentivize more ongoing and continual reporting through the concept of the 'dynamic plaque'.
- Must prove ongoing performance to maintain certification. Examples: LEED has developed a stand-alone program for existing buildings to facilitate benchmarking and award operational improvements. LEED for Existing Buildings Operations and Maintenance (EBOM) must recertify every 1-5 years and the program is moving toward a platform for continuous displaying and reporting real-time data. For Blue Flag certified beaches, the local authority is obliged to ensure compliance with the criteria whenever flying the Blue Flag.

Key Takeaways from Advisory Committee Breakout Group Discussions

At the second Advisory Committee meeting in May 2017, the Technical Working Group presented a summary of their progress and held breakout sessions. The three breakout group sessions addressed unresolved aspects of the credit structure that had come up in both Technical Work Group discussions and amongst the Advisory Committee. Breakout sessions discussed the following topics: (1) Understanding Context: Pre-Design and Site Assessment; (2) Performance-based vs Prescriptive Credits; and (3) Ongoing Performance & Adaptation. Each group was given guiding questions and the specific challenges of the topics and was led through exercises to facilitate discussion and develop recommendations for the Waterfront Alliance.

Breakout Group 1: Understanding Context: Pre-Design and Site Assessment

Discussion questions: (1) Five of the seven WEDG categories include priority credits for some sort of site assessment to be conducted prior to design. Should these credits be combined? If so, how? Should they be required? (2) Pre-certification is a potential strategy to help applicants decide whether their site is eligible for certification and what credits apply by sharing information about the site early on. What are the pros and cons to a pre-certification process? What type of pre-certification would make sense for WEDG?

Key takeaways:

- Develop an optional pre-certification process to act as a screener for potential applicants. This screener would provide an initial assessment of which credits are applicable, and help applicants identify a path for acquiring the minimum credits required for certification. The screener could also rank credits from easiest to most difficult to achieve.
- Locate assessment credits earlier in the certification process, make them more specific, and align site condition assessments to credits. The assessment results should directly inform design strategies. A requirement should be creating a multi-disciplinary team. It may also be useful to differentiate credits by discipline.

Group 2: Performance-Based vs Prescriptive Credits

Discussion questions: In the current version of WEDG, some credits are very prescriptive, awarded based on the implementation of a particular design strategy. In the second version of WEDG, we are aiming for a more performance-based and less prescriptive credit system where feasible, as well as a more consistent organization of each credit by goal, metric, and design strategy options. Based on several examples provided, how can credits be transformed into a more performance-based structure?

Key takeaways:

- Shift most credits to performance-based credits to make the system scalable and to avoid out-of-date technologies.
- To simplify the process, group performance-based credits together.
- Keep prescriptive credits are where appropriate.
- Create certification levels (like LEED) to distinguish levels of achievement. Analyze existing WEDG metrics and code as either "standard", "above standard", "exemplary" based on local and national requirements.
- Change geographically specific credits to fit a more generic national context, or use local examples as examples, not requirements, to encourage adoption outside NYC/NJ.

Group 3: Ongoing Performance & Adaptation

Discussion Questions: A life-cycle approach and acknowledgement of the need for ongoing adaptation is key to the success of waterfront projects as they face inevitable change, through patterns of use, aging of infrastructure, changing climate, etc. What does it look like for a project to engage with WEDG over time? WEDG in its first version began as one-time certification. What value could post- or re-certification offer?

Key Takeaways:

- WEDG must address "Ongoing Performance and Adaptation." This can be achieved by either reframing the "Operations and Maintenance" section or adding an "Ongoing Performance and Adaptation" section at the end of each WEDG category.
- Appropriate scope/method for each metric should be defined as well as a recommended tracking mechanism.
- WEDG should require periodic re-certification to meet the goals of increasing resilience and performance.

Assessment and Recommendations

Based on individual review, lessons from program precedents, breakout group feedback and discussion amongst the reviewers, the Technical Work Group synthesized its findings into the following key crosscutting and category-specific recommendations presented in this section. The first section addresses high-level crosscutting themes that apply to more than one category or the certification process as a whole. The second section includes recommendations that have to do with the structure and format of the document and credits. The third section includes category specific recommendations. Referenced sections and credits are from WEDG 1.0. Unless otherwise noted, they refer to numbering included in the Residential/Commercial project type.

Cross Cutting Themes

1. Temporality and lifecycle in resilience thinking

Social-ecological systems (SES) perspective describe resilience as the ability of a system to tolerate or absorb disturbances as a result of either shocks or stresses to the system without shifting to an alternative system state (Walker and Salt 2006). In ecological terms, a salt marsh, for example, is resilient for as long as it can withstand disturbing influences and stay a salt marsh. Because salt marshes depend on a small range of tidal conditions, once those conditions no longer apply (for example because of sea level rise), the salt marsh transforms into a mudflat or a shallow tidal estuary. In human terms, a coastal development might support maritime activities as one component of its diversified revenue and employment sources; loss of the maritime sector following a storm event and its associated impacts could consequently decrease the resilience of the overall economic system by decreasing the mix of sources of revenues and jobs. Resilience helps maintain a valuable aspect of the system (a waterfront area, in this case) in place despite shock and stress.

In the WEDG context, the TWG suggests that resilience must be explicitly considered in temporal context. Sea level rise provides a critical case. For some period of time it may be possible to resist small amounts of sea level rise, but over longer periods of time, frequent coastal inundation and flooding driven by sea level rise will make it more difficult to maintain aspects of the waterfront in their current state. Instead, coastal areas may need to adapt to new system states more in keeping with the prevailing new conditions. A limitation to the current WEDG credit system is that resilience is assessed on a site-by-site basis. While some larger sites may have the ability to consider longer term trends and planning-level strategies (e.g. regional sediment management), most sites will not. Despite this, the overall WEDG program is well-positioned to tackle these types of discussions with a range of audiences. Drawing out the relationship between site-scale options and regional, longer-term drivers should be made more explicit; without it, the WEDG program falls short of meeting its own objective of "promoting resiliency." As the program transitions to a national scale and takes on education as a more central piece of the Waterfront Alliance's activities, there may be opportunities to embed these types of discussions into the WEDG publications and outreach materials.

WEDG's success, especially in terms of natural resources and coastal risk reduction, is dependent on how the design performs and adapts over time. Therefore, WEDG must be thoughtful about how credits define and addresses the life cycle of a project. Different time-scales may be more significant for different credits and project types depending on ties to:

- Ownership, leasing, or development financing, which may be 10 to 30-years or less

- Infrastructure investments that may be designed for 30-100 years
- Intermittent storm events such as coastal flooding and sudden erosion
- Sea level rise projections and uncertainty. Middle range projections in New York City could be range from 4 to 8 inches by the 2020s and 11 to 24 inches by the 2050s. Similarly, high-end projections for those same periods are 11 inches and 31 inches, respectively, according to the NYC Panel on Climate Change (NPCC).

2. Emphasize importance of early integration of WEDG into project planning to maximize WEDG credit opportunities

Using WEDG from the onset of project planning can maximize the opportunities for a project to earn WEDG credits. Decisions made during early project phases "lock-in" certain attributes that may limit the credits a project can obtain, or make a project ineligible for any WEDG credits if it fails to meet Category 0 prerequisites. These decisions may include selection of location of a building footprint, design of boundaries with neighboring parcels, and materials ordered for use in construction. Early adoption and systematic incorporation of WEDG into the assessment of project success, before decisions and investments have been made, can help define project goals, its relationship to the community, the metrics for success, and the role of WEDG certification in meeting broader project goals.

3. Include "Adaptive Management" as an overarching concept

Adaptive management is the concept of learning from experience and modifying subsequent behavior (Williams and Brown 2012). To better cope with uncertainty about future conditions, an adaptive management approach can allow waterfront projects to continue to perform as originally designed as well as evolve to confront new situations. Adaptive management asks that objectives are set and alternatives considered (e.g., reviewing potential shoreline stabilization options and their potential impacts) before selecting an approach. Monitoring and assessment then help adjust future management decisions, based on ongoing learning about the project performance. While adaptive management has roots in natural resource management (e.g. Walters 1986), it is a useful conceptual framework for addressing any number of changes that may occur over a project's lifespan, such as climate variability, changes in physical conditions, shifts in neighborhood composition and culture, political and economic changes, and extreme events.

The WEDG program could gain a great deal by applying "adaptive management" as an overarching concept. The program should require projects to identify management objectives, and address how problems such as erosion, trash accumulation, invasive species that overgrow their neighbors, etc. will be monitored and addressed throughout the lifetime of the waterfront projects. Specifically, it is our recommendation that the WEDG program implement the following:

- Include as a prerequisite a monitoring and adaptive management requirement to obtain WEDG certification, contingent upon identifying management goals in key areas, and developing a monitoring plan with key indicators.
- Tie adaptive management to a set of baseline conditions that are required to be collected at the project outset.
- Consider adding an 'Ongoing Performance, Management, and Adaptation' section to the end of each of the other WEDG categories instead of having a stand-alone Operations and Management category.
- Assess whether any new credits are necessary to ensure success and improvement post design and construction.

- Make continued WEDG certification contingent upon meeting certain performance goals or making changes to address shortcomings. Recertification would occur at a prescribed interval determined based on the project scope.
- Incentivize learning through program and project evaluation, aided by partnerships with academic institutions, and by rewarding or requiring exchange with a broader audience (see Innovation).

4. Adopt a Performance Based Credit Approach

Currently the majority of WEDG credits are prescriptive and awarded based on the specific strategies implemented. Prescriptive based requirements instruct project teams what to do, while performance based requirements award project teams based on measured outcomes. Most city and state codes are typically prescriptive based, because they are regionally adapted and specific strategies are easy to enforce via drawing review and inspections. However, many crediting frameworks, such as LEED or SITES, encourage project teams to base design on a comprehensive, whole-systems approach assessment of performance and determine the right solution for their context. To be effective, performance based credits must have clear metrics and often have an established baseline by which to determine improvement over what is typical or standard.

In reviewing the current WEDG credits, the TWG noted many cases where the strategies being promoted have benefits applicable to two or more WEDG categories. For example, restoring natural features can and should be done in a way that benefits Edge Resiliency and Ecology & Habitat in a multitude of ways. A more performance based approach would encourage teams to seek strategies that have the greatest benefits and synergies, and therefore points, across the entire suite of credits. This has been an effective approach in frameworks like LEED. For example, rather than creating a credit that specifically awards vegetated (aka green) roofs, vegetated roofing will help a project achieve points under multiple credits including habitat restoration, rainwater management, reduced heat island effect, and improved energy performance.

5. Be aspirational rather than sufficient

Several of the credits (SS&P 3, 5.1, 5.2, 7.1, 7.2, 10) are awarded for meeting code requirements or for taking actions that should be considered the bare minimum for waterfront development projects. Instead of providing a credit for meeting code or sufficient actions, WEDG should be aspirational and encourage developers, waterfront residents, and communities to rethink the way that development is planned in coastal areas. In cases where code requirements may not be triggered (rehabilitation versus new constructions) credits for dry floodproofing and wet floodproofing (SS&P 7.1 and 7.2, respectively) may be appropriate.

For example, SS&P Credit 5.1 provides 2 points for keeping 50% or more of the total square footage outside of the Coastal Erosion Hazard Area, and SS&P Credit 5.2 appears to provide 2 points if 50% of the structures is kept outside of the V-Zone and 6 points if outside of the A-Zone. The 50% value included for these credits may be loosely based on FEMA guidance (the 50% rule) that requires elevation of structures within the 100-year floodplain if repair costs are greater than 50% of value building; however, there does not appear to be supportive literature for the 50% figure.

Similarly, in Public Access and Interaction, most credits award points for regulatory compliance. This can be overcome by including 'beyond required' or other similar language. For example, in many areas of New York City where zoning requires a 40-foot-wide esplanade, credit PA&I 14.2 (a) would award the developer with 2 points simply for complying with regulations.

Further, it is not clear why WEDG should credit any building footprint within the 100-year floodplain, a high erosion area, or that involves development or impact upon a bluefield. While it is noted in several of the credit descriptions that siting outside of the natural floodplain is most effective, awarding of credits for structures that do not meet this effectiveness criteria sends a mixed message.

6. Opportunity to connect with human health

Currently WEDG does not explicitly address direct connections between waterfront development and human health in its principles, categories, or credits. However, there are many WEDG credits that are implicitly tied to health strategies and outcomes, such as improving natural resources, encouraging human-powered transportation and recreation, etc. Two "low hanging" opportunities to integrate human health into WEDG involve the credits around the design of waterfront public spaces. Specifically, how are these spaces designed to (1) promote active living and (2) allow people to connect with nature?

The following is an initial list of potential issues that present the opportunities to address health aspects of site development more directly.

- Promoting Physical Activity
    - Land use mix
    - Walkability & bicycle networks/infrastructure
    - Recreation & play areas
- Access to Healthy Food & Drinking Water
    - Grocery stores & produce markets
    - Health food retail
    - Onsite gardening & farming
- Minimizing Pollution
    - Air & water quality
    - Material health & toxicity
    - Noise & light pollution
- Passive Survivability
    - Emergency function of drinkable water & toilets
    - Habitable temperatures and air for without power
- Connection with Nature
    - Open space & views

Structure and Format Recommendations

1. Restructure categories and credits around outcomes

The TWG believes that several modifications to the overall category structure could help improve the clarity and focus of each category. The result would be five categories and one prerequisite category. Specifically,

- Create a new Category 0 with process-oriented prerequisite requirements (see Category 0)
- Rename the "Edge Resiliency" category to focus more directly on coastal risk reduction and shoreline design.

- Create a new category on "Natural Resources" to encapsulate management of natural habiatat, water, soil, air and energy.
- Dissolve the Materials & Resources category and distribute the credits to other categories.
- Dissolve the Operations and Maintenance category and distribute the credits to other categories.
- Rename Public Access and Interaction "Public Use."

See mock up of revised Score Card (Appendix 2) for a draft of how the overarching system could be streamlined and organized.

Table 2. Recommendations for Overall Program Structure

Existing	Action	Proposed
--	Create new Category 0 for prerequisite requirements	Category 0. Prerequisites
Category 1. Site Selection & Planning	No change.	Category 1. Site Selection & Planning
Category 2. Public Access and Interaction	Modify title.	Category 2. Public Use
Category 3. Edge Resiliency	Limit to coastal risk reduction-type credits; Modify title.	Category 3. Shoreline Design
Category 4. Ecology and Habitat	Modify title.	Category 4. Natural Resources
Category 5. Materials and Resources	Dissolve Materials and Resources and distribute credits.	
Category 6. Operations and Maintenance	Dissolve Operations And Maintenance. Distribute credits to other categories.	
Category 7. Innovation	No change	Category 5. Innovation

2. Provide clear but separate design guidelines

Provide clear-cut direction on how to achieve credits through recommended design guidelines in a separate document. Guidelines for coastal areas are likely to be regional in character, depending on local and state legislation, ecological conditions, and other factors. An important growth area for the Waterfront Alliance rolling out WEDG nationally could be the development of regional guideline documents that address how the WEDG credits can be best achieved in different parts of the country (e.g. the Tri-State Region, Florida, California, etc.).

3. Align WEDG crediting structure with the various phases of project development.

For those projects that do not apply WEDG early in their development (e.g. pre-design/site assessment), effort should be made to direct users of the certification guide to credits that may still be applicable in construction and post-construction phases. Aligning WEDG accreditation with development phases can encourage the incorporation of WEDG into a range of projects, including retrofitting of existing properties.

For example, a site with an existing, selected, and built site and building footprint may still be eligible for WEDG credits as it may be able to incorporate elements that provide WEDG credits, such as redesign of spaces to encourage public use. Matching the types of credits a project can earn to phases of site development (pre-design/site assessment, construction, post-construction) can assist in quickly guiding project managers to relevant sections of the WEDG manual and facilitate uptake of WEDG by the user community. Applications of WEDG to a broad suite of projects, not just those in the pre-design phase, should also assist in moving waterfront projects beyond "business-as-usual" approaches.

4. Simplify and clarify the manual to be more user-friendly

a. Length

The TWG is concerned that the current length of the manual, 148 pages, could deter potential applicants. Reducing the length of the manual to less than 75 pages and simplifying the scorecard would make it more approachable. Pulling guidelines into separate regionally focused documents will help, as would providing annotated links.

b. Consolidate Project Types

Consolidating various project types would streamline the credit system and eliminate redundant text. Rewriting individual credits to maintain flexibility would accommodate for differences that currently exist between different project types. For example, utilizing native plants (Category 5, Credit 4.1) could be adjusted so the definition of native depends on project type. This could be done directly in the text or as a footnote indicating, "native is defined as within 50 miles for a residential project or within 150 miles for an industrial project". The TWG recommends reviewing the various project types and consolidating similar credits. For example, Credit 10 in Category 5 (Residential/Commercial) deals with responsible construction practices, and Credit 11 in Industrial/Maritime deals with the same practices.

c. Credit synergies across categories

There is a range of strategies that could be implemented that could increase visibility of credits that may have synergies or similar strategies, while achieving different outcomes.

To encourage project teams to seek design strategies that result in multiple benefits (like a sea wall made of a material that is both durable and provides habitat), language on recommended strategies can be added to the Guidance section of each credit, along with a list of other credits with potential synergies. More detailed guidance on design best practices could be provided in regionally generated design guidelines that would serve to showcase best practices for implementing WEDG in a particular region. This approach is beneficial if the credits are refocused to be outcome based, rather than strategy based (per recommendation on performance based credits above).

Alternatively, cross-listing credits increases the chances that applicants identify and apply for all of the credits they are eligible for. For example, Category 5: Materials and Resources Credit 7.2, provides points for utilizing materials that create habitat. The credit fits equally well in the ecology category, materials category and could even fit within the edge resilience category. The credit could appear in both (or all 3) with a simple note that the credit is cross-listed in Category 5, Credit 7.2. Strategies that achieve multiple credits should be awarded with points from both credits, but they may be easily missed if these synergies are not made explicit.

d. Eliminate Contradictions

Some credits seem to contradict one another. For example, Category 5: Materials and Resources, has several credits that deal with marine construction. Credit 10.1 recommends reducing in-water construction time but also advocates working from the water. Rewording the credit to better articulate the intent, which is to "utilize construction practices that cause minimal disruption to the local environment", would both simplify and clarify the document.

e. Credit Numbering Parity

Credit names and numbers are not aligned across project types. For example, 14.1 in PA&I Residential and Commercial type is labeled 'Public Walkways and Greenways', while in the Parks type 14.1 is labeled 'Scenic Views and Naturalized Areas'. To create parity across project types, a universal numbering system without overlap or redundancy should be developed. Further credit numbering misalignments include, but are not limited to, PA&I "Transit Access" Credit 11 Industrial, Credit 17 Parks, and Credit 16 Commercial.

5. Develop a consistent standard credit format

a. Credit Format

Structuring all credits around a simple but standard format will increase the clarity and ease of use in implementing WEDG. Adding referenced standards, definitions, and resources will ensure more consistent interpretation and demonstrates how the proposed credits are tied to and supported by research and industry best practices. Creating distinct categories for requirements, guidance, and documentation allows teams to understand how to apply WEDG at different stages of the development process, the intent and requirements inform goal setting, the guidance informs design development and implementation, and documentation prepares the project for certification review. The following proposed outline is informed by the review of precedent programs.

- **Intent**: State objective or environmental, social, or economic benefit
- **Requirements**:
    - Performance Requirements: Award measured performance achievement over an established baseline or benchmark. Some credits include multiple thresholds to award incremental improvements.
        - Referenced Standards: Baseline performance typically established by referenced standard or calculation methodology
    - Prescriptive Requirements:
        - Cases: Indicate how projects with particular pre-existing conditions (example: previously-developed vs greenfield site) or programs (residential vs commercial) can comply.
        - Options: Allow project teams to choose between different actions to satisfy credit requirements. A project can either choose one from a set of options or satisfy as many as possible. Often different options are awarded different point values.
- **Guidance**: Recommended strategies, methodologies, tips, and examples. Example: Many local USGBC chapters have developed more regionally specific application guidelines for LEED.
- **Documentation**: The standard specifics that a project must submit to demonstrate compliance. Documentation often includes a set of typically standardized forms, spreadsheets, and/or calculators supported by project documents (drawings, submittals, maps, etc.).
- **Definitions & Resources**: Additional guidance, information, or research to support a credit.

b. Aggregate Credits and Sub credits into Outcome-based Groupings

Restructure all of the credits into a bulleted format such as Credit 10.1 in Category 5 (Residential/Commercial). Currently, there are a number of credits which could follow a similar format that are instead broken into subcredits such as Credit 6.X in Category 5. Aggregating the credits would reduce the amount of redundant language even further as the language describing the intent/purpose of the credits could be utilized once rather than repeated multiple times for each sub credit. For example, Category 5 Credit 6 could be re-written as:

> Credit 6: Low-impact Materials – Wherever possible, utilize low-impact materials. These materials are intended to minimize negative impacts to the environment. One credit will be given for actions taking leading towards this objective including but not limited to:
> - Use permeable materials…
> - Use high albedo surfaces…
> - Avoid the use of toxic preserved lumber…

Restating the credit in this manner is sort of a hybrid between a performance and a prescriptive metric and allows for the applicant to consider additional actions beyond those called out in the bullets, which fit the overall intent of the credit.

c. Implement a stepped approach to credit structure

For certain credits, change credit metrics to the stepped approach, such as the one used in Edge Resiliency Credits 3.2 and 5.1, where more points are awarded for more structural or ecological benefit. Current research does not provide numbers to inform percent or number of feet required to achieve a given benefit. Amend recommendations as projects are implemented and monitored for performance.

6. Clarify documentation requirements

Documentation requirements are a critical component of WEDG. They not only ensure that individual projects are meeting the WEDG program goals on paper, but also help provide a traceable account to validate the credibility of a project's design and performance over time. At the same time, documentation requirements cannot be so onerous that applicants cannot reasonably provide them. Additionally, they must be presented in a way that makes it easy and clear for reviewers to make consistent determinations.

In its current iteration, WEDG 1.0 contains documentation requirements that are too onerous as well as too vague (e.g., "Provide documentation to demonstrate compliance with this credit"). The TWG offer the following strategies with respect to documentation requirements:

- Develop a simple and standard format that all projects use to ensure that data is collected and shared in similar formats.
- Provide a clear list of required documentation, including specific information to be included in drawings and other materials.
- Use documentation as a means of demonstrating not only intent, but also performance.

Category-Specific Recommendations

Category 0. Prerequisites

The TWG feels that it is critical for WEDG to uphold some mandatory requirements so that every project is exceeding basic compliance in a meaningful way. As such, a new category 0, Prerequisites, could mandate several process-focused credits that would become the threshold for any project to participate in WEDG. However, these decisions must be carefully considered by the Waterfront Alliance to ensure they are designed in a way that still allows for broad participation. Continued input from the design and development community will be important.

Table 3. Recommendations for Category 0 Structure

Existing	Action	Proposed
None	Move SS&P Credit 1 to this category.	1. Develop a multidisciplinary team
None	Combine various assessment credits into one prerequisite.	2. Conduct preliminary site assessment - ecological, social, climate, hydrology and coastal protection
None	Add basic public engagement requirement from SS&P Credit 3	Develop a plan for community engagement and participation.
None	Create new credit on monitoring and adaptive management. Incorporate O&M Credit 8.	3. Plan for monitoring and adaptive management

Category 1. Site Selection and Planning

a. Restructuring recommendations for Category 1

Per above, the TWG recommends moving SS&P Credits 1 and 2 to Category 0 as prerequisites. Additionally, an overarching suggestion for this category is to slightly modify the category description to replace "and resiliency strategies" with "and planning" to highlight the focus of this category on a specific element of resilience related to sea level rise and coastal flooding.

b. Emphasize the importance of creating a sound, integrated knowledge base for design

Credit 1, which addresses the formation of a multidisciplinary team, is a critical step in the overall WEDG process. Given the multi-faceted nature of waterfront design, applicants should develop an integrated knowledge base that draws on individual and combined expertise or information across a range of relevant subject areas or issues. This credit should therefore be emphasized and prioritized by making it a prerequisite. Alternatively, if the prerequisite structure is not adopted, it should be assigned the highest number of points relative to other categories.

Team members with experience in biological, socioeconomic, and physical elements of resilience should be required; however, these requirements should not be exclusive. Relevant professional societies or membership directories can provide useful contacts across these disciplines.

The overall credit for this category could be allocated among the tasks proposed. For example, the formation of the team (prerequisite), pre-design site visit with team (2 points), and WEDG workshop with team (2 points). Clearly, it is infeasible for an individual property owner or small-scale project to convene a team of individuals when planning their project. However, perhaps some credit could be provided for seeking advice from a range of professionals.

c. Highlight and emphasize the vulnerability assessment with stakeholders

Conducting a vulnerability assessment through engagement of community stakeholders ensures representation of a range of viewpoints and perspectives and consequently should be emphasized. This credit is also particularly well aligned with the WEDG objective of promoting resiliency. Credits 1 and 2 together should indicate that residential, commercial, and industrial actors will be better positioned to achieve other credits highlighted in the WEDG guidelines by completing these steps (if these credits are shifted to pre-requisites, framing them in this way can justify their categorization as pre-requisites). The vulnerability assessment can provide a solid, broad project context and database of information that may facilitate other WEDG credits. For example, conducting a vulnerability assessment will necessarily involve consideration and compilation of existing local and regional data sources as well as integration of ideas about public use of and opinions about a potential project. Having this mix of socio-economic, physical and environmental data shared and discussed with public perspectives about the project and potential uses at the site will help inform performance targets and design decisions, and make it easier to achieve and document credits in other categories (e.g., Public Use, Ecology and Habitat). Such an analysis may also assist in determining which WEDG credits may not be feasible because of identified social or ecological vulnerabilities.

d. Provide guidance/examples for use in other contexts and settings

WEDG 1.0 has a strong focus on the New York City metropolitan area creating a challenge for users outside of this area. For example, Credit 2 provides New York and New Jersey specific references in its discussion of conducting a vulnerability assessment. This could be rewritten to provide more general guidance and use the New York and New Jersey cases as examples should no locally relevant plan exist. Federal climate risk mapping tools may be appropriate. Developing or build on existing (i.e. NOAA's Digital Coast website[1]) searchable (by state) database of documents related to coastal vulnerability assessment planning and data and mapping tools may be beneficial as WEDG expands.

WEDG should also provide specific examples of how site planning and design guidelines may be applied in less dense shoreline areas (e.g. suburban and rural areas) where the range of entities involved and potential for public access and interaction with the site might be more limited. The current format favors urban areas, as they may be able to obtain more points given higher density and various land uses. A tiered system for crediting with variation in thresholds based on the type of community concerned (e.g., rural, suburban, urban) would address this.

[1] https://coast.noaa.gov/digitalcoast

Category 2. Public Access and Interaction

a. Restructuring recommendations for Category 2.

- Per the above, the TWG recommends changing the title "Public Access and Interaction" to a more succinct "Public Use."
- Consolidate PA&I Credit 6.1 and 6.2, and renaming "get-down" to "water entry."
- Consolidate PA&I Credits 15.1 and 15.2 'Visual Corridors' into a single category covering quantity and size.
- PA&I Credits 9.1 and 9.2 (Enhanced perimeter design) in Industrial Maritime should be included in Commercial project types as well to address perimeter aesthetics and transparency in privately owned public space (POPS).
- PA&I Credits 14.1 and 14.2 (Scenic Views of Undisturbed Areas), currently only in the Parks Project Types, should be included in all other types.

b. Emphasize upfront stakeholder meeting and encourage exemplary performance

Credit 2, "Engage Local Community and Users" is critical to a successful waterfront project, and could be emphasized by requiring it as a prerequisite for certain minimum levels of community engagement. The credit could be bolstered by adding language on synthesis of community engagement to demonstrate listening and response to community input. Photographs of meetings, salient quotes, synthetic word clouds, and design changes are examples of additional documentation to comply with this credit.

Additionally a new credit (or sub credit) could reward exemplary community engagement, which has evolved significantly in both literature and practice (Arnstein (1969), Minkler et al (2012), Nabachi and Leighninger (2015)). Key aspects of high quality community engagements should address the following:

- Access - who is in the room depends on design of the engagement (time, place, daycare, transit, incentives, outreach, a combination of "thick" and "thin" strategies).
- Diversity - Often multiple engagements are needed to tap into different communities with different constraints. Engage the youth (Red Hook Initiative is a great example) as well as elderly and other populations that are particularly vulnerable in terms of health or economics.
- Existing community leadership & networks - Demonstrate an effort to connect with churches, parent groups, trusted service providers, etc. It is important to connect with both groups already engaged in neighborhood advocacy and planning, but also beyond the "usual actors."
- Creating a unique place or experience to encourage engagement – Such as pop-up events with mock-ups (SCAPE and Interboro Partners do this well). Experiences are an opportunity to connect people to place and ecology.
- Break down barriers – Trust and understanding between professionals and community members often takes time. In early stages, allow for time for professionals to listen and learn while community members shares/teaches their knowledge and passion of place.
- Knowledge exchange – Engagement efforts should facilitate a two-way exchange of knowledge between the community and the project. Aim to build new skills and capacity that stay with people beyond the engagement or project.

c. Incorporate human dimensions into Credit 3 Conduct 'Water Use Assessment'

The existing language in PA&I Credit 3 only covers environmental factors for feasibility assessment, i.e. depth, currents, and wakes. Human factors should also be considered by conducting proximity analysis for adjacent water access points within 10 minute walking distance to avoid redundancy of access types, i.e. too many large fixed piers in a neighborhood with no small floating docks, beaches or water entries.

d. Highlight health benefits of visual access to the water

Peer reviewed studies have shown link between visual access to blue space and increased mental health (K10 Scores) in cities (Nutsford et al (2016)). Add wellness reference to the language regarding the benefits of visual access in PA&I Credit 15.1 and 15.2 (Residential/Commercial)

e. Add bus stop relocation to transit improvement options

Small parcels can also participate in Credit 16: "Incorporate transit access and facilities" if additional text is incorporated into this credit that includes "coordinating a new or relocated bus stop."

Category 3. Edge Resiliency

a. Restructuring recommendations for Category 3

This category follows from the WEDG Guiding Principle "Promote Resiliency". The focus of this category is somewhat confusing, conflating different topics together under the heading of "Edge Resiliency." Most credits reward waterfront design elements that accommodate, mitigate, or make the waterfront more adaptable to sea level rise and increased coastal flooding, with additional credit rewarded if these shoreline protections provide ecological benefit. Credit 9 rewards designs that use green infrastructure to manage the additional stormwater runoff expected with increased and more intense episodes of precipitation. While the shoreline protection elements cluster well for clarity and the discipline of coastal engineering, the sustainable stormwater management appear out of place. The TWG recommends refocusing the entire category on shoreline design and engineering, and removing credits related to hydrologic assessments, climate projections, ecological benefits not integrally tied to shoreline design, as well as stormwater management.

Table 4. Recommendations for Category 3 Structure

Existing	Action	Proposed
1. Assess Waterfront Edge Conditions to Determine Appropriate Design	Move to Category 0 (Prerequisite 2).	
2. Design Waterfront for Climate Conditions Projected for the 2050s	Move to Category 0 (Prerequisite 2).	
3. Shoreline Configuration	Move note to Category 0 (Prerequisite 2) (Note: Changes to the shoreline configuration should be analyzed by the project team for hydrological impacts regarding storm surge/flooding, wave regime, and stream velocity/currents). Move Credits 3.1 and 3.4 to Ecology section Keep Credits 3.2 and 3.3 in Shoreline Engineering but cross-list with Ecology	1. Shoreline Configuration (Credits 3.2 and 3.3)
4. Stabilization Techniques	Award more points for each of the stablization techniques in this section (Stabilize foot (2 pts)) Increase number of surfaces (2 pts, etc.)) 4.3 - Cross list with Category Ecology	2. Stabilization Techniques -
5. Natural Features (Credits 5.1, 5.2, 5.3)	Cross list with Ecology	3. Natural Features
6. Nearshore Structures (Credits 6.1, 6.2, 6.3)	Keep 6.1 and 6.2; Cross-list with ecology. Make 6.3 a requirements, like the preliminary assessments (location TBD)	4. Nearshore Structures (Credits 6.1, 6.2)
7. Create Resilient Landscape Features on Site (Credit 7)	Cross list with ecology	5. Create Resilient Landscape Features on Site
8. Integrate Multiple Edge Resiliency Strategies	No change	
9. Sustainable Stormwater Management (Credits 9.1, 9.2, 9.3, 9.4, 9.5, .9.6)	Move to "Natural Resources" Category	

b. Rename category "Shoreline Design".

The name "Shoreline Design" emphasizes the function of the design elements described in this re-structured category. Choice of the term "shoreline design", rather than "coastal protection" references the term "living shoreline," alluding to both soft and hard engineering solutions proposed to protect the coastline from sea level rise and storm surge. Given the many meanings of the term "resilience," this recommendation is intended to clarify that this credit does not address all resiliency issues, but only those related to shoreline design and stabilization.

c. Emphasize the importance of stabilization strategies.

Stabilization strategies are fundamental to shoreline protection on developed shorelines and are severely undervalued here. Adjust point distribution or separate out individual strategies for Credits 4.2 and 4.3.

d. Expand definition of the migration zone into the coastal shrubland and maritime forest.

Coastal vegetation zonation follows an elevational gradient from the water's edge, through low salt marsh, high marsh, salt-tolerant shrubs, coastal scrubland and into maritime forest. These plants provide friction against erosive forces, open area for inland marsh migration as sea level rises, and support the biodiversity of the entire coastal zone. Amend the figure for Credit 5.3 to show coastal grassland, shrubland and tree species in parts of the mown area. Develop a plan to facilitate inland migration of any wetland vegetation (e.g. adjust mowing regime with water level).

Category 4. Ecology and Habitat

The basic principles of environmental review and the science of conserving and restoring natural resources are well-codified in law and practice and have a long history and applicability well beyond New York City. This strong foundation is well reflected in the credit plan for Ecology and Habitat, for the most part.

a. Restructuring recommendations for Category 4

As described above, this category can be combined with other natural resource management strategies into a single category titled "Natural Resources," thereby acknowledging the connections between these various resources. Additionally, the existing ecology and habitat credits can be simplified and grouped in several key thematic areas.

Table 5. Recommendations for Category 4 Structure

Existing	Action	Proposed
1. Assess Natural Resources	Move basic assessment to Category 0, Credit 2	
2. Preserve or Enhance Existing Natural Resources	Keep and add others	1. Preserve or Enhance Existing Natural Resources (Credits 2, 3, 4, 7, 8.1 and 8.2)
3. Avoid Ecologically Sensitive Areas	Move to "Preserve.."	
4. Contribute to Comprehensive Restoration Plan	Move to "Preserve"	
5. Habitat Continuity (Credits 5.1, 5.2, 5.3	Keep as is	2. Habitat Continuity (Credits 5.1, 5.2, 5.3 and 5.4)

Existing	Action	Proposed
and 5.4)		
6. Habitat Complexity and Robustness (Credits 6.1, 6.2, 6.3 and 6.4)	Combine with credits from M&R on Regional Sourcing	3. Habitat Complexity and Robustness (Credits 6.1, 6.2, 6.3 and 6.4, plus M&R 4.1 & 4.2)
7. Perform Multiple Ecological Functions (Credit 7)	Move to "Preserve…"	
8. Advanced Mitigation Actions (Credits 8.1, 8.2)	Move to "Preserve…"	
9. Disturbance and Pollution (Credits 9.1 and 9.2)	Keep as is.	4. Disturbance and Pollution (Credits 9.1 and 9.2)

b. Rename category "Natural Resources"

As currently composed, this section clearly focuses on conservation and restoration of natural resources as means toward WEDG designs. However, a range of green infrastructure techniques and other natural resource management credits appear in other categories throughout WEDG, primarily in Materials and Resources and Edge Resiliency. By renaming the category "Natural Resources" and grouping these credits within it, it will streamline the various environmental management goals around several key areas.

c. Contextualize

Sites need to be contextualized in some larger ecological plan for the area/region where they are situated. Most sites will be too small to provide the desired ecosystem services on their own, but all should play their part in a larger strategy. For example, in the New York metro area, this may mean identifying how a site fits within and contributes to the NY-NJ Hudson Raritan Estuary Comprehensive Restoration Plan. Likewise, regional based guidelines should identify ecological plans which WEDG design teams should refer when creating their design.

d. Clarify native species credits

Native species credits (6.1 – 6.2): Other things being equal, native plants should be preferred over introduced plants; but it is important to note that introduced species can also provide ecosystem services.

Native plants and animals are important because they help sustain the co-evolved complexes of species in a particular region. They hold genetic diversity that may help them live in the local environment and adapt to changing condition. Because some native species are threatened and endangered, WEDG designers need to take into account legal implications of their designs. Native species also help create a sense of identity and place for people.

e. Habitat credits (5.1 – 5.4)

These credits as written are problematic because by definition, habitat depends on a species. (A "habitat" describes the area that supplies everything a species needs to complete its life cycle.) It is unclear what species are we referring to. Perhaps what is meant are "natural" ecosystems, or even more accurately, non-built ecosystems. These credits will produce very variable results due to the wide range of "habitats."

f. Cross reference green infrastructure from Shoreline Engineering categories.

Set up a page at the end of this category that provides a summary of the green engineering techniques used in Shoreline Engineering and elsewhere in WEDG, linking back to the appropriate pages.

Category 5. Materials and Resources

a. Restructuring recommendations for Category 5

The TWG recommends eliminating the "Materials and Resources" category. Most of the credits could go into a category to focus on "Natural Resources," including soil, energy, air, habitat and stormwater. The following recommendations would streamline the credit system.

Table 6. Recommendations for Category 5 Structure

Existing	Action	Proposed
1. Provide Lifecycle and Service Life Assessment (Credits 1)	Cat 0.	None.
2. Repurposed Fill (Credits 2.1, 2.2, 2.3)	Consolidate M&R 2.1, 2.2 and 2.3 around the theme of use of fill. Include in Natural Resources (Soil). See NYC Soil Bank for language.	Natural Resources: Soil
3. Repurposed Materials (Credits 3.1, 3.2)	Consolidate 3.1, 3.2.Include in Natural Resources category (Energy)	Natural Resources: Energy
4. Regional Sourcing (Credits 4.1, 4.2)	Move 4.1 and 4.2 to Natural Resources: Habitat Complexity and Robustness.	Natural Resources: Habitat
5. Material Resilience (Credits 5.1, 5.2)	Move to SS&P	None
6. Low Impact Materials (Credits 6.1, 6.2, 6.3)	Move to 6.1 to Stormwater Management in Natural Resources Move 6.2 and 6.3 to Natural Resources Resolve 6.2 and 3.2 overlap	Natural Resources: Stormwater Natural Resources
7. Ecologically Beneficial Materials (Credits 7.1, 7.2)	Include in Natural Resources	Natural Resources
8. Renewable Energy (Credits 8.1, 8.2)	Move to Natural Resources (energy)	Natural Resources: Energy
9. Install redundant emergency systems (Credits 9)	Move to SS&P	None
10. Responsible Construction (10.1, 10.2, 10.3)	Move 10.1 to SS&P Move 10.2 and 10.3 to Natural Resources (Energy)	Natural Resources: Energy
	Insert Sustainable Stormwater Management credits from Edge Resiliency here (ER 9.1, 9.2, 9.3, 9.4, 9.5, .9.6)	Natural Resources: Stormwater

b. Consider the definition of local.

Several of the credits (specifically 2, 3, and 4) in this category incentivize the use of "local" materials; however, the definition of local needs to be considered more carefully.

For waterfront construction, the overriding concept is to avoid waste, (re)utilize materials as efficiently as possible, and reduce transport distance. While utilizing "local" materials generally encompasses this concept, it represents an oversimplification. As an example, the reuse of a deteriorated bulkhead or creosote soaked lumber, while efficient, conflicts with the overall objectives of WEDG. Along the same lines, utilizing local materials that are scarce or irresponsibly sourced might be less preferable than importing materials that are more sustainable.

When applied to the ecology, "local" needs to be considered in the broader context of the region and its trajectory. Local ecotypes of plant material are well adapted to local environmental conditions and support local plant and wildlife communities. However, strictly applying the definition of "local" may lead to ecological homogeneity which increases vulnerability to environmental change (Wootton, et al. 2016, N. Y. Foundation 2013). Although sea level rise is discussed throughout the WEDG guidelines, the role it plays in determining the appropriate ecological enhancements is conspicuously absent. The same is true for temperature and precipitation. The credit for utilizing local living materials should incentivize the thoughtful consideration of these questions and a prioritization based on project goals and timeline.

Similarly, the concept of utilizing "local" materials is equally as ambiguous/unsatisfactory when applied to the non-living parts of a shoreline project. While the concept of reutilizing materials on site is well-intended, it must be done in a manner which considers the overall project goals. As an example, the reuse of a deteriorated bulkhead or creosote soaked lumber, while efficient, conflicts with the overall objectives of WEDG. Along the same lines, utilizing local materials that are scarce or irresponsibly sourced might be less preferable than importing materials that are more sustainable.

The revised credit scoring should reflect the overall intent of the credit to prioritize the most responsible/efficient use of materials, rather than simply "buying local". In addition, a credit should be added that incentivizes contributing materials for re-use on other sites. Participation in the NYC Soil Bank is a great example of an activity that could be incentivized through WEDG (York 2017).

c. Emphasize/reward the market transformation potential of the category.

The credits provided through this category need to be better aligned with the market transformation potential of the use of innovative materials and/or the innovative use of traditional materials. This is one of the more successful aspects of LEED (Council 2017) (Todd, Pyke and Tufts 2013) and should be mimicked to the extent possible within WEDG. One of the more successful examples of the use of innovative materials in the marine environment has been the introduction of enhanced concrete to promote colonization by oysters and other invertebrates. Once the technique was introduced and its usefulness documented, several companies (ECOncrete 2012) were founded based on the idea of commercializing the technology. In a similar fashion, several companies have found a niche developing new ways to utilize traditional materials (T. R. Foundation 2014).

As the credit is currently written, points are assigned for adopting previously developed techniques (low pH concrete for example); however, no credit is given for attempting to introduce new materials or new applications for traditional materials. This limits the effectiveness of what could (should?) be one of the more meaningful credits within WEDG. Creating a performance-based credit linked to some type of monitoring, and perhaps cross-listed with an innovation credit, would incentivize innovation within the material category.

Such a credit could potentially encourage the development of partnerships between private industry and local universities.

d. Reexamine the quantitative metrics used to calculate compliance.

The quantitative metric(s) that are used within this category generally fall into one of three bins: cost based metrics (M&R Credits 3 and 4), quantity based metrics (M&R Credit 2), and location or distance based metrics. Within this category credits are assigned for utilizing materials in the most efficient way possible. Credits are awarded when either a cost-based or quantity based threshold is surpassed. The TWG felt that quantity based metrics were preferable to cost based metrics, however both approaches are somewhat flawed.

Awarding credits based upon cost is problematic because costs may not be evenly distributed across the materials. For example, it may be possible to achieve M&R credit 3.1 by salvaging a small piece of expensive material, whereas minimal credit may be obtained for salvaging a significant amount of less expensive material. This is in spite of the fact that salvaging the less expensive material may actually contribute more towards the overall objectives of WEDG. There is a similar issue with M&R Credit 4.1 as utilizing a small amount of local, expensive plant material would trigger the credit, whereas using a large amount of local but inexpensive plant material might not.

Credits based on quantities make more sense, however the point system needs to recognize the difficulty in applying a single metric across all sites. Some sites naturally have a greater capacity to support the types of actions supported by WEDG than others and even more so if the "project types" are collapsed into a single category. The solution is to move away from prescriptive credits and towards a performance based credit.

Lastly there are issues with the quantitative bounds used to define the term "local". One of the problems is that currently "local" is a function of project type. For example, for residential project types, several credits define local as within 50 miles, whereas for industrial sites local is within 100 miles. Assuming the project types are consolidated, a standardized metric that can be applied across all project types needs to be agreed upon. This standardized definition should at least acknowledge local definitions of "local" (states/municipal codes for example), even if the WEDG metric ends up being more strict.

Category 6. Operations and Maintenance

a. Dissolve the category

Remove and reassign the Operations and Maintenance credits to other categories to streamline the guidelines.

Table 7. Recommendations for Category 6 Structure

Existing	Action	Proposed
1. Provide Operations and Maintenance Plan for the Waterfront Edge	Move to the proposed pre-requisites category "Section 0" and incorporate or add to the proposed 'plan for monitoring and adaptive management' credit.	None
2. Provide Regular Condition Assessment of Marine Assets	The referenced ASCE inspection manual is focused on engineered structural systems and should be incorporated as one aspect of the Operations And Maintenance plan described in Credit 1 (see above). Or	None

	moved to the Edge Resiliency section.	
3. Identify Conservation Easement Opportunities for Open Space	Move to Ecology or Site Selection and Planning.	None
4. Identify partner to study site	Move to the Innovation section and group with other proposed learning and capacity building related credits	None
5. Provide Waterfront Emergency Preparedness Plan	Consider making this credit a prerequisite within the proposed pre-requisites category "Section 0". If it is not deemed a prerequisite, move to the Site Selection and Planning.	None
6. Provide Long-term Funding/Endowment Plan	Either move to Edge Resiliency or expand to include long-term funding that applies to more comprehensive than just edge infrastructure maintenance and move to Site Selection & Planning or Innovation.	None
7. Provide Maintenance Plan for Sustainable Stormwater management	Incorporate as one aspect of the proposed Operations And Maintenance plan described in Credit 1 (see above). Or add to Sustainable Stormwater Management credit series. (Note that it has been proposed that Edge Resiliency Credit 9 Sustainable Stormwater Management be move to a new Natural Resources section).	None
8. Develop Monitoring Plan	Move to the proposed pre-requisites category "Section 0" and incorporate or add to the proposed 'plan for monitoring and adaptive management' credit.	None

b. Establish minimum requirements for scope of plans, manuals, and studies.

When a plan, manual, or study is required, WEDG should define the minimum scope and requirements that should be included. An intent for each credit should be established and the requirements should include a clear description or outline of minimum scope and requirements. If a there is clear standard to refer to, consider developing a template. Establishing a minimum scope will provide the guidance needed for projects to develop something that may not be industry standard and will make it easier to determine if a project's efforts and approach are substantial enough to meet the credit intent. More research is needed to identify referenced standards or examples that may be appropriate to adopt or inform a scope for the following credits:

Credit 1: Provide O&M Plan for Waterfront Edge - Establish the minimum requirement and scope for a Maintenance Manual. If no reference exists, consider developing a template.

Credit 2: Provide Regular Condition Assessment of Marine Assets – The referenced ASCE inspection manual is focused on engineered structural systems, as does the Waterfront Facilities Maintenance Management System Inspection Guidelines Manual (NYCEDC). Others to include are the NAVFAC manual "United Facilities Council: MAINTENANCE AND OPERATION: MAINTENACE OF WATERFRONT FACILITIES[2] as well as PIANC manuals[3]

[2] https://www.wbdg.org/FFC/DOD/UFC/ufc_4_150_07_2001_c1.pdf

Additionally, identify or establish an assessment or inspection protocols or guide for water's edge natural systems (see Hudson River Sustainable Shorelines[4]).

Credit 3: Identify Conservation Easement Opportunities for Open Space – Current link in WEDG 1.0 to referenced NOAA website on conservation easements is not working. Is this the website that was intended? https://coast.noaa.gov/czm/landconservation/

Credit 4: Identify Partner(s) to Study Site - Establish minimum requirements and scope for study and assessment. Example: Prospects for Resilience: Insights from New York City's Jamaica Bay. (Sanderson, et al. (2016)

Credit 5: Provide Waterfront Emergency Preparedness Plan - Establish the minimum requirements and scope for a Waterfront Emergency Preparedness Plan. The NYC Community Emergency Planning Toolkit[5] includes a workbook and template (NYC Emergency Management) and FEMA also publishes guidance on emergency response for different types of assets, like Business Emergency Response Plans (FEMA)[6].

Credit 6: Provide Long-term Funding/Endowment Plan - Establish minimum requirements for scope and size of funding. Align to address the facilities covered in the condition assessment required by Credit 2.

Credit 7: Provide Maintenance Plan for Sustainable Stormwater Management - Establish minimum scope and requirements. Consider the EPA guidance for Green Infrastructure Operations and Maintenance,[7] NYC Environmental Protection's Handbook for Bioswale Care,[8] or the USACE Standard Guidelines for or the Design of Urban Stormwater Systems, Standard Guidelines for Installation of Urban Stormwater Systems, and Standard Guidelines for the Operation and Maintenance of Urban Stormwater Systems.[9]

Credit 8 Develop a Monitoring Program -The reference links for Credit 8 are overwhelming. Establish a clear outline of minimum scope and requirements and support by a list of references organized by type.

c. Expand the concept of Operations and Maintenance to include Ongoing Performance, Management, and Adaptation for all WEDG categories.

Whether or not the category is retained or is integrated into different credits, the concept of operations and maintenance should be expanded to more comprehensively address post-design- and- construction issues including:

- Operations: have operational plans and policies in place
- Maintenance: upkeep (who, what, when, where, how)

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[3] http://www.pianc.us/workinggroups/docs_wg/incom-wg25.pdf and http://www.pianc.org/edits/articleshop.php?id=1001030

[4] https://www.hrnerr.org/hudson-river-sustainable-shorelines/

[5] http://www1.nyc.gov/site/em/community_business/plan.page

[6] https://www.fema.gov/media-library/collections/357

[7] https://www.epa.gov/green-infrastructure/green-infrastructure-operations-and-maintenance

[8] http://www.nyc.gov/html/dep/pdf/green_infrastructure/bioswalecare_handbook.pdf

[9] http://ascelibrary.org/doi/book/10.1061/9780784408063

- Training & education: for users & operators
- Ongoing Performance: tracking & reporting (including monitoring)
- Adaptation: plans and demonstration of response to shifting climatic, ecological, and social conditions
- Management: structure for decision-making related to the above

These aspects of post-design-and-construction should be considered more comprehensively for all WEDG categories. The current O&M credits primarily address issues of Edge Resiliency, with some overlap in Site Selection & Planning and Ecology. Consider how the intent of other sections can be supported with credits that encourage longer-term planning and engagements to ensure there is an ongoing aspect to all WEDG goals.

d. Establish a means for ongoing tracking and reporting; consider recertification program.

The long-term success of the WEDG program is inherently tied to how well WEDG certified projects endure and continue to meet the program goals over time. Creating a feedback loop for testing success over time could become a valuable resource for learning within the WEDG community of projects, academic and research institutions, and regulators. Establishing a framework for this type of tracking, reporting, and learning could lead to transformation of waterfront best practices, education, and the regulatory environment.

It is important to collect data at regular intervals to monitor ongoing performance but also to retroactively assesses pre- and post-event conditions to study and learn from elements of vulnerability and resilience. Define appropriate metrics for long term success of goals in each category and the appropriate time-scale and regularity for tracking each metric (aka 'performance period').

Tracking & reporting could become extensive and onerous. Study the range of which WEDG goals can be tracked and then identify priority of key metrics for defining long-term success. Consider mechanisms for incorporating funding for tracking & reporting in capital budgets.

WA/WEDG might not have capacity to collect, track, or analyze data, but if the program establishes a format for publishing open source data (xml, tagging system) then it could fuel government and academic studies.

Category 7. Innovation

a. For documentation, must make the case for innovation (like LEED)

There is a vast body of management research about innovation (e.g. Schumpter 1934; Drucker 1985). While there may not be one overarching theory of innovation, Drucker's (1985) often-cited review suggests that innovations come from seven opportunities: unexpected occurrences, incongruities, novel process needs, industrial and market changes, demographic changes, changes in perception, and new knowledge. Similarly there is an abundance of literature about peak performance, mainly oriented toward individual efforts in sports or art (e.g., Malcata and Hopkins 2014; Privette 1981), but also for groups or organizations. In an interesting study of peak performance in an orchestra (Marotto et al. 2007), peak performance was defined as group-level experience of "flow", "timelessness", and aesthetic experience. That experience was created through the collective effects of a charismatic leader, an "ennobling" task and environment (for example, in front of an audience), and the inspiration and empowerment that members of the group received from each other.

Precisely because what is "innovative" is so hard to define, and the conditions that enable innovation are so context-specific, we recommend that WEDG put the responsibility for defining innovation back on to the project team. We believe WEDG should encourage teams to surpass the mandated or typical practice, so they need to document how their solution is new and/or better. Credits should require project teams to demonstrate how their design is "significantly" different from what is already out there, by contrasting their design solution to the usual or accepted practices for the particularities of their site (referencing an established baseline when possible). Additionally, a description about what 'opportunity' changed the baseline condition and/or created a need for innovation should be provided. For exemplary performance, the documentation requirement depends on exceeding the requirements of any one of the many guidelines that came before. Here the granting of a credit would depend on the definition of "significantly" (2x, 4x, statistically significant difference). It also seems to depend, at least in part, in some sense of what the "usual" performance is for a new solution to be "exemplary."

The authors of WEDG should consider LEED's model for how to document and reward innovation. Applications for LEED Innovation credits must provide a proposed credit structure, including:

- Credit intent
- Requirements (metrics and performance targets)
- A referenced baseline
- A narrative
- Supporting documentation (drawings, calculations, etc.) comparing the innovative strategies and outcomes applied to typical practice

LEED's criteria for awarding Innovation credits is:

- Must fall outside of the existing credit structure
- Must be a comprehensive strategy (more than one product or process)
- Must be significantly better than standard practices
- Demonstrate quantitative performance improvements (comparing a baseline and design case)
- Must be applicable to other projects

The current credit is titled "Inventive Design." In line with the LEED approach, consider replacing the word "inventive" with "innovative". These credits should be focused on achieving better outcomes and better performance than novelty, as invention itself is not inherently sustainable, contextually appropriate, and/or adaptive over time. Similarly, the title should not be specific to design, since WEDG has the opportunity to encourage innovation in research, construction, operations, adaptive management and ultimately, learning.

b. Add credits related to capacity building and learning

Innovation is no good unless it spreads out from the innovators. Rodger's (2003) theory of diffusion of innovation suggests for a new idea or technology to be adopted, it must have relative advantage (as documented with the advice above), compatibility with existing norms and practices, simplicity of presentation, trialability (in terms opportunity for limited experimentation) and observability (that is, can one see a difference in performance as a result of the innovation). Another type of innovation credit(s) should focus on documenting success, making designs and measured results available to a broader community, and sharing innovations in public fora should be encouraged. Capacity building to increase the awareness and advancement of WEDG issues, and create processes for continual learning, could include accredited professionals, educational outreach and programming (note overlap with PAI Credit 22), and publishing data and lessons learned.

One criterion for innovation might be that it is replicable by other projects or that the innovators include some aspect of open-source publishing, education, and/or outreach. Can the credit require this and perhaps provide some guidance on acceptable forms/formats of sharing and educating? Is WEDG in a position to create a platform for sharing innovation? Some examples from LEED are a specific education innovation credit, a pilot credit library, and the LEED User Forum on innovation. Other examples for information sharing include Rebuild By Design and 100 Resilient Cities, who are developing much more creative platforms for knowledge sharing.

c. Incentivize designed experiments and university partnerships

Because some WEDG project teams may not have the capacity or interest in documenting the performance of their innovations, they may miss an opportunity to share their ideas with the wider community. Here we believe that collaborations with the academic and non-profit sector may fill a void. By incentivizing designed experiments and documenting the results, WEDG has an opportunity to facilitate diffusion of innovation. Innovations should be encouraged throughout the project cycle, not just in design. The language of the innovation credits should include encouragement for ongoing research and testing through constructing and operating.

Deep Dives

Deep Dive 1: Develop guidance for integrating an ongoing performance and adaptive management

Background

Two of the key crosscutting recommendations provided by the technical work group are (1) Include "Adaptive Management" as an overarching concept, and (2) Adopt a Performance Based Credit Approach. These concepts are linked, in that there is a continuum that exists between initial site assessment, design performance targets and long-term performance and adaptive management of a site; however this cycle was not always clear in WEDG 1.0. To further support these recommendations, this deep dive looked into ways to integrate these concepts into the WEDG program.

Approach

To clarify and strengthen the connections between initial assessment, and ongoing measurement/adaptive management, we collaboratively developed a table that provides a framework for considering credit goals at each of these phases of project development. Following several rounds of iterations on the table between the Ashley Muse and Jessica Fain from the TWG and Kate Boicourt and Sarah Dougherty at the Waterfront Alliance, the table was vetted with the Advisory Committee at the November 16 meeting. Subsequently, the Technical Work Group provided additional feedback regarding the technical merits of the various metrics included in the table.

Outcomes

The outcome, a cross-cutting matrix, provides useful architecture for the entire WEDG program by highlighting the connections between pre-design data that is collected for the purposes of assessing site conditions, establishing performance targets for WEDG goals during design phase, measuring on-going performance following construction and adapting sites based on changing conditions. It serves as a resource for users to organize the data that they should be collecting to support their assessment and development of an ongoing performance and adaptive management plan in a single place.

Deep Dive 2: Develop decision-support tool to assist with the selection of soft/hybrid shoreline strategies for different shoreline conditions

Background

Credit 2, Edge Design and Stabilization within Category 3 of WEDG aims to promote shoreline edge strategies that balance the needs of the intended use with the physical, ecological, and human context of the site. To advance a more sustainable and ecologically beneficial edge condition, WEDG also aims to limit the use of hardened shoreline strategies and promote the use of "greener" shoreline design, such as living shorelines. To support these objectives, this Deep Dive focused on developing a decision-support tool to assist with the selection of potential shoreline strategies for different shoreline conditions.

Approach

This work predominantly builds on the work that Dr. Jon Miller, Stevens Institute of Technology, and his colleagues have developed for NJ Department of Environmental Protection and the Hudson River Sustainable Shorelines project.

The *NJ Living Shorelines Engineering Guidelines* identifies a set of parameters that are critical to the success or failure of living shorelines, grouped around four categories: (1) system parameters, (2) hydrodynamic parameters, (3) ecological parameters and (4) terrestrial parameters. For five different shoreline treatments focused on open or bayshore coasts, the guidelines provide guidance about the range of conditions under which the different stabilization techniques are suitable, based on literature review and engineering experience. These ranges are grouped into low/medium/high. A basic desktop analysis can help determine how a specific site meets each of these criterion, and point to a set of viable shoreline alternatives.

Since WEDG is interested in a range of shorelines strategies that goes beyond the original five included in the NJ guidance, we expanded the list by adding in two additional strategies included in Miller's unpublished work for application in the Hudson Raritan Estuary. We've also expanded the list to include sixteen additional shoreline strategies, drawing from a literature review of existing methods developed for the Hudson River Shorelines project. The final tool includes twenty-two shoreline strategies that include typical hardened structures to more nature-based features, such as living reefs, vegetated geogrids and marsh sills, and is more representative of the diversity of shorelines likely to be encountered.

A draft of the decision-support tool was shared with the WEDG Technical Advisory Committee on November 16, 2017. A follow-up call on December 4, 2017 with focus group comprised of several members of the Advisory Committee provided additional feedback on the utility of the tool and how to improve it. Many of their recommendations were integrated into the final version of the tool, such as the inclusion of short descriptions of shoreline strategies and parameters. Several of their recommendations went beyond the scope of the Deep Dive but are recommended that the Waterfront Alliance continue to pursue in the future, such as evaluating the breaks in the ranges included in Table B to reflect a wider range of waterfront conditions.

Description of Shoreline Decision-Support Tool

The objective of the tool (Appendix 4) is to provide guidance related to Credit 2 in Category 3 -Shoreline Protection (Step 2) of WEDG about the range of potential shoreline stabilization strategies available at sites

with different waterfront conditions. A base level of information around a set of critical parameters that can be obtained through desktop analysis is typically sufficient to begin narrowing down the alternatives.

Table A (tab 1) describes 22 shoreline strategies and the critical parameters that influence the selection and design. The parameters have been grouped into four categories, and include both traditional engineering parameters, as well as less traditional engineering parameters, such as water quality and sunlight exposure, which become relevant when considering "living" shoreline techniques. In ***Table B*** (tab 2), an attempt has been made to put quantitative bounds on the somewhat subjective limits imposed in Table A. These ranges should be viewed as guidance only and should be complimented by engineering expertise, emerging research and knowledge of local conditions. Based on the data in *Tables A and B,* the ***Worksheet*** (tab 3) allows WEDG users to select the conditions for each parameter at their particular site and view the range of potential strategies that may be appropriate given a basic desktop analysis. The "additional decision-support questions" in the *Worksheet* are designed to help further refine this list.

Definitions - Strategies (tab 4) provides short descriptions of each shoreline strategies. ***Definitions - Parameters*** (tab 5) provides an overview of each parameter and a high-level description about how to go about performing a desktop analysis as well as additional resources and data sources. Whenever possible, site visits should be used to confirm the information obtained during the desk-top analyses, and to look for important details which may not have been captured in the data collected.

Recommendations on WEDG Credit 2, Category 3

In addition to the decision-support tool, we provided recommendations about how to integrate the tool into the WEDG Credit. See marked up credit in Appendix 3 for additional details.

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Appendix 1: Questionnaire (blank)

WEDG Technical Work Group
Questionnaire

Instructions: Each Technical Work Group member will be assigned two WEDG categories to review. For each category, please complete the following questionnaire and return it to Jessica 2 days in advance of the Technical Work Group meeting where it will be discussed.

Name of Reviewer:
Category Name:

Part 1: Credit Credibility

1. **Supported by Research:** Which credits have a solid rationale and/or backed with reliable research studies? List and provide an explanation, including references where applicable. Do not limit review to a New York context; try to use resources that have broad relevance.

2. **Not Supported by Research:** Which credits lack a solid rationale and/or not supported by reliable research studies? List and provide an explanation, including references where applicable.

3. **Validity of Sources:** Are the resources listed in the appendix reliable sources? Are there others that should be included? Are the resources provided relevant at multiple geographic scales (local, regional, national)? If they are New York City specific, are there national references that may be more appropriate?

4. **Validity of Definitions:** Are the glossary definitions relevant to the category clear, accurate, and supported by the literature?

Part 2: Credit Value

1. **WEDG Principles and Category Goals**: Does the category description clearly relate to and support the overall WEDG principles? Is there an outcome or goal that is missing in this category? Does the category description clearly describe the intended goals in that category? Describe why or why not.

2. **Benefit of Credits:** Is the intent and benefit of each credit clearly articulated? If so, what is it? If not, what does it seem to be?

3. **Most Meaningful Credits:** Which specific credits will best lead to the intended outcomes as described in the category goals? Name the credits that are most valuable to achieving the outcomes.

4. **Least Meaningful Credits:** Which credits are least likely to lead to the stated outcomes as described in the category goals? Name them and describe why they may be unlikely to meet stated category goals.

5. **Missing Credits:** Are there any concepts or strategies that are missing that should be included in order to achieve the intended outcomes? Describe generally.

6. **Streamlining of Credits:** Are there opportunities to combine credits that are overlapping? Describe which ones could be combined and why?

7. **Connection to Outcomes:** Do the credits collectively achieve the intended outcomes for the category? Do they align with the overall WEDG principles? Describe why or why not.

8. **Support or Limit Strategies:** Do credits support or present a barrier to specific types of solutions we want to promote or avoid? Do they encourage or limit the project's ability to determine the most contextually appropriate solution?

9. **Credit Weighting:** Is the weighting of the credits commensurate with their value in achieving the intended outcomes and goals? Describe generally which credits may be under- or over-valued.
10. **Economic and market transformation:** Are there economic incentives associated with any of the credits? Where are there opportunities for alignment with other incentives? What type of market transformation could the credits support?

Part 3: Process

Project Process: Are there critical processes a project needs to undertake to achieve the credit(s)? Are design, implementation, or management processes explicitly required by the credit? If so, describe.

Documentation: What kind of documentation is needed to assure that the awarded credits meet intended objectives? Do the current documentation requirements required adequate information to assess whether the credit will be achieved and successful? Are the documentation requirements unreasonable or overly complex? What should be required instead?

Other Comments:

Appendix 2: Mock Up of Revised Scorecard

Category 0: Prerequisites					Possible Points:
Y	?	N			
			Credit 1	Develop a Multi-Disciplinary Design Team	
			Credit 2	Conduct preliminary site assessment (ecological, social, climate, hydrology and coastal protection)	
			Credit 3	Develop a plan for community participatory planning	
			Credit 4	Plan for monitoring, maintenance and adaptive management	

Category 1: Site Selection & Planning					Possible Points:
Y	?	N			
			Credit 1	Engage Local Communities and Users*	
			Credit 2	Conduct a vulnerability asssessment based on exposure and consequences	
			Credit 3	Select sites for access, ecology and resilience	
			Credit 4	Site buildings for access, ecology and resilience	
			Credit 5	Design Flood Resilient Buildings and Sites	
			Credit 6	Minimize Construction Impacts	
			Credit 7	Develop Emergency Planning and Preparedness	

Category 2: Public Use					Possible Points:
Y	?	N			
			Credit 1	Provide access along the water*	
			Credit 2	Provide access to the water	
			Credit 3	Provide opportuities for recreational boating	
			Credit 4	Provide water-based transit	
			Credit 5	Enliven the waterfront with programs, stewardship, and education opportunities	
			Credit 6	Incorporate historical and cultural elements	
			Credit 7	Create Visual Connections	

Category 3: Shoreline Protection					Possible Points:
Y	?	N			
			Credit 1	Optimize Shoreline Configuration	
			Credit 2	Stablize Shoreline for access, ecology and resilience	
			Credit 3	Incoporate Natural Features	
			Credit 4	Design nearshore Structures for access, ecology and resilience	
			Credit 5	Maintain shoreline edge*	

Category 4: Natural Systems					Possible Points:
Y	?	N			
			Credit 1	Preserve or Enhance Existing Natural Resources*	
			Credit 2	Encourage Habitat Continuity	
			Credit 3	Encourage Habitat Complexity and Robustness	
			Credit 4	Minimize Disturbance and Pollution*	
			Credit 5	Soil Conservation and Reuse	
			Credit 6	Energy Conservation and Reuse	
			Credit 7	Stormwater Conservation and Reuse	

Category 5: Innovation					Possible Points:
Y	?	N			
			Credit 1	Innovation	
			Credit 2	Capacity Building and Learning	
			Credit 3	Designed experiments and university partnerships	

* Potential for category requriement

Appendix 3: Deep Dive 2 – Suggested edits to *Edge design and stabilization* (Credit 2)

As a component of the deep dive into shoreline stabilization, specific line edits and comments on Credit 2 were provided using the track edit function.

Credit 2 - Edge design and stabilization: design ~~or rehabilitate/replace~~ an appropriate strategy for the context and intended use

Intent: ensure the structural integrity and sustainability of the shoreline and near-shore using a strategy that is the least possible negative impact or greatest possible positive impact given the intended use and context

Description: this credit aims to promote shoreline edge strategies that balance the needs of the intended use with the physical, ecological, and human context of the site, as well as increasing the structural integrity and stability of the edge over time. ~~(a service life of at least 50 years).~~ Shoreline stabilization is often employed to combat the effects of erosion, storms, and sea level rise, depending on a number of site-specific factors. Stabilization methods ~~on the grayer end of the spectrum~~that employ hardened shoreline structures (i.e. bulkheads and seawalls) can have a big impact on ecology, including loss of shallow-water and wetland habitat as well as an overall decline in habitat in the immediate area.[1,2,3,4] Use of hardened shorelines should be minimized wherever possible, except in cases where they may be necessary due to site conditions or intended use (contamination, working waterfront/heavy industrial sites). As an alternative to hardened shorelines, u~~U~~sing natural and nature-based features (otherwise known as "soft" or "living" shoreline strategies) to address stabilization ~~also~~ can often provide similar stabilization along with~~s~~ additional benefits ~~relative~~ that enhance ~~to~~ resilience, ecology, and public access.[5]

Design strategies: use the below steps to determine an appropriate strategy for the use/context.

- **Step 1:** evaluate if stabilization or replacement of the edge is necessary based on assessment of condition (***Appendix A***), intended use, and WEDG principles/the design guidelines described for this credit, and relevant site-wide strategies described in *Category 1, Credit 1: Avoid or mitigate future flood risk and erosion hazards*. If stabilization is not needed and the natural condition will be maintained, develop a plan to maintain the natural condition over time including native planting and buffers to allow for habitat migration with sea level rise.
- **Step 2:** if stabilization is needed, use the decision matrix in **Appendix** B to identify the range of shoreline strategies that are available. Based on the outputs of the worksheet**,** first consider whether a soft shoreline method is appropriate ~~determine the method~~ based on the site context and project goals~~. using the decision matrix in **Appendix B**~~. If the soft shoreline method is not appropriate and a hardened ~~If the~~ stabilization strategy is ~~hardened~~deemed necessary, provide a rationale for why ~~not and describe how the design is appropriate for at least 2050s sea level rise conditions and will be resistant to the /not vulnerable to the effects of being overtopped or scoured.~~ For any stabilization strategy selected, develop a maintenance and adaptive management plan that addresses structural integrity, environmental management, and adaptability to sea level rise. ~~If stabilization is not needed and the natural condition will be maintained, develop a plan to maintain the natural condition over time including native planting and buffers to allow for habitat migration with sea level rise.~~

In addition, for industrial/maritime sites, consider the following design aspects~~features~~ to create resilient and efficient working edges:

- Design height must be appropriate for easy loading/unloading facilities in all tidal ranges
- Limit ~~without~~ overtopping during storm events and ~~> Reduce~~ scour behind bulkheads/seawalls ~~(i.e., capping)~~
- Armor edges vulnerable to scour with toe protections~~tructures~~ (often caused by dredging of channels, erosion and navigational traffic)

[1] Douglass, S.L. and B.H. Pickel (1999) The tide doesn't go out anymore- the effect of bulkheads on urban bay shorelines. Shore and Beach 67(2-3): 19-25.
[2] Office of Science and Technology Policy (OSTP) (2015) Ecosystem-Service Assessment: Research Needs for Coastal Green Infrastructure.
[3] Patrick, C., D.E. Weller, X. LI and M. Ryder (2014) Effects of shoreline alteration and other stressors on submerged aquatic vegetation in subestuaries of Chesapeake Bay and the Mid-Atlantic Coastal Bays. Estuaries and Coasts 37: 1516-1531.
[4] Seitz, R.D. and A. S. Lawless (2006) Landscape-level impacts of shoreline development on Chesapeake Bay benthos and their predators. In Management, Policy, Science, and Engineering of Nonstructural Erosion Control in the Chesapeake Bay. Proceedings of the 2006 Living Shoreline Summit. Editor Sandra Y. Erdle. CRC Publ. No. 08-164.
[5] National Oceanic and Atmospheric Administration (2015). Guidance for Considering the Use of Living Shorelines. http://www.habitat.noaa.gov/pdf/noaa_guidance_for_considering_the_use_of_living_shorelines_2015.pdf

Comment [j1]: I would take out rehabilitate/replace…its all design whether its new or replacement

Comment [JF2]: I'm not sure if I agree with the logic here. Do soft shorelines get a "bye" with respect to their need to be adaptable?

- Select materials resistant to marine borer activity/corrosion but that allow settlement of native? desirable? marine organisms
- Armor edges against abrasion along the sand line (especially for steel sheeting bulkheads and piles)
- Mitigate for functional elevations during flood scenarios by:
  - Using a floating structure
  - ~~Using a lower elevation wharf/pier structure~~
  - Integrating a stepped edge or tiered platform using a low edge for maritime functionality and a high edge designed to stabilize shoreline and protect higher uplands and facilities

How Scored:

- If stabilization is needed on at least 25% of the shoreline length or no less than 50 feet, edge is facilitated/replaced using a method consistent with the context and project goals, based on analysis in Appendix A (8 pts). If stabilization is not necessary to support the use and prevent erosion, no points are awarded for this credit.
- Natural or nature-based features are employed along at least:
  - 25% of the shoreline (2 pts)
  - 50% of the shoreline (6 pts)
  - 70% or greater (8 pts)
  - 100% or there is an existing intact natural shoreline that is left unmodified (10 pts)
- Edge is designed to an expected service life of at least the following, as well as the projected sea level rise over the service life ~~(e.g., not like to overtop and fail in the future)~~. Narrative must describe how this was taken into consideration, including any strategies to adapt the edge over time due to sea level rise. Only projects for which stabilization is needed and pursued may qualify for this credit.
  - 50 years (2 pts)
  - 75 years (4 pts)
  - 100 years (6 pts)

Note: sea level rise projections from federal, state, regional, or city sources appropriate (regional and local may be more appropriate if available, due to regional differences in subsidence and rebound of land forms).

Materials needed to measure: site plans, edge assessment (Edge Resiliency credit one), completed worksheet in Appendix A, edge strategy narrative including explanation of how sea level rise will be accommodated.

Relevant assessment: existing edge condition and physical forcing

Comment [j3]: Don't see the difference between this one and the scour one

Comment [JF4]: How would a lower elevation wharf/pier mitigate flooding?

Comment [j5]: Do they get any points for considering it but correctly identifying that it's not necessary? That's what we want right?

Comment [JF6]: I imagine very few living shoreline strategies will be designed with a 50-year life in mind. Is this portion of credits only available to hardened structures?

Appendix 4: Deep Dive 2 - Shoreline Stabilization Strategy Decision Support Tool

How to use this tool: *The objective of this tool is to provide guidance related to Credit 2 in Category 3 - Shoreline Protection (Step 2) of WEDG about the range of potential shoreline stabilization strategies available at sites with different waterfront conditions. A base level of information around a set of critical parameters that can be obtained through desktop analysis is typically sufficient to begin narrowing down the alternatives.* ***Table A*** *(tab 1) describes twenty-two (22) shoreline strategies and the critical parameters that influence the selection and design. The parameters have been grouped into four categories, and include both traditional engineering parameters, as well as less traditional engineering parameters, such as water quality and sunlight exposure, which become relevant when considering "living" shoreline techniques.*

In ***Table B*** *(tab 2), an attempt has been made to put quantitative bounds on the somewhat subjective limits imposed in Table A. These ranges should be viewed as guidance only and should be complimented by engineering expertise, emerging research and knowledge of local conditions. Based on the data in Tables A and B, the Worksheet (tab 3) allows WEDG users to select the conditions for each parameter at their particular site and view the range of potential strategies that may be appropriate given a basic desktop analysis. The "additional decision-support questions" in the Worksheet are designed to help further refine this list. Definitions - Strategies (tab 4) provides short descriptions of each shoreline strategies. Definitions - Parameters (tab 5) provides an overview of each parameter and a high-level description about how to go about performing a desktop anaylsis as well as additional resources and data sources. Whenever possible, site visits should be used to confirm the information obtained during the desk-top analyses, and to look for important details which may not have been captured in the data collected.*

Table A: Appropriate Conditions for Various Shoreline Approaches

	Shoreline Strategies (Vertical <--> Horizontal)																**Off Shore Strategies**					
	Bulkhead	Eco Bulkhead**	Timber Cribbing	Live Crib Walls	Gabions	Vegetated Gabions	Rock Revetment*	Eco Revetment	Joint Planted Revetment	Rip- Rap	Veg Geogrid	Sill*	Geotextile Roll	Coconut Fiber (Coir) Rolls	Vegetated Slopes***	Beach	Breakwater*	Wave Screens	Floating Breakwater	Reef Balls*	Living Reef*	Groins and Stream Barbs
System Parameters																						
Erosion History	*Med-High*	*Med-High*	*Med-High*	*Med-High*	*Med-High*	*Med-High*	*Med-High*	*Med-High*	*Med-High*	*Low-Med*	*Low-Med*	*Low-Med*	*Low-Med*	*Low-Med*	*Low*	*Low-Med*	*Med-High*	*Med*	*Med-High*	*Low-Med*	*Low-Med*	*Low-High*
Relative Sea Level	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-High*	*Low-Mod*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*
Tidal Range	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*
Hydrodynamic Parameters																						
Wind Waves	*Low-Mod*	*Low-Mod*	*Low-High*	*Low-Mod*	*Low-High*	*Low-Mod*	*Mod-High*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low*	*Low*	*Low-High*	*High*	*Low Mod*	*Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*
Wakes	*Low-Mod*	*Low-Mod*	*Low-High*	*Low-Mod*	*Low-High*	*Low-Mod*	*Mod-High*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low*	*Low*	*Low-High*	*High*	*Low Mod*	*Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*
Currents	*Low-High*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low*	*Low-Mod*	*Low-Mod*	*Low*	*Low*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-High*
Ice	*Low-High*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low*	*Low*	*Low-Mod*	*Low*	*Low*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Low*	*Low-Mod*
Storm Surge	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-Mod*	*Low-High*	*Low-High*	*Low-Mod*	*Low-High*	*Low-High*	*Low-High*	*Low-Mod*	*Low-Mod*	*Low-High*	*Low-High*	*Low-High*
Terrestrial Parameters																						
Upland Slope	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Low-Mod*	*Mild-Steep*	*Mild-Steep*	*Low-Mod*	*Low-Mod*	*Low-Mod*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Low-Mod*
Shoreline Slope	*Steep*	*Steep*	*Mod-Steep*	*Mod-Steep*	*Mod-Steep*	*Mod-Steep*	*Mild-Steep*	*Mod-Steep*	*Mod-Steep*	*Mild-Mod*	*Steep*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Mod*	*Mild-Mod*
Width	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Mod-High*	*Low-High*	*Mod-High*	*Low-High*	*Low-High*	*Mod-High*	*Mod-High*	*Mod-High*	*Low-High*	*Low-High*	*Mod-High*	*Mod-High*	*Mod-High*
Nearshore Slope	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Steep*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*	*Mild-Steep*	*Mild-Mod*	*Mild-Mod*	*Mild-Mod*
Offshore Depth	*Shallow-Deep*	*Low-High*	*Shallow-Deep*	*Shallow-Deep*	*Shallow-Deep*	*Shallow-Deep*	*Shallow-Deep*	*Shallow-Deep*	*Shallow-Deep*	*Shallow-Deep*	*Shallow-Deep*	*Shallow-Mod*	*Shallow-Deep*	*Shallow-Deep*	*Shallow-Deep*	*Low-Mod*	*Mod-Deep*	*Shallow-Mod*	*Shallow-Deep*	*Shallow-Mod*	*Shallow-Mod*	*Shallow-Mod*
Soil Bearing	*Low-High*	*Low-High*	*Mod-High*	*Mod-High*	*Mod-High*	*Mod-High*	*Mod-High*	*Mod-High*	*Mod-High*	*Low-Mod*	*Low-High*	*Mod-High*	*Mod-High*	*Low-High*	*Low-High*	*Low-High*	*High*	*Low-High*	*Low-High*	*Mod-High*	*Mod-High*	*Mod-High*
Ecological Parameters																						
Water Quality	*Poor-Good*	*Good*	*Poor-Good*	*Good*	*Poor-Good*	*Good*	*Poor-Good*	*Poor-Good*	*Good*	*Poor-Good*	*Poor-Good*	*Poor-Good*	*Poor-Good*	*Poor-Good*	*Good*	*Poor-Good*	*Poor-Good*	*Poor-Good*	*Poor-Good*	*Poor-Good*	*Good*	*Poor-Good*
Soil Type	*Any*	*Any*	*Any*	*Any*	*Sand*	*Sand*	*Any*	*Any*	*Sand*	*Any*	*Any*	*Any*	*Sand*	*Any*	*Any*	*Sand*	*Any*	*Any*	*Any*	*Any*	*Any*	*Any*
Sunlight Exposure	*Low-High*	*Low-High*	*Low-High*	*Mod-High*	*Low-High*	*Mod-High*	*Low-High*	*Mod-High*	*Mod-High*	*Low-High*	*Mod-High*	*Mod-High*	*Low-High*	*Low-High*	*Mod-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Low-High*	*Mod-High*	*Low-High*

Table adapted from:
Miller, et al (2016). "Table 3: Appropriate Conditions for Various Living Shoreline Approaches" in *Living Shorelines Engineering Guidelines.* Prepared for New Jersey Department of Environmental Protection
Rella and Miller (2015) "Table 1: Project selection criteria" in *Living Shorelines Engineering Guidelines Application in the Hudson Raritan Estuary (Draft)*
Rella and Miller (2012). *Engineered Approaches for Limiting Erosion along Sheltered Shorelines: A Review of Existing Methods.* Prepared for Hudson River Valley Greenway and Hudson River National Estuarine Research Reserve, as part of the Hudson River Sustainable Shorelines Project, September 2012.

* Strategies included in the *NJDEP Living Shoreline Engineering Guidelines*

** Strategies included in the *Living Shoreline Engineering Guidelines: Application to the Hudson Raritan Estuary*

***Vegetated Slope techniques include: Live Stake, Brush Mattress, Branch Packing, Live Fascines, Reed Clumps, Dormant Post Planting

Table B: Criteria Ranges

Table B includes quantitative bounds on each parameter. These ranges were developed specifically for sheltered shorelines in New Jersey, and therefore may not be appropriate for other shoreline conditions. In addition, "living" shorelines are an emerging field and significant uncertainty exists in their optimal performance conditions. Therefore, these ranges should be viewed as guidance only and should be complimented by engineering expertise, emerging research and knowledge of local conditions.

	Criterion		
Parameter	Low/Mild	Moderate	Higher/Steep
System Parameters			
Erosion History	<2 ft/yr	2 ft/yr to 4 ft/yr	>4 ft/yr
Sea Level Rise	<0.2 in/yr	0.2 in/yr to 0.4 in/yr	>0.4 in/yr
Tidal Range	< 1.5 ft	1.5 ft to 4 ft	> 4 ft
Hydrodynamic Parameters			
Waves	< 1 ft	1 ft to 3 ft	> 3 ft
Wakes	< 1 ft	1 ft to 3 ft	> 3 ft
Currents	< 1.25 kts	1.25 kts to 4.75 kts	>4.75 kts
Ice	< 2 in	2 in to 6 in	> 6 in
Storm Surge	<1 ft	1 ft to 3 ft	>3 ft
Terrestrial Parameters			
Upland Slope	<1 on 30	1 on 30 to 1 on 10	>1 on 10
Shoreline Slope	<1 on 15	1 on 15 to 1 on 5	> 1 on 5
Width	<30 ft	30 ft to 60 ft	>60 ft
Nearshore Slope	<1 on 30	1 on 30 to 1 on 10	>1 on 10
Offshore Depth	< 2 ft	2 ft to 5 ft	> 5 ft
Soil Bearing Capacity	< 500 psf	500 psf - 1500 psf	> 1500 psf
Ecological Parameters			
Water Quality	-	-	-
Soil Type	-	-	-
Sunlight Exposure	<2 hrs/day	2 to 10 hrs/day	>10 hrs/day

Source: Miller, et al (2016). "Table 4: Criteria Ranges" in *Living Shorelines Engineering Guidelines*. Prepared for: New Jersey Department of Environmental Protection.

Worksheet

Based on a desktop analysis of each parameter, select the condition (L, M, H) that best represents the site.

Parameter	*Select Condition*	*<-- Based on desktop analysis of each parameter, select L, M or H based on the Criteria Ranges recommended in Table B.*
System Parameters		
Erosion History		
Sea Level Rise		
Tidal Range		
Hydrodynamic Parameters		
Waves		
Wakes		
Currents		
Ice		
Storm Surge		
Terrestrial Parameters		
Upland Slope		
Shoreline Slope		
Width		
Nearshore Slope		
Offshore Depth		
Soil Bearing Capacity		
Ecological Parameters		
Water Quality		
Soil Type		
Sunlight Exposure		
Potential Strategies:	Output: List of shoreline strategies that fit 15/17 criteria, sorted by "green" vs" grey"	*<--- Potential shorelines strateiges available based on initial analysis.*

Additional Decision-Support Questions	
1. Will the owner/sponsor be able to provide regular maintence?	Y/N
2. Is the construction required to only include manual labor or can heavy equipment be used?	Manual/Heavy/Either
3. Does the site include or is it adjacent to motorized boat usage or located in a working waterfront area?	Y/N
4. Is there concern about the spread of soil contamination into the waterways?	Y/N

Parameters	Parameter Level 1 Analysis Description	Resources
System Parameters	*System parameters are parameters that represent large scale or regional processes which are not necessarily confined to the project site.*	
Erosion History	Understanding the erosion history of the site is important if a successful living shorelines project is to be designed and constructed. In some cases erosion is a consistent, long-term process, while in others it is episodic and/or related to specific changes to the environment surrounding a project site. If the cause of the erosional problem can be identified, more appropriate solutions can be found. The erosion history of a site can often be determined by examining historic aerial photography and/or digitized shorelines of the project site. There are many free resources that can assist in determining the erosion history of a site.	Google Earth historical aerial imagery: www.googleearth.com Nationwide Environmental Title Research, LLC (NETR) online database: www.historicaerials.com GIS Data Repositories (see state, local and federal repositories) Bing maps (birdseye): http://www.bing.com/maps/ Lidar Data http://www.csc.noaa.gov
Relative Sea Level	Projections of future sea levels vary; however all are consistent in that they indicate future sea levels will be higher than they are today. The simplest approach is to assume that the existing regional sea level trend will persist into the future. NOAA maintains information on sea level trends on its Tides and Currents website.	http://tidesandcurrents.noaa.gov/
Tidal Range	Tidal range is a critical factor in the design of most living shorelines projects. For submerged or low -crested structures such as sills or small breakwaters, the position of the crest relative to the water level plays a role in the amount of energy dissipation that can be expected and the amount of force the structure is subjected to. Tidal range is also critically important for any "living" portion of a living shorelines project. Selection of the appropriate vegetation is highly dependent on the placement of the vegetation with respect to local tidal datums. A first order assessment of the tidal datums and variation at a site can be obtained by identifying nearby gauges and assuming that the local conditions are the same or by utilizing NOAA's VDatum tool. Users of the VDatum tool are cautioned that significant errors can occur during the transformations. It should be noted that significant water level variations can occur over relatively small distances, in rivers and coastal bays, therefore higher level analyses are recommended.	http://vdatum.noaa.gov/ http://tidesandcurrents.noaa.gov/ http://waterdata.usgs.gov/nj/nwis/current/?type=tide&group_key=NONE Also see local universities For short tide gauge records without established tidal datums, see methodology outlined in NOAA's Computational Techniques for Tidal Datums Handbook (National Oceanic and Atmospheric Administration, 2003)
Hydrodynamic Parameters	*Generally, the hydrodynamic parameters at a site represent the dominant forcing mechanism contributing to the existing shoreline condition, and influencing proposed living shorelines projects.*	
Wind Waves	Waves generated by local winds and meteorological conditions tend to be one of the dominant forces impacting shorelines, and are typically considered in all engineered shoreline improvements. The wind speed, the duration of the wind, and the open water distance over which it acts (fetch) will determine how large the waves grow. For living shorelines, there are generally two design waves which may be important: maximum expected or extreme wave and a more frequently encountered condition.	Desktop approaches to estimating wave energy: - Basic fetch approach: Hardaway Jr., et al., 1984; refined by (Hardaway Jr. & Byrne, 1999) - SMB method (US Army Corps of Engineers, 2002)
Wakes	Wakes or ship-generated waves can be one of the most significant sources of wave energy within sheltered water bodies. Divergent waves are waves generated by the bow of the vessel as it moves through the water. Transverse waves are waves generated by the stern and propellers. Due to limited data available on wakes, at the Level 1 Analysis stage, a cursory evaluation of the potential importance of wakes can be made by identifying features such as nearby marinas or navigation channels that will influence the size and frequency of ship traffic.	Sorensen, 1997; CIRIA; CUR; CETMF, 2012
Currents	Although waves are generally considered to be the primary force impacting the design of coastal structures, currents also play an important role, particularly for living shorelines sites located near tidal inlets or along riverbanks. Currents have the capacity to uproot vegetation, scour the bank, and during storms can transport debris which increases the scour potential. It is rare that sufficient current data exists to perform a desk-top analysis, although general data may be obtained from NOAA, USGS and USACE. For some locations, detailed hydrodynamic models, statistical summaries or climatologies based on measured and/or modeled data may exist.	NOAA (http://tidesandcurrents.noaa.gov/curr_pred.html) USGS (http://waterdata.usgs.gov/nj/nwis/rt) U.S. Army Corps of Engineers (http://cirp.usace.army.mil/)
Ice	Like wakes, ice is known to have a significant impact on shoreline and coastal structure stability, yet just like wakes, our knowledge on the process of ice-structure interaction is lacking. In some locations records of ice are collected by organizations such as the coast guard. The National Ice Center archives ice cover within Delaware Bay The data set is based on an analysis of MODIS (Moderate Resolution Imaging Spectroradiometer) imagery (http://modis.gsfc.nasa.gov/) and provides estimates of ice presence but not thickness. Similarly, the Corps of Engineers maintains an archive of historic ice jams; however the level of detail is generally insufficient to be of much use in the design of living shorelines.	National Ice Center: http://www.natice.noaa.gov/index.html USACE Historic Ice Jamshttp://icejams.crrel.usace.army.mil/ An approach for estimating ice thickness based on procedure for calculating ice growth due to heat transfer can be found in (US Army Corps of Engineers Cold Regions Research and Engineering Laboratory, 2004).
Storm Surge	For traditional engineering designs, determination of the storm surge plays a critical role in the design of coastal structures. For living shorelines however, the storm surge takes on less significance because most of the approaches are low lying and will be overtopped during extreme storms. A first order approach is to use the existing FEMA Flood Information Study (FIS) reports and Flood Insurance Rate Maps (FIRMS) to estimate the water level during the 1% annual chance of occurrence storm (nominally, the 1 in 100 year storm). The elevations specified on the FIRMs represent the Base Flood Elevation (BFE) expected during the 1% annual chance of occurrence storm. The BFE is the 100-yr still water elevation plus the larger of the wave run-up or the wave crest elevation. The resulting BFE's are often several feet higher than the still water elevation near the coast. Still water elevations (which include the effect of wave setup) for the 10%, 2%, 1%, and 0.2% annual chance of occurrence storms can be obtained from the accompanying FIS reports. NOAA provides estimates of extreme water level for each of their long term stations . Unlike FEMA's BFEs, The NOAA estimates do not explicitly take into account wave effects. As such the NOAA estimates are more representative of the still water elevation than the BFE appearing on a FIRM.	FIRMS/FIS for FEMA Region 2: http://www.region2coastal.com/. NOAA Extreme Water Levels: http://tidesandcurrents.noaa.gov/est/
Terrestrial Parameters	*Terrestrial parameters represent the condition of the land both below and above the water. Terrestrial parameters play a significant role in dictating what type of shoreline modification is appropriate and in how the selected treatment will respond to the local conditions.*	
Upland Slope	Here the upland slope is defined as the slope of the land from approximately the spring high water elevation to the point at which the upland levels off. The upland slope is critical for determining the type of vegetation that can be supported and the likelihood of scarping during storms. In general, gentler slopes are more susceptible to inundation and less susceptible to erosion. It is often possible to obtain a sense of the upland slope by examining existing data sources. Topographic maps, digital elevation models (DEMs), and Lidar data sets are frequently available online.	USGS topographic maps: http://store.usgs.gov/b2c_usgs/usgs/maplocator/(ctype=areaDetails&xcm=r3standardpitrex_prd&carea=%24ROOT&layout=6_1_61_48&uiarea=2)/.do See GIS repositories for DEM grids For LIDAR Data see NOAA Coastal Services Center (http://www.csc.noaa.gov/)

Shoreline Slope	The shoreline or intertidal slope is important in determining the appropriate shoreline stabilization for a particular site. Here the shoreline slope is defined as the slope from approximately Mean Lower Low Water (MLLW) to the Spring High Water line. It can be more difficult to determine shoreline slopes via a desk-top analysis than upland slopes because the area of interest lies along the boundary between two separate data sets (topographic and bathymetric). Estimating the shoreline slope can be done either by working with a data set such as Lidar that covers the area of interest or by patching together a topographic and a bathymetric data set. If the patchwork approach is selected, particular attention should be paid to the datums to ensure that they are consistent.	
Width	Along developed coastlines, the horizontal space between the developed area and the water's edge is often reduced or eliminated. In order for a living shorelines project to be successful, the amount of available space must meet or exceed that required for the project. When space is not available, generally two options exist for creating it. The first is to landscape back into the site at an appropriate slope. The second is to advance the shoreline through the use of fill, although regulations may prohibit the placement of fill below the MHW (see USACE and State regulations). The available width at a site can often be determined by examining aerial photography and/or digitized shorelines of the project site.	Google Earth aerial imagery: www.googleearth.com GIS Data Repositories (see state, local and federal repositories) Bing maps (birdseye): http://www.bing.com/maps/ Lidar Data http://www.csc.noaa.gov
Nearshore Slope	The nearshore slope plays a critical role in determining the behavior of the waves and currents immediately offshore of the site. The offshore contours will affect the size of waves impacting the shore, where the waves will break, and the amount of scour or sediment transport that should be expected. It is often possible to get a preliminary sense of the nearshore bathymetry at a site from a desk-top analysis. While many freely available bathymetry data sets exist on line, the resolution is typically insufficient for design purposes. Coarse sets of bathymetry data are provided by NOAA. The NOAA Coastal Services Center maintains a database of estuarine bathymetry data (DEMs) created by merging multiple surveys collected over time together.	http://www.charts.noaa.gov/OnLineViewer/AtlanticCoastViewerTable.shtml NOAA Coastal Services Center: http://estuarinebathymetry.noaa.gov/midatlantic.html
Offshore Depth	Offshore water depths are important in the design of living shorelines projects for several reasons. Deeper water reduces the amount of energy dissipation a wave experiences as it travels towards the shoreline. In addition, deep water allows larger ships which are generally capable of generating larger wakes. Depending on the living shoreline approach selected, water depth will also impact the amount of fill material and the size of the structure required. See bathymetric datasets for assessing nearshore slopes.	
Soil Bearing	Soil bearing capacity is an important, often overlooked factor in the design of living shorelines projects. Most living shorelines projects are constructed in areas where the soil conditions would be considered poor to very poor, based on traditional construction standards. Although the size of the materials used in living shorelines projects is typically small compared to traditional engineered approaches, the additional load imposed by structural elements consisting of stone, concrete, or even natural reefs needs to be taken into consideration. If not accounted for properly in the design phase, these additional loadings can cause undesirable settlement which can compromise the performance of the project. Typically only a limited amount of information about the characteristics of the soil at a site exists prior to the collection of project-specific geotechnical information. Some potential sources of information that may be used to get a very general sense of the conditions expected at a site are topographic and geologic maps, groundwater maps, previously published geotechnical studies, and dredging/disposal records.	
Ecological Parameters	*The success or failure of any habitat which the living shorelines project intends to restore, enhance or develop will ultimately be dependent upon a series of ecological parameters. These parameters generally represent the biogeochemical conditions at the site, and will determine the suitability of the growing conditions for living elements of the project.*	
Water Quality	Habitat development is extremely dependent upon water quality. Dissolved oxygen concentrations, water temperature, salinity, and turbidity are significant factors that must be considered when planning any habitat preservation or restoration. Specific habitat types (i.e. marsh plantings, oysters, fish) each have optimal conditions under which they flourish. An initial desk-top analysis of the water quality in the vicinity of proposed living shorelines projects can typically be performed. Increasing regulations on water quality standards and an emphasis on transparency and accountability has resulted in the collection and dissemination of a significant amount of observational data. See USGS, EPA, local and state environmental agencies, universities and environmental organizations for local water quality data repositories.	
Soil Type	Soil type plays an important role in determining the rate of vegetation growth and the penetration and heartiness of the root system. A strong root system is essential for providing erosion resistance during large storms; therefore selecting the right type of soil for use in living shorelines projects is critical. Typically only a limited amount of information about the characteristics of the soil at a site exist prior to the collection of project-specific geotechnical information. Some potential sources of information that may be used to get a general sense of the conditions expected at a site are topographic and geologic maps, groundwater maps, previously published geotechnical studies, and dredging/disposal records.	
Sunlight Exposure	The amount of sunlight available is an important parameter both for aquatic and terrestrial habitat development. Particular attention should be paid to existing and proposed large woody vegetation that may shade out vulnerable incipient marsh vegetation. A desk-top analysis of sunlight exposure can typically be performed using readily available aerial images.	Google Earth aerial imagery: www.googleearth.com GIS Data Repositories (see state, local and federal repositories) Bing maps (birdseye): http://www.bing.com/maps/

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Shoreline strategies	Definition	Habitat Value (L, M, H)
Bulkhead	Traditionally, the most common shoreline hardening technique used to protect vulnerable and eroding shorelines. Used at the base of bluffs or steep shorelines, bulkheads are vertical walls which prevent the loss of soil and the further erosion of the shore.	*L*
Ecologically Enhanced (Eco) Bulkhead**	Walls or barriers that incorporate living plants or stakes into their design. This term is used to refer to a collection of approaches, all of which attempt to soften a traditionally hard edge through the introduction of ecologically friendly modifications.	*M*
Timber Cribbing	Box-like arrangement of interlocking logs or timbers are used to form a “crib”, which is then filled with broken rock.	*L-M*
Live Crib Walls	A 3-dimensional, box-like chamber that is constructed out of untreated log or timber and is placed at the streams base flow level. The interior of the structure has alternating layers of soil and/or fill material and live branches that are meant to root themselves inside the box and eventually extend into the slope of the bank.	*M*
Gabions	Wire mesh containers that can be used to form retaining walls, sea walls, channel linings or revetments. The containers are generally filled with cobbles or crushed rock and stacked to form flexible, permeable, monolithic structures. Gabions are particularly useful when the stones that must be used would normally be too small to be used without being washed away.	*L-M*
Vegetated Gabions	Rock gabions that have had vegetation incorporated into their design. Live branches are placed between each layer of gabions and root inside the baskets as well as in the soil behind the structure, greatly increasing their structural integrity, and softening the edge.	*M*
Rock Revetment*	Shore attached structures built to protect natural sloping shorelines against wave energy and erosion. Revetments use large rocks (or other materials) on the front of a dune or stream bank to dissipate wave and/or current energy to prevent further recession of the backshore.	*L-M*
Eco Revetment	A natural revetment constructed of logs, rootwads, boulders and other natural materials that once established serves both as a habitat for insects and water organisms and as a shoreline stabilization structure.	*M*
Joint Planted Revetment	Joint planting consists of adding live stakes or vegetation into the open spaces, or joints, of an existing rip-rap or rock covered slope. Alternatively, the stakes can also be placed at the same time as the rock reinforcement. When the system of roots from the live stakes develops it creates a living root mat beneath the rocks, binding the soil and preventing washout of the soil and fine material, while also providing habitat.	*M*
Rip- Rap	A rip rap slope functions similar to a revetment; however they are constructed from small rocks, cobble and gravel, instead of large stones. Rip rap structures armor the shoreline by providing a base layer, which is stable under normal stream flow conditions.	*L-M*
Veg Geogrid	A terraced wall consisting of alternating horizontal layers of soil wrapped in synthetic fabric and live branch cuttings. The live branch cuttings serve to both reduce the wave energy and shear stress on the wall and bind the geogrid together, as the vegetation matures.	*M-H*
Sill*	Low-profile, shore parallel mounds placed offshore with the purpose of retaining sediment and elevating the nearshore profile. Sills can be constructed of natural (stone, soil, etc.) or synthetic (geotextile rolls) materials and are typically used as part of a perched beach system or fringe marsh.	*M*
Geotextile Roll	Cylindrical sand filled geotextile tubes which are placed along the shoreline to reduce erosion. The rolls may either be exposed, or designed such that they remain hidden within the dune/bank only becoming “active” during storms.	*M*
Coconut Fiber (Coir) Rolls	Long cylindrical structures composed of coconut husks that are laid parallel to the shore. These structures are intended to help prevent minor slides while encouraging sediment deposition and plant growth.	*M-H*

Vegetated Slopes**	Vegetated slopes encompass a range of techniques such as Brush Mattress, Branch Packing, Live Fascines, Reed Clumps, and Dormant Post Planting. A **brush mattress** is a combination of live stakes, live fascines, and branch cuttings that form a protective cover on an eroding shoreline that acts to protect the shoreline against oncoming waves, capture sediment during floods, and enhance habitat for vegetation. **Branch packing** consists of segments of compacted back fill separated by layers of live branches. This approach is a relatively inexpensive technique used to fill in missing areas of the shoreline, which also provides a succession of barriers to prevent further erosion and scouring. **Live fascines** are cylindrical bundles of branch cuttings that are placed in trenches on sloping shorelines with the purpose of dissipating wave energy at the shoreline. The Latin term for "bundle of sticks" is fascine. **Reed clumps** are individually wrapped root systems that are placed in trenches and staked down on the water's edge. These individual plant systems create a root mat that reinforces and retains soil at the shoreline. **Dormant post** are installed into an eroded bank at or above the waterline. Rootable vegetative material is added to form a permeable revetment along the shoreline.	*H*
Groins and Stream Barbs	**Groins** are fingerlike shaped barriers that are built perpendicular or at an angle to the shoreline that have the effect of creating pockets of reduced currents. These lower currents have the two-fold effect of reducing the erosional pressure on the shoreline, while also encouraging sediment deposition. **Stream barbs** are low sitting rock piles that protrude out from the shore and are constructed to redirect the flow of a stream away from the eroding shores. Stream barbs function similarly to river groins; however are typically more modest in nature.	*L-M*
Beach	Beaches provide critical habitat and access to the water while also protecting the upland from direct wave attack. As waves ride up the beach they dissipate their energy on the sloping beach face reducing their potential impact on the upland areas behind them. While beach nourishments have been used extensively to protect ocean coastlines, they have been used much less frequently in estuarine, bay shore and riverine environments.	*H*
Breakwater*	A structure that is built within a water body to reduce wave energy and erosion in its lee. Types include rubble mound breakwaters, floating breakwaters, and living breakwaters.	*L-M*
Wave Screens	Offshore structures designed to reduce wave (primarily) and current energy at the shoreline. Typically placed perpendicular to the dominant wave direction, these structures consist of horizontal, vertical and diagonal slats affixed to structural support members. The amount of energy dissipation is directly related to the porosity of the structure.	*L*
Floating Breakwater	A special type of breakwater that floats within the water column, but performs the same function as a traditional breakwater. Floating breakwaters can and have been constructed from many different types of buoyant materials including tires, logs, timber, hollow concrete modules, and heavy duty plastic. Floating breakwaters must be securely anchored to the bottom to withstand the often substantial wave and current induced forces.	*L*
Reef Balls*	Reef Balls provide a durable substrate for reef development in areas with intense wave conditions. Ideally, generations of reef species grow over time and large reef structures are eventually formed. Reef Ball breakwaters function similarly to submerged breakwaters, sills, and living reefs, and are more common in the Caribbean and southern United States than the northeast.	*H*
Living Reef*	A breakwater constructed of living (or once living) organisms such as oysters or mussels that reduce shoreline erosion by dissipating incident wave energy.	*H*

Definitions adapted from: Rella and Miller (2012). *Engineered Approaches for Limiting Erosion along Sheltered Shorelines: A Review of Existing Methods.* Prepared for Hudson River Valley Greenway and Hudson River National Estuarine Research Reserve, as part of the Hudson River Sustainable Shorelines Project, September 2012.