TERMINOLOGY FOR THE HUDSON RIVER SUSTAINABLE SHORELINES PROJECT

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About the Hudson River Sustainable Shorelines Project

The Hudson River Sustainable Shorelines Project is a multi-year effort lead by the New York State Department of Environmental Conservation Hudson River National Estuarine Research Reserve, in cooperation with the Greenway Conservancy for the Hudson River Valley. Partners in the Project include Cary Institute for Ecosystem Studies, NYSDEC Hudson River Estuary Program and Stevens Institute of Technology. The Project is facilitated by The Consensus Building Institute. The Project fulfills aspects of Goal 2 of the Action Agenda of the Hudson River Estuary Program.

The Project is supported by the National Estuarine Research Reserve System Science Collaborative, a partnership of the National Oceanic and Atmospheric Administration and the University of New Hampshire. The Science Collaborative puts Reserve-based science to work for coastal communities coping with the impacts of land use change, pollution, and habitat degradation in the context of a changing climate.

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EXECUTIVE SUMMARY

This document fills a need of the Hudson River Sustainable Shorelines Project to have a common understanding and summary of important shoreline, natural resource and social science terms. It is a collection of definitions for terms and concepts that are often used among researchers and partners of the Project. It is intended to limit confusion regarding commonly used and discipline specific terms for a multi-disciplinary team and audience. General definitions of the shorezone, the legal demarcation of shoreline and specific armoring and stabilization approaches are included. Ecologically enhanced shoreline is introduced as an alternative to living or soft shoreline. Examples of shoreline areas along the Hudson River with these treatments are provided wherever possible.

INTRODUCTION

The Sustainable Shorelines Project

This terminology discussion is part of the Hudson River Sustainable Shorelines Project, a multi-year study that will provide science-based information about the best shoreline management options in terms of engineering performance, economic cost, and environmental benefits, in the context of projected changes in climate. This information is intended to be used in decision making about community waterfront planning, shoreline development, and policy and regulatory safeguards. This Hudson River-specific information about best shoreline management practices for Hudson River Estuary shorelines will help protect associated water quality, wildlife habitat, outdoor recreation, and community quality of life while adapting to the impacts of climate change.

The Sustainable Shorelines Coordination Team led by the NYSDEC Hudson River National Estuarine Research Reserve (HRNERR), includes highly qualified natural and social scientists, engineers, natural resource managers, communication specialists and consensus building experts. A diverse group of experts serve on an Advisory Committee.

The Need for Common Terminology

Because of the multi-disciplinary nature of the Project, it is important to have a common understanding and language within the Sustainable Shoreline Project. This document fills the need to define the nomenclature used in the project, including both key social and natural science terms as well as shoreline terms.

Terms related to shores, whether general descriptions, classifications or specific terms for shoreline engineering vary according to region and professional or lay person use. Even within the various natural resources and community resilience efforts for the Hudson River, including the NYS Sea Level Rise Task Force, NYS Department of Environmental Conservation, and Hudson River National Estuarine Research Reserve the definitions and use of the terms and classifications vary. This document represents the agreed upon terminology for the Hudson River Sustainable Shorelines Project. The definitions in this document have been derived from the various work and projects mentioned above, the early work of Sustainable Shorelines Project, as well as the wider engineering literature.

We define both generic shore terms as well as specific engineering methods. We have specifically chosen not to use the terms “living shorelines” or “soft shorelines”. “Living shorelines” is a generic term for shoreline erosion control methods that provide habitat, preserve or restore natural habitat and protect water quality (K. Durhing 2008, in Erdle et al. 2008) and NOAA NMFS Habitat Conservation Restoration Center: Living Shorelines.) However, the definition is still evolving and there is debate as to what constitutes a living shoreline (Pilkey et al. 2012).The term is sometimes used to describe a specific shoreline stabilization method which we refer to as a sill with constructed near-shore wetland.

To the lay person, “soft shorelines” conjures images of sandy beaches rather than of vegetated slopes. To eliminate confusion, we avoid using the term soft shorelines. A diagram illustrating the legal definition of shoreline is in Appendix A.

The choice of the specific engineering methods to include in this document was based on a table adapted

from VanLuven (2011) and a list of ten methods chosen for cost and engineering assessments by Rella and Miller (2012b). Table 1 in Appendix B lists the methods for these two and related studies. Tables 2 to 5 provide documentation of the various terms used in studies under the auspices of HRNERR and the Sustainable Shoreline Project.

For a more thorough description of shoreline protection approaches, see Rella and Miller (2012a) and other references listed in Appendix C.

GENERAL SHORELINE TERMS

Sustainable Shorelines

Shoreline management practices that seek to protect the shore zone's wildlife habitat, ecological benefits, outdoor recreation, community quality of life, and water-dependent businesses for future generations.

Shoreline

The term shoreline is used in many ways, including defining either a line or an area. Therefore several are included here:

- The shoreline is: An "infinitesimally thin line that separates the water from the land." (Strayer and Findlay 2010);
- In New York State, the intersection of the mean high water line with the beach profile; below mean high water is publicly owned and above is privately owned. (see Appendix Afor details);
- The fringe area along the edge of a water body, which connects the shallow aquatic portion of the water body with adjacent upland;
- The zone of contact of a body of water's surface and the land;
- The land along the edge of a body of water.

Related terms: *shore zone, riverfront, coast, shore, waterfront, coastline.*

Shore Zone

The term shore zone is used in many ways, therefore several are included here. The shore zone is:

- The "region closely adjoining the shoreline in which strong and direct interactions tightly link the terrestrial ecosystem to the aquatic ecosystem, and vice versa." (Strayer and Findlay 2010);
- "Roughly three feet below the current low water level and three to six feet above the current high water mark." (VanLuven 2011);
- The zone of contact of a body of water's surface and the land;
- The zone affected by wave and wake energy, typically reaching above and below the extreme high and low tides respectively.

Shoreline Development

Shoreline development is human-made change to the land such as buildings and infrastructure constructed along or near a body of water.

Shoreline Protection

Shoreline protection is a range of engineering responses that focus on protecting land or landward infrastructure from erosion, inundation, or storm-induced flooding through 1) armoring; 2) shoreline stabilization structures and enhancements designed to slow the erosion rate and dissipate wave or current energy; 3) beach maintenance. Armoring includes bulkheads, cribbing, revetment and riprap. Stabilization includes jetties, breakwaters, sills and vegetation. Images of these methods can be found in Allen et al. (2006) and Rella and Miller (2012a).

Beach maintenance is the replacement of beach sediment. Flood protection structures include seawalls and dikes. Beach maintenance and flooding protection structures are included in this definition of shoreline protection for completeness. However, they are not discussed further in this document since these methods are rarely used in the Hudson Estuary.

Related terms: *Altered shoreline, engineered shoreline, modified shoreline, built shoreline, hard shoreline, shoreline construction, constructed shoreline.*

Ecologically Enhanced Engineered Shoreline Protection

This is a subset of shore protection methods that incorporate measures to attract and support both terrestrial and aquatic biota and desirable ecological functions. These can be either modifications to existing structures through the addition of plantings and other ecological measures or the design of new structures incorporating ecologically-friendly materials, geometry, or placement. If correctly designed, ecologically-engineered structures serve to prevent or reduce shore erosion while emulating the physical and biological conditions of naturally occurring, stable shorelines. Valuable ecosystem services are enhanced or restored; including provision of habitat for terrestrial and aquatic species, maintenance of water quality, aesthetic, resilience and sustainability.

An asterisk next to type of engineering methods below describes those that are ecologically enhanced.

Related terms: *Innovative, non-traditional, alternatives to hardening; bio-engineered; eco-alternatives; ecologically enhanced; green; habitat-friendly; non-structural; shoreline softening; soft shorelines; soft approach; soft engineered shoreline; soft shore protection, restored shoreline.*

SHORELINE ENGINEERING ARMORING METHODS

An asterisk next to type of engineering methods below describes those that are ecologically enhanced.

Bio/Green Walls*

These are alternatives to traditional sheer structures such as gabions or bulkheads which are modified using one or more guiding ecological principles. These principles can include the use of living plants or stakes, the incorporation of surface roughness to provide habitat substrate for aquatic or terrestrial species, undulations and elevation changes (terracing) designed to create areas of calm water. This term is used to refer to a collection of approaches, all of which attempt to enhance ecological services.

Bulkheads

Bulkheads are vertical walls which prevent the loss of soil and the further erosion of the shore. Bulkheads are a commonly engineered shoreline method used to provide working waterfront or protect vulnerable and eroding shorelines. They can be made of a variety of materials including but not limited to rock, steel, concrete and wood. Bulkheads are common along the Hudson Estuary, see Figure 1 and Figure 2.

Figure 1: Timber bulkhead.

Figure 2: Steel sheetpile bulkhead.

Crib Walls, Timber Cribbing, Rock Cribs or Cribbing

Box-like arrangement of interlocking logs, timbers, precast concrete or plastic structural members are used to form a "crib", which is then filled with broken rock. Rock cribs made of timber (timber cribbing) were a common armoring method in the Hudson Estuary and are extensive along both shores between Albany and Hudson (especially Coeyman's Landing/Schodack Island area), in various conditions from degraded remnants to intact, see Figure 3.

Figure 3: Degraded timber cribbing.

Figure 4: Gabion wall.

Gabions

Gabions are wire mesh enclosures that can be used to form retaining walls, sea walls, or revetments. The enclosures are generally filled with cobbles or crushed rock and stacked vertically or stair-stepped to form semi-flexible, permeable, massive structures. Gabions allow the use of smaller sized rocks that would otherwise not hold up to the erosive forces. Gabions are uncommon along the Hudson Estuary, particularly as the wire has low durability in brackish or salt water, see Figure 4.

Live Crib Walls, Live Cribbing, or Vegetated Cribbing*

Live crib walls create a box-like structure, similar to crib walls, made of logs or timber members and filled with alternating layers of soil and live branches which extend through the spaces between the alternating members. The live branches eventually establish themselves and their roots anchor the bank and eventually take over the function of the wood members.

Joint Planting, Live Stakes or Vegetated Rip-Rap*

Joint-planting involves modification of a rip-rap or rock covered slope by driving live stakes between the joints or spaces between the rip-rap and rock. The live stakes take root and create a vegetated shoreline.

Revetments

Large sloping structures that armor the shore slope, or bank, to protect against erosion. Typically constructed of large rocks or concrete armor units (see Figure 5), revetments dissipate wave and current energy along their slopes and within their void spaces. Rock revetments differ from traditional rip-rap slope stability methods in that they are designed through a more rigorous engineering analysis and thus provide a higher degree of protection. Rock revetments are a common armoring method in the Hudson Estuary, particularly serving as the beds of the shoreline railroad.

Figure 5: Failing concrete revetment.

Rip-Rap

A method of armoring a sloping shore or riverbank, where small rocks, cobble, broken concrete or brick, are laid along the sloping shoreface to protect the finer sized local sediments from eroding, see Figure 6Rip-rap can also refer to the material itself. Rip-rap slopes typically differ from revetments in that the size of the stone utilized is generally smaller and better graded, and they are typically designed in a less rigorous way. Whereas revetments are designed based on formulas which take into account the weight of the stone and their interlocking, rip-rap structures are typically designed based on the resistance to bed shear stress due to currents.

Figure 6: Rip-rap.

Seawalls

A shore parallel structure constructed on the open coasts and designed to dissipate the energy of larger waves and or hold back floodwaters. Since the terms seawall and bulkhead are sometimes confused and used interchangeably, this definition is supplied for clarity.

SHORELINE ENGINEERING STABILIZATION METHODS

Aquatic or Marsh Vegetation*

Plantings of submerged aquatic vegetation or fringing marshes which dampen wave energy impinging on an embankment.

Jetties and Breakwaters

Structures built within a water body to reduce wave energy and erosion on the shoreward side. They are made of wood, timber, rock, concrete, or rock cribbing. The jetty protecting Rondout Harbor in Kingston is an example, see Figure 7.

Figure 7: Jetty at Rondout Harbor.

Sills

Typically low profile, continuous structures placed parallel to the shore at mean low water. Sills can be made of broken rock, cobbles or other hard material and typically have a trapezoidal cross-section. Sills reduce shoreline erosion by dissipating wave energy which may cause sediment to build up between it and the shoreline. This sediment may provide substrate for marsh growth. In some cases the area between the sill and the shoreline is prefilled and planted to accelerate the marsh creation process. Sills are uncommon or non-existent in the Hudson Estuary.

Sill with Constructed Near-Shore Wetland*

Marsh vegetation is planted in shallow area between the shoreline and the in-water sill. Both the vegetation and the sill function to stabilize shallow soil and provide shoreline protection. Also termed ecologically enhanced marsh sill, see Figure 8.

Figure 8: Degraded timber cribbing acts as a sill, protecting the tidal marsh to the shoreward.

Terrestrial Vegetation*

Vegetative plantings on embankments, including grasses, shrubs or trees whose roots bind soil and prevent erosion.

Vegetated Geogrid*

A terraced, sloped wall consisting of a system of successive soil lifts wrapped in a synthetic erosion control fabric. Live branch cuttings are placed between layers.

SOCIAL SCIENCE & NATURAL SCIENCE TERMS

The following have been selected as key terms necessary for a common understanding and usage within the Sustainable Shoreline Project. The definitions are taken directly from or adapted from the literature.

Social Science

Social Science is the process of describing, explaining and predicting human behavior and institutional structure in interaction with their environments (SSRP 2003). The role of people can be understood through the application of scientific methods. As with other sciences, what makes an endeavor scientific is not the subject of its investigation but the methods applied. To be scientific, we require that a process be objective, transparent, documented, and replicable. The purview of social science disciplines includes sociology, anthropology, demography, economics, geography, education, psychology, communications, political science and law. (NOAA Science Advisory Board's Social Science Working Group 2009)

Human Dimensions Research

Human Dimensions Research is the application of social science in natural resource management. It is the study of the beliefs, values attitudes, behaviors and socioeconomic and demographic characteristics of user groups so they can be incorporated into decisions in natural resource management. (Gigliott and Decker 1992)

Economics

Economics is the process of understanding participants and stakeholders incentives in organizational and economic processes relevant to Sustainable Shoreline Project vision; developing methods for survey data collection, analysis and interpretation, and estimating value of non-market goods and services, such as ecosystem services. (NOAA Science Advisory Board's Social Science Working Group 2009)

Non-market Valuation

Non-market valuation is a method to estimate the value of goods and services that are not commonly bought and sold in markets. Whereas sales prices give very clear signals of the monetary value for goods and services that are routinely bought and sold, environmental project alternatives often must be converted and compared in monetary terms. (Human Dimension website hd.gov)

Ecosystem

An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit. (Millennium Ecosystem Assessment 2005)

Ecosystem services are the benefits people obtain from ecosystems. These include provisioning services such as food, water, timber, and fiber; regulating services that affect climate, floods, disease, wastes, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis, and nutrient cycling . (Millennium Ecosystem Assessment 2005)

Ecosystem Functions

Ecosystem functions refer variously to the habitat, biological or system properties or processes of ecosystems. Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions. (Costanza et al., 1997)

APPENDIX A – LEGAL DEMARCATION OF SHORELINE

"The legal demarcation between private and public lands, the "shoreline," is usually taken to be the intersection of the mean high water (MHW) line with the beach profile."(NRC 2007 and Figure 17 of NOAA NOS COOPS 2000). Based on this diagram, New York State uses MHW, that is, below MHW is publicly owned and above is privately owned.

"This diagram is a good representation of the ownership situation in New York for the tidal portion of Hudson's River when the subject location is in its natural state (no fill) and where there are no grants of lands under water."(Personal Communication, Richard Bennett, L.S. NYS Office of General Services Bureau of Land Management May 4, 2012)

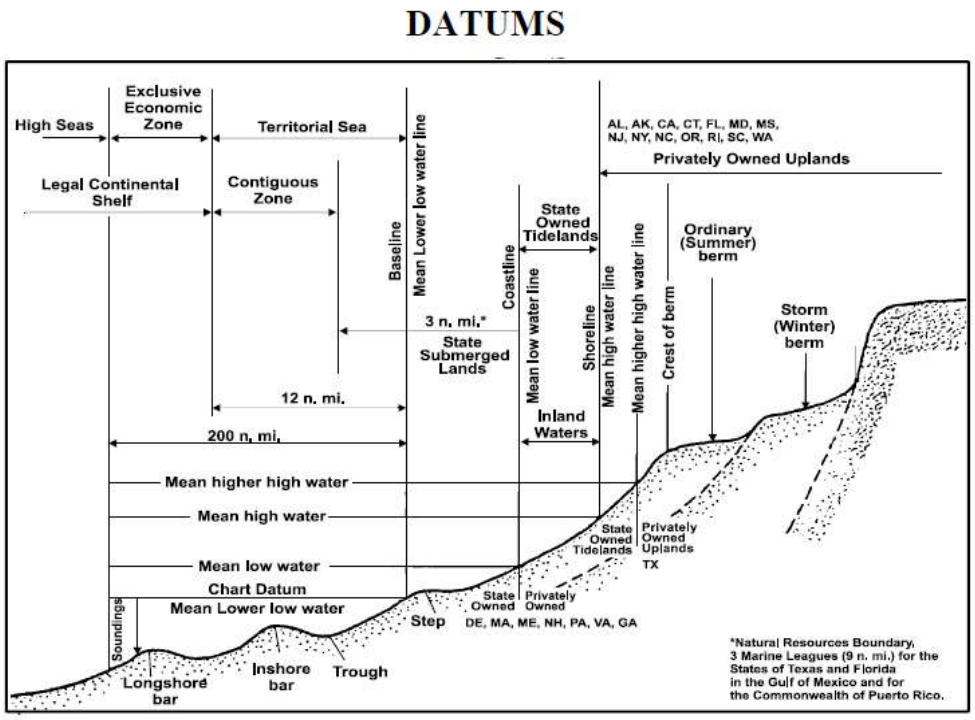

Figure 17. The principal tidal datums related to a beach profile. The intersection of the tidal datum with land determines the landward edge of a marine boundary.

Definitions

"Mean low water and mean high water - Means, respectively, the approximate average low-water level or high-water level for a given body of water at a given location, which distinguishes between predominantly aquatic and predominantly terrestrial habitat…." (9 NYCRR 270-2.1)

"Original mean low water and original mean high water - Means the original average low-water level or high-water level for a given body of water at a given location prior to the placement of fill for the purpose of determining ownership of lands formerly underwater, as such level may be determined from prior survey, historical maps, photographs and similar sources." (9 NYCRR 270-2.1)

"State-owned lands underwater - Those lands now or formerly underwater or periodically subject to the ebb and flow of the tides, any right, title or interest to which is in the State of New York." (9 NYCRR 270-2.1)

Clarification:

"The State of New York claims sovereign ownership to all of the ungranted portions of the Hudson River, up to the last known natural location of the high water.

Over the past two centuries the State has issued hundreds of grants of Lands Under Water in the tidal portions of the river. Historically there grants were made to allow fill to be placed on the bed of the river for commerce purposes. Grants were also issued to the railroad companies along the edge of the river. There are many ungranted places where unauthorized fill has been placed on the bed of the river; the State still claims title to these ungranted filled-in areas." (Personal Communication, Richard Bennett, L.S. NYS Office of General Services Bureau of Land Management May 4, 2012.)

APPENDIX B – HUDSON SHORELINE STUDIES

Various terms have been used in studies for Hudson River National Estuarine Research Reserve or the Sustainable Shorelines Project. David VanLuven developed the first three columns of the following table in May 2011 and the author added the last two. The relevant tables from each study are included in this appendix. This table attempts to match up natural and engineered shoreline according to how they would function. It also illustrates the differences in the use of terms.

Table 1

Summary table				
Economic Study (Project Team Meeting-April, 2011)	Engineering Study (Rella & Miller, 2012a)	Ecological Study (Strayer et al. 2012)	Engineering Study (Allen et al. 2006)	Classification Study (Miller, Bowser, Eckerlin 2005)
Bulkhead	Bulkhead	Bulkhead and smooth revetment	n/a	Bulkhead
Revetment	Revetment	Riprap	n/a	Revetment
Riprap	Riprap	"	n/a	Riprap
Timber cribbing	n/a	Cribbing	n/a	Cribbing made of timbers
Sill	Sill	n/a	n/a	n/a
				Gabions
Timber cribbing (modified for ecological services)	Live crib wall	n/a	live crib wall	Degrading cribbing composed of timber
Bulkhead (modified for ecological services)	Green (bio) wall		vegetated rock gabion walls or mattresses	Degrading bulkhead of varying substrates
Biowall	Green (bio) wall		vegetated rock gabion walls or mattresses	Degrading bulkheads, cribbing or gabions
Revetment (modified for ecological services)	Live stakes/joint planting		joint planting	Riprap with vegetation
Riprap (modified for eco-logical services)	Live stakes/joint planting		joint planting	Riprap with vegetation
Vegetated geogrid	Vegetated geogrid		vegetated geogrid	n/a
Planted shoreline	Living shoreline		brush mattresses	Degraded engineered with vege-tation
				Not included: natural shorelines such as woody unconsolidated rock

Table 2

The shoreline of the Hudson Estuary was inventoried by Miller, D. et al. (2005). They developed this classification scheme for natural and engineered shorelines.

Hudson River Shoreline Classification and Definitions			
L1 Nature	1	Engineered (hard)	Engineered or constructed to stabilize or provide access, usually vertical and without natural vegetated features
	2	Soft Engineered (restored)	Shore stabilized using plant materials or methods intended to improve habitat
	3	Natural	Natural, unengineered shoreline or formerly engineered shoreline that has been colonized by emergent aquatic or woody vegetation. Remnants of engineered structure can be present.
L2 Shoreline Habitat Structure	1	Revetment	Engineered, non-vertical, sloping shoreline protection device
	2	Gabion	Rock held in place by wire mesh enclosure
	3	Cribbing	Rock held in place by timber frames
	4	Bulkhead	Solid vertical wall at river's edge, may be backfilled with a variety of materials
	5	Graminoid or broadleaf vegetation	Broadleaf or graminoid, non-woody vegetation extending from intertidal area to high tide line
	6	Woody vegetation	Brush, scrub or shrub, trees
	7	Unvegetated	No rooted vegetation
	8	Woody debris	Dominated by large woody debris
	9	Other	None apply, requires explanation in comments field
L3 Substrate/ Material	1	Timber-	Milled and assembled wooden material
	2	Sheet pile	Steel interlocking sheets driven into the bottom, can be capped and/or backfilled
	3	Concrete	Cured slabs or blocks of cement
	4	Mixed mud/sand/rock	Mixture of fine clays or sand possibly mixed with larger materials such as pebbles, stones, shale, gravel, bedrock, boulders
	5	Unconsolidated Rock	Pebbles, stones, shale, gravel, bedrock, boulders (all forms larger than sand)
	6	Solid Bedrock	Large, consolidated rock outcroppings
	7	Sand w/ brick	Sandy beaches with discarded bricks from former industry
	8	Other	None apply, requires explanation in comments field

Table 3

The Hudson River Shoreline Restoration Alternatives Analysis (Allen et al. 2006) includes a list of 16 available river bank stabilization techniques from the literature. Their Table 2 gives a short description, pros and cons and discusses the applicability for the Hudson River. The following methods are then discussed in detail:

Table Title
Vegetated Geogrids
Live Crib Wall

Joint Plantings
Brush mattresses
Vegetated Rock Gabions or Mattresses

Table 4

Strayer et al. (2012) defines the following, "based on predominant conditions at and just above the high water mark."

Shoreline definitions from Strayer et al. 2012.
Riprap shores are revetments constructed of large stone (typically [50 cm in diameter),
Cribbing shores consist of wooden pilings (typically *25 cm diameter) back-filled on the land side with crushed stone 15–25 cm in diameter,
Bulkheads are vertical walls or revetments made of steel or concrete.

Table 5

This table is taken from Rella and Miller (2012a) *Engineering Approaches for Limiting Erosion along Sheltered Shorelines: A Review of Existing Methods*. Twenty-eight traditional and nontraditional approaches are discussed and categorized according to relative hardness of the approach, construction and maintenance costs and whether they can be adapted for sea level rise.

Engineering Approach	Approach		Construction Cost		Maintenance Cost		Adaptability	
	Soft	Hard	Low	High	Low	High	Low	High
Bulkhead	■	■	■	□	■	□	■	□
Gabions	■	□	■	□	■	□	■	□
Revetments	■	□	■	■	■	□	■	□
Rootwad Revetment	■	□	■	□	■	□	■	□
Tree Revetment	■	□	■	□	■	□	■	□
Rip-rap	■	□	■	□	■	□	■	■
Jack Fields	■	□	■	□	■	□	■	□
Green Walls	■	□	■	□	■	□	■	□
Timber Cribbing	■	□	■	□	■	□	■	□
Live Crib Walls	■	□	■	□	■	□	■	□
Levees	■	□	■	■	■	□	■	□
Geotextile Roll	■	□	■	□	■	□	■	□
Vegetated Geogrid	■	□	■	□	■	□	■	□
Live Stake	■	□	■	□	■	□	■	□
Brush Mattress	■	□	■	□	■	□	■	□
Branch Packing	■	□	■	□	■	□	■	□
Live Fascines	■	□	■	□	■	□	■	□
Coconut Fiber Rolls	■	□	■	□	■	□	■	□
Reed Clumps	■	□	■	□	■	□	■	□
Dormant Post Planting	■	□	■	□	■	□	■	□
Groins	■	□	■	□	■	□	■	□
Stream Barbs	■	□	■	□	■	□	■	□
Wave Screens	■	□	■	□	■	□	■	□
Breakwater	■	□	■	■	■	□	■	□
Floating Breakwater	■	□	■	■	■	□	■	□
Living Reef Breakwater	■	□	■	□	■	□	■	□
Sills	■	□	■	□	■	□	■	□
Artificial Vegetation	■	□	■	□	■	□	■	□
	Soft	Hard	Low	High	Low	High	Low	High

APPENDIX C - REFERENCES & RESOURCES

Unless otherwise noted, all World Wide Web references were accessed during the period August to September 2011.

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