Design and Construction of Living Shorelines
A course for living shoreline professionals
September 29, 2010

The goal of this project was to provide consultants, contractors and other professionals in the field of shore erosion control with the latest information on the design and construction of living shorelines. Through previous DEQ/NOAA grants, the Shoreline Studies Program (SSP) has gathered and analyzed baseline data on the performance of sills in Chesapeake Bay's low to medium energy environments while biological research projects have determined their viability. In addition, the design of these structures has been evaluated to determine encroachment guidelines. A course was created and held on September 29, 2010. Twenty one professionals attended. The curriculum for the class pulled from the previous research and other available sources in order to summarize the overall knowledge of best management practices for the Bay's sheltered shorelines.

The basis of this class was, in part, Hardaway and Byrne (1999) "Shoreline Management in Chesapeake Bay", "Performance of Sills, St. Mary's City Maryland (Hardaway *et al.*, 2007), and "Encroachment of Sill onto State-Owned Bottom: Design Guidance for Chesapeake Bay" (Hardaway *et al.*, 2009). The text was "Living Shoreline Design Guidance for Shore Protection in Virginia's Estuarine Environments" (Hardaway *et al.*, 2010). These reports are available on the Shoreline Studies Program publications page (http://web.vims.edu/physical/research/shoreline/Publications.htm).

The course consisted of several components including: introduction to shoreline/physical processes and reach considerations; shoreline management strategies and goals; ecosystem functions; system design, construction considerations and standards; and the permitting process. Applications were developed in Google Earth that provide access to data necessary for the design of shore systems throughout Chesapeake Bay. The applications used existing data but it was reformatted to be easily accessible.

Due to the site specific nature of any real-life living shoreline design and construction, the curriculum included both theory as well as on-the-ground applications that enhance problem solving abilities for various design considerations. At the end of the class, a test was administered and a certificate of completion issued.

The reports, curriculum, test, and Google Earth applications are available on VIMS' Shoreline Studies Program website. http://web.vims.edu/physical/research/shoreline/LivingShorelineDesign.html

This project was funded by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant #NA09NOS4190163 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended. The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or any of its subagencies.

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This course made possible by a grant from the

Virginia Coastal Zone Management Program

NOAA

Shoreline Studies Program
VIMS

William & Mary
VIMS
Virginia Institute of Marine Science
School of Marine Science

Center for Coastal Resources Management
Virginia Institute of Marine Science

Course Outline

Part 1	Background
	Site Evaluation Process
	Selecting a Strategy
Part 2	Lessons Learned from Case Studies
Part 3	Work Through Design Examples

Course Instructors

C. Scott Hardaway, Jr.

VIMS since 1979

Shorelines Studies Program Director

Expert in headland breakwater systems

Research projects along Chesapeake Bay and ocean shorelines of Virginia and Maryland

M.S. Geology, East Carolina University 1979

B.A. Geology, East Carolina University 1973

Karen A. Duhring

VIMS since 1999

Center for Coastal Resources Management (CCRM) **Scientist III**

Tidal shoreline advisory program, living shorelines, cumulative wetland impacts

M.S. Coastal Zone Mgmt, FL Institute of Tech. 1988

B.A. Environmental Studies, New College 1986

Who Are You?

What is your name?

What kind of living shorelines work do you do?

Tell us one living shorelines design challenge you are faced with

Why are we all here today?

- CZM contracted with VIMS to prepare design manual and teach a class
- Improve understanding of performance and design standards
- Shoreline management plans with LS targeting
- Regulatory programs now treat living shorelines as preferred methods
- Growing interest in general permits, other streamlining for living shorelines
- Educated professionals are needed to facilitate public interest review of how appropriate living shorelines are

Not Course Objectives

- Cover all living shoreline methods
- Solve all design challenges in 1 class
- Review the entire permit process
- VIMS endorsements

Part 1

Follows outline of Living Shorelines Design Manual

- Living Shorelines Principles
- Chesapeake Bay Shorelines
- Site Evaluation Process
- Selecting Strategy
- Level of protection / design storms
- Encroachment and habitat tradeoffs

Living Shorelines Principles

- Shore protection
  - Solving erosion problems
  - Least impacting, necessary method
- Sustaining ecosystem services
  - Water quality
  - Storm protection
  - Habitat

Integrated Shoreline Management

Riparian Buffer

+

Tidal Wetlands

+

Shallow Water Habitat

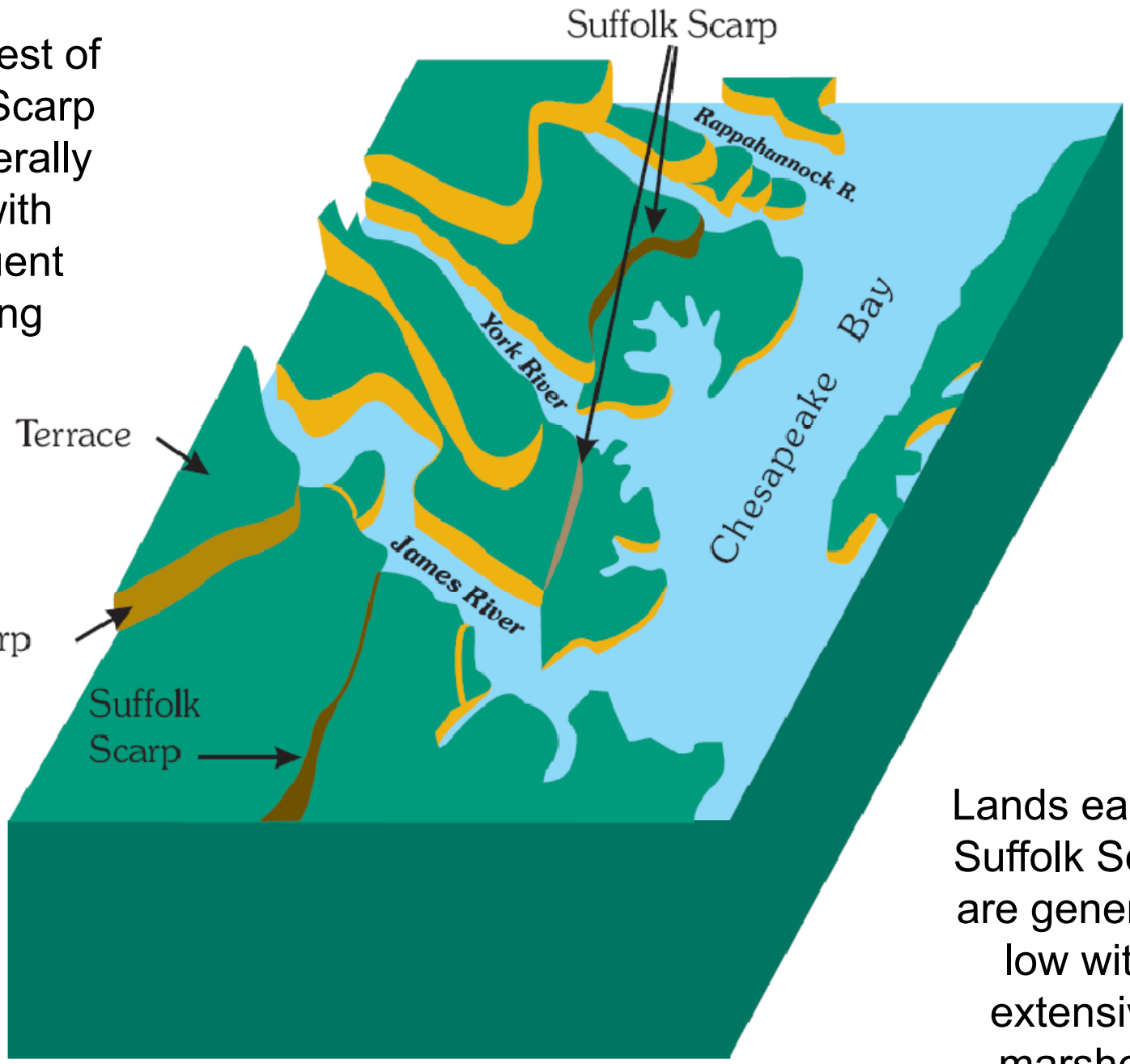
= Combined Protection Benefits

Chesapeake Bay Shorelines
Physical Setting

- How a shore reach has evolved helps determine management options

- Scarps and terraces
  - Determine high and low banks
  - Flooding frequency
  - Erosion trends

Lands west of Suffolk Scarp are generally high with infrequent flooding



Lands east of Suffolk Scarp are generally low with extensive marshes

Chesapeake Bay Shorelines
Sea Level Rise

- **Relative Sea Level Rise**
  - sea level rise + land subsidence

- Variable rates in mid-Atlantic

- Accelerated rates are predicted with uncertainty

Chesapeake Bay Shorelines
Hydrodynamic Setting

- Wave climate
  - Wind influenced everywhere
  - Ocean influence in lower Bay year-round
- Fetch determines wave energy potential
  - Very low <0.5 mile
  - Low 0.5-1 mile
  - Medium 1-5 miles
  - High 5-15 miles
  - Very high >15 miles
- Wind direction
- Tide range
  - Mean
  - Great diurnal or spring
- Storm water levels
- Relative sea level rise

SITE EVALUATION PROCESS

Site Evaluation Process

Each shoreline professional has a method for conducting site evaluations

A standardized data collection process is recommended

Not all parameters have equal weight, professional judgment necessary

Appendix A is a site evaluation worksheet

Site Evaluation

Desktop or Map Parameters

- Existing information available from maps or Internet resources
- Not readily visible or measurable at ground level

Site Visit Parameters

- Site-specific characteristics
- Local setting
- Not easily captured by remote sensing

Site Evaluation

Site Name_____ Date _____
Site Locality _____ Body of Water _____

Pre-Visit Parameters

Shore Orientation(s): N NE E SE S SW W NW

Site Length: _____(ft)

Average Fetch(es):
Very High (> 15 miles) High (5-15 miles) Medium (1-5 miles)
Low (0.5-1 miles) Very Low (< 0.5 miles)

Longest Fetch:_____miles

Shore Morphology: Pocket Straight Headland Irregular

Depth Offshore: _____

Nearshore Morphology: Bars ____ Tidal Flats ____

Nearshore Aquatic Vegetation:_____

Tide Range: _____

Storm Surge: 10 yr_____25 yr_____50 yr _____ 100 yr_____

Erosion Rate: Very High Accretion (> +10 ft/yr) High Accretion (+10 to +5 ft/yr)
Medium Accretion (+5 to +2 ft/yr) Low Accretion (+2 to +1 ft/yr)
Very Low Accretion (+ 1 to 0 ft/yr) Very Low Erosion (0 to -1 ft/yr)
Low Erosion (-1 to -2 ft/yr) Medium Erosion (-2 to -5 ft/yr)
High Erosion (-5 to -10 ft/yr) Very High Erosion (<-10 ft/yr)

Design Wave: Height_____Period_____

Notes:

Site Visit Parameters

Site Boundaries:

Site Characteristics:

Upland Land Use

Proximity to Infrastructure

Cover

Bank Condition:

Bank Face-	Erosional	Stable	Transitional	Undercut
Bank of Bank -	Erosional	Stable	Transitional	

Bank Height: _____

Bank Composition:

RPA Buffer:

Shore Zone: Sand _____Marsh_____

Width

Elevation

Backshore Zone: Sand _____Marsh_____

Width

Elevation

Nearshore Stability: Firm_____Soft_____

Boat Wakes:

Existing Shoreline Defensive Structures:

Desktop or Map Parameters

Shoreline orientation

Fetch

Shore Morphology

Depth Offshore

Nearshore Morphology

Submerged Aquatic Vegetation (SAV)

Tide Range

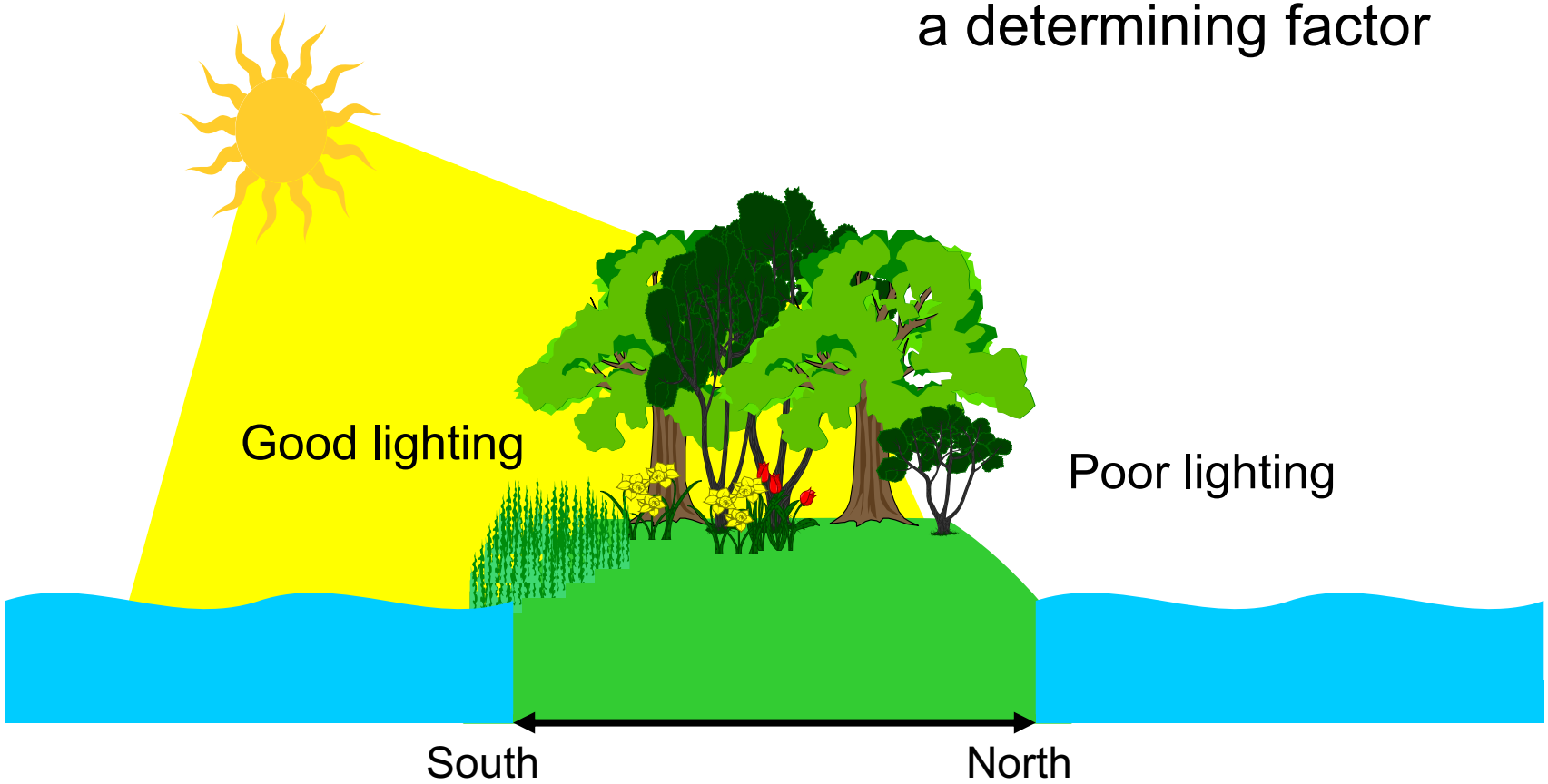
Storm Surge

Erosion Rate

Design Wave

Shoreline Orientation

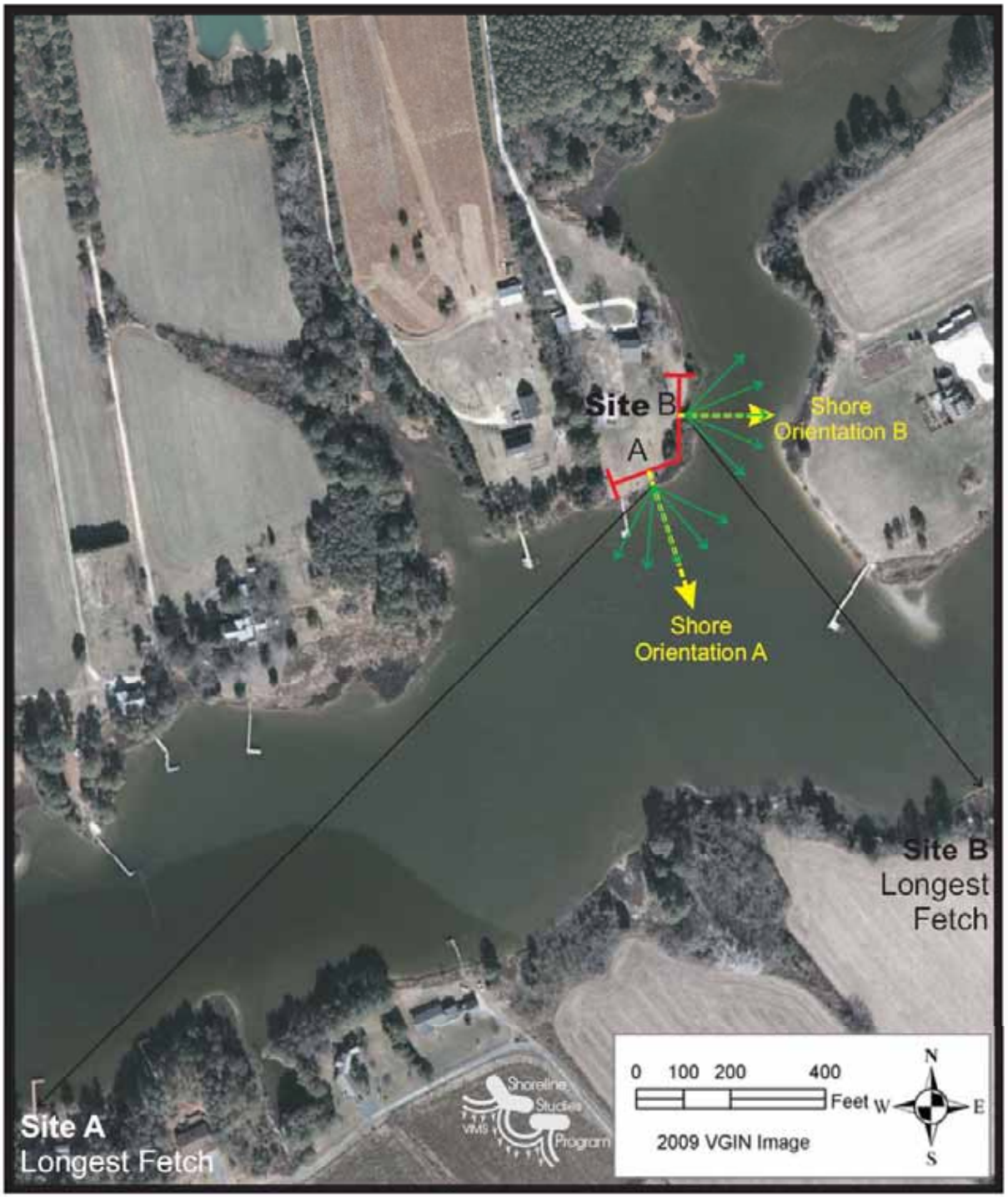
Rule of thumb, not always
a determining factor



Measure Fetch Distances

<u>Longest Fetch</u>
black lines

<u>Average Fetch</u>
measure 5 green arrow vectors and take an average



Shore Morphology

Pocket or embayed shorelines tend to cause waves to diverge and spread wave energy out

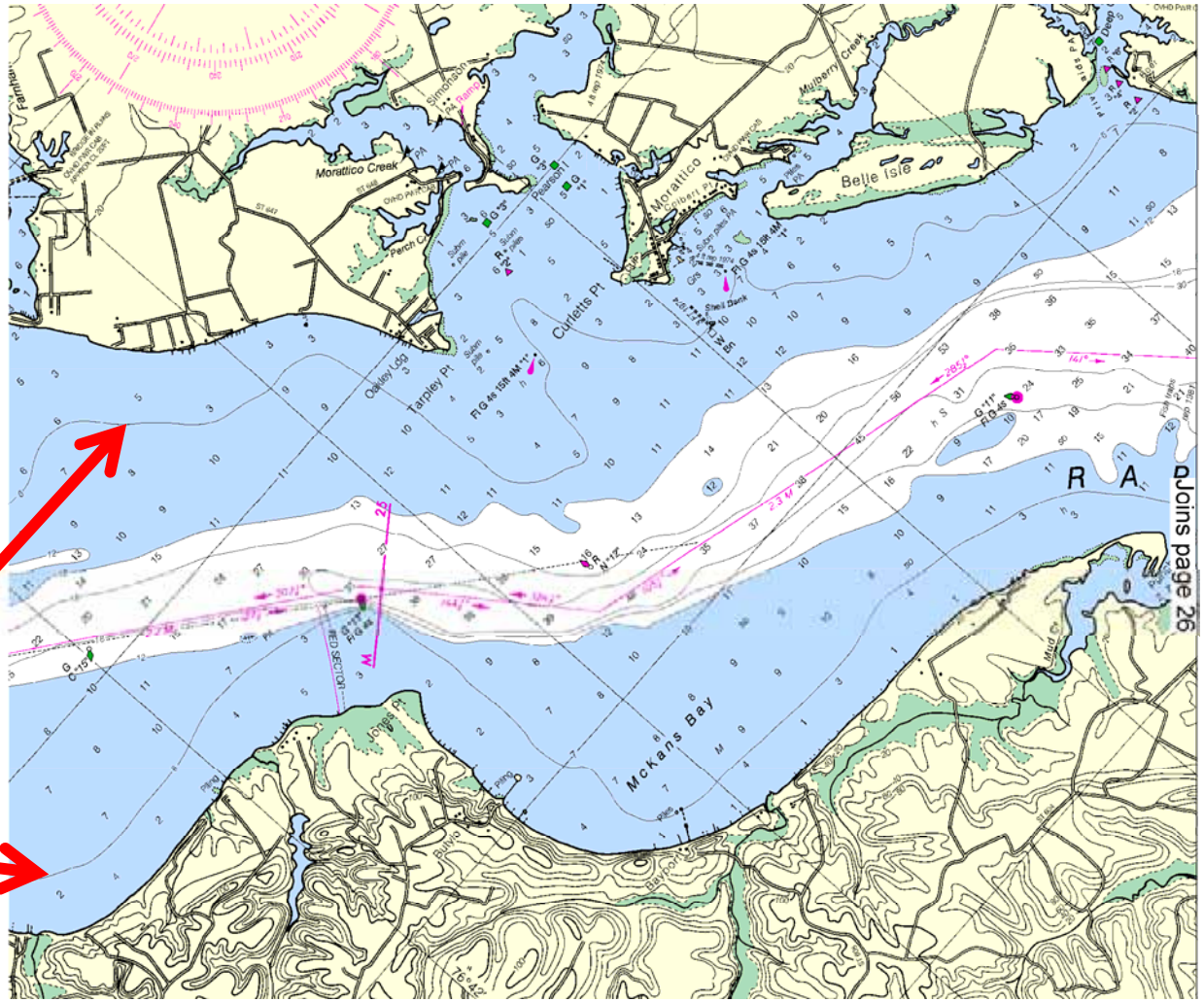
Straight and headland shorelines receive the full impact of the wave climate

Irregular shorelines tend to break up wave crests

Depth Offshore
distance to 6 ft or 2m contour

Broad shallow nearshore has different wave attenuation than narrow deep water with same fetch

6 ft contour lines



NOAA Reduced Scale Navigational Charts
http://ocsdata.ncd.noaa.gov/bookletchart/

Nearshore Morphology

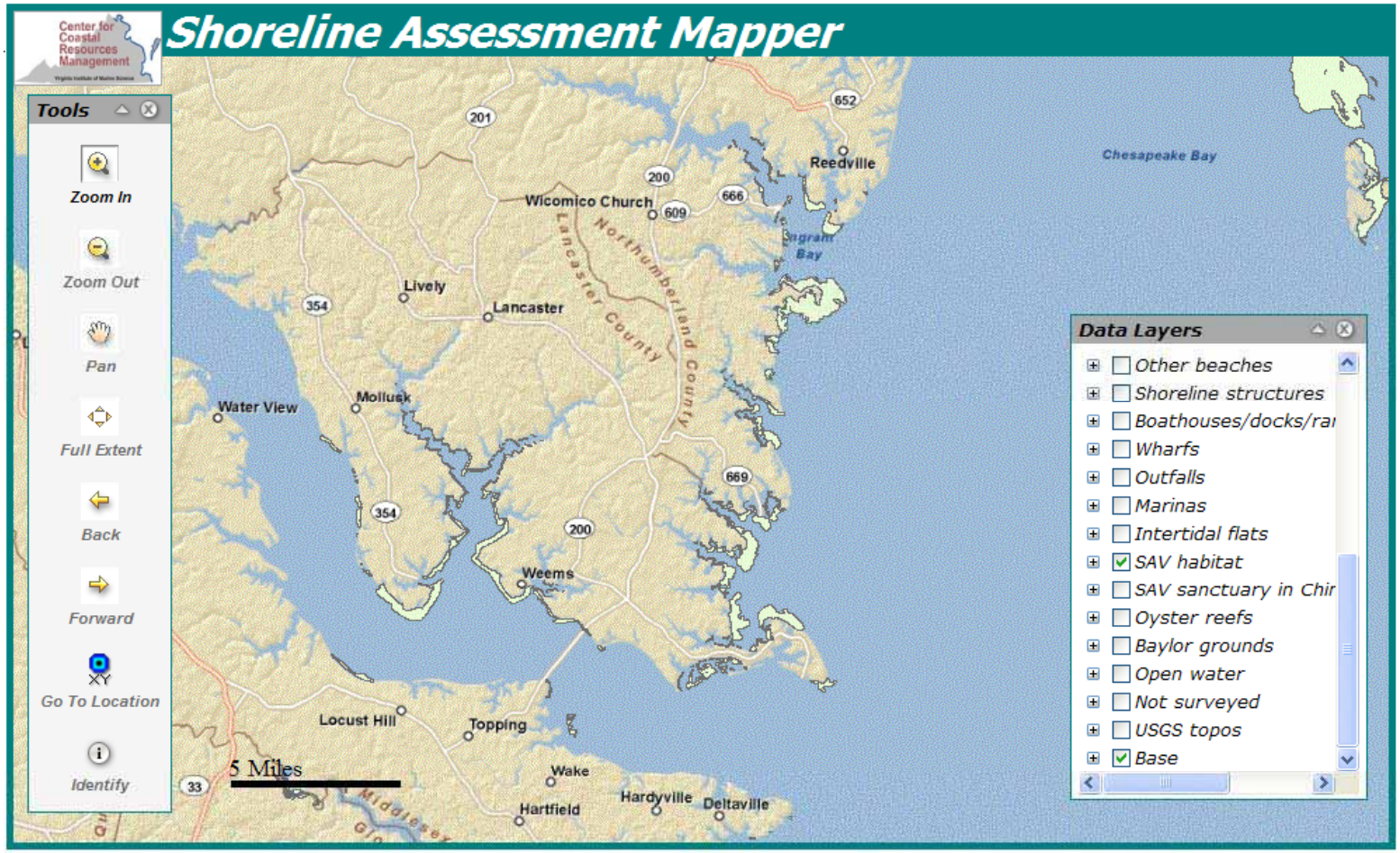
Presence or absence of nearshore tidal flats and sand bars indicate sand supply, bottom conditions

Important consideration for sills and breakwaters

Hard supportive substrate vs. soft, fine-grained sediment

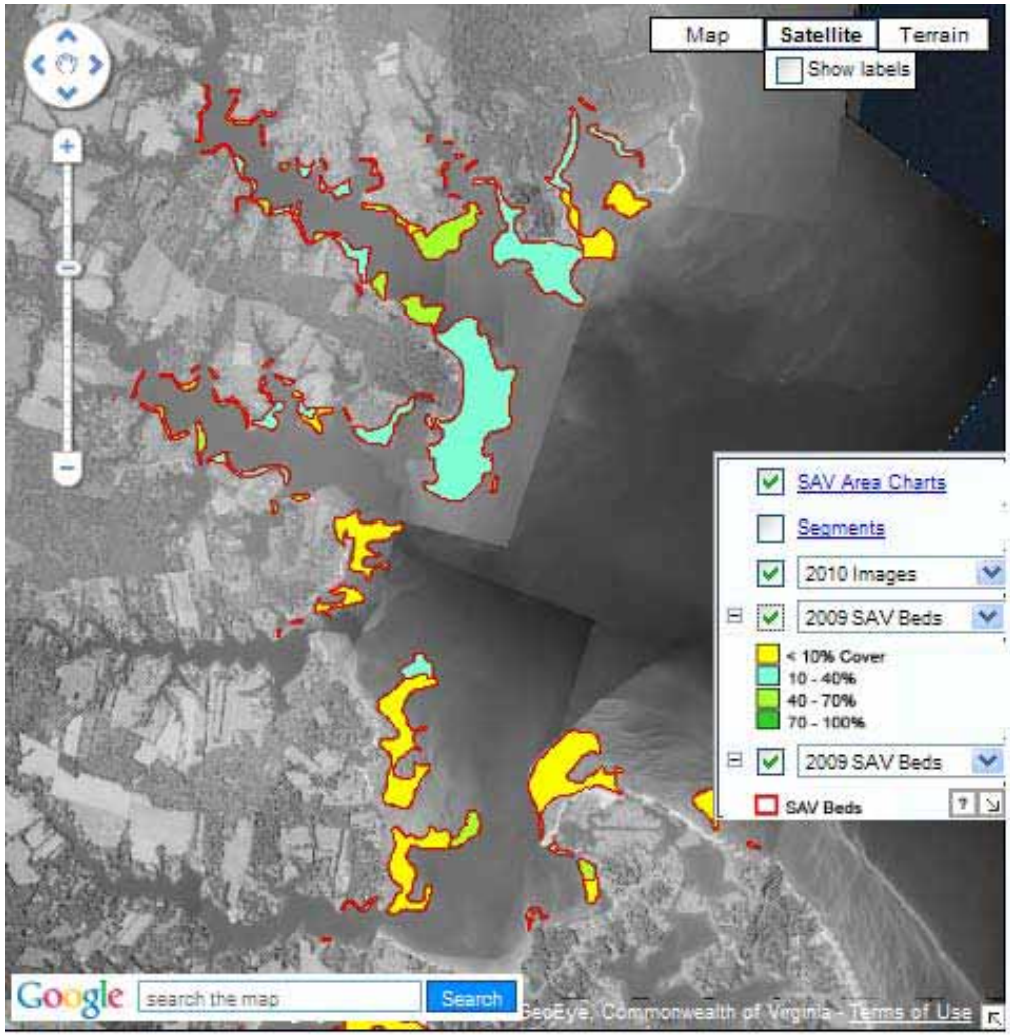
Submerged Aquatic Vegetation (SAV)

Submerged Aquatic Vegetation – Quick Check
CCRM Shoreline Assessment Mapper
Previous 10 yrs SAV combined into 1 polygon



http://139.70.26.131:8008/ShorelineAssessmentMapper/

Submerged Aquatic Vegetation - Details Check
VIMS SAV Inventory and Monitoring
Interactive Map



http://web.vims.edu/bio/sav/?svr=www

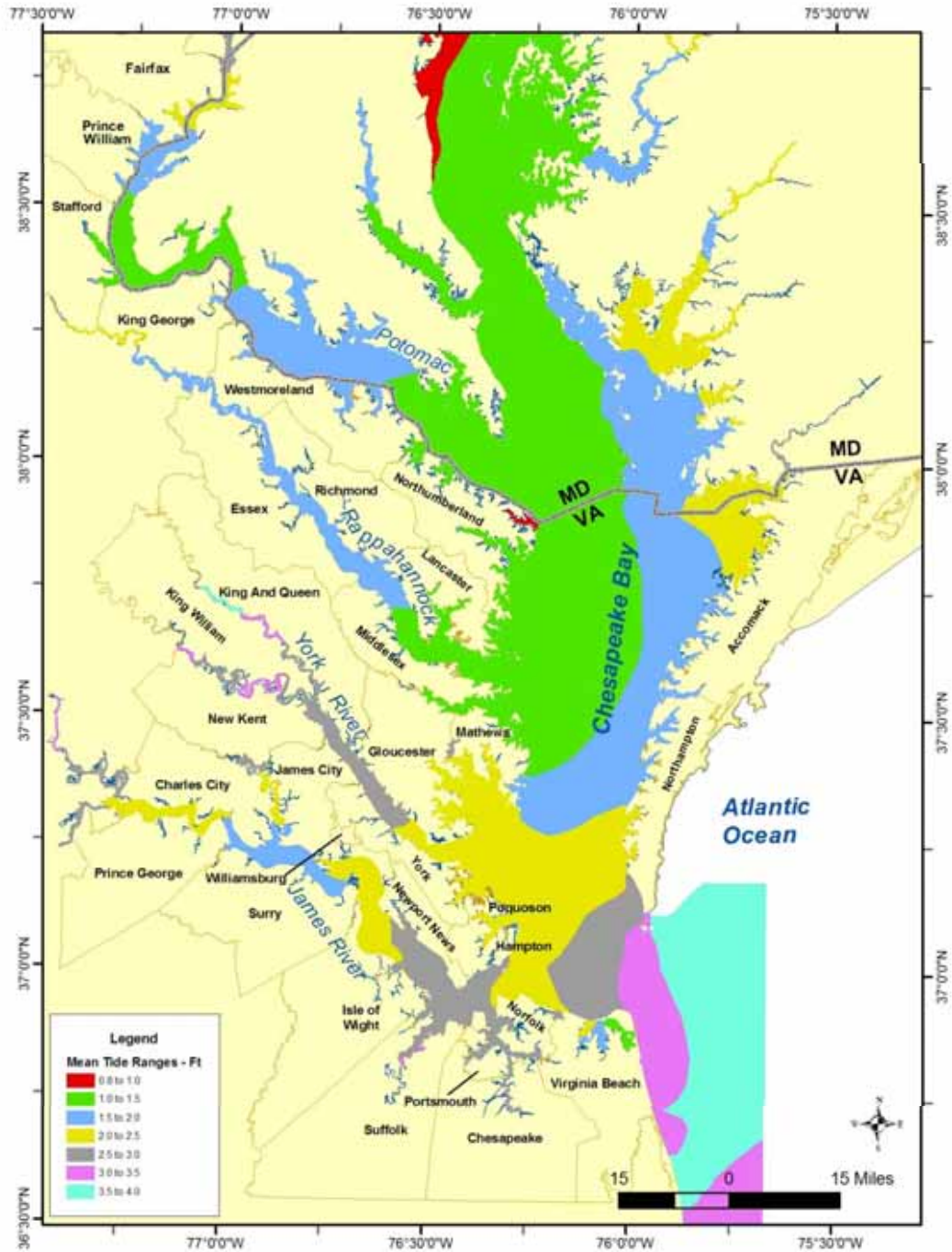
Tide Range

- NOAA Tides and Currents – benchmarks
- Variable by region
- Mean tide range and spring tide range
- Reference to tidal datum
  - NAVD88
- Critical information for planted marshes

Mean Tide Ranges in feet

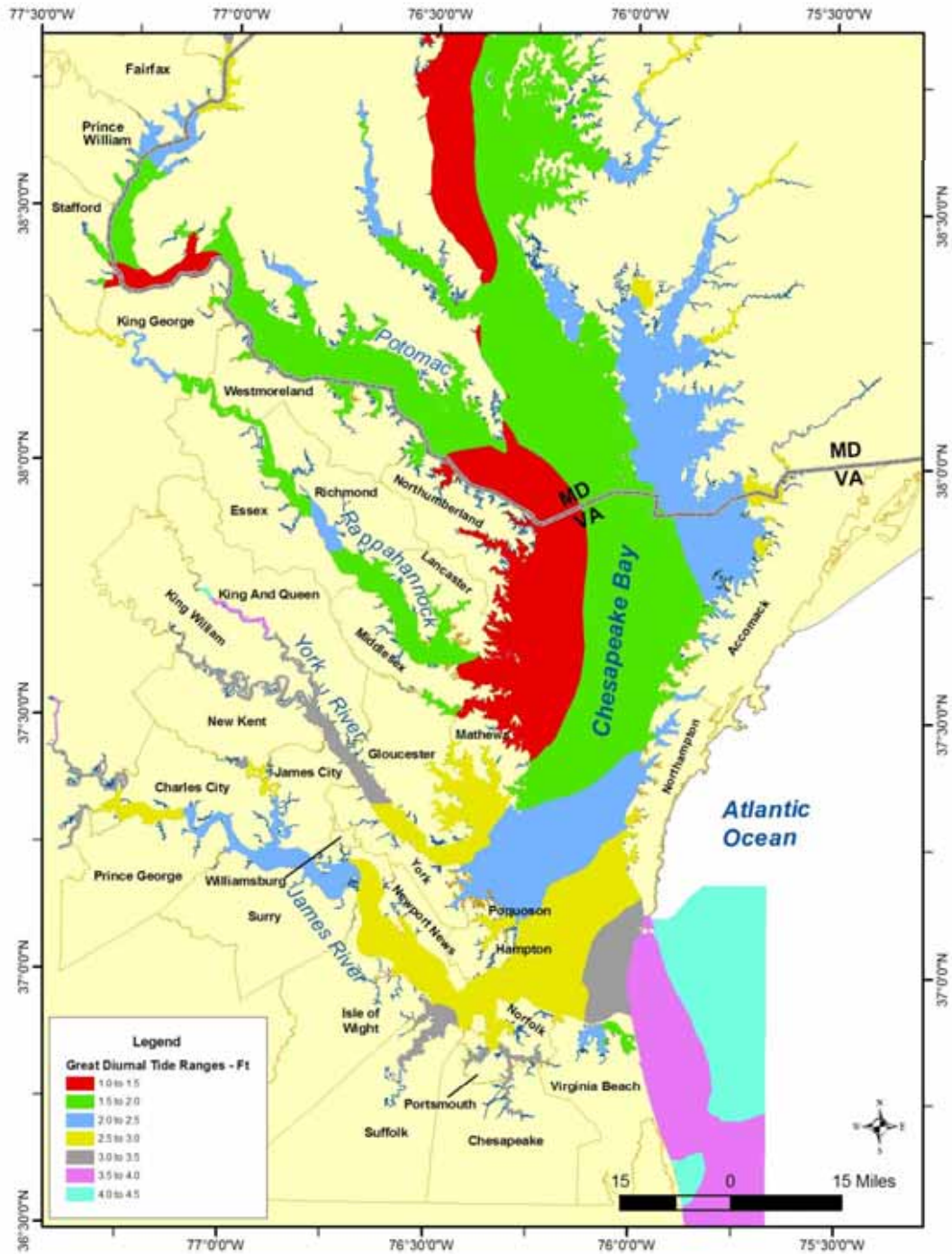
Polygons interpolated from NOAA data points

Figure 1-3, pp. 46



Spring Tide or Great Diurnal Tide Ranges in feet

Figure 1-4, pp. 47



Storm Surge

- Predicted water level during certain storms
- Return frequencies – probability of repeating
  - 100-yr storm = 1% chance
  - 50-yr storm = 2% chance
  - 25-yr storm = 4% chance
  - water level will occur in any given year
- FEMA Flood Insurance Studies web site
  - Look in Product Catalog

Erosion or Shoreline Change Rate

Shoreline Studies Program Evolution Reports

- Northumberland Co.
- Lancaster Co.
- Westmoreland Co.
- Middlesex Co.
- Gloucester Co.
- Mathews Co.
- Newport News
- Poquoson
- York Co.
- Hampton
- Norfolk
- VA Beach
- Accomack County
- Northampton County

Go To
http://web.vims.edu/physical/research/shoreline/Publications-Dune.htm

Example from Shoreline Evolution Report for Gloucester Point

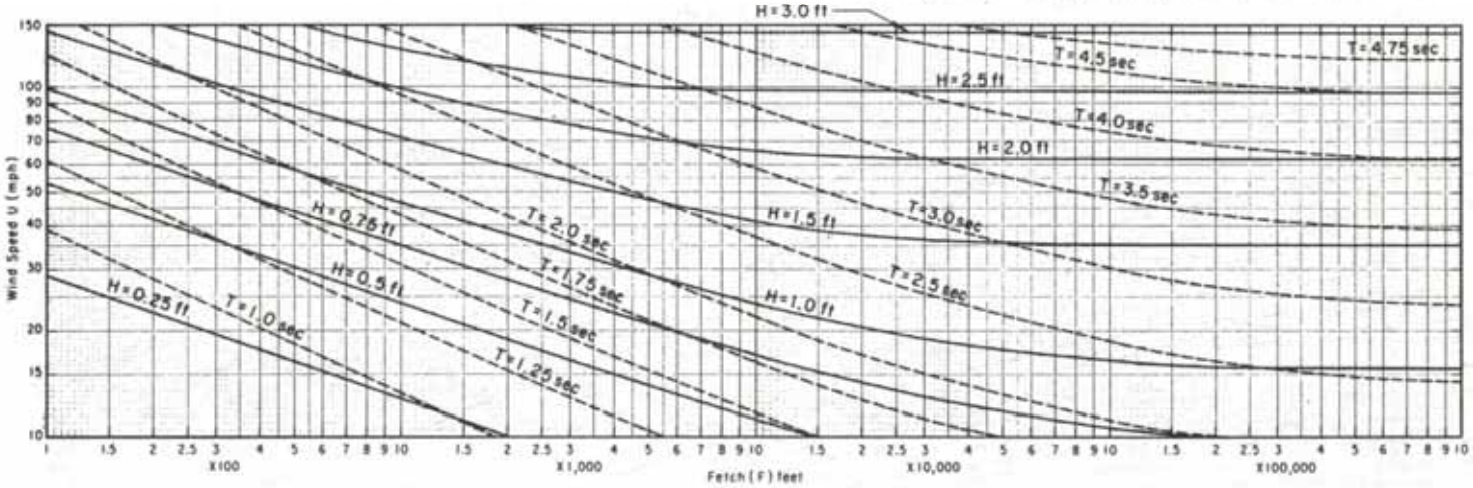
Legend

- Medium Accretion: +5 to +2 ft/yr
- Low Accretion: +2 to +1 ft/yr
- Very Low Accretion: +1 to 0 ft/yr
- Very Low Erosion: 0 to -1 ft/yr
- Low Erosion: -1 to -2 ft/yr
- Medium Erosion: -2 to -5 ft/yr
- High Erosion: -5 to -8 ft/yr

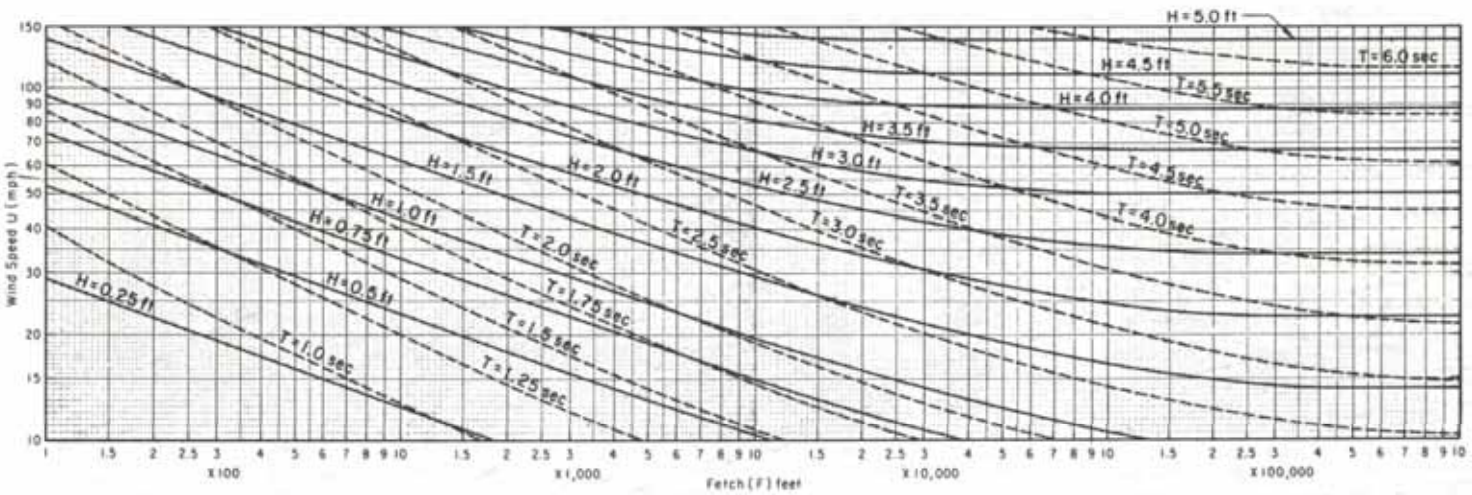
Design Wave

- Significant wave heights are the average of the highest 33% of the wind/wave field
- Wave heights for the highest 10% should be noted to determine rock size
- Predicted waves may be more or less than actual storm wave
- Many sophisticated wave prediction models can be used
- Simple method uses forecasting curves

Design Wave Forecasting Curves



Constant Depth = 5 feet.



Constant Depth = 10 feet.

Source: U.S. Army Corps of Engineers (1977)

Site Visit Parameters

- Site boundaries
- Site characteristics
- RPA Buffer

- Bank condition
- Bank height
- Bank composition

- Shore zone
  - width and elevation
- Backshore zone
  - width and elevation
- Existing shoreline defense structures

- Nearshore stability
- Boat wake potential

Site Boundaries

- Legal property limits
- Determines where end effects and downdrift impacts should be considered
- Construction access options revealed

Site Characteristics

- Current and future upland land use
- Locate visible and invisible improvements
  - Primary and accessory structures
  - Underground utilities
  - Drainfields
  - Groundwater wells
- Presence or absence of improvements determines level of protection needed

Bank Condition

A A stable base of bank and bank face that has been graded and planted with vegetation. James River, Virginia

B An unstable base of bank and bank face. The different colored layers indicates different types of material. Piankatank River, Virginia

C An undercut bank on the East River, Virginia.

Bank Height & Composition

Upper bank

Base of bank

Bank Vegetation Cover
Resource Protection Area Buffer

Densely Vegetated / Forested

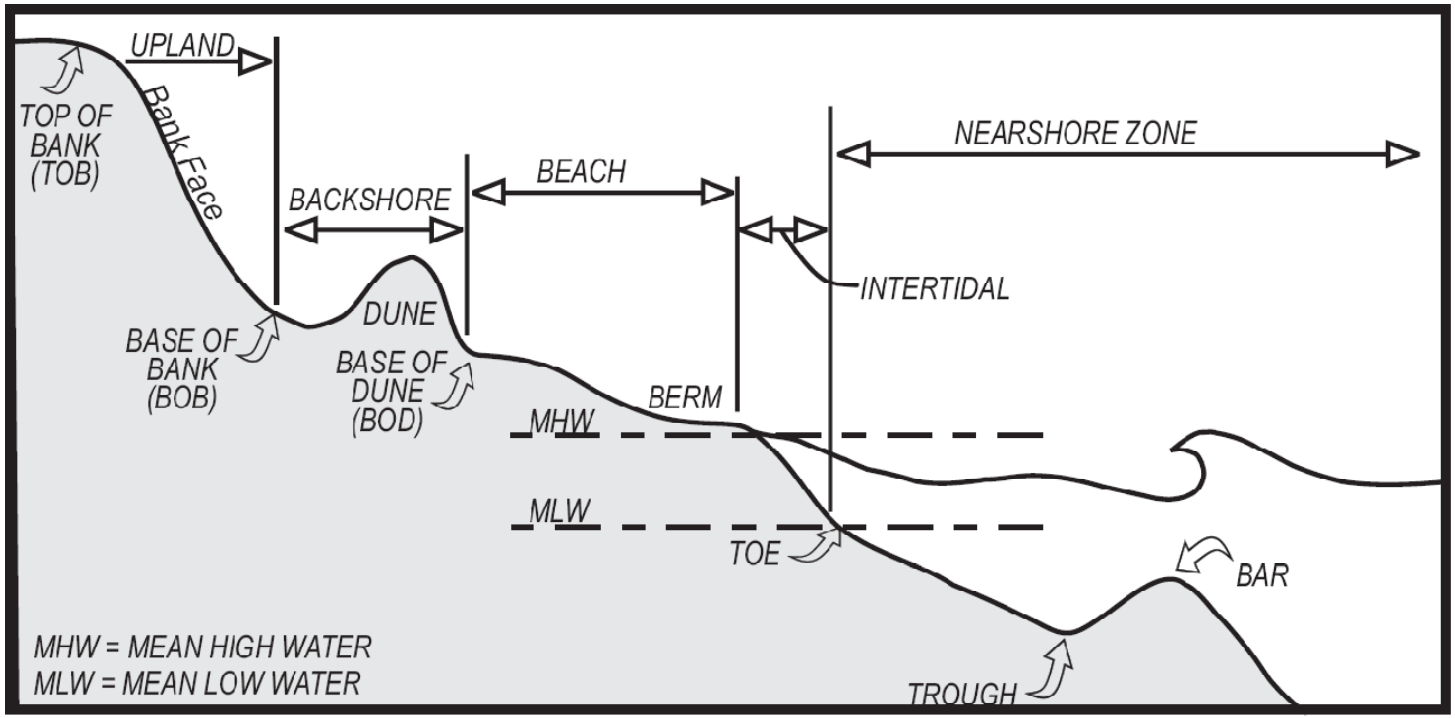
Previously Cleared

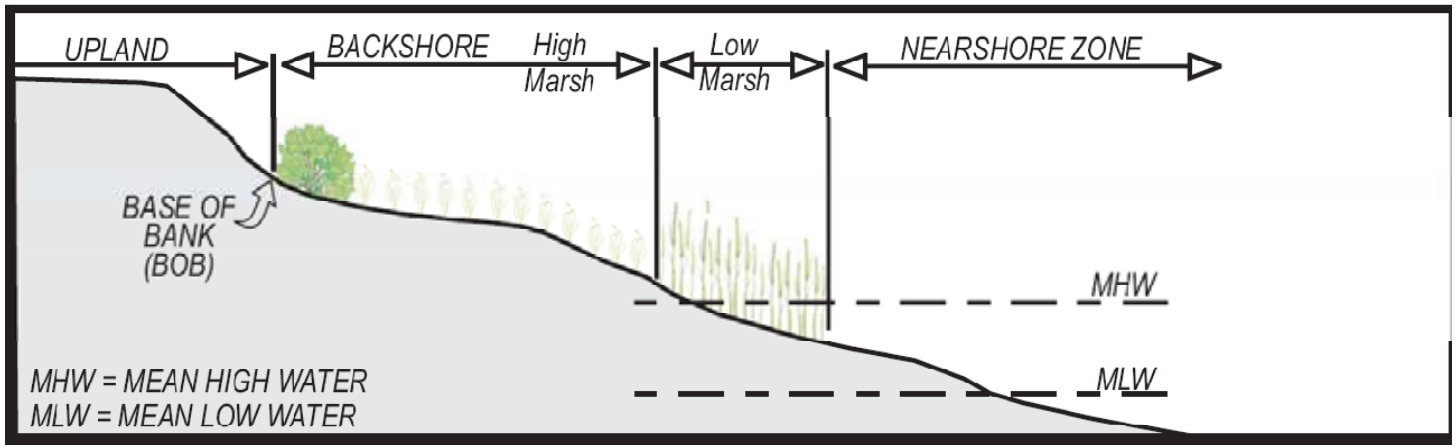
Does vegetation cover contribute to erosion protection or problem?

Should the bank be graded or not ?

Is the absence of vegetation due to active erosion or previous land disturbance?

Combined Shore and Backshore Zone Width and Elevation





Shore Zone Width and Elevation

- Existing tidal wetland
  - Non-vegetated
  - Salt or freshwater marsh
  - Cypress trees
- Existing sand beach
  - Intertidal beach
- Combination
  - Patchy marsh headlands with pocket beaches

- Measure width of each feature in profile
- Identify plant species, jurisdictional limits
- Do existing beach and marsh contribute to erosion protection?
- Can they be temporarily disturbed or enhanced?

Backshore Zone Width and Elevation

- Existing high marsh
  - Saltmeadow hay
  - *Phragmites*
  - Salt bushes
- Existing supratidal beach > MHW
  - Overwash sand
  - Primary & secondary dune features
- Backshore terrace
  - Bank slumping
  - Upland grasses and trees

- Measure width of each feature in profile
- Identify plant species, jurisdictional limits
- Do existing features contribute to erosion protection?
- Can they be temporarily disturbed or enhanced?

Nearshore Stability

Highly suitable for sill or breakwater

Not suitable

Important consideration for sills and breakwaters

Firm vs. soft

Boat Wakes

Boat wake effects are difficult to determine or predict

High boat traffic in narrow waterways will produce severe wave climate not indicated by other parameters (fetch)

Presence or absence of docks, marinas, marked channels

Local knowledge and judgment calls are required to weigh this parameter

Existing Shoreline Defense Structures

Target Shoreline

- Serviceable or failing
- Contributing to erosion protection or problem ?
- Failed structures indicate wave climate, other design alternatives

Adjacent Shoreline

- Consider effects on structural integrity
- Opportunities for reach-based solutions?

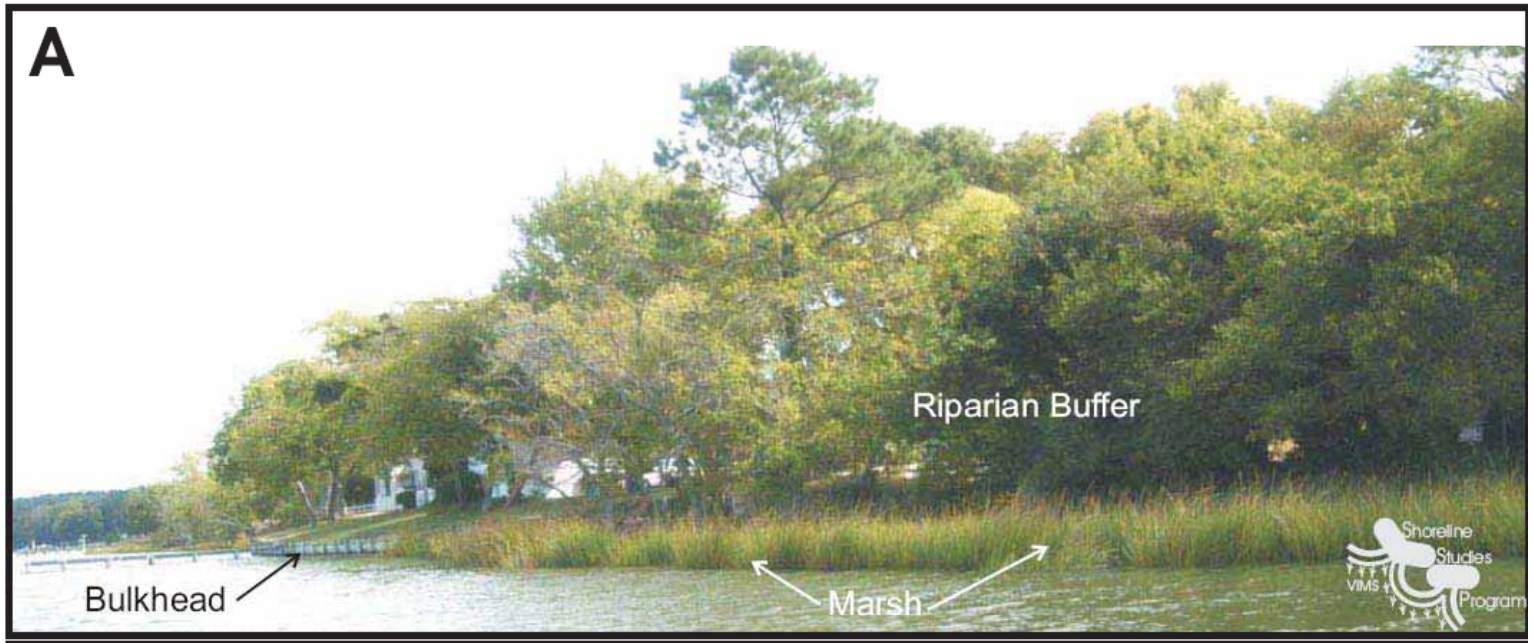
Coastal Profile

- Combine all parameters for site-specific conditions
  - Are all parameters weighed equally?

- Consider how integrated habitats can influence shore protection, water quality and habitat functions

- Each element in the system works to reduce wave energy impacting the upland

Coastal profile examples



SELECTING A STRATEGY

Selecting a Strategy

- First consider if any action is needed, can minor erosion be tolerated?

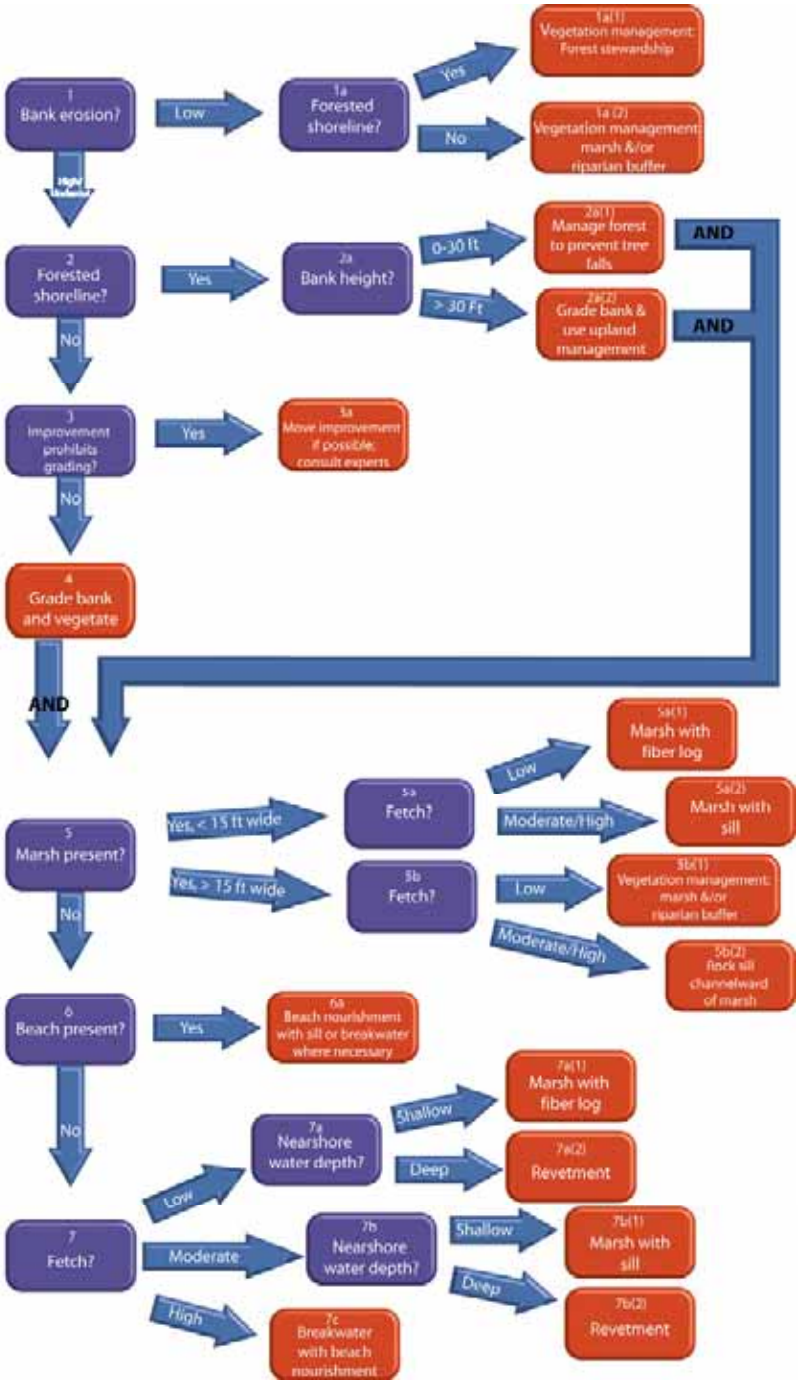
- If No Action is not acceptable, what is the least impacting solution to solve the particular erosion problem?

CCRM Decision Tree for Undefended Shorelines

Suggested strategies in red

Judgment calls required if site doesn't fit perfectly

Does not account for all parameters in a weighted fashion



Marsh Planting and Management

- Non-structural approach
- Very low fetch <0.5 mile
- Planting at grade or into sand fill
- Fiber logs
- Tree pruning

If marsh will not persist without fiber logs, then consider marsh sill

Marsh Sill

- Stone revetment placed near MLW
- Backfilled with sand
- Planted with tidal wetland vegetation

Stone

Sand

Plants

All 3 elements usually required for sustainable design

Marsh Toe Revetment

- Sill placed next to an existing wide marsh
- Maintain desirable marsh ecosystem services
- Natural accretion depends on local sediment supply
- Can also spot fill and plant to fill in non-vegetated areas

Why Tidal Openings ?
Marsh Sills and Marsh Toe Revetments

- Mitigate sill impacts on shallow water – marsh edge interactions
- Tidal inundation and positive drainage for healthy plant growth
- Marsh access for fish, crabs, terrapins

Tightly packed stone in gabions restricts water movement through stones

Algae bloom in warmer, stagnant area

Tidal Openings
When should they be included?

- Site-specific
  - Tidal ponds
  - Natural or created channels
  - Open ends
  - Recreation access

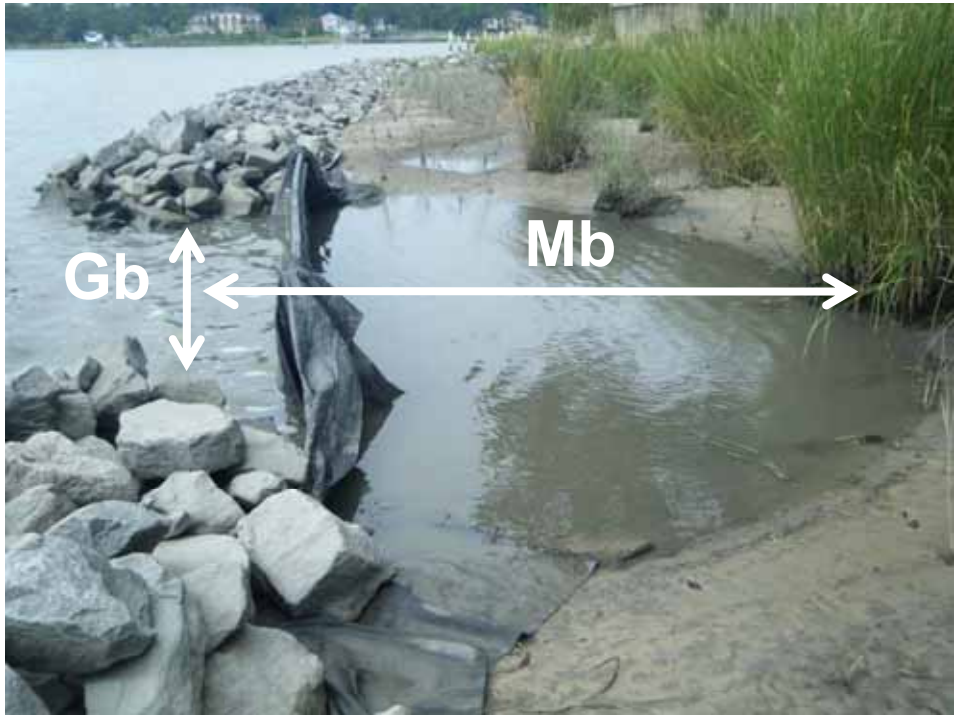
Tidal openings allow access for marine wildlife, but they also introduce wave energy into the planted marsh.

- Sill crest height > MHW

- Sill length > 100 Ft
  - No definitive standard
  - May need more or less

Stable embayments eventually form

Tidal Openings
Design Challenges



More research is needed to confirm a design standard for predicting embayment position

- Minimize sand loss, planted marsh failure at gaps
- How to predict stable embayment position ?
- Use similar ratio as breakwaters ???

Maximum Bay Indentation : Gap Width

Mb:Gb

1:1.65

Tidal Openings
Design Challenges

Sand deposits at pocket beach may restrict tidal inundation into and out of marsh

Not always detrimental to marsh or access, depends on other parameters

Tidal Openings
Other Design Types

Weir Opening or Vented Sill

Gap covered with stone at lower elevation

Sediment deposition still evident

Straight gap with cobblestone

Reduces sand deposits

How is biological activity altered?

Tidal Openings
Other Design Types

Gapped offset sections at pocket marsh
Taper ends toward wave energy

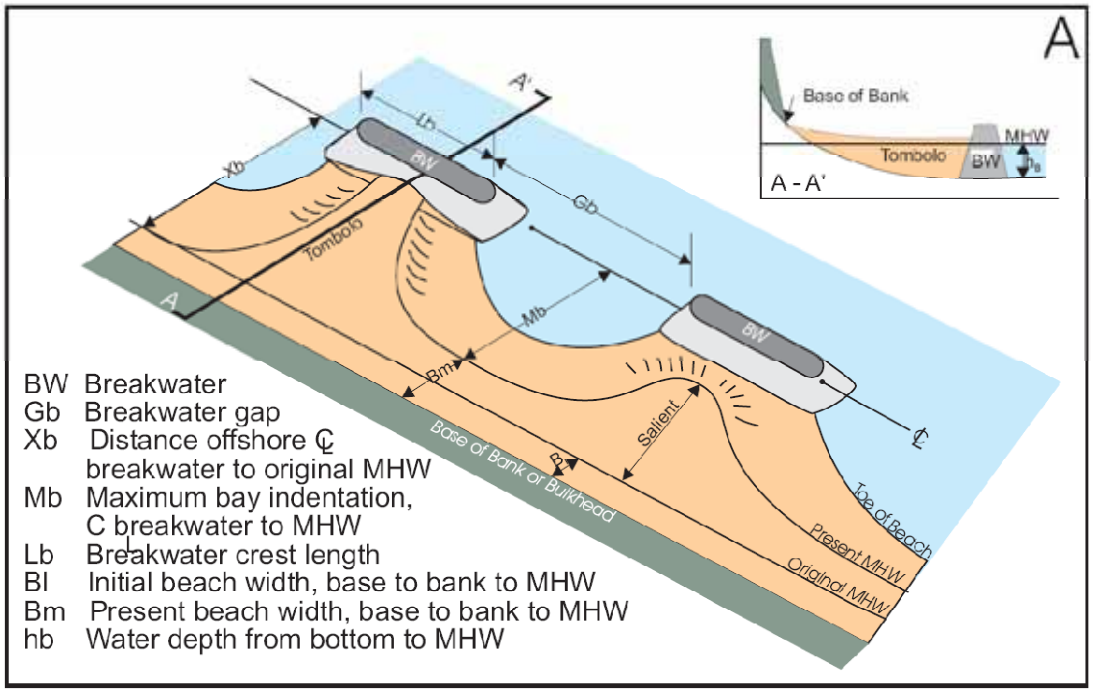
Offshore Breakwaters

- Most appropriate for high energy sand beach sites
- Create stable pocket beaches between fixed headlands
  - At least 2 units
- Proper design requires advanced knowledge of coastal processes at site

Breakwater Design Guidelines

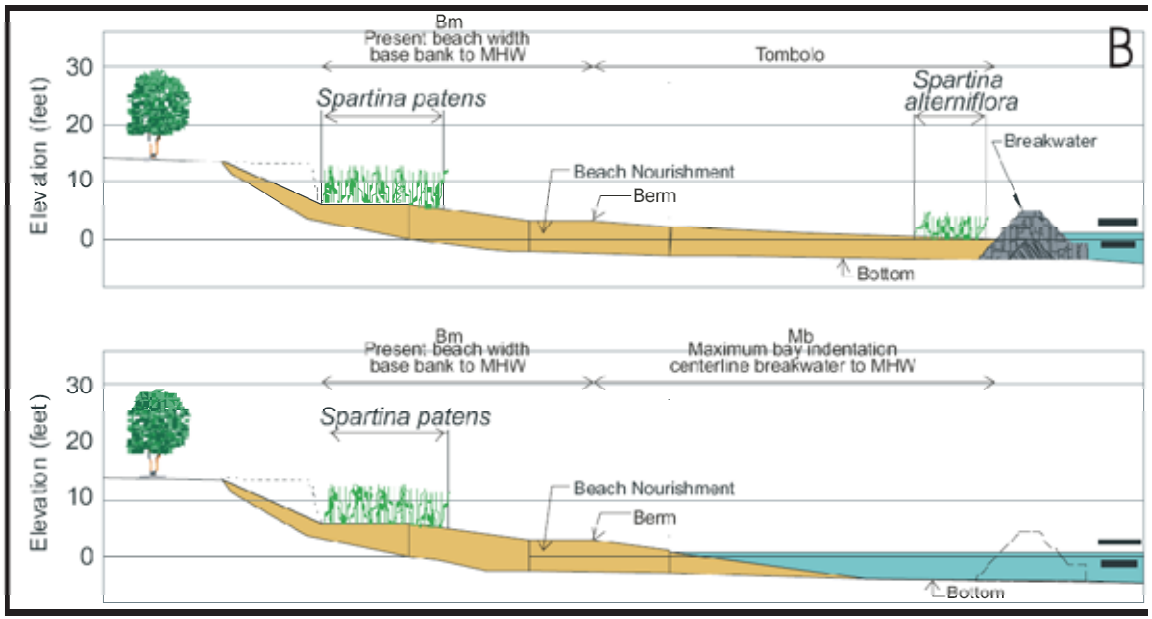
Maximum Bay Indentation : Gap Width

Mb:Gb
1:1.65



Crest Length : Gap Width

Lb:Gb
1:1.4



Level of Protection and Design Storms

- Maximum wind-wave climate expected
- Amount of risk or damage property owner is willing to accept
- Balanced with cost-effectiveness
- Design storms
  - 10 yr
  - 25 yr
  - 50 yr
  - 100 yr
- Set elevations against eroding upland bank

Encroachment / Habitat Tradeoffs

Landward

- Bank grading
- Tree removal
- Upland conversion to tidal wetlands

Channelward

- Non-vegetated to vegetated tidal wetland
- Shallow water conversion to stone and vegetated marsh
- Submerged Aquatic Vegetation
- Sand movement & navigation channels
- Shellfish lease areas

Encroachment / Habitat Tradeoffs

- Which type is more common?
  - Landward or channelward

Encroachment / Habitat Tradeoffs

- Which type is more common?
  - Landward or channelward
- Which conversion typically has the most impact?
  - Upland to wetland
  - Non-vegetated to vegetated wetland
  - Shallow water to vegetated wetland

End of Part 1

Design and Construction of Living Shorelines

Part 2

September 29, 2010

Shoreline Studies Program
VIMS

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Virginia Institute of Marine Science

Part 2

- Case Studies

  real stories with a message, lessons learned over time

  – Poole Marsh Management
  – Hull Springs Farm Marsh Sill
  – Van Dyke Offshore Breakwater

Poole
Marsh Management

Description

- 1982 vegetative erosion control project
- Graded bank
- Narrow intertidal beach planted with *Spartina alterniflora* only
- Adjacent marshes in vicinity

Lessons Learned

- Remained intact for 25 yrs
- Mid-tide level MTL is lower limit for *Spartina alterniflora*

Minor bank grading and temporary toe protection utilizing straw bales was used first then *Spartina alterniflora* was planted to establish a marsh fringe.

At this site, high water impinged upon the base of the bank. Therefore, only the intertidal species (*Spartina alterniflora*) was utilized. This photo shows the site one year After planting.

The established marsh fringe and vegetative upland slope are shown here after six years.

This Marsh Management site after 24 years.

Lee
Marsh Management

Description

- 1982 demo site
- North-Northeast facing low energy
- High upland bank
- Low and high marsh planting areas

Lessons Learned

- After 20 yrs of intermittent maintenance, opted for revetment
- Ongoing shade control needed for viable marsh fringe along north facing shorelines

Lee Marsh Management

Hull Springs Farm
Sill and Revetment

Description

- Grant-funded public demonstration site
- Design process 2005-2008, build 2008
- Large historic oak tree at top of bank
- Bank erosion during design period, modification to include revetment
- 2 different tidal openings

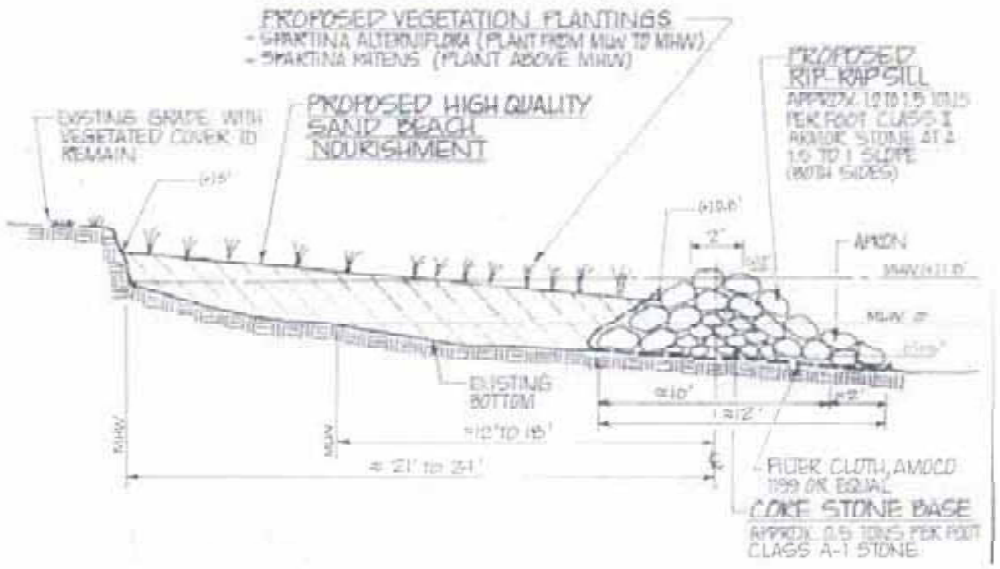
Lessons Learned

- Level of protection needed underestimated
- Unstable bank disguised by dense vegetation cover
- Just one tree can limit options

Hull Springs Farm

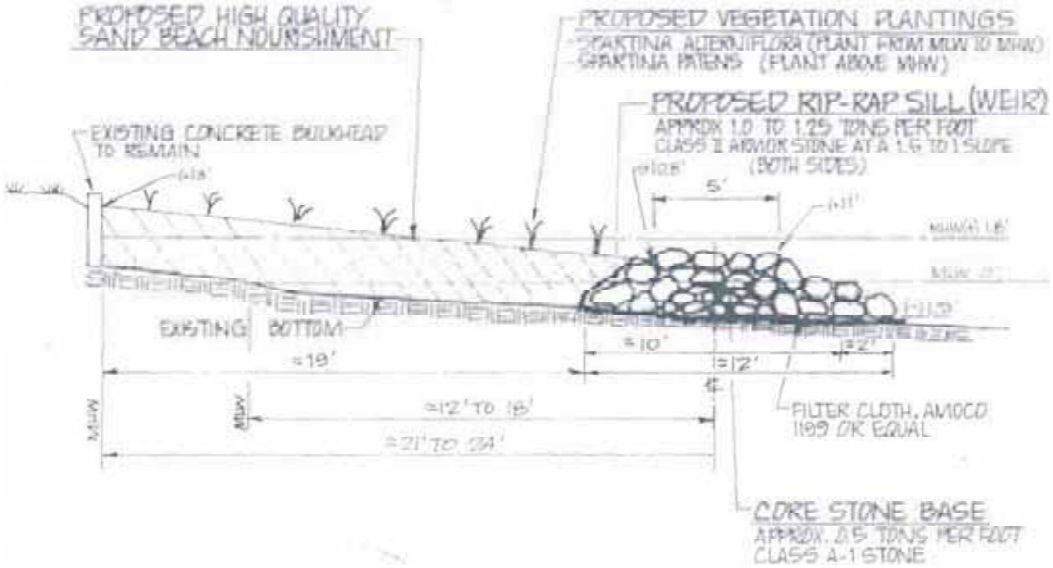
SECTION 'A'-'A'

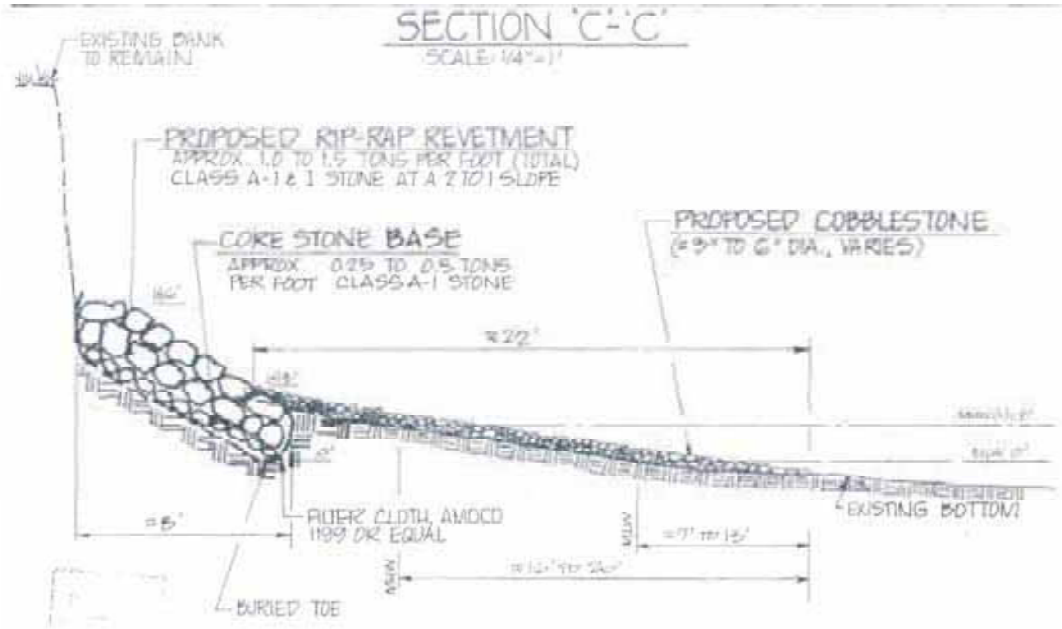
SCALE: 1/4"=1'

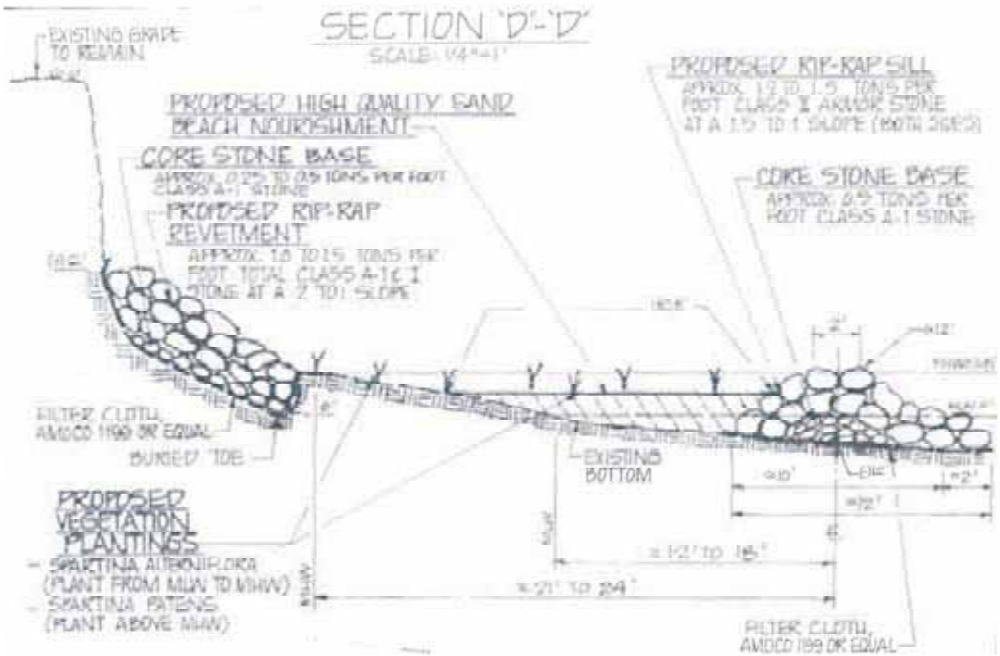


SECTION 'B'-'B'

SCALE: 1/4"=1'




SECTION 'C'-'C'
SCALE: 1/4"=1'
EXISTING BANK TO REMAIN
PROPOSED RIP-RAP REVETMENT
APPROX. 1.0 TO 1.5 TONS PER FOOT (TOTAL)
CLASS A-1 & 1 STONE AT A 2 TO 1 SLOPE
CORE STONE BASE
APPROX. 0.25 TO 0.5 TONS PER FOOT CLASS A-1 STONE
PROPOSED COBBLESTONE
(≈ 3" TO 6" DIA., VARIES)
≈ 22'
FILTER CLOTH, AMOCO 1199 OR EQUAL
EXISTING BOTTOM
≈ 5'
BURIED TOE


SECTION 'D'-'D'
SCALE: 1/4"=1'
EXISTING GRADE TO REMAIN
PROPOSED HIGH QUALITY SAND BEACH NOURISHMENT
CORE STONE BASE
APPROX. 0.25 TO 0.5 TONS PER FOOT CLASS A-1 STONE
PROPOSED RIP-RAP REVETMENT
APPROX. 1.0 TO 1.5 TONS PER FOOT TOTAL CLASS A-1 & 1 STONE AT A 2 TO 1 SLOPE
PROPOSED RIP-RAP SILL
APPROX. 1.2 TO 1.5 TONS PER FOOT CLASS 2 ARMOR STONE AT A 1.5 TO 1 SLOPE (BOTH SIDES)
CORE STONE BASE
APPROX. 0.5 TONS PER FOOT CLASS A-1 STONE
FILTER CLOTH, AMOCO 1199 OR EQUAL
BURIED TOE
EXISTING BOTTOM
PROPOSED VEGETATION PLANTINGS
- SPARTINA ALTERNIFLORA (PLANT FROM MLW TO MHW)
- SPARTINA PATENS (PLANT ABOVE MHW)
≈ 12' TO 16'
≈ 21' TO 24'
FILTER CLOTH, AMOCO 1199 OR EQUAL

Hull Springs Farm
Sill & Revetment

Aug
2008

June
2009

Hull Springs Farm
Sill & Revetment

April
2010

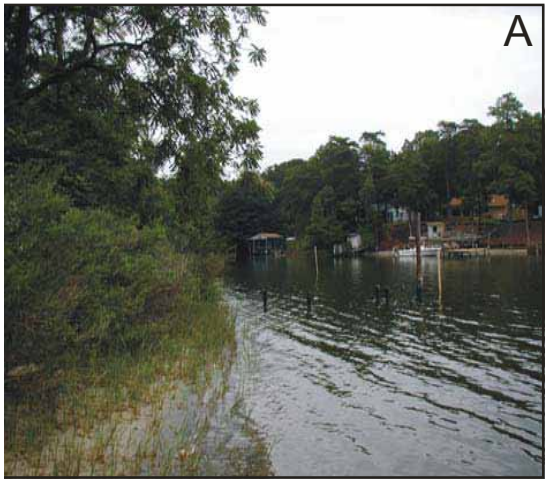
Foxx: Sturgeon Creek

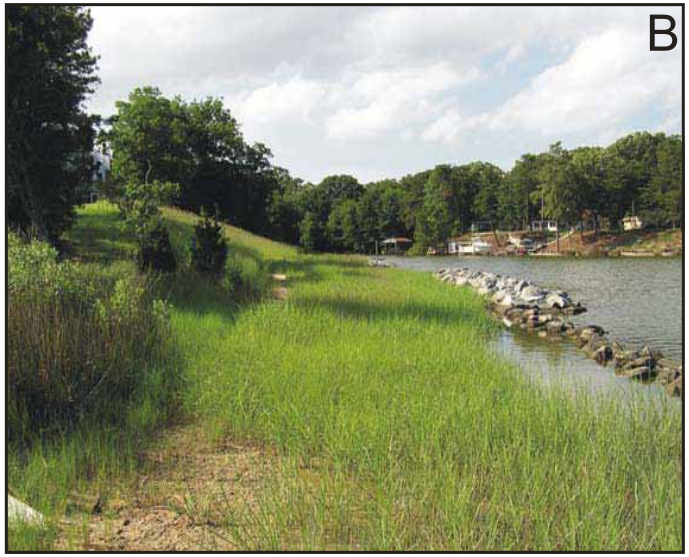
Description

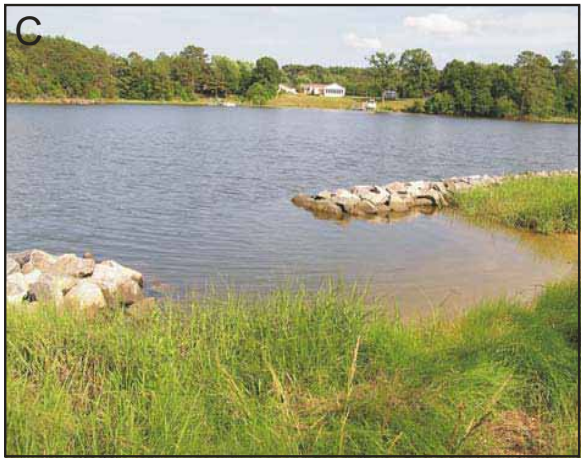
- Constructed in 2005
- 250 ft project
- Longest fetch to ENE 1,500ft
- High sandy bank transitions to low spit
- Bank grading provided sand to project

Lessons Learned

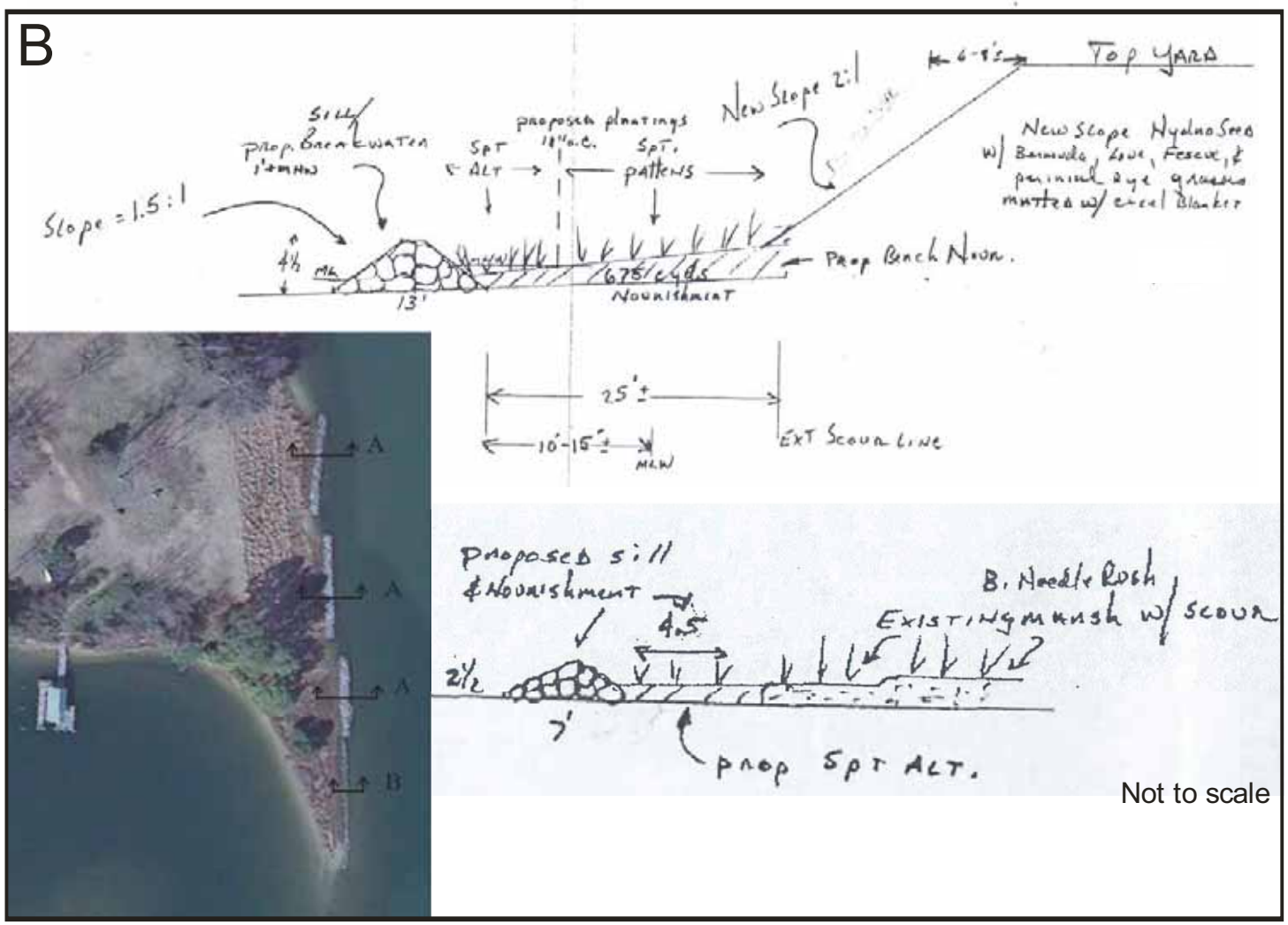
•Site has withstood several significant storms
•Marsh established quickly.
•No signs of bank scarping

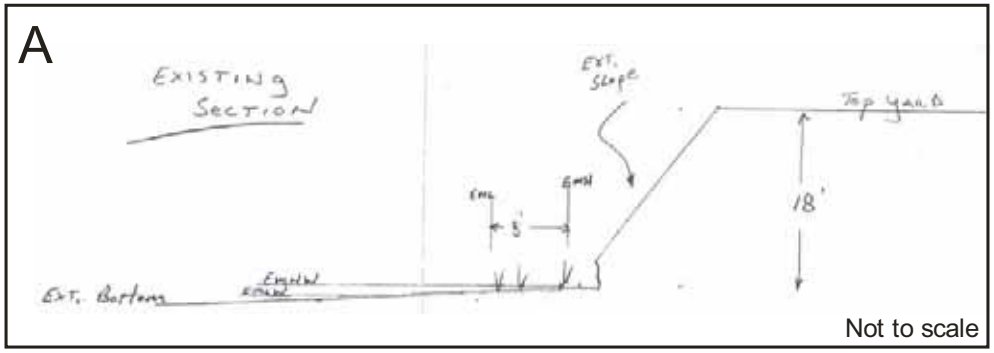

A


B


C

Not to scale


B
Top Yard
New Slope 2:1
Sill
Prop. Breakwater
1'+MHW
Spt Alt
proposed plantings
18" o.c.
Spt. pattens
New Slope Hydro Seed
w/ Bermuda, Love, Fescue, &
perinial rye grasses
matted w/ excel Blanket
Slope = 1.5:1
4½
ML
13'
675 cyds
Nourishment
Prop Bench Nour.
25'±
10'-15'±
MLW
Ext Scour Line
A
A
A
B
Proposed sill
& Nourishment
4.5
B. Needle Rush
Existing marsh w/ scour
2½
7'
Prop Spt Alt.
Not to scale


A
Existing
Section
Ext.
Slope
Top Yard
EML
EMH
3'
18'
Ext. Bottom
EMHW
EMLW
Not to scale

Poplar Grove Sill

Description

- Constructed in 2003
- 1,500 ft project
- Combination revetment, sill and spurs
- Longest fetch south 16 miles, unidirectional
- Low upland bank (+4 to +6 MLW) required little to no bank grading

Lessons Learned

- Site has withstood several significant storms
- Storm waves rolled over the project area and were effectively attenuated
- No signs of bank scarping

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D
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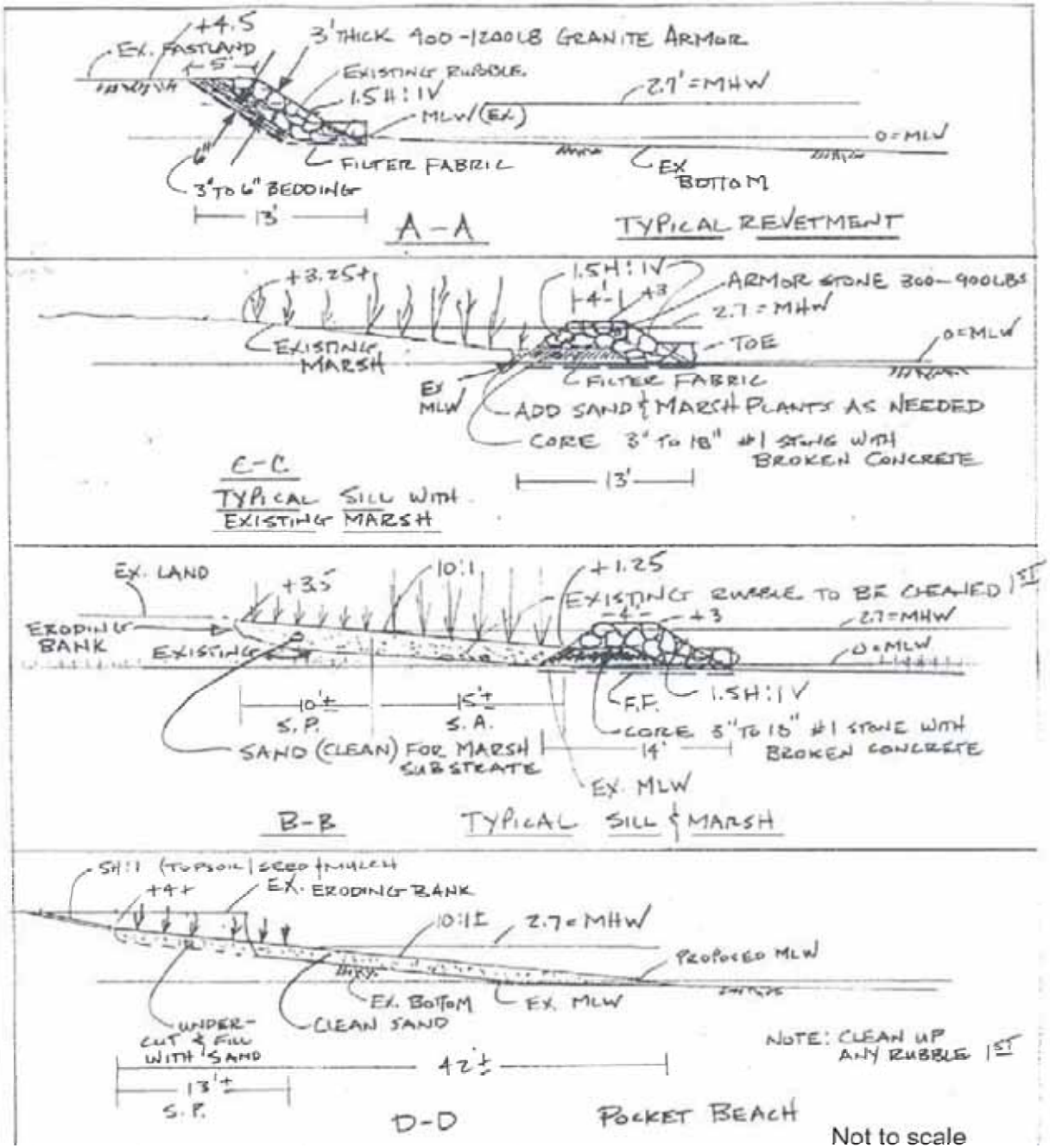
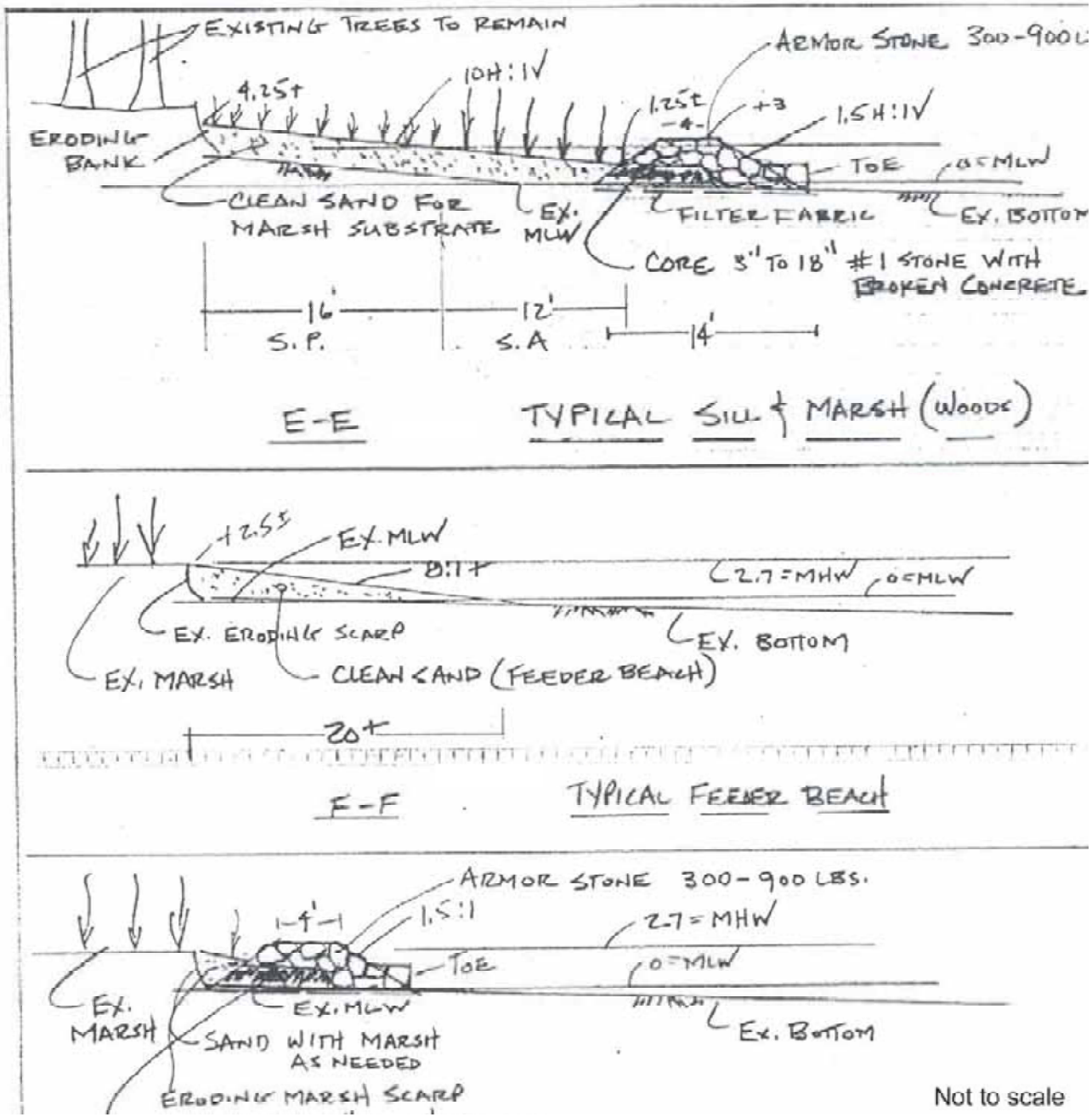
Location of Cross-Sections at Poplar Grove


+4.5
3' THICK 400-1200LB GRANITE ARMOR
EX. FASTLAND
+5'
EXISTING RUBBLE
1.5H:1V
2.7' = MHW
MLW (EX)
0 = MLW
6"
FILTER FABRIC
EX BOTTOM
3" TO 6" BEDDING
13'
A-A
TYPICAL REVETMENT
+3.25+
1.5H:1V
4'
+3
ARMOR STONE 300-900LBS
2.7 = MHW
EXISTING MARSH
TOE
0 = MLW
FILTER FABRIC
EX MLW
ADD SAND & MARSH PLANTS AS NEEDED
CORE 3" TO 18" #1 STONE WITH BROKEN CONCRETE
13'
C-C
TYPICAL SILL WITH EXISTING MARSH
EX. LAND
+3.5
10:1
+1.25
EXISTING RUBBLE TO BE CLEANED 1ST
-4-
+3
2.7 = MHW
ERODING BANK
EXISTING
0 = MLW
10'±
S.P.
15'±
S.A.
F.F.
1.5H:1V
CORE 3" TO 18" #1 STONE WITH BROKEN CONCRETE
SAND (CLEAN) FOR MARSH SUBSTRATE
14'
EX. MLW
B-B
TYPICAL SILL & MARSH
5H:1 (TOPSOIL | SEED + MULCH
+4+
EX. ERODING BANK
10:1
2.7 = MHW
PROPOSED MLW
EX. BOTTOM
EX. MLW
CLEAN SAND
UNDER-CUT & FILL WITH SAND
NOTE: CLEAN UP ANY RUBBLE 1ST
42'±
13'±
S.P.
D-D
POCKET BEACH
Not to scale


EXISTING TREES TO REMAIN
ARMOR STONE 300-900
10H:1V
4.25+
1.25±
+3
1.5H:1V
ERODING BANK
TOE
0=MLW
CLEAN SAND FOR MARSH SUBSTRATE
EX. MLW
FILTER FABRIC
EX. BOTTOM
CORE 3" TO 18" #1 STONE WITH BROKEN CONCRETE
16'
S.P.
12'
S.A
14'
E-E
TYPICAL SILL & MARSH (WOODS)
+2.5±
EX. MLW
8:1+
2.7=MHW
0=MLW
EX. ERODING SCARP
EX. BOTTOM
EX. MARSH
CLEAN SAND (FEEDER BEACH)
20+
F-F
TYPICAL FEEDER BEACH
ARMOR STONE 300-900 LBS.
1-4'-1
1.5:1
2.7=MHW
TOE
0=MLW
EX. MARSH
EX. MLW
SAND WITH MARSH AS NEEDED
EX. BOTTOM
ERODING MARSH SCARP
Not to scale

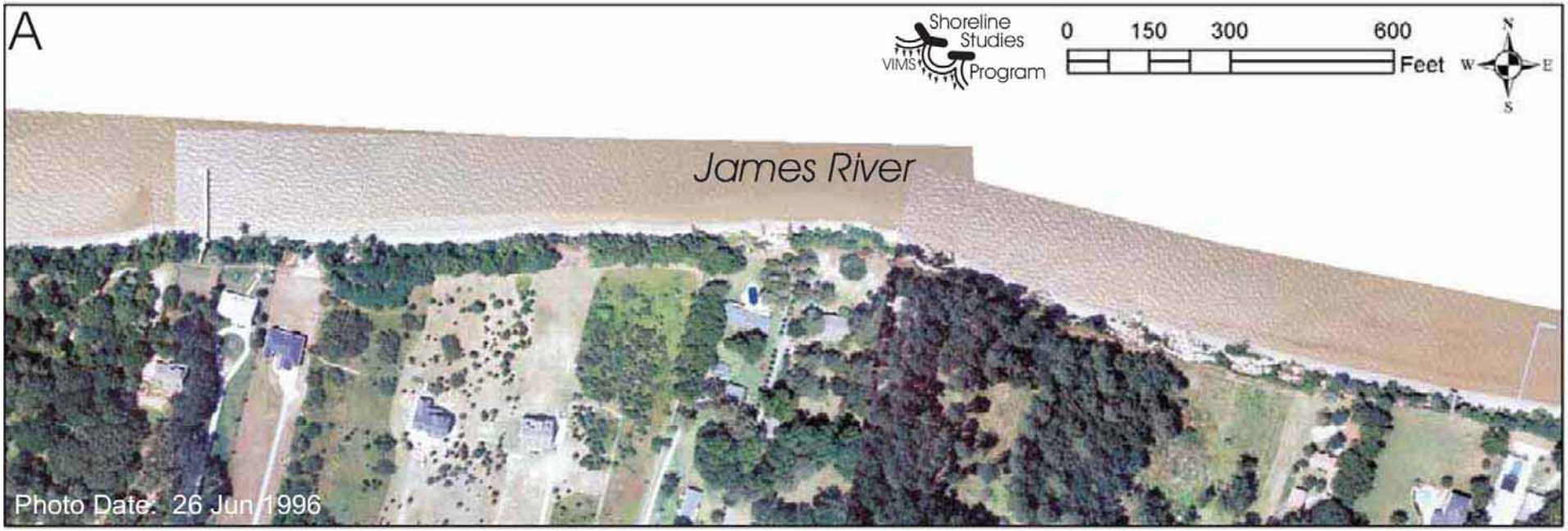
Van Dyke
Offshore Breakwaters

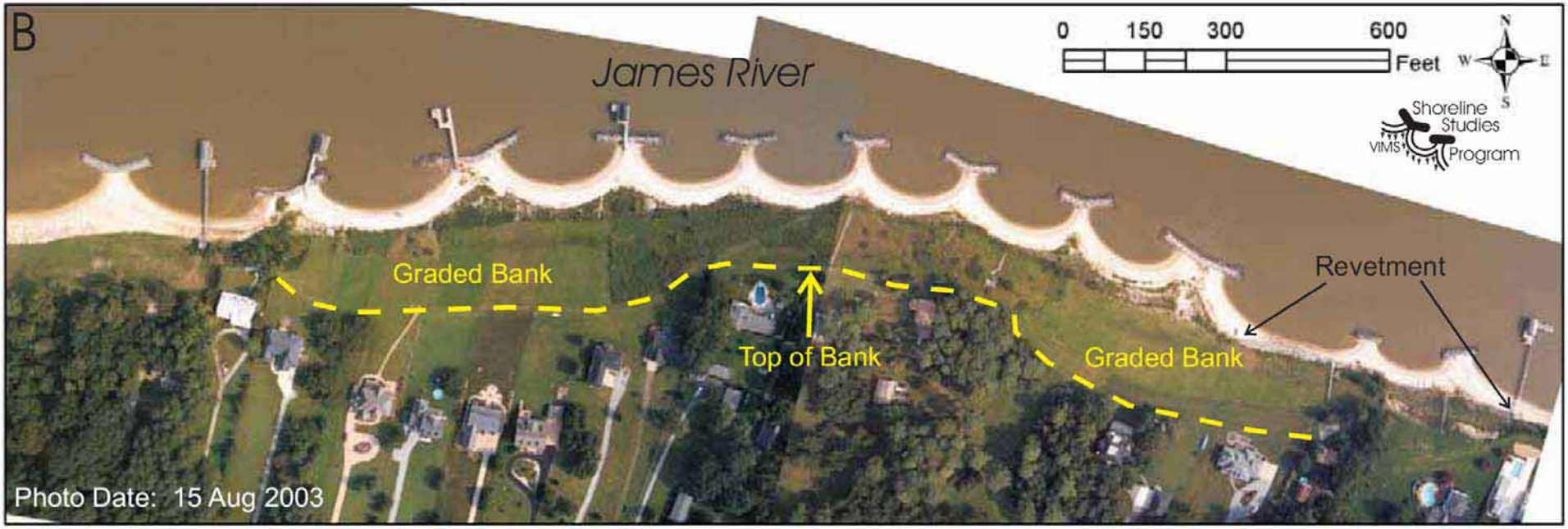
Description

- Constructed in 1997
- 2,300 ft project
- 8 headland breakwaters
- North fetch 12 miles
- “Bimodal” site – wave climate from NW, N, NE
- Bank sand suitable for beach fill
- 15 coordinating property owners

Lessons Learned

- Gradual slopes at interface between backshore and base of bank reduce bank scarps during storm
- Expect shifts and gradual recovery after storms


A
Shoreline Studies Program
VIMS
0 150 300 600
Feet
N
W
E
S
James River
Photo Date: 26 Jun 1996


B
0 150 300 600
Feet
N
W
E
S
Shoreline Studies Program
VIMS
James River
Graded Bank
Top of Bank
Graded Bank
Revetment
Photo Date: 15 Aug 2003

Shoreline
Studies
VIMS
Program
AUG 20 2003

House
Shoreline
Studies
VIMS
Program
AUG 20 2003

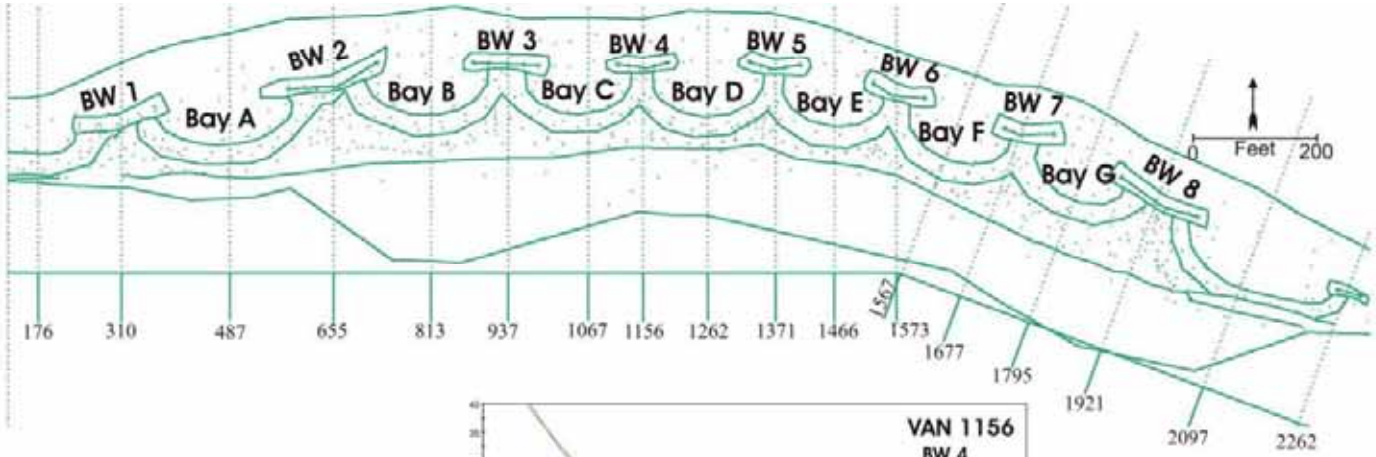
Shoreline
Studies
VIMS
Program
21 2:26PM

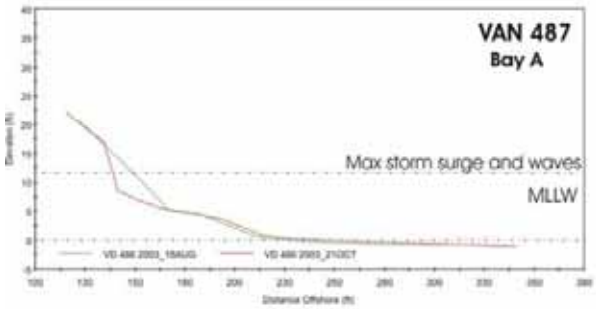
House
Shoreline
Studies
VIMS
Program
21 2:40PM

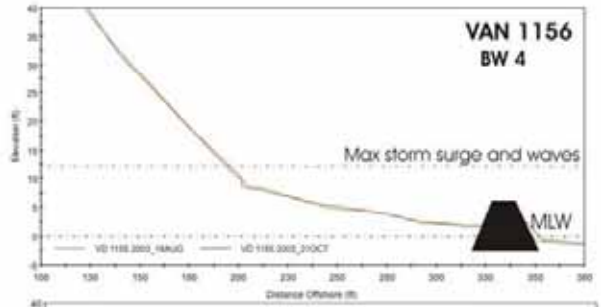
Post Isabel
21 Oct 2003
Graded Bank
+8 ft MLLW Revetment
Shoreline
Studies
Program

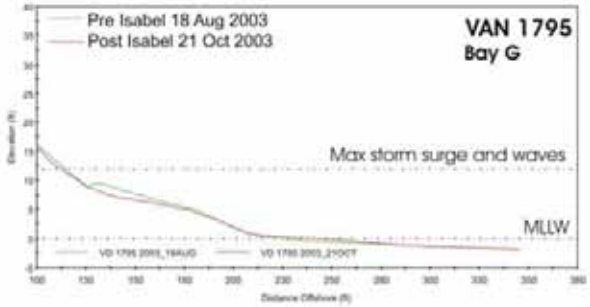
Shoreline
Studies
Program
Graded Bank

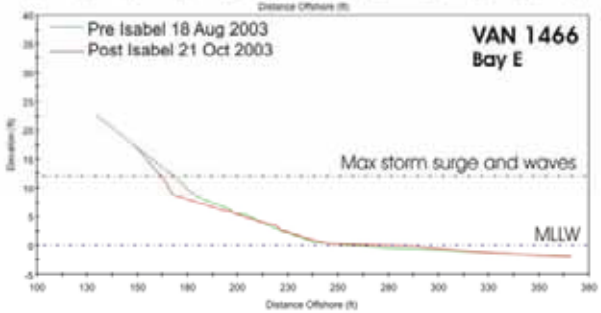
Van Dyke Cross-Sections

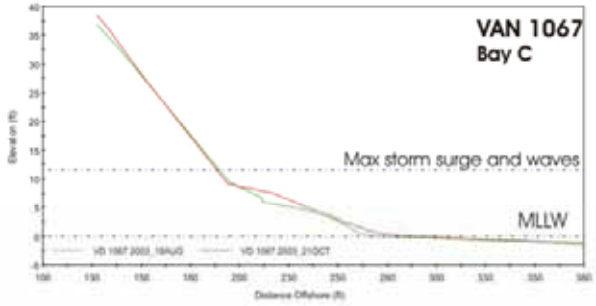


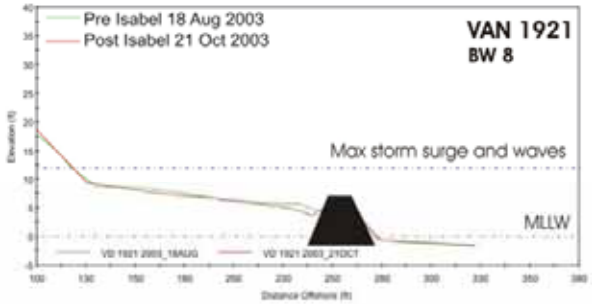


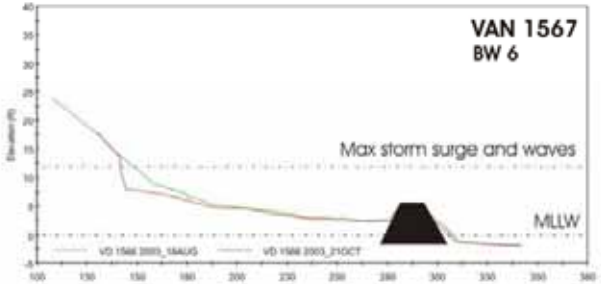


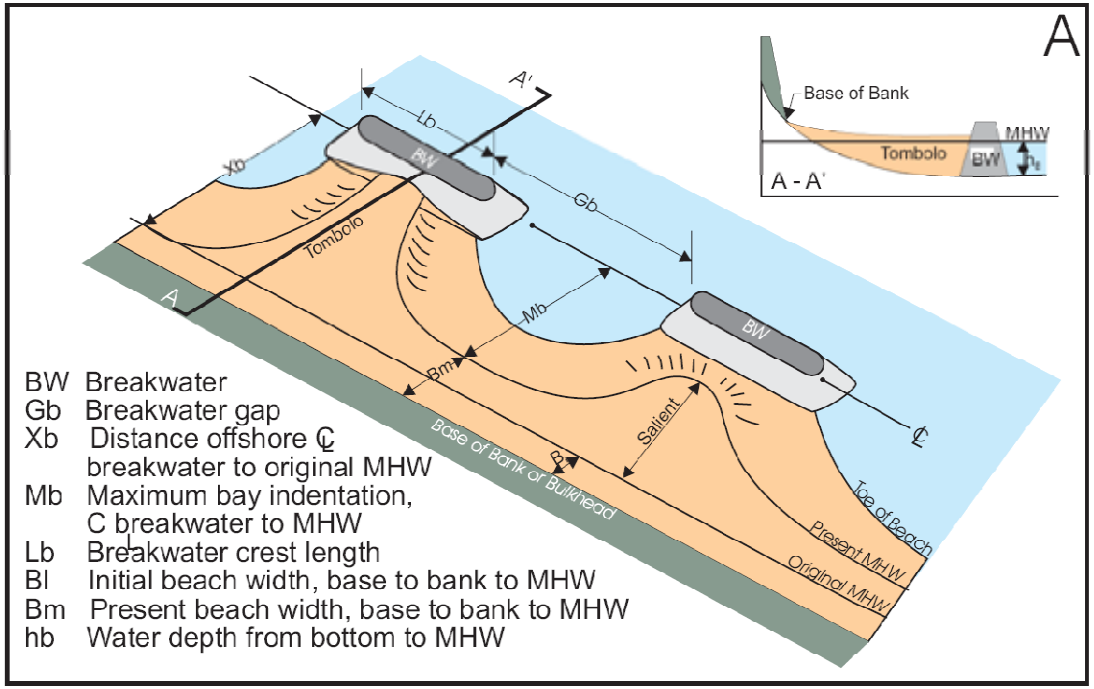


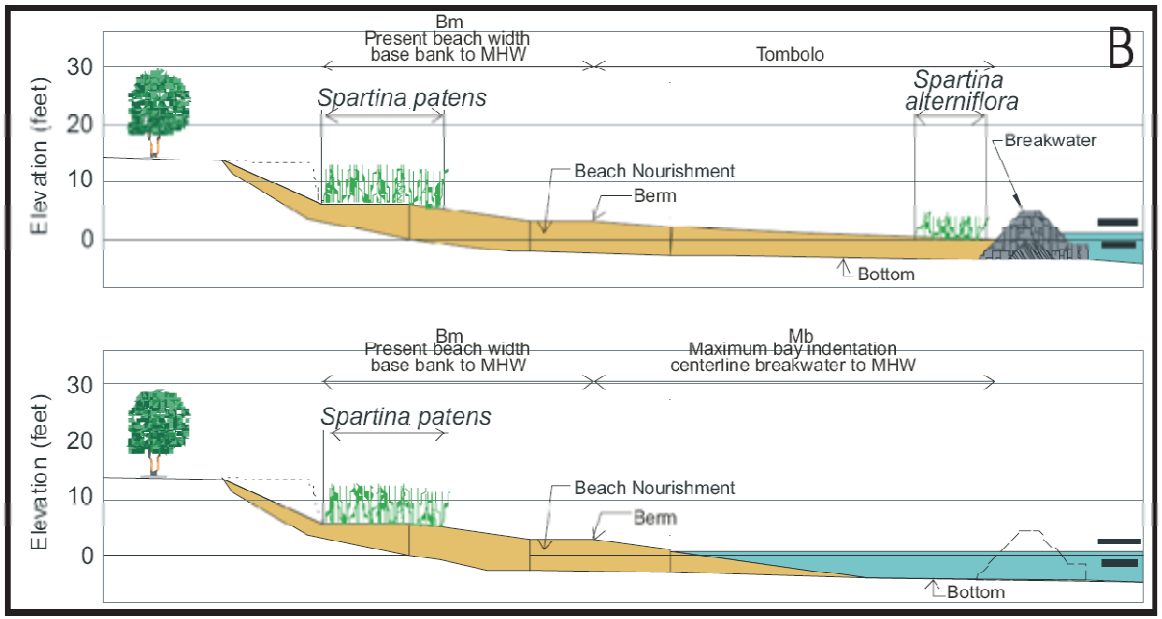









A
Base of Bank
MHW
Tombolo
BW
A - A'
A'
Lb
Xb
Gb
Tombolo
A
Mb
Bm
BW
Salient
Bl
Base of Bank or Bulkhead
Toe of Beach
Present MHW
Original MHW
BW Breakwater
Gb Breakwater gap
Xb Distance offshore ℄ breakwater to original MHW
Mb Maximum bay indentation, C breakwater to MHW
Lb Breakwater crest length
Bl Initial beach width, base to bank to MHW
Bm Present beach width, base to bank to MHW
hb Water depth from bottom to MHW


B
Bm
Present beach width
base bank to MHW
Tombolo
Spartina patens
Spartina alterniflora
Breakwater
Beach Nourishment
Berm
Bottom
Elevation (feet)
30
20
10
0
Bm
Present beach width
base bank to MHW
Mb
Maximum bay indentation
centerline breakwater to MHW
Spartina patens
Beach Nourishment
Berm
Bottom
Elevation (feet)
30
20
10
0

The End

Part 2

Design and Construction of Living Shorelines Part 3

September 29, 2010

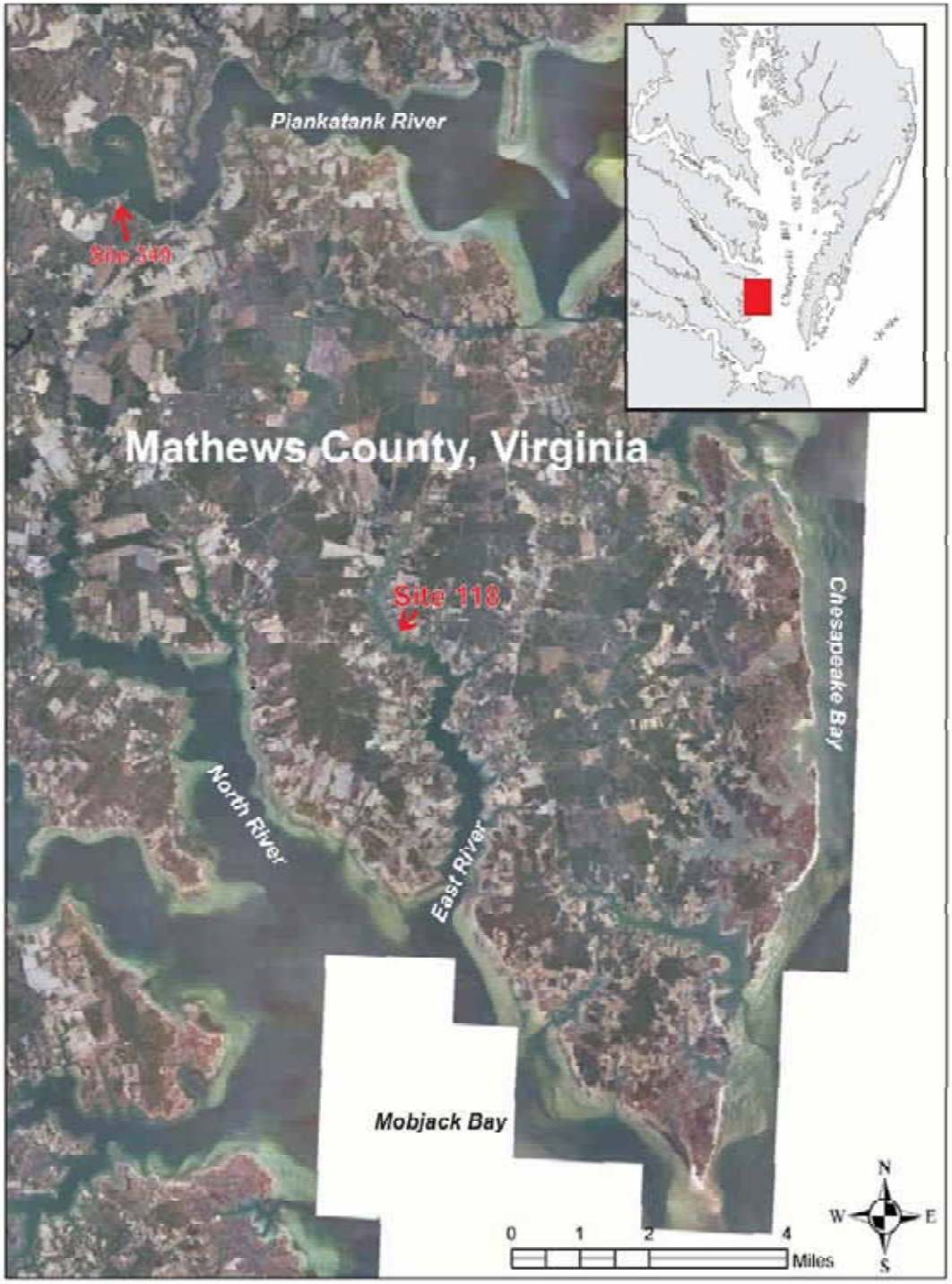
Shoreline Studies Program
VIMS

William & Mary
VIMS
Virginia Institute of Marine Science
School of Marine Science

Center for Coastal Resources Management
Virginia Institute of Marine Science

Part 3
Design Examples

- Real shoreline scenarios
- Work through site evaluation and design process


Piankatank River
Site 340
Mathews County, Virginia
Site 118
Chesapeake Bay
North River
East River
Mobjack Bay
0
1
2
4
Miles
N
W
E
S

Site 349 – Piankatank River

Site Evaluation

Site Name_____ Date _____
Site Locality _____ Body of Water _____

Pre-Visit Parameters

Shore Orientation(s): N NE E SE S SW W NW

Site Length: _____(ft)

Average Fetch(es):
Very High (> 15 miles) High (5-15 miles) Medium (1-5 miles)
Low (0.5-1 miles) Very Low (< 0.5 miles)

Longest Fetch:_____miles

Shore Morphology: Pocket Straight Headland Irregular

Depth Offshore: _____

Nearshore Morphology: Bars ____ Tidal Flats ____

Nearshore Aquatic Vegetation:_____

Tide Range: _____

Storm Surge: 10 yr_____25 yr_____ 50 yr _____100 yr_____

Erosion Rate: Very High Accretion (> +10 ft/yr) High Accretion (+10 to +5 ft/yr)
Medium Accretion (+5 to +2 ft/yr) Low Accretion (+2 to +1 ft/yr)
Very Low Accretion (+ 1 to 0 ft/yr) Very Low Erosion (0 to -1 ft/yr)
Low Erosion (-1 to -2 ft/yr) Medium Erosion (-2 to -5 ft/yr)
High Erosion (-5 to -10 ft/yr) Very High Erosion (<-10 ft/yr)

Design Wave: Height_____Period_____

Notes:

Site Visit Parameters

Site Boundaries:

Site Characteristics:

Upland Land Use

Proximity to Infrastructure

Cover

Bank Condition:

Bank Face-	Erosional	Stable	Transitional	Undercut
Bank of Bank -	Erosional	Stable	Transitional	

Bank Height: _____

Bank Composition:

RPA Buffer:

Shore Zone: Sand _____Marsh_____

Width

Elevation

Backshore Zone: Sand _____Marsh_____

Width

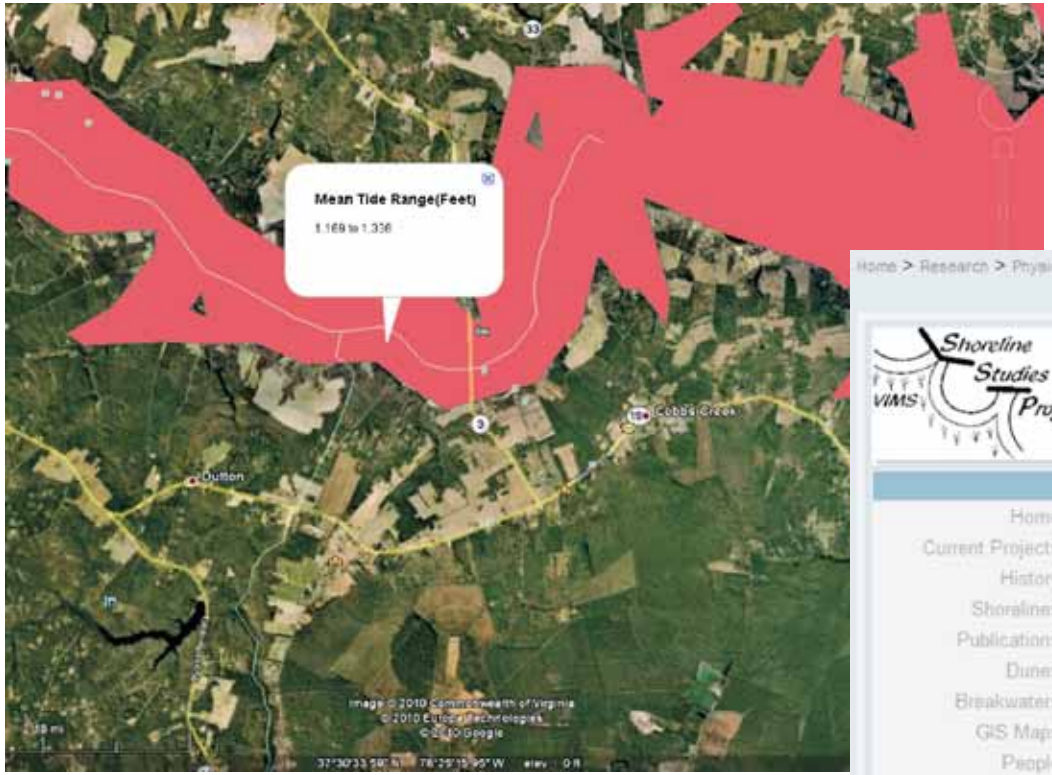
Elevation

Nearshore Stability: Firm_____Soft_____

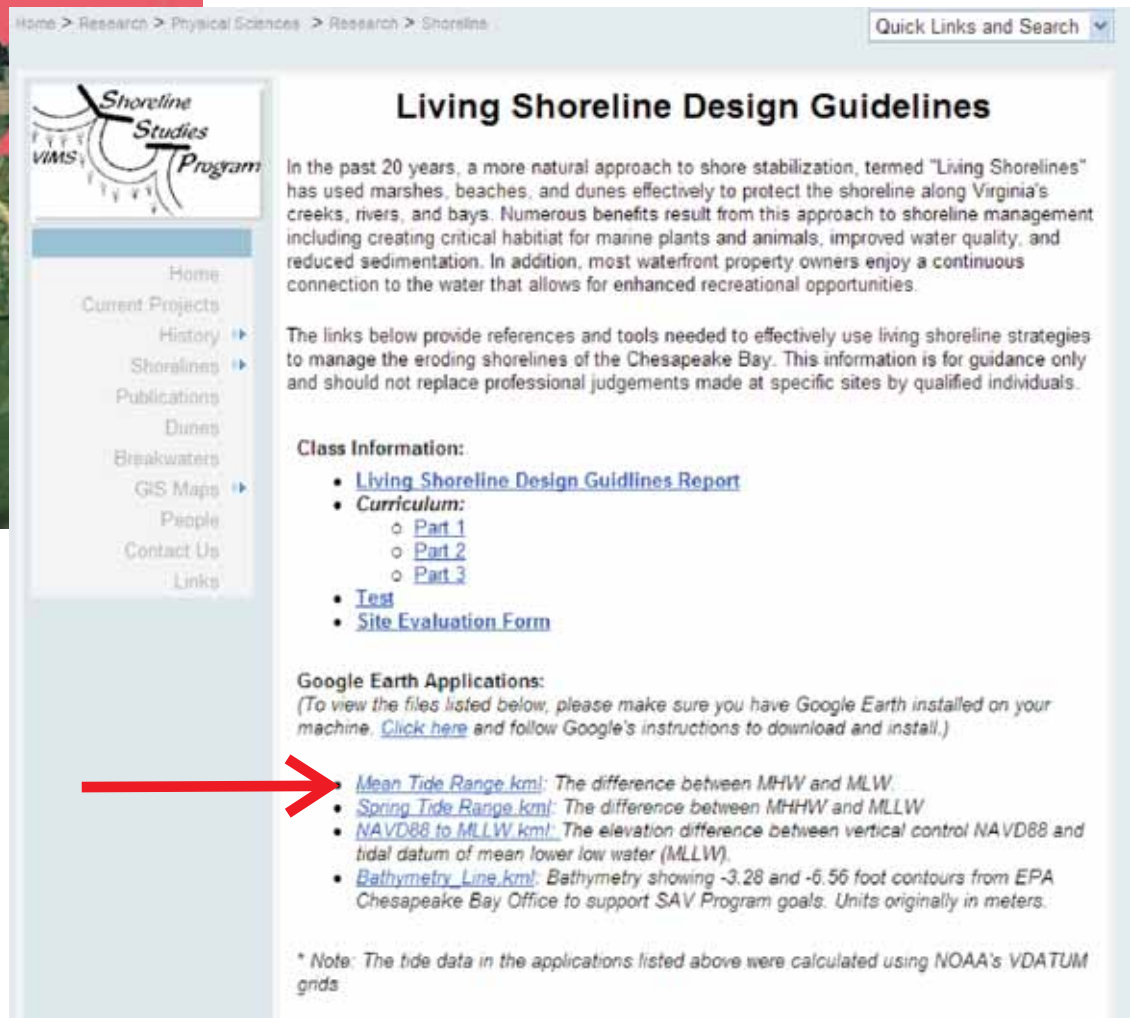
Boat Wakes:

Existing Shoreline Defensive Structures:

Use Shoreline Studies' Google Earth Applications for site information



Mean Tide Range



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Living Shoreline Design Guidelines

In the past 20 years, a more natural approach to shore stabilization, termed "Living Shorelines" has used marshes, beaches, and dunes effectively to protect the shoreline along Virginia's creeks, rivers, and bays. Numerous benefits result from this approach to shoreline management including creating critical habitat for marine plants and animals, improved water quality, and reduced sedimentation. In addition, most waterfront property owners enjoy a continuous connection to the water that allows for enhanced recreational opportunities.

The links below provide references and tools needed to effectively use living shoreline strategies to manage the eroding shorelines of the Chesapeake Bay. This information is for guidance only and should not replace professional judgements made at specific sites by qualified individuals.

Class Information:

- Living Shoreline Design Guidlines Report
- *Curriculum:*
  - Part 1
  - Part 2
  - Part 3
- Test
- Site Evaluation Form

Google Earth Applications:
(To view the files listed below, please make sure you have Google Earth installed on your machine. Click here and follow Google's instructions to download and install.)

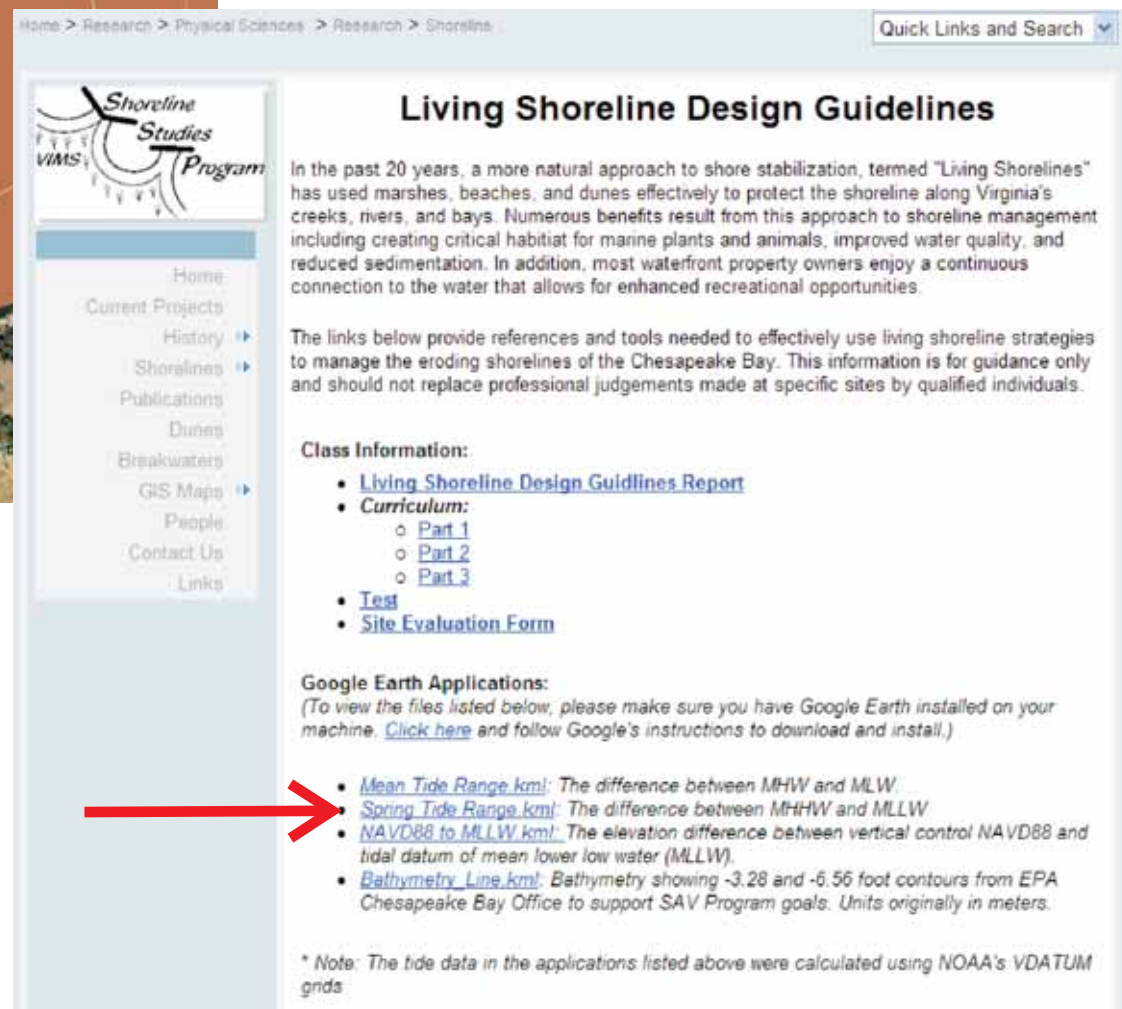
- *Mean Tide Range.kml: The difference between MHW and MLW.*
- *Spring Tide Range.kml: The difference between MHHW and MLLW*
- *NAVD88 to MLLW.kml: The elevation difference between vertical control NAVD88 and tidal datum of mean lower low water (MLLW).*
- *Bathymetry_Line.kml: Bathymetry showing -3.28 and -6.56 foot contours from EPA Chesapeake Bay Office to support SAV Program goals. Units originally in meters.*

** Note: The tide data in the applications listed above were calculated using NOAA's VDATUM grids*

Http://web.vims.edu/physical/research/shoreline/LivingShorelineDesign.html

Use Shoreline Studies' Google Earth Applications for site information

Spring Tide Range



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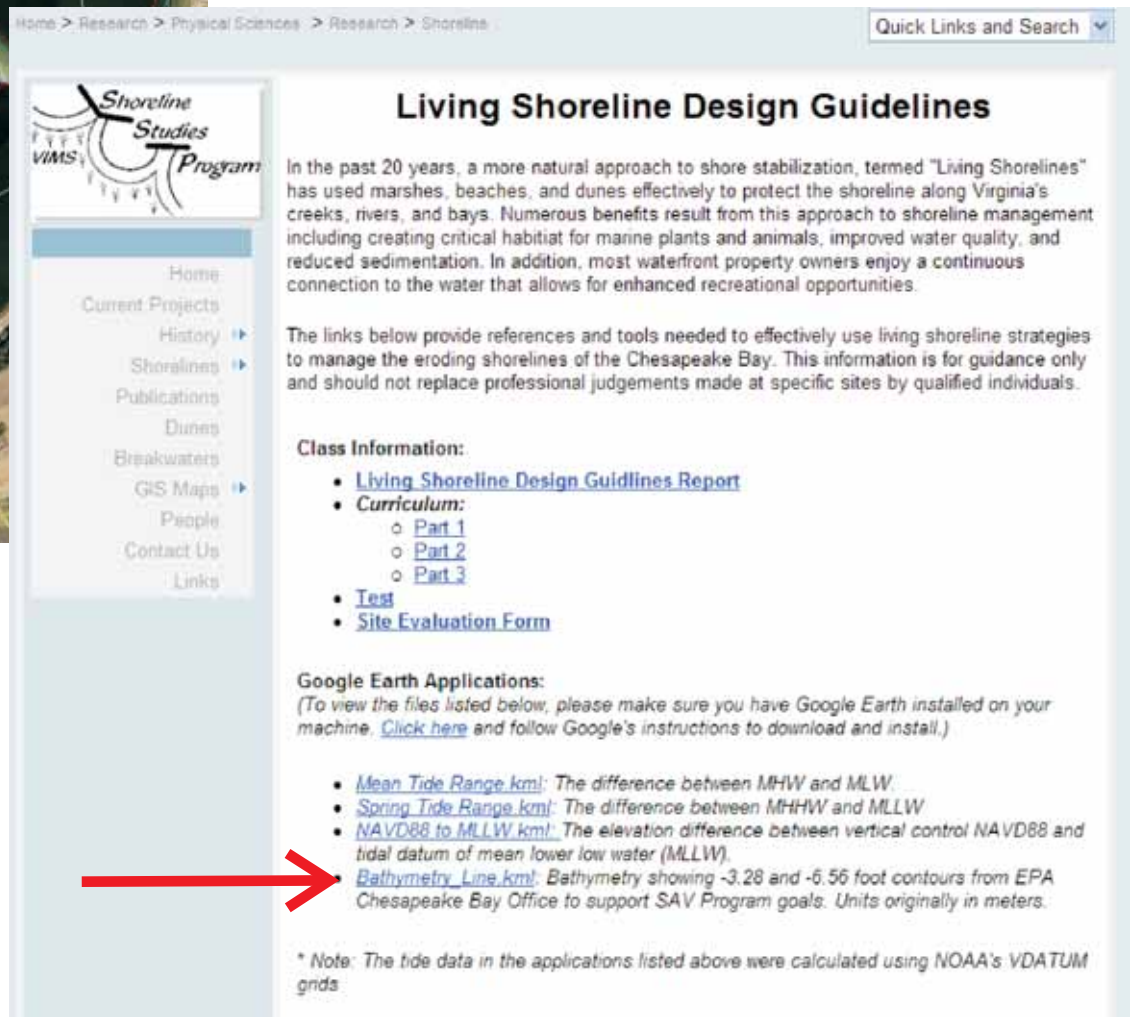
Http://web.vims.edu/physical/research/shoreline/LivingShorelineDesign.html

Use Shoreline Studies' Google Earth Applications for site information

Nearshore Bathymetry



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- Living Shoreline Design Guidlines Report
- *Curriculum:*
  - Part 1
  - Part 2
  - Part 3
- Test
- Site Evaluation Form

Google Earth Applications:
(To view the files listed below, please make sure you have Google Earth installed on your machine. Click here and follow Google's instructions to download and install.)

- *Mean Tide Range.kml: The difference between MHW and MLW.*
- *Spring Tide Range.kml: The difference between MHHW and MLLW*
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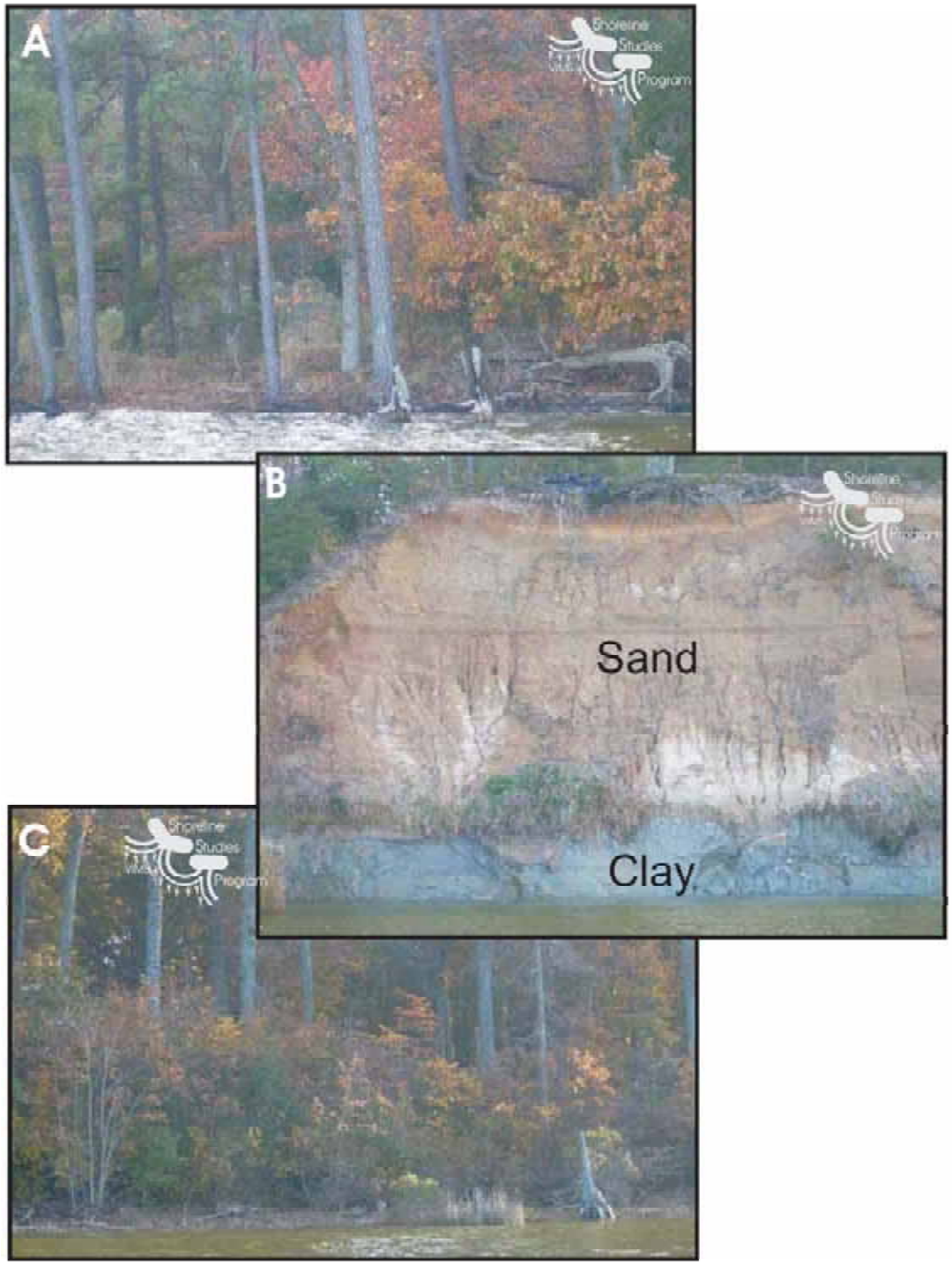
** Note: The tide data in the applications listed above were calculated using NOAA's VDATUM grids*

Http://web.vims.edu/physical/research/shoreline/LivingShorelineDesign.html


A
B
Sand
Clay
C

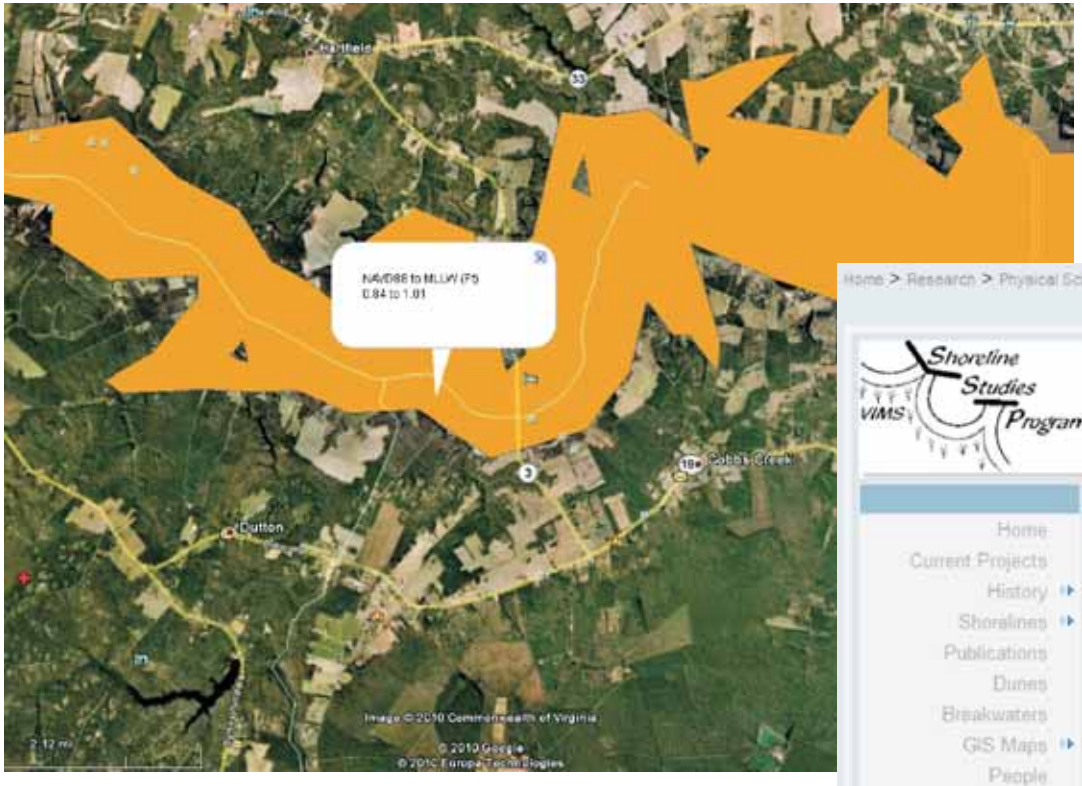
Mathews FIS

TABLE 1 - SUMMARY OF STILLWATER ELEVATIONS

Flood Source and Location	10 Yr 10-Percent-Annual-Chance	50 Yr 2-Percent-Annual-Chance	100 yr 1-Percent-Annual-Chance	500 Yr 0.2-Percent-Annual-Chance
	Elevation (Feet)			
Chesapeake Bay Entire shoreline within county boundary	5.0	6.5	7.3	9.3
Mobjack Bay Entire shoreline within county boundary	5.0	6.5	7.3	9.3
Piankatank River Entire shoreline within county boundary	5.0	6.5	7.3	9.3

Vertical datum NGVD29

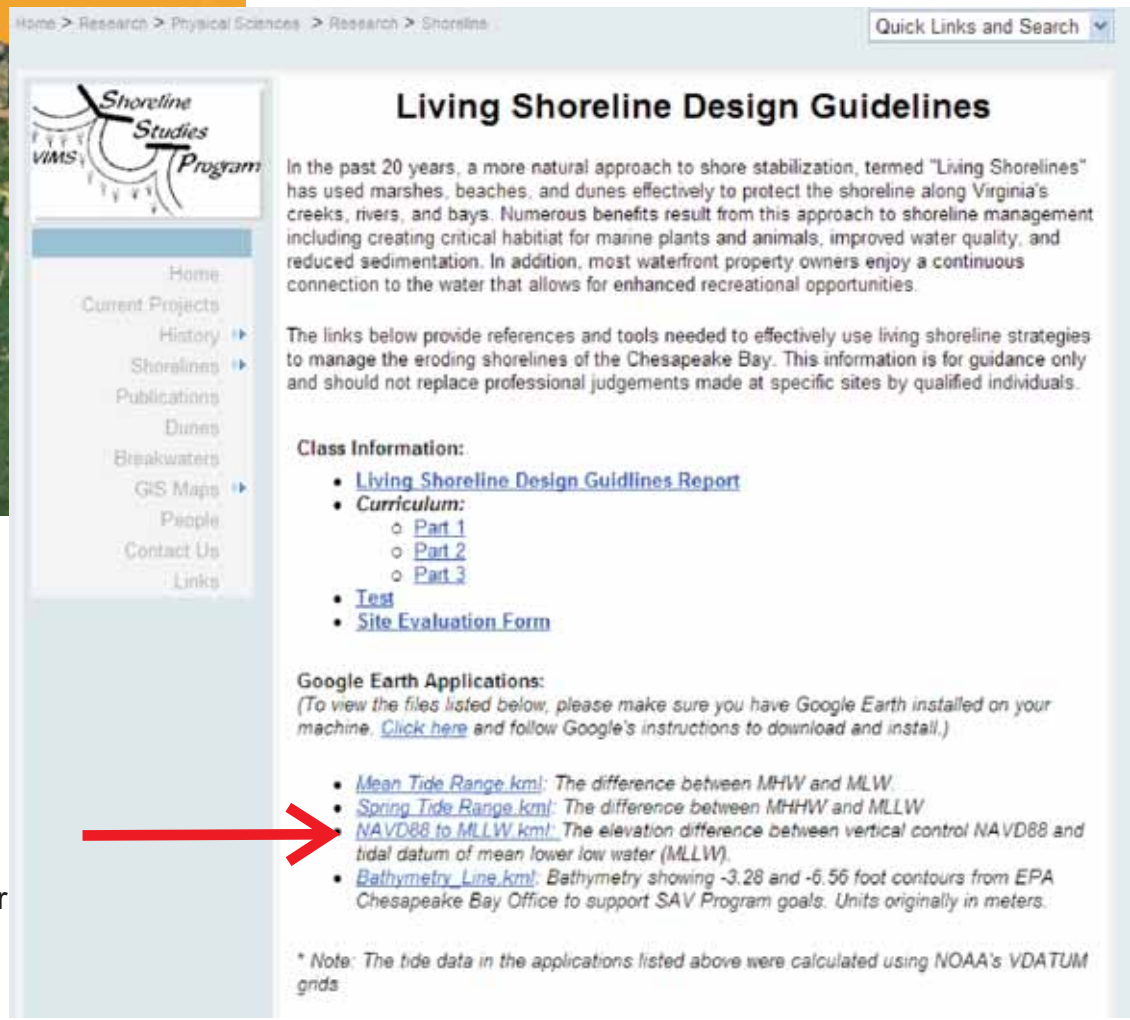
Use Shoreline Studies' Google Earth Applications to convert published storm surge data to a tidal datum



NAVD88 to MLLW

NAVD88 water level in feet + number from Google Earth = water level in ft relative to MLLW

Note: Most new FEMA stillwater elevations are relative to NAVD88. However, some are still relative to NGVD29. For those localities, use the NOAA website to convert to a tidal datum. This KML will not accurately convert NGVD29 to MLLW.



Home > Research > Physical Sciences > Research > Shoreline

Quick Links and Search

Shoreline Studies Program VIMS

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Living Shoreline Design Guidelines

In the past 20 years, a more natural approach to shore stabilization, termed "Living Shorelines" has used marshes, beaches, and dunes effectively to protect the shoreline along Virginia's creeks, rivers, and bays. Numerous benefits result from this approach to shoreline management including creating critical habitiat for marine plants and animals, improved water quality, and reduced sedimentation. In addition, most waterfront property owners enjoy a continuous connection to the water that allows for enhanced recreational opportunities.

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Windmill Point Tide Station

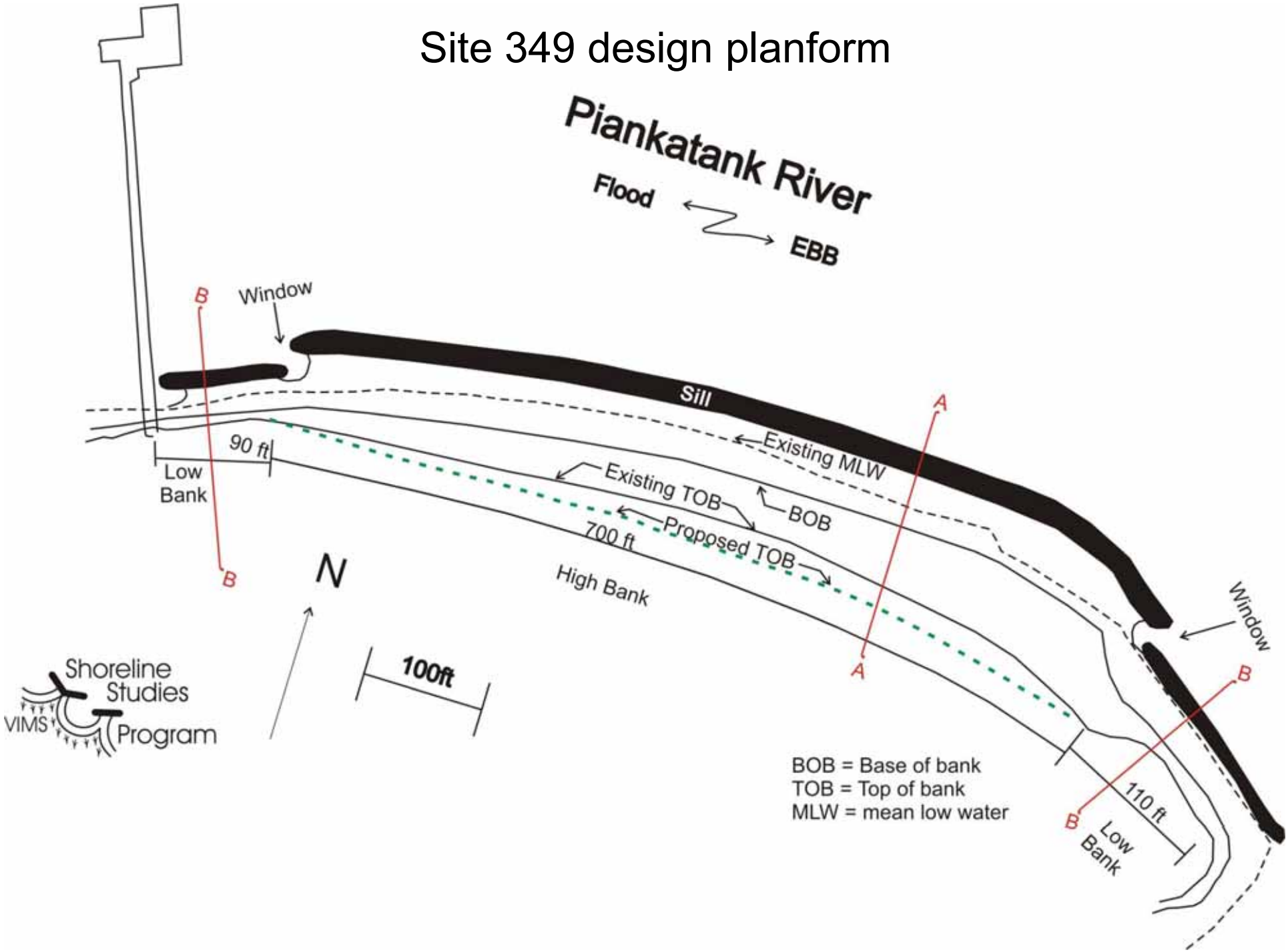
Elevation Information

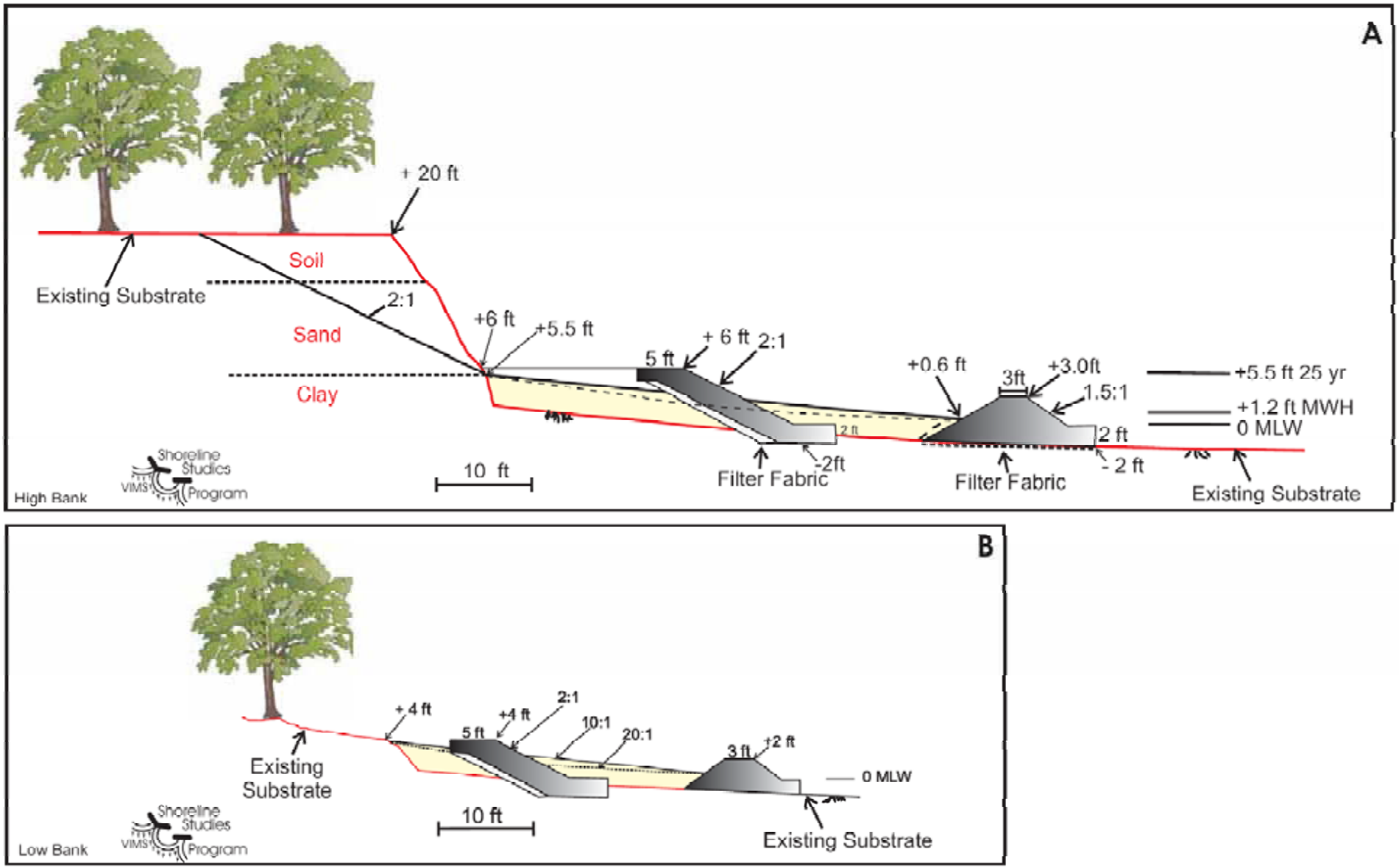
PID:	GV0088
VM:	11254
Station ID:	8636580
Epoch:	1983-2001
Date:	Tue Sep 28 14:38:39 EDT 2010

MHHW	=	1.39 feet (0.424 meters)
MHW	=	1.26 feet (0.384 meters)
MAVD88	=	0.95 feet (0.289 meters)
MSL	=	0.70 feet (0.214 meters)
MTL	=	0.68 feet (0.207 meters)
MOVD29	=	0.15 feet (0.047 meters)
MLW	=	0.10 feet (0.030 meters)
MLLW	=	0.00 feet (0.000 meters)

http://www.ngs.noaa.gov/newsys-cgi-bin/ngs_opsd.prl?PID=GV0088&EPOCH=1983-2001

Site 349 design planform





Typical cross-sections for Site 349 comparing revetment and sill on the A) high bank section and B) low bank section of shoreline

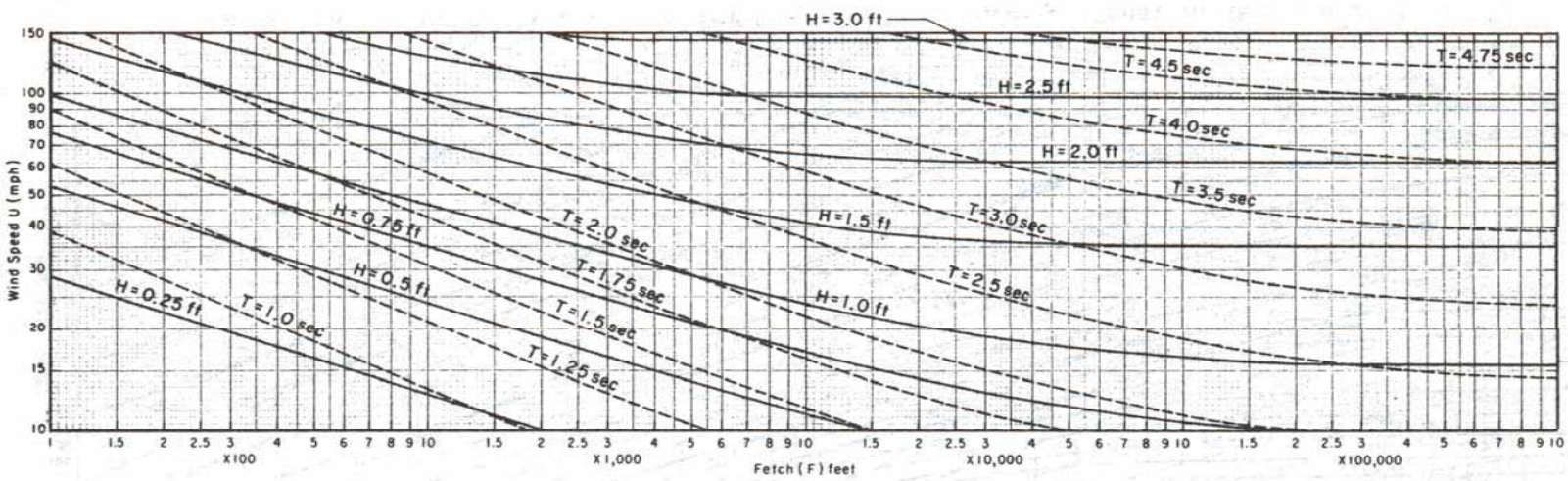


Figure 3-23. Forecasting Curves for Shallow-Water Waves. Constant Depth = 5 feet.

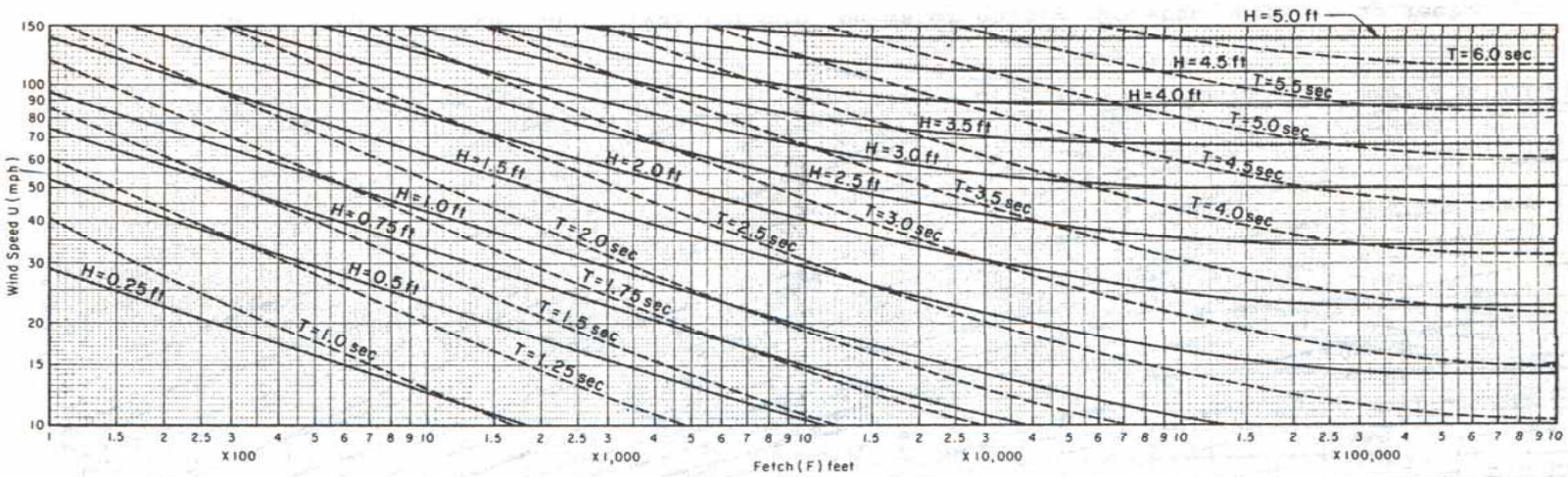


Figure 3-24. Forecasting Curves for Shallow-Water Waves. Constant Depth = 10 feet.

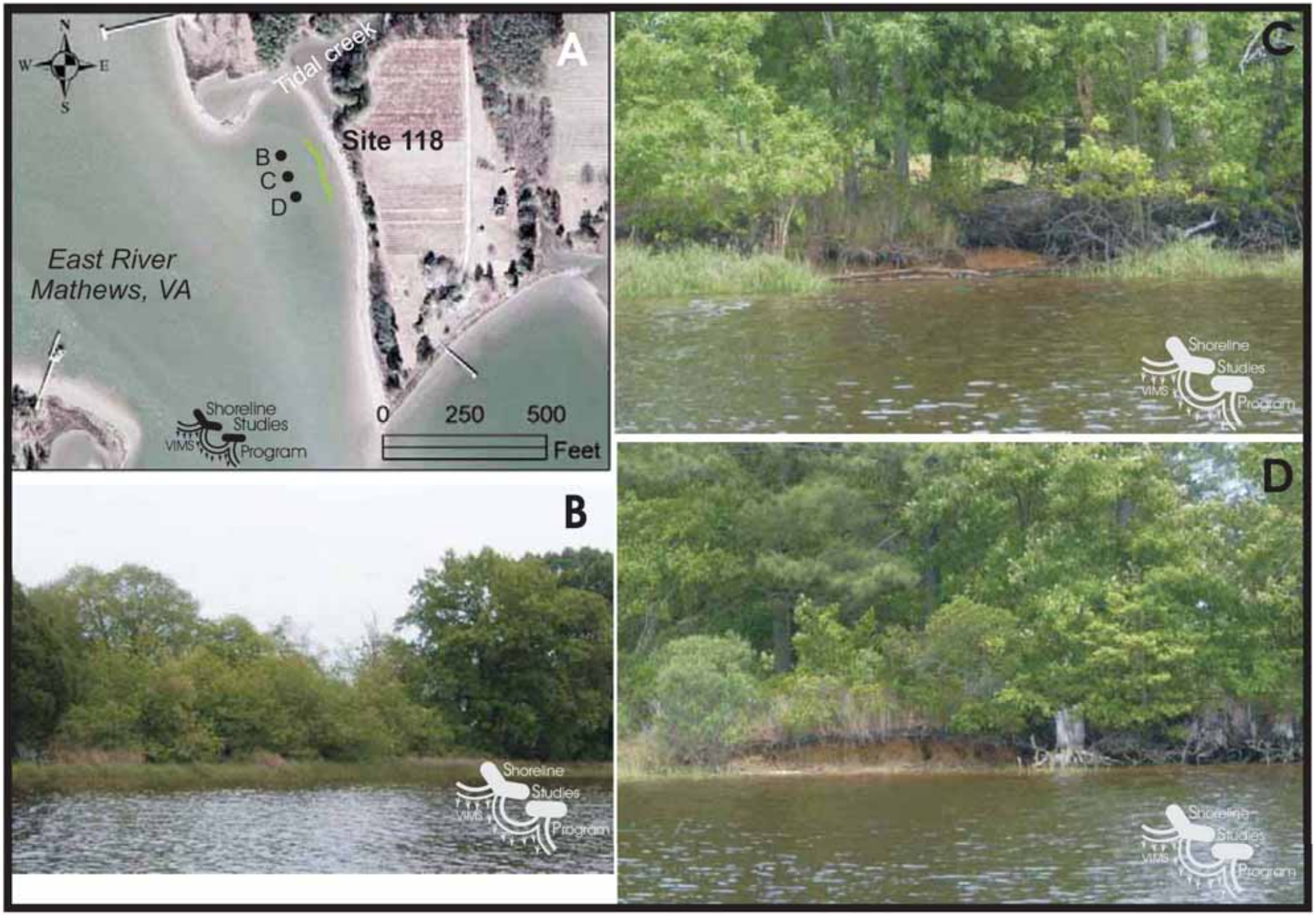
Estimated Costs

	Amount of Material (tons or cubic yards)	Cost per Ton	Cost per cubic yard	Cost per foot	Total Cost per foot*
High Bank					
Revetment					
Rock	3.7	$70		$259	**$309**
Sand	5		$10	$50	
Sill					
Rock	3.7	$70		$259	**$309**
Sand from Bank	5		$10	$50	
Low Bank					
Revetment					
Rock	2.8	$70		$196	**$236**
Subgrade with Sand from Bank	4		$10	$40	
Sill - Option 1					
Rock	2	$70		$140	**$169**
Sand from Bank	2.9		$10	$29	
Sill - Option 2					
Rock	2	$70		$140	**$242**
Sand from Offsite	2.9		$35	$102	

Design Example 2

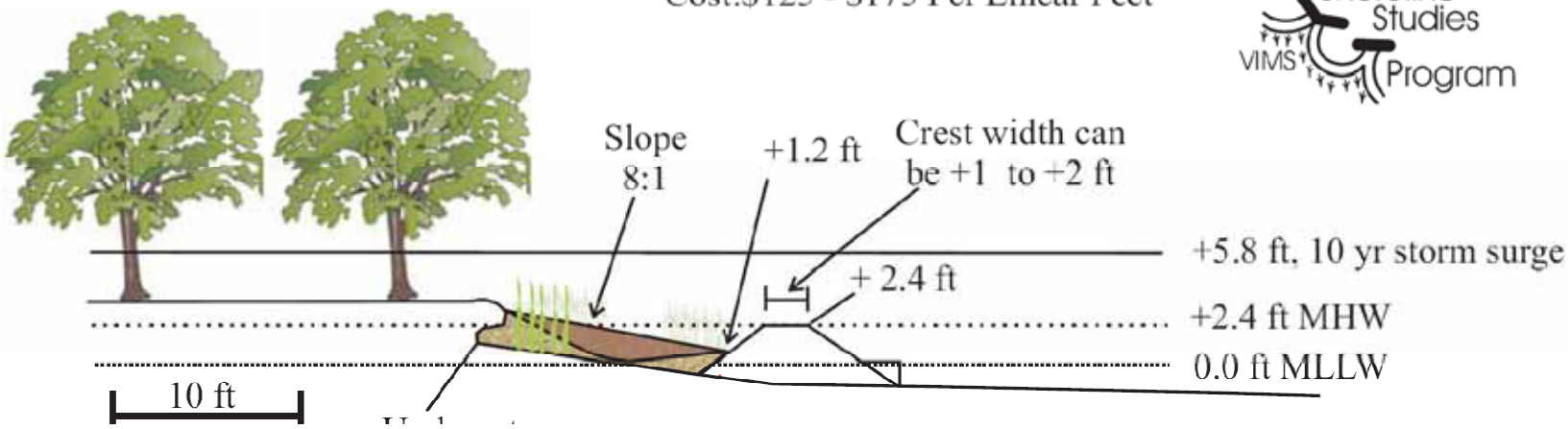
- Site 118 small low sill in tidal creek

Site 118 – East River


A
N
W
E
S
Tidal creek
Site 118
B
C
D
East River
Mathews, VA
Shoreline Studies Program
VIMS
0
250
500
Feet
B
C
D

Typical Small Low Sill

Cost:$125 - $175 Per Linear Feet



Design Example 3

- VIMS Offshore breakwater with beach nourishment

VIMS Beach - West

VIMS Beach - East

Design Example 1

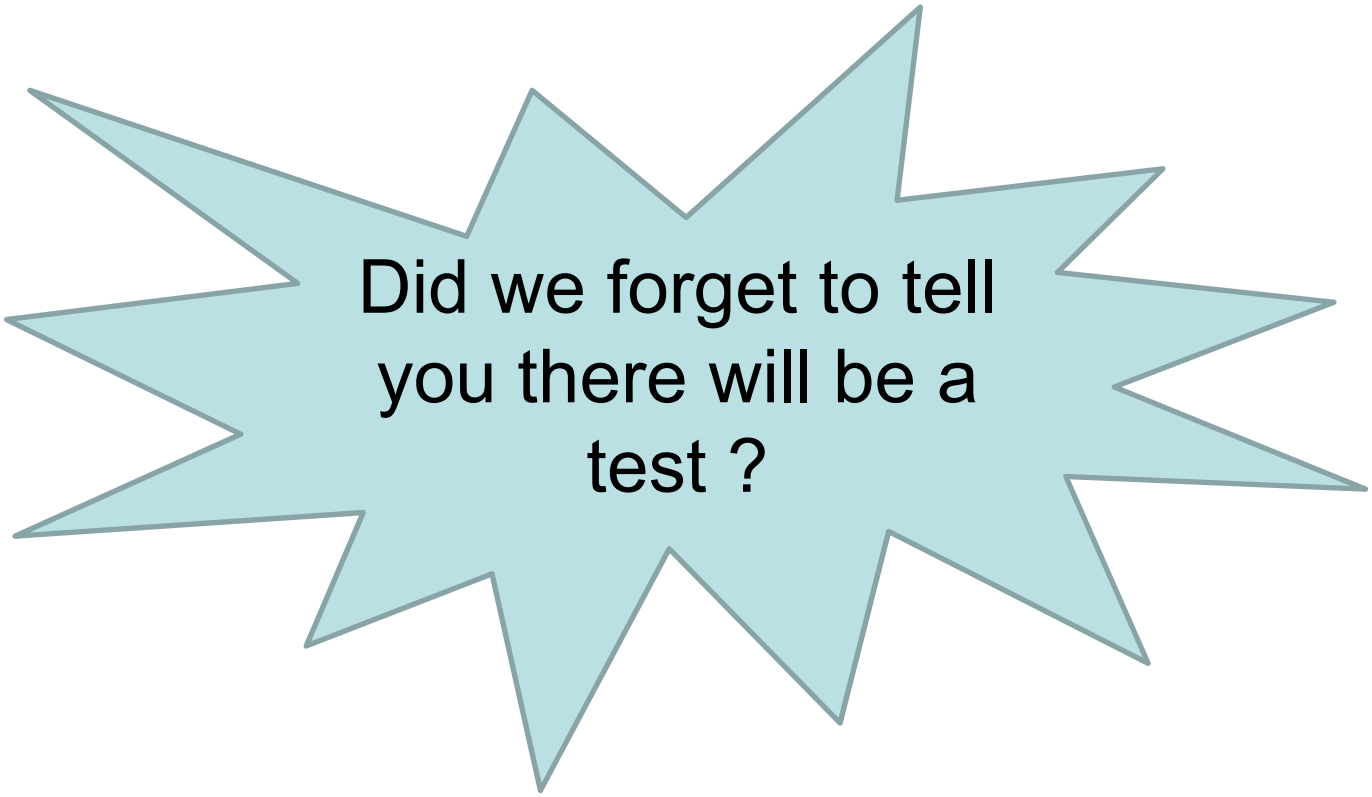
- Medium sill site 349 Piankatank River

West Shore
W5
W4
W3
W1
Watermans Hall
E1
E2
E3
E4
E5
East Shore
West Shore
East Shore
Vims Shore Plan (Option #4c)
Modified December 2008
Shoreline Studies Program
200
0
200 Feet
Legend
MLW
MHW
Plant S. patens
Sand Nourishment
Proposed Outfall Extension
Ex. Concrete Bulkhead
Ex. Revetment
Ex. Shade
Ex. Outfall
Typical Pipe Extension/Breakwater
VIMS East
NTS

VIMS Breakwater Project

Part 4

- Open test
- Review test
- Issue certificates of completion



Design and Construction of Living Shorelines
September 29, 2010

1. What gets "integrated" in "integrated shoreline management"?
   a. Natural and human features
   b. Riparian, wetland, and shallow water habitats
   c. Regulatory agencies combined into one

2. How many fetch measurements should be made to calculate average fetch?
   a. 25
   b. 5
   c. 1
   d. As many as possible

3. Which is least likely to be the design storm?
   a. 10-yr
   b. 25-yr
   c. 50-yr
   d. 100-yr

4. List 3 human improvements that affect the level of protection.

_____

_____

_____

5. Which habitat tradeoff typically has the <u>most</u> overall impact?
   a. Lower uplands to be wetlands
   b. Raise shallow submerged lands to be wetlands
   c. Change non-vegetated to vegetated wetlands
   d. Human land use change / retreat from the shoreline

6. What is the preferred slope of the marsh behind a sill?
   a. 8:1
   b. 10:1
   c. 20:1

7. Which slope maximizes *Spartina alterniflora* area behind a sill?
   a. 8:1
   b. 10:1
   c. 20:1

8. A planted marsh will thrive with little maintenance on a north-facing shoreline.
   a. True
   b. False

9. During large storms that overtop living shorelines, is it better to have an ungraded bank to stop the force of the waves or a graded bank for the waves to run up?
   a. Ungraded
   b. Graded

10. Any time the bank is graded, the excavated material can be placed behind the sill as the base for marsh plants.
    a. True
    b. False

Extra Credit Essay Question

Should the living shorelines permit process be streamlined? If so, why and how? If not, why not?

_____

_____

_____

_____

_____

_____

First Name	Last	Affiliation	Phone	Email	Paid?	pay metho	Cell
Joey	Scott	The Salt and The Earth, Inc.	804-435-1324	jscott@thesaltandtheearth.com	Yes	Check	
Christine	Conrad	Williamsburg Environmental Group	757-220-6869	cconrad@wegnet.com	Yes	CC	
Bradley	Petru	Angler Environmental	703 393 4844	bjpetru@anglerenvironmental.cor	Yes	CC	
Tom	Langley	Langley & McDonald	757-463-4306	tlangley@langleymcdonald.com	Yes	CC	
Karla	Havens	Mid-Atlantic Resource Consulting	804-785-2107	khavens@inna.net	Yes	Check	
Bob	Simon	Waterfront Consulting, Inc.		wcinc1@msn.com			
J.C.	Douglass	CLARK NEXSEN	757.961.7957	jcdouglass@clarknexsen.com	yes	Check	
Fred	Hale	Hale Bulkheading	757 482-2336	bhale21@cox.net	Yes	check	757-469-3755
Lisa	Billow	Stokes Environmental Associates	757-623-0777	lbillow@stokesea.com		CC	
David	Schermerhorn	Shoreline Permits	434 591 1192	dave@shorelines.us	Yes	CC	434 960 8202
Marget	Schermerhorn	Shoreline Permits	434 591 1142	bugmeg2@gmail.com	yes	CC	
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Michelle	Meredith	Hammer Time Marine		HTMPermits@aol.com			
Daniel	Proctor	Williamsburg Environmental Group	757-220-6869	dproktor@wegnet.com	Yes	CC	
Jay	Foster	Agent	804 225 2958	jaylfoster@yahoo.com	yes	Check	
Robert	Baker	Redox Client Services	757-404-8357	JCadvocate87@yahoo.com	Yes	CC	
Jeff	Watkins						
Jim	Gunn	Coastal Design and Construction					
Christine	Breddy	VIMS					

Certificate of Completion

Design and Construction of Living Shorelines

This certificate is awarded to

Ms. Attendee

For attendance of the course held at the
Virginia Institute of Marine Science
Gloucester Point, Virginia

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VIRGINIA INSTITUTE OF MARINE SCIENCE
SCHOOL OF MARINE SCIENCE

C. Scott Hardaway, Jr. — 29 Sep 2010 Date

Karen Duhring — 29 Sep 2010 Date