Lancaster County Shoreline Situation Report

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Protocols for Implementation of a GIS-based Model for the Selection of Potential Wetlands Restoration Sites Southeastern Virginia

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CHAPTER I - Introduction

1.1 Background

In the 1970s, the Virginia Institute of Marine Science (VIMS) received a grant through the National Science Foundation's Research Applied to National Needs Program to develop a series of reports which would describe the condition of tidal shorelines in the Commonwealth of Virginia. These reports became known as the Shoreline Situation Reports. They were published on a county by county basis with additional resources provided by the National Oceanic and Atmospheric Administration's Office of Coastal Zone Management (Morgan et.al., 1978).

The Shoreline Situation Reports quickly became a common desktop reference for nearly all shoreline managers, regulators, and planners within the Tidewater region. They provided useful information to address the common management questions and dilemmas of the time. Despite their age, these reports remain a desk top reference.

The Comprehensive Coastal Inventory Program (CCI) is committed to developing a revised series of Shoreline Situation Reports which address the management questions of today. The series reports shoreline conditions on a county by county basis. New techniques integrate a combination of Geographic Information Systems (GIS), Global Positioning System (GPS) and remote sensing technology. Reports are distributed in hardcopy. The digital GIS coverages developed for the report are available on the web at *www.vims.edu/ccrm/gis/gisdata.html*. CCI is exploring techniques for serving the publications online. Those interested should check the CCI web site periodically at *www.vims.edu/ccrm/publications.html.*

1.2 Description of the Locality

Lancaster County is approximately 133 square miles of land area, with 51 square miles of major surface water (Figure 1). Lancaster County is located in Virginia on the western shore of the Chesapeake Bay, at the southern limit of the peninsula known as the Northern Neck. The county borders Northumberland County to the north, and Richmond County to the west. The southern shore of the county borders the Rappahannock River which divides Lancaster from Middlesex County. The eastern shore of the county is contiguous to the Chesapeake Bay. Major waterways and bays along the eastern edge of the county discharge directly to the Chesapeake. The major waterways influencing the coastal character of the county are the Rappahannock River and the Chesapeake Bay. Major rivers discharging into these waters include the Corrotoman River, Carters Creek, Mosquito Creek, Antipoison Creek, Tabbs Creek, Dymer Creek, and Indian Creek. Indian Creek is the boundary between Lancaster and Northumberland County.

Lancaster County is a rural residential community, with well developed waterfront communities. Recreational and commercial uses of the water are prevalent in the county. The town of Kilmarnock serves as a major center for retail and service business. There are plans to expand economic development opportunities within the county in the near future (Lancaster County Planning Commission, 2000).

Lancaster County has just recently revised its Comprehensive Plan (Lancaster County Planning Commission, 2000). The plan recognizes several important considerations for future development. First, the constraints to development, previous land uses, potential uses, and future needs to allow the county to continue to prosper. These needs include water supply, and opportunities for land conversion. Activities at the shore are addressed and a shoreline management plan is detailed. With more than 97% of the shore in private ownership, maintaining public access is difficult. A study plan is proposed to address this problem.

Tidal shoreline protection is recognized to constrain and guide development activities at the shore. Regulations established through the Clean Water Act, and the Chesapeake Bay Preservation Act are discussed. Approximately 3,356 acres of land in the county is designated within the Resource Protection Areas (RPAs). This designation is reported to be consistent with regulations set forth in the Chesapeake Bay Preservation Act (100 foot buffers landward of all streams, adjoining wetlands, and related sensitive areas). Resource Management Areas (RMAs) include all land outside the RPA. (Lancaster County Planning Commission, 2000).

1.3 Purpose and Goals

This shoreline inventory has been developed as a tool for assessing conditions along the tidal shoreline in Lancaster County. Field data were collected between May 18 - August 23, 1999. Conditions are reported for three zones within the immediate riparian river area: riparian land use, bank and buffers, and the shoreline. A series of maps and tabular data are published to illustrate and quantify results of an extensive shoreline survey. The survey extends from the border of Lancaster County and Northumberland County on Indian Creek south along the Bay to Windmill Point. From Windmill Point the survey includes the main shoreline of the Rappahannock River and all navigable tidal rivers in the county to the county border with Richmond County (Figure 1).

1.4 Report Organization

This report is divided into several sections. Chapter 2 describes methods used to develop this inventory, along with conditions and attributes considered in the survey. Chapter 3 identifies potential applications for the data, with a focus on current management issues. From existing literature and the current survey, Chapter 4 reports the general state of the county's shoreline, and integrates a series of maps which illustrate current conditions.

1.5 Acknowledgments

This report has been primarily funded by the Comprehensive Coastal Inventory Program (CCI) with monies appropriated by the General Assembly. The Virginia Coastal Resources Management Program at the Department of Environmental Quality provided funds to support data processing through Grant # NA770Z0204 of the National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management, under the Coastal Zone Management Act of 1972, as amended. The Chesapeake Bay Local Assistance Department supported the publication of this report through award number 011D300. This work was completed entirely with staff support and management from the Virginia Institute of Marine Science's CCI Program. A host of individuals are acknowledged. In addition to those listed as preparers, the project directors would like to thank Dave Weiss of CCI, the VIMS Vessel Center, the VIMS Publication Center for their support, and Troy Anderson for his assistance in the field.

CHAPTER 2 - The Shoreline Assessment: Approach and Considerations

2.1 Introduction

The Comprehensive Coastal Inventory Program (CCI) has developed a set of protocols for describing shoreline conditions along Virginia's tidal shoreline. The assessment approach uses state of the art Global Positioning Systems (GPS), and Geographic Information Systems (GIS) to collect, analyze, and display shoreline conditions. These protocols and techniques have been developed over several years, incorporating suggestions and data needs conveyed by state agency and local government professionals.

Three separate activities embody the development of a Shoreline Situation Report: data collection, data processing and analysis, and map generation. Data collection follows a three tiered shoreline assessment approach described below.

2.2 Three Tiered Shoreline Assessment

The data inventory developed for the Shoreline Situation Report is based on a three-tiered shoreline assessment approach. This assessment characterizes conditions in the shorezone, which extends from a narrow portion of the riparian zone seaward to the shoreline. This assessment approach was developed to use observations which could be made from a moving boat. To that end, the survey is a collection of descriptive measurements which characterize conditions. GPS units log location of conditions observed from a boat. No other field measurements are performed.

The three tiered shoreline assessment approach divides the shorezone into three regions: 1) the immediate riparian zone, evaluated for land use; 2) the bank, evaluated for height, stability, cover, and natural protection; and 3) the shoreline, describing the presence of shoreline structures for shore protection and recreational purposes. Each tier is described in detail below.

2.2a) Riparian Land Use: Land use adjacent to the bank is classified into one of eight categories (Table 1). The categories provide a simple assessment of land use, and give rise to land management practices which could be anticipated. GPS is used to measure the linear extent along shore where the practice is observed. The width of this zone is not measured. Riparian forest buffers are considered the primary land use if the buffer width equals or exceeds 30 feet. This width is calculated from digital imagery as part of the quality control in data processing.

2.2b) Bank Condition: The bank extends off the fastland, and serves as an interface between the upland and the shore. It is a source of sediment and nutrient fluxes from the fastland, and bears many of the upland soil characteristics which determine water quality in receiving waters. Bank stability is important for several reasons. The bank protects the upland from wave energy during storm activity. The faster the bank erodes, the sooner the upland will be at risk. Bank erosion can contribute high sediment loads to the receiving waters. Stability of the bank depends on several factors: height, slope, sediment composition, vegetative cover, and the presence of buffers to absorb energy impact to the bank itself.

The bank assessment in this inventory addresses four major bank characteristics: bank height, bank cover, bank stability, and the presence of stable or unstable natural buffers at the bank toe (Table 2). Conditions are recorded continuously using GPS as the boat moves along the shoreline. The GPS log reflects any changes in conditions observed.

A GPS operator observes shoreline conditions from a shoal draft boat.

Table 1. Tier One - Riparian Land Use Classes

Forest	stands greater than 18 feet / width greater than 30 feet
Scrub-shrub	stands less than 18 feet
Grass	includes grass fields, and pasture land
Agriculture	includes croplands
Residential	includes single or multi family dwellings
Commercial	includes industrial, small business, recreational facilities
Bare	lot cleared to bare soil
Timbered	clear-cuts
Unknown	land use undetectable from the vessel

Bank height is described as a range, measured from the toe of the bank to the top. Bank cover is an assessment of the percent of either vegetative or structural cover in place on the bank face. Natural vegetation, as well as rip rap are considered as cover. The assessment is qualitative (Table 2). Bank stability characterizes the condition of the bank face. Banks which are undercut, have exposed root systems, down vegetation, or exhibit slumping of material qualify as a "high erosion". At the toe of the bank, natural marsh vegetation and/or beach material may be present. These features offer protection to the bank and enhance water quality. Their presence is noted in the field, and a general assessment (low erosion/high erosion) describes whether they are experiencing any erosion. Sediment composition and bank slope cannot be surveyed from a boat, and are not included.

2.2c) Shoreline Features: Features added to the shoreline by property owners are recorded as a combination of points or lines. These features include defense structures, which are constructed to protect shorelines from erosion; offense structures, designed to accumulate sand in longshore transport; and recreational structures, built to enhance recreational use of the water. The location of these features along the shore are surveyed with a GPS unit. Linear features are surveyed without stopping the boat. Structures such as docks, and boat ramps are point features, and a static ten-second GPS observation is collected at the site. Table 3 summarizes shoreline features surveyed. Linear features are denoted with an "L" and point features are denoted by a "P." The glossary describes these features, and their functional utility along a shore.

2.3 Data Collection/Survey Techniques

Data collection is performed in the field, from a small, shoal draft vessel, navigating at slow speeds parallel to the shoreline. To the extent possible, surveys take place on a rising tide, allowing the boat to be as close to shore as possible. The field crew consists of a boat operator, and two data surveyors. The boat operator navigates the boat to follow the shoreline geometry. One surveyor collects information pertinent to land use and bank condition. The second surveyor logs information relevant to shoreline structures.

Data is logged using the handheld Trimble GeoExplorer GPS unit. GeoExplorers are accurate to within 4 inches of true position with extended observations, and differential correction. Both static and kinematic data

Table 2. Tier 2 - Bank Conditions

Bank Attribute	Range	Description
bank height	0-5 ft	from the toe to the edge of the fastland
	5-10 ft	from the toe to the edge of the fastland
	> 10 ft	from the toe to the edge of the fastland
bank stability	low erosion	minimal erosion on bank face or toe
	high erosion	includes slumping, scarps, exposed roots
bank cover	bare	<25% cover; vegetation or structural cover
	partial	25-75% cover; vegetation or structural cover
	total	>75% cover; vegetation or structural cover
marsh buffer	no	no marsh vegetation along the bank toe
	yes	fringe or pocket marsh present at bank toe
marsh stability (if present)	low erosion	no obvious signs of erosion
	high erosion	marsh edge is eroding or vegetation loss
beach buffer	no	no sand beach present
	yes	sand beach present
beach stability (if present)	low erosion	accreting beach
	high erosion	eroding beach or non emergent at low tide

Table 3. Tier 3 - Shoreline Features

Feature	Feature Type	Comments
Control Structures		
riprap	L	
bulkhead	L	
breakwaters	L	first and last of a series is surveyed
groinfield	L	first and last of a series is surveyed
jetty	P	
miscellaneous	L	can include tires, rubble, tubes, etc.
Recreational Structures		
pier/wharf	P	includes private and public
boat ramp	P	includes private and public
boat house	P	all covered structures, assumes a pier
marina	L	includes piers, bulkheads, wharfs

collection is performed. Kinematic data collection is a collection technique where data is collected continuously along a pathway (in this case along the shoreline). GPS units are programmed to collect information at a rate sufficient to compute a position anywhere along the course. The shoreline data is collected at a rate of one observation every five seconds. Land use, bank condition, and linear shoreline structures are collected using this technique.

Static surveys pin-point fixed locations which occur at very short intervals. The boat actually stops to collect these data, and the boat operator must hold the boat against tidal current, and surface wind waves. Static surveys log 10 GPS observations at a rate of one observation per second at the fixed station. The GPS receiver uses an averaging technique to compute one position based on the 10 static observations. Static surveys are used to position point features like piers, boat ramps, and boat houses.

Trimble GeoExplorer GPS receivers include a function that allows a user to pre-program the complete set of features they are surveying in a "data dictionary." The data dictionary prepared for this Shoreline Situation Report includes all features described in section 2.2. As features are observed in the field, surveyors use scroll down menus to continuously tag each geographic coordinate pair with a suite of characteristics which describe the shoreland's land use, bank condition, and shoreline features present. The survey, therefore, is a complete suite of geographically referenced shoreline data.

2.4 Data Processing

Data processing occurs in two parts. Part one processes the raw GPS field data, and converts the data to GIS coverages (section 2.4a). Part two corrects the GIS coverages to reflect true shoreline geometry (section 2.4b).

2.4a.) GPS Processing: Differential correction improves the accuracy of GPS data by including other "known" locations to refine geographic position. Any GPS base station within 124 miles of the field site can serve as one additional location. The VIMS' base station was used for most of the data processing in Lancaster County. Data from base stations maintained by the United States Coast Guard at Cape Henry, or the VA Department of Transportation in Richmond were also available. Both of these stations are no longer active.

Differential correction is the first step to processing GPS data. Trimble's Pathfinder Office GPS software is used. The software processes time synchronized GPS signals from field data and the selected base station. Differential correction improves the position of the GPS field data based on the known location of the base station, the satellites, and the satellite geometry. When Selective Availability was turned off in late Spring, 2000, the need to post process data has nearly been eliminated for the level of accuracy being sought in this project.

A hand-held Trimble GeoExplorer logs field data observed from the boat.

Although the Trimble GeoExplorers are capable of decimeter accuracy (~ 4 inches), the short occupation of sites in the field reduces the accuracy to 5 meters (~16 feet). In many cases the accuracy achieved is better, but the overall limits established by the CCI program are set at 5 meters. This means that features are registered to within 5 meters (~16 feet) (or better) of their true position on the earth's surface. In this case, positioning refers to the boat position during data collection.

An editing function is used to clean the GPS data. Cleaning corrects for breaks in the data which occur when satellite lock is lost during data collection. Editing also eliminates erroneous data collected when the boat circles off track, and the GPS unit is not switched to "pause" mode.

The final step in GPS processing converts the files to three separate ArcInfo GIS coverages. The three coverages are: a land use and bank condition coverage (lanc_lubc), a shoreline structure coverage (lines only) (lanc_sstruc), and a shoreline structure coverage (points only) (lanc_astruc).

2.4b.) GIS Processing: GIS processing uses ESRI's ArcInfo® GIS software, and ERDAS' Imagine® software. Several data sets are integrated to develop the final inventory products. First, the shoreline situation data are derived from the GPS field data, and the three coverages discussed above. The attributes are summarized in Tables 1, 2, and 3. Second, the basemap coverage is derived from a digitized record of the high water shoreline illustrated on 7.5 minute, 1:24,000 USGS topographic maps for the study area. Since it is available for the entire Tidewater area, this shoreline has been selected as the baseline shoreline for development of all Shoreline Situation Reports. The digital coverage was developed by the CCI program in the early 1990s using most recent topographic maps available. These maps range from the late 1960s to the early 1980s. As USGS updates these maps, revisions to the digital basemap series can be made. Finally, the third data set integrated is digital color infra-red imagery known as Digital Ortho Quarter Quadrangles (DOQQs). These products are circulated by the USGS. DOQQs are fully rectified digital imagery representing one quarter of a USGS 7.5 minute quadrangle. They were released in 1997, and use imagery flown in 1994. The imagery are used as background during data processing and map production. They are an important quality control tool for verifying the location of certain landscape attributes, and provide users with additional information about the coastal landscape.

GIS processing includes two separate parts. Step one checks the relative accuracy of the shoreline coverage. Since this coverage was developed from topographic maps dating back to the 1960s, significant changes in the shoreline orientation may have occurred. While this process does not attempt to recompute a shoreline position relative to a vertical tidal datum, it adjusts the horizontal geographic position to reflect the present shoreline geometry. Using ERDAS' Imagine software, the 1994 DOQQ imagery is displayed onscreen behind the digitized USGS shoreline coverage. The operator looks for areas where the digitized shoreline departs greatly from the land water interface depicted in the background image. The digitized shoreline coverage is then corrected to align more closely with the land water interface displayed using Imagine's onscreen digitizing techniques. This revised shoreline coverage is used in all subsequent inventory steps and products.

Step two corrects the coverages generated from the GPS field data to the shoreline record. These coverages, having been processed through GPS software, are geographically coincident with the path of the boat, from where observations are made. They are, therefore, located somewhere in the waterway. Step two transfers these data back to the corrected shoreline record so the data more precisely reflects the location being described along the shore.

The majority of data processing takes place in step two, which uses all three data sets simultaneously. The corrected shoreline record, and the processed GPS field data are displayed onscreen at the same time as ArcInfo coverages. The imagery is used in the background for reference. The corrected shoreline is the base coverage. The remaining processing re-codes the base shoreline coverage for the shoreline attributes mapped along the boat track. Each time the boat track data (i.e. GPS data) indicates a change in attribute type or condition, the digital shoreline arc is split, and coded appropriately for the attributes using ArcInfo techniques.

This step endures a rigorous sequence of checks to insure the positional translation is as accurate as possible. Each field coverage; land use, bank condition, and shoreline condition, is processed separately. The final products are three new coded shoreline coverages. Each coverage has been checked twice onscreen by different GIS personnel. A final review is done on draft hardcopy printouts.

2.4c.) Maps and Tables: Large format, color maps are generated to illustrate the attributes surveyed along the shore. A three-part map series has been designed to illustrate the three tiers individually. Plate A describes the riparian land use as color coded bars along the shore. A legend keys the color to the type of land use.

Plate B depicts the condition of the bank and any natural buffers present. Three lines, and a combination of color and pattern symbology gives rise to a vast amount of bank and natural buffer information. One line depicts bank cover (inland line), a second line illustrates bank height and stability (middle line), and a third line describes any natural buffers present (channelward line). Erosional conditions are illustrated in red for both bank and buffer. Stable or low erosion conditions are illustrated in green. Bank height varies with the thickness of the line; where the thickest lines designate the highest banks (> 10 feet). Bank cover is distinguished by colors. Bare banks (<25% cover) are illustrated in pale pink, partial cover (25-75%) is illustrated by a pale orange line, and total cover (>75%) is indicated by a pale blue line. Natural buffers, when present, are described by small circles parallel to the shore. Open circles just seaward of the line indicate a natural fringe marsh along the base of the bank. Solid circles indicate a sand beach buffer at the base of the bank. It is possible to have both. The length of the symbology along the shore reflects the length alongshore that the features persist. The symbology changes as conditions change.

Plate C combines recreational and shoreline protection structures in a composition called Shoreline Features. Linear features, described previously, are mapped using color coded bar symbols which follow the orientation of the shoreline. Point features use a combination of colors and symbols to plot the positions on the map.

DOQQ imagery are used as a backdrop, upon which all shoreline data are superimposed. The imagery was collected in 1994. The color infra red image is used as a backdrop to Plate A. A gray-scale version of this same image is used for Plates B and C.

For publication purposes the county is divided into a series of plates set at a scale of 1:12,000. The number of plates is determined by the geographic size and shape of Lancaster County. An index is provided in Chapter 4 which illustrates the orientation of plates to each other. The county was divided into 26 plates (plate 1a, 1b, 1c, etc.), for a total of 78 map compositions.

Tables 4 and 5 quantify features mapped in the county. These are generated using frequency analysis techniques in ArcInfo. Table 4 bases its calculations on the river reaches which were delineated in the 1970s by VIMSs coastal geologists to represent short, process similar stretches of shoreline. They provide a unit of measure for comparative purposes over time (Byrne and Anderson, 1983). The reach boundaries are illustrated in Figure 2. Table 4, quantifies present conditions (1999) on a reach by reach basis. There are 96 reaches in Lancaster County (reaches 328-337 on the western shore of the Bay; reaches 145-232 on the Rappahannock River). Table 4 reports the linear attribute data as a percent of the total reach length, and point data as the number of features per reach.

Tables 5 also quantifies features mapped along the rivers using frequency analysis techniques in ArcInfo. The values quantify features on a plate by plate basis. For linear features, values are reported in actual miles surveyed. The number of point features surveyed are also listed on a plate by plate basis. The total miles of shoreline surveyed for each plate is reported. A total of 316.49 miles of shoreline were surveyed. Two hundred and sixty-six miles (266 miles) were surveyed in the field. Fifty miles were surveyed using remote sensing and photo interpretation techniques. These 50 miles could not be reached by boat due to shallow water conditions. Since there is plate overlap, total survey miles can not be reached by adding the total shoreline miles for each plate. The last row of Table 5 does, however, report the total shoreline miles surveyed for the county (316.49) and the total amount of each feature surveyed along the measured shoreline.

Chapter 3. Applications for Management

3.1 Introduction

There are a number of different management applications for which the Shoreline Situation Reports (SSRs) support. This section discusses four of them which are currently high profile issues within the Commonwealth or Chesapeake Bay watershed. The SSRs are data reports, and do not necessarily provide interpretation beyond the characteristics of the nearshore landscape. However, the ability to interpret and integrate these data into other programs is key to gleaming the full benefits of the product. This chapter offers some examples for how data within the SSRs can be integrated and synthesized to support current state management programs.

3.2 Shoreline Management

The first uses for SSRs were to prepare decision makers to bring about well informed decisions regarding shoreline management. This need continues today, and perhaps with more urgency. In many areas, undisturbed shoreline miles are almost nonexistent. Development continues to encroach on remaining pristine reaches, and threatens the natural ecosystems which have prevailed. At the same time, the value of waterfront property has escalated, and the exigency to protect shorelines through stabilization has increased. Generally speaking, this has been an accepted management practice. However, protection of tidal shorelines does not occur without incidence.

Management decisions must consider the current state of the shoreline, and understand what actions and processes have occurred to bring the shoreline to its current state. This includes evaluating existing management practices, assessing shore stability in an area, and determining future uses of the shore. The SSRs provide data to perform these evaluations.

Plate A defines the land use adjacent to the shoreline. To the extent that land use directs the type of management practices found, these maps can predict shoreline strategies which may be expected in the future. Residential areas are prone to shoreline alterations. Commercial areas may require structures along the shore for their daily operations. Others frequently seek structural alternatives to address shoreline stability problems. Forested riparian zones, and large tracts of grass or agricultural areas are frequently unmanaged even if chronic erosion problems exist.

Stability at the shore is described in Plate B. The bank is characterized by its height, its state of erosion, and the presence or absence of natural buffers at the bank toe. Upland adjacent to high, stable banks with a stable natural buffer at the base are less prone to flooding or erosion problems resulting from storm activity. Upland adjacent to banks of lesser height (< 5 feet) are at greater risk of flooding, but if banks are stable with marshes or beaches present, erosion may not be as significant a concern. Survey data reveals a strong correlation between banks of high erosion, and the absence of natural buffers. Conversely, the association between stable banks and the presence of marsh or beach is also well established. This suggests that natural buffers such as beaches and fringe marshes play an important role in bank protection. This is illustrated on the maps. Banks without natural buffers, yet classified as low erosion, are often structurally controlled with rip rap or bulkheads.

Plate C delineates structures installed along the shoreline. These include erosion control structures, and structures to enhance recreational use of the waterway. This map is particularly useful for evaluating requests from property owners seeking structural methods for controlling shoreline erosion problems. Shoreline managers can evaluate the current situation of the surrounding shore including: impacts of earlier structural decisions, proximity to structures on neighboring parcels, and the vicinity to undisturbed lots. Alternative methods such as vegetative control may be evaluated by assessing the energy or fetch environment from the images. Use this plate in combination with Plate B to evaluate the condition of the bank proposed for protection.

A close examination of shore conditions may suggest whether certain structural choices have been effective. Success of groin field and breakwater systems is confirmed when sediment accretion is observed. Low erosion conditions surveyed along segments with bulkheads and riprap indicate structures have controlled the erosion problem. The width of the shorezone, estimated from the background image, also speaks to the success of structures as a method of controlling erosion. A very narrow shorezone implies that as bulkheads or riprap have secured the erosion problem at the bank, they have also deflated the supply of sediment available to nourish a healthy beach. This is a typical shore response, and remains an unresolved management problem.

Shoreline managers are encouraged to use all three plates together when developing management strategies or making regulatory decisions. Each plate provides important information independent of the others, but collectively the plates become a more valuable management tool.

3.3 Non-Point Source Targeting

The identification of potential problem areas for non-point source pollution is a focal point of water quality improvement efforts throughout the Commonwealth. The three tiered approach provides a collection of data which, when combined, can allow for an assessment of potential non-point source pollution problems in a waterway.

Grass land and agricultural land, which includes pasture land and cropland, respectively, have the highest potential for nutrient runoff. These areas are also prone to high sediment loads since the adjacent banks are seldom restored when erosion problems persist. Residential, bare, and commercial land uses also have the potential to contribute to the non-point source pollution problem due to the types of practices which prevail, and large impervious surface areas.

The highest potential for non-point source pollution combines these land uses with "high" bank erosion conditions, bare or nearly bare bank cover, and no marsh buffer protection. The potential for non-point source pollution moderates as the condition of the bank changes from "high" bank erosion to "low" bank erosion, or with the presence or absence of stable marsh vegetation to function as a nutrient sink for runoff. Where defense structures occur in conjunction with "low" bank erosion, the structures are effectively controlling erosion at this time, and the potential for non-point source pollution is reduced. If the following characteristics are delineated: low bank erosion, stable marsh buffer, riprap or bulkhead; the potential for non-point source pollution from any land use class can be lowered.

At the other end of the spectrum, forested and scrub-shrub sites do not contribute significant amounts of non-point source pollution to the receiving waterway. Forest buffers, in particular, are noted for their ability to uptake nutrients running off the upland. Forested areas with stable or defended banks, a stable fringe marsh, and a beach would have the lowest potential as a source of non-point pollution. Scrub-shrub with similar bank and buffer characteristics would also be very low.

A quick search for potential non-point source sites would begin on Plate A. Identify the "grass" or "agricultural" areas. Locate these areas on Plate B, and find those which have eroding banks (in red) without any marsh protection. The hot spots are these sites where the banks are highest (thick red line), so the potential sediment volume introduced to the water is greatest. Finally check plate C to determine if any artificial stabilization to protect the bank has occurred. If these areas are without stabilizing structures, they indicate the hottest spots for the introduction of non-point source pollution.

3.4 Designating Areas of Concern (AOC) for Best Management Practice (BMP) Sites

Sediment load and nutrient management programs at the shore are largely based on installation of Best Management Practices (BMPs). Among other things, these practices include fencing to remove livestock from the water, installing erosion control structures, and bank re-vegetation programs. Installation of BMPs is costly. Cost share programs provide relief for property owners, but funds are scarce in comparison to the capacious number of waterway miles needing attention. Targeting Areas of Concern (AOC) can prioritize spending programs, and direct funds where most needed.

Data collected for the SSR can assist with targeting efforts for designating AOCs. AOCs can be areas where riparian buffers are fragmented, and could be restored. Use Plate A to identify forested upland. Breaks in the continuity of the riparian forest can be easily observed in the line segments, and background image. Land use between the breaks relates to potential opportunity for restoring the buffer where fragmentation has occurred. Agricultural tracts which breach forest buffers are more logical targets for restoration than developed residential or commercial stretches. Agricultural areas, therefore, offer the highest opportunity for conversion. Priority sites for riparian forest restoration should target forested tracts breached by "agriculture" or "grass" land (green-fuchsia-green line pattern; green-blue-green line pattern, respectively).

Plate B can be used to identify sites for BMPs. Look for where "red" (i.e. eroding) bank conditions persist. The thickness of the line tells something about the bank height. The fetch, or the distance of exposure across the water, can offer some insight into the type of BMP which might be most appropriate. Re-vegetation may be difficult to establish at the toe of a bank with high exposure to wave conditions. Plate C should be checked for existing shoreline erosion structures in place.

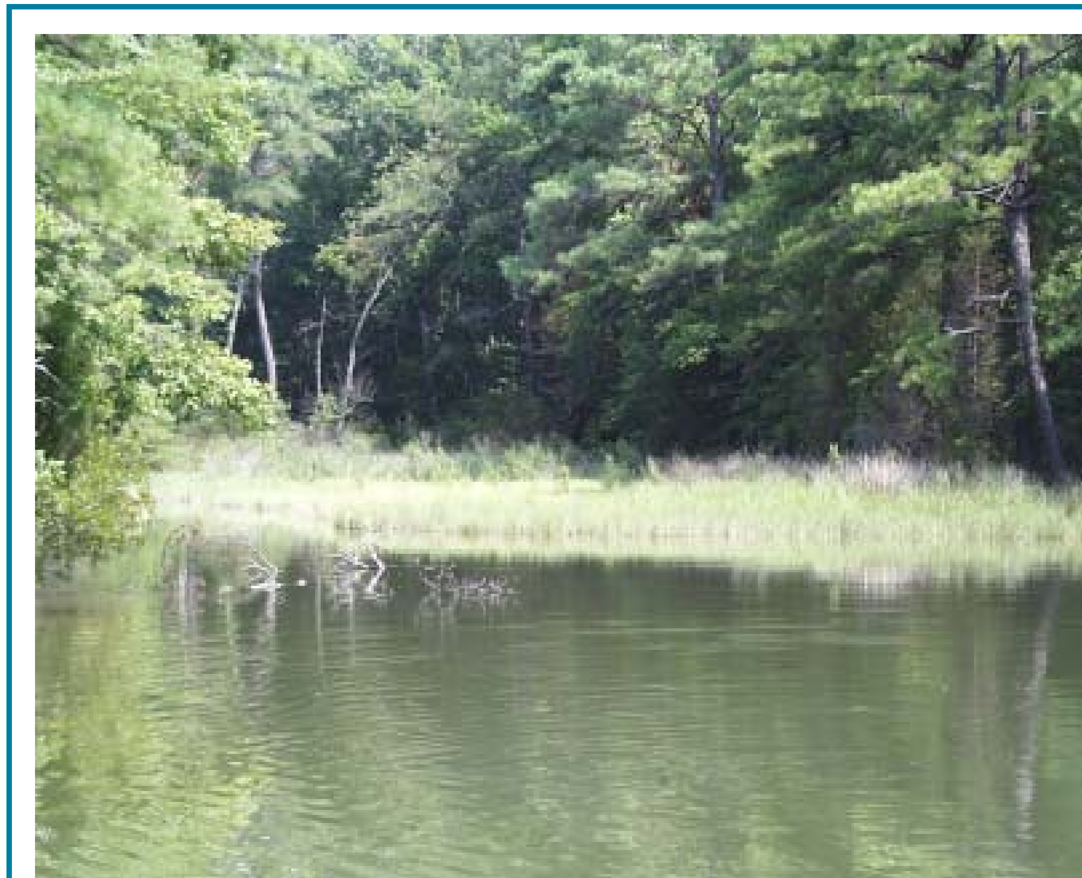
Tippett et.al.(2000) used similar stream side assessment data to target areas for bank and riparian corridor restoration. These data followed a comparable three tier approach and combine data regarding land use and bank stability to define specific reaches along the stream bank where AOCs have been noted. Protocols for determining AOCs are based on the data collected in the field.

3.5 Targeting for Total Maximum Daily Load (TMDL) Modeling

As the TMDL program in Virginia evolves, the importance of shoreline erosion in the lower tidal tributaries will become evident. Total maximum daily loads are defined as a threshold value for a pollutant, which when exceeded, impedes the quality of water for specific uses (e.g. swimming, fishing). Among the pollutants to be considered are: fecal coliform, pathogens, nitrogen, phosphorous, and sediment load.

State agencies will develop models to address each of these parameters. In upper watersheds, nutrient and fecal coliform parameters will be critical where high agricultural land use practices prevail. Sediment loads will eventually be considered throughout the watershed. In the lower watersheds, loads from shoreline erosion must be addressed for a complete sediment source budget. Erosion from shorelines has been associated with high sediment loads in receiving waters (Hardaway et.al., 1992), and the potential for increased nutrient loads (Ibison et.al., 1990). Virginia's TMDL program is still developing. Impaired stream segments are being used to initially identify where model development should focus. For Virginia, this streamlining has done little to reduce the scope of this daunting task, since much of the lower major tributaries are considered impaired. Additional targeting will be necessary to prioritize model development.

Targeting to prioritize TMDL can be assisted by maps which delineate areas of high erosion, and potential high sediment loads. Plate B in this inventory delineates banks of high erosion. Waterways with extensive footage of eroding shorelines should be targeted. The volume of sediment entering a system is also a function of bank height. Actual volumes of sediment eroded can be estimated by using bank height, and the linear extent that the condition persists along the shore. Bank height is an attribute defined in Plate B by the width of the line. Eroding banks (in red) with heights in excess of 10 feet (thickest line) would be target areas for high sediment loads. Plate A can be used in combination with Plate B to determine the dominant land use practice, and assess whether nutrient enrichment through sediment erosion is also a concern. This would be the case along agriculturally dominated waterbodies. Tables 4 and 5 quantify the linear extent of high, eroding banks on a reach by reach, or plate by plate basis, respectively.



Headwaters of Meyer Creek.

Chapter 4. The Shoreline Situation

The shoreline situation is described for conditions in Lancaster County along its primary and secondary waterways. Characteristics are described for all navigable tidal waterways contiguous to the western shore of the Chesapeake Bay and Rappahannock River. A total of 316.49 miles of shoreline are described. More than 266 miles were surveyed in the field. The remaining 50 miles are described using image interpretation techniques and ancillary data sources. These areas are dominated by tidal creeks with restricted openings at the mouth, or headwater channels of secondary creeks which wind upstream. Photo interpretation was made using DOQQs to detect land use, natural buffers, and shoreline structures where possible. Along these tidal channels, upland banks are assumed to be well protected by vegetation, and erosion low. It is possible, however, for these banks to experience undercutting from tidal currents. This could not be verified since field visits were not performed. Bank height conditions along reaches characterized using remote sensing techniques were estimated from USGS 1:24,000 topographic maps.

Brief descriptions of the county are provided on the basis of river segments, the boundaries of which are geographically determined. These descriptions summarize tabular data (Table 5) and notable features present. Four segments are defined. Segment 1 includes plates 1-6; Segment 2 includes plates 7-10; Segment 3, plates 11-19, and Segment 4, plates 20-26. An index preceding the map compositions illustrates the plate boundaries. Important documentation pertaining to each plate follows the segment description below.

Cattle in the water pose a threat to water quality.

Bank erosion on Indian Creek.

Segment 1 (Plates 1-6)

Description: Segment 1 includes plates with rivers that drain into the Chesapeake Bay. The segment extends from the border with Northumberland County on Indian Creek, south through Fleets Bay, and east to Windmill Point. The segment includes the southern shore of Indian Creek, Dymer Creek, Tabbs Creek, and Antipoison Creek. Smaller tributaries to these waterbodies are also surveyed. A total of 93.64 miles of shoreline is described. Eighty-four miles were surveyed in the field. The remaining shoreline was surveyed using remote sensing techniques. The major rivers to the north generally trend northwest-southeast. Fetch in these tributaries is greatest in these directions, and winds from the northwest or southeast can generate the largest waves. South along the Bay side toward Fleets Bay, the rivers become oriented more west to east. There is significant exposure to the northeast, where the shore is subject to waves generated from northeasters across the Bay.

Land Use: More than 75% of the riparian area is either forested or residential land use. These respectively account for 38 and 32 miles of linear shoreline. While the upland has several large farm tracts, only 2.49 miles of the immediate riparian area is agricultural. Scrub-shrub frequently buffers these areas. No concentrated uses can be distinguished among the major land uses. Residential and forested areas are dispersed throughout the region here. There were nine commercial operations identified on the shore. Three of these are marinas offering services to recreational boaters (delineated as “marina” on the plates 1-6 ”C”). Other commercial enterprises were not specified but include: related services to commercial fisherman, private industry, or other recreational facilities (e.g. campgrounds). The earlier Shoreline Situation Report for Lancaster County only evaluated 43 miles of shore in this area (Morgan et.al., 1978). A trend in landuse use change at the shore is difficult to conclude through any comparison.

Bank Condition: Ninety-two percent of bank heights along this segment are below 5 feet. The majority of these banks are classified as stable or low erosion. More than 91% of the banks have total cover (between 75-100%). This includes vegetative as well as structural coverage. This contributes to the overall stability observed in the survey. The highest banks in this segment are

Riprap protection along Mosquito Creek.

located at the headwaters of Dymer Creek (Plate 3). The most extensive erosion noted along the banks surveyed was at the headwaters of Tabbs Creek, where bank heights ranged from 5-10 feet, and there was no marsh vegetation or beaches observed. Marsh vegetation was observed along 59 miles of shoreline. Less than three miles showed obvious signs of erosion. Thirty-five miles of shoreline measured has no marsh vegetation. According to Morgan et.al. (1978), flood hazard potential is high for this segment. Their assessment of elevations at the shore are consistent with this survey. They acknowledge that many structures are built at or below the five foot elevation mark and these are all subject to flooding and inundation during periods of high water.

Shore Condition: Twenty-four miles of erosion control structures have been installed along this segment. They include nearly 14 miles of riprap, and 4.23 miles of bulkheading. There are several groin fields totaling more than 2 miles of groins. The longest series is found in Fleets Bay at the entrance to Tabbs Creek. Five hundred private piers are in place, along with 28 boathouses, and forty ramps. There are no public landings located in this segment. However, there is a ramp located at the private marina by Warehouse Point on Indian Creek (Plate 1C) which may allow boaters to launch for a fee. Historic erosion rates are not available for the creeks in this segment. However, rates reported for the Bay shoreline range from 1.6 to 7.9 ft/yr. in Byrne and Anderson (1983). Highest rates are found at Windmill Point (reach 328, Figure 2).

Segment 2 (Plates 7-10)

Description: Segment 2 begins just west of Windmill Point and covers the Rappahannock River past Mosquito Point, the Route 3 bridge, Carter Creek and the surrounding town of Irvington. Portions of Antipoison Creek, Harpers Creek, Mosquito Creek, and Carters Creek are described. Field surveys were performed in May and August of 1999. Actual dates are reported in the plate descriptions found in this chapter.

Segment two is protected from major northeast wind and waves. Winds from the southeast, more typical in the warm months, can generate large waves along the Rappahannock. Segment 2 covers 61.51 miles of shoreline. General land use is similar to Segment 1; where residential and forest cover equally describes the area. The upland is studded with large agricultural tracts. The town of Irvington is the most densely populated region, and waterfront development in the branches of Carters Creek is extensive. Some photo interpretation was necessary in Segment 2. Thirteen and one half miles of the total 61.51 miles of shore were surveyed remotely. Two creeks on plates 8 and 9 were surveyed remotely for land use, beaches and marshes. No assessment of erosion condition or bank cover are made in these areas.

Land Use: Land use along the shoreline is dominated by a combination of forest cover and residential land use. Forest cover accounts for 23.65 miles of shore, and residential 22.36 miles. Ten miles of shoreline was designated as scrub-shrub. Three miles of shoreline account for commercial development. Several of these areas are commercial marinas. Very little agricultural uses are within the immediate riparian zone.

Bank Condition: Bank heights range from less than 5 feet to greater than 10 feet in Segment 2. Fifty-eight percent the banks are below five feet in elevation. Eighteen percent are between 5 and 10 feet. Twenty four percent of the banks are greater than 10 feet. High banks greater than 10 feet are located along the Rappahannock river shoreline from Mosquito Creek to the Route 3 bridge. Isolated areas of eroding shoreline was noted. Most of the banks surveyed in the field had total cover (81.5%). This might account for the overall stability of the shore. Marshes are present along roughly half of the shorelines measured. Beaches are rare, comprising only 9 miles of shore. According to Morgan et.al., 1978, flood potential in this area is generally low. However, this assessment reveals a number of low-lying areas within which structures are built below the five foot elevation mark. These structures may be at risk to flooding during storms or abnormally high water events.

Shore Condition: Fringe marshes occur along less than 27 miles of shore. Marshes tend to dominate in the creeks. Over 9 miles of beaches were surveyed. In this segment they are notable along the lower Rappahannock shoreline. The shore along the Irvington community has little of either. Only a relatively small percentage of the shore has erosion control structures (17 miles). Private access is gained via 295 piers, 52 boathouses, and 16 ramps. There are no public ramps in the segment, but several marinas do have private launching facilities. Erosion rates estimated by Byrne and Anderson (1983) for the main stem of the Rappahannock shoreline range between 0.5 and 2.7 ft/yr.

Segment 3 (Plates 11-19)

Description: Segment 3 focuses on the Corrotoman River System. The entrance to the Corrotoman is marked by Corrotoman Point on the east and Towles Point to the west. The river includes more than 113 miles of shoreline inclusive of several major branches and small tributaries. One hundred and thirteen miles of shoreline was surveyed between May and July, 1999. The survey includes the main stem, the Eastern Branch (Hills Creek, Bells, Creek, Punches Cove, Browns Creek, Quarter Cover) to Camps and Norris Prongs, Taylor Creek, Moran Creek, the Western Branch (John Creek, Lowrey Creek, Senior Creek, Davis Creek, Little Branch) to its headwaters, Myer Creek, Town Creek, Millenbeck and Ewells Prongs, and Whitehouse Creek . The mainstem of the river is oriented roughly north south. Exposure and fetch distances varies in the two main branches. The Eastern Branch is open to northeast winds, while the Western Branch, oriented northwest-southeast is impacted more by northwest winds.

Land Use: The majority of the riparian landcover is forested (59%). Residential use accounts for 31% of the riparian area. There are no major centers of development in this area. Residential use is spread along the shoreline. The adjacent upland is dominated by forest cover and agricultural use. A few agricultural tracts are within the riparian zone. Commercial use at the shore is sparse; only 0.76 mile cumulatively.

Fringe marsh protects this grassy bank from erosion.

Bank Condition: Bank heights are variable here. Thirty-nine percent are low (< 5 feet), 30% are moderate (5-10), and 31% are high (> 10 feet). Erosion was noted along 26% of all banks surveyed, and most prevalent along banks greater than 5 feet. Forty-eight percent of the banks had fringe marsh protection, and beaches protected 14% or approximately 15 miles of banks. The survey indicates that 80 miles of bank observed are 75-100% cover. The flood hazard is variable due to the variation in elevation across the segment. Morgan et.al., 1978 classifies the flood hazard potential for this area as low, non critical, except for isolated areas.

Shore Condition: Erosion control structures extend along 25 miles of shoreline in Segment 3. Riprap dominates (19.18 miles), but there is some bulkheading. There are 689 piers surveyed, and 72 boathouses. Private property owners have installed a total of 26 boat ramps. There are no public launch facilities in the segment. Byrne and Anderson (1983) computed historic erosion rates within the Corrotoman River ranging from 0.0 ft/yr to 5.1 ft/yr. Highest rates were computed for reach 182 (figure 2) which extends from the mouth of Taylor Creek to the entrance of Moran Creek on the eastern shore of the river. Today this area is primarily residential, and erosion control structures are in place along the entire reach. No revised rates are available.

Segment 4 (Plates 20-26)

Description: Segment 3 runs up the Rappahannock River from northwest of the entrance to the Corrotoman River to the county border with Richmond County on Lancaster Creek. The segment describes conditions along the main Rappahannock shoreline, the headwaters of Whitehouse Creek, Beach Creek, Paynes Creek, Greenvale Creek, Deep Creek, Mulberry Creek, and Lancaster Creek. The segment surveys 62.49 miles of shoreline. Twenty miles were surveyed remotely in areas where navigation was not possible. The Rappahannock is oriented northwest southeast here, and the tributaries are oriented northeast. Winds from the northwest can generate significant waves along the mainstem of the Rappahannock River.

Land Use: Like the other segments, Segment 4 is also dominated by forest or residential land use in the riparian zone. The majority of the riparian landcover is forested (56%). Residential use accounts for 24% of the riparian area. Scrub shrub is the dominant cover along 11% of the shore.

Bank Condition: While bank heights are variable, almost 43 miles (69%) of the banks adjacent to the shore are less than or equal to 5 feet. Forty miles are stable, and the just over 3 miles of eroding low shore was observed. Overall, bank stability is high here. Only 8 miles of the total 62.49 miles surveyed in the segment exhibit typical signs of erosion. Marsh vegetation buffers 39 miles of shore, and beaches another 7. As expected, marshes are generally associated with stable banks except in cases where banks are greater than five feet. In these areas, bank erosion may still persist. Beaches are restricted to the main stem of the Rappahannock and frequently are in the vicinity of eroding bluffs (>10 feet) which provide the sediment source for beach material. Several areas in this segment were designated by Morgan et.al., 1978 with a high, non critical or high, critical flood hazard potential. These include the stretches from Towles Point to Beach Creek, Beach Creek, and Belle Isle. Moderate risk for flooding was noted between Midway Creek and Deep Creek. Other areas were classified as a low risk for flooding.

Shore Condition: Erosion control structures extend along 10 miles of shore, roughly 16%. This is relatively low. There are a number of private recreational structures. Two hundred and six piers, fifteen boathouses, and two ramps were surveyed. Both ramps are public landings. One is located at Belle Isle on Deep Creek, and the second is located upriver from the entrance to Greenvale Creek. These are the only public landing facilities for launching a boat in Lancaster County. Byrne and Anderson (1983) computed historic erosion rates for several areas within the segment. They range from 0.0 ft/yr to 4.4 ft/yr. Highest rates were computed for the section of shoreline between Curletts Point to the entrance of Lancaster Creek.

High bluffs are eroding along Deep Creek.

Map Compositions

Lancaster County

Plate 1

Location: Indian Creek to Lancaster/Northumberland County boundary; 3 miles of Northumberland County shoreline data included.
Major River: Indian Creek
Reach(s): 337 (partial)
Total Shoreline Miles: 13.06
Shoreline Miles Surveyed: 13.06
Survey Date(s): 8/3/99
Plate Rotation: 36 degrees W

Plate 2

Location: Dymer Creek and 0.7 mile of southwestern shore of Indian Creek
Major River: Dymer Creek
Reach(s): 334, 335 (partial), 336, 337 (partial)
Total Shoreline Miles: 22.85
Shoreline Miles Surveyed: 22.85
Survey Date(s): 8/3/99, 8/10/99, and 8/16/99
Plate Rotation: 0 degrees

Plate 3

Location: Headwaters of Dymer Creek and Pitmans Cove
Major River: Dymer Creek
Reach(s): 305 (partial), 337 (partial)
Total Shoreline Miles: 9.26
Shoreline Miles Surveyed: 9.26
Survey Date(s): 8/3/99, 8/10/99, and 8/16/99
Plate Rotation: 90 degrees W

Plate 4

Location: Headwaters of Antipoison Creek; 0.18 mile north of Clark Point through Tabbs Creek to 0.3 mile south of Dymer Creek.
Major River: Fleets Bay
Reach(s): 330 (partial), 331 (partial), 332, 333
Total Shoreline Miles: 19.17
Shoreline Miles Surveyed: 19.17
Survey Date(s): 8/16/99, 8/17/99, and 8/18/99
Plate Rotation: 0 degrees

Plate 5

Location: Rappahannock River from North portion of Mosquito Islands to neck of Fleets Island; Little Bay and Antipoison Creek.
Major River: Rappahannock River
Reach(s): 150, 151, 152, 153 (partial), 154, 155 (partial), 328 (partial), 329 (partial), 330 (partial)
Total Shoreline Miles: 20.58
Shoreline Miles Surveyed: 17.27
Survey Date(s): 8/2/99, 8/18/99, and 8/23/99
Plate Rotation: 0 degrees

Plate 6

Location: Fleets Island
Major River: Rappahannock River
Reach(s): 145, 146, 147, 148, 149, 150 (partial), 329 (partial), 328
Total Shoreline Miles: 25.57
Shoreline Miles Surveyed: 17.41
Survey Date(s): 8/2/99, 8/18/99, and 8/23/99
Plate Rotation: 25 degrees W

Plate 7

Location: Portion of Antipoison Creek, Mosquito Point and Mosquito Bay
Major River: Rappahannock River
Reach(s): 151 (partial), 152, 153, 154, 155, 156, 157, 158,159, 60 (partial), 329 (partial), 330 (partial).
Total Shoreline Miles: 18.46
Shoreline Miles Surveyed: 12.52
Survey Date(s): 8/2/99 and 8/18/99
Plate Rotation: 0 degrees

Plate 8

Location: Headwaters of Antipoison Creek and Mosquito Creek; 1 mile north of Mosquito Point to Cherry Point.
Major River: Rappahannock River
Reach(s): 330 (partial), 156, 157 (partial), 160 (partial), 161, 162, 163, 164 (partial)
Total Shoreline Miles: 14.82
Shoreline Miles Surveyed: 9.93
Survey Date(s): 8/2/99 and 8/18/99
Plate Rotation: 0 degrees

Plate 9

Location: 0.5 mile east of Cherry Point to Crab Point; southern portion of Yopps Cove.
Major River: Rappahannock River
Reach(s): 163 (partial), 164, 165, 166, 168, 169, 171 (partial)
Total Shoreline Miles: 11.36
Shoreline Miles Surveyed: 6.21
Survey Date(s): 5/18/99 and 8/2/99
Plate Rotation: 0 degrees

Tides Inn at Irvington.

Plate 10

Location:	Carter Creek and Eastern Branch
Major River:	Carter Creek
Reach(s):	169 (partial), 170, 171 (partial), 172 (partial)
Total Shoreline Miles:	23.85
Shoreline Miles Surveyed:	23.85
Survey Date(s):	5/18/99 and 5/19/99
Plate Rotation:	0 degrees

Plate 11

Location:	Portion of Carter Cove, around Orchard Point and Corrotoman Point to confluence of Taylor Creek.
Major River:	Corrotoman River
Reach(s):	171 (partial), 172 (partial), 173, 174, 175, 176, 178, 179, 180
Total Shoreline Miles:	8.61
Shoreline Miles Surveyed:	8.03
Survey Date(s):	5/19/99 and 6/23/99
Plate Rotation:	90 degrees W

Plate 12

Location:	Taylor Creek, Moran Creek, and the confluence of Eastern and Western Branch.
Major River:	Corrotoman River
Reach(s):	180 (partial), 181, 182, 183, 184, 185 (partial), 187 (partial). 188 (partial)
Total Shoreline Miles:	16.29
Shoreline Miles Surveyed:	16.07
Survey Date(s):	6/23/99, 7/19/99, 7/20/99, and 7/26/99
Plate Rotation:	0 degrees

Plate 13

Location:	Mouth of Eastern Branch to Punches Cove; 0.81 mile along northeast shore of Western Branch from West Point.
Major River:	Eastern Branch Corrotoman
Reach(s):	185 (partial), 186 (partial)
Total Shoreline Miles:	15.94
Shoreline Miles Surveyed:	13.97
Survey Date(s):	7/19/99, 7/20/1999 and 7/21/99
Plate Rotation:	0 degrees

Plate 14

Location:	Headwaters of the Eastern Branch including Browns Creek, Quarter Cove, and Punches Cove.
Major River:	Eastern Branch Corrotoman
Reach(s):	185 (partial)
Total Shoreline Miles:	16.32
Shoreline Miles Surveyed:	16.32
Survey Date(s):	7/19/99 and 7/20/1999
Plate Rotation:	0 degrees

Plate 15

Location:	0.7 mile southeast of Merry Point to mouth of Davis Creek on northeast shore of Western Branch; 0.55 mile south east of Ottoman Wharf through Senior Creek on southwest shore.
Major River:	Western Branch Corrotoman
Reach(s):	186 (partial), 186a (partial)
Total Shoreline Miles:	13.69
Shoreline Miles Surveyed:	13.17
Survey Date(s):	7/21/99 and 7/26/99
Plate Rotation:	0 degrees

Plate 16

Location:	Middle section of Western Branch; Senior Creek and Davis Creek to the south, through Little Branch and 1 mile east along Western Branch.
Major River:	Western Branch Corrotoman
Reach(s):	186a (partial)
Total Shoreline Miles:	15.71
Shoreline Miles Surveyed:	15.71
Survey Date(s):	7/21/99 and 7/26/99
Plate Rotation:	90 degrees W

Plate 17

Location: Headwaters of Western Branch of Corrotoman River from Route 3 south.
Major River: Western Branch Corrotoman
Reach(s): 186a (partial)
Total Shoreline Miles: 7.41
Shoreline Miles Surveyed: 3.78
Survey Date(s): 7/21/99
Plate Rotation: 0 degrees

Plate 18

Location: 1.1 miles north of Western Branch mouth through Myer Creek and Town Creek.
Major River: Corrotoman River
Reach(s): 186 (partial), 187, 188, 189, 190, 191, 192. 193
Total Shoreline Miles: 15.99
Shoreline Miles Surveyed: 15.99
Survey Date(s): 7/26/99, 7/27/99 and 7/29/99
Plate Rotation: 90 degrees W

Plate 19

Location: Mouth of Town Creek, through Whitehouse Creek and around Towles Point.
Major River: Corrotoman River
Reach(s): 192 (partial), 193, 194, 195, 195a, 196, 197, 198, 199, 199a, 200 (partial)
Total Shoreline Miles: 16.09
Shoreline Miles Surveyed: 13.97
Survey Date(s): 5/17/99, 7/27/99 and 7/29/99
Plate Rotation: 90 degrees W

Plate 20

Location: Towles Point to 0.34 mile north of Bulls Creek
Major River: Rappahannock River
Reach(s): 195a (partial), 199a, 200, 201, 202, 203, 204, 205, 206, 207 (partial)
Total Shoreline Miles: 11.11
Shoreline Miles Surveyed: 5.56
Survey Date(s): 5/17/99 and 7/29/99
Plate Rotation: 90 degrees W

Plate 21

Location: 0.27 mile north of Bulls Creek to 0.5 mile north of Mouth of Greenvale Creek.
Major River: Rappahannock River
Reach(s): 207 (partial), 208, 209, 210 (partial), 211 (partial)
Total Shoreline Miles: 9.42
Shoreline Miles Surveyed: 4.56
Survey Date(s): 5/12/99 and 5/17/99
Plate Rotation: 90 degrees W

Plate 22

Location: Greenvale Creek, 0.4 mile north of Greenvale Creek mouth to Monaskon
Major River: Rappahannock River
Reach(s): 210 (partial), 211 (partial), 212, 213, 214, 215 (partial)
Total Shoreline Miles: 6.15
Shoreline Miles Surveyed: 6.15
Survey Date(s): 5/12/99 and 5/17/99
Plate Rotation: 90 degrees W

Plate 23

Location: Monaskon to Boer
Major River: Rappahannock River
Reach(s): 213 (partial), 214, 215, 216, 217, 218, 219, 220, 221, 222 (partial)
Total Shoreline Miles: 3.69
Shoreline Miles Surveyed: 3.69
Survey Date(s): 5/12/99
Plate Rotation: 90 degrees W

Groins offer protection along this residential waterfront community on the Rappahannock.

Plate 24

Location:	Deep Creek, Belle Isle, Mulberry Creek
Major River:	Rappahannock River
Reach(s):	221, 222, 223, 224, 225, 226 (partial)
Total Shoreline Miles:	18.79
Shoreline Miles Surveyed:	16.89
Survey Date(s):	5/11/99 and 5/12/99
Plate Rotation:	0 degrees

Plate 25

Location:	North shore of Mulberry Creek, around Curletts Point, and approximately 3 miles up Lancaster Creek.
Major River:	Rappahannock River
Reach(s):	226 (partial), 227, 228, 229, 230, 231, 232, 232a (partial)
Total Shoreline Miles:	13.50
Shoreline Miles Surveyed:	11.25
Survey Date(s):	5/11/99
Plate Rotation:	0 degrees

Plate 26

Location:	Upper reaches of Lancaster Creek and Balls Branch
Major River:	Lancaster Creek
Reach(s):	232a (partial)
Total Shoreline Miles:	9.02
Shoreline Miles Surveyed:	2.17
Survey Date(s):	5/11/99
Plate Rotation:	0 degrees

This commercial operation supports local waterman

Glossary of Shoreline Features Defined

Agricultural - Land use defined as agricultural includes farm tracts which are cultivated and crop producing. This designation is not applicable for pasture land.

Bare - Land use defined as bare includes areas void of any vegetation or obvious land use. Bare areas include those which have been cleared for construction.

Beaches - Beaches are sandy shores which are subaerial during mean high water. These features can be thick and persistent, or very thin lenses of sand.

Boat house - A boathouse is considered any covered structure alongside a dock or pier built to cover a boat. They include true "houses" for boats with roof and siding, as well as awnings which offer only overhead protection. Since nearly all boat houses have adjoining piers, piers are not surveyed separately, but are assumed. Boat houses may be difficult to see in aerial photography. On the maps they are denoted with a blue triangle.

Boat Ramp - Boat ramps provide vessels access to the waterway. They are usually constructed of concrete, but wood and gravel ramps are also found. Point identification of boat ramps does not discriminate based on type, size, material, or quality of the launch. Access at these sites is not guaranteed, as many may be located on private property. The location of these ramps was determined from static ten second GPS observations. Ramps are illustrated as purple squares on the maps.

Breakwaters - Breakwaters are structures which sit parallel to the shore, and generally occur in a series along the shore. Their purpose is to attenuate and deflect incoming wave energy, protecting the fastland behind the structure. In doing so, a beach may naturally accrete behind the structures if sediment is available. A beach nourishment program is frequently part of the construction plan.

The position of the breakwater offshore, the number of breakwaters in a series, and their length depends on the size of the beach which must be maintained for shoreline protection. Most breakwater systems sit with the top at or near MHW and are partially exposed during low water. Breakwaters can be composed of a variety of materials. Large rock breakwaters, or breakwaters constructed of gabion baskets filled with smaller stone are popular today. Breakwaters are not easily observed from aerial imagery. However, the symmetrical cuspate sand bodies which may accumulate behind the structures can be. In this survey, individual breakwaters are not mapped. The first and last breakwater in the series are surveyed as a ten-second static GPS observation. The system is delineated on the maps as a line paralleling the linear extent of the breakwater series along the shore.

Bulkhead - Bulkheads are traditionally treated wood or steel "walls" constructed to offer protection from wave attack. More recently, plastics are being used in the construction. Bulkheads are vertical structures built slightly seaward of the problem area and backfilled with suitable fill material. They function like a retaining wall, as they are designed to retain upland soil, and prevent erosion of the bank from impinging waves. The recent proliferation of vertical concrete cylinders, stacked side by side along an eroding stretch of shore offer similar level of protection as bulkheads, and include some of the same considerations for placement and success. These structures are also included in the bulkhead inventory.

Bulkheads are found in all types of environments, but they perform best in low to moderate energy conditions. Under high energy situations, the erosive power of reflective waves off bulkheads can scour material from the base, and cause eventual failure of the structure.

Bulkheads are common along residential and commercially developed shores. From aerial photography, long stretches of bulkheaded shoreline may be observed as an unnaturally straight or angular coast. In this inventory, they are mapped using kinematic GPS techniques. The data are displayed as linear features on the maps.

Commercial - Commercial zones include small commercial operations and larger industrial facilities. These operations are not necessarily water dependent businesses.

Dock/Pier - In this survey, a dock or pier is a structure, generally constructed of wood, which is built perpendicular or parallel to the shore. These are typical on private property, particularly residential areas. They provide access to the water, usually for recreational purposes. Docks and piers are mapped as point features on the shore. Pier length is not surveyed. In the map compositions, docks are denoted by a small green dot. Depending on resolution, docks can be observed in aerial imagery, and may be seen in the maps if the structure was built prior to 1994, when the photography was taken.

Forest Land Use - Forest cover includes deciduous, evergreen, and mixed forest stands greater than 18 feet high. The riparian zone is classified as forested if the tree stand extends at least 33 feet inland of the seaward limit of the riparian zone.

Grass - Grass lands include large unmanaged fields, managed grasslands adjacent to large estates, agriculture tracts reserved for pasture, and grazing.

Groinfield - Groins are low profile structures that sit perpendicular to the shore. They are generally positioned at, or slightly above, the mean low water line. They can be constructed of rock, timber, or concrete. They are frequently set in a series known as a groinfield, which may extend along a stretch of shoreline for some distance.

The purpose of a groin is to trap sediment moving along shore in the littoral current. Sediment is deposited on the updrift side of the structure and can, when sufficient sediment is available in the system, accrete a small beach area. Some fields are nourished immediately after construction with suitable beach fill material. This approach does not deplete the longshore sediment supply, and offers immediate protection to the fastland behind the system.

For groins to be effective there needs to be a regular supply of sediment in the littoral system. In sediment starved areas, groin fields will not be particularly effective. In addition they can accelerate erosion on the downdrift side of the groin. The design of "low profile" groins was intended to allow some sediment to pass over the structure during intermediate and high tide stages, reducing the risk of down drift erosion.

From aerial imagery, most groins cannot be observed. However, effective groin fields appear as asymmetrical cusps where sediment has accumulated on the updrift side of the groin. The direction of net sediment drift is also evident.

This inventory does not delineate individual groins. In the field, the first and last groin of a series is surveyed. Others between them are assumed to be evenly spaced. On the map composition, the groin field is designated as a linear feature extending along the shore.

Marina - Marinas are denoted as line features in this survey. They are a collection of docks and wharfs which can extend along an appreciable length of shore. Frequently they are associated with extensive bulkheading. Structures associated with a marina are not identified individually. This means any docks, wharfs, and bulkheads would not be delineated separately. Marinas are generally commercial operations. Community docks offering slips and launches for community residents are becoming more popular. They are usually smaller in scale than a commercial operation. To distinguish these facilities from commercial marinas, the riparian land use map (Plate A) will denote the use of the land at the site as residential for a community facility, rather than commercial.

Marshes - Marshes can be extensive embayed marshes, or narrow, fragmented fringe marshes. The vegetation must be relatively well established, although not necessarily healthy.

Miscellaneous - Miscellaneous point features represent short isolated segments along the shore where material has been dumped to protect a section of shore undergoing chronic erosion. Longer sections of shore are illustrated as line features. They can include tires, bricks, broken concrete rubble, and railroad ties as examples.

Residential - Residential zones include rural and suburban size plots, as well as multi-family dwellings.

Riprap - Generally composed of large rock to withstand wave energy, riprap revetments are constructed along shores to protect eroding fastland. Revetments today are preferred to bulkhead construction. They reduce wave reflection which causes scouring at the base of the structure, and are known to provide some habitat for aquatic and terrestrial species. Most revetments are constructed with a fine mesh filter cloth placed between the ground and the rock. The filter cloth permits water to permeate through, but prevents sediment behind the cloth from being removed, and causing the rock to settle. Revetments can be massive structures, extending along extensive stretches of shore, and up graded banks. When a bulkhead fails, riprap is often placed at the base for protection, rather than a bulkhead replacement. Riprap is also used to protect the edge of an eroding marsh. This use is known as toe protection. This inventory does not distinguish among the various types of revetments.

Riprap revetments are popular along residential waterfront as a mechanism for stabilizing banks. Along commercial or industrial waterfront development such as marinas, bulkheads are still more common since they provide a facility along which a vessel can dock securely.

Riprap is mapped as a linear feature using kinematic GPS data collection techniques. The maps illustrate riprap as a linear feature along the shore.

Scrub-shrub - Scrub-shrub zones include trees less than 18 feet high, and is usually dominated by shrubs and bushy plants.

Shallow nearshore on Moran Creek.

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