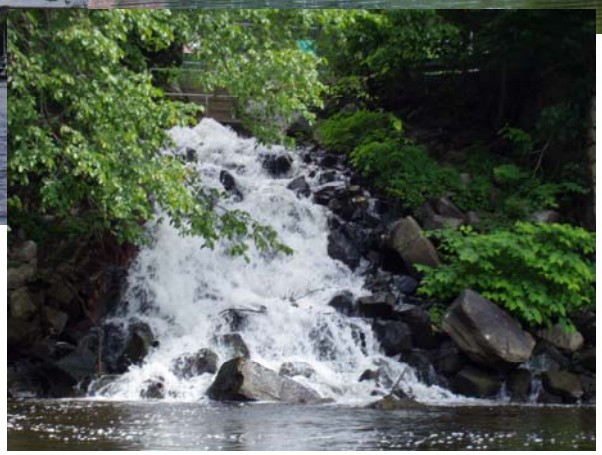
Fairfax County and the City of Alexandria, Virginia Shoreline Inventory Report Methods and Guidelines



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Special report in Applied Marine Science and Ocean Engineering No. 419 of the Virginia Institute of Marine Science

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Fairfax County and the City of Alexandria - Shoreline Inventory Report

Supported by the Virginia Institute of Marine Science, Center for Coastal Resources Management, Comprehensive Coastal Inventory Program

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Chapter 1. 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 that 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 (Hobbs et al., 1975).

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 desktop reference.

The Comprehensive Coastal Inventory Program (CCI) is committed to developing a revised series of Shoreline Situation Reports that address the management questions of today and take advantage of new technology. New techniques integrate a combination of Geographic Information Systems (GIS), Global Positioning System (GPS) and remote sensing technology. Reports are now distributed electronically unless resources become available for hardcopy distribution. The digital GIS coverages, along with all reports, tables, and maps are available on the web at http://ccrm.vims.edu/gis_data_maps/shoreline_inventories/index.html by clicking on Fairfax County and the City of Alexandria.

1.2 Description of the Localities

Fairfax County

Fairfax County is located in Northern Virginia and shares borders with Arlington, Loudoun, and Prince William Counties as well as the cities of Alexandria and Falls Church. The Potomac River lies to its north and southeast. According to the United States Census Bureau, the Fairfax County has a total area of 1,053 km^2 (407 mi^2), of which, 1,023 km^2 (395 mi^2) of it is land and 30 km^2 (12 mi^2) of it is water.

Fairfax County is one of the most dynamic jurisdictions in the Washington Metropolitan Region. The County is a versatile employment center, a generator of retail sales, which are among the highest in the country, and an assemblage of residential communities that are home to a rapidly growing and increasingly diverse population. The county's role as an agricultural producer has practically disappeared, to the extent that preservation of remaining farm land, conservation of areas of high environmental and scenic value, and protection of open space have become high priorities (Fairfax County Comprehensive Plan, 2007).

The County has been highly engaged in environmental issues. In 2009, Fairfax County adopted an energy policy, which encourages energy efficiency and conservation practices among County employees, employers and residents. The policy endeavors to reduce energy consumption and greenhouse gas emissions.

City of Alexandria

The City of Alexandria is an independent city in the Commonwealth of Virginia. It is located along the Western bank of the Potomac River. The City is bounded on the north and northwest by Arlington County and on the south by Fairfax County. According to the United States Census Bureau, the City of Alexandria has a total area of 39.9 km2 (15.4 mi2), of which, 39.3 km2 (15.2 mi2) of it is land and 0.6 km2 (0.2 mi2) of it is water.

The City of Alexandria is home to a rising base of high-technology firms, management consulting companies, professional services, and professional association headquarters. Alexandria has the fourth largest concentration of professional associations and trade associations in the country, behind only New York City, Washington, D.C. and Chicago (City of Alexandria Virginia - Community Profile).

The City has been very proactive in its efforts to control stormwater runoff. Throughout the development of Alexandria's Stormwater Management Plan, the City engaged in an extensive assessment of existing stormwater management options, ordinances, and programming and has evaluated them against the National Pollutant Discharge Elimination System (NPDES) compliance requirement. Whereas the NPDES command will require some new stormwater pollution prevention initiatives, many of the City's current pollution control activities serve as the foundation (City of Alexandria – Home Page).

1.3 Purpose and Goals

This shoreline inventory is developed as a tool for assessing conditions along the tidal shoreline in Fairfax County and the City of Alexandria. Field data were collected during June and August 2010, and maps were generated using basemap imagery from the Virginia Base Mapping Program (VBMP 2009). Conditions are reported for three zones within the immediate riparian river area: riparian land use, bank and buffers, and the shoreline. Shorelines of the Potomac River, Pohick River, Occoquan River, Little Hunting Creek, Hunting Creek, Fourmile River and Doque Creek, including small tributaries, were surveyed. Some sections were coded using remote sensing techniques because the shoreline was inaccessible by boat.

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. All products are located online.

1.5 Acknowledgments

This project was funded in part 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.

This work was completed entirely with staff support and management from the VIMS Center for Coastal Resources Management's, Comprehensive Coastal Inventory Program (CCI). A host of individuals are acknowledged. In addition to those listed as preparers, the project directors would like to thank the VIMS Vessel Center for their support.

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 (Berman and Hershner, 1999).

Three separate activities embody the development of a Shoreline Inventory 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 Inventory 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 that could be made from a moving boat. To that end, the survey is a collection of descriptive measurements that 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, tree fringe and canopy overhang; 2) the bank, evaluated for height, stability, cover, and natural protection; and 3) the shoreline, describing the presence of shoreline structures for shore protection as well as recreational access. Each tier is described in detail below.

2.2a) Riparian Land Use: Land use adjacent to the bank is classified into one of thirteen classes (Table 1). The classification provides a simple assessment of land use, which provides insight to land management practices that may 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 is considered the primary land use if the buffer width equals or exceeds 30 feet. This

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 cropland
Commercial	small and moderate business operations, recreational facilities
Industrial	includes large industry and manufacturing operations
Bare	lot cleared to bare soil
Timbered	clear-cuts
Paved	areas where roads or parking areas are adjacent to the shore
Military	military installations
Unknown	land use undetectable from the vessel

Note: occurrence of tree fringe with/without canopy is noted along non-forest dominated shoreline

width is calculated from digital imagery as part of the quality control in data processing. If the width is less than 30 feet some other primary land use is designated.

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 that 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 and characteristics, vegetative cover, and the presence of buffers to absorb energy impact to the bank itself. The bank assessment in this inventory addresses: bank height, bank cover, bank stability, and the presence of natural (beach, marsh) 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.

Bank height is reported as a range, estimated from the toe of the bank to the top. Bank cover is an assessment of the percent of cover on the bank face, and includes vegetative and structural cover, in this case. The assessment is qualitative (Table 2). Bank stability characterizes the condition of the bank face. Banks that have exposed root systems, down vegetation, or exhibit slumping of material qualify as “high erosion”.

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
	10-30ft	from the toe to the edge of the fastland
	> 30 ft	from the toe to the edge of the fastland
bank stability	low erosion	minimal erosion on bank face
	transitional	bank shows signs of instability
	high erosion	includes slumping, scarps, exposed roots
	undercut	erosion at the base of the bank
bank cover	bare	<25% vegetated cover
	partial	25-75% vegetated cover
	total	>75% vegetated cover
marsh buffer	no	no marsh vegetation along the bank toe
	yes	fringe, extensive, or embayed
beach buffer	no	no sand beach present
	yes	sand beach present
Phragmites australis	no	no Phragmites australis present on site
	yes	Phragmites australis present on site

Table 2. Tier 2 - Bank Conditions and Natural Buffers

Undercutting at the bank toe is also noted. 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 recorded in the field.

Sediment composition and bank slope cannot be surveyed from a boat, and are not included.

2.2c) Shoreline Features: Structures added to the shoreline by property owners are recorded as a combination of points or lines. These features include defense structures, such as riprap, constructed to protect the shoreline from erosion; offense structures such as groins, designed to accumulate sand in transport; and recreational structures, built to enhance public or private use of the water (Table 3). The location of these features along the shore is surveyed with a GPS unit. Linear features are surveyed kinematically without stopping the boat. Structures such as docks,

Table 3. Tier 3 - Shoreline Features

Feature	Feature Type	Comments
Control Structures		
riprap	L	
bulkhead	L	
dilapidated bulkhead	L	structure no longer performing its function
breakwaters	L	first and last of a series is surveyed
groinfield	L	first and last of a series is surveyed
jetty	P	
miscellaneous	L	includes debris and unconventional treatments
marsh toe revetment	L	rock placed at the toe of the marsh
seawall	L	solid structure that performs like a bulkhead
Recreational Structures		
pier	P	includes private and public
dilapidated pier	P	appears unsafe
wharf	L	includes private and public
boat ramp	P	distinguishes private vs. public landings
boat house	P	all covered structures, assumes a pier
marina	L	includes infrastructure such as piers, bulkheads, wharfs
Others		
outfall	P	

L= line features; P= point features

and boat ramps are point features, and a static six-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 with a “P.” The glossary describes these features, and their purpose 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 one data surveyor. The boat operator navigates the boat to follow the shoreline geometry and collects data pertaining to shoreline features. The surveyor collects information pertinent to

all land use and bank condition.

Data is logged using the handheld Trimble GeoExplorer III, GeoExplorer XT, or GeoExplorer XH GPS unit. GeoExplorers are accurate to within 4 inches of true position with extended observations and differential correction. Without post processing, these units can achieve accuracies around 3 ft (1 meter). Both static and kinematic data collection is performed. Kinematic data collection is a collection technique where data is collected continuously along a pathway (in this case along the waterway). 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 that 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 6 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 6 static observations. Static surveys are used to position point features like piers, boat ramps, and boathouses.

The Trimble GPS receivers being used include a function that allows a user to pre-program the complete set of features surveyed into what is known as a "data dictionary". The data dictionary prepared for this Shoreline Inventory 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 that describe the shoreland's land use, bank condition, and shoreline features present. The survey, therefore, is a complete set 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 CORS base station operated by the

National Geodetic Survey in Sterling, Virginia, was used for most of the data processing in Fairfax County and the City of Alexandria.

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.

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 that 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 shapefiles: a land use and bank condition shapefile (alex_ffax_lubc), a shoreline structure shapefile (lines only) (alex_ffax_sstru), and a shoreline structure shapefile (points only) (alex_ffax_astru).

2.4b.) GIS Processing: GIS processing uses both ESRI's ArcGIS® GIS software, and ERDAS' Imagine® software. Several data sets are integrated to develop the final inventory products. GIS processing corrects the shapefiles generated from the GPS field data to the shoreline record. These shapefiles are geographically coincident with the boat track; from where observations are made. They are, therefore, located somewhere in the waterway. Processing transfers these data back to the shoreline basemap so the data more precisely reflect the location being described along the shore. All attributes summarized in Tables 1, 2, and 3 are included.

A digital shoreline coverage is generated to use as the basemap. This shoreline is extracted from a digital terrain model generated from 2009 high resolution imagery collected as

part of the Virginia Base Mapping Program (VBMP). The shoreline represents a land-water interface and is not corrected to any tidal datum. Any offsets in the shoreline noted from the imagery are corrected. The same VBMP imagery is also used for all background imagery used in data processing and map production. This imagery is an important quality control tool to verify the location of certain landscape attributes, and provides users with additional information about the coastal landscape.

Data processing uses all three data sets simultaneously; the baseline shoreline, the post-processed GPS field data, and the shapefiles. The imagery is used in the background for reference. The processing re-codes the base shoreline with the 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.

The GIS processing under goes 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 newly coded GIS shapefiles; alex_ffax_lubc (depicting land use and bank condition), alex_ffax_sstru (depicting linear structures), alex_ffax_astru (depicting point structures).

Quality control and assurance measures require that each shapefile be checked twice onscreen by different GIS personnel. Draft hardcopy maps are printed and reviewed in the third and final QA/QC step. When completed, maps and tables are generated for the website.

2.4c.) Maps and Tables: Maps and tables are available as pdf files and accessible through the web site. A color printer is required on the user end. A four-part map series was necessary to display all the shoreline attributes surveyed. To try and capture the variability, combinations of colors and patterns are used.

Plate A describes the riparian land use as color-coded bars along the shore. If the line is highlighted underneath with pale pink, there is tree fringe on site. If the line is highlighted underneath with brown, there is tree fringe with canopy overhang. The background imagery is natural color VBMP imagery at a publication scale of 1:12,000. Users should note that the imagery is sometime rotated in order to meet the scale requirements. This means that “north” is not always to the top of the page.

Plate B depicts the condition of the bank; specifically bank stability and bank height. The colors light green, red and yellow are used to report if the bank is stable, erosional, or transitional, respectively. If each of these conditions occurs with undercutting at the base of the bank, the colors become, dark green, fuchsia, olive green, respectively. The thickness of the line reflects the bank height; where the thickest lines designate the highest banks (> 30 feet). Plate B uses natural color VBMP imagery for the backdrop.

Plate C combines recreational and shoreline protection structures in a composition called Shoreline Features. These are generally anthropogenic alterations constructed to gain access to the water or to stabilize a shoreline from existing and future bank erosion. Linear features, described previously (Table 3), are mapped using color coded bar symbols that follow the orientation of the shoreline. Point features use a combination of colors and symbols to plot the positions on the map. Natural color imagery is used as a backdrop.

On Plate D a pattern of small colored circles along the shoreline describes any natural buffers present. These are limited to marshes and beaches. Orange open circles represent embayed marshes. Purple open circles are extensive marshes. Red open circles indicate the presence of fringe marshes that are less than 5 feet in width. Dark blue open circles represent fringe marshes that are 5-10 feet in width. Fringe marshes 10-15 wide are depicted with light green open circles. If the fringe marsh is greater than 15 feet the open circles will be dark green. The invasive species *Phragmites australis* is designated with blue line shown behind the shoreline. Beaches, if present are delineated with solid yellow balls.

For publication purposes Fairfax County and the City of Alexandria are divided into a series of maps. Maps are scaled at 1:12,000 for publication at 11x17. Scale will vary if printed at a different size. There are total of 15 maps that cover Fairfax County and the City of Alexandria. The maps are determined by the geographic size and shape of the region. For each map there are four plates (plate 1a, 1b, 1c, 1d, etc.), for a total of 60 map compositions. On the website (Figure 1), an index is provided to help users locate the area of interest and view the orientation of the maps to each other (Figure 2). Each plate can be individually selected and viewed from the plate list along the left hand column of the index page.

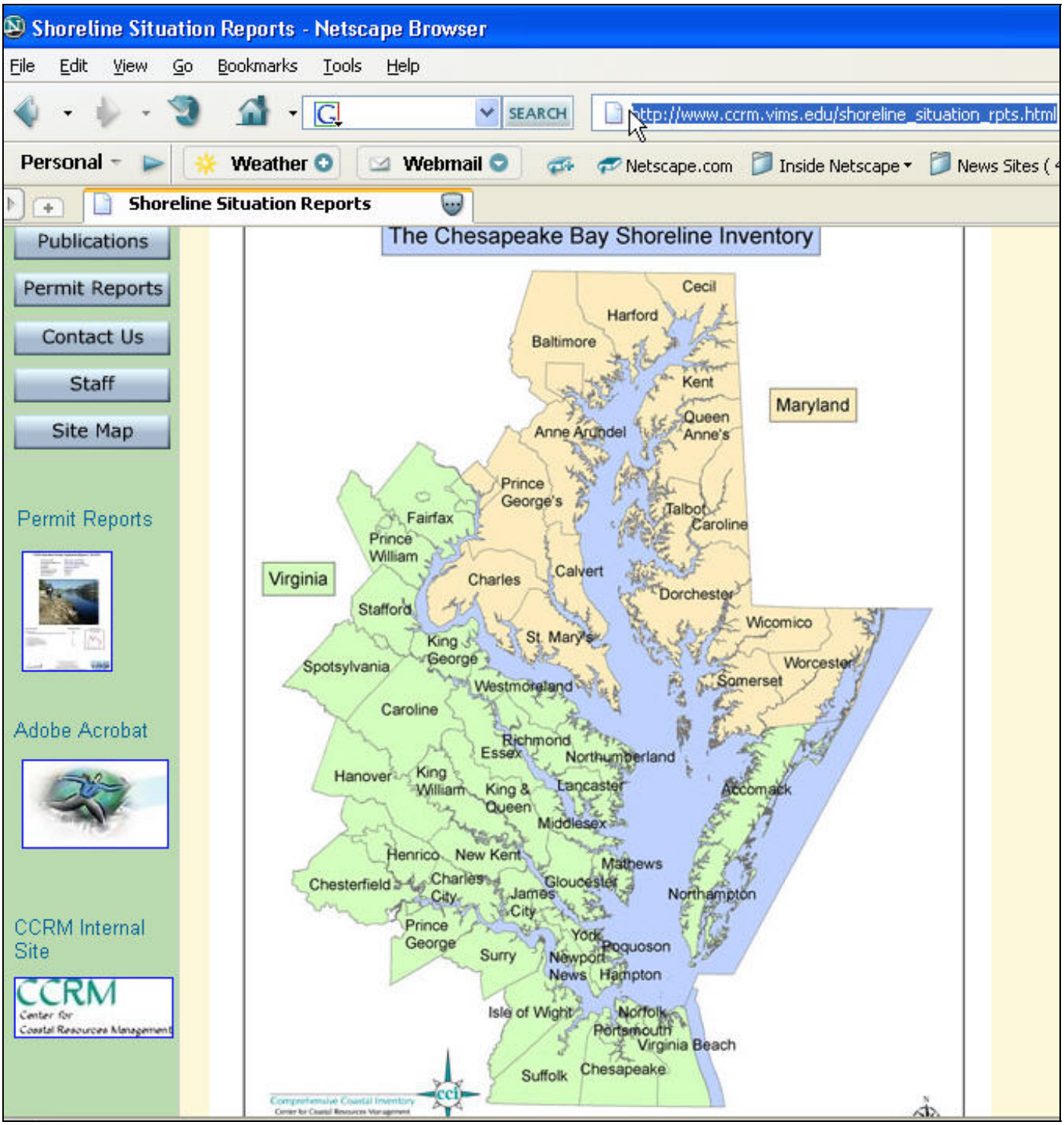

Figure 1. Shoreline Inventory Website

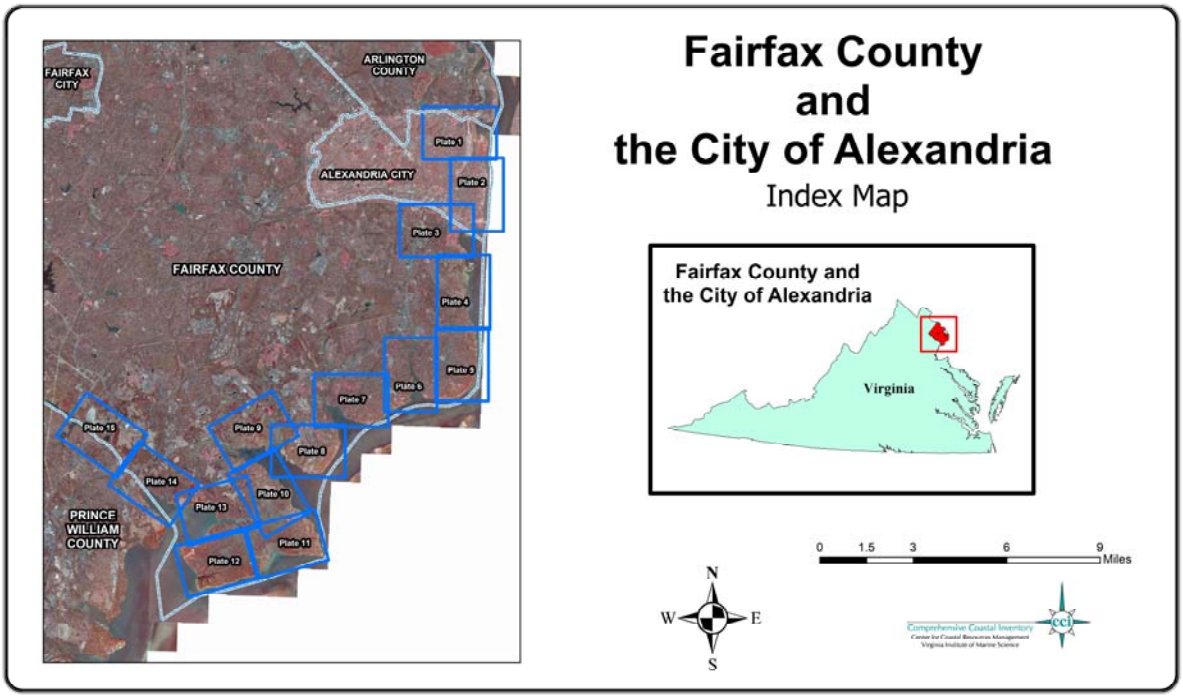

Figure 2. Map index for Fairfax County and the City of Alexandria

Tables 4, 5, 6 and 7 quantify features and conditions mapped along the rivers using frequency analysis techniques in ArcInfo. The values quantify features by river systems (Figure 3). For linear features, values are reported in actual miles surveyed. Point features are enumerated. The total miles of shoreline surveyed for each tributary is reported. For Fairfax County and the City of Alexandria, a total of 98.87 miles were surveyed in the field. Approximately 28.39 miles of shoreline were surveyed using remote sensing techniques. Figure 4 illustrates where field surveys were conducted and where remote sensing techniques were applied. Remote sensing occurred in places where navigation was restricted. Table 6 reports the survey dates, miles surveyed, and miles surveyed remotely.

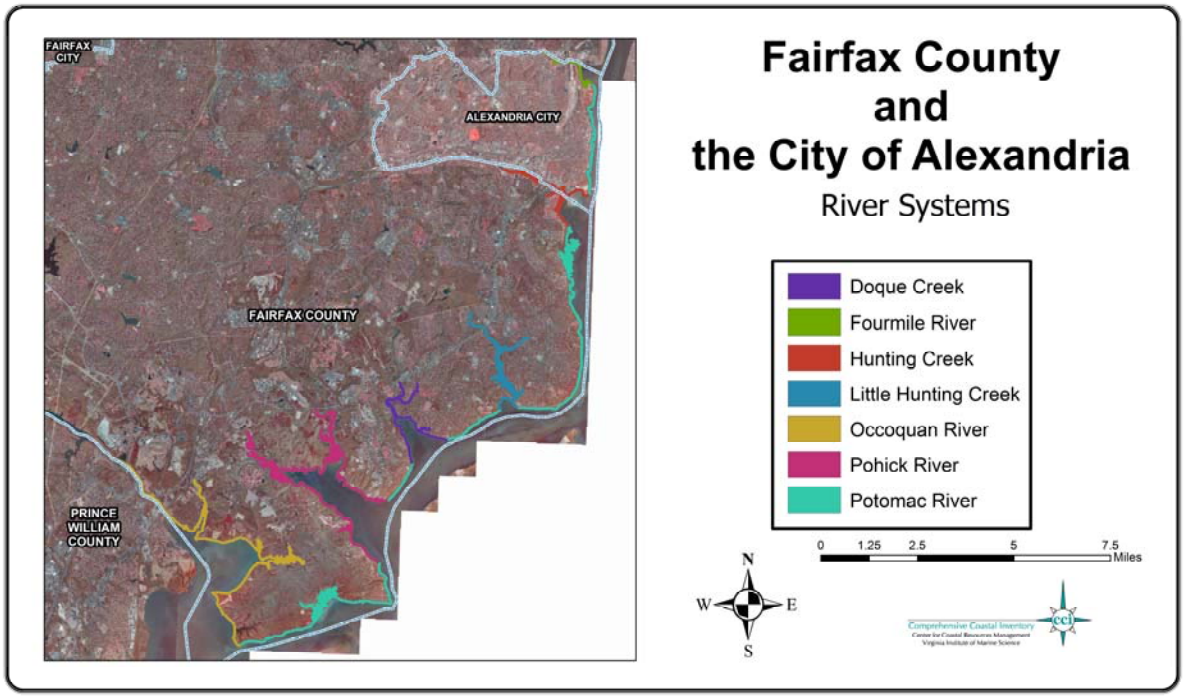

Figure 3. Delineation of river systems used for data reporting

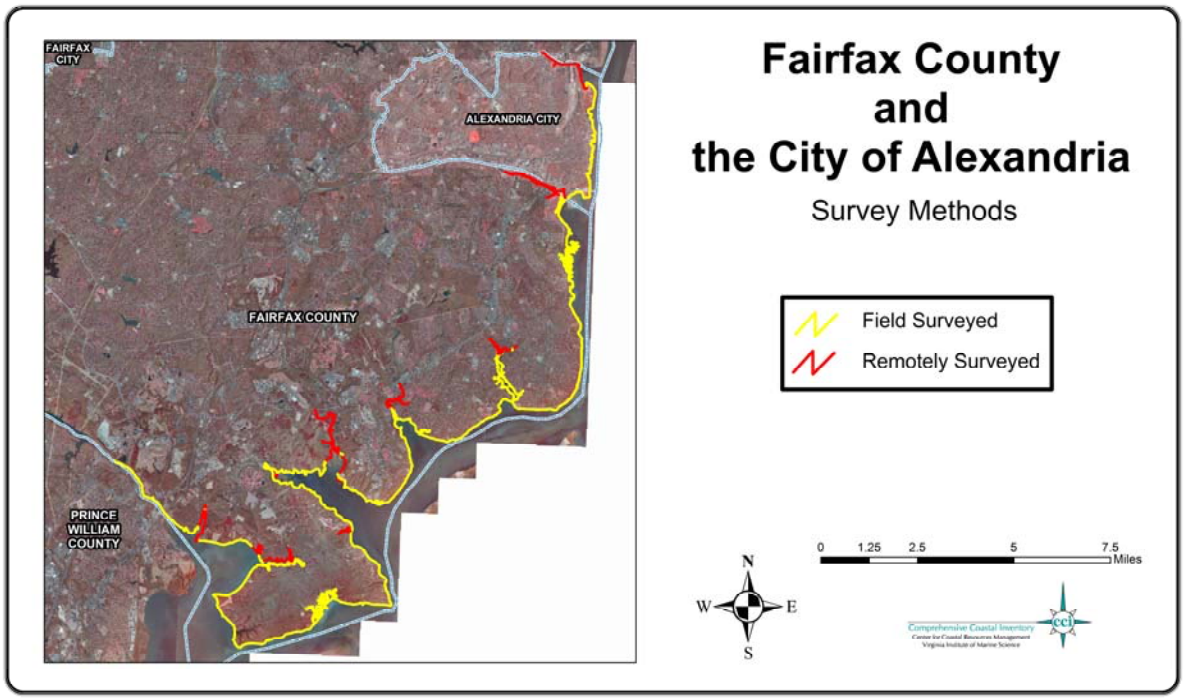

Figure 4. Location of field surveys and remotely sensed data collection.

Chapter 3. Applications for Management

There is a number of different management applications for which the Shoreline Inventory Reports support. This section discusses several high profile issues within the Commonwealth or Chesapeake Bay watershed. The inventories are data reports, and the data provided are intended for interpretation and integration into other programs. This chapter offers some examples for how data from the Shoreline Inventory can be analyzed to support current state management programs.

3.2 Shoreline Management

The first uses for Shoreline Inventory 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 that have persisted. At the same time, the value of waterfront property has escalated, and the exigency to protect shorelines as an economic resource using stabilization practices has increased. 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 with respect to current states and future sea level rise scenarios, and determining future uses of the shore with regards to ecosystem services, economic development, and climate change impacts. The Shoreline Inventories provide data for such assessments. These data are currently being used to determine best strategies to counter erosion based on existing condition. Shoreline Inventories are the backbone for the development of Shoreline Management Plans that integrate data and scientific rationale to strategize best management practices on a reach-by-reach basis.

For example, land use, to some extent, directs the type of management practices one can expect to find along the shoreline. The land use data, illustrated in plate “a” of the map series illustrates current land use at the time of survey that may be an indicator of shoreline management practices existing or expected in the future. Residential and commercial areas are frequently altered to counter act shoreline erosion problems or to enhance private access to the waterway. In contrast forested or agricultural uses are frequently unmanaged even if chronic erosion problems exist. Small forest tracks nestled among residential lots have a high

probability for development in the future. These areas are also target areas then for shoreline modifications if development does occur. If these banks happen to be low-lying, as indicated in plate “b” then there are risks associated with flooding and erosion due to storms and sea level rise. Areas primed for development can be assessed in advance to determine the need for shoreline stabilization, and the type of stabilization that should be recommended.

Stability at the shore is illustrated in plates “b” and “d”. The bank is characterized by its height, the amount of cover on the bank face, the state of erosion, and the presence or absence of natural buffers at the bank toe. Upland adjacent to high, stable banks with a natural buffer at the base are less prone to flooding or erosion problems resulting from storm activity. Uplands adjacent to banks of lesser height (< 5feet) are at greater risk of flooding, but if banks are stable with marshes or beaches present, erosion may not be a significant 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 riprap or bulkheads. Check plate “c” to verify this.

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 new 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” which indicates qualitatively the state of erosion made during the survey. The presence of marshes (plate “d”) at or in the vicinity of the planned project may indicate the potential for a successful marsh planting to control erosion.

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 may be indicative that structures have controlled an erosion problem, however, a pre-existing erosion problem cannot be verified. 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 may have secured the erosion problem at the bank, they have also deflated the supply of sediment available to nourish a healthy beach. The structure may actually be enhancing erosion at the base of the structure due to scour and wave reflection. The deepening of the nearshore can adversely affect the benthic community. This is a typical shore response, and has lead many coastal managers to deny applications requesting the construction of bulkheads.

In the development of a shoreline management plan, all these possibilities are taken into account. Shoreline managers are encouraged to use all four 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 Stream Restoration for Non-Point Source Management

The identification of potential problem areas for non-point source pollution is a focal point of water quality improvement efforts throughout the Commonwealth. This is a challenge for any large landscape. Fortunately, we are relatively well informed about the landscape characteristics that contribute to the problem. This shoreline inventory provides a data source where many of these landscape characteristics can be identified. The three tiered approach provides a collection of data which, when combined, can allow for an assessment of potential non-point source pollution problem areas in a waterway. Managers can effectively target river reaches for restoration sites. Below, methods for combining these data to identify problem sites are described.

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 are also hot spots for non-point source pollution.

To identify areas with the highest potential for non-point source pollution combine these land uses with “high” bank erosion conditions, 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 plates “b” and ”d” and find those that 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. Shoreline managers can use these data to target areas for restoration.

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, construction of living shorelines, and bank re-vegetation programs. Installation of BMPs is costly. There are 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 shoreline inventory 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.

Plates “b” and “d” can be used to identify sites for BMPs. Look for where 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 that might be most appropriate. Marsh planting may be difficult to establish at the toe of a bank with high exposure to wave conditions. Look for other marsh fringe on Plate “d” in the vicinity as an indicator that marshes can successfully grow. A riparian forest may include a tree canopy with overhang that could be trimmed to increase sunlight to promote marsh growth. Plate “c” should be checked for existing shoreline erosion structures in place. We can combine this information with the above to determine if structural control is really necessary.

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.

As water quality programs move into implementation phases the importance of shoreline erosion in the lower tidal tributaries will become evident. Erosion from shorelines has been associated with high sediment loads in receiving waters (Hardaway et al., 1992), and the potential for increased nutrient loads coming off eroding fastland is a concern (Ibison et al., 1990). The contribution to the suspended load from shoreline erosion is not quantified. Water quality modelers are challenged by gathering appropriate data for model inputs. In Maryland, where there is a complete Shoreline Inventory for each locality, data from the inventory is being used to assess shoreline areas where the introduction of sediment from shoreline erosion is possible. Using data illustrated in plate “c”, Maryland is able to identify areas that have been stabilized versus those that are undefended. They are combining these data with computed shoreline erosion rates to determine the volume of sediment entering the system at points where the shoreline is unprotected.

This type of assessment would be very beneficial in Virginia and may assist in the water quality modeling efforts underway; especially those addressing suspended sediment loads. The

shoreline inventory provides a resource of relatively recent data that could assist in defining areas of high erosion, and potential high sediment loads (e.g. plate “b”). Waterways with extensive footage of eroding shorelines represent areas that should be flagged as hot spots for sediment input. The volume of sediment entering a system is generally estimated by multiplying the computed shoreline recession rate by the bank height along some distance alongshore. Estimated bank height is mapped along all surveyed shorelines in plate “b”. Banks designated as “eroding” and in excess of 30 feet 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 shoreline Table 4 quantifies the linear extent of high, eroding banks on a tributary by tributary basis. Using the GIS data site-specific calculations can be made.

3.5 Summary

These represent only a handful of uses for the Shoreline Inventory data. Users are encouraged to consider merging these data with other local or regional datasets. Now that most agencies and localities have access to some GIS capabilities, the uses for the data are even greater. While the conditions mapped represent a snap shot in time, CCRM hopes to update these on a regular basis. Unfortunately, this goal is hindered by an absence of recent funds available for data collection. The program continues to seek resources and will modify goals and objectives as necessary.

As new issues emerge for coastal managers, and technology improves, the development of the current Chesapeake Bay Shoreline Inventory Report series will evolve to reflect these changes.

Chapter 4. The Shoreline Inventory for Fairfax County and the City of Alexandria

Shoreline condition is described for Fairfax County and the City of Alexandria and along primary and secondary shoreline. Characteristics are described for all navigable tidal waterways contiguous to these shorelines. A total of 98.87 miles of the total 120.38 miles of shoreline are described. Less than 30 miles (28.39 miles) were coded remotely

Shoreline Inventory Reports are only available electronically. From this website: http://ccrm.vims.edu/gis_data_maps/shoreline_inventories/index.html users can access digital maps, tables, reports, GIS data, and metadata. The website is organized to encourage users to navigate through a series of informational pages before downloading the data. A map of the Chesapeake Bay region depicting counties and cities is shown (Figure 1). Scroll over the County/City name to link to the completed inventory. There is a list of completed inventories by state below the map. Click on "Fairfax County and the City of Alexandria" to access the information available.

From Fairfax County and the City of Alexandria Shoreline Inventory homepage, the user will be presented with a project review and disclaimer explaining data use limitations. The link to "maps" will take you to an index page illustrating the plate boundaries (Figure 2). The index map illustrates the distribution of plates geographically. This is useful if you are interested in a specific area. There are generally 5 links at the bottom of the disclaimer page. These links are self-explanatory.

Once you determine which plate you want, the scroll down menu on the left has links to the four part series for each plate (Figure 5). At the top of the scroll bar Riparian Land Use (plate a) is first. You can scroll down to see links to maps illustrating Bank Conditions (plate b), Shoreline Features (plate c), and Natural Buffers (plate d). The content and details of the four part plate series was described in detail in Chapter 2. The actual map will come up when you click on the plate number. For example, Figure 6 is the riparian land use map for plate 7. Figure 7 is the map illustrating bank conditions for the same area. Figure 8 shows all the shoreline features for plate 7, and Figure 9 the natural buffers associated with that section.

For the 28.39 miles of remotely coded shoreline, an index is provided that identifies where these areas are (Figure 4). Along these areas, photo interpretation of the 2009 VBMP imagery occurred to detect land use, natural buffers, and shoreline structures where possible. Since most

shoreline that could not be accessed by boat occurs in well protected, low fetch environments, the remote coding assumes that upland banks are well protected by vegetation, and erosion is low. It is possible, however, for these banks to experience undercutting from tidal currents. This cannot 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.

You may open any and all plates in the series, but can view only one at a time in most browsers. Tools for zooming and panning should be on the tool bar. The maps can be printed at full resolution up to 11x17 color. Color printers are necessary.

Summary statistics for all data are reported in tables accessed through the “Tables” button on the inventory project page. The summary statistics are reported by watershed shown in Figure 3.

The link to the GIS data is found on the project page as well. Files are compressed and easily downloaded. The metadata is a separate link that can also be downloaded. Users are encouraged to read the metadata carefully as well as all other information in the disclaimer.

View "Riparian Land Use", "Bank Conditions ", "Shoreline Features" or "Natural Buffers" for the area of interest by clicking on the corresponding plate. See the index map to the right for plate boundaries.

Riparian Land Use

Plate 1
Plate 2
Plate 3
Plate 4
Plate 5
Plate 6
Plate 7
Plate 8
Plate 9
Plate 10
Plate 11
Plate 12
Plate 13
Plate 14
Plate 15

Figure 5. Scroll down menu for plates

Figure 6. Sample riparian land use map for Fairfax County and the City of Alexandria

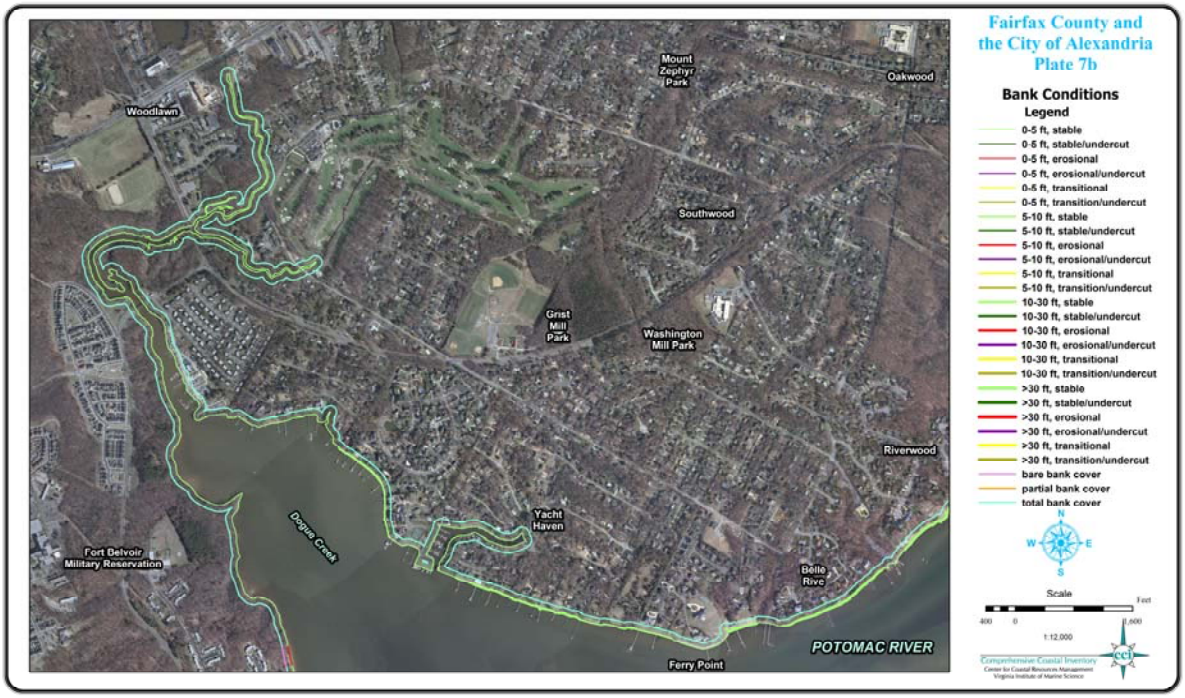

Figure 7. Map illustrating bank conditions for plate 7

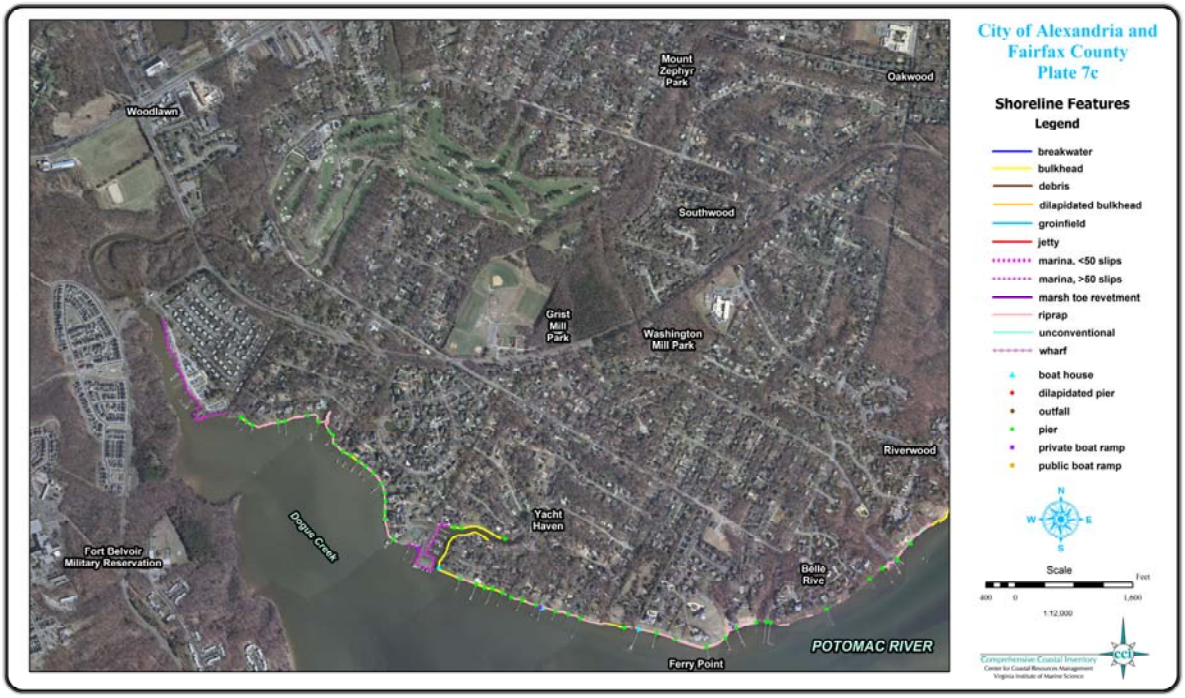

Figure 8. Map illustrating shoreline features for plate 7

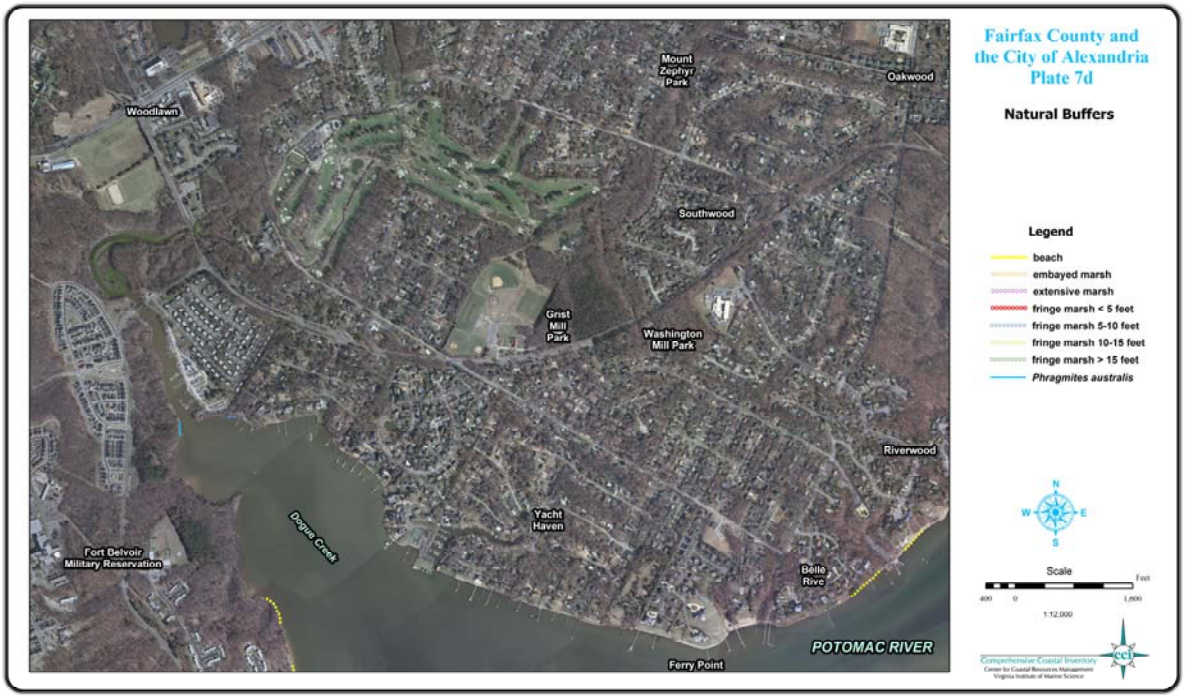

Figure 9. Map illustrating natural buffers for plate 7

Glossary of Shoreline Features Defined

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

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

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

Boathouse - 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 that offer only overhead protection. Since nearly all boathouses have adjoining piers, piers are not surveyed separately, but are assumed. Boathouses 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. Private and public ramps are denoted where possible. Private ramps are illustrated as purple squares. Orange squares represent public ramps. The location of these ramps was determined from static 6 second GPS observations.

Breakwaters - Breakwaters are structures that 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 that 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 that may accumulate behind the structures can be. In this survey, individual breakwaters are not mapped. The first and last breakwater in the series is surveyed as a six-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.

For a variety of environmental reasons, bulkheads are not a desirable alternative for shoreline protection. Nevertheless they are still very common along residential and commercially developed shoreline. From aerial photography, long stretches of bulkheaded shoreline may be observed as an unnaturally straight or angular coast. In this inventory, bulkheads are mapped using kinematic GPS techniques. The data are displayed as linear features on the maps.

Commercial - Commercial zones include small commercial operations as well as parks or campgrounds. 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 - Grasslands 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. We assume those in between are evenly spaced. On the map composition, the groin field is designated as a linear feature extending along the shore.

Industrial - Industrial operations are larger commercial businesses.

Marina - Marinas are denoted as line features in this survey. They are a collection of docks and wharfs that 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. However, if a boat ramp is present it will be surveyed separately and coded as private. 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. The survey estimates the number of slips within the marina and classifies marinas as those with less than 50 slips and those with more than 50 slips.

Marshes - Marshes can be extensive, embayed or fringe marshes. Extensive marshes generally occupy significant acreage. Embayed marshes are similar to pocket or headwater marshes and are often fill and surround headwater areas. Fringe marshes are narrow strips of marsh vegetation that extend along the shoreline. In all cases, vegetation must be relatively well established, although not necessarily healthy.

Marsh toe revetment – A marsh toe revetment is a low profile revetment, typically constructed of stone, placed along the eroding edge of an existing tidal marsh. The structure may include tidal openings to allow for the easy exchange of free swimming organisms during tidal cycles.

Military – location of federal military reservations

Miscellaneous - Miscellaneous features represent segments along the shore where unconventional material or debris has been placed dumped to protect a section of shore. Miscellaneous can include tires, bricks, broken concrete rubble, and railroad ties as examples.

Paved - Paved areas represent roads which run along the shore and generally are located at the top of the banks. Paved also includes parking areas such as parking at boat landing, or commercial facilities.

Phragmites australis - a non-native, invasive wetland plant known to thrive in areas that have experienced disturbance. The plant is prolific and is known to out complete native species. Various types of eradication methods have been used to stop the growth of this plant.

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. 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 marsh toe protection. This inventory does not distinguish among the various types of revetments.

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 are usually dominated by shrubs and bushy plants.

Tree Canopy - When the forest cover or the tree fringe (see below) appears to overhang the bank a canopy is formed that provides shading and sometimes cooling of the bank and shallow nearshore.

Tree Fringe - When the dominant riparian land use is not forested but a line of trees is maintained along the bank edge, the land use is noted to include a tree fringe.

References

Berman, M.R., and C.H. Hershner, 1999. Guidelines for Developing Shorelines Situation Reports Establishing Protocols for Data Collection and Dissemination, final report to US EPA Region III, Wetlands Development Grant Program.

Byrne, R.J. and G.L. Anderson, 1983. Shoreline Erosion in Tidewater Virginia. Special Report in Applied Marine Science and Ocean Engineering No. 111, Virginia Institute of Marine Science, Gloucester Point, VA, 102 pp.

City of Alexandria Virginia - Community Profile. 10 pp. http://www.alexecon.org/uploadedFiles/AEDP-wwwroot/AboutAEDP/AlexandriaCommunityProfileVEDP.pdf

City of Alexandria, Virginia – Home Page – Environmental Quality. Watershed Management.

Fairfax County Comprehensive Plan, 2007 Edition. Policy Plan Preface, Amended through 5-11-2010.

Hardaway, C.S., Thomas, G.R., Glover, J.B., Smithson, J.B., Berman, M.R., and A.K. Kenne, 1992. Bank Erosion Study. Special Report in Applied Marine Science and Ocean Engineering No. 319, Virginia Institute of Marine Science, School of Marine Science, College of William and Mary, Gloucester Point, VA, 73 pp.

Hobbs, C.H., III, Owen, D.W., and L.C. Morgan, 1979. Summary of Shoreline Situation Reports for Virginia's Tidewater Localities. Special Report in Applied Marine Science and Ocean Engineering No. 209, Virginia Institute of Marine Science, Gloucester Point, VA, 32 pp.

Ibison, N.A., Baumer, J.C., Hill, C.L., Burger, N.H., and J.E. Frye, 1992. Eroding bank nutrient verification study for the lower Mathews Bay. Department of Conservation and Recreation, Division of Soil and Water Conservation, Shoreline Programs Bureau, Gloucester Point, VA.

Tippett, J., Sharp, E., Berman, M., Havens, K., Dewing, S., Glover, J., Rudnicky, T., and C. Hershner, 2000. Rapidan River Watershed - Riparian Restoration Assessment, final report to the Mathews Bay Restoration Fund through the Center for Coastal Management and Policy, Virginia Institute of Marine Science, College of William and Mary.