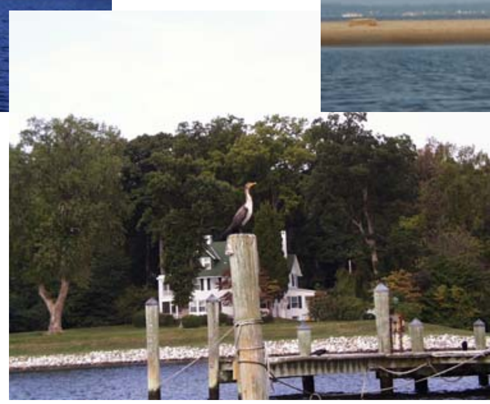
Development of the Maryland Shoreline Inventory Methods and Guidelines for Anne Arundel County



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Executive Summary

The Comprehensive Shoreline Inventory for Maryland surveys and maps shoreline condition along all tidal waters in the state. A protocol for data collection, analysis, and illustration was developed by the Comprehensive Coastal Inventory Program (CCI) at the Virginia Institute of Marine Science (VIMS) for use in Virginia. This same protocol is being followed in Maryland.

The statewide shoreline inventory was accomplished in a series of phases over four years beginning in 2002. Tidal shoreline was digitally generated from digital ortho-imagery (DOQQs) for all tidal localities in Maryland. Shorelines have been surveyed using Global Positioning Systems (GPS) following protocols developed by CCI.. Handheld GPS units log conditions observed from a shoal draft boat moving along the shoreline. Riparian land use, bank characteristics, shoreline modifications, shoreline habitat, and bank and shoreline stability are classified.

All shoreline data collected in the field are processed using GIS techniques and corrected to the shoreline basemap developed from DOQQs. Frequency analyses are run to compute distribution of features and conditions surveyed.

Following a rigorous series of quality control measures, final maps are developed to illustrate shoreline conditions for the locality. A three part plate series uses a combination of colors and symbols to depict riparian land use, bank condition, and shoreline features. Tables report cumulative conditions for each plate or each major tributary. Final report, maps, and processed GIS data are available on a website http://ccrm.vims.edu/disclaimer_shoreline_situation.html.

Chapter 1. Introduction

1.1 The Shoreline Situation Reports are a desktop reference designed to assist with management and planning of tidal shorelines. They provide extensive data pertaining to waterfront condition and use. The reports target state and local government officials responsible for structuring activities along the shore. This includes local planners developing comprehensive plans for waterfront development and conservation, managers evaluating status and trends in shoreline condition, and environmental protection agents who regulate or monitor activities along the shore. The data applications are numerous.

Methods and approaches applied in the shoreline classification system are derived from a parallel effort in Virginia (Berman and Hershner, 1999). Both efforts are directed by the Comprehensive Coastal Inventory Program (CCI), a GIS and remote sensing program within the Center for Coastal Resources Management (CCRM) at the Virginia Institute of Marine Sciences (VIMS). The Maryland Shoreline Inventory extends coverage of shoreline condition from Virginia through Maryland. Therefore the project assists to complete a shoreline evaluation along the entire tidal portion of the Chesapeake Bay applying a single classification system. This has enormous value for comparing trends in riparian land use and condition throughout the Bay.

The development of the Maryland Shoreline Inventory was accomplished in a series of phases over a period of 3 years. The inventory compiles information on a county-by-county basis and generates individual county reports knows as Shoreline Situation Reports. These reports are electronic and are being released to provide users access to maps, tables, and GIS data. The report focuses on the classification and the methodology for generating, processing and reporting data. All information can be downloaded from this website: http://ccrm.vims.edu/disclaimer_shoreline_situation.html.

1.2 Purpose and Goals

This shoreline inventory compiles field data collected along tidal shoreline in Anne Arundel County between September, 2002 and May, 2005. Conditions are reported for three zones within the immediate riparian river area: riparian land use, bank and natural buffers, and shoreline. A series of maps and tabular data are published digitally to illustrate and quantify results of this extensive shoreline survey. All navigable streams and tributaries were surveyed.

1.3 Report Organization

This report is divided into several sections. Chapter 2 describes methods used to develop this inventory, and includes conditions and attributes considered in the survey. Chapter 3 identifies potential applications for the data, with a focus on current management issues. Digital maps, tables, GIS coverages, and metadata are available on the web at http://ccrm.vims.edu/disclaimer_shoreline_situation.html.

1.4 Acknowledgments

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This work was completed entirely with staff support and management from the Virginia Institute of Marine Science's (VIMS) 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, and the VIMS Publication Center for their support.

1.5 The Locality

Anne Arundel County lies nearly in the center of the State of Maryland and is located on the western shore of the Chesapeake Bay. The county is bordered by Baltimore County and the City of Baltimore to the north, Prince George's County to the west, Howard County to the northwest, Calvert County to the south and the Chesapeake Bay to the east.

Anne Arundel County is mostly coastal plain, interlaced with hundreds of miles of shoreline on the rivers and tributaries of the Chesapeake Bay. It has more coastlines on the Chesapeake Bay than any other part of Maryland. According to the U.S. Census Bureau, the county has a total area of 588 square miles; 416 square miles of land and 172 square miles of water. The far northern part of the county is urban in Brooklyn Park, however most of the county is suburban except for a few rural regions in the far southern areas of the county. Even though the amount of farmland in Anne Arundel has continued to decline, the county has recently revised its farm and woodland preservation program in order to increase participation.

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 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 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; 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 eleven classes (Table 1). The categories provide a simple assessment of land use, and give rise to land management practices that may be anticipated. GPS is used to survey the linear distance 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.

Table 1. Tier One - Riparian Land Use Classes	
Forest	stands greater than 18 feet high / width greater than 30 feet
Scrub-shrub	stands less than 18 feet high
Grass	includes grass fields, and pasture land
Agriculture	includes cropland
Residential	includes single or multi family dwellings
Commercial	includes 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
Unknown	land use undetectable from the vessel

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 four major bank characteristics: bank height, bank cover, bank stability, and the presence of 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.

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 riprap is considered as cover. The assessment is qualitative (Table 2). Bank stability characterizes the condition of the bank face. Banks designated high erosion, have exposed root systems, down vegetation, or exhibit slumping of material. Undercut banks show erosion at base of the bank but are otherwise stable on the bank face. 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. Depending on time of tide during the survey, it is sometimes difficult to assess the true condition of the marsh.

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
	10-30ft	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 or toe
	high erosion	includes slumping, scarps, exposed roots
	undercut	erosion at the base of the bank
bank cover	bare	<25% cover; vegetation or structural cover
	partial	25-75% cover; vegetation or structural
	total	>75% cover; vegetation or structural
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
Phragmites australis	no	no *Phragmites australis* present on site
	yes	*Phragmites australis* present on site

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, constructed to protect the shoreline from erosion; offense structures, designed to accumulate sand in transport; and recreational structures, built to enhance public or private use of the water. The location of these features along the shore is 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 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 functional utility along a shore.

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	
debris	L	can include tires, rubble, tubes, etc.
unconventional	L	constructed with non-traditional material
Recreational Structures		
pier/wharf	P	includes private and public
boat ramp	P	distinguishes private vs. public landings
boat house	P	all covered structures, assumes a pier
marina	L	includes piers, bulkheads, wharfs

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 or GeoExplorer XT GPS unit. GeoExplorers are accurate to within 4 inches of true position with extended observations, and differential correction. 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 - 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 individual 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 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 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 Annapolis, Maryland was used for most of the data processing in Anne Arundel County.

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 CCI are 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 ArcInfo® shape files. These are converted into three coverages: a land use and bank condition coverage (annar_lubc), a shoreline structure coverage (lines only) (annar_sstru), and a shoreline structure coverage (points only) (annar_astru).

<u>2.4b. GIS Processing</u>: GIS processing includes two major steps. They use ESRI's ArcInfo® GIS software, and ERDAS' Imagine® software. Several data sets are integrated to develop the final inventory products. The processing is intended to correct the new GIS coverages so they reflect conditions at the shoreline, and not along the boat track. All attributes summarized in Tables 1, 2, and 3 are included.

Step one generates a digital shoreline coverage to use as a base map. A new digital shoreline record was generated using photo-interpretation techniques and Digital Ortho Quarter Quadrangles (DOQQs) flown from 1989 to 1995. The shoreline coverage is generated by interpreting the land water interface observed on the DOQQ. While this process does not attempt to re-compute 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 DOQQ is displayed onscreen, and an operator digitizes the land water interface using photo-interpretation techniques. This new base map does not represent a tidally corrected shoreline like other available datasets, however, the improved accuracy of the land water interface justifies the integration of this product for this project.

GIS processing corrects the coverages generated from the GPS field data to the shoreline record. When first converted from the GPS files, the coverages are geographically coincident with the boat track; from where observations are made. They are, therefore, located somewhere in the waterway. The first processing step 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 this step, which uses all three data sets simultaneously. The shoreline record and the processed GPS field data are displayed onscreen at the same time as GIS coverages. The DOQQ imagery is used in the background for reference. With the shoreline as the base map coverage, the remaining processing re-codes the 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 ArcMap 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. Quality control and assurance measures require each coverage checked twice onscreen by different GIS personnel. Draft hardcopy maps are printed and reviewed as the last QA/QC steps.

2.4c. Photo interpreted shoreline conditions: Remote sensing techniques are applied to some areas where navigation was prohibited due to water depth, obstructions, weather, or tide. DOQQs provide the remote sensing platform for the data interpretation. The resolution and scale of this product poses some limitations to what can be synthesized. The product is also more than 10 years old and therefore, may not reflect conditions present today. Using remote interpretation, does, however, establish the framework and baseline for use in future data collection.

Land use can be interpreted with a high degree of confidence. The imagery is also very good for identifying piers, breakwaters, and groinfields. Occasionally bulkheading can be seen because of the straight unnatural geometry of the shoreline. This is not always clear with riprap construction.

The imagery is not good for determining features describing the bank. Since the image is vertical and not oblique, conditions along the bank cannot be observed. Sometimes bank height is assumed based on surrounding conditions that have been surveyed. Other times a topographic map is consulted. Assumptions are made about bank stability. Shoreline exposed to long fetches may be assumed “erosional”. If adjacent areas surveyed are erosional, the shoreline may be coded as erosional as well.

Natural buffers can sometimes be captured in DOQQ imagery. This depends on the width of the buffer. Wide sandy beaches and fringe marshes can frequently be delineated. A strand plain beach or narrow fringe marshes are most likely missed. Since species identification is impossible with this imagery, no attempt to classify Phragmites *australis* is made.

The Carris Creek, Broadwater Creek and part of the Parker Creek were surveyed using these remote sensing techniques. The shallow water depth of these creeks made impossible the access to these parts of the shoreline by boat. On a plate by plate basis, Table 6 reports the number of shoreline miles analyzed using remote sensing interpretation.

2.4c.) Maps and Tables: Maps and tables can be viewed or downloaded as .pdf files. A color printer is required on the user end. 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. The background imagery is the natural color DOQQ published at a scale of 1:12,000. Users should note that the imagery is sometimes rotated in order to meet the scale requirements. This means that “north” is not always to the top of the page.

Plate B illustrates bank condition and any natural buffers present. Four lines, and a combination of color and patterns are used to depict bank and natural buffer information. The line furthest inland describes the bank cover. Bank cover is distinguished by colors. Bare banks (<25% cover) are illustrated in pink, partial cover (25-75%) is an orange line, and total cover (>75%) is indicated by a light blue line. Colors may vary with different printers. Moving toward the water, the next line represents bank height and stability. Bank height varies with the thickness of the line; where the thickest lines designate the highest banks (> 30 feet), and the thinnest line indicates the bank is between 0 and 5 feet high. A red line indicates the bank is unstable, a green line indicates stability, and a yellow line indicates the bank is undercut. If present a darker blue line will delineate the occurrence of *Phragmites australis.* A pattern of small circles just channel ward of the shoreline delineates the presence of natural buffers. Open circles represent 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. If the buffer exhibits erosion the circles will be red, and green if the buffer is stable. As conditions change, the symbology changes. Plate B uses a gray scale version of the DOQQ image for the backdrop.

Plate C combines recreational and shoreline protection structures in a composition called Shoreline Features. Linear features, described previously in Table 3, are mapped using color coded bars that follow the orientation of the shoreline. Point features use a combination of colors and symbols to plot the positions on the map. Grey scale DOQQ imagery is used as a backdrop, and all shoreline feature data are superimposed.

For publication purposes the county is divided into a series of plates. Plates are scaled at 1:12,000 for publication at 11x17. Scale will vary if printed at a different size. The number of plates is determined by the geographic size and shape of Anne Arundel County. The county was divided into 52 plates (plate 1a, 1b, 1c, etc.), for a total of 156 map compositions. On the website, an index is provided to help users locate the area of interest. Each plate can be individually selected and viewed from the plate list along the left hand column of the index page.

Table 4 and 5 quantify attributes mapped along the rivers using frequency analysis techniques in ArcMap. The values quantify these attributes on a plate-by-plate basis. For linear features, values are reported in actual miles surveyed. The number of point features surveyed is also listed on a plate-by-plate basis. The total miles of shoreline surveyed for each plate is reported. A total of 463.71 miles were surveyed in the field. The county may have significantly more shoreline, however, these shoreline segments could not be reached by small boat, constituted military areas, or represented large expansive wildlife areas. Since there is plate overlap, total survey miles cannot be reached by adding the total shoreline miles for each plate. The last row of Tables 4 and 5 reports the total shoreline miles surveyed for the county (471.15 miles), and the total amount of each feature surveyed along the measured shoreline. Table 6 reports distribution of *Phragmites australis.*

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 several high profile issues within the Chesapeake Bay watershed. The SSRs 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 SSRs can be analyzed 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 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, and determining future uses of the shore. The SSRs provide data for such assessments.

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 SSR 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. Local governments can do some enhanced and proactive planning if resources allow and the SSR data is readily available. 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 plate "b". 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 fully covered, and 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 (< 5feet) is 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 that indicates the qualitative erosion assessment made during the survey.

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. The structure may actually be enhancing erosion at the base of the structure due to scour and wave reflection. 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 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.

Grassland and agricultural land, which includes pastureland 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 Plate B, 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.

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.

Plate "b" 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 in the vicinity as an indicator. 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.

As water quality programs move into implementation phases the importance of shoreline erosion in the 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. Already in Maryland, data from the inventory is being used to assess shoreline areas where the introduction of sediment from shoreline erosion in possible. Using data illustrated in plate "c", Maryland is able to identify areas that have been stabilized versus those that are undefended. . The state is combining these data with computed shoreline erosion rates to estimate the volume of sediment entering the system at points where the shoreline is unprotected.

The SSR provide 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 shoreline 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 plate by plate basis.

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 many 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, they provide an important spatial and temporal frame of reference. Future surveys could be undertaken to evaluate status and trends and compute changes in important baseline statistics such as sediment loads, miles of shoreline hardened, dock density. Updated surveys can also support tracking conditions that reflect permitted activities along the shoreline.   As new issues emerge for coastal managers, and technology improves, the development of new inventories in the future will evolve to reflect these changes.

Chapter 4. The Shoreline Situation

The shoreline situation is described for conditions in Anne Arundel County along primary and secondary shoreline. Characteristics are described for all navigable tidal waterways contiguous to these shorelines. A total of 471.15 miles of shoreline are described.

Shoreline Situation Reports are only available electronically. From this website: http://ccrm.vims.edu/disclaimer_shoreline_situation.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 Virginia and Maryland highlights each county with a completed inventory (Figure 1). Click on "Anne Arundel County" to access all the information available.

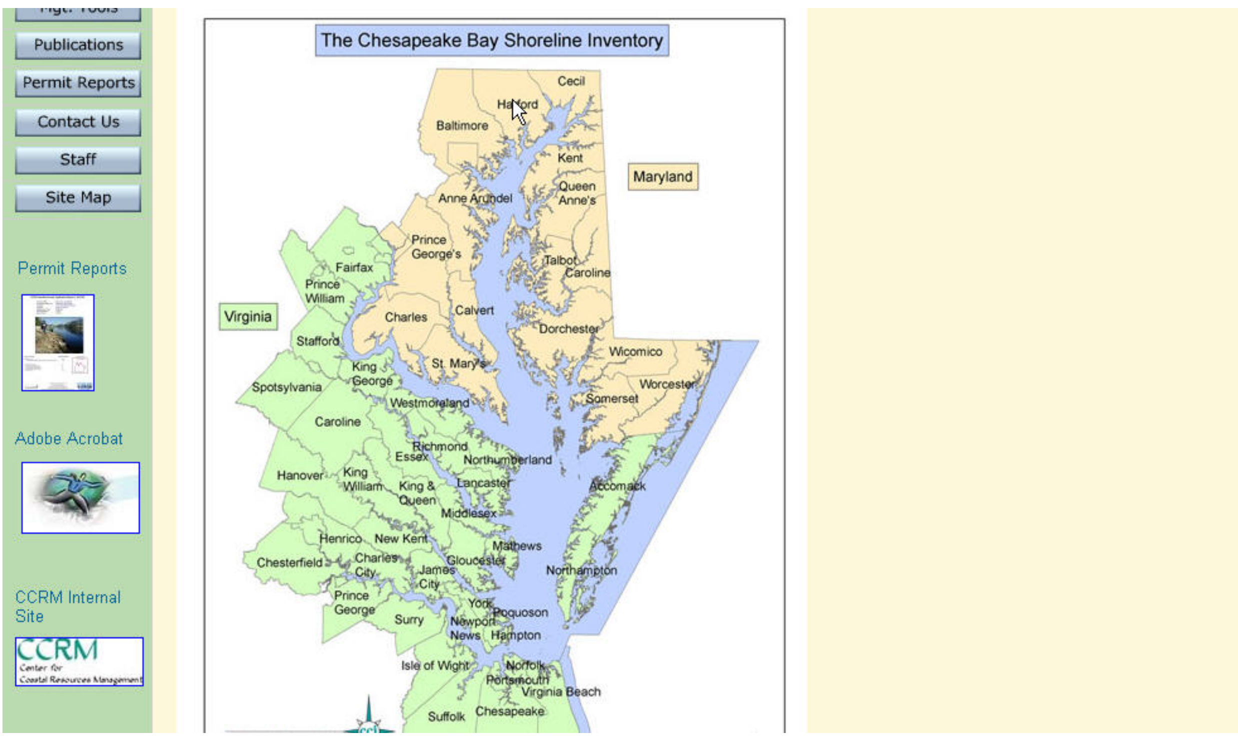

Figure 1. Shoreline (Inventory) Situation Report Website

From the page above, the user will be linked to a project review and disclaimer page where basic project and data use limitations are presented. There are 6 links at the bottom of the disclaimer page. The links are self-explanatory. The link to maps will take you to an index page illustrating the plate boundaries (Figure 2). This is useful if you are interested in a specific area. When you click on "Maps" the county index page will appear. The index illustrates the distribution of plates geographically.

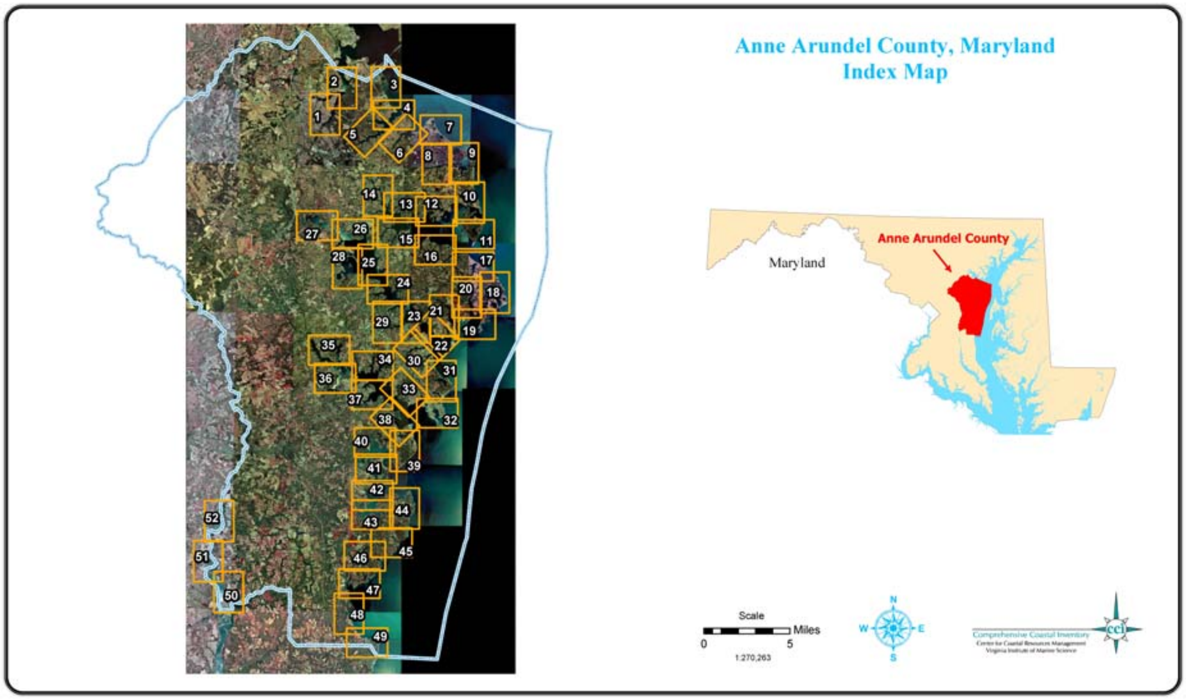

Figure 2. Map index for Anne Arundel County

Once you determine which plate you want, the scroll down menu on the left has links to the three part series for each plate. Riparian Land Use is first (Figure 3). You can scroll down to see the link to Bank and Buffer conditions and Shoreline Features. The content and details of the three 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 4 is the riparian land use map for plate 10. Figure 5 is the map illustrating Bank and Buffer conditions for plate 10, and Figure 6 shows all the shoreline features for that same area. You may open all three plates for 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 (see link on the project disclaimer page).

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

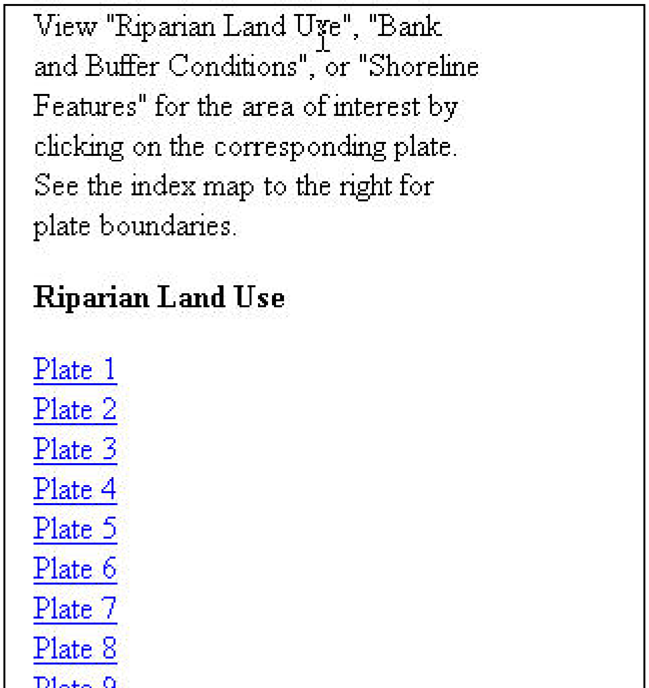

Figure 3. Sample scroll down menu for plate

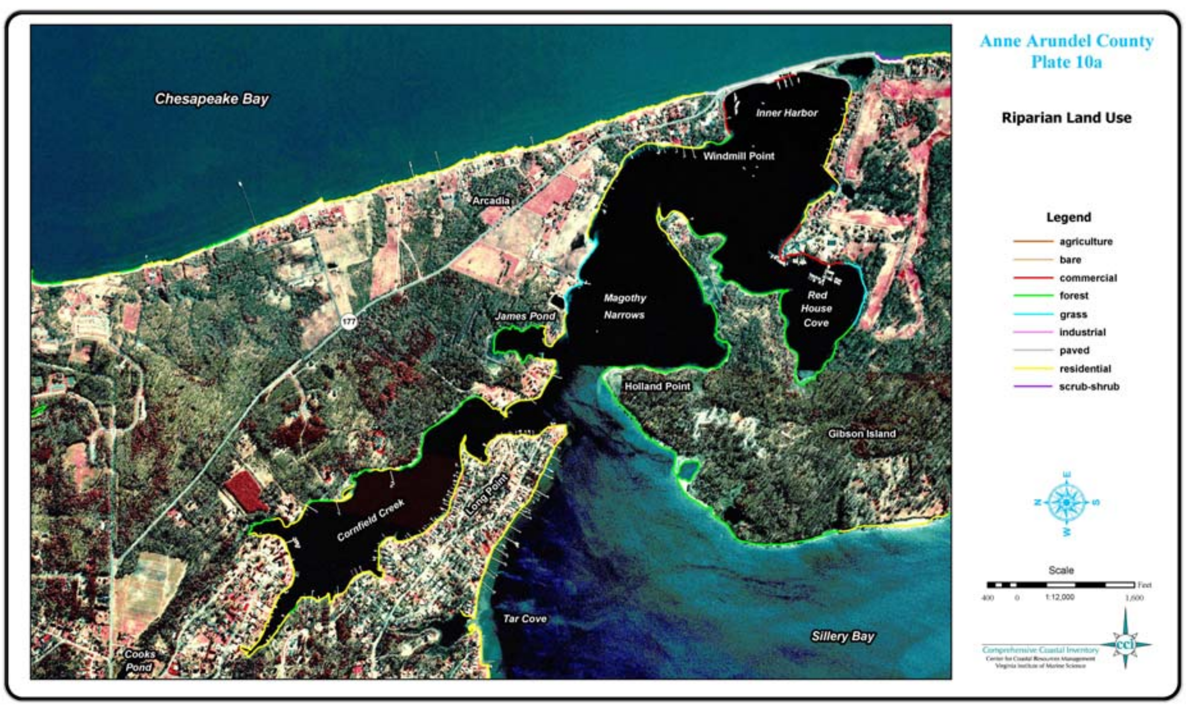

Figure 4. Riparian Land Use map for plate 10 in Anne Arundel County.

Figure 5. Map illustrating bank and buffer conditions for plate 10 in Anne Arundel County

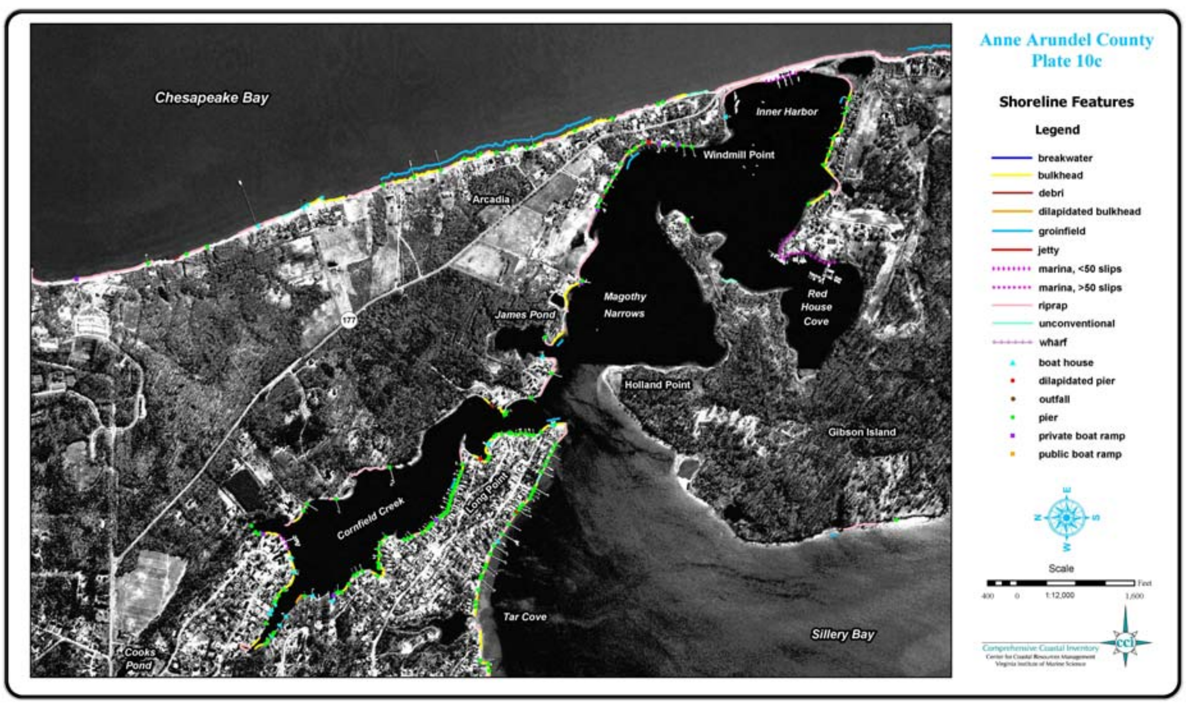

Figure 6. Map illustrating shoreline features for plate 10 in Anne Arundel County

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. 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 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 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 as well as parks or campgrounds. These operations are not necessarily water dependent businesses.

Debris* – Shoreline protection using miscellaneous rubble in a haphazard manner is considered debris. Material could include junk tires, bricks, or randomly placed concrete block.

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.

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. 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.

Industrial - Industrial operations are larger commercial businesses.

Marina – By definition marinas are a collection of docks and wharfs generally forming slips that provide a resting place for boats. Electrical and water services are provided at the dock. Marinas encompass a broad range of shoreline structures that can extend along an appreciable length of shore. Frequently they are associated with extensive bulkheading in addition to the docks and pilings. This inventory does not delineate all internal structures associated with a marina. They are mapped as a single line feature under shoreline features.

Marinas are generally commercial operations, however 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.

Paved - Paved areas represent roads that 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.
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 that can 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.

Unconventional*: Structures designated “unconventional” represent shoreline protection structures that have been carefully planned and installed, but may be constructed of unconventional materials. They should not be confused with debris.

* Shoreline surveys collected in the early phases of this project included a structure class called “miscellaneous”. Miscellaneous structures included debri and unconventional designs using non-traditional materials. Later surveys replaced the “miscellaneous” class with “debri” and “unconventional”.

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