Priority Areas for Wetland Restoration, Preservation, and Mitigation in Maryland's Coastal Bays

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EXECUTIVE SUMMARY

Background

Maryland's Coastal Bays consist of five small watersheds that drain into the Atlantic Ocean, without draining first into the Chesapeake Bay. The Coastal Bays contain habitat for threatened and endangered species, migratory birds, and fin and shellfish resources important for commercial and recreational use. Some relatively large forest and wetland areas still remain. However, agriculture is currently contributing large amount of nutrients to the ecosystem and the region is under intense development pressure, primarily in the northern region. Major environmental problems that have been identified include: degraded water quality, chemical contamination, habitat loss, changes in living resources, and unsustainable growth and development. In order to address these issues, the Maryland Coastal Bays Program adopted a plan: *Today's Treasures for Tomorrow: A Comprehensive Conservation and Management Plan for Maryland's Coastal Bays* (CCMP) in 1999.

The CCMP notes that approximately 1,500 acres of tidal wetlands and 25,000 acres of non-tidal wetlands have been lost since the 1930's. Bulkheads installed for stabilization led to some loss of tidal wetlands. These wetland losses also resulted in habitat loss and reduction in nutrient and sediment filtration.

The Coastal Bays Management Conference was formed to recommend strategies to protect and enhance the Coastal Bays. The Management Conference included representatives from all levels of government, business, and private interests. The CCMP listed several specific goals and challenges for which the Department of the Environment (MDE) and other partner agencies are responsible.

Challenge: Conservation of wetland resources (FW3.1 in CCMP)

"Protect existing and new wetlands and increase the amount of wetlands by 10,000 acres in order to improve water quality, replace lost function of wetlands, and improve habitat for living resources." An action to achieve this solution is to target wetland restoration and creation to where historic losses have occurred and encourage creation of wetlands for water quality improvement and wildlife habitat.

Challenge: Facilitate Wetlands Mitigation (FW 3.3 in CCMP)

The Coastal Bays watershed exceeds other watersheds in non-tidal wetland losses since the State regulatory program began in 1991. While losses of non-tidal wetlands through 2002 were relatively low (70.8 acres) compared to historic losses, there is still a net loss of wetlands due to lack of mitigation projects. By the end of 2002, there was a net loss of nearly 14 acres. This is due to the many small projects being authorized, usually single family houses in older subdivisions. The State has been unsuccessful to date in obtaining mitigation areas of an adequate size to compensate for future losses over the next decade. This is largely due to the shortage of State employees needed to locate restoration sites and oversee mitigation projects, as well as the high cost of land and logistics of site acquisition. The CCMP recommends a private/public mitigation program to create suitable mitigation sites.

The purpose of this report is to prepare background information and recommendations to meet these challenges of wetland protection, restoration and mitigation. While future losses of wetlands are expected from regulated activities, there are numerous wetlands remaining and many potential restoration sites. Growth pressure, increased land cost, and agricultural land preservation goals are factors which may limit the availability and opportunity to secure sites for restoration, protection, or mitigation. In order to best meet the challenge of wetland protection, restoration, and mitigation, it is necessary to identify the priority areas that will best meet these goals while supporting other management needs. This plan may be used to direct interested parties to areas that may provide sites for potentially high-functioning restored wetlands or especially valuable wetlands in need of protection. The priority sites are also evaluated as a targeted approach to mitigation by the State and permittees.

MDE has combined some of the past Coastal Bays targeting efforts, general and specific targeting recommendations from other documents, and our own priorities to develop the wetland targeting plan for the region. We hope to locate areas that may provide the highest amount of wetland function. This plan attempts to find general areas for wetland restoration and preservation based mainly on available desktop data and past studies. This plan may be used to direct interested parties to areas that may provide sites for potentially high-functioning restored wetlands or especially valuable wetlands in need of protection.

Methods

Various sources of restoration information, protection goals, and new analysis have been consolidated using GIS and office information to prepare a set of comprehensive recommendations. Key GIS information included soils, Green Infrastructure, water quality, Rural Legacy, ecologically important areas, Stream Corridor Assessment and zoning. The targeting approach reflected the recognized need for water quality and habitat improvement. We sought areas on which wetlands could easily be re-established without harm to other resources, and that would provide the greatest functional benefit in comparison with other locations. Management recommendations from existing sources such as the Coastal Bays Management Plan, Worcester County Comprehensive Plan, Isle of Wight/Newport/Sinepuxent Watershed Restoration Action Strategies, and Coastal Bays Sensitive Resources Report, were also considered in this targeting project to meet the goals of stakeholders for condition of the Coastal Bays watershed. Results of past functional assessments, such as the State Highway Administration study for the Rte. 113 corridor, and a U.S. Fish and Wildlife Service report of a GIS-based functional assessment, were also considered.

New analysis was conducted by MDE to identify the highest priority sites for restoration, using existing recommendations as well as previously unconsidered factors. The analysis confirmed that wetland establishment is possible in nearly every part of the watershed, though the amount of work needed to create the proper condition varies. In addition, all parts of the watershed would benefit from wetlands providing water quality improvement, so locating sites based on poor water quality was less a factor than anticipated. Stream benthic scores were also generally poor or very poor and were less of a discriminating factor in prioritizing sites. However, Isle of Wight, Newport, and Assawoman Bays generally had worse water quality then Chincoteague and Sinepuxent Bays, and more priority wetland restoration areas are identified in these three northern bays. Certain factors were also used to eliminate potential sites. No new wetlands were recommended in wellhead protection areas, in which the wetland construction might reduce the natural infiltration capability of soils to remove pollutants before reaching drinking water sources. Areas of prime farmland were also eliminated from consideration. Preference was given to soils with naturally high organic matter content, since this is linked to greater ability to remove and/or alter nutrients or pollutants. Forested areas were not considered a top priority, however, MDE recognizes that many remaining forested wetlands have been altered by drainage, and thus may be good candidates for enhancement. Presence within the Green Infrastructure was also given weight in setting priorities. The analysis also considered logistical factors in prioritizing wetland sites. Sites on large parcels with development restrictions, zoned resource conservation, agriculture, or estate, were considered the most likely to have landowners willing/able to consider a moderate-sized restoration on their property.

In preparation for the wetland preservation section of this report, MDE contracted with the Maryland Department of Natural Resources (MDNR) to develop management recommendations for designated Nontidal Wetlands of Special State Concern. These are wetlands of exceptional ecological or educational value, listed in state regulation, usually with threatened or endangered species or unique community types. Results of this study are also included in the Sensitive Resources section. Other wetlands that are not currently designated as Nontidal Wetlands of Special State Concern, but that may quality for the designation, are also listed. Wetland preservation was also considered in conjunction with other preservation targeting efforts, such as the Green Infrastructure Assessment and likelihood of future impacts. In addition to preservation of Nontidal Wetlands of Special State Concern, large remaining areas of wetlands, and connecting corridors, are recommended as high priorities for wetland preservation.

Results

Restoration

In the Maryland Coastal Bays watershed, all potential wetland restoration and preservation projects supported by interested landowners should be considered and evaluated for meeting restoration goals. The criteria listed below were used to target locations where we recommend actively seeking restoration or preservation opportunities. Due to the conditions of this region, with little effort wetlands can be restored in almost any area having hydric soil. Our intent is to predict the areas where restored wetlands would provide the most beneficial functions.

Recommended restoration areas were sorted into two categories: Priority 1 and Priority 2. Priority 1 restoration areas had hydric soils that were very poorly drained and high organic matter content. Other screening criteria were a location within/adjacent to the Green Infrastructure network and zoning classification of resource conservation, agriculture, estate, and private or protected public land. Exclusionary criteria were sites on hydric soils that were prime farmland when drained, forested areas, existing wetlands areas, and wellhead protection areas. Adjacency to unbuffered streams, wetlands or other natural areas, pollution sources, poor water quality or farmed wetlands was also considered.

Priority 2 sites considered some of the same criteria and exclusions. Poorly drained soils were added as selection criteria. Existing drained forested wetlands and out-of-kind water quality improvement projects were also considered. Opportunities for establishing wetlands off line from Public Drainage Association ditches were considered in both Priority 1 and 2.

Preservation

There are also two rankings for priority preservation areas. Most of the Priority 1 preservation sites fall within Newport Bay and Chincoteague Bay. Only one site is within Isle of Wight (West Ocean City Pond) and none are within the Sinepuxent Bay or Assawoman Bay watersheds. All existing designated Nontidal Wetlands of Special State Concern, and potential Nontidal Wetlands of Special State Concern, are recommended as Priority 1 protection areas. Additional Priority 1 sites are all within or adjacent to designated Rural Legacy area or other protected land. Other considerations are as follows: wetlands within MDNR-designated Ecologically Significant Areas (ESA**)**, areas identified as being important in the Aquatic Sensitive Species Report, and areas within or adjacent to Green Infrastructure network. Priority 2 sites were those that met at least some of the Priority 1 criteria, or that were large wetland complexes, headwater wetlands, or restored Priority 1 wetlands.

Mitigation

Mitigation has been difficult to accomplish in the Coastal Bays for several reasons, including lack of staff, logistics, and costs of projects. In order to overcome these challenges, MDE will undertake several tasks, one being to form more partnerships. MDE has had initial discussions with Worcester County and the Corps of Engineers. Sites on larger parcels, such as estate or rural conservation zoning, may allow establishment of a wetland without sacrificing development opportunities and are recommended for targeting. MDE will also support mitigation requirements that are a combination of restoration, enhancement, preservation, or out-of-kind projects.

Appendix A – Background

Appendix A contains background information on the geology, soils, and physical processes, including erosion, that affect wetland formation, characteristics, and function. Ground water resources, aquifers, well locations, and recharge are described since these factors play a role in siting wetlands that will not adversely affect drinking water. Land use is also summarized.

A description of the types of tidal and nontidal wetlands in the watershed, with maps, is included. The extent of wetland acreage varies, depending on the reference or maps used, and several estimates are included here. Common plant species and typical functions, and functional assessment findings are also listed. Hydrology of different wetland types is illustrated. A table is provided showing estimated wetland losses. Designated Nontidal Wetlands of Special State Concern are described.

There are additional sections on extent of resources such as submerged aquatic vegetation, wildlife, rare, threatened and endangered species, fish and shellfish and forests.

Protected land, land noted in protection planning tools, and different protection mechanisms used in the Coastal Bays are described. These include agricultural land preservation programs, Rural Legacy, Green Infrastructure, and Greenways.

Stream assessments and other stream monitoring results from the Stream Corridor Assessments, Nutrient Synoptic Surveys, Maryland Biological Stream Survey, Stream Waders, and other agencies are summarized. Results include biological indicators and chemical measurements for various water quality parameters, including nutrient levels, chlorophyll a, and dissolved oxygen. Findings from mandatory reports, such as the 2002 Maryland Section 305(b) Water Quality Report, 303(d) List of Impaired Surface Waters, and Total Maximum Daily Loads are included and were considered in the restoration targeting. Pollution sources are described.

Appendix B – GIS Methods

Appendix B contains more details on the GIS methods employed in the prioritization results section.

This report also included a comprehensive bibliography.

TARGETING

Background

The Coastal Bays watershed in eastern Worcester County supports one of Maryland's most diverse ecosystems. Maryland's Coastal Bays consist of five bays and their corresponding watersheds, Assawoman, Isle of Wight, Newport, Sinepuxent, and Chincoteague, which have hydrologic exchange with the Atlantic Ocean through two inlets (Figure 1). These bays are enclosed by the coastal barriers, Fenwick and Assateague Islands, with ocean water entering the bays through the Ocean City inlet and the Chincoteague inlet in Virginia. The watershed for these bays encompasses 111,810 acres of land and 65,680 acres of open water within Maryland, in addition to smaller areas in Delaware and Virginia (USACE, 1998). According to the 2000 U.S. Census, the area immediately adjacent to Isle of Wight Bay and Assawoman Bay, including Ocean Pines and Fenwick Island (Ocean City), have the densest resident population (1,000-4999.9 people/mi^2) in the coastal bays (and the county). Berlin, while slightly lower density (200-999.9 people/mi^2), is also highly populated. Chincoteague Bay watershed is the least populated region in the coastal bays (<40 people/mi^2). Although this resident population is still fairly low overall, the county population is expected to double by the year 2020 (MCBP, 1999), with most of this increase being focused in the northern Coastal Bays region. These U.S. Census estimates do not take into account the high seasonal tourist population (roughly 12 million; MCBP, 1999).

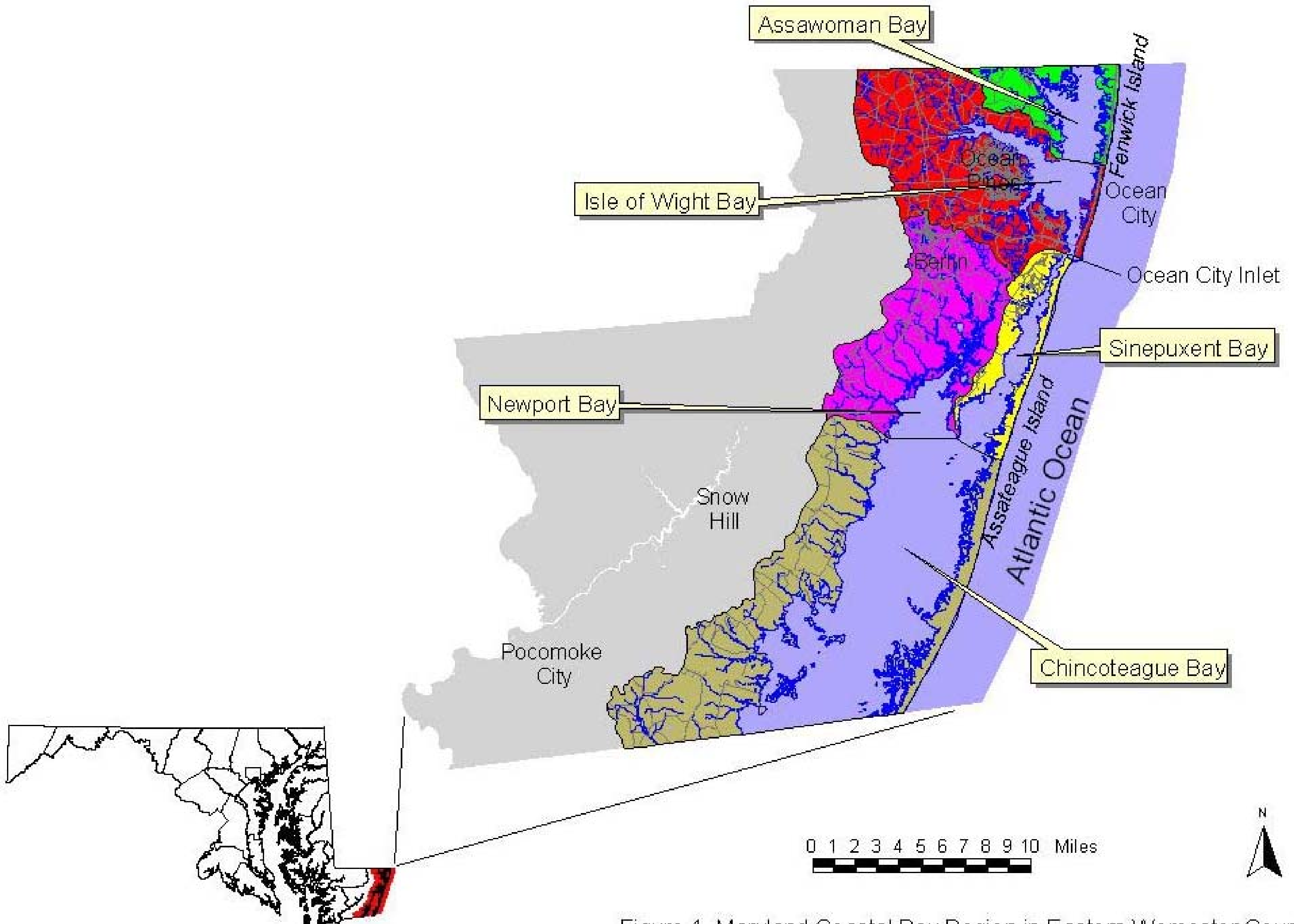


Figure 1. Maryland Coastal Bay Region in Eastern Worcester County.

Wetlands and wetland loss

Wetlands in the Coastal Bays

The natural physical condition of the Coastal Bays, including the low topographic relief (leading to sluggish drainage) and high water table, results in large amounts of wetlands (Figure 2). The U.S. Army Corp of Engineers defines wetlands as "Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas." The State of Maryland has a similar definition in its Nontidal Wetland Act and wetland regulations.

Tidal and nontidal wetlands

Tidal wetlands

Sipple (1999) presents a description of the tidal marshes and their formation in the Coastal Bays. Tidal wetland marshes in the Coastal Bays differ geomorphically from tidal wetlands in Chesapeake Bay. Coastal Bays wetlands were formed as the rate of sediment accretion surpassed that of sea level rise, and where tidal and storm derived sediments were deposited behind barrier islands. In contrast, tidal marshes in Chesapeake Bay were formed by more recent deposits of sediment in stream channels and estuarine meanders or sea level inundation of uplands. The tidal marshes also differ geomorphically within the Coastal Bays, between the wetlands adjacent to the mainland, and those wetlands on the west side of the barrier islands. The wetlands on the barrier islands have alternating layers of sand and peat, caused by the movement of the islands to "roll back and over" the back barrier environments (Sipple, 1999). Since neither flood-tidal inlet deposits nor overwash deposits occur anymore around the Fenwick barrier, marsh on the bayside of the barrier is no longer being created (Spaur, 2004). Historically, sediments would also accumulate in shallow lagoons behind the islands, allowing invasion of cordgrass (Sipple, 1999). However, according to (Spaur, 2004), the low tidal range in the Maryland portion of the coastal bays does not allow enough sediment accumulation for marsh development (although some have formed this way in Virginia). These marshes on the bay-side of the barriers are still eroding though (Spaur, 2004). On the mainland, the marshes are eroding on their eastern fronts, particularly from storms that occur during low tides (Sipple, 1999). The wetlands here are on deeper sediments, and are generally higher and older marshes. Only parts of these wetlands are flooded by daily tides, by an elaborate dendritic structure of tidal guts. On the upland side of the mainland tidal marshes, the wetland vegetation is encroaching due to sea level rise (Sipple, 1999).

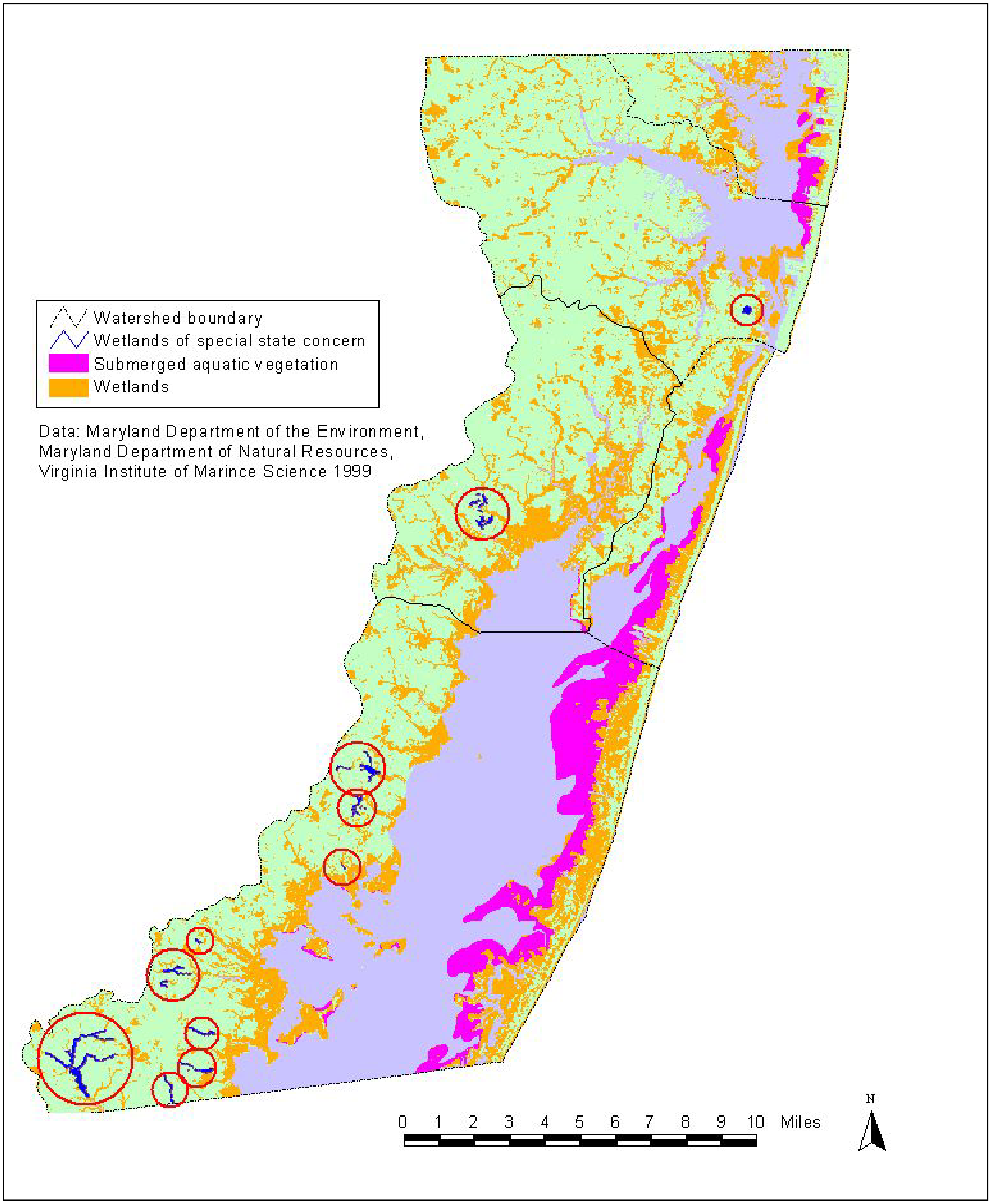


Figure 2. Wetlands and submerged aquatic vegetation in Maryland Coastal Bay region. Wetlands of special state concern are circled in red.

Tiner and Burke (1995) describes the Coastal Bays tidal wetlands as gradually grading into tidal fresh marshes, then to palustrine forested wetlands, or areas that end abruptly at the upland. Spaur (2004) suggests that since there is only a small amount of freshwater marsh (as shown in McCormick and Somes, 1982), there is often a distinct break between brackish tidal wetland and nontidal wetland. Depressions within the high marsh are known as “salt pans,” where salt water collects after high tides. Evaporation of water subsequently results in salt accumulation in the soil, which can be so extreme that at times no plant life survives. At other times, vegetation may be abundant. This pan may revert to a freshwater system after heavy rains.

Based on *Coastal Wetlands of Maryland*, the majority of tidal wetlands were classified as saline high marsh or saline low marshes (McCormick and Somes, 1982). These areas typically have low plant species diversity due largely to the high salinity levels, except at the high marsh to the upland border where effects of salinity are diminished. Saline high marshes are dominated by Meadow cordgrass (*Spartina patens*) and/or Spikegrass (*Distichlis spicata*), Marshelder/Groundselbush (*Iva frutescens/Baccharis hamifolia*) and Needlerush (*Juncus roemerianus*). Saline low marshes are dominated by Smooth cordgrass (*Spartina alterniflora*) in its tall or short growth forms. These tidal wetlands have the highest salinities of any tidal wetlands in Maryland.

There has been some encroachment from *Phragmites* in the Coastal Bays tidal wetlands, but it has not been extensive (Dawson, pers. comm.).

Nontidal Wetlands

The Maryland State Highway Administration (1998) compiled a recent list of wetland vegetation from fieldwork within the US 113 study corridor. Most nontidal wetlands in the Coastal Bays watershed are forested, and primarily associated with floodplains along stream channels. Other wetlands were found on broad upland flats and depressions with poor drainage. Most of the wetlands on the flats were in the northern Coastal Bays watersheds, and have been altered by logging and farming activities. The water table in many areas has been lowered by extensive ditching. The Worcester Soil Conservation District has restored the hydrology in numerous ditched forested wetlands (mainly in Southern Coastal Bays) with support from the USDA Wetlands Reserve Program.

Dominant tree species include Red maple (*Acer rubrum),* Sweetgum *(Liquidambar styraciflua),* and Black gum *(Nyssa sylvatica).* Other common trees in the canopy include Green ash *(Fraxinus pennsylvanica),* Loblolly pine *(Pinus taeda)* and Willow oak *(Quercus phellos)*. Common understory shrubs included Spicebush *(Lindera benzoin),* Arrowwood *(Viburnum dentatum),* American holly *(Ilex opaca),* Sweet pepperbush *(Clethra alnifolia)*, and Sweetbay *(Magnolia virginia).* A state-designated rare species, Seaside alder, *(Alnus maritima)* is found in at least one wetland.

Limited areas of bald cypress swamp still occur in the Coastal Bays watershed, including Church Branch cypress swamp (USACE, 1998) and others (Dennis, 1986). It is speculated that cypress swamp was historically located in the Maryland Coastal Bays watershed portion, adjacent to the Great Cypress Swamp on the Maryland/Delaware border. Based on presence of Atlantic white cedar in other similar coastal lagoon systems, it is highly likely that this species was historically located in the Coastal Bays watershed (Spaur et al., 2001).

Wetland Classification

The Coastal Bays consist of several types of wetlands. A National Wetlands Inventory report from 2000 estimated that Coastal Bays watersheds had 525 acres marine wetlands (beach), 18,154 acres estuarine wetlands, and 17,757 acres palustrine wetlands (Tiner et al., 2000). The following wetland descriptions are based on Tiner and Burke (1995) with wetland classification being based on Cowardin et al. (1979) (Figure 3, Figure 4).

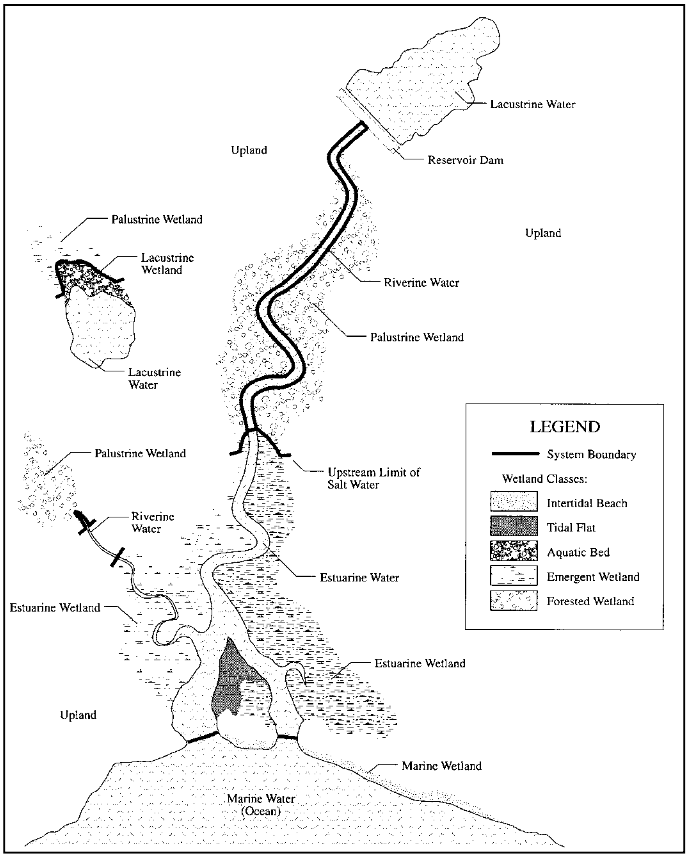


Figure 3. Wetland classes that may be present in a continuum of lacustrine, riverine, palustrine, estuarine, and marine environments of Maryland (Tiner and Burke, 1995).

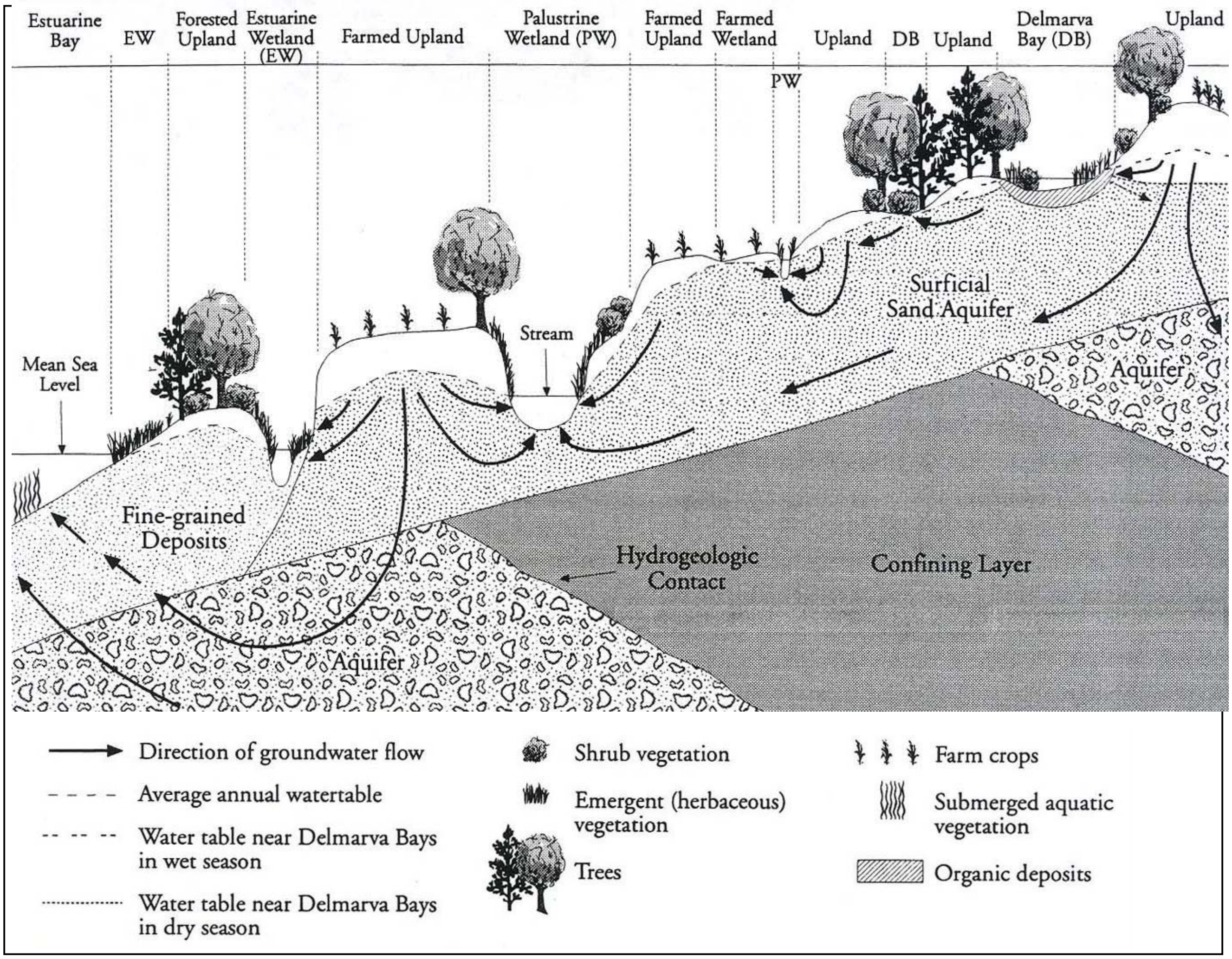


Figure 4. Groundwater flow in the Coastal Bays region. Vertical scale is exaggerated (Tiner and Burke, 1995; modified from Martha Hayes, U.S. Geological Survey).

Marine wetlands

Marine wetlands are all tidally influenced. This category encompasses ocean area above the continental shelf and the high-energy coastline, including sandy beaches along the Atlantic Ocean. These are most common on Assateague Island and have only sparse amounts of vegetation. Since these areas cannot support vegetation, therefore failing to meet the USACE definition of a wetland, it is controversial whether these areas should be included as wetlands.

Estuarine wetlands

Estuarine wetlands are all tidally influenced and contain salt or brackish water, with amounts of salinity and flooding heavily impacting wetland function. They occur in areas where ocean water is at least partially diluted with freshwater and extend upstream to the zone of freshwater. Subtidal wetlands are permanently inundated with tidal water while intertidal wetlands alternate between flooded and non-flooded conditions. Estuarine emergent subtidal wetlands occur along the west coast of Fenwick and Assateague Islands. These wetlands have the potential to provide valuable habitat for wildfowl (USACE, 1998). Estuarine intertidal emergent wetlands are common on the mainland shorelines. In the Assawoman Bay Watershed, there are extensive sections of emergent wetland. Other emergent wetlands are in the Isle of Wight Bay Watershed at the wider parts of Turville Creek and Herring Creek, and a few areas in the northern shorelines of St. Martins River. There are also extensive emergent wetlands along Trappe Creek, at Brockanorton Bay, Martin Bay, Johnson Bay, and on small islands within the Chincoteague Bay. Aquatic beds occur in shallow water areas and often support submerged aquatic vegetation. There are extensive SAV beds in Sinepuxent and Chincoteague Bays that are also classified as estuarine wetlands. NWI data is not too accurate for SAV identification. Instead, the best source for SAV information, including annual changes, is VIMS. VIMS has SAV data back to 1986.

Palustrine wetlands

Palustrine wetlands are tidal and non-tidal freshwater wetlands located on floodplains associated with streams and rivers, upland depressions, and in flats between drainage systems. The headwaters within the Coastal Bays contain relatively few wetlands, especially in Newport Bay watershed (near Berlin) and Isle of Wight Bay watershed, likely due to historic draining and filling of wetlands for agriculture, upland forest or urban development. In the Coastal Bays, forested wetlands are the most common palustrine type. Palustrine emergent and shrub wetlands are also present in small amounts. Based on Tiner et al. (2000), the majority (over three-quarters) of the palustrine wetland is not associated with a stream or river.

Wetland Acreage

Based on GIS data

Estimates of total wetland acreage in the Coastal Bays watershed (excluding deepwater habitat) based on different data sources have resulted in extremely different amounts. For this reason, we do not advocate the use of any one wetland estimate over the other, but simply report them as they are found. Therefore, acreage discrepancies found throughout this document are due to this fact. In estimating wetland acreage using existing GIS data, we eliminated deepwater habitats, a method employed by the USFWS in Tiner and Burke (1995) and Tiner et al. (2000). These deepwater habitats included:

- Marine: subtidal areas
- Estuarine: subtidal areas
- Riverine: unconsolidated bottom, rock bottom, open water (on older maps)
- Lacustrine: limnetic

Comparing the wetland amount should be done with extreme caution due to differences in methods employed by each survey. Extreme caution should be used when comparing wetland changes based on these surveys. GIS wetland acreage estimates are based on classification methods in Cowardin et al. (1979) (excluding deepwater habitats as defined above). For this report, we are focusing on all MDE regulated vegetated wetland types, with the exception of SAV wetlands (Table 1). We are not considering SAV wetlands or unvegetated wetlands for our prioritization efforts (Table 2).

Table 1. Estimates of regulated vegetated wetlands in the Coastal Bays watershed (excluding SAV wetlands) based on GIS data.

Wetland Classification	GIS data source		
	NWI	MDNR	Tiner et al. 2000
Estuarine: emergent, scrub-shrub, forested	16,763	16,893	17,093
Palustrine: emergent, scrub-shrub, forested	5,488	9,990	17,110*
Palustrine: farmed	N.A.	443	47
Total vegetated wetlands	22,251	27,326	34,250*

Table 2. Estimates of other wetlands in the Coastal Bays watershed (including SAV wetlands) based on GIS data.

Wetland Classification	GIS data source		
	NWI	MDNR	Tiner et al. 2000
Marine	718	370	525
Estuarine: aquatic beds, unconsolidated shore, flat, beaches and bars, unconsolidated bottom	1,086	6,404	1,086
Palustrine: flat, open water, aquatic bed, unconsolidated bottom, unconsolidated shore	369	555	615
Total unvegetated wetlands	2,173	7,329	2,226

NWI GIS data was based on digital ortho quads from 1981-1982 infrared photographs. MDNR GIS data was largely based on digital ortho quarter quads from 1988-1989 infrared photographs. Since the MDNR data was done at a more detailed scale (quarter quads versus quads), this method should result in more wetlands identified, which is the case. Tiner et al. (2000) GIS data was based on the MDNR GIS wetlands data, 1998 black and white photography, VIMS SAV data, and digitized hydric soils data. Due to the nature of the data, it is NOT valid to compare wetland change over time between the three different studies. *In the Tiner et al. (2000) document, they acknowledge that palustrine forested wetlands may be overestimated due to difficultly in distinguishing between forests that are currently wetlands and ones that were drained but still have hydric soils. Additional differences in wetland acreage (e.g. unconsolidated shoreline) may be due to the when the photos were taken (e.g. during which part of the tidal cycle) or various methods used. With this said, none of these GIS wetland layers are completely accurate, and should only be used as a rough estimate of wetland acreage and locations. Therefore, based on this GIS data, it is hard to make any accurate determinations about wetland gain or loss, only generalizations.

Based on US Army Corp of Engineers

According to US Army Corp of Engineers, there are approximately 16,600 acres of salt marsh along the Coastal Bays, with most being in Chincoteague Bay and only about 2,500 acres in the northern Coastal Bays. The USACE estimated the amount of nontidal wetlands, mostly forest and shrub wetland, to be 5,300 acres (USACE, 1998).

Based on Coastal Wetlands of Maryland

The Maryland Department of the Environment recommends use of *Coastal Wetlands of Maryland* (McCormick and Somes, 1982) as the most accurate source of information on tidal wetland acreage (Table 3). Tidal wetland acreage for major watersheds, including the Coastal Bays, were mapped (scale 1 inch = 200 feet) and calculated in the mid 1970's from aerial photography. Despite the age of the document and maps, they are considered to offer the most accurate information due to the scale of resulting maps and the extensive field verification (between 1976 and 1977). The actual limit of tidally-influenced wetlands is believed to have changed considerably, however. Some areas that were partially filled and not mapped in the 1970's have now become revegetated and would be considered as tidal wetlands (Dawson, pers. comm.).

Table 3. Tidal wetlands in the Coastal Bays watershed based on vegetation type (McCormick and Somes, 1982). *Total vegetated coastal marsh does not include open water, mudflat, sandbar/beach, or SAVs.

Wetland type	Vegetation type	Acreage
Shrub Swamp *(fresh)*	Red maple/Ash	29
Wooded Swamp *(fresh except Loblolly pine which is often brackish)*	Bald cypress	2
	Red maple/Ash	35
	Loblolly pine	4
Fresh Marsh	Smartweed/Rice cutgrass	4
Brackish High Marsh	Meadow cordgrass/ Spikegrass	18
	Marshelder/Groundselbush	50
	Cattail	46
	Rosemallow	2
	Switchgrass	23
	Threesquare	348
	Common reed	26
Brackish Low Marsh	Smooth cordgrass	26
Saline High Marsh	Meadow cordgrass/ Spikegrass	2,304
	Marshelder/ Groundselbush	1,780
	Needlerush	121
Saline Low Marsh	Smooth cordgrass, tall growth form	95
	Smooth cordgrass, short growth form	9,449
Open Water Category	Ponds	638*
Mud Flats and Sandbars/Beaches	Mudflat	136*
	Sandbar/Beach	503*
SAVs		1,586*
Total Vegetated Coastal Marsh (Tidal)		14,362

Wetland Acreage By Watershed

Based on the MDNR wetland GIS data (as discussed previously), wetland acreage by watershed is as follows:

- Assawoman Bay: 2,746 wetland acres (including 20 acres farmed palustrine wetlands).
- Isle of Wight Bay: 5,648 wetland acres (including 193 acres farmed palustrine wetlands) in watershed.
- Newport Bay: 6,546 wetland acres (including 120 acres farmed palustrine wetlands) and 422 meters additional linear wetlands.
- Sinepuxent Bay: 4,023 wetland acres (including 23 acres farmed palustrine wetlands).
- Chincoteague Bay: 15,530 wetland acres (including 87 acres farmed palustrine wetlands) and 6,212 meters additional linear wetlands in watershed.
- Atlantic Ocean: 162 wetland acres.

Wetland Hydrology

The source of water to the wetland is important in determining the functions the wetland may provide (Figure 5). In some systems, the majority of water in a wetland enters through surface runoff. In these cases, it may be desirable to have a wetland with high clay content and/or high organic matter to bind water contaminants, acting as a filter for water quality. Other wetlands may receive most water from groundwater. In cases where this groundwater is rising up from the ground, sandy soils with high organic matter may allow high levels of denitrification (the change of nitrogen to a gas phase which is then released to the atmosphere).

The formation and maintenance of the Ocean City Inlet resulted in higher salinity inside the bays and the conversion of some fresh water and low-salinity forested tidal wetlands to salt marsh. The estuaries affect over half the wetlands in this region, from salt and brackish wetlands to tidal freshwater wetlands (Tiner et al., 2000). Most tidal areas are brackish and include salt marshes, brackish marshes, and scrub-shrub wetlands.

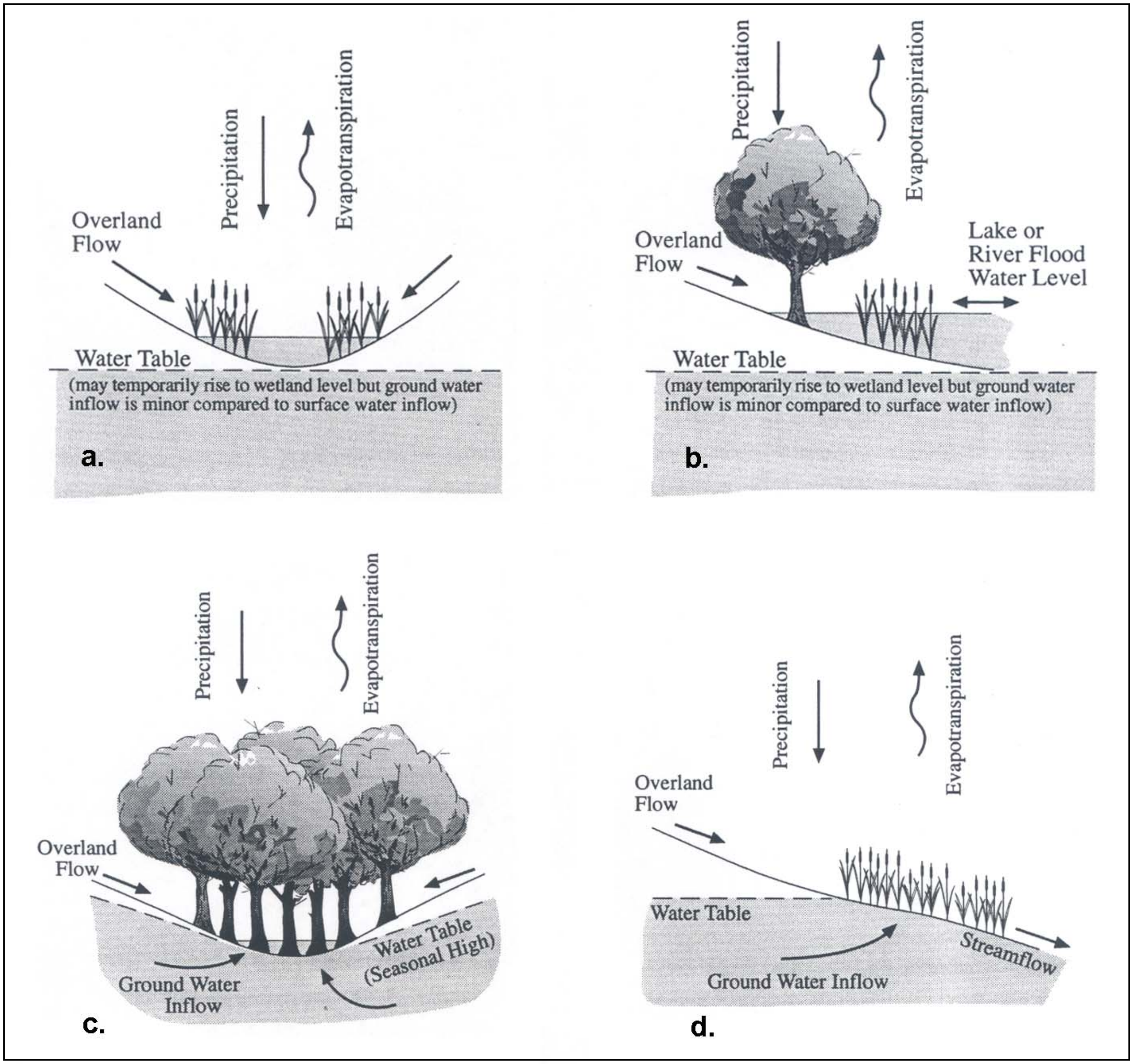


Figure 5. Hydrology of nontidal wetlands: a. depressional wetland, fed by surface water; b. floodplain wetland, fed by surface water; c. depressional wetland, fed by surface and ground water; d. sloping wetland, fed by surface and ground water (Tiner and Burke, 1995; as modified from Novitski, 1982).

Wetland Functional Assessment Methods

Background

We looked at existing wetland functional assessments to determine possible feasibility of using an existing functional assessment method in this project and to get ideas as to what indicators we should use in our evaluation. It may be desirable to evaluate future wetland restoration success using one or a combination of these functional assessment methods. The following information is summarized from Fugro-McClelland (East), Inc. (1993). Wetland assessments have been developed and used in various forms since the 1960's, after enactment of State wetland statutes in Connecticut and Massachusetts, and more frequently since 1972 after passage of the federal Clean Water Act. Methods typically involve a quantitative or qualitative evaluation of indicators believed to predict whether or not a wetland has the opportunity to perform a certain function. Other factors have also influenced assessment methods. For example, in recent years there has been more interest in predicting not only which functions a wetland may perform, but also attempting to determine the extent to which the functions are performed in comparison with similar wetlands. Some assessment methods consider the characteristics a wetland has for performing a certain valued function, in addition to other conditions that provide the wetland with the opportunity to perform the function. For instance, a wetland downgradient from a pollutant source has a higher opportunity to perform water quality improvement function. The most recent work in wetland assessment seeks to not only evaluate wetland function, but to determine the "health" or condition of a wetland. The assessment method under development to consider wetland condition and function is called the hydrogeomorphic (HGM) method.

The HGM approach is based on three factors that affect how wetlands function: position in the landscape (geomorphic setting), water source (hydrology), and the flow and fluctuation of the water once the water is in the wetland. Wetlands are initially classified based on the three factors. The method then defines functions performed by each class of wetland. The range of function is determined by evaluating numerous wetlands within the class, including wetlands that exhibit various levels of degradation, from severely impacted to nearly pristine in condition.

While there are numerous types of wetland assessments, the indicators used to predict function or determine condition are often quite similar. Most assessments consider factors such as presence of endangered species, inlet or outlets for surface water, flooding or ponding characteristics, vegetation type, size, adjacent land use, connection to another water body, other fish/wildlife habitats. Indicators used to assess the wetland condition and degradation includes: hydrological modification such as ditching, presence of exotic or invasive species, vegetation removal, fragmentation, excess nutrients or sediment, and lack of wildlife. Functions commonly assessed include water quality improvement through nutrient/sediment removal, flood attenuation, fish/wildlife habitat, groundwater discharge and recharge, and societal values.

Specific functional assessments

Tiner et al. (2000) classified wetlands in the Coastal Bays region using a classification scheme that bridged the NWI classification to the HGM classification. This method is described in the document entitled *Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors* (Tiner, 2003a). In Tiner et al. (2000), as a base map, they used the wetlands identified in the National Wetland Inventory (NWI). They modified this NWI map by photointerpretating 1998 1:40,000 black and white aerial photography and incorporating state digital wetland maps (from 1989 photography), digital submerged aquatic vegetation data, and Natural Resource Conservation Service digital hydric soil data. Additionally, investigators conducted a limited amount of field surveying.

These wetlands were classified into HGM types based on landscape position, landform, and water flow direction of the wetlands, determined by comparing the wetland maps with topographic maps and aerial photos. Wetlands in the Coastal Bays watershed were classified into five groups depending on their landscape positions, or their relationship to an adjacent waterbody: marine, estuarine, lotic (adjacent to freshwater streams and rivers), lentic (associated with lakes), and terrene (isolated or headwater). The majority of non-tidal wetlands were classified as terrene. These wetland types were further subdivided based on where they occur within these classifications and their water flow path.

Tiner et al. (2000) then assessed the potential ability of each wetland classification to provide a given function in the process called "Watershed-based Preliminary Assessment of Wetland Function". This assignment of function based on wetland type is described in the document entitled *Correlating Enhanced National Wetlands Inventory Data with Wetland Functions for Watershed Assessments: A Rationale for Northeastern U.S. Wetlands* (Tiner 2003b). The evaluated functions included: surface water detention, streamflow maintenance, nutrient transformation, sediment and particulate retention, coastal storm surge detention and shoreline stabilization, inland shoreline stabilization, fish and shellfish habitat, waterfowl and waterbird habitat, other wildlife habitat, and conservation of biodiversity. This assessment method did not take into account disturbance to the wetland, actual ecosystem health (e.g., water quality of adjacent waters), or difference between two wetlands of similar type. This analysis resulted in different types and amounts of potential wetland function between the Coastal Bays watersheds (Table 4). More intensive fieldwork may produce different results, since some HGM types are difficult to distinguish from one another. In addition, some functions rely on characteristics only seen in the field, such as micro-topography.

Table 4. Wetlands having moderate to high potential to provide a given function within each Coastal Bays watershed. The percentage of wetlands providing the given function excludes ponds, deepwater habitats, and aquatic beds. Aquatic beds provide a habitat function for fish, shellfish, and waterfowl are also listed (Tiner et al., 2000).

Watershed	Functions					Fish/ shellfish/ waterfowl habitat in aquatic beds (acres)
	Nutrient cycling (%)	Sediment deposition (%)	Surface water detention (%)	Coastal storm detention/ shore stabilization (%)	Fish/ shellfish/ waterfowl habitat (%)	
Assawoman	79	81	7	81	73	462
Isle of Wight	33	35	57	30	22	219
Newport	55	55	45	56	44	84
Sinepuxent	67	76	11	74	69	1,910
Chincoteague	67	72	29	65	56	5,947

The State of Maryland Nontidal Wetlands Protection Act of 1989 lists several important functions wetlands may provide:

- Ground water discharge
- Flood flow attenuation
- Sediment/toxic retention
- Aquatic diversity/abundance
- Production export

- Sediment stabilization
- Nutrient removal/transformation
- Wildlife diversity/abundance

Fugro East, Inc developed a document called *A Method for the Assessment of Wetland Function* for MDE to assess these nontidal wetland functions; it includes looking at many measurable indicators of function (Fugro East, Inc., 1995). Within this model were a method for field assessment and a method for desktop assessment using GIS. The level of effort required to obtain values for each of these measurable indicators varies significantly. Each of the indicators results is a score. For instance, for the sediment stabilization function, one of the indicators is: "What is the frequency of overbank flooding?". If you rate frequency of flooding as: does not flood, score=0; low frequency of flooding, score=1; high frequency of flooding, score=2. Each function has several indicators, with each being assigned a score. At the end, these scores are added up and this number is divided by the total number possible, to get the functional capacity index. A partial list of wetland variables used in the assessment model and their associated indicators are as follows:

- Hydrogeomorphic class
- Landscape variables
    - size of wetland
    - location relative to other wetlands
    - watershed land use
    - regional scarcity of wetland type
    - wetland significance
    - topographic position
    - proportion of wetland edge bordering sediment source
- Hydrologic variables
    - water level fluctuation
    - water regime
    - adjacent to water body
    - surface water connection
    - overbank flooding
    - seeps/springs

    - surficial geologic deposit
    - wetland land use
    - topographic gradient of wetland
    - inlet/outlet properties (e.g., outlet restriction)
    - ratio of wetland area to watershed area
    - contribution from overland flow
    - ditching
- Soil variables
    - Soil type (i.e., organic matter content and texture)
- Vegetation variables
    - Dominant wetland vegetation
    - Dead plant material (e.g., standing or fallen tree trunks)
    - Vegetation characteristics (e.g., vegetation layers, percent cover, distribution)
    - Interspersion of open water and vegetation (e.g., proportion and distribution)
    - Wetland edge complexity
    - Stream sinuosity
    - Adjacent to fish habitat
    - Rare, threatened, endangered species
    - Adjacent to upland habitat
    - Connection to wildlife corridor

At this time, this method is not well utilized at MDE. When MDE reviews applications for wetland impact, wetland functions (based on a list of possible functions) are estimated based on best professional judgment, rather than on these indicators. This list of possible functions was based loosely on functions defined in different functional assessment methods (this one included). In the past, Montgomery County used an assessment method based on the Fugro East method. Since the Fugro East assessment method was designed for use with HGM, when HGM classifications are better documented for the area, we will reevaluate our limited use of the Fugro East method.

Maryland State Highway Administration (SHA) also has indicators used to assess wetland function. For the Rt. 113 project, partially located in the Coastal Bays watershed, they conducted functional assessments of the wetlands to be impacted by the project, using the USACE *Highway Methodology*

Workbook (USACE, 1995). This publication suggests indicators of wetland functions for tidal and nontidal wetlands, with examples of wetland functions/values not included in the MDE model being as follows: Recreation, Educational/Scientific Value, and Visual Quality.

In order to evaluate the usefulness of these methods to this project, we attempted to replicate results from the SHA Rt. 113 wetland impact study using only available GIS data, with the following conclusions. Some considerations/qualifiers (indicators) used in the SHA assessment based on the USACE *Highway Methodology Workbook Supplement* were impossible to estimate accurately without more detailed data or a field visit (e.g., evidence of fish, wetland edge is intermittently aerobic, no indicators of erosive forces are present, diffuse water flows are present in the wetland, indicators of erosion or siltation are present). Another finding was that some of the considerations/qualifiers used in the SHA method were vague, allowing a lot of room for personal judgment. Additionally, the determination of which functions were the principal functions (i.e. the most important/dominant functions this wetland provides) was based on personal judgment, and could be biased. These results are not especially surprising since the USACE *Highway Methodology Workbook Supplement* acknowledges that the considerations/qualifiers are flexible and based on best professional judgment. Keeping these limitations in mind, the majority of the considerations/qualifiers that we were able to estimate based on GIS data, had similar results. This suggests that functions can be estimated from GIS data, at least on a preliminary basis. The functions that we were best able to evaluate with our GIS data included flood flow alteration, fish and shellfish habitat, sediment/toxicant retention, and nutrient removal.

Next we determined the wetland functions for the Rt. 113 wetland impact study sites using the MDE methods versus using the SHA method. Some of the MDE desktop method indicators were not easily attainable from available GIS data (e.g., inlet/outlet characteristics, vegetation density and richness, etc.) other than rough estimates from aerial photos. Many of the wetland function results were the same as for the SHA study. Conflicts generally arose when determining if the function was a principal one or just present to a lesser degree. The MDE method results in a functional capacity index, which makes it hard to estimate if it is a principal function. The MDE method was less biased since the indicators were clearly described. For instance, descriptions for each indicator were detailed and even quantitative where appropriate. It may be desirable to consider indicators from both methods when evaluating wetland function potential.

SHA also used the method described in the *Highway Methodology Workbook* to determine the mitigation plan for Route 113. In order to satisfy requirements of replacing wetlands lost due to the highway construction, SHA and their consultant used infrared photography to look for wet sites, mainly in agricultural land, that were adjacent to the destroyed wetland or in the same watershed. Of these sites, they looked for ones that could potentially provide the same functions as the destroyed wetlands. In evaluating wetland function, SHA considered landscape position, location in the watershed, adjacent land-use, connection with other habitat, and sediment and nutrient sources (Jellick et al., 2002). They estimated what the functions of the site would be if it was a wetland. The amount of excavation required to create a wetland was also considered in site selection. Landowners were contacted to see who was interested in participating, and this ended up being a huge factor in site selection (Coastal Resources, Inc., 1999).

In the current study, we are loosely using these functional assessments to understand what general conditions (indicators) are desirable in order to have maximum function in restored and existing wetlands. For example, to maximize water quality function, one indicator is having a higher percent wetland edge bordering upland sediment source. In the future, it is possible that a more detailed investigation would include the stricter use of one of these functional assessment methods.

Wetland Loss

The most extensive wetland loss has occurred in Isle of Wight, Newport Bay, and Chincoteague Bay watersheds (MDNR and MDE, 2000). The following information is based on a 1998 report of wetland loss conducted by the Corp of Engineers (USACE, 1998; Spaur et. al., 2001). There has been a 10% loss of salt marsh area since 1900, with losses concentrated in the northern Coastal Bays [northern Coastal Bays (i.e., Isle of Wight and Assawoman Bays) had a loss of 37% salt marsh, or 1,530 acres, while the Southern Coastal Bays (i.e., Newport, Sinepuxent, and Chincoteague Bays) had a loss of 228 acres]. The northern bays, excluding Fenwick Island, had 580 acres of salt marsh loss, concentrated in Ocean Pines and Ocean City North of the inlet. Fenwick Island had 950 acres of salt marsh loss. A large portion of the once extensive zone of emergent salt marsh along the bayside of Fenwick Island is gone. In addition to direct wetland losses, coastal engineering and maintenance of the ocean city inlet may have prevented the natural formation of wetlands in some areas such as the bay side of Fenwick and Assateague.

Loss of forested wetland in the Coastal Bays due to conversion (e.g. filling) to agriculture and development was estimated at 44% or 24,768 acres total (21,000 acres converted to agriculture and 3,700 acres to development) (USACE, 1998). Once again, these losses were worse in the North than the South (52% or 13,562 acres and 37% or 11,205 acres, respectively). Most of the wetlands not directly converted (26,300 acres) have been hydrologically modified by artificial drainage to create forested uplands (e.g. timber plantations), agriculture, and urban area, so are no longer wetlands. For this reason, loss of non-tidal forested wetlands may be as high as 90%. Highest amounts of forested wetland loss occurred in the St. Martin River, Isle of Wight Bay, Manklin Creek, and Newport Bay subwatersheds. USACE recommends restoring and creating forested wetland to improve water quality in the St. Martin River, Turville/Herring Creek, and Newport Bay subwatersheds. While historically forested wetlands were common on the interstream divide and depressional landscapes, it is recommended that restoration for water quality be at locations of maximum pollution interception. They locations along the landscape will often be different than where they were historically found (Spaur et al., 2001). They also recommend restoring salt marsh in the northern bays wherever suitable sites exist, but restoring salt marsh in the southern bays only where it previously existed (Spaur et al., 2001). MDE tracks wetland losses and gains in the region (Table 5).

Sea level rise is also contributing to losses in wetland area. As sea-level rises, marsh can encroach upon drowned mainland and stream valleys. It is now believed that landward marsh migration would not be able to maintain pace with losses due to sea-level rise due to steeper slopes that are now being encountered along the mainland (Hennessee and Stott, 1999). However, since the area is rapidly developing, this landward migration of wetlands is not possible. The once continuous salt marshes on the north of Isle of Wight Bay Island are now fragmented due to development, sea level rise and erosion (USACE, 1998). Shoreline erosion is higher in the northern coastal bays. Structural shoreline stabilization practices, such as bulkheads and riprap, prevent encroachment from sea level rise that would have resulted in new tidal wetlands. Some threats to wetland function include jet skis, boating, and feral horses (Conley, 2004). Construction of long piers across the tidal marsh destroys wetland habitat under the pier, accelerates erosion, fragments the marsh system (degrading bird habitat), and allows invasion by non-native species (Ayella, 2004). In an attempt to reduce mosquitoes, ditches have been created in many of the tidal wetlands. Although the success of these efforts in reducing mosquitoes is questionable, these ditches clearly impact the natural wetland system.

Table 5. Wetland gains and losses as tracked by MDE. “Permanent impacts” includes permanent wetland losses that required a MDE permit. “Permittee mitigation” includes compensatory mitigation of wetland restoration or creation completed by the permittee, as required under their wetland impact permit. Since this is based on the date of approval of authorization for impact, rather than the date the impact or mitigation actually occurred, not all mitigation or impacts have actually been completed by 12/31/2003. “Programmatic mitigation” includes compensatory mitigation of wetland restoration/creation completed by MDE using compensation fund money (permitees pay into the compensation fund for mitigation requirements rather than performing mitigation themselves). “Other gains” includes other wetland restoration/creation that required a permit. “Voluntary gains” includes wetland restored/creation through other programs: NRCS Conservation Reserve Enhancement Program (CREP), NRCS Wetlands Reserve Program (WRP), USFWS, MDNR, and Ducks Unlimited. Tidal wetlands data includes SAV, open water, mudflat, and vegetated wetlands. *2004 voluntary restoration records are incomplete.

Nontidal/ Tidal	Action (gain/loss)	Coastal Bays watershed						Total change
		AB	IOW	SB	NB	CB	Unkn.	
Nontidal 1991-2003	Permanent impacts (regulatory)	-0.7	-67.6	-4.5	-5.6	-2.0	0	-80.5
	Permittee mitigation	0	46.9	3.5	3.5	0	0	53.8
	Programmatic mitigation (MDE)	0	5.0	3.0	0.5	11.4	0	19.9
	Other Gains	0	1.2	0.1	0.8	3.9	0	6.0
	Net change (regulatory)	-0.7	-14.6	2.1	-0.9	13.3	0	-0.8
Tidal 1996-2003	Permanent impacts (regulatory)	-<0.1	-0.3	-0.2	-0.2	0	0	-0.8
	Mitigation	0	0.5	0.1	0	0	0	0.5
	Net change (regulatory)	-<0.1	0.1	-0.1	-0.2	0	0	-0.2
Nontidal / Tidal 1998-2004*	Voluntary gains	92.2	143.3	39.1	213.6	565.0	823.4	1876.6
Total		91.7	128.8	41.1	212.6	578.3	823.4	1874.7

Existing management plan goals

In selecting possible sites for wetland restoration, creation and preservation, we tried to consider the goals from other interested parties. These main groups are Worcester County Government, Maryland Coastal Bays Program, and Maryland Department of Natural Resources. After reviewing some of these recommendations, discussing the issues with professionals in the field, and summarizing relevant literature, a suggested targeting plan was developed. It is our goal to address local concern, provide wetlands that have the highest amount of functional potential, and integrate these sites with other projects.

Comprehensive Development Plan: Worcester County

The Comprehensive Development Plan for Worcester County (Worcester County, 1989) discusses the importance of preserving agricultural land, coastal resources, and forest. It also recommends reducing pollution to the bays from point and non-point sources. In this plan, the region is divided into three categories: Coastal, Upland, and Agriculture. "Coastal" is within 250 feet of tidal waters or tidal wetlands, "uplands" is upland area not being used for agriculture, and "agriculture" is upland area where agriculture is present. The distinction between uplands without agriculture and uplands with agriculture is important since preserving agriculture, even at the expense of other natural resources, is a goal of the county. Using these three categories, the plan outlines protection objectives for each. The protection goal for coastal wetlands is to protect 100% of the tidal wetlands and 50% of the non-tidal wetlands. The protection goal for non-tidal wetlands is to protect 100% in uplands and 30% in agriculture. For the buffer, the goal is to protect 100% in coastal areas, 50% in uplands and 25% in agriculture. Protecting and restoring forested land in the coastal areas and drainageways, and protecting areas of high erosion hazard, bays, beaches, bluffs, and floodplains is also important. The plan suggests maintaining areas of high recreational value, including Ocean City Harbor, Bishopville Prong, Herring Creek, St. Martin River, Manklin Creek, Turville Creek, and Trappe Creek. Areas zoned as "Rural Estate" have limited subdivision potential. Therefore, these "Rural Estate" areas may be good locations to target restoration, mitigation, or preservation.

A supplement to this plan was established in 1997. This included the requirement of the 1992 Planning Act to address strategies to protect sensitive areas. These sensitive areas and the protection plans are as follows:

- *Habitats of threatened and endangered species*. Protect these areas and discourage development nearby.
- *Stream corridors*. Protect sensitive stream sections and their associated buffers. The Soil Conservation District is encouraging grassed buffers along small agricultural ditches and 10-foot herbaceous plants and shrubs along larger agricultural ditches.
- *Steep slopes, over 15%*. These slopes comprise only 0.3% of the county. Forested areas on steep slopes should be protected.
- *100-year floodplains*. These areas are often highly developed, especially in the coastal area. Protect forest within the 100-year floodplain. Discourage development in the 100-year floodplain, and instead encourage open areas, including recreational and natural areas.
- *Wetlands, Forests, and Coastal Bays*. Protect, restore, and create wetlands. Protect forest, including within the Rural Legacy Areas. Restore or create forests, especially in the northern Coastal Bays.

<u>Comprehensive Conservation and Management Plan for Maryland's Coastal Bays</u>

The Comprehensive Conservation and Management Plan for Maryland's Coastal Bays (MCBP, 1999) provides guidelines to preserving and restoring the valuable resources in the Coastal Bays. Many goals were outlined in this document including for water quality, fish, wildlife, recreation, navigation, and community and economic development. Goals relating to the present wetland prioritization project are summarized below:

- Decrease nutrient, sediment and chemical inputs from developed land, agriculture, stormwater runoff, and point sources.
- Increase fish and shellfish, enhance forest habitat and wetlands, protect threatened and endangered species, and control invasive species.
- Enhance water recreation and access.
- Educate the public.

Suggested actions to achieve these goals include:

To reduce nutrients from stormwater runoff (Goal WQ #2)

- Increase residential buffers to reduce runoff from lawns.
- Preserve wetlands and their buffers in riparian areas to decrease stormwater nutrient runoff.

- Build new/retrofit storm water management facilities, which may include the use of wetland treatment.

Reduce nutrients from agriculture (Goal WQ #4)

- Encourage adoption of nutrient management strategies
- Investigate new agricultural ditch management for water quality improvements (currently being used in Delaware).

Reduce sediment inputs (Goal WQ #6)

- Encourage soft protection of shoreline along eroding shores.
- Establish shoreline buffers of wetlands, riparian buffers, and shore grasses to protect the shoreline, focusing on property owners experiencing severe erosion.
- Restore shoreline marshes.
- Encourage stream restoration to reduce shoreline erosion.
- Reduce development in shoreline areas that are highly erodible.

Increase fish and shellfish (Goal FW #1)

- Protect bay beaches and other horseshoe crab habitat.
- Improve habitat for fish and shellfish.
- Retrofit drainage into dead-end canals and interconnect canals with 8 ft. diameter pipes.
- Promote and protect natural shoreline and adjacent areas.

Improve forest habitat (Goal FW #2)

- Protect migration and breeding habitat of neotropical songbirds.
- Protect large tracts of hardwood/mixed forest and forests adjacent to streams and wetlands.
- Mitigate forest loss in areas where forest was impacted.
- Encourage habitat development in agricultural land by creating buffers and grasslands.
- Restore riparian areas and wetlands on agricultural land.

Protect and restore wetlands (Goal FW #3)

- Focus wetland restoration/creation in areas of high historic losses and target types and functions lost.
- Preserve wetlands.
- Create wetlands to provide wastewater treatment, sediment retention, stormwater management, and wildlife habitat.
- Protect, enhance, and restore bird habitat.

- Educate and poll landowners to determine possible mitigation/restoration locations.

Protect threatened/endangered species (Goal FW #4)

- Protect habitat of threatened and endangered species and adjacent habitats.
- Create and restore potential habitat for threatened and endangered species if feasible.

Reduce negative impacts from recreational activities (Goal RN #3)

- Protect sensitive areas from negative impacts of water-based recreation.
- Create sensitive habitat in areas where disturbance by water-based recreation is not a threat.

Improve water recreation and water access (Goal RN #5)

- Encourage passive recreation and access in the floodplains and near Chincoteague Bay, E.A. Vaughn Wildlife Management Area, and other protected sites.
- Develop greenways between developments and recreation areas.

<u>Isle of Wight Bay Watershed Restoration Action Strategy</u>

The *Isle of Wight Bay Watershed Restoration Action Strategy* (Worcester County, 2002) makes several suggestions related to restoration and management of the Isle of Wight Bay watershed as summarized below.

- The land is classified into three types: Development Areas, Transition Areas, and Resource Use and Conservation Areas. The intent is for new development to be focused in the Development Areas, lower intensity development to be focused in the Transition Areas, and to limit development in the Resource Use and Conservation Areas.
- A habitat protection area with a 100-foot buffer of native woody vegetation should be established along the tidal water bodies and wetlands.
- Forest should be protected by reducing forest lost to development, requiring mitigation for losses, and preserving forest for wildlife corridors.
- Avoid impacts to any land surrounding the habitat of species considered threatened, endangered, or in need of conservation.
- Incorporate a 100-foot buffer around colonial waterbird nesting sites.
- Protect and create wildlife and plant corridors between important habitats.
- Install soft stabilization for shoreline erosion.
- Require 25-foot vegetated buffer between agriculture and a waterway or require a nutrient management plan.

- Protect natural areas.
- Redesign the ditches to allow establishment of natural vegetation and higher sinuosity.
- Create natural vegetation buffers of different width around perennial streams. This buffer should include floodplains, steep slopes, wetlands, and important habitats.
- Construct wetlands for wastewater treatment or additional treatment of septic systems.

<u>Maryland Coastal and Estuarine Land Conservation Plan DRAFT</u>

This Maryland Department of Natural Resources draft document (MDNR, 2004 Draft) discusses land preservation at a general scale for the coastal zone counties (16 out of the 23 counties). In this plan, they suggest focusing preservation efforts on areas within the state-designated Green Infrastructure network or Ecologically Significant Areas. Qualifying properties would then be "evaluated on their relationships to the GI/ESAs, the ecologic or ESA importance of the property, as well as other factors relevant to habitat, water quality, and safeguarding environmental research". The final step in reviewing potential properties would be to assess management options and how the site relates to other plans.

<u>USACE</u>

The USACE (1998) and Spaur et al. (2001) targeted the northern coastal bays for salt marsh restoration due to the high amount of historic loss and because the natural process of marsh creation is no longer possible in that region. Since the natural process of marsh creation is still operational in the southern bays, salt marsh restoration in that region should only be located on historic salt marsh sites. For water quality improvement, they recommended that nontidal wetland restoration be focused in St. Martin's River, Turville/Herring Creek, and Newport Bay. Unfortunately, in order to achieve the possible water quality improvement, restored wetlands may not be located in the same landscape setting as where they were historically.

Existing targeting efforts

MDE has combined some of the past Coastal Bays targeting efforts, general and specific targeting recommendations from other documents, and our own priorities to develop the wetland targeting plan for the region. We hope to locate areas that may provide the highest amount of wetland function. This plan attempts to find general areas for wetland restoration and preservation based mainly on available desktop data and past studies. This plan may be used to direct interested parties to areas that may provide sites for potentially high-functioning restored wetlands or especially valuable wetlands in need of protection.

There are a few wetland targeting efforts that do exist for this region. They vary in the area they are evaluating and in their methods, but include: Tiner et al. (2000), Isle of Wight WRAS, Newport/Sinepuxent WRAS, USACE (for St. Martin's River), and SHA mitigation for Rt. 113.

Tiner, Starr, Bergquist, and Sword (2000)

In the document entitled *Watershed-based Wetland Characterization for Maryland's Nanticoke River and Coastal Bays Watersheds: A Preliminary Assessment Report*, Tiner et al., (2000) proposed wetland restoration sites in the Coastal Bays watershed totaling 25,365 acres. These sites were classified into two categories: former wetlands (Type 1) and existing impaired wetlands (Type 2). They were scattered throughout the watershed. Type 1 sites included filled wetlands (without any buildings on them), farmed wetlands, and those converted to deepwater. He did not include any additional sites with hydric soils. The Type 2 sites were classified as wetlands in the Tiner study. These included impounded, excavated, ditched, tidally restricted, and shallow pond wetlands. The majority of wetlands were classified as Type 2. Potential wetland function was not evaluated.

WRAS for Isle of Wight, Newport, and Sinepuxent Bays - sites identified for restoration

When determining potential restoration sites within WRAS, Worcester County looked for sites within the general areas designated by the Watershed Characterization. These included:

- Hydric soils. Digitized soil data was based on the Natural Soil Groups Classification developed by Maryland Department of Planning. "Hydric soil" status may have been difficult to establish due to vague groupings used in the Natural Soil Groups and changes in "hydric soil" definition since the groupings were made.
- Wetness of soil. MDNR estimated nutrient retention of soil assuming higher wetness of soil equates to higher nutrient retention.
- Adjacent land use. Select hydric soils between a stream and cropland.
- Proximity to wetlands. Select hydric soils within 300 feet of a wetland.
- The MDNR water quality and macroinvertebrate community data (Primrose, 1999).
- Stream Corridor Assessment data (Czwartacki and Yetman, 2002).

Although the county planned to use property owner interest to choose final sites from the five proposed areas, and acknowledged that this may be a limiting factor, the initial selection process did not take landowner interest into account. Additionally, they focused on agricultural areas, excluding forest and developed areas from restoration consideration. For the Newport/Sinepuxent WRAS, they did include citizens' recommendations of additional restoration sites.

For the Isle of Wight, there were five identified potential restoration areas. All areas had stream sites with channel alteration, very poor buffers, and lateral ditching. Bishopville #1 is located north of St. Martins Neck Road between Route 367 and Mumford Road and drains into Bishopville Prong (above Shell Mill Road). Within this section, there were also stream sites with minor erosion. Bishopville #2 is west of Bishopville Prong, between Jarvis Road and Hammond Road. These streams drain into Slab Bridge Prong and Perkins Creek before entering Bishopville Prong. Carey #1 is in the headwaters of Carey Branch and includes a high density of agricultural ditches. Birch #1 is on Birch Branch, west of Rt. 113 and south of Carey #1. Birch #2 is south of Peerless Road and drains into Birch Branch and Middle Branch. USACE is considering projects in some of these areas.

After the Isle of Wight WRAS was completed and potential areas were located, property owners were contacted to assess interest. Unfortunately, there was no owner interested in any of the five proposed areas. Instead, the county found interested property owners in the Ocean Pines area. Since this will be a concern with any restoration effort, we have to remember this prioritization is meant to be a long-term planning tool. The Newport Bay and Sinepuxent Bay WRAS are still in progress and should be completed in early fall. The Chincoteague Bay WRAS should be completed in 2005.

<u>USACE St. Martin's River Aquatic Ecosystem Restoration</u>

The USACE looked in greater detail at some areas identified in the Isle of Wight WRAS, within the St. Martin River watershed. They identified areas for: potential shoreline stabilization, riparian restoration, improved water quality, wetland restoration, oyster reef construction, and removal of fish blockages. Although the USACE did intend to implement projects based on this analysis, funding issues in the Corp's Continuing Authorities Program have resulted in a postponement.

Great Cypress Swamp Aquatic Ecosystem Restoration Project in Delaware

While this project is located in Delaware, it is still within the vicinity of the Coastal Bays and is very relevant to that area. This restoration may include several thousands of acres. This study is also on hold due to inadequate funding from the Corp's Continuing Authorities Program.

SHA Wetland Mitigation for Route 113

SHA used the method described in the *Highway Methodology Workbook* to determine the mitigation plan for Route 113. This procedure is discussed in detail in the Background Wetlands section within this document.

As noted, this wetland mitigation plan was only for selecting sites to satisfy current wetland mitigation requirements. It was not meant as a long-tem plan for wetland restoration/mitigation. Additionally, they focused only on areas near the impacted sites.

MDNR's Green Infrastructure Assessment

MDNR established a green infrastructure network that included hubs and corridors. These areas should be the focus of protection (MDNR, 2004 Draft) and restoration in order to preserve an important ecological network through the state. It is desirable to convert open land areas and disturbed areas within Green Infrastructure hubs and corridors to natural vegetation where possible (i.e., convert agriculture or barren land to natural vegetation). Additionally, some areas of Green Infrastructure should be considered high priority areas for preservation, especially areas of high ecological ranking and high development risk (as determined in the *Green Infrastructure Assessment*). The following descriptions are based on GIS data of protected lands (2002), MDNR wetlands (interpreted from 1988-1995 photos), NWI wetlands (interpreted from 1981-1982 photos), and Green Infrastructure Assessment data (2000-2003). Most of the hubs contain spots of agriculture in or around them that can be converted to natural vegetation. Nearly all hubs contain some portion of wetlands, many of these unprotected. There is relatively little Green Infrastructure located in the Isle of Wight Bay watershed, in comparison to the other watersheds. Also, development pressure is higher in the northern bays, Sinepuxent Bay, and northern Newport Bay. Protection of the areas with high development risk is especially important. There is a hub in western Isle of Wight watershed (in the headwaters) that is connected by a corridor to another hub running from Assawoman Bay watershed (around Greys Creek) to the mouth of St. Martin's River (including Isle of Wight Island). There is another hub in southern

Isle of Wight watershed (around Herring Creek) that connects with the hubs in the southern bay watersheds. In the southern Coastal Bays area, the Green Infrastructure is quite extensive, covering over half of the area. There is a long hub covering the majority of Assateague Island and hubs or corridors lining most of the Newport and Chincoteague Bay mainland shoreline. Only a small portion of the land designated as Green Infrastructure is currently protected, with largest areas including Assateague Island, several significantly-sized properties in Newport Bay, and near E.A. Vaughn Wildlife Management Area. Restoring and protecting adjacent systems may also enhance the wildlife benefits. Gaps in the Green Infrastructure are mainly agriculture land, with a few barren land cover areas in northern Chincoteague Bay watershed. The *Green Infrastructure Assessment* includes useful data on some of these Green Infrastructure gaps, including evaluation of the ecological benefit that wetland restoration projects within these gaps might provide.

NRCS wetland restoration

This document would not be complete if it did not mention the local wetland restoration efforts conducted by the NRCS. The following information is based on discussions with Bruce Nichols from NRCS. This restoration is not a targeting effort but is instead based on opportunity. Generally, after an interested landowner contacts NRCS, NRCS looks at maps, aerial photos, and conducts site visits to determine for which program they qualify (e.g. CREP, CRP, WRP). NRCS is generally looking for characteristics that indicate if the site can easily become a wetland. This includes a broad interpretation of the conditions present. The soil must be such that it will provide hydrology necessary to establish a wetland (e.g., fine-textured sediment present at least in the subsoil or very high water table). They do a mixture of restoration techniques, including plugging ditches and excavating to create a berm. Sites are chosen on hydric soils (with a few exceptions), since they are so extensive in the area. Many successful projects have been completed through this program on agricultural fields and drained forest. Some projects have even resulted in habitat for uncommon species. They allow and even encourage responsible timber harvesting within restored wetlands because by making the wetlands economically important, the program will be more successful. This economic importance of wetlands may also be possible through certain types of aquaculture. Estimated acreage of wetland restoration completed through this program and other programs (both voluntary and programmatic) is included in the background (Wetlands section). The majority of wetland restoration through this program is located in Chincoteague Bay watershed.

Additional targeting considerations

In addition to the existing targeting and restoration programs, there are many general recommendations and data that should be considered in this current targeting effort:

Water Quality

All five Coastal Bays watersheds are on the 303(d) List for low dissolved oxygen, high fecal coliform, and nutrients (although the only water body on the 303(d) List for nutrients in Chincoteague Bay was Big Millpond). The 1998 *Maryland Clean Water Action Plan* classified all five Coastal Bays watersheds as Category 1, watersheds not meeting clean water and other natural resource goals and therefore needing restoration. In addition to having the failed indicator of being on the 303d List, these watersheds had other failed indicators as follows (MDNR and MDE, 2000):

- *Assawoman Bay*: high nutrients, poor SAV abundance, high percentage impervious surface (11.6%), high percentage unforested stream buffer (40%)
- *Isle of Wight Bay*: poor SAV abundance, poor Non-Tidal Benthic IBI, and high historic wetland loss (16,129 acres)
- *Newport Bay*: high nutrient concentration, poor SAV abundance, poor Non-Tidal Benthic IBI, and high historic wetland loss (17,025 acres)
- *Sinepuxent Bay*: high percent unforested stream buffer (45%)
- *Chincoteague Bay*: high historic wetland loss (28,820 acres).

Assawoman Bay, Isle of Wight Bay, and Newport Bay watersheds were classified as Category 1 “Priority”, watersheds being most in need of restoration since they failed to meet at least half of the restoration goals. Additionally, Newport Bay and Chincoteague Bay watersheds were classified as Category 3, a pristine or sensitive watershed that needs protection due to containing the select indicators as follows: Newport Bay – contains a migratory fish spawning area and a high number of wetland-dependent species; Chincoteague Bay contains a migratory fish spawning area, imperiled aquatic species, and a high number of wetland-dependent species. Chincoteague Bay was also a “selected” Category 3, a watershed that should be ranked one of the highest for protection.

Water quality data generally found northern Coastal Bays and Newport Bay watersheds to have worse conditions than Chincoteague Bay and Sinepuxent Bay watersheds (Boynton et al., 1993). According to the *Draft Aquatic Ecosystem Health 2004* report, nitrogen was the worst in the upper tributaries (Greys Creek, Bishopville Prong, Shingle Landing Prong, Turville Creek, Trappe Creek, Ayres Creek, Newport Creek and Marshall Creek), St. Martin River, northern Assawoman Bay and Herring Creek. St. Martin River and upper Newport Bay had highest chlorophyll, especially Bishopsville Prong and Trappe Creek. Areas with poor water quality should be the focus of wetland restoration/mitigation efforts. Based on TMDL results for the completed waterways, MDE is requiring the following pollutant reductions: a 31% reduction in nitrogen and a 19% reduction in phosphorus for St. Martin River, Shingles Landing Prong and Bishopville Prong; a 13% reduction in phosphorus for Turville and Herring Creeks; a 45% reduction in nitrogen for Ayer Creek, Newport Bay, and Newport Creek; and a 69% reduction in phosphorus in Big Millpond (in Chincoteague Bay watershed).

The largest pollutant sources for nitrogen and phosphorus were non-point sources, mainly agricultural runoff (MDE, 2001). Developed areas can also contribute high amount of nutrients per area (Jellick et al., 2002), but agriculture results in much higher total nutrient loads in the Coastal Bays due to the high amount of agricultural land use. Sediment loads to the bays are mainly from row crops, shoreline erosion, and a smaller amount from development (Wells et al., 2002).

Stream benthic scores (benthic IBI) from MBSS and Stream Waders for the Coastal Bays were mainly poor and very poor, so were not utilized extensively when choosing sites in need of restoration. The stream corridor assessment for Isle of Wight Bay watershed indicated that the most common problem was stream channel alteration. This problem was most common in the headwaters, especially in the northern watershed. Inadequate stream buffers were also a problem, followed by minor stream erosion in the southern part of the watershed, construction erosion, trash, and sewage discharge. Minor fish migration barriers were encountered at some sites, mainly in the southern part of the watershed.

The most impacted benthic communities in St. Martin watershed were Carey's Branch and Church Creek (Primrose, 1999). A MDNR study also found high nutrient concentrations at three stations: a tributary to St. Martin at St. Martin Neck Road, Buntings Branch at Delaware Rt. 54 in Selbyville, and Church Creek at Rt. 113 (Primrose, 2002). The area with the highest total dissolved nitrogen load (79.5 mg/L) was on Buntings Branch at Delaware Route 54 in Selbyville. Other areas of high nutrients were at Birch Branch at Route 113, Birch Branch at Campbelltown Road, and a tributary to Birch Branch at Murray Road. Of the communities sampled in Newport, Sinepuxent, and Chincoteague Bays during the

2003 nutrient synoptic survey, highest nitrate/nitrite concentrations and yields tended to be in Newport Bay watershed (Primrose, 2003). Orthophosphate concentrations were high or excessive in sites from all three watersheds, but yields were only excessive at three sites, two in Newport Bay watershed (Kitts Branch at Flower St., Kitts Branch at Rt. 346) and one in Chincoteague Bay watershed (an unnamed tributary to Robins Creek at Taylor Road). Nitrate/nitrite yields were also excessive at these three sites. Benthic populations were ranked as poor or very poor and fish populations were rated as fair or poor. These low ratings were likely due to poor habitat from ditching and flow of storm water. Subwatersheds with sites having poor physical conditions, poor benthic communities, or excessive nutrients should be targeted for restoration.

The highest volume of total macroalgae per station was found at Isle of Wight Bay and the highest abundance of "nutrient responsive algae" was in Isle of Wight Bay and Southern Chincoteague Bay (Goshorn et al., 2001). Pfiesteria was found in Turville Creek (MDNR, 1999) and high densities of Aureococcus were reported in Newport Bay, Public Landing, Tingles Island, and Green Run Bay (Tarnowski and Bussell, 2002). Areas with high macroalgae levels may have water quality impairment and should be targeted for possible wetland restoration/mitigation.

According to MDE, restricted shellfish harvesting areas are in the St. Martin River, Turville Creek, Herring Creek, Ocean City (Ocean side near route 90), and a small section in Johnson Bay.

The *Maryland Coastal Bays Aquatic Sensitive Areas Initiative* (2004) was created to identify, describe, and map sensitive aquatic resources (both important habitat and species). This report found some of the highest ranked areas to be along the bayside of the barrier islands, especially Assateague Island. Additional smaller sections, with relatively high rankings, were in the main tidal tributaries, spots along the mainland coastline, and around bay islands. Restoration and protection for wildlife and habitat should focus in these areas or upstream of these areas to improve local water quality.

Soils

Many of the Coastal Bays wetlands were drained historically for agriculture. In order to have the most cost-effective wetland projects, it is ideal to restore sites where little effort is required to obtain the wetland by restoring the hydrology. Major excavation is expensive and can be minimized in an area where the majority of land has an elevation near the water table. Therefore, in the Coastal Bays region, we were able to select only sites with hydric soils and include the majority of the watershed.

A summary of discussions with scientists from NRCS, USFWS, Coastal Resources, Inc., Virginia Tech, and University of Maryland, in addition to interpreting indicators used in the documents Highway Methodology Workbook Supplement and MDE's Method for the Assessment of Wetland Function, is as follows. High organic matter in soils results in high nutrient and contaminant retention and is highly beneficial to wetland systems. Unfortunately, in created wetlands it takes many years before there are significant increases in organic matter. Supplementing a created wetland with organic matter is possible. But to increase organic matter levels to those found in natural wetlands or in high organic soils is difficult. For these reasons, ideal potential wetland sites will already have high organic matter content. Soils classified as histosols and soils having a histic epipedon have very high organic matter that developed over many years of wetland conditions. Histosols that are not presently wetlands (most of these soils are currently wetlands) would make ideal sites. Other soils having high organic matter include those with an umbric epipedon. Pocomoke soils, desirable for wetlands partly because of their high organic matter content, have been divided within Maryland into three different soils, all having umbric epipedons (Brewer, pers. comm.). These are Pone (which does not exist in Worcester County), Berryland, and Mullica. Berryland also has a spodic horizon, a layer of high aluminum. It is possible this soil may absorb higher rates of aluminum and other metals, which are linked with degradation of fish in low pH waters (pH <5), and so may be important in areas of low pH (Rizzo, pers. comm.). In selecting ideal wetland sites, soils having an umbric epipedon are desirable. Enhancement of existing wetlands would also have the benefit of already containing a high amount of organic matter.

Soil texture is important in holding water. Soils that are sandy or coarse textured may drain quickly and become droughty, not providing hydrologic conditions suitable for a wetland. However, the issue of soil texture is not a clear-cut one. Even if the surface layer is coarse textured, if there is a subsurface layer of fine textured sediment, water will still be retained in the system. Additionally, coarse textured soils with a water table very close to the surface may also contain hydrology to support a wetland system. High levels of organic matter also hold water in the system. For this reason, in soils with very high levels of organic matter, soil texture may not be as important. As mentioned, high clay content in soils may increase nutrient (especially phosphorus) and contaminant retention. This may not be a factor when there is a high amount of organic matter since organic matter will also hold the nutrients and pollutants. This factor may get complicated as coarser-textured materials may get water from the groundwater and allow high denitrification, while soils with high clay may receive water mainly from runoff. Additionally, sandy soils may have a buried clay layer limiting water movement and absorbing pollutants. Nitrogen removal through denitrification (loss of nitrogen to the atmosphere) is higher in soils with high organic matter and a fluctuating water table near the soil surface.

Flooding frequency is important because the soils that flood frequently also have higher rates of denitrification and a higher chance of nutrient removal. The flood frequency was estimated for the soils based on the description in the soil survey. Location within the landscape was also noted, as it will lead to different wetland functions. For instance, soils located within the floodplain will provide different functions than those located in depressions. Erodibility is important when selecting sites because wetlands adjacent to highly erodible land (especially row crops) have the potential to provide more water quality improvements. While it may be easiest to restore wetlands on soils classified as very poorly drained, it should be noted that soils classified as poorly drained are more likely to have been drained for agriculture (e.g. Elkton, Othello, Fallsington, etc.). For instance, in the wetland mitigation for U.S. 113, they did not have the opportunity to restore wetlands on soils classified as very poorly drained (Jellick, pers. comm.). However, it may be possible to find soils classified as very poorly drained in artificially drained forest. Forested areas are often overlooked in restoration plans. These sites also make excellent wetlands, as seen in artificially drained forested sites converted to forested wetland through the NRSC program (Nichols, pers. comm.). Most forested areas are artificially drained or are indirectly drained by nearby drains. For this reason, these areas should also be considered.

<u>Streams</u>

Headwater streams are mainly ditched or otherwise physically altered, especially in the headwaters of the northern Coastal Bays watershed. There is a lack of riparian buffers for a large portion of streams, especially in the watersheds of Assawoman Bay, Sinepuxent Bay, and Isle of Wight Bay. These areas are suitable for restoration. The headwater streams may have higher nutrient retention capacity. Streams adjacent to agriculture (especially row crops) and developed land generally receive higher nutrient and sediment runoff than streams adjacent to naturally vegetated areas. Locations where livestock have direct access to the streams are high pollution locations (this situation is rare in the Coastal Bays).

Public Drainage Associations and other ditches

Many of the Coastal Bays wetlands are ditched. Removing these ditches would improve wetland function. Wetland restoration and mitigation may be possible along PDA ditches. However, it is important that any wetland restoration/creation along the PDAs does not alter upstream agricultural drainage. To restore the hydrology, the wetland drains can be plugged (on-line) or the wetland can be built adjacent to the ditch (off-line) using a low-level berm (Nichols, pers. comm.). The ideal sites would be those created by plugging the drain. This may be possible at the top of the artificial drainage system or where these wetlands will not negatively impact upstream agriculture. Unfortunately, in most cases, there is either a perceived or real threat that the upstream drainage will be reduced by restoring an on-line wetland. In these instances, building small berms around the wetland and keeping them off-line (connected through the ditches by an outlet rather than having the wetland encompass the ditch) may prevent the wetland from altering upstream drainage of agricultural land. This second approach is generally more expensive and does not provide as large of a watershed for the wetland. Water entering the wetland is primarily from stream/ditch overflow during high flow periods and from groundwater. These systems may be flooded frequently but for short durations or they may be flooded for long periods. SHA designed an off-line system for the Rt. 113 project to improve water quality while not impacting upstream ditches. This included diverting high flow into a basin next to the stream. While this system does provide some function, likely it is not as desirable as an in-stream system that receives low-flow as well.

Roadside Drainage Ditches

In the 2004 document entitled *Management of Roadside Drainage in Worcester County for Water Quality: A Pictorial Guide*, Worcester County Department of Comprehensive Planning recommends designing roadside drainage to improve water quality, provide habitat, and be aesthetically pleasing. Some examples that could incorporate these functions while still providing adequate drainage and road safety include wetland ditches, sediment traps, and meandering drainageways. Deep ditches or steep slopes should be avoided since they may drop the surrounding water table and/or increase erosion. Poorly designed or failing roadside ditches could be upgraded to improve function.

Mosquito ditches

Many of the Coastal Bays tidal wetlands are ditched in an effort to reduce mosquitoes. During ditch maintenance, the ditches are dredged with the sediment being thrown to the sides (on the marsh surface). Since this ditching alters the natural wetland system (e.g., altering accessibility of fish and possibly reducing wetland nutrient/pollutant filtration), the wetlands may benefit from mosquito ditch removal. Restoration of hydrology in these extensive ditched tidal wetlands is currently being considered.

Prime farmland

Some things in conflict with wetland restoration and mitigation are soils designated by NRCS as prime farmland. With farmland rapidly being converted to development in many areas, it is desirable to preserve highly productive land as agriculture. Prime farmland when drained is also important land, especially when currently in farmland. For these reasons, when targeting for wetland restoration sites, we eliminated sites having prime farmland or prime farmland when drained (currently in farmland).

Wellhead Protection Areas

It is undesirable to excavate soil to build a wetland in wellhead protection areas, especially when the public water is drawn from the unconfined aquifer (MDE, 2004). Soil layers located above the water table retain some contaminants before they reach the water table. Since excavating reduces the depth of soil to the water table, this may reduce the filtering capacity of the soil. Wetlands may improve well water quality when they are in areas previously acting as pollutant sources (i.e. creating wetlands in the place of row crops), and when they act as discharge areas, pulling the water from the ground into the wetland. Although the wellhead protection areas have not been delineated for all community wells, the well locations are known. Community wells are located in the northern Coastal Bays, in the areas of the largest development. Caution should be used when selecting sites in these immediate areas.

Shoreline stabilization

Where possible, shoreline stabilization efforts should employ marsh vegetation. This may be especially feasible in smaller waterways (e.g. Turville Creek, Herring Creek, Bishopsville Prong). In areas with higher erosion rates, it may be necessary to use hard structures, like a low profile stone revetment structure, which is basically stone stabilization that protects the toe of the slope while not exceeding the marsh elevation. Each site should be assessed individually.

Forested land

It is more desirable for us to restore agricultural fields to wetlands than to restore forest to wetlands. This is because farmland generally contributes a higher nutrient and pollutant load than forest. Forest, even pine forest, does provide habitat and water quality functions. Additionally, in many wetland restorations that take place in forest, berm construction may remove several acres of forest, resulting in a loss in forest cover. With this being said, wetland restorations taking place in forest land often make beautiful wetlands, so should not be excluded. We considered converting recently cleared forest and artificially-drained pine forests back to forested wetland. Although the forest industry in the region is an important entity, pine forest stands provide much less habitat than hardwood or mixed stands (Wilson, 2001). For this same reason, it is undesirable to convert upland hardwood forest to forested wetland, since this area already provides good habitat. Wetland forest that is ideal for preservation includes large parcels of high quality forest.

Property ownership

Small lots are undesirable for targeting because the property owner may not be interested or the prices might be too high to purchase easements because they do not have much land. Smaller sites are more common around areas of higher development and may be zoned as residential or commercial, which also may influence the owner interest. Additionally, the wetland site would be small and unconnected with other wetlands. Since it is desirable to have contiguous sections of wetland and other wildlife habitat, we are selecting large lots where large wetlands can be created or wetlands near other wetlands or desirable habitat (e.g., forest). Owners of large lots may feel that putting several acres into an easement or converting it to wetland may not make a large impact on their total lot value and usefulness. Additionally, these lots may be less expensive, especially if the lot cannot be extensively subdivided (e.g., zoned Resource Conservation). Since a major limitation in selecting a site is interest by the property owner, we will focus on areas with zoning that significantly limits subdivision potential (e.g., zoned agriculture, conservation, or estate). We will also include public land. Government-owned land was targeted because owners may be more open to this type of program. Other considerations include churches that own large amounts of land.

Rural Legacy

The area designated as Rural Legacy includes an area adjacent to Chincoteague Bay, from the Virginia line to Brockanorton Bay. Although large portions of this land are already protected by the state (including some Chesapeake Forest Land), Maryland Environmental Trust Easements, county, and agricultural easements, further protection and restoration should be focused in this area. In January 2002, there were 2,700 acres of land protected through Rural Legacy easements (MDNR, 2002b).

Critical Area

The portion of the Coastal Bays designated as the Critical Area may also be good locations for preservation and restoration.

Greenways

The Assateague Island National Seashore is a protected greenway roughly connected with the greenway along Sinepuxent Bay and Chincoteague Bay shore. The Sinepuxent Bay water trails are located off Assateague Island and traverse through marsh. Some of these greenways are not currently well protected, but should be protected. The Isle of Wight greenway on the Isle of Wight Island provides opportunities for restoration of marshland and extension of this greenway in the northern salt marsh region. The proposed Snow Hill Rail Trail, located in Southern Chincoteague Bay watershed, is mostly unprotected.

Ecologically Significant Areas (ESAs)

These areas are determined by MDNR to contain rare, threatened, or endangered species or rare/exemplary natural communities. It is important to protect these areas (MDNR, 2004 Draft). All of the NTWSSCs are included within the ESAs. Many of these ESAs are included within the Green Infrastructure network (with the exception of some smaller fragmented ecologically important areas).

Wetland proximity

In order to achieve a contiguous protected habitat area, rather than many fragmented wetlands, it is desirable to locate the site adjacent to other wetlands, forests, or other habitat. It is important to note that some isolated wetlands may be part of the metapopulation, isolated populations connected through emigration or immigration of propagules or individuals, and may be important for the overall maintenance of species diversity.

Historic Wetland Loss

As mentioned previously, wetland losses, both salt and fresh, were highest in the northern Coastal Bays watershed. Losses of forested palustrine wetlands, due to drainage or conversion may be 90%, with highest losses occurring in St. Martin River, Isle of Wight Bay, Manklin Creek, and Newport Bay subwatersheds (USACE, 1998). Additionally, there have been more recent wetland losses around some of the other waterways (e.g. Herring Creek and Turville Creek). A larger proportion of restoration/mitigation effort should be focused in the areas with high wetland loss. A high amount of forested palustrine wetlands should be created since they suffered such high losses. Additionally, high losses of salt marsh occurred on Fenwick Island, Ocean Pines, and bayside of Assateague Island. Since Fenwick Island and Ocean Pines are highly developed, wetland restoration opportunities in these areas will be limited.

Wetland type

What type of wetland should be restored? There is some debate on this subject. While some recommend restoring wetlands to their previous condition, this is often not a realistic option. As mentioned, there are many factors to consider. We need to design wetlands to be compatible with surrounding land use, the desires of the landowner (e.g. landowners may request certain wetland functions such as an open water element), and watershed needs (e.g. one watershed may need water quality improvements above other wetland functions). Wetlands can support certain types of recreation, including fishing, hunting, biking, hiking, bird watching, and limited boating (e.g., canoeing and kayaking).

Wetlands of special interest

For wetland habitat function, top priority should be to preserve wetlands known to provide exceptional habitat. It is difficult, if not impossible, to recreate some of these rare habitats. Wetland preservation and enhancement may include the nontidal wetlands of special state concern (NTWSSC) and other wetlands containing important habitat or threatened, rare or endangered species. Enhancement projects are very site-specific and may include removing invasive species or suppressing woody succession. All bogs and sea-level fens should be protected from nutrient additions (communication with Chris Spaur, 2004). These projects should be based on the MDNR Heritage Program NTWSSC surveys and discussions with that group. If wetland restoration or mitigation occurs adjacent to these areas, MDNR Heritage Program should be contacted so they can study the associated impacts to the NTWSSC.

MDNR Natural Heritage Program surveyed the NTWSSC sites in 2002 and 2003, compiling the results in the document *Nontidal Wetlands of Special State Concern of Five Central Maryland Counties & Coastal Bay Area of Worcester County, Maryland*. Specific site recommendations that resulted from this study are summarized below. Also summarized below is protection information based largely on MDNR GIS data with supplemental Worcester County GIS data. For a complete site listing and description of the wetlands of special state concern refer to the Background section of this document.

- *Isle of Wight Bay*
    - West Ocean City Pond - Forested buffers around the lake should be maintained. In the future, the water willows growing in the shallow southern section of the pond may need to be controlled; otherwise, they may eventually replace native vegetation or alter the pond hydrology. This area is unprotected.
- *Newport Bay*
    - Ironshire Swamp – Since MDNR added this site to Porter Neck Bog, it is described under that name.
    - Porter Neck Bog - The spring needs to be protected. Natural disturbance to maintain the open vegetative structure is necessary for the sensitive species. In the absence of this natural disturbance (the current condition), woody succession should be manually controlled. This area is not protected.
- *Chincoteague Bay*
    - Hancock Creek Swamp - The main threat is logging in the wetland, the buffer, and the surrounding forested slopes. The majority of this area is not protected.
    - Little Mill Run – Tornadoes have created canopy gaps allowing invasive vegetation (Oriental stilt-grass) to establish. Although herbicides are generally needed to control this grass, it is not recommended in this case since it would likely harm the sensitive species. Additionally, the floodplain and surrounding slopes should be protected and logging should be avoided in the wetland, buffer, and surrounding uplands. A small portion of this area is protected.
    - PawPaw Creek – Main threats include trail development and mowing. While the sensitive species require some natural disturbance, direct disturbance would harm them. Japanese honeysuckle is present and should be monitored, but no action is recommended at this time. This area is not protected.
    - Pikes Creek – includes Pikes Creek and Stockton Powerlines

        - Pikes Creek - Logging should be avoided in the wetland and buffer. This area is partially protected.
        - Stockton Powerlines - This site is located in the headwaters of Chincoteague Bay, so contributes to the Bay's water quality (MDNR, 1987). Fire or manual woody succession suppression is necessary to maintain the open habitat required of the sensitive species. Most of this area is protected.
    - Powell Creek - Logging should be avoided in the wetland and buffer. The surrounding slopes and upland area should also be protected. This area is unprotected.
    - Riley Swamp - Logging should be avoided in the wetland and buffer. Invasive plant species, especially near Greenback Road, should be manually controlled. This area is unprotected.
    - Scarboro Creek Woods - Logging within the wetland and buffer should be avoided. The surrounding forest should also be maintained. The majority of this area is protected.
    - Scotts Landing Pond - This pond is very susceptible to changes in hydrology. There is a ditch connecting this pond to a nearby marsh system. In a high water event, salt water could be transported up this ditch and into the pond, essentially destroying the current vegetative system. It is recommended this ditch be plugged. Additionally, any new nearby wells could reduce the water table and substantially alter the critical hydrology. Woody species may need to be manually removed in the future to control woody succession. Logging should be avoided in the buffer. This area is not protected.
    - Tanhouse Creek - Logging in the wetland, buffer, and upland forest should be avoided. Oriental stilt-grass, entering the site from the logging road to the south, should be controlled through herbicidal spraying. This area is not protected.

Threats to the additional wetland areas of potential importance within the Coastal Bays watershed as identified by the Maryland Natural Heritage Program (MDNR, 2004) are as follows:

- *Newport Bay*
    - Icehouse Branch. Avoid logging in the surrounding forest. Protect wetland buffers.
    - Massey Branch. The surrounding watershed, including an adequate buffer, should be maintained to limit impacts from agricultural runoff and development, since these plant species generally require healthy water quality. The landowners should be contacted to encourage protection.

    - St. Lawrence Neck. Overall protection of the sea-level fen and slope are top priority. Logging should be avoided in the wetland, buffer, and upland forest to reduce impacts from erosion and runoff. One of the rare species benefits from mowing along Langmaid Road. Fire or manual removal of woody vegetation should be employed to control woody succession in the seepage areas.
- *Chincoteague Bay*
    - Pikes Creek Woods. This site will be surveyed by Natural Heritage Program soon.
    - Spence Pond. The main threat is alteration of the hydrology.
    - Truitt Landing. Overall protection of the sea-level fen and slope are top priority. Logging should be avoided in the NTWSSC, adjacent wetlands, buffer, and upland forest. Fire or manual removal of woody vegetation should be employed to control woody succession in the seepage areas.
    - Waterworks Creek. Threats include impacts to the water quality from agricultural runoff and development.

Additional non-tidal wetlands of significant, as identified in USACE (1998):

- Church Branch. This cypress swamp is one of the largest in the coastal bays watershed. It needs protection from logging and impacts of development.
- Great Cypress Swamp. This swamp is on the Maryland/Delaware Line, including within St. Martin's River. While much of it has been drained, including large portions within the St. Martin's River watershed, there is good potential for restoration and reconnection with some of the remaining cypress swamp. The Delaware Wildlands Trust owns some of the swamp located in the Pocomoke River watershed and in Delaware.

Tidal Coastal Bays wetlands identified by the Emergency Wetlands Resources Act of 1986 as being especially important to waterfowl include: Big Bay Marshes, Mills Island, and Tizzard Island (USACE, 1998).

<u>Other potential sites</u>

There are known areas where restoration or protection would be beneficial. These include the following:

- *The marshes on the northern side of the Isle of Wight Island*. These marshes are currently eroding (USACE, 1998). This island is owned by MDNR and is used for recreation.

- *Dead-end canals*. As suggested by the Comprehensive Conservation and Management Plan for Maryland's Coastal Bays, to improve the water flushing of the dead-end canals, they can be connected by pipes. Other restoration opportunities within the dead-end canals will be considered, but due to possible resistance from existing property owners, restoration of the canals may be difficult. Although this may not be directly related to wetlands, it may improve local water quality.
- *Skimmer Island (North of the Route 50 bridge)*. Bay islands are important for colonial waterbird nesting. Skimmer Island is an important rookery, shorebird-feeding site, and horseshoe crab-spawning site and is currently unprotected (USACE, 1998).
- *Chesapeake Forests land*. Located in the western portion of Chincoteague Bay watershed, these areas provide opportunities for wetland restoration and creation (MDNR, 2003b).

GIS data sources

<u>Soils</u>

We utilized the 2000 USDA NRCS Soil Survey data for Worcester County (scale 1:24,000). In addition to being the most recent, designations of hydric soils are also more accurate than those in the MDP Natural Soils Groups. This data allowed us to select for or against the following attributes: hydric soil, drainage, prime farmland (including prime farmland when drained or irrigated), highly erodible soils, soil texture, soil organic matter, flood frequency, permeability, epipedons, histosols, or soil name.

<u>Other</u>

- Area background
    - Aerial Photos 1998-2000
    - Infrared Photography 1989
    - QUADS 1971-1986 (USGS)
    - ADC Map
- Green Infrastructure (MDNR 2000-2003)
    - Hubs, naturally vegetated corridors, agriculture, developed, or barren in potential corridors
    - Ecological rankings
    - Development risk
    - Gaps

- Protected lands (federal, state, county, private conservation properties, Maryland Environmental Trust easements, agricultural easements, Natural Heritage Areas – MDNR; additional sites – WO CO; partial list of WRP, CRP, and CREP - NRCS)
- Rural Legacy designation and priority preservation areas (as designated through the Rural Legacy Program - MDNR)
- Interior forest (including general forest quality – MDNR)
- Land use (MDP 2002)
- Shoreline change (MGS)
- Sensitive Species Project Review Areas and Ecologically Significant Areas within the Coastal Bays (MDNR)
- Property ownership and lot designations (MDP 2003)
- Zoning designations (Worcester County)
- Wetlands
    - Wetlands categorized using Cowardin classification (MDNR, NWI) and HGM type (Tiner et al., 2000)
    - Wetlands of Special State Concern (MDNR)
    - Other wetlands of special interest (proposed NTWSSC - MDNR)
    - Submerged aquatic vegetation (VIMS/MDNR)
- Streams
    - Streams and ditches (MDNR and Tiner, 2000)
    - MBSS (MDNR)
    - Isle of Wight Bay watershed SCA (MDNR)
    - Newport Bay/Sinepuxent Bay watersheds SCA (MDNR)
- Floodplain
    - 100-year floodplain (FEMA)
    - Properties with multiple flood damage (MDE)
- Water quality
    - Water samples from MDE, MDNR, MDNR volunteer data, NPS
    - Point sources of discharge for municipal and industrial (MDE)
- Drinking water
    - Well locations (including areas of high reported nitrates - MDE)

- Designated Wellhead Protection Areas (MDE)

Summary of restoration targeting information - existing recommendations

General Sites

- Stream corridors (MCBP, 1999; Fugro East, Inc., 1995; USACE, 1995; Worcester County, 1997)
    - Headwater streams (Worcester County, 2002)
    - Adjacent to pollutant source (Fugro East, Inc., 1995; USACE, 1995)
    - Establish more natural ditches through natural vegetation and sinuosity (Worcester County, 2002)
- Adjacent to a lake (Fugro East, Inc., 1995; USACE, 1995)
- 100-foot buffer around tidal waters and wetlands (Worcester County, 2002)
- 100-year floodplains (Worcester County, 1997, 2002)
- Shoreline stabilization (MCBP, 1999; Worcester County, 2002)
- Sources of pollutants
    - Agriculture (especially row crops) (Boynton et al., 1993; MCBP, 1999; Fugro East, Inc., 1995; MDE 2001; Worcester County, 2002)
        - Install riparian areas and wetlands on agricultural land (MCBP, 1999)
        - Target areas where livestock have direct access to streams
    - Highly erodible land (Fugro East, Inc., 1995)
    - Urban land (Jellick et al., 2002)
- Rural Legacy Area (Worcester County, 1997)
- Green Infrastructure (Weber, 2003)
    - Gaps within high-ranking hubs and corridors based on ecological ranking and development risk.
    - Areas within or adjacent to the hub and corridor network that will increase connectivity and interior condition (e.g., reducing edge habitat).
- Chesapeake Forest Land (MDNR, 2003b)
- Other forest (Spaur et al., 2001)
- Critical Area (Fugro East, Inc., 1995)
- Residential buffers (MCBP, 1999)

- In areas of high historic wetland losses, targeting types lost (i.e. forested wetlands) (MCBP, 1999; USACE, 1998)
- Wastewater treatment, sediment retention, stormwater management, and wildlife habitat (MCBP, 1999; Worcester County, 2002)
- Recreation
    - Where water-based recreation is not a threat to the system (MCBP, 1999)
    - Connect development and recreation (MCBP, 1999)
    - Maintain recreational areas (Worcester County, 1989)
- Habitat
    - Habitat for fish and shellfish (MCBP, 1999)
    - Bird habitat (MCBP, 1999)
    - Corridors between important habitats (Worcester County, 2002)
    - Types of regional significance (e.g. bald cypress swamps, Atlantic white cedar swamps, Delmarva Bay wetlands, sea-level fens) (Spaur et al., 2001)
- Soils
    - Soils – hydric (Worcester County, 2002)
    - High organic matter (discussions with several scientists, Fugro East, Inc., 1995; USACE, 1995)
        - Histosols (Fugro East, Inc., 1995)
        - Containing histic or umbric epipedons (discussions with Brewer, Rizzo, Jellick, Rabenhorst)
    - High clay content (may not be as important as organic matter) (Shanks, 2001; Worcester County, 2002; USACE, 1995)
    - Flood frequency high (Shanks, 2001; Fugro East, Inc., 1995)

<u>Specific Sites</u>

- Northern Coastal Bays watershed (high wetland losses forested palustrine wetlands) (USACE, 1998; Worcester County, 1997)
- Northern Coastal Bays watershed (salt marsh) (USACE, 1998, Spaur et al., 2001).
- Isle of Wight Bay (Boynton et al., 1993; MDNR and MDE, 2000; Worcester County, 1989; USACE, 1998)

- Assawoman Bay (Boynton et al., 1993; Chaillou et al., 1996; MDNR and MDE, 2000; Worcester County, 1989)
- Newport Bay watersheds (Boynton et al., 1993; MDNR and MDE, 2000; USACE, 1998)
- St. Martins River (Chaillou et al., 1996; MDE, 2001; USACE, 1998; Worcester County, 1989)
- High nutrient concentrations based on nutrient synoptic survey for Isle of Wight (Primrose, 1999, 2001)
    - Station 1. Tributary to St. Martin at St. Martin Neck Road
    - Station 2. Tributary to St. Martin at St. Martin Neck Road
    - Station 4. Bunting Branch at Delaware Rt. 54 in Selbyville
    - Station 7. Careys Branch at Rt. 113
    - Station 8. Tributary to Birch Branch at Murray Road
    - Station 11. Tributary to Perkins Creek at Jarvis Road
    - Station 13. Birch Branch at Rt. 113
    - Station 15. Church Creek at Rt. 113
    - Station 17. Birch Branch at Campbelltown Road
    - Station 22. Church Creek at Careys Road
- High nutrient concentrations based on nutrient synoptic survey for Newport/Sinepuxent Bays (Primrose, 2003)
    - Station 1. Tributary to Marshall Creek at Langmaid Road
    - Station 14. Bottle Branch at Harrison Road
    - Station 15. Kitts Branch at Flower Street
    - Station 17. Kitts Branch at Rt. 346
    - Station 18. Kitts Branch at railroad tracks near Rt. 50
    - Station 21. Tributary to Sinepuxent Bay at Eagles Nest Road
    - Station 29. Tributary to Trappe Creek at Rt. 376
    - Station 30. Tributary to Kitts Branch at Seahawk Road
    - Station 31. Ayers Creek at Sinepuxent Road
    - Station 41. Poplartown Branch at Beaverdam Creek Road.
- Shingles Landing Prong (MDE, 2001)
- Bishopville Prong (MDE, 2001; Worcester County, 1989)
- Bishopville #1 is north of St. Martins Neck Road between Route 367 and Mumford Road, draining into Bishopville Prong above Shell Mill Road. (Worcester County, 2002)

- Bishopville #2 is west of Bishopville Prong, between Jarvis Road and Hammond Road. Draining into Slab Bridge Prong and Perkins Creek before entering Bishopville Prong. (Worcester County, 2002)
- Turville Creek (MDE, 2001; Worcester County, 1989)
- Trappe Creek (Chaillou et al., 1996; MDE, 2002a; Worcester County, 1989)
- Herring Creek (MDE, 2001; Worcester County, 1989)
- Ayer Creek (MDE, 2002a)
- Newport Bay (Chaillou et al., 1996; MDE, 2002a)
- Newport Creek (MDE, 2002a)
- Big Millpond (in Chincoteague Bay watershed) (MDE, 2002b)
- Ocean City Harbor (Worcester County, 1989)
- Carey #1 is located in the headwaters of Carey Branch (Worcester County, 2002)
- Birch #1 is on Birch Branch, west of Rt. 113 and south of Carey #1. (Worcester County, 2002)
- Birch #2 is south of Peerless Road and drains into Birch Branch and Middle Branch. (Worcester County, 2002)
- Manklin Creek (high wetland losses) (USACE, 1998; Worcester County, 1989)
- Fenwick Island, Ocean Pines, and bayside of Assateague Island (high salt marsh loss) (USACE, 1998)
- The marshes on the northern side of the Isle of Wight Island (USACE, 1998)
- Dead-end canals (MCBP, 1999; Chaillou et al., 1996)
- Chesapeake Forests land – western portion of Chincoteague Bay watershed (MDNR, 2003b)
- Great Cypress Swamp – northwestern edge of Isle of Wight watershed (MDNR Natural Heritage Program, USACE, 1998, Spaur et al., 2001)

<u>Excluded Areas</u>

- Public Drainage Associations – do not alter upstream drainage or maintenance. Exceptions (locations within the PDAs where restoration/mitigation may be possible) include in the upper areas. Off-line sites will not significantly disturb hydrology of the PDAs, so are options for restoration/mitigation.
- Prime farmland (Worcester County, 1989)
    - Prime farmland without alteration

    - Prime farmland when drained, currently in agriculture
- Wellhead Protection Areas (MDE Water Supply Program) – restoration/enhancement should be okay, as long as there is no excavation.
    - Do not excavate area acting as a filter
    - Community wells are all located in the northern Coastal Bays watershed
- Forested land containing high quality hardwood forest habitat

Most sources recommended restoration of the northern watersheds and Newport Bay watershed, mainly because of the poor water quality in these areas and the high amount of historic wetland loss. Within this northern area, there were several sources recommending restoration in St. Martins River watershed. Several sources also recommended Bishopville Prong and Birch Branch. Some literature sources and personal contacts suggested trying to improve water quality in the dead-end canals, if possible. Additionally, there were many recommendations to restore other waterways.

MDE restoration analysis and final recommendations

In Maryland Coastal Bays watershed, we will consider all wetland restoration and preservation projects having interested landowners. The below prioritization effort is intended to target locations where we should actively seek restoration or preservation opportunities, and recommend the list for other entities as well. Due to the conditions of this region, with little effort wetlands can be restored in almost any area having hydric soil. Our intent is to predict the areas where restored wetlands would provide the most function. For information on the GIS methods used, please refer to Appendix B.

<u>Priority 1 restoration sites</u>

Selecting sites

1) **Hydric soils**: In the Coastal Bays watershed, we were able to select only sites with hydric soils and include the majority of the watershed.
2) **Rank hydric soils**: We ranked soil names based on readily obtainable attributes from the 2000 NRCS soil survey. Most wetland restoration projects occurring on hydric soils in the Coastal Bays watershed are successful in creating wetlands, regardless of the soil organic matter or texture. However, wetland functioning may be higher on certain soil types. After discussions with many soil scientists (including Gary Jellick, Al Rizzo, Jim Brewer, John

Galbraith, and Marty Rabenhorst), we came up with a soil ranking (Table 6). Location within the landscape was noted, as it will lead to different wetland functions (e.g., soils located within the floodplain will provide different functions than those located in depressions). Soils with a landform = "Estuarine Tidal Marsh" may become acidic when drained. These soils are very poorly drained and many have high organic matter or a histic epipedon. High organic matter in soils results in high nutrient and contaminant retention and is highly beneficial to wetland systems. In general, these soils have not been converted from wetlands, but there are some exceptions. These soils would be ranked top for preservation and restoration. Additional soils with histic epipedons (but not having a landform of estuarine tidal marsh) are also ranked top priority for restoration and preservation. Soils that are very poorly drained with umbric epipedons (also high in organic matter) are ranked next priority. These soils (very poorly drained) were historically very wet, so wetland hydrology may be easier to restore than soils classified as poorly drained. Soils that are poorly drained and have a high amount of organic matter or fine textures are ranked next. The worst ranked are poorly drained soils with low organic matter and coarse texture. Coarse-textured soils may drain too quickly to establish adequate wetland hydrology and may have lower nutrient and contaminant retention. This may not be as large of a factor when there is a high amount of organic matter. While it is often easiest to restore wetlands on soils classified as very poorly drained, it should be noted that soils classified as poorly drained are more likely to have been drained for agriculture (e.g. Elkton, Othello, Fallsington, etc.). However, it may be possible to find soils classified as very poorly drained in artificially drained forest (Jellick). For the general site prioritization, we only ranked the soils "very poorly drained" and "poorly drained" because we did not want to eliminate other soils at this level. However, a GIS data layer was created that does rank the NRCS soil data into more fine-tuned ranking as found in the table. This may be useful when comparing between specific on-the-ground sites.

3) **Exclude prime farmland when drained on agriculture from targeting effort**: We excluded prime farmland when drained on agricultural land.
4) **Within Green Infrastructure network**: We looked for areas of very poorly drained hydric soils, without prime farmland when drained on agriculture, within the GI network.
5) **Exclude areas currently in forest**: For priority 1 sites, we excluded forested land. NRCS projects within the Coastal Bays watershed that do convert drained forest to wetlands have

resulted in beautiful wetlands with diverse ecology. Therefore, we do consider restoring forest (especially pine forest) to wetland in priority 2.

6) **Exclude areas currently in wetlands**: We excluded areas classified as MDNR and NWI wetlands. However, this method excluded some other sites, which we added later.
7) **Include zoning with restrictions on development lot size and include protected land**. For the analysis of priority 1, we wanted to consider only areas within county zoning classifications of Resource Conservation, Agriculture, or Estate. Therefore, we excluded areas zoned other than these three, with the exception of protected land (owned by the county, state, federal, private conservation, and Maryland Environmental Trust).
8) **Exclude MDE-designated wellhead protection areas.** We excluded areas within designated wellhead protection areas.

The above eight criteria resulted in a map highlighting several areas**.** All of these areas may be desirable restoration sites, but some are relatively small. While these sites are good locations, this map may be missing some sites and not considering other factors. Therefore, we analyzed the data considering additional factors.

9) **Look for additional sites on orthophoto based on the below criteria.** We basically tried to find areas with the highest concentration of these desirable elements:
   - **Adjacent to or within Green Infrastructure network**: We visually assessed the proximity to GI network, favoring areas that would contribute to the GI network if restored.
   - **Adjacent to streams with no forest/wetland buffer (with pollutant source)**: We looked for inadequately buffered streams having an adjacent pollutant source (agriculture, barren, or developed land use). We selected portions of the 150-foot stream buffer having urban, agriculture, or barren land use on hydric soil. This method was employed in the WRAS characterization for IOW. Many Coastal Bays wetland systems are discharge wetlands, with the water coming up from the water table. Additionally, most precipitation falling to this area infiltrates rather than running off the soil, so wetlands not directly along the stream may also benefit water quality. Wetlands having deep-rooted vegetation (e.g. trees) may be the most effective at removing nutrients from

the groundwater. In many cases, wetlands created next to the streams will need to be built off-line to address actual or perceived reduction in upstream drainage.

- **Adjacent to wetlands or other natural systems**: To assess the surrounding natural systems, we looked at adjacent streams and wetlands.
- **Pollution source**: We looked for areas that were a pollution source themselves or were downstream of a pollution source. These were also included in the selection of inadequate stream buffers on agricultural land (see above).
- **MDNR farmed wetlands**. Wetlands that are currently being farmed may be good options for wetland enhancement. It is also likely that these areas are not extremely productive as farmland since they are so wet. We looked for areas with a high concentration of farmed wetlands.

10) **Consider actual property lot size**: Although we already excluded from consideration certain zoning classifications that would suggest smaller property size (e.g., zoned residential), we wanted to further evaluate the dominant property size of the selected areas. We looked at the property ownership of the desirable sites that we had highlighted. All of the highlighted sites are at least partially on moderate to large sized lots. The site with some of the smallest lots is in Sinepuxent Bay watershed.
11) **In areas of poor water quality**: Water quality data was used to divide the priority 1 sites into two groups, ones in areas of poor water quality and ones in areas of better water quality. Areas with better water quality may not be as desirable for overall Coastal Bays watershed restoration, but for restoration where it is desirable to restore within the same 8-digit watershed as the impact. For instance, most recommendations suggest the Northern Coastal Bays and Newport are most in need of restoration, but if wetland restoration is required in Chincoteague or Sinepuxent Bays, there are still some priority 1 sites from which to chose.

We used summary data from State of the Bays Report and TMDL recommendations. Essentially all areas were on the 303(d) List, so that itself was not a good way to prioritize areas. For the headwater areas, sites with the worst nutrient concentrations during the MDNR synoptic survey were used. These coincided with the other recommendations, but were helpful in selecting specific areas within the headwaters.

All of the above criteria resulted in maps of priority 1 restoration sites (Figure 6: Isle of Wight, Assawoman, Newport, Sinepuxent Bays and Figure 7: Chincoteague Bay).

Table 6. Soil characteristics and ranking for the hydric soils within Maryland Coastal Bays watershed. Characteristics are based on the 2000 Worcester County Soil Survey (USDA, 2000).

Map Symbol	**Soil Name**	**Family or higher taxonomic class**	**Drainage**	**Epipedon**	**OM**	**Texture**	**Landform**	**Acid when drained**	**Rank**
As	Askecksy	Siliceous, mesic Typic Psammaquents	pd	ochric	2	1	FL/DEP	N	4
Bh	Berryland	Sandy, siliceous, mesic Typic Haplaquods	vpd	Umbric (spodic horizon)	4	1	FL/DEP	N	2
Br	Broadkill	Fine-silty, mixed, nonacid, mesic Typic Sulfaquents	vpd	ochric	4	3	TM	Y	1
BX	Boxiron (40%); Broadkill (40%)	Boxiron: Fine-silty, mixed, nonacid, Histic Typic Sulfaquents; Broadkill: Fine-silty, mixed, nonacid, mesic Typic Sulfaquents	vpd	histic	5	organic	TM	Y	1
Ch	Chicone	Coarse-silty, mixed, acid, mesic Thapto-Histic Fluvaquents	vpd	buried histic	4	2	FP	N	2
Ek	Elkton	Fine-silty, mixed, mesic Typic Endoaquults	pd	ochric	2	3	FL/DEP	N	3
Em	Elkton	Fine-silty, mixed, mesic Typic Endoaquults	pd	ochric	2	3	FL/DEP	N	3
Fa	Fallsington	Fine-loamy, mixed, mesic Typic Endoaquults	pd	ochric	2	3	FL/DEP	N	3
Hu	Hurlock	Coarse-loamy, siliceous, mesic Typic Endoaquults	pd	ochric	2	2	FL/DEP	N	4
In	Indiantown	Coarse-loamy, siliceous, acid, mesic Cumulic Humaquepts	vpd	umbric	3	2	FP	N	2
Ke	Kentuck	Fine-silty, mixed, mesic Typic Umbraquults	vpd	umbric	4	3	FL/DEP	N	2

Table 6 (continued)

Map Symbol	Soil Name	Family or higher taxonomic class	Drainage	Epipedon	OM	Texture	Landform	Acid when drained	Rank
Ma	Manahawkin	Sandy or sandy-skeletal, siliceous, dysic, mesic Terric Medisaprists	vpd	histic	5	organic	S/FP	N	1
MC	Mannington (50%); Nanticoke (45%)	Mannington: Fine-silty, mixed, nonacid, mesic Typic Hydraquents; Nanticoke: Fine-silty, mixed, nonacid, mesic Typic Hydraquents	vpd	buried histic	3	3	MF	N	2
Mu	Mullica (55%); Berryland (30%)	Mullica: Coarse-loamy, siliceous, acid, mesic Typic Humaquepts; Berryland: Sandy, siliceous, mesic Typic Haplaquods	vpd	umbric	4	2	FL/DEP	N	2
Ot	Othello	Fine-silty, mixed, mesic Typic Endoquults	pd	ochric	2	3	FL/DEP	N	3
Pk	Puckum	Dysic, mesic Typic Medisaprists	vpd	histic	5	organic	S/FP	N	1
Pu	Purnell	Sandy, mixed, mesic Histic Sulfaquents	vpd	histic	5	organic	TM	Y	1
Su	Sunken	Fine-silty, mixed, mesic Typic Endoaqualfs	vpd	ochric	4	3	TM	Y	1
Tk	Transquaking	Euic, mesic Typic Sulfihemists	vpd	histic	5	organic	TM	Y	1
TP	Transquaking (55%); Mispillion (35%)	Transquaking: Euic, mesic Typic Sulfihemists; Mispillion: Loamy, mixed, euic, mesic Terric Sulfihemists	vpd	histic	5	organic	TM	Y	1
Zk	Zekiah	Coarse-loamy, siliceous, acid, mesic Typic Fluvaquents	pd	ochric	4	2	FP	N	3

Drainage: pd=poorly drained, vpd=very poorly drained. Organic matter represents undrained organic matter. Higher numbers indicate higher organic matter. Drained OM is generally lower. Soil texture: 1=sandy; 2=coarse-silty/coarse loamy; 3=fine-loamy/fine-silty; organic=histic. Landform: FL/DEP=Lowland flat and depressions, TM=Estuarine tidal marshes, FP=Flood plains, S/FP=Swamps and floodplains, MF= Mud flat. Ranking: Higher numbers indicate more desirable soils for wetland restoration.

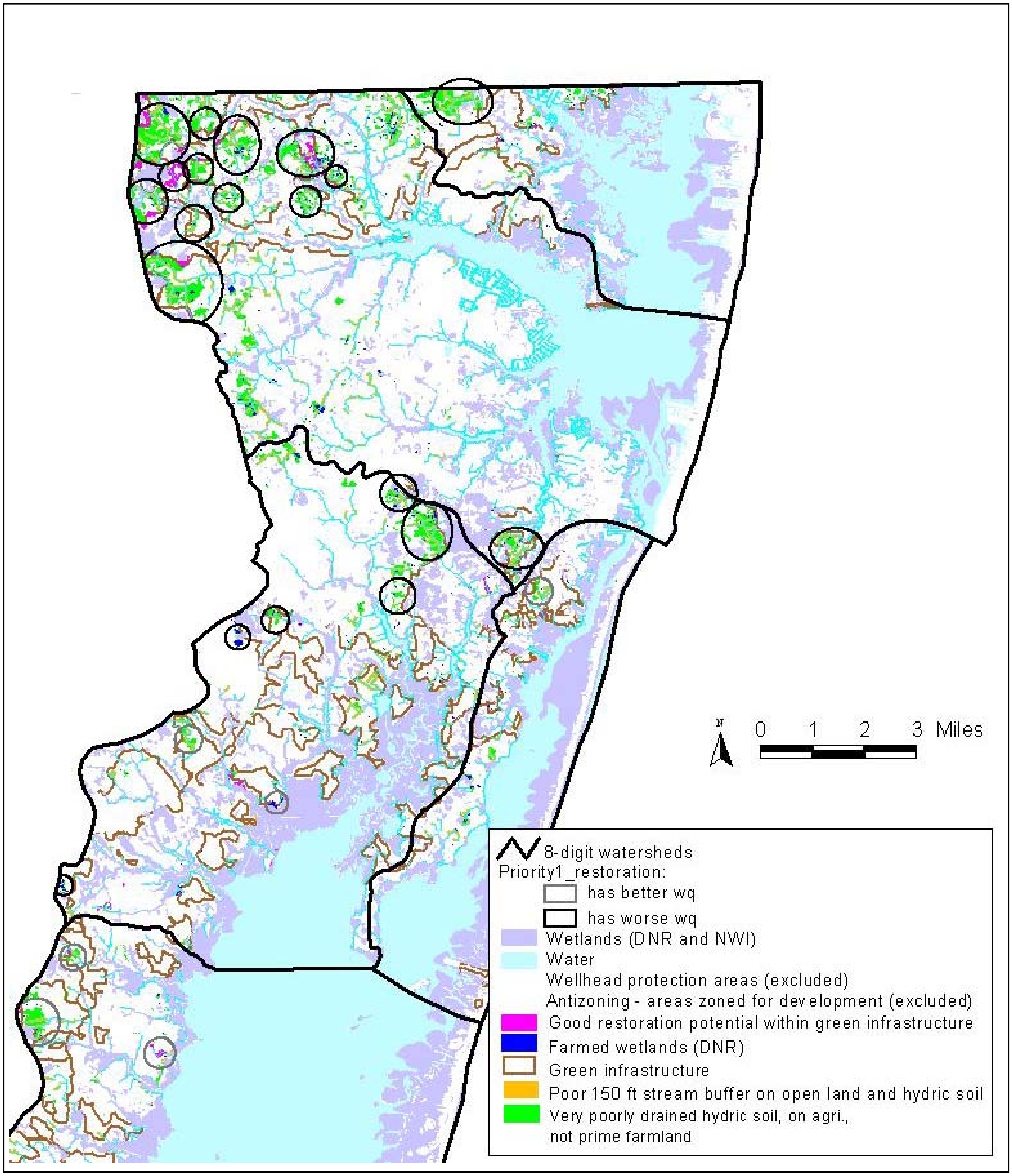


Figure 6. Priority 1 wetland restoration sites for four northern Coastal Bays watersheds.

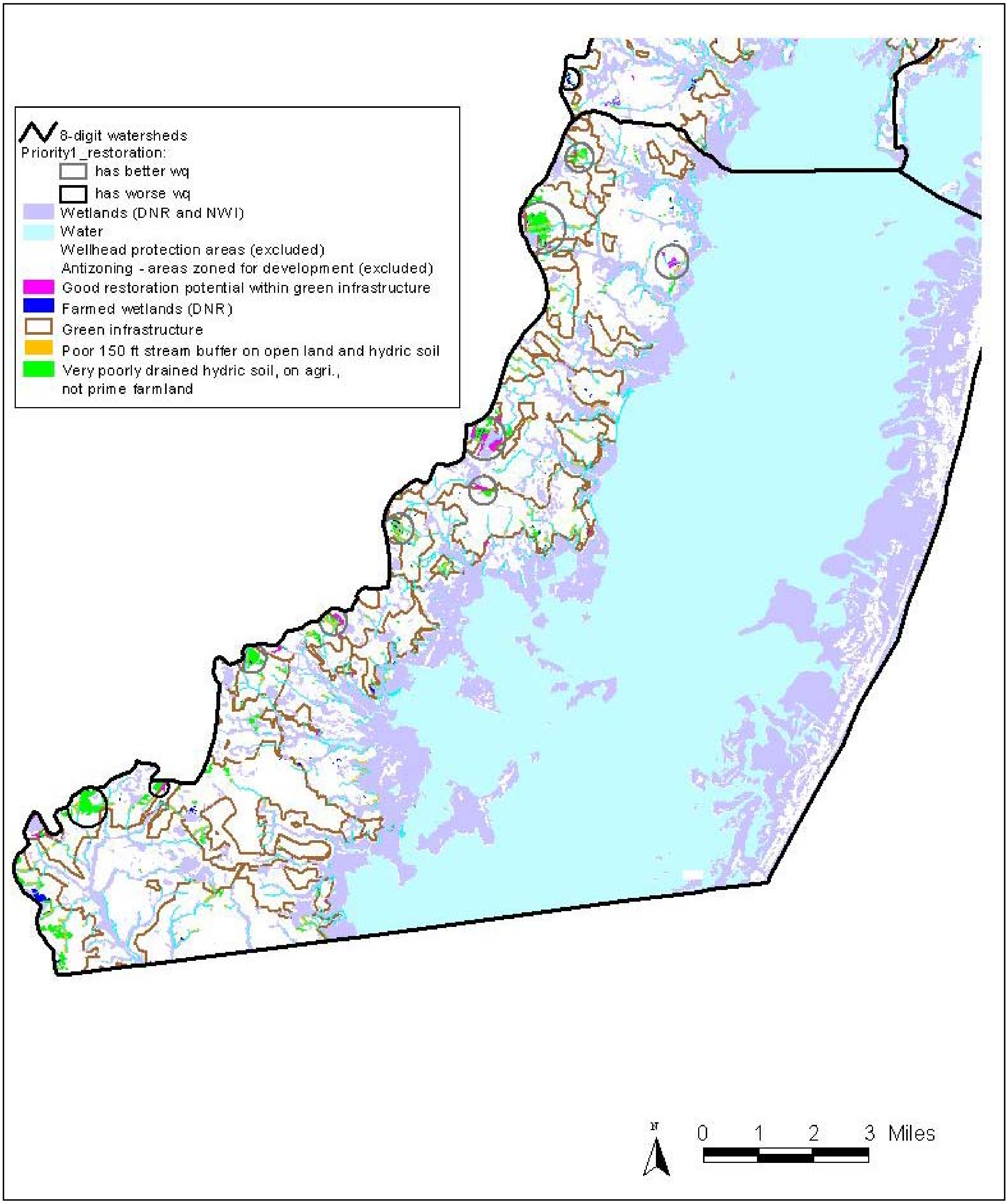


Figure 7. Priority 1 wetlands restoration sites for Chincoteague Bay watershed.

How this compares to the WRAS (IOW) potential restoration sites.

We compared our priority 1 results with the Isle of Wight WRAS results. Our results highlighted most of the sites they chose. Exceptions were Birch #2 (south of Peerless Road) since it is dominated by prime farmland which we excluded, and Bishopsville #1 since it was not within or adjacent to Green Infrastructure. Bishopsville #1 is a site that we ranked as priority 2. This site is in Bishopsville watershed (an area having poor water quality), it has large areas of very poorly drained soils currently in agriculture (including several MDNR classified farmed wetlands), and there are many streams and ditches without a buffer. This is a site that sticks out as being an exception to the rules of priority 1. From this comparison, we determined that our methods are finding similar results as the WRAS method, but we are finding more sites. Even mimicking the methods employed for the IOW WRAS, we found slightly different results due to the different data sources employed (e.g. we used different stream and soil layers and an additional wetland layer).

<u>Priority 2 restoration sites</u>

Basically, in determining priority 2 sites, we considered many of the same principals as for priority 1, but were less restrictive.

- **Include both poorly and very poorly drained soils.**
- **Still exclude prime farmland and wellhead protection areas.**
- **Include artificially drained forest when it is on very poorly drained hydric soil in or adjacent to Green Infrastructure.** Restoring artificially drained forest to wetland may provide less water quality improvement than converting marginal cropland to wetland (partly because agriculture land use is a much higher pollutant source), but forested wetlands can provide more water quality function than forested upland. Additionally, upland forested areas often provide more habitat than farmland, so it may be less desirable to convert forest to wetland than to convert farmland to wetland. However, when wetland hydrology is restored to these drained forests, they often become beautiful ecologically diverse wetlands. This type of restoration has the benefit of providing immediate forest cover in the wetland (versus wetlands built on agricultural land that may take a few decades to develop forest cover). We selected soils ranked very poorly drained, within the GI network, currently forest but not wetland.

The above criteria resulted in maps of priority 2 restoration sites (Figure 8: Isle of Wight, Assawoman, Newport, Sinepuxent Bays and Figure 9: Chincoteague Bay).

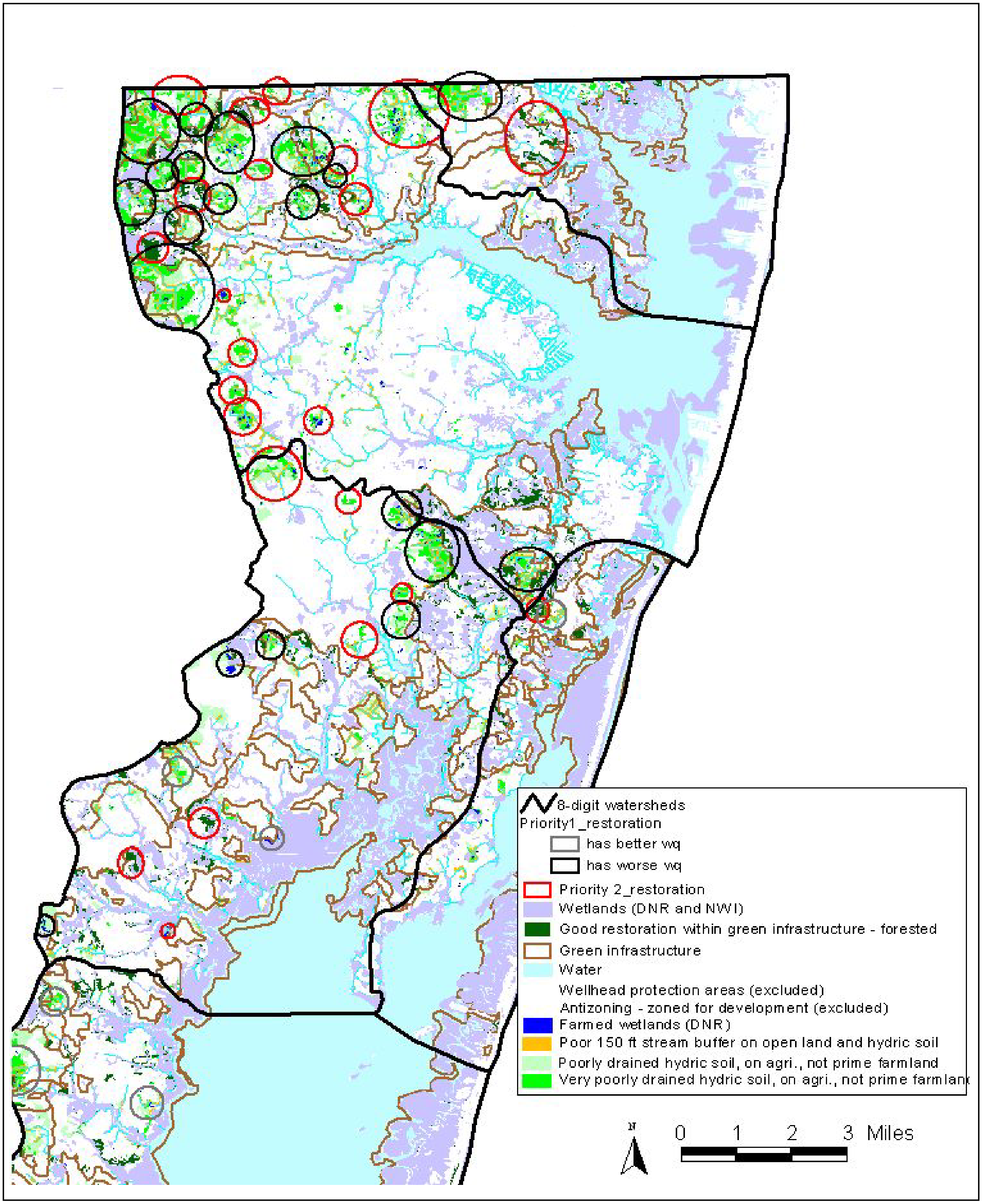


Figure 8. Priority 1 and 2 wetland restoration sites for four northern Coastal Bays watersheds

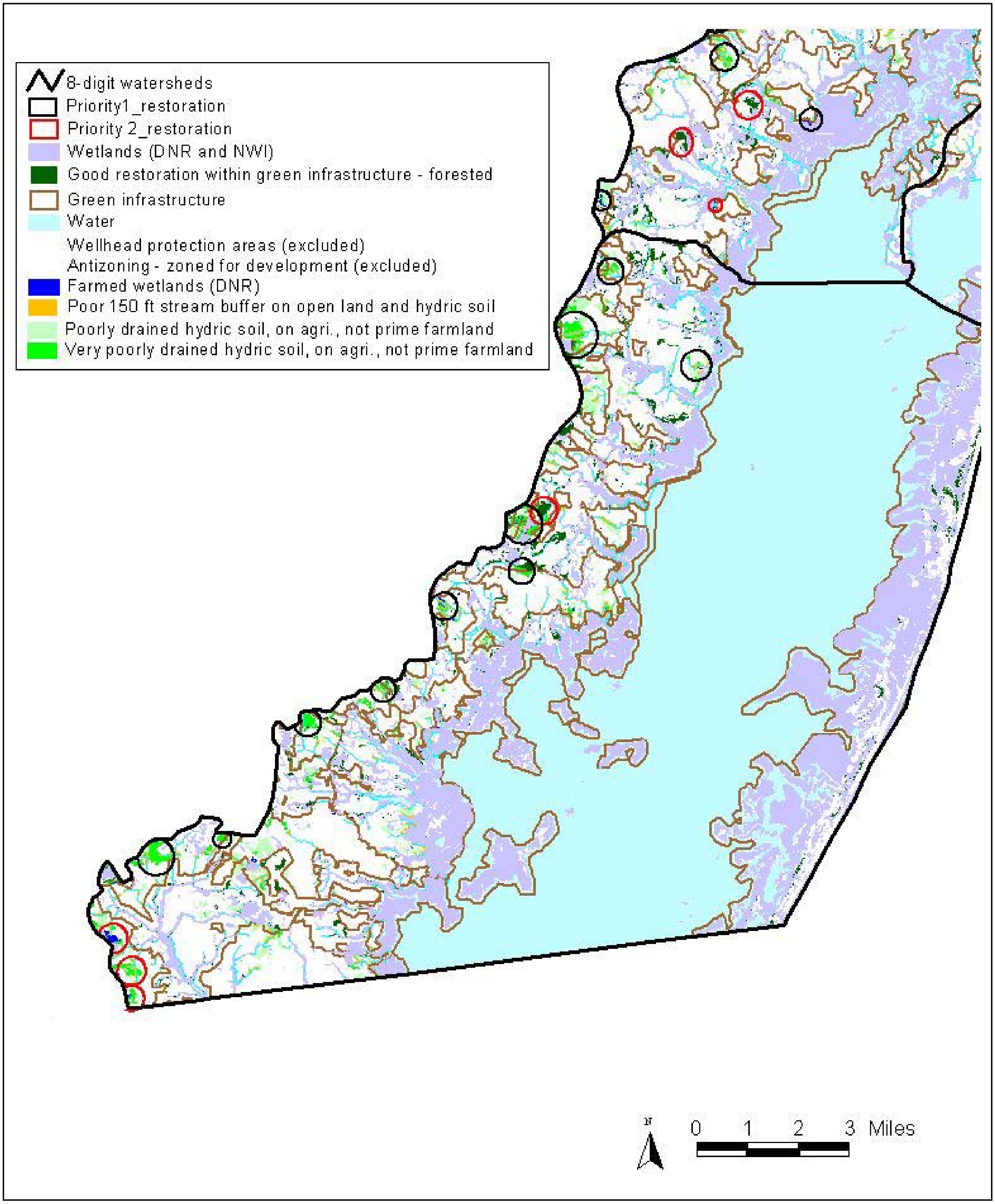


Figure 9. Priority 1 and 2 wetland restoration sites for Chincoteague Bay watershed.

Protected land

Protected land was targeted because owners may be more open to the idea of restoration on their property. We looked for areas that are protected (private conservation, Maryland Environmental Trust easements, federal, state, county land, Chesapeake Forest land) on hydric soil, and not currently designated as wetlands. We did not include agricultural easements, CREPs, or WRPs.

This resulted in a map showing restoration opportunities on currently protected land (Figure 10: Isle of Wight, Assawoman, Newport, Sinepuxent Bays and Figure 11: Chincoteague Bay).

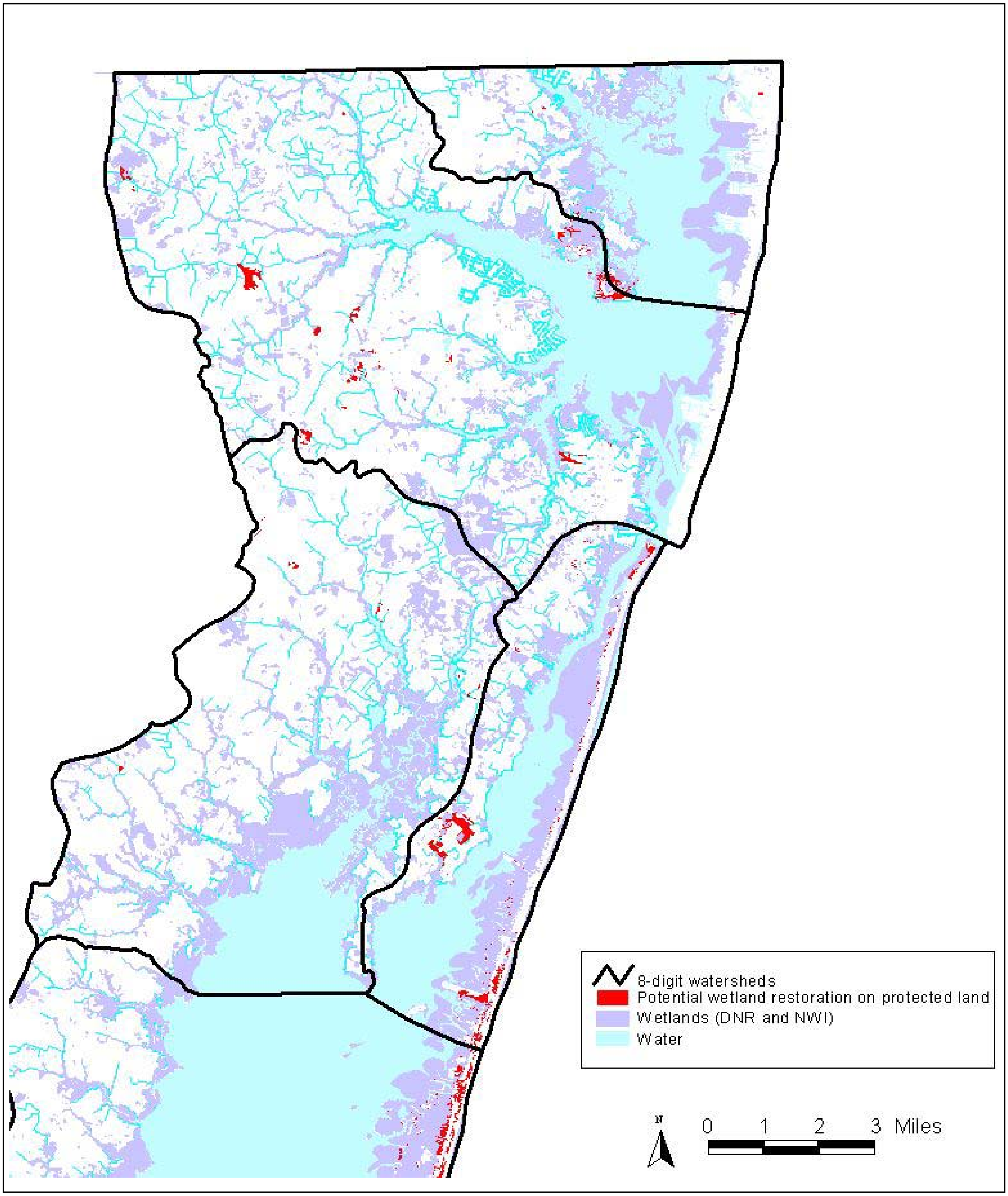


Figure 10. Potential wetland restoration sites for protected land within the four northern Coastal Bays watersheds.

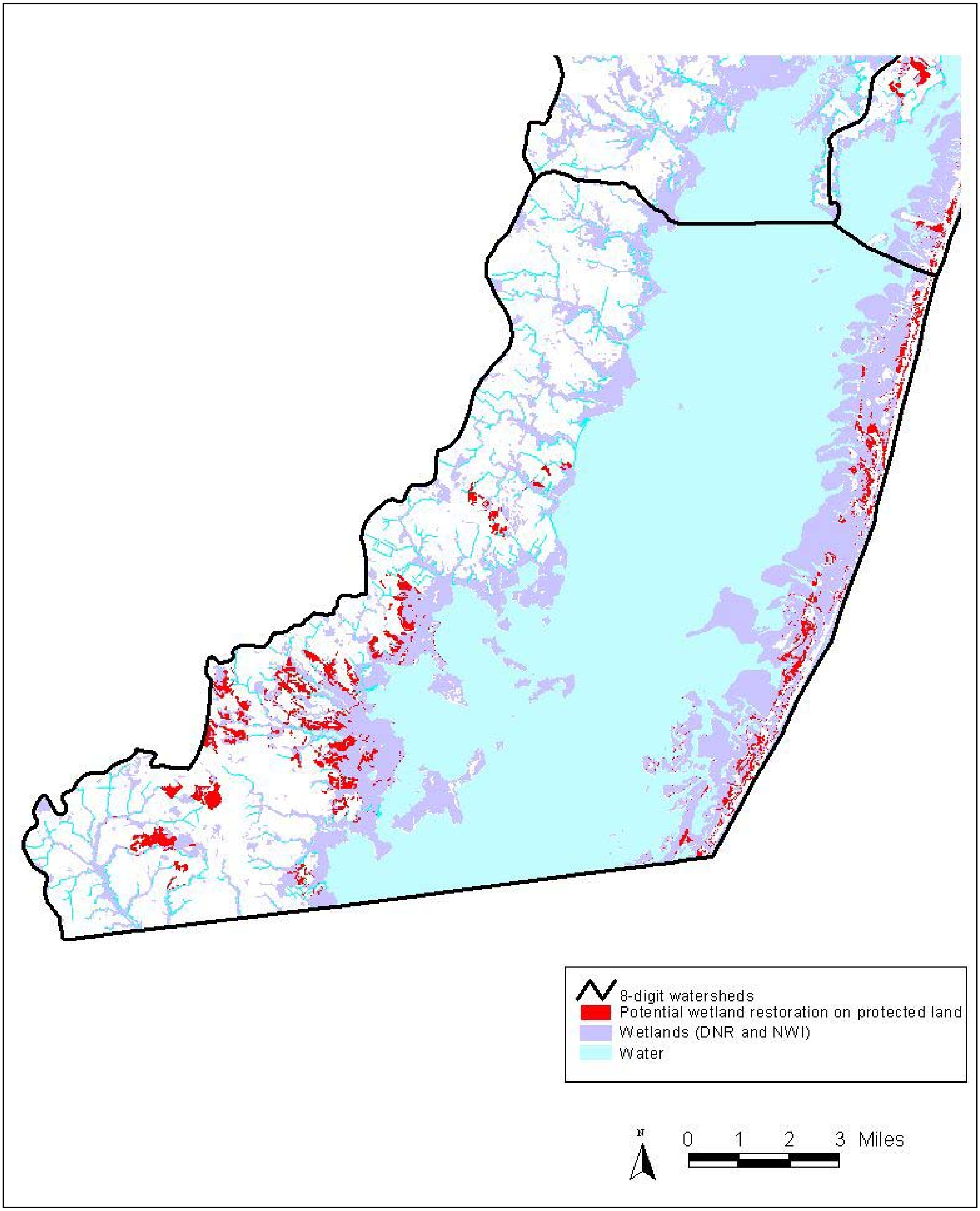


Figure 11. Potential wetland restoration sites for protected land within Chincoteague Bay watershed.

Previous recommendations for restoration sites

- **Stream "problem" sites as identified through the SCA (IOW, Newport, Sinepuxent) having**:
    - Stream erosion. We selected sites with moderate to severe stream erosion (severity 1 to 3).
    - Inadequate buffers. We selected buffers ranked very severe (severity 1 and 2)
    - Fish barriers. We excluded debris barriers because we felt many of these may be temporary or may be removed by methods easier than restoration. Of the remaining barriers, only one is severe – Bishopsville Dam (which is planned for removal). The remaining blockages had a low severity (severity 4 and 5). Therefore, identified fish barriers are only a minor variable inhibiting aquatic ecosystem, when compared to other issues.
- **Tiner.** Sites identified for restoration during the Tiner et al. (2000) study should be considered as enhancement options, especially ditched estuarine and palustrine wetlands, tidally restricted wetlands, and farmed wetlands. As discussed in the background section of the report, palustrine forested wetlands may be overestimated in the Tiner wetlands layer.
- **Additional recommendations.** In order to address all of the specific site recommendations within the targeting section, ones that were not directly addressed in the previous section are listed below.
    - Isle of Wight, Assawoman, and Newport Bays (these bays also have some of the worst water quality so were generally the target of restoration).
    - Marshes on the northern side of Isle of Wight Island.
    - Dead-end canals (this would likely be an out-of-kind structure).
    - Ocean City Harbor.
    - Manklin Creek, Fenwick Island, and Ocean Pines.
    - Great Cypress Swamp

These additional previous recommendations for restoration are also shown on a map (Figure 12).

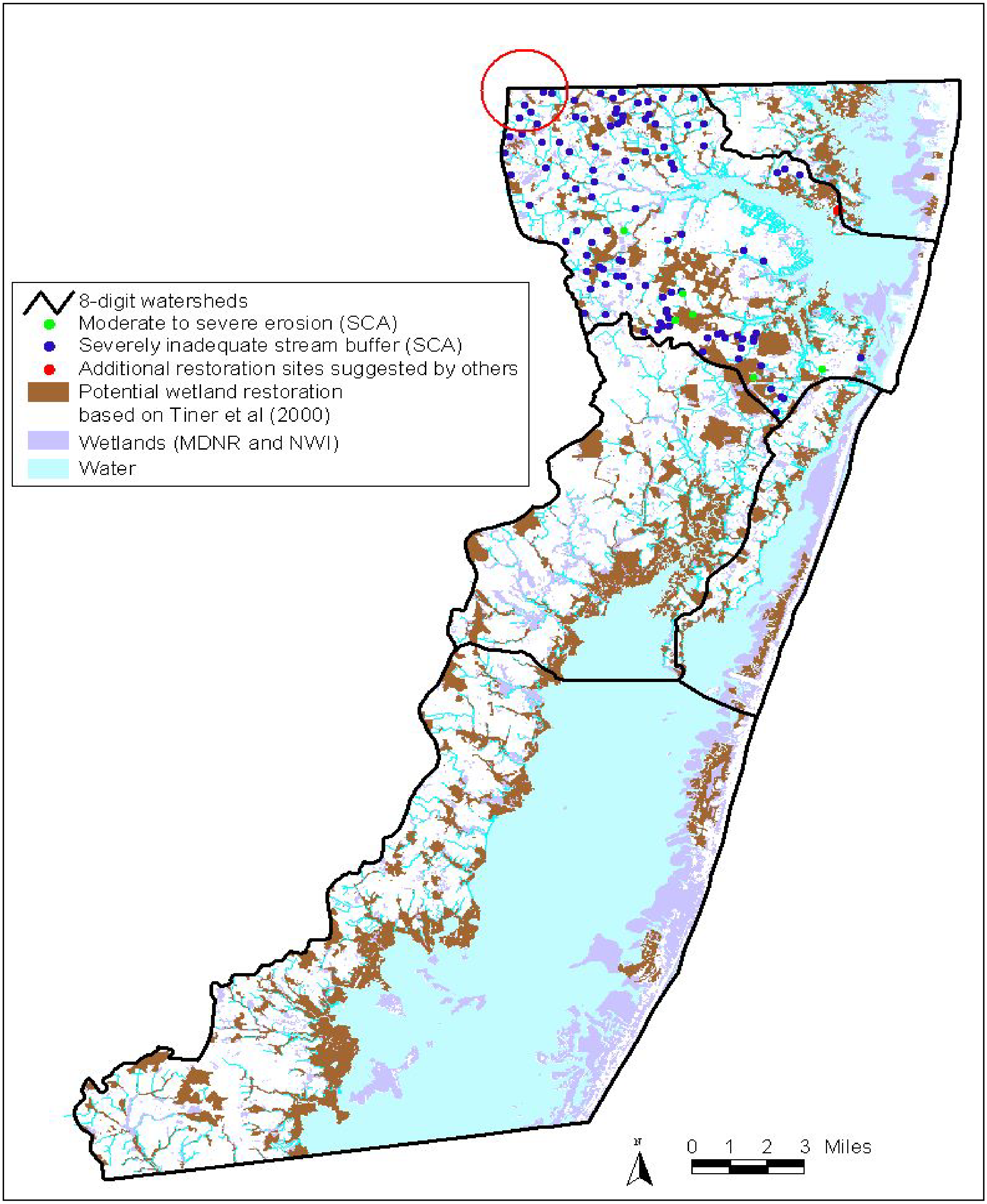


Figure 12. Additional wetland restoration sites within the Coastal Bays watershed.

Summary of protection targeting information - existing recommendations

General Sites

- Aquatic systems
    - Coastal Resources (Worcester County, 1989)
    - Wetlands (MCBP, 1999; Worcester County, 1997, 2002)
    - Drainageways (Worcester County, 1989)
    - 100-ft buffer around tidal waterbodies and wetlands (Worcester County, 2002)
    - Stream corridors and their buffers (MCBP, 1999; Worcester County, 1997)
    - Natural shoreline and surrounding areas (MCBP, 1999)
- Areas of high erosion (Worcester County, 1989)
- Bays, beaches, bluffs (MCBP, 1999; Worcester County, 1989)
- Floodplains (Worcester County, 1989, 1997, 2002)
- Forests
    - Forests in general (Worcester County, 1989)
    - Forests adjacent to streams and wetlands (MCBP, 1999)
    - Large parcels of hardwood/mixed forest (MCBP, 1999)
- Recreational
    - Areas of high recreational value (Worcester County, 1989)
    - Greenways between development and recreation (MCBP, 1999)
    - Sensitive areas from detrimental impacts of water-recreation (MCBP, 1999)
- Rural Legacy Area (Worcester County, 1997)
- Green Infrastructure (MDNR, 2004 Draft)
    - Hubs with high ecological ranking and high development risk
    - Corridors connecting hubs of high ecological ranking
- Non-fragmented systems (USACE, 1995)
- Histosols (Fugro East, Inc., 1995; USACE, 1995)
- Important habitat
    - Habitats of threatened and endangered species (MCBP, 1999; Fugro East, Inc., 1995; Worcester County, 1997, 2002)
    - Ecologically Significant Areas (MDNR, 2004 Draft)
    - Horseshoe crab habitat (MCBP, 1999)

    - Migration and breeding habitat of neotropical songbirds (MCBP, 1999)
    - 100-foot buffer around colonial waterbird nesting sites (Worcester County, 2002)
    - Corridors between significant habitat (Worcester County, 2002)
    - Connected to other wildlife habitat (USACE, 1995)
    - Bird habitat (MCBP, 1999)

<u>Specific Sites</u>

- Newport Bay and Chincoteague Bay watersheds (MDNR & MDE, 2000)
- Skimmer Island (USACE, 1998)
- West Ocean City Pond (MDNR, 1987)
- Ironshire Swamp (MDNR, 1987)
- Porter Neck Bog (MDNR, 1987)
- Hancock Creek Swamp (MDNR, 1987)
- Little Mill Run (MDNR, 1987)
- PawPaw Creek (MDNR, 1987)
- Pikes Creek (MDNR, 1987)
- Powell Creek (MDNR, 1987)
- Riley Swamp (MDNR, 1987)
- Scotts Landing Pond (MDNR, 1987)
- Tanhouse Creek (MDNR, 1987)
- Sinepuxent Bay water trail (MDNR, 2000)
- Snow Hill Rail Trail (MDNR, 2000)
- Church Creek cypress swamp (Spaur, 2004)
- Other cypress swamp sites when identified (Spaur, 2004)

Because Chincoteague Bay generally has the best water quality within the Coastal Bays, and is currently the least developed, it is desirable to protect this area. Recommendations of which waterways to protect were mixed, with no one area being recommended the most.

MDE protection analysis and final recommendations

<u>Priority 1 protection sites</u>

- **Nontidal Wetlands of Special State Concern (NTWSSC) or proposed Nontidal Wetlands of Special State Concern** (MDNR, 2004). Since all NTWSSC and proposed NTWSSC either have unique flora or fauna, or provide unique habitat, we ranked all NTWSSC and proposed NTWSSC as priority 1 for protection. We looked for NTWSSC or proposed NTWSSC that were not already protected. Within this priority 1 layer, we ranked these sites further. We wanted to protect wetlands that were surrounded by protected natural land, either currently or planned, since a large contiguous natural system is desirable for habitat function. For this reason, sites were ranked based on Green Infrastructure (GI), ecological ranking, Rural Legacy (RL), surrounding land use (LU), and surrounding protected land.
    - Isle of Wight
        - *West Ocean City Pond*. This site is outside of the GI and RL and is surrounded by residential LU.
    - Newport Bay
        - *Porter Neck Bog* (Ironshire Swamp, as listing in COMAR, is now included under this name). This site is within the GI but outside of RL. It is mostly surrounded by forest and some agriculture.
        - *Icehouse Branch*. This proposed NTWSSC is within the GI but outside of RL. It is mostly surrounded by forest and some agriculture.
        - *Massey Branch*. This proposed NTWSSC is within the GI but outside of RL. It is mostly surrounded by forest and some agriculture.
        - *St. Lawrence Neck*. This proposed NTWSSC is within the GI but outside of RL. It is mostly surrounded by forest and some agriculture.
    - Chincoteague Bay
        - *Waterworks Creek*. This proposed NTWSSC is within GI but outside of RL. It is surrounded by mixed forest and wetlands.
        - *Spencer Pond*. This proposed NTWSSC is within GI but outside of RL. It is surrounded by mixed forest.
        - *PawPaw Creek*. This NTWSSC is within GI but outside of RL. It is surrounded by mostly pine forest.
        - *Tanhouse Creek*. This NTWSSC is within GI. Although it is outside of the RL, it is very close. Some nearby RL land is protected. It is surrounded by mixed forest and some agriculture.

- *Scotts Landing Pond* – This NTWSSC is within GI but outside of RL (surrounded by it). It is surrounded by pine forest and wetland.
- *Truitt Landing*. This proposed NTWSSC is protected by a MET.
- *Scarboro Creek Woods*. This site is within GI and RL. It is partially protected by E.A Vaughn WMA and is surrounded by mixed forest and agriculture.
- *Pikes Creek Woods*. This proposed NTWSSC is not within GI, but is adjacent to it. It is within RL. The ecological ranking was not as high as the other sites. This site is next to a lot of protected land (E.A. Vaughn WMA, MDNR-owned Chesapeake Forest land, and a MET). This site is largely surrounded by agriculture.
- *Pikes Creek*. Over half of this site is protected by Chesapeake Forest land and the other portion is adjacent to E.A. Vaughn WMA and a MET. This site is within GI and RL, and is surrounded by pine forest and agriculture.
- *Stockton Powerlines*. The majority of the site is protected by MDNR-owned Chesapeake Forest land. This site is within GI and RL, and is surrounded by mixed forest and agriculture.
- *Riley Creek Swamp*. This site is within GI and RL, and is surrounded by mainly agriculture (and a thin strip of mixed forest).
- *Hancock Creek Swamp*. This site is within GI and RL, and is surrounded by forest. It is partially protected and has some protected land around it.
- *Powell Creek*. This site is within RL but outside of GI. It is surrounded by agriculture and was given a relatively low ecological ranking.
- *Little Mill Run*. A small amount of this site (in the NE) is protected by MDNR-owned Chesapeake Forest land. This site is within GI, but the GI is mainly agriculture. It is outside of RL. It is mostly surrounded by agriculture, with thin strips of forest.

Although all of the above sites should be ranked priority 1, some of the most desirable NTWSSC and proposed NTWSSC sites for protection include Tanhouse Creek, Scotts Landing Pond, and sites within both designated Green Infrastructure network and Rural Legacy. The sites Pikes Creek, Pikes Creek Woods, Scarboro Creek Woods, and Stockton Powerlines are close together and are near large areas of protected land. If these areas were all protected, it would create a large protected area, which is desirable. NTWSSC sites with lowest preservation priority include West Ocean City Pond, Powell Creek and Little Mill Run.

Additional sites were added to priority 1 based on the following:

- Within or adjacent to designated Rural Legacy area and other protected land.
- Wetlands within MDNR-designated Ecologically Significant Areas (ESA).
- Within or adjacent to Green Infrastructure or corridor. Consider ecological ranking and development risk. Look for remaining wetlands in high ecological ranking area.
- Adjacent to waterways or other natural systems (i.e. wetlands, hardwood forests).
- Areas identified by the Emergency Wetlands Resources Act of 1986
- Church Branch Cypress Swamp

Most of the priority 1 protection sites fall within Newport Bay and Chincoteague Bay, areas identified by Unified Watershed Assessment as being high priority for preservation (Figure 13). Only one site is within Isle of Wight (West Ocean City Pond) and none are within Sinepuxent or Assawoman.

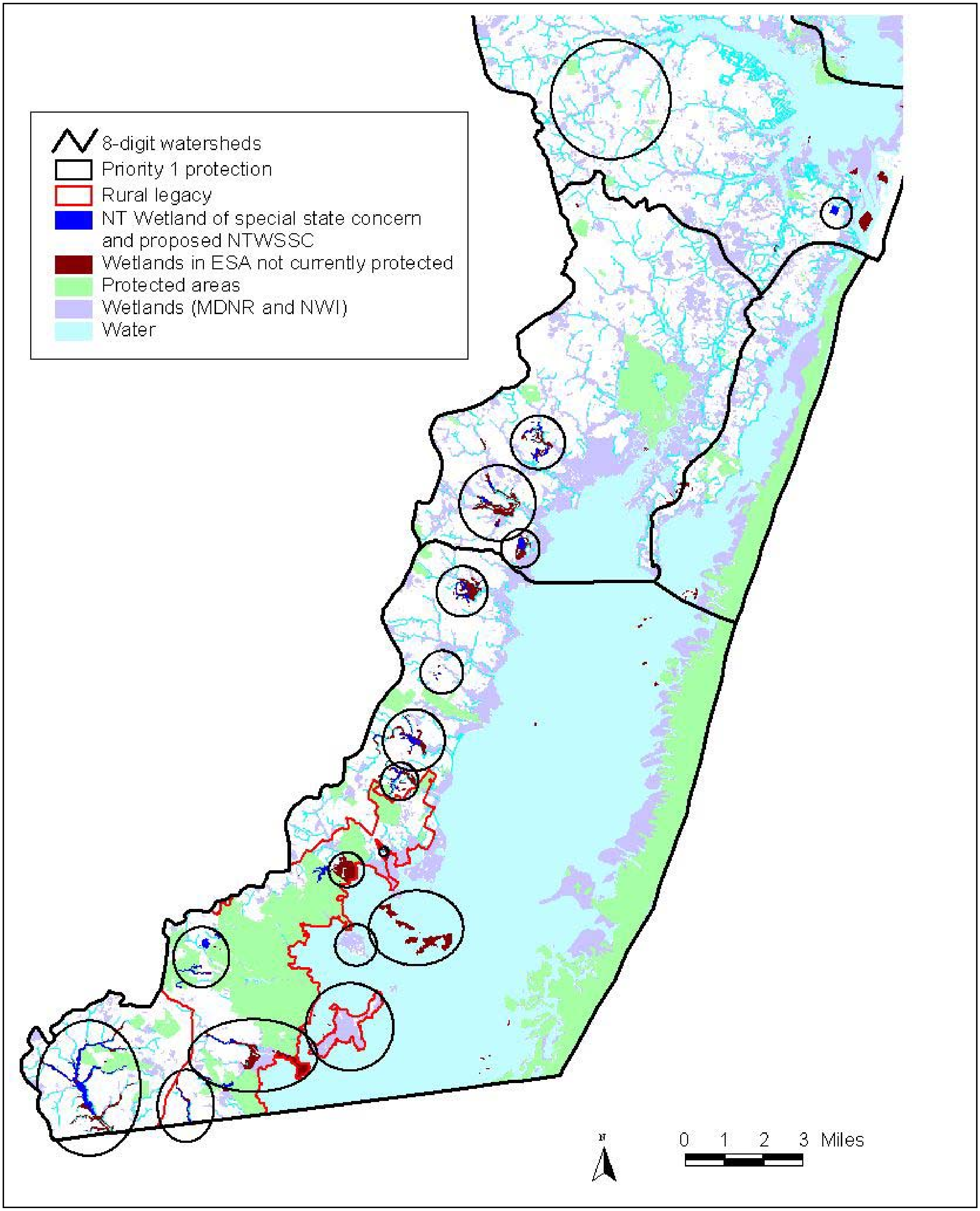


Figure 13. Priority 1 wetland preservation sites within the Coastal Bays watershed.

Priority 2 protection sites: priority 2 uses many of the same factors as priority 1, but is not as strict. For instance, if some of the criteria were met, the site would be considered (e.g. Priority 2 sites within Isle of Wight watershed are not within or adjacent to RL or protected land, but are within the GI network and are the largest wetland systems in that watershed).

- **Within or adjacent to Rural Legacy.**
- **Adjacent to protected land.**
- **Wetlands within MDNR-designated Ecologically Significant Areas (ESA)**. We selected wetlands that were not yet protected that intersected (xtools) with the ESA layer.
- **Areas identified as being important in the Aquatic Sensitive Species Report**.
- **Within or adjacent to Green Infrastructure or corridor**. Consider ecological ranking and development risk. Look for remaining wetlands in high ecological ranking area. We also considered ecological ranking, which was closely related to Green Infrastructure. All priority two sites are in areas of high ecological ranking. This layer may be more useful in comparing areas outside of the Green Infrastructure network.
- **Adjacent to waterways or other natural systems** (i.e. wetlands, hardwood forests).
- **Large wetland systems.**
- **Tiner wetland functional assessment.** We added two sites that Tiner classified as being important for biodiversity since they were large wetland complexes. These areas do not have many MDNR or NWI wetlands identified on them. Therefore, further site investigation will determine if these sites are actually wetlands.
- **Headwater wetlands.** Existing headwater wetlands with high estimated function for maintaining water quality should also be protected. These may largely include headwater wetlands in Isle of Wight and the northern half of Newport Bay.
- **Once priority 1 restoration areas are restored, they should be protected.** There are currently few extensive wetland areas within Isle of Wight watershed, but many priority 1 restoration areas are located there. Once these sites are restored, if they are considered important in maintaining water quality or providing a natural vegetation network, these areas should be protected.

Priority 2 protection sites are shown on the maps (Figure 14: Isle of Wight, Assawoman, Newport, Sinepuxent and Figure 15: Chincoteague Bays.

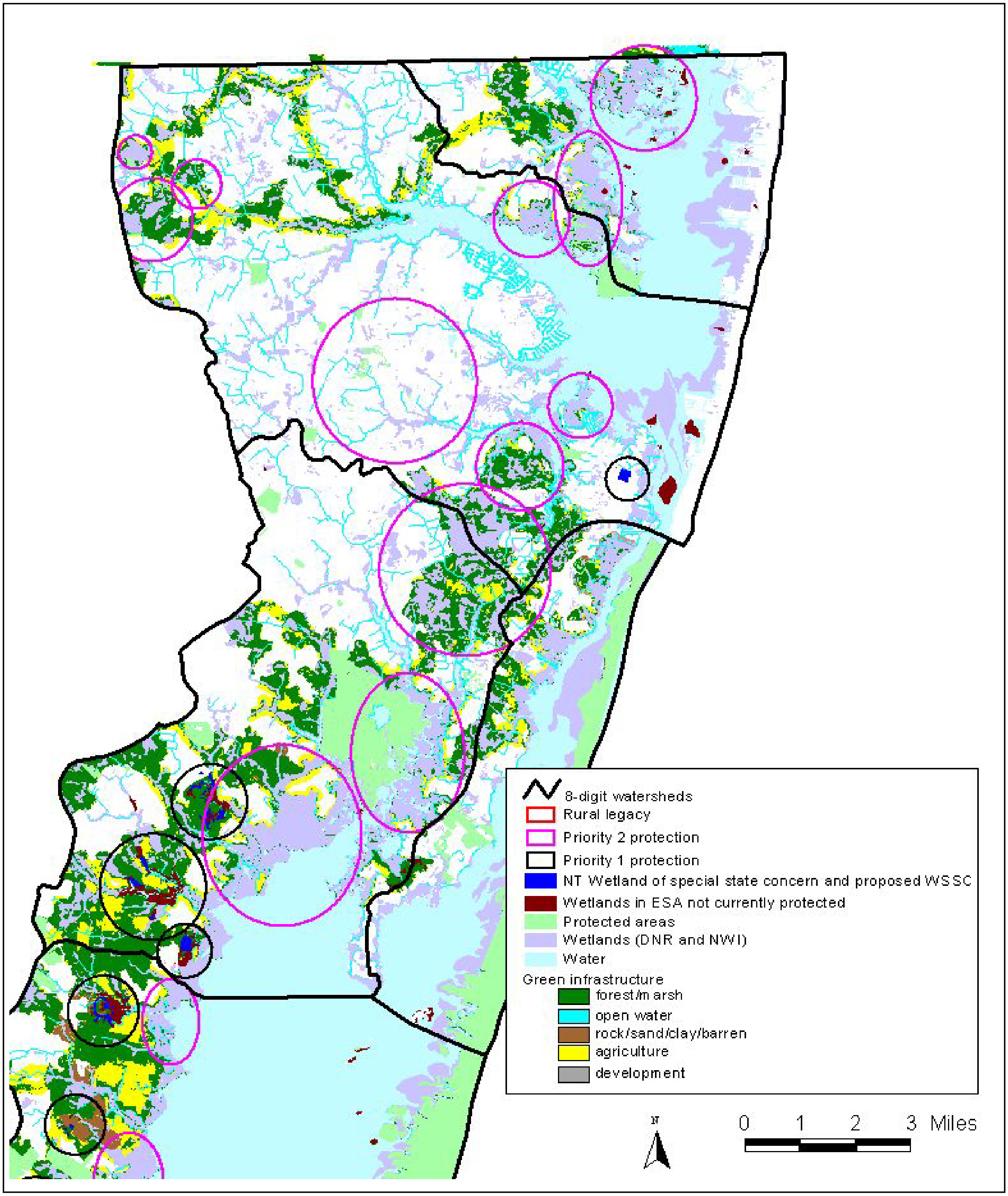


Figure 14. Priority 1 and 2 wetland preservation sites with the four northern Coastal Bays watersheds.

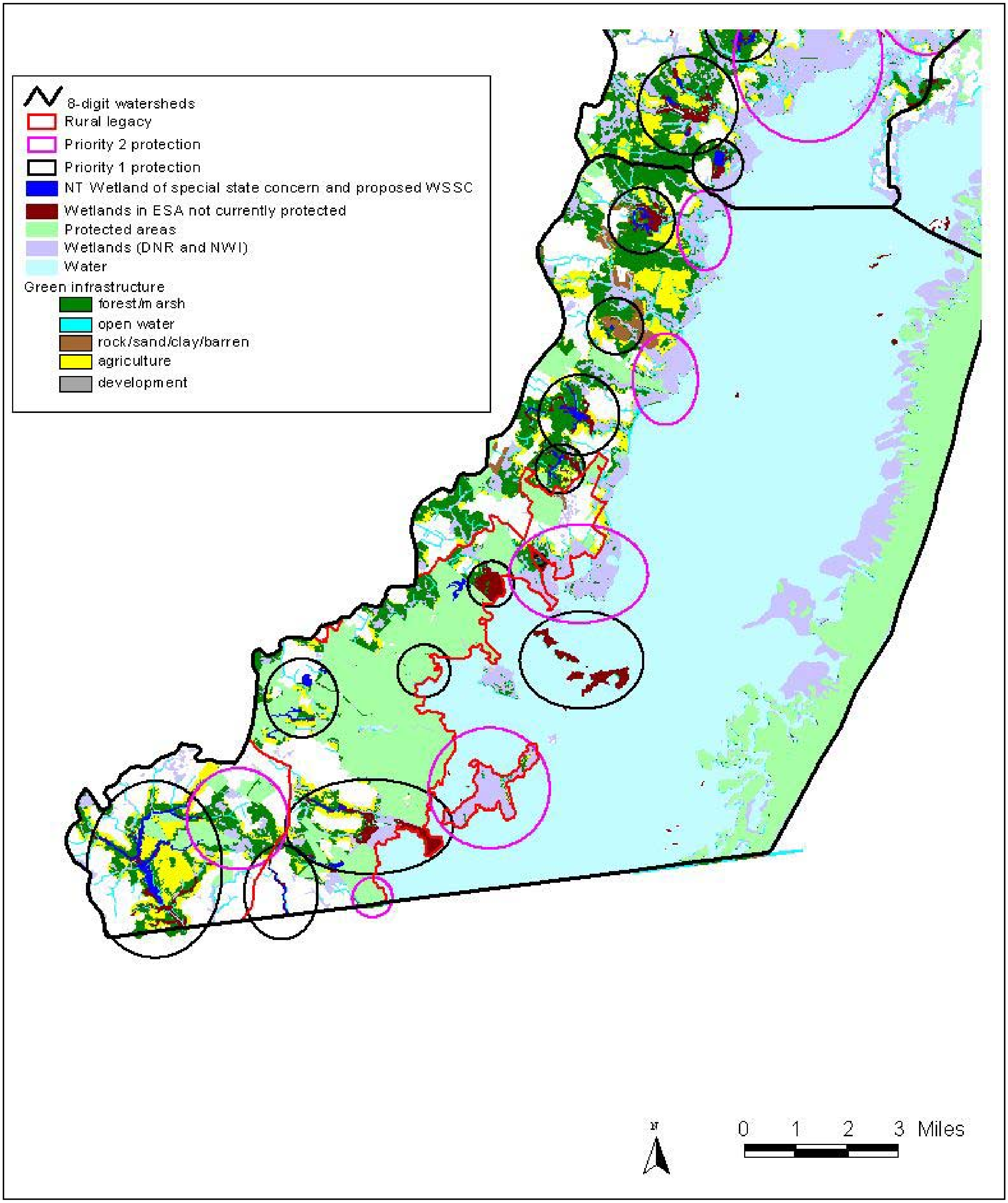


Figure 15. Priority 1 and 2 wetland preservation sites within Chincoteague Bay watershed.

Mitigation

Compensatory mitigation is the replacement of wetlands lost through regulated activities. Mitigation is a state and federal requirement of permittees, with a goal of achieving a no-net-loss of wetland acreage and function. Mitigation usually results in a requirement to create new wetlands or restore former wetlands to compensate for losses of wetland acreage and function. On some occasions, enhancement of existing wetlands is accepted as mitigation. Enhancement of existing wetlands is generally less preferable than restoration or creation, since there is no increase in wetland acreage. Enhancement of wetlands does improve wetland function, condition, and value. Other less common types of mitigation are preservation, which is the long-term protection of an existing wetland, without an increase in acreage or function. Another type of mitigation evaluated for this project is “out-of-kind” mitigation, an activity that does not directly create, restore or enhance a wetland, but improves other aquatic resources or establishes an environmental benefit or function that a wetland may provide. Examples are riparian buffers, stream restoration, or water quality improvement projects.

The State holds permittees responsible for conducting mitigation for wetland losses greater than 5,000 square feet in size. MDE assumes responsibility for mitigation of the cumulative remaining smaller wetland losses, and funds its projects from fees accepted from permittees in lieu of permittee-conducted mitigation. Due to the prevalence of losses from development of many small lots in areas such as Ocean Pines, MDE’s greatest mitigation debt is in the Coastal Bays watershed.

Despite the extensive amount of suitable area for wetland creation and restoration, MDE has not been successful in compensating for all authorized losses. This section of the report presents tasks to facilitate wetland mitigation in the Coastal Bays while considering the findings of the targeted information for restoration and preservation.

MDE’s lack of progress in adequately compensating for losses is attributed to:

1) Lack of public land with suitable, available area. Public land, such as parks, is often used by MDE across the State for mitigation due to compatibility of wetlands with other management plans for the site. Access to public land does not require acquisition of land or an easement, which are costly and time consuming processes.

2) Lack of staff. The lack of public land means that mitigation must be accomplished on private land. This requires an additional effort of outreach that staff has been unable to accommodate. Active outreach is a principal reason that voluntary restoration through agricultural cost share programs has been successful.
3) Land costs. Landowners will need incentives beyond gaining wetland benefits in order to undertake wetland projects and restrict the use of an area located on potentially buildable land. Fair compensation for use of land is necessary, however, land costs are increasing throughout the Coastal Bays.
4) Logistical difficulties. State land acquisitions of easements or fee simple purchases are extremely time consuming and require involvement and support of multiple agencies.

In order to overcome these challenges, MDE will:

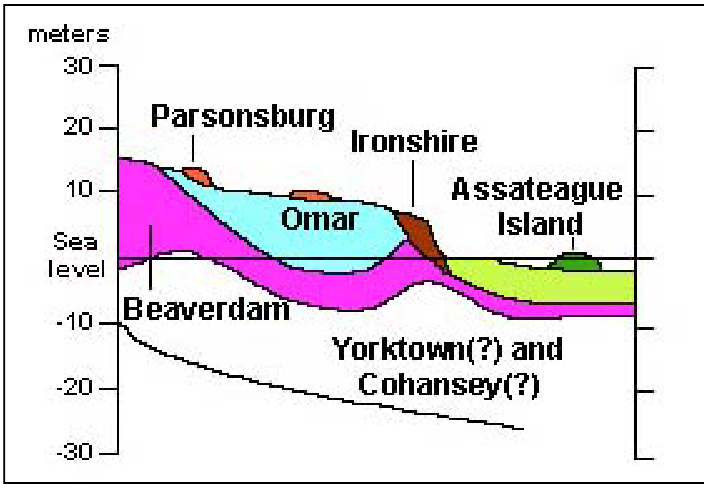
a) Form more partnerships. MDE will work with Worcester County, Natural Resources Conservation Service, and the Corps of Engineers to contact landowners. Preliminary discussions have begun.
b) Focus on larger parcels, so there is room to allow establishment of a wetland without sacrificing development opportunities. Sites in estate or rural conservation zoning will be targeted.
c) Support mitigation requirements that are a combination of restoration, enhancement, preservation, or out-of-kind projects. At a minimum, there will be 1:1 mitigation requirement in the form of restoration or creation. Other forms of mitigation such as enhancement, preservation, or out-of-kind projects will be considered for the remaining balance of any mitigation requirements.

APPENDIX A - BACKGROUND INFORMATION

Geology

The Coastal Bays watershed is within the Coastal Plain Province, a physiographic area having a thick layer of unconsolidated sediment reaching a depth of nearly 8,000 feet at Fenwick Island (Rassmussen and Slaughter, 1955). The surface geologic deposits strongly influence soil formation, habitat for potential aquatic organisms in a particular area, and groundwater storage capacity. Characteristics of the deposits also determine likelihood for contamination, as small-textured sediments often hold pollutants such as metals and organic toxins. The geologic cross-section for the land portion of the Coastal Bays watershed (Figure 16) reveals mainly Quaternary sediments at the surface, underlain by Tertiary sediments (Beaverdam sand from the Pliocene age and Yorktown-Cohansey Formation from the Miocene age) (Wells et al., 2002). Beneath these sediments is a southeast sloping layer of undifferentiated Crystalline Rock.

The following description of surface geologic formation locations is based on the 1978 Maryland Geological Survey *Geologic Map of Worcester County* (Owens and Denny, 1978). Barrier sand dominates the barrier islands. Tidal marsh deposits, clay or silt with abundant decayed organic matter, are common on the western shores of the barrier islands and mainland shoreline. Directly west of these on the mainland are Sinepuxent and Ironshire Formations, consisting of sand and silt with smaller amounts of clay. The Omar Formation, consisting of sand, silt, and moderate amounts of clay, is the dominant sediment in the western part of the Coastal Bays. There are also spots of Parsonsburg sand in the west, alluvium around several creeks (sand, gravelly sand, and clayey swamp deposits), and spots of exposed Beaverdam sand.



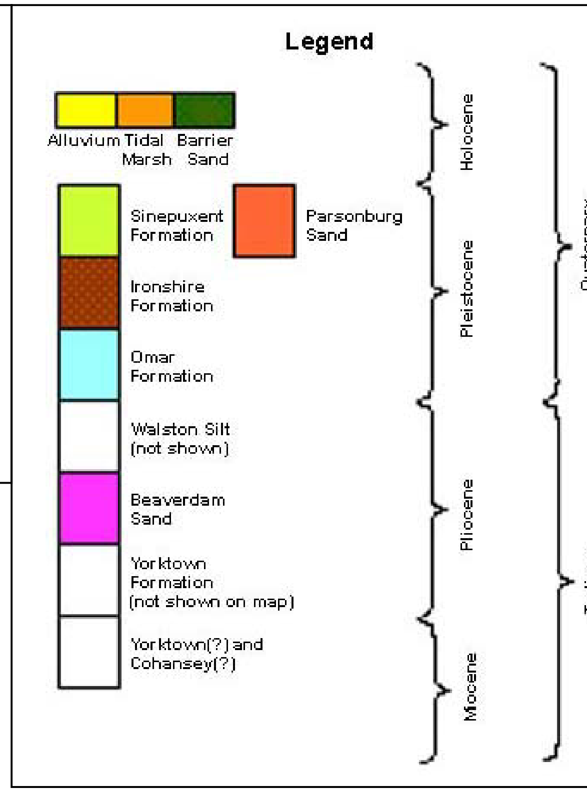


Figure 16. Cross-sectional map of geologic formations from Berlin, across Sinepuxent Bay, to Ocean City. Legend includes geologic formations, series, and system (Wells et al., 2002, as modified by Owens and Denny, 1978).

Soils

Soils strongly influence nutrient and pollutant filtering/cycling, vegetation, and water supply. Additionally, soils may indicate where historic wetlands were located. According to the 2000 *Soil Survey of Worcester County*, the Coastal Bays region generally has flat topography and low depth to water table, generally being much less than 25 feet to the water table. Most soils in this region have poor drainage (due to the high water table), requiring artificial drainage in order to farm.

As summarized from the *Draft General Soil Map of Worcester County, Maryland* (USDA, 2003), soil associations in the Coastal Bays watershed are mainly Hurlock-Hambrook-Sassafras, with some relatively small portions of other soil associations. Hurlock-Hambrook-Sassafras is dominant on the mainland, consists of loamy-textured poorly to well-drained soil. The majority of the land has a slope less than 5 percent. Transquaking-Purnell-Boxiron is found mainly on the mainland shoreline, with the exception of Sinepuxent Bay and most of Isle of Wight Bay, which is Hurlock-Hambrook-Sassafras. Transquaking-Purnell-Boxiron is also found on the bayside shoreline of Assateague Island. This is generally very poorly drained, organic and silty estuarine material. This area is nearly level and occurs in all of the saltwater tidal marsh zones. Brockatonorton-Acquango soil association is located mainly on Eastern Assateague Island and Fenwick Island. This area is nearly level to moderately sloping and was formed from windblown sand. There are small spots of Puckum-Manahawkin-Indiantown along stream floodplains. This soil is nearly level, very poorly drained organic and sandy alluvium. The soil association Nassawango-Mattapex-Matapeake is found mainly in the Newport Bay area and in the western portion of the Coastal Bays watershed. This area includes nearly level to gently sloping land with well-drained to moderately well-drained silty-textured soils. Most of these soils are used for agriculture since they have good water holding capacity and have few limitations. The soil association Mullica-Berryland is located mainly in the far northern section of Isle of Wight Bay watershed. These areas have acidic, sandy soils with nearly level to gently sloping gradient. They are very poorly drained to moderately well-drained. Othello-Kentuck is in the western part of the mainland and is on nearly level to gently sloping terrain. They are silty and poorly drained. Urban land occurs on most of Fenwick Island, on which impervious surfaces dominate.

A large percentage of these soils are classified by the Natural Resource Conservation Service as being hydric soils (Figure 17). A hydric soil is defined as being "a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part" (Federal Register, 1994). Hydric soils are one of the factors suggesting an area is currently a wetland or may have been historically (prior to a change in hydrology). High clay content in soils may increase nutrient (especially phosphorus) and contaminant retention, with different types of clay retaining different amounts. Nitrogen can be converted to a gaseous state (and lost to the atmosphere) through the process of denitrification. For this process to occur, there must be areas of oxygen in the soil (aerobic conditions) to create the right form of nitrogen, and areas of no or low oxygen (resulting in anaerobic conditions). Areas with a fluctuating water table near the soil surface or flooding conditions may result in high denitrification due to the alteration between aerobic and anaerobic conditions. Highest denitrification rates occur in soils with temperatures between 2 and >50˚C (with highest denitrification between 25 and 35˚C), high organic matter, nitrates, and portions of the soil with very low or no oxygen (resulting in anaerobic conditions) (Brady and Weil, 1996). High organic matter may also contribute to high nutrient/contaminant retention and other wetland functions. It takes a long time to accumulate high levels of organic matter in the soil since organic matter accumulates when biomass production exceeds decomposition, mainly due to anaerobic soil conditions leading to reduced decomposition rates. In other non-hydric soils in this area, soil is composed of only a small percentage organic matter in the top few inches (0-5%; USDA, 2000). In some of the hydric soils in this region, soils may reach 90% organic content for a depth of several feet. High amounts of organic matter often result in the formation of an umbric or a histic epipedon within the soil, with histic epipedons being the highest in organic matter. There are also a large percentage of soils that are designated by the Natural Resources Conservation Service as prime farmland based on their potential for producing high crop yields. Some of these prime farmland areas must be drained to produce the high yields.

The following information is based on documents by Wells and Conkwright (1999), Wells et al. (1994), and Wells et al. (1996). Sediments at the bottom of the Coastal Bays water are mostly sand, clayey silt, and silty sand, with texture size decreasing further west (Figure 18). Exceptions include the northern portion of Sinepuxent Bay, which is mostly sand. Roughly 45% of the bay bottom is covered in sandy material, washed over the barrier islands or through the barrier island inlets. Clayey silts are located in the tributaries and mainland shore and are also common in Newport Bay. Silty clays are common in the tributaries of Isle of Wight Bay and Assawoman Bay. The sediments in the upper tributaries are often finer textured than in the mouths of the tributaries and are covered with organic material. This smaller-grained material originates from surface runoff or shoreline erosion. Sediment eroding from the land is separated by texture, with fine-grained sediments depositing in areas of lower wave energy, such as marshes and areas of deeper water.

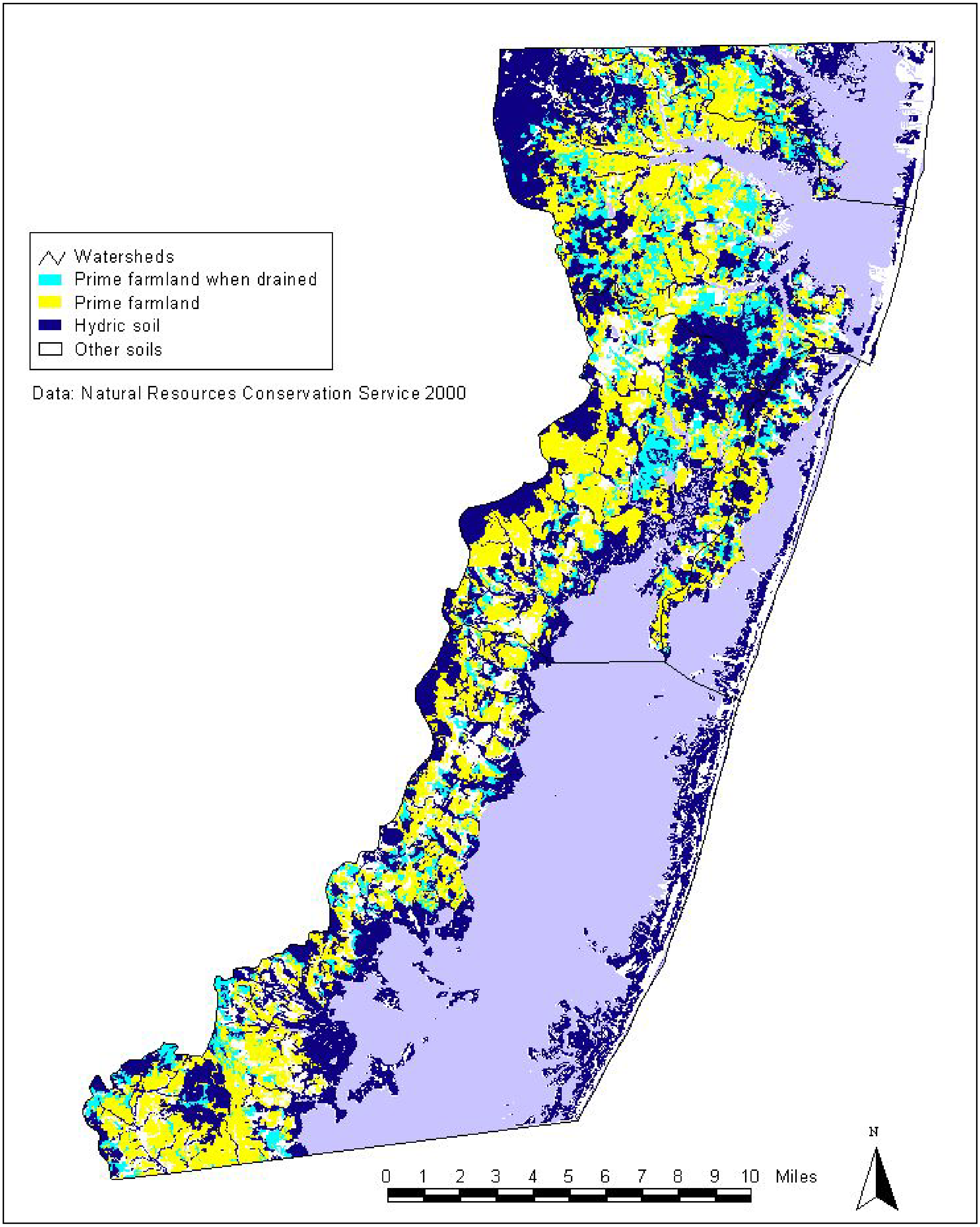


Figure 17. Characterization of Maryland Coastal Bay soils.

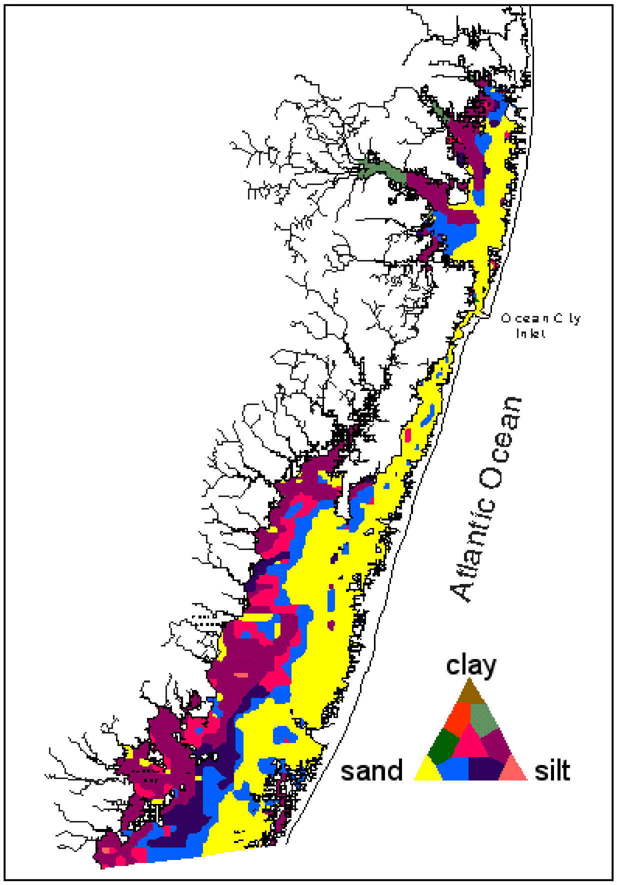


Figure 18. Sediment texture distribution within Maryland Coastal Bays waters (Wells and Conkwright, 1999). Sediment texture is illustrated by colors, which correlate with textures from the Shepard's Classification textural triangle (Shepard, 1954).

Physical processes

The coastal bays are very dynamic, alternating between erosional and depositional processes. The Ocean City inlet formed naturally by a hurricane in 1933, but is now artificially dredged and stabilized by jetties (USACE, 1998). Maintenance of this inlet has led to many changes within the bays, including changes in water circulation patterns, sediment deposition/erosion patterns, and access for aquatic organisms. Water currents are highest around the Ocean City and Chincoteague Inlets, but decrease rapidly with distance. The majority of water is a salinity range of polyhaline (>18 ppt salinity) (Chaillou et al., 1996). Water salinity is high at the inlets, 30-33 ppt, and decreases with distance from the inlet, being 25-32 ppt in the open bays and sometimes higher during late summer and early fall. MDNR water samples found lower salinity in the tributaries (often in the mesohaline range of 5-18 ppt) and some stations with large fluctuations. This is also true of the tidal range, which is 1.1 to 1.3 meters at the inlet, 0.7 to 0.8 meters in Isle of Wight Bay, 0.3 meters at northern Assawoman Bay, and

0.1 meters at Public Landing in Chincoteague Bay. The shallow waters of the bays encourage good vertical mixing of water, reducing stratification (USACE, 1998).

The water current along the Atlantic coast, known as the longshore transport system, continuously moves sand from up the coast and from the seafloor in a southern direction along the undisturbed shoreline, maintaining the barrier islands. This transport system was disrupted by the Ocean City inlet jetties, leading to reduced migration of sediment to Assateague Island (Figure 19). For this reason there is high erosion at the North end of Assateague Island and a low amount of dune and salt marsh (USACE, 1998). In addition, natural overwash is causing Assateague Island to move west towards the mainland (Figure 20) at a rate of 200 feet since 1933 (USDA, 1973). The stabilization of Fenwick and the OC inlet has inhibited the formation of new inlets and flood-tidal deltas, which would have naturally resulted in bay islands (communication with Chris Spaur, 2004).

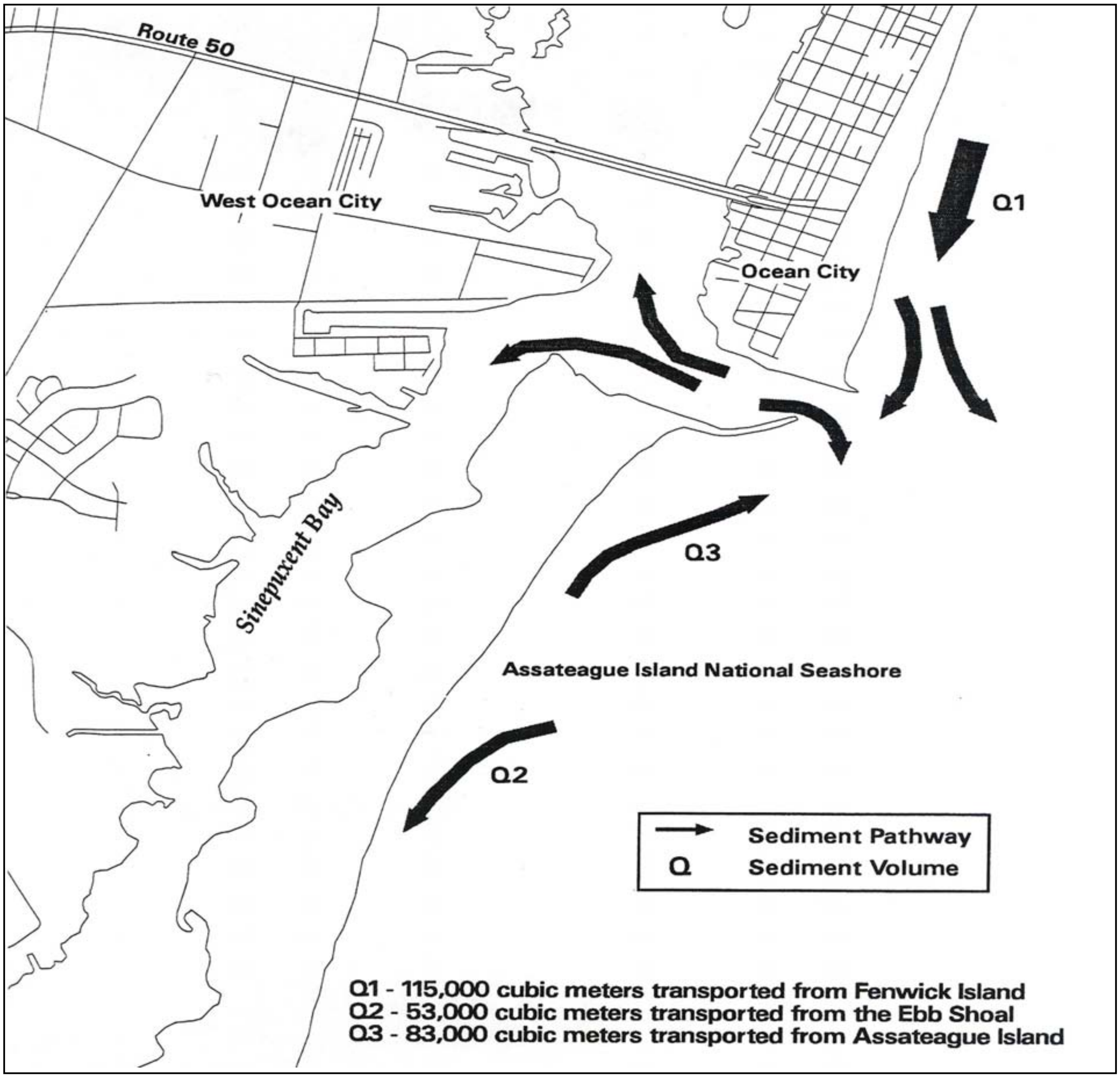


Figure 19. Sediment movement in the Ocean City vicinity (U.S. Army Corp of Engineers, 1998).

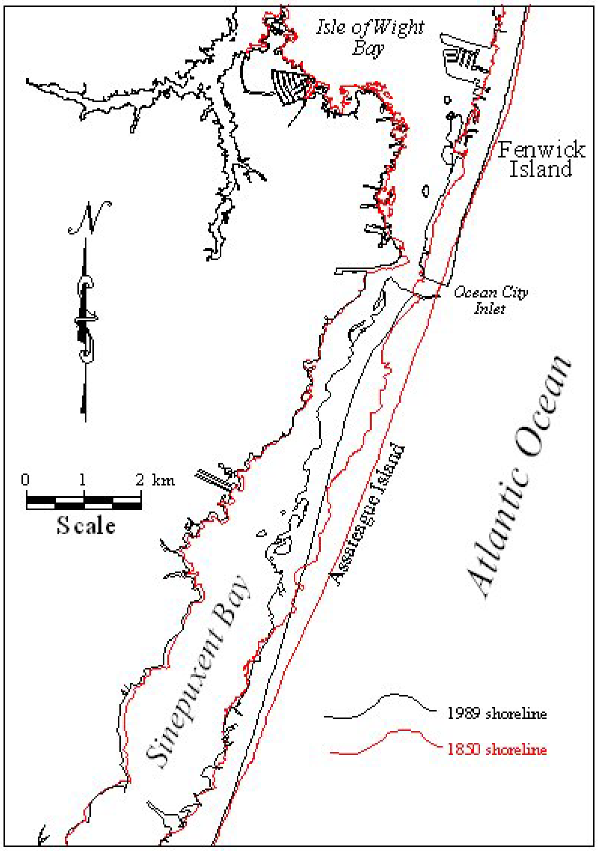


Figure 20. Illustration of Assateague Island retreating west towards the mainland during the period between 1850 and 1989 (Maryland Geological Survey, Coastal and Estuarine Geology Program).

<u>Erosion Pattern</u>

In barrier island systems, small islands and depositional shoals are frequently forming or disappearing. In the coastal bays, stabilization of the Ocean City inlet and USACE efforts to prevent any new inlet from developing has inhibited the natural formation of new islands. Erosion of existing coastal bays islands is very high. The Corp of Engineers maintains navigation channels within the bays and has historically created many small bay islands with the dredge material, of which most have disappeared due to erosion. An example of a remaining created island is the 2.3 acre South Point Spoils Island in northern Chincoteague Bay, which provides good nesting habitat for colonial waterbirds including Gulls, Egrets, Herons, American oystercatchers, Glossy ibis, and Double-crested cormorants (USACE, 1998). Current shoals include the ebb shoal, in the Atlantic Ocean south of the ocean city inlet, and the flood shoal, within the southern Isle of Wight Bay and northern Sinepuxent Bay.

Several studies were conducted by Maryland Geological Survey to evaluate shoreline erosion in the Coastal Bays (Hennessee, 2001; Hennessee and Stott, 1999; Hennessee et al., 2002a; Hennessee et al., 2002b; Stott et al., 1999, 2000). Shoreline erosion in the Coastal Bays has resulted in a large amount of land lost in the period between 1850 and1989 (Table 7). Eastern Sinepuxent Bay gained acreage during that time due to the overwash from the Atlantic Ocean. During the period between 1942 and 1989, it is estimated that over 11 million kg/yr of sediment entered the bays of Assawoman, Isle of Wight, and St. Martin River from shoreline erosion, with erosion being highest in the St. Martin River (Wells et al., 2002). A study comparing shoreline change rates from the mid-1800s until roughly 1990, largely comparing shoreline erosion along the Atlantic Ocean side of the barrier islands, found highest erosion rates on the northern shore of Assateague Island (Figure 21). Other areas with lower erosion included the southern-most section of Atlantic shoreline on Fenwick Island and the mainland shoreline of southern Chincoteague Bay. Areas of soil accretion included the remainder of the Atlantic Ocean shoreline of the barrier islands.

Table 7. Shoreline length, total land lost or gained (1850-1989), and land lost or gained per mile of shoreline (Hennessee and Stott, 1999; Hennessee et al., 2002a).

		1989 Shoreline length (miles)	Total land lost or gained (acres)	Acre lost or gained per mile shoreline (acres/mile)
Assawoman	Entire bay	76.9	-948	-12.3
Isle of Wight	Entire bay	43.9	-159	-3.6
St. Martin	Entire	18.7	-254	-13.6
Newport	Entire bay	48.9	-452	-9.2
Sinepuxent	Eastern shore	39.7	+1,017	+25.6
	Western shore	26.0	-283	-10.9
	Entire bay	65.7	+735	+11.2
Chincoteague	Eastern shore	139.7	-304	-2.2
	Western shore	58.6	-1,358	-23.2
	Entire bay	198.3	-1,662	-8.4

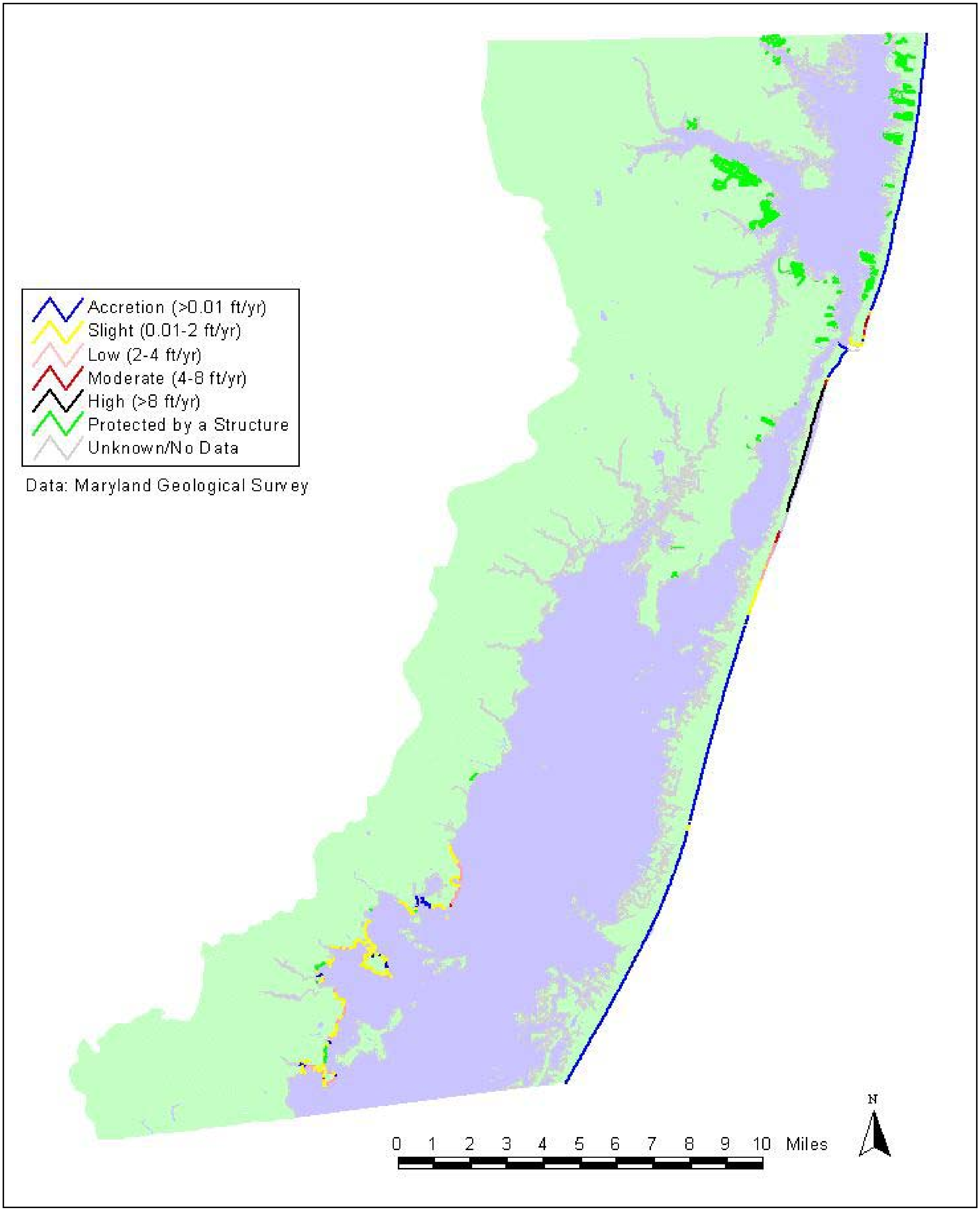


Figure 21. Shoreline erosion rates in Maryland Coastal Bays

Shoreline protection using bulkheads or stone riprap have resulted in unstable bottom sediments, loss of wetlands and shallow water habitat for birds, terrapins, and horseshoe crabs, and leaching of contaminants (e.g., chromium, copper, arsenic) from treated lumber of bulkheads (Chaillou et al., 1996). The Northern Coastal Bays had the highest percentage shoreline protected by a hard structure in 1989 (Hennessee and Stott, 1999; Hennessee et al., 2002a). South Fenwick Island bay shoreline is bulkheaded and the adjacent mainland section is mostly riprap (Figure 21). Isle of Wight Island is eroding and marshes on the northern side are degrading. This island also had hard shoreline stabilization on the southeast side (a recent USACE project "softened" this shoreline using segmented rock breakwater, rock placed off the shoreline to reduce water energy, with emergent marsh behind). In areas with slower erosion rates due to lower energy waves, natural stabilization may be possible.

Dead-end Canals

Dead-end canals were built along the coast to allow residents water-access to the bays. Many of these dead-end canals are located in Ocean Pines (at the mouth of the St. Martins River) and Ocean City (Figure 22). These canals have poor water circulation and poor flushing, since they are often surrounded by land on three sides, are deeper than surrounding bay waters, and have a high input of organic detritus and residential chemical runoff. For these reasons, dead-end canals often have poor water quality and provide poor habitat.

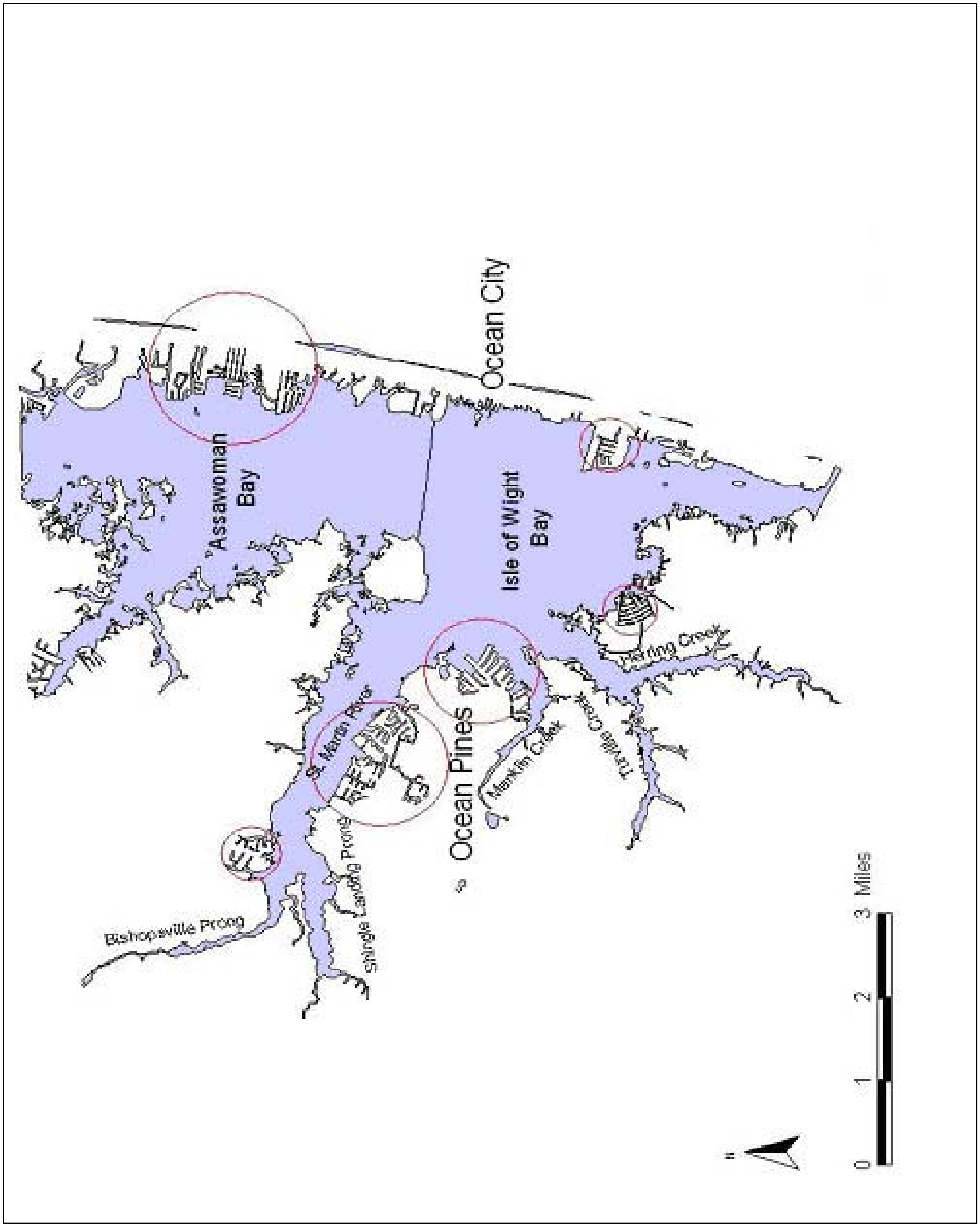


Figure 22. Examples of dead end canals in the Northern Coastal Bays region.

Flooding

Most repeated claims for property damage due to flooding were in Assawoman, Isle of Wight, and Sinepuxent watersheds. Within these areas, flood-damaged sites were located on the shoreline of these bays or on Fenwick Island. A few flood-damaged sites were also located in the Ocean Pines area. Maps from the Federal Emergency Management Agency (FEMA) show designated floodplains cover most of these sites, except the Ocean Pines locations.

Groundwater resources

Groundwater enters mainly through precipitation that filters through the soil or that infiltrates from streams, lakes, or ponds to the water table. The water table is essentially a zone of saturated soil where all pore space is occupied by water. The water table elevations roughly follow the surface topography, sloping towards the bays and ocean. Since there is little vertical movement of water into the underlying aquitard, an area of much lower permeability, there is a regional pattern of shallow groundwater moving horizontally towards the southeast, eventually reaching the bays and Atlantic Ocean (Dillow and Greene, 1999). Additionally, there is some local movement of groundwater to the streams and rivers. Ditching can bypass the natural movement of groundwater by cutting into the shallow groundwater table and providing a direct pathway to streams, especially when the water table is high and the ditches are carrying water (USACE, 1998). For these reasons, contaminants entering the groundwater can easily reach the bays. Deeper ground water is also available for uptake by wells. The main aquifer is the Columbia aquifer, with other deeper confined aquifers in the region including the Manokin aquifer and the Pocomoke aquifer (Figure 23). The Columbia aquifer is generally unconfined, except in some areas with surface confining layers (Figure 24).

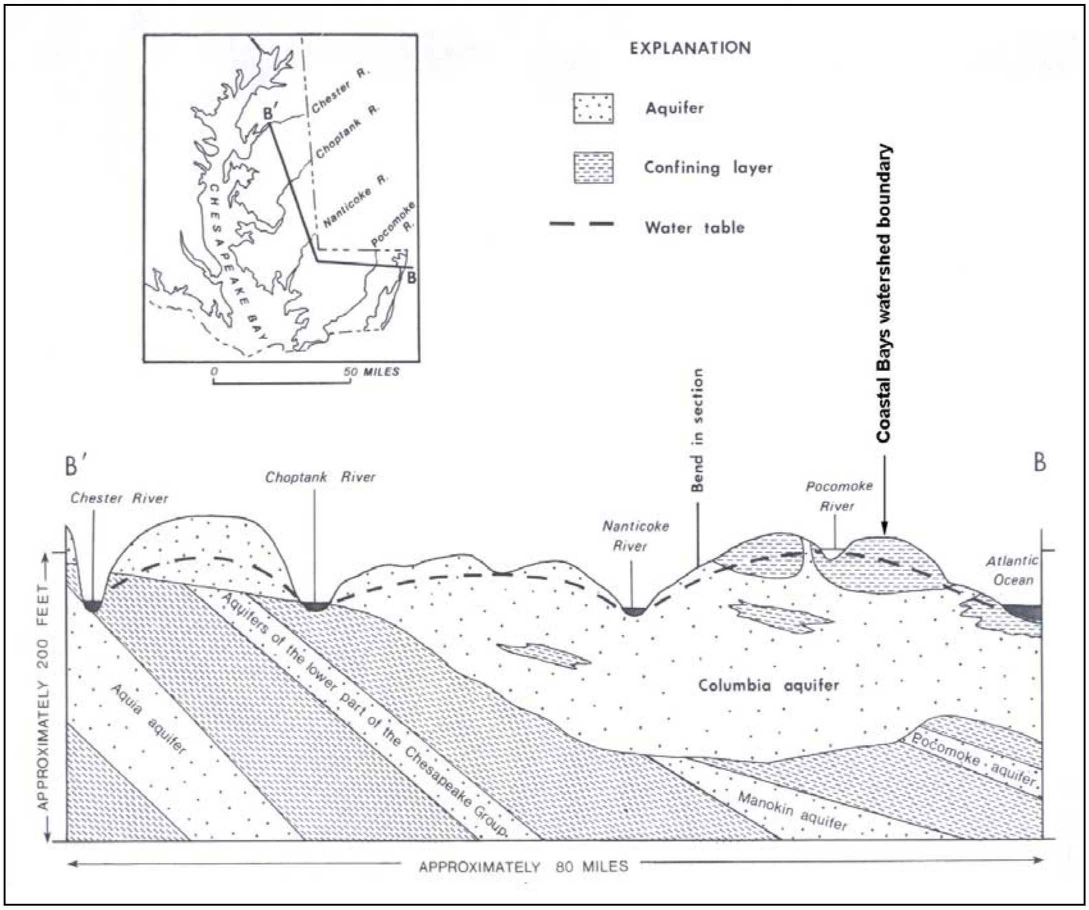


Figure 23. Cross-section of predominant aquifers in Maryland's Eastern Shore (Bachman, 1984).

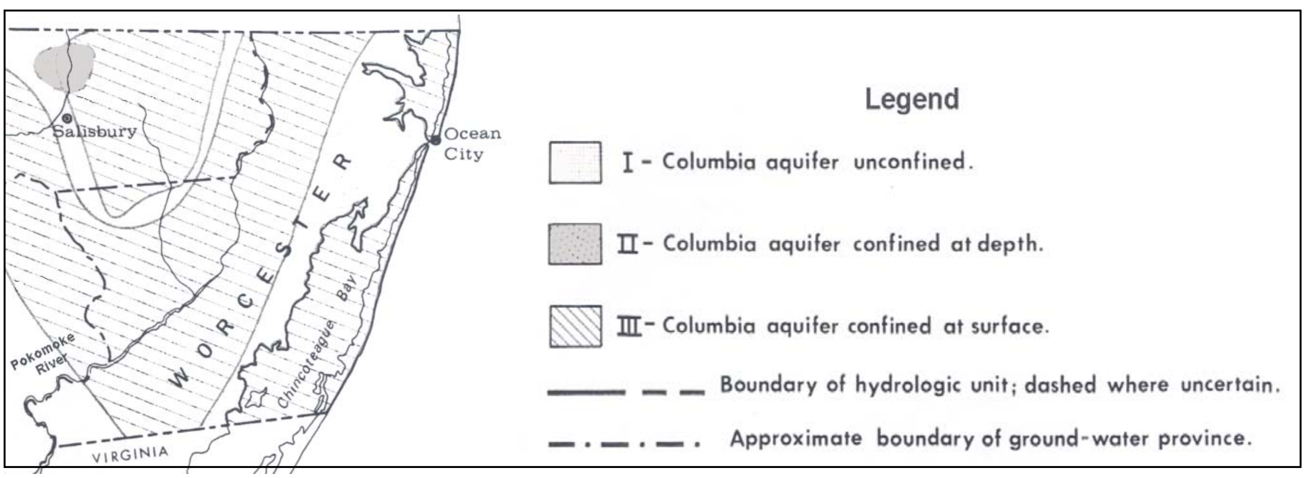


Figure 24. Characteristics of confining layers to the Columbia aquifer within Worcester County (Bachman, 1984).

Unconfined aquifer

Infiltration directly contributes to the unconfined aquifer and the surface of the water table is also the surface of this unconfined aquifer. The areas classified as barrier sand, tidal marsh deposits, and alluvium, provide a small amount of water to wells (Lucas, 1972). The Sinepuxent Formation, Ironshire formation, Omar formation, and Parsonsburg sand provide a moderate to large amount of water to wells, which may contain relatively high levels of iron. Beaverdam sand provides moderate to very large amounts of water to wells and also may contain relatively high levels of iron. The area North of Ocean City has the greatest thickness of this Beaverdam sand, at more than 100 feet (Owens and Denny, 1978). In general, the unconfined aquifer bottom is less than 100 feet below the surface. Although this is a relatively small area from which to draw water, there is a high amount of storage in the aquifer so it yields a high amount of water with little drawdown (Rasmussen and Slaughter, 1955). The aquifer in this region has higher levels of nitrogen than found in nature, due to human influences (Dillow and Greene, 1999).

Confined aquifer

The confined aquifer, or aquitard, has an impermeable or semi-impermeable layer limiting direct flow of water from the above unconfined aquifer. For this reason, infiltration from the Coastal Bays region is not a large contributor of water. Instead this water is recharged outside Worcester County, mainly in Somerset and Wicomico Counties. The Yorktown-Cohansey (?) Formation is the upper limit of the aquitard and contains clayey silt with layers of sand, only providing small to moderate quantities of water to wells (Lucas, 1972). The upper part of this formation begins at 50 feet below sea level in Chincoteague Bay, at roughly 110 feet below sea level at Berlin (Owens and Denny, 1978). Ocean City withdraws a large amount of water from this formation at 240 feet below sea level (Lucas, 1972). This aquitard contains a large amount of water, but water pressure is low due to small texture size and low permeability (Rasmussen and Slaughter, 1955).

Well locations

There is an abundant supply of groundwater and surface water, but contamination of drinking water is a concern. Over a third of the community wells draw from the unconfined aquifer. These wells are located in Isle of Wight Bay watershed and Newport Bay watershed, and include Ocean Pines and Berlin. Of the non-community wells, there are roughly three times as many unconfined wells as confined wells. Since the topographic gradient in this region is so low, these wells draw water from roughly a circle around the well (MDE, 2003). This aquifer recharges from infiltration of rain and is directly impacted by adjacent land use, so the potential for contamination is high (MDNR, 2003e). Unconfined wells in the region have some contamination from nitrate and volatile organic compounds (from leaking underground fuel tanks and gas stations). Wellhead protection areas around the wells are currently being designated by MDE, and should be used for future land use management. Wellhead protection areas are being delineated for the Coastal Bays region, and have been completed for Ocean Pines, Berlin, and Briddle. Since nearby storm water management ponds have been found to pollute some wells, they should not be sited near the wells. Agriculture releasing high nutrient and pesticide loads and paved surfaces releasing high levels of pollutants should also be outside of wellhead protection areas. Other wells, mainly for large towns including Ocean City, are deeper and draw from the confined aquifer, which recharges outside of Worcester County. Although contamination of these deeper aquifers from local land practices is low, some local recharge does occur in winter months.

Reported contaminants to the wells are not a serious problem at this time, but do include iron, nitrogen, volatile organic compounds (VOCs), and some salt-water intrusion. Although high iron levels are not harmful to humans, it can result in stains, poor water taste, and problems with pipes (Bachman, 1984). Nitrogen enters the ground water through the leaching of nitrate from septic tanks, municipal sewage systems, and fertilizer. Since sandy soils, as in the Coastal Bays region, do not hold nutrients well, high levels of fertilizer are applied to the soil to grow crops. High levels of nitrate in drinking water can be harmful to infants and juvenile livestock. VOCs can enter the groundwater mainly through leaking underground storage tanks and gas stations. High levels in VOCs in drinking water can act as a carcinogen. Salt-water intrusion is a concern due to the high predicted population growth and associated increase in water withdrawal from aquifers. As fresh water is withdrawn from the water table at rates too high for natural recharge of freshwater, salt water from the bays and ocean enters the water table. The potential for groundwater contamination in this region is high due to the sandy soils and high water table. Additionally, ditching may result in direct connectivity of contaminants to the bays and indirect connectivity via the shallow groundwater (MDNR, 1999). Other potential sources of contaminants to the water supply include agricultural pesticides and chemicals, industrial organic chemicals, metals, and landfill leachate. There are two landfills in Berlin that are no longer in operation. As discussed, wetlands can improve water quality, which may improve the drinking water from shallow wells.

Recharge areas

The majority of land contributes recharge (water) to the groundwater and aquifer systems, but some land areas may contribute more recharge than others (Andres, 1991). Some soils, mostly described as droughty and highly porous, allow rapid permeability of water into the groundwater. Since these areas act as rapid recharge areas and allow water with a high amount of contaminants to enter the water table, special attention should be given to them. These areas should be reforested or planted with grasses to act as a buffer. Wetlands receiving groundwater from these areas may play an especially important role in improving water quality.

Economy/Land Use

Economy

The economy in this region is largely based on agriculture and tourism. Agriculture is dominated by poultry and crops produced for poultry feed (USACE, 1998). Hogs are also important to the region. Major crops include corn, soybeans, and wheat. Tourism is especially important around Ocean City. Ecotourism, including canoeing, fishing, biking, and wildlife, is increasing in popularity. This type of tourism is the focus of the Delmarva Low Impact Tourism Experiences (DLITE) coalition, now developing and marketing a birding trail from Cape May New Jersey to Cape Charles Virginia, a Delmarva Biking Trail, and a Delmarva canoe trail (Wilson, 2002).

Land Use

Coastal Bays land use patterns consist of development in Isle of Wight Bay watershed, Assawoman Bay watershed and Berlin, forestry and agriculture on the mainland, and wetlands located near the shores. Table 8 is based on 2002 Maryland Department of Planning land use GIS data. Due to the scale of the data, it should only be used to get a general estimate of land use in the area. For this reason, the wetlands category is not a good estimate of wetland acreage (MDNR or NWI wetland estimates should be used instead). Additionally, the wetlands category does not include SAV cover, which may be significant in some areas. There is also some mineral extraction of sand and gravel for paving and construction needs. These deposits are mainly east of Berlin to east of Newark (Worcester County, 1989). The county is zoned for development to be focused mainly around the Isle of Wight Bay, Southern St. Martins River, Southern Assawoman Bay, and around Berlin (Figure 25).

Table 8. Land use for the watersheds within the Maryland Coastal Bays (MDP, 2002).

Watershed	Urban %	Agriculture %	Forest %	Wetland %	Barren %	Total Acres
Assawoman	28	23	25	21	2	6,848
Isle of Wight	24	37	35	4	<1	33,567
Sinepuxent	22	11	31	23	12	7,503
Newport	10	35	43	12	<1	27,228
Chincoteague	2	33	40	23	2	42,728

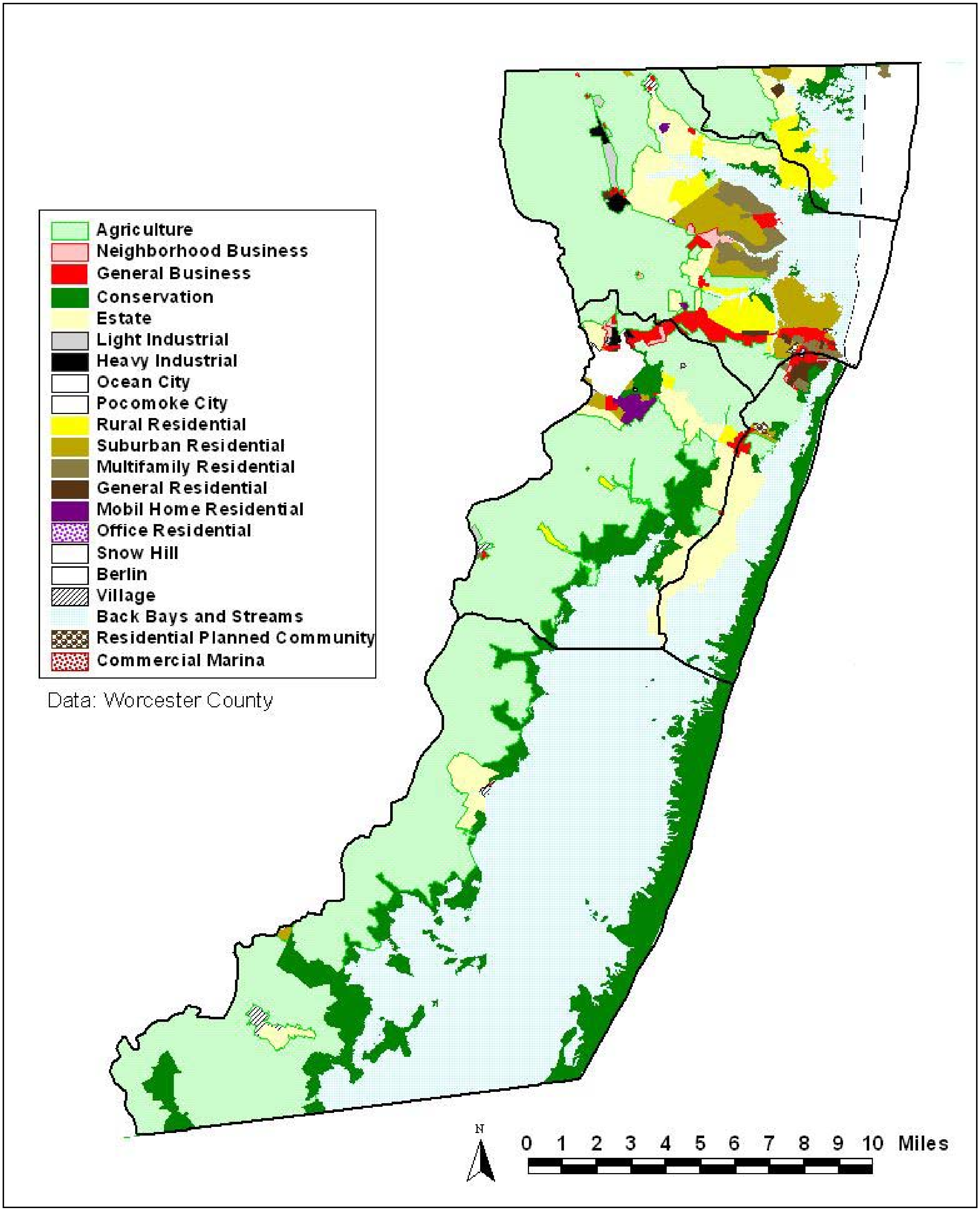


Figure 25. Zoning in Maryland Coastal Bays

Submerged Aquatic Vegetation

Submerged Aquatic Vegetation (SAV) beds are important for many species and may provide good nursery ground for juvenile spot, weakfish, white perch, summer flounder, anchovy, and black seabass (USACE, 1998) in addition to many species of shellfish. SAV provide other functions within the water including recycling nutrients, increasing dissolved oxygen, stabilizing sediments, and acting as food for waterfowl (Conley, 2004). The two most common SAV species in the Coastal Bays are Eelgrass (*Zostera marina*) and Widgeon grass (*Ruppia maritima*). Limitations to SAV include high nutrient and sediment levels that increase algae blooms and lead to decreased light availability, physical damage by boats, dredging, and commercial fishing activities (Conley, 2004). There may be extensive areas in the Coastal Bays that are suitable for SAV establishment, especially since nearly half of the open water is less than 3.3 feet deep, shallow enough to support SAV populations. Water less than 3 feet dominates in Assawoman and Isle of Wight Bays and water deeper than 3 feet dominates in Sinepuxent, Chincoteague, and Newport Bays (USACE, 1998). Only about a third of this shallow depth habitat is covered with SAV. It should be noted that factors in addition to water depth and light availability are important for SAV including sediment type, water quality, and organic content. The relationship of these factors to SAV establishment is not well understood (Conley, 2004).

Although historical data is not completely clear, it appears there was an extensive amount of submerged aquatic vegetation in the Coastal Bays during the early 1900's but the eelgrass population crashed in the early 1930's due to eelgrass fungus disease (USACE, 1998; Conley, 2004). This condition may have been more prevalent in Chincoteague Bay than in the northern bays, since the northern bays had much lower salinity prior to 1930's, so eelgrass growth may have been severely limited in that region in the early 1900's. Data from the mid 1980's to 2002 in Maryland's Coastal Bays shows an increasing trend in SAV cover (Figure 26), but some speculate that SAV cover may be leveling off (MDNR/MCBP, 2004).

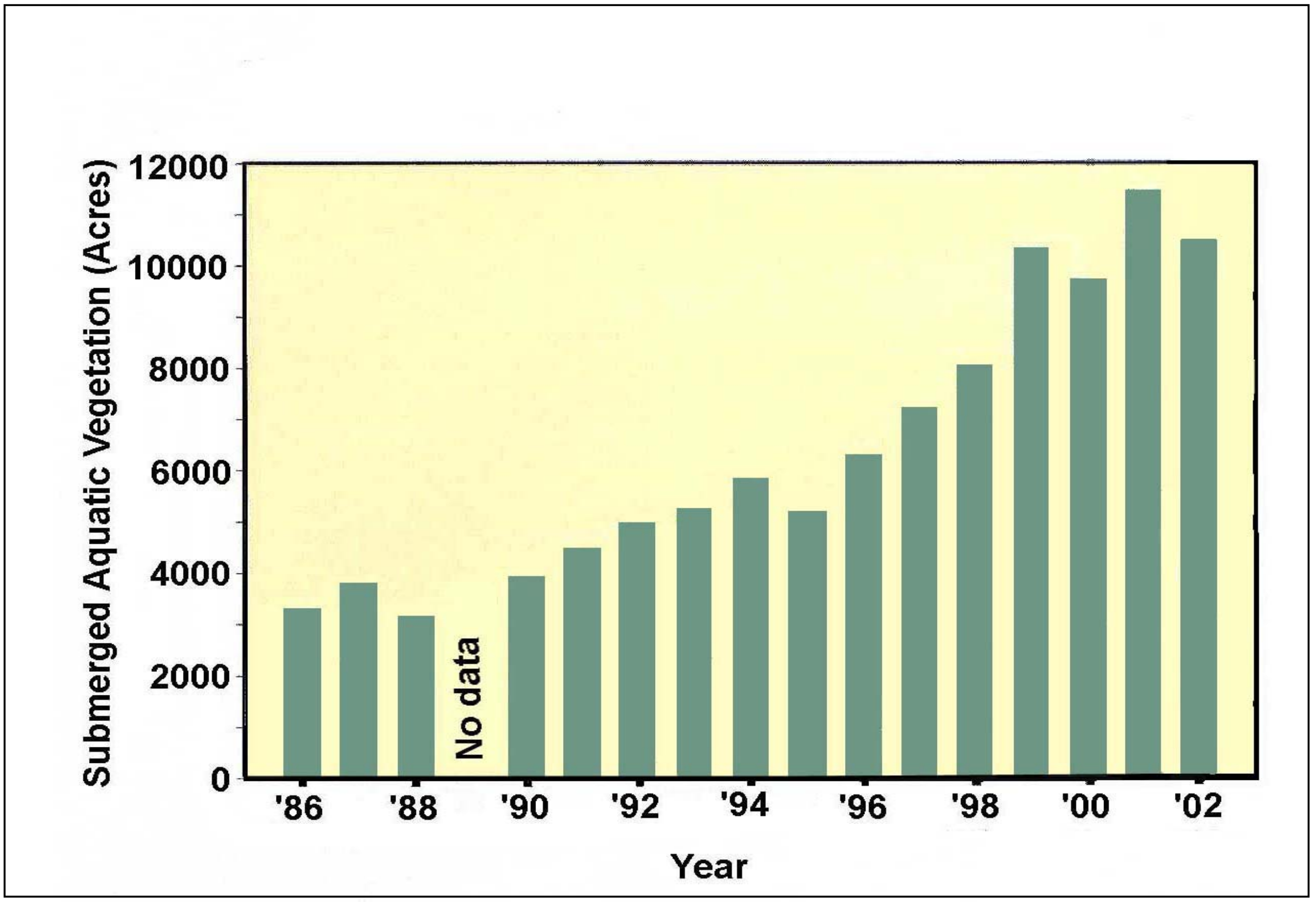


Figure 26. Change in acreage of submerged aquatic vegetation in Maryland Coastal Bays during the period between 1986 and 2001 (MDNR, 2003a; based on Virginia Institute of Marine Science data).

Now, as SAV increases in Chincoteague Bay, bay scallops have begun to appear (and some areas have been stocked by MDNR). The majority of the SAV is currently located on the bay side of the barrier islands (with the exception of southern Fenwick Island and northern Assateague Island around the Ocean City inlet) and in extensive beds within Chincoteague Bay (Figure 2). Small SAV beds have also spread out along the mainshore coastline in sandy bay-bottom sediments. The following describes water depth and SAV conditions in the Coastal Bays. Note: a more up-to-date bathymetric survey has been conducted by Maryland Geological Survey.

- *Assawoman Bay*: Average depth of open water is 3.3 feet, with 55% of the open water site being shallower than 3 feet mean low water (MLW) (USACE, 1998). SAV cover is poor (MDNR and MDE, 2000).

- *Isle of Wight Bay*: 60% of the open water is shallower than 3 feet MLW (USACE, 1998). SAV cover is poor, although it has been increasing since 1991, and is mainly located in the eastern shores of the Isle of Wight Bay (VIMS, 2003). New SAV is establishing at Turville Creek and the Southern and Western shores of Isle of Wight (Shanks, 2001). In the St. Martin River, Ocean Pines, Herring/Turville Creeks, SAV may be limited by water quality, sediment type, tidal current, waves, and dynamic substrate.
- *Newport Bay*: Open water is shallower than 3 feet MLW in 30% of the areas (USACE, 1998).
- *Sinepuxent Bay*: The majority of open water, 95%, is shallower than 3 feet MLW (USACE, 1998).
- *Chincoteague Bay*: 40% of the open water is less than 3 feet MLW (USACE, 1998).

Forestry

As summarized by a 2002 Coastal Bays Forestry report, in 1998 the forest composition within the Coastal Bays consisted of 21% pine, 53% mixed pine/hardwood, 20% hardwood, 4% oak/sweetgum/cypress, and 2% elm/ash/red maple. The percentage hardwood species is higher in the northern Coastal Bays than in the southern Coastal Bays. There has been a significant decrease in hardwood species and increase in pine in the last 15 years.

Harvesting of timber is important in the area, especially of Loblolly Pine, which often grows in dense stands. Forestry production reserves these forests from development and provides valuable water quality improvement and wildlife habitat to the area. When the area was first settled, it was dominated by hardwood species, Oaks in the moderately drained areas, mixes of Oak, Maple, and Sweetgum in the wetter areas, and Loblolly Pine and Virginia Pine in the coarse-textured droughty soils (Worcester County, 1989). The following information is from the Maryland Coastal Bays Program website: While some species do prefer pine stands, many more species of birds and reptiles require hardwood forests to survive and prosper, including scarlet tanagers, certain warblers, barred owls, orioles, gnatcatchers, brown creepers, flycatchers, leopard frogs, wood frogs, tree frogs, carpenter frogs, mud salamanders, tiger salamanders, mud turtles, and spotted turtles. The increase in pine forests has resulted in lower species diversity. The amount of loblolly pine in the Coastal Bays region went from 4-7% historically to 40% at present (Wilson, 2001). It is hard to make estimates of historical pine cover, because pine cover changed drastically through time based on climate, fire frequency (Indian burning would encourage pine), and agricultural clearing and later reversion to forest (pine is a pioneer species). But we can say that pine has increased. Since forestry is a critical key to conserving green space, it is desirable to plant tree species that are both economically profitable as timber but also provide ecological benefits. As many timber stands are reaching maturity and will soon be harvested, it is desirable that they be replanted or allowed to naturally regenerate in a mix of hardwood species (e.g., oaks and hickories for high habitat value) and loblolly pine. Additionally, it is predicted that there will be a decrease of 11.5% forest cover in Coastal Bays by the year 2020 (CBFC, 2002). For these reasons, a Coastal Bays Forestry Committee has developed a plan to promote hardwood planting, but also retain existing forests of pine, mixed, or hardwood. In reference to wetlands, it is desirable to encourage growth of hardwood/mixed forests and minimize pine forests. For instance, wetland restoration may include trying to increase hardwood forest wetland, including converting pine forest to mixed or hardwood forest. With that same logic, wetland preservation is more desirable on areas with hardwood/mixed forest than in pine forests.

Strategic Forest Lands Assessment

Over the past several years, MDNR's Watershed Services unit, in cooperation with the Maryland Forest Service, has carried out a *Strategic Forest Lands Assessment* (SFLA) to help guide both land protection and forest management initiatives. The SFLA used a variety of indicators to examine three characteristics of the state's forested land base: ecological value, socio-economic values, and vulnerability to conversion to non-forest use. The assessment results show the high economic value of the forests in much of the Newport Bay and Chincoteague Bay watersheds and the relatively low ecological ranking and high vulnerability of the remaining forest lands in the northern Coastal Bays. The models used in the SFLA project a high probability that commercial timber management can be sustained in the lower portions of the Coastal Bays and a low probability for sustainable forestry in the Assawoman and Isle of Wight Bay watersheds. The SFLA is documented at http://www.dnr.state.md.us/forests/planning/sfla/.

Wildlife

Much of the following section on faunal data is summarized from the MDNR *Maryland Coastal Bays Aquatic Sensitive Areas Initiative* (Conley, 2004).

Finfish and Shellfish

Over 300 species of benthic invertebrates have been identified in the Coastal Bays, including most of the major phyla. These organisms are typically characterized by sedentary or limited mobility and are affected by chronic low-level disturbance. Environmental threats to these organisms include shoreline erosion, low dissolved oxygen, runoff, contaminants, boat wakes, dredging, non-native species invasion, and changes in SAV abundance.

The Coastal Bays have a diverse molluscan population (over 70 species) (Homer et al., 1997). A 1997 MDNR shellfish survey found higher mollusk densities south of the Ocean City inlet than North of the inlet and higher average densities and higher species per sample in the main bays than in the tributaries (Homer et al., 1997). Chincoteague Bay had the highest average density of mollusks, with *Gemma gemma* being dominant, and was ranked one of the highest for average number of species per station. Isle of Wight Bay had the second highest density, dominated by *Turbonilla interrupta*. The most commonly occurring species included *M. mercenaria*, *M. lateralis*, *A. canaliculata*, *N. vibex*, *T. interrupta*, *M. tenta*, *T. agilis*, and *E. directus*. Several species were found primarily in certain regions, with Sinepuxent Bay being the transition zone between the north and south bay species. The ribbed mussel, *Geukensia demissa*, was dominant in the intertidal zone of the Coastal Bays and is thought to be the most ecologically important mollusk in Chincoteague Bay due to the ability to filter algae, process nutrients, and stabilize the substrate. Since the ribbed mussel has higher densities on natural salt marsh than on mad-made structures, loss of intertidal marsh habitat is the main threat. Small populations of oysters reside in the intertidal waters. Oysters require a hard substrate such as bulkheads, bridge pilings, or stone rip-rap. Both the ribbed mussel and the oyster are susceptible to chemical pollution from development and marinas, boat wakes, low dissolved oxygen, overharvesting, and predation from non-native crabs.

The hard clam is a species that benefited from the opening of the Ocean City inlet due to the associated higher salinities. A 2002 MDNR hard clam survey found highest densities of hard clams in the Isle of Wight, followed by Sinepuxent and Southeastern Chincoteague Bay, with southwest Chincoteague ranked sixth (Tarnowski and Bussell, 2002). This density was significantly lower than the previous year at southwest and southeast Chincoteague, a trend likely due to fishing mortality and increased clamming in these regions. Newport Bay had the lowest density of hard clams in 2002, followed closely by Assawoman Bay and Western Chincoteague Bay. Bay scallops also require minimum salinities to thrive, so should have been positively affected by the opening of the Ocean City inlet. However, lack of their preferred habitat, eelgrass beds, limited their success. After a large Bay scallop reintroduction effort sponsored by MDNR, Bay scallop populations are expanding the range from Southern Chincoteague Bay to all of the Coastal Bays except Newport Bay. Threats to these species include chemical and sediment pollution, low dissolved oxygen from shoreline development, marinas, boats wakes, dredging, and oil spills. Non-native predators, such as the green crab, may also reduce populations. Additional threats to bay scallops include loss of eelgrass habitat and overharvesting.

According to the Maryland Department of the Environment, Technical and Regulatory Services Administration, shellfish harvesting has been restricted in some areas of the Coastal Bays due to high levels of fecal coliform, requiring harvesters to place the shellfish in approved waters to cleanse them before sale. These restricted areas are the St. Martin's River, Turville Creek, Herring Creek, Ocean City (Ocean side near route 90), and a small section in Johnson Bay.

The blue crab provides an important commercial fishery in the region. Their habitat includes SAV beds and marshy, tidal guts. Resource threats include the parasitic dinoflagellate *Hematodinium perezi*, loss of habitat, and low dissolved oxygen (as they will leave an area with low oxygen levels). Another factor having an unknown effect on blue crab populations is competition with the non-native green crab.

The Coastal Bays have a diverse finfish population (120 species reported by Boynton, et al., 1993) that is dominated by Atlantic silversides, bay anchovy, Atlantic menhaden, and spot (Chaillou et al., 1996). In the Coastal Bays and adjacent Atlantic Ocean, over 40 fish species are commercially harvested and over 20 species are recreationally harvested. Many juvenile fish use the shallow protected areas of the bays as a nursery and the inlet as entryway. Larger individuals are found within the channels. Yearly fluctuations in species abundance are common, but there have been a few significant trends in recent years. A MDNR fisheries survey reported no significant difference in index of biotic integrity during the last 20 years but there was a decrease in forage fish (spot, bay anchovy, Atlantic silverside, and juvenile menhaden) (MDNR, 1999). Other declining fish species, species that spawn outside of the Coastal Bays area, include summer flounder, bluefish, Atlantic croaker, and American eel. These may be affected by regional issues. Commercial finfish areas include the mouth of Greys Creek, Newport

Bay and Newport Bay mouth, and the edge of St. Martin's River (USACE, 1998). Recreational fishing is popular around the Ocean City inlet, jetties, fishing pier, and Route 50 for species including summer flounder, bluefish, weakfish, seabass, tautog spot, croaker, kingfish, hake, striped bass, scup, blowfish, and sharks. Threats to the fish population include overharvesting, water pollution, and loss of habitat. Marsh loss may negatively impact the food chain of juvenile fish.

Horseshoe crabs, *Limulus polyphemus*, use the Coastal Bays for spawning and nursery habitat. They spawn on the sandy beaches and subtidal areas beginning in the spring, and juvenilles spend their first two summers on the intertidal flats. Older horseshoe crabs forage in the deeper waters. The main threats to the horseshoe crabs include those that affect the beaches, such as erosion, development, and some shoreline stabilization methods.

Since the fisheries contribute substantially to the Coastal Bays economy, state and federal programs have found it necessary to manage several species due to threats of overharvesting (Chaillou et al., 1996). Management plans have been completed for blue crab and hard clams.

Waterbirds

Colonial waterbirds are birds nesting in colonies, often on or near the ground. They are associated with coastal, lentic, or lotic systems. Many colonial waterbirds in the Coastal Bays utilize areas with low threat from predators, namely on the bay islands. Of the 22 breeding species in Maryland, 20 species are found in the Coastal Bays, including the state endangered Royal Tern (*Sterna maxima*), state threatened Least Tern (*Sterna antillarum*), Gull-Billed Tern (*Sterna nilotica*), and Black Skimmer (*Rynchops niger*). There are several other species breeding in the Coastal Bays that rarely breed in Maryland. Threats to the bird populations include disturbance of nesting colonies, erosion of nesting areas, increased predation of eggs, decreases in prey population, and oil and chemical spills.

There have been 42 species of shorebirds recorded in the coastal region of the county, with only a few breeding in the region. The Maryland Coastal Bays area and adjacent Virginia land have been designated as an International Shorebird Reserve due to the high importance for shorebird migration stopover. Due to the dependence upon aquatic prey, shorebirds are a good water quality indicator. Main threats to shorebirds include disturbance of nesting and feeding areas, loss of habitat through erosion, and reduction in water quality.

Additionally, more than 100 bird species live in Worcester County on a permanent or seasonal basis (Worcester County, 1989).

Reptiles and Amphibians

The Diamondback Terrapin, *Malaclemys terrapin terrapin*, lives in the brackish waters, including tidal flats, lagoons, estuaries, and marshes of the Coastal Bays. The turtles lay their eggs in June and July on sandy and loamy shores and then cover the eggs with this soil. The snapping turtle (*Chelydra serpentina serpentina*) is commonly found in the upper reaches of the tributaries due to the fresher water. The loggerhead turtle (federally threatened), leatherback turtle (federally endangered), and the green turtle are also occasionally seen in the Coastal Bays area. Threats to the Terrapin turtle include overharvesting, destruction of nesting habitat from erosion, development, and certain types of shore erosion stabilization, and increased predation of eggs. Additionally, near-shore crab pots (that lack devices to exclude the turtles) can drown them and speedboats can kill them. Another species within the Coastal Bays, Carpenter Frog (*Rana virgatipes*), is listed as being In Need of Conservation and tracked by the MDNR Heritage program.

This same document (Conley, 2004) also ranked the aquatic resources in Maryland Coastal Bays (Figures 27 and 28).

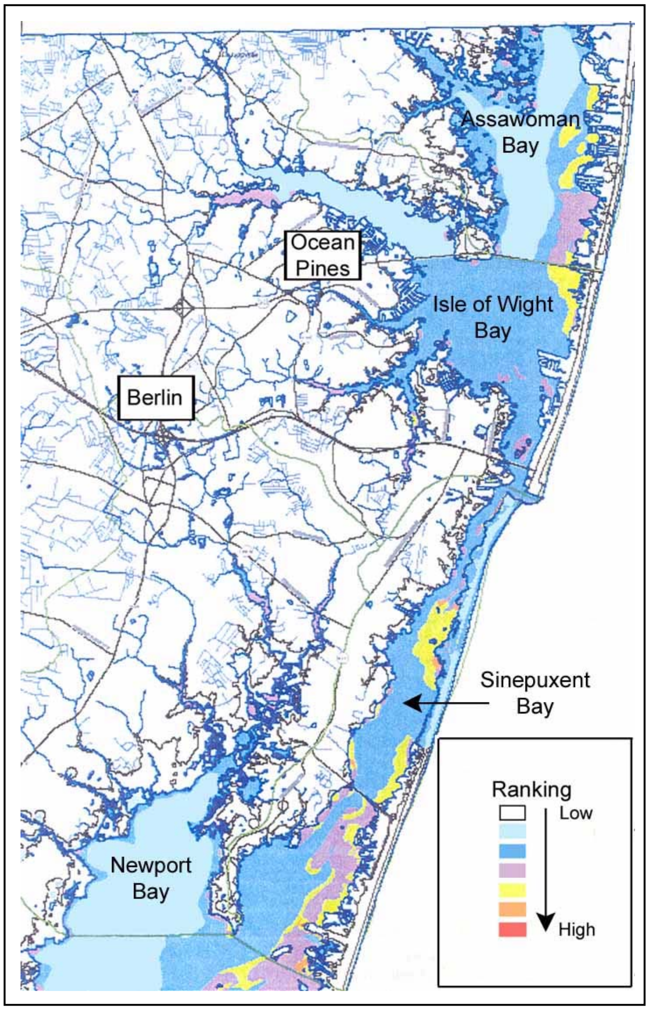


Figure 27. Aquatic Sensitive Areas Ranking in Assawoman, Isle of Wight, Newport, and Sinepuxent Bays (Conley, 2004).

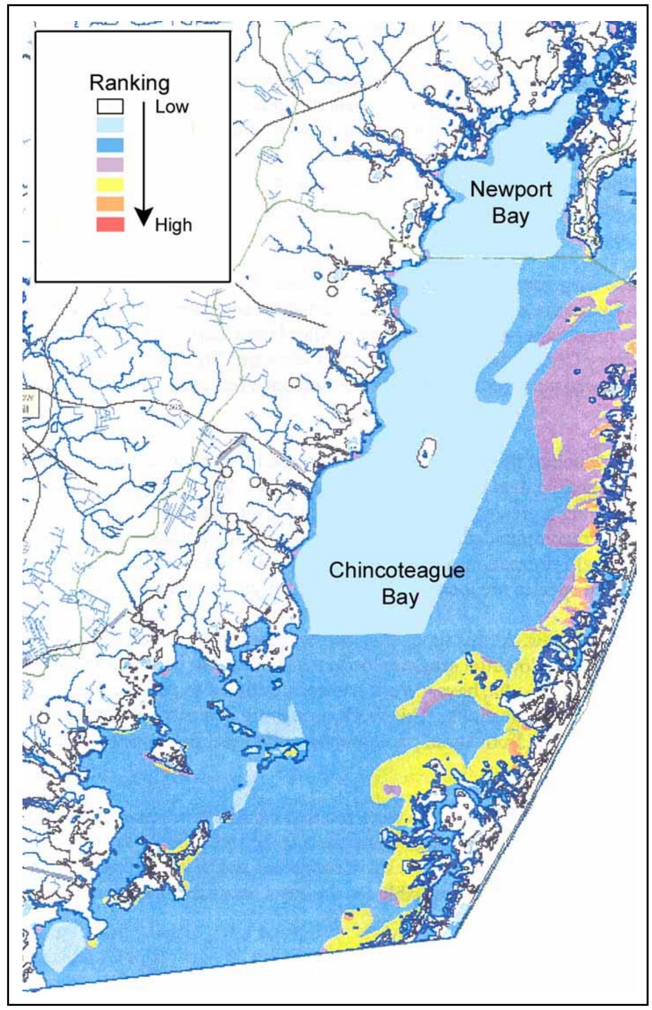


Figure 28. Aquatic Sensitive Areas Ranking in Chincoteague Bay (Conley, 2004)

<u>Upland Wildlife</u>

There are many additional wildlife species in the Coastal Bays. An extensive listing of species that occur in Worcester County is summarized in the Maryland SHA document: *Final Environmental Impact Statement: US 113 Planning Study*. This list includes freshwater fish (59 species), amphibians (19 species), reptiles (29 species), birds (307 species), and mammals (38 species). There are likely many species missing from these lists (e.g. brackish and salt water fish, Assateague Island feral horses). Bottlenose dolphin and harbor seals can be seen in Southern Isle of Wight Bay (USACE, 1998). Bald eagles and wild turkeys have been increasing in population (USDA, 2000).

Significant resources

<u>Wetlands of special interest</u>

Tidal

Three Coastal Bays wetlands were identified by the Emergency Wetlands Resources Act of 1986 as being especially important to waterfowl. These wetlands are all located in the Chincoteague Bay near Stockton and include: Big Bay Marshes, Mills Island, and Tizzard Island.

Non-tidal

Wetlands containing rare, threatened, endangered species or unique habitat were classified as wetlands of special state concern by the MD Department of Natural Resources. These areas are scattered throughout the Coastal Bays watersheds (Figure 12). Sites listed as nontidal wetlands of special state concern (COMAR 26.23.06) and descriptions (from various MDNR documents) are as follows. Note: RTE status is based on the document in which the information was found (2004 for NTWSSC and 2002 for proposed NTWSSC), rather than on the latest 2003 reclassification.

- *Isle of Wight Bay*
  - West Ocean City Pond - This is a large, shallow freshwater pond/wetland that contains a state-endangered plant species. The site is important for migrating and wintering waterfowl and resident waterfowl (MDNR, 2004).
- *Newport Bay*
  - Ironshire Swamp – Although this site is listed in COMAR under the name Ironshire Swamp, MDNR Natural Heritage Program has combined
  - it with the NTWSSC Porter Neck Bog, and it is now described under that name.
  - Porter Neck Bog – This is a forested seepage wetland containing three RTE species and two state "Watch List" species. This site is located in the Porter Creek headwaters (MDNR, 2004).
- *Chincoteague Bay*
  - Hancock Creek Swamp - This site is located south of Stockton. It is a mature deciduous swamp surrounded by steep forested slopes. It contains a state-threatened species (also

globally rare), a state-endangered plant species, and a state “Watch List” plant species (MDNR, 2004).

- Little Mill Run – This site is located along Little Mill Run, Marshal Ditch, Marshall Mill Run, Payne Ditch and Big Millpond. This is a diverse wetland complex of bottomland forest, seepage wetland, and aquatic habitat including open water at Big Millpond. It has some areas of steep slopes along Little Mill Run. This site contains three threatened or endangered plant species, a vulnerable threatened species, and a vulnerable species “In Need of Conservation”. Recently, canopy gaps created during tornadoes have allowed oriental stilt grass to invade the site (MDNR, 2004).
- PawPaw Creek - This wetland/stream complex is unusual for the lower coastal plain, having a relatively steep bluff and topography more similar to the Piedmont in one section (MDNR, 1987). The lower section is low open forest. This site contains two threatened species (one which is globally rare), and a state “Watch List” plant species (MDNR, 2004).
- Pikes Creek – This site contains Pikes Creek and Stockton Powerlines, since they are a connected system.
    - Pikes Creek – One of the habitats at this site, mature bottomland hardwood forests are fairly rare for the region due to past draining and clearing. Although forest covered the majority of the site only a decade ago, many areas have been recently clear-cut. Plant species at this site are more common in the Piedmont than the Eastern Shore (MDNR, 1991). This site contains a state-threatened species (MDNR, 2004). The surrounding habitats contain other threatened or endangered species (MDNR, 2002a). The important plant species generally occur under the powerline right-or-way or in the recent clear-cut areas (MDNR, 2002a).
    - Stockton Powerlines – This is a bog-like wetland that was once fairly common to the region, but is now unusual (MDNR, 1987). This site is located in the headwaters of Chincoteague Bay, so is important for the bay’s water quality (MDNR, 1991). It contains seven state-RTE species and two state “Watch List” species (MDNR, 2004).
- Powell Creek - This mature deciduous forested wetland (MDNR, 1987) is located along Powell Creek and is surrounded by steep forested slopes. It has a state threatened (also

considered to be globally rare) species and other uncommon plant species (MDNR, 2004). Forest interior birds are also present (MDNR, 1987).

- Riley Creek Swamp – This deciduous forested wetland contained a state-threatened (also considered globally rare) species during past surveys (although not found in this 2003 survey). It is possible that the invasion of weedy species caused by nearby bridgework and fallen trees is to blame. Most of the swamp is in good condition (MDNR, 2004).
- Scarboro Creek Woods - This area is a mature deciduous forest and swamp within the headwaters of Scarboro Creek (MDNR, 1987). It contains a state-threatened (also considered globally rare) species and two state "Watch List" plant species (MDNR, 2004).
- Scotts Landing Pond – This 1-acre herbaceous Delmarva Bay, or seasonal depression wetland, is in good condition (MDNR, 2004). It is one of the few naturally occurring open freshwater wetlands in this region (MDNR, 1987). It is more unusual because it is rarely dry (MDNR, 1991). It contains two state "Watch List" plant species and provides good amphibians habitat (MDNR, 2004).
- Tanhouse Creek - This swamp forest is unusual for the lower coastal plain, having a relatively steep topography (MDNR, 1987). There is a diverse sedge community present and two RTE species (one also considered globally rare). This wetland is surrounded by diverse forest (MDNR, 2004).

MDNR Natural Heritage Program proposed additional wetland areas to be classified as NTWSSC. These sites have characteristics that qualify as wetlands of special state concern, but are not currently designated as such. The MDNR 2004 document *Nontidal Wetlands of Special State Concern of Five Central Maryland Counties and Coastal Bay Area of Worcester County, Maryland* summarizes most of these sites:

- *Newport Bay*
    - Icehouse Branch. This tidal creek has characteristics of the rare sea-level fen and contains five RTE plant species and one "Watch List" species.
    - Massey Branch. This is a brackish marsh with characteristics of a rare sea-level fen. There are three RTE plant species and two "Watch List" plant species, mostly located in this ecotone between the brackish marsh and forest.

- St. Lawrence Neck. This site contains rare sea-level fen habitat, two RTE plant species, and one “Watch List” species. Additionally, there are areas of wet forest, salt marsh, and a seepage slope. Some areas are now tidally influenced due to ditches.

- *Chincoteague Bay*
    - Pikes Creek Woods. This site will be surveyed by Natural Heritage Program soon.
    - Spence Pond. This site has three seasonal ponds containing one state-designated endangered plant species and two “Watch-List” plant species. It is surrounded by a pine plantation and has a logging road adjacent.
    - Truitt Landing. This site contains a rare sea-level fen, two RTE species and two “Watch List” species. It also contains salt marsh and a seepage slope. Some areas are now tidally influenced due to the ditching.
    - Waterworks Creek. This is a brackish marsh and mixed pine forest ecotone containing one rare plant species and one “Watch List” plant species.

<u>Other areas</u>

Skimmer Island (North of the Route 50 bridge) is an important rookery, shorebird-feeding site, and horseshoe crab-spawning site. Assateague Island is protected by federal and state governments and provides habitat and recreational opportunities for swimming, boating, fishing, and camping. The island provides habitat for several important species, including the piping plover species, a federally threatened species; the beach tiger beetle, a state endangered species (USACE, 1998); and Peregrine falcons. The State Wildlife Management Areas of the Isle of Wight, Ernest Vaughn in Chincoteague Bay area, and Sinepuxent islands provide opportunities for fishing, crabbing, birding, and waterfowl hunting. Newport Bay has some migratory fish spawning areas (MDNR and MDE, 2000).

<u>Rare/Threatened/Endangered Species</u>

There are 24 species of animals and 78 species of plants in the Coastal Bays that are tracked through the Biological Conservation Database, due to being endangered, threatened, in need of conservation, extirpated, or state-rare (Table 9). Of these, 4 species are federally endangered and 4 species are federally threatened. Since most of these organisms require unique habitats to survive, destruction of these specific habitats can be detrimental.

Table 9. Coastal Bays species listed by Maryland Department of Natural Resources on the Biological Conservation Database as being endangered, threatened, in need of conservation, extirpated, or state-rare. "A" indicates the species is an animal and "P" indicates the species is a plant. * indicates the species is listed as federally threatened and ** indicates the species is federally endangered (Davidson, 2004).

Common name	A/P	Common name	A/P	Common name	A/P
**Atlantic leatherback turtle	A	Carolina clubmoss	P	Sea-beach three-awn	P
*Atlantic loggerhead turtle	A	Carolina fimbry	P	Sea-purslane	P
*Bald eagle	A	**Chaffseed	P	*Seasbeach amaranth	P
Black rail	A	Climbing dogbane	P	Seaside alder	P
Black skimmer	A	Coast bedstraw	P	Seaside knotweed	P
Carpender frog	A	Coppery St. John's wort	P	Sessile-fruited arrowhead	P
Gull-billed tern	A	Cross-leaved milkwort	P	Sessile-leaved tick-trefoil	P
Least bittern	A	Dotter water-meal	P	Silvery aster	P
Least tern	A	Dwarf trillium	P	Single-headed pussytoes	P
Little white tiger beetle	A	Evergreen bayberry	P	Slender pondweed	P
Mud sunfish	A	Fascicled gerardia	P	Slender sedge	P
Northern harrier	A	Few-flowered panicgrass	P	Small's yellow-eyed grass	P
Northern pine snake	A	Grass-leaved ladys' tresses	P	Smooth fuirena	P
Pied-billed grebe	A	Grass-like beakrush	P	Southern wildrice	P
*Piping plover	A	Hairy ludwigia	P	Spreading pogonia	P
**Red-cockaded woodpecker	A	Koehne's ammannia	P	Stiff tick-trefoil	P
**Roseate tern	A	Log fern	P	Swamp-oats	P
Royal tern	A	Long-awned diplachne	P	Sweet-scented ladys' tresses	P
Sandwich tern	A	Long-beaked arrowhead	P	Swollen bladderwort	P
Sedge wren	A	Many-headed rush	P	Tall swamp panicgrass	P
Spotfin killifish	A	Marsh fleabane	P	Ten-angled pipewort	P
White tiger beetle	A	Mitchell's sedge	P	Three-ribbed arrow-grass	P
Wilson's plover	A	Mosquito fern	P	Tiny-headed beakrush	P
Yellow-crowned night heron	A	Northern willowherb	P	Torrey's beakrush	P
A sedge	P	Red bay	P	Torrey's rush	P
Atamasco lily	P	Red milkweed	P	Walter's paspalum	P
Awned mountain mint	P	Reticulated nutrush	P	Water-meal	P
Beach plum	P	Rigid tick trefoil	P	White fringed orchid	P
Beaked spikerush	P	Rough cyperus	P	White spikerush	P
Big carpet grass	P	Sacciolepis	P	White-bracted boneset	P
Big-headed rush	P	Sandplain flax	P	Whorled nutrush	P
Blue-hearts	P	Sea ox-eye	P	Wiry witch grass	P
Broadleaf water milfoil	P	Sea-beach sandwort	P	Woolly three-awn	P
Broad-leaved beardgrass	P	Sea-beach sedge	P	Wrinkled jointgrass	P

Protected Land

Protected land includes Maryland Environmental Trust (MET) easements, mainly in Chincoteague Bay watershed, with other small parcels in the watersheds of Isle of Wight Bay and Sinepuxent Bay. Federally protected land includes the majority of Assateague Island. State protected land includes the Chesapeake Forest Land (as described below), E.A. Vaughn Wildlife Management Area, Isle of Wight Wildlife Management Area, small islands which are part of Sinepuxent Bay Wildlife Management Area, the remaining portion of Assateague Island and the section of Assateague State Park on the mainland in Sinepuxent Bay watershed. There are small parcels of county-owned land throughout the Coastal Bays. There are a few agricultural easements in the watersheds of Newport Bay and Chincoteague Bay.

The Department of Natural Resources and The Conservation Fund purchased many large parcels of land on the lower Eastern shore from the Chesapeake Forests Products Company (MDNR, 2003b). This land, totaling 58,000 acres, is now being managed by MDNR with the goals of maintaining the habitat and natural resources, timber harvesting, water quality, and public access. These areas also provide opportunities for wetland restoration and creation. Within the Coastal Bays area, there are a few parcels in the western portion of Chincoteague Bay watershed.

Rural Legacy Program

The Southern Coastal Bays area has been designated as a Rural Legacy Area due to the diverse landscape of agriculture, forest, wetland, and bays. Since this area currently has high biodiversity and is one of the most pristine in the Coastal Bays, it is important to protect it from future development (MDNR, 2002b). In total, there are 16,200 acres in this Rural Legacy area. The area slated for protection includes an area adjacent to Chincoteague Bay, from the Virginia line to Brockanorton Bay. Protecting these properties would contribute to protecting the greenway between Pocomoke State Forest, E.A. Vaughn Wildlife Management Area, and Assateague Island National Seashore (MDNR, 2003f). It would also preserve 16 miles of undeveloped shoreline (Worcester County, 2003). The partners, including Worcester County, the Lower Shore Land Trust, and The Conservation Fund, intend to protect half of this area with Rural Legacy easements. They also are seeking donated easements. Additionally, NRCS has restored hundreds of acres of wetlands in this area, and continues to do so. Large portions of this land are already protected by the state (including some Chesapeake Forest Land), Maryland Environmental Trust easements, county, and agricultural easements.

Maryland Agricultural Land Preservation Foundation (MALPF)

The Maryland Agricultural Land Preservation Foundation (MALPF) was designed to protect agricultural land and control urban sprawl. There are a few MALPF easements in the Coastal Bays, protecting agricultural lots.

Critical Area Program

Recently the Maryland Coastal Bays was added to the Critical Area program. This means a 1,000-foot area around the tidal waters and tidal wetlands of the Maryland Coastal Bays has been designated as a critical area, requiring water quality and habitat protection similar to that established for the Chesapeake Bay (Coyman, 2002). Regulations designate the amounts and locations of development in order to focus growth in certain areas while minimizing development in sensitive areas. Additionally, it establishes a 100-foot buffer along tidal waters, tidal wetlands, and streams for most land use types. Agriculture and forestry operations are required to institute conservation plans and forest harvesting plans.

Green Infrastructure

Maryland Department of Natural Resources identified the Green Infrastructure in the Coastal Bays watershed by classifying large blocks of interior forest and wetlands as hubs (Figure 29). Vegetated connections between these hubs, either existing or potential, are identified as corridors. This network is important for the survival and movement of wildlife and plant propagules in the area. Hubs and corridors were ranked in *Maryland's Green Infrastructure Assessment* based on ecological significance and development risk. Therefore, in addition to simply knowing that an area is a hub or corridor, we also know which have the highest ecological values or are most vulnerable to being developed, and can focus our efforts on these locations. *Maryland's Green Infrastructure Assessment* is described at http://www.dnr.state.md.us/greenways/gi/gi.html

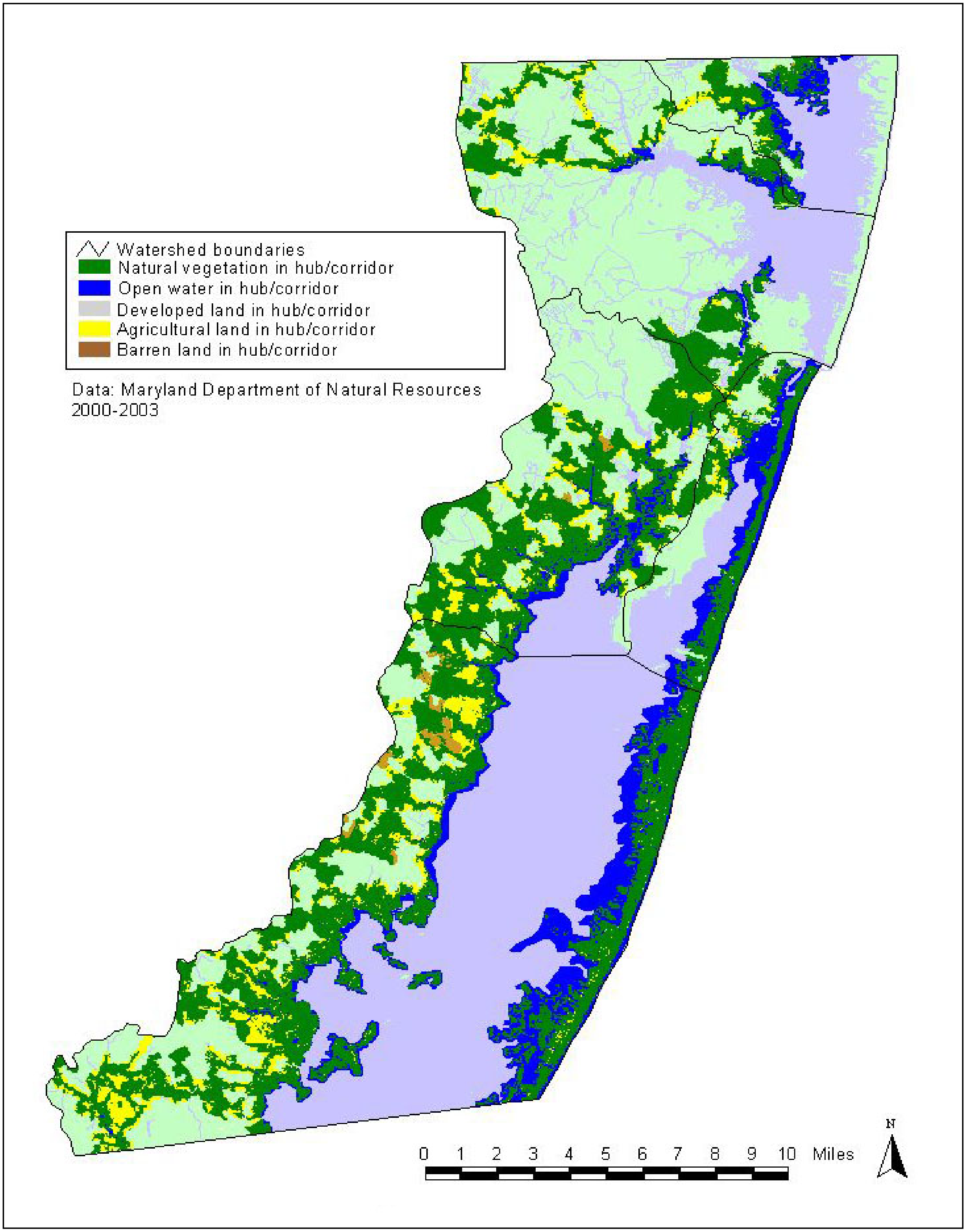


Figure 29. Green infrastructure hubs and potential corridors in Maryland Coastal Bays watershed.

Greenways

There are a few established greenways providing ecological or recreational functions in the Coastal Bays watershed, according to the Maryland Greenways Commission (MDNR, 2000a). The Assateague Island National Seashore is a protected greenway roughly connected with the greenway along the Sinepuxent Bay and Chincoteague Bay shore. The Sinepuxent Bay water trails are located off Assateague Island and traverse through marsh. The Isle of Wight greenway is a short greenway on the protected Isle of Wight Island. Opportunities for restoration of marshland and extension of this greenway exist in the northern salt marsh region of this island. The only proposed greenway is the recreational Snow Hill Rail Trail, which is located in Southern Chincoteague Bay watershed and continues north to the Pocomoke River watershed.

Stream assessments

Characteristics

The streams are mainly shallow and slow moving, with headwater streams often having been ditched. Based on 1901 USGS quad maps (Maptech, Inc., 2003) and Tiner et al., (2000), the majority of streams in the watershed have been physically altered, especially in the headwaters of the northern Coastal Bays watershed (Figure 3
0). Estimates from Tiner et al. (2000) suggest there are 448.7 miles of ditches, 166.2 miles of channelized streams, and 19.9 miles of natural streams. Public Drainage Associations (PDAs) manage and maintain artificial drainage systems for agriculture using landowner tax money. These PDAs manage 71.8 stream miles in the Coastal Bays, within the watersheds of Isle of Wight Bay and Newport Bay. The majority of these drainage systems are sprayed with herbicide and mowed on a regular basis to maintain water flow. A frequently encountered environmental concern is the lack of riparian buffers for a large portion of the stream miles. According to 1994 Maryland Department of Planning data, this problem is most common in the watersheds of Assawoman Bay, Sinepuxent Bay, and Isle of Wight Bay. Stream erosion is only a minor concern due to the flat topography and slow stream velocities.

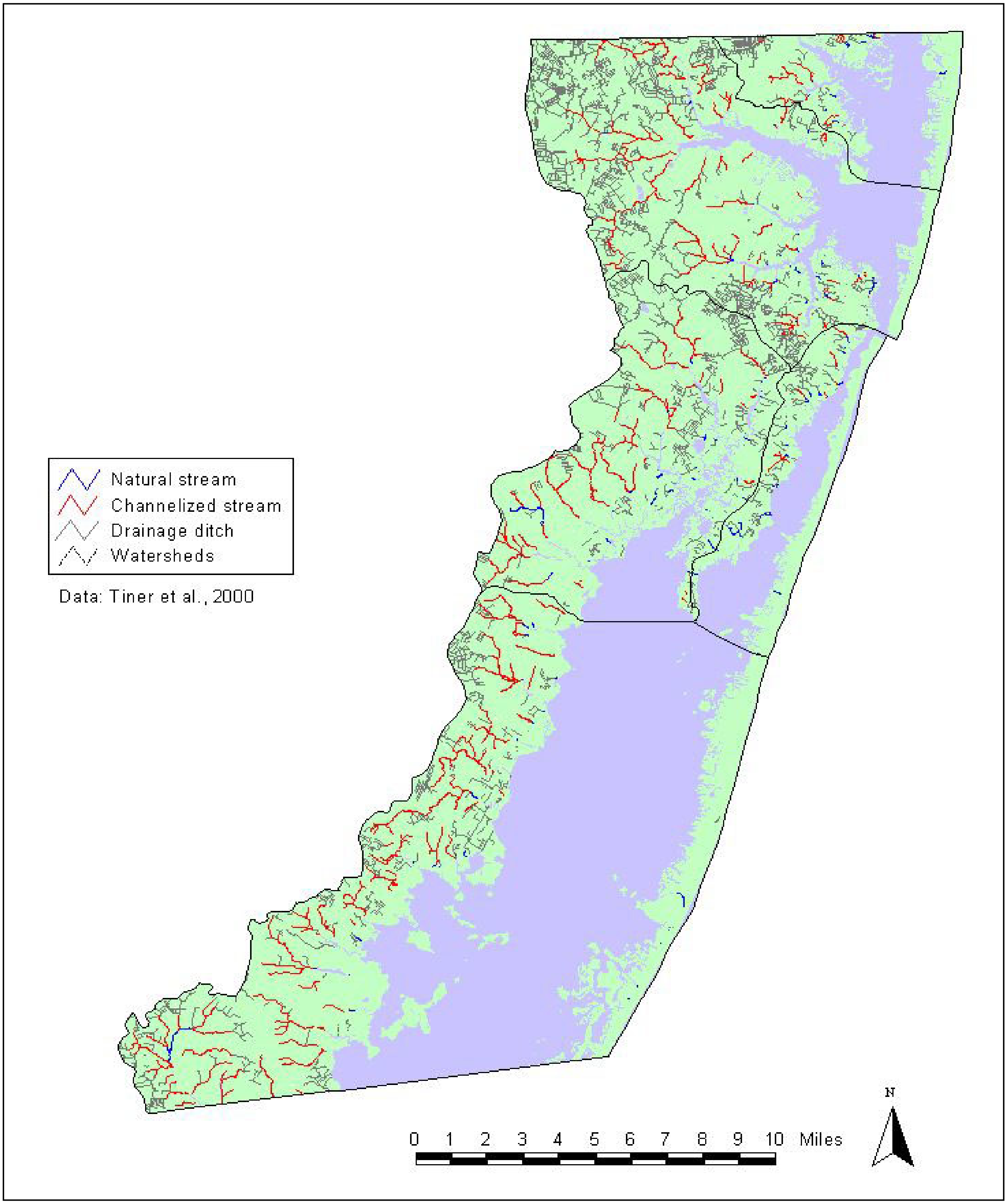


Figure 30. Natural streams, channelized streams, and drainage ditches in Maryland Coastal Bays watershed.

Code of Maryland Regulations (COMAR) Designated Uses

All Maryland stream segments are given a “designated use” in the Code of Maryland Regulations 26.08.02.08. The Coastal Bays are as follows:

Use II, shellfish harvesting waters for all ocean and estuarine sections of the Coastal bays and tributaries except Bishopville Prong and tributaries, Shingles Landing Prong and tributaries, Herring Creek and tributaries, Ocean City Harbor (above entrance to West Ocean City Harbor).

Stream monitoring

Stream parameters were assessed at several stations within the Coastal Bays. Most of these surveys indicated that fish and benthic communities were degraded in comparison to reference sites (in this case, minimally impacted streams). Evaluations of benthic and fish communities have been made in non-tidal portions of the watershed and were reported as an index of biotic integrity (IBI), basically a rating system characterizing the fish or benthic community integrity for a given site. IBI scores can range from 1.0 to 5.0, with higher numbers depicting higher biological integrity and being closer in comparison with reference streams. The MDNR Maryland Biological Stream Survey (MBSS) quantitatively monitored sites in the Coastal Bays watershed in 1997 and 2001. The Stream Waders Program, a portion of the MBSS, utilizes volunteers to survey streams in the same subwatersheds as the MBSS, thereby increasing the number of sampled stations. MDNR has sampled additional stations within the Isle of Wight watershed and the St. Martins River watershed in 1999 and 2001 (Primrose, 1999; 2002) and the watersheds of Newport and Sinepuxent in 2003 (Primrose, 2003). A compilation of this stream data follows:

- *Assawoman Bay*: Stream Waders monitored two sites from this watershed in 2001, resulting in a family index of biotic integrity (IBI) of very poor.
- *Isle of Wight Bay*: Stream Waders monitored 18 sites in 2001, reporting family IBI ratings of very poor (17 out of 18 sites) to poor (1 site). The one site monitored in the 1997 MBSS found benthic IBI of fair. The 2001 MBSS surveyed 4 sites, finding poor to fair values for fish IBI and very poor to poor values for benthic IBI. The MDNR Landscape and Watershed Analysis Division monitored 19 sites in the St. Martin’s River, finding most impacted communities on Carey’s Branch and Church Creek (Primrose, 1999). Dead-end canals had lower macroinvertebrate abundance and biomass relative to open Coastal Bays (USACE, 1998).

MDNR conducted a stream corridor assessment for this watershed in 2001. From this assessment, it was noted that the most common problem was stream channel alteration, as 69% of the stream channels had been converted, mainly into agricultural ditches. This problem was most common in the headwaters, especially in the northern watershed. Inadequate stream buffer (<50ft) was the next most common problem encountered (64%). Other less-frequently encountered issues included stream erosion in the southern part of the watershed, construction erosion, trash, and sewage discharge. Minor fish migration barriers were encountered at 32 sites, mainly in the southern part of the watershed. These consisted of sites inhibiting fish passage due to shallow water or a drop in water (e.g., a culvert of fixed elevation with an outfall into a stream with an eroded bottom). The one reported dam was above Bishopville Road and is scheduled for removal.

- *Newport Bay*: The Stream Waders Program monitored 6 sites, finding family IBI values of very poor to poor. The one site monitored in the 1997 MBSS had benthic IBI rating of very poor. There were 2 sites monitored by the 2001 MBSS, finding that fish IBI was fair and benthic IBI was very poor to poor. The three sites monitored in the 2003 MDNR Nutrient Synoptic Survey had benthic IBI of very poor. MDNR conducted a stream corridor assessment for this watershed in 2003. Data will be available shortly.
- *Sinepuxent Bay*: Family IBI was found to be very poor for the three stations surveyed by the Stream Waders in 2001. MDNR conducted a stream corridor assessment for this watershed in 2003. Data will be available shortly.
- *Chincoteague Bay*: The Stream Waders Program monitored 20 sites from this watershed in 2001. Results found non-tidal family benthic index of biotic integrity ratings from very poor (15 out of 20 sites) to fair. The one station monitored in the 1997 MBSS found a benthic IBI of poor. There were three stations monitored in the 2001 MBSS. These sites had poor fish IBI and very poor to poor benthic IBI. The two sites monitored in the 2003 MDNR Nutrient Synoptic Survey had benthic IBI of poor and very poor. MDNR is currently conducting a stream corridor assessment for this watershed (in 2004). Data will be available in 2004/2005.

Bottom line: The streams are generally in poor condition and may benefit from improvements in stream habitat.

Water quality

<u>Algae</u>

An abundance of algae can block sunlight to submerged aquatic vegetation, deplete the water of oxygen, interfere with shellfish feeding, and inhibit boating. Excessive phytoplankton/algae are frequently seen in the Coastal Bays tributaries. Some algae may be especially harmful to aquatic life and/or humans. *Prorocentrum minimum* resulted in fish kills within the Coastal Bays. *Aureococcus*, an algae that causes brown tides, was reported at high densities in Newport Bay, Public Landing, Tingles Island, Green Run Bay, and at lower densities in all other bays and major tributaries except Sinepuxent Bay (Tarnowski and Bussell, 2002). *Microcystis aeruginosa* resulted in beach closures. *Pfiesteria* was confirmed in Turville Creek (MDNR, 1999). A study conducted by MDNR in 1998 and 1999 looked at frequency and abundance of macroalgae species in the Coastal Bays (Goshorn et al., 2001). Of the 25 genera found, the top most abundant were *Agardhiella* and *Gracilaria*. The highest volume of total macroalgae per station was found at Isle of Wight Bay in both years (Table 10). The abundance of "nutrient responsive algae", algae species assumed to benefit from nutrient enrichment (*Enteromorpha* spp., *Ulva lactuca*, *Cladophora vagabunda*, *Gracilaria tikvahiae*, *Chaetomorpha* spp., and *Agardhiella* spp.), was highest in Isle of Wight Bay and southern Chincoteague Bay.

Water system	**Volume/Station 1998 (ml)**	**Volume/Station 1999 (ml)**
Assawoman	787	7
St. Martin	48	31
Isle of Wight	1257	2855
Sinepuxent	70	343
Newport	39	36
Chincoteague	319	514

Table 10. Total volume macroalgae per sampling station within each Coastal Bays embayment (Goshorn et al., 2001).

Bottom line: By increasing wetlands that function to decrease nutrients, chlorophyll blooms may be reduced.

Impaired Water Quality

Since the Coastal Bays are shallow and have relatively low flushing, they are vulnerable to pollution (Worcester County, 1989). A number of water quality concerns have been identified for this region, with problems often being worse in the northern bays and Newport Bay, and best in Sinepuxent and Chincoteague Bays (Boynton et al., 1993). Areas with high amounts of flushing with ocean water, near the Ocean City inlet, have better water quality (USACE, 1998).

A 1996 EPA Joint Assessment focusing on Assawoman Bay, Chincoteague Bay, St. Martin River, Trappe Creek, and dead-end canals (in addition to systems in the Delaware Coastal Bays) found impaired water quality in many of the Coastal Bays regions (Chaillou et al., 1996). Tidal benthic communities were degraded in nearly half of the areas sampled, especially in dead-end canals and St. Martin River, with Chincoteague Bay being the least degraded. Threshold levels used in the 1996 EPA document were based on values used in Dennison et al. (1993) based on SAV habitat requirements. Indicator levels were also set in the MDNR and MCBP STAC draft document *Aquatic Ecosystem Health 2004, MD Coastal Bays Monitoring Report*. These levels were often different than those in the 1996 EPA document.

Nitrogen

High nitrogen levels can lead to high levels of phytoplankton, which then die, leading to reduced levels of oxygen in the water.

- Dennison et al. (1993): The SAV restoration goal for dissolved inorganic nitrogen, which includes NO_3, NO_2, and NH_4, is 11µm (0.15 mg/l N).
- 2004 MDNR/MCBP STAC: Total nitrogen of 1.0 mg/l is considered hypereutrophic; The SAV restoration goal for total nitrogen is 0.65 mg/l.

Phosphorus

- Dennison et al. (1993): The SAV restoration goal for dissolved inorganic phosphorus, PO_4, is 0.64µm (0.02 mg/l P).
- 2004 MDNR/MCBP STAC: Total phosphorus of 0.01 mg/l is considered hypereutrophic; The SAV restoration goal for total phosphorus is 0.037 mg/l.

Water clarity

Water clarity may be impacted by suspended soil, phytoplankton and zooplankton, and dead plant material. Causes of turbidity include storms and wave action, runoff, and shoreline erosion (MDNR, 2003c). High turbidity decreases light penetrating the water to the SAV, hinders filter-feeding processes, can clog fish gills, and reduces sight of aquatic predators. The SAV restoration goal for the light attenuation coefficient (K_d>1.5/m) is related to the maximum water depth where secchi disk is readable.

Chlorophyll a

High levels of chlorophyll a indicate an excess of phytoplankton and water quality impairment. It has been found that chlorophyll rates are directly related to nitrogen loading in the Coastal Bays (Boynton, 1993). Dissolved oxygen was also strongly related to levels of chlorophyll a. Chlorophyll a of <50 ug/l is necessary to maintain dissolved oxygen. The SAV restoration goal for chlorophyll a is <15ug/l.

Dissolved oxygen

The state requires dissolved oxygen (DO) levels of at least 5mg/l in the low flow months of July through October. Values lower than 5mg/l are harmful to some aquatic organisms, especially hard clam, white perch, striped bass, blueback herring, and alewife. Bay anchovies, alewife, blue crabs, and juvenile blueback herring require 3 mg/l, spot require 2 mg/l, and Atlantic menhaden require 1.1 mg/l. Although aquatic species may survive at low oxygen levels, their growth and reproduction may by negatively impacted. Organisms especially susceptible to low dissolved oxygen levels are species that can not move from the area, while more mobile organisms, such as fish and crabs, usually can detect the low oxygen levels and leave the area. However, low dissolved oxygen has been reported as the cause for some recent fish kills. Low dissolved oxygen levels are due to algae blooms, organic enriched sediments, marsh vegetation (the process of respiration, reducing night DO levels), macroalgae, phytoplankton, and poor water circulation (MDE, 2001). Daytime DO levels do not reflect daily minimum (i.e. worst case scenarios) since lowest DO levels often occur at night during periods of highest plant respiration.

Contaminants

Chemical contaminants include inorganic and organic chemicals that reduce ecological integrity and result in safety concerns for seafood consumption. They originate largely from agriculture, industry, automobiles, and development, with historic inputs also being important, as some contaminants are quite persistent. Some examples are pesticides, polychlorinated biphenyls (PCBs), heavy metals, and polynuclear aromatic hydrocarbons. These may accumulate in relatively large quantities in sediments at the bottom of the bay. Based on the data from Maryland and Delaware Coastal Bays, most contaminant concentrations were higher in the dead-end canals than in the bay system overall. The most widespread contaminants at high levels were DDT, arsenic, and nickel. A dead-end canal station (on the east side of Assawoman Bay) had the highest number of contaminants at high levels. The MDNR/MCBP STAC draft report *Aquatic Ecostystem Health 2004, MD Coastal Bays Monitoring Report* stated that chemical contamination within the coastal bays is not a major concern. There are some localized areas of higher sediment contaminants in the northern bay tributaries and Newport Creek.

<u>2002 Maryland Section 305(b) Water Quality Report</u>

The *2002 Maryland Section 305(b) Water Quality Report* summarizes water quality in the Coastal Bays as follows:

- *Assawoman Bay* failed to fully support all designated uses due to low oxygen.
- *Isle of Wight Bay* failed to fully support all designated uses due to low oxygen and bacteria from industrial discharge, non-point sources, natural sources, and low tidal flushing. The nontidal wadeable tributaries to St. Martins River, Herring Creek, Turville Creek, and Manklin Creek failed to support all designated uses in some portions (5.8 miles) due to poor biological community and had inconclusive results in other portions (17.6 miles). Some tributaries to St. Martin River and Turville Creek had low oxygen and high chlorophyll (MDNR, 2000b). Bishopville Pond (60.2 acres) also failed to support all designated uses due to high nutrients and low oxygen from non-point sources, upstream sources, high sediment oxygen demand (SOD), and natural sources.
- *Newport Bay* tidal embayment and tidal creeks and rivers failed to support all designated uses due to low oxygen from non-point sources and eutrophication. The tidal embayment also had high macroalgae. A tributary to Newport Bay had elevated levels of turbidity (MDNR, 2000b). Nontidal wadeable tributaries had portions (2.9 miles) that failed to fully support all designated uses due to a poor biological community and portions (11.6 miles) that had inconclusive results.
- *Sinepuxent Bay* had low levels of dissolved oxygen, but results were inconclusive (8.8 miles) as to weather this waterway fully supported all designated uses.

- *Chincoteague Bay* failed to support all designated uses due to bacteria, low oxygen, and macroalgae from non-point sources, low tidal flushing, and natural sources. The nontidal wadeable tributaries had portions (1.4 miles) that did not support all uses due to a poor biological community, while the majority (11.1 miles) had inconclusive results. Big mile pond (60.2 acres), failed to fully support all designated uses due to nutrients, siltation, and low oxygen levels from non-point sources, natural sources, upstream sources, and sediment oxygen demand (SOD).

<u>Total Maximum Daily Loads (TMDLs)</u>

Total Maximum Daily Loads (TMDLs) were developed by Maryland Department of Environment to establish the maximum pollutant values that can be discharged to a waterway, while still allowing the water body to meet specified water quality requirements. Surface water bodies that are on the draft 2004 Impaired Surface Water 303(d) List and either are in need of a TMDL or have a completed TMDL but are still impaired, are as follows:

- *Assawoman Bay*:
    - Nutrients (causing low seasonal DO <5mg/L)
    - Although some background information was included in the Northern Coastal Bays TMDL, no TMDL was actually completed for Assawoman Bay.
- *Isle of Wight*:
    - Nutrients (causing low seasonal DO <5mg/L and high pH)
    - Herring Creek/Turville Creek subwatershed (021301030687): fecal coliform
    - Crippen Branch subwatershed (021301030690): poor biological community
    - Church Branch subwatershed (021301030691): poor biological community
    - TMDL approved for nutrients at St. Martin River, Shingle Landing Prong, Bishopville Prong, Herring Creek, and Turville Creek. A TMDL will be conducted for the remaining tributaries later.
- *Newport Bay*:
    - Nutrients (causing low seasonal DO <5mg/L and high pH)
    - Kitts Branch subwatershed (021301050685): poor biological community
    - TMDL of approved for Ayer Creek, Newport Creek, Newport Bay mainstem, and biochemical oxygen demand TMDL for Kitts Branch.
- *Sinepuxent Bay*:

- Nutrients (causing low seasonal DO <5mg/L)

- *Chincoteague Bay*:
  - Nutrients (causing low seasonal DO <5mg/L)
  - Powel subwatershed (021301060671): poor biological community
  - Waterworks/South Creek subwatershed (021301060680): poor biological community
  - Fifteen Mile Branch subwatershed (021301060680): poor biological community
  - Big Mill Pond: nutrients
  - TMDL approved for Big Millpond

<u>Sampling</u>

Water quality data from MDE in 1998, MDNR in 1998, ASIS (Assateague Island National Park Service) in 1998, and MCBP in 1997-1999 are summarized below. The MDNR nutrient synoptic surveys (part of the WRAS) conducted in 1999 and 2001 (Isle of Wight and St. Martin River) and 2003 (Newport, Sinepuxent, with a few stations in Chincoteague) are also included. There was a high concentration of sampling stations in the northern Coastal Bays (Figure 31). Median annual data (based on years 2001-2003) based on DNR and ASIS data and trends based on ASIS data as reported in the document *Draft Aquatic Ecosystem Health 2004, Maryland Coastal Bays Monitoring Report*, including nitrogen and phosphorus levels (Figures 32 and 33) is also summarized below.

- *Assawoman Bay*: Greys Creek is the main tributary to Assawoman Bay. Most sites in this watershed had chlorophyll a levels exceeding the SAV habitat requirement of 15ug/l. Highest chlorophyll a levels were measured in shoreline areas receiving less flushing. The station at Ocean City, 79th street, had a chlorophyll a level of 98ug/l in 1998. Ocean City stations generally had high DIN. Assawoman Bay had DO levels above 5.0mg/l at the surface but below 5.0mg/l at the bottom. Greys Creek had DO values below 5.0mg/l.

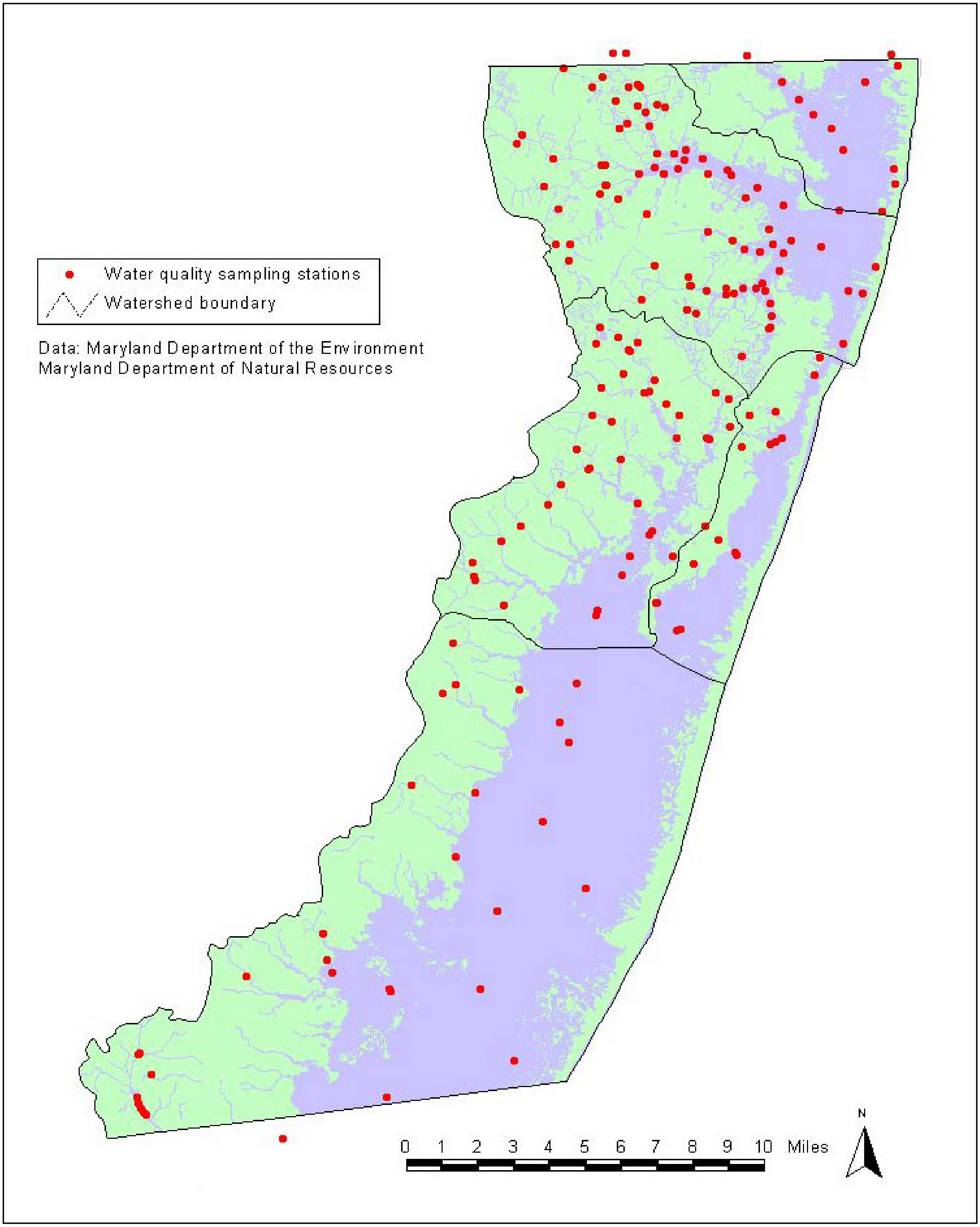


Figure 31. Water quality sampling stations within Maryland Coastal Bay region.

- *Isle of Wight Bay*: The majority of freshwater entering Isle of Wight Bay is from the St. Martin River. Major tributaries to the St. Martin River include Bishopville Prong and Shingle Landing Prong. Other tributaries to the Isle of Wight Bay include Manklin Creek, Turville Creek, and Herring Creek. St. Martin's watershed had the highest pollutant load and unit per area load within Isle of Wight watershed (USACE, 1998), including high nutrient loads and high fecal coliform (Shanks, 2001). During the low flow periods, the open bays had a fairly low level of chlorophyll a (10-20ug/l) and surface DO levels were at or above 5.0mg/l but bottom water DO levels were reported to be below 5.0mg/l. In the St. Martin River, chlorophyll a levels were higher, with average low flow values for each year ranging between 15ug/l and 50ug/l. Some higher values were reported along the shorelines. According to TMDL results, this river had low DO values where the upstream tributaries enter the river and where the river enters the Isle of Wight Bay, due to higher deposition at these locations. In Shingles Landing Prong and Bishopville Prong, chlorophyll a values were very high. Chlorophyll a generally exceeded 50ug/l with values occasionally exceeding 250ug/l in Bishopville Prong (just below the dam). Based on data used in the northern Coastal Bays TMDL, Bishopville Prong had several very low DO concentrations, with lowest individual readings found just below the dam and in the dam. According to TMDL results, there was high DIN and high DIP in Bishopville Prong and North of the MD/DE line. Although values in Shingles Landing Prong were above 5.0mg/l during the day, TMDL results suggest values drop below 5.0mg/l in the early morning hours. Shingles Landing Prong also had some high individual readings of dissolved inorganic phosphorus (DIP; ortho-phosphate) and dissolved inorganic nitrogen (DIN) in low flow months. For both Shingles Landing Prong and Bishopville Prong, MDE is requiring a 31% reduction in non-point source nitrogen based on the TMDL. Turville Creek and Herring Creek had chlorophyll a above 15ug/l and DO values <5mg/l during low flow conditions. Some stations in Turville Creek had high DIN during low flow conditions and Herring Creek had high DIN and high DIP during low flow months. Manklin Creek had some DO values below 5.0mg/l in low flow months and chlorophyll a values above 15ug/l. Results from a MDNR study in 1999 for the St. Martins Watershed found high nutrient concentrations at three stations: a tributary to St. Martin at St. Martin Neck Road, Buntings Branch at Delaware Rt. 54 in Selbyville, and Church Creek at Rt. 113 (Primrose, 2002). The area with the highest total dissolved nitrogen load (79.5mg/L) was on Buntings Branch at Delaware Route 54 in Selbyville. Other areas of high nutrients were at Birch Branch at Route 113, Birch Branch at Campbelltown Road, and a tributary to Birch Branch at Murray Road.

- *Newport Bay*: The main tributaries of Newport Bay include Ayer Creek, Trappe Creek, Newport Creek, and Marshall Creek. Based on the 2003 nutrient synoptic survey, several locations had high or excessive nitrate/nitrite concentrations or yields, or had high orthophosphate concentrations (Primrose, 2003). These may be due to point sources, row crops, poultry manure stock-piling or application, and septic systems. Kitts Branch was influenced by high BOD levels from Tyson Food, Inc, and had extremely high DIN and DIP, and chlorophyll a levels above 15ug/l. Some site had excessive estimated nitrate/nitrite and orthophosphate yields, likely due to the point discharge (Kitts Branch at Flower St. and Kitts Branch at Rt. 346, Primrose, 2003) Trappe Creek had chlorophyll a levels exceeding 50ug/l. Ayer Creek had chlorophyll a levels above 50ug/l, high DIN, and high DIP. Newport Creek had chlorophyll a levels above 50ug/l and high DIN at the headwaters of Beaverdam Creek (a tributary to Newport Creek). Newport Bay has chlorophyll a levels above 15ug/l in low flow months. The headwaters of Marshall Creek had very high chlorophyll a levels, high DIN, and high DIP. Bottle Branch (at Harrison Road) had excessive orthophosphate yields likely due to the Berlin WWTP (Primrose, 2003). DO levels were below 5.0mg/l in all sampled areas of Newport Bay watershed, with DO < 2.5mg/l at Ayer Creek.
- *Sinepuxent Bay*: Of the sites sampled in the 2003 nutrient synoptic survey (Primrose, 2003), two had high or excessive orthophosphate concentrations (unnamed tributary to Sinepuxent Bay at Rt. 611 and at Eagles Nest Road, respectively). Nitrate/nitrite levels and orthophosphate yields were baseline. Chlorophyll a levels were below 15ug/l and dissolved oxygen levels were generally at or above 5mg/l even during low flow periods (some MDNR samples in the Coastal Bays had low dissolved oxygen readings at depth). DIN and DIP values were moderately high in some years.
- *Chincoteague Bay*: Chincoteague Bay had low flow chlorophyll a levels at or near 15ug/l, with one station reaching roughly 23ug/l in 1998. Elevated levels of chlorophyll a, DIN, and DIP were roughly near the shoreline, but were generally not as high as in the northern Coastal Bays. Dissolved oxygen levels were consistently above 5mg/l. Big Millpond had excessive phosphorus and sediment loads. Polluted water from Newport Bay drains into Chincoteague Bay, reducing water quality (USACE, 1998).

Nitrogen and phosphorus levels were reported in the MDNR/MCBP 2004 State of the Bays Report (Figures 32 and 33). Summary of water quality status and trends data as stated in MDNR/MCBP 2004 DRAFT STAC data and shown in MDNR/MCBP 2004 State of the Bays Report (Figures 34 through 36):

Upper tributaries (Greys Creek, Bishopville Prong, Shingle Landing Prong, Turville Creek, Trappe Creek, Ayres Creek, Newport Creek and Marshall Creek) are severely nutrient enriched. St. Martin River, northern Assawoman Bay and Herring Creek are also highly enriched. Sinepuxent Bay, southern Chincoteague Bay and open Isle of Wight Bay have lowest total nitrogen. Phosphorus enrichment appears to be more widespread with few sites meeting SAV threshold for TP.

The SAV chlorophyll threshold was met in Isle of Wight, Sinepuxent and Chincoteague Bays; while the St. Martin River and upper Newport Bay failed. STAC chlorophyll threshold show hypereutrophic conditions are present in Bishopsville Prong and Trappe Creek.

Daytime measurements show that DO falls below 5 mg/l during the summer months throughout the St. Martin River and areas of Newport Bay, as well as Manklin Creek, Herring Creek, Turville Creek and areas in Chincoteague Bay near Figgs Landing and Green Run Bay.

Bottom Line: Wetlands in the headwaters and tributaries may be used to improve the generally degraded water quality.

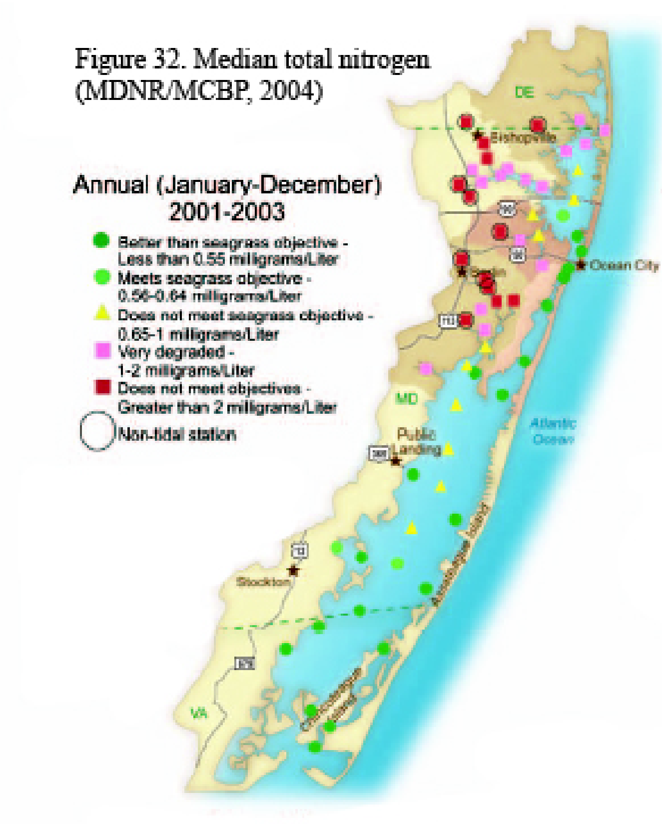


Figure 32. Median total nitrogen (MDNR/MCBP, 2004)

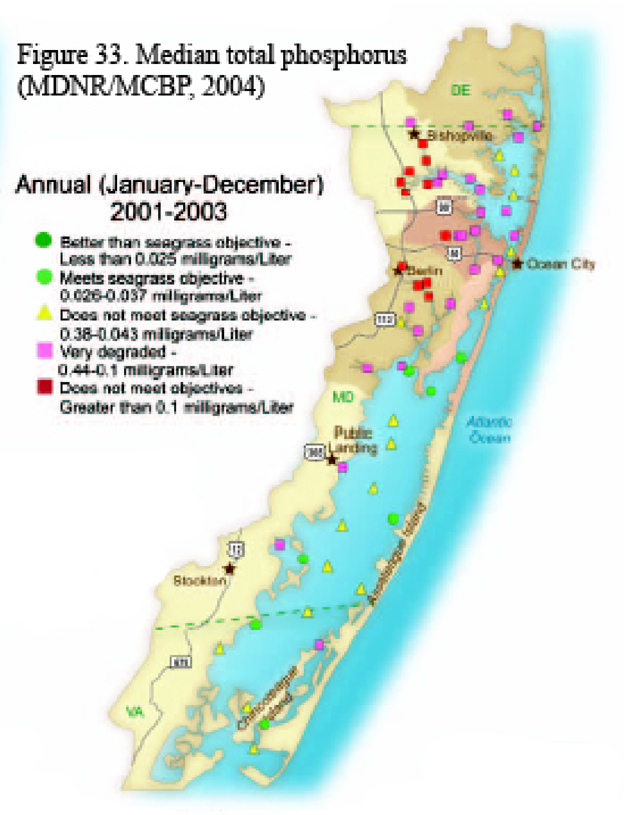


Figure 33. Median total phosphorus (MDNR/MCBP, 2004)

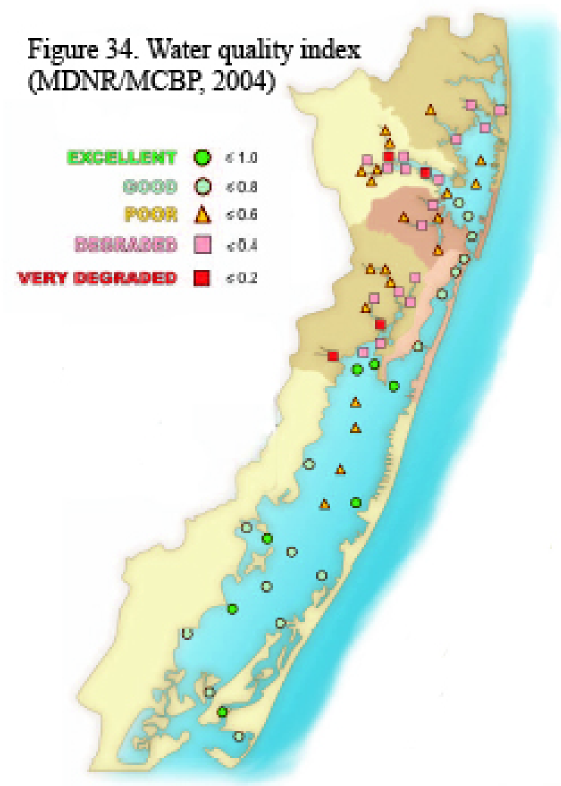


Figure 34. Water quality index (MDNR/MCBP, 2004)

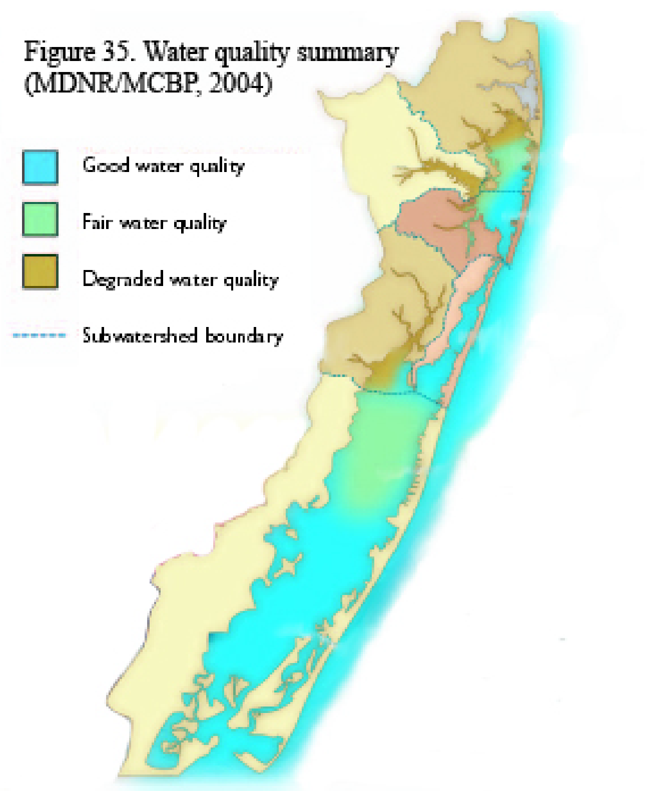


Figure 35. Water quality summary (MDNR/MCBP, 2004)

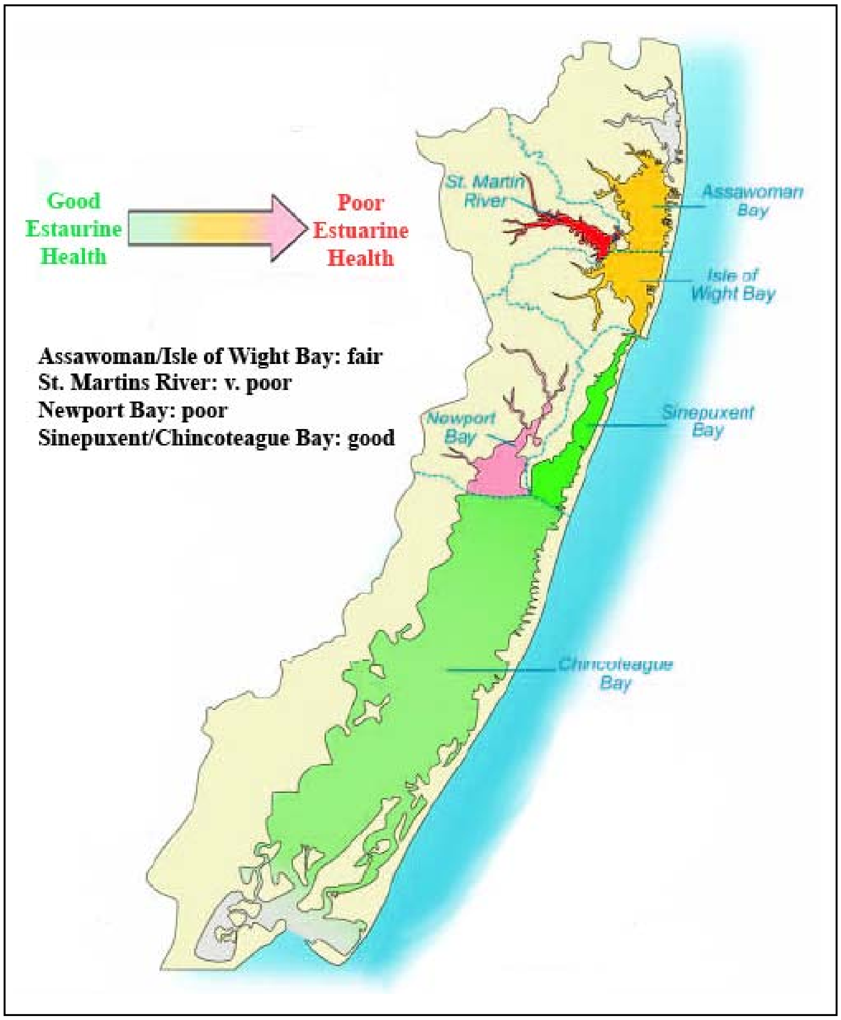


Figure 36. Summary of estuarine health, based on indices of water quality, living resources, and habitat (MDNR/MCBP, 2004).

Pollutant sources

Overall

During the TMDL process, MDE estimated nutrient sources entering several waterways (Table 11). The largest pollutant source for both total nitrogen and total phosphorus loading were non-point sources, mainly agricultural runoff. Developed areas contribute a high amount of nutrients per area, but agriculture results in much higher total nutrient loads due to the high amount of land use (Jellick et al., 2002). Poor septic systems also contribute nutrients. There was assumed to be no phosphorus entering through the ground water, since phosphorus binds to soil particles and generally does not leach into the groundwater.

Table 11. Sources of average annual total nitrogen and total phosphorus loads entering the specified waterway based on MDE TMDLs (MDE, 2002a, 2002b).

Waterway	Nutrient	Agriculture (%)	Urban (%)	Forest/ Herbaceous (%)	Point Sources (%)	Direct Atmospheric Deposition (%)	Direct Groundwater Discharge (%)
Assawoman	N	38	11	7	0	37	7
	P	56	13	6	0	25	0
Isle of Wight	N	52	11	8	9	17	3
	P	66	13	6	5	10	0
Herring Cr.	N	29	23	29	0	16	3
	P	38	29	23	0	10	0
Turville Cr.	N	61	17	17	0	4	1
	P	68	18	12	0	2	0
St. Martin Rr.	N	66	7	7	13	6	1
	P	77	8	5	7	3	0
Shingle Landing P.	N	66	5	7	22	0	0
	P	86	6	5	3	0	0
Bishopville P.	N	82	9	9	0	0	0
	P	85	9	6	0	0	0
Newport Bay	N	38	4	7	30	9	12
	P	67	5	8	20	0	0
Newport Cr.	N	60	3	14	0	2	12
	P	79	9	12	0	0	0
Ayer Cr.	N	73	4	11	0	2	10
	P	84	8	8	0	0	0

Estimates of nutrient loadings for Northern Coastal Bays (including Assawoman and Isle of Wight watersheds) were updated in a 2002 Maryland Geological Survey report from the MDE TMDL for the northern Coastal Bays, based on new data of shoreline erosion as a source of nutrients (Figure 37).

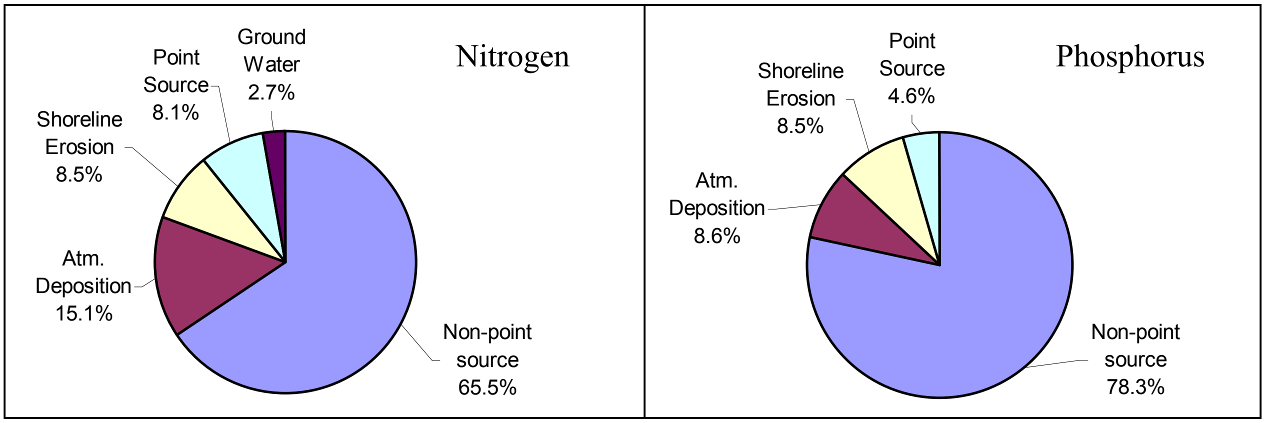


Figure 37. Source of annual total nitrogen and total phosphorus loads to the northern Coastal Bays (Wells et al., 2002).

Sediment loads to the bays are mainly from row crops, shoreline erosion, and a smaller amount from development. The proportion of total suspended solids (TSS) entering the northern bays overall (Assawoman Bay, Isle of Wight Bay, and St. Martin River) from shoreline erosion is only a third that entering from overland runoff (Wells et al., 2002). For TSS, shoreline erosion contributes a higher proportion than does overland runoff in Assawoman Bay, but shoreline erosion contributes a smaller proportion in Isle of Wight Bay and St. Martin River.

Point Source Discharges

There are several MDE-permitted point source sewage effluent and industrial discharges in the Coastal Bays (Figure 38), estimated to contribute 4% of the nitrogen and phosphorus loads (MDNR, 1999):

- *Isle of Wight Bay*: There are two major point sources releasing nitrogen and phosphorus within the St. Martin River Watershed: Ocean Pines Service Area Waste Water Treatment Plant (WWTP), discharging into the St. Martin River, and the Perdue Farms processing plant, discharging into an unnamed tributary of Church Branch (a tributary of Shingle Landing Prong) (MDE, 2001). Other less significant point sources include: the Ocean City WWTP discharging into the Atlantic Ocean, Showell Farms discharging to Birch Branch (a tributary to Shingle Landing Prong) and the Perdue Hatchery on Bishopville Prong.

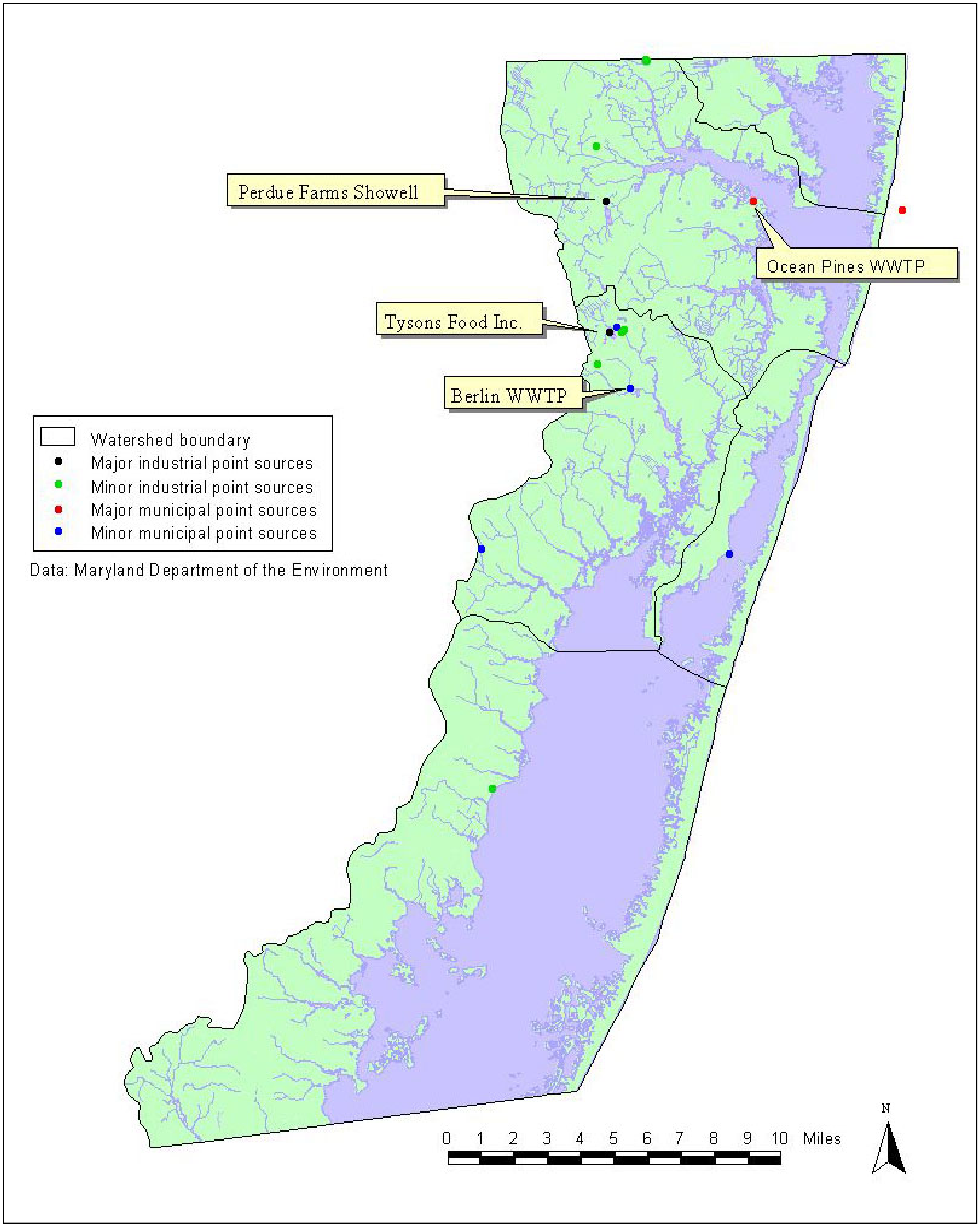


Figure 38. Point sources of water pollution within Maryland Coastal Bay region.

- *Newport Bay*: There are two major point sources to this bay: Berlin WWTP that discharges in winter months to Bottle Branch, a tributary to Trappe Creek, and Tyson Food, Inc. that discharges into Kitts Branch, a tributary to Trappe Creek (MDE, 2002a). Other point sources include: Kelly Foods Corp, Newark WWTP, Ocean City Ice and Seafood, and Berlin Shopping Center (now closed).
- *Sinepuxent Bay*: There is a point source discharge from Assateague Island National Seashore Visitor Center.
- *Chincoteague Bay*: Public Landing Harbor Marina discharges into this bay.

APPENDIX B - GIS METHODS

The following information relates specifically to the GIS methods involved in the prioritization. To minimize repetition between this section and the prioritization results section, we maintained the same general format (i.e., same subheadings) so they can be readily compared. We do not discuss sections that are self-explanatory. We chose not to use a raster model of assigning strict values to the different variables. Assigning values can be quite biased and limiting. By assessing importance values, you are also excluding areas that may be desirable for other reasons. We instead chose to highlight areas with desirable sites, leaving shapefiles on the individual elements, so the reviewer can do their own assessment and modifications if desired. We were not able to incorporate elevation data because sufficient elevation GIS data for this region does not yet exist. It may be released by the end of 2004, at which point, it would be desirable to incorporate it into the consideration.

Priority 1 restoration sites

1) **Hydric soils**: We selected only hydric soils (based on the website http://www.sawgal.umd.edu/nrcsweb/Maryland/index.htm) from the NRCS soil survey data (*hydric.shp*).
2) **Rank hydric soils from #1** (*hydric.shp*): Although we ended up using only the soil rankings based on "very poorly drained" and "poorly drained" for the general prioritization, a shapefile was created that does rank the NRCS soil data into more fine-tuned ranking as found in the table.
3) **Exclude prime farmland when drained on agriculture**: We selected hydric soils on prime farmland when drained (this was the only prime farmland type on hydric soils - Fallsington) and created the shapefile (hydprime.shp). From Landuse 2002, we selected for land use does not equal agriculture. We erased (xtools) this land from the hydric soils on prime farmland when drained. The remaining polygons were hydric prime soil when drained on agriculture. We used this file to erase the areas from the original hydric soil layer. This resulted in a layer with hydric soil but no prime farmland when drained on agricultural land (*hynoprag.shp*).
4) **Within Green Infrastructure network**: We selected "very poorly drained" soils from #3 (hynoprag.shp) that were within the Green Infrastructure hub or corridor (xtools clip). This

layer (called *hy3gir34.shp*) are very poorly drained hydric soils, without prime farmland when drained on agriculture, within the GI network.

5) **Exclude areas currently in forest**. We intersected (xtools) hy3gir34.shp with our 2002 MOP land use shapefile, and selected only land use types of urban, agriculture, and barren land. This layer (*hy3girlu.shp*) excludes forest.
6) **Exclude areas currently in wetland**: We unioned the MDNR and NWI wetland layers (excluding MDNR classified farmed wetlands). (Wowet.shp). We erased these wetlands from the layer hy3girlu.shp to get *hy3grlnw.shp*. We deleted areas <1 acre and areas on forest (according to DOQQ, that were mistakenly included when using MDOP data).
7) **Include zoning with restrictions on development lot size and include protected land**. We selected all zoning other than Resource Conservation, Agriculture, or Estate to be our area of non-inclusion. From the shapefile, we removed the protected lands owned by the county, state, federal, private conservation, and Maryland Environmental Trust. We overlayed this resulting shapefile (*Antizpro.shp*) on top of the polygons under consideration, so we would not select priority sites here.
8) **Exclude MDE-designated wellhead protection areas.** We overlayed the wellhead protection areas shapefile on top of the other areas, so we would not select priority sites here.
9) **Look for additional sites on orthophoto based on the below criteria.** We looked for areas with the highest concentration of these desirable elements:
    - **Adjacent to or within Green Infrastructure network**. We visually assessed the proximity to GI network, favoring polygons that would contribute to the GI network if restored. If an area was separated from the GI network by a narrow strip of less-desirable soil, it could still be considered for restoration.
    - **Adjacent to streams with no forest/wetland buffer (with pollutant source)**: We made a stream buffer (150 ft similar to that used by DNR during the WRAS process) intersected with MDOP 2002 landuse (xtools) to get the landuse type within the 150 foot stream buffer. We selected portions of the stream buffer having urban, agriculture, or barren land. We then intersected this layer with our hydric soil layer to get only sections of the stream with urban, agriculture, or barren land within 150 feet of the stream on hydric soil (*st150luh.shp*). We used the DNR Coastal Bays stream layer for this procedure. This layer does not include some of the small ditches (largely intermittent) but corresponds well with the orthophotos. The stream layer with the

detailed ditches (Tiner data) lined up very poorly with the orthophoto, so we were not able to use it for the GIS analysis (since in some cases, the drawn ditch was >40 meters from the ditch shown on the orthophoto).

- **Adjacent to wetlands or other natural systems** We used stream and wetlands shapefiles, and orthophotos.
- **Pollution source**: We looked for areas that were a pollution source themselves or were downstream of a pollution source using orthophotos and MDOP land use data.
- **MDNR farmed wetlands**. We looked for areas with a high concentration of farmed wetlands using the MDNR wetland shapefile (created shapefile with only farmed wetlands *wowetpf.shp*).

10) **Consider actual property lot size**: Property size of the above highlighted sites was based on the MDOP Propertyview layer.
11) **In areas of poor water quality**: We created shapefiles ranking general areas of poor and moderate water quality using summary data from State of the Bays Report, TMDL recommendations, and MDNR synoptic surveys.

Protected land: We merged the protected land shapefiles including private conservation, Maryland Environmental Trust easements, federal, state, and county land. We then selected areas on hydric soil (xtools intersect) and removed the MDNR and NWI wetlands (xtools erase) from these sites. This resulted in polygons (*prohynw.shp*) that are protected, on hydric soil, and not currently designated as wetlands.

BIBLIOGRAPHY

Andres, A.S. 1991. Methodology for Mapping Ground-Water Recharge Areas in Delaware's Coastal Plain. Delaware Geological Survey. Open File Report No. 34. Newark, DE.

Ayella, R. 2004. Concerns Raised about Piers across Tidal Marshes. Maryland Coastal Bays Program. http://www.mdcoastalbays.org/archive/2004/01_02_04.html. Verified April 21, 2004.

Bachman, L.J. 1984. The Columbia Aquifer of the Eastern Shore of Maryland: Part 1 Hydrogeology. U.S. Geological Survey and Maryland Department of Natural Resources.

Boward, D. 2003. Maryland Biological Stream Survey data. Maryland Department of Natural Resources.

Boward, D. and R. Bruckler. 2002. Maryland Stream Waders Sample Year 2001 Report. Maryland Department of Natural Resources, Chesapeake Bay and Watershed Programs, Monitoring and Non-Tidal Assessment. Annapolis, MD

Boynton, W.R., L. Murray, W.M. Kemp, J.D. Hagy, C. Stokes, F. Jacobs, J. Bowers, S. Souza, B. Krinsky, and J. Seibel. 1993. Maryland's Coastal Bays: An Assessment of Aquatic Ecosystems, Pollutant Loadings, and Management Options. Maryland Department of the Environment, University of Maryland System, and Coastal Environmental Services, Inc.

Brady, N.C., and R.R. Weil. 1996. The Nature and Properties of Soils. Prentice Hall, Inc., Upper Saddle River, NJ.

Brewer, J. 2003. Personal Communication. U.S. Department of Agriculture, Natural Resources Conservation Service.

Chaillou, J.C., S.B. Weisberg, F.W. Kutz, T.E. DeMoss, L. Mangiaracina, R. Magnien, R. Eskin, J. Maxted, K. Price, and J.K. Summers. 1996. Assessment of the Ecological Condition of the Delaware and Maryland Coastal Bays. U.S. Environmental Protection Agency, Office of Research and Development. Environmental Monitoring and Assessment Program. Washington, DC. EPA/620/R-96/004.

Chucoski, J. 2003. Shellfish Data. Maryland Department of the Environment.

Coastal Bays Forestry Committee. 2002. Coastal Bays Forestry White Paper.

Coastal Resources, Inc. 1999. U.S. 113 Mitigation Plan for Wetlands and Waterways: Final Report. Prepared for Maryland Department of Transportation.

Conley, M. 2004. Coastal Bays Sensitive Resources Report. Technical Task Force Report. Maryland Department of Natural Resources, Coastal Zone Management Division.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service, Biological Services Program. Washington, DC. FWS/OBS-79/31.

Coyman, S. 2002. FAQ's about the Worcester County, ACB Critical Area Program. Maryland Coastal Bays Program.

Czwartacki, S., and K. Yetman. 2002. Isle of Wight Stream Corridor Assessment Survey. Maryland Department of Natural Resources, Coastal and Chesapeake Watershed Services, Watershed Restoration Division.

Davidson, L. Data on Rare, Threatened, Endangered Species in the Coastal Bays. Maryland Department of Natural Resources. Received July 9, 2004.

Dawson, S. 11/12/2003. Personal communication. Maryland Department of the Environment.

Dennis, J.V. 1986. The Bald Cypress in the Chesapeake Bay Region. Atlantic Naturalist, 36: 5-9.

Dennison, W.C., R.J. Orth, K.A. Moore, J.C. Stevenson, V. Carter, S. Kollar, P.W. Bergstrom, and R.A. Batiuk. 1993. Assessing Water Quality with Submerged Aquatic Vegetation. Bioscience 43 (2): 86-94.

Dillow, J.J.A. and E.A. Greene. 1999. Ground-Water Discharge and Nitrate Loadings to the Coastal Bays of Maryland. U.S. Geological Survey. Water-Resources Investigations Report 99-4167.

Fugro East, Inc. 1995. A Method for the Assessment of Wetland Function. Prepared for Maryland Department of the Environment. Baltimore, MD.

Fugro-McClelland (East), Inc. 1993. Review of Existing Wetland Assessment Methods and their Applicability to a Landscape Level Desk Top Method.

Galbraith, J. 2004. Personal Communication. Virginia Tech.

Goshorn, D., M. McGinty, C. Kennedy, C. Jordan, C. Wazniak, K. Schwenke, and K. Coyne. 2001. An Examination of Benthic Macroalgae Communities as Indicators of Nutrients in Middle Atlantic Coastal Estuaries: Maryland Component Final Report 1998-1999. Maryland Department of Natural Resources, Resource Assessment Service, Tidewater Ecosystem Assessment Division. Annapolis, MD.

Hennessee, L. 2001. Acquiring a Modern Digital Shoreline for Maryland from Recent (1988-1995) orthophotography. Maryland Geological Survey. Baltimore, MD. Coastal and Estuarine Geology File Report No. 00-7.

Hennessee, L., and J. Stott. 1999. Shoreline Changes and Erosion for the Northern Coastal Bays of Maryland. Maryland Geological Survey. Baltimore, MD. Coastal and Estuarine Geology File No. 99-7.

Hennessee, L., Stott, J., and T. Bethke. 2002a. Shoreline Changes and Erosion Rates for the Southern Coastal Bays of Maryland. Maryland Geological Survey. Baltimore, MD. Coastal and Estuarine Geology File Report No. 00-1.

Hennessee, E.L., Valentino, M., Lesh, A.M., and L. Myers. 2002b. Determining Erosion Rates for the Coastal Regions of Maryland (Part 1). Maryland Geological Survey, Baltimore, MD. Coastal and Estuarine Geology file Report No. 02-04.

Homer, M.L., M.L. Tarnowski, R. Bussell, and C. Rice. 1997. Coastal Bays Shellfish Inventory. Maryland Department of Natural Resources, Fisheries Service, Shellfish Program.

Jellick, G., J. Hett, and D. Wilson. 2002. Integrating Maryland highway construction with the Coastal Bays Program. In: J. R. Lesnik (editor). Coastal Water Resources. AWRA 2002 Spring Specialty Conference Proceedings, American Water Resources Association, Middleburg, VA, TPS-02-1.

Jellick, G. 2003. Personal Communication. Coastal Resources, Inc.

Lazarus, N. 2003. Public Water Supply Data. Maryland Department of the Environment.

Lucas, R.C. 1972. Worcester County Ground-Water Information: Well Records, Pumpage, Chemical Quality Data, and Selected Well Logs. Department of Natural Resources, Maryland Geological Survey. Water Resources Basic Data Report No. 6.

Maptech, Inc. 2003. Historic Maps. http://www.historical.maptech.com. Verified April 21, 2004.

Maryland Coastal Bays Program. 1999. Today's Treasures for Tomorrow: Towards a Brighter Future. The Comprehensive Conservation and Management Plan for Maryland's Coastal Bays.

Maryland Department of the Environment. 2001. Total Maximum Daily Loads of Nitrogen and Phosphorus for Five Tidal Tributaries in the Northern Coastal Bays System, Worcester, County: Final. Baltimore, MD.

Maryland Department of the Environment. 2002a. Total Maximum Daily Loads of Nitrogen for Three Tidal Tributaries and Total Maximum Daily Load of Biochemical Oxygen Demand for One Tributary in the Newport Bay System, Worcester County, Maryland: Draft. Baltimore, MD.

Maryland Department of the Environment. 2002b. Total Maximum Daily Loads of Phosphorus and Sediment to Big Millpond, Worcester County, Maryland: Final. Baltimore, MD.

Maryland Department of the Environment. 2002c. 2002 List of Impaired Surface Water [303(d) List] and Integrated Assessment of Water Quality in Maryland. Baltimore, MD.

Maryland Department of the Environment. 2003. Discussions with Water Supply Program. Baltimore, MD.

Maryland Department of the Environment. 2004. Draft 2004 List of Impaired Surface Water [303(d) List] and Integrated Assessment of Water Quality in Maryland. Baltimore, MD.

Maryland Department of Natural Resources. 1987. Management Plans for Significant Plant and Wildlife Habitat Areas of Maryland's Eastern Shore: Worcester County. Natural Heritage Program. Annapolis, MD.

Maryland Department of Natural Resource. 1991. Ecological Significance of Nontidal Wetlands of Special State Concern: Worcester County. Maryland Natural Heritage Program. Annapolis, MD.

Maryland Department of Natural Resources. 1999. Maryland Coastal Bays Program Eutrophication Monitoring Plan. http://www.dnr.state.md.us/coastalbays/mon_plan.html. Accessed January 8, 2003.

Maryland Department of Natural Resources. 2000a. Maryland Atlas of Greenways, Water Trails and Green Infrastructure. Maryland Greenways Commission.

Maryland Department of Natural Resources. 2000b. 2000 Maryland Section 305(b) Water Quality Report. Annapolis, MD.

Maryland Department of Natural Resources. 2002a. Ecologically Significant Areas in Worcester County: Rare Plant Sites Newly Identified or Updated in 2001. Natural Heritage Program. Annapolis, MD.

Maryland Department of Natural Resources. 2002b. Rural Legacy FY2003. Applications and State Agency Review. Annapolis, MD.

Maryland Department of Natural Resources. 2002c. 2002 Maryland Section 305(b) Water Quality Report. Annapolis, MD.

Maryland Department of Natural Resources. 2003a. Bay Grasses in the Coastal Bays. http://www.dnr.state.md.us/coastalbays/living_resources/coast_bay_grasses.html. Verified April 21, 2004.

Maryland Department of Natural Resources. 2003b. The Chesapeake Forest Lands. http://www.dnr.state.md.us/forests/chesapeakeforests. Verified April 21, 2004.

Maryland Department of Natural Resources. 2003c. Maryland Coastal Bays Volunteer Water Quality Monitoring Program. http://www.dnr.state.md.us/coastalbays/volunteer/stations.html. Verified April 21, 2004.

Maryland Department of Natural Resources. 2003d. Maryland's Strategic Forest Lands Assessment. Watershed Services. Annapolis, MD. Document available at http://www.dnr.state.md.us/forests/planning/sfla/.

Maryland Department of Natural Resources. 2003e. Monitoring the Coastal Bays. http://www.dnr.state.md.us/coastalbays/monitor/monitor.html. Maryland Coastal Bays. Accessed January 8, 2003.

Maryland Department of Natural Resources. 2003f. The Rural Legacy Program. Annual Report Fiscal Year 2002. Annapolis, MD.

Maryland Department of Natural Resources. 2004. Nontidal Wetlands of Special State Concern of Five Central Maryland Counties and Coastal Bay Area of Worcester County, Maryland. Natural Heritage Program. Annapolis, MD. Prepared for Maryland Department of the Environment.

Maryland Department of Natural Resources. 2004 Draft. Maryland Coastal and Estuarine Land Conservation Plan. Coastal Zone Management Division. Annapolis, MD.

Maryland Department of Natural Resources and Maryland Coastal Bays Program, Scientific and Technical Advisory Committee. 2004. Draft Aquatic Ecosystem Health 2004, MD Coastal Bays Monitoring Report.

Maryland Department of Natural Resources and Maryland Coastal Bays Program. 2004. State of the Maryland Coastal Bays.

Maryland Department of Natural Resources and Maryland Coastal Bays Program, Scientific and Technical Advisory Committee. 2004. Draft Aquatic Ecosystem Health 2004, MD Coastal Bays Monitoring Report.

Maryland Department of Natural Resources and Maryland Department of the Environment. 2000. Maryland's Surf Your Watershed, Maryland Integrated Watershed Data and Information System. Document can be found at http://www.dnr.state.md.us/watersheds/surf/.

Maryland Department of Planning. 2002 Land Use/Land Cover for Maryland (GIS data).

Maryland Geological Survey, Coastal and Estuarine Geology Program. Assateague Island shoreline change illustration.

Maryland State Highway Administration and Federal Highway Administration. 1998. Final Environmental Impact Statement: US 113 Planning Study from Snow Hill, MD to the Delaware State Line. Worcester County, MD, USA.

McCormick, J. and H. A. Somes, Jr. 1982. The Coastal Wetlands of Maryland. Maryland Department of Natural Resources. Jack McCormick and Associates Inc. Chevy Chase, MD.

Millard, C.J. P.F. Kazyak, and A.P. Prochaska. 2001. Worcester County Results of the 1995-1997 Maryland Biological Stream Survey: County-Level Assessments. Maryland Department of Natural Resources. Annapolis, MD.

Nichols, B. Personal Communication. 2004. U.S. Department of Agriculture, Natural Resources Conservation Service.

Owens, J.P. and C.S. Denny. 1978. Geologic Map of Worcester County. U.S. Geological Survey and Maryland Geological Survey.

Pokharel, S. 2003. Water quality data. Maryland Department of the Environment.

Primrose, N.L. 1999. Characterization of Nitrogen and Phosphorus Loads, Macroinvertebrate Communities and Habitat in the Non-Tidal Portions of the St. Martins River: Final Report. Maryland Department of Natural Resources. Chesapeake Bay and Coastal Watershed Administration, Watershed Restoration Division.

Primrose, N.L. 2002. Report on Nutrient Synoptic Surveys in the Isle of Wight Watershed, Worcester County, Maryland, April 2001 as part of the Watershed Restoration Action Strategy. Maryland Department of Natural Resources. Chesapeake and Coastal Watershed Service, Watershed Restoration Program, Watershed Evaluation Section. Annapolis, MD.

Primrose, N.L. 2003. Report on Nutrient Synoptic Surveys in the Newport and Sinepuxent Bay Watershed, Worcester County, March, 2003 as part of the Watershed Restoration Action Strategy. Maryland Department of Natural Resources. Watershed Services. Annapolis, Maryland.

Rabenhorst, M. 2004. Personal Communication. University of Maryland.

Rasmussen, W.C. and T.H. Slaughter. 1955. The Water Resources of Somerset, Wicomico and Worcester Counties. Department of Geology, Mines, and Water Resources. Department of Geology, Mines, and Water Resources. Bulletin 16, Maryland Geological Survey. Baltimore, MD.

Rizzo, A. 2003. Personal Communication. U.S. Fish and Wildlife Service.

Roth, N.E., M.T. Southerland, G. Mercurio, J.C. Chaillou, P.F. Kazyak, S.S. Stranko, A.P. Prochaska, D.G. Heimbuch, and J.C. Seibel. 1999. State of the Stream: 1995-1997 Maryland Biological Stream Survey Results. Versar, Inc. Columbia, MD. Prepared for Maryland Department of Natural Resources. Annapolis, MD.

Roth, N.E., M.T. Southerland, G.M. Rogers, and J.H. Vølstad. 2003. Maryland Biological Stream Survey 2000-2004 Volume II: Ecological Assessment of Watersheds Sampled in 2001. Versar, Inc. Columbia, MD. Prepared for Maryland Department of Natural Resources. Annapolis, MD.

Shanks, K. 2001. Isle of Wight Bay Watershed Characterization. Maryland Department of Natural Resources. Watershed Management and Analysis Division. Annapolis, MD.

Shanks, K. 2003. Newport Bay and Sinepuxent Bay Watersheds Characterization. Maryland Department of Natural Resources. Watershed Services. Annapolis, Maryland.

Shepard, F. P. 1954. Nomenclature based on sand-silt-clay ratios. Journal of Sedimentary Petrology v.24. p. 151-158.

Sipple, W.S. 1999. Days Afield. Gateway Press. Baltimore, MD.

Spaur, C.C. Nichols, B.E., Hughes, T.E., and P.M. Noy. 2001. Wetland Losses in Maryland’s Coastal Bays Watershed Since the Beginning of the Twentieth Century and Their Implications for Wetlands Restoration p. 291-302. In: G.D. Therres (ed.), Conservation of Biological Diversity: A Key to the Restoration of the Chesapeake Bay and Beyond. Conference Proceedings. May 10-13, 1998. Maryland Deptartment of Natural Resources, Annapolis, MD.

Spaur, C.C. 2004. Personal Communication. US Army Corp of Engineers.

Stott, J.A., Hennessee, E.L., and R.T. Kerhin. 1999, 2000. Shoreline Changes. Maryland Geological Survey, Baltimore, MD.

Tarnowski, M. and R. Bussell. 2002. Report on the Maryland Department of Natural Resources 2002 Coastal Bays Hard Clam Survey and Other Related Subjects. Maryland Department of Natural Resources, Fisheries Service. Annapolis, MD.

Tiner, R.W. 2003a. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. U.S. Fish and Wildlife Service, National Wetlands Inventory Program. Northeast Region. Hadley, MA. 44 pp.

Tiner, R.W. 2003b. Correlating Enhanced National Wetlands Inventory Data with Wetland Functions for Watershed Assessments: A Rationale for Northeastern US Wetlands. U.S. Fish and Wildlife Service, National Wetland Inventory Program, Region 5, Hadley, MA. 26 pp.

Tiner, R., W. Starr, H. Bergquist, and J. Swords. 2000. Watershed-based Wetland Characterization for Maryland's Nanticoke River and Coastal Bays Watersheds: A Preliminary Assessment Report. U.S. Fish and Wildlife Service, National Wetlands Inventory (NWI) Program, Northeast Region, Hadley, MA. Prepared for the Maryland Department of Natural Resources, Coastal Zone Management Program (pursuant to National Oceanic and Atmospheric Administration award). NWI technical report.

Tiner, R. W. and D. G. Burke. 1995. Wetlands of Maryland. Maryland Department of Natural Resources, Annapolis, MD and U.S. Fish and Wildlife Service, Hadley, MA. Cooperative National Wetlands Inventory Report.

U.S. Army Corp of Engineers (USACE). 1995. The Highway Methodology Workbook Supplement. Wetland Functions and Values: A Descriptive Approach. New England Division.

U.S. Army Corp of Engineers (USACE). 1998. Ocean City, Maryland and Vicinity Water Resources Study: Draft Integrated Feasibility Report and Environmental Impact Statement. Baltimore District.

U.S. Department of Agriculture, Natural Resources Conservation Service. 2000. Soil Survey of Worcester County, Maryland.

U.S. Department of Agriculture. Natural Resources Conservation Service. 2003. General Soil Map of Worcester County, Maryland: Draft.

U.S. Department of Agriculture, Soil Conservation Service. 1973. Soil Survey of Worcester County, Maryland.

Virginia Institute of Marine Science. http://www.vims.edu/bio/sav. Verified April 21, 2004.

Wazniak, C. 2003. Water Quality Data. Maryland Department of Natural Resources.

Weber, T. 2003. Maryland's Green Infrastructure Assessment. Maryland Department of Natural Resources, Watershed Services Unit. Annapolis, MD.

Wells, D. V. and R. D. Conkwright. 1999. Maryland Coastal Bays Sediment Mapping Project. The Physical and Chemical Characteristics of the Sediments – Atlas and Synthesis Report (Coastal and Estuarine Geology File Report No. 99-5). Maryland Geologic Survey, Baltimore, MD. Map available at http://www.mgs.md.gov/coastal/vmap/czmatlas/czmseddistr.html.

Wells, D. V., R. D. Conkwright, R. Gast, J. M. Hill, and J. Park. 1996. The Shallow Sediments of Newport Bay and Sinepuxent Bay in Maryland: Physical and Chemical Characteristics. Coastal and Estuarine Geology File Report No. 96-2, Maryland Geologic Survey, Baltimore, MD.

Wells, D. V., R. D. Conkwright, J. M. Hill, and J. Park. 1994. The Surficial Sediments of Assawoman Bay and Isle of Wight Bay in Maryland: Physical Chemical Characteristics. Coastal and Estuarine Geology File Report No. 94-2, Maryland Geologic Survey, Baltimore, MD.

Wells, D., E. L. Hennessee, and J.M. Hill. 2002. Shoreline Erosion as a Source of Sediments and Nutrients: Northern Coastal Bays, Maryland. Maryland Department of Natural Resources, Maryland Geological Survey, Resource Assessment Service. Coastal and Estuarine Geology File Report No. 02-05.

Wilson, D. 2001. Planting Hardwoods has Major Benefits. Coastal Bays Program.

Wilson, D. 2002. Offering Tourists Quality Ecotourism Experiences. Maryland Coastal Bays Program.

Worcester County. 1989. Comprehensive Development Plan: Worcester County Maryland. Submitted by Redman/Johnston Associated, LTD. Easton, MD.

Worcester County. 2002. Isle of Wight Bay Watershed Restoration Action Strategy: Worcester County, Maryland. Maryland Coastal Zone Management Program.

Worcester County Planning Commission. 1997. Supplement to the Worcester County 1989 Comprehensive Plan. Snow Hill, MD.

Worcester County Department of Comprehensive Planning. Worcester County's Rural Legacy Program. http://www.co.worcester.md.us/RLpage.htm. Snow Hill, MD. Verified July 6, 2004.

Worcester County Department of Comprehensive Planning. 2004. Management of Roadside Drainage in Worcester County for Water Quality: A Pictorial Guide. Snow Hill, MD.

ABBREVIATIONS

CBFC	Coastal Bays Forestry Committee
CCMP	Comprehensive Conservation and Management Plan (MCBP, 1999)
DDT	Dichlorodiphenyltrichloroethane
DLITE	Delmarva Low Impact Tourism Experiences
DO	Dissolved Oxygen
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
HGM	Hydrogeomorphic
IBI	Index of Biotic Integrity
K_d	Light Attenuation Coefficient
MBSS	Maryland Biological Stream Survey
MCBP	Maryland Coastal Bays Program
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
MDNR	Maryland Department of Natural Resources
MET	Maryland Environmental Trust Easements
MGS	Maryland Geological Survey
MLW	Mean Low Water
N	Nitrogen
NH_4	Ammonium
NO_3	Nitrate
NO_2	Nitrite
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NTWSSC	Nontidal Wetlands of Special State Concern
NWI	National Wetlands Inventory
P	Phosphorus

PCB	Polychlorinated biphenyl
PDA	Public Drainage Association
PO_4	Orthophosphate
RTE	Rare, threatened, or endangered species
SAV	Submerged Aquatic Vegetation
SCA	Stream Corridor Assessment
SCAM	Stream Corridor Assessment Methodology
SFLA	Strategic Forest Lands Assessment
SHA	State Highway Administration
SOD	Sediment Oxygen Demand
STAC	Scientific and Technical Advisory Committee
TMDL	Total Maximum Daily Load
USACE	United States Army Corp of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VIMS	Virginia Institute of Marine Science
VOC	Volatile Organic Compound
WRAS	Watershed Restoration Action Strategy
WWTP	Waste Water Treatment Plant