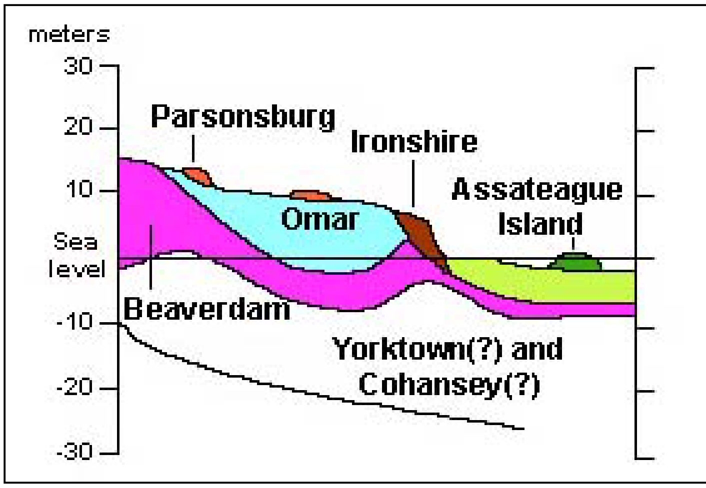
APPENDIX A - BACKGROUND INFORMATION

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.



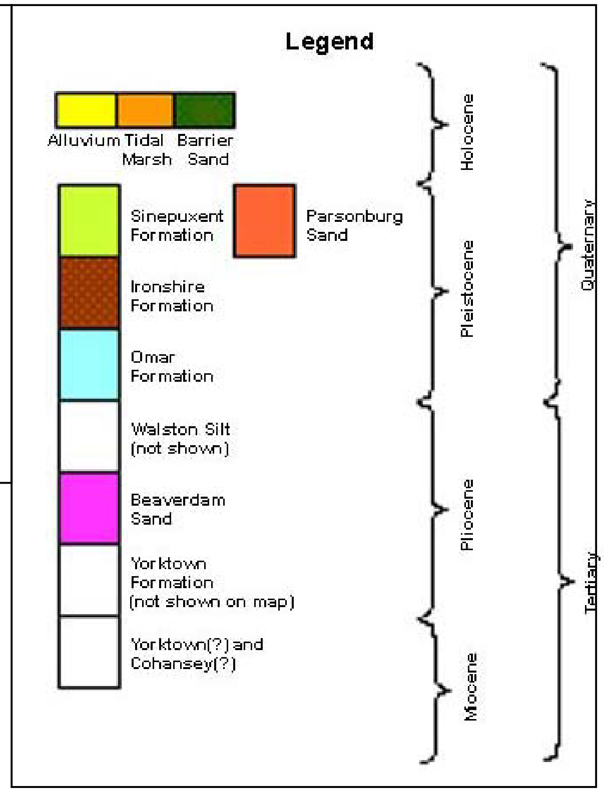


Figure 16. Cross-sectional map of geologic formations from Berlin, across Sinepuxent Bay, to Ocean City. Legend includes geologic formations, series, and system (Wells et al., 2002, as modified by Owens and Denny, 1978).

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.

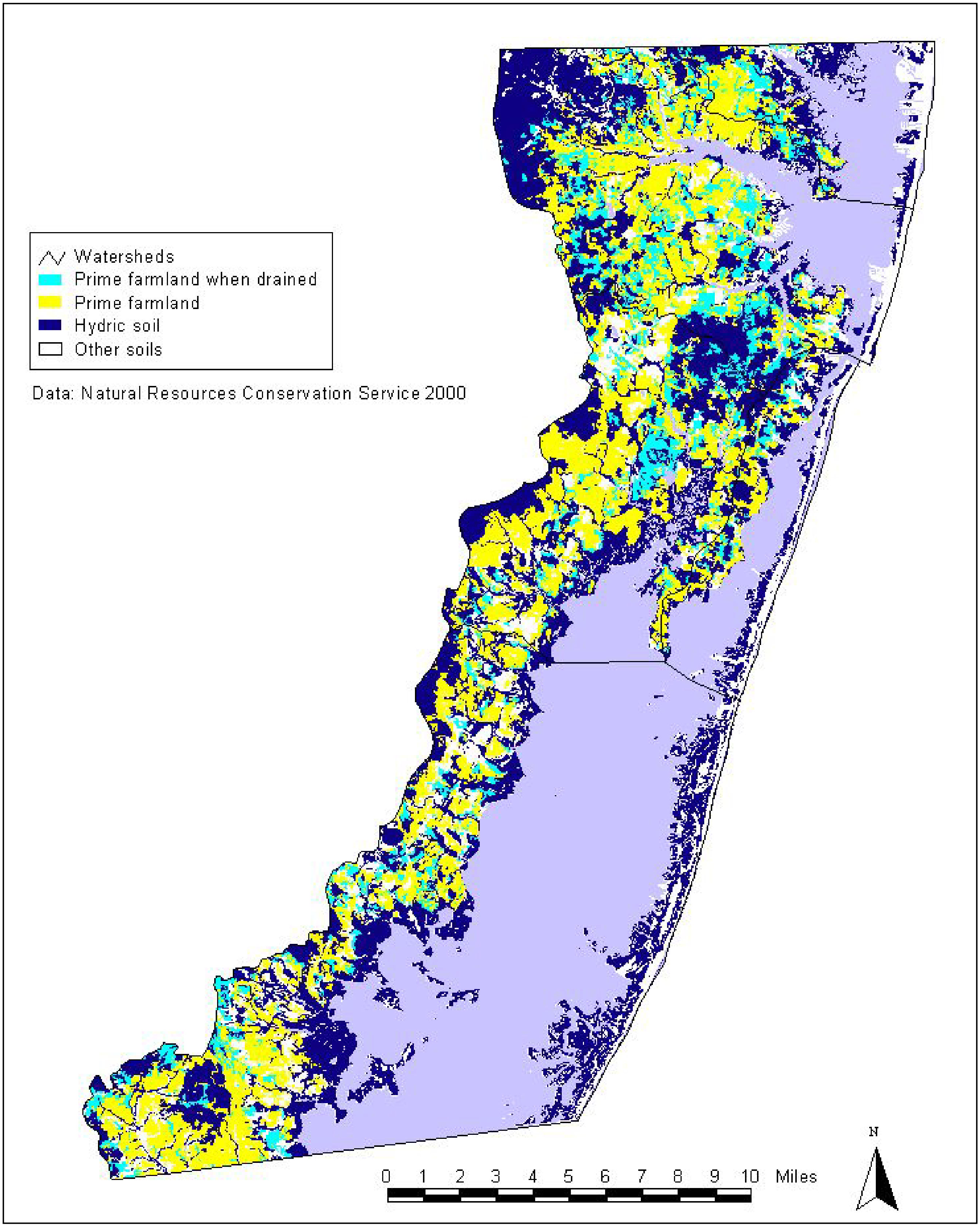


Figure 17. Characterization of Maryland Coastal Bay soils.

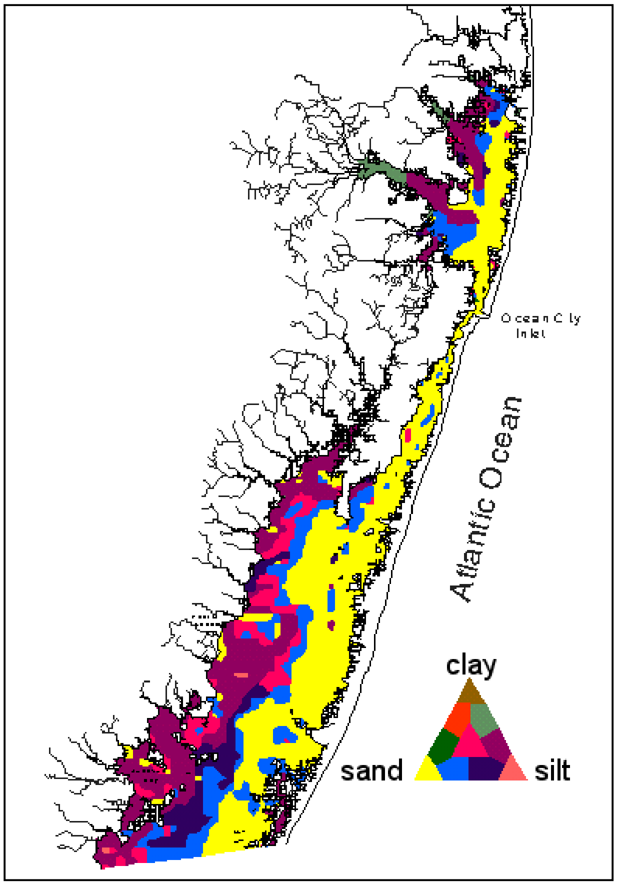


Figure 18. Sediment texture distribution within Maryland Coastal Bays waters (Wells and Conkwright, 1999). Sediment texture is illustrated by colors, which correlate with textures from the Shepard's Classification textural triangle (Shepard, 1954).

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).

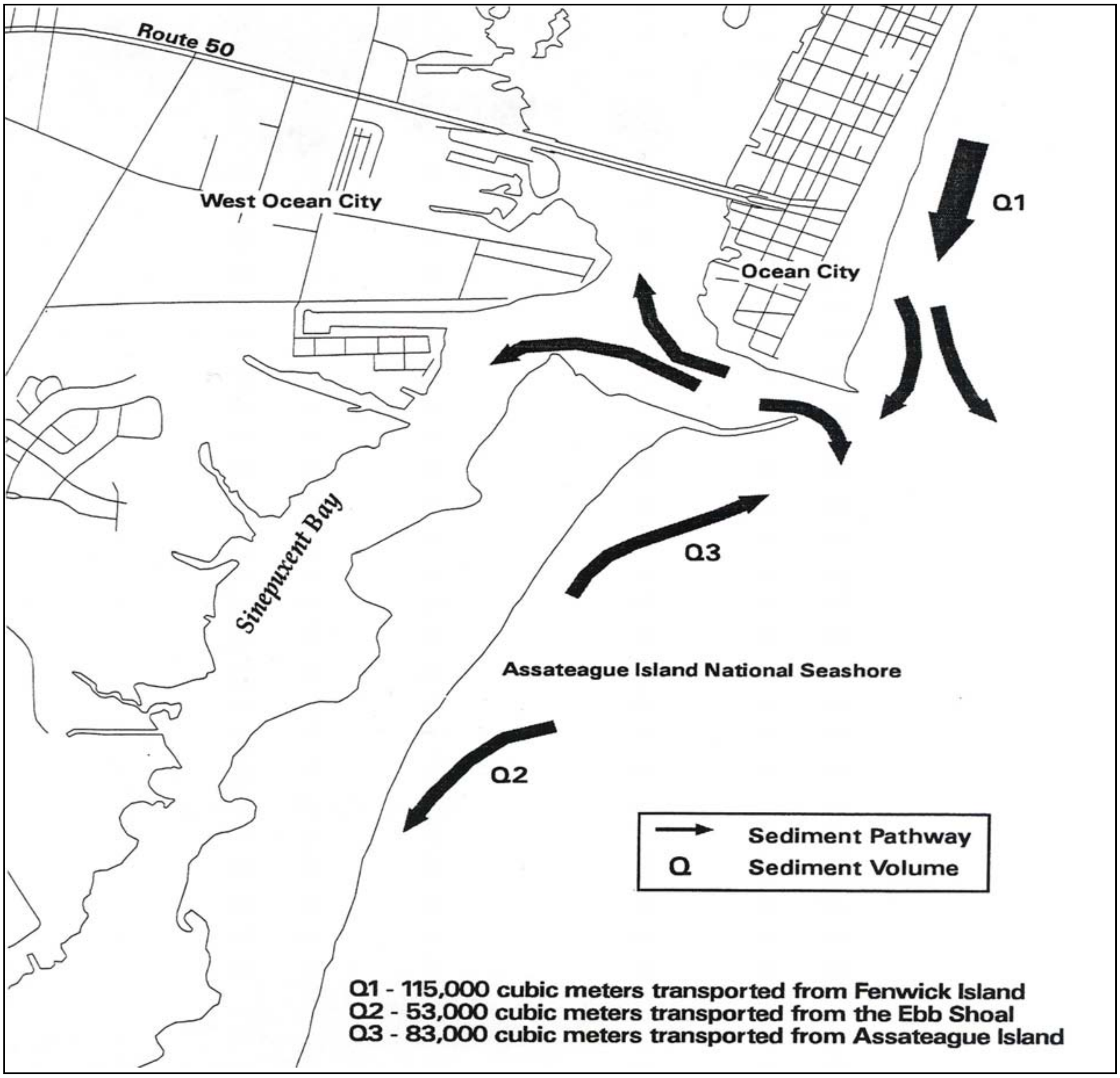


Figure 19. Sediment movement in the Ocean City vicinity (U.S. Army Corp of Engineers, 1998).

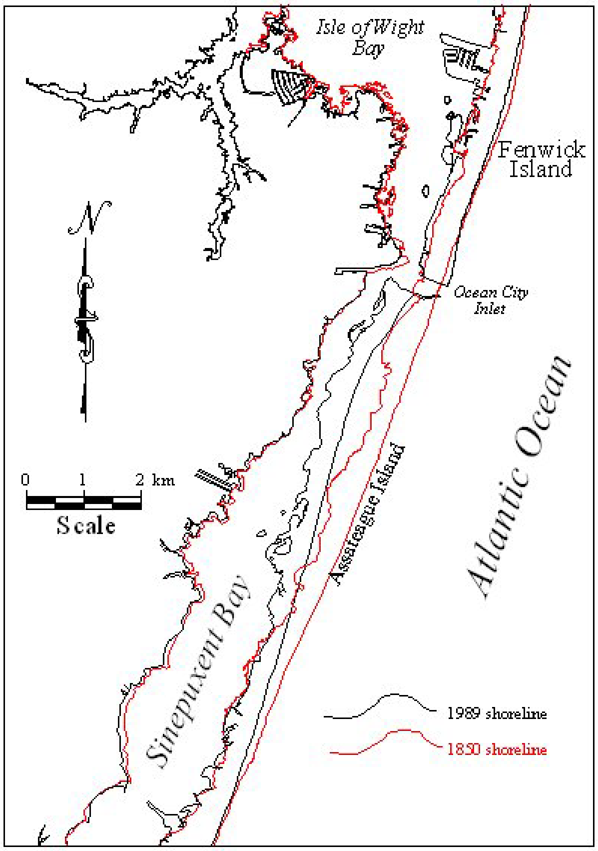


Figure 20. Illustration of Assateague Island retreating west towards the mainland during the period between 1850 and 1989 (Maryland Geological Survey, Coastal and Estuarine Geology Program).

<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

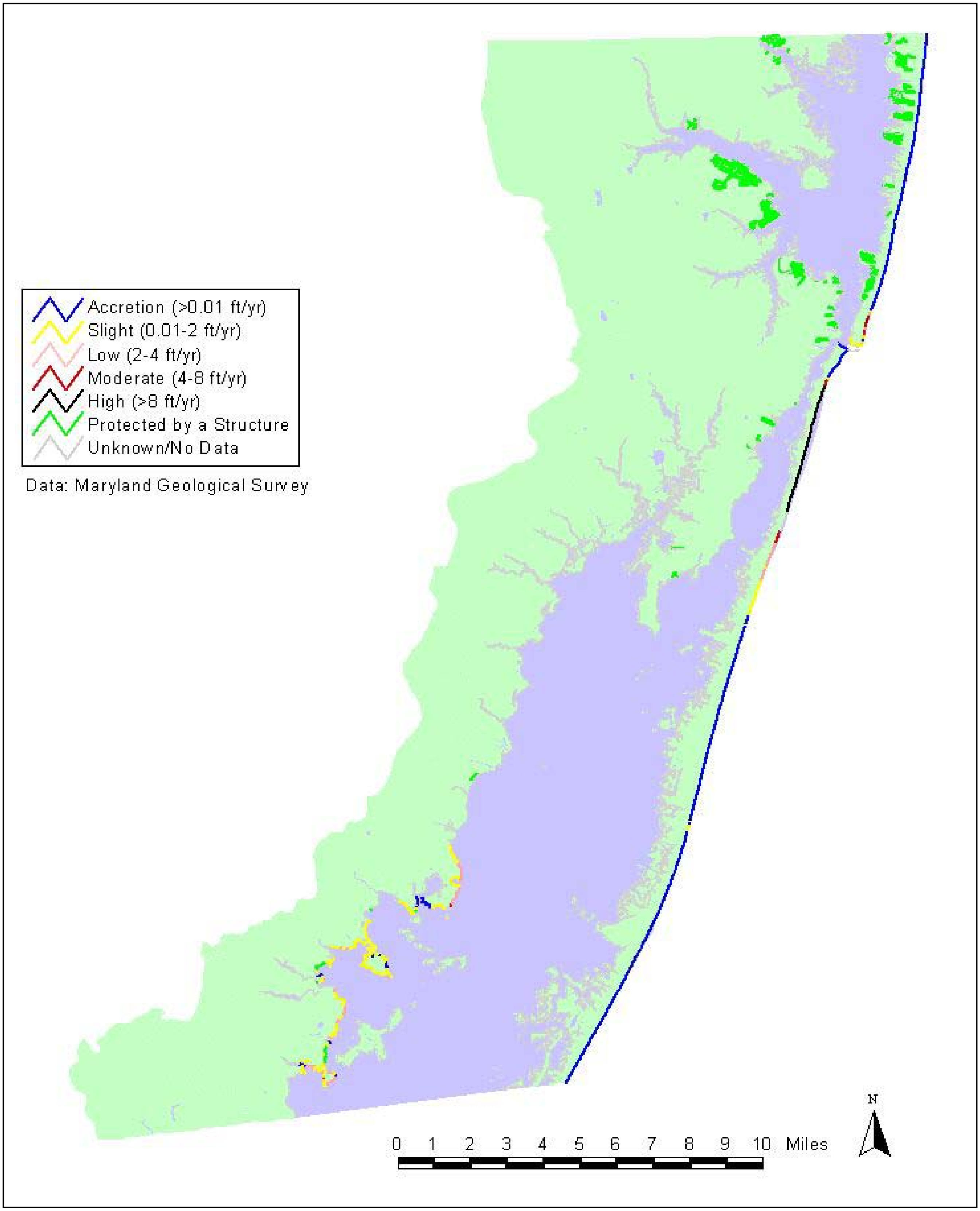


Figure 21. Shoreline erosion rates in Maryland Coastal Bays

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.

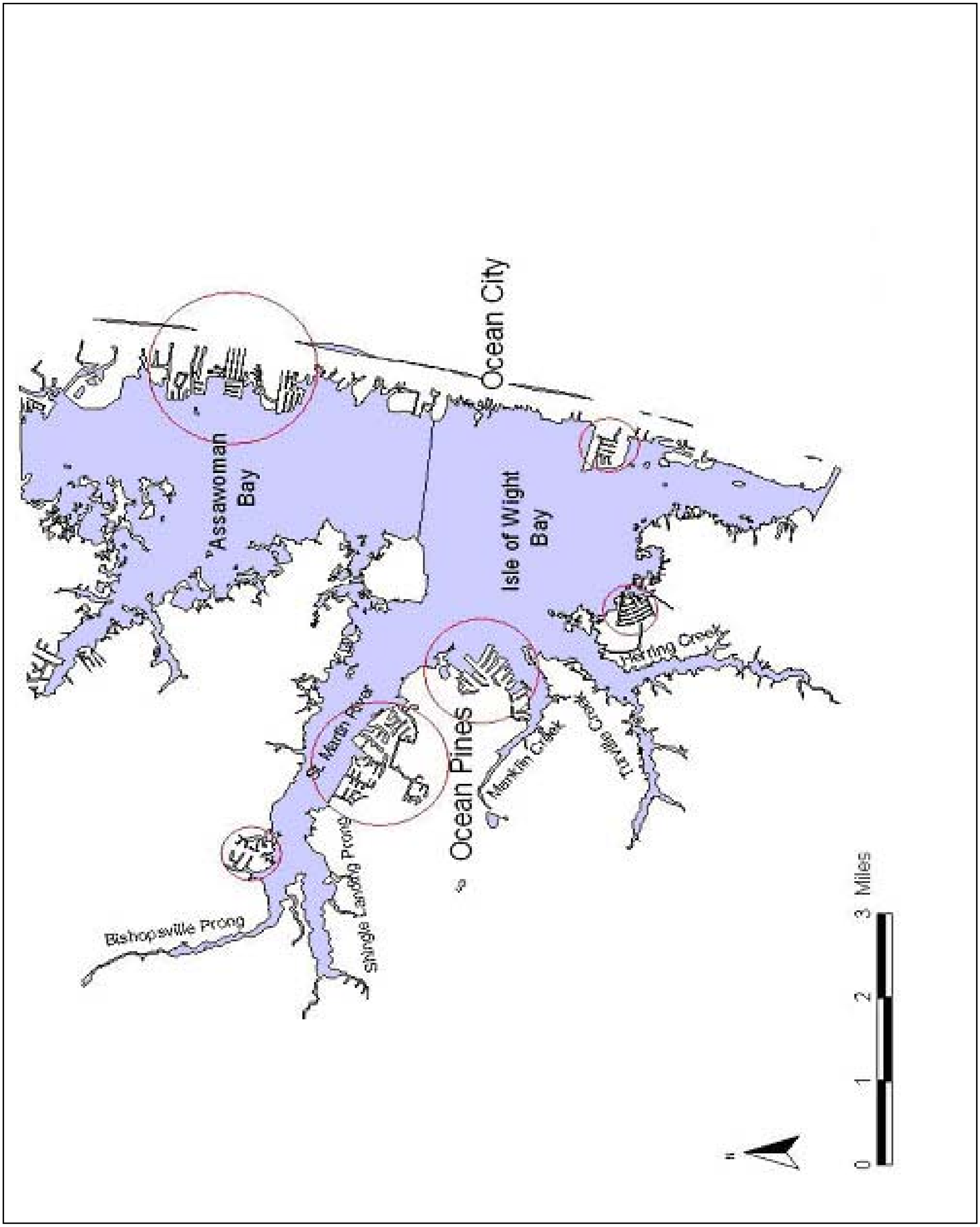


Figure 22. Examples of dead end canals in the Northern Coastal Bays region.

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).

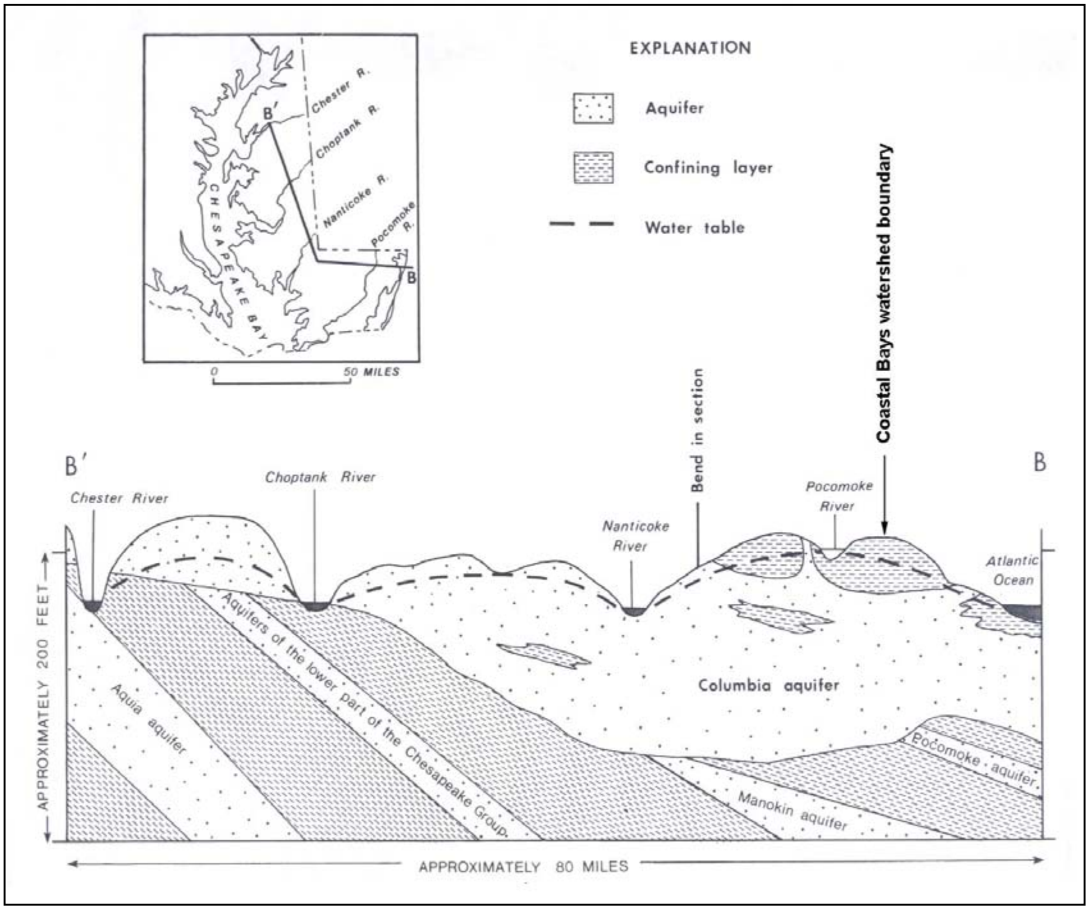


Figure 23. Cross-section of predominant aquifers in Maryland's Eastern Shore (Bachman, 1984).

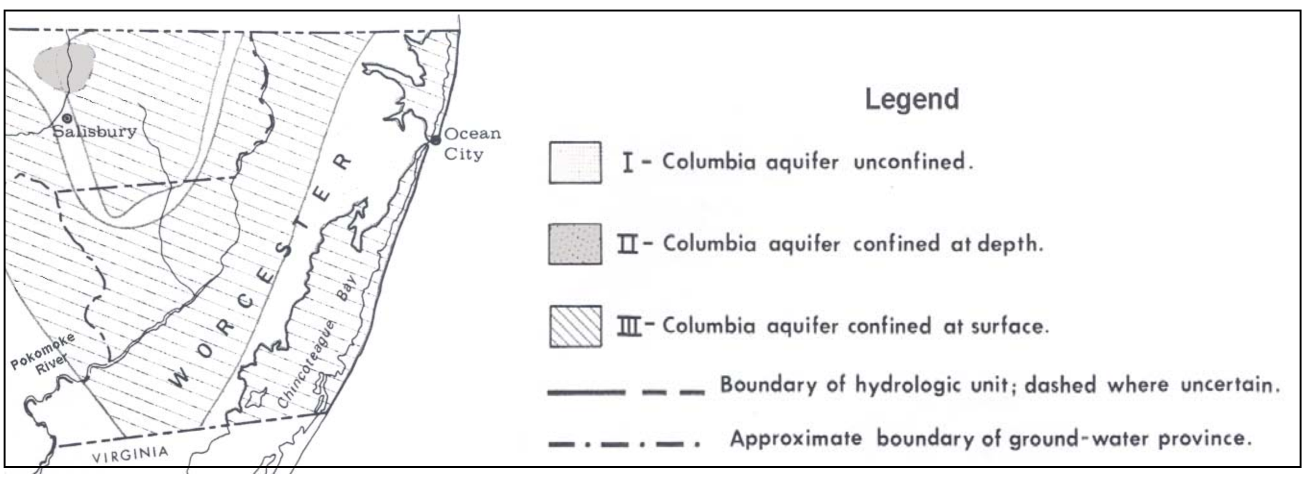


Figure 24. Characteristics of confining layers to the Columbia aquifer within Worcester County (Bachman, 1984).

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

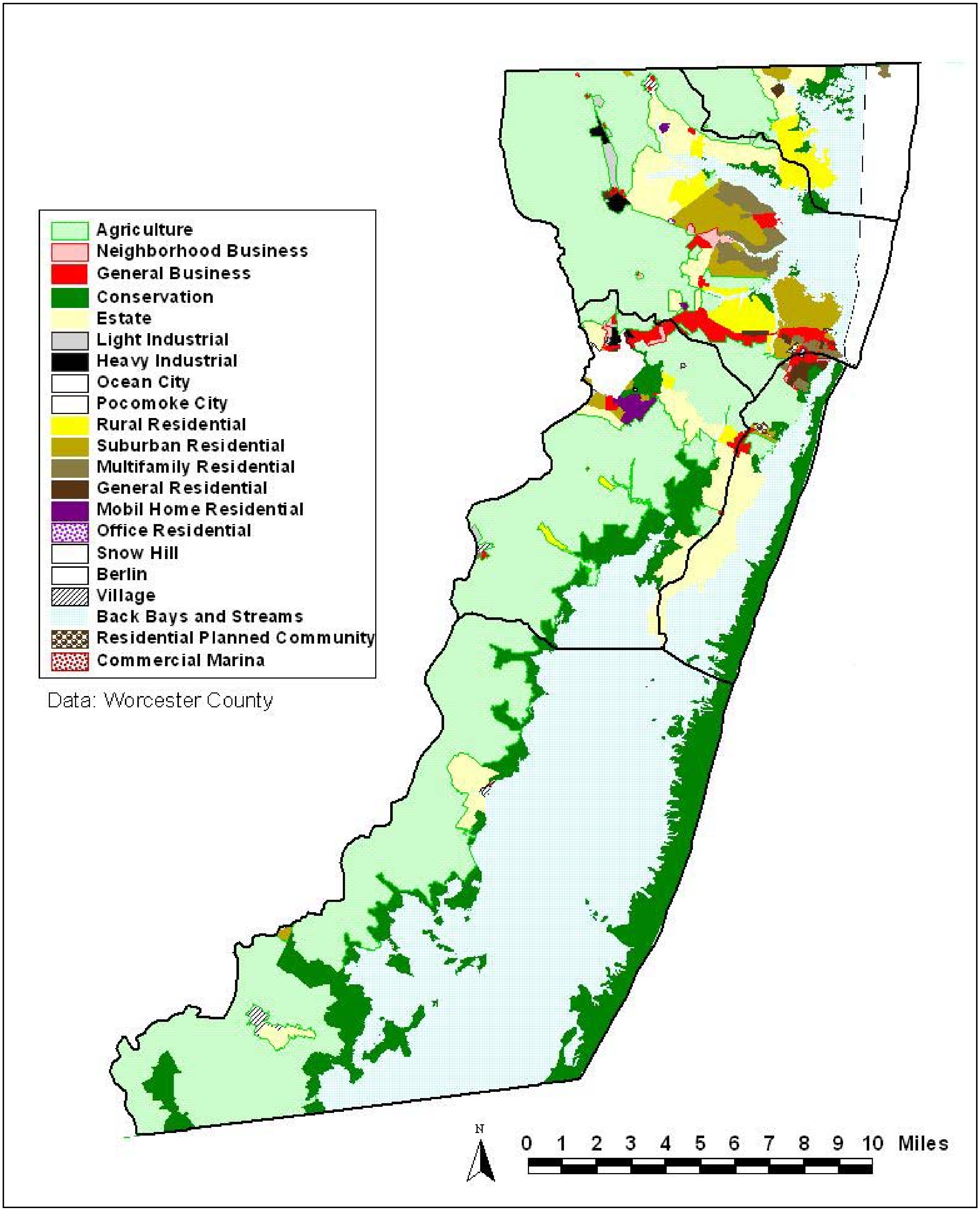


Figure 25. Zoning in Maryland Coastal Bays

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).

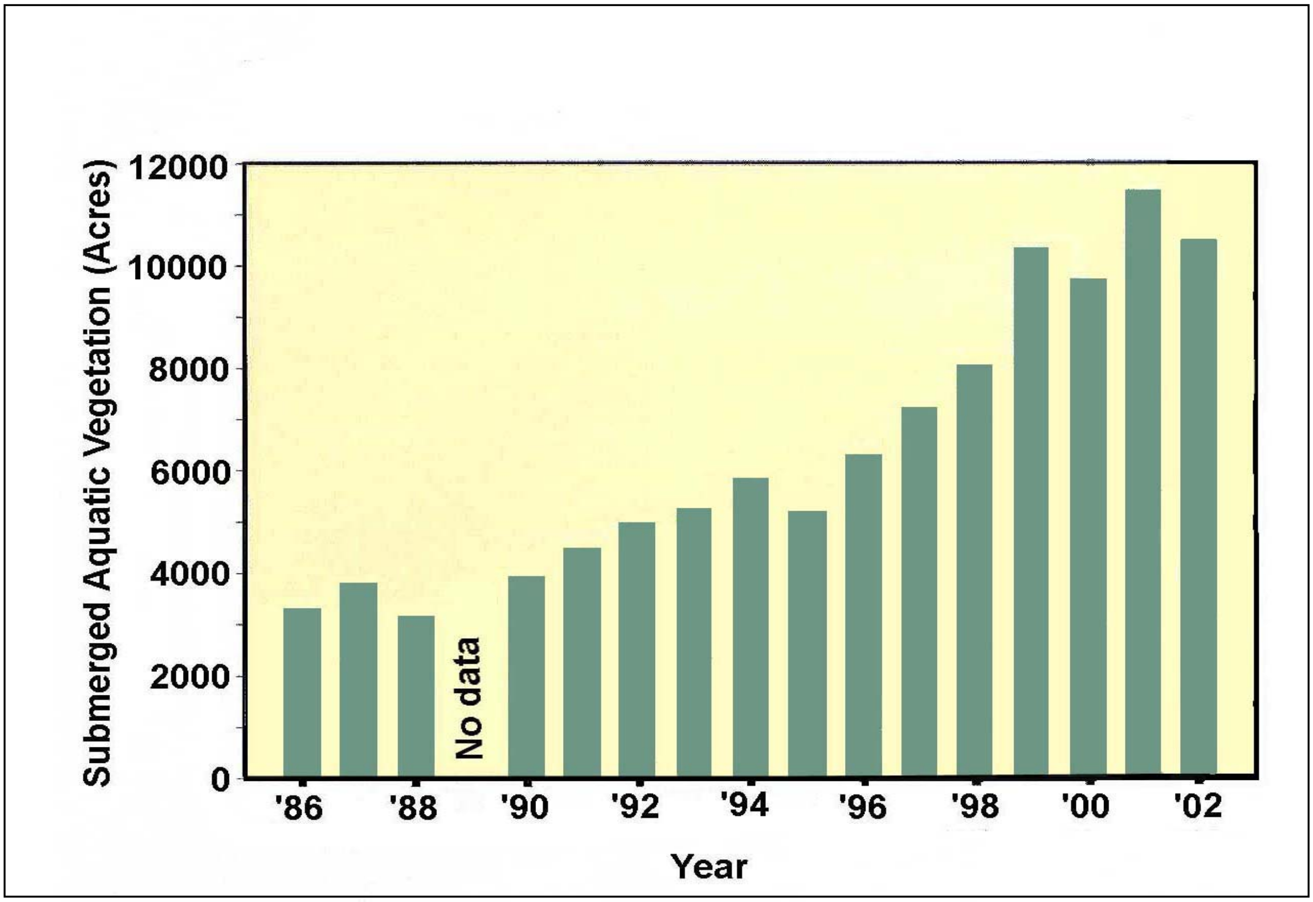


Figure 26. Change in acreage of submerged aquatic vegetation in Maryland Coastal Bays during the period between 1986 and 2001 (MDNR, 2003a; based on Virginia Institute of Marine Science data).

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.

<u>Waterbirds</u>

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).

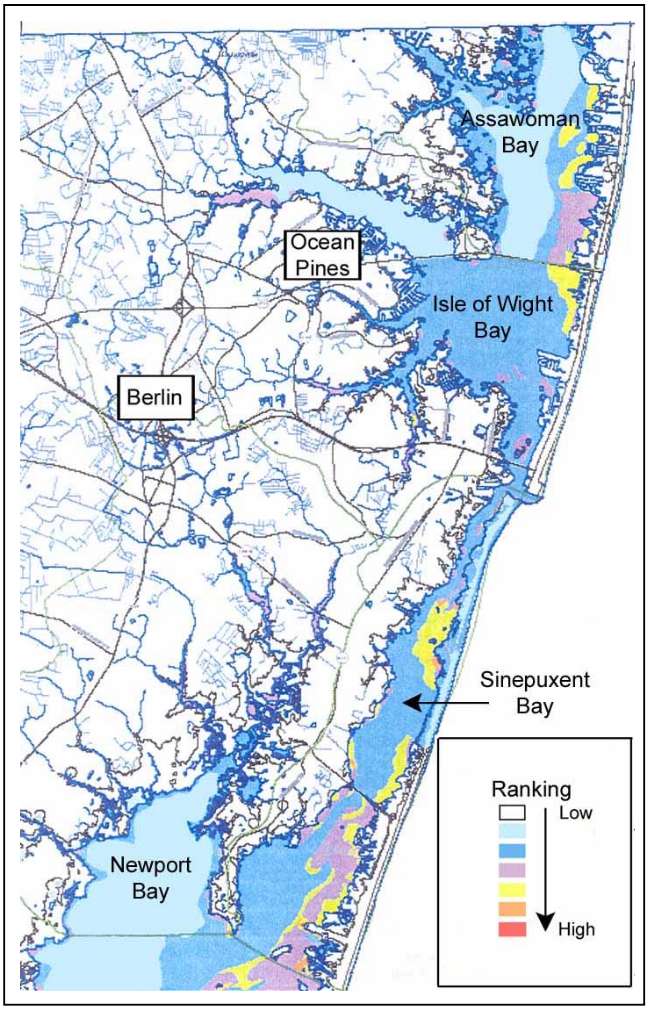


Figure 27. Aquatic Sensitive Areas Ranking in Assawoman, Isle of Wight, Newport, and Sinepuxent Bays (Conley, 2004).

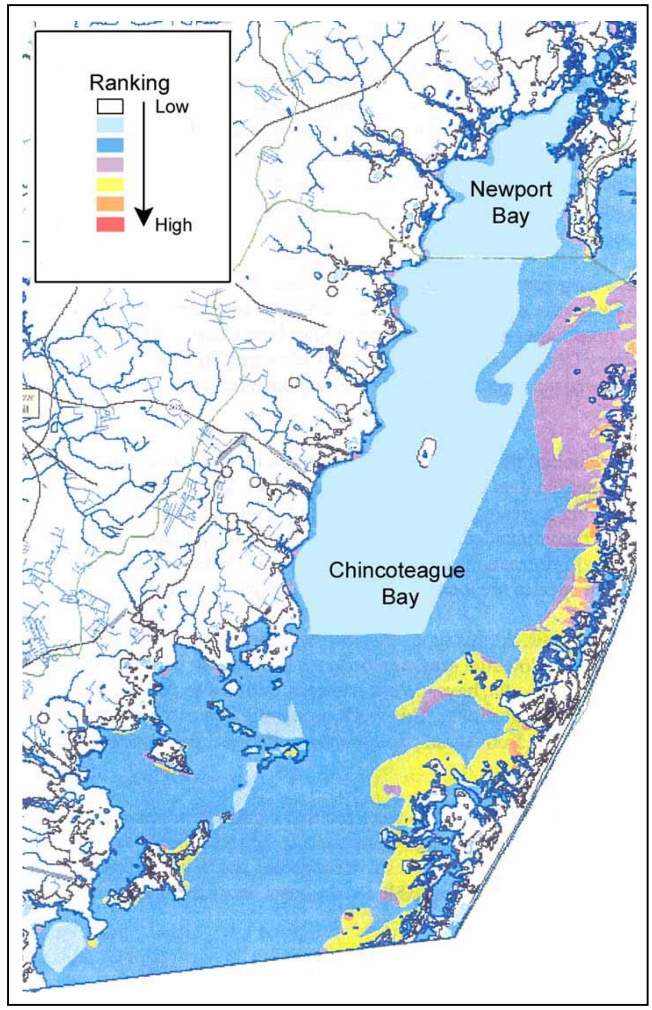


Figure 28. Aquatic Sensitive Areas Ranking in Chincoteague Bay (Conley, 2004)

Upland Wildlife

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

Wetlands of special interest

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

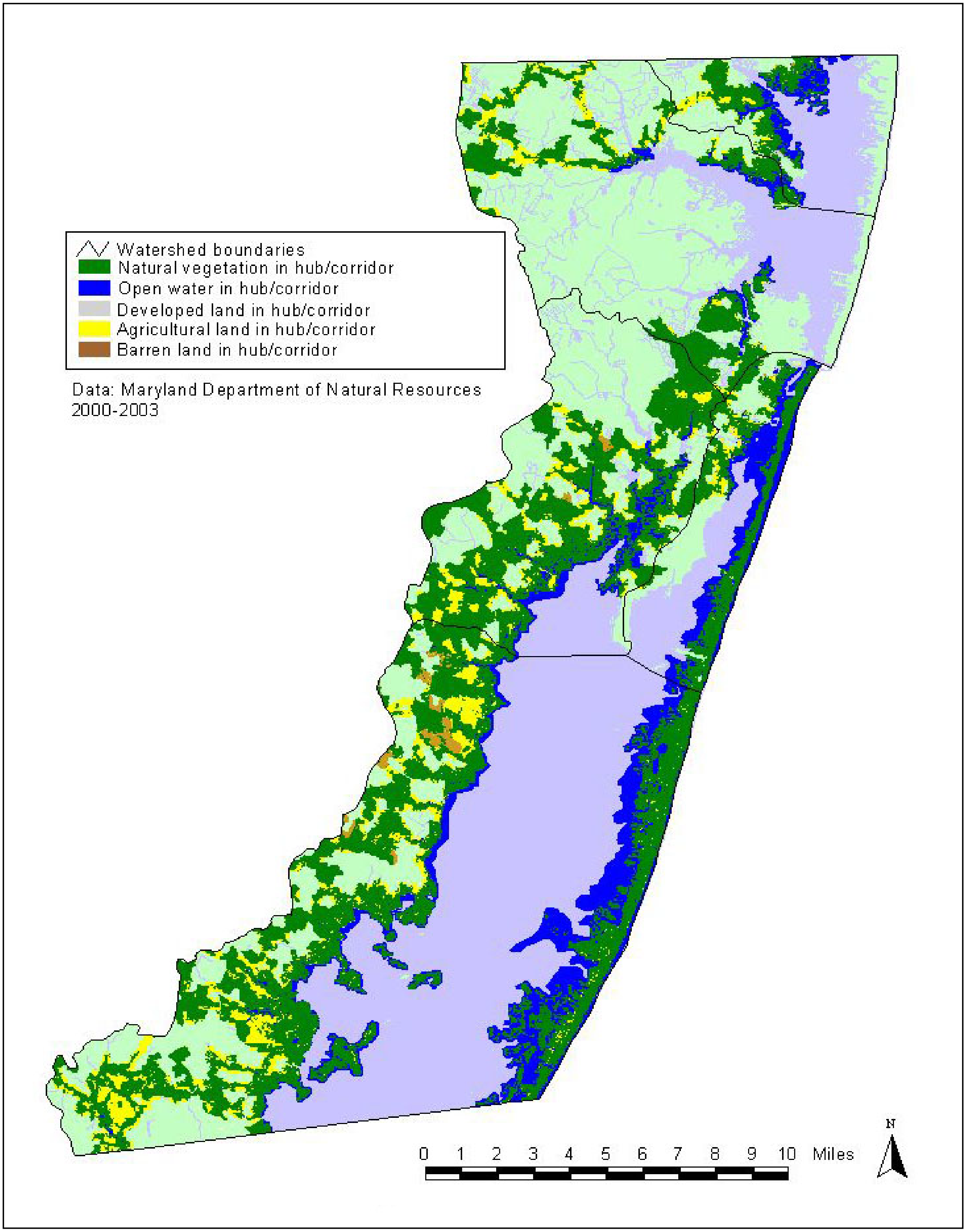


Figure 29. Green infrastructure hubs and potential corridors in Maryland Coastal Bays watershed.

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.

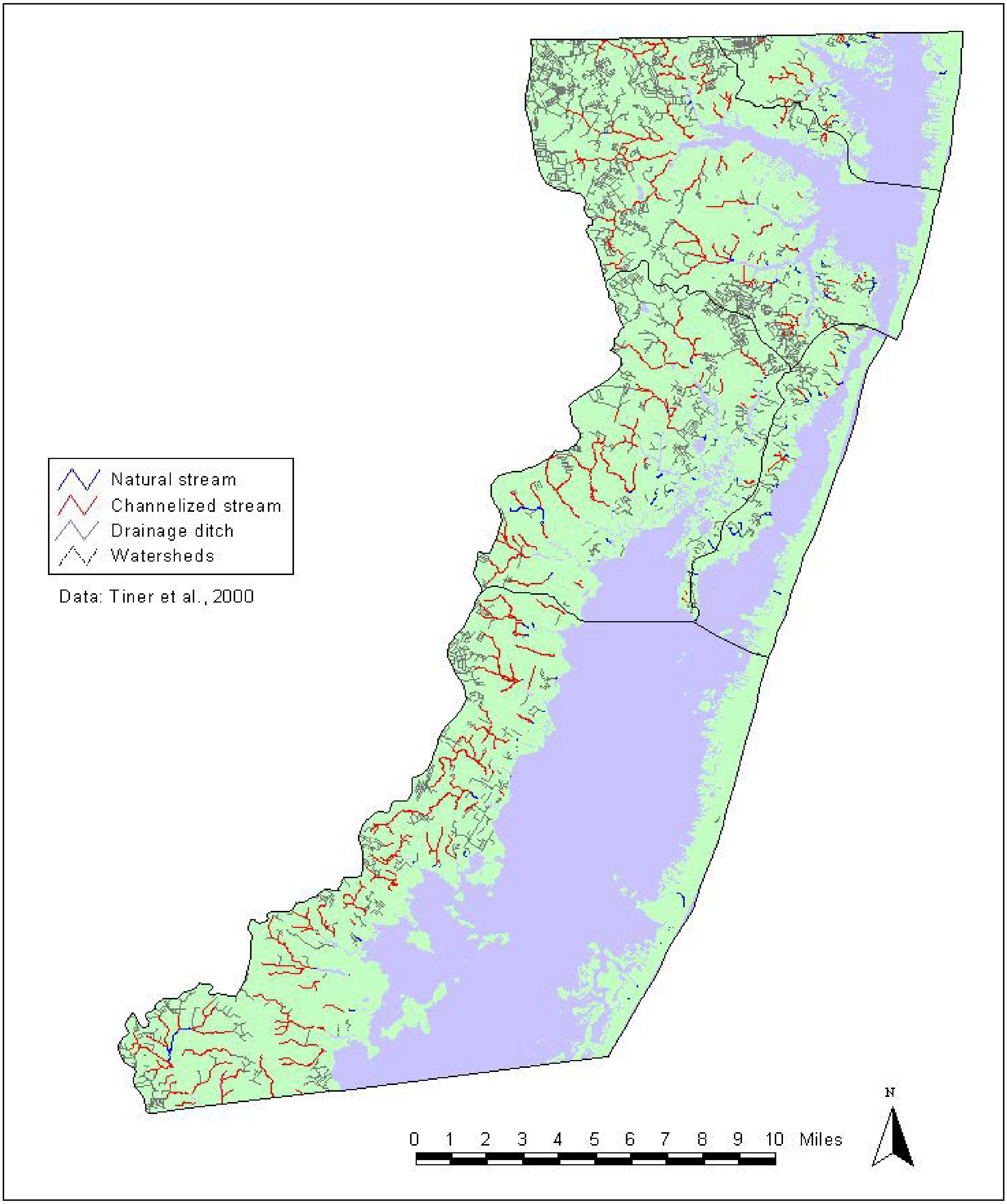


Figure 30. Natural streams, channelized streams, and drainage ditches in Maryland Coastal Bays watershed.

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

Algae

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

Sampling

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.

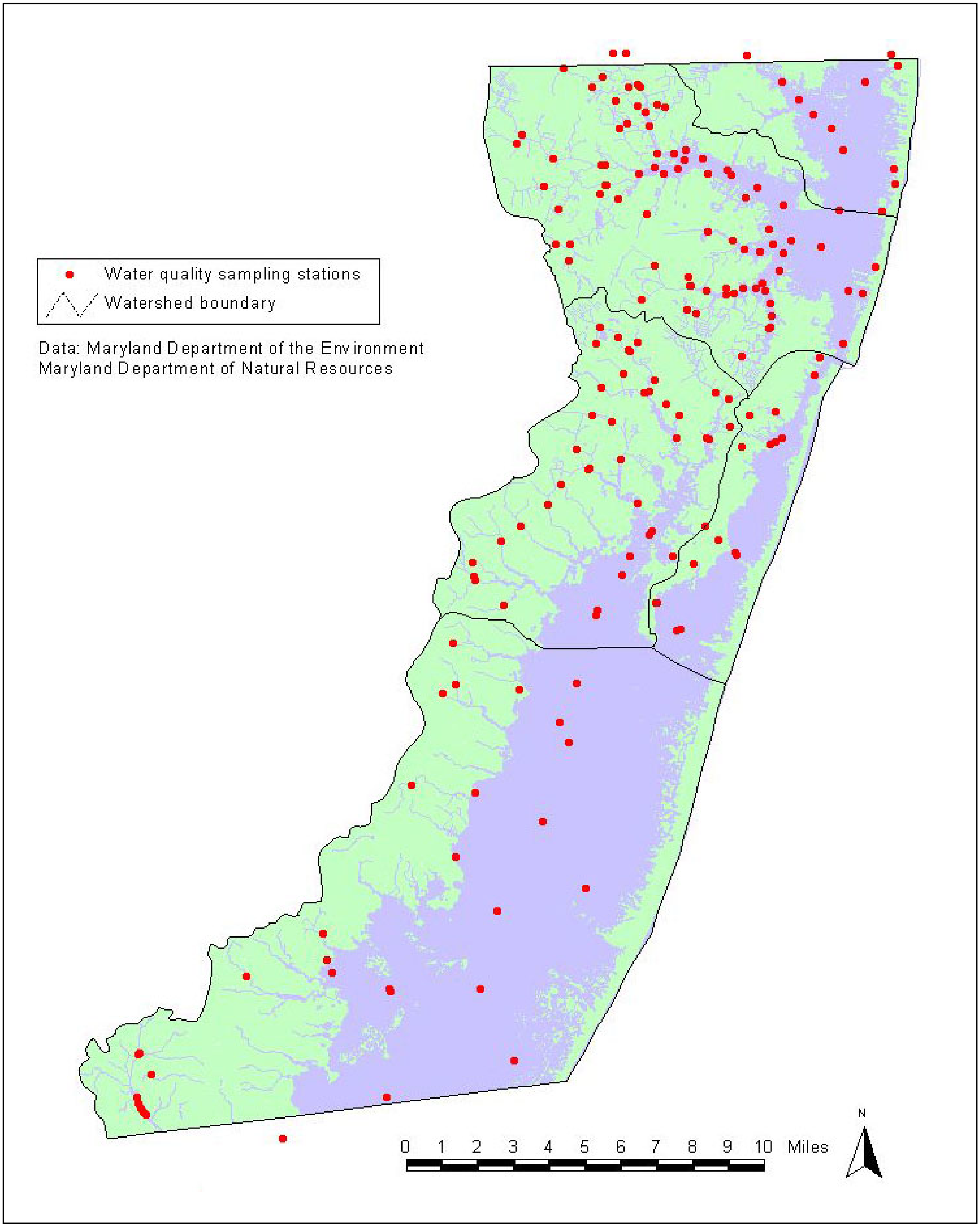


Figure 31. Water quality sampling stations within Maryland Coastal Bay region.

- *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)

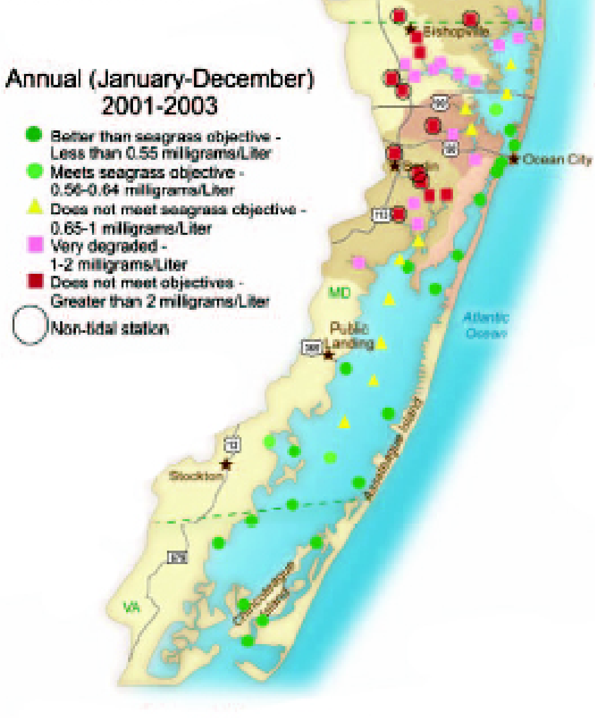


Figure 33. Median total phosphorus (MDNR/MCBP, 2004)

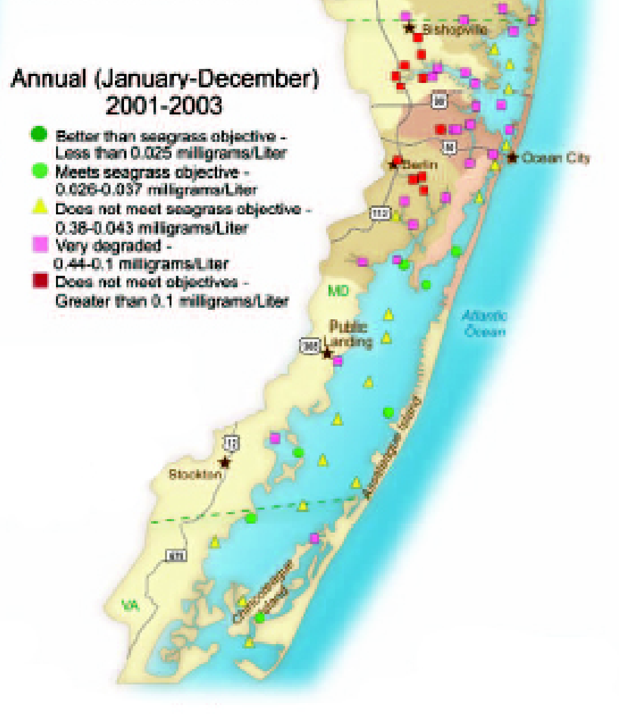


Figure 34. Water quality index (MDNR/MCBP, 2004)

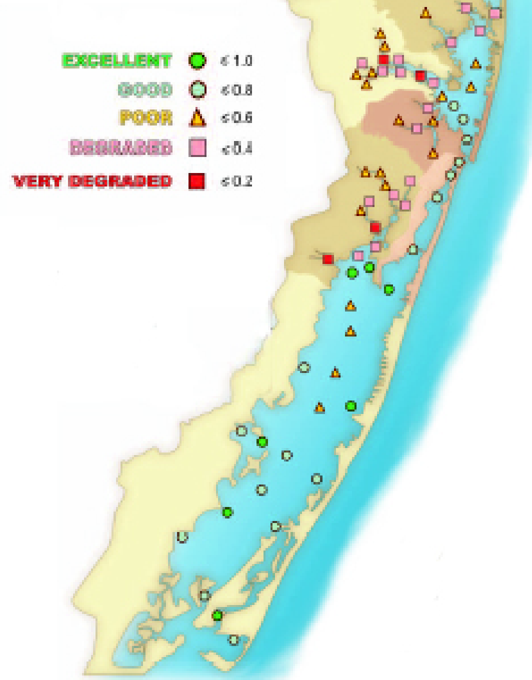
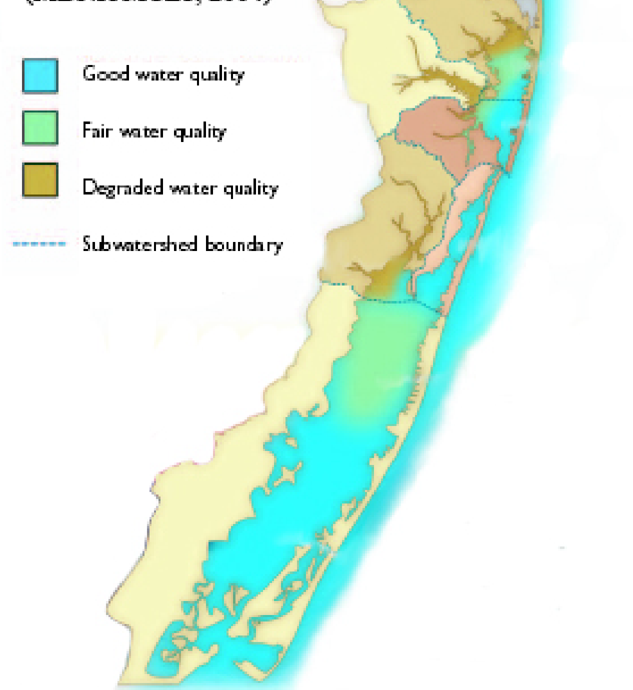


Figure 35. Water quality summary (MDNR/MCBP, 2004)



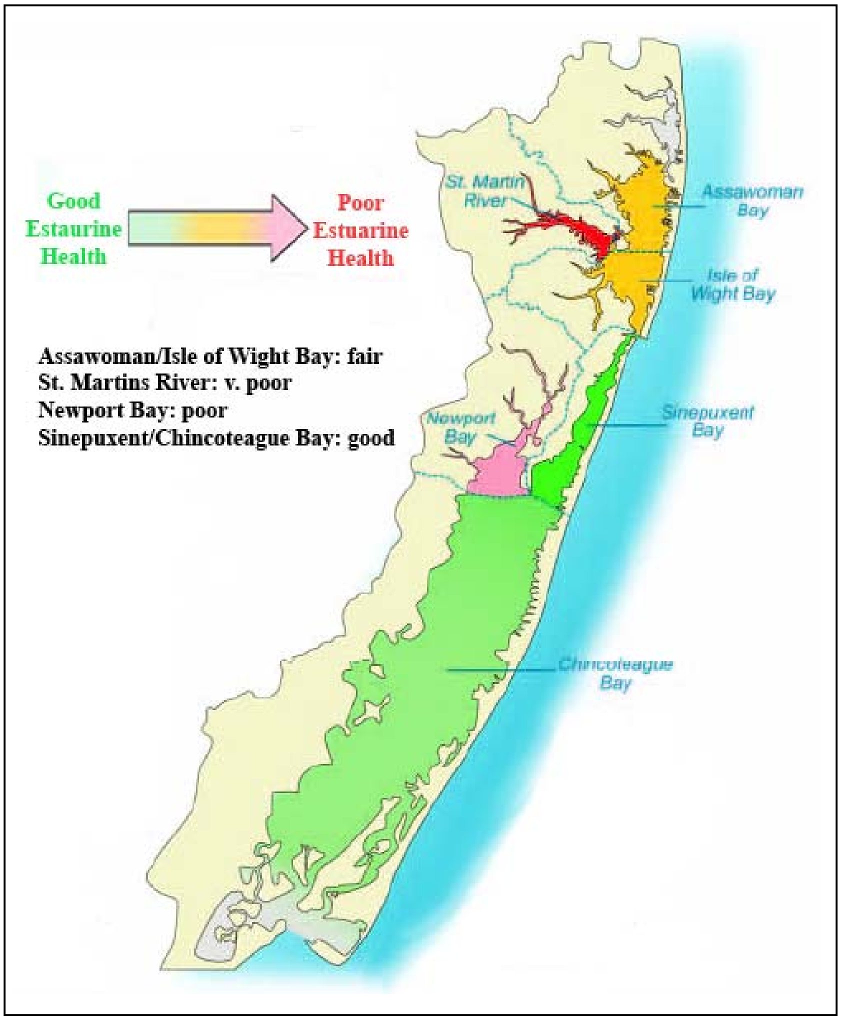


Figure 36. Summary of estuarine health, based on indices of water quality, living resources, and habitat (MDNR/MCBP, 2004).

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).

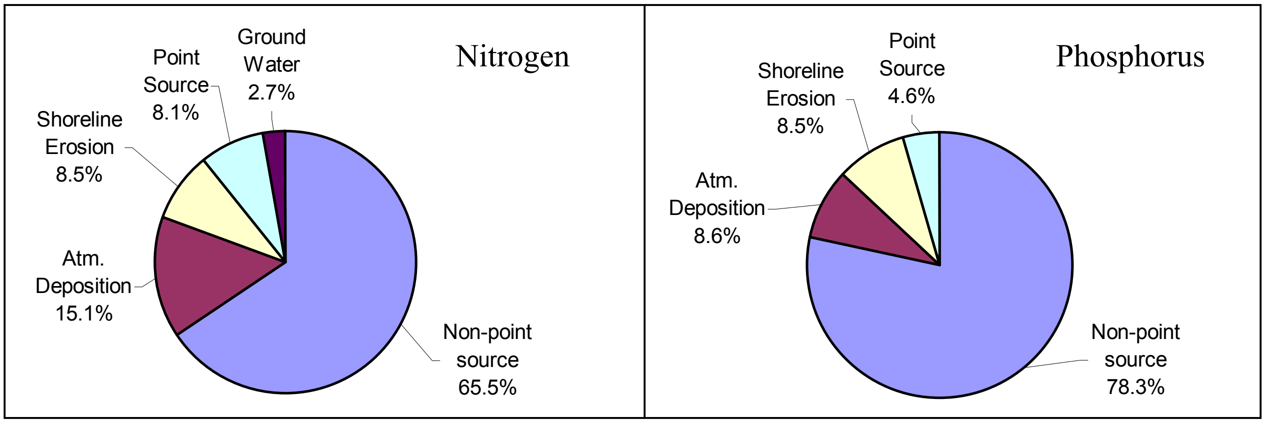


Figure 37. Source of annual total nitrogen and total phosphorus loads to the northern Coastal Bays (Wells et al., 2002).

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.

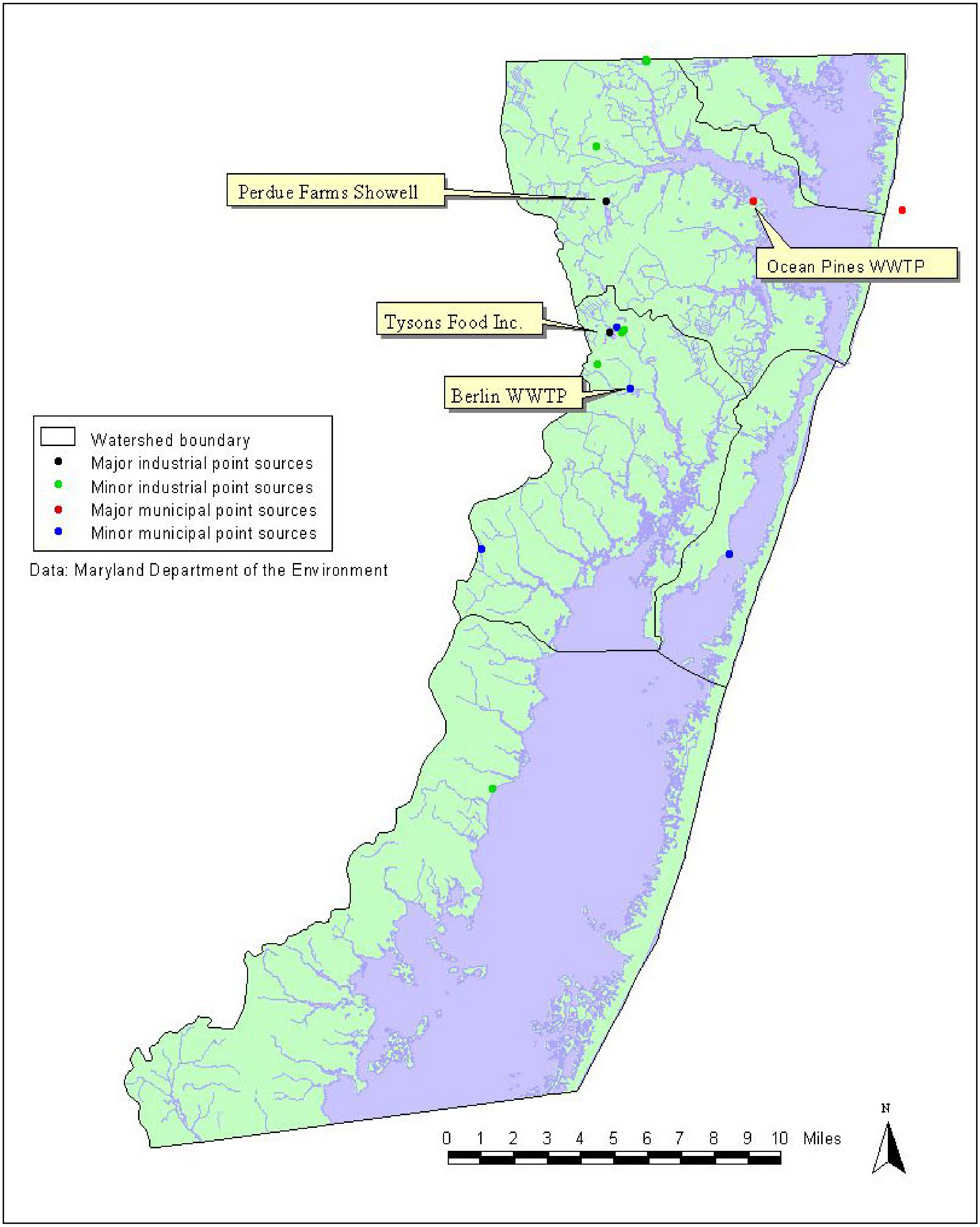


Figure 38. Point sources of water pollution within Maryland Coastal Bay region.

- *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.