DRAFT—01/12-09

St. Mary's River Watershed Characterization

March 2009

Prepared by the St. Mary's River Watershed Association, Inc. in partnership with St. Mary's County Government, Maryland Department of Natural Resources, St. Mary's College of Maryland, and local agencies and businesses.

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March 2009

a supporting document to the
Watershed Restoration Action Strategy
for the
St. Mary's River

St. Mary's River Watershed Association, Inc.
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EXECUTIVE SUMMARY

OVERVIEW

The St. Mary's River Watershed Characterization Report, produced by the St. Mary's River Watershed Association and partners, is a summary of all readily available natural resources and other data for this watershed. This is data that has been collected at a broad-based state scale, at a regional scale, and at the local scale. The Characterization Report includes information on river history, heritage resources, water quality, landscape and land use, human needs and services, living resources, habitat, restoration, and conservation. It also includes information on projects related to this characterization. For more information on the Watershed Characterization Report, please contact Bob Lewis at St. Mary's River Watershed Association at 301-737-2903 or smwatershed@yahoo.com.

The Synoptic Survey Report (September 2008), produced by Dr. Robert W. Paul at St. Mary's College of Maryland with the assistance of the Watershed Assessment Division of the Maryland Department of Natural Resources (DNR), is a water chemistry analysis (nutrients, temperature, conductivity, pH), and a biological survey (macro invertebrates, fishes, habitat) on 16 sites along stream corridors in the watershed. This Survey is summarized in this report and can be downloaded at: http://www.stmarysriver.org/pdfdocs/report_phase1_SS.pdf

The Stream Corridor Assessment Report (September 2008), produced by Dr. Robert W. Paul at St. Mary's College of Maryland with the assistance of the Watershed Services Unit of the Maryland Department of Natural Resources (DNR), summarizes results from a 118-mile stream corridor assessment survey using DNR's Stream Corridor Assessment Methodology. Of the watershed's 175 miles of streams, permission granted to access 68% of the stream corridors dictated the survey area. Streams were walked and assessed for such problems as pipe outfalls, erosion sites, lack of buffers, fish passage blockages, sewer outfalls, or unusual conditions. Each site is rated for accessibility, severity, and correct-ability. Local governments are given the geographically referenced information on compact disc. Reports accessed within this characterization report are only summaries of the geographically referenced data. This Assessment is summarized in this report. If you would like more information please contact Bob Lewis at 301-737-2903 or download the reports at http://www.stmarysriver.org/pdfdocs/report_phase1_SCATSS.pdf

The Water Quality Assessment (September 2008, produced by Dr. Robert W. Paul at St. Mary's College of Maryland with the assistance of the Watershed Assessment Division of the Maryland Department of Natural Resources (DNR), is a comprehensive scientific compilation of information related to water quality over the past ten years. This Assessment is summarized in this report and can be downloaded at: http://www.stmarysriver.org/pdfdocs/report_phase1_WC.pdf

The Watershed Restoration Action Strategy is written by the St. Mary's River Watershed Association and partners. It is developed by considering the above technical assessment information plus local knowledge from stakeholder involvement. The final strategy or WRAS is the plan that can then be "shopped around" to secure funding for project implementation. The strategy includes:

- a well-stated, overarching goal aimed at protecting, preserving, and restoring habitat and water quality
- a description of the stakeholder process
- opportunities, concerns, and challenges
- a very detailed, prioritized, description of natural resource management objectives
- a prioritized list of feasible and fundable restoration projects

HERITAGE

St. Mary's City, located on the banks of the tidal St. Mary's River, was host to the fourth permanent English settlement in the New World—a settlement that served as Maryland capitol until 1695. The site is steeped in history and is recognized as the birthplace of religious tolerance, the site of the first African American descendent to vote, and the place where women first launched the fight for voting rights. Today this site is secured by the State as a living museum on several hundred acres and features a working plantation, a replica oceanic vessel, and a state-of-the-art interpretive center.

Additionally, the site boasts extensive archeological opportunities and, in partnership with St. Mary's College, provides a museum studies undergraduate program. Some work has been done on aquatic archeology.

Historic sites abound in the watershed although few have been preserved and only one other, Drayden Schoolhouse, has been preserved, interpreted, and is open to the public. The Navy secured land from the Jesuits in 1942 and today runs a large research facility on the east bank of the tidal river.

WATER QUALITY

Monitoring of the St. Mary's River watershed has increased substantially in the past 10 years. Overall the St. Mary's River watershed has good water quality; however, research indicates that increased urbanization and related pollution could pose a potential threat if not managed. A statewide assessment of all watersheds identified the St. Mary's River watershed as a pristine or sensitive watershed in need of an extra level of protection.

The watershed currently does not support all the designated uses assigned to it by state regulations, and first through fourth order streams are impaired for protection of aquatic life. The cause of the impairment is unknown. In addition, there are areas restricted for shellfish harvesting and a fish consumption advisory for St. Mary's Lake.

Excess nutrient loads have contributed to algal blooms and low dissolved oxygen in the tidal areas. Increased nutrient levels in spring runoff fuels algal blooms, which subsequently die off and decompose, reducing oxygen levels below levels adequate to support aquatic life. Erosion and sediment have also been identified as a problem in some areas of the watershed.

Studies have cited storm events as a leading cause of perturbation in St. Mary's River, transporting nutrients and sediments into the tidal main steam from various tributaries in the watershed and as far away as the development

The 73.78 square mile St. Mary's River watershed encompasses almost a quarter of St. Mary's County's 296 square miles. The watershed extends from the county airport south to St. George's Island and Kitt's Point at the mouth of Smith creek. Land area west of Route 235 and south of Airport Road for approximately seven and a half miles make up a good portion of the county's targeted development district, and is also within the watershed.

Aerial Photo needed

Landscape indicators of environmental health include impervious surface area, population density, historic wetland loss, unbuffered streams, and soil erodibility. General downward trends in environmental health are evident in all of these indicators.

Nearly half of the St. Mary's County population—46,000 people—live within the St. Mary's River watershed. Development in the Lexington Park development district and along Route 235 corridor to California has been intensive in recent years. Rapid increase in paved or otherwise impervious surfaces forces the river to run faster and dirtier.

Land use in the watershed is varied and typical of the southern Maryland region. Agriculture encompasses about XXX% of the watershed area. Additional industrial use such as mining are confined to small parcels less than 250???? acres. Office business parks and commercial use are extensive along the Route 235 and Great Mills Road corridors with additional commercial use along Route 5 in Great Mills and Callaway. Residential land use make up the largest percentage of developed land area.

Large contiguous protected areas exist in the upper central watershed and are comprised of the St. Mary's River Wildlands, and the former Hackerman and Bevan properties—both pur-

HUMAN NEEDS AND SERVICES

LIVING RESOURCES

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Coordination, staff, and funding needed to create this document was provided by the St. Mary's River Watershed Association.

Additional staff support was provided by the St. Mary's County Department of Land Use and Growth Management and St. Mary's College of Maryland.

Technical support and assistance was provided by Science Applications International Company (EMA), Loiederman Soltesz Associates, and St. Mary's College of Maryland.

Financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration (NOAA). A report of the Maryland Coastal Zone Management Program, Department of Natural Resources pursuant to NOAA Award No. A06NOS4190237.

Additional funding provided by the Chesapeake Bay Trust Stewardship Grant program, St. Mary's County Commissioners, The Boeing Company, and Liberty Home Builder—Glazed Pine—Live Work Play.

Although this project is funded by a partnership, the opinions expressed are those of the WRAS Steering Committee and the St. Mary's River Watershed Association.

Print format of this document is on 100% recycled paper. This and other referenced documents can be found online or downloaded from www.StMarysRiver.org. Copies on CD-R can be requested from St. Mary's River Watershed Association, PO Box 94, St. Mary's City, MD 20686.

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INTRODUCTION

Background
- Location
- Purpose of Characterization
- Additional Characterization Work
- Identifying Gaps in Information

Bob L.

The St. Mary's River: History and Ecological Changes

The current condition of the St. Mary's River is the result of over four centuries of human activities that have deeply impacted the nature of this estuary. Therefore, in evaluation of its status, one must comprehend the nature and causes of changes that have created the conditions that are currently being monitored by the St. Mary's River project. Few aspects of the entire river system can be considered in a "natural" state uninfluenced by human actions. While natural processes continue to shape the overall character of the St. Mary's, androgenic factors have had a powerful influenced upon the drainage over the past 400 years. This section will very briefly review the history of human habitation, examine evidence of past vegetation and estuarine resources, and utilize a series of oyster shell samples to assess changes in the river.

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Prehistoric Peoples

The St. Mary's area was the scene of Native American habitation for a period of more than 12,000 years. Previous archaeological research has divided this broad span from ca. 11,000 B. C. to 1600 A.D. into three major segments. These are the Paleo-Indian Period (11,000 B.C. to 8000 B.C.), the Archaic Period (8000 B.C. to 1000 B.C.) and the Woodland Period (1000 B.C. to 1600 A.D.). These periods are defined by general cultural traits, environmental conditions and key artifacts, primarily stone projectile points and ceramics. The Archaic and Woodland periods are divided into a number of sub-periods that are thought to reflect changes in cultural development.

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The most ancient evidence for humans yet found in the area is a Clovis spear point from ca. 11,000 years ago discovered near the mouth of the St. Mary's. There is abundant evidence of people residing along the river in the subsequent Archaic period and even more sites from the Woodland period. Over this time, it is unlikely that humans had any significant effect upon the environment of the area, with one exception. That is the use of fire to manage the forest understory, facilitate travel, stimulate the growth of browse vegetation for white tailed deer, and drive deer in hunting. Data from other areas of the Chesapeake suggests that prehistoric peoples began using regular burning as a means of forest management as much as 6000 years ago. Hence, even the forests encountered by the first Maryland colonists were not, as they assumed, a reflection of pure natural conditions but was the result of human efforts. With the arrival of agriculture around 900 A.D., clearance of land for food production began. However, the Chesapeake Indians employed a sustainable form of agriculture based on the use of hoes, slash and burn methods and long fallow periods. Probably originating in Central America, this agrarian method resulted in only small land areas being in production at any given time. There was some intensification of agriculture in the period between ca. 1200 and 1600 A. D. but given its small scale and methodology, it had no measurable impact on the overall forested environment. We only know the name of the most recent group of people who lived on the St. Mary's, the Yaocomico Indians. Their population at the time the Maryland settlers arrived in the 1630s is difficult to determine, but is unlikely to have been more than 500 people.

Historic Period (ca. 1630-2008)

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The St. Mary’s River is one of the most historically significant locations in the state of Maryland. It is where Lord Baltimore’s colony began in 1634. Along the river, the colonists built Fort St. Maries, the first Governor's house, a Catholic chapel and the homes of the early settlers. The site became the capital for the colony from its founding until 1695, when the government was moved to Annapolis. It is where the first government policy of religious freedom and non-establishment of religion was employed in the New World. The St. Mary’s River also saw development of the first tobacco plantations in the colony, as settlers gradually moved from Fort St. Mary’s in 1636 or 1637. In 1668, the first incorporated city in Maryland was established here. Other notable historical aspect of the river is that the first industrial activity in the colony occurred along it, beginning with a water mill in the 1630s, the first large scale brick manufacture, and the attempt to make iron in the mid-17th-century. And it was on the St. Mary’s River that the craft of printing began in all of English America outside of Boston.

Following departure of the provincial government in 1695 and movement of the county government to Leonardtown in 1708, all urban life ended along the St. Mary’s and it became a completely rural landscape. Large plantations, middling family farms, the quarters of enslaved Africans and later African Americans, and poor tenant farms dotted the landscape of tobacco, corn and wheat fields, pastures and scrub land. A modest industrial complex did arise at a place named Great Mills. Poor agricultural practices, the impact of the American Revolution and destruction by the British in the War of 1812 affected residents of the St. Mary’s River and led to the departure of some to new lands in Kentucky and elsewhere. But throughout the 19th century and for the first three quarters of the 20th century, the river area remained primarily a rural setting of farms. A good indication of the stable population is the U.S. Census data. From the first census in 1790 until the onset of World War II, the population of St. Mary’s County did not change dramatically. In 1790, there were 15,544 people in the county, while in 1940, 14,626 people lived here. Over that 150 year period, the peak population was in 1900 with 17, 182 and the low occurred in 1820, after the trauma of the War of 1812, with only 12,794 people residing in the county. It was construction of the Patuxent River Naval Air Station in 1942 that brought dramatic changes to the county. But much of this impact was initially restricted to the newly emerging Lexington Park area.

Population growth, residential construction and economic development begin to intrude on the St. Mary’s River drainage by the 1960s. One element was expansion of military research and development activities at Webster Field on St. Inigoes Creek. Even more significant was construction of new housing along the shorelines of the river, intensive commercial and residential development in the Lexington Park area, and the beginning of dramatic growth of St. Mary’s College.

Vegetation Changes in the St. Mary's River Drainage

The nature of the terrestrial vegetation in the St. Mary's River drainage can be evaluated to some extent by using pollen found in sediment samples. Core sampling has been conducted at the Aud site in a marsh called Pete's Bog at the head of the St. Mary's (Brush 1996), just downstream from where Route 5 crosses the river, and in St. John's Pond at St. Mary's City (Kraft and Brush 1981). Based upon radiocarbon dating, these core samples extend back to 6380 years ago at Aud and 5339 years ago at St. Mary's City.

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The very oldest layer at the Aud site contains pollen from hemlock, likely a remnant of vegetation from the much colder proceeding era. In that sample, cedar, alder, birch and walnut are present. A marsh environment did not exist there 6000 years ago. Higher in the core, however, in layers deposited after 2500 B.C., there is clear evidence that a marsh had developed by that time. Indicators include cattail, some sedge and other marsh plants. This marsh development is likely related to sea level rise. Estuarine conditions are known to have been established in the Potomac and, hence the lower St. Mary's River, by 3000 B.C., based on oyster shell middens excavated along the Potomac (Potter 1992).

Still higher in the Aud site sample are layers deposited around 500 A. D., in which pollen from the holly is very abundant, oak and black gum are common, and plants like cinnamon fern, goldenrod and arrowood are present. The topmost layers in this core contain large quantities of pine and ragweed, indicating that these were deposited after plow agriculture was underway.

At St. Mary's City, over the past 5000 years, the lands were covered with a mixed deciduous forest, with some conifers. Little change in the composition of these forests is indicated by the core samples over most of this period. St. John's pond had a cattail marsh along its shores over 4000 years ago. Before ca. 2000 B.C., brackish to salt water had intruded into the pond area (as determined from Mercenaria mollusk fragments). Oak and hickory were the most abundant trees, with maple, river birch, beech, ash, and sweet gum major elements of the forest. Present in low frequencies was walnut, red cedar some pine, and perhaps chestnut. Chestnut is a poor pollen producer and this species was probably more common than the pollen samples suggest.

The greatest change in the pollen is associated with the arrival of Europeans. Since the colonists disembarked in 1634, the primary changes in the pollen profile have been a decline in oak and hickory and increases in pine, ragweed, chenopodium and grasses. These changes are almost certainly due to the clearance of land for agriculture and its temporary abandonment as part of the slash and burn and long fallow system, or the rise of more permanent plow agriculture. One significant feature of the pollen record at St. Mary's is that cheno-podium (pigweed) shows a strong increase around the time of colonization but it suddenly declines in the early 19th century. Palynologist Grace Brush suggests that this is associated with cycles of land clearance and abandonment associated with slash and burn agriculture that was used for tobacco and corn production in 17th and much of the 18th century in Maryland. In contrast, ragweed displays a significant increase in the early 19th-century. It can be associated with broad scale land disturbance, as occurs with plowing. Historical evidence indicates a transition occurred from hoe-based slash and burn agriculture to plow agriculture in the late 1700s or early 1800s and the pollen data support this.

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Human Usage of the St. Mary's River Drainage in History

While high quality scientific measurement of the status of the St. Mary's River drainage now spans more than a decade of time, it is essential to recognize that the current conditions are a consequence of long term natural processes and roughly four centuries of human actions. Earlier Chesapeake Indians had an impact on vegetation by regular use of fire to manage the forest understory but this probably did not have a major impact on the estuary itself. What was the river like in past centuries, when did major changes occur in its nature and what caused these changes? Some insights can be derived from data sets provided by archaeology and pollen analysis.

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When the first settlers arrived, the shores were covered with massive forest, except for the areas that had been farmed by the Yaocomico peoples. During the 17th-century, settlement was restricted to the lower, tidal portion of the river and the upper drainage area above Great Mills remained in forest. As tract maps developed by Historic St. Mary's City reveal, it was only in the 18th century that interior areas were settled and the forests cleared on lands suitable for agriculture in this inland zone. Due to the varied topography of interior areas, however, it is likely that many of the slopes and watercourses remained covered by vegetation.

Archaeological evidence from St. Mary's City shows that the river contained a diversity of wildlife. The most common fish are benthic-oriented species, especially the Sheephead, Red Drum, and Black Drum. Other species include white perch, sturgeon, sea trout. Today, the Sheepshead is nearly extinct in the Chesapeake, as is the Atlantic Sturgeon. Drums are rare in the St. Mary's. Abundant oyster shell deposits indicate the prevalence of the American Oyster in the river. Clams are not found, indicating that they were never a significant species on the St. Mary's. Attached organisms or epifauna on the shells include various sponges, oyster mudworms, and occasional barnicles. In some samples, oyster spat are common. This is strong evidence that a rich and vibrant benthic community existed in the St. Mary's River in past centuries, and this biotic community is significantly different today.

Since the St. Mary's river drainage was forest covered for thousands of years, one would anticipate that nutrient inflows were stable and sedimentation rates low. As noted above, the small human populations and use of the shifting field-slash and burn methods with hoes as the only tools would have added little to the input of nutrients or sediment into the St. Mary's River. English colonists adapted the same agrarian method using hoes for production of corn and tobacco. Although the human population grew at a very rapid rate after the mid-1600s, reliance upon the sustainable method of rotating field-slash and burn agriculture would have created only modest increases of nutrients and silt into the estuarine environment. The major consequence was a shift in the composition of the

Human Usage of the St. Mary's River Drainage in History continued

terrestrial vegetation, with an increase in species such as pine and ragweed. Field abandonment for a 20 year cycle encouraged the growth of succession species such as pine, at the expense of slower growth oak, hickory and other hardwoods.

PHOTO

Androgenic impacts apparently did not become significant until a substantial shift in land use methods occurred. In this case, it was the change from hoe-based to plow agriculture. Plows had been present from the first decade of Maryland but due to massive trees with extensive root systems, it was normally more efficient to utilize the aboriginal method of hoe agriculture. Economic factors in the later 18th-century led to the widespread shift from tobacco to grain production in the Southern Maryland region, especially immediately after the Revolutionary war (Walsh 2001; Marks 1979). As a result, far larger areas of soil were left exposed each year to erosion, leading to a significant increase in the quantities of nutrients and sediment entering the rivers and creeks of the region. This nutrient enrichment may have initially enhanced the estuarine environment in terms of biological productivity. The upper courses of streams likely captured a substantial amount of the sediment initially, although major storm events would have flushed this silt into the main body of the river. In this regard, the development of millworks in the Great Mills area may have helped reduce this to some extent, since the mill ponds would have acted as unintended sediment traps. Nevertheless, severe storms would have resulted in the benthic environment being periodically inundated with a rain of sediment. In some cases, such as in Horseshoe Bay at St. Mary's City, the bottom may have been covered with silt. Evidence from the Tolle-Tabbs archaeological site inhabited in the first half of the 19th century suggests this. In its food bone sample, there is for the first time at any St. Mary's City site an absence of once common benthic species such as sheepshead and drum. Pelagic fish predominate. It seems quite clear that the move to plow-based agriculture around the turn of the 19th century resulted in the first significant androgenic changes in the natural environment of the St. Mary's River. In particular, eutrophication of the river occurred and the level of primary biological productivity would have increased.

But gradual improvements in agriculture and some reforestation in the river area may have resulted in slight reduction of sedimentation in the later 19th century. After the Civil War, major commercial exploitation of oysters began, and this included exploitation of the St. Mary's. The river contained a number of very productive oyster bars and reefs, as late 19th-century oyster maps indicate. Over-harvesting of shell fish in the late 19th-century removed a vital element, filter feeders, which had helped cope with and reduce the negative consequences of eutrophication. Indeed, into the mid to late 20th century, the St. Mary's was still regarded as an important area for seed oyster production.

Sedimentation Rates in the St. Mary's River

As described above, the historical record provides strong evidence of changes in land use and one can suggest the consequences of this on the estuary. A major factor in these changes to the estuarine environment is sediment deposition. While sedimentation is a normal geological process, human activities can have a major influence on the extent of such deposition. In addition to the pollen evidence they yield about vegetation, core analysis can provide reliable measurements of the rate of annual deposition.

PHOTO

During the era preceding the arrival of the Maryland settlers, we can assume that most of the St. Mary's River shoreline and its drainage were covered by mature forest. As a result, annual sedimentation is predicted to have been relatively low. After agriculture began with land clearance for tobacco and maize farming, sedimentation should have increased. However, the use of the Native American method of agriculture meant that a given parcel was only farmed for a decade or less, followed by its abandonment for at least 20 years if not longer. With this method, only relatively small amounts of land are left bare and exposed to erosion at any one time. With the onset of plow agriculture, however, extensive areas are left open and susceptible to soil erosion. Research with census records has shown that in Southern Maryland in the early 18th century, the amount of land needed to grow the annual tobacco crop represented about 1.4% of the total and this rose to 3.6% by the 1770s (Froomer 1978). With the shift to grain production, a dramatic increase occurred, and by the 1830s nearly 40% of the land was in annual agricultural production. We would therefore predict that sedimentation rates on the St. Mary's River should reflect this changing land use.

Data on this is available from the Aud and St. Mary's sites (Table 1). While these are marsh or pond settings, the deposition rates found there reflect the silt that was potentially entering the river itself. In the centuries prior to the arrival of Europeans, there was apparently a low annual sedimentation rate, as one would anticipate. At the Aud site before ca. 500 A. D., this rate was only 0.005 cm per year, while it rises to 0.03 in the period from ca. 500 to 1600 A. D. (Brush 1996:1). In the 17th and 18th centuries, it increased to 0.05 cm/year. At St. Mary's City in the millennia before English colonization, the rate was 0.14 cm/year (Kraft and Brush 1981:9). This is higher than found at Aud at this time, and the difference is probably explained by the presence of a number of Chesapeake Indian settlements at St. Mary's City, as indicated by archaeology. In the 17th and 18th centuries, deposition at the Aud site rose to 0.05 cm/year, while at St. Mary's it was 0.25 cm/year. Again, there was far more intense human occupation at St. Mary's during this period than in the immediate vicinity of the Aud site. With the rise of plow agriculture, the rate at St. Mary's City increase still further, to 0.4 and 0.65 cm/year. Thus, the core data confirms that the sedimentation rate into the St. Mary's River did change significantly over time, with the changes almost certainly related to methods of land use.

Sedimentation Rates in the St. Mary's River continued

Table 4-1: Annual Sedimentation Rates From Core Samples on the St. Mary's River

Time Period	Aud Site*	St. Mary's City**
Pre-500 A. D.	0.005 cm/yr	
Ca. 500-1600 A.D.	0.03 cm/yr	0.14 cm/yr
Ca.1600-1800 A. D.	0.05 cm/yr	0.25 cm.yr
Post-1820s	0.08 cm/yr	0.65 cm/yr

*Brush 1996 ** Kraft and Brush 1981

Oysters and Ecological Change

Given the above information, a significant question is how did the biotic community in the St. Mary's River respond to these changes? Did nutrification enhance or rapidly degrade the river environment? One way to address these questions is to examine the St. Mary's River oysters collected from well dated archaeological contexts. Due to the substantial level of archaeological research in the area, samples of shells dating from prehistory up to the present are available. Oysters can serve as sensors in an estuarine environment, and reflect the changes that occur within it. Shell shape, growth rates, isotopic content, attached epifauna, etc. all can provide insights into past conditions. Biologist Michael Kirby and Henry Miller conducted an analysis of oyster shell samples from 24 St. Mary's and Patuxent River sites (Kirby and Miller 2005) in an effort to examine the issues of eutrophication and shifts in the estuarine environment. Shell growth rates were one key data set collected by measuring shell length, shell thickness and the surface area covered by the abductor muscle, and determining the age of each oyster from growth ring analysis. Samples dating between the early 17th century and the early 21st century were used. Samples from sites along the lower portion of the Patuxent River were studied to provide comparative data.

Shell samples were divided into four temporal phases, based upon historical evidence regarding land use and harvesting intensity. These are:

1. (ca. 1600 – 1760) Era of Hoe-based Agriculture,
2. (ca. 1760-1860) Plow Based Agriculture and Limited Oystering
3. (ca. 1860-1920s) Era of Intensive Commercial Oystering
4. (ca. 1920s – 2002) Estuarine Degradation

We assume that the Chesapeake Bay remained in a relatively stable condition for centuries due to a forest-covered drainage, and a massive population of filter feeders, especially oysters, that consumed much of the phytoplankton, especially their preferred food of diatoms. In such a situation, nutrients were converted into biomass, removed from the water column by filter feeders that in turn supported a rich marine fauna. Our study hypothesized that oysters would initially respond to the nutrient enrichment caused by the greater sedimentation from plow agriculture by an increase in growth. However, as eutrophication continued to expand and commercial fishing began removing the majority of the Bay's shellfish population, growth would begin to decline due to degrading conditions, such as the onset of damaging algae blooms and hypoxia.

The shells reveal notable changes (Table 2). In both the St. Mary's and the Patuxent, a significant increase in oyster growth occurred during the initial eutrophication period between the late 18th century and mid 19th century. The increase was approximately one third greater growth compared to pre-plowing times. In both drainages, growth declines in the post-Civil War era. The decline is likely due to a very substantial increase in nutrient inputs (this is based on analysis of nutrient levels in sediments from cores taken in the Chesapeake Bay by Zimmerman and Canuel (2002), and overharvesting of filter feeder species. The oyster shell evidence shows similar responses by oysters in the St. Mary's and Patuxent from the time of initial colonial settlement until the early 20th century. However, in the post-1920 period, the Patuxent and St. Mary's data sets differ. Oyster growth rates on the Patuxent continue to decline while they return to early colonial rates on the St. Mary's. This may be due to a relatively stable human population in the St. Mary's area until late in the century, re-forestation of substantial portions of the St. Mary's river drainage in the 20th century, with the consequent reduction of nutrient and sediment inputs. On the Patuxent, however, ongoing agriculture, the increase of residential populations and nutrient inputs from sewage and other sources is the likely reason oyster growth in that river continued a downward trend.

Table 4-2: Oyster Shell Growth in Height By Time on the St. Mary's and Patuxent*

St. Mary's	1600-1760	1760-1860	1860-1920	1920-2002
Shell Height in mm/year	25.3	37.3	20.0	24.8
Patuxent				
Shell Height in mm/year	23.5	34.3	24.1	16.9

*** From Kirby and Miller (2005)**

Oysters and Ecological Change continued

This evidence fits with the fact that the St. Mary's River was still considered an important source of seed oysters by the Maryland Department of Natural Resources into the later 20th century. Shellfish data therefore reveals notable changes over time, changes related to variations in estuarine conditions that are ultimately linked to the nature of terrestrial land use. The later 20th-century shell evidence matches the findings of the recent monitoring conducted by the St. Mary's River project, indicating that excessive eutriphication is not as serious a problem here as is found in some other drainages. However, diseases such as Dermo and MSX have taken a toll, along with continued harvesting, leaving only a tiny remnant population of the once abundant oyster in the St. Mary's.

PHOTO

PHOTO

The fact that the oysters responded to eutrophication by higher shell and soft tissue growth rates shows that they were consuming a portion of the greater primary biological production occurring in the river as a result of more nutrient inputs. By removing this organic matter, the oysters helped reduce the negative effects of initial eutrophication. They also made this increased biomass available to their predators and other species higher in the food chain. The concept that shellfish and other filter feeding species had a key role in maintaining the biological stability of the Chesapeake estuary by preventing the accumulation of excess organic matter is well established (Newell 1988; Jackson et al 2001). Throughout prehistory, the colonial period and the early Federal era, the Chesapeake Bay had a biotic system in which the phytoplankton suspended in the water column were consumed in large part by suspension feeding species in the benthic environment. This prevented the accumulation of unused organic matter and kept bacterial activity at a reduced level. However, when the oyster populations were decimated in the later 19th and early 20th century (see Rothschild et al 1994), this controlling element was severely degraded. Research indicates that this led to a change in the basic structure or tropic system of the Bay to one where bacteria consumed the accumulated organic material and the environment became dominated by microbes (Jonas 1997; Jackson et al. 2001). Algae blooms become more common, and algae can be harmful to oysters and are probably of less food value to the shellfish than diatoms. In turn, the microbial decomposition of the unused organic matter removes oxygen from the water column, leading to episodes of hypoxia (Paerl et al 1998). This shift to a bacteria-dominated ecology is directly related to degradation of estuaries.

Oysters and Ecological Change continued

The St. Mary's oyster study is the first to demonstrate with data directly from the historic period of initial nutrient enrichment that shellfish were indeed responding by removing a portion of the greater biological production from the water, as reflected in their enhanced growth. But the fact that this growth did not continue, despite continual increases in the amount of nutrients entering the water and thus even more abundant food, points to other factors, especially this shift in tropic systems from a plankton- and filter feeder-based one to one dominated by bacteria. This is not the place to present more data about this process but it does indicate that the health of the Chesapeake is in large part dependent upon the presence of huge numbers of filter feeders, especially the oyster.

PHOTO

PHOTO

Archaeology and history provide a valuable picture of the St. Mary's river in previous centuries and the amazingly rich bounty it once offered. This summary is a very cursory review of a large quantity of evidence and research. It is obvious that the decline of biological productivity in the St. Mary's River is very recent when compared to this long record. Reestablishment of a healthy benthic community, including SAV, control of nutrient inputs, intensive repopulation of filter feeders of various species, and a moratorium on harvesting are appropriate steps for maintaining and even restoring the St. Mary's River to some small reflection of its past abundance. Unlike many estuaries, the St. Mary's is not totally degraded and has many features that could allow it to recapture some of this lost productivity, especially in the form of the vital benthic filter feeders.

Water quality is in many respects the driving condition in the health of Maryland's streams. Historically, the emphasis has been on chemical water quality. More recently, interest has focused on the biological conditions in streams and estuaries; active consideration of the physical parameters is even more recent. This developmental path is reflected in the ways in which streams have been monitored, the types of data gathered, and the regulatory approach taken.

Water Quality Standards and Designated Uses

All streams and other water bodies in Maryland are assigned a designated use in the Code of Maryland Regulations, COMAR 26.08.02.08, which is associated with a set of water quality criteria necessary to support that use. In the St. Mary's River watershed all waters are categorized under two uses:

Use I, Water Contact Recreation and Protection of Aquatic Life: All surface waters not designated as Use II.

Use II, Shellfish Harvesting Waters: All estuarine areas.

Map X Designated Uses and Use Restrictions depicts the distribution of surface waters in each category. For official regulatory information consult COMAR or MDE.[41,42]

[41]Code of Maryland Regulations: www.dsd.state.md.us/comar/
[42]Maryland Department of the Environment: www.mde.state.md.us/

Map X Designated Uses and Use Restrictions

Use Impairments (Non-supporting Uses), Use Restrictions and Advisories

The Federal Clean Water Act requires states to assess and identify waters that do not meet water quality standards, sections 303(d), 305(b) and 314. Maryland meets these requirements by submitting a biennial report that integrates these sections. The Integrated Report describes the ongoing efforts of the state to monitor, assess, track and restore its waters.[43] The report identifies waters that do not support their designated uses, impaired waters, in a list often referred to as the 303(d) list. Waters on the list are prioritized and may require a Total Maximum Daily Load (TMDL). Information considered in setting the 303(d) list priorities includes the severity of the problem, threat to human health and high value resources, extent of understanding of problem causes and remedies.[44]

Biological

First through fourth order streams in the St. Mary's River watershed have been identified by MDE as impaired in *2008 Integrated Report of Surface Water Quality in Maryland*. The impaired designated use is Aquatic Life and Wildlife (under Use I) because of a combination of benthic and fish bioassessments. The source of the impairment is unknown and the watershed was first placed on the 303d list for biological impairments in 2002. The St. Mary's River watershed is listed as a low priority for TMDL development.

Mercury

Tissue samples of fish taken from St. Mary's Lake also show high levels of methyl mercury due to atmospheric deposition and bioaccumulation of mercury. A Total Maximum Daily Load was approved for St. Mary's Lake in 2004; therefore, it does not appear on the 303(d) list.

Total Daily Maximum Loads (TMDL)

Segments of the St. Mary's River were identified as impaired by nutrients, sediments and bacteria on the1996 303(d) list.[45] A TMDL has been completed for bacteria. St. Mary's Lake also appeared on the list in 1996 for nutrients, but a water quality analysis was done subsequently and it was determined that there were no uses impaired by nutrients and it was later removed from the list.[46]

[43]Maryland Department of the Environment. *The 2008 Integrated Report of Surface Water Quality in Maryland.* www.mde.maryland.gov/Programs/WaterPrograms/TMDL/Maryland/303dlist/ 2008_Final_303d_list Accessed December 2008.
[44].Maryland Department of the Environment. TMDL home page. www.mde.state.md.us/tmdl/ Accessed September 2002.
[45]ibid, p5,7.Maryland Department of Natural Resources. *Water Quality Newsletter for the Potomac River Tributaries of St. Mary's County*. April 2008. Pub 12-4142008-300.
[46] Rowe, Matthew. Maryland Department of the Environment. Personal communication. December 2008.

What Causes Water Quality Impairment?

Biological

Within selected stream segments, populations of benthic macroinvertebrates and fish and their associated physical habitat have been assessed by the Maryland Biological Stream Program. Based on criteria developed for each physiographic/ ecological zone in Maryland, each stream segment is rated as good, fair, poor or very poor. Ratings of poor and very poor were listed as biological impairment for the first time in Maryland in the draft 2002 303(d) list of impaired waters.

Nutrients

In Maryland, most water bodies naturally have low levels of the nutrients nitrogen or phosphorus. These nutrients enter waterways from all types of land and from the atmosphere. Nutrient pollution or over-enrichment problems may arise from numerous sources. Residential land can be an important contributor of nutrients depending on fertilizer use, extent of lawn and the status of septic systems. Many farmers carefully manage nutrients using different approaches, so nutrients entering waterways from crop land varies greatly depending on management techniques. Typically, smaller amounts of nutrients reach surface waters from an acre of forest land than from an acre of other types of land. The atmosphere can contribute various forms of nitrogen arising from the burning of fossil fuels in power plants and other industries, and from automobiles.

Suspended Sediment

Most unpolluted streams and tidal waters naturally have limited amounts of sediment moving suspended in the water. Excessive amounts of suspended sediment in waterways are considered pollution because they can inhibit light penetration, prevent plant growth, smother fish eggs, clog fish gills, etc. Sediment in streams tends to arise from stream bed and bank erosion and from land that is poorly vegetated or disturbed. Suspended sediment pollution may arise from construction sites, crop land, bare ground and exposed soil. The amount of sediment contributed varies greatly site to site depending upon stream stability, hydrology, management controls and other factors.

Fecal Coliforms

One class of bacteria typically found in the digestive tract of warm-blooded animals, including humans, is known as fecal coliforms. Fecal coliform bacteria are always found in animal waste and human sewage (unless it is treated to kill them). In unpolluted streams and tidal waters, it is common for water samples to contain very few of these bacteria. Water samples exhibiting significantly larger fecal coliform bacteria populations are indicators of contamination by animal, including human, waste. Depending on local conditions, sources of fecal contamination may include any combination of the following: inadequately treated sewage, failing septic systems, wild or domestic animals, urban storm water carrying pet waste and similar sources.

Toxic Substances

A wide array of materials may be considered toxic substances because they exhibit poisonous or lethal effects or otherwise harm aquatic life. These materials are very diverse in their sources and effects. Sometimes toxic substances can occur naturally. However, toxic substances of concern for water quality restoration are those types that are the product of human activity. For regulatory purposes, the U.S. Environmental Protection Agency maintains a list of substances that are considered to be toxic. Examples include heavy metals, polychlorinated biphenyls (PCBs), asbestos and many other materials.

Shellfish Harvesting Restrictions

Portions of the St. Mary's River watershed are affected by shellfish harvesting restrictions. The Maryland Department of Environment is responsible for regulating shellfish harvest. Shellfish, such as oysters and clams, are filter-feeders, which means they filter water through their gills in order trap their food. If the water is contaminated with disease-causing bacteria, the bacteria are also trapped. This could pose a possible health risk if contaminated shellfish are eaten.[47]

PHOTO

Restricted areas are those in which no harvesting is allowed at any time. In conditionally approved areas, harvesting can occur except for the three days following a rain event of greater than one inch in a twenty-four hour period due to the potential for elevated bacteria levels due to runoff. Harvesting can occur at any time in areas designated as open or approved.

There areas are shown in Map X Designated Uses and Use Restrictions. Please visit the MDE's Shellfish Harvesting Areas Web page for the most up-to-date information (http://www.mde.state.md.us/CitizensInfoCenter/FishandShellfish/harvesting_notices/index).

Total Maximum Daily Loads

Waters that appear on the 303(d) list may require a Total Maximum Daily Load. A TMDL establishes the maximum amount of pollutant a water body can receive and still meet water quality standards and designated uses. To calculate the TMDL, pollutant loads from point sources, nonpoint sources, projected growth and a margin of safety are determined and added together.[48] In general, TMDLs include several key parts:

- Existing conditions for pollutant loads and pollutant sources.
- Maximum pollutant load that the water can accept while still allowing the water body to meet its intended use.

PHOTO or graphic

[47]Maryland Department of the Environment. Shellfish Harvesting Areas. http://www.mde.state.md.us/CitizensInfoCenter/FishandShellfish/harvesting_notices/index Accessed January 2009.
[48]Maryland Department of the Environment. TMDL home page. http://www.mde.state.md.us/Programs/WaterPrograms/TMDL/home/index Accessed December 2008.

Allocation of the maximum pollutant load to specific pollutant sources:

1. St. Mary's Lake TMDL

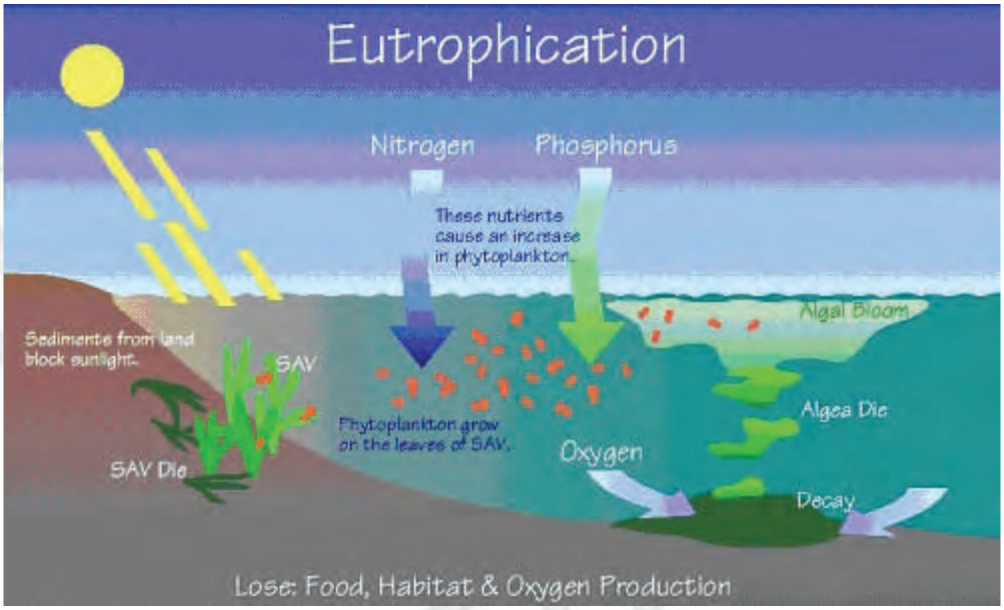
A TMDL for mercury in St. Mary's Lake was approved by EPA in 2004.

St. Mary's Lake receives mercury from atmospheric deposition and other industrial sources in the watershed. Mercury has accumulated in the lake over time, and it is important to note that sources of mercury air emissions from outside Maryland and even the United States contribute to the impairment. According to EPA the primary source of mercury air emissions in Maryland is power plants. Municipal waste combustors, medical waste incinerators, cements plants and other industries also contribute, but to a lesser extent.

The TMDL report lists a number of recent and ongoing initiatives within Maryland, ranging from voluntary to regulatory, that involve the phase-out of mercury usage, industrial handling of mercury-containing products and wastes, and consumer recycling of mercury containing products.

2. St. Mary's River Watershed TMDL

A TMDL for fecal coliforms, a type of bacteria, for restricted shellfish harvesting areas in the St. Mary's River watershed was approved by EPA in 2005. The development of a TMDL for the current biological impairment is rated as a low priority by MDE.



Graphic courtesy Florida International University Department of Environmental Studies *LAB 4: Nutrient Analysis*. http://www.fiu.edu/~envstud/labs/nutrientanalysis.html Accessed January 2009.

What Are the Effects of Nutrient Over-Enrichment?
National Academy Press, Clean Coastal Waters (2000)

The productivity of many [lake, estuary and] coastal marine systems is limited by nutrient availability, and the input of additional nutrients to these systems increases primary productivity [microscopic organisms including algae]. In moderation in some systems, nutrient enrichment can have beneficial impacts such as increasing fish production; however, more generally the consequences of nutrient enrichment for [lake, estuarine and] coastal marine ecosystems are detrimental. Many of these detrimental consequences are associated with eutrophication.

The increased productivity from eutrophication increases oxygen consumption in the system and can lead to low-oxygen (hypoxia) or oxygen-free (anoxic) water bodies. This can lead to fish kills as well as more subtle changes in ecological structure and functioning, such as lowered biotic diversity and lowered recruitment of fish populations.

Eutrophication can also have deleterious consequences on estuaries even when low-oxygen events do not occur. These changes include loss of biotic diversity, and changes in the ecological structure of both planktonic and benthic communities, some of which may be deleterious to fisheries. Seagrass beds are particularly vulnerable to damage from eutrophication and nutrient over-enrichment.

Harmful algal blooms (HABs) harm fish, shellfish, and marine mammals and pose a direct public health threat to humans. The factors that cause HABs remain poorly known, and some events are entirely natural. However, nutrient over-enrichment of coastal waters leads to blooms of some organisms that are both longer in duration and of more frequent occurrence.

Although difficult to quantify, the social and economic consequences of nutrient over-enrichment includes aesthetic, health, and livelihood impacts.

SOURCE: National Academy of Sciences. *Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution*. National Academy Press. 2000.

Water Quality Indicators – Setting Priority for Restoration and Protection

Maryland's Clean Water Action Plan 1998 *Unified Watershed Assessment*[48] established priorities for watersheds in the state for restoration and protection.

As the basis for the prioritization, indicators of water quality, landscape and living resources were developed for all watersheds in Maryland. Other approaches to assessing water quality have been in use for several years and are further described below. In general they do not look comparatively at watersheds as the *Unified Watershed Assessment* did in an effort to set priorities. It also considered a range of living resource and landscape indicators discussed later.

The *Unified Watershed Assessment* looked at five water quality indicators in comparing the state's 134 watersheds (based on Maryland's 8-digit watershed code), though not all watersheds had information to allow generation of each indicator.

In the plan, the St. Mary's River watershed fell into two of four categories but was not considered a priority for restoration: Category 1 - Watersheds not meeting clean water and other natural resource goals and therefore needing restoration and Category 3 (Select) - pristine or sensitive watersheds that need an extra level of protection. The other categories were Category 2 -Watersheds currently meeting goals that need preventive action to sustain water quality and aquatic resources and Category 4 – insufficient data. [Include table of results? What are the five categories? Water Quality, Aquatic Living Resources, Landscape Parameters, Clean Water Requirements and ? Should water quality (N/P) and clean water requirements be discussed here?]

PHOTO or graphic

[49]Clean Water Action Plan Technical Workgroup. Maryland Clean Water Action Plan. December 1998. www.dnr.state.md.us/cwap/ Accessed January 2009.

[Include table of results? What are the five categories? Water Quality, Aquatic Living Resources, Landscape Parameters, Clean Water Requirements and ? Should water quality (N/P) and clean water requirements be discussed here?]

TABLE

Water Quality Monitoring

There has been a large amount of water quality and related data collected in the St. Mary's River watershed in recent years. In 1999, the St. Mary's River Project began collecting water quality data from approximately 25 tidal and non-tidal stations in the area. A stream corridor assessment and tidal shoreline survey was conducted in 2008 by St. Mary's College with support from DNR, NOAA and SMRWA. The assessment identified several potential problem sites and record basic habitat information.[50] St. Mary's College of Maryland also completed a synoptic survey in 2008 which included water quality monitoring and nutrient analysis.[51]

Three shore stations monitored by citizens were established by the Alliance for the Chesapeake Bay and St. Mary's College of Maryland in 1997 in the tidal St. Mary's River to determine the feasibility of restoring species of SAV.[52]

The Maryland Department of Natural Resources Maryland Biological Stream Survey (MBSS) began sampling nontidal wadable streams on a five-year rotation throughout the state in 1994, including fish, benthic macroinvertebrates, water chemistry and habitat. Two streams were monitored in the watershed in 1995. Several more streams were monitored in 2000 and 2003, with plans to monitor again in 2009.[53]

In addition, the U.S. Army Corps of Engineers and Maryland DNR have conducted studies in the watershed.[54] The Maryland Department of the Environment historically collected fecal coliform and other limited water quality data because of concern over commercial shellfish harvests.[55] There is also a U.S. Geological Survey gaging station in the St. Mary's River which has been collecting annually since 1946, with the exception of 2006.[56]

[50]Paul, Robert W. *St. Mary's River Stream Corridor Assessment and Tidal Shoreline Survey*. September 2008. 48 pages. http://stmarysplanning.org/pdfdocs/report_phase1_SCATSS.pdf
[51]Paul, Robert W. *St. Mary's River Watershed Synoptic Survey*. September 2008. 49 pages. http://stmarysplanning.org/pdfdocs/report_phase1_SS.pdf
[52]Paul, Robert W. *St. Mary's River Watershed Water Quality Assessment*. September 2008. 123 pages.
[53]Maryland Department of Natural Resources. MBSS Data Search http://mddnr.chesapeakebay.net/mbss/search Accessed January 2009.
[54]Paul, Robert W. *St. Mary's River Watershed Water Quality Assessment*. September 2008. 123 pages. Duplicate, Change in Final.
[55]ibid.
[56]ibid.

Water Quality Overview

The St. Mary's River watershed consists of approximately 175 miles of streams. It consists of non-tidal freshwater and tidal areas. About 74 percent are first order streams.

Water quality in the St. Mary's River watershed is generally good.

St. Mary's River Project

St. Mary’s College with support from DNR, NOAA and SMRWA prepared a report that reviewed the past 10 years of data collected though the St. Mary’s River Project. A brief summary of the findings follows:

Non-tidal Portion

Dissolved Oxygen

Dissolved oxygen levels in the non-tidal portions of the St. Mary’s River watershed were consistently high in the last 10 years of data collected. Readings below 5mg/L in surface waters indicate insufficient oxygen to support aquatic life.

Nutrients

Nutrients were typically low; however, there were some sites with higher levels. The Locust Grove Cove site has higher nutrient levels compared to others, and data suggests taht nutrients are primarily from organic sources. The tributary from the St. Andrew's Church Landfill also has higher nutrient levels and is experiencing increased urbanization. Nutirents are lower further downstream. The Hickory Hills tributary has higher levels of nutrients which could also be due to runoff and land development. It is suspected that heavy precipitation probably plays large role in transporting nutrients into St. Mary's River tributaries.

Total Suspended Solids

Generally, the mean TSS values were relatively low (<20mg/L) in the watershed. Variability was closely tied to precipitation, and was most noticeable in Pembrook Run, Fisherman Creek, and Church Creek. The Church Creek site was observed to have poor storm water controls and high discharges that lead to erosion. In addition, high levels of sediment in St. Indigoes Creek have been noted by nearby residents.

Alkalinity, pH and Dissolved Organic Carbon

Alkalinity and pH in the St. Mary’s River watershed are similar to levels in other areas of the coastal plains. Alkalinity is generally low, less than 50 mg/L of $CaCO_3$, and pH levels are generally between 6.5 and 7 standard units. Overall, dissolved organic carbon levels were low, less than 10mg/L, with the exception of the tidally-influenced site at Locust Grove Cove.

Temperature

Temperatures of the non-tidal sites averaged 25C, and followed a seasonally pattern. Temperatures of St. Mary’s Lake were higher overall due to surface warming, and the sample site downstream of the release also had higher temperatures. In addition, the tidally influenced Locust Grove site also had higher temperature. Healthy levels are typically below 30C.

Visit the St. Mary’s River Project:
http://smrpweb.smcm.edu/

St. Mary's River Project continued

Tidal Portion

Much of the variability in tidal results seems to be driven by season weather patterns, precipitation, algal growth and decay, and oxygen profiles in the water column.

Dissolved Oxygen

Low oxygen levels have been found at the deeper sites of St. Mary's River every summer for the past nine years. Tidal creek stations also showed low oxygen levels, but not as severe as the main channel of the river. It is believed that this low oxygen is related to nutrient enrichment in the spring from runoff, which fuels algal blooms, which subsequently die off and decompose, reducing oxygen levels.

Nutrients

Nitrogen concentrations were quite variable, but generally occurred in relatively low concentrations at all sites. The tidal stations located furthest upstream, closest to freshwater sources, generally had the highest nitrogen and phosphorus levels.

Total Suspended Solids

Concentrations were variable between stations and sampling periods, ranging between less than 5mg/L to nearly 100mg/L. TSS was linked to precipitation and was highest in spring and summer. Higher levels were sometimes recorded after storm events. For Use I waters Maryland water quality standards state that sediment loads should not be more than 150 at any one time, or 50 as a monthly averages. Concentrations of 15 mg/l or greater are is believed to generally inhibit growth of SAV because light can not penetrate to the plants' leaves.

Chlorophyll

Chlorophyll can be used to assess phytoplankton in the water column. Phytoplankton blooms are stimulated by a combination of factors including high nutrient levels and light. In spring of 2000 Maryland DNR reported the highest densities of a dinoflagellate species in 20 years. While no fish kills were reported for the St. Mary's River, observations of a mahogany color of the surface waters and high levels of chlorophyll indicate that a bloom occurred in the river as well. The chlorophyll threshold is exceeded most years, but the highest chlorophyll values were reported in spring of 2000, and the summers of 2001 and 2003. The high chlorophyll and algal concentrations likely contributed to decreased oxygen levels in the bottom waters of the St. Mary's River and its tributaries.

St. Mary's River Project continued

pH

The sites located furthest up-river tended to display the lowest pH values and the most variation because these sites are more directly effected by activities on land and are farther from the cleansing and stabilizing forces of oceanic waters, explaining the lower and more variable pH at the upper most end of the tidal river.

Salinity

The tidal portion of St. Mary's River is largely a partially-mixed mesohaline (moderate salinity) estuary with salinities between 10ppt and 20ppt. Salinity showed an annual cycle with highest levels in the fall and early winter and lowest levels in late spring and summer due to increased rainfall.

Temperature

Water temperature showed pronounced seasonal variation at all tidal stations. For most of the year the water column was partially mixed, but distinct temperature and/or salinity layers were observed, indicating that the river can become highly stratified.

Tributary Team Characterization for Potomac River - 2005

[Tributary Team Characterization for Potomac–should this be included? Outdated, data has been collected through 2005.]

[51]D

Sources of Pollution

Since European settlement of North America there has been an explosive growth in human population, supported by more intensive agriculture and the growth of industry. Vast transportation systems have been developed making the entire continent mutually interdependent. In general, water quality in the St. Mary’s River watershed is good and most problems in the watershed are localized.

Point Sources

Discharges from a single identifiable source, such as a pipe or other discrete conveyances are called point sources. This includes discharges from waste water treatment plants and industrially sources. Point sources may contribute pollution to surface water or to groundwater. Identifying point source discharges in a watershed can be useful in potential restoration measures.

There are few permitted point source discharges in the St. Mary's River watershed. Summary information is present in Table XX and on Map XX.

St. Andrews Landfill is permitted to discharge in tributaries in the upper St. Mary's River watershed.

[Others]

Information on permits can be obtained from MDE’s Environmental Permits Service Center (EPSC).

Nonpoint Sources

Nonpoint sources are also significant contributors of pollutants, particularly nutrients and sediments. This pollution comes from many diffuse sources. This includes rain water that runs off roofs, streets and parking lots, as well s runoff from farm fields, yards and to a lesser extent forests. Atmospheric deposition and contributions from groundwater, where septic systems are a factor, are also considered nonpoint source pollution.

Nonpoint source pollution is a potential problem in the St. Mary's River watershed. Storm events have a major impact on the river and streams by carrying sediments and nutrients downstream and into the tidal river.

Shoreline Erosion

Wherever land and open water meet, change in the form of erosion or accretion of land is typically the inevitable result of natural processes. Human activity in these areas either tends to inadvertently accentuate these natural processes or purposefully attempts to control movement of water and/or loss of land. Erosion of shorelines can contribute significant amounts of nutrients (mostly phosphorus) and sediment (water column turbidity, habitat loss.)

Countywide shoreline erosion is summarized in the following table.[57]

St. Mary's County Shore Erosion Rate Summary (Miles to Shoreline)				
Total Shoreline	Total Eroding Shoreline	Erosion Rate		
		0 to 2 feet / year	0 to 4 feet / year	4 or more feet / year
297	87 (29%)	61	9	17

Maps of historic shoreline change were produced in 1999 by the Maryland Geological Survey (MGS) in a cooperative effort between DNR and the National Oceanic and Atmospheric Administration (NOAA). These maps included digitized shorelines for several different years in St. Mary's County. The maps show that extensive changes have occurred adjacent to large bodies of open water. Copies of these 1:24000 scale maps are available from the MGS.

Currently, DNR is working to improve our ability to predict areas of high-rate shoreline erosion. In addition to considering historic erosion rates, contributory effects of land subsidence and sea level rise are being considered. To help generate predictive tools, two pilot areas have been selected: St. Mary's County and Dorchester County. Results from this work are not currently available but information will be shared with St. Mary's County and other interests when they become available.[Is this data available?]

[57]Maryland Shore Erosion Task Force. *Final Report, State of Maryland Shore Erosion Task Force.* January 2000. 64 pages. http://www.mgs.md.gov/esic/publications/download/drnerostf.pdf

Sources of Pollution continued

Impact of the Potomac River

The mouth of the St. Mary's River empties into the Potomac River, but because of the tidal nature the Potomac River can have an impact on St. Mary's River water quality.

Landscape Indicators
1. Impervious Surface (KCI Study)
2. Population Density
3. Historic Wetland Loss
4. Unbuffered Streams (Mark Muir)
5. Soil Erodibility
Land Use
2008 RPD Task Force Study
2008 Encroachment Study
Lands With Significant Natural Resource Value and Large Area
1. Green Infrastructure
2. Large Forest Blocks
Mining – need and impacts
Protected Lands
1. St. Mary's River Wildlands
2. St. Mary's Lake
3. County Parklands
Soils of the St. Mary's River Watershed
1. Interpreting Local Conditions with Natural Soil Groups
2. Soils and Watershed Planning
Wetlands
1. Wetland Categories (Eyes on the Bay web site)
2. Tracking Wetlands (ground truthing wetlands)
3. Interpreting Wetland Distribution
Floodplains
Steep Slopes
Low Elevation Areas Subject to Sea Level Rise
Hurricane and Storm Inundation
KCI Study on mitigation sites
Lands Targeted for Development
1. Lexington Park Development District
2. Towns, Villages, and Rural Centers

Bruce/Sue—erodibility

Bruce— soils, mining,

Robin—encroachment, & Navy

Dudley—protected lands

Bob L.—lands targeted for development, AICUZ

Sue—landscape indicators, lands of significant, wetlands, floodplains, steep slopes, land ...sea level rise

—RPD task force

Housing & Welfare
- Workforce Housing Study
- Homeless ?? do we have anything?
- Soup Kitchens
- Health & Medicine ?? do we have anything?
- Mental Health Clinics

Employment
- Water-based economies and businesses – impacts and greening

Infrastructure
- Transportation – impacts from snow removal

Joe—housing, welfare

Bob L.—employment
John Groeger—public transportation, waste issues, etc.

Point Source Discharges—Sewerage and Landfills

Discharges from pipes or other discrete conveyances are called point source. Point sources may contribute pollution to surface water or to ground water. For example, wastewater treatment plant discharges may contribute to nutrient or microbes that consume oxygen measured as Biochemical Oxygen Demand (BOD). The BOD reduces the oxygen supply available for aquatic life where discharge occur . Industrial point sources may contribute various forms of pollution. Some understanding of point source discharges in a watershed can be useful in helping to identify and prioritizing potential restoration measures.

In the St. Mary's River watershed, there are several permitted point source discharges based on information from the Maryland Department of the Environment.

- The Webster Field Sewage Treatment Plant is the only treatment plant discharging directly into the St. Mary's River. The plant is permitted for a capacity of 45,000 gallons per day. The plant handles the domestic waste generated on the Navy's Webster Field facility. (Permit No. NPDES #MD0020095)
- The St. Andrews Municipal Landfill is also located in the watershed. The landfill is currently not in operation; however there is an open permit to expand the filling activities in the future if the need arises. (Permit No. 2005-WMF-0138)
- The Knott Land Clearing Debris Landfill is permitted by the Maryland Department of the Environment and is located ¼ of a mile north of the intersection of Flat Iron Road and Booth Road in Great Mills, MD. (Permit No. 2006-WLC-0134)

Other large industrial and institutional sites in the watershed are:

- Valero Petroleum Company's transshipment and storage facility. The facility is of regional importance since it supplies petroleum to the Washington D.C. area.
- The Harry Lundeberg School of Seamanship is also located with in the St. Mary's River drainage area. The school specializes in providing vocational training to those persons seeking a career in Merchant Marines.

Can we get two photos?? Outfall of Webster Field and Landfill?

Point Source Discharges—Existing Sewer Systems

A large portion of the St. Mary's River watershed lies within the St. Mary's County Metropolitan Commission's Sanitary Districts #5 (Piney Point) and #8 (Lexington Park). The lower eastern shore of the St. Mary's River is within the Sanitary District #7 which is not served by public facilities at this time. The public sewage collection system in these areas directs the sewage to the Marley Taylor Water Recovery Facility and after treatment the effluent is discharged into the Chesapeake Bay. There are 42 major sewage pumping stations in Sanitary District #8 and four major pump stations in Sanitary District #5. Those pump stations are shown in Table 7-1.

Only 32 in table—text mentions "42"

Pump Station	Pump Station ID	Sanitary District	Address	Design Flow
Great Mills	015	8	20208 Pint Lookout Road	400
Greenbrier	029	8	47113 Schwarzkopf Drive	450
Hickory Hills	022	8	45599 Amber Drive	825
Hilton Run	017	8	46740 Hilton Drive	273
Hunting Quarters	034	8	20881 Hunting Quarter Drive	300
Laurel Glen	031	8	26695 Laurel Glen Road	80
Lynn Drive	009	8	21325 Lynn Drive	250
Meadow Lake	048	8	45484 Columbine Place	194
Moorings	028	8	48261 Keel Drive	80
Patuxent Park West	016	8	21637 Liberty Street	240
Pegg Road	047	8	21895 Pegg Road	92
Pembrooke	054	8	20540 Pershing Drive	600
Picketts Harbor	024	8	48251 Pisketts Harbor Court	107
Planters Court	035	8	46839 Planters Court	120
Riverbay	052	8	48053 Spinnaker Circle	209
Rue Woods	044	8	22666 Sylvan Way	85
Southgate	021	8	21111 Three Notch Road	65
Spring Valley	011	8	46485 Rosewood Drive	250
St. Mary's City	004	8	17061 Point Lookout Road	568
St. Mary's Industrial Park	027	8	23751 Three Notch Road	293
St. Mary's Square	007	8	21592 Great Mills Road	150
Waters Edge	019	8	48400 Surfside Drive	145
Westbury	056	8	21572 Croaker Court	260
Widgeon	042	8	44919 Widgeon Place	42
Wildewood #1	003	8	23251 Laurel Hill Drive	446
Wildewood #2	026	8	45574 Aspen Lane	295
Wildewood #3	032	8	44437 Redwood Lane	243
Willow Woods	051	8	46687 Sandalwood Street	40
Piney Point	002	5	45271 Bloch Avenue	350
Piney Point Landings	025	5	17999 Driftwood Drive	220
Sheehan	041	5	17831 St. Georges Park Road	125
St. George Island	030	5	16668 Piney Point Road	140

Table 7-1. Source: St. Mary's County Metropolitan Commission, 2009.

Ground Water and Water Supply—Aquifers

Potable water is supplied through three confined aquifers throughout St. Mary's County. They are the Piney Point, Aquia, and Upper Patapsco. Sporadic use, mostly for agriculture, is supplied by a fourth unconfined aquifer, the surficial aquifer commonly referred to as the water table. This source is generally not reliable in drought years or seasonally. The surficial aquifer may contain contaminants.[71] Historically, hand-dug wells into the surficial aquifer were used for potable usage. Over time and through extensive Federal water projects in the 1940s, these wells have been replaced with public water supplies or modern wells drilled into the Piney Point or Aquia. It is not known how many, if any, of these wells that supply drinking water are still in existence.

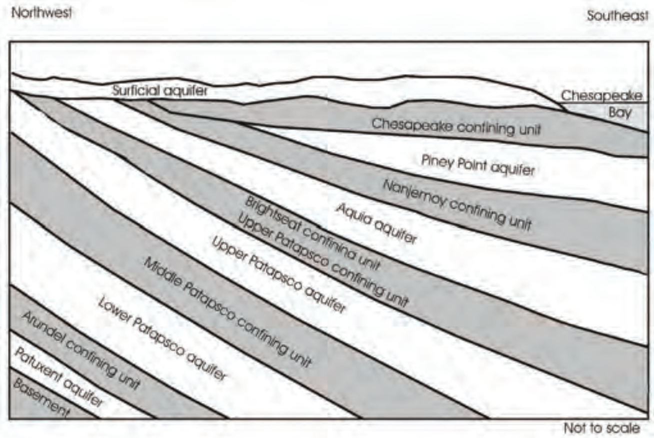


Figure 7-1. Schematic cross section of the hydrogeological units in southern Maryland. Source: Drummond, 2005, p27.

Figure 7-1 depicts the aquifers and the separating clay layers, which inhibit the movement of ground water. Shown from highest to lowest elevation, they are the surficial, Piney Point, Aquia, Upper Patapsco, Lower Patapsco, and Patuxent. Below the Patuxent is bedrock and it is not considered to be a significant water supply.[72] The aquifers and confining units are sloped downward from northwest to southeast, thus allowing the northwest end of each aquifer to subcrop (extend to the land surface) and mix with the surficial aquifer. These areas allow surface water to enter each of the confined aquifers and recharging water supplies. Confined aquifers are under pressure from the weight of the land and water causing the water to rise in height within wells to a level somewhat above the top of the aquifer at each well location. This water level is referred to as the potentiometric surface.

5.

Maryland Department of the Environment regulates water withdrawal from aquifers. When potentiometric surface levels reach a point 80% below the land surface and the top of the aquifer, additional withdrawals are curtailed. Withdrawal below this level may cause land subsidence, reduced productivity, and/or brackish water intrusion.[73]

The **Piney Point** aquifer, known in some research reports as the Nanjemoy or Piney Point Nanjemoy, subcrops in central Charles and Calvert counties. It is primarily used for private domestic water supply for older homes in the Lexington Park development district and homes in rural areas of the St. Mary's River watershed. Water supplies from the Piney Point are high quality and generally contain only trace amounts, if any, of arsenic. The Piney Point is available throughout the St. Mary's River watershed.

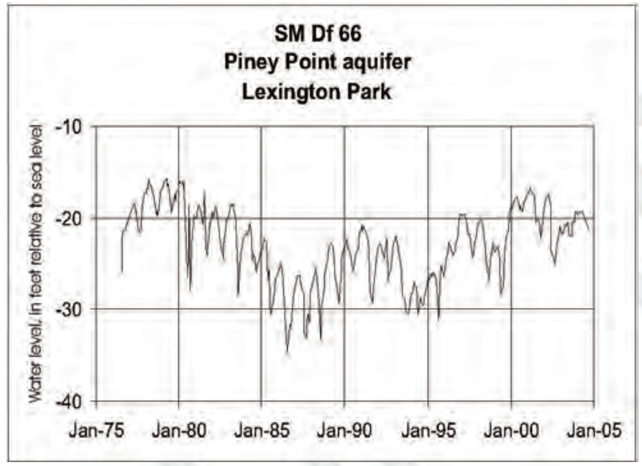
[71]Drummond, David D., WATER-SUPPLY POTENTIAL OF THE COASTAL PLAIN AQUIFERS IN CALVERT, CHARLES, AND ST. MARY'S COUNTIES, MARYLAND, WITH EMPHASIS ON THE UPPER PATAPSCO AND LOWER PATAPSCO AQUIFERS; Maryland Department of Natural Resources Resource Assessment Service; June 2005, p4.
[72]ibid, p3.
[73]Drummond, D.D., 1988, Hydrogeology, brackish-water occurrence, and simulation of flow and brackish-water movement in the Aquia aquifer in the Kent Island area, Maryland: Maryland Geological Survey Report of Investigations No. 51, p31.

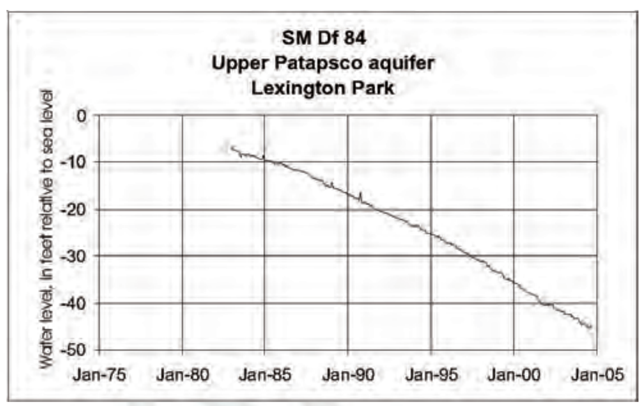
Ground Water and Water Supply—Aquifers continued

The **Aquia** aquifer is separated from the Piney Point by the Marlboro Clay confining layer. This aquifer is used extensively for domestic and major-user supplies in southern Maryland, as well as in Virginia and the Eastern Shore of Maryland. It is also used by commercial, industrial, and military users within the watershed. The Aquia subcrops in northwestern Charles County.[74] It is available throughout the St. Mary's River watershed (it is not productive in southern St. Mary's County).

Water quality in the Aquia is generally good, except arsenic concentrations exceed the new U.S. Environmental Protection Agency Maximum Contaminant Level (MCL) of 10 micrograms per liter (µg/L) (Federal Register, 2001) for public water supplies.[75] For this reason, expansion of public water supplies are supplied by the Patapsco. Existing waters supplies in the Aquia not meeting the new MCL are being terminated and replaced by the Patapsco. Lowered potentiometric surface in excess of 220 feet form a deep cone of depression in the Lexington Park area due to heavy withdrawals. (see Map 7-1) Levels dropped more than 90 feet in the 1990s.[76]

The **Upper Patapsco** and **Lower Patapsco** aquifers are believe to have some localized exchange of water. Within each aquifer there are complex stratified sandy units separated locally by silty sand and clayey units. These sands appear to be interconnected at a regional scale to form a single aquifer.





Figures 7-2, 7-3, 7-4. Hydrographs showing long-term potentiometric surface trends in Lexington Park. Source: Drummond, 2005, p35.

[74] Drummond, David D., WATER-SUPPLY POTENTIAL OF THE COASTAL PLAIN AQUIFERS IN CALVERT, CHARLES, AND ST. MARY'S COUNTIES, MARYLAND, WITH EMPHASIS ON THE UPPER PATAPSCO AND LOWER PATAPSCO AQUIFERS; Maryland Department of Natural Resources Resource Assessment Service; June 2005, p5.
[75] ibid, p5.
[76] ibid, p5,7.

Recharge of the Patapsco is at or near to the fall line or along Interstate 95. Salt water intrusion at Indian Head is believed to be due to a cone of depression allowing the interconnection between the subcrop area and the Potomac River. Potentiometric surface of the Upper Patapsco in Lexington Park has dropped 37 feet since 1983.[77] Water quality in the Patapsco is very good and no arsenic has been detected.

The **Patuxent** aquifer lies on bedrock and is the deepest aquifer in southern Maryland. A test well in Lexington Park supplied brackish water, therefore, the Patuxent is not considered a source of potable water.[78]

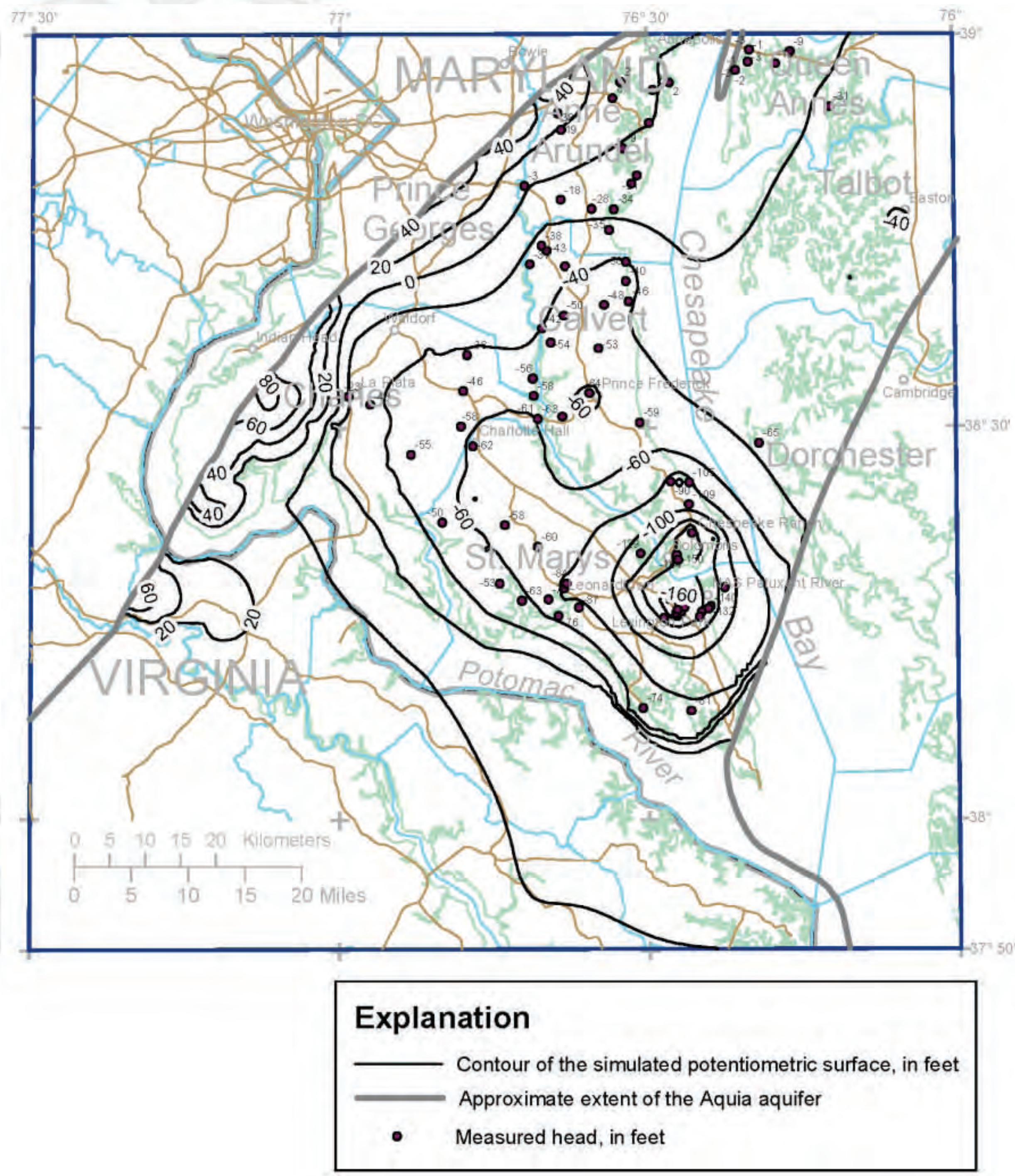
A fourth confined aquifer, the **Magothy** regionally located between the Aquia and the Upper Patapsco, does not extend into the St. Mary's River watershed area.

Effects of falling potentiometric surface can negatively affect private wells. Wells have been constructed with 4-inch diameter casings near to the land surface to accommodate a submersible pump, but reduce to 2-inch diameter below that to save on construction costs. These are referred to as **telescoping wells**. Drummond writes, "If the potentiometric level falls below the reduction point (or near to the reduction point due to pump drawdown) in such a well, the pump cannot be lowered further and the well must be replaced. … [this] may cause significant economic impact in areas where telescoping wells are common."[79]

Within the St. Mary's River watershed area the effects of withdrawals and lower potentiometric surface of the Aquia generally have no effect on the water table.[80] A lowered water table may include reduced base flow to streams, a decrease in water available for plant transpiration, and altered ecology of wetlands.[81] These processes are complex and localized, and were not addressed in the June 2008 Drummond study. Additionally, excessive drawdown may invite river water or Bay water intrusions; this effect noted currently in the Indian Head area for the Upper Patapsco.

According to the June 2008 Drummond study, **future pumping trends** in the St. Mary's River watershed and the Lexington Park area do not anticipate any significant negative effects to the three confined aquifers through the year 2030. As the public supply continues to limit additional pumpage in the Piney Point and Aquia, potentiometric surface lowering should decrease. Increased use of the Patapsco was studied according to land use regulations at the time. Recently, the county adopted new rules for designated growth patterns (Annual Growth Policy, August 19, 2008), which may increase development pressure in the Lexington Park development district and cause further lowering of potentiometric surface than Drummond's model projected. Likewise, the Drummond model does not anticipate any new major users (industrial, agricultural, military, or extraction).

[77]Drummond, David D., WATER-SUPPLY POTENTIAL OF THE COASTAL PLAIN AQUIFERS IN CALVERT, CHARLES, AND ST. MARY'S COUNTIES, MARYLAND, WITH EMPHASIS ON THE UPPER PATAPSCO AND LOWER PATAPSCO AQUIFERS; Maryland Department of Natural Resources Resource Assessment Service; June 2005, p7.
[78]Hansen, H. J., and Wilson, J. M., 1984, Summary of hydrogeologic data from a deep (2,678 ft.) well at Lexington Park, St. Mary's County, Maryland: Maryland Geological Survey Open-File Report No. 84-02-1, p61.
[79]Drummond, June 2005, p8.
[80]ibid, p.
[81]Achmad, Grufron, 1991, Simulated hydrologic effects of the development of the Patapsco aquifer system in Glen Burnie, Anne Arundel County, Maryland: Maryland Geological Survey Report of Investigations No. 54, p90.



Map 7-1. Simulated potentiometric surface in the Aquia aquifer, 2002. Source: Drummond, 2005, p29.

The public water system is operated by the St. Mary's County Metropolitan Commission and utilizes water supplied through confined aquifers. The production wells for this system are screened in three unconsolidated confined aquifers. Ranging from shallowest to deepest these are the Piney Point, Aquia, and Patapsco Aquifers. Most of the wells are screened in the Aquia Aquifer (16 wells), while the Patapsco (5 wells) and the Piney Point (3 wells) aquifers feature a significant fewer number of wells. A similar ratio is exhibited for the well population supporting the small community systems.

Presently the St. Mary's County Metropolitan Commission operates 24 production wells in the Lexington Park system with a total average pumping capacity of about 220 gallons per minute per well across a range of 55 to 600 gallons per minute. Independent of the public system, more than 35 small community systems (trailer parks, developments, military bases) operate 104 wells to meet the local demand in St. Mary's County. The public wells in the Lexington Park area are shown in Table 7-2.

Need to mention that METCOM has removed service from some wells (arsenic) and replace that service with wells in the Patapsco...

Well	Pump Flow Rate	Aquifer	MDE Allocation*
Abberly Farms	450	Patapsco	450
Bank Square	270	Aquia	1010
Colony Square	170	Aquia	1010
Espranza Farms	140	Aquia	1010
Essex Drive	140	Aquia	100
First Colony #1	220	Patapsco	330
First Colony #2	300	Patapsco	330
Great Mills	140	Piney Point	140
Greenbrier #1	450	Patapsco	80
Greenbrier #2	280	Aquia	30
Greenview Knolls #3	120	Aquia	60
Hickory Hills	55	Aquia	10
Laurel Glen	200	Aquia	40
Pegg Road	435	Aquia	1010
San Souci	120	Aquia	1010
St. Mary's Industrial Park	350	Patapsco	240
Town Creek #3	115	Piney Point	140
Town Creek #6	145	Piney Point	140
Tubman Douglas	60	Aquia	30
Wildewood #1	85	Aquia	240
Wildewood #2	80	Aquia	240
Wildewood #3	120	Aquia	240
Wildewood #4	600	Aquia	600
Willow Road	140	Aquia	1010

*Note: Flow Rate and MDE Allocation given in gallons per minute

Table 7-2. Source: St. Mary's County Metropolitan Commission, 2009.

Emergency Services

Emergency Services
1. Hazard Mitigation Plan
2. Emergency Evacuation Plan

Agriculture
- Growing for Local Consumption
- Grains and bio-fuel
- Animal Operations
- Equine Facility Needs & Impacts

—emergency services

Bruce/Donna—agriculture

Chris—SAV (indicators, status, & potential), oysters

Ernie??—FIDS, birds

Becki/Lindsay—migratory fish, IBI, headwaters, fish & crabs, Benthos, sensitive species, rare/threatened, Fish Consumption Advisory

Many fish are safe to eat; however, some fish contain chemicals that may harm children and adults. The Maryland Department of the Environment is responsible for determining how much of a given species caught in Maryland's waters can be safely consumed.

There are statewide advisories for the consumption of small and largemouth bass from all public waters, as well as an advisory on sunfish, including bluegill, from lakes and other impoundments. St. Mary's Lake has an additional advisory for small and largemouth bass due to high mercury levels.

For more information on state and federal fish consumption advisories, please contact MDE or visit the MDE Fish and Shellfish home page, www.mde.state.md.us/CitizensInfoCenter/FishandShellfish/home/index.

Benthic Macroinvertebrates

RESTORATION AND CONSERVATION TARGETING

2009 Corps Reports

1. Report 1
2. Report 2 (etc. through 5)

2007 VIMS Performance of Sills - shoreline study

Conservation Programs

1. Agricultural Conservation Programs(RuralLegacy, Ag Dist., Ag Pres, CREP)
2. Energy
3. Oyster Floats

Smart Growth

1. Priority Funding Areas
2. Transfer of Development Rights
3. Forest Stands and Open Space

Green Site Design

1. Adding Green Infrastructure to Developments

Green Building

1. Gray Water Reuse
2. Septic System Upgrades and Grant Program
3. Energy Conservation

Marina Programs (Clean Marinas web page on DNR site)

SAV Restoration Potential

Maryland Department of Natural Resources Programs

1. Fish Blockage Removal

Stream Buffer Restoration

1. Benefits and General Recommendations
2. Using GIS
3. Headwater Stream Buffers
4. Land Use and Stream Buffers
5. Nutrient Uptake from Hydric Soils in Stream Buffers
6. Optimizing Water Quality Benefits by Combining Priorities

Forestation and Wetland Restoration (KCI Study)

Jon—corps reports, adding green infrastructure to developments

Bruce—sillreport (please summarize)

Bob L.—ag consv., smart growth, PFAs TDRs, marina programs, nutrient uptake,

Donna—forest stands/open space (lands targeted)

Larry—green building

Chris—SAV restoration

—fish blockage removal programs (DNR programs?)

Bob P./Chris—Stream Buffer Restoration, Using GIS, Headwater Stream Buffers, Land Use and Stream Buffers, Optimizing Water Quality Benefits by Combining Priorities

Bob P.—forestation/wetland/KCI study (Bob to provide study)

PROJECTS RELATED TO THE WRAS PROCESS

Corps Studies

Watershed Evaluation for St. Mary's River Watershed

Piney Point Aquiculture Facility

1. SAV and Crab Study
2.

St. Mary's River Watershed Association Oyster Recovery Assessment Study

Potomac Riverkeeper River Watchers

Potomac Riverkeeper Get The Mud Out

Lexington Park Redevelopment Campaign

Transportation

1. Pegg Road Extension
2. Chancellors Run Road Expansion
3. FDR Boulevard

SMC Dept. Public Works & Transportation Survey of Storm Water Control Facilities

Potomac River Association Storm Water Facilities Survey

Robin—LP redevelopment campaign

John G.—transportation, survey of SW facilities,

Bob L.—PRA SW survey

—Corps Studies, Watershed Evaluation for St. Mary's River Watershed, Piney Point Aquiculture Facility, SMRWA Oyster Recovery Assessment Study, Potomac Riverkeeper River Watchers, Potomac Riverkeeper Get The Mud Out

POTENTIAL BENCHMARKS FOR WRAS GOAL SETTING

REFERENCES

GLOSSARY

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BACK COVER