State of Maryland's Comprehensive Water Monitoring Strategy

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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EXECUTIVE SUMMARY

Maryland has updated its Comprehensive Water Quality Monitoring Strategy for all State waters in response to recent EPA guidance provided in their "Elements of a Water Monitoring and Assessment Program" document (EPA 841-B-03-003). This Strategy covers all water body types throughout the State, including rivers and streams, lakes, tidal waters, ground water and wetlands.

Maryland's water quality monitoring programs were designed to support State Water Quality Standards (Code of Maryland Regulations Title 26, Subtitle 08) for the protection of both human health and aquatic life. This Strategy identifies the programs, processes and procedures that have been institutionalized to ensure State monitoring activities continue to meet defined programmatic goals and objectives. The strategy also discusses current data management and quality assurance/quality control procedures implemented across the State to preserve data integrity and guarantee that data are of sufficient quality and quantity to meet their intended use. Samples sizes, confidence limits, analytical procedures and weight-of-evidence approaches to determining water body impairment status are also included herein.

In addition to discussing current water quality monitoring programs, this update includes a 10-year implementation timeframe for strengthening existing programs, developing new assessment tools, as well as improving public access to and documentation of State water quality data. Resource and other constraints to program improvements are also discussed.

Although Maryland's Strategy effectively addresses all State waters and meets current priorities and goals, it is still very much a living document that will evolve with updated standards, new monitoring tools and technologies, emerging issues, more sensitive analytical techniques, and with increased collaboration and cooperation among citizens and stakeholders. Maryland looks forward to working with partners across all levels of government and the private sector to build upon these current successes, forge new partnerships and initiatives, and make more efficient use of limited State monitoring resources. Watersheds are a common resource that defy political boundaries and connect us all. Therefore the measure of our success will be determined solely on our ability to work together in preserving and improving Maryland's unique aquatic resources.

1.0 <u>Monitoring Program Strategy and Design</u>

The State of Maryland has a comprehensive water monitoring strategy that provides for assessment of all State waters and which addresses specific resource management and regulatory objectives. The key components of this strategy, responsible agencies and primary funding sources are provided in Table 1.

Table 1: Major functional monitoring needs.

Program Function	Responsible Agencies	Primary Funding Sources
305(b) and 303(d) assessments (integrated report)	MDE and DNR	State general funds, Federal 106 grant
Water Quality Standards[1] development	MDE and DNR	Federal 106 grant, State funds
TMDL development	MDE	Federal 106 grants, State funds
TMDL implementation (WRAS)	DNR	Federal 319 grant, State and local funds
Water quality characterization/trends/criteria assessment (Core/Trend stations, Chesapeake Bay and tidal tributary stations)	DNR	Federal 106, 117 grants, State general funds
Ambient condition (aquatic life use) monitoring (Maryland Biological Stream Survey, Chesapeake Bay Benthic, Plankton, HAB monitoring)	DNR	Federal 106, 117 grants, Environmental Trust Funds
Public health protection at beaches	Local health departments (MDE oversight and guidance)	Local funds supplemented by funds from federal (National Beaches) grant
Tissue contaminants for fish and shellfish[2]	MDE	State general funds
Wetlands condition	MDE and DNR	State and federal funds
Drinking water supplies	MDE	State general funds and DWSRF
Classification of shellfish waters	MDE	Federal 106 grant, State general funds
Groundwater	MDE	Safe Drinking Water Act Funds

[1]The existing data from the Chesapeake Bay monitoring program contributed significantly to the development of Chesapeake Bay standards; a separate grant has been received for development of nutrient criteria in rivers and streams.

[2]Power plant funds have provided funding for mercury in fish in impoundments in the past.

Other key aspects of the monitoring strategy are: (1) interagency cooperation across all levels of government (federal, state, and local) and the private sector; (2) building on agency strengths and experience; (3) actively seeking additional funding to improve and expand monitoring programs; and, (4) public participation and outreach. The State also capitalizes on opportunities to obtain technical assistance through federal agency experience, workshops, symposia, and relationships with academic institutions in order to improve State water monitoring programs.

Maryland's monitoring framework adequately assesses rivers and streams, impoundments (Maryland has no natural lakes), wetlands, and estuarine, and tidal waters, and meets public health requirements with respect to toxic contaminants in fish and shellfish, and the presence of pathogens in waters. Different monitoring designs, water quality indicators and sampling frequency are utilized depending on project-specific goals and objectives. Most monitoring programs collect samples monthly, seasonally, annually or on a multi-year cycle and are, at times, integrated with special supplemental studies developed to answer specific questions.

1.1 Sampling Design

Maryland employs multiple sampling designs to address different programmatic needs. As the regulatory agency in the State, the Maryland Department of the Environment (MDE) generally uses targeted monitoring and fixed stations to evaluate point source discharges associated with permitted facilities, develop water body specific TMDLs, and to protect public health. The Department of Natural Resources (DNR) is responsible for conducting statewide assessments on the condition of Maryland's living resources. Accordingly, DNR uses both fixed-station as well as probabilistic, stratified random design to statistically sample the entire State at regular intervals. Close coordination between DNR's assessment programs and MDE's regulatory programs ensures that water quality concerns across the State are effectively identified, prioritized and addressed. These programs address both public health and aquatic life needs.

1.1.1 Application of probabilistic monitoring design

Probabilistic monitoring using biological assessment tools (Maryland Biological Stream Survey – MBSS, and Chesapeake Bay Benthic Monitoring - CBBM) provides for the integrated and comprehensive assessment of most State waters. Biological communities are sensitive to multiple environmental stressors over relatively long timeframes, which, coupled with a probability based site selection, provides for an efficient means of Statewide water quality assessment. Biological assessments effectively address the potential for both cumulative impacts as well as provide a screening mechanism for identifying emerging pollutants.

Bioassessment methods are well documented and their application to 305(b) reporting and 303(d) listing is published in the Integrated 305(b)/303(d) report. MBSS monitoring of fish and benthic macroinvertebrate communities is conducted on a five-year cycle and reassessed at the end of each cycle. Common nutrient and physical parameters as well as stream habitat data are collected in conjunction with biological monitoring. The CBBM, which includes fixed as well as probabilistic stations, randomly selects new sites on an annual basis and across multiple habitats (six different salinity strata, and two sediment types).

1.1.2 Application of fixed station monitoring and Watershed Cycling

1.1.2.1 Environmental Health and Aquatic Life Use Support

Fixed station monitoring serves several purposes. Maryland assesses the entire state using physical/chemical monitoring on a five-year cycle that will become consistent with environmental permitting cycles. These data are used to evaluate the effectiveness of permits, are integrated with biological assessments for 305(b) and 303(d) purposes, and aid in the development of TMDLs. Chesapeake Bay monitoring has been redesigned to accommodate the new water quality standards and assessment methods published as regional guidance. Although not yet promulgated, those water quality standards are in preparation.

1.1.2.1.1 Wetlands

MDE and DNR submitted a joint grant proposal in 2004 to develop a statewide wetland assessment methodology (see section 3.4). The objectives for Maryland's wetland monitoring and assessment program include:

1) Meet 305(b) reporting requirements;
2) Improve existing wetland and waterway regulatory programs;
3) Provide additional information for targeting wetland/waterway restoration and protection efforts;
4) Comply with TMDL requirements, if applicable;
5) Develop use designations and water quality standards for wetlands;
6) Assist in evaluating the effectiveness of compensatory mitigation;
7) Improve our ability to comprehensively assess landscape and watershed function;
8) Develop the capability to study and assess the status of wetland condition over time; and
9) Make wetland condition and functional value information available for use in federal, State, local and citizen group-driven natural resource conservation and restoration efforts (examples include Tributary Strategies, Watershed Restoration Action Strategies, TMDL implementation plans, Green Infrastructure Assessment/GreenPrint Program, Strategic Forest Lands Assessment, etc.).

1.1.2.1.2 Monitoring for Modeling Needs

Fixed stations provide the data necessary to calibrate watershed models for TMDL development and provide data for load duration models. This monitoring design necessarily accommodates the location of gauging stations and model segmentation. In addition, this monitoring serves to refine and calibrate the Chesapeake Bay water quality model.

1.1.2.2 Public Health and Recreational Uses

1.1.2.2.1 Shellfish

Bacterial monitoring in estuarine waters is conducted consistent with the requirements of the United States Food and Drug Administration (USFDA)/State National Shellfish Sanitation Program to protect public health related to shellfish harvest and consumption. Fixed stations are used, but visits are randomly assigned consistent with the relevant guidance. Fecal coliform bacteria continue to be the indicator required by USFDA. NSSP monitoring also includes shoreline surveys to look for sources of bacteria.

1.1.2.2.2 Monitoring at Beaches

Maryland is in the process of implementing the requirements of the 2000 Beach Act. Beaches monitoring is conducted by local governments and is in the process of being modified on a risk basis consistent with current EPA guidance.

1.1.2.2.3 Fish and Shellfish Tissue Monitoring

MDE monitors fish tissue on a triennial basis, addressing approximately one third of the State's waters each year. Individual and composite fillet samples from target species are analyzed for a broad suite of metals and organic contaminants, and tissue levels are assessed following EPA's risk-based guidance. In addition to finfish, the crabmeat and hepatopancreas from the blue crab are also analyzed for contaminants. Finally, Maryland shellfish stocks are sampled for toxics at regular intervals in accordance with NSSP requirements.

When appropriate, fish consumption advisories and updates are released as new data indicates increased (or decreased) risk to consumers. Education and outreach, especially for sensitive populations, is conducted. These efforts are coordinated with the Children's Environmental Health Advisory Committee to address children's issues related to contaminated fish. Periodic surveys of recreational fishermen's consumption behaviors help to guide the program for the long term.

1.1.2.2.4 Drinking water (both surface and ground water sources)

The Maryland Department of the Environment Water Supply Program’s (WSP) goal is to ensure that the water quality and quantity at all public water systems meets the needs of the public and that the drinking water is in compliance with federal and State regulations. Monitoring activities are undertaken on a routine basis to ensure that public drinking water systems provide safe water to their consumers; this monitoring is accomplished through testing performed by State and private laboratories and at water treatment plants. Water suppliers using surface water conduct daily and more frequent tests for water quality information needed to optimize water treatment.

In 2003, water systems were required to sample for up to 83 different contaminants on a routine basis, depending on the population served and source type of the water system.

Following recent changes to the regulations, over 90 contaminants are regulated for public drinking water systems. Approximately 3700 water systems are routinely monitored according to the Safe Drinking Water Act requirements. MDE uses information concerning the vulnerability of a source to determine the frequency of monitoring for various chemical contaminants. This enables the state and water systems to maximize the efficiency of limited resources and target monitoring where needed most.

MDE conducts source water assessments that identify potential sources of contaminants and the susceptibility of water sources to contaminants regulated by the Safe Drinking Water Act. These assessments rely on data from water suppliers, ambient monitoring from other programs and testing of the water system by the State. Information from the assessments helps determine the frequency and necessity of monitoring for various contaminants. Local governments and water suppliers use the assessments as the basis for plans to protect their water sources before contamination occurs. Other important WSP activities include regular on-site inspections of water systems to identify any sanitary defects in the systems and a permitting process that helps systems obtain the best possible source of water. Special monitoring is conducted for permitting of new sources and in response to emergencies, spills or other events.

1.1.2.2.5 Special Studies

Maryland performs special studies as needed to assist with permit compliance and enforcement efforts, stressor identification, harmful algae blooms, fish kills, and source water and dredging assessments, to name a few. Targeted MBSS style biological sampling has been used to confirm the impacts of unpredictable, sporadic discharges of pollutants to surface waters. Also, the State is currently developing a methodology for using watershed surveys (both stream corridor and upland), rigorous land-use analysis, and fixed-station biological sampling to both delineate and characterize the causes of 303(d) listed biological impairments in non-tidal waters. MDE and DNR are working together, with planned future input and assistance from local governments and communities, on ways to expedite TMDL implementation in impaired watersheds by using tools such as watershed management plans, best management practices, targeted restoration or mitigation projects and other alternative approaches to TMDLs that result in more rapid project implementation and ecosystem response. Furthermore, Maryland has conducted several special studies to investigate the environmental impacts of dredging and both natural and anthropogenic sources of pollution in drinking water. Both MDE and DNR have emergency response capabilities that allow the State to respond to episodic events like fish kills and harmful algae blooms as well as implement rapid sampling to identify causal agents.

1.2 Sampling Frequency and Timeline

Sampling frequencies and timelines are developed as an integral part of the monitoring design and are determined by the goals of the monitoring project, available resources, temporal scale of the parameters being monitored, and programmatic guidance. For example, the National Shellfish Sanitation Program requires approximately 30 samples taken over three years to appropriately classify an area for harvest. The Shellfish Monitoring Program therefore monitors approximately twice per month over three years providing up to 36 samples, but also allowing for additional samples assuming that some trips may be cancelled due to inclement weather.

As another example, surface water monitoring is on a five-year cycle and is meant to coincide with permit cycles, while Beaches monitoring follows the Beaches Guidance and responds to the need for frequent monitoring before and during the recreational bathing period, but with few samples during winter in a temperate location like Maryland.

Although each monitoring program has specific goals, objectives and timing constraints to which it adheres, it is also periodically reviewed in the broader State Strategy context. During each 5 year Strategy evaluation cycle, each monitoring project or program is evaluated to determine how it fits into the goals for the State's overall strategy and whether there is some program redundancy or efficiency gains that could be realized through program consolidation, elimination or through combined sampling efforts.

1.3 Strategy Flowchart

The flowchart depicted in Figure 1 below graphically illustrates the critical components and programmatic relationships that define the State's Water Monitoring Strategy, pursuant to the federal Clean Water Act. The succeeding sections of this document (Sections 2.0 through 9.0) describe each of these components in greater detail.

The foundation of Maryland's Water Monitoring Strategy is the State's Water Quality Standards (WQS – square #1 in the flowchart, see section 6.1.1 for details). Maryland's Water Quality Standards (WQS – COMAR 26.08.02) set the minimum thresholds for acceptable water quality that the State is required to enforce. As a result of these standards, Maryland developed a State Water Monitoring Strategy to provide data for making regulatory and resource management decisions necessary to protect human health and aquatic life uses.

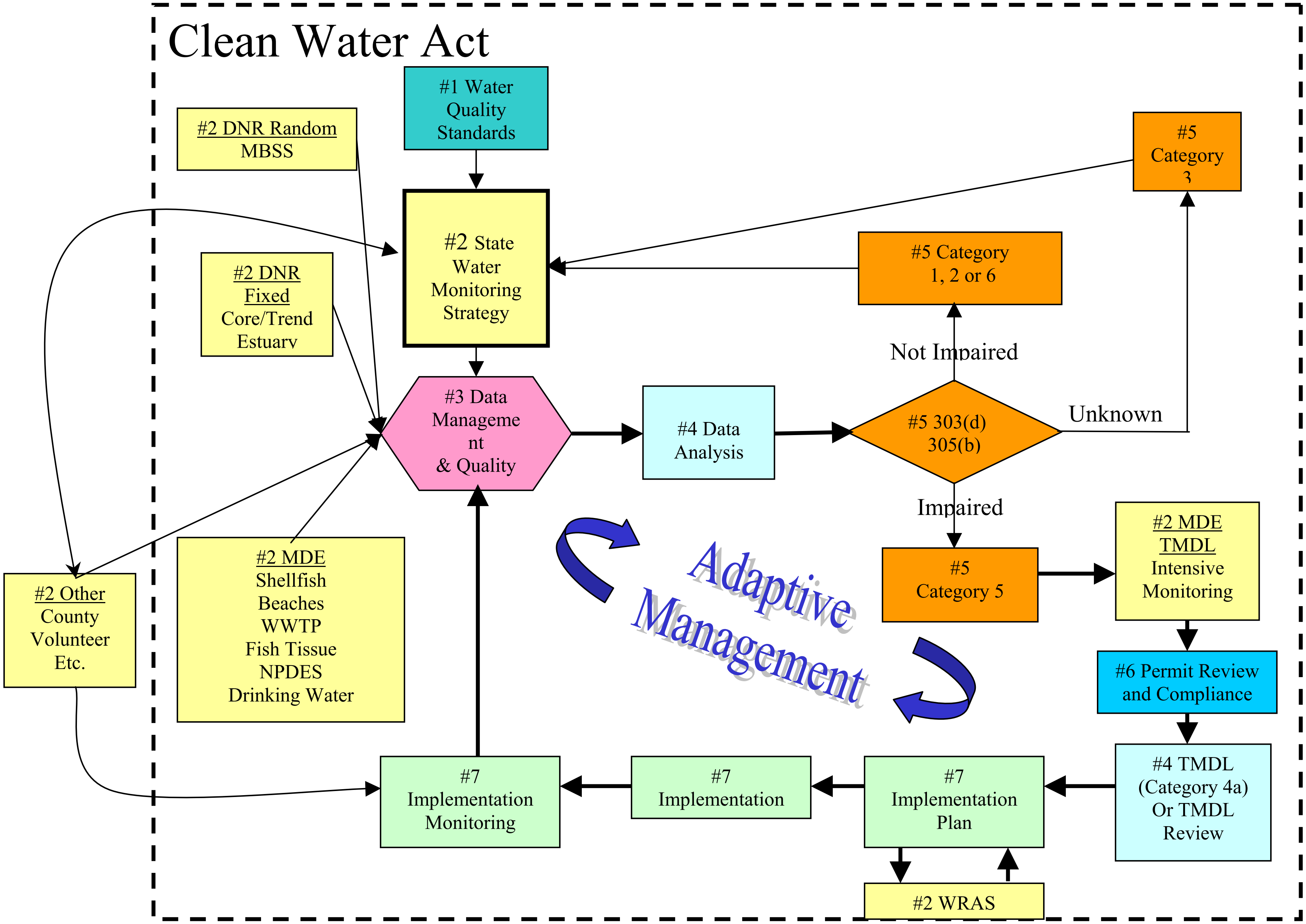

Figure 1: Flowchart Depicting Maryland's Comprehensive Water Monitoring Strategy

The State programs that form the cornerstone of Maryland's Water Monitoring Strategy are identified by the #2 squares in the flowchart (see Section 3.0). All of these programs have independent programmatic evaluation processes designed to determine adherence to project-specific goals and objectives. However, the goals and objectives for each project or program also feed back into the goals and objectives of Maryland's larger Strategy (see section 9.0). The TMDL monitoring program is unique in that it is required only if a water body has been listed as impaired on Maryland's 303(d) List. Local and volunteer water monitoring programs are identified in the flowchart as well. Maryland recognizes the importance of using these data for water body assessments and feels strongly that local and volunteer programs should be fully considered in development of the State's Strategy. A monitoring programs and goals document compiled by the Maryland Water monitoring Council is included in Appendix B. Maryland is using this document as a starting point for better integration of State and local water monitoring programs.

All water monitoring data collected by State agencies must meet quality assurance plan requirements prior to entry into a digital medium (see sections 4.0 and 5.0, respectively). The #3 "Data Management and Quality" hexagon represents this critical component of the State's strategy. The Maryland Department of the Environment (MDE) currently uses STORET (http://www.epa.gov/storet) for ambient water quality monitoring data while the Department of Natural Resources (DNR) uses the Chesapeake Information Management System (http://www.chesapeakebay.net/cims). Furthermore, MDE has hired American Management Systems, Inc., (AMS) to license, implement, and install their TEMPO™ product Department-wide as an Environmental Enterprise Management System designed to meet the database management and regulatory process requirement for the State's environmental programs. MDE is working closely with the developer to make sure this system is integrated with STORET.

Once these data have been quality assured and are electronically available, the State uses publicly reviewed Listing Methodologies to interpret and analyze these environmental data for water body attainment decisions (see section 6.0 and Appendix A). For permitted facilities, MDE uses a 5-year watershed cycling approach to review environmental permits and ensure compliance with permit limits. This process is represented by the #4 "Data Analysis" square in the middle of the flowchart.

Subsequent to data analysis and application of the State's Listing Methodologies, a water body impairment determination is made. All impaired water bodies are identified in the State's 305(b) Report and trigger a category 5 303(d) Listing (e.g., they require a TMDL). All water bodies that are either unimpaired or indeterminate fall into different 303(d) Listing categories (Categories 1, 2, 3 or 6) that do not require a TMDL. These various components of the 303(d) List and 305(b) Report are represented by the #5 boxes and diamond. Additional data will be collected to reassess unimpaired or indeterminate waters to evaluate whether they are meeting Water Quality Standards (WQS) or whether the data support listing them as impaired.

For impaired waters, the State: (1) conducts monitoring for TMDL development (#2 square at bottom right); (2) conducts permit reviews and determines compliance with permit conditions (#6 square at bottom right); (3) develops TMDLs (#4 square on the bottom right); and, (4) then moves into the Watershed Restoration Action Strategy (WRAS – #2 square) and TMDL implementation phase (#7 rectangles). Implementation monitoring data then goes back into the data management, analysis, and 305(b)/303(d) phase to see if implementation has resulted in attainment of WQS. This management process is labeled as adaptive management because it creates a constant feedback loop where implementation planning, restoration projects, and best management practices are related back to the TMDL and permitting process to determine if the proposed TMDL reductions are achievable. If not, one or more components may need to be further adjusted to meet water quality standards.

2.0 <u>Water Quality Standards and Core Indicators</u>

As mentioned in the previous section, Maryland's Water Quality Standards (WQS) define the State's water quality goals and provide the foundation for water pollution control efforts. Maryland classifies all surface waters based upon a set of defined ("designated") uses that may not be currently supported, but that should be attainable. The State's minimum water use designation (Use I) includes "water contact recreation" (e.g., swimming, wading), "fishing, protection of aquatic life and wildlife, and agricultural and industrial water supply" (COMAR §26.08.02.02). Use I waters are equivalent to the national goal "for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water" - a goal often referred to as "fishable and swimmable".

Waters that support more specific resource uses (shellfish harvesting, trout, drinking water) have designated uses to protect these resources/uses which are supported by the appropriate criteria. When a specific resource can be supported, the State may recognize these 'higher quality' waters by upgrading the use classification of a water body from (e.g. Use I to Use III (natural trout) or for potable waters, by adding a "P" to the use class). Designated uses include:

1. **Use I waters:** The minimum standard for all waters throughout the State, protects waterways for recreation, fishing, and aquatic life use;
2. **Use II waters:** Protected for shellfish harvesting and consumption;
3. **Use III waters:** Protected to maintain natural trout populations; and,
4. **Use IV waters:** Protect waters utilized for put-and-take trout fishing.

2.1 Anti-degradation

Maryland's anti-degradation policy, defined in COMAR §26.08.02.04, assures that water quality conditions support designated uses. Where existing water quality conditions are better than the standards, this policy requires that the higher water quality be maintained. Implementation procedures for the anti-degradation policy were recently promulgated.

2.2 General Water Quality Indicators

Specific environmental indicators are used to measure whether or not WQS are being achieved. An environmental indicator is a measurable feature that singly or in combination provides valid evidence for assessing environmental and ecosystem quality or reliable evidence of trends in quality. Environmental indicators need to be measured using available technology that is scientifically valid for assessing or documenting ecosystem quality. To make sound resource management and regulatory decisions, the State's monitoring program must include a comprehensive suite of indicators covering all aspects of ground and surface water quality. Parameters measured as part of a monitoring program can be physical, chemical or biological in nature. Physical characteristics of water quality include temperature, dissolved oxygen and suspended solids. Chemical parameters are a measure of substances, such as nutrients and toxic chemicals, which are dissolved in the water or in particulate form. Biological parameters refer to aspects of the living environment, from microscopic algae (periphyton) and macroinvertebrates to macrophytes and fish assemblages.

Measuring a combination of water quality parameters allows for a comprehensive representation of the state of a water resource. If only physical or chemical parameters are measured, it may be difficult to gauge the impact of those stressors on the biota. Similarly, measuring biological parameters allows the Department to assess the level of stress on an ecosystem, but not necessarily the cause(s) of the stress. The combined data can be used to generate information essential for those managing and protecting natural resources, and allowing managers to determine trends in water quality over time as well as the impact of management initiatives.

2.2.1 Indicator Categories

Resource limitations require the State to use a tiered monitoring design that includes a core set of baseline indicators selected to represent each applicable designated use, plus supplemental indicators selected according to site-specific or project-specific decision criteria. The tiered approach enables efficient use of resources in making water quality management decisions. These decisions include assessment of designated use attainment, identifying needed changes to water quality standards, describing causes and sources of impairments, and developing water quality-based source controls.

Core indicators are considered most important for measuring water quality for designated uses. These indicators (e.g., water quality parameters) should consist of the physical/habitat, chemical/toxicological, and biological/ecological endpoints as appropriate, that reflect designated uses, and that can be used routinely to assess attainment with applicable water quality standards throughout the State. Designated uses include aquatic life, recreation, public water supply, and fish and shellfish consumption. This core set of indicators is monitored to provide Statewide or basin/watershed level information on the fundamental attributes of the aquatic environment and to assess water quality standards attainment/impairment status. Previously, chemical and physical indicators were emphasized; however, biological monitoring and assessment has recently assumed a more prominent role in State monitoring.

The core indicators are supplemented with additional indicators based on the characteristics of the watershed, designated uses, and potential stressors (point and non-point sources) influencing the water body. For example, when there is a reasonable expectation that a specific pollutant may be present in a watershed, when core indicators indicate impairment, or to support a special study such as screening for potential pollutants of concern at a Statewide, watershed, or water body scale. These supplemental indicators may include each water quality criteria in the State's water quality standards, any pollutants controlled by the National Pollutant Discharge Elimination System (NPDES), and any other constituents or indicators of concern.

2.3 Core Indicators

2.3.1 Water Quality

Physiochemical water quality characteristics affect the ability of organisms to persist in a given aquatic habitat. Water quality data are collected to determine the acid-base status, trophic condition (nutrient enrichment), and chemical stressors. Physical parameters include light penetration (e.g., water clarity [Secchi depth] turbidity, and suspended solids), temperature and ionic strength (e.g., conductivity). Chemical parameters include the concentrations of dissolved gases, major cations, anions, and nutrients (i.e., nitrogen, phosphorus). These indicators are compared to the water quality criteria specific to each designated use.

2.3.2 Aquatic Macroinvertebrate Assemblages

Aquatic macroinvertebrates play important functional roles in aquatic ecosystems and are used to help determine compliance with the aquatic life use support standard as identified in Section 26.08.02.02-B1-d (go to: http://www.dsd.state.md.us/comar/26/26.08.02.02.htm). Aquatic macroinvertebrates represent a fundamental link in the food web between organic matter resources (e.g., leaf litter, periphyton, detritus) and fishes. In lotic systems within specific biogeographical regions, aquatic macroinvertebrate assemblages respond in predictable ways to changes in stream environmental variables. Because many aquatic macroinvertebrates have limited migration patterns or a sessile mode of life, they are particularly well suited for assessing site-specific effects.

2.3.3 ***Fish and Aquatic Vertebrate Assemblage***

The fish and other aquatic vertebrates can indicate water and habitat quality and are used as another measure to evaluate compliance with Maryland's aquatic life use standard. Extensive life history information is available for many species, and because many are high order consumers, they often reflect the responses of the entire trophic structure to environmental stress. Also, fish provide a more publicly understandable indicator of environmental degradation. Fish generally have long life histories and integrate pollution effects over longer time periods and large spatial scales.

2.3.4 Physical Habitat Structure

Physical habitat structure includes all of those structural attributes that influence or sustain organisms within the aquatic ecosystems. In lotic systems, habitat assessments generally provide a critical understanding of a stream's ecology. Some common physical habitat attributes are stream size, channel gradient, channel substrate size and type, habitat complexity and cover, riffle/pool ration, riparian vegetation cover and presence of large woody debris. Understanding the physical habitat of an area allows for better assessments of the stream ecosystem and human caused effects. Physical habitat conditions assessment and documentation also allow the State to determine if aquatic life use impairments are the result of pollutants or more related degraded aquatic habitat.

2.3.5 Submerged Aquatic Vegetation (SAV)

SAV plays a number of important ecological roles in tidally influenced systems like the Chesapeake Bay. In addition to providing food and habitat for waterfowl and aquatic living resources, the grasses serve as a nursery habitat and refuge for many species of fish and invertebrates. SAV also has important water quality functions, from producing oxygen through photosynthetic processes to sediment removal from the water column, and reducing shoreline erosion by slowing wave action. Finally, SAV removes excess nutrients such as nitrogen and phosphorus, thus reducing the potential for nuisance algae in the surrounding waters. The new water quality criteria for Chesapeake Bay have light attenuation requirements for shallow water that designate critical SAV zones and habitat.

2.3.6 Bacteria

Pathogen indicator species such as *Escherichia coli* and *Enterococcus spp*. Are used to determine the human health risk associated with recreational water contact. Maryland has numeric water quality criteria for fecal coliform and is developing new standards for *E. coli* and entrococci. Bacterial monitoring is conducted to determine water body compliance with these criteria. The bacteria selected for water quality monitoring rarely cause human illness; rather the occurrence of these bacteria indicates that fecal contamination may have occurred and pathogens may be present in the water. Maryland also participates in the commercial harvest of shellfish (oysters and clams). The State monitors fecal coliform levels as a requirement of the NSSP since shellfish harvested from polluted water may cause human illness. The Department of the Environment is responsible for classifying and managing Maryland's shellfish harvesting areas. The goal of shellfish harvesting area classification and management is to provide maximum utilization of shellfish resources and to reduce the risk of shellfish-borne illness.

2.3.7 Fish/Shellfish Tissue Monitoring

The Department of the Environment recognizes that many chemical pollutants discharged into state waters by point and non-point sources may impair public uses and/or aquatic life. Specifically, some of these chemical pollutants accumulate and persist in aquatic sediments and in the tissue of aquatic organisms, including various edible species of fish and shellfish, at potentially toxic concentrations. In addition, chemical pollutants that bioaccumulate tend to magnify in concentration as they pass through aquatic food chains and may cause detrimental effects to consumers, including humans. Maryland routinely monitors fish and shellfish tissues to evaluate the fishability of State waters as mandated in COMAR section 26.08.02.03-1A-2c (go to: http://www.dsd.state.md.us/comar/26/26.08.02.03%2D1.htm).

2.4 Supplemental Indicators

2.4.1 Ambient Toxicity

Ambient water and sediment quality tests may be useful as water body-specific indicators to identify trends in the occurrence of toxicity. Deterministic stations may be strategically placed to identify toxicity from known or suspected sources and probabilistic stations may be used to assess conditions across broad geographic areas (i.e. MAIA Chesapeake Bay Study). Toxicity tests do not provide a direct measure of ecological health; therefore, test results are more useful for identifying water quality problems or for use as a screening mechanism rather than for use as environmental indicators. The State monitors both tidal and non-tidal waters to determine compliance with numeric chemical criteria set forth in COMAR 26.08.02.03-2-G1 (go to: http://www.dsd.state.md.us/comar/26/26.08.02.03%2D2.htm)

2.4.2 Organism Health

Exposure to environmental stressors can result in biochemical, physiological and histological (tissue) alterations in living organisms. The presence of these alterations may serve as "biomarkers," signaling exposure to stressors or adverse effects, which can range from molecular, cellular and tissue damage to genetic alterations. In the aquatic environment, such stressors include physical parameters such as temperature, pH or salinity, as well as toxic concentrations of chemical pollutants or any combination of stressors. Organism health metrics are recorded during fish kill incidents and during Maryland Biological Stream Survey fish sampling, and have played important roles in previous investigations such as the *Pfiesteria* outbreak in the late 90's. Maryland uses organism health as another indicator of aquatic life use support.

2.4.3 Chemicals of Concern

The Department monitors priority pollutants in water body segments where land use(s) indicate a current or historic potential for chemical releases. Chemical water quality monitoring may be done to determine loads or concentrations or both. Chemical pollutant monitoring is used as a screening tool in Maryland's watershed cycling strategy, while intensive monitoring of water column and/or sediments occurs as part of the assessment required by the TMDL program. Maryland uses this information to determine compliance with numeric water quality criteria for chemicals (see Section 2.4.1).

2.4.4 Periphyton

Periphyton are algae, fungi, bacteria, and protozoa associated with channel substrates. Periphyton are useful indicators of environmental condition because they respond rapidly and are sensitive to a number of anthropogenic disturbances, including habitat degradation, contamination by nutrients, metals, herbicides, hydrocarbons, and acidification. Periphyton are yet another indicator of aquatic health and a pilot study is underway to determine the feasibility of using periphyton to develop nutrient criteria for non-tidal waters.

2.4.5 Aesthetics

MDE field crews include general documentation of the aesthetic conditions at a sampling site. The aesthetic indicators selected used in Maryland include water clarity, odor, water color, visible debris, and signs of obvious pollution. For drinking water, indicators include color, taste, and odor. Maryland considers changes in water body aesthetics as an indication of water's suitability for contact recreation.

3.0 Monitoring Programs, Goals and Objectives by Water Body Type

3.1 Tidal Waters

Tidally influenced rivers, tributaries and embayments of Chesapeake Bay, as well as the coastal lagoons behind the Atlantic barrier islands, account for an estimated 2,522.4 square miles or 20 percent of the State's total surface area (Figure 2). Modifications to estuarine waters include dredging for navigation purposes (channels, canals, anchorage areas), dredging for oyster shell and oyster bar shoreline erosion, stabilization projects (bulkheads, jetties) and shore structures (piers, wharves).

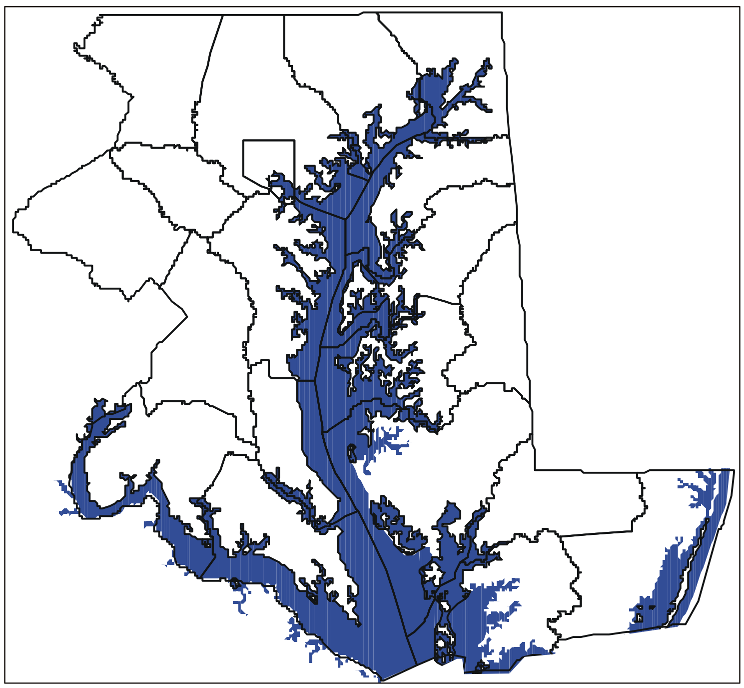

Figure 2: Estuarine waters (shaded) in Maryland

3.1.1 Tidal Monitoring Programs

3.1.1.1 Chesapeake Bay Monitoring Program

Agency: DNR Resource Assessment Service
Contact: Bruce Michael (410-260-8627); bmichael@dnr.state.md.us
Watersheds: Chesapeake Bay (all counties in Maryland)
Media: water column, aquatic resources
Goals: The general goals of Maryland's Chesapeake Bays Monitoring Program are:

1) Monitor the physical, chemical and biological components that are indicators of water quality status and trends in the Chesapeake Bay and its tidal tributaries,
2) Reduce the impacts of excess nutrients on the Bay that will result in improvements in dissolved oxygen levels and in the habitat for submerged aquatic vegetation (SAV),
3) To assist in the development and implementation of management policies to protect and restore the economic and recreational value of Chesapeake Bay, and
4) To measure progress towards meeting the ultimate goal of protecting and restoring Chesapeake Bay.

Program Description: The multidisciplinary monitoring program direct measurements of the physical/chemical environment (including nutrient levels), measurements of point and non-point source pollutant loadings, determination of biological indicators of water quality (zooplankton, phytoplankton and benthos), and measured rates of important ecosystem processes such as photosynthesis, metabolism, and nutrient limitation.

- *Mainstem/Tributary Monitoring* - water chemistry samples are collected 14 times a year (monthly from September through March and in June and twice each month in April, May, July and August) at 22 stations located in Maryland's Chesapeake Bay mainstem and 12 to 20 times a year at 55 stations sampled in the tidal tributaries. A map of monitoring stations is available at http://www.chesapeakebay.net/pubs/maps/2004-149.pdf.
- *River Input* component quantifies the amount of nutrients and sediment entering the Chesapeake Bay from four Maryland tributaries that represent the range of different sources of runoff contribution to the Bay (Susquehanna, Potomac, Patuxent and Choptank Rivers). In cooperation with the US Geological Survey, each river site is monitored for flow, sediment and nutrient concentrations during both base flow and storm events in each season. This information provides a measure of the success of management actions in the Bay's watersheds on reducing nutrients and sediment loading to the Bay. Laboratory activities are performed under contract by the University of Maryland's Chesapeake Biological Laboratory. A map of the monitoring stations is available at http://va.water.usgs.gov/chesbay/RIMP/map.html.
- *Nutrient Limitation* component determines the specific factors, primarily nutrients, that limit algal growth at various times in Chesapeake Bay and its tributaries by measuring phytoplankton growth rates under ambient nutrient conditions and under various combinations of nitrogen and phosphorus additions. This information is used to determine locations where either nitrogen or phosphorus or both is/are limiting algal growth to target future nutrient reduction efforts and to interpret monitoring data used to track the restoration. Water samples are collected from sample locations in the Patuxent, Potomac and Choptank Rivers and in the mainstem Chesapeake Bay. These samples are tested using a bioassay to determine if a sample is:
  - Nitrogen limited (excess phosphorus),
  - Phosphorus limited (excess nitrogen), or
  - Nutrient Saturated (excess phosphorus and nitrogen or inadequate light)

  In addition, data from this component has been used to develop a predictive model that uses routinely measured water quality components (total nitrogen, total phosphorus, dissolved inorganic nitrogen, dissolved inorganic phosphorus, salinity and water temperature) to estimate the nutrient limitation status for locations where bioassay samples are not collected. This model has been applied to determine annual patterns of nutrient limitation for all DNR monitoring sites. Laboratory activities are performed under contract by the University of Maryland's Horn Point Environmental Laboratory.

- The *benthic monitoring program* consists of two elements - a fixed site sampling effort of samples from 27 sites to see if management actions designed to improve water quality are resulting in healthier benthic communities and a probability-based sampling program (150 randomly-selected sites sampled in the summer in 6 major salinity regions and two sediment types in the Chesapeake Bay mainstem and tributaries in Maryland) designed to estimate the area of the Bay where benthic communities meet the Chesapeake Bay Program's Benthic Community Restoration Goals. Sampling and laboratory activities are performed under contract by Versar, Inc. (http://www.baybenthos.versar.com). A map of monitoring stations is available on-line at ftp://ftp.chesapeakebay.net/Pub/Living_Resources/maps/mdbenthos.PDF.
- *Plankton monitoring program* evaluates phytoplankton productivity and biomass at 12 Bay mainstem and tidal tributary stations 14 times per year. Zooplankton community monitoring ended in 2002; however, a limited effort to monitor zooplankton in terms of the Food Availability Index (a measure of the critical zooplankton densities required for juvenile fish survival) may resume in 2004. Phytoplankton are a critical component of the Bay ecosystem and represent the first biological response to the Bay's nutrient enrichment problem. Detecting the presence of potential "harmful" algal species and possible toxins that may be discharged during bloom events and may affect aquatic life and human uses provides additional emphasis on this program. A map of monitoring stations is available on-line at ftp://ftp.chesapeakebay.net/Pub/Living_Resources/maps/stations2001.pdf.

Data Management: Data are initially processed in the field or various laboratories; the datasheets and/or electronic data are submitted to DNR's Tidewater Ecosystem Assessment Division. DNR staff review the data quality (manually and automatically) and make corrections/changes as needed; the process described in each monitoring program QA Project Plan and the Department's Quality Management Plan. Corrected data are processed and stored in the Department's data server as Access® database files. These data can be transported to other formats for analysis (e.g., Excel® datasets, SAS® datasets. Each month (or at an interval prescribed in each QAPP/grant), data are submitted to the US Environmental Protection Agency's Chesapeake Bay Program and are posted online (www.chesapeakebay.net).

Programmatic Issues/Needs: A continuous disconnect between management needs for more water quality/resource data and low prioritization for funding water monitoring activities hamper efforts to provide timely, adequate information to managers. Years of funding levels that are static or may be reduced results in a re-evaluation of monitoring effort to determine how efforts can be reduced without compromising the objectives of the monitoring program.

3.1.1.2 Shallow water monitoring

Agency: DNR Resource Assessment Service

Contact: Mark Trice (410-260-8649); mtrice@dnr.state.md.us

Watersheds: Chesapeake Bay embayments/tributaries (Anne Arundel, Baltimore, Calvert, Cecil, Charles, Dorchester, Harford, Kent, Prince George's, Queen Anne's, St. Mary's, Somerset, Talbot, Wicomico, Worcester Co.)

Media: water column, aquatic resources

Goals: The general goals of the Shallow Water Monitoring Program are:

1) To better assess important water quality and habitat conditions in dynamic environments;
2) Discern the links between water quality, harmful algal blooms, and fish kills;
3) Analyze shallow water habitat for Submerged Aquatic Vegetation requirements and nursery areas for juvenile fishes; and
4) Assessment of proposed Bay criteria that support habitat and aquatic resource needs focused in the Chesapeake Bay 2000 Agreement.

Program Description - ***New monitoring technologies – continuous monitoring***

One of the 1996 federal Clean Water Action Plan goals was to provide timely, readily useful information about local environmental conditions. The US Environmental Protection Agency initiated the Environmental Monitoring for Public Access and Community Tracking (EMPACT) Program to demonstrate how environmental data could be collected, organized, and presented in a manner that makes it easily accessible to the public (*http://www.epa.gov/empact/*). One EMPACT project, sponsored by the Department of Natural Resources (DNR), was to provide timely and relevant information regarding harmful algal blooms (focusing on *Pfiesteria piscicida*) and water quality on Maryland's lower Eastern Shore.

1998 - two EMPACT stations were established in the Pocomoke River at Cedar Hall Wharf and Williams Point in Shelltown. Water temperature, specific conductance, salinity, dissolved oxygen concentration are automatically recorded every 15 minutes between May and October. Once every week, each station is accessed, the meters are retrieved and replaced, and the stored data are transferred electronically into a computer spreadsheet. Additional water samples are taken at each location weekly and analyzed to calibrate the meters and to check the data for accuracy. Results are posted online (www.eyesonthebay.net).

1999 - two more locations were added: one surface water monitor upstream near Rehobeth and an additional bottom meter was added at the Cedar Hall Wharf location.

2000 - this effort was expanded to the Magothy and Chicamacomico River tributaries.

2001 - a similar, near-real-time water quality monitor was installed at Fort McHenry in Baltimore Harbor. These data are provided to the National Aquarium in Baltimore, which established a kiosk and an educational display describing what visitors see on-line. These projects were designed to allow people to learn more about Maryland's waterways and keep up to date with water quality conditions, impacts such as storm events and harmful algal blooms. Although EPA's EMPACT funding ended in 2002, this monitoring effort continues with funding from NOAA and other partners, which is actively sought to continue and expand this continuous monitoring network to other key tidal tributaries around the Bay.

2002 - monitoring stations were relocated from the Chicamacomico and the Transquaking Rivers into the Severn River. One of the goals of this move is to be able to compare the continuous monitoring data with "Dataflow" information that is collected on a weekly basis May-Oct. Two sites also were established in the Coastal Bays (Bishopville Prong and Turville Creek).

2003 - all meters were relocated from the Pocomoke River to new sites on Fishing Bay, a new site on Transquaking River and sites on the Chester, Bush, Gunpowder and Middle Rivers with support from groups including the Chester River Association and Harford County. The University of Maryland's Chesapeake Biological Lab provided a companion set of continuous monitors for seven sites on the Patuxent River.

2004 - meters in the Magothy and Severn Rivers were relocated to the South River, West/Rhode River complex and the upper tidal Potomac River. With additional partner support, continuous monitors have been set up in St. Mary's River (St. Mary's College), Sandy Point State Park on Chesapeake Bay (Anne Arundel County Health Department for an ongoing bacterial study) and in Eastern Bay and Harness Creek (South River) for shellfish/SAV habitat studies.

A map of the monitoring stations associated with this project can be found at http://mddnr.chesapeakebay.net/eyesonthebay/index.cfm.

New monitoring technologies **–** *Spatially intensive monitoring*
This program collects and analyzes geographically referenced, continuous surface water temperature, salinity, dissolved oxygen, chlorophyll, and turbidity data aboard a small moving vessel. These data aid in the assessment of Chesapeake 2000 Agreement's focus on water quality criteria and shallow water habitats that are vital for submerged aquatic vegetation, fish, and shellfish. In conjunction with continuous monitoring and fixed long-term monitoring station data, these spatially-intensive monitoring data can provide a comprehensive spatial and temporal portrait of water quality conditions. In 2001, this program collected data on a biweekly basis from the Severn and Magothy Rivers, and on a monthly basis in Tangier Sound. Results are posted as water quality maps on the Department's Internet site along with additional information about the project (*http://mddnr.chesapeakebay.net/sim/*).

Data Management: Data are processed for data quality in a manner similar to the Chesapeake Bay Program data, except that data from some real-time sources are posted automatically to the Eyes on the Bay website. Programming for analysis of the data and posting on the Internet is accomplished in-house. There are electronic and overall evaluation/review of the data, which are stored in Access on a server hosting the EyesontheBay site. Data are reviewed and are annually submitted to the EPA Chesapeake Bay Program.

Programmatic Issues/Needs: Rotating continuous monitors in the State's principal Chesapeake Bay tributaries on a three-year schedule provides an opportunity to assess new shallow water Bay criteria that were established throughout the State's tidal tributaries

3.1.1.3 Coastal Bays Monitoring Program

Agency: DNR Resource Assessment Service
Contact: Cathy Wazniak (410-260-8638); cwazniak@dnr.state.md.us /
Matt Hall (410-260-8632); mhall@dnr.state.md.us
Watersheds: Atlantic Ocean coastal bays (Worcester Co.)
Media: water column, aquatic resources
Goals: The Maryland Coastal Bays Comprehensive Monitoring Program is designed to:

1) To measure the effectiveness of implementing the management actions identified in the Comprehensive Conservation Management Plan (CCMP),
2) To provide information that can be used to redirect and refocus the CCMP over time,
3) To provide information that will assist in anticipating water quality responses to implementation of proposed management actions, and
4) To bring the monitoring and evaluation of Coastal Bays up to par with efforts in the Chesapeake Bay.

Program Description: Eutrophication and its impacts to living resources was identified in the Maryland Coastal Bays Program (1998) characterization report as the most pressing environmental issue facing these waters. As a result, the Scientific and Technical Advisory Committee (STAC) recommended that the initial focus of the monitoring plan be on nutrient and sediment inputs to the coastal bays and their impacts on living resources (Maryland Coastal Bays Program, 1999). Five general categories of monitoring activities were identified:

1) Tracking management actions;
2) Nutrient and sediment inputs from the watershed and airshed;
3) Ambient water quality;
4) Eutrophication impacts to habitat; and,
5) Eutrophication impacts to living resources.

Structure: Actions in the monitoring plan have been organized into three levels: Landscape Monitoring (Level I), Stressor Monitoring (Level II), and Response Monitoring (Level III). The lower the level, the more directly the monitoring is related to management actions. Inherent within all three levels is monitoring for both baseline and long-term trends. The resulting Comprehensive Environmental Monitoring Program was developed by DNR with extensive input from local, State, and federal agencies operating in Maryland's Coastal Bays, peered reviewed for technical merit and approved by the STAC.

Baseline monitoring determines the current status of important indicators of environmental health to measure change and to determine if management actions have an impact. DNR has been monitoring 24 fixed-station sites since 1998 and an additional 18 sites since 2001 using a suite of water quality indicators, including water column chlorophyll, dissolved oxygen, and nutrients (see a map of monitoring locations at http://www.dnr.state.md.us/coastalbays/water_quality/index.html). The National Park Service at Assateague Island (ASIS) has been monitoring 18 fixed-station sites in the southern Coastal Bays since 1987. These programs are providing critical baseline data. In addition, DNR has installed continuous water quality monitors in Bishopville Prong and Turville Creek. These monitors provide nearly instantaneous data on water quality conditions and aid in tracking events such as harmful algae blooms. Comprehensive analysis of the water quality data provided by these programs, as well as related management activities, will be presented in a *State of the Coastal Bays* report (release date - August 2004).

Landscape monitoring (Level I) tracks activities going on in the watershed (e.g., nutrient and chemical application rates, implementation of best management practices and land cover). This can often be directly related to implementation of management actions and may not need intense field monitoring. This monitoring process may need to be reviewed, depending on the outcome of the final management plan and its goals, to evaluate the adequacy of current programs to track important aspects of landscape conditions and activities.

Stressor monitoring (Level II) determines the amount of pollutants (nutrient, sediment or chemical contaminants) entering the bays or extent of habitat alteration or loss occurring in the watershed. While it may be very difficult to do in a comprehensive fashion, the STAC decided to initiate some of the high priority monitoring elements in this category related to nutrient inputs. DNR and ASIS currently monitor nutrient levels in the Coastal Bays. The abundance of SAV habitat is also closely monitored, though an investigation into the habitat requirements of Coastal Bays SAV is needed. Ambient sediment toxicity was tested in 2000 (under the Coastal 2000 initiative), and MGS just completed a review of sediment toxicity for the 2004 State of the Coastal Bays report.

Response monitoring (Level III) uses indicators to show how the system is responding to management actions (changes in stressors) over time. This monitoring information is very important to the public (e.g., - Is the water degraded? What is the condition of the fish?). Now that many management actions presented in the original CCMP are underway and monitoring infrastructure is in place, response monitoring can be undertaken.

Programmatic Issues/Needs: A comprehensive, peer-reviewed monitoring strategy for the Coastal Bays should lead to a full implementation of the approved Monitoring Plan. Maryland allocated partial funding for ambient water quality monitoring; however, additional funds are needed to fully implement those activities. Partial implementation of key programs were implemented and funded through the Coastal 2000 program (habitat impacts from eutrophication including harmful algal blooms, macroalgae, impacts to SAV and the benthic community).

Harmful algal blooms pose a threat to uses of coastal bays. Beginning in 1998, several HAB species have been identified in Coastal Bay waterways. Although the presence of these organisms has not yet affected human health risks or impaired uses, their presence emphasizes the need to control nutrient inputs to these lagoons.

Submerged aquatic vegetation (SAV) abundance should continue to be monitored using aerial photography. SAV habitat criteria need to be established specifically for the Coastal Bays. Seasonal, intensive macroalgae surveys have been conducted to characterize the taxa found in the Coastal Bays as well as determining spatial and temporal coverage and estimates of biomass. The relationships between macroalgae and, SAV, habitat and water quality are still being investigated.

System-wide benthic monitoring began in 2000 as part of the EPA National Coastal Assessment (NCA), but is not a long-term part of the management plan. The spatial and temporal variability due to physical and biological factors can confound attempts at detecting anthropogenic disturbances in the molluscan community over time. Indicator development and analysis of benthic/fish data as it relates to eutrophication needs more study.

3.1.1.4 ***Watershed Cycling Strategy***

Agency: MDE Technical and Regulatory Services Administration
Contact: Nauth Panday (410-537-3901); npanday@mde.state.md.us;
John Steinfort (443-482-2728); jsteinfort@erols.com;
Watersheds: Statewide - focus on impaired watersheds on State's 303(d) list and NPDES modeling needs.
Media: water column
Goals:
(1) Provide the detailed spatial data needed for modeling and development of total maximum daily loads (TMDLs) necessary to achieve water quality standards, and
(2) Provide detailed data for determining permit limits for all facilities in a given watershed that are operating under National Pollutant Discharge Elimination System (NPDES) permit.
Program Description - The Clean Water Act requires that impaired watersheds be evaluated and monitored in a comprehensive manner so to identify all point and nonpoint sources of pollutants, and to allocate the pollutant loads among the various sources. This process is designed to produce the information necessary to allow managers to estimate the pollutant loads and develop total maximum daily load (TMDL) estimates so that impairments to the designated uses of the water can be corrected. When impairments or potential impairments are demonstrated by CORE/Trend water monitoring data, Maryland Biological Stream Survey data, Chesapeake Bay Monitoring Program and/or other data, the intensive watershed monitoring and evaluations conducted under this program will confirm the extent of the impairment. These data are then used to calibrate the models necessary to develop and define the TMDL and permits needed to correct the impairment.

This program has been designed to focus monitoring at a large number of sites in a portion of the State each year. One fifth of the state is monitored intensively each year in order to cover the entire State in a five-year rotation. Referred to as the "Watershed Cycling Strategy", the effort includes integrated monitoring, TMDL development and permit development of each of the five regions of the state on a five-year rotation (MD Dept. of the Environment, 1999c).

Maryland has instituted a five-year watershed cycling strategy. The State has been divided up into five large watersheds, each encompassing approximately 20% of the State. The strategy consists of three steps: monitoring, modeling and TMDL development (if required) and implementation, which is not in the context of this agreement. Maryland anticipates that each step will take approximately one year to complete in each watershed. Because the cycling strategy repeats itself, the watershed cycling strategy establishes a natural evaluation framework as the cycle is repeated. Implementation of the steps will be staggered through each of the watersheds and resources for each step focused in one watershed each year starting with the Lower Eastern Shore in 1998.

This monitoring program tracks the hydrologic year, sometimes termed the "water year", which begins on October 1st. This full-year monitoring allows for the collection of information on representative hydrologic flow regimes. Critical 7-day, 10-year low flow conditions and those associated with flooding are obtained from flow records maintained by the US Geological Services gauging station network. The monitoring design is to collect water quality samples from key points located throughout the water body of interest, during three low flow and three high flow periods during the annual cycle. Parameter coverage is determined each year based on the impairment being investigated. Monitoring activities include measurements of streambed geometry and/or tidal bathymetric profiles that are necessary mathematical model inputs.

Maryland's cycling strategy has been successful in that all monitoring throughout the five larger watersheds has been completed for eutrophication. A major portion of the toxic monitoring has also been completed. In years six (2004) and seven (2005), Maryland will be focusing on monitoring for sediments, fecal coliform and additional toxics monitoring to address numerous listings. In year eight (2006), Maryland intends to reevaluate the first large watershed (the Lower Eastern Shore) and return to the original five-year monitoring schedule.

3.1.1.5 Potomac and Patuxent River programs

Agency: DNR Resource Assessment Service
Contact: Bruce Michael (410-260-8627); bmichael@dnr.state.md.us
Watersheds: Tidal Potomac, Patuxent Rivers (Anne Arundel, Calvert, Charles, Howard, Prince George's, St. Mary's) Atlantic Ocean coastal bays (Worcester Co.)
Media: water column
Goals: The general goals of the Potomac and Patuxent River monitoring programs are:

1) To characterize the health of the estuary;

2) To provide information that will assist in anticipating water quality responses to implementation of proposed management actions; and
3) To develop monitoring datasets from these principal Chesapeake Bay tributaries that would be used by the Chesapeake Bay Program to bring the monitoring and evaluation of Coastal Bays up to par with efforts in the Chesapeake Bay.

Program Description: The Potomac River and Patuxent River estuarine water quality monitoring programs are often considered part of the CORE or Chesapeake Bay monitoring efforts, as some monitoring sites are incorporated/used by both datasets. Both efforts have unique origins, high levels of public interest and would likely continue as priority monitoring programs if the CORE or Bay Program monitoring effort was reduced.

The Potomac estuarine monitoring effort was part of a coordinated interstate monitoring effort in the Potomac and tributaries around the metropolitan Washington area. The Interstate Commission on the Potomac River Basin (ICPRB) and the Metropolitan Washington Council of Governments (MWCOG) initially coordinated monitoring activities in the area and focused on development of an area wasteload model. Monitoring coordination activities continue through COG efforts.

Intensive sampling in the Patuxent River began in 1983, one year prior to the initiation of the Bay Program monitoring program, in an effort to characterize the estuary's health and document its response to the State's nutrient control strategy in the basin, especially in terms wastewater discharges in the upper watershed. Like the Chesapeake Bay Program, samples for analysis of physical and chemical parameters and chlorophyll, are collected at 13 stations throughout the year.

3.1.1.6 Chesapeake Bay Programs – Submerged Aquatic Vegetation

Agency: DNR Resource Assessment Service
Contact: Bruce Michael (410-260-8627); bmichael@dnr.state.md.us
Watersheds: Tidal tributaries and Mainstem Chesapeake Bay
Media: water column
Goals: The goals of the Submerged Aquatic Vegetation (SAV) monitoring program are:

1) To assess areas designated for bay grass use in terms of Chesapeake Bay shallow water quality criteria, and
2) To annually assesses segment-specific bay grass populations in Chesapeake and Coastal Bays and corresponding water quality data to identify specific reasons for lack of bay grass in those segments.

Program Description: Bay grasses (technically known as Submerged Aquatic Vegetation or SAV) are an important part of the Chesapeake Bay ecosystem. Fifteen varieties of bay grasses are commonly found in the Chesapeake Bay and surrounding rivers. Not only do bay grasses improve water quality, they also provide food and shelter for waterfowl, fish, and shellfish. Because of their importance, the restoration of bay grasses in the Chesapeake and Coastal bays is a priority for Maryland as well as the other Bay partners (see the monitoring transects surveyed at http://www.vims.edu/bio/sav/sav03/quadindex.html). Adopted in December 2003, the enhanced bay-wide bay grass restoration goal calls for the protection and restoration of 185,000 acres to be met in 2010. The new strategy commits Maryland and other Bay Partners to four major initiatives

- Meet Chesapeake Bay Program water quality criteria in areas designated for bay grass use
- Provide existing bay grass beds greater protection
- Enhance bay grass research, citizen involvement and education, and
- Accelerate bay grass restoration by planting 1,000 acres of new bay grass beds by December 2008

Some of the monitoring efforts are directed by specific management questions -

- **Technical Assessments -**
  - Annual assessment of segment-specific bay grass populations in Chesapeake and Coastal bays – under contract to Virginia Institute of Marine Science
  - specific technical assessments (ex. historic bay grass distribution, role of personal watercraft/recreational boats in damaging bay grass beds, etc) to direct management actions to protect existing bay grass beds
- **Large-scale Bay Grass Restoration Projects:**
  - evaluation of water quality and habitat (Geographic Information System data project involving water quality and habitat data layers) to determine potential for future large-scale projects in some grass-barren areas. MD-DNR is committed to achieving or exceeding the Bay Program's goal of planting 1,000 acres of bay grass by 2008. This represents bay grass restoration on a scale never before attempted, and will require the development and implementation of numerous new technologies. In our efforts to achieve this goal, MD-DNR:
- **Education and Outreach:**
  - SAV Resource Center website offers technical support, issues permits, and tracks progress for groups or individuals interested in undertaking bay grass restoration projects.

3.1.1.7 Harmful Algal Blooms

Agency: DNR Resource Assessment Service
Contact: Bruce Michael (410-260-8627); bmichael@dnr.state.md.us
Watersheds: Tidal Potomac, Patuxent Rivers (Anne Arundel, Calvert, Charles, Howard, Prince George's, St. Mary's) Atlantic Ocean coastal bays (Worcester Co.)
Media: water column
Goals: The general goals of the Potomac and Patuxent River monitoring programs are:

1) To characterize the health of the estuary;
2) To provide information that will assist in anticipating water quality responses to implementation of proposed management actions; and
3) To develop monitoring datasets from these principal Chesapeake Bay tributaries that would be used by the Chesapeake Bay Program into bring the monitoring and evaluation of Coastal Bays up to par with efforts in the Chesapeake Bay.

Program Description: The Department of Environment manages a program to investigate discolored water, analyze composition, and initiate emergency containment and recovery initiatives if a pollutant is detected. This response program responds directly to public complaints. Because nuisance algae blooms are typically responsible for discoloring water, this program maintains the capability to identify common algae organisms. The program typically responds to non-toxic mahogany tide bloom organisms including *Prorocentrum minimum*, *Gyrodinium esturiale*, *Gymnodinium uncatenum*, and *Katodinium rotundatum*, and often initiates state wide response if a toxic species such as *Mirocystis* or *Pfiesteria* is suspected or confirmed. Harmful Algae Blooms (HAB) are quickly forwarded to the DNR Harmful Algal Bloom monitoring program for follow-up monitoring. HAB's are responsible for fish kills by both passive and direct association. Most of the typical non-toxic mahogany tide organisms are responsible for massive low dissolved oxygen-induced fish kills and may be indicative of habitual nutrient or gross organic pollution requiring immediate regulatory response and follow-up. This program enhances the fish kill response program as part of the Clean Water Act Section 106 grant initiative. Go to http://www.dnr.state.md.us/bay/hab/index.html for more details and locations of blooms in Maryland.

3.1.1.8 Shellfish harvesting area monitoring

Agency: MDE
Contact: Ms. Kathy Brohawn (410-537-3608); kbrohawn@mde.state.md.us
Watersheds: Chesapeake Bay and tidal tributaries (adjoining counties), Atlantic Ocean coastal bays (Worcester Co.)
Media: water column
Goals: The goals of this program are to ensure that the shellfish (oysters, clams and crabs) harvested from State waters are safe for human consumption, and to provide information on potential sources and trends in water pollution levels.
Program Description: Shellfish have the potential to accumulate human pathogens, heavy metals or organic chemicals in their tissues even when these materials cannot be measured in the water column. This makes these aquatic animals good indicators of environmental pollution in a body of water. Monitoring contaminant levels in tissues also allow the determination of potential human health effects. Go to http://www.mde.state.md.us/CitizensInfoCenter/Health/shellfish/index.asp for locations of shellfish harvesting waters in Maryland.

3.1.1.9 Fish Kill Response and Investigations

Agency: MDE Ecological Assessment Division
Contact: Chris Luckett (443-482-2731; cluckett@mde.state.md.us)
Charles Poukish (410-537-4434 or 410-482-2732; cpoukish@mde.state.md.us)
Watersheds: All - wherever kill incidents are reported
Media: water column, fish, crabs
Goals: Investigation and associated monitoring of fish kill events is designed to identify the causes of these events, which would provide information to help prevent or reduce the threat of future events.
Program Description: MDE has the responsibility to investigate all fish kills associated with pollution. Events that are caused by disease are investigated by DNR. Since the cause of an event cannot be determined until an investigation is conducted, MDE takes the lead in receiving and responding to reports. Although MDE is the designated lead agency, the resources of DNR are relied upon heavily to assist in the investigations.

The two agencies operate with a standard monitoring plan to ensure that basic information is obtained in a timely manner. Depending upon the nature of the event and the condition of the fish, field investigators will collect, count, and identify affected organisms. Appropriate water and tissue samples are collected for laboratory analysis. Field measurements, such as temperature, pH, dissolved oxygen, and other related water quality measures are taken and recorded. Fish and fish tissue samples for histological and pathological examination are collected, when required, and transported to cooperating laboratories. Go to http://www.mde.state.md.us/programs/multimediaprograms/environ_emergencies/fishkills_md/index.asp for monitoring program details.

3.1.1.10 Algal Bloom Response

Agency: MDE Ecological Assessment Division
Contact: Chris Luckett (443-482-2732); cluckett@mde.state.md.us
Charles Poukish (410-537-4434 or 410-482-2732; cpoukish@mde.state.md.us)
Watersheds: All - wherever algae and aquatic odor complaints occur
Media: water column, aquatic resources
Goals: (1) Respond to public complaints of discolored water in order to identify and document nuisance algae blooms that may be misinterpreted as gross pollution in waters of the state and

(2) Determine algae community composition in response to algae driven low dissolved oxygen induced fish kills in waters of the State, and

(3) Document pollution induced algae blooms and characterize for regulatory response.

Program Description: The Department of Environment manages a program to investigate discolored water, analyze composition, and initiate emergency containment and recovery initiatives if a pollutant is detected. This response program responds directly to public complaints. Because nuisance algae blooms are typically responsible for discoloring water, this program maintains the capability to identify common algae organisms. The program typically responds to non-toxic mahogany tide bloom organisms including *Prorocentrum minimum*, *Gyrodinium esturiale*, *Gymnodinium uncatenum*, and *Katodinium rotundatum*, and often initiates state wide response if a toxic species such as *Mirocystis* or *Pfiesteria* is suspected or confirmed. Harmful Algae Blooms (HAB) are quickly forwarded to the DNR Harmful Algal Bloom monitoring program for follow-up monitoring. HAB’s are responsible for fish kills by both passive and direct association. Most of the typical non-toxic mahogany tide organisms are responsible for massive low dissolved oxygen-induced fish kills and may be indicative of habitual nutrient or gross organic pollution requiring immediate regulatory response and follow-up. This program enhances the fish kill response program as part of the Clean Water Act Section 106 grant initiative.

3.1.1.11 Tissue Monitoring Program

Agency: MDE Technical and Regulatory Services Administration
Contact: Joseph Beaman (410-537-3633); jbeaman@mde.state.md.us
Watersheds: Selected commercial/recreational harvesting areas in non-tidal and tidal tributaries and lakes - 10 sites each year

Media: water column, aquatic resources (fish, shellfish and crabs)
Goals: The goals of this program are to ensure that aquatic resources harvested from State waters are safe for human consumption, and to provide information on potential sources and trends in water pollution levels.
Program Description: Fish and shellfish have the potential to accumulate heavy metals or organic chemicals in their tissues even when these materials cannot be measured in the water column. This makes these aquatic animals good indicators of environmental pollution in a body of water. Monitoring contaminant levels in tissues also allow the determination of potential human health effects. Go to http://www.mde.state.md.us/CitizensInfoCenter/Health/fish_advisories/index.asp for more monitoring program details.

The evaluation of the data in determining potential health effects considers:

- Persistence and fate of chemical contaminants in waters and sediments;
- Types of aquatic animals present in the water body;
- Fat content, feeding, and migration habits of those aquatic animals;
- Ability of each contaminant to accumulate in tissues of aquatic animals and humans;
- Human and animal health effects information for each contaminant;
- Preparation, cooking, and fish consumption behaviors of fishers/crabbers;
- Likelihood that sensitive populations eat these animals.

MDE has monitored chemical contaminant levels in Maryland's fish and shellfish since the 1960s. Fish monitoring focuses on species that are either predators (bass, perch, and sunfish) or bottom feeders (catfish, carp, and suckers). Within these categories, efforts are focused on those species with a relatively high fat content, however, game fish are preferred targets. Consistency in species throughout the State allows for the assessment of regional trends. Sampling is generally conducted from the end of summer through early fall to avoid biological extremes that can be linked to spring spawning. The goal is to composite five fish in each species sample. Where quantities and weights allow, fish fillets and whole fish samples are collected to provide for both human health and environmental evaluations. Standard procedures for collecting, handling, preserving and analysis have been established to maximize data integrity.

Historical sampling strategies have included annual and biennial collections at approximately 30 sites for general trend assessments. A triennial sampling strategy has been utilized since 1990, with 1/3 of the State sampled each year. Sampling is conducted in localized areas where special needs have been identified.

MDE also has been monitoring chemical contaminant levels in shellfish (oysters, clams) and crabs from the Bay and its tributaries. Because of low levels of contaminants and negligible yearly changes in those levels, this Bay-wide monitoring effort occurs every three years. If necessary, small intensive surveys are performed during off years. Sampling in the estuarine program from the beginning of summer to late fall prior to harvesting.

3.2 Non-tidal Streams and Rivers

Maryland has thousands of miles of freshwater streams and rivers (Figure 2---map showing stream network). These waterways drain the landscape and transport ground water along with nutrients, sediment and contaminants to Delaware Bay, Atlantic Ocean, Chesapeake Bay, and the Gulf of Mexico via the Ohio and Mississippi rivers. Free-flowing and non-tidal streams and rivers are found throughout the State, except in some low-lying Coastal Plain areas and on barrier islands.

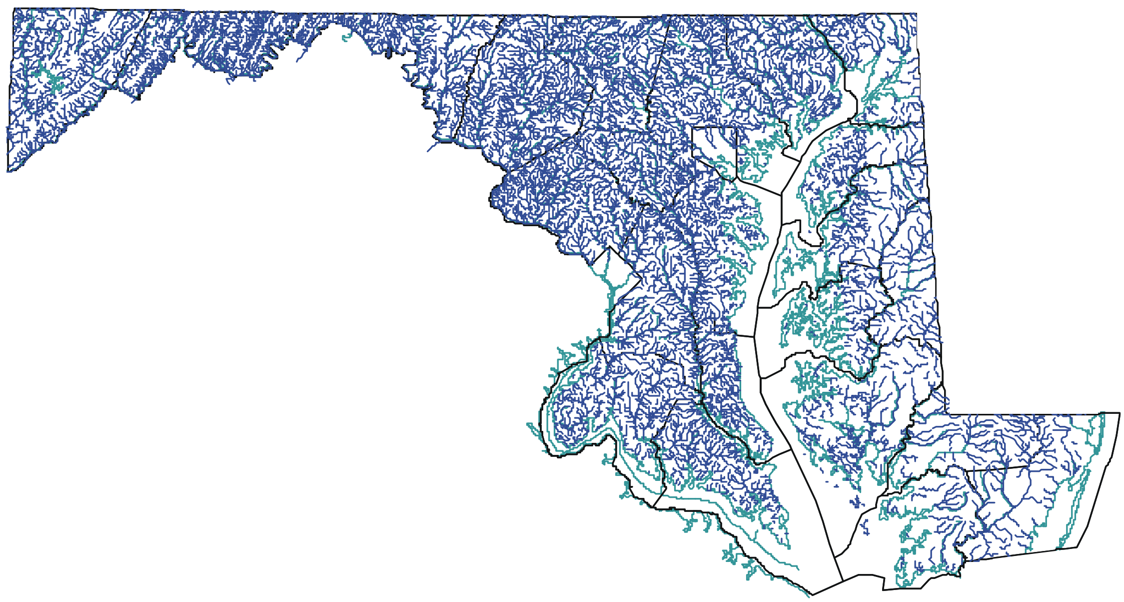

Figure 3: Stream drainage network in Maryland (overlain on county boundaries)

Using a 1:100,000 scale USGS map, we currently identify 9,941 miles of streams and rivers in Maryland. An unknown number of miles of small 1st order perennial streams, in addition to ephemeral and intermittent streams, are not captured on a 1:100,000 scale map. Stream patterns are dendritic, so most mileage is in the smallest streams (Table 2). The widely used Strahler classification scheme (Strahler 1957) identifies 1st order streams as the smallest, most upstream, and permanently flowing (perennial) reaches. The convergence of two streams of order n yields a stream of order n +1 (i.e., the merger of two 1st order streams creates a 2nd order stream, the merger of two 2nd order streams creates a 3rd order stream, and so on; the merger of a 1st order stream with a 2nd order stream creates another 2nd order stream). This classification scheme is usually a surrogate of catchment area and also provides a convenient way to compare streams of similar size (Allan 1995).

Various modifications to streams and their corridors occur across the State. Ditching is a common practice in parts of the Eastern Shore to drain low-lying lands and make them tillable. In many agricultural areas, stream channels are often re-routed to increase usable land area. Streams are sources of irrigation water and are also used as natural watering troughs for livestock.

Table 2: Extent of stream miles by reach order in Maryland

Reach Order	Stream Miles	Percent of Total
1	6,480.08	65.2 %
2	1,561.4	15.7 %
3	739.7	7.4 %
4	412.6	4.2 %
5+	747.0	7.5%
TOTAL	**9,940.7**	

(Source: ArcView analysis - 1:100,000 scale stream trace)

Stream systems have also been extensively modified in urban and rapidly developing suburban areas to more quickly carry storm water flows away from buildings and roadways. Increases in impervious land area associated with development have disrupted the hydrologic cycle and caused extensive bank erosion, channel down-cutting, and increased sediment transport. In older urban areas, like Baltimore City, many miles of streams are buried and now flow in underground pipes.

Highway and bridge construction can modify stream streams within the rights-of-way, although adverse impacts can also occur upstream and downstream from the construction sites. Poorly designed culverts block fish migrations and accelerate bank and channel erosion.

In western Maryland, many miles of streams have been rendered nearly or completely lifeless by the impacts of acid mine drainage (AMD). Acid deposition impacts on streams tend to be less acute than AMD-related impacts, but are more widespread across the State.

3.2.1 Short-term Monitoring Goals and Objectives for Non-tidal Streams and Rivers

Maryland's monitoring goals for non-tidal streams and rivers are basically three- fold: (a) to conduct probability-based and fixed station sampling programs in 1st through 4th order, wadeable streams and fixed station sampling programs in larger streams and rivers; (b) to assess the current status of these flowing waters; and (c) to document temporal trends in water and habitat quality. Probability-based sampling ensures that all wadeable streams have a known probability (greater than zero) of being sampled. Estimates of current chemical, physical, and biological stream characteristics (status) can be calculated with known levels of precision. Fixed station sampling provides the best information for tracking changes (trends) in water and habitat quality over time, for tracking water quality permit compliance, for monitoring fish and shellfish populations to ensure that they are safe for human consumption, for developing/evaluating TMDLs, but also for providing information on current status.

Specific objectives and programmatic issues/needs for non-tidal stream and river monitoring programs are given below.

3.2.2 Non-tidal Rivers and Streams Monitoring

3.2.2.1 CORE/TREND Monitoring Program

Agency: DNR Resource Assessment Service
Contact: Paul Miller (410-260-8616), pmiller@dnr.state.md.us
Watersheds: Statewide (14 of 20 basins; 39 of 138 watersheds)
Media: Water column chemistry and one biological assemblage (macroinvertebrates)
Goals: Assess status and trends in water quality and the benthic invertebrate assemblage for 305(b) report, Tributaries Strategies, and nutrient/sediment load estimation from selected watersheds. Sample areas where future development may influence water quality/habitat condition and provide data needed for the development, implementation, and evaluation of TMDL's. Determine the relationships between water chemistry, stream flow, and the benthic macroinvertebrate assemblage.
Program Description: This ambient water quality program is a network of fixed stations located in larger, non-tidal streams and rivers (4^{th} order and larger). At present, there is minimal overlap with the Maryland Biological Stream Survey (MBSS) that operates further upstream and is focused on 1^{st} through 4^{th} order, wadeable non-tidal streams. The data collected by DNR in the Core/Trends network are used to assess water quality status and also examine long-term changes. Monitoring at the Core stations is funded by U.S. EPA through the Clean Water Act Section 106 grant. Many stations in this network have been sampled since the early 1970's. One to three stations in 39 of the 138 watersheds (54 stations total) are sampled monthly for water chemistry. The benthic macroinvertebrate assemblage is sampled annually at a subset of the water chemistry stations using Surber and Hester-Dendy multiplate samplers. Thirty-two of the monitoring stations are co-located with a USGS flow gage. The distribution of monitoring stations is focused on the Potomac River and central Maryland watersheds, but is sparse on the eastern and western shores of Chesapeake Bay, as well as in the Southern Coastal Plain (Figure 4). This pattern reflects the focus on point-source discharge concerns when the network was established in the early 1970's. Physico-chemical properties (temperature, dissolved oxygen, pH, conductivity, alkalinity, turbidity, total suspended solids, total organic carbon, chlorophyll, nitrogen and phosphorous species) are sampled from near the surface by DNR staff and analyzed in the Maryland Department of Health and Mental Hygiene's laboratory. Benthic macroinvertebrate samples are collected and processed by DNR.
Data Management: Water chemistry samples are delivered by DNR staff to the Maryland Department of Health and Mental Hygiene (DHMH) laboratory in Baltimore for analysis. The raw data sheets are forwarded by DHMH to DNR's Tidewater

Ecosystem Assessment Division (TEA) for data entry. TEA staff post the water chemistry data files (in SAS format) on DNR's server. Data from this program are analyzed and interpreted by DNR's Monitoring and Non-Tidal Assessment Division (MANTA). The water chemistry data files are also sent by DNR to the Chesapeake Bay Program for posting on their web site (www.chesapeakebay.net) to facilitate downloading by the general public. Benthic macroinvertebrate samples are collected and processed at MANTA's laboratory in Annapolis. This group also handles data entry and data file maintenance. The benthic macroinvertebrate data files and are analyzed and interpreted by MANTA staff. Station locations, sample collection procedures, parameter analyses, and detection limits are described in a document titled
"Quality Assurance/Quality Control Plan: Section 106 Ambient Water Quality Monitoring" that was prepared by DNR in September 1995.

Programmatic Issues/Needs: This program should be expanded to include larger non-tidal streams and rivers on the Eastern Shore and in southern Maryland that are not currently being sampled. Recent discussions by a multi-jurisdictional workgroup within the Chesapeake Bay Program should address this need. Funds will soon be available to expand this monitoring network in 2004 and add at least four stations. The increased funding will allow DNR to add suspended sediment concentrations to the parameter list and also conduct storm event sampling. Two new monitoring stations will be added to the Core/Trend network. More new funds will be needed to continue these expansions to the current program beyond June 2007. DNR and MDE are working with EPA/ORD staff to explore ways to re-design the Core/Trend program so that the data collected from this fixed station monitoring network can be seamlessly combined with the data being collected by the probability-based MBSS, and thereby produce more comprehensive watershed assessments of water quality and habitat conditions.

Figure 4: **Map showing Maryland's CORE/TREND Monitoring Stations**

3.2.2.2 Maryland Biological Stream Survey

Agency: DNR Resource Assessment Service
Contact: Paul Kazyak (410-260-8607), pkazyak@dnr.state.md.us
Watersheds: Statewide (all 18 basins except mainstem Chesapeake Bay, 134 of 138 watersheds, wadeable 1st through 4th order streams)
Media: Biological assemblages (fish, invertebrates, amphibians, reptiles, mollusks, plants), water chemistry, in-stream and riparian habitats
Goals: Assess the current status of the biota in streams; quantify the extent to which acid deposition is affecting the biota; examine which other water chemistry, physical habitat, and land use factors may be affecting the biota; provide a statewide inventory of stream biota; establish a bench mark for documenting trends; map locations of high quality streams for protection; and target local-scale assessments and mitigation measures needed to restore degraded streams.
Program Description: The Survey's focus is on wadeable (1st, 2nd, 3rd, and 4th order) non-tidal streams in all of the State's 18 major basins (except for the mainstem Chesapeake Bay) and in 134 of 138, 8-digit watersheds grouped into 84 primary sampling units. Data are collected from about 300 stream segments of fixed length (75 m) each year and analyzed to assess current conditions, identify local degradation issues, and target restoration actions. The locations of about 210 of these segments are randomly selected each year. The rest are fixed location sites selected for special purposes (e.g., high quality sentinel sites used to evaluate natural variations in stream conditions). Statewide sampling is conducted over a three-year (Round One, 1995-1997) or five-year (Round Two, 2000-2004 and beyond) schedule, so a portion of the State's eligible streams is sampled each year. During each round, some watersheds are sampled twice. The Survey uses a probability-based sampling design as a cost-effective way to assess the status of stream resources statewide. By randomly selecting sites, the Survey can make quantitative inferences about the characteristics of the 10,000 or so miles of wadeable, non-tidal streams in Maryland. EPA is encouraging the use of probability-based sampling designs to assess status and trends in surface water quality (EPA 1993). The Survey's random sampling design is stratified by year, region (western, central, eastern), watershed, and stream order. Fish and benthic macroinvertebrate assemblages are the major indicators of stream health; however, observations on the presence/absence of amphibians, reptiles, mollusks, and plants are also recorded. Several regionally-specific, fish and benthic IBIs were developed by DNR for Maryland's wadeable, non-tidal streams. A suite of chemical parameters (emphasis on acid-base chemistry and nutrients) and a continuous record of water temperature are measured at each site. An array of quantitative and qualitative physical habitat parameters (in-stream and riparian zone) is also measured. A regionally-specific, multimetric physical habitat indicator was developed by DNR from Survey data. Each sampled site is geo-referenced in the field so later analyses can determine the drainage area and land cover/land use in each site's catchment using GIS. Methods manuals are available for both the field sampling and benthic macroinvertebrate sample processing portions of the Survey (Boward and Friedman 2000, Kazyak 2001). For additional monitoring program information, please go to http://www.dnr.state.md.us/streams/mbss/index.html.

Data Management: All survey crews use standardized, pre-printed data sheets developed for the Survey to ensure that all data collected at each sampled stream site is recorded and only standard units of measure are used. The field crew leader and a second reviewer check all data sheets for completeness and legibility before they leave the sampling site. The original data sheets are submitted to the Data Management Officer who requests a review by the Quality Control Officer. Copies of all data sheets are retained by the field crew leader. Data entry is completed using entry screens designed in Microsoft Access. Except for water chemistry measurements conducted at the University of Maryland's Appalachian Laboratory and identifications of benthic macroinvertebrates completed in DNR's laboratory, all Survey data are independently entered into two data bases and then compared using a computer program, one quality-control procedure. Differences between the two databases are resolved using original data sheets or through discussions with field crew leaders. Each year, a report is prepared that documents the quality assurance/quality control activities associated with the Survey (e.g., Mercurio et al. 2004).

Programmatic Issues/Needs: The second statewide round of the Survey will be completed in 2004. Prior to beginning a third round of five-year duration, the sampling design, methods, and indicators will be examined to determine if changes or refinements are needed to more effectively and efficiently achieve Survey goals. Changes will be made only if they do not diminish data comparability for Rounds One and Two. Possible changes to the Survey for Round Three that will begin in 2006 include: (a) addition of a salamander IBI for assessing the status of small headwater streams where fish diversity is very low, (b) addition of more quantitative measures of sediment flux, (c) incorporation of data from the volunteer-based Stream Waders program with Survey data to better assess stream conditions at the smaller 12-digit watershed scale,
(d) selection of the best combination of random and fixed location sampling designs to allow monitoring of both status and trends, and (e) expansion of the current Survey into tidal fresh and brackish streams. An important need for the Survey is a long-term, consistent funding base. To complete Rounds One and Two, DNR had to secure and pool a multitude of funding sources (from short-term, usually one-time grants and cooperative agreements with U.S. EPA, National Park Service, NOAA, and others) to supplement support from Maryland's Environmental Trust Fund. DNR's Maryland Biological Stream Survey has been lauded by EPA and several university scientists as one of the best, if not the best, state stream monitoring programs in the country. Therefore, we urge EPA to increase the Section 106 grant to Maryland and provide sufficient federal funds every year to support at least 40% of the Survey costs. Without a consistent, long-term funding base, DNR may not be able to continue finding and pooling enough short-term, one-time source of funds to keep the Survey going long enough to conduct meaningful trends analyses.

3.2.2.3 Watershed Cycling Strategy (see Section 3.1.1.4)

3.2.2.4 NPDES point source permit monitoring

Agency: MDE Technical and Regulatory Services Administration

Contact: John Steinfort (410-974-3238); jsteinfort@erols.com
Watersheds: Statewide - water bodies with permitted wastewater discharges
Media: water column
Goal: The goal of this monitoring effort is to provide facility-specific water quality data essential for determining pollutant sources and pollutant loads in the vicinity of the discharge in order to support the development of facility specific permits.
Program Description: MDE conducts between four and 8 localized intensive water quality studies annually addressing specific permitting concerns. These studies are conducted to evaluate pollutant loading for resolution of disputed permit renewals or requests for increased constituent loads. This monitoring program is designed to compliment the *Watershed monitoring ("Cycling Strategy") for water quality impairment determination and TMDL development* described above.

3.2.2.5 NPDES Permit Compliance Monitoring

Agency: MDE Technical and Regulatory Services Administration
Contact: William Beatty (410-974-3238); billbeatty@starpower.net
Melvin Knott (410-631-3605); mknott@mde.state.md.us
Watersheds: Statewide - water bodies with permitted wastewater discharges
Media: water column
Goal: provide data to verify the accuracy of data reported by the permitted facilities under self-reporting requirements established in the permits.
Program Description: This function is a required under the Section 106 federal grant to the State. It has been conducted since the early 1980s. It involves monitoring at approximately 60 "major" domestic wastewater treatment plants that discharge more than one million gallons per day. Facilities demonstrating non-compliance with established permit limitations, regardless of flow or facility size, are also included in the monitoring program.

The monitoring protocol involves collection of a series of discreet effluent samples over a two-day period along with a composite sample (generally of 24 hours duration), which is routinely split with the facility. Composite duration may be of either 8- or 12-hour duration if the facility's permit is written for that interval. Flow measurements are made for discrete samples, and total flow is recorded for the compositing period. Pollutant loadings are then calculated and compared to permit authorizations. Samples are also secured for Whole Effluent Toxicity (WET) testing. These samples are taken to the Department's contract laboratory to determine whether the effluent demonstrates toxic effects on invertebrate and fish organisms. Any positive findings trigger additional monitoring by the State and facility with a Toxic Reduction Evaluation (TRE) conducted by the facility upon confirmation of toxic conditions.

3.2.2.6 NPDES Pretreatment Monitoring

Agency: MDE Water Management Administration
Contact: Gary Kelman (410-631-3630); gkelman@mde.state.md.us
Melvin Knott (410-631-3605); mknott@mde.state.md.us
Watersheds: Statewide

Media: water column

Goal: The goal of the Pretreatment Monitoring program is to assure that user-provided information about pretreatment reduction of pollutants of concern from industrial facilities will not pass through or interfere with operations of publicly owned treatment works (POTWs) or to affect the beneficial uses of POTW biosolids.

Program Description: Significant industrial users which discharge wastes to municipal wastewater systems are directly regulated by MDE and are responsible for self-monitoring wastewater at least twice per year. This ensures that representative samples of the industrial wastewater discharges into local sanitary sewers are analyzed for permitted pollutants of concern. This is accomplished by MDE oversight of local industrial user pretreatment programs as well as MDE permitting of significant industrial users in non-pretreatment areas of the State. In order to confirm and amend these data, MDE samples their sanitary sewer effluent for the same pollutants of concern.

Where applicable, 24-hour composite samples are collected. Grab samples are taken for pH, oil and grease, total petroleum hydrocarbons, volatile organics, sulfides and other parameters where this type of sampling is applicable. Flows are measured where this is a regulated parameter. All samples are collected at the same or a location equivalent to where the SIU takes its samples. All data are forwarded to the Water Management Administration's Pretreatment Section and analytical results are compared with industry permit requirements. Appropriate management and enforcement actions are taken when necessary.

3.2.2.7 NPDES Stormwater Monitoring (Municipal - Nonpoint source)

Agency: MDE Water Management Administration

Contact: Brian S. Clevenger (410-631-3543); bclevenger@mde.state.md.us

Watersheds: Selected watersheds in 10 large municipalities

Media: water column

Goal: The goals of the municipal NPDES stormwater monitoring program include the pollutant characterization of urban runoff from specific land uses and the assessment of receiving stream morphology and biological integrity to guide management program implementation.

Program Description: Municipal NPDES stormwater permits are intended to control storm drain system pollution from places with populations over 100,000. Among the myriad of tasks required to be performed by these permits is a significant effort to monitor the effects of stormwater runoff on urban receiving waters. These monitoring efforts include chemical, biological, and physical assessments within a very specific area.

Each of ten major Maryland jurisdictions and the State Highway Administration is required to select a major storm drain system outfall to monitor storm events throughout their respective five-year permit terms. The selection of these sampling locations is crucial because each jurisdiction is requested to monitor a specific land use in order to determine the types of pollutants produced by that land use. Therefore, each

NPDES municipal permit requires the most populated localities in the State to choose an outfall that discharges runoff from one homogeneous area. In addition to this selected storm drain system outfall, a second, downstream ambient monitoring station is required to be established. Storm events are monitored at this instream location in the same way as the upstream outfall. Data are submitted annually that report the results of the sampling activities that occur during the reporting period.

At both outfall and instream monitoring locations, 12 storm event samples are required to be collected and analyzed each year for a suite of constituents including: biochemical oxygen demand, total cadmium, total Kjeldahl nitrogen, nitrate+nitrite, total petroleum hydrocarbons, total phosphorus, total copper, total phenols, total zinc, fecal coliform bacteria, total lead, oil and grease (optional), and total suspended solids.

For biological assessment, the receiving stream system between the storm drain outfall and the ambient station is monitored twice annually (Spring and Fall). The United States Environmental Protection Agency's (EPA) Rapid Bioassessment Protocol III is used to determine the health and long-term changes in the benthic community present. Data are submitted annually with chemical monitoring results.

Finally, within this same stream reach, a geomorphologic assessment is performed annually to detect trends with regard to instream changes. A series of permanently monumented stream channel cross sections is required to be established. These cross sections, along with stream profiles, are surveyed annually to track geomorphologic changes that occur.

Information collected as a result of this monitoring program is compiled by MDE and analyses are performed to determine the types of pollutants found in runoff from specific urban land uses (e.g., residential, industrial, highway, etc.). Taken together with the data generated from biological and physical stream assessments, these data will help MDE determine how best to tailor management program implementation in the future. Additionally, this monitoring approach will improving the State's stormwater management program.

3.2.2.8 Stream Gauging Network

Agency: DNR Maryland Geological Survey
Contact: Emery Cleaves (410-554-5503);
Watersheds: Selected perennial streams Statewide
Media: water column
Goal: Stream gages are operated throughout Maryland to meet numerous water-resources management goals of federal, State, and local government agencies. Streamflow data are crucial to water-resources management goals in three fundamental ways - evaluation of current conditions, watershed management and planning, and decision-support systems.
Program Description: In recent years, the stream-gauging network in Maryland has ranged from 95 active stations in 1985 to 76 active stations by the end of 1995.

Ninety-seven stations were being operated throughout Maryland as of November 15, 1999. Gauged locations range in drainage area from 0.03 square miles (mi^2) to 27,100 mi^2. Approximately one-third of the stations have 50 or more years of continuous record. Gauging stations are located in each of Maryland's physiographic provinces. The network is operated and maintained by the US Geological Survey, in cooperation with State, County, and local government agencies.

Recommendations: Based upon recommendations of the Maryland Water Monitoring Council (Cleaves and Doheny, 2000) it is recommended that Maryland's stream-gauging network be increased from 97 gages (in existence as of November 15, 1999) to 157 gages. The additional gages should be activated in stages according to six priority management goals: Coastal Plain Harmful Algal Blooms, small watershed, core network, Clean Water Action Plan, flood hazard, and other unmet coverage (CORE/trend network, unmet 6- or 8-digit Hydrologic Unit Codes, unmet spatial coverage, and unmet physical-matrix categories). Drought assessment is also a major concern, and requires the continued operation of stream gages with long-term records.

3.2.2.9 Fish kill investigations (see Section 3.1.2.6)

3.2.2.10 Algal Bloom Response (see Section 3.1.2.5)

3.2.2.11 Drinking water protection program

Agency: MDE Water Management Administration

Contact: Bill Beatty - compliance (410-974-3238); billbeatty@starpower.net
John Grace - source water protection (410-631-3713); jgrace@mde.state.md.us

Watersheds: Surface water intakes/utilities in streams classified as potable water supply

Media: water column

Goals: To protect the physical, chemical and biological integrity of the ground water resource in order to protect human health and the environment, to ensure that in the future an adequate supply of the resource is available, and to manage that resource for the greatest beneficial use of the citizens.

Program Description:

Source Water Protection Program **-** MDE's Water Management Administration oversees the surface water intake monitoring results from utilities, monitors basic water quality, documents chemical quality conditions at water intakes, and provides a basis for monitoring future trends. These sites are tested for major dissolved ions, bacterial indicators, selected trace elements, selected volatile organic compounds, several classes of pesticides, and selected radionuclides - (***see Ground water - Source Water Protection Program***).

Finished Water Protection Program **-** Maryland's public drinking water monitoring program meets all Federal mandates of the Safe Drinking Water Act. This program monitors 1,024 municipal drinking water supplies for maximum contaminant levels established by the US Environmental Protection Agency. Self-monitoring is required of all public supplies as specified in federal regulations. Compliance monitoring is conducted by the Water Management Administration for specific constituents including bacteriological, chemistry, THMs (trihalomethanes), VOCs (volatile organic carbons), pesticides, radiation, radon, metals, and nutrients (nitrates and nitrites). Monitoring efforts also include responses to consumer complaints and emergencies where protection of public health is a primary concern.

3.2.2.12 Tissue Monitoring Program (see Section 3.1.2.6)

3.2.2.13 Ground Water

Ground water is an abundant natural resource that serves as a significant source of drinking water in Maryland. Ground water levels in unconfined aquifers undergo seasonal fluctuation and are principally recharged by precipitation during the fall and winter months, while ground water levels in confined aquifers are not as responsive to short-term variability in climate or precipitation. About 31 percent of the State's population use ground water as a drinking water supply. In Southern Maryland and the Eastern Shore, ground water meets practically all of the water supply needs. About half of the Marylanders using ground water for drinking obtain water from a well that they own, while the other half obtain their drinking water from public water supplies that use ground water. Ground water contributes to base flow water in the State's rivers, streams, tidal tributaries and the Chesapeake and Coastal Bays. Other major uses of ground water include agriculture and industry.

Geologic conditions vary widely across Maryland and produce significant variations in the quantity and quality of ground water. Aquifers in Maryland fall into two major types-unconsolidated sedimentary rock aquifers of the Coastal Plain Physiographic Province found east of the Fall Line, and hard rock (consolidated sedimentary and crystalline rock aquifers found in the western part of the State (*Figure 4*). The Coastal Plain aquifers, composed primarily of sand and gravel with layers of silt and clay, are productive, and generally of good quality. The hard rock aquifers typically have a lower yield than unconsolidated sedimentary aquifers of the Coastal Plain.

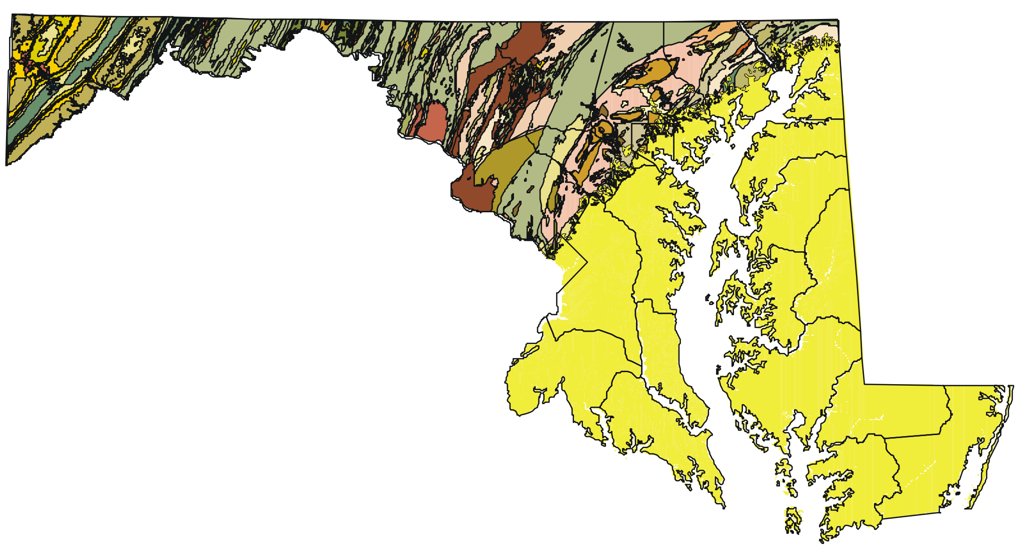

Figure 5: Coastal Plain aquifers and upland geological formations in Maryland

3.2.3 Short-Term (2 to 5 years) Ground Water Monitoring Strategy and Objectives

The State of Maryland is committed to protect the physical, chemical and biological integrity of the ground water resource, in order to protect human health and the environment, to ensure that in the future an adequate supply of the resource is available, and in all situations, to manage that resource for the greatest beneficial use of the citizens of the State. To this end, the State will continue to: monitor ambient groundwater conditions on a five year rotation; work with counties to develop special studies on pollutants of concern; monitor public water systems (for both quantity and quality) that serve communities of 25 people or greater for more than 60 days a year; and, monitor ground water in areas of known pollution sources to protect public health and the environment. Also, the State will continue to monitor wells serving 25 people or greater in non-transient, non-community areas (schools, work places, etc.) for both acute and chronic levels of contaminants.

3.2.4 Ground Water Monitoring Programs

3.2.4.1 Maryland Ground Water Quality Monitoring Network

Agency: Maryland Geological Survey
Contact: David Drummond (410-554-5551); drummond@mgs.state.md.us
Watersheds: Ground water wells selected to provide ambient conditions (cycling)
Media: ground water
Goals: To collect samples from a statewide network of wells and springs in order to document the baseline chemical-quality conditions of aquifers and to provide a basis for measuring future trends.
Program Description: MGS resamples approximately 100 network wells and springs every five years and analyzes the data for long-term changes in ground-water quality. Samples are analyzed for major ions, nutrients, nitrogen isotopes, trace metals, volatile organic compounds, pesticides and pesticide breakdown products, and radionuclides. For additional monitoring program information, please go to http://www.mgs.md.gov/hydro/qwindex.html.

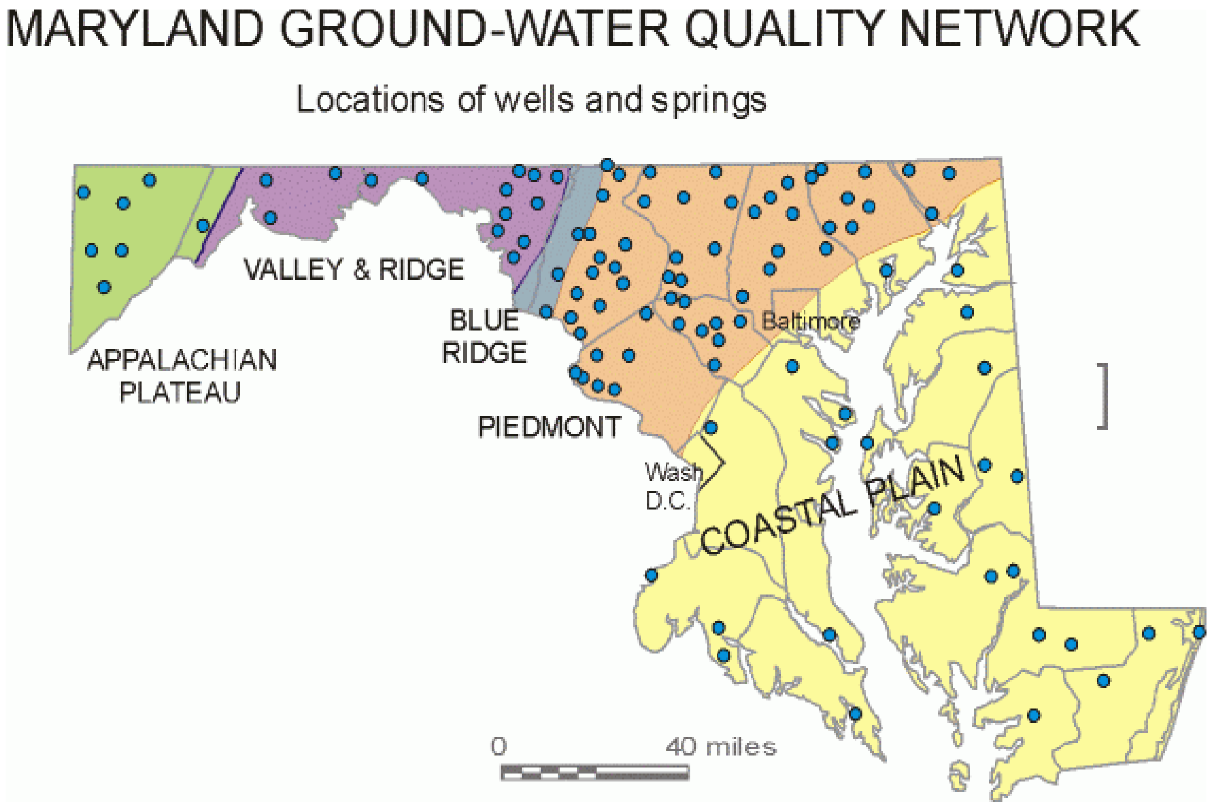

Figure 6: Maryland's Groundwater Quality Monitoring Network

3.2.4.2 Superfund Program

Agency: MDE Waste Management Administration
Contact: John Fairbank (410-537-3475); jfairbank@mde.state.md.us
Watersheds: Ground water wells
Media: Ground water
Goals: Obtain the data necessary to identify the highest priority sites that pose a threat to human health or the environment. Investigate, oversee remediation or perform cleanup of these high priority sites. A primary goal of remediation activities is to protect ground water by ensuring that contaminant sources are removed or contained in a manner which minimizes future impacts to ground water. To the maximum extent practicable ground water resources, which have been impacted by contamination, will be restored to their maximum beneficial use or treated to safe levels prior to end use.
Program Description: The federal "Superfund' program, authorized by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), was established to identify, prioritize and cleanup hazardous waste sites. The Environmental Restoration and Redevelopment Program within the Waste Management Administration ensures that state requirements are met during investigation and cleanup of sites designated for the National Priority List (NPL) and federal facilities under the federal "Superfund" program. In Maryland, 21 sites have

been placed on the NPL; 16 of these sites are currently active. The remaining five sites have been removed from the NPL or are in the final stages of completing the remediation process. Additionally, the MDE has a memorandum of agreement with the Department of Defense (DoD) covering 44 federal facilities, 37 of which are not on the NPL. Currently, the DoD is actively working on 22 sites at which MDE is actively overseeing the investigation or remediation of ground water contamination.
State Superfund Program: A similar program under State law, the State Superfund Program, conducts investigations and oversees the remediation and cleanup of sites listed on the State Master List that are not included on the NPL or are not owned by the federal government. The State Master List contains 439 sites that have been identified statewide with known or potential contamination. In Maryland, there are approximately 35 State Superfund sites at which MDE is actively overseeing the investigation or remediation of ground water contamination. For additional program information go to http://www.mde.state.md.us/Land/land_programs/index.asp.

3.2.4.3 Oil Control Program

Agency: MDE Waste Management Administration
Contact: Herb Meade (410-537-3385); hmeade@mde.state.md.us
Watersheds: Ground water supply wells
Media: ground water
Goals: Monitoring activities conducted under the Oil Control Program are designed to identify problem conditions with historic tank operations, track the recovery of remediation efforts, and to verify that the integrity of currently installed systems is secure. These efforts are intended to protect surface and ground waters and associated aquatic life from the harmful effects of petroleum and to ensure that potable surface and ground water quality is maintained.
Program Description: The Oil Control Program, within the Department of the Environment's Waste Management Administration, is the unit responsible for the implementation of the Underground Storage Tank (UST), Leaking Underground Storage Tank, and Aboveground Storage Tank programs. These programs provide for preventive actions to minimize ground and surface water pollution from the storage of petroleum and hazardous substances and for remedial actions to restore sites that have been contaminated by oil or hazardous substances. Under the oversight of the UST program, which began in 1988, the active universe of motor fuel underground storage tanks in the State has been reduced from over 21,000 to just fewer than 8,500. Those motor fuel underground storage tanks that remain have been required to be replaced or upgraded to meet federal standards that became effective on December 22, 1998. These standards include requirements for corrosion protection, leak detection, and spill and overfill protection. With more than 93 percent of Maryland's underground storage tank owners meeting the 1998 federal compliance deadline, the UST program is actively working with the remaining underground storage tank owners to achieve full compliance with the federal requirements. In addition to the motor fuel facilities, Maryland regulates the storage of heating fuel in over 3,700 underground storage tanks.

One of the major causes of releases from underground storage tank systems has been the corrosion of bare steel tanks and lines. Investigations of releases from these tanks are required and those with groundwater impacts are required to define the vertical and horizontal extent of the contamination. Once defined a Corrective Action Work plan is implemented to mitigate the impact of the contamination. The effectiveness of remediation systems is normally evaluated through groundwater monitoring. The Leaking Underground Storage Tank (LUST) Program has tracked reports of over 14,500 confirmed releases throughout Maryland. Of these releases, over 7,500 cleanups have been completed while the Oil Control Program continues to provide oversight of over 7,500 ongoing cleanups.

The Oil Control Program administers the regulation of the transportation and aboveground storage of oil through a series of permitting requirements. The above ground storage facility permits include requirements for monitoring storm water and test water discharges while petroleum contaminated soil treatment facilities are required to also monitor groundwater.

These storage tank programs all work together to prevent the pollution of surface and ground water from releases that can occur from the handling and storage of oil and hazardous substances. For additional program information go to http://www.mde.state.md.us/Land/land_programs/index.asp.

3.2.4.4 Water Supply Program

Agency: MDE Water Management Administration
Contact: John Grace - source water protection (410-537-3714); jgrace@mde.state.md.us
Watersheds: Ground water supply wells
Media: ground water
Goals: To ensure safe and adequate public drinking water in Maryland. .
Program Description: The Water Supply Program (WSP) is responsible for ensuring safe and adequate public drinking water in Maryland. Statewide about 800,000 residents, served by about 460 community ground water systems, use over 80 million gallons of water per day. Additionally there are about 3,300 Maryland facilities relying on ground water, which are defined by the Safe Drinking Water Act as non-community public water systems. These small facilities include schools, day care centers, places of work, restaurants, churches, community centers and campgrounds that have their own source of water. For additional program details, please visit http://www.mde.state.md.us/Programs/WaterPrograms/Water_Supply/home/index.asp.

3.2.4.4.1 Water Quality

A significant amount of sampling occurs at public water systems to determine if the water being supplied is in compliance with State and Federal drinking water standards. Sampling requirements depend on system type, system size, source type, system vulnerability and contaminant. Community ground water systems are subject to monitoring requirements for over 80 contaminants that have health-based standards or maximum contaminant levels. Forty-two other unregulated contaminants are also tested at these systems. Water supply systems often use ground water with little additional treatment. The most common treatment objectives to improve ground water quality, in descending order, are: pH adjustment, iron removal, corrosion control, inorganics removal, softening, particulate removal, organics removal, manganese removal, and radionuclide removal.

Wellhead Protection

The Wellhead Protection Program (WHPP) is a preventive program designed to protect public water supply wells from contamination by establishing a wellhead protection area (WHPA) around each well. Existing and potential contamination sources are identified and plans for management are developed. EPA approved Maryland's Wellhead Protection Program in June of 1991. The program coordinates wellhead protection activities among State agencies, public water suppliers, local governments, and the public. The WSP assists local governments in delineating WHPAs, and in developing management programs to protect water supplies within the wellhead protection areas (see http://www.mde.state.md.us/Programs/WaterPrograms/Water_Supply/wellheadprotection/index.asp).

Source Water Assessments

Maryland is enhancing previous wellhead protection activities by committing to developing source water assessments for all community ground water systems by the end of 2004. All source water assessments have recommendations for protection of the water supply and water suppliers are strongly encouraged to develop and implement protection measures. Maryland's Source Water Assessment Program (SWAP) is described in detail on its web site at: http*://www.mde.state.md.us*. The SWAP was approved by EPA in November 1999.

One priority for the WSP is to ensure the safety of new public water supplies by reviewing and evaluating proposals for the siting of new wells. To ensure that wells are sited in the safest locations, staff review Departmental databases to identify existing or potential contamination sources, and use site investigations to verify this information and evaluate any additional factors that might influence the safety of the water supply. In FY 2003 the program reviewed proposals for the siting of approximately 50 new public water supply wells (see http://www.mde.state.md.us/Programs/WaterPrograms/Water_Supply/sourcewaterassessment/index.asp).

3.2.4.4.2 Water Quantity

MDE's Water Supply Program has the responsibility of controlling the impacts of ground water withdrawal through the water appropriation and use permit process. With few exceptions, all ground water uses must be authorized through MDE's permitting process. Exempt from the requirement for a water appropriation permit are uses for temporary construction dewatering (up to 30 days and 10,000 gallons per day), creation of small subdivisions (10 lots or fewer), individual domestic use, agricultural use under 10,000 gallons per day, and extinguishing a fire.

Each permit application is evaluated for the reasonableness of the amount of water planned for a particular use and the impact of that use on the resource and other users of the resource. Aquifer testing, fracture trace analysis, water level monitoring, the development of a water balance and other investigation techniques are part of the evaluation. Through the permit review process, the Water Supply Program attempts to avoid impacts to other water users and assures that ground water withdrawals do not exceed the sustained yield of the State's aquifers.

In addition, MDE has delineated some areas for special management considerations. An example is Kent Island where, to prevent further degradation of the Aquia aquifer from salt-water intrusion, new appropriations are directed to deeper aquifers. Ground water modeling is also used to project the impacts of comprehensive land use plans and direct future development.

Agricultural water use has been growing steadily in recent years, particularly for irrigation on Maryland's Eastern Shore. In general, MDE directs large irrigators to use the water table aquifer, reserving the more protected confined aquifers for individual potable and municipal uses. In some areas, however, the water table aquifer produces low yields, or is nonexistent, compelling an increasing number of farmers to seek water appropriation permits for confined aquifers.

The Maryland Geological Survey has and continues to conduct special studies to evaluate water supply, including: a four-year study begun in 1991 of the hydrogeologic characteristics and water supply potential of the Patapsco aquifer system in southern Maryland; a study of the water-supply potential and natural water quality of the Aquia and Magothy aquifers in southern Anne Arundel County; as well as a study to determine optimum pumping scenarios for wells in the Waldorf system pumping from the lower Patapsco aquifer.

3.2.4.5 Solid Waste Program

Agency: MDE Waste Management Administration
Contact: Edward M. Dexter, P.G. (410-537-3376); edexter@mde.state.md.us
Watersheds: Ground water supply wells
Media: ground water
Goals: The Solid Waste Program is charged with the maintenance of this monitoring program to insure that the public health, safety and comfort, and the quality of the environment, are not compromised due to pollutants discharged from the regulated solid waste and sewage sludge facilities. Several indicators relate to this important function. For Managing Maryland for Results, the Program reports the number of evaluations of groundwater quality at landfills performed each year, and the percentage of received reports reviewed (MMR Goal #3 - Insuring Safe Drinking Water). For the Environmental Partnership Agreement (EnPA) with the United States Environmental Protection Agency (EPA), SWP reports the number of active municipal waste landfills in compliance with groundwater standards.

Program Description: The Solid Waste Program (SWP) oversees the environmental monitoring of landfills and sewage sludge storage facilities. This activity includes the direction and review of the groundwater and surface water monitoring systems at these sites, to help protect the public health and the environment from pollution, which could be caused by these facilities. Authority for the program is provided in the Environment Article, Subtitles 9-2 and 9-3 of the Annotated Code of Maryland. Also, federal regulations governing municipal waste landfills (40 CFR 258 are applicable for those sanitary landfills accepting municipal waste which operated after 1993.

Classes of facilities monitored include active municipal waste landfills; active rubble landfills; active industrial waste landfills; closed municipal waste landfills which are subject to the federal regulations; closed municipal waste landfills which are not subject to the federal regulations; closed rubble and industrial waste landfills; and sewage sludge storage lagoons. Approximately 78 facilities are monitored routinely, with over 140 separate reports submitted to the Solid Waste Program each year. In addition, one to three special projects are managed each year, which often involve sampling by SWP of surface water, groundwater, waste, and suspected discharges. Some projects also involve sampling of domestic wells, which is coordinated with the local County Health Departments.

Groundwater and surface water sampling is typically on a semiannual frequency, although due to their geologic setting some facilities are on a quarterly frequency for some parameters, while closed facilities which have stabilized or have not experienced a pollutant release may be reduced to an annual sampling frequency. Some sites only sample groundwater; others not only perform sampling for this program but also sample surface or ground water discharges under the NPDES or State Groundwater Discharge Permit programs.

Sampling is performed by contractors or technicians working for the applicants and analyzed at approved laboratories, in accordance with sampling and analysis plans approved by the Solid Waste Program. Some County governments perform sampling using their own technicians, and some have hired the Maryland Environmental Service or other companies to perform this work. The Maryland Department of Health and Mental Hygiene's laboratory performs the analytical work for some sites, whereas most of the analysis is performed by commercial laboratories approved by SWP. SWP requires that laboratories used be certified by DHMH for analysis of drinking water samples, or have an equivalent certification acceptable to SWP.

Data evaluation is performed by the staff of the Investigations and Remediation Section, consisting of a senior geologist/section head, a staff geologist, and a registered environmental sanitarian. Other duties assigned to this section include review of monitoring plans, groundwater investigations, remedial plans, landfill soil gas monitoring plans and data, and landfill closure plans. Go to http://www.mde.state.md.us/Programs/LandPrograms/Solid_Waste/index.asp for more program details.

3.2.4.6 Voluntary Clean-up Program

Agency: MDE Waste Management Administration
Contact: John Fairbank (410-537-3475); jfairbank@mde.state.md.us
Watersheds: Ground water wells
Media: Ground water
Goals: To provide a streamlined process for the remediation and redevelopment of former industrial or commercial properties that are contaminated, or perceived to be contaminated with controlled hazardous substances.
Program Description: Sites on the NPL, under active enforcement by MDE, subject to a State issued Controlled Hazardous Substances permit or contaminated after October 1, 1997 and owned by a " responsible party" are not eligible for participation in the program. Upon successful completion of the program, participants are also provided limitations on liability for the eligible property. Upon completion of site remediation and restoration activities, each property owner receives a Certificate of Completion or a No Further Requirements Determination. Frequently these sites are issued requirements that prohibit the use of ground water beneath the property for any purpose. See http://www.mde.state.md.us/Programs/LandPrograms/ERRP_Brownfields/index.asp for more program details.

3.2.4.7 Waste Water Permits

Agency: MDE Water Management Administration
Contact: Jay Prager (410-537-); jprager@mde.state.md.us
Watersheds: All
Media: Ground water
Goals: To protect public health and the groundwater resource through the issuance of State Discharge Permits for the discharge of waste water to ground water and oversight of on-site sewage disposal systems and wells.
Program Description: This program is divided into four divisions. Two of the divisions issue wastewater discharge permits for wastewater discharges to surface waters under the NPDES program.

The State Groundwater Discharge Permits Division protects the public health and ground water source through the issuance of State Discharge Permits. These permits control the discharge of industrial and municipal wastewater to ground water through a variety of methods such as injection wells, large on-site sewage disposal systems and land application systems.

The On-site Systems Division protects public health and the ground water resource by providing oversight, technical support, project review and enforcement of MDE regulations implemented by local governments and which pertain to on-site sewage disposal systems, subdivision of land and well construction. For additional program details, go to http://www.mde.state.md.us/Water/water_programs/index.asp.

3.2.4.8 Pesticides Management

Agency: Maryland Department of Agriculture

Contact:
Watersheds: All
Media: Ground water
Goals: To develop pesticide management plans to minimize Ground Water quality impacts associated with specific pesticides of concern.
Program Description:
The Maryland Department of Agriculture (MDA) Pesticide Regulation Section, the State's lead agency for implementing the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), has finalized a second draft of the generic Pesticide Management Plan (PMP). This plan will be used as the basis for the specific pesticide management plans that will be developed to protect the State's ground water resources from contamination by specific pesticides identified by EPA. The PMP rule is currently undergoing revision. Once these revisions have been finalized, Maryland's PMP will be revised and comments will be sought from the agricultural community, pesticide industry and public interest groups before submission to EPA. MDA plans to form a committee, representing the different interests in the PMP process, in order to help develop pesticide specific PMP's. For additional program details, please go to http://www.mda.state.md.us/plant/ipm.htm.

3.2.5 Other Special Ground Water Studies and Pilot Projects

3.2.5.1 Ground Water Virus Study

A second of two studies was completed by the U.S. Geological Survey (USGS) for MDE in 2002, concerning the occurrence and distribution of viral contamination in selected public supply wells. Both studies selected public supply wells using less than 10,000 gallons per day.

One study ranked over 270 wells in Worcester and Wicomico counties based on depth and surrounding land use. Twenty-seven wells, which were ranked highest for potential for viral contamination and where permission was secured from the property owner, were sampled. Each site was sampled for basic water quality parameters (nutrients, major cations and anions, pH, temperature and conductance), RNA and DNA viral fragments, bacteria, culturable viruses and coliphages. For additional information, please go to http://md.water.usgs.gov/publications/wrir-01-4147/.

The second study randomly selected 91 wells from all public systems pumping less than 10,000 gallon/day in Baltimore and Harford counties. The wells were sampled for the same suite of indicators, viruses and water chemistry parameters as identified above.

3.2.5.2 Radium in Coastal Plain Ground Water

As a continuation of a study of radium occurrence in ground water, a project was undertaken for MDE by the MGS to examine the aquifer materials as related to the radium measured in the ground water in aquifers in Anne Arundel County. A report describing a study of the geochemistry of aquifer materials from two core holes in northeastern Anne Arundel County was prepared by MGS for distribution in June

2003. The study was undertaken because ground-water samples from shallow wells in the Magothy and Patapsco Formations often contain measurable concentrations of radium (even though concentrations of radon, a decay product of radium, tend to be low), whereas samples from shallow wells in the Aquia Formation generally have low radium concentrations but, in some cases, relatively high radon concentrations. For additional program details, go to http://www.mgs.md.gov/hydro/aagisindex.html.

3.2.5.3 Arsenic in Ground Water in the Major Aquifers of the Maryland Coastal Plain

In accordance with the funding and agreement with MDE the MGS continued its investigation of arsenic in ground water in the major aquifers of the Coastal Plain. About 25 percent of samples from the Aquia aquifer and 10 percent of samples from the Piney Point aquifer exceeded USEPA's newly established drinking-water standard of 10 micrograms per liter (µg/L); most of the exceedances were from Queen Anne's, Talbot, Dorchester, and St. Mary's Counties. Arsenic was detected only sporadically in wells from other aquifers. Following the initial phase of the study, about 60 wells were resampled and analyzed for major ions, nutrients, and arsenic species. Most arsenic was present as arsenite (the reduced form), which tends to be more mobile in ground water than arsenate (the oxidized form). Additional samples were collected from the Aquia aquifer in the Kent Island area to gather information on local variability in arsenic concentrations (both vertically and laterally). Data analysis is continuing. For more program details, see http://www.mgs.md.gov/hydro/arsenic/index.html.

3.2.5.4 MTBE

A multi-phased approach has been initiated by MDE to determine the extent of MTBE's impact to ground water in Maryland. Emergency legislation passed during the 2000 legislative session created a 16-member Task Force in which MDE participated, to investigate and assess the environmental impact of MTBE to Maryland's waters. The Task Force reported its findings in December 2001. The Oil Control Program also began an initiative to identify existing and potential pathways of migration of petroleum from active USTs to ground water and to assess the threat of past releases of petroleum that were cleaned up prior to analysis for MTBE. For more details, please go to http://www.mde.state.md.us/programs/landprograms/oil_control/mtbe_update/index.asp.

3.2.5.5 Pesticides

In July 2002, MGS and MDA (Pesticide Regulation Section) began a project in which 20 wells in central and southern Maryland were analyzed for approximately 60 pesticides, nitrogen isotopes, and other constituents. The objectives of this study were to determine the types and concentrations of pesticides that are present in ground water in central and southern Maryland, and to evaluate the relationship between nitrate concentrations, $^{15}N/^{14}N$ isotope ratios, pesticide detections, and other data in order to identify sources of nitrate (i.e., agricultural, residential, or natural sources). Preliminary data indicate that deethyl atrazine (a breakdown product of atrazine and other triazine herbicides), atrazine, and metolachlor were the most frequently detected pesticide residues. All pesticide detections were less than 1 µg/L, and none of the detections exceeded drinking-water standards (although not all the pesticides detected have drinking-water standards established). Nitrogen-isotope data in conjunction with other water-quality data suggest a variety of sources for nitrate in samples having above-background levels of nitrate. Data analysis has not yet been completed.

3.2.6 Long-Term (5 to 10 years) Ground Water Monitoring Goals and Objectives

Maryland delegates local jurisdictions (all but three) with the responsibility for permitting well construction for public systems only. Some water quality data (nitrates and bacteria) are collected in the permitting process. However, many counties do not store these data in an electronic medium. The State would like to have these data available for decision-making and plans to assist the local jurisdictions in this effort.

3.3 Lakes

All of the principal lakes in Maryland are man-made reservoirs created by impounding water behind a dammed stream or river. There are numerous, small natural lakes created by beaver dams, as coastal impoundments created by natural shoreline drift, and as natural, water-filled depressions. Based on connecting River Reach traces (1:100,000 scale), the US Environmental Protection Agency identified 947 lakes in Maryland, however, these include many stormwater and waste treatment lagoons and impoundments surrounded by private lands or on federal property - these are often inaccessible to the public. For implementation of Clean Water Act Section 314, the State identified 58 'significant, publicly-owned lakes' as water bodies having public access, a surface area of five acres or greater, providing public benefit, and available for other public uses (e.g., public water supply, fishing). 'Run-of-the-river' lakes, formed behind relatively low dams on rivers, are not included in this profile.

Maryland's significant, publicly-owned lakes are found in all physiographic provinces and in all counties except Calvert, Dorchester and Talbot Counties (Figure 7*)*. These lakes range in size from 5 to 4,500 acres and account for a total surface area of 21,010 acres. Most lakes are small (the 45 smallest lakes account for 10 percent of the total lake area; the 4 largest lakes account for more than half of the State's total lake acreage).

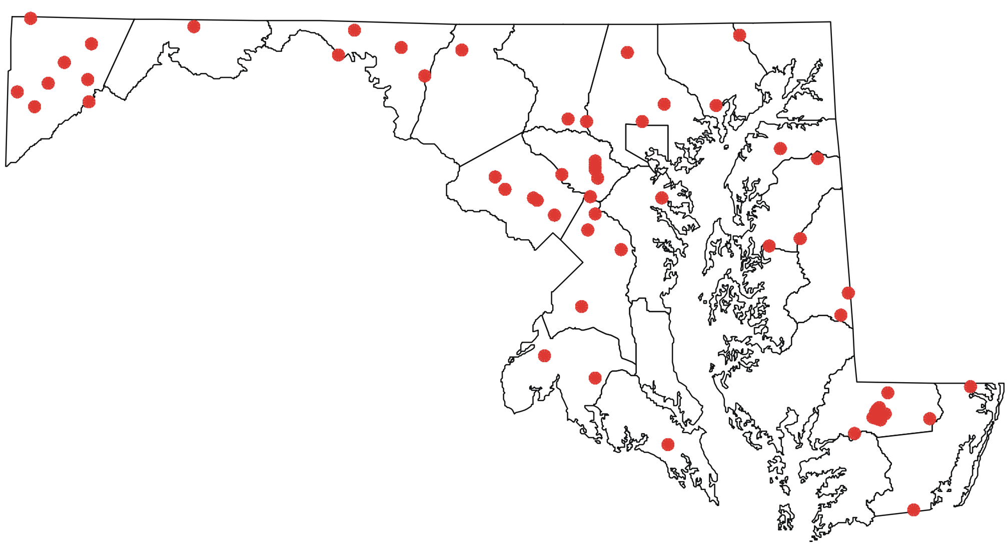

Figure 7: Significant, publicly owned lakes in Maryland

3.3.1 Short-Term Lakes Monitoring Strategy and Objectives

Maryland's current monitoring strategy for lakes is five-fold:

1. Continue targeted monitoring of lakes listed on the State's 303(d) in order to achieve Water Quality Standards for those water bodies;
2. Continue cycling throughout the State's recreational lakes to monitor for contaminants in fish tissue;
3. Continue to respond to citizen complaints and investigate fish kill/algal bloom events in lakes when notified;
4. Support existing and proposed local agency and volunteer monitoring efforts in lakes that can support State agency needs; and
5. Support Congressional efforts to appropriate funding for reauthorized Section 314 (Clean Lakes Program) projects to fund lake assessment/restoration projects that Section 319 (Nonpoint Source Program) set-aside funding for lakes cannot support.

3.3.2 Current Status of Lakes Monitoring in Maryland

3.3.2.1 <u>See Fish Tissue Monitoring Program (Section 3.1.2.6)</u>

3.3.2.2 <u>Watershed Cycling Strategy (see Section 3.1.1.4)</u>

3.3.2.3 <u>See Fish Kill Response and Investigations (Section 3.1.2.4)</u>

3.3.2.4 <u>Algal Bloom Response Program (see Section 2.1.2.5)</u>

3.3.2.5 <u>Local Agency/Volunteer Lake Monitoring support</u>

Agency: DNR – Resource Assessment Service
Contact: Sherm Garrison (410-260-8624); sgarrison@dnr.state.md.us
Watersheds: All watersheds with significant, publicly owned lakes and local interest in monitoring water quality in these water bodies
Media: water column, aquatic plants, fish, invertebrates
Goals: Assess status (trends where applicable) of environmental conditions.
Program Description: A number of publicly-owned lakes in Maryland are operated as water supply or water quality/flood control reservoirs by federal agencies (e.g., US Army Corps of Engineers), local agencies (e.g., Baltimore City Department of Public Works, Carroll County Bureau of Planning, City of Frostburg), or quasi-governmental organizations (e.g., Washington Suburban Sanitary Commission, Upper Potomac River Commission). These agencies may have ambient water

monitoring programs that collect physical and chemical water quality information in an effort to determine ambient conditions or trends and /or are used to implement reservoir management strategies related to withdrawals (water supply needs) or downstream releases (improving water quality, meeting minimum downstream flow or increasing storage capacity needs).

For these programs, a study design is implemented following defined QA Project Plans or Standard Operating Procedures. In some lakes, agencies may use volunteer/citizen monitors to collect data. These data are reviewed and managed internally. The data and/or summary reports may be published for intra-agency or public consumption or the data may be available as a public request for information.

Data Management: Management of these data is the responsibility of the originating agency; Maryland cannot dictate or prescribe the use of certain database software or formats. All water quality datasets should meet minimum data elements defined by the Maryland Water Monitoring Council (MWMC). Generally, some database structure is used (spreadsheet, like Excel; database, like Access/Oracle; GIS format, like ArcInfo). Lake water quality data provided to the Department of Natural Resources (DNR) in digital format are stored as Excel files on a computer with Clean Lakes Program software in DNR's Water and Habitat Quality Program (contact information above). Reports are stored in watershed files in the same office. Digital data and reports are subject to storage/disposal action through the State's records retention policies.

Programmatic Issues/Needs:

1) A Statewide assessment of trophic conditions in lakes was last done in 1991/1993. Although trophic conditions are believed to change only gradually with time, a reassessment is long overdue. New, publicly owned lakes have been created and basic water quality information is needed. Proposals for funding a Statewide trophic lake assessment project thus far have had low priority within the State's Section 319 (Nonpoint Source) Program.

2) Expansion of the Maryland Water Monitoring Council's Monitoring Roundtable to include data from other water bodies (lakes) will provide opportunities for sharing information and cooperation on lake monitoring activities.

3.3.3 Monitoring Program Development Activities

Maryland has developed a draft proposal to update the 1993-1995 Statewide Trophic Lake Assessment for use in 305(b) and 314 reporting and 303(d) listing. Secchi depth, total phosphorus and chlorophyll a data collected would be used to update this information. New, publicly owned lakes and other lakes not previously examined might be included. An expanded database would be used to develop a Maryland-specific trophic condition index. Updated trophic conditions will be reported in the State's Integrated 305b/303d report that, with other water quality and physicochemical data collected, will help evaluate use support. Inclusion of this information in this report meets the 314 reporting requirements for future funding. Samples collected across seasons and in different lake zones would provide information about spatial and temporal variability in trophic classification. The trophic assessment data collected with concurrent satellite imagery data eventually would be used to develop a satellite-based trophic assessment process for future updates.

3.3.4 Long-Term Lake Goals and Objectives

Congressional recession of Clean Lakes funds in 1995 ended activities in Maryland's developing Statewide Lake Management Program. In November 2000, the Estuaries and Clean Water Act of 2000 (P.L. 106-457) authorized funding for Clean Lakes through FY2005, however, the Administration has never requested and Congress has not appropriated funds for this effort. Because demand far exceeds available funds, lake project proposals submitted for lake management suggested in the §319 (Nonpoint Source) program have never been identified as "high priority" projects or funded. Reauthorization of the Clean Lakes Program funding beyond FY2005 and Administration support for fund appropriation is critical for restarting Maryland's Lake monitoring efforts.

If Maryland were to receive funding to reestablish a Statewide Lake Water Quality Assessment Program and analyze data on trophic condition, the State will update its listing methodologies to incorporate the latest data, analytical and statistical techniques. The listing methodology will then be open to public review and comment prior to application for 303(d) listing purposes. Development of a lake index of biotic integrity is another useful assessment tool that may be worthy of pursuing in future years.

3.4 Wetlands

There are a total of approximately 707,424 acres of wetlands in Maryland; roughly 342,626 acres are nontidal wetlands and 261,309 acres are tidal wetlands. The remaining wetland areas are non-tidal shoreline areas adjoining river and lakes (Tiner and Burke 1995). Wetland areas occur in all physiographic regions of the State and in all counties. In Maryland, most wetland areas have been lost due to filling, drainage, agriculture, urbanization, transportation, and other commercial uses.

3.4.1 Short-Term Wetlands Monitoring Strategy and Objectives

To build on current monitoring efforts and research in order to implement a statewide wetlands assessment program.

3.4.2 Current Status of Wetlands Monitoring in Maryland

The US Environmental Protection Agency has developed national draft guidance for assessing tidal and non-tidal wetland condition. To date, most wetland monitoring in Maryland has been an inventory effort to update the US Department of the Interior's National Wetlands Inventory or to track regulatory wetland losses and gains as well as voluntary wetland gains. Some other status and trend monitoring has taken place in parts of the Chesapeake Bay watershed. However, various agencies within the State have conducted research for monitoring wetland condition. The USGS Patuxent Wildlife Refuge developed an IBI assessment for restored wetlands in the Mid-Atlantic States (EPA-822-R-03-013 2003).

In addition, the Maryland Department of Natural Resources Watershed Management and Analysis Division, in conjunction with the Smithsonian Environmental Research Center, has conducted a pilot study on the Nanticoke River watershed to determine the feasibility of wetland condition monitoring in Maryland (MD DNR in review; Whigham et al 1999). The Maryland Department of the Environment has developed a method for the assessment of wetland function in non-tidal, palustrine vegetated wetlands (Fugro East, Inc 1995). Furthermore, Maryland participates in the Mid-Atlantic Wetland Workgroup that was formed to discuss the progress of wetland condition evaluation in the Mid-Atlantic States. Maryland anticipates receiving a grant award from EPA to develop a comprehensive wetland monitoring strategy. The strategy and supporting documentation should be completed in 2008.

3.4.3 Monitoring Program Development Activities

Using some of the assessment techniques developed for the Nanticoke River Pilot Project, Maryland is in the process of formulating a state strategy for wetland condition assessment. DNR's Landscape and Watershed Analysis Division and MDE's Wetlands and Waterways Program has submitted a joint proposal to EPA's Region 3 to develop a comprehensive state monitoring strategy for wetlands. A three-tiered approach has been proposed to assess the overall condition of wetlands in an entire watershed using a statistical sampling procedure. The Three tiers are:

1. Landscape level (GIS based) analysis of wetland condition by HGM class. Requires trained personnel, software, current databases and adequate computing power but can do large areas in a short period of time.
2. Rapid on-site assessment method (RAM) for a selected sample of wetlands within the watershed population of wetlands of that class. We don't know yet how many people will be required for our final strategy.
3. Intensive field sampling of a relatively small number of sites. The results will be used for calibration of landscape level and rapid assessments.

This tiered approach is mutually interdependent. The intensive measurements validate the results of the RAM, the on-site RAM validates the landscape level analysis. The intensive sampling yields indices that are scaled to reference conditions. Without on-site verification, of at least a random sample of locations, a landscape level GIS exercise is meaningless.

3.4.4 Future Goals and Objectives

Once statewide wetlands bioassessment methods are finalized and implemented, these assessments can be used in 305(b) reporting and 303(d) Listings. Before this can happen, however, Maryland will need to develop water quality standards for wetland communities. Subsequently, the State will need to develop and publicly review a listing methodology to establish the thresholds, sample size, and statistical confidence levels necessary to make 303(d) Listings decisions.

4.0 Quality Assurance

All State agencies that collect water quality data in fulfillment of the State's Water Monitoring Strategy are required to have a quality assurance project plan (QAPP) that documents quality assurance/quality control (QA/QC) procedures as well as an implementation framework. Overlapping layers of QA/QC procedures ensure that water data collected in these programs are of sufficient quality to meet the project's data quality objectives.

Reinforcing the importance of quality data, EPA requires that recipients of funds for work involving environmental data collection comply with the American National Standard ANSI/ASQC E4-1994, "*Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs*". As part of the monitoring planning process, EPA requires:

1. Documentation of the State agency's quality management system, and
2. Documentation of the application of quality assurance and quality control activities to a specific monitoring activity (e.g., QAPP).

Using guidance provided by the US Environmental Protection Agency (1999b), both the Department of the Environment and the Department of Natural Resources have developed and implemented agency-wide plans for water monitoring QA/QC processes (MD Dept. of the Environment, 1999b and MD Dept. Natural Resources, 1999, respectively). These documents describe each agency's Quality Management System and institutionalize the agency processes required to achieve adherence to project-specific data quality objectives. For the multi-jurisdictional Chesapeake Bay Program, a Quality Assurance Management Plan (Chesapeake Bay Program, 1999a) has also been developed and follows the guidelines for EPA programs.

Each water monitoring program funded by the EPA is required to have an approved QAPP that documents project layout, purpose, data quality objectives, staff training needs, sample design and methods, sample handling and analytical methods, quality control, instrument calibration, data management, assessment and reporting, and data validation. EPA provides comprehensive guidance (1999a) to assist groups in the development of these plans.

For each water monitoring program, an approved QAPP must be in place before field sampling occurs. Approval is required by the assigned agency QA Officer. For monitoring programs supported by EPA funds (including programs contracted outside of State agencies as well as monitoring efforts used to match EPA-funded projects), EPA's Regional QA Officer also must approve the monitoring plan. Water monitoring programs not funded through EPA still are encouraged to develop and use the QA Project Plan process to ensure that data generated are of the highest quality.

Each field operation or laboratory has QA/QC procedures that address aspects of training, vehicle operation, sample handling, custody processes, safety, data entry, and instrument operation. These issues are addressed in Standard Operating Procedure documents that are readily available to field/laboratory staff. Updates to these basic procedures usually are focused on modifications to sampling gear, handling and instrumentation, but new programs require development of new procedures or modifications to existing procedures and training and evaluation programs.

The State is also working very closely with the Maryland Water Monitoring Council to develop a quality assurance workshop where interested parties can attend a one-day practicum in water monitoring quality assurance/quality control. Attendees will review a suite of QA/QC issues, examine practical problems, practice defining confidence and take home resources (documents, software, contacts) needed to examine, review, and improve their water monitoring programs. Providing interested parties with this kind of training will ultimately increase the amount of data that the State can use for water quality assessments.

As a result of this iteration of the State's Comprehensive Water Monitoring Strategy, an effort has been undertaken to centralize all of the QAPPs for State programs. MDE has agreed to house these QAPPs in a central STORET library at MDE's Baltimore headquarters. This will serve as the central repository of QAPPs for all programs integral to the State's Strategy. Also, the State will continue its work on making more of this quality assurance/quality control information available on-line

5.0 Data Management

The State of Maryland requires water quality and quantity information for a range of management purposes and recognizes that the value of the information is greatly enhanced by it being easily accessible. The value of data is also directly linked to its quality.

Water quality and quantity data are available from many sources including:

- State agencies
    - ✓ MDE - Maryland Department of the Environment
    - ✓ DNR – Department of Natural Resources
    - ✓ SHA – State Highway Administration
    - ✓ MPA – Maryland Port Administration
- Federal agencies
    - ✓ EPA – Environmental Protection Agency
    - ✓ USGS – United States Geological Service
    - ✓ COE – U.S. Army Corps of Engineers
    - ✓ USFWS – U. S. Fish and Wildlife Service
    - ✓ NOAA – National Oceanic and Atmospheric Administration
- Local governments
    - ✓ Counties
    - ✓ Municipalities
- Interstate River Commissions (e.g. Interstate Commission on the Potomac River, Susquehanna River Basin Commission, ORSANCO)
- Academic institutions
- Private consultants
- Volunteer and non profit organizations
- Others

EPA mandates that states enter or submit water quality data that they collect under the Clean Water Act to its STORET system. Centralized collection and management of data by most organizations is not mandated in this manner. In recognition of the fact that there is no overarching authority to direct the activities of these diverse organizations regarding the management of their data, the State is actively working through the auspices of the Maryland Water Monitoring Council to foster coordination, cooperation, and collaboration in all water monitoring activities, including data management.

The Maryland Water Monitoring Council (MWMC) is a volunteer organization that was created (circa 1995) with the idea that the promoting discussion among those interested in water quality would lead to enhanced cooperation among the members, including improved data sharing and information exchange. Encouraging utilization of common database structures will improve both information sharing and the value of the data. The MWMC also promotes consistency and coordination in monitoring plans, monitoring methods, data analysis, and reporting. As consensus is achieved in these activities, data management benefits through more consistent and standardized data collection and handling.

While the ideal situation would be to have all data in a single database that could be readily accessible to all participating groups and the public, it is recognized that this is not possible in the immediate future. Newer computer systems, programming language and software applications enable communication and database consolidation on a real-time basis. Through these mechanisms, an alternative approach to the single database is a network of linked, distributed databases. There are probably an optimum number of distributed databases in a manageable decentralized data-sharing network. It is the goal of the State to work with the various data managers to determine this number and then encourage the consolidation of the existing data sources to achieve maximum efficiency.

There are several major data hubs already in existence or under development and they include:

- EPA's Chesapeake Bay Program – CIMS (Chesapeake Information Management System)
- EPA's STORET (STOrage and RETrieval) system, and the system employed by the
- USGS's WATSTORE
- MDE's Enterprise Environmental Management System (EEMS – currently under development)

Each university, volunteer organization, consulting firm, and local government has, or should have, some system for managing their data. The State is encouraging the use of systems that will interface with either the CIMS or STORET databases employed by DNR and MDE. To the extent practicable, the use of the STORET system is being encouraged because of its mandated national structure. For permitting, compliance and enforcement data, Maryland has negotiated a contract with American Management Systems, Inc. to license, install, implement and maintain their TEMPO® product for the State's environmental regulatory programs.

Data sharing and migration into a central hub also has the benefit of providing data security. While most large agencies have data backup systems and procedures to secure the data from catastrophic system failures, local entities and small organizations may not. Thus, providing for migration into a centralize data hub has an added security benefit that is not always readily appreciated.

5.1.1 Surface Water:

The DNR has been primarily utilizing CIMS for the storage of its data, but also maintains local databases for selected projects. CIMS data are available from a Web site (http://www.chesapeakebay.net) and even provides access to some online real-time data from remote sensing devices. MDE has established a local STORET system for managing its data and is actively migrating data into that system. Monthly uploads of MDE data to EPA's national STORET system is occurring. Public access is available to those data uploaded to the national STORET system via EPA's STORET Web site (www.epa/gov/storet).

The State plan is to promote the utilization of compatible systems, to encourage the transfer and uploading of data into one of these data hubs, and/or create a limited number of other hubs where data can be easily accessed. Under the auspices of the Maryland Water Monitoring Council, initial efforts have been directed to establish a metadata hub that facilitates data sharing, interagency communication and coordination among groups collecting water-monitoring data in Maryland. Known as the "clickable map", this system allows interested data generators to post the location of their monitoring network and contact information on a Web-based GIS system (go to http://cuereims.umbc.edu/MWMC/) maintained by MDE and hosted by the University of Maryland, Baltimore County. Links from this site to individually maintained web accessible data as well as the ability to download shapefiles into desktop GIS applications have been developed to enhance information sharing and data analysis. This is the State's initial step in promoting the concept of a web-based distributed database system.

5.1.2 Groundwater

Although MDE does maintain a database for public water supply systems serving 25 people or greater, most county data for private wells are not electronically available. It will be a priority of the State to explore candidate databases to house this information. The Department of the Environment has several options for consideration in this regard. The first is the existing local STORET system, and the second is an EEMS system that is primarily a business management tool, but it also has a module to support water quality data storage, and it can readily exchange the data with EPA's STORET system. Some counties are more advanced in electronic capture of citizen well data and these counties could be used as a model for broader statewide efforts. USGS is also understood to have groundwater data management capabilities. These and other systems will be considered as database hubs for at least MDE's groundwater data.
Coordination and data exchange will be explored to promote the concept of ready access.

5.1.3 Data Access

Public access to water quality data is a prime goal of the State's water monitoring plan. Through the CIMS and STORET systems, public access has been greatly improved and it continues to be enhanced through improved online query processes. Progress with the Maryland Water Monitoring Council and the "clickable map" project have also made more water quality monitoring data available to a larger audience. Current procedures for accessing data that is not within these systems remain to be enhanced. Migration of these data into a few primary hubs will improve public access.

6.0 Data Analysis

Responsibility for collection, compilation, and analysis of water quality monitoring data is shared between the Maryland Department of Natural Resources (DNR) and Maryland Department of Environment (MDE). DNR compiles *Maryland's Inventory of Water*

Quality [the "305(b) Report"] every two years pursuant to Section 305(b) of the CWA while MDE is responsible for compiling the State's list of impaired water bodies. DNR and MDE share water quality data and assessment methods to ensure that all data received are reviewed in a consistent manner.

The 305(b) Report is written to provide the federal government, citizens, and concerned stakeholders with information on the water quality status of waters throughout the State. This Report utilizes water quality monitoring information collected by the State and other sources, including direct requests to federal agencies, local environmental agencies, colleges and universities, citizen monitoring groups, and private firms. The 303(d) List analyzes information assembled in the 305(b) water quality assessment report, applies methodologies for interpretation of compliance with State standards, and identifies water quality impairments that may require a Total Maximum Daily Load (TMDL). Interstate water bodies are considered for 303(d) listing only after close coordination with respective water management representatives from neighboring states. Where available, recent interstate data are analyzed during the 303(d) listing decision process. Interpretation of neighboring state standards is often problematic but interstate data are given equal consideration prior to formally adding any new interstate water bodies to Maryland's 303(d) List. Data considered must be no older than 5 years.

Assessing attainment of water quality standards in Maryland is based on the analysis of all readily available data. A joint Maryland Department of Environment/Department of Natural Resources (MDE/DNR) data solicitation letter is widely distributed one year prior to publishing the biennial 303(d)/305(b) List. Data submittal is preferred electronically, in accordance with approved QA/QC guidelines (see Section 4.0). The State actively pursues water quality data that will compare to criteria published in regulation (e.g., temperature, dissolved oxygen, pH, turbidity, fecal coliform bacteria, specific toxins - see COMAR §26.08.02.03). Water quality data not specifically defined by State standards (e.g., field measures such as salinity, analysis of nutrients, chlorophyll, alkalinity levels, benthic macroinvertebrate and fish communities, habitat conditions, and field observations of the environment) are also actively solicited and highly regarded as supporting factors for the characterization of water quality conditions. Discharge monitoring reports are submitted to MDE periodically by permitted facilities and are used to determine facility compliance with permit conditions. These data are reviewed and analyzed in comparison to target discharge goals and limits set forth by permit. The permits are designed to achieve water quality standards in the receiving waters.

6.1.1 Listing Methodology Development

To provide consistency in interpretation of Maryland's designated uses as well as to provide opportunities for stakeholder input, MDE published eight listing methodologies in concert with development of the 2004 303(d) List (see appendix A). They include the Chesapeake Bay Index of Biotic Integrity, Combined and Sanitary Sewer Overflows (CSO/SSO), Sedimentation, Biocriteria, Dissolved Oxygen in Stratified Lakes, pH, Bacteria, and Toxics. All listing methodologies were publicly reviewed for a period of 45 days and MDE responded to all related comments and concerns in a comment-response document.

Listing Methodologies establish how the State's analyzes water quality data to determine water body compliance with WQS. The Methodologies identify the acceptable sampling frequency, minimum data requirements, and statistical analyses to minimize effects of site and seasonal variability, as well as establish phased, tiered, or weight of evidence type approaches that promote standardization and consistency in making water body impairment determinations. The Listing Methodologies also establish the impairment thresholds under which certain waters fall into the various listing categories in the Integrated 305(b) report and 303(d) List. As a result, independent investigators using the same data should reach similar conclusions about a water body's impairment status. The implementation of publicly reviewed listing methodologies promotes transparency in the regulatory decision-making process and allows more objective interpretation of the State's WQS.

Listing Methodology	Use Support Type (aquatic life or human health)	Supporting Regulations in COMAR
Non-Tidal Biocriteria	Aquatic Life Use Support	26.08.02.02-B1-d
Tidal Biocriteria	Aquatic Life Use Support	26.08.02.01-A3 and 26.08.02.01-B2-c
Bacterial	Human Health	26.08.02.03-3A-1-5 and 26.08.02.03-3C-1-2
CSO/SSO	Human Health	26.08.02.03-3A-1-5 and 26.08.02.03-3C-1-2
Dissolved Oxygen in Stratified Lakes	Aquatic Life Use Support	26.08.02.03-3A-*6*
Chemical Contaminants	Human Health and Aquatic Life Use Support	26.08.02.03-2-G1
Sediments	Aquatic Life Use Support	26.08.02.03-3A-9
pH	Aquatic Life Use Support	26.08.02.03-3A-8

The Department considers the methodologies evolving documents that change to incorporate improved scientific standards and methods as well as the development of new WQS. As the Methodologies are revised or developed, the public and stakeholders will be given opportunity for review and comment. All comments will be responded to in a comment-response document.

7.0 Reporting

There are a variety of ways that information about water monitoring activities in Maryland is disseminated to managers, funding agencies and other stakeholders (agencies, businesses, scientists, and the public - individuals, students, community groups, consultants, politicians). The reporting format and media used often are dictated by the perceived needs of the audience.

In compliance with the Federal Clean Water Act (CWA), Maryland submits reports in accordance with sections 305(b), 303(d), 314 and 319. Statewide assessments of water quality are submitted biennially to EPA in 305(b) reports. All water body types are assessed, including the miles or surface area of the water supporting or not supporting designated uses, as well as those waters that cannot be assessed (i.e., insufficient quantity or quality of data). For the 2004 submittal, Maryland integrated both its 305(b) reporting and 303(d) Listing into one consolidated report. Now water quality assessments are more closely linked to the impaired waters list. Maryland will continue to submit integrated reports to improve consistency between interdepartmental programs.

Section 314 (Clean Lakes Program) of the federal Clean Water Act requires annual/periodic reporting of lake status, trophic condition, and a description of lake management programs. Failure to submit this report may result in the State being listed as ineligible for Section 314 monitoring/restoration funds. As the Congress has not appropriated any Clean Lakes funding since FY1996, this reporting requirement is truly an unfunded mandate. Because the 314 reporting requirements are similar to what is required in the Section 305(b) reports, EPA has modified its 314 and 305(b) guidance and most Clean Lakes reporting requirements are now addressed in the State's Integrated 305(b)/303(d) reports.

Section 319 (Nonpoint Source Program) requires periodic reporting of water quality conditions affected by non-point source pollution and reports of management activities. These reports are developed whenever they are detailed as a deliverable product or a special condition in the Section 319 grant to the State.

In addition to these, funding agencies have specific reporting requirements spelled out under contract that may include monthly or quarterly data submissions or activity reports, summary data and/or interpretive reports. Managers often need summaries of interpretive reports to develop/support or modify management actions. Some programs produce annual technical reports (e.g., Coastal Bays Program) or reports that focus on specific watersheds (TMDL reports, MD Biological Stream Survey basin reports). For different audiences, less technical summary reports may be developed for more diverse readership (e.g., Chesapeake Bay Program State of the Bay report, State of the Streams report, Tributary Strategy annual reports). Other programs have regular newsletters (e.g., MD Biological Stream Survey) that are mailed to an open-ended mailing list. These general water quality reports and newsletters are widely distributed to the public through mailings, meetings and exhibitions.

Maryland has a State Repository Library system that collects, documents and distributes State agency reports among State Archives and selected library systems across the State. DNR has an Information Resource Center that serves as a library for the Department and serves the public as well. Long-term document storage is available via storage at Jessup (microfiche/document).

One modern format being used extensively to provide and distribute both general and technical information about water monitoring activities is through the Internet. All State agencies have Web sites that are accessible 24 hours a day, seven days a week. Local library systems across the State have public Internet accounts permitting access to State information.

Both DNR and MDE have posted information about water monitoring programs on their Web sites (http://www.dnr.state.md.us/and http://www.mde.state.md.us/, respectively). Depending on the program, this information may include descriptive information about monitoring programs, contact information (telephone, e-mail), opportunities to access data in water monitoring databases or to access close to real-time data. Some Web pages provide summaries of water monitoring results (shellfish harvesting closures, Tributary Team water quality status and trends). Technical or educational reports may be posted and read on-line or downloaded. In the near future, more water monitoring information will be accessible on the Internet through a mandate that State agencies post 80 percent of their reports on agency Web sites by 2004.

8.0 Program Evaluation

The State of Maryland's Water Monitoring Strategy is an iterative process that is continually under review and development. To align with the short-term (2-5 years) and long-term (5-10 years) monitoring program goals and objectives established in this strategy (section 3.0), Maryland will submit an updated strategy to EPA every five years. Furthermore, this five year submittal window is concurrent with the State's watershed cycling strategy as well as the data cut-off used for 305(b) reporting and 303(d) Listing.

A State Strategy Working Group has been formed as a result of the current iteration of the State's Strategy. This core group will serve as the coordinating body for future efforts. The core group will meet as needed to revisit Strategy goals and objectives to see if they mirror current State priorities and to determine if existing monitoring programs continue to meet these priorities. At minimum, the Strategy Working Group will convene every fourth year to initiate this larger programmatic evaluation effort and meet the 5-year deadline for report submittal.

Nested within this 5 year update and submission process for the larger strategy are the myriad monitoring programs, processes and procedures, interagency coordination efforts, publications and reports, public outreach activities, etc., which have more frequent review, evaluation and implementation timelines. State monitoring programs review their protocols, procedures, goals and objectives on an annual basis. Monitoring program goals can rapidly shift when new or heightened public health concerns emerge, new science and analytical techniques become available, and when monitoring results suggest data gaps or emerging issues. These annual reviews, which frequently include interagency participation as well as public input and involvement, result in the incremental changes to monitoring programs that ensure attainment of shifting goals and objectives. This lag time between programmatic review processes and Statewide strategy development provides adequate time for changes in programs to occur and be evaluated before they are institutionalized in a larger strategy framework. It also allows time for the Water Quality Standards Triennial Review process to take place prior to updates of the State's comprehensive strategy so that any changes to Maryland's Water Quality Standards are incorporated (see http://www.mde.state.md.us/ResearchCenter/Data/waterQualityStandards/index.asp).

Even more frequent than annual programmatic reviews is the interagency coordination and technology transfer that come from the State's involvement in countless interstate commissions, regional programs and partnerships, symposia, work groups, committees, regular meetings, as well as through inter and within agency program coordination efforts. These are invaluable forums for sharing information and ideas, and discussing current issues. The knowledge and exchange resulting from this coordination and collaboration feeds back into the State's strategic planning process for water monitoring. A critical group involved in this process is the Maryland Water Monitoring Council (MWMC). The Council consists of local, State and federal government agencies, academia, the private sector, volunteer groups and non-profit organizations involved with water monitoring activities in Maryland. The MWMC provided State officials valuable insights and suggestions in the development of the current Strategy.

The State has several members on the MWMC Board as well as personnel who serve as chairpersons in MWMC subcommittees. This forum has been essential in soliciting local government perspectives and programs factored into the State's water monitoring plan (see Appendix B). The clickable map project (see section 5.1.1) developed by the MWMC identifies and georeferences monitoring programs in Maryland waters. The State is working closely with the Council to increase participation in this mapping effort by all appropriate organizations and groups. This effort will help better target limited State resources to the most critical needs by reducing program redundancy and identifying data gaps. A strong component in future plans submitted to EPA will be using existing local and other water monitoring programs as a cornerstone of the State's strategy. The State can potentially limit monitoring activities in areas where rigorous, quality assured local programs are providing readily available data streams, thereby redirecting State resources to underfunded areas.

The State's mandatory reporting process to EPA, in accordance with sections 305(b) and 303(d) of the Clean Water Act, provides another mechanism for revisiting State monitoring programs, goals and objectives. These biennial reports on the status of Maryland waters have their own review requirements, including public participation for 303(d). Maryland made its first effort this year to integrate these two pillars of the Clean Water Act. Since the Maryland Department of Natural Resources is responsible for 305(b) while the Maryland Department of the Environment is responsible for 303(d), report integration necessitates close interagency collaboration between the two departments, which collect the majority of the State's water monitoring data for both resource assessment and regulatory decision-making. Now more than ever, report integration is helping MDE and DNR to collaborate upon and standardize procedures for data solicitation, data standards, data analysis and interpretation, and management actions. Furthermore, these reports, particularly the 303(d) List, are used extensively to set goals and priorities for future water monitoring activities and are a valuable tool used in State Strategy review.

Related to the 303(d) List are the State's Listing Methodologies used for determining the impairment status of Maryland waters. Listing Methodologies are reviewed as part of biennial 303(d) List development. Since these methodologies outline sample frequency, magnitude and duration necessary to list waters as impaired, as well as the analytical techniques used to make these determinations, they are a driving force behind monitoring program design. New or revised methodologies can increase sample collection frequency or modify sampling methods to minimize variability, increase statistical confidence, and incorporate new measures for interpreting State Water Quality Standards. All of these changes feed back into the State's overall Strategy goals and objectives.

As Maryland moves forward with TMDL implementation planning and projects over the next 5 years, monitoring priorities and frequencies may also be reallocated. Implementation planning is currently underway and is rapidly evolving. Development of stressor identification frameworks and TMDL implementation pilot studies are being discussed at the State level   Data quality objectives for evaluating the success of implementation projects may be different than those developed for Statewide water quality assessment purposes. As a result, monitoring methods may change and new programs may be needed to provide appropriate data for evaluating the success of restoration techniques and best management practices. Furthermore, close cooperation with local governments and integration of small-scale local projects will be essential. This shift towards an implementation framework will be a larger part of future State Strategies that will be incorporated as it develops.

Maryland's use of STORET is another programmatic evaluation tool that is used to gauge progress and implementation of State water monitoring programs. The State will work to make more of its monitoring data readily available via STORET. This can be a reliable measure by which the State Strategy is periodically evaluated since monitoring data are a direct result of program implementation. Maryland will continue to make regularly monthly uploads to EPA's STORET as well as work with local jurisdictions and volunteer monitoring organizations to make their monitoring available in STORET. Maryland's data entry process for the STORET system includes a data approval process whereby senior personnel must "sign-off" on data before it enters STORET. This ensures another level of programmatic review that assists with data validation and ensures consistency with project goals and objectives.

Finally, Maryland's Quality Management Planning and project-specific Quality Assurance Project Plans establish internal quality control measures and oversight processes that preserve the integrity of State data. Development of data quality objectives, field and laboratory protocols, minimum sample sizes, field and lab quality assurance procedures, personnel roles and responsibilities, and departmental as well as project-specific review and evaluation process provides yet another mechanism for programmatic evaluation of State water monitoring programs. These procedures create a feedback loop where State monitoring programs are continually validated for consistency with data quality objectives.

These activities (Table 3) form the core of the State Strategy's programmatic evaluation and strategic planning process. The review activities built into each one of these efforts ensures that project designs will be continually re-evaluated for meeting their specific goals and outcomes. Interagency collaboration will further ensure that projects are coordinated across programs and different levels of organization. A year before the State Strategy update is due to EPA, the State will convene key program personnel to review the status of water monitoring activities in Maryland and determine if current programs are fulfilling the State's objectives. In addition, the State's broader goals will also be re-evaluated at this time to capture any changes to State WQS and guarantee adaptation of State Water Monitoring activities to the most critical needs.

Table 3: Programmatic Evaluation Elements and Frequencies

Water Monitoring Strategy Element	**Evaluation Frequency**
State Strategy Working Group	Annually – Quadrennially
Water Quality Standards Triennial Review	Triennially
305(b) Reporting/303(d) Listing	Biennially
Listing Methodologies	- Biennially
Monitoring Program Review (Q: Internal review?)	Annually (internal) Biennial/Triennial (external-EPA)
Quality Management and Quality Assurance Project Planning	Annually
TMDL Development, Implementation planning and restoration/mitigation efforts	Monthly, quarterly, annually and biennially
External Coordination Efforts (meetings, work groups, etc.)	Monthly, quarterly, annually and biennially
STORET Development and Upload	Monthly

9.0 <u>General Support and Infrastructure</u>

The State of Maryland, with Chesapeake Bay at its cornerstone, is one of the more progressive states in the union when it comes to environmental monitoring and public support for environmental programs. Even so, much work remains to be done and many programmatic improvements have yet to be realized. The following sections highlights some of the State's on-going and future initiatives designed to improve Maryland's environmental monitoring programs and restore/preserve water quality over the next decade (see Figure 8), as well as identifies critical resources.

9.1 10-Year Implementation Timeframe

The State has identified several water monitoring related initiatives that are planned to be developed or implemented over the next 10 years. These planned improvements fall into five broad categories. They include:

1. Aquatic life Use Support and/or Public Health Initiatives;
2. Watershed Cycling;
3. STORET and Quality Management;
4. TMDL Implementation and/or alternative approaches
5. 303(d)/305(b) and Integrated Reporting; and,
6. Program Evaluation and Restructuring.

9.1.1 Aquatic life Use Support and/or Public Health Initiatives

Increasingly, the State is relying upon biological communities as harbingers of change in area watersheds. Maryland adopted Biocriteria in its 2002 Integrated Report to EPA on the status of State waters. The State would like to expand upon these initial efforts in several ways.

Currently, Maryland does not have sufficient statewide assessment programs for lakes or wetlands. The State intends to develop these programs, over the next 1 to 7 years, to the point where they can be used to confidently monitor and assess the water quality conditions of all lakes and wetlands in Maryland. A wetlands proposal was recently submitted to EPA and Maryland expects some federal funds to develop a wetlands program. For lakes, however, insufficient federal dollars are currently provided to implement a statewide monitoring and assessment program.

Secondly, the State intends to develop new biological indices to support development of nutrient criteria in both tidal and non-tidal waters. This summer (2004), Maryland launched a field study, with EPA and USGS support, to evaluate the use of periphyton as an indicator of nutrient enrichment in n on-tidal streams of the Piedmont ecoregion. A preliminary report to EPA is scheduled in the next two years. Simultaneously, Maryland will be conducting a data review of all available nutrient data to look for baselines and trends in nutrient concentrations to better identify break points or critical concentrations that may be useful in developing nutrient criteria.

Over the next 2 to 10 years, the State is interested in developing a nutrient index, using macroalgae, for the Coastal Bays. Maryland is also interested in developing a benthic community index for the Coastal Bays, similar to that developed for the Chesapeake Bay.

A new initiative is underway at MDE to develop a stressor identification framework to help identify the primary pollutants responsible for biological impairments in non-tidal waters. A Stressor ID work group is meeting on a monthly basis to draft a framework that will guide the State's future efforts in this arena. Field validation and testing will also be required to test the accuracy of the framework. These efforts should culminate over the next 1 to 3 years.

Over the next 4 to 9 years, the State is interested in looking at the Maryland Biological Stream Survey detail in greater detail. DNR is currently experimenting with different ways of analyzing these data. Specifically, the State is interested in going beyond the current scoring system for MBSS (i.e., a 1, 3 or 5 scoring framework) to begin looking at things like biological condition gradients, indicator organisms, large/rare taxa, and a more refined scoring network or sensitive scoring range. Also, Maryland is interested in having more monitoring programs effectively evaluate tiered aquatic life uses.

Lastly, Maryland is continuing its commitment to protecting public health through its implementation of the federal Beaches Act. Efforts are underway to update Maryland regulations with respect to bacterial contamination in public swimming areas. By 2005 or 2006, the State expects to have fully implemented the Beaches program.

9.1.2 Watershed Cycling

MDE has a 5-year watershed cycling strategy for it's targeted watershed monitoring, TMDL development, implementation tracking and evaluation efforts. It is a high priority for the State to integrate more monitoring programs into this 5-year cycle in order to characterize all waters for a broad range of pollutants. In so doing, Maryland will be better able to document patterns and relationships between pollutants and more effectively evaluate watershed response. This will also provide the State with a richer dataset upon which to base regulatory decisions and future management actions, as well as assist with adaptive management efforts to customize programs amid changing demands, science and expectations. A more comprehensive watershed cycling strategy will also allow the State to better involve local communities by focusing resources into a smaller region of concern.

9.1.3 STORET and Quality Management

In October 2003, the State made its first upload to EPA's STORET database. Since that time, Maryland has continued to make regular monthly uploads to STORET. Due to the importance of this effort, MDE has made internal organizational changes and aligned staff resources to expedite STORET development.

STORET will continue to be a high priority effort in Maryland over the next decade. Although some institutional and staffing obstacles still remain, the State is working to centralize environmental monitoring data in STORET with the goal of relying increasingly on this system to conduct water body assessments and develop the State's Integrated Report.

The State is also very committed to documenting the quality of the data in the STORET system. Over the next 1 to 6 years, Maryland will centralize the QAPPs for State monitoring programs in MDE's STORET library located in Baltimore, MD. Furthermore, the State will continue its efforts to make more of this quality assurance documentation available on-line and/or through STORET.

9.1.4 303(d)/305(b) Integrated Reporting

Maryland is dedicated to making improvements to its 305(b) and 303(d) reporting obligations as required under the federal Clean Water Act. In 2002, Maryland developed 8 Listing Methodologies to standardize the decision making process by which State waters are listed as meeting or not meeting Water Quality Standards. This exercise allowed the public and other stakeholders the opportunity to comment on the State's procedures for assessing waters. It also established minimum sample size requirements and data analysis protocols to increase confidence in water body impairment determinations. Over the next decade, Maryland will continue to develop, revise, and improve these Listing methodologies to reflect the best possible science and to evaluate designated use support.

EPA encourages States to adopt the Assessment Database and the National Hydrography Dataset as the preferred repository for water body assessment and listing information. Maryland commits, over the next 1 to 4 years, to explore the feasibility of using this system for Integrated Reporting efforts.

9.1.5 Program Evaluation and Restructuring

The State is working on three programmatic initiatives: (1) inclusion of non-State programs into the Maryland Comprehensive Water Monitoring Strategy; (2) using probabilistic monitoring to evaluate TMDL implementation efforts; and (3) TMDL implementation and alternative approaches to water quality standards attainment.

Maryland recognizes that limited State monitoring resources could be better utilized by increased cooperation and coordination with other non-state monitoring programs. Delegating biological monitoring to counties with strong existing programs so that more targeted MBSS work can be done is one way to streamline State monitoring efforts. This would help accomplish the second goal of increasing use of probabilistic monitoring for evaluating TMDL implementation over the next 1 to 7 years.

State officials will continue their strong presence on the Maryland Water Monitoring Council over the next 10 years to look for these and other coordination opportunities.

The State will also continue to evaluate local and other monitoring programs to determine their use for water body assessments and efficiency gains.

Furthermore, Maryland recognizes the importance of both TMDL implementation as well as, where more timely, efficient, and effective water quality improvements can be realized, exploring alternative approaches to the traditional TMDL framework. Non-point sources are overwhelming State efforts to address pollution through traditional means (i.e., permits, TMDLs, etc.). In addition, TMDLs and permits routinely get tied up in litigation so that timely and/or effective implementation/water quality restoration is unachievable. In some cases, current or alternative technologies, partnership agreements/memoranda of understanding, cost-sharing, in-kind services, grassroots and community involvement, may be the most efficient way of addressing Maryland's impaired waterways. Over the next decade, through these and other measures, Maryland will commit more resources and effort to expediting local water quality improvement projects and initiatives outside of the traditional TMDL framework. Maryland will also work to implement those TMDLs that have already been established.

9.2 Resource Needs and Implementation Obstacles

There are several programmatic, institutional and fiscal constraints that currently limit Maryland's Comprehensive Water Monitoring Strategy. Some of these constraints are internal to Maryland while others are external and not directly under Maryland's control.

9.2.1 Internal Constraints

Maryland is currently experiencing difficulty in recruiting and retaining personnel. State monitoring programs need more statisticians, computer programmers and analysts, GIS specialists, database and Web designers, to store, analyze, interpret and publicly disseminate monitoring results and conclusions.

As in many other states, water quality monitoring programs in Maryland are increasingly underfunded. More federal funds need to be appropriated to both monitoring and restoration activities to meet increased federal mandates and so that the State can effectively and confidently document water quality improvements, evaluate management/regulatory program success, and partner with local governments and communities on small watershed scale projects. This lack of funding also translates into a heavier workload per staff unit and fewer training and educational opportunities to enhance staff technical knowledge.

9.2.2 External Constraints

The current two year cycle for 303(d) listing and 305(b) reporting is too short to allow for rigorous analysis of monitoring data to support water body impairment determinations.

By the time that the Integrated List receives final EPA approval, it is almost time to gear up for the next reporting cycle. A four year listing cycle would allow the State more time to adequately assess all State waters and report on their status, while a five year cycle would better align with Maryland's watershed cycling strategy.

The current federal emphasis on Statewide monitoring and assessment needs to be balanced with more federal money for TMDL implementation and small watershed restoration. Too few restoration projects are currently being implemented at too broad a scale to discriminate among current best management practices and watershed restoration activities.

Lastly, coordination between various government and private groups that conduct monitoring in Maryland always proves a daunting challenge. Maryland is fortunate to have such an active and well-represented State Water Monitoring Council, but the MWMC remains a strictly volunteer group with limited ability to weigh in on interagency management concerns and larger policy decisions.

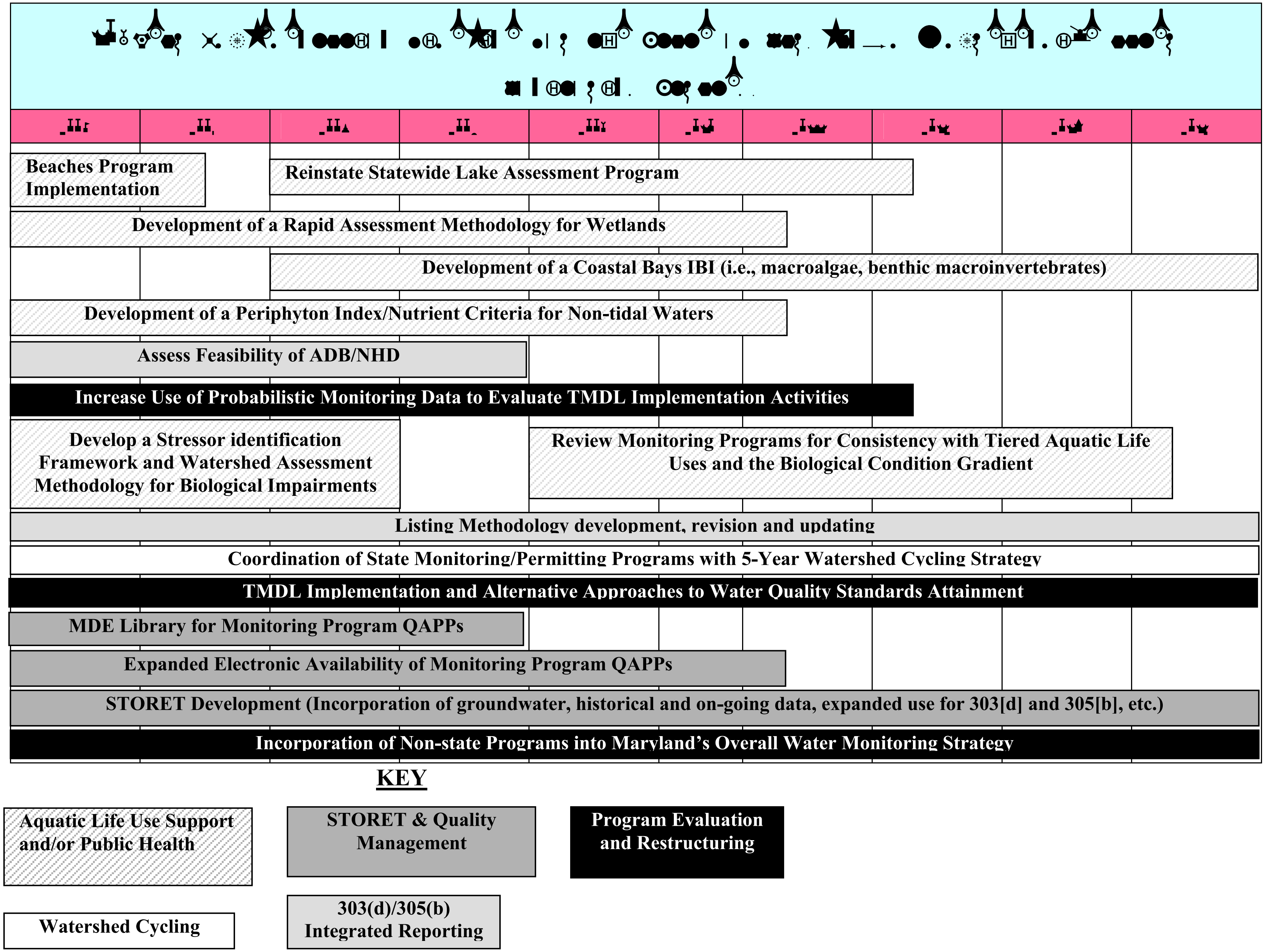

Figure 8: 10-Year Implementation Timeframe for the State of Maryland's Comprehensive Water Monitoring Strategy.

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11.0 APPENDIX A – Listing Methodologies

11.1 Listing Methodology for Implementation of COMAR §26.08.02.01-B(2): Biological Assessment of Water Quality

11.1.1 ABSTRACT

Biological assessment data from first to fourth order non-tidal streams will be used to assess waters of the State for the purposes of the Water Quality Inventory [305(b) Report] and the List of Impaired Waters [Integrated 303(d) List]. The method presented below relies on a statistical measure of uncertainty (confidence interval) to determine whether the mean of the results from the sites sampled in a watershed is above or below the Index of Biotic Integrity (IBI) value considered indicative of satisfactory water quality. Where at least 10 sites have been sampled in a watershed (8-digit), watershed-specific confidence intervals will be calculated. If the upper bound of the confidence interval is less than 3, that watershed will be determined to not meet water quality criteria. Where fewer sites have been sampled, subwatersheds (12-digit) will be the evaluation unit. In such cases, a default confidence interval has been calculated based on the coefficient of variation calculated from replicate samples (benthos) or sampling of proximate segments (fish). Certain exceptions are noted based on the empirical applicability of the IBI. The State is required to consider all readily available data and therefore guidelines for the incorporation of local biological data into the assessment process have also been provided. Local data that are based on Maryland Biological Stream Survey (MBSS) or comparable methods and that can be fully integrated with MBSS data to assess watersheds would be integrated into 12- and/or 8-digit watershed evaluations (Tier 1). Data of documented quality, but not based on methods comparable to MBSS will be used to supplement MBSS and local Tier 1 data. Data not meeting the requirements stated above may be helpful for non-regulatory purposes (e.g., targeting, education). Such data will be stored and documented for these uses.

11.1.2 SCOPE

All of the State's waters must be of sufficient quality to provide for the protection and propagation of a balanced population of shellfish, fish, and wildlife and allow for recreational activities in and on the water [40 CFR §130.11 and COMAR §26.08.02.01-B(2)]. Biological criteria (biocriteria) provide a tool with which water quality managers may directly evaluate whether such balanced populations are present. Maryland's biocriteria uses two indices of biological integrity, one based on fish communities (F-IBI) and the other on benthic (bottom) communities of invertebrates (B-IBI). Both indices implicitly define "balanced populations" by comparison to biological communities in minimally impaired reference waterbodies and both will be used in Maryland to determine the extent to which aquatic life is being supported in Maryland streams. These indices, as described below, are based on several characteristics of fish and benthic communities judged to be relevant to assessing the ability of streams to support aquatic life, and can be calculated in a consistent and objective manner. This framework provides a method for evaluating biological data for the CWA requirements.

The (MBSS) program, on which these interim methods are based, is designed to assess water quality, biological communities and physical habitat condition in Maryland streams on a statewide and watershed scale. The first round of MBSS sampling was designed to assess major drainage basins. The second round was designed to assess finer (Maryland 8-digit) watersheds. Data collected from this stratified random sampling design support the assessment of first, second, third and fourth order non-tidal streams (determined based on the solid blue line shown on the current edition of U.S. Geological Survey 1:100,000 scale maps) throughout the State. Although the MBSS data can also be used to evaluate the individual stream segments sampled, the locations of sampled segments are selected randomly and not targeted to assess the impacts of specific stressor locations. The use of random assignment of sampling locations within the population of first, second, third and fourth (fourth order in round two of sampling only) order streams supports the assessment of all of the State's waters. The results of biological sampling will be applied for management and regulatory purposes [i.e., CWA §303(d)] at the same spatial resolution (8-digit watersheds) used in the Water Quality Inventory [305(b) report]. When there are sufficient data, sampling results will be averaged within these watersheds and compared to the thresholds discussed below for determination of impairment. When there are not sufficient biological data to evaluate the 8-digit watershed, smaller 12-digit subwatersheds where biological samples indicate some level of degradation will be evaluated to determine whether the 12-digit subwatershed is impaired.

If a watershed or subwatershed is determined to be impaired, corrective action must be taken. That action may begin with additional monitoring and evaluation to determine the cause of the impairment. This is known as stressor identification. Once the stressor has been identified, in many cases it may be appropriate to develop an estimate of the Total Maximum Daily Load (TMDL) of the stressor that can be assimilated by the body of water and still allow it to achieve the water quality criteria necessary to maintain its designated use.

11.1.3 APPLICATION

11.1.3.1 Stream Order

The fish and benthic indices shall be applied only in "wadeable" first, second, third**,** and fourth order non-tidal streams except as described below under "Exceptions." Biological indices and criteria will be developed in the future for other categories of waterbodies (e.g., larger streams, estuaries, and impoundments) that are currently assessed by chemical and physical monitoring programs. However, the streams to which the current indices apply account for about 90% of Maryland's stream miles. The sampling sites will be analyzed within 8- or 12-digit watersheds for the purposes of evaluation, application of management practices, and listing methods. Eight-digit watersheds are on average 90 square miles; 12-digit watersheds average 11 square miles.

11.1.3.1.1 Procedures for 8-digit watersheds

Data from at least 10 sites are needed within an 8-digit watershed in order to evaluate watersheds at the 8-digit level. In watersheds with 10 benthic IBI scores but less than 10 fish IBI scores, the benthic IBI alone will be used for the 8-digit analysis. In these cases, fish IBI scores will be incorporated into 12-digit subwatershed analysis to avoid losing information about possible impairments.

In general, MBSS currently employs 8-digit watersheds as primary sampling units. In a few cases, where individual 8-digit watersheds have a small number of stream miles, primary sampling units include more than one 8-digit watershed apiece. These are not assessed at the 8-digit level, because of insufficient sample size within individual 8-digit watersheds. Possible impairments in these areas will be assessed at the 12-digit subwatershed scale based on analysis of individual samples.

Where sufficient data are available within an 8-digit watershed (at least 10 sites with IBI scores), mean IBIs and one-sided 90% confidence interval values are calculated from the data as follows.

if IBI_{mean} is < 3, $CL_{Upper} = IBI_{mean} + (z * SE)$, or

if IBI_{mean} is ≥ 3, $CL_{Lower} = IBI_{mean} - (z * SE)$

Where

CL_{Upper} = upper confidence limit

CL_{Lower} = lower confidence limit

z = normal variate (in this case, z = 1.28 for one-sided 90% confidence interval, assuming a normal distribution for mean IBI)

SE = standard error of the mean = $sd / \sqrt{n}$, where *sd* = standard deviation

The following rules will be applied to give one of three ratings for 8-digit watersheds:

1. **Does not meet criteria:** If the mean and upper bound of the one-sided 90% confidence interval (CL_{Upper}) of either index (FIBI or BIBI) is less than 3.0, the 8-digit watershed is listed on Part-5 of the 303(d) as failing to meet the proposed criteria.

2. **Meets criteria:** If the mean and lower bound of the one-sided 90% confidence interval (CL_{Lower}) of both indices (FIBI and BIBI) are greater than or equal to 3.0, the 8-digit watershed is listed as meeting the proposed criteria.

3. **Inconclusive:** All other cases are inconclusive, including watersheds not meeting the minimum 10 station threshold.

Within 8-digit watersheds that meet criteria, constituent subwatersheds may still be rated as not meeting criteria or inconclusive. Also, within 8-digit watersheds that are inconclusive, particular 12-digit subwatersheds within them may be rated as not meeting criteria. The 12-digit subwatershed analysis is described below.

11.1.3.1.2 Procedures for 12-digit (sub)watersheds

Data from individual sites are used to flag 12-digit subwatersheds that may be impaired. One-sided 90% confidence intervals associated with single samples are calculated using an average coefficient of variation (*cv*) of the IBIs from replicate samples, (for example, $cv = 0.08$, as derived from previous analysis of IBI variability (Roth et al. 2001)). Confidence intervals around scores for individual samples are calculated as follows:

if IBI is < 3, $CL_{Upper} = IBI + (z * SE_{Est})$, or

if IBI is ≥ 3, $CL_{Lower} = IBI - (z * SE_{Est})$

where

CL_{Upper} = upper confidence limit

CL_{Lower} = lower confidence limit

z = normal variate (in this case, z = 1.28 for one-sided 90% confidence interval, assuming a normal distribution for mean IBI)

SE_{Est} = estimated standard error of the mean = IBI x $(cv / \sqrt{n})$ (in this case, n=1)

Following the guidelines of the interim biocriteria framework, the following rules will be applied to give one of three ratings for 12-digit subwatersheds:

1. **Does not meet criteria:** If for any site, the value and upper bound of the one-sided 90% confidence interval (CL_{Upper}) of either index (FIBI or BIBI) is less than 3.0, the 12-digit subwatershed is listed on Part-5 of the 303(d) as failing to meet the proposed criteria.

2. **Meets criteria:** If for all sites, the value and lower bound of the one-sided 90% confidence interval (CL_{Lower}) of both indices (FIBI and BIBI) are greater than or equal to 3.0, the 12-digit subwatershed is listed as meeting the proposed criteria.

3. **Inconclusive:** All other cases are inconclusive.

If more than one site is sampled in a 12-digit watershed, each site result is evaluated separately. If any one result indicates impairment, that subwatershed will be listed as impaired. Although that single site may not be representative of the entire subwatershed, the State determined that it is more effective to manage at the watershed level of resolution. Further sampling for stressor identification and/or TMDL development will later define the extent of the impairment.

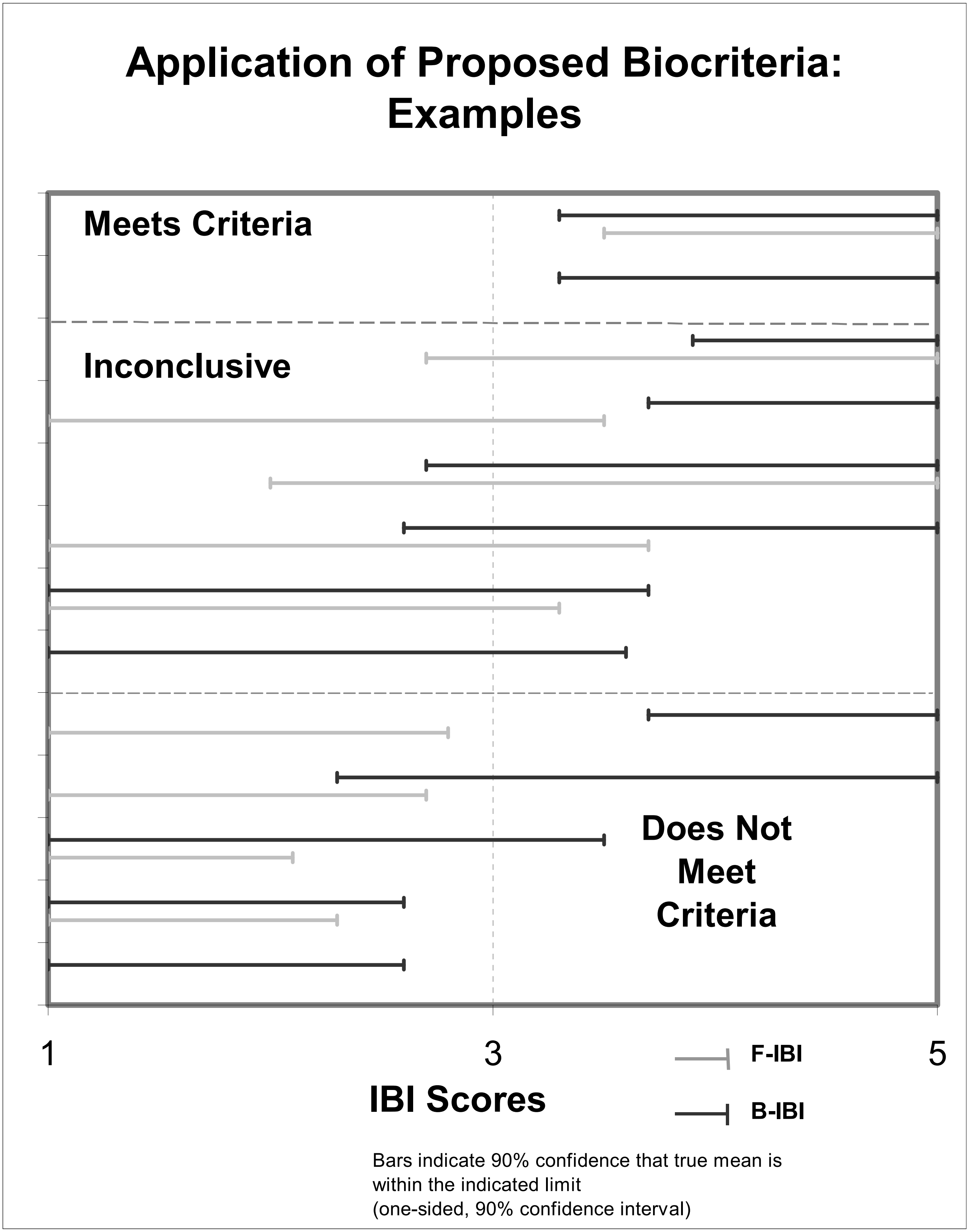

Figure 9: Biological impairment determination based upon confidence intervals.

11.1.4 PRIORITIZATION FOR WATERSHEDS WHERE MONITORING INTERPRETATION IS INCONCLUSIVE

Prioritization for additional monitoring to try to resolve inconclusive results and make a determination that the criteria are, or are not, met.

1a. Mean less than 3 (the lower the IBI score the higher priority for attention), and large confidence interval. Rationale: low IBI scores indicate more significant problems; large confidence intervals can be reduced efficiently with a moderate increase in the amount of data available.

1b. Large confidence interval where lower limit just includes 3 and mean much above. Rationale: in such cases, managers will be close to making a decision. Just a few additional samples may give a clear answer in one direction or the other.

2. Ecological importance, e.g., spawning area, chemical and physical data, habitat. Rationale: Areas that deserve high priority from a resource management perspective (e.g., spawning areas) should also be considered a high priority for monitoring and conclusive evaluation.

11.1.5 REPORTING

A. 305(b) Report - If a watershed is determined to not meet criteria based on biological data, the watershed will be identified in the 305(b) database as "Not supporting aquatic life uses". A watershed determined to meet criteria based on biological data will be identified in the 305(b) database as "Fully supporting aquatic life uses". If the result of the biological data is "inconclusive," the watershed will be listed as "inconclusive."

B. 303(d) List - If a watershed is determined to not meet criteria based on biological data provided for the 305(b) report and a review of other biological data, the watershed will be identified on Part-5 of the Integrated 303(d) List as "Impaired". A watershed determined to meet criteria or for which the data are inconclusive based on biological data will not be identified on the Integrated 303(d) List, but may require follow-up monitoring to clarify inconclusive results.

11.1.6 EXCEPTIONS

(a) The fish index (F-IBI) does not apply in watersheds smaller than 300 acres.
(b) In all Use III and IV streams (cold water streams), where brook trout are present and the F-IBI is less than 3.0, the stream will not be rated as impaired by the F-IBI; if the F-IBI is greater than or equal to 3.0, the stream will be rated as good. Cold-water streams tend to have a naturally low fish diversity and biomass. Brook trout are normally indicators of high quality waters. So although the index may be low, the presence of brook trout indicates that the water is not impaired.
(c) In blackwater streams (dissolved organic carbon greater than 8 mg/l and either pH less than 5 or acid neutralizing capacity (ANC) less than 200 μeq/L) and where the F- or B-IBI is less than 3.0, the stream will not be consider impaired. If the B-IBI or the F-IBI is greater than or equal to 3.0, the stream will be rated as good.

(d) For limestone streams (defined operationally in the Valley and Ridge physiographic region) with ANC greater than 600 μeq/L, if the F- or B-IBI is less than 3.0, it will be evaluated on a case-by-case basis because limestone streams typically have elevated alkalinity levels that favor the survival and reproduction of crustaceans such as scuds (Gammaridae). However, high alkalinities can also place physiological limitations on the survival and reproduction of other aquatic invertebrate taxa, including craneflies (Tipulidae) and some mayflies (Ephemeroptera), which results in hyper-abundance and dominance of selected species and overall lower species richness.

(e) If the number of organisms in a benthic sample is less than 60, that sample will not be used and the stream segment "not rated" unless supporting data (e.g., habitat rating, water quality data) indicate impairment and there is no evidence of sampling error or unusual natural phenomena.

(f) Samples taken within two weeks of runoff events (e.g., heavy rains, sudden heavy snow melt) that result in significant bedload movement (i.e., erosion and transport of sediment) may be considered invalid in the best professional judgement of state biologists and not used for evaluation of stream condition.

(g) Stream sampling sites that are tidally influenced, affected by excessive drought (seasonally dry) or impounded by beaver dams will not be evaluated in terms of affected Biotic Indices. For example, a site within a natural impoundment that was created by beaver activity between the spring benthic macroinvertebrate sampling and the summer fish sampling activities may be evaluated only in terms of benthic Biotic Index. Man-made alterations to selected stream segments (channelization, dredging) should be noted, but they do not disqualify the utility of these Biotic Indices.

11.1.7 APPROACH TO USE OF NON-MBSS DATA IN BIOCRITERIA

Given that a key use of these procedures is for the Integrated 303(d) List of Impaired Waters, and that the State is required to consider all readily available data, MDE recognizes the need to incorporate local biological data into the assessment process. Counties or other water monitoring programs that intend to submit their data to support decisions made using the biocriteria framework. should carefully follow the general guidelines below. All data will be placed in one of several data quality tiers and used appropriately according to the quality criteria of the data tier.

11.1.7.1 Tier 1

Data are documented to be of good quality and can be fully integrated with MBSS data. MBSS or comparable field and lab protocols are followed. MBSS or comparable IBI methodologies are used. Field, laboratory, and IBI methods will be considered comparable to MBSS if methods can be demonstrated to yield stream condition ratings that agree with, or can be calibrated to yield the same ratings as, those of the MBSS methods. A quality assurance/ quality control (QA/QC) document and monitoring protocol is available for the monitoring program. Data are provided in a format readily available for merging into the MBSS database. Benthic macroinvertebrate and/or fish communities are monitored and identified to the lowest practicable taxonomic level (generally genus for benthic macroinvertebrates and species for fish).

At the 12-digit level, the proposed biocriteria framework relies on IBI scores at one or more individual sites, along with the estimated expected sampling error for repeated sampling at a single site. Thus, a county or other program would need to supply fish and/or benthic IBI scores that are unbiased for a site and that have quantifiable precision. If MBSS field, lab, and IBI methods are used, the estimated variance previously derived for repeated sampling at a single site using the MBSS IBIs would apply and a new precision (standard error) estimate would not be required. If MBSS field, lab, and IBI methods are not used, the program would need to demonstrate (in accordance with guidance and technical direction from the State) the following:

- Calibrate the program's IBI scores with MBSS IBI scale to show how scores on the different scales yield stream ratings in agreement, so that a consistent threshold is used to determine impairment.

- Conduct variability analysis for the program's IBI, to estimate variability for repeated sampling at a single site. This variability estimate is needed to calculate the confidence interval around individual site results.

- At the 8-digit level, the proposed biocriteria framework relies on quantifiable estimates of watershed-wide IBI mean and standard error. In addition to the factors listed above, the County or other program must also provide (in accordance with guidance and technical direction from the State):

- An unbiased estimate of the watershed mean IBI, with 90% confidence interval. This can be achieved with various probability-based sampling approaches (e.g., simple or stratified random sampling), as long as derived estimates are consistent with a survey design that gives unbiased estimates of mean and variance (i.e., all sites have a known, non-zero probability of being selected for sampling, and areawide estimates account for sampling weights based on the inclusion probabilities). Supplemental information on the survey design, sample frame, and site selection procedures may be useful for integration of this watershed estimate with MBSS results.

11.1.7.2 Tier 2

Data are documented to be of good quality; however, MBSS field and lab protocols are not followed. A probability-based sampling approach may or may not be used. A QA/QC document and monitoring protocol including replicate data and development of known precision are available for the monitoring program. Data are provided in a format readily available for merging into database formats used by the State. Monitoring is generally limited to either the benthic macroinvertebrate or fish communities and may be identified to the lowest practicable taxonomic level.

- Data will need to be assessed for general compatibility with MBSS methodology, consistency with good scientific practice, and documentation of adequate quality.

- Data will be used to supplement Tier 1 data. At the 12-digit level, tier 2 data can be used to augment assessments based on a single Tier 1 observation. At the 8-digit watershed level, tier 2 data can supplement watershed characterizations.

- Where local data support the State assessment, conclusions can be stated with greater confidence.

- Where local data contradict the State assessment, water quality assessors must understand the basis for the difference before a final determination is made. There may be many valid reasons for differences, but if local data over-ride conclusions based on State data, a rationale must be provided.

- Where there are no State data, local data may be used to make water quality assessment decisions, if in the determination of the assessor, the data meet quality criteria equivalent to those used in the MBSS program.

Other situations: Data not meeting the requirements stated above may be helpful for non-regulatory purposes (e.g., targeting, education). Such data will be stored and documented for these uses. State biologists may refer submitters to information sources that will help them to improve the quality of their monitoring data.

11.1.8 STRESSOR IDENTIFICATION

Stressor identification (cause/source identification) - If a watershed is determined to be impaired based on biological data, the cause of the impairment(s) will then be determined by a review of all of the relevant chemical, physical, and physical habitat data. If the source of the impairment(s) cannot be determined from the data, an on-site evaluation of the watershed may be undertaken including more detailed diagnostic testing such as sediment and water column chemistry and toxicity and geomorphic analyses. Habitat evaluation during sampling, with chemical and physical data will be used to evaluate the potential causes of impairments. It may be determined in some cases that the appropriate remedy is stream restoration rather than reduction of a specific chemical pollutant.

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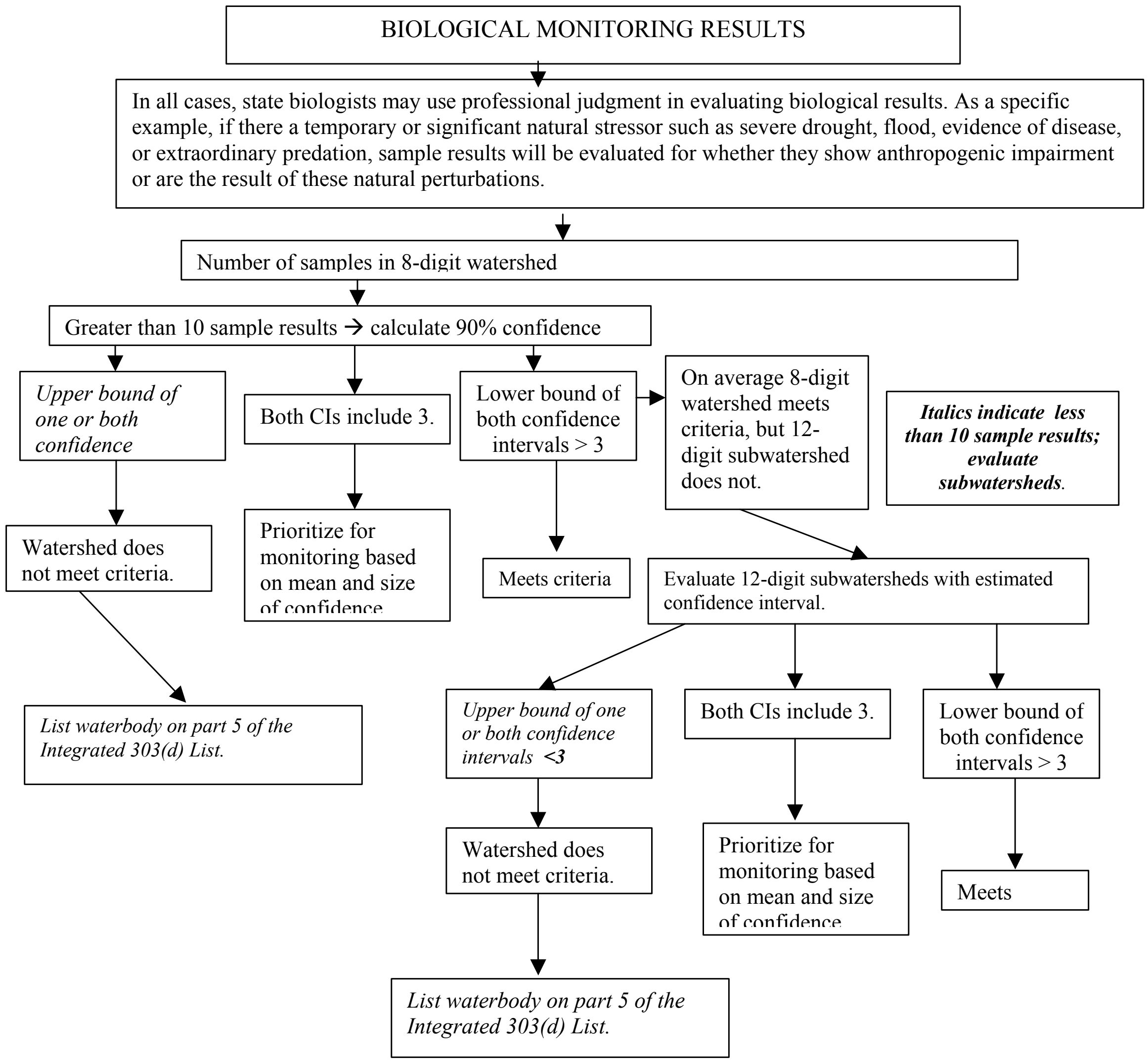


Figure 10: Biological Monitoring Decision Flow

11.2 Methodology for the Interpretation of Dissolved Oxygen Standards in Maryland's Thermally Stratified Lakes[1]

11.2.1 INTRODUCTION

Maryland has a minimum dissolved oxygen (DO) criterion of 5.0 mg/l for all waters at all times, except as resulting from natural conditions [COMAR 26.08.02.03-3A(2)]. Bottom waters in thermally stratified lakes may naturally become depleted of DO during periods of stratification (Wetzel 1975). In the absence of a standard specifically addressing stratified lakes, MDE is adopting an interim interpretation of the existing standard utilizing the percentage of oxygen saturation in the hypolimnion as a metric.

The natural evolution of lakes is toward eutrophication (Reid, 1961). Eventually, ecological succession by marsh, meadow and forest follows, unless human intervention slows or reverses the process. In view of this natural progression, selecting and maintaining an endpoint to represent attainment of a water quality standard is difficult. The challenge is to select a reasonable trophic status for a given lake. Upon selecting a reasonable trophic status to maintain, dissolved oxygen concentrations in the lake can be predicted.

11.2.2 BACKGROUND FOR PROPOSED INTERM INTERPRETATION OF DO STANDARDS AS APPLIED TO THERMALLY STRATIFIED LAKES IN MARYLAND

In idealized cases, lakes stratify into three distinct layers—the epilimnion, metalimnion and hypolimnion. The epilimnion is the well-mixed surface layer of relatively warm water. The metalimnion, the middle layer, is a zone of a distinct downward temperature gradient. The hypolimnion is the bottom layer of relatively cold and undisturbed water (Wetzel 1975).

Often, stratified lakes do not exhibit a separation into three distinct layers. The epilimnion is typically present as defined above; however, temperature in the underlying waters may decrease continuously down to the lake bottom. In this document, the term "hypolimnion" is used to define waters below the epilimnion, regardless of whether the lake exhibits three-layered thermal stratification.

Chapra (1997) describes hypolimnetic DO saturation as a function of lake trophic status. This relationship is summarized in Table 13 below.

[1] Source: Maryland Department of the Environment, 1999

Table 4: Relationship between Lake Trophic Status and Dissolved Oxygen Saturation in the Hypolimnion of a Thermally Stratified Lake

Trophic Status	**Hypolimnetic Dissolved Oxygen Saturation**
Eutrophic	0% - 10%
Mesotrophic	10% - 80%
Oligotrophic	80% - 100%

Adapted from Chapra (1997)

Reid (1961) provides a means of computing a dissolved oxygen concentration in water at a given temperature, elevation, and percentage of oxygen saturation (see Figure 11). This expected hypolimnetic DO concentration provides a reasonable basis for a hypolimnetic DO criterion in lakes of a given trophic state.

Correction Factors for Oxygen Saturation at Various Altitudes

Altitude		Pressure	
Feet	Metres	mm.	Factor
0	0	760	1.00
330	100	750	1.01
655	200	741	1.03
980	300	732	1.04
1310	400	723	1.05
1640	500	714	1.06
1970	600	705	1.08
2300	700	696	1.09
2630	800	687	1.11
2950	900	679	1.12
3280	1000	671	1.13
3610	1100	663	1.15
3940	1200	655	1.16
4270	1300	647	1.17
4600	1400	639	1.19
4930	1500	631	1.20
5250	1600	623	1.22
5580	1700	615	1.24
5910	1800	608	1.25
6240	1900	601	1.26
6560	2000	594	1.28
6900	2100	587	1.30
7220	2200	580	1.31
7550	2300	573	1.33
7880	2400	565	1.34
8200	2500	560	1.36

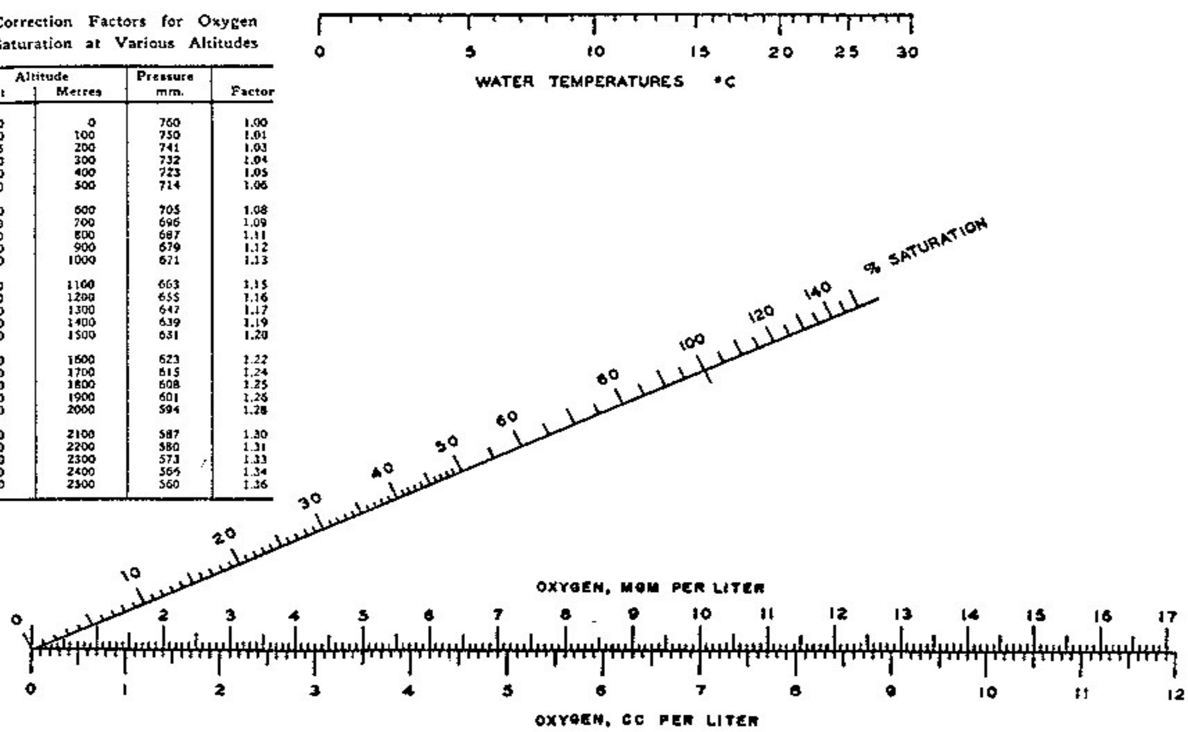


Figure 11: Nomogram showing relationship between water temperature, DO concentration, and DO saturation. ***Source*****: Reid 1961.**

11.2.3 LISTING METHODOLOGY FOR INTERPRETATION OF DO STANDARD AS APPLIED TO THERMALLY STRATIFIED LAKES IN MARYLAND

MDE is adopting the following general procedure to define the interim interpretation of the dissolved oxygen criteria for lakes exhibiting seasonal thermal stratification:

- A minimum dissolved oxygen concentration of 5.0 mg/l will be maintained in the epilimnion at all times.

- The allowable minimum hypolimnetic dissolved oxygen concentration will be determined as follows, given the selection of a reasonable trophic status[2] to be maintained:

1. The minimum percentage of dissolved oxygen saturation will be determined based on an adaptation of Table 13 above to accommodate Maryland's additional categories within the mesotrophic range (Table 14). This adaptation subdivides the mesotrophic range cited by Chapra into three zones each spanning approximately 23 percentage points.

Table 5: Extended Relationship between Lake Trophic Status and Dissolved Oxygen Saturation in the Hypolimnion of a Thermally Stratified Lake

Trophic Status	Minimum Hypolimnetic Dissolved Oxygen Saturation
Eutrophic	0%
Meso-eutrophic	10%
Mesotrophic	33%
Oligo-mesotrophic	56%
Oligotrophic	80%

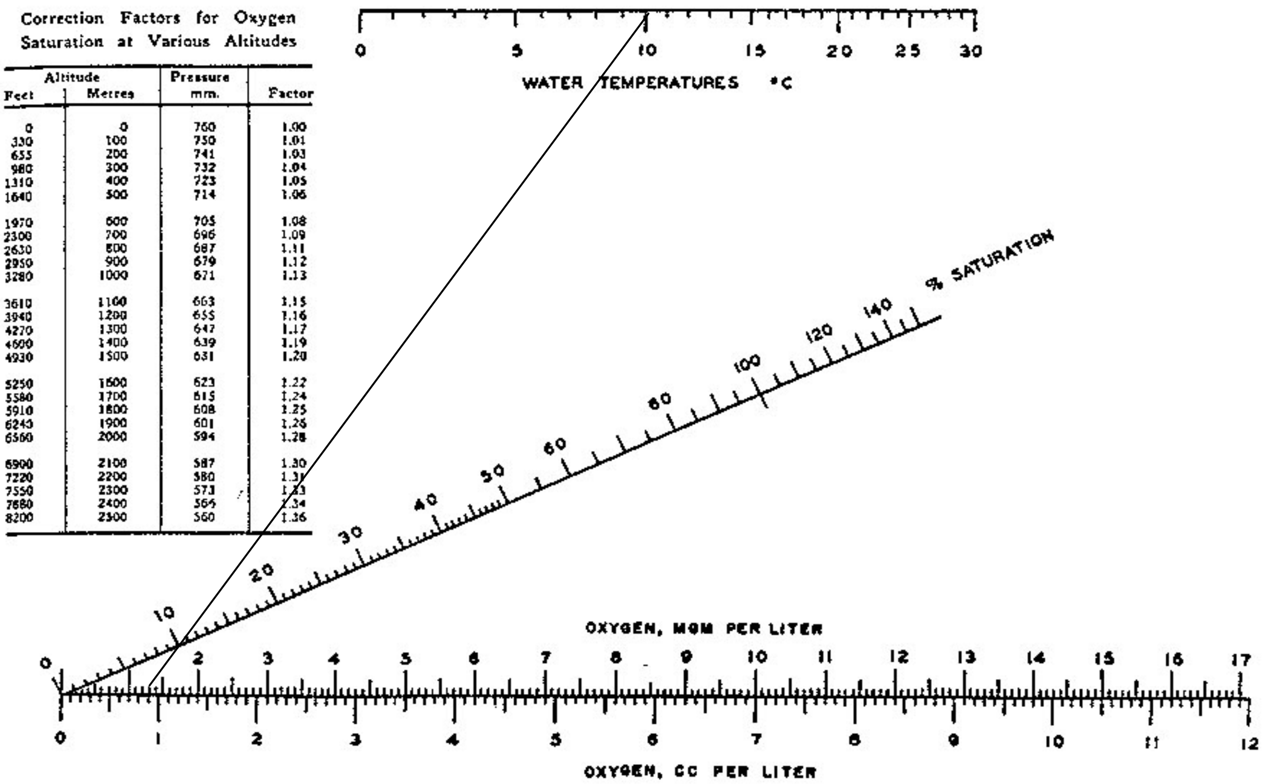
2. Given observed water temperatures, minimum dissolved oxygen saturation (from above) and elevation, the expected range of dissolved oxygen concentrations will be determined using published nomograms such as that presented by Reid (1961), or comparable calculation methods[3].

As an example, consider a meso-eutrophic lake, at sea level, with an observed temperature within the hypolimnion of 10^{o}C. The minimum allowable oxygen saturation in the hypolimnion

[2] Trophic status for the interim interpretation described will be that cited in the Maryland Lakes Water Quality Assessment Report, 1997 (Maryland Department of Natural Resources 1998). Future refinement of this interpretation will ensure that the selected trophic status is compatible with the lake's designated use.

[3] Although this interim procedure can yield high DO concentrations, it is not intended to result in a minimum DO criterion exceeding 5.0 mg/l.

would be 10%. Using the nomogram from Reid (1961), this would translate to a minimum allowable DO concentration of approximately 1.2 mg/l (see Figure 12).



Correction Factors for Oxygen Saturation at Various Altitudes

Altitude Feet	Altitude Metres	Pressure mm.	Factor
0	0	760	1.00
330	100	750	1.01
655	200	741	1.03
980	300	732	1.04
1310	400	723	1.05
1640	500	714	1.06
1970	600	705	1.08
2300	700	696	1.09
2630	800	687	1.11
2950	900	679	1.12
3280	1000	671	1.13
3610	1100	663	1.15
3940	1200	655	1.16
4270	1300	647	1.17
4600	1400	639	1.19
4930	1500	631	1.20
5250	1600	623	1.22
5580	1700	615	1.24
5910	1800	608	1.25
6240	1900	601	1.26
6560	2000	594	1.28
6900	2100	587	1.30
7220	2200	580	1.31
7550	2300	573	1.33
7880	2400	565	1.34
8200	2500	560	1.36

Figure 12: Minimum allowable hypolimnetic dissolved oxygen saturation and concentration in a meso-eutrophic lake (T = 10^{o}C).

11.2.4 REFERENCES

Chapra, Steven C. 1997. Surface Water Quality Modeling. McGraw – Hill.

Maryland Department of Natural Resources. 1998. Maryland Lake Water Quality Assessment Report, 1997.

Reid, G. K. 1961. Ecology of Inland Waters and Estuaries. D. Van Nostrand, Inc., New York, U.S.A.

Wetzel, R. G. 1975. Limnology. W. B. Saunders, Inc., Philadelphia, U.S.A.

11.3 Listing Methodology for pH and Mine Impacted Waters

All pH impairments are identified based on COMAR §26.08.02.03, which states that: "Normal pH values may not be less than 6.5 or greater than 8.5" in Use I, IP, II, III, IIIP, IV, or IVP waters. It is undesirable to incorrectly identify a waterbody as impaired when the observed condition is of a natural origin. Factors, such as the presence of a peat or black water bog or swamp would be considered as natural conditions, and therefore, not impaired under the CWA §303(d) listing process.

Other natural conditions, which should not be used to identify a waterbody as pH impaired would include an abundance of algae or aquatic plants that elevate pH levels above 8.5 as a result of photosynthetic driven chemical reaction, unless the condition is being caused by a defined nutrient enrichment source. Certain conditions in close proximity to limestone springs may also have natural pH values outside of the standards. Streams that do not meet the criterion for pH and which cannot be demonstrated to result from natural conditions will be listed as impaired.

Streams influenced by abandoned coal or clay mining operations (those that predate the permitting authority or designated as "pre-law") and having a pH below 6.5 would be listed as impaired.

Waterbodies displaying acidic conditions as a result of atmospheric deposition will be placed on the 303(d) list if it is determined that there is not adequate natural buffering capacity in the watershed.

The decision process for evaluating pH in Maryland waters is summarized in the following flowchart shown in Figure 13.

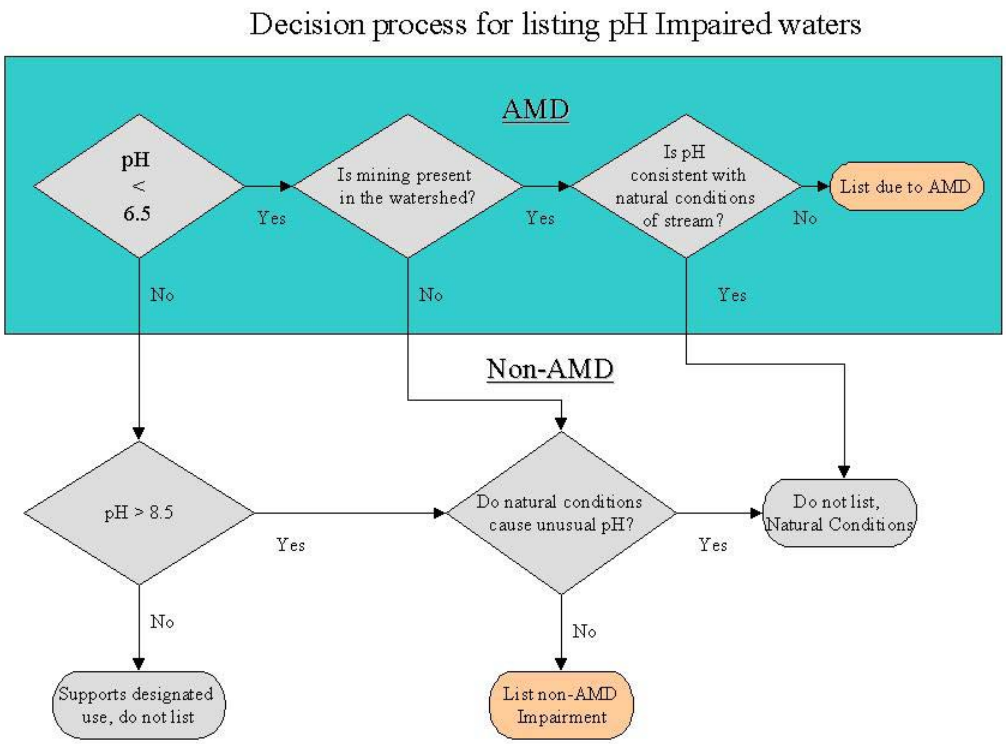


Figure 13: Decision flowchart for pH impaired waters.

The flow chart applies to Maryland 8-digit watersheds evaluated for the 303(d) list.

Ideally, an impairment decision should be based on a sufficient number of samples to adequately characterize potential diurnal and seasonal variations.

If 10% or more of the samples violate the pH numeric criteria and cannot be traced to naturally occurring conditions, the 8-digit stream watershed will be considered to not meet the standards for its designated uses and listed as impaired.

4. If less than 10% of the samples violate the pH numeric criteria, best professional judgement will be used to determine if the 8-digit watershed should be listed as impaired. In the event the waterbody is not listed, additional samples will be collected for future consideration.

11.4 Listing Methodology for Identifying Waters Impaired by Bacteria on Maryland's 303(d) List

11.4.1 INTRODUCTION

The rules used by MDE to interpret data and apply the water quality standards are discussed below in three sections. Each of those sections describes the application to a distinct water use: shellfish harvesting; permitted beaches; and general recreation waters. Although in each case a bacteriological indicator applies, the criterion and in some cases the indicator itself differs according to the requirements of the National Shellfish Sanitation Program (NSSP), water quality standards, or public health requirements.

11.4.2 INTERPETATION OF FECAL COLIFORM DATA IN USE II, SHELLFISH HARVESTING AREAS

(1) RESTRICTED:
Those areas restricted to shellfish harvesting because they do not meet State requirements for Use II waters or do not meet the strict requirements under the NSSP are listed. These requirements are found in the *National Shellfish Sanitation Program Guide for the Control of Molluscan Shellfish*, 1997 revision. Copies can be obtained from the U.S. Department of Health and Human Services, PHS, FDA. Data used to determine these restrictions include routine bacteriological water quality sampling, sanitary survey, and strict adherence to the NSSP procedures, protocols and requirements.

(1A)
Those areas restricted to shellfish harvesting because they are located in the vicinity of a wastewater treatment plant (WWTP) discharge pipe but where there is <u>no evidence of actual bacteriological impairment</u> are not listed. This restriction is an important application of the principals and practices of public health protection and is required under the NSSP. State law requires MDE to monitor these areas for fecal coliform bacteria. MDE also evaluates treatment plant performance and its impact to shellfish harvesting waters. These administrative closures are not based on water quality criteria but are designed to be protective buffer areas in case of a system failure. <u>These areas meet the bacteriological portion of the standard</u>. These areas are also closed as a requirement for compliance with the NSSP.

(1B)
The upper Chesapeake Bay is restricted to shellfish harvesting for administrative reasons and is not listed. This area is designated as Use II waters; however there is insufficient shellfish resource for harvesting due to the fresh water input from the Susquehanna River. Since there are no oysters or clams to harvest, MDE does not spend valuable staff resources to complete shoreline surveys. To remain in compliance with the NSSP, MDE must therefore classify the area as restricted. In order to protect shellfish waters directly below this area, the Use II designation is a valuable protective measure so the area remains designated Use II waters. <u>Water quality is routinely monitored in this area for fecal coliform and meets the bacteriological portion of the standard</u>. If the collected data shows violations with State standards (notwithstanding the fact that the area is under an administrative closure or restriction) it will be listed appropriately.

(2) CONDITIONALLY APPROVED WATERS:
Before being opened for conditional harvesting, areas need to meet the stringent shellfish bacteriological standards. However, those areas classified as conditionally approved are closed to harvesting for three days following a rainfall event of greater than or equal to one inch in twenty-four hours. This happens an average of 10 - 15 times per year when we cannot be completely certain that bacterial levels are not elevated in response to rain. The rest of the time, these areas meet the water quality standards for Use II waters, these areas are not listed.

(3)APPROVED WATERS:
Areas classified as approved for harvesting meet the water quality standards for Use II waters.

11.4.3 INTERPRETATION OF FECAL COLIFORM DATA FOR SWIMMING BEACHES

The 305(b) Report includes a table on beach closures. This table is derived by sending a survey out to the county health departments who have the authority to close bathing beaches. Most closures are short lived and related to an extreme storm event, sewage spill, etc. The cause of the closure is usually investigated quickly with appropriate action taken as soon as possible to abate the problem. It is not appropriate to assign impairments to areas based on intermittent bathing beach closures. However, those areas permanently closed or having long-term or chronic closures are listed.

Maryland has implemented the EPA recommended enterococcus (marine or freshwater) and *E. coli* (freshwater only) standards at permitted beaches. Where frequent or chronic closures based on these indicators occur, those waters will be listed.

11.4.4 INTERPRETATION OF FECAL COLIFORM DATA FOR USE I, II OR IV WATERS

Routine monthly sampling provides limited bacteriological information. MDE also routinely receives information from local health departments, reports on non-compliance with various water quality permits, etc. that covers areas of the State not included in the Water Quality Tributary Monitoring coverage.

Data generated by water monitoring programs will be used to plot a long-term geometric mean of fecal coliform levels using a minimum of one year and maximum of five years worth of data. Segments where the geometric mean exceeds 200 MPN/100 ml will be evaluated further by sanitary survey. In addition, information collected from other sources indicating a potential bacteriological impairment will be evaluated further by sanitary survey. The information generated for completing a sanitary survey is listed below.

1. A land use map of the segment in question will be studied to determine potential sources of fecal coliform pollution.

2. It will be determined if the area is served by individual on-site wastewater treatment or served by public or private sewer including the presence or absence of a combined storm water/wastewater system.

3. A regional Sanitarian, the local health department, the local agency responsible for wastewater treatment infrastructure, and Inspection & Compliance Program staff will be contacted to determine what potential or actual problems exist regarding on-site wastewater treatment in the vicinity or any other potential bacteriological pollution problems (such as collection system or sewage treatment plant problems, surface water quality permit violations, etc.)

4. Based on the result of the sanitary survey (see discussion below for more details on types of information and actions available for conducting a sanitary survey) or other information reported to the Department, a determination will be made to list or not to list the segment as impaired.

   a) Those segments impacted by faulty sewer lines, excess inflow and infiltration, or other impacts allowing a technological fix will be listed if the problem cannot be fixed before the next listing period. Attainment of water quality standards or the probability that water quality standards will be attained by the next listing period must be demonstrated.

   b) Those segments where no technological fix is feasible, or where that repair cannot be completed by the next listing period, or where there is a potential human health risk, are listed on Part-5 of the 303(d) List.

11.4.5 DISCUSSION

It is critical that the sampling be carried out in a way that is representative of conditions in time and space. High spatial and temporal variability suggest that infrequent or moderately elevated bacteriological levels alone do not necessarily represent a human health risk. The bacteriological standard is descriptive and includes numerical criteria. The intent of the criteria is to allow the 'number' to be judged in conjunction with the sanitary survey that identifies probable sources of fecal coliform and allows regulators to assess the probability of human health risk. The standard recognizes the inherent variability of the fecal coliform measurement and recognizes the inadequacies of fecal coliform as an indicator organism. The Most Probable Number (MPN) test used to determine the level of fecal coliform is not a direct count but a statistical estimation subject to a high degree of variability.

Maryland's fecal coliform standard protects the public from harmful human pathogens. One or two high values may or may not be indicative of impairment because fecal coliform is fairly ubiquitous in the natural environment and is used as an <u>indicator</u> of <u>possible</u> human fecal contamination from point and nonpoint sources. Therefore, it is necessary to evaluate the fecal coliform values along with sanitary survey information to assess bacteriological water quality conditions.

MDE has a fairly aggressive pollution prevention program and the authority to abate pollution problems. Chronic problems or serious public health issues are addressed through local health departments, MDE’s Inspection and Compliance Program, and the local soil conservation districts. The local health departments conduct sanitary surveys, enforce requirements for on-site sewage treatment, and address citizen complaints regarding sewage pollution. MDE's Inspection and Compliance Program has the authority to address pollution concerns, inspect and abate pollution problems concerning on site sewage treatment and farm operations, inspect and enforce permit requirements for all dischargers, etc. The local conservation districts work with farmers to ensure best management practices. If an animal operation is identified as a source of fecal pollution to surface waters, MDE has the authority to abate the problem. Until a problem from agricultural sources is abated, impaired waters will be listed.

The intent of Maryland's bacteriological water quality criteria is for State regulators to have a tool (one of many) to provide adequate public health protection as well as water quality protection required under the CWA. Public health protection is most efficient and effective when the fecal coliform standard is interpreted in conjunction with the results of a sanitary survey.

11.5 Listing Methodology for Determining Impaired Waters By Chemical Contaminants for the Maryland 303(d) List

11.5.1 BACKGROUND

The designated uses define the water quality goals of a waterbody. At a minimum, the Maryland Department of the Environment (MDE) must provide water quality for the protection and propagation of fish, shellfish, and wildlife, and provide for recreation in and on the water, where attainable (CWA Section 101(a)). The MDE is required to adopt water quality criteria that protect designated uses. Such criteria must be based on sound scientific rationale, must contain sufficient parameters to protect the designated uses, and can be expressed in either numeric or narrative form. Narrative criteria are descriptions of the conditions necessary for a waterbody to attain its designated use, while numeric criteria are concentration or threshold values deemed necessary to protect designated uses. Narrative criteria can be used to assess water quality, and also to establish pollutant-specific discharge limits where there are no numeric criteria or where such criteria are not sufficient to protect the designated use.

Although several approaches exist to assess water quality (e.g., numeric criteria, whole effluent toxicity, etc.), few approaches exist to assess sediment quality due to its complexities. Nevertheless, sediments are an integral component of aquatic ecosystems, providing habitat, feeding, spawning, and rearing areas for many aquatic organisms and are, therefore, protected under the narrative criteria. Furthermore, sediment quality can affect whether or not waters are attaining designated uses. Consequently, it is necessary and appropriate to assess and protect sediment quality, as an essential component of the total aquatic environment, to achieve and maintain designated uses. The difficulty lies in implementing the narrative criteria, which is qualitative in nature. To circumvent this obstacle, MDE is implementing an approach to quantitatively interpret narrative criteria statements, and determine water quality standard violations from contaminated sediments.

11.5.2 INTRODUCTION

Under section 303(d)(1) of the Federal Clean Water Act (CWA), MDE is required to establish Total Maximum Daily Loads (TMDLs) for those waterbody segments that do not meet applicable water quality standards and are therefore considered “impaired”. To achieve this, MDE is required to consider all existing and readily available water quality data and information, and develop methods to interpret this data for each potential impairing substance (e.g., pH, nutrient, fecal coliform, etc.).

EPA does not provide guidance for interpreting water quality data for the purposes of developing the 303(d) List. However, EPA does provide guidance on making “use support determinations” for the State Water Quality Assessments [305(b) Report] (EPA, 1997). In general, MDE adopted the 305(b) guidance for identifying waterbody segments impaired due to chemical contaminants. Even though the Department will adhere to these methods as closely as possible, there may be instances where determinations may vary based on scientifically defensible decisions. It is important to note that there maybe situations which do not support an impairment determination from chemical contaminants, but rather from another stressor (e.g., dissolved oxygen, biocriteria), and would therefore be addressed elsewhere. This document provides the specific methodology used by MDE for identifying waterbody segments impaired due to *chemical contaminants*.

It is not the intent of this methodology to include waters that do not meet water quality criteria solely due to natural conditions or physical alterations of the waterbody not related to anthropogenic pollutants. Similarly, it is not the intent of this chapter to include waters where designated uses are being met and where water quality criteria exceedances are limited to those parameters for which permitted mixing zones or other moderating provisions (such as site-specific alternative criteria) are in effect. The Department will examine these situations on a case-by-case basis, and evaluate the context under which the exceedance exists. Determination of compliance with water quality criteria may be facilitated through special analyses (e.g. normalization of metals to common reference element to determine anthropogenic influences), or monitoring (e.g. compliance monitoring for mixing zones).

MDE considers all existing readily available chemical, toxicological, and biological data from water column, sediments, and fish tissue in determining if a waterbody segment should be classified as impaired due to chemical contaminants and listed on the 303(d) List. As a result, MDE has divided the impairment evaluation process into three media categories (water column, sediment, and fish tissue). The Department will evaluate the monitoring plans, Quality assurance, and Quality Control (QA/QC) programs of data providers, and will use best professional judgment to include/exclude data where documentation does not exist.

11.5.3 WATER COLUMN

Ambient water column contaminant data are screened against numerical ambient water quality criteria if available. These water quality criteria are utilized because they represent science-based threshold effect values and are an integral part of the Maryland's water quality standards program. These criteria are divided into the following categories that directly relate to Maryland's surface water use designation classification (COMAR 26.08.02):

1) All surface waters of the state (USE DESIGNATIONS - I, II, III, & IV)

- Criteria for the protection of aquatic life
    - Fresh water (Chronic & Acute)
- Saltwater (Chronic & Acute)
- Criteria for the protection of human health from fish tissue consumption (Organism Only)

2) Surface waters used for <u>public water supply</u> (USE DESIGNATION - P)

- Criteria for the protection of human health from fish tissue consumption & drinking water (Water + Organism)
- Drinking water only (Maximum Contaminant Levels-MCLs)

EPA does not provide guidance in interpreting water column data for the purposes of developing the 303(d) list but does for the development of the 305(b) Report (Maryland's Water Quality Inventory). The 305(b) guidance states that, with a minimum of 10 samples over a three-year period, the designated use is not supported if greater than 10% (i.e. 2 out of 10) of the samples exceed the appropriate benchmark (EPA 1997). MDE had adopted this rule to identify waterbodies impaired by chemical contaminants. In other words, with a minimum of 10 samples over a three-year period, an impairment would exist if greater than 10% of the samples exceed the criteria. An appropriate statistical procedure (e.g., confidence interval approach) will be applied if sample size for a segment is deemed adequate. If there are less than 10 samples for a given area, MDE interprets the available data on a case-by-case basis and determines if an impairment exists. In such cases, a number of factors are considered such as:

- The magnitude of the criteria exceedance for any one contaminant,
- The number of criteria exceeded,
- Water column bioassay (toxicity) data indicating toxicity to test organisms.
- Data quality

If it is determined that a potential impairment exists, but there is insufficient data to make an impairment determination, the segment will be placed on Part-3 (Insufficient data), or Part-4 (Impaired/Threatened but TMDL not required due to forthcoming compliance or previous completion of a TMDL). Segment will then be prioritized for additional monitoring. In these instances, the Department will use its best professional judgment based on the available data to make its determination.

In the case that no criteria are available for a particular contaminant or no criteria are exceeded, other impairment indicators (e.g., ambient water column toxicity data) will be evaluated using best professional judgment. During this evaluation process, if toxicity is indicated, a Toxicity Identification Evaluation (TIE) maybe considered to further identify the possible contaminant source(s) causing toxicity. A TIE is a comprehensive approach used in the Whole Effluent Toxicity (WET) Program to identify possible causes of toxicity. When warranted, MDE will also utilize spatial and temporal trend analyses as an additional evaluation tool for making impairment determinations.

As mentioned previously, MDE considers all existing and readily available data, including independent studies conducted by sources external to MDE. These ambient water column data are screened to determine if they are of acceptable quality (i.e., documented methods and an acceptable QA/QC plan). If the data are unacceptable (i.e., poor or no QA/QC) but suggest an exceedance of the appropriate criteria, the segment is targeted for additional monitoring, and evaluated using other approaches.

In many cases, there may be no ambient water quality data (chemical or toxicity) available for an impairment evaluation. In such cases, MDE will apply a weight-of-evidence approach using other data as described below.

11.5.4 SEDIMENT

Protecting sediment quality is an important part of restoring and maintaining the biological integrity of our State's waters. Sediment is an integral component of aquatic ecosystems, providing habitat, feeding, spawning, and rearing areas for many aquatic organisms. Sediment also serves as a reservoir for chemical contaminants and therefore a source of chemical contaminants to the water column and organisms. Chemicals that do not easily degrade can accumulate in sediments at much higher levels than those found in the water column.

Contaminated sediments can cause adverse effects in benthic or other sediment-associated organisms through exposure to pore water or direct ingestion of sediments or contaminated food. In addition, natural and human disturbances can release chemical contaminants to the overlying water, where water column organisms can be exposed. Sediment contaminants can reduce or eliminate species of recreational, commercial, or ecological importance, either through direct effects or by affecting the food supply that sustainable populations require. Furthermore, some chemical contaminants can bioaccumulate through the food chain and pose human health risks even when sediment-dwelling organisms are not themselves impacted. This specific pathway will be addressed later in the fish tissue approach.

MDE is using the following comprehensive weight-of-evidence approach in making impairment determinations. This approach, also referred to as the Sediment Quality Triad, consists of three components (Chapman, 1992):

- Ambient sediment bioassays - to measure toxicity
- *In situ* biological variables - to measure alteration of resident biota (*e.g.,* change in benthic community structure)
- Ambient sediment chemistry - to measure chemical contamination

These components provide complementary data to each other, that when combined may provide an efficient tool for determining an impairment. However, each component has its limitations, which necessitates a sound scientific interpretation of the data and best professional judgment on a case-by-case basis. The scientific community, in fact, has previously indicated that sediment assessments are strongest when the three data components are used in combination to balance their relative strengths and weaknesses (Chapman, 1992, Long et al., 2000, Anderson et al. 2001, Ingersoll et al., 1997, EPA 1997).

11.5.4.1 Ambient Sediment Bioassay Data

Ambient sediment bioassays are a type of biological data, in which test organisms are exposed under controlled conditions to the field collected sediment sample. Although we have confidence in this type of data because of the controlled conditions, it can be inconsistent, especially where toxicity is minimal or subtle. Laboratory artifacts, although generally controlled, can produce false results. For this reason, at least two or more non-microbial tests are required to exhibit toxicity to determine that the potential for adverse effects from contaminated sediment is high.

This type of data is essential in assessing sediment contaminants. If toxicity is exhibited to the tested benthic/epibenthic organisms, it is generally considered indicative of water quality that is incapable of supporting aquatic life, which is in violation of our State's water quality standards. Furthermore, it also suggests that the adverse effects observed in the toxicity tests may be related to chemical contaminants because other non-contaminant related causes (e.g. dissolved oxygen, pH, temperature) are controlled in the laboratory setting. In addition, the information from this data component is quantitative and can be correlated to the toxicity of other sediments or chemicals to the test species. For this reason, the greatest weight is given to toxicity test data among the three data components.

However, a limitation of this data is that it does not identify the causative pollutant, which necessitates the need for sediment chemistry data. The sediment chemistry data provides the best link for establishing an impairment determination resulting from contaminant exposure, which is the basis of this document. Additionally, the laboratory conditions under which bioassays are conducted may not accurately reflect field conditions of exposure to toxic chemicals, and thus introduces uncertainties when extrapolating to population dynamics. This point is important to understand because while attempting to control for non-contaminant related stressors (e.g., dissolved oxygen, pH, temperature), contaminants in the sediments may be rendered toxic to the test organisms that would not be toxic under field conditions, thus providing a false positive result (e.g., sulfide and ammonia in sediments, pH shift for metals).

11.5.4.2 Sediment Chemistry Data

Although EPA has been working on sediment quality criteria (SQC) for many years, no final numeric water quality criteria have been published. This is due to the difficulty in determining the fraction of the chemical contaminant that is biologically available to exert its toxic effect on the exposed population and in establishing a criteria derivation process that could be shown to be consistent with other evaluative tools. In fact, the EPA has redirected their efforts to derive equilibrium sediment guidelines (ESGs), rather than criteria, for the following five substances; acenaphthene (EPA, 1993a), fluoranthene (EPA, 1993b), phenanthrene (EPA, 1993c), dieldrin (EPA, 1993d), and endrin (EPA, 1993e).

In the absence of such guidelines, a set of screening values devised by National Oceanic and Atmospheric Administration (NOAA) has been generally accepted as a screening tool to evaluate the likelihood of adverse effects (Long and Morgan, 1990/NOAA, 1991; Long *et al*., 1995). The Effects Range-Median (ER-M) values are defined as the median (50^{th} percentile) of the distributions of the effects data for a particular contaminant. However, these values should only be used to screen sediments for levels of possible concern, and should not be construed to indicate an adverse effect in the absence of additional corroborative data (Long and MacDonald, 1998). In their development of a classification scheme for the National Sediment Quality Inventory, EPA also recognized the limitations of the ER-Ms by requiring that the bulk sediment chemistry data exceed two separate sediment benchmarks in classifying sediments as Tier I (probable adverse effects to aquatic life and human health) (EPA 1996).

In the absence of EPA ESGs and NOAA ER-M values, sediment quality benchmarks (SQBs) were derived by MDE for non-ionic organic substances using the EPA-recommended equilibrium partitioning approach, (e.g**.,** alpha-BHC, beta-BHC, lindane, chlordane, chlorpyrifos, heptachlor, etc.). This is also consistent with EPA's National Sediment Quality Inventory. MDE will compare sediment chemistry data according to the described thresholds in the following order (see Table 15):

a) EPA ESGs,
b) NOAA ER-M values,
c) MDE derived SQBs, and

d) Other toxicological sediment benchmarks (*i.e.,* toxicity data)

Both the quality of sediment chemistry data and associated screening thresholds are considered when conducting an evaluation. Once the quality of data has been established, the potential for adverse effect from contaminated sediment is said to be high if either of the following conditions are met:

1. The sediment chemistry data exceeded the EPA ESG, or

2. The sediment chemistry data exceeded the ER-Ms or other screening values by a factor of two[5] for any one contaminant, or

3. The mean ER-M quotient[6] is greater than 0.5 (Long et al. 2000 & Anderson et al. 2001), or

4. The sediment chemistry data exceeded more than 5 ER-Ms[7] (Long et al. 2000 & Anderson et al. 2001).

Furthermore, various environmental conditions in the sediment can have a profound effect on the availability and toxicity of the sediments to aquatic environment (e.g., acid volatile sulfide for metals, organic carbon for organics, etc.). If data on these parameters are available, MDE will use best professional judgment to interpret the effects of these parameters on the sediment chemistry data.

When the measured chemical exceeds the appropriate sediment threshold, any observed adverse effects to the test species may be due to the measured chemical with the likelihood increasing as the chemical concentration increases. When a chemical is measured at a level below the threshold, any observed adverse effects are not likely to be due to the measured chemical. It is recognized, however, that sediments are rarely, if ever, contaminated by a single chemical. Therefore, in cases where a chemical is measured at a level below a threshold, the sediment may still cause adverse effects. Such cases could include, for example, contaminated sediments where chemicals not covered by a threshold are creating or contributing to toxicity, or where bioaccumulation or biomagnification up the food chain is a concern (EPA, 2000).

The mere exceedance(s) of a sediment threshold, however, does not in itself establish an adverse effect from toxicity, but helps to identify the chemical that might be responsible for any observed adverse effects from toxicity. Given these limitations, MDE does not believe that the

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5 The factor of two was derived as the geometric mean of the ratios for those substances for which ER-Ms and SQCs were available; acenaphthene (ER-M/SQC ratio=4.6), fluoranthene (ER-M/ESG ratio=0.6), and phenanthrene (ER-M/ESG ratio=1.6). Although it was possible to calculate a ratio for dieldrin (ER-M/ESG ratio=25), it was not considered because the ratio was greater than 5 times the highest of the other three ratios. This condition serves the purpose of confirming the severity of contamination for any one contaminant above background concentrations, and therefore demonstrating the potential for impairing that segment.

6 An ER-M quotient is calculated as the ambient sample concentration over the ER-M (toxicity weighted average).

7 Long et al.,(2000) showed that there is a much higher probability (>48%) that samples would be toxic in which six or more ERM values are exceeded or in which mean ERM quotients exceed 0.5.

exceedance(s) of sediment thresholds are appropriate as sole indicators of use attainment. Instead, we recommend using all three data components as a basis for interpreting narrative criteria and developing pollutant reduction strategies.

11.5.5 BIOLOGICAL BENTHIC ASSESSMENT DATA

In freshwater, MDE currently uses biological community data independently in making an impairment determination. The methodology dealing with biological assessments is addressed elsewhere under the biocriteria framework. This type of data is generally considered a good water quality indicator, because it measures a community (population) response to water quality and integrates through time and cumulative impacts. Thus, if this assessment data or other types of assessment data (e.g. Chesapeake Bay restoration goals) do not indicate an alteration (or degradation) of the biological benthic community, the waterbody is not considered for an impairment determination, despite data from the other components because:

1. It is supportive of aquatic life (at a community level), and thus meets its designated use,

2. The biological assessment component is a more rigorous method of assessing water quality than chemical and bioassay data which may be highly dependent on uncontrollable variables

3. It measures a community response to water quality rather than subjective endpoints from the other components (e.g. ER-M, significant level of toxicity, toxicity to one species)

4. It is consistent with the biological assessments method developed elsewhere

It is more likely to observe an alteration of the biological community where none should be present (false positive) than not to observe alteration of the biological community where one should present (false negative). Anderson et al., 2001 found that laboratory toxicity tests were indicative of benthic impacts in Los Angeles and Long Beach Harbor stations in California. Single and multivariate correlations showed significant positive relationships between amphipod survival in laboratory toxicity tests and measured benthic community structure in field samples. For this reason, MDE would further investigate the chemistry and toxicity data where an alteration of the biological community has been observed. These data would be used to confirm that the community effect is due to exposure to contaminants and to identify the probable contaminant of concern. However, although biological assessment data alone could indicate an impairment, it would not necessarily result in a "toxics" impairment determination. This is because non-contaminant effects (e.g., competition, predation, sediment type, salinity, temperature, recent dredging) may confound interpretation of this data with respect to chemical contamination (Anderson et al., 2001).

11.5.6 WEIGHT-OF-EVIDENCE APPROACH (Sediment Quality Triad)

A comprehensive approach using multiple assessment methods helps eliminate false conclusions brought about by relying solely on one method of evaluation. Consequently, MDE would assess sediment quality, and thus an impairment determination, using a weight-of-evidence approach (Winger, et al., 2001). Biological assessments could be used to supplement findings of impaired waters, or as a prioritization tool to determine where additional testing should be performed. These components provide complementary data to each other, that when combined may, provide an efficient tool in determining an impairment. However, each component has its limitations, which necessitates a sound scientific interpretation of the data and best professional judgment on a case-by-case basis. Consequently, the individual use of these data components as sole indicators of use attainment is inappropriate. Instead, we recommend using all three data components as a basis for interpreting narrative criteria and developing pollutant reduction strategies.

Sediment chemistry data provide information on contamination, and when used with sediment thresholds or other indicators, also provide insight into potential biological effects. However, they provide little insight on the bioavailability of the contaminant unless data on other mitigating factors (e.g., AVS for metals, organic carbon for organic contaminants) are collected simultaneously. Sediment bioassays are an important component of sediment assessment because they provide direct evidence of sediment toxicity. However, they do not identify the causative pollutant. Additionally, the laboratory conditions under which bioassays are conducted may not accurately reflect field conditions of exposure to toxic chemicals. *In situ* biological studies (such as benthic community composition analyses) are useful because they account for field conditions. However, interpretation with respect to chemical contamination may be confounded by non-contaminant effects. Because each component alone has limitations, the Triad approach uses all three sets of measurements to assess sediment contamination. Table 15 lists possible conclusions that can be drawn from various sets of test results, followed by possible listing decisions.

Table 6: Possible Conclusions Provided by Using the Sediment Quality Triad Approach (Chapman, 1992)

Scenario	Toxicity	Chemistry	Community Alteration	Possible Conclusions	Listing Decision
1	+	+	+	Strong evidence for chemical contaminant-induced degradation.	**List (Part-5)**
2	-	-	-	Strong evidence for absence of chemical contaminant-induced degradation.	**Do not list for toxics**
3	-	+	-	Chemical contaminants are not bioavailable.	**Do not list for toxics Additional monitoring**
4	+	-	-	Unmeasured chemical contaminants or conditions may exist that have the potential to cause degradation.	**Do not list for toxics Additional monitoring**
5	-	-	+	Alteration is probably not due to chemical contaminants.	**Do not list for toxics**
6	+	+	-	Chemical contaminants are likely stressing the system. However, the waterbody is still meeting its designated use due to the presence of an unimpaired benthic community.	**Do not list for toxics Additional monitoring**
7	+	-	+	Unmeasured chemical contaminants are causing degradation.	**Do not list for toxics Additional monitoring**
8	-	+	+	Chemical contaminants are not bioavailable or alteration is not due to contaminants.	**Do not list for toxics Additional monitoring**

"+" Indicates measured difference between test and control or reference conditions.
"–" Indicates no measurable difference between test and control or reference conditions.

As indicated in Table 15, there may be scenarios where sediment chemistry data, sediment bioassays, and benthic community analyses produce conflicting results. In these scenarios, the interpretation becomes more complex, but it does not necessarily indicate that any of the data sets are "wrong", although this possibility should not be ruled out without sound evidence.

Scenario #1: This decision is due to the overwhelming evidence of impairment from all three data components.

Scenario #2: This decision is based on the overwhelming lack of evidence from all three data components.

Scenario #3: Without evidence of toxicity or a degraded biological community, the most likely conclusion is that the chemical contaminants, although elevated, are not bioavailable. If the biological community data shows no adverse effect, the water quality is deemed to be supportive of aquatic life and its designated use is fully supported.

Scenario #4: The basis for this decision is due to the biological community response, and is supported by sediment chemistry. The clear results from the healthy biological community and the lack of chemical concentrations consistent with toxic impacts suggests that the toxicity test results may be anomalous, due to artifacts and not to chemical contaminants. It is possible that there are unmeasured contaminants, but the impact is not sufficient to impair the designated use, as demonstrated by the biological community. However, if the magnitude of the effect observed in the bioassays were severe (e.g. less than 50% survival), the Department may re-evaluate its listing decision. Nevertheless, additional monitoring would be required to confirm the findings of the Triad, and to determine if further actions are required.

Scenario #5: Without evidence of toxicity or elevated chemical concentrations, the most likely conclusion is that the degraded biological community is not due to chemical contaminants. This scenario, however, is be captured by other Listing Methodologies.

Scenario #6: Where a good tool exists for evaluating the biological community, it is usually a good indicator of water quality in general and is very sensitive because it integrates impacts from different stressors as well as impacts through time. Practical experience has shown that where "IBI"-type indicators are considered, they indicated impairments not supported by the other data components (i.e., toxicity and chemistry). Therefore, where biological community data of this type exist showing non-degraded biological communities, it will be considered as sufficient evidence of a supported designated use, despite the implications of toxicity and chemistry.

However, where no such data exists or where those indicators are not applicable, the Department will apply its best professional judgment, but will likely determine that the designated use is not supported.

Scenario #7: The basis for this decision is the adverse response observed from the toxicity and biological community data. In this scenario, the water quality is not supportive of aquatic life and is likely due to chemical contaminantion with no applicable chemical threshold or some unmeasured chemical contaminant. This scenario would require listing on Part-3 of the new 303(d) list. Additional monitoring would be required to determine the impairing substance(s).

Scenario #8: The basis of this decision is the absence of effect in the bioassays. Although the biological community show adverse effects, the lack of toxicity in the tests are indicative that the adverse effect is not due to chemical contaminants, or that they are not bioavailable. If chemical contaminants were truly affecting the designated use, the impacts of those contaminants should have been observed in the bioassay.

These bioassays control for confounding factors such as low D.O., or habitat impacts. This scenario, however, is be captured by other Listing Methodologies.

The scientific community has indicated that in order to obtain a reliable and consistent assessment, data from all three components (i.e., toxicity, chemistry, and biological community) are required (Chapman, 1992, Ingersoll et al., 1997, Long et al., 1998, Long et al., 2000; and Anderson et al., 2001). However, if data are not available for all three components, the Department will use its discretion but will consider an impairment determination if;

a) The magnitude of any single indicator is overwhelmingly suggesting an impairment determination,
b) A Toxicity test shows toxicity and is confirmed either by chemistry data or a degraded biological community, its designated use is not likely supported and an impairment determination will likely be concluded.
c) All other cases are considered to present insufficient evidence of impairment and will be prioritized for additional monitoring as resources become available.

Under the Triad approach, MDE would evaluate appropriate lethal and sublethal sediment bioassays. A finding of toxicity may trigger a sediment chemistry analysis, if one has not already been performed. Sediment chemistry data would be used to support an impairment determination. The chemical analysis should be performed on samples originating from the same composited homogenate used for the bioassays, so that paired data can be obtained (Chapman, 1992). The chemistry data can be compared to sediment thresholds to help determine which chemicals may be causing toxicity. If no sediment thresholds are exceeded, sediment Toxicity Identification Evaluation (TIE) should be performed to determine a chemical cause, if possible.

Chemistry data themselves are useful in determining sediment contamination trends, and may also help identify areas that may have the potential for adverse impacts. MDE uses sediment chemistry data, as an effective prioritization tool to help determine which sediments should be targeted for additional monitoring. That is, other factors being equal, sediments with chemical concentrations exceeding sediment thresholds would have higher priority for additional monitoring compared with sediments that meet the sediment thresholds. Chemical concentrations exceeding these thresholds could also indicate the need to monitor and assess water column concentrations for those chemicals. Sediment chemistry alone should not, however, be used to make an impairment determination.

11.5.7 FISH TISSUE

Section 101(a)(2) of the CWA establishes as a national goal "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable." These are commonly referred to as the "fishable/swimmable" goals of the Act. Section 303(c)(2)(A) requires water quality standards to protect the public health and welfare, enhance the quality of water, and serve the purposes of the Act (EPA 2000). EPA, along with the Department, has interpreted these regulations to mean that not only should waters of the State support thriving and diverse fish and shellfish populations, but when caught, may also be safely consumed. Some waterbodies may have elevated levels of contaminants, especially in the sediment. Some of these contaminants (especially mercury and PCBs) tend to bioaccumulate to elevated levels in the tissues of gamefish and "bottom-feeders" (largemouth bass and catfish, respectively). When tissue levels of a contaminant are sufficiently elevated to increase the risk of chronic health effects if the fish is consumed regularly, the State has the responsibility to issue a fish consumption advisory to protect public health. Fish consumption advisories are designed to protect the general population as well as sensitive populations (i.e. young children; women who are or may become pregnant). If a consumption advisory is issued for a waterbody, it's designated use <u>may</u> not be supported and that waterbody <u>may</u> be listed as impaired for the contaminant(s) responsible for the fish consumption advisory.

The Department of the Environment has defined "fishable" as the ability to eat AT LEAST 4 meals/month (general population level) for common recreational fish species from a given waterbody. The tissue level corresponding to this will be the upper threshold at the 4 meal/month level for a given contaminant. In addition to this, if the tissue concentration is within 5% of the threshold, the waterbody's designated use will be considered impaired. The 5% "safety factor" accounts for the uncertainty and spatial/temporal variability in monitoring data and sampling regimes. This safety factor is designed to protect and maintain the "fishable" designated use status of a waterbody. When tissue levels in fish are observed within this range, enhanced monitoring will be recommended to ensure the fishable use of the waterbody is not impaired. To determine if a waterbody is impaired, the appropriate measure of central tendency (i.e. geometric mean) for a contaminant from the fillet samples of common recreational fish species will be compared to the established threshold.   If the threshold is exceeded, the waterbody's designated use is not met, and the waterbody is considered impaired.

11.5.7.1 <u>Data Requirements</u>

The data required to list a waterbody as impaired are similar to the data requirements for the development of a fish consumption advisory.   The same decision rules are used to test data adequacy, and spatial and temporal representation.   Consumption advisories based on the minimum required samples that resulted in an impairment decision <u>will</u> be re-sampled prior to TMDL development to insure that the advisory was not due to a localized condition, and that the impairment is still temporally relevant. The data requirements for listing a waterbody are:

a. *The advisory is based on fish and shellfish tissue data. All available data will be used.*
b. *The data are collected from the specific waterbody in question.*
c. A minimum of 5 fish from a given species (individual or composite analysis) for a given waterbody.
d. Species used to determine impairment should be representative of the waterbody; migratory and transient species may be used if they are the dominant recreational species, but should only be used in conjunction with resident species, especially in the case of tidal rivers of the Chesapeake Bay.
e. *Contaminant thresholds used will reflect concentrations used to set consumption recommendations for the general population.   The general population is defined as women beyond the years of childbirth (~45); and adult males.*

11.5.7.2 Contaminant Thresholds

The acceptable contaminant thresholds are based on a risk assessment calculation that incorporates numerous risk parameters such as contaminant concentration, Reference dose/cancer slope factor, exposure duration, lifetime, and for some contaminants, cooking loss. The concentration thresholds for the contaminants of concern are currently:

Mercury: 300 ppb	4 meals/month	General Population
PCBs : 39 ppb	4 meals/month	General Population

Over time, advances in science may require changes in risk assessment parameters that may increase or decrease the contaminant thresholds, and also the levels at which impairment decisions are made for a waterbody's designated uses. When this happens, waterbodies that may have been impaired may no longer be impaired, as well as new impairments for waterbodies that were previously not impaired.

In some instances, it may be inappropriate to consider certain fish and shellfish consumption advisories in making an impairment determination. For example, a State may have issued a statewide or regional warning, based on data from a subset of waterbodies and species or a higher consumption value may have been used in determining the need for an advisory to protect a specific sensitive population compared to the value used in establishing water quality criteria for the protection of human health. In such instances, these types of advisories were not considered for making an impairment determination. This approach is consistent with EPA's current recommendations regarding impairment determinations using contaminant data from fish advisories.

11.5.8 REFERENCES

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Table 7: Table of Sediment Screening Values

Contaminant	*Sediment Screening Values (ppb)*		
	EPA ESGs	**NOAA ERMs**	**MDE SQBs**
α-BHC			4,357
Acenaphthylene		640	
Acenaphthene	2,300	500	
Anthracene		1,100	
Arsenic		70,000	
β-BHC			9,406
Benz(a)anthracene		1,600	
Benzo(a)pyrene		1,600	
Cadmium		9,600	
Chlordane		6	51
Chlorpyrifos			4,214
Chromium		370,000	
Chrysene		2,800	
Copper		270,000	
DDT Sum		46	
Dibenz(a,h)anthracene		260	
Dieldrin	200	8	3,616
Endrin	7.6		7,368
Fluoranthene	3,000	5,100	
Fluorene		540	
Heptachlor			1,433
Heptachlor epoxide			1,433
Hexachlorobenzene			6,114,892
Lead		218,000	
Mercury		710	
Methyl naphthalene, 2-		670	
Naphthalene		2,100	
Nickel		51,600	
p,p-DDD (TDE)		20	
p,p-DDE		27	
p,p-DDT		7	
PAHs (High MW)		9,600	
PAHs (Low MW)		3,160	
PAHs (Total)		44,792	
PCB (Polychlorinated Biphenyl)		180	
Phenanthrene	2,400	1,500	

Pyrene		2,600	
Silver		3,700	
Zinc		410,000	

11.6 Listing Methodology for Solids

In 2002, the Department made a distinction in the sediment listings between “suspended sediment” and “sedimentation”. “Suspended sediment’ was considered a water column or turbidity impairment while sedimentation was supposed to identify the sediment deposition process that can impair benthic communities and habitat. Since the 2002 List, there has been confusion about the basis for this distinction and what methodology was used for making this determination. Because consistent data requirements and methodologies were not used to make a distinction among sediment impacts, MDE has opted to not make any distinction in sediment impairments but rather leave them listed as sediments. All sediment listings have thus been revised.

In the existing Water Quality Inventory [303(d) List], there are numerous impairments for "sediments." Many of these were assessed and projected based on land use and the likelihood of such impairments. Unfortunately, the term "sediments" does not accurately inform the public as to the nature of the impairment, nor provide helpful guidance to those who need to develop TMDLs to remediate the problem.

In this current list, impairments previously listed for sediments, and new impairments evaluated for this report will be determined and listed as described below.

11.6.1 FREE-FLOWING STREAMS

11.6.1.1 Water Clarity

Impairing substance: Total Suspended Solids (TSS)
Measure: Turbidity as measured in Nephelometer Turbidity Units (NTUs)
Criterion: Turbidity criteria are addressed in COMAR §26.08.02.03-3(A)(5):

11.6.1.1.1 Turbidity

(a) Turbidity may not exceed levels detrimental to aquatic life.
(b) Turbidity in the surface water resulting from any discharge may not exceed 150 units at any time for 50 units as a monthly average. Units shall be measured in NTUs.

11.6.1.2 Erosional and Depositional Impacts (limited to wadeable streams)

Impairing substance: Soils or sediment

Measure: Biocriteria. The application of biocriteria for assessment decisions for the Integrated 303(d) List is addressed elsewhere in this document.
Criterion: Addressed under the narrative criteria:

26.08.02.02(B) Specific designated uses.

(1) Use I: Water Contact Recreation, and Protection of Aquatic Life. This use designation includes waters which are suitable for:
  (c) The growth and propagation of **fish** (other than trout), **other aquatic life**, and wildlife

(4) Use III: Natural Trout Waters. This use designation includes waters which have the potential or are:
  (a) Suitable for the growth and propagation of **trout**; and
  (b) Capable of supporting self-sustaining **trout** populations and **their associated food organisms**.

(5) Use IV: Recreational Trout Waters.
  (a) Capable of holding or supporting adult trout for put-and-take fishing; and
  (b) Managed as a special fishery by periodic stocking and seasonal catching.

Waters must be protected for these designated uses (26.08.02.02(A)). Key phrases supporting the use of biocriteria to protect against impacts from eroded or deposited sediments are highlighted.

- If MBSS data indicates impairment, the habitat data related to sediments will be assessed.
- If there is no indication of a sediment problem (e.g., embeddedness does not indicate a problem), follow-up monitoring will occur to determine the stressor affecting the biological community.
- If there does appear to be a sediment problem, it will be listed for soils or sediment.

11.6.2 IMPOUNDMENTS

Maryland has no natural lakes. This decision rule covers reservoirs and other manmade lakes. Estuaries, such as Chesapeake Bay will be covered under new regulations currently being developed and which specifically address water clarity and sediment.

11.6.2.1 Water Clarity

Impairing substance: Total Suspended Solids (TSS)
Measure: Turbidity as measured in Nephelometer Turbidity Units (NTUs)
Criterion: Turbidity criterion are addressed in COMAR §26.08.02.03-3(A)(5):

11.6.2.1.1 Turbidity

(d) Turbidity may not exceed levels detrimental to aquatic life.
(e) Turbidity in the surface water resulting from any discharge may not exceed 150 units at any time for 50 units as a monthly average. Units shall be measured in Nephelometer Turbidity Units.

If turbidity exceeds the indicated levels, chlorophyll shall also be measured. If chlorophyll is high, the impairment will be attributed to excessive nutrient enrichment, rather than solids. Exceptions may be made and professional judgment applied in areas where soil and local geologic conditions would normally have high sediment runoff.

11.7 Listing Methodology – Sewage Releases

11.7.1 INTRODUCTION

Bacteria released during single or rare combined sewer overflows, sanitary sewer overflows or other releases will dissipate naturally after several hours, days, or weeks. However, repeated sewage releases of significant size may result in violations of the water quality standards, particularly if the volumes are large or frequent and the waterbodies are small, slow moving or poorly flushed. Under such spill conditions, violations are presumed to have occurred even in the absence of actual monitoring data. Notwithstanding such documented spill events, if the water quality is consistent with the bacterial water quality standards at that time, a Water Quality Analysis demonstrating the lack of such an impairment will be completed and the waterbody will become eligible for de-listing. However, if data indicates that water quality standards are not being met the waterbody will remain listed.

11.7.2 METHODOLOGY

Based on data in MDE's spill databases, if any waterbody segment has received two spills greater than 30,000 gallons over any 12-month period or after system improvements have been made, that waterbody will be considered as impaired. This listing methodology will be applied only in the absence of bacterial monitoring data; if such monitoring data are available, the decision methodology for bacteria will apply. Further, the part of the list on which the waterbody is listed may be determined by the existence of consent orders, enforcement agreements, work in progress, or other factors that may negate the need for a TMDL.

12.0 APPENDIX B – Maryland Water Monitoring Council's Local Monitoring Programs Summary

MARYLAND WATER MONITORING STRATEGY--Update

In the year 2000, the Maryland Departments of the Environment and Natural Resources prepared the Maryland Water Monitoring Strategy as the State's plan to monitor its water resources. These are the two principal state agencies that conduct water monitoring, focusing on regulatory and ambient water resource issues. The document addressed the importance of clearly identified goals when designing a monitoring program and using a sample design which includes the number of stations and frequency of sampling necessary to provide data to accurately describe conditions and trends at the scale desired to achieve monitoring goals.

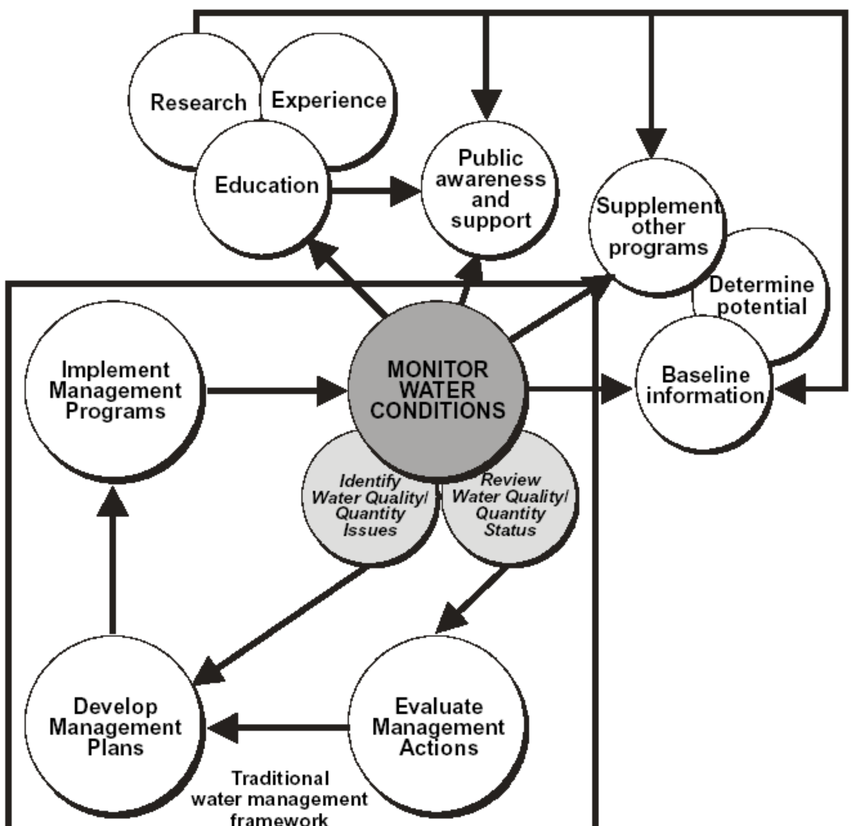

Figure 2. Role of water monitoring within a universe of uses/needs,

Figure 14: Role of Water Monitoring Within A Universe of Uses/Needs.

The State's plan recognized that academic institutions, local and federal government agencies, community groups, and the private sector were also conducting water monitoring throughout the state. These additional monitoring activities had been established to meet a broader range of goals and objectives, including research, environmental outreach, and in support of other programs. The plan recognized the need to integrate across these programs as part of a statewide water monitoring strategy. Figure 14 is taken from that plan, an attempt to show the relationship between water monitoring, the diversity of uses, and the complexity of feedback among programs.

Toward that end, the Maryland Water Monitoring Council initiated two major work program efforts to facilitate coordination across monitoring groups and encourage integration of results across group program boundaries.

One was the establishment of an annual Monitoring Roundtable, at which groups that plan to do monitoring in the next year can meet and exchange specific information about goals, locations, and parameters. The station location information has been converted to map format and posted on the MWMC web site for reference. This information can be used to minimize duplication of stations, which could lead to more areas being monitored and also provide greater sharing of results for areas of common interest.

The second major coordination and integration effort began with the dissemination of a survey to collect information on water monitoring throughout the state. The first round of responses identified a number of locally based programs. These were typically focused on smaller watersheds than those used for the State's monitoring programs and often for very specific project evaluations. A number of federally-supported monitoring programs were also identified, providing important links across interjurisdictional waters such as the Potomac River and the mainstem Chesapeake Bay.

A second round of survey during 2002-2003 led to this document--a summary of the results. The major categories listed are those of the state's Maryland Water Monitoring Strategy (2000), listed on the next page. Three categories were added: urban best management practice monitoring, water quality, and water use.

One thing which stood out as these results were compiled was that identifying by categories did not exactly reflect the goals or purpose for which the monitoring was being conducted. For example, the Baltimore City Reservoir Tributary Monitoring is listed under the Non-Tidal Rivers and Streams category in this document. The goals for that monitoring though are also tied to Reservoir Water Quality--how are these tributary inputs affecting the receiving water body?

One survey response included monitoring across multiple water resource levels--groundwater, surface water, sediment characteristics. This was the USGS Water Quality Monitoring Program, with a goal to monitor water quality across the State. In the State strategy, this program would have been repeated under each of the media categories. That type of listing, does not, however, reflect the fact that this program was originally set up with the express intent to link water quality across resource boundaries and provide cause and effects between water chemistry conditions in one media and that in another--e.g. Surface water and groundwater.

MARYLAND'S WATER RESOURCES AND MONITORING PROGRAMS.

Non-tidal rivers and streams

- CORE/Trend program
- Maryland Biological Stream Survey
- Watershed monitoring for water quality impairment determination and TMDL development
- NPDES point source permit monitoring
- NPDES permit compliance monitoring
- NPDES pretreatment monitoring
- NPDES stormwater monitoring
- Stream gaging network
- Fish kill investigations
- Algal bloom response program
- Drinking water program
- Source water protection program
- Finished water protection program
- Tissue monitoring program

Estuarine rivers and embayments

- Chesapeake Bay monitoring program
- Coastal Bays monitoring program
- Harmful Algal Bloom monitoring program
- Pfiesteria investigations - water quality and fisheries/
- Lower Eastern Shore pollutant input monitoring program
- Shellfish monitoring program
- Tissue monitoring
- Fish kill investigations
- Dredge activity monitoring program

Lakes and reservoirs

- Drinking water source water protection program
- Fish kill investigations
- Tissue monitoring program

Ocean

- Shellfish monitoring program

Wetlands

Ground water

- Waste monitoring programs
- Federal "Superfund" programs
- State Superfund program
- Storage tank monitoring programs
- Source water protection program
- Maryland ground water quality network
- Solid waste facility ground water monitoring program

In Table 8, the two Maryland monitoring agencies have summarized the agency mission and water-resource related goals. To develop a comprehensive monitoring strategy, it would seem preferable to list goals first, rather than agency. For example, many of the local jurisdictions are conducting surface water monitoring to characterize storm water runoff. Integrating results from these programs is best done not by mission statements but rather by why the monitoring is being done.

An example of this alternative approach is shown in Table 9. A next step for the Maryland Water Monitoring Council is to expand this framework for water-resource related goals across programs and refine the presentation such that integration across programs is more easily facilitated.

Table 8: Selected Agency Mission Statements and Water-related goals

Table 1. Selected Maryland agency mission statements and water-related goals

Agency	Mission Statement	Water-related Goals
MDE - Department of the Environment	Protect and restore the quality of Maryland's air, land, and water resources, while fostering economic development, healthy and safe communities, and quality environmental education for the benefit of the environment, public health, and future generations.	• Ensure safe drinking water • Reduce the threat to public health from the presence of hazardous waste and hazardous materials in the environment • Ensure that water is clean and safe for harvesting of fish and shellfish • Improve and protect Maryland's water quality • Ensure adequate protection and restoration of Maryland's wetland resources • Prevent pollution and increase compliance assistance
DNR - Department of Natural Resources	For today and tomorrow the Department of Natural Resources inspires people to enjoy and live in harmony with their environment, and to protect what makes Maryland unique -- our treasured Chesapeake Bay, our diverse landscapes and our living and natural resources.	• A vital and life-sustaining Chesapeake and Coastal Bays and their tributaries. • Sustainable population of living resources and healthy ecosystems. • Enjoyment of diverse outdoor recreation opportunities for Maryland citizens and visitors. Vibrant local communities in balance with natural systems.

Table 9: MWMC's Proposed Goal-Oriented Approach to Describing Maryland's Water Monitoring Programs.

WATER -RESOURCE MONITORING RELATED GOAL	AGENCY	PROGRAM
Ensure quality and quantity of drinking water	U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District	U.S. Geological Survey Ground-Water Level Monitoring
	Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section	RESERVOIR IN-LAKE PROGRAM
		RESERVOIR TRIBUTARY PROGRAM
Reduce the threat to public health from hazardous waste and hazardous materials	MDE Technical and Regulatory Services Administration	Tissue monitoring program
		Shellfish monitoring program
Maintain aquatic ecosystem integrity	DNR Monitoring and Non-tidal Assessment	Maryland Biological Stream Survey
	MDE Technical and Regulatory Services Administration	Dredge activity monitoring program
	U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District	U.S. Geological Survey Ground-Water Level Monitoring

GROUNDWATER

<u>AGENCY GROUP</u>: U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District

Program Name: U.S. Geological Survey Ground-Water Level Monitoring

Contact: Earl Greene, Ground Water Specialist

8987 Yellow Brick Road
Baltimore, MD 21237

410-238-4204 (phone)

410-238-4210 (fax)

eagreene@usgs.gov

Goal/Purpose: Measure and publish ground-water levels for Maryland

Scale: State of Maryland

Watersheds/Aquifer: All 8-digit HUCS/all aquifers that are used for water supply

County: All Maryland counties

State watersheds: 02040205, 02050306, 0206 (all), 02070002-3-4-8-9-10-1, 05020006.

Approach/Description: Continuous and periodic ground water level monitoring

Media: Ground water, aquifers, artesian wells, confined wells, water table wells

Data uses: State monitoring efforts, other federal agencies, water resources managers, hydrologic study chiefs, consultants, educators, researchers, students, and the general public.

Future: Continuous monitoring.

Publications: Ground water data: http://md.water.usgs.gov/publications/md-de-01-2/

Updated: Published annually and available online: http://md.waterdata.usgs.gov/nwis/gw.

Issues/Needs: Collect statewide ground-water data

LAKES AND RESERVOIRS

AGENCY/GROUP: Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section

Program Name: RESERVOIR *IN-LAKE PROGRAM*

Contact: William Stack, 410-396-0732

Watersheds/Aquifer:

Loch Raven 02130907, Liberty 02130805 and Prettyboy Reservoirs - 02130806

Goal/Purpose: 1) Monitor in-lake water quality to determine water quality problems and monitor trends related to restoration and /or perturbations (e.g., development, drought) in the watershed. 2) Better understand the environmental conditions that result in algal blooms and taste, odor problems and disinfection byproducts. 3) Determine the relationship between in-lake stations and raw water at the treatment plants.

Scale (3) 8 digit watersheds

Approach/Description: Water chemistry and chlorophyll a

There are 11 in-lake reservoir monitoring stations distributed among the City's three reservoirs. At each of these stations, a vertical series of samples and field measurements are taken at discrete depths in the water column. Most stations, including the primary sampling stations located near the raw water withdrawal intakes, are sampled in all seasons. The primary stations are sampled more frequently than the other stations.

Media: water chemistry data available in ACCESS

Data uses: Comparisons and trends across reservoirs, verify relationships between nutrients and other parameters

Publications: Reservoir Watershed Management Progress Reports (1996, 2001)

Issues/Needs: Need to expand program to disinfection byproduct precursors. Need to be able to relate reservoir water quality to watershed loadings

NON-TIDAL RIVERS AND STREAMS

AGENCY/GROUP: Anne Arundel County, Office of Environmental and Cultural Resources

Program Name: ***TOWN CENTER SURFACE WATER QUALITY MONITORING PROGRAM***

Contact: Chris Victoria 410.222.7441, cvictoria@mail.aacounty.org

Goal/Purpose: To characterize water quality of drainage of the Town Center areas in Anne Arundel County.

Scale: Small watershed

Watersheds/Aquifer:
Severn River (02-13-10-02): Picture Spring Branch Weems Creek
South River (02-13-10-03): Broad Creek

Approach/Description: Water chemistry, biological monitoring, physical assessment. A total of 4 stations are monitored as described below:

At two stations (Picture Spring Branch and Weems Creek), water samples are collected during stormflow (12/year) automated water quality monitoring equipment and during baseflow (1 per month) using grab samples. The following parameters are monitored: BOD5, PO4, TSS, Alkalinity, Turbidity, ammonia, COD, NO3-NO2, Total P, TKN, TN, TOC, Ca, Cu, Fe, Mg, Hardness, Zn. All stations have continuous flow and rainfall data collection, logged at 5 to 15 minute intervals. Temperature and pH are measured at Picture Spring Branch.

Biological monitoring has been done occasionally within this watershed. In addition, a stability assessment of channel conditions has been performed in Picture Spring Branch.

At two stations (Picture Spring Branch 2 and Broad Creek), only baseflow water quality samples are collected. Water quality parameters above are also monitored at these stations.

Media: Flow, rainfall, and water chemistry data avail in Microsoft Excel, biological data available in ERDAS, geomorphology data available in Excel.

Data uses: Trend analysis of water quality in Town Center Areas. Loading and EMC calculations, water quality and quantity model calibration.

Publications: Various summary reports available. QAPP done in 1997 scheduled for revision and updating in 2003.

Issues/Needs: Sites unique enough such that results not readily applicable in all county watersheds. Limited stormflow data.

AGENCY/GROUP: Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section

Program Name: ***BIOLOGIAL MONITORING PROGRAM***

Contact: William Stack, 410-396-0732

Goal/Purpose: 1) To monitor trends in macrobenthological and fish communities in Baltimore City streams associated with restoration and /or environmental perturbation. 2) Measure health of living resources for targeting restoration.

Scale: entire city

Watersheds/Aquifer: 02130905 - 02130901 - 02130904

Approach/Description: The approach is a probability-based stratified random sampling design using Maryland Biological Stream Survey (MBSS) guidelines. The sampling method is a multi-habitat twenty-sweep dip net approach that the State uses in coastal plain and non-coastal plain regions. This is the beginning of a three-year rotation, focusing on the Jones Falls watershed during the first year.

Media:

Data uses: Assessment of health, targeting for restoration, monitoring trends

Publications: The City of Baltimore NPDES Stormwater Permit Program Annual Report

Issues/Needs:

Program Name: ***RESERVOIR TRIBUTARY PROGRAM***

Contact: William Stack, 410-396-0732

Goal/Purpose: 1) Monitor trends in nutrient and sediment loadings and relate these to activities in the watershed (drought, development, restoration) 2) Relate tributary loadings to receiving water data 3) Identify pollutant sources

Scale: Small watersheds

Watersheds/Aquifer:

Loch Raven 02130907, Liberty 02130805 and Prettyboy Reservoirs - 02130806

Approach/Description: Water chemistry, flow data

There are fifteen tributary sampling stations. Six of these are sampled during both storm and dry weather flows; and the rest are sampled on a fixed monthly schedule.

Media: data available in ACCESS

Data uses: characterize external loads to the reservoirs, load comparisons for wet and dry weather

Publications: 1996 and 2001 Reports

Issues/Needs: Storm sampling has lapsed because of manpower. Need to expand to be able to relate watershed loadings to reservoir quality. Need to include measurements of TOC and DOC to address THM sources. Need to expand storm sampling in Prettyboy watershed.

Program Name: NPDES *STORMWATER PROGRAM*

Contact: William Stack, 410-396-0732

Goal/Purpose: 1) Characterize stormwater discharges from an outfall draining a specific land use and an associated in-stream station 2) Monitor trends in loadings and relate these to changes in the watershed (e.g., development, restoration)

Scale: Medium residential watershed

Watersheds/Aquifer: Moores Run (Hamilton Ave, Radecke Ave.) 02130901

Approach/Description: water chemistry, flow

A minimum of 12 storm events are monitored per year at both stations and baseline samples are collected monthly. Automated samplers are used to collect discrete samples and samples are select to represent the ascending, peak and descending limbs of the storm.

Media: Flow data in EXCEL; chemical data in ACCESS

Data uses: characterize runoff and impacts to receiving streams; estimate pollutant loads; calculate EMC's.

Publications: City of Baltimore NPDES Stormwater Permit Program Annual Report
Updated: annually since 1995

Issues/Needs: Better method for separating storm and baseflow samples. Need to reconcile error introduced by using automated samplers.

Program Name: ***NPDES DRY WEATHER PROGRAM***

Contact: William Stack

Goal/Purpose: Conduct chemical screening downstream of all major storm sewer outfalls during dry weather in order to detect and eliminate significant illicit discharges to the streams 2) Measure changes in ambient water quality associated with changes in the watershed (e.g., restoration)

Scale: 4 large watersheds

Watersheds/Aquifer: 02130905 - 02130903 - 02130901 - 02130904

Approach/Description: water chemistry, flow measurements

Collect monthly stream samples at 37 sites distributed amongst the 4 major watersheds in Baltimore City.

Media*:* chemical data available in ACCESS

Data uses: characterize dry weather flow;

Publications: The City of Baltimore NPDES Stormwater Permit Program Annual Report

Updated: annually

Issues/Needs: field-screening tools

AGENCY/GROUP: Charles County Department of Planning and Growth Management

Program Name: ***Mattawoman Creek Water Quality Monitoring. Charles County MD Partnership with USGS (USGS Project ID# 9B211)***

Contact: Karen Wiggen, 301-645-0683

Goal/Purpose: Develop a long-term trend characterization of water quality in Mattawoman Creek non-tidal watershed, which is the location of the Charles County Development District

Scale: 57.7 sq. mile watershed

Watersheds/Aquifer: Mattawoman Creek 02 - 14 - 01 - 08

Approach/Description: Water Flow and Chemistry at USGS station ID# 01658000, data record Oct 2000-present.
Water flow and chemistry at automated station, including base-flow and high-flow grab samples. Storm event discrete samples are taken to characterize rising, peak, and falling limb of hydrograph and used to generate storm event mean concentrations. Parameters analyzed: Suspended sediment (one third of samples will also be analyzed for sand-fine fractions), Soluble phosphorus, TKN, total phosphorus, Soluble kjeldahl nitrogen, Orthophosphate, Nitrite, Nitrate plus Nitrite, and Ammonium. On 15 minute intervals dissolved oxygen, water temperature, specific conductance, turbidity and pH will be measured.

Once adequate samples have been collected, the measured nutrient concentration values will be related to concurrent values of continuously measured parameters to estimate nitrate, total nitrogen, total phosphorus, and suspended-sediment concentrations in the stream water at 15-minute intervals.

Media: Water column.

Data uses: Characterize trends in pollutant load of stormwater runoff over long term from expected growth of County's Development District. Data available on USGS website. Users may include USGS, county planners or others.

Future: Continue station, and modify as needed.

Publications: USGS website posts data at http://md.waterdata.usgs.gov. *Project summary available on USGS website at http://md.usgs.gov/watershed/9B211/index.html.*

Issues/Needs: Long term trend record of water quality in receiving stream of County Development District.

Program Name: ***NPDES MS4 Integrated Monitoring 1999 - 2007 Permit***

Contact: Karen Wiggen, 301-645-0683

Goal/Purpose: Characterize stormwater runoff to Charles County streams

Scale: Small watershed outfall (DA~ 64 ac.) from discrete land use (high density residential) paired with downstream ambient station

Watersheds/Aquifer: Zekiah Swamp, Jordan Swamp

State Watershed: 02 - 14 - 01 - 08

Approach/Description: Water Chemistry, biology, and physical habitat monitoring including stream cross sections.

Water chemistry at outfall and downstream ambient stations includes monthly grab samples during dry weather to contrast with monthly automated storm event sampling. Storm event discrete samples are taken to characterize rising, peak, and falling limb of hydrograph and used to generate storm event mean concentrations for high density residential land use. Parameters measured: COD, BOD_5, TSS, Fecal Coliform, Oil and Grease, Total Petroleum Hydrocarbons (TPH), TKN, Nitrate plus Nitrite, TP, CD, PB, CU, ZN and pH. Also monitor NOx, DO, water temperature, conductivity, TDS, and turbidity.

Media: Water column, benthic macro invertebrates, habitat assessment, and cross sections.

Data uses: Characterize stormwater runoff and impacts to receiving streams from high density residential land use, estimate pollutant loads

Future: Assessing pollutant loads and runoff impacts

Publications: Flow, rainfall, and water chemistry data available in ACCESS; biology and habitat data available in summary tables. Summaries and final report with NPDES Stormwater Permit annual report

Issues/Needs: Comparisons/compilation across jurisdictions for representative estimates of pollutant loads by land use types and impacts on receiving stream resources.

<u>AGENCY/GROUP</u>: Montgomery Co. Department of Environmental Protection/Watershed Management Division

Program Name: ***NPDES MS4 Integrated Monitoring 2001-2006 Permit***

Contact: Meosotis C. Curtis 240-777-7711

Goal/Purpose: Characterize stormwater runoff to County streams

Scale: Small watershed, with paired outfall from discrete land use (high density urban) and downstream ambient station.

Watersheds/Aquifer: Name(s): Anacostia, Paint Branch

State watershed: 02 - 14 - 02 - 05
Approach/Description: Water chemistry, biology, and physical habitat monitoring.

Water chemistry at outfall and downstream ambient stations includes monthly grab sample during dry weather to contrast with monthly automated storm event sampling. Storm event discretes are taken to characterize rising, peak, and falling limb of hydrograph and used to generate storm event mean concentrations. Pre- and post-retrofit monitoring for industrial land use. Parameters required: BOD5, TSS, Fecal Coliform, Oil and Grease, TKN, NO23, TP, CD, CU, PB, ZN, and pH. Also monitor DO, water temperature, conductivity, chloride, hardness.

Biology and physical habitat monitoring above and below where tributary receiving outfall discharges enters stream. Pre- and Post- retrofit monitoring of benthic macroinvertebrates, rapid habitat assessment, and quantitative cross-section measurements to assess effects on stream resources.

Media: flow, rainfall, and water chemistry data available in ACCESS, dBase; biology and habitat data available in summary tables; web page to be developed

Data uses: Characterize stormwater runoff and impacts to receiving streams from urban land use and from mixed use watershed; pre-to-post retrofit changes in stormwater runoff; estimate pollutant loads

Future: Tracking bmp effectiveness; assessing pollutant loads and runoff impacts

Publications: QAPP (2/02); summaries and final report with NPDES Stormwater Permit annual report; Stream Monitoring Protocols (revised 2/1997).

Issues/Needs: Comparisons/compilation across jurisdictions for more representative estimates of pollutant loads by land use types, impacts on receiving stream resources, and retrofit effectiveness.

AGENCY/GROUP: U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District

Program Name: U.S. Geological Survey Streamflow Monitoring

Contact: Gary T. Fisher, Surface Water Specialist

8987 Yellow Brick Road
Baltimore, MD 21237

410-238-4259 (phone)

410-238-4210 (fax)

gtfisther@usgs.gov

Goal/Purpose: Measure and publish streamflow data for Maryland

Scale: State of Maryland

Watersheds: Back River, Bush River, Chesapeake Bay, Choptank River, Elk River, Gunpowder River, Monongahela River, Patuxent River, Patapsco, Manokin River, Pocomoke River, Potomac River, Severn River, St. Martin River, Susquehanna River, Wye River.

County: All Maryland counties

State watersheds: 02040205, 02050306, 0206 (all), 02070002-3-4-8-9-10-1, 05020006.

Approach/Description: Streamflow is measured using real-time and continuous recorders following USGS guidelines. Check measurements are made regularly, often monthly.

Media: surface water, streams, lakes, ponds, reservoirs.

Data uses: State monitoring efforts, other federal agencies, water resources managers, hydrologic study chiefs, consultants, educators, researchers, students, and the general public.

Future: Continuous streamflow monitoring

Publications: see District publications: http://md.water.usgs.gov/publications/online.html

Updated: Continuous or ongoing

Issues/Needs: Collect statewide surface-water data

STREAM RESTORATION

<u>**AGENCY/GROUP**</u>: Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section

Program Name: ***STREAM RESTORATION***

Contact: William Stack

Goal/Purpose: Maximize the water quality in a small watershed using efforts that are definable with measurable effects.

Scale: 3 Small sub-watersheds, 10.9 sq. mi.

Watersheds/Aquifer:

Approach/Description: Watershed Restoration plans have been developed for 3 sub-watersheds (Moores Run, Stony Run and Maidens Choice.

Media: ________________________________

Data uses: ____

Future: ____

Publications: ____

Issues/Needs:

AGENCY/GROUP: Montgomery Co. Department of Environmental Protection/Watershed Management Division

Contact: Keith Van Ness 240-777-7707

Program Name: ***Stream Restoration Project Monitoring***

Goal/Purpose: Evaluate the effectiveness of stream restoration projects in achieving instream habitat and biological community improvement

Scale: Varies

Watersheds/Aquifer: Name(s): Potomac, Anacostia, and Patuxent

State watershed: 02-14-02 (Middle Potomac, not Anacostia or Rock Creek); 02 -14 -02-05 (Anacostia); 02-14-02-06 (Rock Creek); and 02-13-11-07 (Rocky Gorge)

Approach/Description: Channel stability, habitat, and biology (benthics and fish) monitoring.

Monitoring will follow the 1997 DEP Stream Monitoring Protocols (or most recent update as available) which includes benthic macroinvertebrate and fish community sampling, physical habitat assessments, and quantitative stream system measurements (e.g. fixed cross-sections and longitudinal profiles). Contract monitoring will occur for at least three years after construction is completed. In addition, the DEP staff will maintain extensive photo documentation and video capture records before and after restoration throughout the project reaches and periodically re-visit and re-evaluate these sites after contract monitoring is completed.

Media: Biology and habitat in computerized database; biology and habitat data available in summary tables project locations, drainage areas, and practices in GIS (ArcView/Arc Map); web page to be developed

Data uses: Tracking changes in stream reaches with implemented projects

Future: Tracking effectiveness of implemented projects and making recommendations for better designs

Issues/Needs: Comparisons/compilation on parameters to monitor and analyzing data for changes and trends.

URBAN BEST MANAGEMENT PRACTICES

<u>**AGENCY/GROUP**</u>: Baltimore City Department of Public Works, Environmental Services Division, Water Quality Management Section

Program Name: ***STREET SWEEPING PROGRAM***

Contact: William Stack, 410-396-0732

Goal/Purpose: Test the effectiveness of street sweeping as a BMP for pollution removal
Scale: Large watershed

Watersheds/Aquifer: Hamilton subwatershed -02130901

Approach/Description: Chemical Analysis

Pilot watershed upstream of the NPDES Stormwater stations was selected for bi-monthly sampling. A representative solid and liquid sample is collected and analyzed for a select group of parameters.

Media: chemical data available in ACCESS

Data uses: estimate pollutant removal

Publications: 2002 City of Baltimore NPDES Stormwater Permit Program Annual Report
Issues/Needs: Separating trash from solids is a problem and estimating the volume of liquid waste.

Program Name: NPDES MS4 Design Manual Monitoring 2001-2006 Permit

Contact: Keith Van Ness 240-777-7726

Goal/Purpose: Evaluate the effectiveness of a stormwater management system constructed in accordance with the 2000 Maryland Stormwater Design Manual for stream channel protection effectiveness.

Scale: Small watershed of about 1 square mile

Watersheds/Aquifer: Name(s): Seneca Creek, Little Seneca

State watershed: 02 - 14 - 02 - 08

Approach/Description: Channel stability, habitat, and biology monitoring.

Permanently monumented cross-sections and detailed geomorphic analyses following the USFWS 2000 protocols. Biology and habitat monitoring using DEP revised protocols. Groundwater wells and stream flow monitoring following Special Protection Area BMP monitoring Manual.

Media: flow, rainfall, biology, and habitat in computerized database; biology and habitat data available in summary tables; web page to be developed

Data uses: Tracking changes in flow and physical conditions associated with intense development

Future: Tracking bmp effectiveness for channel protection and other stream channel morphological changes

Publications:

Issues/Needs: Comparisons/compilation on how to select test and reference watersheds and analyzing geomorphic data for changes and trends.

WATER QUALITY

AGENCY/GROUP: U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District

Program Name: U.S. Geological Survey Water-Quality Monitoring

Contact: Cherie V. Miller, Water Quality Specialist

8987 Yellow Brick Road
Baltimore, MD 21237

410-238-4254 (phone)

410-238-4210 (fax)

cvmiller@usgs.gov

Goal/Purpose: Monitor water quality across Maryland

Scale: State of Maryland

Watersheds/Aquifer: Name(s): Potomac River, Chesapeake Bay, Susquehanna River, … ,

County: All Maryland counties

State watersheds: 02040205, 02050306, 0206 (all), 02070002-3-4-8-9-10-1, 05020006.

Approach/Description: Water chemistry

Media: Surface water, ground water, bed sediments in streams, biology & habitat

Data uses: National USGS water quality programs, research, State monitoring efforts, other federal agencies, water resources managers, hydrologic study chiefs, consultants, educators, students, and the general public.

Future: Continuous monitoring of water chemistry, sediment, biology, habitats

Publications: see District publications: http://md.water.usgs.gov/publications/online.html

Updated: Continuous or ongoing

Issues/Needs: Collect statewide water quality data

WATER USE

AGENCY/GROUP: U.S. Geological Survey, Water Resources Discipline, Maryland-Delaware-D.C. District

Program Name: USGS Maryland-Delaware-DC District Water Use PROGRAM

Contact: Judith C. Wheeler, Water Use Specialist

8987 Yellow Brick Road
Baltimore, MD 21237

410-260-8816 (phone)

410-974-2833 (fax)

jwheeler@usgs.gov

Goal/Purpose: Collect, analyze, store, and disseminate water-use information for local, State, and national needs.

Scale: Statewide

Watersheds/Aquifer: All 8-digit HUCS/all aquifers that are used for water supply

County: All Maryland counties

State watersheds: 02040205, 02050306, 0206 (all), 02070002-3-4-8-9-10-1, 05020006.

Approach/Description: Maryland water-use information is collected from various sources, but primarily from the Maryland Department of the Environment (MDE). In Maryland, all water uses, except for homes with individual wells; water used for extinguishing a fire; some temporary dewatering; and agricultural water use less than 10, 000 gallons per day are required to have a water appropriation permit. Water users that withdraw 10,000 gallons or more per day are required to report withdrawals to MDE. Ancillary data used to determine water use are obtained from sources such as the Maryland Office of Planning, Maryland Department of Agriculture, County water and sewerage plans, University of Maryland Cooperative Extension Service, Maryland State Mining Program, U.S. Environmental Protection Agency, U.S. Department of Energy, U.S. Department of Commerce, and the U.S. Bureau of Census. In addition, various estimating techniques and coefficients are used to calculate water use when reported data are not available.
Data are collected, analyzed, and stored annually. Monthly and annual ground-water and surface- water withdrawal data from 1980 to 2001 are currently stored in the USGS Site-Specific Database System (SWUDS) for water users that withdrawal 10,000 or more per day. Other data such as aquifer codes and stream names, latitude/longitude for well fields and surface-water intakes, water use codes, county and hydrologic unit codes, and owner names and addresses are also stored in SWUDS. Since 1985, aggregated annual data for Maryland have been compiled and stored in the USGS Aggregated Water-Use Database (AWUDS). Data are summarized by county and by 8-digit hydrologic unit code for public supply, domestic, commercial, industrial, thermoelectric power, mining, livestock watering, aquaculture, and irrigation uses. The database was originally designed for

States to store data necessary for the USGS Circular Estimated Use of Water in the United States that has been published every 5 years since 1950. The USGS Maryland water-use program updates the database annually to provide a useful level of data for water-use information requests.

Media: ground water, surface water, water use

Data uses: Water Resources planning and management, hydrologic studies, evaluating ground-water level networks, land planning and management.

Data users: Water Resources managers, hydrologic study chiefs, State cooperators, other federal agencies, consultants, educators, students, and the general public.

Future: Analyze trends in water use for various categories of use using additional parameters such as precipitation, water rates, and socio-economic factors to assess changes or patterns of use.

- **Publications:** Withdrawal data available in Excel, ACCESS, GIS, and ASCII formats. Summary tables of table for 1990, 1995, and 2000 are available on these web pages:
- http://water.usgs.gov/watuse/
- http://md-internal/database/swuds/index.html#MD2000data
- USGS Open File Report 87-540 *Ground-water use in the Coastal Plain of Maryland, 1900-1980*
- USGS WRIR 93-4220 *Water withdrawal and use in Maryland, 1990-1991*
- USGS Fact Sheet FS-115-98 *Freshwater use in Maryland, 1995*
- http://md.water.usgs.gov/publications/fs-98-115/
- USGS Fact Sheet FS-xxx-xx *Freshwater use in Maryland, 2000* (in preparation)

Issues/Needs: More information is needed to determine the quantity of water withdrawn and aquifers sources for certain categories of water use, particularly self-supplied domestic and agricultural water use. Coefficients are currently used for estimating withdrawals for these uses. More information is needed to improve estimates of public-water-supply distribution to residences, commercial establishments, and industries.

Table 10: Table of Programs Surveyed by the Maryland Water Monitoring Council

AGENCY	MEDIA	GOAL/PURPOSE	PROGRAM NAME	ELEMENTS
Anacostia Watershed Society	Streams	daily fecal coliform testing.	**Anacostia and Potomac Rivers Water Quality Monitor**	watertemp, ph, dissolved_ox, conductivity, turbidity; otherbio
Baltimore County DEPRM	Streams	Monitor stream baseflows over 70 sites throughout the Deer Creek and Gunpowder Basins in 2004 In alternate years baseflow monitoring is done in the Patapsco/Back River Basin.	**Baseflow Monitoring Program**	Chemistry, metals, organics, inorganics, watertemp, ph, conductivity; Nutrients, Flow, GIS
Baltimore County DEPRM	Streams	Pre and post project monitoring normally for a 3 year period of stream restoration projects as required by Federal and State Permits.	**Capital Improvement Projects Monitoring Program**	Biology, Fish, Benthos, otherbio
Baltimore County DEPRM	Streams	MBSS protocols for benthic IBI at 100 sites in the Deer Creek & Gunpowder Basins during 2004. During alternate years, samplin throughout the Patapsco/Back River Basin.	**Probabalistic Macroinvertebrate Monitoring**	Biology, Benthos; physhab
Baltimore County DEPRM	Streams	Stream monitoring of storm flows at 17 USGS gaged sites in the Deer Creek/Gunpowder Basins during 2004; during alternate years sampling will be done in the Patapsco/Back River Basin.	**Stormflow Monitoring Program**	Chemistry, metals, organics, inorganics, watertemp, ph, conductivity; Nutrients,Flow, GIS, physhab
Baltimore County DEPRM	Streams	Chemical, biological and geomorphological monitoring on Windlass Run before and after proposed construction of the estension of MD Route 43 (East of Interstate 95) is to evaluate the effectiveness of application of the new Maryland Stormwater Management Design Manual.	**Windlass Run Project**	Chemistry,metals,organics,inorganics,watertemp,ph,;Biology,Fish,Benthos, otherbio; Nutrients,Flow,GIS,physhab
Community College of Baltimore County	Streams	Volunteer monitoring of SAV and certain water parameters (temp, Phosphate, nitrates, salinity, DO) in the Dundee area of the Gunpowder river since 1990.	**SubmergedAquaticVeg monitoring project**	Chemistry,watertemp,ph,dissolved_ox,turbidity;Biology,SAV;Nutrients
Frederick County DPW	Streams	Peter Pan Run, a tributary to Bush Creek, is monitored annual by Frederick County, using MBSS methods, for fish, benthos, habitat, and in situ water quality as part of the County's NPDES program.	**2004 Annual Stream Monitoring**	watertemp,ph,dissolved_ox, conductivity, turbidity; Biology, Fish, Benthos; Flow, GIS,physhab
Howard County DPW	Streams	A five year biological monitoring program that follows MBSS protocols within the Howard COunty watersheds.	**Biological Stream Survey**	Biology,Fish,Benthos;physhab
Howard County DPW	Streams	Restoration Project in the Cherry Creek community near the Rocky Gorge reservoir.	**Cherry Creek Watershed**	Biology,Benthos;Nutrients,Flow,GIS, physhab
Howard County DPW	Streams	Monthly storm sampling under NPDES requirements	**Font Hill NPDES Sampling**	Chemistry,metals,inorganics,watertemp, ph, otherchem; Nutrients, Flow, physhab
Howard County Parks and Recreation	Streams	Monthly macroinvertebrate samples are conducted from April - October at fixed locations using the rapid bioassessment method.	**Volunteer Stream Monitoring**	Biology,Benthos
ICPRB	Streams	Springtime electrofish monitoring of river herring runs in the Anacostia River and stocking of herring fry in Rock Creek and Anacostia tributaries.	**Anacostia & Rock Creek River Herring Monitoring an**	watertemp,ph,dissolved_ox, conductivity, turbidity; Fish
SHA	Streams	Sampling will be conducted to supplement existing data in a planning study for the Inter-County Connector.	**Inter-county Connector**	Chemistry,watertemp,ph,dissolved_ox,conductivity,turbidity;Biology,Benthos;
SHA	Streams	Monitor the biological effect of a stream restoration project on White Marsh Run.	**MD 43 Extended**	Chemistry,watertemp,ph,dissolved_ox,conductivity,turbidity;Biology,Benthos;Flow,physhab
SHA	Streams	Provide pre-, during and post-construction monitoring data for stream mitigation sites associated with the Woodrow Wilson Bridge Project.	**Woodrow Wilson Bridge Project**	Chemistry,watertemp,ph,dissolved_ox,conductivity,turbidity;Biology,Fish, Benthos; Flow,physhab
Smithsonian Environmental Research Center	Streams	Linking watershed land cover to ecological indicators in freshwater streams and subestuaries of Chesapeake Bay	**Atlantic Slope Consortium**	Chemistry,watertemp,ph,dissolved_ox,conductivity;Benthos; Nutrients, GIS, physhab
Susquehanna River Basin Commission	Streams	Quarterly (or annual) biological, physical habitat, and chemical water quality monitoring at stations along the Pa-Md state line to assess stream conditions.	**Interstate Streams Water Quality Monitoring Networ**	Chemistry, metals, watertemp, ph, dissolved_ox, conductivity, turbidity, otherchem; Biology,Benthos;Nutrients,Flow, physhab
Towson University	Streams	Investigation of blacknose dace (Rhinichthys atratulus) biology across an urban-rural gradient, including life history analyses, physiology and molecular biology.	**blacknose dace biology**	Biology,Fish;GIS,physhab
UMD-College Park	Streams	Conducting a number of research projects involving macroinvertebrates, including environmental impacts, bioassessment, and conservation.	**Aquatic Macroinvertebrates, Bioassessment, and Con**	Chemistry, ph, dissolved_ox, conductivity; Biology,Benthos
UMD-College Park	Streams	Collecting data on structural and functional characteristics of streams in urban, suburban, and rural Maryland to linking geomorphological, hydrological, and ecological data to watershed land use practices.	**Linking Economics, Hydrology, and Ecology to Evalu**	Chemistry,watertemp,dissolved_ox, conductivity; Biology,Benthos; Nutrients, Flow, GIS, physhab
US Forest Service	Streams		**Baltimore Ecosystem Study**	Chemistry,inorganics,watertemp;Biology, Benthos,otherbio;Nutrients,Flow,GIS,physhab
USGS	Streams	Automatic water sampling near mouths of NE and NW branch. Real-time water-quality parameters.	**Anacostia River monitoring**	Chemistry,metals,organics,inorganics,watertemp,ph,conductivity;Biology, otherbio;Nutrients,Flow
USGS	Streams	Twice monthly samples and up to 12 storms per year.	**Assateague nitrates**	Chemistry,inorganics;;Nutrients,Flow
USGS	Streams	Monthly and storm sampling near fall line of Potomac, Patuxent, Susquehanna, and Choptank Rivers. Compute loads and trends.	**Chesapeake Bay River Input Monitoring**	Chemistry,inorganics,otherchem; Nutrients,Flow