Water for Maryland's Future: What We Must Do Today

Final Report of the Advisory Committee on the Management and Protection of the State's Water Resources

M. Gordon Wolman
Chairman

VOLUME 2: APPENDICES

July 1, 2008

2

First Edition July 1, 2008

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This Report and the previous two reports of the Advisory Committee on the Management and Protection of the State's Water Resources are available at MDE's web site under the heading of "More Publications."

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APPENDIX A

Executive Order 01.01.2005.25 (2005)

EXECUTIVE ORDER 01.01.2005.25

Advisory Committee on the Management and Protection of the State's Water Resources

(Rescinds Executive Orders 01.01.2002.05 and 01.01.2003.08)

A. Established. An Advisory Committee on the Management and Protection of the State's Water Resources is established to advise the State in implementing programs and policies relating to the management, development, conservation and protection of the State's water resources.

B. Membership and Procedures.

(1) Membership. The Advisory Committee shall consist of up to 15 members, including:

(a) A member of the House of Delegates, appointed by the Speaker of the House;

(b) A member of the Senate of Maryland, appointed by the President of the Senate;

(c) The Secretary of the Department of the Environment or a designee;

(d) The Secretary of the Department of Health and Mental Hygiene or a designee;

(e) The Secretary of the Department of Agriculture or a designee;

(f) The Secretary of the Department of Natural Resources or a designee;

(g) The Secretary of the Department of Planning or a designee; and

(h) Up to 8 members appointed by the Governor to include representatives of local government, the environmental, agricultural, and business communities, and other individuals from the general public with relevant interest or expertise.

(2) Members appointed by the Governor shall serve at his pleasure.

(3) The Governor shall designate the chairperson of the Advisory Committee.

(4) A member may not receive compensation for serving on the Advisory Committee, but is entitled to reimbursement for expenses under the Standard State Travel Regulations as provided in the State budget.

C. Duties. The Committee shall perform the following duties:

(1) Review the latest information from State, local and federal agencies concerning assessments of the quality and quantity of the State's ground and surface water resources;

(2) Review local, State and federal laws, regulations and policies related to the management, development, conservation and protection of ground and surface water resources;

(3) Assess the adequacy of existing governmental resources, regulatory enforcement and monitoring programs that are available for the management, development, conservation and protection of the State's ground and surface water resources;

(4) Identify alternatives for additional sources of water supply, such as storage, reservoirs, water system interconnections, inter-basin water transfers, or other means that may be necessary to meet future water demand;

(5) Recommend additional actions, studies, policies, regulations or laws necessary to assure that the management and protection of the State's surface and ground water resources is conducted in a manner consistent with their long-term sustainable use and protection;

(6) Identify appropriate State, federal and local government and private funding mechanisms to ensure that the actions, studies, policies, regulations or laws recommended by the Committee may be appropriately implemented; and

(7) Develop and recommend a comprehensive strategy, including the above elements and any other elements the Committee believes are necessary to ensure the adequacy of the State's water resources to meet the current and projected demand for water through 2030.

D. Staffing. Staff support to the Advisory Committee shall be provided by the Maryland Department of the Environment.

E. Meetings. The Advisory Committee shall meet on a quarterly basis or more often if necessary.

F. Report. The Advisory Committee shall report its interim findings and recommendations to the Governor by July 1, 2006, and its final findings and recommendations by July 1, 2008.

Effective date: May 16, 2005 (32:12 Md. R. 1028)

APPENDIX B

Advisory Committee Position
on the Use of
Water from State Lands

Advisory Committee Position on the Use of Water from State Lands

At the January 2006 meeting of the Advisory Committee on the Management and Protection of the State's Water Resources, staff from the Department of Natural Resources (DNR) made a presentation on the disposition of water originating on land managed by that Department. DNR indicated that it had received inquiries about the transfer of water or water rights from State lands, and that with increased development pressures such requests would become more frequent. Lacking guidance in the form of a law, regulation or policy, DNR solicited the views of the Committee on how to evaluate these requests. DNR subsequently forwarded a draft policy statement to the Committee and, at the Committee's November 2007 meeting, requested its review.

An *ad hoc* subcommittee was formed to consider the matter. After reviewing the findings of the subcommittee and discussing the matter at several meetings, the Committee advised against the transfer of water or water rights from State lands. It forwarded its recommendation to DNR Secretary John R. Griffin in the attached letter.

APPENDIX B

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ADVISORY COMMITTEE ON THE MANAGEMENT AND PROTECTION OF THE STATE'S WATER RESOURCES

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Martin O'Malley
Governor

Anthony G. Brown
Lieutenant Governor

M. Gordon Wolman, Ph.D.
Chair

May 5, 2008

Mr. John R. Griffin, Secretary
Maryland Department of Natural Resources
Tawes State Office Building
580 Taylor Avenue
Annapolis, MD 21401

Dear Secretary Griffin:

At the request of your staff, the Advisory Committee on the Management and Protection of the State's Water Resources reviewed the draft Recommended Policy for the Disposition of Water Resources on Water Rights from Fee-Simple Ownership Held by the Department of Natural Resources, dated November, 2007. After several presentations by DNR staff and lengthy discussions at several meetings, the Advisory Committee then created a subcommittee to review the proposal in detail. Following still additional discussion at its April 15 meeting, the Advisory Committee approved the recommendations of the Subcommittee, which stated the following:

> It is the opinion of this Subcommittee that DNR should not be in the business of selling, leasing, or giving away water rights, either groundwater or surface water, associated with State lands. The Subcommittee strongly recommends that water originating on DNR properties or the associated water rights not be transferred or in any way diminished, except for cases of emergency that cannot be met by any alternative. The conditions of any transfer should be very clearly defined, and further, once the emergency situation is addressed and either the water from the DNR property is not needed or the need can be met by an alternative, the temporary allocation must cease. For the purposes of this recommendation, the term "emergency" shall mean an emergency condition as defined in COMAR 26.17.06.01B(10): "a situation when lack of water poses an immediate danger to the health and welfare of people or animals."

> The Subcommittee believes that emergency conditions should seldom, if ever, occur once local governments fully comply with the provisions of HB 1141 (2006), particularly the provisions relating to the Water Resources Element. Further the Subcommittee recommends that this policy acknowledge that water appropriation and allocation is subject to the State water appropriation law and regulations administered by MDE.

David Goshorn, your representative on the Advisory Committee, was provided additional back-up information that was considered in preparing the recommendation.

Although coincidental to the Advisory Committee's recommendation, the Committee noted the similarity of this issue with the proposal to use state-owned land for placement of wind turbines and, even more significant, Governor O'Malley's rejection of that use saying "we will not do so at the expense of the special land we hold in the public trust." The Committee believes the Governor's position is equally applicable to the disposition of water from DNR lands.

The Advisory Committee appreciated the opportunity afforded it to comment on DNR's draft policy.

Sincerely yours,

Gordon Wolman

Gordon Wolman
Chairman

cc: Secretary Shari Wilson
Deputy Secretary Bob Summers
Advisory Committee Members

APPENDIX C

Water Quality Report of the Advisory Committee

MANAGEMENT AND PROTECTION OF THE QUALITY OF MARYLAND'S DRINKING WATER SOURCES: CHALLENGES AND RECOMMENDATIONS

Advisory Committee on the Management and Protection of the State's Water Resources

Water Quality Subcommittee

April 16, 2008

Water Quality Subcommittee

- Alan Brench, Ph.D., Chief, Division of Food Control, Maryland Department of Health and Mental Hygiene
- James M. Gerhart, Director, MD-DE-DC Water Science Center, U.S. Geological Survey (Chair)
- David Goshorn, Ph.D., Acting Director, Office for a Sustainable Future, Maryland Department of Natural Resources
- Matthew G. Pajerowski, Chief, Regional Hydrologic Assessment Section, MD-DE-DC Water Science Center, U.S. Geological Survey
- Lyn Poorman, Chief, Water Policy and Security Division, Water Supply Program, Maryland Department of the Environment
- Joseph Tassone, Director, Environmental Planning, Maryland Department of Planning
- Frank L. Wise, Division of Environmental Health, Prince George's County Department of Health
- C. Victoria Woodward, Esq., Executive Director, Safe Waterways in Maryland

Other Contributors

- Gul Behsudi, Maryland Department of the Environment
- David Bolton, Maryland Geological Survey
- Emery Cleaves, Maryland Geological Survey
- Eric Dougherty, Maryland Department of the Environment
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- Norman Lazarus, Maryland Department of the Environment
- Barry O'Brien, Maryland Department of the Environment
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- Jay Prager, Maryland Department of the Environment
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EXECUTIVE SUMMARY

There are more than 5.6 million citizens currently living in Maryland, and another 1.1 million expected by 2030. Population growth and development over the past 50 years has already impacted water quality in agricultural and urban areas of Maryland. As Maryland continues to build new homes, new commercial development, and new roads to meet the needs of these additional citizens, water supplies will become more susceptible to impacts from this development. Runoff from impervious surfaces, chemical discharges, wastewater overflows, contamination of ground water, and other side-effects of growth could seriously impair the State's ability to meet water supply needs. Unless steps are taken to ensure that growth occurs sustainably and in a way that is protective of drinking water sources, Maryland citizens face the prospect of increased public health risks and increased costs for water treatment.

Since 2003, two separate Advisory Committees on the Management and Protection of the State's Water Resources have studied issues related to water supply in Maryland. Although the primary focus of the Committees has been water quantity, both Committees have recognized that water quality plays an important role in determining and managing water supply. Water supplies must remain of good quality to meet the needs of current and future citizens of the State. In order to appropriately address water quality issues, the 2005 Advisory Committee on the Management and Protection of the State's Water Resources formed a Water Quality Subcommittee to review and evaluate the impact of water quality on Maryland's water supplies, and determine if existing laws, regulations, and programs are adequate to ensure safe drinking water for current and future generations. This report was prepared to present the Subcommittee's work.

Challenges and Recommendations

The Water Quality Subcommittee comprehensively assessed the existing laws, regulations, policies, and programs related to the quality of Maryland's source waters. There are numerous water quality challenges in Maryland, however the Subcommittee focused on three specific challenges where existing laws, regulations, policies, or programs may not be adequate to ensure the long-term safety of Maryland's drinking water supplies. For these situations, Maryland must consider new approaches in order to ensure adequate water supplies to meet projected needs. Increased resources, modified programs, and new efforts are needed to address the concerns raised by this Subcommittee. To ensure sustainable supplies of drinking water for Maryland's citizens, it is important to begin addressing these concerns immediately.

Challenge: Protecting Sources of Drinking Water

Current efforts to protect water sources are inadequate to ensure their long-term safety. The Maryland Department of the Environment has completed source water assessments for all public drinking water systems in Maryland, and many of the larger systems have developed and implemented programs to protect their water supplies. For surface water systems, however, the watershed drainage area that needs to be protected is usually quite large and may span multiple jurisdictions. Smaller ground water systems may not have control of the land use affecting their water supply. As a result, many Marylanders obtain their water from supplies that are not fully protected. Local officials have many competing priorities, and the State must identify ways to make water supply protection a greater priority for local water resource managers and elected officials.

Two specific concerns related to surface water exacerbate this challenge. *Wastewater overflows* pose a serious threat to water supplies in Maryland. Although steps have been taken to upgrade wastewater infrastructure, the number and frequency of overflows is significant, and the pathogenic nature of the effluent poses a serious health threat. *Eutrophication*, which has long been a concern for the Chesapeake Bay, also poses a significant threat to sources of drinking water, particularly in the reservoirs that store water for many large water systems. Excess nutrients in water promote excessive plant growth and decay and may cause severe reductions in water quality. Organic and inorganic materials in the water can react with chlorine used to disinfect the water, and form disinfection byproducts, which have been found to cause a variety of health problems. As population increases, sediment and nutrient loading to water sources is also likely to increase, further exacerbating this water quality concern.

To improve protection of sources of drinking water in Maryland, the Subcommittee recommends the following:

- The Maryland Department of Environment (MDE), Maryland Department of Planning (MDP), and Maryland Department of Natural Resources (DNR) should provide technical support, guidance, and resources to assist local governments and water suppliers in their efforts to protect drinking water sources while promoting sustainable growth and development.

- The State should develop or strengthen laws and regulations to ensure that local governments are taking appropriate steps to reduce the impacts of development on drinking water sources.

- MDE should better integrate source water protection goals into other program priorities and activities.

- MDE and Maryland Department of Agriculture (MDA) should review and evaluate existing laws and regulations to identify changes that could reduce contaminant loadings that threaten sources of drinking water.

Challenge: Assisting Well Owners In Ensuring Safe Drinking Water

Citizens using private wells sample and maintain their own potable water supply systems and are not required to comply with the same regulations as public water systems. Sampling is typically required only at the time a well is constructed, and usually only for limited water quality constituents. As a result, citizens using private wells may be consuming water that does not meet current federal and State drinking water standards. In addition, fairly significant areas of Maryland, including parts of Washington, Allegany, Carroll, Frederick, and Baltimore Counties, obtain ground water from extremely vulnerable aquifers where fecal bacteria and other pathogens are commonly present. Public water systems in these areas must comply with stringent federal and State requirements for sampling and treatment; however, individual wells are not subject to the same sampling and treatment requirements as public water systems. Citizens using private wells in these areas may be routinely exposed to disease-causing organisms.

To better protect Maryland residents who obtain their drinking water from individual private wells, the Subcommittee recommends the following:

- MDE should revise regulations governing the monitoring of individual wells, including requiring testing for specific contaminants when the well is near a source of contamination, and requiring testing at property transfer or more frequently for leased properties.

- MDE should modify current policies for issuing appropriation permits to require water quality testing for new subdivisions.

- The General Assembly should provide increased resources for local health departments to support training, technical assistance, and public outreach efforts aimed at owners of individual domestic wells.

- MDE should require construction of public drinking water systems instead of individual wells for new developments where ground water testing indicates serious water quality concerns.

Challenge: Improving the Availability of Water Quality Data

Although water quality data are collected every day for a wide variety of purposes, water supply managers frequently do not have ready access to the data they need to make sound planning decisions. Better access to water quality data, and additional sampling to fill data gaps, would assist planners and regulators in limiting the impacts of agricultural and urban development, and would provide information to help private well owners and local governments make sound decisions regarding their water supplies. There are different data gaps related to each particular region of Maryland. For example, in coastal areas, additional sampling is needed to evaluate the occurrence and potential impact of salt water and brackish water intrusion, which may cause water quality to deteriorate and become nonpotable. Sampling is also needed to assess the occurrence and potential impact of emerging contaminants that are not currently regulated under existing federal and State regulations. The health effects of many of these contaminants are under study by the U.S. Environmental Protection Agency, but Maryland needs to acquire a better understanding of which contaminants occur in Maryland, where the contaminants occur, and at what concentration the contaminants are occurring.

To increase the available information about contaminants in Maryland’s drinking water sources, and to improve access to water quality data, the Subcommittee recommends the following:

- MDE and DNR should initiate a comprehensive water quality monitoring program to assess the condition of Maryland’s drinking water sources and to track the progress of other programs designed to protect and improve source water quality

- MDE and DNR should initiate studies designed to determine the occurrence and distribution of selected high priority contaminants in Maryland’s source waters and their relationship to human health problems

- MDE and DNR should coordinate the establishment of an electronic clearinghouse for water quality data

LIST OF ACRONYMS

CCL – Contaminant Candidate List

COP – Certificate of Potability

CSO – Combined Sewer Overflow

CWA – Clean Water Act

DBP – Disinfection Byproduct

EDC – Endocrine Disrupting Compound

EPA – Environmental Protection Agency

I&I – Inflow and Infiltration

LTCP – Long Term Control Plan

MDE – Maryland Department of the Environment.

MTBE – methyl *tert*-butyl ether

NPDES – National Pollution Discharge Elimination System

PFA – Priority Funding Area

SDWA – Safe Drinking Water Act

SSES – Sanitary Sewer Evaluation Study

SSO – Sanitary Sewer Overflow

SWTR – Surface Water Treatment Rule

TMDL – Total Maximum Daily Load

TOC – Total Organic Carbon

WRE – Water Resource Element

INTRODUCTION

"Water, water, everywhere, nor any drop to drink." Samuel Taylor Coleridge's famous line was written in another context, but it also applies in varying degrees to the source waters that provide Maryland's drinking water. As plentiful as water is in Maryland, it is often unfit to drink without some form of treatment. Although it is generally of good overall quality for use as drinking water, the water in Maryland's rivers, streams, reservoirs, and aquifers frequently contains contaminants, usually at low concentrations. Some of these contaminants have natural origins, but others are the result of human activities such as urbanization, industry, agriculture, businesses, and mining.

Maryland State government administers numerous programs to lessen the impacts of natural and manmade contaminants on the quality of Maryland's source waters, and to ensure that Maryland residents have water of suitable quality to drink. Recent legislation requires that the quality of source waters be factored into local governments' plans for water supply development. Understanding the current water quality challenges facing Maryland's source waters, and recognizing where new strategies are needed, are important components of water supply planning at both the State and local levels.

Until now there has not been a substantive review of water quality specifically related to drinking water supply. The Water Quality Subcommittee met from December 2006 through July 2007 and systematically reviewed data and programs related to water supply to identify the areas where water quality problems are impacting or have the potential to impact water supplies. The Subcommittee spent considerable time conducting in-depth reviews of existing laws, regulations, and programs to evaluate their effectiveness and to identify areas where current programs may be inadequate.

The purpose of this report is to spotlight the most important and problematic water quality challenges currently facing Maryland's drinking water sources, and to present recommendations for addressing those challenges. The report begins with a discussion of the factors that can affect water quality. Maryland has diverse geology, topography, and climate, and all of these factors have an impact on the types of contaminants present in the water sources. In addition to natural factors, the Subcommittee found that human activities have a significant impact on water quality. As population density increases, and more land is developed, water quality will degrade unless steps are taken to protect the water sources. As Maryland continues to grow, the potential impacts on water quality will intensify in every area of the State.

The Subcommittee then identified the most common contaminants in Maryland's source waters, and reviewed the occurrence and health risks of those contaminants. The report presents an overview of drinking water quality across the State, including both naturally-occurring contaminants and contamination caused by human activities.

The Subcommittee also reviewed existing programs, policies, and regulations aimed at protecting drinking water quality, and evaluated their efficacy in meeting the needs of water supply managers. The approaches currently used include monitoring and detection, treatment to remove contaminants, regulation and control of sources of contaminants, protection of water sources, licensing and certification of personnel, and non-regulatory guidance.

The report presents three significant challenges to Maryland's source water quality. Each challenge is described, and the approaches currently being used to address each challenge are discussed. Recommendations for more comprehensively addressing each challenge are then presented and discussed. Although there are other water quality issues related to the treatment or distribution of water, the Subcommittee did not review those issues. Instead, the Subcommittee focused on water quality challenges specifically related to drinking water sources.

Water quality is important to Maryland's environment as well. Although the Subcommittee did not attempt to assess the impacts of recommendations outside of their potential effects on drinking water sources, it is important to note that many of the Subcommittee's recommendations will have benefits that extend beyond their intended purpose. Many of the actions recommended to ensure the adequate quality of drinking water for Maryland's citizens also may have positive impacts on Maryland's natural environment, including the Chesapeake and Coastal Bays.

FACTORS AFFECTING WATER QUALITY

Water quality can be influenced by a number of different factors, including the source of water (surface water or ground water), the physical nature of the landscape, the underlying geology, and the number and types of human activities that occur at the land surface. Maryland's diverse landscape, complex geology, and rapidly growing population present a wide array of water quality problems and vulnerabilities across the State.

The Hydrologic Cycle

The hydrologic cycle drives many of the processes that affect water quality. Surface water is water that occurs in large bodies on the land surface. Ground water occurs below the land surface in aquifers, which are bodies of unconsolidated sediment or rock where ground water fills the voids. Ground water and surface water are closely interconnected through the hydrologic cycle, which is the continuous movement of water through the environment. When water evaporates, the moisture eventually condenses into clouds and falls back to the earth as rain or snow. Precipitation can fall directly on a surface water body, or can fall onto the land where it is taken up by plants, runs across the land surface as stormwater until it reaches a surface water body, or seeps into the ground where it recharges ground water in aquifers. Water in an aquifer eventually flows back to the land surface either from a spring, or by seeping into rivers, streams, or other surface water bodies.

Maryland Water Supplies

Maryland can be divided into two distinct hydrogeologic regions that are separated by a northeast-southwest trending line (Figure 1). This line, termed the "Fall Line" because of the numerous waterfalls that historically marked the limit of upstream navigation, is located approximately along Interstate 95. West of the Fall Line, surface water is the main water source for large water supply systems. The large population living in the metropolitan regions of Baltimore and Washington, D.C., obtains its water largely from the Baltimore City reservoir system and the Potomac and Patuxent Rivers. There are several other public water systems in the western part of the State that rely mainly on surface water, such as those supplying the cities of Hagerstown and Frederick.

Ground water from unconfined fractured rock aquifers and limestone and marble aquifers is widely used by mid-sized and small water supply systems, as well as private individual water users, in the Piedmont Plateau, Blue Ridge, Ridge and Valley, and Appalachian Plateau Physiographic Provinces of central and western Maryland. In the Coastal Plain Physiographic Province, located east of the Fall Line, potable ground water for both public supply and individual private users comes almost exclusively from aquifers in unconsolidated sediments. Most of these aquifers are confined aquifers, separated from the land surface and each other by clay confining units.

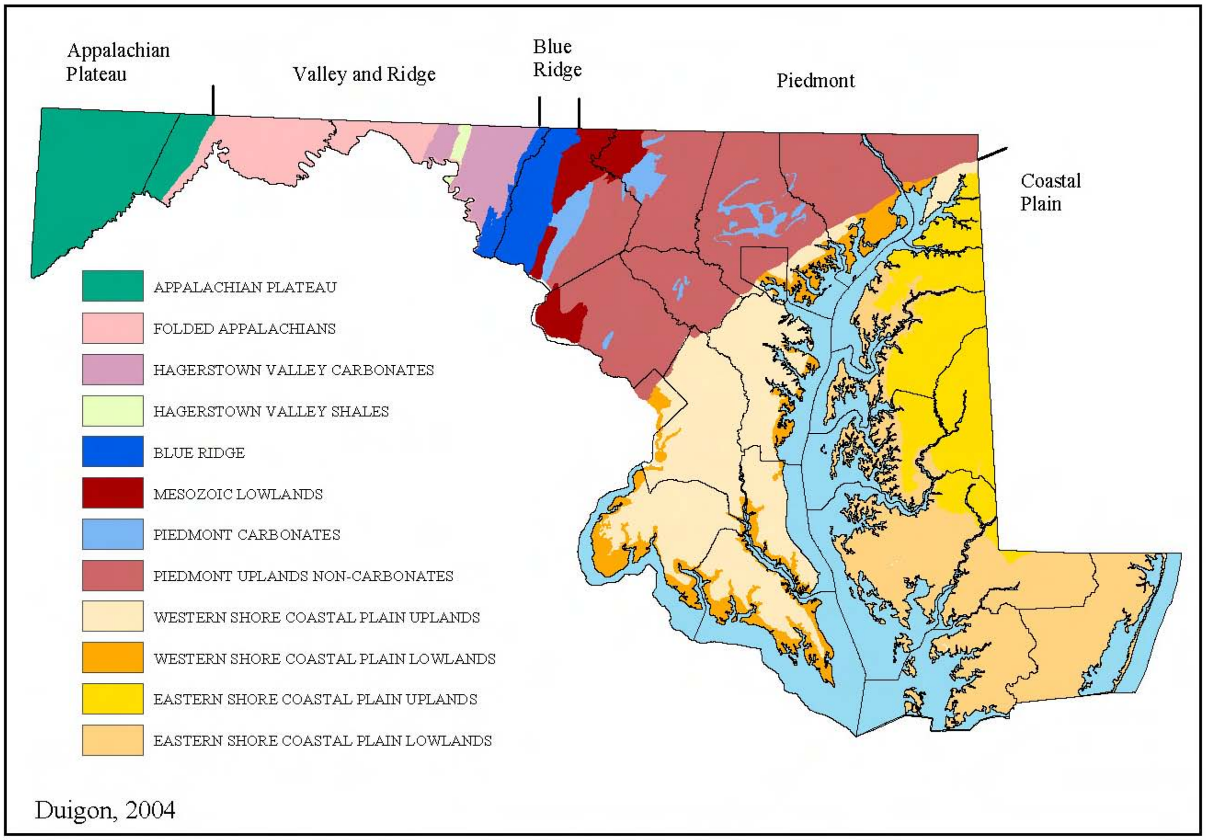


Figure 1. Generalized physiography and hydrogeology of Maryland.

Surface Water

Surface water includes rivers, streams, lakes, and reservoirs, as well as the bays that connect streams to the ocean. Rivers and streams have a noticeable downstream flow, while lakes and reservoirs move much more slowly and can have distinct differences in temperature and other qualities between the surface of the lake and the bottom of the lake. Rivers, streams, and reservoirs are diverse ecosystems, and the quality of water depends on the general topography, geology, and type and level of human activities nearby. The topography can impact the velocity of flow and thus the amount of turbidity, suspended sediment, and biological activity of the river or stream source. Geology can also affect water quality. For example, streams in limestone and marble areas are commonly alkaline, while those on coal-bearing rocks can be acidic. Lakes and reservoirs can become repositories for nutrients, sediments, and toxic substances that are transported in incoming rivers. Many of these contaminants are ultimately derived from the landscape comprising the watershed of the lake or reservoir. Human activities that occur in the watershed can therefore have important impacts on water quality.

Ground Water East of the Fall Line

Coastal Plain aquifers consist of unconsolidated sediments, in which water is stored in the space between the grains of sand, silt, and gravel. The Coastal Plain sediments used for both public and private water supply occur in a series of aquifers separated by clay confining units (Figure 2). The environments in which the sediments were deposited significantly affect the ground water quality in the aquifers. For example, the Aquia aquifer was deposited in a marine environment, and in many areas has abundant shell material that renders the ground water fairly hard and the pH somewhat neutral to alkaline. By contrast, much of the Patapsco aquifer was deposited by streams in a continental environment; it is composed of less reactive quartz and feldspar minerals, and Patapsco aquifer ground water often has low pH and low dissolved solids. Water quality also depends on the chemistry of the water that recharges the aquifer, minerals along the flow path of the water, the geochemical environment, and residence time. The amount of time that water remains in an aquifer affects its water quality characteristics, and can differ greatly. Ground water may move through an unconfined aquifer in a matter of weeks, months, or years, but may take hundreds or thousands of years to move through deeper, confined aquifers.

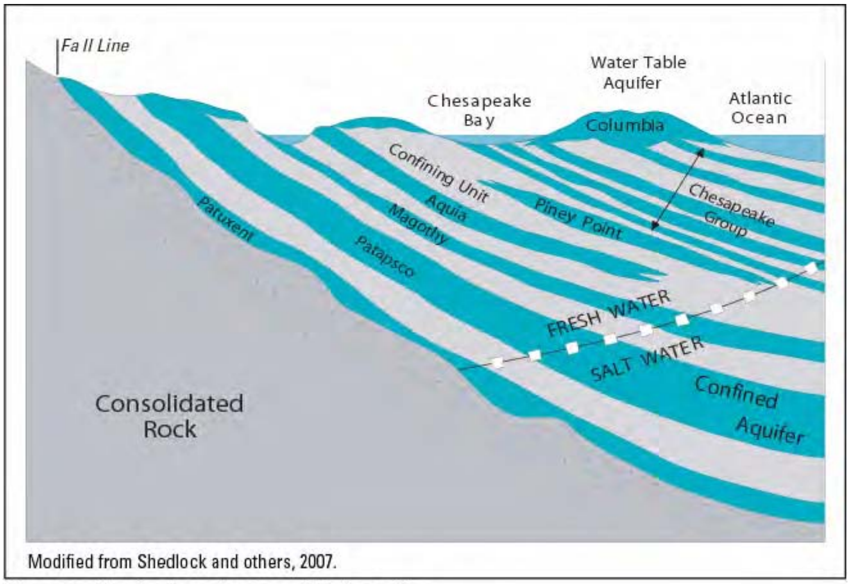


Figure 2. Maryland's major Coastal Plain aquifers.

Ground water for public and private water supply in the Coastal Plain region comes primarily from confined aquifers (Figure 2). Confined aquifers are protected from surface-derived contaminants by a confining unit (geologic material that restricts transmission of water and contaminants). Confined aquifers are therefore much less vulnerable to contamination from human activities than unconfined aquifers.

Unconfined aquifers are vulnerable to contamination from substances applied or accidentally released at the land surface, including petroleum products, nutrients, pesticides, road salt, and other chemicals. Two areas of the Coastal Plain region rely on unconfined aquifers for significant quantities of water. One area occurs in a belt roughly paralleling the Fall Line, where the otherwise confined Coastal Plain aquifers are exposed at the surface. The second area is the central part of the Delmarva Peninsula, where the highly productive unconfined Columbia aquifer is a major water source for agriculture. The Town of Salisbury and many older private wells also utilize this unconfined aquifer.

Ground Water West of the Fall Line

The ground-water flow regime west of the Fall Line is quite localized, tending to be controlled by local watersheds, compared to the subregional and regional flow systems in the Coastal Plain sediments. Instead of water moving around the unconsolidated grains of sand, silt, and gravel that comprise Coastal Plain aquifers, infiltrating water in this region moves down through the soil and decomposed rock (saprolite) and along joints, faults, and fractures in the underlying rock (Figure 3). Well yields depend upon the size of fractures as well as the interconnections between fractures. Because confining layers are rare, ground water quality can be highly susceptible to contamination from human activities at the land surface.

In the Piedmont Plateau and Ridge and Valley Provinces, there are fairly large areas underlain by limestone and marble aquifers, especially in the Hagerstown and Frederick Valleys. Limestone and marble aquifers dissolve easily to form sinkholes and other fairly large cavities that allow water to move very rapidly within the aquifer and from the land surface into the aquifer. Extensive pumping and drawdown of ground water can further contribute to the formation of sinkholes. Although both limestone and marble aquifers are generally more productive than other aquifers in this region, they are both extremely susceptible to contaminants entering the aquifer from the land surface.

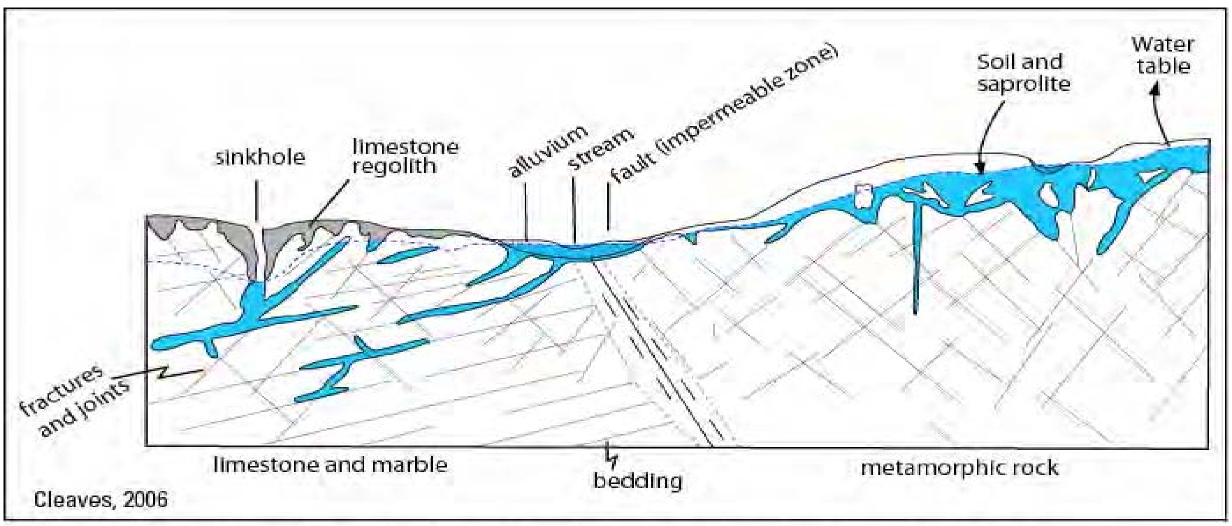


Figure 3 . Cross-section showing hydrogeologic framework in the Piedmont of Maryland.

Sources of Contaminants

Natural and manmade influences affect the quality of water. Every water source has its own unique set of water quality vulnerabilities. Figure 4 shows the relative sensitivity of shallow aquifers in Maryland to ground water contamination. Natural factors include climate, watershed characteristics, geology, water temperature, and the presence of naturally occurring contaminants such as metals and radioactive materials. These sometimes occur naturally at levels that exceed drinking water standards, as ground water dissolves contaminants from the aquifer material over periods of time. In general, naturally occurring contaminants cannot be prevented from occurring, so it is important to be aware of their potential health impacts and of their known distribution.

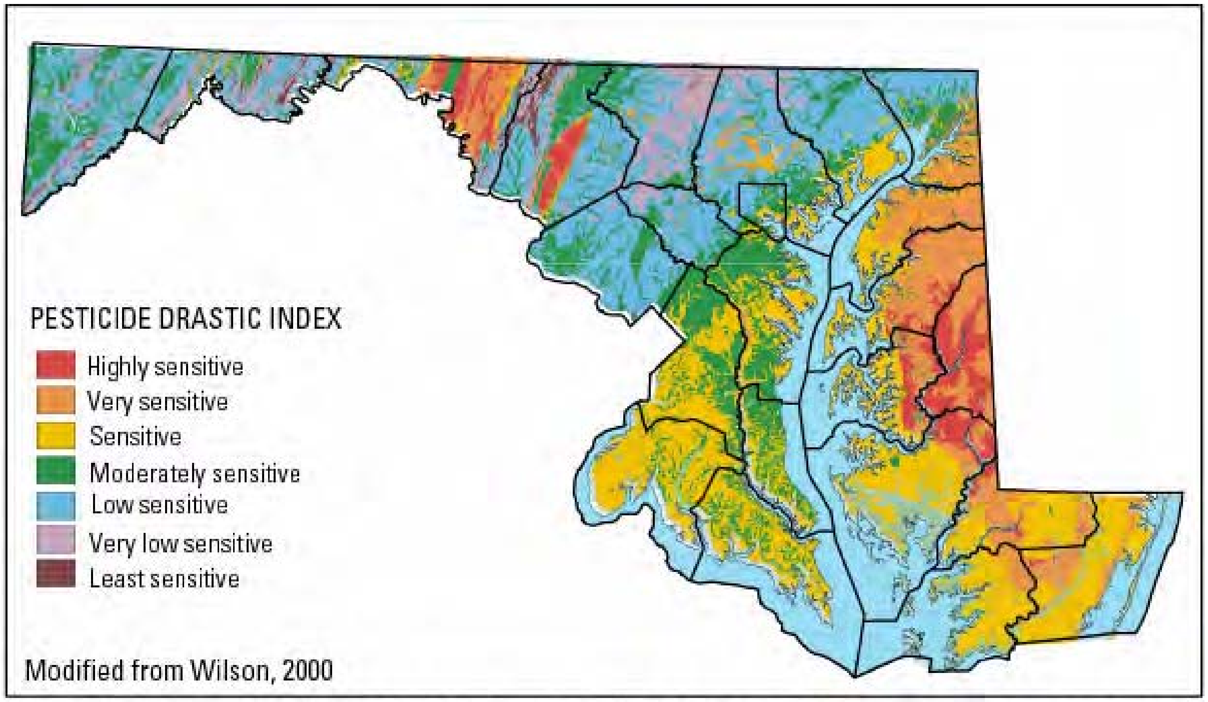


Figure 4. Appoximate sensitivity of shallow aquifers in Maryland to ground water contamination.

Human factors influencing water quality are usually categorized as either point sources or nonpoint sources. Point sources, such as wastewater treatment plant discharges, industrial discharges, and spills, are regulated through numerous federal and State programs, and substantial progress has been made toward controlling point sources over the past several decades. Although the impact of point source contamination is less serious than in the past, these activities can result in a number of contaminants entering the water supply.

Nonpoint sources include agriculture, developed land, erosion, septic systems, and atmospheric deposition. Nonpoint sources resulting from farming, lawn fertilization, runoff from developed land, and septic systems may increase nutrient loads to both surface water and ground water sources. Nonpoint sources are more difficult to identify and control than are point sources, but nonpoint sources must be addressed adequately to ensure safe drinking water supplies. For reservoir systems, nonpoint source nutrient loads can be particularly vexing. Excess nutrients cause algal blooms and other biological growth that is detrimental to the delicate ecology of the reservoir system, and can ultimately result in eutrophication, a condition in which the decay of algae and other organic matter depletes the water of oxygen. This condition can make the water more difficult and expensive to treat effectively, and can lead to the formation of potentially cancer-causing disinfection by-products.

Land Use, Population, and Growth

As Maryland's population continues to grow, the potential impacts on water quality will increase substantially. More development means more buildings, roads, wastewater treatment plants, septic systems, gas stations, highly fertilized landscapes, and a greater risk of accidental spills. All of these have the potential to contaminate surface waters and ground waters. Developed land also has more impervious surface and less naturally vegetated land cover, which means that more water runs off and less is adequately filtered through the soil before reaching the drinking water source. Water running across paved surfaces picks up contaminants along its path, transports them to surface waters, and is made unavailable to infiltrate the soil to recharge aquifers.

The implications of projected growth and associated land use changes for water quality can be examined in terms of where growth will occur, the amount of land that will be affected, and the potential for more and greater sources of contamination associated with human activities. Currently, higher population densities are concentrated in the Baltimore and Washington, D.C., metropolitan areas and the corridor between them. Figure 5 shows the distribution of population in 2000 against a background of agricultural, forested, and wetland land uses. The most recent projections indicate that the State's population will increase by roughly 20 percent or 1.1 million people, from 5.6 million people in 2005 to 6.7 million people in 2030[1]. Figure 6 indicates substantial increases in population extending from the central counties of Maryland throughout the southern Maryland counties and major portions of the rest of the State.

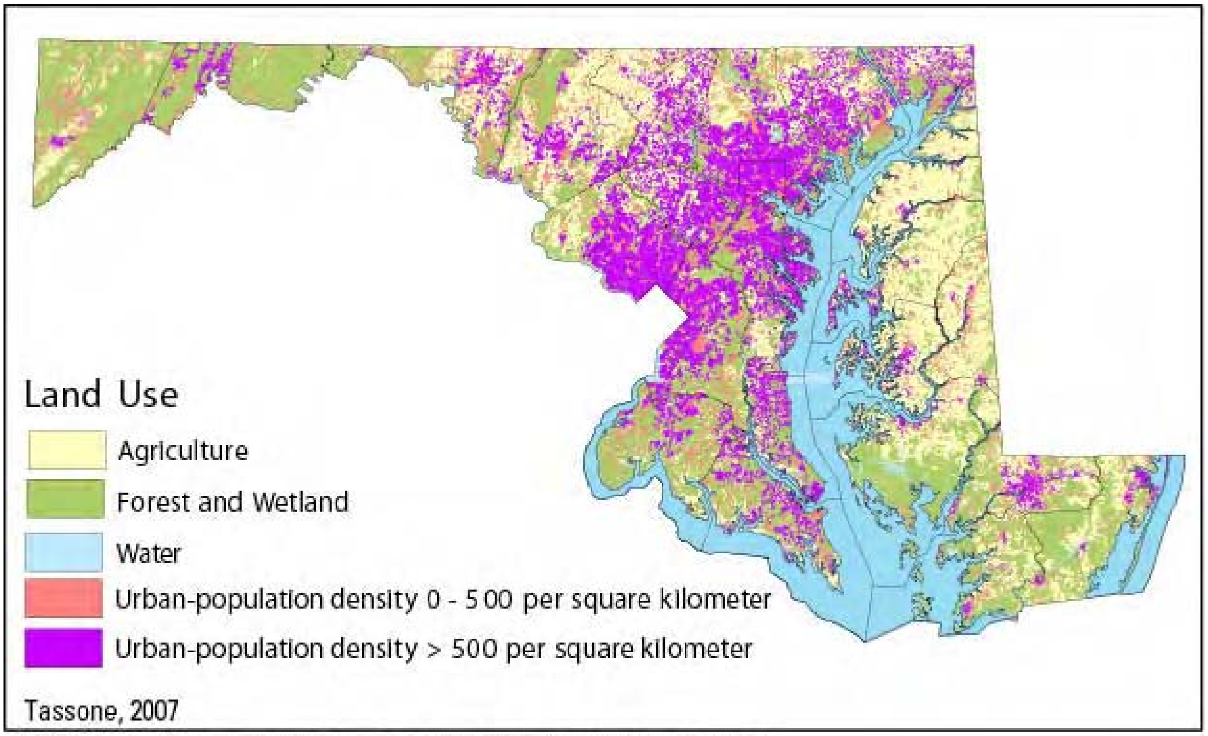


Figure 5. Population density and land use in Maryland, 2000.

Priority Funding Areas (PFAs) are areas designated by local governments as growth areas with planned public water and sewer services. Although only 27 percent of single-family residential parcels developed from 1990 through 2004 were outside PFAs, those parcels consumed more than 75 percent of the land used for single family residential development. During this period, the average lot outside PFAs consumed more than 8.5 times the land consumed on average inside PFAs[2]. This general pattern was similar between 1990 and 1997 and 1997 to 2003, and appears to be continuing. Figure 7 shows the status and vulnerability of rural resource land, that is, land outside PFAs, to additional subdivision and development. All of the land that is not dark green on Figure 7 is either substantially or highly vulnerable to development and therefore vulnerable to water contamination under existing zoning.

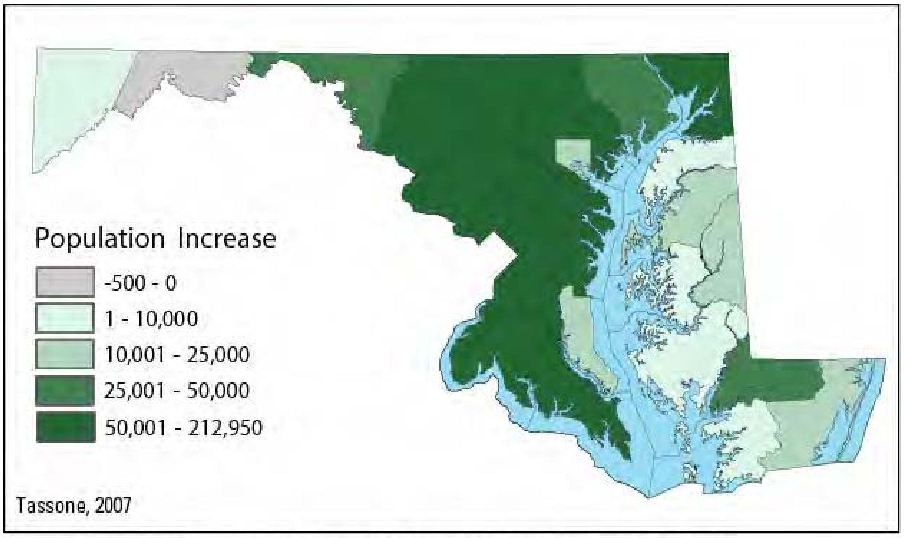


Figure 6. Projected population increase from 2005 to 2030 in Maryland.

These data indicate that:

- The potential impacts of population growth and development on the quality of water supply will increase in every part of the State and in almost every county.
- Despite the fact that the majority of residential development will occur in areas served by public water, large amounts of land in rural areas (areas outside PFAs) will be developed in all parts of the State and in almost every county.
- Population growth and increased urban land use will affect major surface water supplies in metropolitan regions, where much of the land in contributing watersheds is now rural. Outside of the metropolitan regions, increasing development will also affect ground water supplies, which now lay beneath largely rural (albeit rapidly developing) landscapes.

Thus, in both the metropolitan and rural areas, effectively managing water supply vulnerabilities associated with nonpoint sources of contamination will be critical to minimizing water quality impacts, assuming that existing control mechanisms and technology for point sources remain effective in controlling them as sources of contamination.

Economic Factors

Treatment technologies are available to remove or inactivate contaminants in water. However, the cost of such treatments can be prohibitive, and experience has shown that preventive measures are more effective. The economic impact of contaminated drinking water sources can be widespread. For example, if drinking water becomes contaminated, a community may need to obtain a temporary alternative water source, install complex treatment, provide highly trained operators, and meet new regulatory requirements. Illness can occur, with associated health care costs. In extreme cases, citizens may lose confidence in their drinking water, resulting in a decrease in property values and a subsequent loss of tax base for the community.

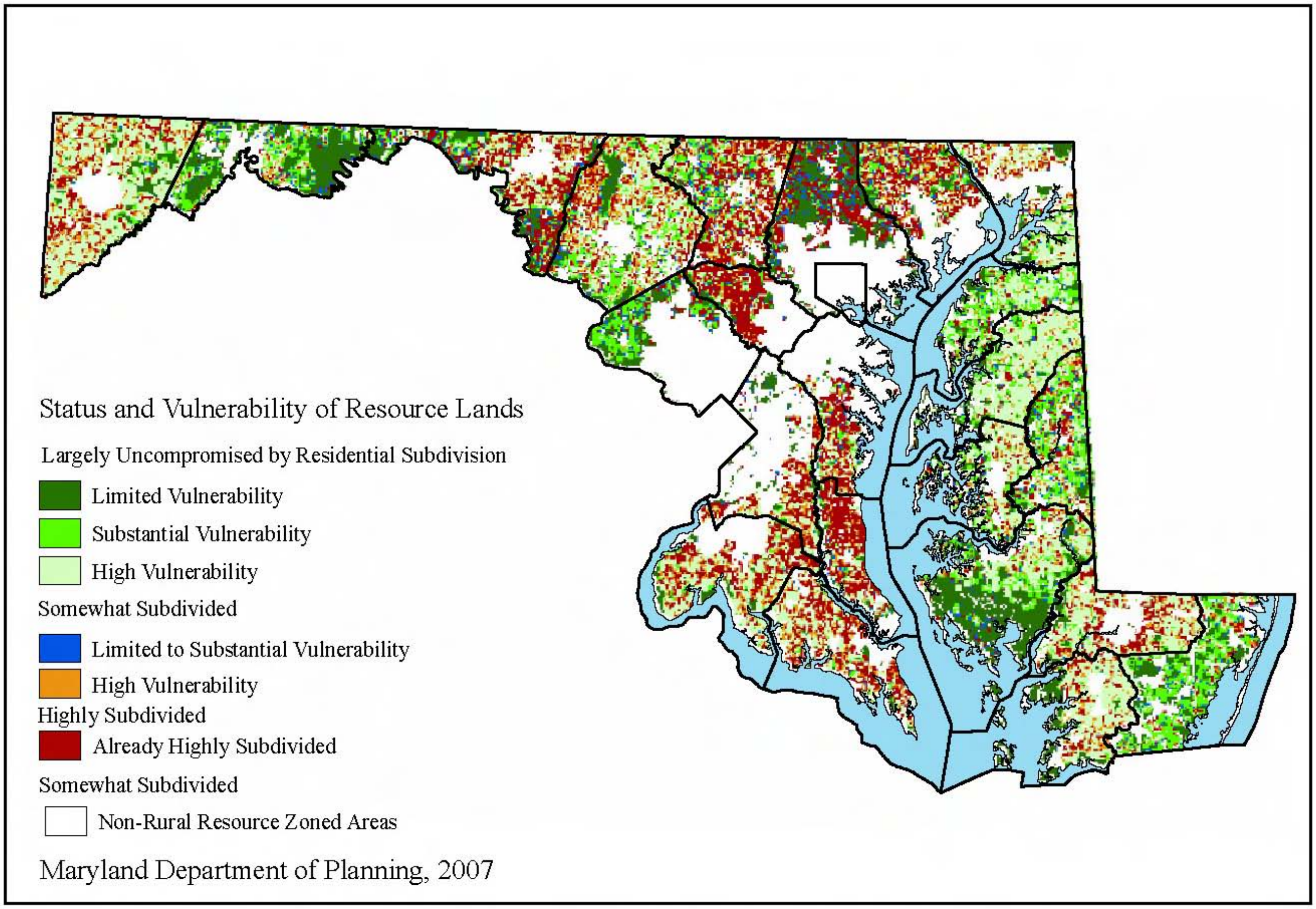


Figure 7. Status and Vulnerability of Rural Resource Land in Maryland.

OVERVIEW OF CONTAMINANTS IN MARYLAND'S SOURCE WATERS

Maryland's drinking water is obtained from surface water and ground water sources. Surface water sources include rivers, streams, and reservoirs; ground water sources include confined and unconfined aquifers. The quality of Maryland's source waters is determined by a combination of natural and human-influenced factors. Where those factors cause the source waters to contain contaminants, treatment is required to make the source waters potable. Most source waters in Maryland require some level of treatment before they can be used for drinking water.

The major contaminants found in Maryland's surface and ground waters are briefly described in the following paragraphs. This report focuses only on the implications for drinking water. These contaminants also can have serious adverse effects on ecological resources and on receiving waters such as the Chesapeake Bay.

Selected Contaminants in Surface Water

***Sediment* -** Composed of sand, silt, and clay, sediment enters rivers and streams by overland runoff and stream bank erosion, and is transported in river and stream channels mostly during storm events. Sediment clouds surface water and reduces the storage volume of reservoirs over time. It also serves as a transport mechanism for other compounds that adhere to the particles and cause water quality impairments, such as nutrients, organic compounds, metals, and pathogens. Sediment can be removed from surface water sources through filtration, sedimentation, and coagulation to produce drinking water.

Nitrogen - Inorganic nitrogen is highly soluble in water and is one of the most common contaminants in surface waters, originating from atmospheric deposition, fertilizers, and human and animal waste. In addition to causing algal blooms that can foul rivers, streams, and reservoirs, excess nitrogen in the form of nitrate also can have serious human health implications when ingested in high concentrations, especially when ingested by infants and pregnant women[3]. Nitrogen can be removed from source waters by ion exchange, reverse osmosis, and electrodialysis in the production of drinking water.

Phosphorus - Phosphorus, which is not as soluble as nitrogen, usually enters water by attaching to sediment particles. It originates from fertilizers and human and animal waste. It is transported in rivers and streams primarily during storm events and accumulates with sediment in reservoirs and streams. High concentrations of phosphorus do not have any serious human health effects, but can contribute to algal blooms and low dissolved oxygen in surface waters, which can necessitate additional treatment steps to minimize taste and odor problems. Phosphorus can be removed from surface water sources to produce drinking water through filtration, sedimentation, and coagulation.

Organic carbon - Organic carbon originates primarily as organic matter that falls or washes into water bodies and is transported to receiving bodies of water such as reservoirs. Another source of carbon is algal blooms that are enhanced by excess nitrogen and phosphorus. Organic carbon by itself is not a human health concern, but the treatment of source waters to make drinking water can cause the formation of chlorinated organic chemicals that may be a human health concern. Chlorine, used to disinfect drinking water, can react with organic carbon as well as inorganic compounds to form disinfection byproducts such as trihalomethanes and haloacetic acids, which are known to cause liver and kidney problems, as well as anemia and cancer[4]. Disinfection byproducts are strictly regulated in drinking water; the most effective means of controlling disinfection byproducts is by limiting the organic material in the source water. Organic carbon can be removed through treatment processes such as membrane filtration and charcoal filtration before chlorine is introduced in the treatment process.

Bacteria - Waterborne pathogens include fecal bacteria, measured by the indicators fecal coliform and *Escherichia coli* (*E. coli*), which originate from human and animal waste. Bacteria are common in Maryland's surface waters; sources include raw sewage, inadequately treated sewage, stormwater runoff, domestic animal waste, and wildlife waste from agricultural and forested areas. Bacteria in drinking water can cause diseases with symptoms including diarrhea, cramps, nausea, and headaches, especially in children, elderly people, and people with weakened immune systems[5]. Bacteria are strictly regulated in Maryland's drinking water and are removed from surface waters by disinfection with chlorine-based chemicals, ozonation, or ultraviolet light.

Protozoa - *Cryptosporidium* and *Giardia* are protozoa that originate from human and animal waste, and can be resistant to traditional water treatment processes. Rivers and streams that drain forested areas or that receive effluent from sewage treatment plants and animal feedlots are particularly at risk. *Cryptosporidium* can cause cryptosporidiosis, a typically moderate gastrointestinal disease, but one which can be fatal for individuals with compromised immune systems[6]. *Giardia* also causes gastrointestinal illness, usually marked by severe diarrhea, vomiting, and cramps[7]. Drinking water regulations require that surface waters be treated through disinfection and filtration to remove *Cryptosporidium* and *Giardia*, and that turbidity levels be carefully monitored.

Road Salt - The application of salt (sodium chloride) to roadways to prevent winter icing is a source of contamination to rivers and streams draining areas with high road density. Rivers and streams in the colder parts of Maryland are most susceptible to this kind of contamination. Chloride in high concentrations can impart a salty taste to water, but it is not a human health concern. Sodium in high concentrations presents a health concern for people on sodium-restricted diets. Drinking water treatment methods for sodium include reverse osmosis and distillation. These are expensive technologies, and are typically not used by public water systems. Instead, alternative sources are generally sought.

Acid mine drainage - In western Maryland, acid mine drainage originates from the exposure of coal and associated rocks to air and water during the mining process. Sulfide minerals associated with the coal react with air and water to form iron hydroxides and sulfuric acid that can contaminate surface waters with high levels of dissolved metals and low pH. Acid mine drainage can be reduced by sealing the exposed coal and associated rocks from air and water, and can be treated by dosing affected waters with caustic materials such as lime and soda ash. There are currently no public drinking water supply systems using water from rivers and streams impacted by acid mine drainage in western Maryland. However, as the demand for water supply increases, streams affected by acid mine drainage may become more of a limiting factor for water supply in western Maryland.

Emerging contaminants - These are compounds that have only recently been identified as environmental contaminants, and about which little is known concerning the effects on human health. Emerging contaminants are found virtually everywhere and they include antibiotics, steroids, pharmaceuticals, hormones, plasticizers, insecticides, microbes, fire retardants, and personal care products. They originate in wastewaters of all types—residential, agricultural, commercial, and industrial—and are therefore more likely to be found in rivers and streams below wastewater discharge locations or in areas where untreated wastewater is discharged through sanitary sewer overflows (SSOs) or combined sewer overflows (CSOs), particularly below intensely urbanized areas and livestock production areas. Many of these emerging contaminants are very soluble in water and are resistant to biodegradation. Some emerging contaminants may be endocrine disrupters, interfering with the natural processes of reproduction and growth, but for most of these compounds, there are little data on human health effects. Some emerging contaminants, particularly microbial contaminants, may cause food contamination when food sources come in contact with contaminated surface water sources. Many emerging contaminants have been found in Maryland's surface water sources and even in treated wastewaters, as they survive traditional treatment methods.

Selected Contaminants in Ground Water

Iron and manganese - Ground water in contact with aquifer materials in certain geochemical settings can cause undesirable chemicals to be released from the aquifer materials. Iron and manganese are two of the most commonly occurring natural contaminants in Maryland's ground water sources (Figure 8). They can be found in ground water in some of the confined aquifers in the Coastal Plain, in the bedrock aquifers of western Maryland, as well as in other settings in Maryland. Figure 8 shows the distribution of iron and manganese in ground water in Maryland. There is no health-based drinking water standard for iron and manganese, but their presence in drinking water can cause a metallic taste as well as staining and encrustation of household fixtures, appliances, and pipes. Both contaminants have secondary drinking water standards, which are non-enforceable standards established by EPA for aesthetic reasons. Treatment options include filtration, ozonation, and ion exchange.

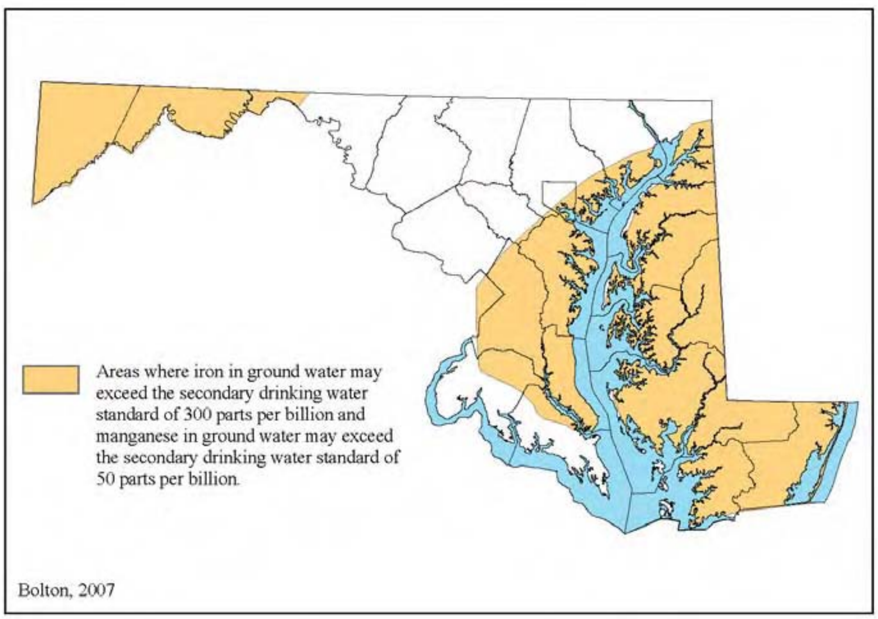


Figure 8. Distribution of iron and manganese in ground water in Maryland.

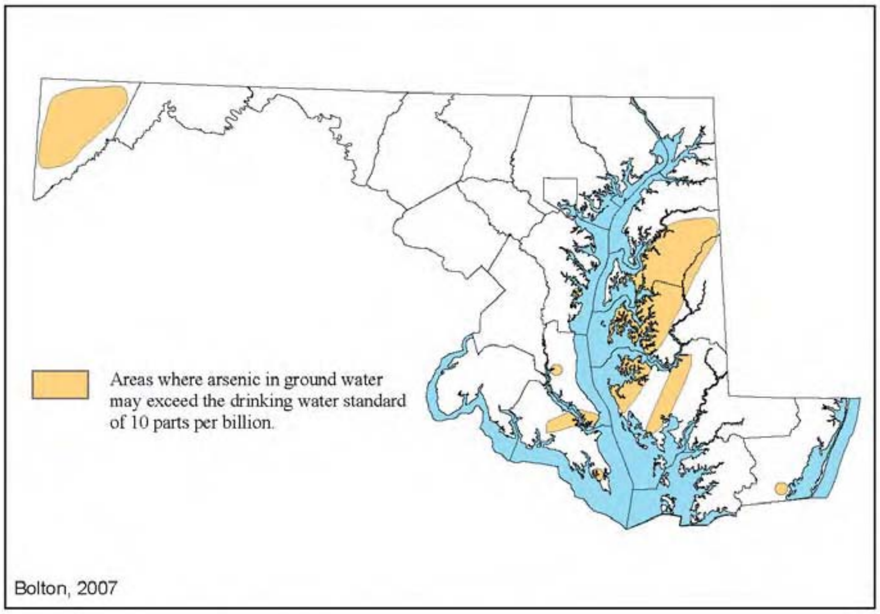


Figure 9. Distribution of arsenic in ground water in Maryland.

Arsenic - This naturally occurring contaminant has been found in the Maryland Coastal Plain in selected portions of the Aquia and Piney Point aquifers, and more locally in parts of aquifers in Worcester and Anne Arundel Counties. It also has been found in parts of the Hampshire and Pocono aquifers in western Maryland. Figure 9 shows the distribution of arsenic in Maryland's ground water. Arsenic has been shown to cause nausea, vomiting, diarrhea, partial paralysis, blindness, and several types of cancer[8]. As a result, arsenic is strictly regulated in drinking water. The recent lowering of the arsenic drinking water standard has caused some public water systems depending on ground water in Maryland to be out of compliance. Arsenic can be removed from ground water sources to produce drinking water by several treatment processes, including activated alumina filtration, ion exchange, reverse osmosis, and a combination of coagulation, filtration, and softening.

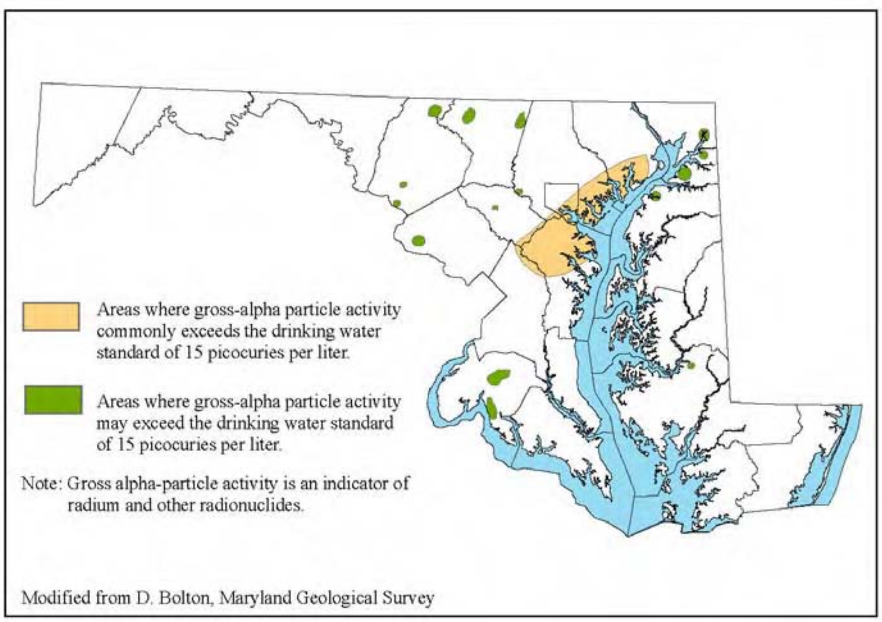


Figure 10. Distribution of radium in ground water in Maryland.

Radium - This naturally occurring contaminant originates from the decomposition of uranium and thorium and is found in ground water in some areas of the Coastal Plain of Maryland, particularly in the unconfined parts of the Patuxent, Patapsco, and Magothy aquifers in Anne Arundel County, and less commonly in the upper Chesapeake Bay area[9]. It has also been found in localized areas in the central Maryland Piedmont. For drinking water, gross alpha radioactivity is a screen that is used to indicate the level of radium and other radionuclides. Areas where radium is a concern are shown in Figure 10.

Radium is of concern to human health because it is known to cause increased risk of cancer[10], and is regulated by drinking water standards. It can be removed from drinking water by cation exchange, reverse osmosis, softening, and distillation.

Radon - Radon is a gas that originates from the radioactive decay of uranium. Radon occurs in ground water in the shallow Piedmont aquifers of Maryland, particularly in the aquifers composed of schist, gneiss, and granitic rocks; it is less concentrated in the Coastal Plain aquifers of Maryland. Radon can cause lung cancer[11]. It is a threat in drinking water because it can be released into the air from water and subsequently inhaled. New regulations for radon in drinking water are currently being developed. Radon can be removed by aeration or granular activated carbon to produce safe drinking water. Areas in Maryland with a potential to have elevated levels of radon in ground water are depicted in Figure 11.

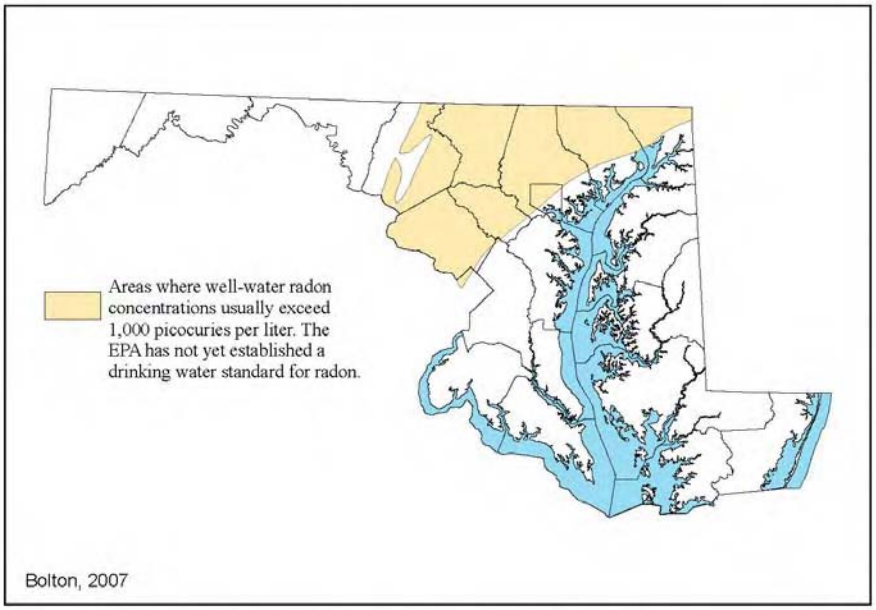


Figure 11. Distribution of potential for radon in ground water in Maryland.

Bacteria - Fecal coliform and *E. coli* are two indicators of contamination that originate from human and animal waste. Bacteria from the waste are carried into shallow aquifers by infiltration. Ground water beneath agricultural areas where animal waste is applied to fields, and beneath septic systems in residential areas, is susceptible to contamination by bacteria. Especially vulnerable are areas where agricultural and septic sources occur in limestone and marble settings where large solution openings, including sinkholes, create a direct conduit from the land surface to the water table. Bacteria in drinking water from ground water sources cause a number of common ailments in humans, and are treated mostly by disinfection with chlorine. Bacteria are strictly regulated in public water supplies but are not routinely monitored in individual private wells other than for the initial issuance of a Certificate of Potability (COP).

Protozoa - *Cryptosporidium* and *Giardia* are protozoans that can be found in ground water, especially in limestone and marble settings where the water table is in direct connection with the land surface or surface waters. *Cryptosporidium* and *Giardia* can cause gastrointestinal disease[12], and both originate from human and animal waste. *Cryptosporidium* and *Giardia* can be removed or inactivated by disinfection (not always completely effective), filtration, and reverse osmosis. Federal and State regulations require fairly complex treatment techniques for public drinking water sources vulnerable to *Cryptosporidium* and *Giardia*, but less rigorous standards apply for private domestic wells.

Nitrate - Nitrate in ground water originates from a variety of sources, including atmospheric deposition, fertilizers, animal waste applied to agricultural fields, and discharges from residential septic systems. Nitrate is very soluble in water and once in an aquifer it can persist along flow paths for decades. Nitrate is among the most common contaminants found in Maryland public water system sources, according to Maryland's Source Water Assessments. Ground water in limestone and marble settings and well-drained sandy Coastal Plain settings is particularly vulnerable to nitrate contamination. The main human health concern for nitrate in drinking water is blue-baby syndrome in infants and pregnant women[13]. (See Figure 12 for distribution of high nitrate in public ground water systems.) Nitrate can be removed by ion exchange, reverse osmosis, and electrodialysis.

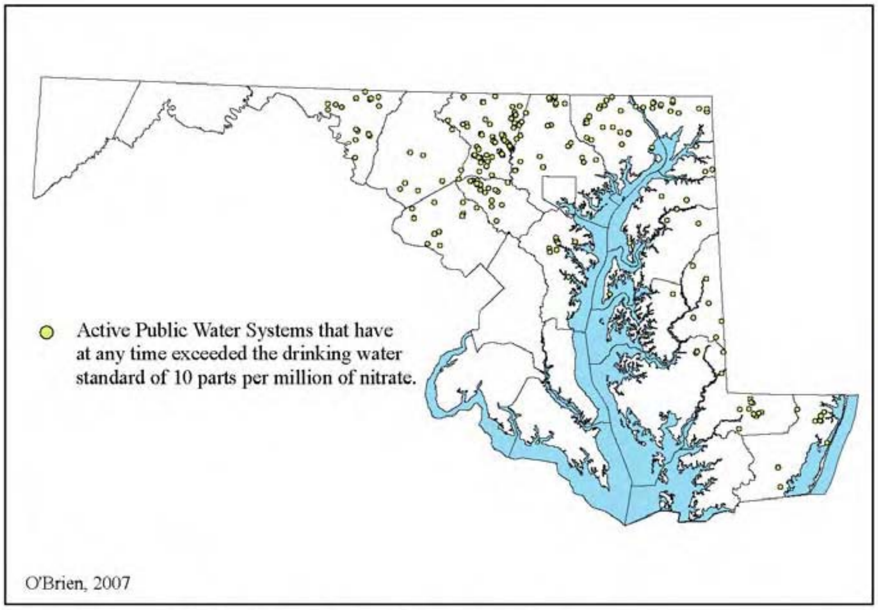


Figure 12. Occurrence of nitrate in Maryland Public Water Systems.

Viruses - Viruses may also be found in ground water sources, especially where the water table is in direct contact with the land surface or surface waters. They also may occur in shallow ground water in aquifers that are fractured or well drained. Viruses in ground water originate from human and animal waste from septic systems and livestock operations. Viruses, including *Echovirus*, *Hepatitis*, *Rotavirus*, and *Norovirus*, can cause gastrointestinal diseases, and in some cases may cause meningitis, hepatitis, and myocarditis[14]. Drinking water standards call for the inactivation of viruses. In Maryland, viruses have been found in only a small percentage of wells where testing has been done.

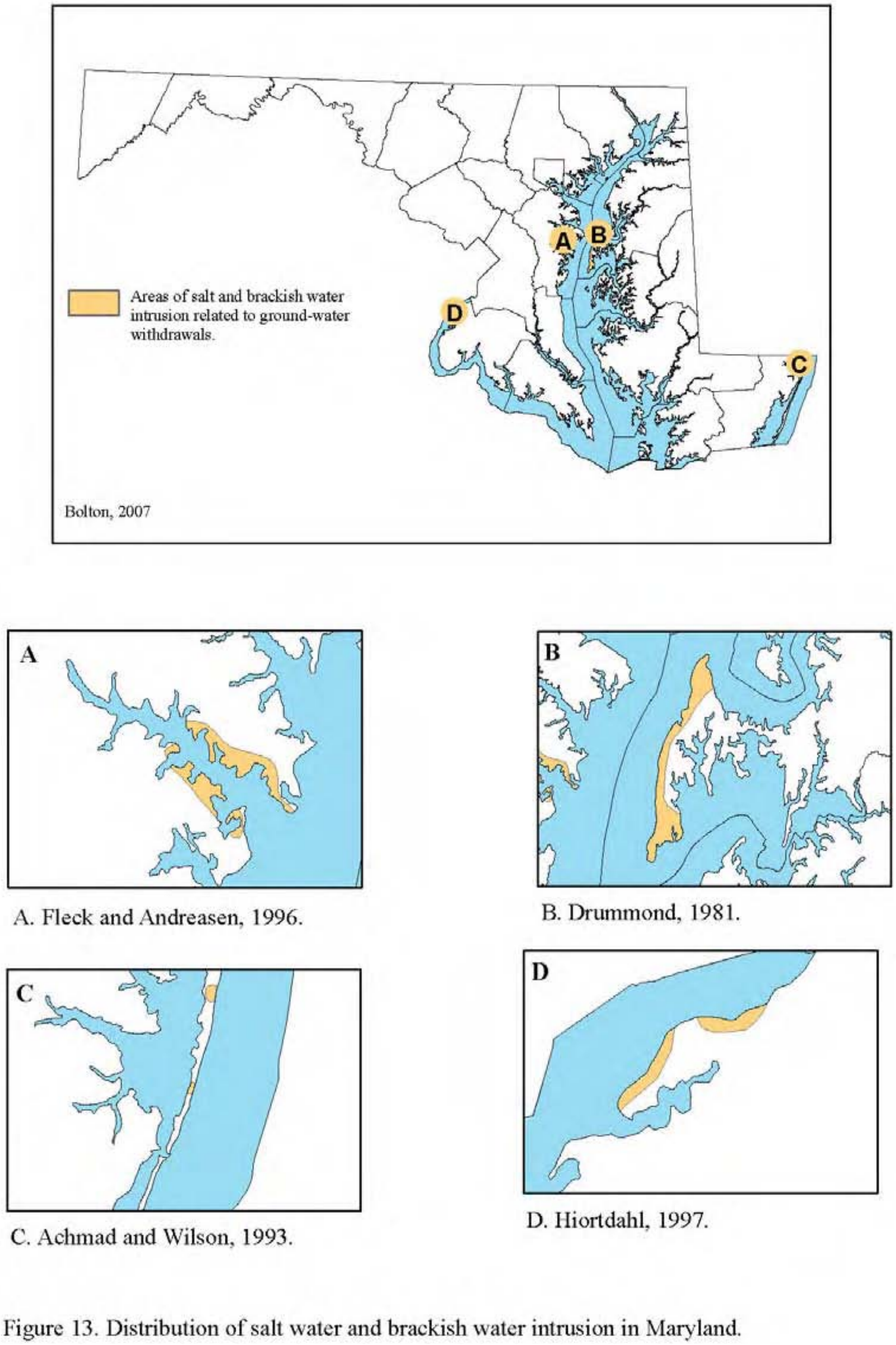
Pesticides - These include herbicides, insecticides, and fungicides, which occur in ground water as the result of application of pesticides to the land surface in agricultural, urban, and suburban areas. In some areas, ground water contains numerous pesticides, but concentrations are usually very low. Concentrations of pesticide breakdown products are often greater than their parent products. Human health effects from the breakdown products are unknown. Pesticides in ground water are more prevalent in areas underlain by limestone and marble such as the Hagerstown Valley of Maryland, and areas underlain by well-drained sandy sediments such as the Coastal Plain of the Eastern Shore. Human health implications are numerous, including problems with major organs and reproductive and nervous systems, and cancer[15]. Only a relative few of the many types of pesticides are regulated with drinking water standards. Most traditional treatment processes are ineffective at completely removing pesticides from ground water used for drinking water, but powdered activated carbon and reverse osmosis have been shown to be effective for selected pesticides.

MTBE - Methyl *tert*-butyl ether (MTBE). MTBE is an additive used to reduce air pollution from automobile emissions. While being used in Maryland, MTBE comprised 11 to 15 percent of gasoline[16]. It is very soluble in water and moves very easily within aquifers. It enters shallow aquifers from gasoline leaks and spills, and has been found in many public supply wells and domestic wells near gasoline storage and distribution sites. The human health effects of MTBE are not well known, but it is a suspected carcinogen. Maryland regulates MTBE in drinking water through an advisory level based on taste and smell. MTBE is treated by granular activated carbon filtration, which is generally effective, but MTBE has been found in low concentrations in about 10 percent of treated drinking water in Maryland[17].

Perchlorate - This manmade contaminant is used in rocket fuel, explosives, pyrotechnics, and blasting materials. In Maryland, perchlorate has been found in ground water beneath and adjacent to military installations, including Aberdeen Proving Ground, Fort Meade, and Indian Head Naval Ordnance Station. Perchlorate is known to cause hypothyroidism, especially in people with weakened immune systems[18]. It is regulated in Maryland's drinking water through use of an advisory level, and it is treated by ion exchange and dilution by mixing of contaminated water with uncontaminated water.

Road Salt - The application of salt (sodium chloride) to roadways to prevent winter icing is a source of contamination for ground water. Elevated chloride levels due to road salt storage and application have been documented in residential wells in Baltimore County. Chloride in high concentrations can impart a salty taste to water, but it is not a human health concern. Sodium in high concentrations presents a health concern for people on sodium-restricted diets. Drinking water treatment methods for sodium include reverse osmosis and distillation. These are expensive technologies, and are typically not used by public water systems. Instead, alternative sources are generally sought.

Salt water and brackish water intrusion - Naturally salty and brackish water in aquifers beneath coastal margins can replace fresh ground water under the influence of pumping. As fresh ground water is withdrawn by pumping, lowered pressure heads can induce the adjacent salty or brackish water to move inland toward the pumping well. Once salty or brackish water moves into an aquifer, that portion of the aquifer may be unfit for further use as a drinking water source, even if pumping is stopped. Salt water intrusion has occurred in the Manokin and Ocean City aquifers in Ocean City. Brackish water intrusion has been documented in the Aquia aquifer in Kent Island; the Aquia and Monmouth aquifers in eastern Anne Arundel County; and the Patapsco aquifer in northwestern Charles County. Areas of salt and brackish water intrusion are indicated in Figure 13. The chemical signature of salt water and brackish water intrusion is elevated chloride and sodium concentrations. Chloride poses no human health problems, but causes drinking water to taste salty. Sodium at high concentrations causes health problems for people on sodium-restricted diets. Salty and brackish water can be treated to remove chloride and sodium by reverse osmosis and distillation, but in cases where intrusion has occurred, water supply wells are usually abandoned or water from affected wells is mixed with water from unaffected wells to obtain a finished water that is not salty to the taste.



A. Fleck and Andreasen, 1996.

B. Drummond, 1981.

C. Achmad and Wilson, 1993.

D. Hiortdahl, 1997.

Figure 13. Distribution of salt water and brackish water intrusion in Maryland.

ADDRESSING DRINKING WATER QUALITY

The efforts currently employed to ensure that drinking water used by Marylanders is safe and of an acceptable quality are implemented through numerous laws, regulations, policies, and programs, which are carried out variously on federal, State, county and local government levels. An exhaustive review of every effort and authority is beyond the scope of this report, but a general overview is presented which groups the efforts that share similar objectives or strategies. Information on specific regulatory programs is available at MDE's website: http://www.mde.state.md.us.

Monitoring and Detection

A crucial step in the delivery of safe water through public water systems is the monitoring of water quality to detect contaminants known or suspected to cause adverse health effects. The U.S. Environmental Protection Agency (EPA) sets maximum contaminant levels (MCLs) for contaminants, which are established to protect the public against consumption of drinking water contaminants that present a risk to human health. Under the federal Safe Drinking Water Act (SDWA), public systems are required to sample and analyze source water and treated water for up to 93 chemical contaminants and 11 microbes[19]. Through Primacy agreements, the States agree to enforce these drinking water regulations, that include monitoring and treatment requirements for water systems to meet the MCLs. In addition, EPA has established secondary maximum contaminant levels (SMCLs), which are generally associated with aesthetic properties of drinking water such as taste, odor, or color. Water exceeding SMCLs can also result in cosmetic effects such as skin or teeth discoloration, and technical effects such as corrosivity, staining of fixtures or laundry, and scaling and sediment deposits in hot water heaters or pipes[20]. EPA assesses additional contaminants on a periodic basis to determine whether new regulations are needed to protect drinking water. EPA recently asked for comment on a list of 102 possible drinking water contaminants that may need to be regulated in the future[21].

In Maryland, the MDE's Water Supply Program oversees the implementation of monitoring requirements and enforces compliance. In addition to implementing federal standards, the State has the authority to establish its own water quality standards. For example, MDE has adopted its own standards in cases where federal standards are absent, by establishing advisory levels for perchlorate and MTBE. Water from private domestic wells, which are not regulated under the SDWA, is required under State regulations to be monitored for water quality only at the time of well construction. Individual wells are required by regulation to be sampled for bacteria, nitrate, and any other contaminants known or suspected to be present in the area of the well. Individual wells must meet the same drinking water standards established for public water systems when they are brought on line.

Treatment of Water to Remove Contaminants

Closely related to monitoring is the removal or inactivation of contaminants by appropriate treatment methods. The particular treatment used depends upon the quality of the source water and the targeted contaminants. Surface waters generally are more vulnerable to a wider array of contaminants than ground water. Often, more than one treatment process may be available to effectively remove contaminants, and the option chosen depends on several factors, including installation cost, required maintenance, and reliability. Federal regulations under the authority of the SDWA establish acceptable treatment processes for public water systems; the MDE Water Supply Program enforces treatment requirements in Maryland.

Proper construction, operation, and maintenance of treatment systems for public water systems is ensured through the State's permitting and inspection programs, under the authority of State regulations. Prior to building a treatment facility or any major water facility including mains, pumping stations and storage tanks, a water supplier must obtain a Water Construction Permit. The permit ensures that infrastructure projects throughout the State are designed on sound engineering principles and comply with State design guidelines to protect water quality and public health. The MDE Water Supply Program also maintains a routine inspection program. Engineers and sanitarians regularly inspect water treatment facilities, and recommend improvements to facilities, processes, and procedures, where needed.

For private wells and springs, no federal oversight exists. However, State law does grant the Secretary of the Environment broad authority to protect public health. It is through this authority, delegated to County Health Officers, that some treatment of private well water has been required in specific areas where known water-quality threats exist, such as radium removal in parts of northern Anne Arundel County, and arsenic removal in some parts of the Aquia and Piney Point aquifers.

Advanced water treatment processes are capable of improving water quality of virtually any water source to drinking water standards. However, such treatment comes at a high cost, and not without risk. Because there is some risk of breakdown or failure with any type of treatment process, federal and State policy makers agree that protection of public health is best accomplished by utilizing the cleanest possible water source.

Regulation and Control of Sources of Contaminants

For many substances that are known to present a health or environmental risk to water quality, the use and release of such substances is controlled through various laws, regulations, and programs. These efforts do not focus solely on drinking water quality, but are intended to prevent the release of contaminants into the environment. Nevertheless, when effective, these laws, regulations and programs prevent harmful contaminants from entering private and public drinking water sources.

The direct discharge of wastewater into surface and ground waters is controlled through the State's Surface Water Discharge Permit Program, and Ground Water Discharge Permit Program, respectively. Under the federal Clean Water Act (CWA), the State has the authority to regulate the discharge of municipal and industrial wastewater into surface waters. Authority to regulate ground water discharges is found in both federal and State regulations. The discharge of stormwater also carries pollutants, and municipal storm sewer systems are regulated by the State's stormwater discharge permit program under the authority of the CWA and State regulations. Through a Toxic Materials Permit, the State also regulates the use of chemicals to control mosquitoes and algae in ponds, ditches, and other surface water bodies.
Pollution and siltation of streams can be caused by land use changes associated with urbanization. The State's Erosion and Sediment Control Program regulates construction

activities to minimize these impacts through the approval process for erosion and sediment control plans. In addition, a General Permit for Construction Activity is required for any construction activity that will disturb more than one acre. The permit requires compliance with approved sediment and erosion control plans. While silt is not regulated as a drinking water quality contaminant itself, erosion can carry other pollutants into streams, and the presence of suspended fine particles in high concentrations can interfere with some water treatment processes, reducing their effectiveness.

Other pollutants in the State's waters can pose serious health risks for drinking water. Several State programs exist to address various types of pollutants. The State's Oil Control Program regulates various activities related to the storage and transfer of oil, including permits for surface water and ground water discharge permits specific to oil facilities. The Solid Waste Program regulates the construction and operation of landfills, which may be sources of ground water contamination, and the land application of sewage sludge. The Hazardous Waste Program regulates the use and removal of underground storage tanks, as well as the hauling and disposal of hazardous substances. Proper administration of these programs prevents the release of pollutants into the environment, helping to protect the quality of drinking water sources.

Protection of Water Sources

While regulation of contaminants does offer protection of water sources as described above, additional efforts exist which do not focus on specific contaminants, but on measures that can protect source waters from multiple threats. Maryland's Source Water Assessment effort, required under the SDWA and carried out by MDE, has evaluated the water source for every public water system in the State. The assessments identify potential threats to water quality related to activities in the upstream watershed of surface water supplies, or on the land overlying the area contributing ground water to wells. The next step in utilizing the Source Water Assessments would be the adoption and implementation of Source Water Protection Plans, as recommended but not required by EPA. Such plans would establish wellhead protection areas for public supply wells, and would require actions to control certain human activity on the overlying land that could pose a threat to ground water quality in the zone of contribution to a well. MDE's Water Supply Program provides guidance and grants and has prepared a model ordinance for jurisdictions that wish to establish Source Water Protection Plans. However, the absence of funding to protect water sources and the lack of regulatory requirements has hindered the implementation of Source Water Protection Plans in Maryland.

Planning efforts can provide additional opportunities to protect the quality of drinking water resources. In Maryland, each county is required to prepare a Comprehensive Plan to guide future growth, along with a Water and Sewerage Plan, which establishes areas that will be served by public water, and identifies the planned infrastructure that will be needed to provide water service. In addition, each county regulates land use (in at least high growth areas) through local zoning ordinances.

With the passage of House Bill 1141 in 2006, County Comprehensive Plans are now required to include a Water Resource Element (WRE). Within a WRE, the local government must indicate the sources from which it intends to obtain adequate water supplies that will be necessary to support expected growth indicated elsewhere in the Plan. In order to meet the October 2009 deadline for preparing WREs, local governments must begin planning immediately. The new requirement offers a chance for local governments to carefully assess the adequacy of their current water supplies, and of the water resources available for future development. Assessing the quality of water resources is an integral part of the evaluation. The WRE serves as an ideal opportunity to plan for the protection of present and future drinking water sources. Implementation of the plan can be accomplished through the Water and Sewerage Plan, through zoning decisions that are protective of source water quality in Source Water Protection Areas, and through other appropriate local ordinances.

Licensing and Certification of Personnel

The technical nature of many activities that can affect water quality usually requires special skills, training, or knowledge. For professionals working in specified fields, licensing or certification programs exist to ensure that qualified persons are performing the work. Such programs exist for several activities directly related to drinking water supply. Well drillers in Maryland must be licensed by the Board of Well Drillers, which sets standards and administers qualifying examinations for any person who drills or performs work on water supply wells, water pumps, or other well system equipment. One of the objectives of the licensing system is to ensure that ground water used for drinking water supplies is not contaminated due to improper well construction activities. Local and State government environmental sanitarians are also required to obtain a license. Sanitarians perform inspections and investigations related to the enforcement of health and environmental laws, including systems for water supply and treatment, as well as wastewater management and disposal. Waterworks and wastewater system operators must meet minimum education, experience, and examination requirements to be State-certified, ensuring that public health and the environment are being protected through the safe and proper operation of facilities under their care. Drinking water sampler certification is required of lab personnel, water system operators, health officials, and others who collect samples to assure compliance with the SDWA.

In addition to programs for personnel directly involved in water supply activities, licensing and certification programs exist for personnel involved in other activities that could impact water supplies as well as the environment. Such programs include an oil transfer license; certification for those involved in installation or removal of underground storage tanks; certification for haulers of hazardous waste; certification of medical waste haulers; certification and training for those responsible for implementation of erosion and sediment control plans; certification of pesticides applicators; and licenses related to several coal-mining activities.

Non-Regulatory Guidance

In addition to regulatory activities, MDE provides guidance related to water quality to water systems and well owners through various efforts. Through its Capacity Development Program, the State helps public water systems develop the technical, financial, and management capacity needed to successfully provide safe and adequate water supplies. MDE’s Water Supply Program has produced a guidance document on Water Supply Capacity Management Plans. Guidance is currently being developed for local governments to assist them in preparing the WREs of their Comprehensive Plans.

WATER QUALITY CHALLENGES AND RECOMMENDATIONS

A number of specific challenges with respect to drinking water quality in Maryland have arisen over the past two decades. A brief discussion of three major challenges follows, along with a discussion of various options for addressing them and specific recommendations.

Challenge: Protecting Sources of Drinking Water

Source Water Assessments have been completed for all public drinking water systems in Maryland. The State needs to make sure that source waters are better protected from the threats identified in the assessments.

Source water is the water from rivers, streams, reservoirs, or aquifers that is treated and used for drinking water purposes. A Source Water Assessment is a process for evaluating the source water at a public drinking water system and assessing its vulnerability to contamination. Under the 1996 SDWA amendments, states are required to evaluate all public water system sources. MDE has completed Source Water Assessments for all of Maryland's public drinking water systems[22] (approximately 3,600 systems). The assessments include descriptions and maps of the Source Water Assessment Areas and potential water quality threats, as well as recommendations for actions needed to protect the sources.

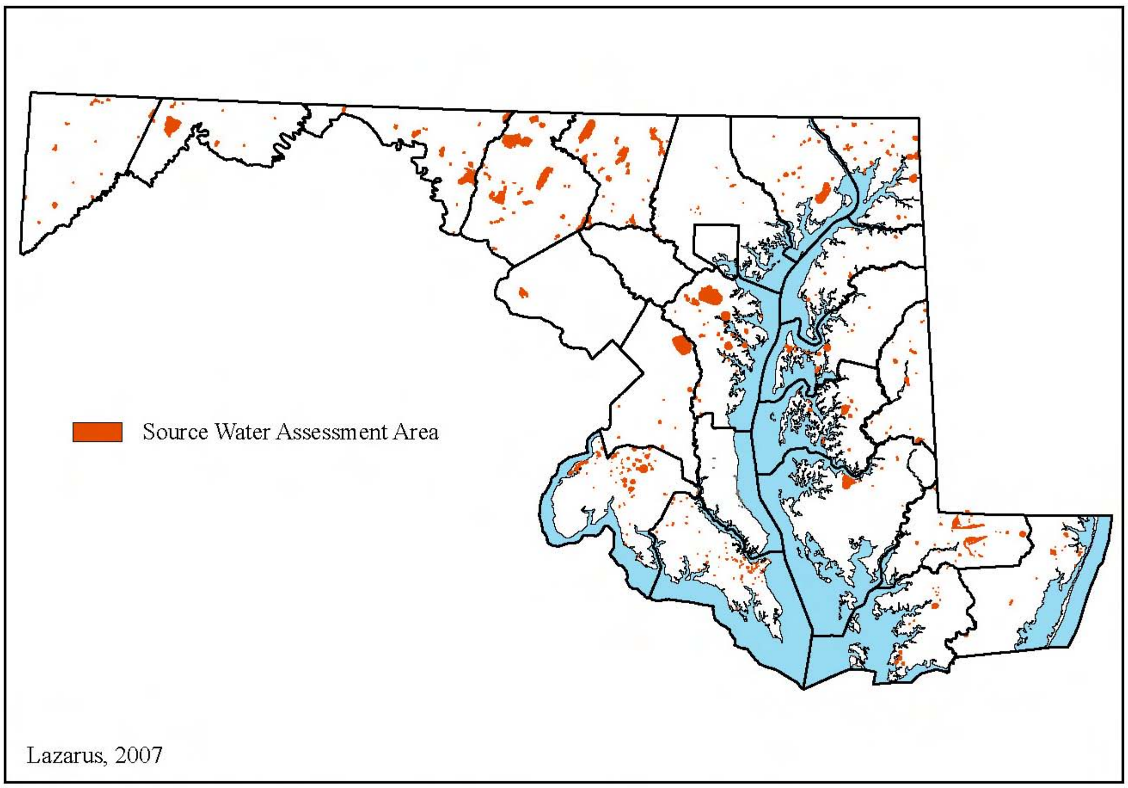


Figure 14. Distribution of ground water supplies for which Source Water Assessment Areas are defined in Maryland.

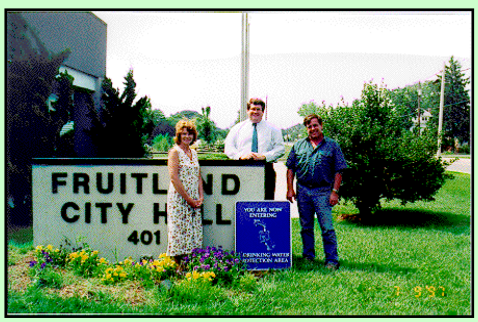
The underlying goal of a Source Water Assessment is for the water system to develop a Source Water Protection Plan. A Plan would provide details on steps the water system and/or local government will take to protect the water supply. Strategies can include activities such as increased monitoring, preserving forested land, restricting development within the Source Water Protection Area, and working with developers, farmers, and industry to implement best management practices that reduce contaminant loadings. Ideally, growth should be directed to areas where the geologic setting is inherently protective of water quality (i.e. confined aquifers).

The good news is that about 70 percent of Maryland citizens that rely on public water systems are served by systems that have Source Water Protection Plans in place (see example for ground water protection areas in Figure 14). Another 8 percent obtain their drinking water from confined aquifers, which are naturally protected from contaminants that originate at the land surface[23]. Watershed protection plans developed for the Baltimore City and Washington Suburban Sanitary Commission watersheds provide good examples of cooperative and collaborative efforts among various entities to protect the water supply.

The challenges are great, however, for the remaining systems, mostly small and medium-sized systems. For surface water systems, the greatest challenge is that the water system must protect the entire watershed. While some watersheds are a manageable size, others are not. The Potomac River basin, for example, covers an area that includes all or part of nine counties in Maryland, as well as parts of West Virginia, Pennsylvania, Virginia, and the District of Columbia. The logistics of trying to protect an area of this magnitude are problematic, and clearly it is unreasonable to prohibit all development or other threatening activities within the entire basin. Any protection efforts must involve considerable cross-jurisdictional coordination between and among states and counties. For ground water systems, the goal of protecting the source is challenging for another reason. Many ground water systems are quite small (more than 80 percent of Maryland's community ground water systems serve fewer than 1,000 individuals[24]). These small systems are not likely to control all of the land that contributes to their water supply, frequently do not have a role in making decisions about land use in their water supply shed, and must work with extremely limited resources. Again, cross-jurisdictional coordination is crucial to protecting the water supplies for these small systems.

Source Water Protection in Fruitland, Maryland

The City of Fruitland installed signs at the perimeter of its defined wellhead protection area and provided information in water bills to inform citizens about protecting the City's water supply. As a result, an alert resident contacted the Water Superintendent one night, informing him about an illegal dumping in the wellhead protection area. City personnel responded to the call and were able to prevent the potential contamination to their water supply.



While the 1996 amendments to the SDWA mandated Source Water Assessments, they did not include requirements to implement Source Water Protection Plans. Similarly, federal funds were made available for assessments, but no funds were made available for protection of surface water sources and only limited funds were made available for ground water sources (wellhead protection). A similar lack of protection exists for water supplies that are not currently used for public water systems, including areas served by individual residential wells and areas that may serve as drinking water sources in the future.

Land use management is a key component of source water protection. A major source of water supply degradation is contamination resulting from developed land uses and associated activities, including urbanization and agriculture[25]. Previous efforts to implement best management practices for controlling animal wastes and soil erosion, reducing impacts of road salt, planting cover crops to reduce nutrients in ground water, and keeping animals out of streams, have not been sufficiently successful in reducing drinking water quality problems. Water suppliers need to work cooperatively with soil conservation districts and farmers to ensure that these programs are adequately funded and implemented. State programs to address these water quality issues, such as the TMDL and Tributary Strategy programs, need to prioritize their efforts to ensure that Source Water Protection Areas receive the highest level of protection.

Maryland government places the responsibility for determining land use at the local level. The State lacks regulatory mechanisms to limit development to levels and types commensurate with sustainable water supplies. There is no regulatory mechanism to do so directly; nor is there a regulatory framework within which to ensure that local governments do so through their zoning and land use management authority. Thus, although water quality standards and State Anti-Degradation Policy require that water quality be maintained, there is no regulatory link to prevent development and associated land uses that violate that requirement. The primary water resource regulatory mechanisms – National Pollution Discharge Elimination System (NPDES) and stormwater permitting – do not directly address land use; nor do they provide local governments with a practical, usable framework according to which they must exercise their land use authority.

Other factors can compete with water resource protection for land use management decisions. For example, allowing certain types and amounts of development may provide jobs, support the local economy, provide local tax revenues, and/or provide landowners with development opportunities. However, the same types and amounts of development may degrade water supplies. Greater constraints on types and amounts of development may be necessary to protect them. Without a regulatory requirement for such constraints, the necessary land use management actions by local government remain discretionary. Even if local planners identify the threat inherent in certain land use activities, they generally can only suggest that those uses will degrade the integrity of a water resource as a water supply. A stronger water resource regulatory framework is necessary to ensure that local comprehensive plans and activities related to development are properly integrated with water supply planning.

House Bill 1141, enacted by the Maryland General Assembly in 2006, is intended in part to relate State regulatory responsibilities to the land use authority of local governments. The statute requires local governments to identify drinking water sources that will be adequate for the needs of existing and future development proposed in the land use element of the plan, and identify suitable receiving waters and land areas to meet storm water management and wastewater treatment and disposal needs of existing and future development proposed in the land use element of the plan.

Guidelines issued jointly by the Maryland Departments of Planning, Environment, and Natural Resources in June 2007 recognize that zoning and land use management tools and decisions can profoundly impact the risk of contamination to water sources[26]. The guidelines advise local governments to use the Source Water Assessment reports available from MDE, including maps of recharge and watershed areas. The guidelines also call for source protection strategies where applicable to ensure that water supplies are adequate and safe to meet future needs. To the extent possible, existing state regulatory tools such as NPDES and stormwater permits and TMDLs should be used to protect water supply sources.

These guidelines and the new planning process required by House Bill 1141 will do much to call attention to the need to proactively use land use plans and the regulatory process to address water supply quality issues. But as currently conceived, the process will not create a direct link between the water resource regulatory framework and that used to regulate land use.

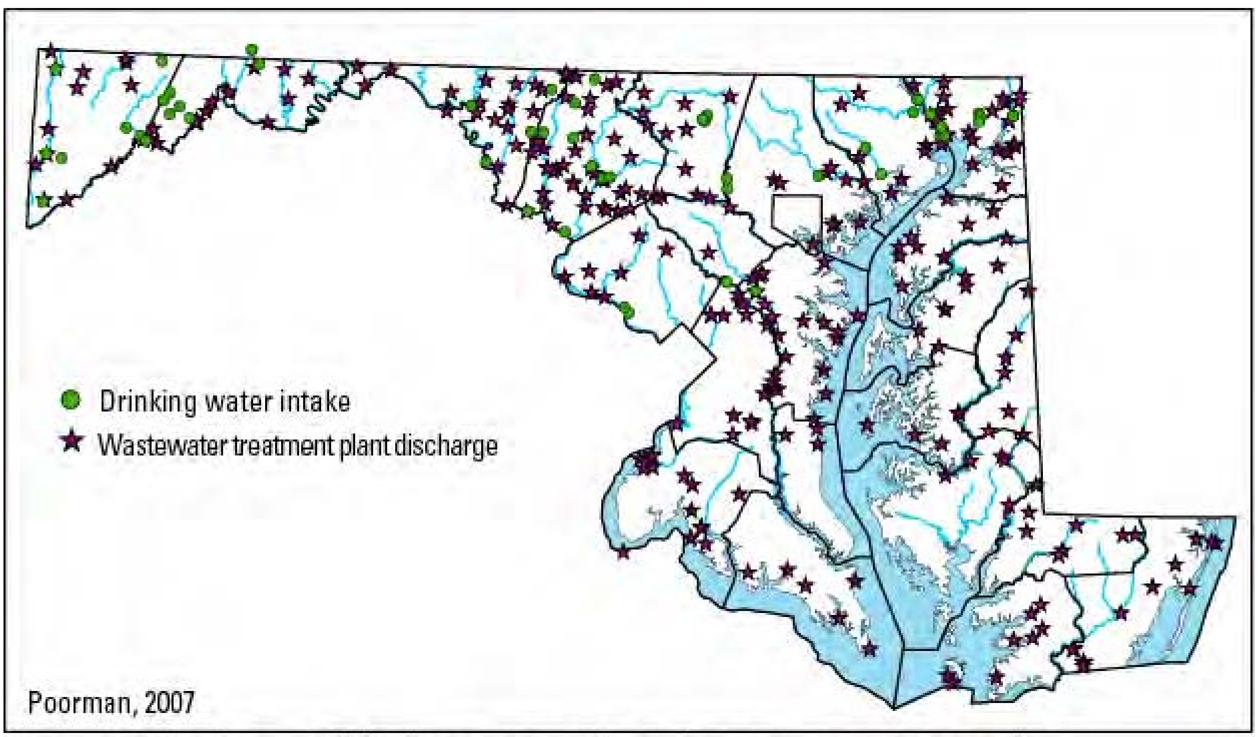


Figure 15. Distribution of drinking water intake and wastewater treatment plant discharges in Maryland.

Wastewater Overflows

One major threat to surface water sources is wastewater overflows. During rain events, combined sewer overflows (CSOs) and sanitary sewer overflows (SSOs) may discharge into Maryland's rivers and streams. A CSO occurs when there is an overflow of a combined sewer system carrying both stormwater and sanitary wastewater, and an SSO occurs when there is an overflow of a sanitary sewer. Concerns exist over the effect that these discharges of raw and partially treated sewage have on water quality, especially for the Potomac River and its tributaries, which are the source of water for Washington, D.C., and major portions of Maryland, Virginia, and West Virginia. Discharges from CSOs and especially SSOs may contain high levels of microbial pathogens (bacteria, viruses, and parasites). In addition, CSOs and SSOs contain oxygen depleting substances, total suspended solids, toxics, nutrients, and floatables as their principal pollutants. Figure 15 shows the locations of wastewater treatment plant discharges relative to drinking water intakes in Maryland. Two earlier reports, the Final Report of the Water Security and Sewerage Systems Advisory Council and the Preliminary Report of the Interagency Technical Assistance Committee, discuss water quality problems associated with CSOs and SSOs. During dry weather, combined systems carry sewage and industrial wastewater only, but during wet weather events, stormwater enters the system and is conveyed to the wastewater treatment plant. During wet weather events, the capacity of the treatment plant is often exceeded and CSOs occur. Combined sewers are designed to discharge flows exceeding their capacity to surface waters prior to treatment.

Sanitary sewers carry untreated wastewater from residential, commercial, and industrial areas to wastewater treatment plants. A SSO results when the sewer is undersized, or has a blockage or broken line or other defect that allows ground water or excess storm water to enter the line or allows sewage to escape. SSOs occur during dry or wet weather, and lead to millions of gallons of untreated sewage escaping into the environment, exposing humans to unsafe waterborne pathogens, and creating a public health issue. In addition to drinking water supply contamination, beach closures, shellfish bed closures, and other water quality impairments can result from SSOs.

Addressing CSOs in Cumberland, Maryland

The City of Cumberland's Long Term Control Plan for combined sewer overflows involves multiple phases, including a study, new pipelines, improvements to a wastewater pumping station, and a ten million gallon overflow storage facility, to allow slower releases that can be treated at the wastewater treatment plant. The estimated total cost is $47M.

Many conveyance systems are old and undersized, and are prone to CSOs and SSOs. Some of these systems are also prone to failure through inflow and infiltration (I&I). Inflow occurs, for instance, where water enters through an illegal connection. Infiltration is a result of ground water entering through cracks and broken joints in the pipelines. Wastewater pumping stations, usually located along streambeds, are also prone to failure, allowing untreated wastewater to overflow and enter the environment.

Owners of wastewater collection systems in Maryland are required by their NPDES discharge permits to report CSOs and SSOs immediately upon discovery and to follow up in writing within five days. Total statewide CSO and SSO discharges vary from year to year but can be as high as 431 million gallons per year for CSOs and 371 million gallons per year for SSOs[27].

MDE generally enters into a consent agreement, consent order, or judicial consent order to require Sanitary Sewer Evaluation Studies (SSESs) and improvements to the collection systems for chronic SSO violations. MDE also has enforcement actions with all eight CSO systems (Allegany County, Cumberland, Frostburg, LaVale, Westernport, Baltimore City, Cambridge, and Salisbury; Figure 16). The CSOs in Allegany County all flow into the Potomac River, a source used for drinking water. In addition, West Virginia has CSOs at Piedmont, Keyser, and Martinsburg, which discharge upstream of Maryland water plant intakes on the Potomac River[28].

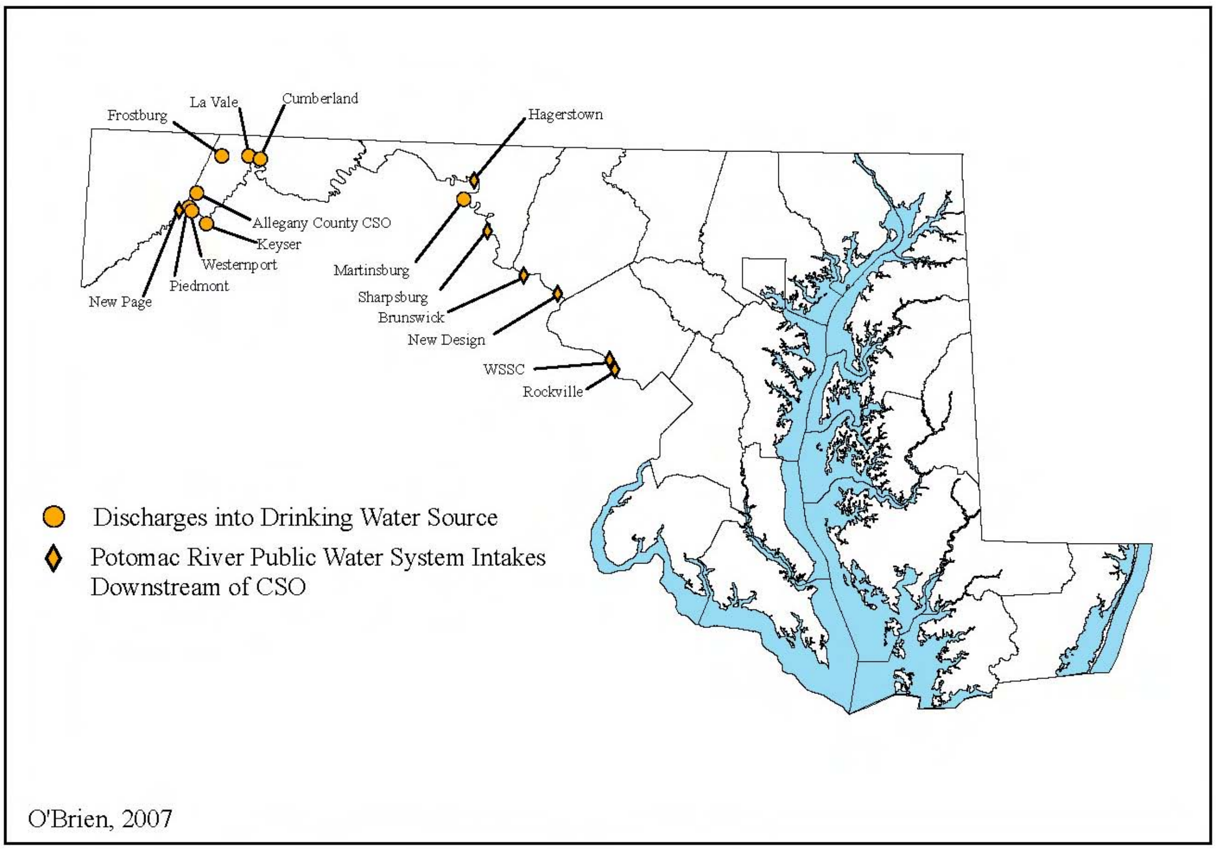


Figure 16. Combined Sewer Overflow Locations in Maryland.

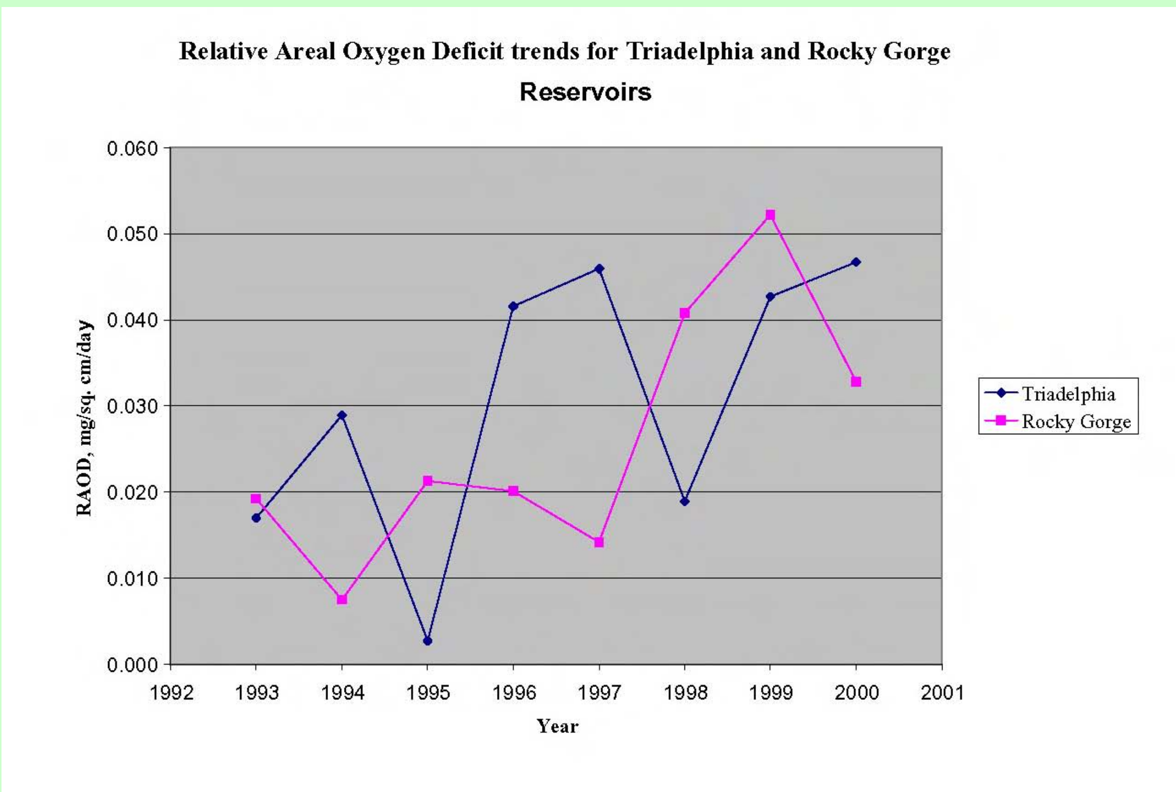
MDE has an EPA-approved project priority system that ranks water quality capital projects according to the severity of public health and environmental impacts. Local governments submit requests for funding to reduce infiltration and inflow into sanitary sewers, which contribute to SSOs. MDE assists in funding the repair or replacement of older sewers with inflow and infiltration problems at a grant funding level of about $500,000 per year. In addition, many millions of dollars in low interest loans are available from MDE. The Interagency Technical Assistance Committee estimates that the total costs needed to resolve SSO and I&I is $1.2 billion and for CSOs, $357 billion.

Eutrophication and Disinfection Byproducts in Patuxent River Reservoirs

The Triadelphia and Rocky Gorge Reservoirs are owned and operated by the Washington Suburban Sanitary Commission. These reservoirs collect water from a 132 square mile mostly rural watershed that spans three counties in central Maryland and provide the water supply for more than 500,000 customers.

Phosphorus from non-point residential and agricultural sources, whether in dissolved form or carried by sediment inputs from the watershed, is the limiting nutrient for these reservoirs, and causes eutrophication stresses in the reservoir system. The primary negative impacts of eutrophication include the resultant higher levels of algae and Total Organic Carbon (TOC), which increases treatment plant coagulant chemical requirements and residual sludge, increases production of Disinfection Byproducts (DBPs), increases the likelihood of customer taste and odor complaints associated with algae blooms, and increases the risk of significant health concerns related to potential algal toxins.

The extent of Patuxent reservoir eutrophication has been studied extensively since 1981, and its current status is moderate but trending towards increased intensity. Seasonal low oxygen conditions associated with eutrophication are becoming progressively worse, indicating that the stress from eutrophication will probably worsen in the future unless appropriate protection and abatement measures to control phosphorus and sediment loadings to the reservoirs are taken.



Eutrophication and Disinfection Byproducts

Another problem that plagues surface water sources is eutrophication from excess nutrients. Water supply reservoirs, estuaries, and even slow-moving rivers are vulnerable to eutrophication. Eutrophication is caused by an increase in nutrients in the water, especially nitrogen and phosphorus, and is frequently the result of human activities such as the release of sewage effluent into water bodies, lawn and farm field fertilization, increased sediment loadings, or the use of onsite sewage disposal systems. Excess nutrients in the water promote plant growth and decay and may cause severe reductions in water quality. As population density increases, sediment and nutrient loadings to reservoir systems are likely to increase. Nutrients and the resulting eutrophication of water systems have long been a source of concern for the Chesapeake Bay and its tributaries, but this ecosystem degeneration is also a concern when the affected water sources are used to provide drinking water. Eutrophication can seriously interfere with treatment processes and in extreme cases can result in taste and odor problems in treated water.

The use of chlorine disinfection in water supplies has dramatically reduced the incidence of disease in developed countries, and is responsible for virtually eliminating diseases such as cholera and dysentery in this country. When water sources contain excess nutrients and algal growth, however, chlorine can react with organic and inorganic materials present in the water to form disinfection byproducts (DBPs) such as trihalomethanes and haloacetic acids. Exposure to high levels of these chemicals over long periods of time may cause health problems, including damage to blood and kidneys[29]. Virtually everyone in Maryland who is served by a public water system consumes water that has been disinfected with chlorine. Because of the large population exposed (more than 90 percent of Maryland's citizens who are served by public water systems obtain their drinking water from surface water sources), health risks associated with DBPs, even if small, need to be taken seriously. The risks are greater for surface water systems, due to the relatively high levels of organic materials that exist in surface waters.

Federal regulations require public water systems to monitor for DBPs and their primary precursor, total organic carbon. If the DBPs exceed federal standards, systems must modify their treatment processes or otherwise work to improve their source water in order to reduce levels of DBPs to below the standard. With new regulations scheduled to become effective in 2012, more systems may have difficulty meeting federal requirements[30]. Resolving a problem with elevated DBPs is a complex balancing act between maintaining adequate chlorine residual in the distribution system and ensuring that levels of DBPs remain below the standard. In some cases, systems can modify treatment processes to resolve the problem; however, the ideal solution is to improve the water quality of the source.

Recommendations

To improve protection of sources of drinking water in Maryland, the Subcommittee recommends the following:

- **MDE, MDP, and DNR should provide technical support, guidance, and resources to assist local governments and water suppliers in their efforts to protect drinking water sources while promoting sustainable growth and development.**

  Efforts should be geared toward providing technical support and guidance as counties develop their Water Resource Elements required under House Bill 1141 to ensure that plans include mechanisms for ensuring that source water quality will not be degraded by future land use changes and associated human activities. In addition, the State should continue to develop programs that direct growth to certain areas and preserve forested land. It is critical that funding be identified to support local and inter-jurisdictional efforts to protect water supplies. It may be possible to leverage new local funding sources with a moderate investment of State funds.

- **The State should develop or strengthen laws and regulations to ensure that local governments are taking appropriate steps to reduce the impacts of agricultural and urban development on drinking water sources.**

  Regulations should be modified to require public water systems to develop an approved Source Water Protection Plan as a condition for obtaining a new or increased water appropriation permit and/or as part of the Water and Sewerage Plan. Plans should require MDE review and approval based on the plan's ability to ensure that source water quality will not be degraded by future land use changes and associated human activities.

- **MDE should better integrate source water protection goals into other program priorities and activities.**

  Better integration of source water protection efforts into other water quality programs, such as TMDL implementation, Tributary Strategy Programs, stormwater management, and land conservation, could provide the opportunity to achieve source protection goals within the context of other program goals.

- **MDE and MDA should review and evaluate existing laws, regulations and programs to identify changes that could reduce contaminant loadings that threaten sources of drinking water**

  MDE and MDA should review and evaluate existing programs that regulate wastewater discharges and wastewater overflows, require urban or agricultural best management practices, manage road salt storage and application, restore stream channels, encourage forest preservation, etc., and propose changes to strengthen these programs as appropriate to ensure that drinking water sources are adequately protected.

Challenge: Assisting Well Owners in Ensuring Safe Drinking Water

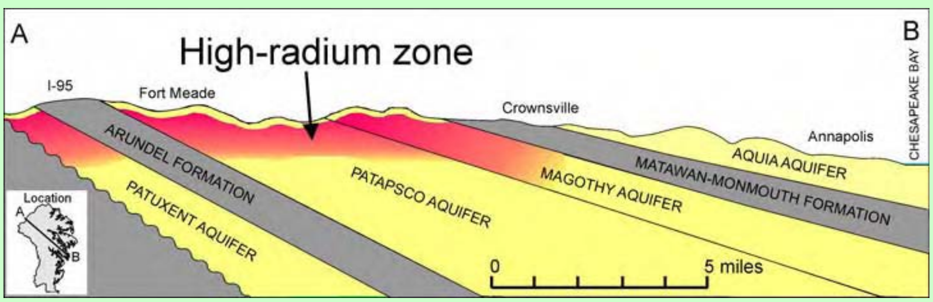
Many Maryland residents obtain their drinking water from private wells instead of public water systems. The State needs to make sure that well owners understand how to ensure that their water is safe.

More than one million residents of Maryland (about 16 percent of the State's population) obtain their drinking water from privately owned wells[31], which are not required to be monitored for water quality to the same extent as public drinking water systems. These individual wells serve primarily rural residents across the State, in every jurisdiction except Baltimore City. As a result, residents who rely on individual wells may be at a greater risk for drinking contaminated water.

Individual wells serving fewer than 25 people or 15 homes are not regulated under the Safe Drinking Water Act (SDWA). While the SDWA requires public drinking water systems using ground water to sample routinely for up to 90 contaminants, Maryland well construction regulations require private homeowner wells to be sampled only at the time of well construction[32]. County health departments are delegated the authority to enforce the well construction regulations, and a well must meet drinking water standards before the county can issue a Certificate of Potability (COP). While State regulations require that newly constructed wells be sampled for bacteria and nitrate, and for any other contaminant that is known or likely to occur in the location where the well is being drilled, no other water quality requirements exist for new or existing wells. It is the well owner's responsibility to monitor the water quality being produced after the well is placed into service.

Radium in Wells in Anne Arundel County

In 1997, radium levels exceeding the EPA's drinking-water standard were discovered in private wells during a reconnaissance study of carcinogens in Anne Arundel County well water. A follow-up study determined that radium concentrations decrease with increasing well depth. As a result, the County now requires that all new wells in the affected area be drilled to a County-specified minimum depth. Ninety-five percent of new wells have radium concentrations below the drinking-water standard, compared with 33 percent of wells prior to the minimum depth requirements.



Vertical scale is greatly exaggerated

While State regulations require additional water quality tests beyond bacteria and nitrate when a contaminant is known or suspected to be present, local government officials may not always be aware of which contaminants should be tested in a given location. No comprehensive ground water quality database exists that authorities can use to ascertain whether additional testing may be needed to insure that a well meets drinking water standards. Special local and regional monitoring and studies have revealed a number of situations statewide where water quality does not meet drinking water standards, largely due to naturally occurring contaminants, but much of Maryland's ground water quality remains unknown. Examples of situations where special monitoring and studies have provided more detailed knowledge of ground water quality problems include: (1) radium in Anne Arundel County; (2) arsenic in southern and eastern Maryland; and (3) radon in the Piedmont region. Once local authorities become aware of contamination problems such as these in their jurisdictions, local health departments can undertake additional sampling to identify the areal extent of the contamination, but limited laboratory capacity, insufficient staffing, and inadequate technical expertise and equipment make it very difficult for the local governments to address this type of problem.

The absence of federal regulation for individual wells means that no federal funds are dedicated to ensuring public health for citizens using individual wells. State funds provide some support for regulatory programs, which is supplemented by county governments, but these funds are limited. Financial constraints result in limited staff time being devoted to enforcing well construction regulations at both the State and local level. Applicable regulations for well construction are delegated by MDE to local health departments, with MDE providing technical assistance and guidance to county programs. Staffing at the State level is limited, however, and local health department staff are stretched between water quality programs and their many other responsibilities.

State regulations allow local authorities to issue COPs for new wells where certain contaminants exceed the drinking water standard if treatment is installed to remove or inactivate the contaminants. The regulation does not allow the issuance of a COP when treatment is needed to address a water quality problem with volatile organic compounds such as petroleum products, or synthetic organic compounds such as pesticides and other industrial chemicals[33]. This could have an impact on future development, as some areas may not be developable based on degraded water quality. As continued population growth further stresses water supplies, the result could be localized regions where degraded water quality prohibits the construction of individual wells. Changing the regulations to allow treatment is one option, however it is important that a mechanism for overseeing the routine operation and maintenance of the treatment units be incorporated into any change.

Even when information is available about a water quality problem in a given area, water quality testing is typically required only when a new well is constructed. As a result, existing wells are usually not routinely tested. State and local programs attempt to educate homeowners about potential health risks. Some homeowners have installed treatment systems on their existing wells, but others may either be unaware of the risk, or choose to consume the water without treatment. Furthermore, no law or regulation requires installation of treatment on existing homeowner wells, maintenance of treatment systems, or disclosure of contamination to potential buyers of the property (although real estate disclosure requirements may apply in some cases). It is vital that residents using individual wells have sufficient information to make informed decisions.

Ground Water Under the Influence of Surface Water

Areas where ground water may be under the influence of surface water present unique challenges. Due to the nature of the problem, it is more technically challenging and expensive to identify and to treat wells that are under the influence of surface water.

Ground water users in some areas of Maryland rely on limestone and marble aquifers. When weathered, the rock forms the karst terrane familiar in some parts of the Hagerstown Valley and Piedmont regions of Maryland. Water can dissolve these limestone and marble rocks, forming enlarged cracks, fissures, and sinkholes that allow water from the land surface to reach the aquifer and drinking water sources within a relatively short time period. Therefore, ground water in these vulnerable settings is considered to be under the direct influence of surface water. Figure 4 shows areas in Frederick and Washington Counties that are highly sensitive to ground-water contamination. Limestone and marble aquifers are particularly prevalent in Washington, Carroll, Frederick, Baltimore, and Allegany Counties. This is a concern because the surface water is not adequately filtered through the soil and travels so rapidly downward that microbiological organisms do not die off before they reach the ground water supply. Various types of fecal bacteria, viruses, and protozoa such as *Cryptosporidium* and *Giardia* can be found in ground water obtained from wells located in this vulnerable setting. Exposure to these contaminants through drinking water can result in serious intestinal disease, and, for vulnerable populations, death. In 1993, a *Cryptosporidium* outbreak in Milwaukee resulted in at least 50 deaths and 400,000 illnesses[34]. The occurrence of such disease-causing organisms in the ground water increases after substantial rain events.

Unlike public water supply systems, which are required under federal and State regulations to routinely test and treat wells that are under the direct influence of surface water, private homeowner wells under the influence of surface water are not protected to the same degree. Although Maryland law requires homeowner wells to meet drinking water standards before being placed into service, the typical testing regimen may not be sufficient to identify wells vulnerable to surface water influence. Routine testing for bacteria may not provide sufficient information to determine whether a well is under the direct influence of surface water, especially if the sampling occurs during dry weather. Tests for *Cryptosporidium* and *Giardia* are difficult to conduct, expensive, and not readily available at Maryland laboratories, and for those reasons, MDE has developed a sampling protocol for identifying vulnerable public water systems, using fecal bacteria as an indicator organism and requiring multiple samples. This sampling regimen may be prohibitively expensive for individual homeowners. In addition, appropriate monitoring and treatment technology is complex and expensive, and requires a high level of training.

Recommendations

To better protect Maryland residents who obtain their drinking water from individual private wells, the Subcommittee recommends the following:

- **MDE should revise regulations governing monitoring of individual wells, including requiring testing for specific contaminants when the well is near a source of contamination, and requiring testing at property transfer or more frequently for leased properties**

  Monitoring at private wells should include testing for both naturally-occurring and man-made contaminants when they are known or suspected to be in the vicinity of the well. Monitoring of private wells at property transfer, and requirements for notifying affected parties would provide property owners with better information to make decisions that affect their health. Requirements should include provisions for landlords to sample periodically and provide results to their tenants.

- **MDE should modify current policies for issuing appropriation permits to require water quality testing for new subdivisions.**

  Requiring water quality testing for subdivisions prior to issuing an appropriation permit would provide an opportunity for MDE to evaluate water quality considerations and recommend appropriate alternatives for addressing public health concerns.

- **The General Assembly should provide increased resources for local health departments to support training, technical assistance, and public outreach efforts aimed at owners of individual domestic wells**

  Well owners frequently do not fully understand the health implications of water quality, and health departments often do not have resources to provide the needed level of outreach services and technical assistance. Particularly in areas where ground water is under the direct influence of surface water, public education efforts to inform residents about the potential risks, ways to identify disease, and treatment options are needed to ensure that all residents living in vulnerable areas understand the health risks and potential remedies.

- **MDE should require construction of public drinking water systems instead of individual wells for new developments where ground water testing indicates serious water quality concerns**

  Developers should be required to address water quality concerns as part of their development plan. Public water systems should be required where they are consistent with planned growth density, and water quality sampling indicates contamination that may be difficult for private well owners to address (such as fecal contamination). In low-density areas where public water supplies may be too expensive or inconsistent with planned growth objectives, developers should be required to install treatment systems at each home, and establish a mechanism for qualified operators to oversee the maintenance and operation of the treatment systems.

Challenge: Improving the Availability of Water Quality Data

Data on the quality of Maryland's source waters is not as comprehensive or available as it should be to support water supply decisions. The State needs to fill in data gaps and make all water quality data more accessible to everyone.

The quality of Maryland's surface and ground waters has been the subject of many investigations and monitoring programs over the past three decades. Tens of thousands of water samples have been collected; hundreds of individual drinking water contaminants have been analyzed; and dozens of studies have been conducted by local, county, State, and federal agencies, as well as by investigators at universities and in private firms. Ongoing regulatory programs require the collection of hundreds of water quality samples every year as part of the effort to assure safe drinking water. Even so, the lack of adequate available data remains a major challenge for water suppliers, regulators, and planners.

The vast diversity of past and current investigations and programs helps explain why there are still gaps in water quality information. Each sampling effort necessarily focuses on particular contaminants, issues, and study areas relevant to its own objectives. A comprehensive and thorough assessment of all waters across the State has not been undertaken. While some data have been developed, much remains unpublished and inaccessible to the general public, and to the larger community interested in water quality.

Much water quality information has been developed as a result of efforts directed toward restoring the Chesapeake Bay. While some of these data are not relevant to drinking water sources, many Bay-related investigations produce water quality data for ground water sources or fresh water Bay tributaries that are also existing or potential drinking water sources. Not only do efforts to restore water quality of tributaries to the Bay benefit efforts to protect source water quality, but the accumulated wealth of water quality data may also provide insight to drinking water quality issues as well.

The lack of available water quality data presents challenges for those seeking safe water supplies, both public and private. For public water suppliers, the lack of available water quality data limits their ability to plan for future supplies. For example, greater availability of water quality data could help guide decisions about where to locate new wells, or the optimal depth for a new well to assure the best possible water quality. For private water supplies, the benefits of having adequate water quality data are even more important. While individual well owners may have little choice in the location of a new well due to constraints of property size, an understanding of ground water quality at varying depths can help to avoid producing water from an aquifer that would require water treatment to meet standards. Unlike public water suppliers, individual well owners are not required to monitor the quality of their water. Therefore, adequate water quality data for available aquifers could provide a critical indication of the safety of potential supplies. For planners and regulators, greater availability of water quality data could help to focus efforts on identifying areas where water of acceptable quality could support new development, and where to develop new sources. Regulators and researchers could identify and prioritize areas needing additional monitoring and investigations of water quality.

Monitoring to Support the Preceding Two Challenges

The two preceding sections of this report outlined challenges associated with protecting the quality of drinking water sources and assisting well owners in ensuring safe drinking water. Addressing these challenges is made more difficult by the lack of comprehensive knowledge available on the quality of Maryland's source waters. Monitoring and investigations are needed to effectively address each of these two challenges, and to track improvements as they are addressed. Data are lacking for some critical decision-making, and the data that do exist are not readily available for those who might wish to use them.

Protecting the quality of drinking water sources - One of this report's major recommendations to protect the quality of drinking water sources is to reduce the amount of nutrients and sediment delivered to Maryland's rivers and streams, which feed drinking water reservoirs. It is important to know which rivers and streams carry the heaviest loads of nutrients and sediment, and to monitor the effectiveness of efforts to reduce those loads. Maryland currently has two major programs that address nutrient and sediment loads--the TMDL program and the Tributary Strategy program. Both programs have produced large volumes of nutrient and sediment data for many rivers and streams in Maryland. However, some rivers and streams still do not have sufficient data, and neither program is set up for long-term comprehensive monitoring under a range of flow conditions. A more comprehensive monitoring program would provide all the nutrient and sediment necessary for water resource managers, water suppliers, and the public to make informed decisions about the quality of current and future drinking water sources. Such a monitoring program should focus on nutrients and sediment in rivers and streams upstream from major water supply reservoirs such as those that serve the large population centers of the metropolitan Washington, D.C. and Baltimore areas, and should include monitoring during storm events.

Another of this report's major recommendations is to undertake improvements in wastewater infrastructure in order to reduce Combined Sewer Overflows (CSOs) and Sanitary Sewer Overflows (SSOs) that contribute microbial pathogens, nutrients, toxics, and oxygen depleting substances to rivers and streams in Maryland. It is important to characterize the levels of these contaminants being contributed by CSOs and SSOs throughout Maryland, and to monitor the progress being realized through infrastructure improvements. Currently, there is no comprehensive program to monitor the quality of rivers and streams affected by wastewater overflows. With such a monitoring program in place, water resource managers and wastewater plant operators would have a basis for targeting infrastructure improvements where they would be most effective. Monitoring should be done downstream of major wastewater treatment plants where CSOs and SSOs occur, and should address both ambient water quality as well as event-based water quality.

Assisting well owners in ensuring safe drinking water - This report also provides recommendations that will help owners of private wells ensure the quality of their drinking water. Little comprehensive water quality data are available for the wide variety of hydrogeologic and land use settings from which Maryland's private well owners obtain their drinking water. A comprehensive ground water monitoring program would provide the data needed by water resources managers, well drillers, and private well owners to make more informed decisions concerning water treatment or the development of alternate water supplies. The monitoring program should address those contaminants expected to occur in each major hydrogeologic and land use setting, and should include monitoring across seasons. Once sufficient monitoring has been done to determine the occurrence and distribution of contaminants, investigations could be conducted to determine the relation between the contaminants, settings, land uses, and human health problems.

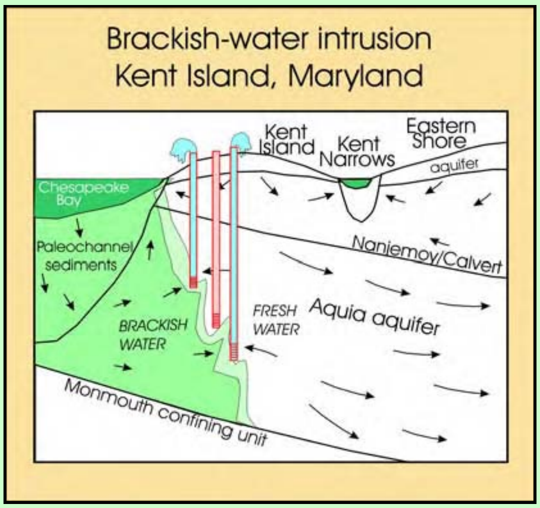
Monitoring and Investigation of Two Important Issues

Saltwater Intrusion - Salty and brackish waters are known to be present in parts of several fresh water aquifers in Maryland's Coastal Plain. The intrusion of salty or brackish water into a fresh water aquifer can cause the aquifer to become unfit for use as a source for drinking water supply. Sources of intruded salty or brackish water in Maryland include the Atlantic Ocean, the Chesapeake Bay, coastal bays, large tidal rivers, and aquifer brines remaining from earlier geologic periods when the aquifer sediments were filled with salt water.

The salty or brackish water in an aquifer comes into contact with the fresh water in the aquifer in a zone that is commonly referred to as the salt water or brackish water interface. Wells drilled too near the interface may yield salty or brackish water. Pumping a well cased near the interface can pull the interface toward the well, causing the well to produce salty or brackish water. Salty or brackish water also may enter wells that are drilled too close to shorelines and too far downdip in aquifers.

In Maryland, salt water and brackish water intrusion has been documented in several locations along the Atlantic and Chesapeake coasts, including Ocean City, Kent Island, Anne Arundel County, and Charles County (fig. 13). These four areas have been identified by MDE as Water Management Strategy Areas. MDE closely scrutinizes water withdrawal requests in these areas, and requests are usually directed to aquifers with less potential for salt water or brackish water intrusion.

Saltwater Intrusion on Kent Island, Maryland



Kent Island has undergone significant development since the Bay Bridge opened in 1952. Along the island's western shore, most residential wells draw water from the Aquia aquifer, which is in direct contact with sediments beneath the Chesapeake Bay. Many of the wells near the shoreline have encountered brackish water in the Aquia aquifer, and pumping has caused "upconing" of the brackish water. The community of Bay City is now connected to a municipal water supply, and new wells requiring ground-water appropriation permits must be drilled into deeper aquifers. A network of wells is tested annually to monitor trends in chloride concentrations.

In general, any population center that pumps ground water for its water supply near a salty or brackish surface water body is potentially vulnerable to salt water or brackish water intrusion. This is true for large population centers, but also can be true for smaller communities with shallow wells. As the population of coastal areas in Maryland continues to grow, there will be increased pressure on ground water resources, and salt water and brackish water intrusion will continue to be a threat to water supply wells.

To date, the problems of salt water and brackish water intrusion have been studied only where they have already occurred. Because the potential exists for intrusion throughout the coastal areas of Maryland, it is only a matter of time before increased water usage in the coastal areas leads to the occurrence of salt water and brackish water intrusion in other areas. The pre-development identification of areas where intrusion is likely to occur could potentially save major investments in water supply planning and infrastructure. Also, a more thorough understanding of the impact of ground water pumpage on the movement of the salt water interface would enable water supply managers to optimize the amount of ground water obtainable without causing the interface to move close enough to contaminate water supply wells. Monitoring and investigations should be conducted to identify the current location of the salt water interface in Maryland's coastal areas, and to determine the potential impacts of water supply development near the interface.

Emerging Contaminants - The number of contaminants that are of concern for drinking water supplies has been increasing in recent years. The federal EPA regulates more than 90 specific contaminants in public water supplies under the SDWA because of their known or suspected human health effects. The EPA tracks other potential contaminants as unregulated contaminants, due to their suspected health effects and the potential to be regulated under the SDWA in the future. In addition, the presence in drinking water supplies of a large number of new contaminants has emerged relatively recently; they are grouped under the collective term, "emerging contaminants."

Reflecting the fairly recent awareness of and the developing understanding of emerging contaminants, the very term itself is not universally defined. Generally, a contaminant may be considered emerging if (1) it has been newly discovered; (2) a new pathway for it has been discovered; or (3) its toxicity has been recently re-assessed. For this report, the definition used by the Consortium for Research and Education on Emerging Contaminants serves well: "Those chemicals that recently have been shown to occur widely in water resources and identified as being a potential environmental or public health risk, and yet adequate data do not exist to determine their risk."[35]

Emerging Contaminant in the Baltimore Area

In 2004, triclocarban was detected in streams in the Greater Baltimore area. Triclocarban has been marketed as a non-agricultural pesticide for decades, and is commonly added to soaps, cleaners and personal care products as an anti-bacterial agent. A study conducted by a Johns Hopkins University researcher analyzed water samples from several streams, as well as from water filtration plants and wastewater treatment plants in the Baltimore area. Stream samples contained concentrations of triclocarban up to 5.6 parts per billion, and wastewater samples up to 6.7 parts per billion. While no Maximum Contaminant Level has been established for triclocarban, the detected levels were as much as 20 times higher than any previously reported levels, which EPA has used to evaluate its ecological and health risks. The ecological and human health impacts of triclocarban in water at these concentrations are unknown.

The following groups or classes of contaminants generally are considered as emerging contaminants: Endocrine disruptors, pharmaceuticals and personal care products (PPCPs), plasticizers, insecticides, flame retardants, nanomaterials, hormones, antibiotics, and algal toxins. These groups are not all mutually exclusive, and some contaminants may fall into more than one group. Some individual contaminants commonly listed as emerging are lead, mercury, MTBE, perchlorate, perflourooctanoic acid (PFOA), and two common flame retardants, polybrominated biphenyls (PBB) and polybrominated diphenyl ether (PBDE). In Maryland, MTBE and perchlorate are not considered emerging because they are regulated through action levels; PPCPs and PBDE were listed by Maryland as top concerns among emerging contaminants[36].

Some chemicals, such as pharmaceutical and personal care products, have only recently been discovered in drinking water sources at low levels that were previously undetectable. Advances in detection methods have made it possible to measure these chemicals in small concentrations. Therefore, it is impossible to know for how long and at what concentrations these chemicals have been present in drinking water supplies in Maryland. Some emerging contaminants (including pharmaceuticals and personal care products) have been found in Maryland surface waters, including the Potomac River.

Many emerging contaminants are common chemicals found in household or pharmaceutical products that make their way into the waste stream. Routine wastewater treatment processes are not always effective at removing these chemicals, resulting in their discharge into receiving waters. Consequently, they are likely to be found in any surface water body that receives treated wastewater, and at higher concentrations nearer to discharge points. Figure 15 shows locations of drinking water intakes and wastewater treatment plants in Maryland. Many contaminants may also find their way into ground water supplies through onsite sewage disposal systems. At least one state, Virginia, is considering a pharmaceutical take-back program that would help ensure that unused pharmaceuticals are properly disposed.[37]

The relatively low concentration of emerging contaminants does not eliminate concerns about possible adverse health effects. The health effects of many emerging contaminants are under study by the EPA, the Centers for Disease Control, and others. Some health effects have been observed in animals. For example, bass in the Potomac River have exhibited a high incidence of intersex conditions (such as eggs found in male fish), which is believed to be related to the presence of endocrine disrupting compounds (EDCs)[38].

For many emerging contaminants, human health effects are unknown. For some emerging contaminants with known health effects, the effect at detected low concentrations is unknown, particularly for long-term exposure and for mixtures of compounds. Some emerging contaminants occur in drinking water at levels that are already of concern. For example, the concentration of hormones found naturally at therapeutic levels in the human body is only an order of magnitude greater than levels measured in drinking water.

Little information exists for emerging contaminants in Maryland's source waters. As more is learned about the potential health effects of the wide range and mixtures of emerging contaminants, it is likely that the concerns of water resource managers, water suppliers, and the public will increase. A monitoring program to identify the occurrence and distribution of emerging contaminants in Maryland's source waters would provide the background data necessary to make decisions about water supply development and treatment as more is learned about the health effects of the contaminants. The monitoring program should include both surface and ground water sources of drinking water, and should address seasonality. It also should be designed to understand the effect of drinking water treatment and wastewater treatment on emerging contaminants, as some have shown indications of surviving traditional treatment methods.

Access to Water Quality Data

Ready electronic access to existing water quality information would be a great public benefit, and a boon to researchers. Accessible water quality data could take the form of a common database, shared by regulators, water suppliers, scientists and researchers, and the general public. Data meeting minimum quality assurance standards could be uploaded and made available for comparison to other available data. Accessible water quality data could also take the form of statewide water quality maps showing the known occurrence of particular contaminants, both naturally occurring and the results of human activity. Some steps have been made in this direction. The University of Maryland has enlisted the help of MDE in developing a public health database, which would include water quality data available from some of MDE's databases. The MDE Waste Management Administration maintains a set of maps on its website which show the location of some sites known to have contaminated ground water as a result of human activities.

Recommendations

To increase the available information about contaminants in Maryland's drinking water sources, and to improve access to water quality data, the Subcommittee recommends the following:

- **MDE and DNR should initiate a comprehensive water quality monitoring program to assess the condition of Maryland's drinking water sources and to track the progress of other programs designed to protect and improve source water quality.**

  This program should be designed to augment existing programs such as the TMDL, Tributary Strategy, and Wellhead Protection programs, and should address a wide variety of contaminants. This program should provide data that will assist local governments in developing their Water Resource Elements and Water and Sewerage Plans. For rivers and streams upstream of major drinking water reservoirs, monitoring should include nutrients, sediment, protozoa, toxics, and emerging contaminants. For ground water, monitoring should include contaminants that are likely to occur in shallow ground water in different hydrogeologic and land use settings, and should include nitrate, chloride, bacteria, viruses, protozoa, arsenic, MTBE, radium, radon, and other selected contaminants. The program should monitor water quality conditions under a range of flow conditions and across seasons.

- **MDE and DNR should initiate studies designed to determine the occurrence and distribution of selected high priority contaminants in Maryland's source waters and their relationship to human health problems.**

  These studies should include a study to measure or estimate the position and rate of movement of the salt water or brackish water interface in affected coastal areas, and a study to investigate the link between vulnerable geology, contaminants, and the occurrence of human health problems.

- **MDE and DNR should coordinate the establishment of an electronic clearinghouse for water quality data.**

  The clearinghouse should contain water quality data compiled from many sources, and should make the data readily accessible for a wide variety of users. The clearinghouse will enable the identification of gaps in surface water and ground water data and point out where more sampling is needed.

CONCLUSION

Adequate supplies of safe drinking water are critical to Maryland's quality of life and economic future. This extensive review of water quality conditions related to drinking water supply clearly indicates that Maryland must take steps to preserve and protect water quality in order to ensure adequate sustainable drinking water supplies for future generations. The Water Quality Subcommittee's recommendations include modifying current regulations, laws, policies, and programs to protect sources of drinking water, to assist well owners in ensuring safe drinking water, and to improve the availability of water quality data. These steps are critical to Maryland's viability as a culturally vibrant, healthy, and economically vital state.

GLOSSARY OF TERMS

Anthropogenic – originating from human activities as opposed to those occurring in natural environments without human influence.

Aquifer – a geologic formation, group of formations or part of a formation that contains permeable sediment sufficiently saturated to yield significant quantities of water to wells and springs.

Capacity development – a process for improving the financial, managerial, and technical capacity of public water systems. Under the federal Safe Drinking Water Act, each State must develop a Capacity Development Program.

Coastal Plain – flat low-lying land adjacent to seacoast. In Maryland, the Coastal Plain lies east of the Piedmont, and its eastern border is the Atlantic Ocean.

Comprehensive plan – Plan developed by local governments, which encompasses advanced planning, environmental planning, policy planning, coordinated land use, zoning, transportation, research, maps, and other elements. All local jurisdictions in Maryland are required to develop and regularly update a Comprehensive Plan.

Confined aquifer – an aquifer that is overlain by a layer of clay or other material known as a confining bed, which is significantly less permeable than the aquifer. Water in the confined aquifer is under greater than atmospheric pressure.

Contaminant – any physical, chemical, biological, or radioactive substance in drinking water that makes the water unusable for a particular purpose.

***Cryptosporidium* –** a protozoan pathogen that causes a diarrheal illness called cryptosporidiosis**.**

Disinfection byproducts – organic or inorganic compounds that are often generated from the reaction between a disinfectant and naturally occurring materials in water.

***Escherichia coli (E.coli)* –** bacteria living in the lower intestines of animals and humans. The presence of *E.coli* in water is a strong indication of recent sewage or animal waste contamination.

Eutrophication – the process by which water becomes enriched with plant nutrients, most commonly phosphorus and nitrogen. Eutrophication can cause excessive growth of aquatic plant and algae in water bodies. Decay of this biomass can result in low concentrations of dissolved oxygen in the water column.

Fall Line – a line joining the easternmost water falls on rivers that marks where they descend from the upland to the lowland. It also serves as a boundary between the unconsolidated sediments of the Coastal Plain and the crystalline rocks of the Piedmont. In Maryland, the Fall Line corresponds approximately with Interstate 95.

***Giardia* –** a genus of protozoa that infect the gastrointestinal tract of some animals including humans.

House Bill 1141 – a bill passed by the 2006 Maryland General Assembly and signed into law. The law requires local governments to include a Water Resources Element in their Comprehensive Plans.

Hydrologic cycle – the basic pattern of movement of water on earth. Water moves from the atmosphere to the earth by precipitation, from the land to the oceans by stream runoff and ground water flow, then back to the atmosphere by transpiration from vegetation and evaporation.

Impervious surface – a sealed surface that repels water or prevents precipitation or melt water from infiltrating soils. This includes soils compacted by urban development, constructed surfaces, roof tops, side walks, roads, and parking lots covered by asphalt, concrete brick and stone.

Karst terrane – a landscape found in limestone, dolomite and marble areas characterized by sinkholes, sinking streams, caves, and limited surface drainage.

Oocysts – a thick walled structure in which sporozoan zygotes develop and that serves to transfer them to new hosts. Oocysts protect *cryptosporidium* and allow them to survive for lengthy periods outside a host and remain resistant to chlorine disinfection.

Public water system – a system that provides water for human consumption to the public through pipes or other constructed conveyances, if the system has at least 15 service connections or regularly serves at least 25 individuals daily at least 60 days out of the year.

Saprolite – highly weathered and disintegrated rock formed when ground water moves through the fractured upper layer of bedrock and chemically alters the most soluble constituents, leaving behind the original texture and structure of the parent rock.

Source Water Protection Areas – the areas delineated for source water intakes or wells for the purpose of defining the geographic boundaries for a source water assessment.

Turbidity – Cloudiness or haziness in water caused by individual particles (suspended solids) that are generally invisible to the naked eye.

Water Resources Element – a new requirement under House Bill 1141, that must be included in each local jurisdiction's Comprehensive Plan. The Water Resources Element must identify drinking water and other water resources that will be adequate for the needs of existing and future development proposed in the land use element of the plan, and must identify suitable receiving waters and land areas to meet storm water management and wastewater treatment and disposal needs of existing and future development proposed in the land use element.

Water and Sewer Plan – a plan developed by each county in the State, to be consistent with the comprehensive plan, that shall be used as a tool to implement the county development policy so that (1) An ample supply of water may be collected, treated and delivered to points of use; (2) waste water may be collected and delivered to points best suited for waste treatment and disposal or for re-use; and (3) waste water can be either treated before any discharge to state waters, in compliance with applicable water quality standards and discharge permit conditions, or disposed of to minimize most effectively adverse effects on legitimate water uses.

Water Supply Capacity Management Plan – a plan developed by a public water system, which evaluates water system capacity as it relates to existing and projected demand.

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APPENDIX D

Status of Streamflow and Ground-Water-Level Monitoring Networks in Maryland, 2005

The Status of Streamflow and Ground-Water-Level Monitoring Networks in Maryland, 2005

by **James M. Gerhart** (U.S. Geological Survey) and **Emery T. Cleaves** (Maryland Geological Survey)

Abstract

The monitoring of streamflow and ground-water levels in Maryland is vitally important to the effective management and protection of the State's water resources. Streamflow and ground-water-level monitoring networks have been operated for many years in Maryland, and in recent years, these networks have been redesigned to improve their efficiency. Unfortunately, these networks are increasingly at risk due to reduced and fluctuating funding from Federal, State, and local agencies. Stable, long-term funding is necessary to ensure that these networks will continue to provide valuable water data for use by State and local water-resources managers.

The Importance of Water in Maryland

Water is one of the most valuable natural resources in Maryland. It is essential to the life and health of all Maryland residents, the quality of the State's environment, and the vitality of its economy. In 2000, Marylanders used an estimated 1.45 billion gallons per day of freshwater for public supply, commercial, industrial, irrigation, and other purposes (Wheeler, 2003). Although there usually is more than enough water to meet that level of water demand, periodic droughts like the ones in the early 1930s, the mid-1960s, 1999, and 2002 can cause serious water shortages in some parts of the State. As the population of

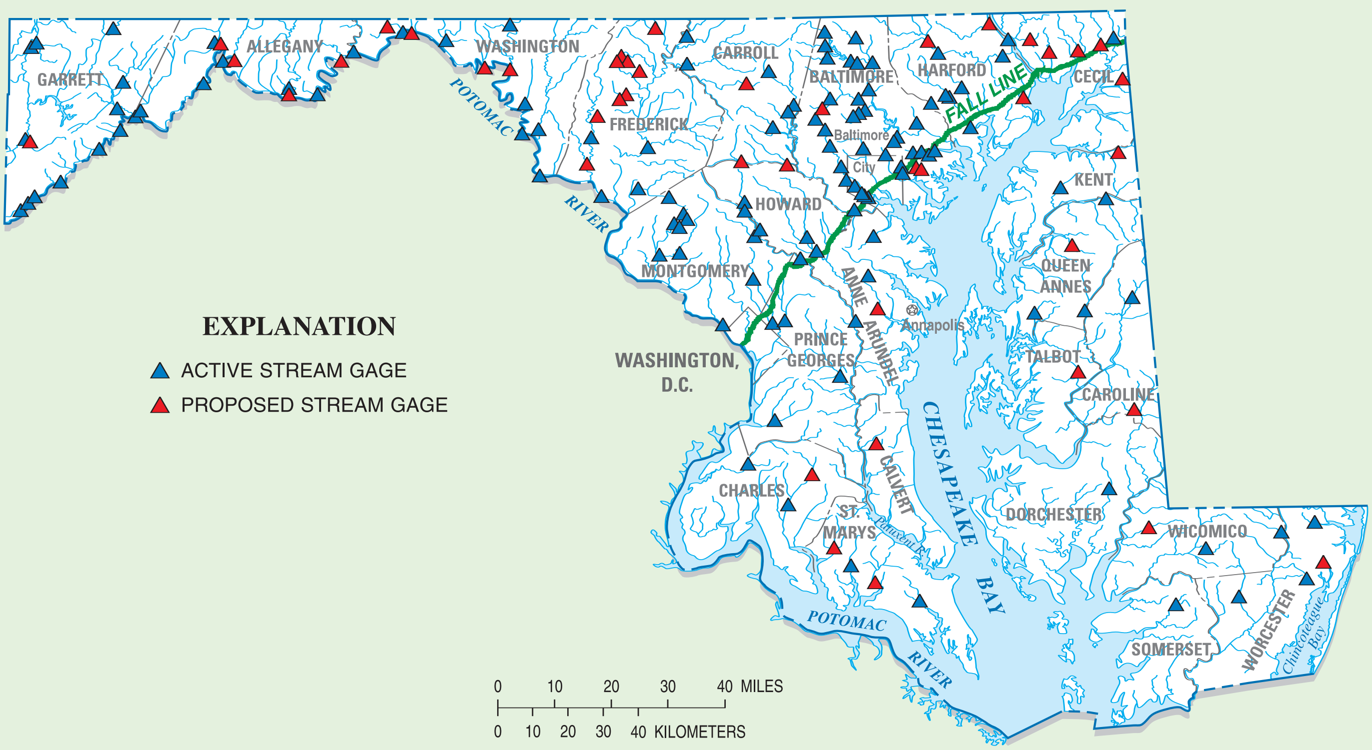

Figure 1. The optimal streamflow-monitoring network in Maryland, showing the 119 current (2005) stream gages, and the 43 recommended additional stream gages needed to reach the optimal network design.

Stream gage 01619500 on Antietam Creek near Sharpsburg, Maryland, in Washington County. *(Photograph by Charles J. Strain, USGS)*

Maryland and the demand for water continue to increase, water shortages are expected to become more common. Long-term planning for the efficient use of Maryland's water resources is critical for avoiding major water shortages in the future.

The State Advisory Committee Report

The Governor's Advisory Committee on the Management and Protection of Maryland's Water Resources was established in late 2003 to map out a long-term plan for managing and protecting the State's water resources. In August 2004, the Committee released a report (State of Maryland, 2004) containing numerous recommendations, including one for maintaining and enhancing the monitoring of Maryland's water resources. The Committee's report recognized that without adequate monitoring data, "...it will become difficult or impossible to determine the availability of surface water or ground water, to assess and react to droughts, to determine the potential interference of competing water users, and to assess the impacts of water use on the State's aquifers and streams, while maintaining minimum stream flows" (State of Maryland, 2004).

Two Major Water-Monitoring Components

Two critical components of water-resources monitoring in Maryland are the monitoring of streamflow and the monitoring of ground-water levels. Maryland is fortunate to have a long history of streamflow and ground-water-level monitoring. Streamflow in most major streams in the State has been monitored for about the last 50-100 years, and ground-water levels in most major aquifers in the State have been monitored for about the last 50 years. Both of these long-term monitoring programs have been operated primarily by the U.S. Geological Survey (USGS), in partnership with the Maryland Geological Survey (MGS), and with the financial support of many other Federal, State, and local agencies.

Streamflow Monitoring Network

Currently (2005), the USGS operates 119 streamflow-monitoring gages in Maryland (fig. 1). Stream stage is monitored at each gage every 15 minutes. Streamflow is calculated from stream stage through the use of rating curves that have been developed over time and frequently updated. Streamflow data for 83 of 119 gages are available in near real time on the USGS website *(http://waterdata.usgs.gov/md/nwis/rt)*. All streamflow data are reviewed and published annually, and are available on the USGS website. A streamflow hydrograph for Deer Creek at Rocks, Maryland, for the period October 1, 1998 through September 30, 2003, is shown in figure 2; the hydrograph illustrates the low streamflows during the

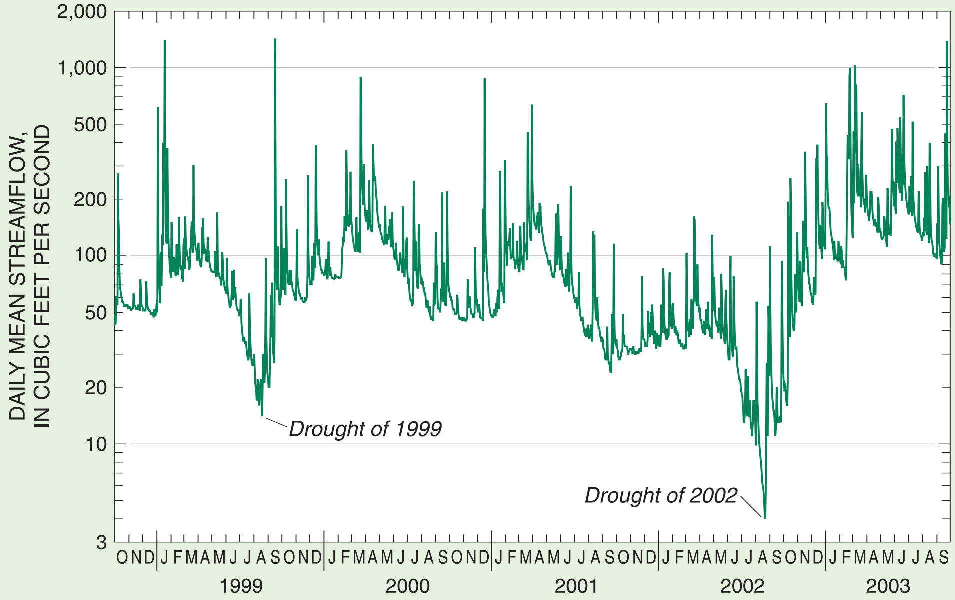

Figure 2. A 5-year streamflow hydrograph for the stream gage at Deer Creek at Rocks, Maryland. Note the low streamflows during the 1999 and 2002 droughts.

droughts of 1999 and 2002.

Streamflow data are used by many Federal, State, and local agencies in Maryland. Some of the many uses of streamflow data include: (1) water-supply assessment; (2) watershed management; (3) stream restoration; (4) bridge design; (5) flood warning; (6) sediment and contaminant loading; and (7) recreational activities. The principal funding agencies for the Maryland streamflow-monitoring network are USGS, MGS, Maryland State Highway Administration, U.S. Army Corps of Engineers, Maryland Department of the Environment, Maryland Department of Natural Resources, Baltimore County, and Baltimore City.

The number of Maryland's streams that are monitored each year depends on the availability of funding. In 1996, the number of gages in Maryland totaled only 75, the lowest number in recent years (fig. 3). In the late 1990s, as a result of an interagency workshop and a concerted effort by many agencies working together through the Maryland Water Monitoring Council, a report that presents a design for an optimal gage network in Maryland was published (Cleaves and Doheny, 2000). As a direct result of that effort, as well as the reaction to the droughts of 1999 and 2002, the number of gages had risen to 110 by 2002. By the beginning of 2005, the number of gages was 119 (fig. 3).

Even though the number of gages has increased fairly steadily over the last decade, the number of long-term (greater than 50 years of record) gages threatened by funding shortages has been increasing in the last few years. A threatened gage is sometimes "saved" at the last minute by funding from an interested Federal, State, or local agency. In some cases, however, a gage is discontinued when replacement funding is not available. Stable, long-term funding would guarantee the continuation of these especially valuable long-term gages, as well as the gage network as a whole.

The Advisory Committee's report (State of Maryland, 2004) suggests that all currently operating gages be maintained with stable, long-term funding to prevent breaks in the long-term continuous records at the monitoring sites. In addition, the report recommends that gages be added on 43 other streams in Maryland as funds allow, for the purposes of addressing unmet small-watershed, core-network, and geographic-coverage needs. The desired complete network of gages would provide the data needed to make sound management and protection decisions for all important streams and watersheds in the State.

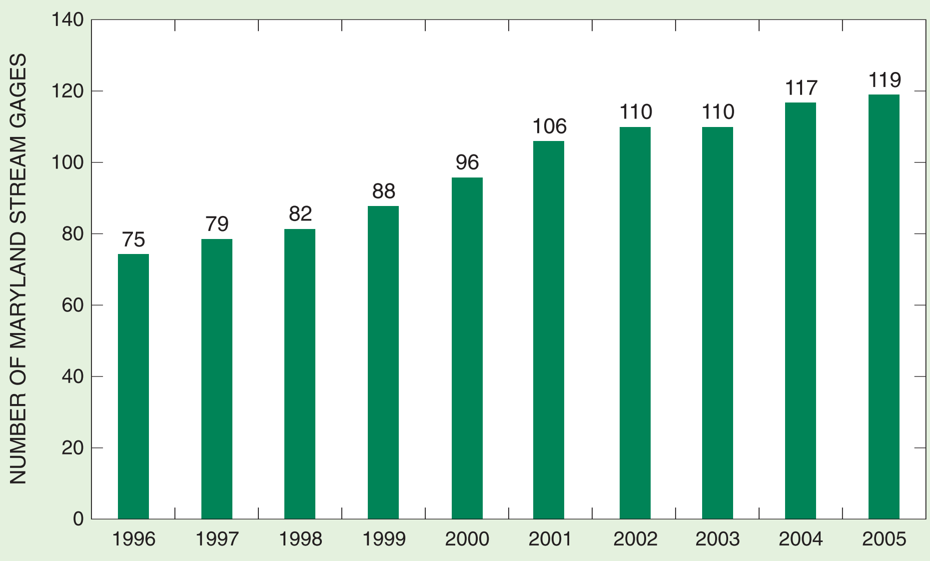

Figure 3. The number of Maryland stream gages during 1996-2005. Note the steady increase, which is attributed to the efforts of the Maryland Water Monitoring Council and the reaction to the droughts of 1999 and 2002.

Observation well WA Ci 82 in Washington County, Maryland, with near-real-time transmission equipment. *(Photograph by Charles J. Strain, USGS)*

Ground-Water-Level Monitoring Networks

Ground-water-level data provide one of the only direct measures of the health of Maryland's aquifers. Ground-water-level data are used by many Federal, State, and local agencies to: (1) discern long-term trends; (2) provide drought warning and tracking; and (3) inform the State's ground-water appropriation permitting process. The funding agencies for Maryland's large-scale ground-water-level networks are USGS and MGS. Other smaller networks are operated by USGS and MGS for specific local purposes, and are supported by the Interstate Commission on the Potomac River Basin, Calvert County, Charles County, Anne Arundel County, and other local jurisdictions.

The USGS and MGS measure ground-water levels in aquifers in Maryland for two primary purposes. The water table in the fractured-rock and unconsolidated-sediment aquifers is monitored statewide for the effects of climate variability; the water levels in the confined unconsolidated-sediment aquifers of the Atlantic Coastal Plain are monitored for the effects of ground-water pumpage (M.T. Duigon, Maryland Geological Survey, written commun., 2004). In each network observation well, water level is either measured by hand using an electric tape, or continuously using an automated logging device. Nine wells are equipped with near-real-time capability.

Under the auspices of the Maryland Water Monitoring Council, a multi-agency workshop was convened in June 2002 to begin the process of redesigning the ground-water-level monitoring networks for Maryland. By 2004, new optimal designs had been adopted for both the water-table-aquifer and the confined-aquifer observation-well networks.

Water-Table-Aquifer Network

The first of the two ground-water-level networks in Maryland—the water-table-aquifer network (fig. 4)—ideally would include 81 observation wells and is designed to capture the effects of precipitation on ground-water levels in key topographic settings in all major physiographic and geologic units in Maryland. In the fractured-bedrock aquifers west of the Fall Line, most wells would be paired, with one in the bedrock and one in the weathered material above the bedrock; in the unconsolidated-sediment aquifers east of the Fall Line, single wells would be used (fig. 4). Water-level data from this network would be used to track the progress of droughts and subsequent recovery from them, and would be used by the State as a guide for imposing drought-related water restrictions on a regional basis. The water-level hydrograph in figure 5 covers a 5-year period from October 1, 1998 through September 30, 2003 for well MO Eh 20 in Montgomery County, and shows the low water levels during the droughts of 1999 and 2002.

Unfortunately, the optimal water-table-aquifer network currently is not complete. Water levels have been measured in 30 of the 81 wells for many years, but 51 additional wells are needed to complete the network and fully represent all the key topographic settings in the major hydrogeologic units in Maryland. The Advisory Committee's report (State of Maryland, 2004) recommends that all current wells be maintained and that the additional needed wells be added as funding permits.

Confined-Aquifer Network

The second of the two ground-water-level networks in Maryland—the confined-aquifer network—is designed to capture the effects of ground-water pumpage, and ideally would include 159 observation wells in the seven most important aquifers in Maryland's Coastal Plain (the Chesapeake Group, Piney Point-Nanjemoy, Aquia, Magothy, upper Patapsco, lower Patapsco, and Patuxent aquifers). The optimal network for one of these aquifers, the Aquia, is shown in figure 6 and indicates the number of wells that are currently being monitored and the number of additional wells needed to meet the optimal network design. Similar optimal

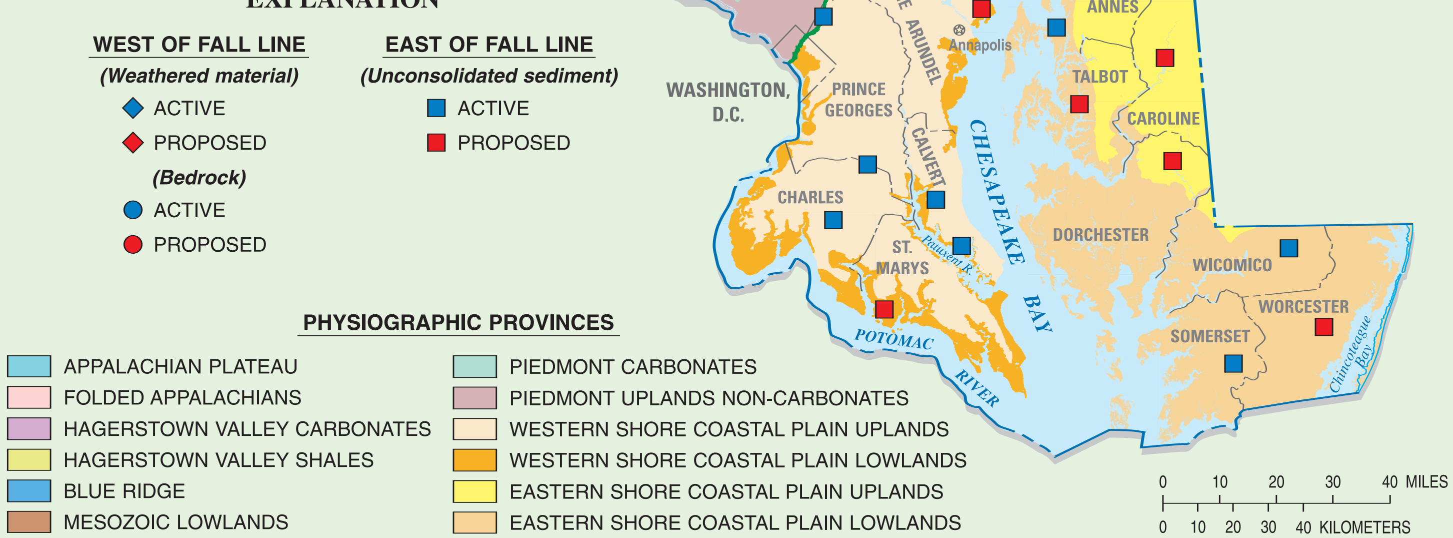

Figure 4. The optimal water-table aquifer, observation-well network in Maryland, showing the 30 current (2005) observation wells, and the 51 recommended additional observation wells needed to reach the optimal network design (modified from M.T. Duigon, Maryland Geological Survey, written commun., 2004).

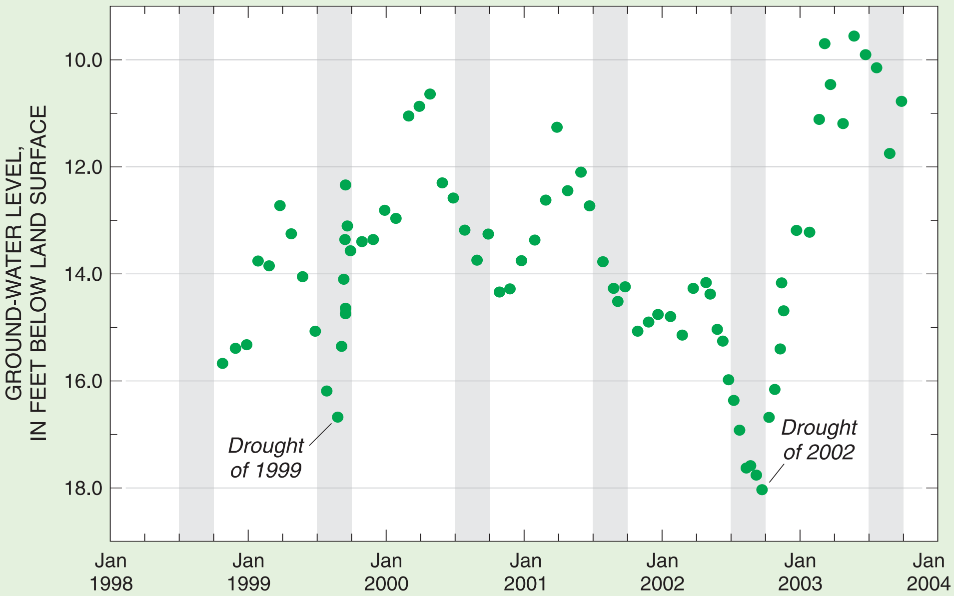

Figure 5. A 5-year ground-water-level hydrograph for water-table-aquifer observation well MO Eh 20 in Montgomery County, Maryland, showing seasonal variations in ground-water levels and the low levels during the droughts of 1999 and 2002. (Gray bars indicate July-October of each year.)

networks have been designed for each of the other six major Coastal Plain aquifers.

As ground water is pumped from these confined aquifers, the pressure in the aquifers decreases, causing water levels in observation wells to decline. A water-level hydrograph for an observation well (CA Gd 6) in the Aquia aquifer near Solomons in Calvert County, where the water level has been declining since the 1960s due to ground-water pumpage, is shown in figure 7. The hydrograph shows that the rate of decline increased significantly in the mid-1980s, with the total decline over the past 45 years being about 120 feet. The amount and rate of water-level decline are valuable indicators used in determining the availability of ground water to meet future demands from each of these aquifers.

As is the case with the water-table-aquifer network, the confined-aquifer network is also incomplete. The current observation-well networks for all seven major Coastal Plain aquifers consist of 110 observation wells, but 49 additional wells are needed to complete the networks as designed and to provide all the necessary data to support sound ground-water allocation decisions for all areas in Maryland where the seven major confined aquifers are present. The Advisory Committee's report (State of Maryland, 2004) recommends maintenance of the current number of observation wells and the addition of new wells, including drilling when necessary, as funding permits.

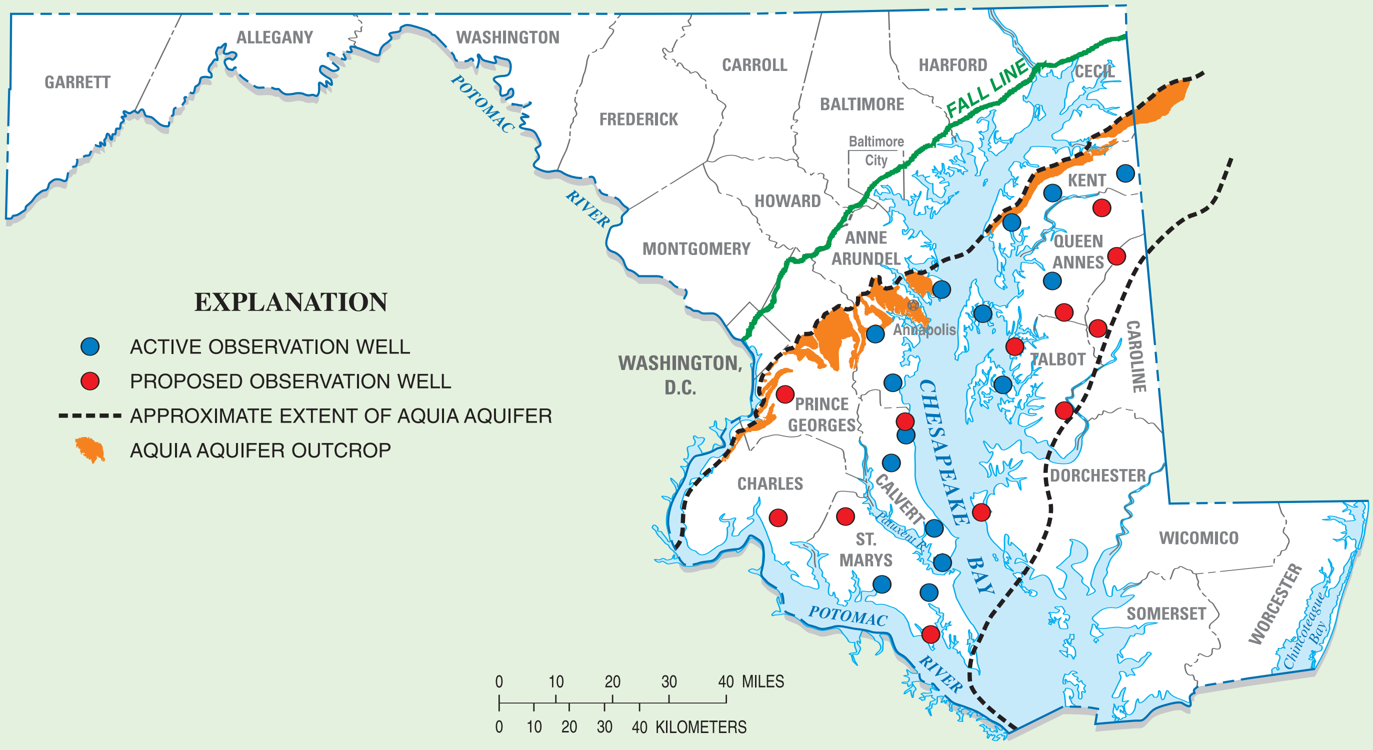

Figure 6. The optimal confined-aquifer, observation-well network in Maryland's Aquia aquifer, showing the 15 current (2005) observation wells, and the 12 recommended additional observation wells needed to reach the optimal network design for the Aquia aquifer.

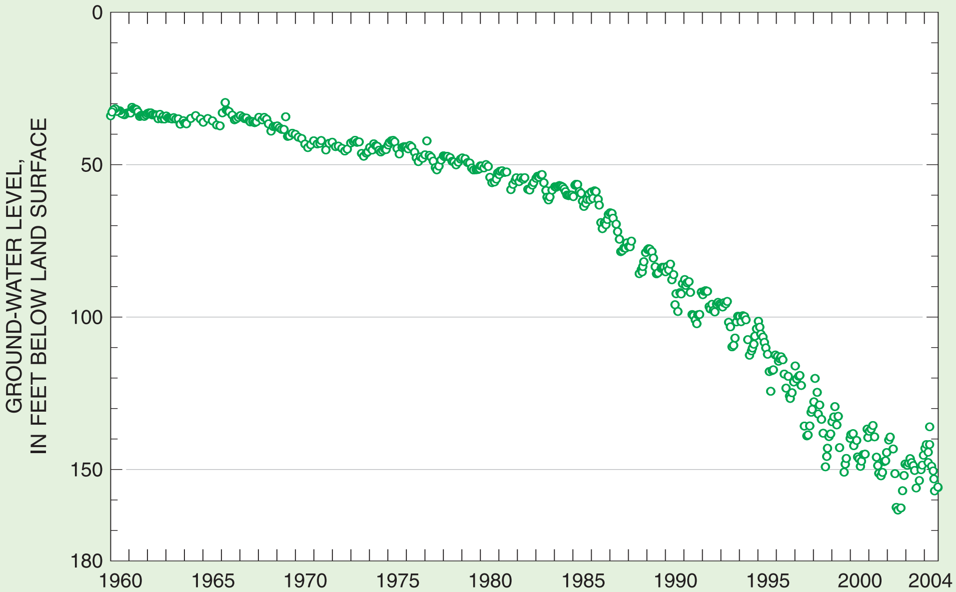

Figure 7. A 45-year ground-water hydrograph for confined-aquifer observation well CA Gd 6 near Solomons in Calvert County, Maryland, showing the declining water levels due to ground-water pumpage. Note the significant increase in rate of decline in the mid-1980s.

Summary

Monitoring of streamflow and ground-water levels in Maryland is necessary for the sound management and protection of the State's water resources. Numerous Federal, State, and local agencies support the current monitoring efforts, and use the streamflow and ground-water-level data to inform many important decisions being made in Maryland. The Advisory Committee on the Management and Protection of Maryland's Water Resources strongly supports the continuation and enhancement of streamflow and ground-water-level monitoring in Maryland. Long-term data on streamflow and ground-water levels are readily available on the U.S. Geological Survey website, and optimal networks for streamflow and ground-water-level monitoring have been designed through multi-agency efforts. The full implementation of the optimal networks, which will supply the water data necessary to provide sound and efficient water-resources management and protection decisions, depends on adequate funding from Federal, State, and local agencies. Stable, long-term funding support is needed to guarantee that streamflow and ground-water-level data are available when needed.

Stream gage 0158397967 on Minebank Run near Glen Arm, Maryland, in Baltimore County. *(Photograph by Michael A. Hansen, USGS)*

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8987 Yellow Brick Road
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or visit the Maryland-Delaware-District of Columbia District homepage on the World Wide Web at:
http://md.water.usgs.gov

To access near-real-time streamflow data for Maryland, visit: **http://waterdata.usgs.gov/md/nwis/rt**

For information about the Maryland Department of Natural Resources, visit:
http://www.dnr.state.md.us

To learn more about the Maryland Water Monitoring Council, visit:
http://www.mgs.md.gov/mwmc

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APPENDIX E

Description of the Coastal Plain Aquifer Study:

Sustainability of the Ground-Water Resources in the Atlantic Coastal Plain of Maryland

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Sustainability of the Ground-Water Resources in the Atlantic Coastal Plain of Maryland

A 2004 report by the Advisory Committee on the Management and Protection of the State's Water Resources identified the need for a comprehensive assessment of ground-water resources of the Maryland Coastal Plain, where the population is expected to grow by 37 percent between the years 2000 and 2030. Accordingly, the Maryland Geological Survey (MGS) and the U.S. Geological Survey (USGS) have begun the first phase of a three-phase assessment of Maryland's Coastal Plain aquifer system. This Fact Sheet describes this assessment and the current and planned activities necessary for its implementation.

Importance of Ground Water in the Atlantic Coastal Plain of Maryland

Ground water is the primary source of water supply in most areas of Maryland within the Atlantic Coastal Plain (fig. 1), and is pumped from sand and gravel layers underlying the Coastal Plain. These sand and gravel layers alternate with layers of silt and clay to form a wedge-shaped system of sediments that begins at the Fall Line (the boundary between the Atlantic Coastal Plain and the Piedmont Physiographic Provinces) and gently tilts and thickens to the southeast toward the Atlantic Ocean (fig. 2). The buried sands and gravels form a sequence of confined aquifers that is overlain by sandy deposits that form a surficial aquifer. These aquifers are the primary water supply for southern Maryland and the Eastern Shore.

Why is this Assessment Necessary?

1) Water Levels in the Aquifers are Declining at a Significant Rate

Withdrawals from Maryland Coastal Plain aquifers have caused ground-water levels in confined aquifers to decline by tens to hundreds of feet from their original levels (fig. 3). The current rate of decline in many of the confined aquifers is about 2 feet per year. The declines are especially large in southern Maryland and parts of the Eastern Shore, where ground-water pumpage is projected to increase by more than 20 percent between the years 2000 and 2030, with some regions experiencing significantly greater increases. Continued water-level declines at current rates could affect the long-term sustainability of ground-water resources in Maryland's heavily populated Coastal Plain communities and the agricultural areas of the Eastern Shore.

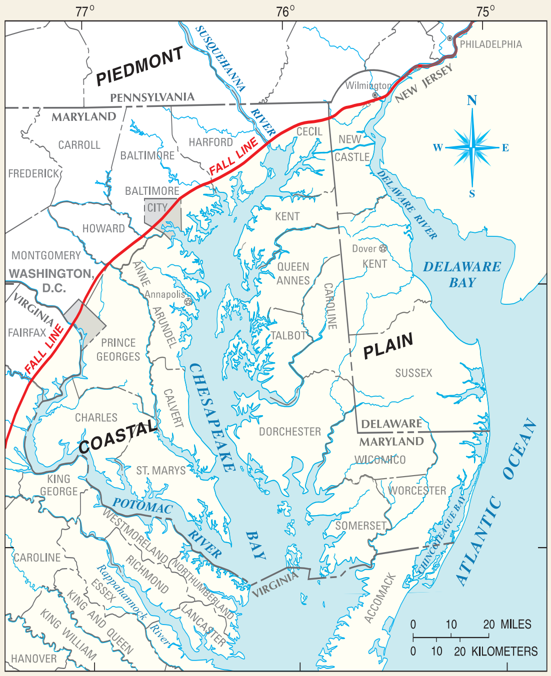

Figure 1. Extent of the Atlantic Coastal Plain in Maryland and adjacent states.

2) Water Quality in Some Areas is Significantly Compromised

Water quality in the Coastal Plain aquifers is a concern for several reasons. Contamination by saltwater intrusion is a significant water-quality issue for the confined aquifers, and has been documented in several of Maryland's waterfront communities. However, the potential for saltwater intrusion is not well known in the deeper parts of the aquifer system because few data are available. Some areas have problems with naturally high concentrations of trace-element contaminants (including arsenic and radium), and further evaluation of these public health issues is warranted. Elevated concentrations of nutrients and agricultural chemicals in the surficial aquifer is a significant concern, especially on the Eastern Shore, where shallow ground water is the water-supply source for many homeowners and provides much of the base flow to streams.

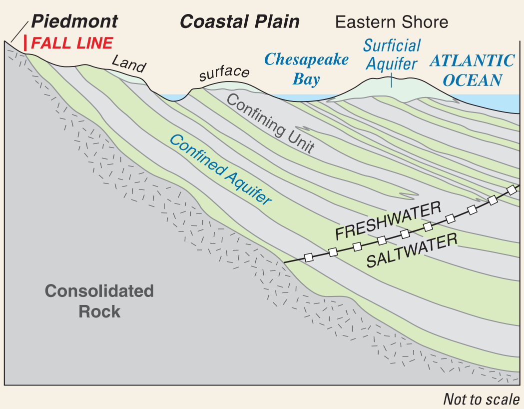

Figure 2. Schematic of the Atlantic Coastal Plain aquifer system in southern Maryland.

3) Ground-Water Resource Managers Need Better Tools

Water managers, policymakers, planners, and developers need to know how much ground water is available in the different areas of the Maryland Coastal Plain for public and domestic water supply, agriculture, industry, and electric power generation. Ground-water withdrawals in Maryland are managed by the Maryland Department of the Environment (MDE) through the Water Appropriations Permit Program. While studies of individual aquifers or multi-aquifer subregions are available, MDE needs more comprehensive

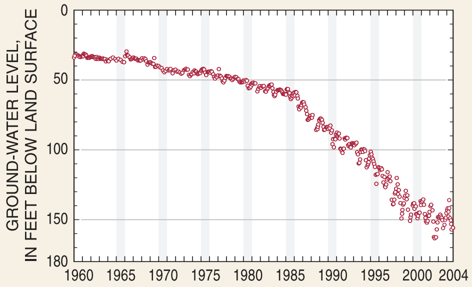

Figure 3. Hydrograph showing declining water levels in a well in the Aquia aquifer in southern Maryland.

and interactive tools for making management and permitting decisions. Specifically, MDE needs information systems and simulation tools to evaluate the effects of increased withdrawals on the entire aquifer system in important subregions and throughout the Maryland Coastal Plain. These tools need to take into account that some of the aquifers are units of a regional system that extends into and is used for water supply in adjacent states.

Evaluation of alternative water-management strategies requires enhancements in the monitoring networks for ground-water levels and streamflow throughout the Coastal Plain. Water managers and planners need to understand where and when continued withdrawal of ground water may reduce streamflow and/or induce changes in water quality that would require additional treatment or limit uses of the water resource.

Plans for the Comprehensive Assessment of the Coastal Plain Aquifer System in Maryland

In response to the Advisory Committee's 2004 report recommendations, MGS and USGS are preparing a science plan and implementation plans for conducting a comprehensive regional assessment of the Coastal Plain aquifers in Maryland and appropriate areas of surrounding states.

Comprehensive Assessment is Underway

MGS and USGS started Phase I of the Comprehensive Assessment in January 2006. Phase I activities are being jointly supported by funds and services from MDE, MGS, and USGS. Phases II and III of the assessment will require significant additional investment from current and new funding partners from 2008 to 2013.

Goals of the Assessment

- Document the geologic and hydrologic characteristics of the aquifer system in the Maryland Coastal Plain and appropriate areas of neighboring states.
- Conduct detailed studies of the regional ground-water-flow system and water budget for the Coastal Plain aquifer system in Maryland.
- Improve documentation of patterns of water quality in all Coastal Plain aquifers, including the distribution of saltwater.
- Enhance ground-water-level, streamflow, and water-quality monitoring networks in the Maryland Coastal Plain.
- Develop tools to facilitate scientifically sound management of the ground-water resources in the Maryland Coastal Plain.

Implementation Plans

PHASE I (2006-2008) *Getting Started and Building Partnerships*	PHASE II (2008-2012) *Filling in the Gaps and Building the Resource Management Tools*	PHASE III (2010-2013) *Using the Tools to Manage and Optimize the Resource*
• Develop an aquifer information system. • Refine the aquifer framework. • Determine management criteria. • Identify information gaps. • Develop plans for addressing gaps. • Build partnerships and inform the public.	• Develop and test ground-water-flow model. • Simulate flow system and conduct field studies of recharge and leakage. • Enhance ground-water-level and streamflow-monitoring networks. • Conduct water-quality studies.	• Develop optimization model. • Link flow and optimization models to create interactive management model. • Test water-management scenarios. • Inform partners and stakeholders.

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APPENDIX F

Description of the Fractured Rock
Water Supply Study

Fractured Rock Water Supply Study

In the region of the State west of the Fall Line, ground water is obtained from fractured rock aquifers. Watershed based, water balance methods are used to determine if sufficient ground and surface water is available to supply the requested need without unreasonable adverse impact on the streams in the watershed. The evaluations are conducted by WSP staff using land use information and hydrologic data from a variety of databases. Increasing development pressures are expected to greatly increase the demand for water over the next 20 years. There is concern that some of the assumptions and limitations of the current water balance methods may result in unacceptable impacts on streams, particularly in heavily developed watersheds or watersheds where seasonal low flows are substantially lower than annual average flows. For example, the methodology may not fully account for the cumulative impacts of ground water and surface water withdrawals in the same watershed, may not be sufficiently protective during severe droughts, or may not account for the full impacts of water withdrawals concentrated in one part of a watershed. Information on the relationship between water quantity and stream ecology is limited, and thus it is difficult to predict the potential impacts of withdrawals on aquatic biota.

Some watersheds in the fractured bedrock areas of Maryland have already shown signs of reaching the limits of their ability to provide water without adverse impacts on ground water and streams. This is expected to occur more frequently as Maryland's population continues to grow. As the requests for new water withdrawals increase, it is critical that the Maryland water managers have a set of tools to assist in evaluating new requests for water.

MDE has proposed, with cooperation from the U.S. Geological Survey and the Maryland Geological Survey, a study of water supply in the fractured rock region of the State, with special emphasis on the Piedmont aquifers. The project would provide MDE with a set of improved tools with which to plan the development and management of ground and surface water in that part of Maryland underlain by fractured bedrock. These new tools will utilize the same watershed based, water balance concepts as the current methods, but they will allow decisions about future water withdrawals to be made more reliably and efficiently. These tools will also be user friendly, and make efficient use of staff time needed to evaluate permit applications.

The completed project will provide a set of tools that can be used by MDE staff to evaluate water availability and new permit applications in that part of Maryland north and west of the Fall Line, particularly in the Piedmont and Blue Ridge provinces. An Aquifer Information System, similar in concept to one developed for the Coastal Plain Aquifer Study, will be developed. This tool will include water use data, stream information, hydrogeologic information, well data, and precipitation data, and will present data in a geographical context. This tool will be linked with a second application that will allow users to estimate natural stream flows as well as the potential impacts of surface water or ground water withdrawals on stream flows.

The project will also correlate data from the Maryland Biological Stream Survey with the water availability and use data in an attempt to establish relations between stream flow, water withdrawals, and the diversity and/or abundance of riverine species or communities in Maryland. The results of this task will provide additional guidance for determining appropriate stream flows needed to protect aquatic resources.

Understanding the factors related to ground water availability in central and western Maryland is an important component of water resources management. Because stream base flow is derived entirely from ground water discharge, factors affecting ground water availability will have a direct bearing on stream flow. In addition, a number of communities in Maryland have experienced situations where numerous wells have been drilled in an attempt to locate wells with sufficient yield. This study will attempt to determine factors that influence ground water availability in various hydrogeologic settings.

Finally, two research watersheds will be established in the Piedmont/Blue Ridge province to address water resource issues that are not readily answered at a larger scale, and to establish sites for long term hydrologic monitoring. Issues that may be addressed include but are not limited to the relation between ground water withdrawals and stream flow, the effects of seasonal variability in recharge and withdrawals, the sensitivity of aquatic organisms to variations in stream flow, water availability in headwaters versus downstream areas of the watershed, and the effects of changing land use on surface and ground water availability and quality. Long term monitoring of biological and water resources at the watershed scale would enable researchers to identify cause-and-effect relationships as land use and other changes occur through time within the watershed.

APPENDIX G

Proposed Budget

Water Resources Advisory Committee Recommended Funding Needs

SFY 2010 - 2017 Proposed Budget (in thousands of dollars)	2010	2011	2012	2013	2014	2015	2016	2017	8 Yr Total
1. Watershed Assessment and State Plan									
* Contractual (Coastal Plain aquifer study)	1,375	2,350	2,850	2,400	1,800	1,000			11,775
* Contractual (Fractured Rock water supply study)	986	1,397	1,164	1,114	1,051				5,712
* Contractual (Hydrologic monitoring of ground water and surface water - expansion of network and O&M)	1,095	1,420	1,760	1,960	910	937	965		9,047
* Technical personnel (to oversee contracts with other study agencies, review data, coordinate development with existing program, update and maintain modeling system) (2 MDE positions)	136	142	149	156	163	170	178	186	1,280
* Technical personnel to conduct biological studies and develop policies for protection of instream biota (2 DNR positions)	124	130	136	142	148	155	162	170	1,167
* Contractual services (develop State Water Supply Plan)	100	100	100	0	0	0	0	0	300
* Administrative personnel to assist with fiscal activities such as grant applications, contract oversight (1 MDE position)	60	63	66	69	72	75	79	82	565
* Date entry personnel (1 MDE position)	39	41	43	45	47	49	51	53	367
* Operational support	33	12	12	20	25	12	20	12	146
Total 1	**$3,948**	**$5,655**	**$6,279**	**$5,905**	**$4,216**	**$2,399**	**$1,455**	**$504**	**$30,359**
2 Support to Local Govts/Regional Facilitation									
* Contractual (grants to local governments)	2,200	2,200	2,200	2,200	2,200	2,200	2,200	2,200	17,600
* Technical personnel (to provide technical support for WREs, review and comment on WREs and capacity management plans, facilitate regional planning, and manage Water Supply Plan after development) (6 MDE positions)	435	455	476	498	521	545	570	596	4,095
* Technical personnel (to provide technical support for WREs, review and comment on WREs and capacity management plans and facilitate regional planning) (2 MDP positions)	136	142	149	156	163	170	178	186	1,280
* Administrative personnel to support technical personnel (1 MDE position)	47	49	51	54	56	59	62	64	442
* Operational support	70	41	41	50	61	41	50	41	395
Total 2	**$2,888**	**$2,887**	**$2,917**	**$2,957**	**$3,001**	**$3,015**	**$3,059**	**$3,088**	**$23,813**
3 Water Allocation and Permit Enforcement									
* Contractual services (database development and maintenance, with incorporation of GIS capabilities)	500	100	100	100	100	100	100	100	1,200

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SFY 2010 - 2017 Proposed Budget (in thousands of dollars)	2010	2011	2012	2013	2014	2015	2016	2017	8 Yr Total
* Permitting - Technical and administrative personnel to enhance turnaround times for appropriation permits, coordinate permit issuance with reviews of water and sewerage plans and other regulatory programs, adopt new regulations, fulfill regulatory requirements such as triennial reviews of permits and Public Information Act requirements and work individually with permittees to resolve special situations)(13 MDE positions)	937	980	1,025	1,072	1,122	1,173	1,227	1,284	8,821
* Enforcement - Technical personnel (to conduct enforcement activities, including reviewing and evaluating compliance with permit limits, special conditions, and reporting requirements, and preparing enforcement actions (4 MDE positions)	261	273	286	299	312	327	342	358	2,457
* Operational support	129	60	60	89	100	60	89	60	647
Total 3	**$1,827**	**$1,413**	**$1,471**	**$1,560**	**$1,634**	**$1,660**	**$1,758**	**$1,801**	**$13,124**
4 Source Water Protection									
* Technical personnel (to assist local governments with development and implementation of source water protection programs) (2 MDE positions)	140	146	153	160	168	175	183	192	1,318
* Operational support	8	4	4	8	4	4	8	4	44
Total 4	**$148**	**$150**	**$157**	**$168**	**$172**	**$179**	**$191**	**$196**	**$1,362**
5 Interstate Coordination									
* Technical personnel (to participate in interstate planning and coordination with ICPRB, SRBC, etc) (1 MDE position)	77	81	84	88	92	96	101	105	725
* Operating costs	3	2	2	3	2	2	3	2	19
Total 5	**$80**	**$83**	**$86**	**$91**	**$94**	**$98**	**$104**	**$107**	**$744**
6 Outreach/Education									
* Contractual Services (to develop outreach program for MDE's water resources programs)	200	10	10	10	10	10	10	10	270
* Contractual Services (printing, distribution, advertising costs)	150	150	150	150	150	150	150	150	1,200
* Contractual services to promote good agricultural practices	50	50	50	50	50	50	50	50	400
* Administrative personnel to manage and oversee the program (1 MDE position)	72	75	79	82	86	90	94	99	678
* Operational support	3	2	2	3	2	2	3	2	19
Total 6	**$475**	**$287**	**$291**	**$295**	**$298**	**$302**	**$307**	**$311**	**$2,567**
Annual Total	9,366	10,475	11,201	10,977	9,415	7,653	6,875	6,007	
8-YEAR NEED TO ENHANCE PROGRAMS									**$71,969**

1. Monitoring costs are based on adding 16 gages per year for 3 years and 25 wells per year for 4 years. Cost estimates include installation plus operation and maintenance, but do not include laboratory analytical costs.

2. Personnel costs include salary, fringe, and indirect costs. 2009 salaries were used with an estimated 4.6% increase per year.

3. Operational costs include vehicles, reference materials, computers, office supplies, technical equipment, printing, travel, etc.

4. Fractured Rock study estimates based on preliminary project proposal.

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APPENDIX H

Status of Previous Recommendations

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Status of Recommendations from Previous Advisory Committee Reports

May 2004 Report

1. Continue the Comprehensive Evaluation of Watersheds and Aquifers that are Significant Sources of Water Supply. Continue an Advisory Committee to Provide Guidance in Implementing the Recommendations.

- Continue conducting, in cooperation with the other participating agencies (Agriculture, Health and Mental Hygiene, Planning, and Natural Resources), the statewide evaluation of water supply sources, and repeat the evaluations at regular intervals to ensure consistency with changing demographics and resource conditions.
    - MDE conducted a detailed study of water availability and use in the Catoctin Creek watershed of Carroll County. The study provided a number of insights into the Piedmont region and MDE's water allocation policies, which highlighted the need for a more comprehensive water supply study in the Piedmont region of the State.
    - MDE, MGS, and USGS developed a preliminary proposal to study the water resources in the fractured rock region of the State, focusing on the Piedmont counties. The proposed project will study the ecological impacts of water withdrawals as part of an overall assessment of water availability in the region. The Interim Report recommends completion of this project. This project has not been funded, and no work has begun. The Final Report again recommends the need for studying water supply in the Piedmont region of the State.
- Develop a comprehensive multi-aquifer model for the Coastal Plain to be used for ground water management purposes such as issuing permits for wells and developing appropriate County Water and Sewerage Plans.
    - MDE, through contracts with the U.S. Geological Survey (USGS) and the Maryland Geological Survey (MGS), began a comprehensive study of the Coastal Plain aquifer systems of southern Maryland and the Eastern Shore. Phase I of the study, which was initiated in January 2006, was funded by MDE, with in-kind contributions from MGS and USGS.
- Establish an Advisory Committee to provide periodic evaluation of implementation of the recommendations.
    - The Advisory Committee was reauthorized May 16, 2005 and is submitting its Final Report July 1, 2008.

2. Restore Funding for Existing Observation Wells and Stream Gages Deleted from the FY2005 Budget; Expand Monitoring Networks as Funding Becomes Available.

- Promptly restore funding for the statewide stream flow and ground water monitoring networks so that there is no interruption in the essential continuity of the data collection.
    - o MDE identified funding to continue operation of the existing monitoring wells and stream gages that were targeted to be eliminated. These wells and gages continue to be operational.
- Prioritize expansion of the two monitoring networks and phase in new monitoring stations as funding becomes available.
    - o Recommendations were developed for expanding the monitoring well and stream gage networks. The budget estimates include both infrastructure costs for installing the necessary equipment, and ongoing annual costs for operating and maintaining the wells and gages. The Advisory Committee's final report recommends full funding for this effort.

3. Improve Coordination Between Maryland and Virginia Regarding Water Allocations from the Potomac River.

- Initiate discussions with Virginia to establish a coordinated permit review process.
    - o Virginia and Maryland have had preliminary discussions regarding coordination of permit evaluations from the Potomac.
- Coordinate with Virginia to update drought management procedures relative to the Potomac River Basin.
    - o Virginia promulgated new regulations for surface water withdrawals that became effective on July 25, 2007. The regulations include special conditions for withdrawals from the Potomac River. Further coordination is needed to better manage withdrawals upstream of the metropolitan Washington area.

4. Support Water and Sewer Planning at the State and Local Government Levels.

- Restore staff support at the State level to provide technical assistance for development of Water and Sewerage Plans at the local level.
    - o No progress.
- Restore financial assistance where needed for counties to prepare the Water and Sewer Plans.
    - o No progress.

- Consider changes to enhance the utility of the water and sewer planning process, such as incorporation of source protection plans and assessments of available water resource.
  - o No progress. This Final Report also recommends development of requirements for source water protection

5. **Implement a Comprehensive Outreach Program to Educate Maryland Citizens and Create Partnerships for Stewardship of the State's Water Resources.**

- Include outreach as one of the responsibilities for additional State staffing.
  - o The July 2006 Interim Report also recommended the development of an outreach program to educate Maryland citizens, the regulated community, and State and local officials regarding the importance of water resource management, water supply protection, and water conservation and efficiency practices. The recommendation is repeated in this Final Report of the Advisory Committee.
- Encourage water utilities to employ water conservation and efficient water use technologies to meet their resource needs.
  - o MDE has identified funding to support one or two demonstration projects with local water suppliers. The Department is currently seeking local governments willing to participate in the projects.
  - o In May 2007, MDE provided financial support and collaborated with the Joint Chesapeake Water Environment Association and Chesapeake Section: American Water Works Association Water Reuse Committee to sponsor a seminar on water reuse that focused on public health implications of using reclaimed water. The Department actively participates on this Joint Committee, which sponsors annual seminars.
- Encourage water utilities to conduct routine water audits, identify unaccounted losses, and pursue leak detection and repair programs.
  - o Since 2003, large water systems serving more than 10,000 persons must submit information about their best management practices for water conservation when applying for a new or expanded water appropriation permit. No formal program has been developed to encourage or assist water utilities to make more efficient use of their water resources

6. **Exempt Withdrawals below a Minimum Threshold in the Appropriation Permit Law.**

- Modify State statutes and regulations.

  - Legislation was enacted to exempt withdrawals under 5,000 gallons per day, with certain exceptions, from the requirement to obtain a permit.

7. Review Laws, Regulations, Funding Resources, and State Laboratory Capacity Relative to Comprehensive Management of the State's Water Resources.

- Establish a process to ensure that local governments approve new developments based on the adequacy of the water supply for the new developments.
  - Although not a direct outcome of the Committee's recommendations, the 2006 Maryland General Assembly passed a law that requires all local jurisdictions to include a Water Resources Element (WRE) in their comprehensive plans by October 2009.
- Establish administrative penalties to ensure compliance with water appropriation permits.
  - Both the Interim Report and the Final Report again recommend that MDE be granted administrative penalty authority for enforcing water appropriation permits.
- Encourage consistency among jurisdictions in the implementation of the water and sewer planning process.
  - No progress.
- Incorporate source water protection measures into the comprehensive plans developed by each county.
  - Local governments are expected to include source protection measures as part of their Water Resource Elements in their comprehensive plans.
- Establish a process to ensure that abandoned wells are properly sealed.
  - Well construction regulations are currently being modified to clarify the definition of abandoned wells. No progress has been made regarding proper abandonment of wells that have been submerged and for which property ownership is unclear.
- Review the well constructions standard and modify if necessary in order to enhance protection of the quality and quantity of ground water.
  - Emergency well regulations were promulgated in December 2007 to require a minimum 4" diameter for all wells drilled in the State. Regulations are being developed that will make this change permanent, and will also make other changes that strengthen well construction requirements.

- Provide sufficient laboratory capability for drinking water analysis to accommodate the additional workload.
    - No progress.

July 2006 Interim Report:

1. Develop a State Water Resources Management Plan within three years to provide guidance for the Maryland Department of Environment (MDE) in carrying out its water management responsibilities and for local governments developing the plans required under new legislation enacted in 2006.
    - This recommendation is further elaborated upon in the Final Report of the Committee. The Final Report emphasizes the need to establish regional planning processes among State, county and municipal governments.

- Continue the comprehensive evaluation of the State's watersheds and aquifers to determine their adequacy in meeting expected demands. Expand ground and surface water monitoring networks to provide the data for this analysis and the continuing management of the State's water resources.
    - Work continued on Phase I of the Coastal Plain Aquifer Study. Phase I accomplishments include publishing a Science Plan, developing implementation plans for the study, preparation of a digital geologic framework for the region, and developing an Aquifer Information System, which is currently undergoing beta-testing. Funding for full implementation of the project, which is anticipated to take about 8 years, has not been identified, however MDE has been active in seeking funding for this project from other sources.
    - MDE applied for and obtained a Base Realignment and Closure-related grant from the Department of Defense, Office of Economic Adjustment, to conduct aspects of the aquifer studies, focusing specifically on areas surrounding the Aberdeen Proving Ground and Fort Meade. This study is scheduled to begin in 2008 and be completed in 2009.
- Identify and develop new water sources and make better use of existing resources.
    - There has been no progress in developing new water sources. MDE is currently seeking local governments to participate in projects demonstrating water conservation and more efficient water use technologies.
- Provide support for local water supply planning by providing information and technical assistance as required by HB1141 (codified as Chapter 381,

2006 Laws of Maryland) and implementing recommendations of the Interagency Technical Advisory Committee.

- MDE and the Maryland Department of Planning have issued written guidance and held workshops throughout the State to assist local governments in meeting the requirements of HB1141. No resources or staffing were provided to either State or local governments to implement the requirements of this law. The Final Report recommends full support for this effort.

- Establish regional planning initiatives to more fully integrate planning processes among State, county and municipal governments.
  - Existing staff at MDE have been working, on a limited basis, with several regional multi-jurisdictional groups to help the groups coordinate efforts related to water resources management and planning. Again, the Final Report recommends full support for this effort.
- Avoid where possible, or minimize and appropriately mitigate the ecosystem impacts of any water resource management decision that changes or modifies natural conditions.
  - Additional studies, such at the Piedmont Water Supply study and Coastal Plain Aquifer study, are needed to fully understand the impacts of cumulative withdrawals on aquatic ecosystems and biota.

2. Enact legislation to:

   a. Improve efficiency of the water appropriation permit process by eliminating the requirement to obtain a permit for withdrawals under 5,000 gallons per day.
      - The 2007 Maryland General Assembly passed a law that exempts ground water withdrawals under 5,000 gallons per day, with certain exceptions, from the requirement to obtain a water appropriation permit. The law became effective on October 1, 2007. All exempted users are required to register their use with MDE. To date, MDE has issued more than 500 exemptions.

   b. Protect the sources of drinking water supplies to insure their long-term availability.
      - No progress. The Final Report again recommends that legislative and/or regulatory changes be made to better protect sources of drinking water

   c. Enact an effective mechanism for enforcing appropriation permits to provide equity among users and the data needed for management purposes.

- The 2007 Maryland General Assembly gave MDE judicial civil penalty authority for enforcing water appropriation permits. The law became effective on October 1, 2007. The Water Supply Program has reorganized and established an enforcement section to undertake formal enforcement actions with permittees who violate permit conditions or fail to obtain or renew permits. The Final Report again recommends that MDE be given administrative enforcement authority to provide a more efficient and effective means of ensuring compliance with water appropriation regulations.

3. Develop an outreach program to educate Maryland citizens, the regulated community, and State and local officials regarding the importance of water resource management, water supply protection, and water conservation and efficiency practices.
    - No outreach program has been developed to date. The Final Report again recommends that an outreach program be developed and properly staffed.
4. Identify funding to support water resource management programs by initiating a dialogue with various stakeholders to evaluate funding alternatives.
    - The Committee emphatically states in its Final Report that little improvement can be expected in managing the State's water resources unless adequate funding is provided. The Final Report outlines the programmatic expenditures necessary to carry out the Committee's recommendations. Dissemination of this report will provide the basis for discussions with various stakeholder groups.

Martin O'Malley, Governor

Anthony G. Brown, Lt. Governor