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A STRATEGY FOR A STREAM-GAGING NETWORK IN MARYLAND

by

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Prepared for the Maryland Water Monitoring Council
in cooperation with the Stream-Gage Committee

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Multiply	By	To obtain
foot (ft)	0.3048	meter (m)
square foot (ft^2)	0.0929	square meter (m^2)
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
square mile (mi^2)	2.590	square kilometer (km^2)

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called "Sea Level Datum of 1929."

Water year: In this report, “water year” refers to the 12-month period beginning October 1 and ending September 30. The water year is determined according to the calendar year in which it ends and includes 9 of the 12 months. The year beginning October 1, 1999 and ending September 30, 2000 is called “water year 2000.” All references to years of operation for stream gages in this report are water years.

A STRATEGY FOR A STREAM-GAGING NETWORK IN MARYLAND

EXECUTIVE SUMMARY

by Emery T. Cleaves [1] and Edward J. Doheny [2]

Water is a keystone resource. In abundance, it supplies cities, industries, and agriculture. To maintain healthy natural and human ecosystems, water must not only be present in adequate quantity, but it must be of suitable quality for its intended use. Water quality depends on the amount, or load, of contaminants, both natural and anthropogenic, that it contains. Accurate assessment of these contaminants requires that the amount of water flowing in a stream or river be known. To quantify streamflow in a given stream or river and the variation of that flow through time, it must be measured by use of stream gages. Monitoring water flow is fundamental to managing and protecting water resources, and requires a collaborative effort by all interested parties, including Federal, State, and local government agencies.

This report was prepared by the Stream-Gage Committee of the Maryland Water Monitoring Council. The Committee has been guided by the discussions and recommendations of a stream-gaging workshop (convened by the Council on October 16, 1997) and by responses to a data-users questionnaire sent by the Committee to 500 users of stream-gage data.

The Maryland Water Monitoring Council Stream-Gage Committee recommends that Maryland's stream-gaging network be increased from 97 gages (in existence as of November 15, 1999) to 157 gages. The additional gages should be activated in stages according to six priority management goals: Coastal Plain Harmful Algal Blooms, small watersheds, core network, Clean Water Action Plan, flood hazard, and other unmet coverage (core/trend network, unmet 6- or 8-digit Hydrologic Unit Codes, unmet spatial coverage, and unmet physical-matrix categories; table 1). Drought assessment is also a major concern, and requires the continued operation of stream gages with long-term records.

Stream gages are operated throughout Maryland to meet numerous water-resources management goals of Federal, State, and local government agencies. Streamflow data are crucial to water-resources management goals in three fundamental ways — evaluation of current conditions, watershed management and planning, and decision-support systems. Evaluation of current conditions includes issues related to (1) accounting for and tracking the distribution of streamflow, (2) regional and area assessments, (3) water quality, (4) ecosystems and aquatic living resources, (5) recreation, and (6) flood-hazard warning. In the area of watershed management and planning, streamflow data is basic to issues such as stream protection and restoration, water quality, forecasting floods and droughts, and living resources (ecosystems). The stream-gaging network is also a vital decision-support system in which streamflow data are collected at the gages and then transmitted to a data-collection center. The data are then placed in a data base that is managed by the U.S. Geological Survey. Data from the data base are made publicly available in near real-time on the Internet, or in paper copy. This system supports many information and assessment needs for environmental management purposes, including emergencies such as flooding, contaminant spills, fish kills, or sediment violations, as well as modeling and model calibration, and research.

In recent years, the stream-gaging network in Maryland has varied from 95 active stations in 1985 to 76 active stations by the end of 1995. Ninety-seven stations were being operated as

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Table 1. Summary of additional gages recommended for the stream-gaging network in Maryland

[**Note:** Because of the multiple uses of stream gages, a gage used for the Coastal Plain Harmful Algal Bloom priority may also provide data for small watersheds, flood hazards, core network, and so on. This has been taken into account in tabulating the total additions recommended for each subnetwork]

Subnetwork priority	Re-activated stations	New stations	Total additions
Coastal Plain Harmful Algal Blooms	7	1	8
Small watersheds	11	10	21
Core network	20	2	22
Clean Water Action Plan	0	2	2
Flood hazard	2	3	5
Other unmet coverage	0	2	2
TOTAL	**40**	**20**	**60**

of November 15, 1999. Gaged watersheds range in drainage area from 0.03 square miles to 27,100 square miles. Approximately one-third of the stations have 50 or more years of continuous record. The oldest station in operation in Maryland is on the Potomac River at Point of Rocks (station number 01638500) with continuous record from February 1895 to the present.

To effectively address water-resource management goals, an adequate stream-gaging network for Maryland should include (1) gages that represent most of the region's principal watersheds, (2) various combinations of watershed size, land-use types, and physiography and geology of the State, and (3) gages that are continuously operated for extended periods of time. Because of the great natural range and variation in Maryland's physiography, geology, and watersheds, statewide stream-gage coverage is necessary.

Analysis of the physical matrix clearly indicates that Maryland's best current stream-gage coverage is in the Piedmont East Province. Most watershed-size and development categories in the Piedmont East are represented by at least one stream gage. The Piedmont West, Blue Ridge, and Valley and Ridge Provinces have very little coverage except for large or regional watersheds with significant flow regulation or diversions. The entire Coastal Plain East in Maryland is represented by only six long-term stream gages. In addition, 13 of 18 of Maryland's large (6-digit Hydrologic Unit Code) watersheds lack stream gages at their downstream end. Eighty-four of Maryland's 134 intermediate size (8-digit Hydrologic Unit Code) watersheds have no active stream gages on their mainstem or tributaries. The Committee recommends activation of 2 new gages to meet this priority. Because of the multiple-use aspect of stream-gage data, only 2 additional gages would be necessary if the other priority subnetwork needs are met.

The stream-gaging network in Maryland also was analyzed in terms of its adequacy for meeting the information needs of a series of subnetworks: Coastal Plain Harmful Algal Blooms, small watersheds, core network, Clean Water Action Plan, flood warning, droughts, and nontidal core/trends. Harmful algal blooms, such as *Pfiesteria*, are a continuing concern in the Chesapeake Bay and the Potomac River, especially in the sub-estuaries. These blooms are thought to be fueled in part by nutrients in streams that discharge into the sub-estuaries. To determine nutrient loadings of streams, streamflow information is combined with water-quality data. In Maryland, 27 stream gages in the Coastal Plain are currently active, down from 51 in operation in previous years. As a result, there are significant gaps in stream-gage coverage, especially on the Eastern Shore. Reactivation of seven gages is recommended (five on the Eastern Shore and two on the Western Shore). The Committee also suggests activation of one new gage in the Oceans/Coastal area of the Eastern Shore, on Trappe Creek.

Analysis of the watersheds across Maryland indicates that more than 50 percent of Maryland's river miles can be categorized as first- or second-order streams. The matrix shows a lack of long-term data in small watersheds of less than 5 square miles. On a statewide basis, only seven stream gages in small watersheds have 10 or more years of systematic record. At present, most stream gages are located on higher-order streams and are too few in number to assess the headwater area of the watersheds. The most significant problem raised at the Maryland Water Monitoring Council stream-gaging workshop in October 1997 was a lack of stations and long-term data in first- and second-order watersheds. Such gages are the key to understanding quantity and patterns in streamflow, ground-water contributions to the streamflow during periods of no runoff, and determination of contaminant loads that may be contributing to diminished water quality in the rest of the watershed. The active stream-gaging network includes 11 stations on first- and second-order watersheds. The Coastal Plain East, Piedmont West, Blue Ridge, and Valley and Ridge Provinces are completely unrepresented in this category. To address this data and information gap, the Committee recommends adding 10 new stream gages on small watersheds and re-activating 11 discontinued gages.

Core network stream gages represent natural hydrologic conditions and trends that reflect the effects of land use, physiography, and geology. They provide a data record needed to assess the effects of natural and manmade changes in Maryland's watersheds over time. In water year 1999, 57 core network stream gages were in operation in Maryland. Although the total number of core network gages in Maryland increased from 51 in 1994 to 57 in 1999, the core network stations continue to change. Most physiographic regions, including the Coastal Plain East, Coastal Plain West, Piedmont West, Blue Ridge, and Valley and Ridge Provinces, are poorly represented. On a statewide basis, Maryland does not have an adequate core network of stream gages at the present time. The Committee recommends that 20 gages be re-activated and 2 new ones be added to address this priority issue.

The Clean Water Action Plan is an initiative designed to fulfill the original goals of the Clean Water Act—fishable, swimmable, and safe water for all Americans (Clean Water Action Plan Technical Workgroup, 1998). As part of the Clean Water Action Plan, the State of Maryland has identified twelve Category 1 priority watersheds where restoration is required, and five Category 3 priority watersheds where protection is required. Of the twelve Category 1 watersheds, five are currently ungaged: (1) Deep Creek Lake, (2) Mattawoman Creek, (3) Upper Elk River, (4) Wye River, and (5) Lower Pocomoke River. Another of the priority watersheds, Upper Monocacy River, has partial coverage, but additional coverage is needed to understand the aquatic systems on a watershed level. The five Category 3 watersheds are related to surface-water reservoirs and are considered high priority for protection. These include (1) Prettyboy Reservoir, (2) Liberty Reservoir, (3) Loch Raven Reservoir, (4) Brighton Dam at the Triadelphia Reservoir and (5) Rocky Gorge Dam at the T. Howard Duckett Reservoir. Prettyboy Reservoir, Liberty Reservoir, and Loch Raven Reservoir do not have stream gages at their outlets. The Committee recommends that two new stream gages be added, in addition to those recommended for subnetwork priorities 1, 2, and 3.

Flood-hazard warnings, flood predictions, and identification and assessment of droughts require long-term stream-gage data. Ten years of peak-flow values is generally accepted as a minimum requirement for development of a flood probability estimate. As of water year 1998, Maryland had 43 stream gages that (1) had 10 or more years of continuous data with no breaks in the record, (2) were representative of Maryland's individual physiographic provinces rather than larger, multiple-physiographic regions, and (3) were not affected by extensive or complete regulation that would prevent development of a flood-frequency distribution. The Committee recommends that 2 stream gages be re-activated and 3 new stream gages be established so that flow data needed for flood- and drought-related analyses can be collected in locations where none is presently available.

Below-normal rainfall during 1998 and 1999 resulted in Maryland's most severe drought since those of 1930–31 and 1965–66. Record-low streamflow conditions and reservoir levels led to statewide restrictions on water. Fish kills occurred due to low levels of dissolved oxygen in streams and rivers. In addition, the drought also had severe economic impacts due to lost crops and inadequate grazing conditions for livestock. Fifty stream gages in the active network have continuous records dating back through the 1965–1966 drought. These records allow hydrologists to compare and contrast these two major events. Of these 50 gages, 12 have continuous records dating back to the 1930–1931 drought. These data and their comparative value emphasize the need to operate stream gages for long periods of time.

The present core/trends water-quality network focuses on the Piedmont East, Piedmont West, Blue Ridge, and Valley and Ridge Provinces. Re-activation of the 6 discontinued stream gages associated with the network sites in these areas would strengthen nutrient-loading analyses of the State's watersheds and enhance estimates of Total Maximum Daily Loads that currently are being made by the Maryland Department of the Environment. This can be achieved by re-activation of stream gages in Subnetwork Priorities 1–6. As the core/trends water-quality network expands into the Coastal Plain East and Coastal Plain West, it could be paired with the existing stream-gage network (currently 27 stream gages) and proposed re-activation of 7 stream gages to help provide data for nutrient loadings related to Harmful Algal Blooms. Establishment of new stream gages throughout Maryland should take into account the needs of the core/trends network.

The uses and users of stream-gage data were identified through a users survey in the spring of 1998. Five hundred questionnaires were distributed, and 102 responses were received. Twenty specific uses were identified, of which 18 were common to all gages. For each stream gage there were a minimum of 7 and a maximum of 15 users.

The Committee recommends that future stream-gage costs be shared on the basis of data needs and Federal, State or county/municipal interest. Federal interest focuses on basin-scale (6-digit Hydrologic Unit Code watersheds) and regional trends and conditions related to water-quality assessment. Such stream gages should be funded 100 percent by the Federal Government. Shared Federal, State and county/municipal interests include representative 8-digit Hydrologic Unit Code watersheds, Clean Water Action Plan watersheds, water-supply reservoirs, flood-drought hazards, and small watersheds. The costs of these gages can be shared by Federal (50 percent), State (25 percent), and county/municipal agencies (25 percent) through the U.S. Geological Survey Federal-State Cooperative Program, pending availability of such funds. In locations where gaps remain in the spatial coverage and physical matrix categories, the Committee recommends that cost sharing be split between State or county/municipal sources and the U.S. Geological Survey Federal-State Cooperative Program, pending availability of such funds.

WHY STREAM GAGES?

Introduction

Water is a keystone resource. In abundance, it supplies cities, industries, and agriculture. To maintain healthy natural and human ecosystems, water must not only be present in adequate quantity, but it must be of suitable quality for its intended use. To know how much streamflow is present in a given stream or river, it must be measured. The key to measuring streamflow, the water that flows in streams and rivers, is the stream gage.

The stream gage is a fundamental data-collection mechanism that supports water-resources studies, projects, research, and understanding of regional hydrology. Stream gages are the key to surface-water data collection, data management and assessment, and information distribution. Streamflow information is vital to understanding water quality and possible impacts of contaminants on human and aquatic health. Without stream gages, knowledge of water resources and water quality are based more on estimates and hypothesis than facts and observations.

Stream gages are used to measure the availability of water or changes in flow conditions. Stream gages produce stage and discharge data that are useful for many purposes, such as regional flood prediction and warning, water-supply estimates, ecosystem stability and diversity, river restoration and stream stability, watershed land-use studies, water-quality studies, and contamination-load estimations. The City of Baltimore, Md. uses stream-gage data to estimate the availability and status of the water supply in its drinking-water reservoirs. The data also are used for highway and bridge design by the Maryland State Highway Administration (MDSHA), for determining Total Maximum Daily Loads (TMDLs) by the Maryland Department of the Environment (MDE), for calculating pollutant loadings by the Chesapeake Bay Program, for ecosystem evaluations by the Maryland Biological Stream Survey Program, for wading and boating conditions by fishermen and swimmers, and by many others.

A group of stream gages serving a specific purpose in a particular region forms a network. To ensure that the stream-gaging network in Maryland is adequate for meeting the needs of the water-resources community, it must represent the range of hydrologic conditions found in the State. It must also include an appropriate number of stream gages to account for hydrologic variability (Preston, 1997). If a stream-gaging network is constructed such that (1) the majority of the region's principal watersheds are gaged, (2) various combinations of watershed size, land-use types, and physiography and geology of the region are adequately represented, and (3) the stream gages are operated continuously for extended periods of time without breaks in the record, the network should be adequate for representing the overall hydrology and temporal hydrologic variations of the region.

The continuous operation of stream gages, however, has significantly fluctuated from year to year. Due to inflation, shifting financial support, and changes in funding priorities, funding from supporting agencies can vary significantly on an annual basis. As a result, stream gages with long-term periods of record are discontinued or have breaks in the systematic record. Others may be discontinued with periods of record that are too short for evaluating regional hydrologic conditions and long-term trends. In Maryland, the funding base and priorities for stream gages have fluctuated significantly during the past 20 years. In 1985, there were 95 active stream gages in Maryland. By 1996, only 76 were still in operation. Between 1985 and 1994, approximately 18 stream gages with record lengths of 10 years or greater were discontinued. Over the past 2 years, some progress has been made in reversing this trend. Coverage in the Piedmont East Province, primarily in Baltimore County, has been significantly improved through cooperation between the U.S. Geological Survey (USGS) and the Baltimore County Department of Environmental Protection and Resource Management (DEPRM).

Although stream-gage data have many applications and many users, there is no single high-profile office or program in the Federal or State government to emphasize their importance. At the Federal level, the USGS operates a nationwide system of stream-gaging stations and networks. Only in times of major flooding or severe droughts, however, such as the Mississippi River floods in 1993 or the 1998–1999 drought in the Northeastern United States, do stream gages and the data they provide emerge from obscurity. The Maryland Department of Natural Resources, Maryland Geological Survey (MGS) and MDSHA are the focal points for much of the State effort in Maryland, in cooperation with the USGS as part of the Federal-State Cooperative Program.

Because of the natural variability of Maryland's physiography, geology, and watersheds, stream-gage coverage is necessary on a statewide basis. Population growth and development are also changing Maryland's landscape continuously. With population growth and urbanization of the landscape, increased runoff to streams, channel instability, sediment supply, water quality, and water supply are issues of concern. Streamflow data collected before, during and after watershed land-use changes can provide a valuable record of physical and hydraulic adjustments of rivers and streams in response to development

(Doheny, 1998).

To improve the stream-gaging network in Maryland, the state of the active network must be evaluated. Because of limited funding, new and re-activated stream gages designed to improve coverage must be carefully located. This report presents an analysis of the current stream-gaging network in Maryland, and recommends a strategy for improving coverage throughout the State.

Water-Resources Management Goals

Stream gages are operated throughout Maryland to meet numerous water-resources management goals of Federal, State, and local government agencies. Streamflow data, its collection, assessment, and distribution contribute to water-resources management goals in three fundamental areas–evaluation of current conditions, watershed management and planning, and decision-support systems.

Evaluation of current conditions includes issues related to (1) accounting for and tracking the distribution of streamflow, (2) regional and area assessments, (3) water quality, (4) ecosystems and aquatic living resources, (5) recreation, and (6) flood-hazard warning. For example, quantifying streamflow is necessary for issues concerning discharge of effluent from wastewater treatment plants and for water supply in Maryland's reservoirs. With regard to ecosystems, it is crucial to monitor and characterize streamflow in regions of similar climate, physiography, and geologic framework to evaluate impacts of changing land use, and to characterize inflows into the Chesapeake Bay estuarine system. In the area of water quality, streamflow data are needed to address water-quality conditions and trends, contaminant transport, sediment loads, and TMDLs.

In the area of watershed management and planning, streamflow data are basic to issues such as stream protection and restoration, water quality, forecasting floods and droughts, and living resources (ecosystems). In local watershed management and restoration, data are needed to calibrate indicators of the bankfull or channel-forming stage and discharge to known streamflow for use in geomorphic assessments in gaged and ungaged watersheds. Streamflow data are also used to develop reliable estimates of bankfull and peak discharges for use in design of highway bridges and culverts, design of flood control and storm-water management facilities, and the design of stream restoration and relocation projects. In the area of water-quality management, modeling, and remediation, stream gages provide discharge data for calibrating watershed-pollution models that are developed on the basis of land use and watershed size. These models can be useful in targeting remediation efforts. Streamflow data also are needed to assess the results of remediation efforts in watersheds.

The stream-gaging network is a vital decision-support system in which streamflow data are collected at the gages and then transmitted to a data-collection center and placed in a data base that is managed by the USGS. Data from the data base are made publicly available through near real-time via the Internet, or in paper copy. The stream-gaging network represents an extensive data-collection, data-storage and -management, and information-distribution system that supports many information and assessment needs for environmental management purposes, as well as modeling and model calibration, and research.

On occasion, water-management decisions must be made quickly as a result of emergencies such as flooding, contaminant spills, fish kills, or sediment violations. Rapid dissemination of streamflow data from gages can assist water-resources managers in making decisions that may save lives, or protect watersheds from being ecologically harmed. Technological advances in recent years have made it possible to post near real-time data on the World Wide Web. Currently, about 30 percent of the active stream-gaging network stations in Maryland have near real-time data available on the USGS, Maryland-Delaware-D.C. District web page at the following address: *http://md.water.usgs.gov/realtime*

The ultimate goal is to get as many stations as possible onto the real-time network. The percentage of stations with real-time data is expected to increase with technological advances and increased user interest.

THE CURRENT STREAM-GAGING NETWORK

In recent years, the stream-gaging network in Maryland has ranged from 95 active stations in 1985 to 76 active stations by the end of 1995. Ninety-seven stations were being operated throughout Maryland as of November 15, 1999 (figure 1). Gaged locations range in drainage area from 0.03 square miles (mi^2) to 27,100 mi^2. Approximately one-third of the stations have 50 or more years of continuous record. The oldest station in operation in Maryland is on the Potomac River at Point of Rocks (station number 01638500), with continuous record from February 1895 to the present.

To effectively address water-resources management goals, the stream-gaging network in Maryland must have adequate spatial distribution (physiographic/geologic diversity), represent watersheds of various size, and include major land-use categories. The changes in composition of the network from year to year make it difficult to maintain adequate network coverage in the various regions of Maryland, and to represent these different combinations of physical characteristics, hydrologic characteristics, and land-use types. A major recommendation from the stream-gaging workshop sponsored by the Maryland Water Monitoring Council (MWMC) in October 1997 was for construction of a physical matrix of selected basin characteristics for gaged watersheds to pinpoint gaps in current network coverage. During the workshop, an interagency Stream-Gage Committee was created to address concerns raised regarding the stream-gaging network.

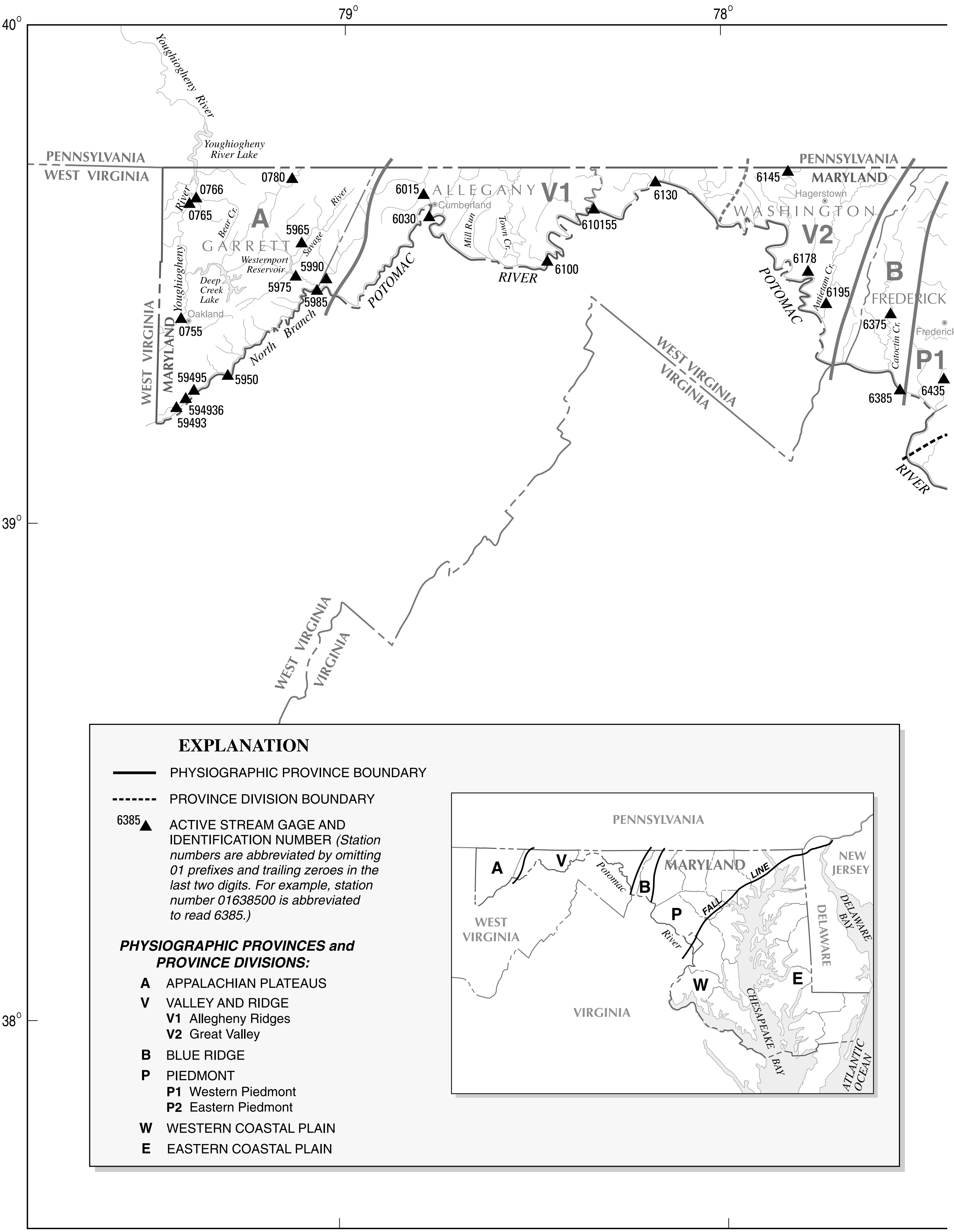
During 1998, the Committee developed a physical matrix and conducted an analysis of stream-gage locations, and evaluated gaps in coverage. A questionnaire to obtain input from the water-resources community in Maryland regarding uses of stream-gage data was designed. Funding support for the network was also analyzed. On the basis of these analyses, problems with the current stream-gaging network were documented.

Physical Matrix of Selected Basin Characteristics

Water-resource managers who attended the MWMC stream-gaging workshop focused on several problems with stream-gage coverage in Maryland. Some of the issues raised included (1) a lack of adequate coverage in all physiographic regions and principal watersheds of Maryland, (2) a need for more adequate representation of different land-use types, including reference watersheds in undeveloped and urban areas, and (3) a lack of stream gages and long-term data in small watersheds. In an effort to quantify these problems, a recommendation was made that a physical analysis of the network be performed. In addition to quantifying network gaps, it was also suggested that such an analysis would enhance the understanding of the potential effects of removing specific stream gages from the network.

On the basis of recommendations from the MWMC stream-gaging workshop, a physical analysis of the stream-gage network in Maryland was conducted using a matrix of selected basin characteristics (appendix 1). To determine which basin characteristics should be included in the matrix, it was necessary to determine which basin characteristics are common to all, or nearly all, data uses and water-resources management goals. After careful review and extended discussions among the members of the Committee, it was decided that three basin characteristics are common to nearly all data needs for stream-gage data and should be the basis for a physical analysis of the stream-gaging network: watershed size, physiographic province, and development condition. In addition, the length of continuous gage record was deemed crucial.

Watershed sizes were divided into categories of small (less than 5 mi^2), intermediate #1 (5–25 mi^2), intermediate #2 (25–50 mi^2), large #1 (50–150 mi^2), large #2 (150–500 mi^2), and regional (greater than 500 mi^2). Physiographic provinces are divided into seven units: Piedmont East and Piedmont West, Coastal Plain East and Coastal Plain West, Blue Ridge, Valley and Ridge, and Appalachian Plateau. Development conditions were divided into categories of rural (less than 11 percent impervious), suburb (11–30 percent impervious), and urban (greater than 30 percent impervious). Stations with 10 or more years of systematic record are shown in bold. Other symbols were used to indicate stations that are regulated or have substantial diversions.



BASE FROM U.S. GEOLOGICAL SURVEY, 1:500,000, 1979

Figure 1. Physiographic provinces and location of active stream gages in Maryland, 1999.

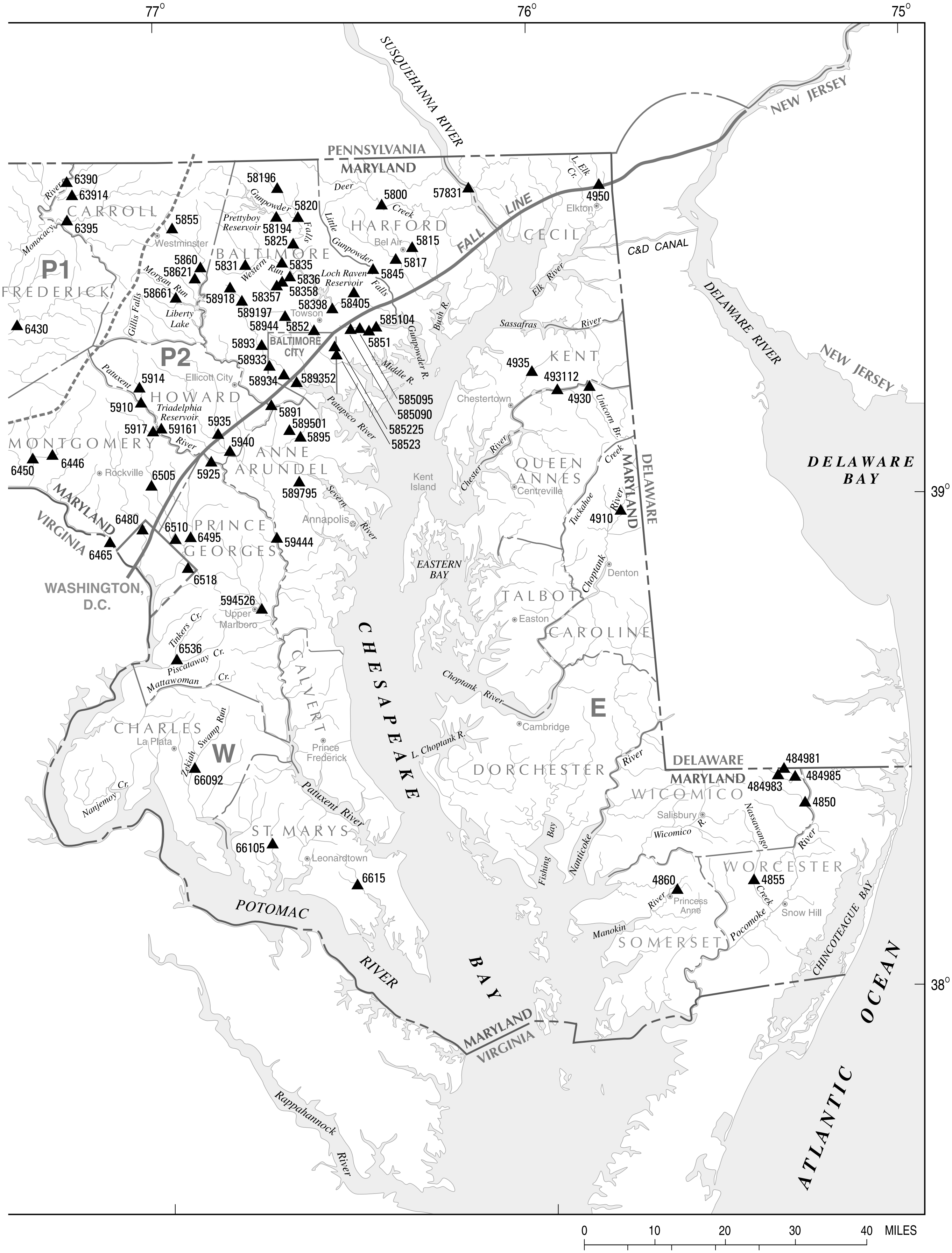


Figure 1. Physiographic provinces and location of active stream gages in Maryland, 1999 -- Continued

Analysis of the physical matrix (appendix 1) clearly shows that Maryland's most extensive stream-gage coverage is in the Piedmont East Province. Most watershed-size and development categories in the Piedmont East have at least one stream gage representing them. The Piedmont West, Blue Ridge, and Valley and Ridge Provinces have very little coverage other than large or regional watersheds with significant flow regulation or diversions. The entire Coastal Plain East in Maryland is represented by only six long-term stream gages. Even with the abundance of stream gages in the Piedmont East, the matrix shows a lack of long-term data in small watersheds of less than 5 mi^2. On a Statewide basis, only seven stream gages in small watersheds have 10 or more years of systematic record (appendix 1).

Spatial Coverage

A physical analysis of the stream-gaging network must also consider total spatial coverage in addition to coverage by basin characteristics. Another method of determining adequacy of spatial coverage is to determine the approximate drainage area covered by stream gages in Maryland (table 2). Drainage-area contributions from regional stations (drainage areas of 500 mi^2 or greater) are excluded.

Spatial coverage based on drainage area varies from province to province. The Appalachian Plateau and the Piedmont Provinces have the largest percentage of drainage area gaged by the current network (table 2). Current coverage in the Piedmont exceeds 50 percent of the total land area, and includes contributions from more than 40 stream gages in both province divisions. About 60 percent of the coverage in the Appalachian Plateau, however, is provided by 2 stream gages on both the Youghiogheny River and Savage Rivers. Approximately 65 percent of the current coverage in the Valley and Ridge Province results from a single stream gage on Antietam Creek. The Coastal Plain and Blue Ridge Provinces have the smallest percentage of drainage area gaged by the current network.

Table 2. Stream-gage coverage by physiographic province in Maryland

[**Note**: Numbers exclude drainage area from all stream gages on the Potomac River, except for station 01595000, North Branch Potomac River at Steyer, Md.; mi^2 = square miles, % = percent]

Physiographic province	Total land area (mi^2)	Approximate land area gaged (mi^2)	Percentage of total land area gaged (%)
Coastal Plain	5,000	591	11.8
Piedmont [A]	2,500	1,286	51.4
Blue Ridge	600	30	5.0
Valley and Ridge [B]	800	295	36.9
Appalachian Plateau [C]	800	553	69.1
TOTAL	**9,700**	**2,755**	**28.4**

A. Numbers exclude drainage areas from station 01643000, Monocacy River near Frederick, Md., and from station 01578310, Susquehanna River at Conowingo, Md.

B. Numbers include 176.0 mi^2 of drainage area from station 01619500, Antietam Creek near Sharpsburg, Md.

C. Numbers include 226.0 mi^2 of drainage area from stations on the Youghiogheny River, and 106.0 mi^2 from stations on the Savage River.

Network coverage by watershed must also be considered as part of the physical analysis. The Committee compiled a list of Maryland's principal watersheds to determine which watersheds currently have stream gages on the mainstem or tributaries (table 3). This allowed the group to determine which watersheds are not represented by current network coverage. Thirteen of 18 of Maryland's 6-digit Hydrologic Unit Code (HUC) watersheds lack stream gages at their downstream end. Eighty-four of Maryland's one hundred thirty-four 8-digit coded watersheds have no active stream gages either on the mainstem or tributaries. Fifty-nine of these watersheds have tidal streams where stream gages cannot be operated on the mainstem. If stream gages are to be activated in any of these watersheds, they will have to be placed in smaller, nontidal tributaries in headwater areas. In addition, the Committee recommends that all nontidal watersheds have one or more stream gages that include streamflow discharged from at least 75 percent of the watershed area. Using this criteria, only 5 of the eighteen 6-digit HUCs and twenty-four of the one hundred thirty-four 8-digit HUCs are adequately gaged.

Further analysis of table 3 shows watersheds where improved coverage is necessary: the Nanticoke River Basin, Choptank River Basin, Chester River Basin, Elk River Basin, Bush River Basin, Lower Potomac River Basin (Coastal Plain West below Washington, D.C.), Upper Potomac River Basin (tributaries to Potomac River in Washington County and Allegany County, Maryland) and the Ocean/Coastal region of Maryland's Eastern Shore.

Flood Warning and Prediction

Floods are among the most frequent and costly natural disasters in terms of human hardship and economic loss (Mason and Weiger, 1995). In Maryland, many cities, towns, and municipalities are located close to rivers and streams that will overflow their banks from time to time. Major floods have occurred in different regions of Maryland, most recently in 1971, 1972, 1975, 1979, 1985, and 3 times in 1996, resulting in millions of dollars in flood damage and loss of life in some cases. Western Maryland, which includes Frederick, Washington, Allegany and Garrett Counties, suffered the most damage during the 1996 floods, leading to the creation of the Governor's Flood Mitigation Task Force for Western Maryland. This task force has been charged with overseeing short-term and long-term solutions to flooding problems in Western Maryland in the aftermath of the 1996 floods (Governor's Flood Mitigation Task Force, 1997).

Maryland currently has 114 communities that participate in the National Flood Insurance Program (NFIP) through the Federal Emergency Management Agency (FEMA). This program requires that communities establish and adopt restrictive ordinances to manage development within 100-year floodplains to minimize future flood damage (Maryland Department of the Environment, n.d.).

To define a floodplain boundary based on a 100-year recurrence interval[1], or any other recurrence interval, stage and discharge data from stream gages are required to develop statistical flood probabilities. Ten years of peak-flow values at a station is generally accepted as a minimum requirement for development of a flood-probability estimate. The longer the period of record for a station, the greater the accuracy in estimating flood probabilities, especially those in the 50- to 100-year recurrence interval. Estimates based on shorter periods of record are generally not recommended because they may be more representative of a particular series of unusually wet or dry years. Once enough data is available to develop flood probabilities, stage data recorded by the stream gage can be related to the discharge data and flood probabilities to develop estimates of floodplain boundaries.

Sixty-eight of 82 active stream gages in water year 1998 had 10 or more years of record (table 4). Three of the original 82 stations were discontinued during water year 1998, and are not included in this analysis. Eight of the 68 stations are extensively regulated and are probably not useful for most types of regional analyses. Seven other stations are located on the North Branch or the mainstem of the

1. The recurrence interval of a specific flood is the average number of years during which the peak discharge can be expected to be exceeded once.

Table 3. Number of gaged watersheds in 6- and 8-digit Hydrologic Unit Code watersheds in Maryland

6-digit watershed	6-digit watershed; gaged or ungaged	Number of 8-digit subwatersheds	Number of gaged 8-digit subwatersheds with 75 percent or more coverage	Number of gaged 8-digit subwatersheds with less than 75 percent coverage	8-digit watersheds with no active gages	Partially tidal 8-digit watersheds
Lower Susquehanna River	Gaged	5	1	1	3	1
Ocean/Coastal Area	Ungaged	5	0	0	5	5
Pocomoke River	Ungaged	8	0	3	5	8
Nanticoke/Wicomico River	Ungaged	8	0	0	8	7
Choptank River	Ungaged	5	0	1	4	5
Chester River	Ungaged	11	0	1	10	11
Elk River	Ungaged	11	1	0	10	8
Bush River	Ungaged	6	0	2	4	3
Gunpowder River (and Conewago Creek)	Ungaged	8	0	4	4	3
Patapsco River	Ungaged	8	1	4	3	3
West Chesapeake Area	Ungaged	5	0	1	4	5
Patuxent River	Ungaged	8	4	2	2	1
Lower Potomac River	Ungaged	11	1	2	8	11
Potomac-Washington Metropolitan Area	Gaged	8	2	2	4	4
Middle Potomac River	Gaged	5	2	2	1	0
Upper Potomac River	Ungaged	12	5	1	6	0
North Branch Potomac River	Gaged	6	5	0	1	0
Youghiogheny River	Gaged	4	2	0	2	0
TOTALS	–	**134**	**24**	**26**	**84**	**75**

Table 4. Stream gages in Maryland with ten or more years of record by physiographic province, 1998 water year

[**Note**: 3 stations discontinued during the 1998 water year are excluded from the table]

	Appalachian Plateau	Valley and Ridge	Blue Ridge	Piedmont West	Piedmont East	Coastal Plain West	Coastal Plain East
10 or more years of record	12	7	1	6	26	10	6
Extensively regulated	2	0	0	0	5	1	0
Unregulated stations with breaks in the record	0	0	0	1	5	3	1
Potomac River	2	3	0	1	0	1	0

Potomac River. Most of these stations have very large drainage areas that are more representative of regional conditions than of individual physiographic regions of Maryland. Of the remaining stations, 10 have breaks in the systematic record ranging from 2.5 years to 17 years. Although flood probabilities are often developed for stations with breaks in the record, quantifying the cumulative effects of broken record on the flood probabilities of individual stations can be very difficult. Therefore, as of water year 1998, Maryland had 43 stream gages that: (1) had 10 or more years of continuous data with no breaks in the record, (2) were representative of Maryland's individual physiographic provinces rather than larger, multiple-physiographic regions, and (3) did not have extensive or complete regulation that would prevent their use in a flood-frequency analysis.

Because of the need to develop extensive floodplain boundaries in most areas of Maryland and the limited availability of streamflow data, hydraulic models must be relied upon for developing most floodplain-boundary estimates. Estimates of floodplain boundaries can be improved by activating stream gages in ungaged principal watersheds that are considered to be at high risk for flood damage. With the recent history of flooding problems in Western Maryland, ungaged principal watersheds in this area should be considered as a high priority for the activation of new stations to aid in calibrating 100-year flood boundaries. Undeveloped watersheds in Western Maryland should also be carefully considered for stream gages to prevent any future development within 100-year floodplain boundaries. As a second priority, streams or rivers in other areas of Maryland that are known to be of greatest risk for flood damage should be considered for stream gages to significantly improve the calibration and accuracy of 100-year floodplain boundaries. Stream gages may also be targeted for towns and municipalities that are at higher risk for flooding in order to provide adequate flood warning for evacuation and preventing loss of life. A starting point for developing priorities might be the NFIP communities that currently have no stream gages, and are willing to provide funding for a stream gage in their community.

Droughts and Long-Term Stream-Gage Records

Below-normal rainfall during 1998 and 1999 resulted in Maryland's most severe drought since those of 1930–31 and 1965–66. Record-low streamflow conditions and reservoir levels led to statewide restrictions on water. Fish kills occurred due to low levels of dissolved oxygen in streams and rivers. The drought also had severe economic impacts due to lost crops and inadequate grazing conditions for livestock.

The streamflow record from the gage on the Patuxent River near Unity, Md. (figure 2) clearly shows the dramatic decrease in streamflow associated with the 1998–99 drought. Daily streamflow dropped below the normal range in April 1999, and kept declining well into the summer months. Similar streamflow records from gaging stations throughout Maryland document the same significant decline. The Unity station has a continuous record dating back to 1945, and is one of 50 stations in the current network with continuous record dating back to the 1965–1966 drought. Such records allow hydrologists to compare and contrast these two major events. Of these 50 gages, 12 have continuous record dating back to the 1930–1931 drought (table 5). These data and their comparative value emphasize the need to operate stream gages for long periods of time.

Core Network Stream Gages

A primary objective of a stream-gaging network is to characterize surface-water resources and evaluate regional hydrologic conditions so that regional and area assessments can be made by water-resource managers. From the network of active stream gages in Maryland, a selected group form a core network. Core network stream gages are those on streams and rivers that (1) are

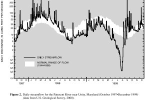


Figure 2. Daily streamflow for the Patuxent River near Unity, Maryland (October 1997–December 1999) (data from U.S. Geological Survey, 2000).

Table 5. Network stream gages in Maryland with continuous record from the 1930–31,1965–66, and 1998–99 droughts

[mi^2 = square miles]

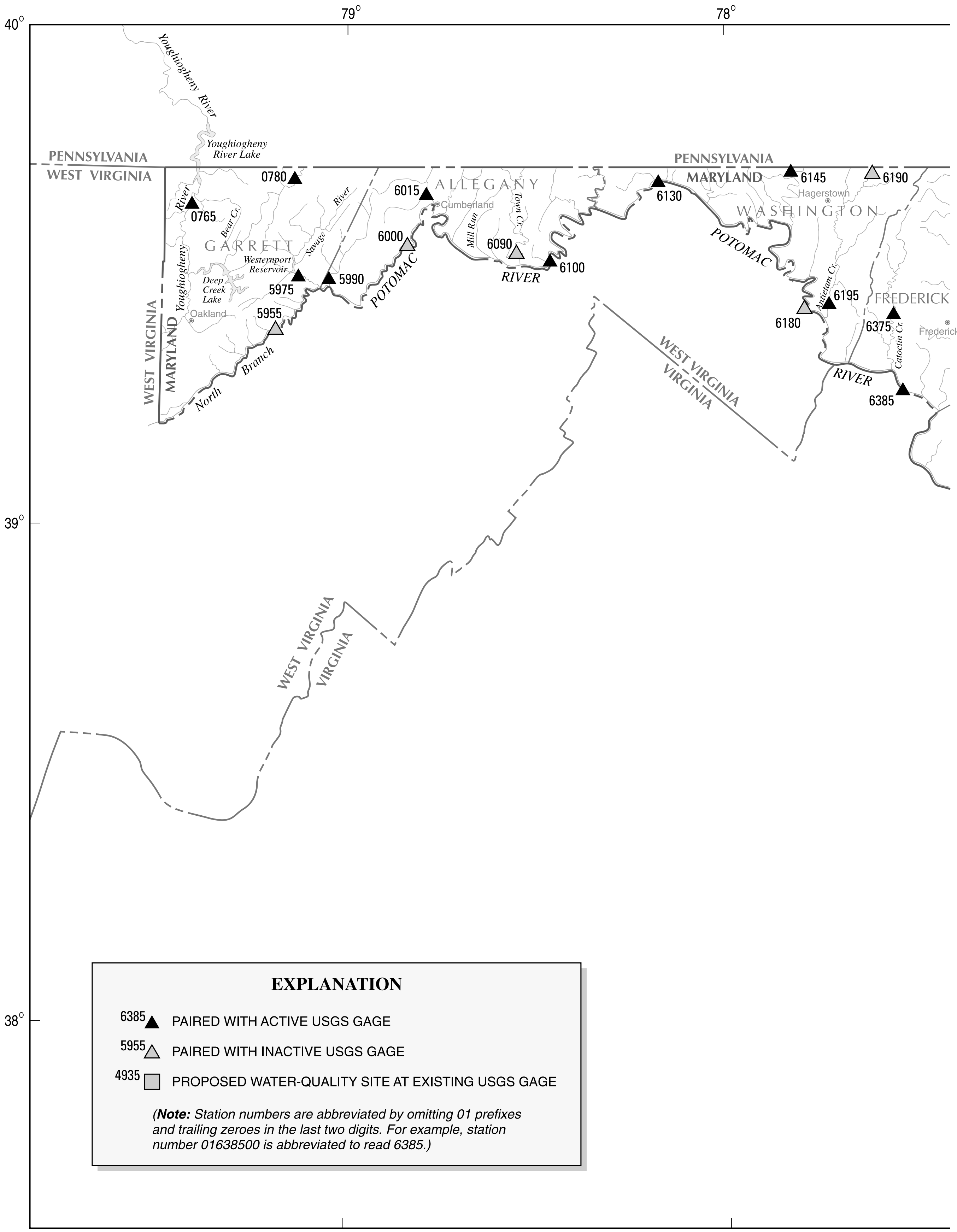
Station no.	Station name	Drainage area (mi^2)	Physiographic province	Period of record (years)
01580000	Deer Creek at Rocks, Md.	94.4	Piedmont East	1926–present
01599000	Georges Creek at Franklin, Md.	72.4	Appalachian Plateau	1905–1906, 1929–present
01601500	Wills Creek near Cumberland, Md.	247	Valley and Ridge	1905–1906, 1929–present
01603000	North Branch Potomac River near Cumberland, Md.	877	Valley and Ridge	1929–present
01614500	Conococheague Creek at Fairview, Md.	494	Valley and Ridge	1928–present
01619500	Antietam Creek near Sharpsburg, Md.	281	Valley and Ridge	1897–1905, 1928–present
01638500	Potomac River at Point of Rocks, Md.	9,651	Piedmont West	1895–present
01643000	Monocacy River at Jug Bridge near Frederick, Md.	817	Piedmont West	1929–present
01645000	Seneca Creek at Dawsonville, Md.	101	Piedmont East	1930–present
01646500	Potomac River near Washington, D.C.	11,560	Piedmont East	1930–present
01648000	Rock Creek at Sherrill Drive at Washington, D.C.	62.2	Piedmont East	1929–present
01650500	Northwest Branch Anacostia River near Colesville, Md.	21.1	Piedmont East	1923–1983, 1997–present

predominantly unregulated, (2) have no major watershed withdrawals, (3) are located on streams that drain through Maryland, (4) lie within a drainage area greater than 1 mi^2, but less than 300 mi^2, and (5) have been gaged for more than 5 years (Preston, 1997). Funding and operation of core network stream gages should be of the highest priority because they most closely represent hydrologic characteristics and trends resulting from the effects of geology, physiography, and land use.

Maryland's core network had 76 stations in 1985 and 51 stations in 1994. In 1999, the number of stations was 57. Gages re-activated since 1994, however, now have gaps in the period of record averaging 13 years, and ranging from 8 to 28 years. These gaps make analysis of hydrologic trends much more difficult and less precise because the streamflow data from intervening years must be estimated.

Nontidal Core/Trends Monitoring Network

The Maryland Department of Natural Resources (MD DNR), Monitoring and Nontidal Assessments, monitors selected water-quality parameters on a monthly basis at 55 locations on nontidal streams and rivers (third-order and higher); 32 of these sites are paired with stream gages (figure 3). Information obtained from each site includes: temperature, dissolved oxygen (DO), pH, total organic carbon (TOC), ammonia (NH_3), total kjeldahl nitrogen (TKN), nitrite (NO_2),



BASE FROM U.S. GEOLOGICAL SURVEY, 1:500,000, 1979

Figure 3. Core and trend water-quality and stream-gage sites in Maryland, 1999.

Figure 3. Core and trend water-quality and stream-gage sites in Maryland, 1999 -- Continued

nitrate (NO_3), phosphate (PO_4), total phosphorus (TP), total suspended solids (TSS), chlorophyll a (Chla), pheophytin, coliform, alkalinity, and at selected sites, sulphate (SO_4). Sampling at 29 locations (which constitute the "core" network) was instituted in 1976 as part of U.S. Environmental Protection Agency's (USEPA) Section 106 Ambient Water-Quality Monitoring (Bowen, 1994). The remaining 26 sites, identified as "trend" sites, pre-date the core fixed-station network and use identical collection and analysis methods.

The information obtained from this network is used for the bi-annual 305(b) report (Garrison, 1996), watershed assessment, nonpoint-source abatement, and watershed nutrient-loading estimates. Nutrient-load estimates are calculated at 20 locations where USGS stream gages are located (figure 3). Trends are calculated for total nitrogen, total phosphorus, and total suspended solids at all sites on the basis of concentration only. Seven stream gages have been discontinued since the inception of this monitoring program (figure 3 and table 6).

Uses and Users of Stream-Gage Data

To determine the various uses and users of stream-gage data in Maryland, the Committee conducted a survey in the water-resources community in Maryland. A data-users questionnaire was developed based on a similar survey by a work group in Wisconsin (H.S. Garn, USGS, written commun., 1997) (appendix 2). When the survey was conducted in March 1998, the network included 82 stream gages in Maryland and 2 in the District of Columbia.

The mailing list for the survey was based on information compiled from agencies represented by the Committee. Approximately 500 questionnaires were mailed out to Federal, State and local government agencies, regional planning agencies, flood plain managers, local colleges and universities, watershed associations, recreational groups, and consultants. One hundred and two responses were received, representing 54 different organizations. Of the 102 responses, 54 were sufficiently detailed so that users and uses by specific stream gage could be identified. The approximate breakdown of responses was as follows: Federal (9 percent), State (38 percent), county (15 percent), regional agencies (14 percent), consultants (8 percent), municipalities (5 percent), recreational groups (5 percent), universities (4 percent), and watershed associations (2 percent).

The results of the survey identified 20 specific uses for stream-gage data (appendix 3). Eighteen of these uses were common to all 82 stream gages in Maryland. Many of the Federal and State agencies use data from all 82 gages. Other users may use data from only a few gages at any one time. Some groups were under-represented by the survey, especially consultants and recreational users.

Seven respondents use the data from all 82 stream gages (USGS, Water Resources Division, Maryland-Delaware-D.C. (MD-DE-DC) District; MDE, Water Rights Division; MDE Technical and Regulatory Services Administration, Compliance and Monitoring Division; MDE, Flood Hazard Mitigation Section; MDE, Non-tidal Wetlands and Waterways Division, MDE, Surface Discharge Permits Division; and MDSHA, Division of Bridge Design). Other major users included FEMA, who indicated use of more than 50 stream gages; the U.S. Fish and Wildlife Service (USFWS), Chesapeake Bay Field Office, who indicated use of 22 gages; and the MD DNR, who indicated use of approximately 20 gages.

For any specific stream gage, there were a minimum of 7 and a maximum of 15 users (figure 4). The survey also indicated that 22 specific gages had 10 different users, 5 gages had 14 different users, and 11 gages had 8 different users. Because any individual user may utilize data from a stream gage for more than one purpose, a particular stream gage may have 7 users who each use the data for 18 purposes. For example, 35 stream gages are used by 4 different users for regional and area assessments. Data from each of 2 stream gages are used by 10 different agencies and groups for analysis of floods and droughts.

The main limitation of the survey is that it represents only a partial sampling of all the users and uses of the data. This sampling clearly showed, however, that the current stream-gaging network in Maryland is used by a wide array of organizations for multiple purposes.

Table 6. Core and trend water-quality sites in Maryland that are paired with active and discontinued stream gages

[Refer to **key** in **Appendix 1 (pages 44–47)** for full name and location of sites; USGS = U.S. Geological Survey]

Core/trend site no.	Site name	Core station	Trend station	USGS station no.	Gage active or discontinued
1	NBP0689	X		01595500	Discontinued–1985
3	SAV0000 [A]		X	01597500	Active
4	GE00009	X		01599000	Active
6	NBP0326	X		01600000	Discontinued–1985
8	WIL0013 [A]		X	01601500	Active
11	TOW0030	X		01609000	Discontinued–1981
12	POT2766 [A]		X	01610000	Active
13	POT2386	X		01613000	Active
14	CON0180		X	01614500	Active
16	POT1830	X		01618000	Discontinued–1993
17	ANT0366		X	01619000	Discontinued–1981
19	ANT0044		X	01619500	Active
20	CAC0148		X	01637500	Active
22	POT1595 (MD)		X	01638500	Active
24	MON0528	X		01639000	Active
25	BPC0035		X	01639500	Active
27	MON0155	X		01643000	Active
31	SEN0008		X	01645000	Active
33	POT1184	X		01646500	Active
35	ANA0082	X		01649500	Active
36	PIS0033		X	01653600	Active
37	PXT0972	X		01591000	Active
38	PXT0809	X		01592500	Active
39	PXT0603	X		01594440	Active
40	NPA0165	X		01586000	Active

Table 6. Core and trend water-quality sites in Maryland that are paired with active and discontinued stream gages—Continued

Core/trend site no.	Site name	Core station	Trend station	USGS station no.	Gage active or discontinued
41	PAT0285		X	01589000	Discontinued–1995; To be re-activated–2000
43	GWN0115	X		01589300	Discontinued–1988; re-activated–1996
44	JON0184	X		01589440	Discontinued–1988; re-activated–1996
48	SUS0109	X		01578310	Active
50	CHO0626	X		01491000	Active
51	CAS0479 [A]		X	03078000	Active
53	YOU0925 [A]		X	03076500	Active

[A.] Sampling suspended in April 1999.

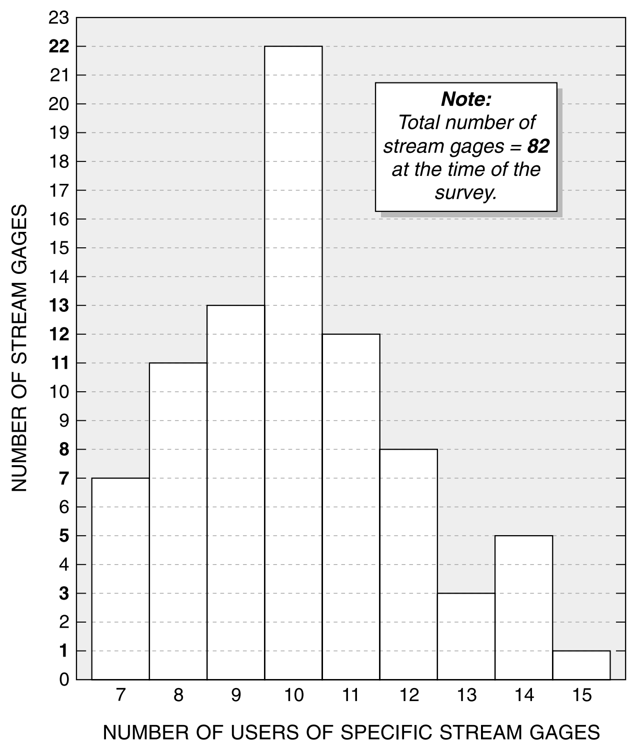


Figure 4. Number of users per stream gage.

Funding Support

Funding for the operation and maintenance of stream gages in Maryland is currently provided by a group of Federal, State, local, and regional-planning agencies. The USGS, MD-DE-DC District operates and maintains the stream gages and analyzes and publishes the data each year. Through the USGS Federal-State Cooperative Program, USGS can provide up to 50 percent of the maintenance and operation costs for individual stations. The remainder of the maintenance and operation costs are paid by other State, local, and regional-planning agencies that need the data for their missions. Because USGS cannot match money from other Federal Agencies through the Federal-State Cooperative Program, any maintenance and operation costs for stream gages that are paid by Federal Agencies must be unmatched. Table 7 presents approximate percentages of funding by agency for the stream-gaging network in Maryland during Federal fiscal years 1985, 1998, and 1999. Fiscal year 1998 percentages are based on 82 stream gages. In the 18 months since the information was compiled, 3 gages have been discontinued and 18 gages have been re-activated or newly activated. These changes to the network are reflected in the fiscal year 1999 percentages. Both the change in number of active stream gages and the change in funding by agency indicate the continuing variability in the network and its financial support.

The analyses of data users and uses and the breakdown of agency funding indicates that there are far more data users than financial supporters of the network. The data-users questionnaire also indicated that some financial supporters of the network also are able to make significant use of stream-gage data supported by other agencies. Certain divisions and sections of MDE, which extensively use the stream-gage data for water-quality analyses and modeling, contribute modestly to the network's support.

Agencies such as FEMA and the National Weather Service use the data extensively, but do not currently provide any financial support. Consultants also provide no financial support for the network. This can be explained in part by the practices of some Federal, State, and local government agencies that provide the data to consulting firms who bid on contracts requiring the information for the work. Because stream-gage data can be used for many purposes, which can and do change over time, there currently appear to be major inequities in financial support of the network. Various ways of addressing these inequities and recommendations for securing a more stable funding mechanism are presented in the Recommendations Section.

The cost of operation, maintenance, and distribution of data for Maryland stream gages was $9,500 per gage in Federal fiscal year 1999. This cost remains the same in fiscal year 2000. An analysis of stream-gage cost in Maryland since 1975 indicates that the current costs are approximately 4 percent higher than the increase in the national average Consumer Price Index (CPI) during the same period (U.S. Department of Labor, 1999) (appendix 4). The difference can be explained in part by the fact that Maryland has a relatively higher cost of living than the national average as a result of its proximity to Washington, D.C. There are also more resources available to the average data user than there were in 1975. For example, current unit-value data for stream gages are more readily available to the average user. Historical annual peaks and daily-mean discharges can also be downloaded from the World Wide Web. In addition, users now have the option of obtaining real-time data for selected stream gages.

Table 7. Percentage of stream-gage funding by agency in Maryland, Federal Fiscal Years 1985, 1998, and 1999

[–, no funding provided]

Agency	Percentage of stream-gage funding, 1985, based on 95 stations	Percentage of stream-gage funding, 1998, based on 82 stations	Percentage of stream-gage funding, 1999, based on 97 stations
U.S. Geological Survey	38.5	38.3	35.6
Maryland State Highway Administration	–	10.1	13.4
Maryland Department of Natural Resources	13.1	18.9	12.5
U.S. Army Corps of Engineers	24.1	8.5	7.7
National Park Service	1.5	–	–
Baltimore County Department of Environmental Protection and Resource Management	–	4.2	8.8
Baltimore County Department of Public Works	9.9	–	–
Baltimore City Department of Public Works	–	6.6	5.7
Baltimore Ecosystem Study (Long-Term Ecological Research)	–	1.2	5.7
Washington Suburban Sanitary Commission	6.2	5.4	4.8
Maryland Department of the Environment	5.6	2.0	1.9
Anne Arundel County Department of Public Works	–	1.2	1.0
Prince Georges County	–	1.2	1.0
Interstate Commission on the Potomac River Basin	–	1.1	0.9
Upper Potomac River Commission	1.1	0.8	0.5
Montgomery County Department of Environmental Protection	–	0.5	0.5
TOTAL	**100.0**	**100.0**	**100.0**

GAPS IN NETWORK COVERAGE AND ANALYSIS OF NEED

To be useful for current and future hydrologic investigations, the stream-gaging network needs to be stable for an extended period of time and include enough stations to represent the geographic and hydrologic variability of Maryland. Recently, major concern has been expressed at all levels of the water-resources community in Maryland as to whether or not an adequate number of stream gages are currently being operated throughout the State, and whether or not the full range of geographic conditions are represented (Preston, 1997). This analysis quantifies these concerns, and is used to provide a summary of problems with the current stream-gaging network.

Current Statewide Coverage

Analysis indicates that there are gaps in statewide coverage from different perspectives, including basin characteristics, percentage of physiographic regions gaged, as well as gaged and ungaged watersheds. The data-users questionnaire also established that many Federal and State agencies, such as the USGS, FEMA, MDSHA, and MDE have statewide data needs. Individual county governments and regional planning agencies have data needs that are specific to their individual regions; however, improvement of statewide coverage is critical to ensuring that stream-gage data is available in all regions of Maryland.

Statewide coverage can be improved by re-activating existing stream gages, and prioritizing and targeting currently ungaged watersheds, thereby increasing the percentage of drainage area covered by stream gages in different physiographic regions. For purposes of recommending improvements to the stream-gaging network, any stream gage that increases the percentage of drainage-area coverage in particular regions will be considered beneficial to the statewide network.

Despite recent progress made in Baltimore County and the Piedmont East Province, many other counties and physiographic regions in Maryland lack adequate stream-gage coverage. Roughly one-third of Maryland's total land area has stream-gage coverage. Large spatial gaps in coverage exist in the Coastal Plain West, Western Piedmont, Blue Ridge, and Valley and Ridge Provinces. The Coastal Plain East Province in Maryland is represented by only six long-term stream gages. Figure 1 shows these gaps in coverage.

Core Network Stream Gages

In water year 1999, 57 core network stream gages were in operation in Maryland (appendix 5). Although the total number of core network stream gages in Maryland increased from a minimum of 51 in 1994 to 57 in 1999, the core network continues to be unstable, as 2 core network stations were discontinued in 1998. Most physiographic regions, including the Coastal Plain East, Coastal Plain West, Piedmont West, Blue Ridge, and Valley and Ridge Provinces are poorly represented. On a statewide basis, Maryland does not have an adequate core network at the present time.

Because core network stream gages are most representative of natural hydrologic conditions and trends reflecting land use, physiography, and geology, efforts to improve statewide stream-gage coverage should include careful consideration of discontinued stream gages that meet the core-network criteria. Re-activation of discontinued core network stations can aid in furthering the understanding of regional hydrology in Maryland. Forty-six such stations have been identified (table 8). Obtaining current data at any of these stations to compare with that of the previous period of record would also be useful in assessing natural and manmade changes occurring in the watersheds over time.

Small Watersheds

Analysis of the various watersheds across Maryland has indicated that more than 50 percent of Maryland's river miles can be categorized as first- or second-order streams. At present, most stream gages are located in higher-order streams and are too few in number to assess the headwater areas of the watershed (J.P Reger, MWMC, Small Watersheds Studies Workgroup, written commun., 1998). In fact, most stream gages located on small streams using the criteria in the physical matrix (drainage area less than 5 mi^2) are of higher order than first- or second-order streams. The most common problem that was raised during the MWMC Stream-Gaging Workshop by the various attendees was a lack of stations and long-term data in first- and second-order watersheds.

In Maryland, the MWMC has established a Small Watershed Studies Workgroup to investigate the possibility of establishing small watershed research projects in each of the major physiographic regions. One of the critical factors in establishing small watersheds research projects is the monitoring network on which the research will be based. Stream gages are the key to understanding quantity and patterns in streamflow, ground-water contributions to the streamflow during periods of no surface runoff, and determination of contaminant loads that may be contributing to diminished water quality in the rest of the watershed.

Table 8. Discontinued stream gages in Maryland that meet the core network criteria

[mi^2 = square miles; CSG = Crest-Stage Gage; period of record indicates water years]

Station no.	Station name	County	Physiographic province	Drainage area (mi^2)	Period of record
01486500	Beaverdam Creek near Salisbury, Md.	Wicomico	Coastal Plain East	19.5	1938–75
01489000	Faulkner Branch at Federalsburg, Md.	Caroline	Coastal Plain East	7.10	1950–92
01490000	Chicamacomico River near Salem, Md.	Dorchester	Coastal Plain East	15.0	1951–80
01492000	Beaverdam Branch at Matthews, Md.	Talbot	Coastal Plain East	5.85	1950–81
01495500	Little Elk Creek at Childs, Md.	Cecil	Piedmont East	26.8	1949–58
01496000	Northeast Creek at Leslie, Md.	Cecil	Piedmont East	24.3	1949–84
01496200	Principio Creek at Principio Furnace, Md.	Cecil	Piedmont East	9.03	1967–92
01579000	Basin Run at Liberty Grove, Md.	Cecil	Piedmont East	5.31	1949–58, 1965–76 (CSG)
01580200	Deer Creek near Kalmia, Md.	Harford	Piedmont East	125.0	1967–77
01583000	Slade Run near Glyndon, Md.	Baltimore	Piedmont East	2.09	1947–81
01585300	Stemmers Run at Rossville, Md.	Baltimore	Coastal Plain West	4.46	1959–72, 1974–89
01585400	Brien Run at Stemmers Run, Md.	Baltimore	Coastal Plain West	1.97	1958–87
01587500	South Branch Patapsco River at Henryton, Md.	Howard	Piedmont East	64.4	1948–80
01588000	Piney Run near Sykesville, Md.	Carroll	Piedmont East	11.4	1931–58
01590000	North River near Annapolis, Md.	Anne Arundel	Coastal Plain West	8.50	1932–74
01593710	Middle Patuxent River near Simpsonville, Md.	Howard	Piedmont East	48.4	1987–95
01594400	Dorsey Run near Jessup, Md.	Howard	Coastal Plain West	11.6	1948–58, 1959–68 (CSG)
01594500	Western Branch near Largo, Md.	Prince Georges	Coastal Plain West	30.2	1950–75
01594600	Cocktown Creek near Huntingtown, Md.	Calvert	Coastal Plain West	3.85	1957–76
01594670	Hunting Creek at Huntingtown, Md.	Calvert	Coastal Plain West	9.38	1989–98
01594710	Killpeck Creek at Huntersville, Md.	St. Mary’s	Coastal Plain West	3.26	1986–98
01594800	St. Leonard Creek near St. Leonard, Md.	Calvert	Coastal Plain West	6.73	1957–68
01597000	Crabtree Creek near Swanton, Md.	Garrett	Appalachian Plateau	16.7	1948–81
01609000	Town Creek near Oldtown, Md.	Allegany	Valley and Ridge	148.0	1928–35, 1967–1981
01609500	Sawpit Run near Oldtown, Md.	Allegany	Valley and Ridge	5.08	1948–58, 1963–76 (CSG)

Table 8. Discontinued stream gages in Maryland that meet the core network criteria—Continued

Station no.	Station name	County	Physiographic province	Drainage area (mi^2)	Period of record
01612500	Little Tonoloway Creek near Hancock, Md.	Washington	Valley and Ridge	16.9	1947–63, 1964 (CSG)
01637000	Little Catoctin Creek at Harmony, Md.	Frederick	Blue Ridge	8.83	1947–59, 1968, 1961–67 (CSG), 1969–77 (CSG)
01639375	Toms Creek at Emmitsburg, Md.	Frederick	Blue Ridge	41.3	1986–90, 1996 (CSG)
01640000	Little Pipe Creek at Avondale, Md.	Carroll	Piedmont West	8.10	1947–56, 1959–65 (CSG), 1967–80 (CSG)
01640500	Owens Creek at Lantz, Md.	Frederick	Blue Ridge	5.93	1932–84
01640965	Hunting Creek near Foxville, Md.	Frederick	Blue Ridge	2.14	1982–94
01640970	Hunting Creek Tributary near Foxville, Md.	Frederick	Blue Ridge	4.01	1982–91
01649080	Bear Branch near Thurmont, Md.	Frederick	Blue Ridge	.38	1990–95
01641000	Hunting Creek at Jimtown, Md.	Frederick	Piedmont West	18.4	1950–92
01641500	Fishing Creek near Lewistown, Md.	Frederick	Blue Ridge	7.29	1948–84
01641510	Fishing Creek Tributary near Lewistown, Md.	Frederick	Piedmont West	.40	1988–95
01645200	Watts Branch at Rockville, Md.	Montgomery	Piedmont East	3.70	1957–87
01646550	Little Falls Branch near Bethesda, Md.	Montgomery	Piedmont East	4.10	1944–59, 1962–79, 1979–84 (CSG)
01647685	Williamsburg Run near Olney, Md.	Montgomery	Piedmont East	2.25	1967–74
01647720	North Branch Rock Creek near Norbeck, Md.	Montgomery	Piedmont East	9.73	1967–77
01647725	Manor Run near Norbeck, Md.	Montgomery	Piedmont East	1.01	1967–74
01650050	North West Branch Anacostia River at Norwood, Md.	Montgomery	Piedmont East	2.45	1967–74
01650085	Nursery Run at Cloverly, Md.	Montgomery	Piedmont East	.35	1967–74
01658000	Mattawoman Creek near Pomonkey, Md.	Charles	Coastal Plain West	54.8	1950–72, 1973–86 (CSG)
01661000	Chaptico Creek at Chaptico, Md.	St. Mary’s	Coastal Plain West	10.4	1947–72
03077940	South Branch Casselman River near Bittinger, Md.	Garrett	Appalachian Plateau	3.22	1977–81

Table 9. Active stream gages in Maryland on first- or second-order streams

[mi^2 = square miles; period of record indicates water years]

Station no.	Station name	Physiographic province	Drainage area (mi^2)	Period of record	Approximate stream order [A]
01581940	Mingo Branch near Hereford, Md.	Piedmont East	0.78	1999–present	2
01583570	Pond Branch at Oregon Ridge, Md.	Piedmont East	.16	1983–86, 1998–present	1
01583580	Baisman Run at Broadmoor, Md.	Piedmont East	1.47	1964–69, 1970–76 (CSG), 1999–present	2
01583980	Minebank Run at Loch Raven, Md.	Piedmont East	2.90	1997–present	2
01585200	West Branch Herring Run at Idlewylde, Md.	Piedmont East	2.13	1957–65, 1966–87, 1997–present	2
01585225	Moores Run Tributary at Baltimore, Md.	Coastal Plain West	.21	1996–present	1
01589501	Sawmill Creek Tributary near Ferndale, Md.	Coastal Plain West	.56	1995, 1997–present	1
01589795	South Fork Jabez Branch at Millersville, Md.	Coastal Plain West	1.0	1989–90, 1997–present	1
01589180	Gwynns Falls at Glyndon, Md.	Piedmont East	.32	1998–present	1
01594936	North Fork Sand Run near Wilson, Md.	Appalachian Plateau	1.91	1980–present	2
01594950	McMillan Fork near Fort Pendleton, Md.	Appalachian Plateau	2.30	1986–present	2

A. Stream orders are based on blue-line streams from 7.5-minute topographic maps.

The current stream-gaging network includes 11 stations on first- and second-order watersheds (table 9). Only 3 of the 11 stations have periods of record greater than 10 years. One of those 3 stations, West Branch Herring Run at Idlewylde, was recently restarted after almost a 10-year break in the continuous record. Of the other 8 stations, 1 has 5 years of continuous record and 4 also have breaks in the record. Even in the Piedmont East Province, where stream gages are most abundant in Maryland's current network, long-term data on first- and second-order watersheds is not available. The Coastal Plain East, Piedmont West, Blue Ridge, and Valley and Ridge Provinces are also completely unrepresented in this category.

Clean Water Action Plan Priority Watersheds

The Clean Water Action Plan (CWAP) is an initiative aimed at fulfilling the original goals of the Clean Water Act—fishable, swimmable, and safe waters for all Americans (Clean Water Action Plan Technical Workgroup, 1998). One key element of CWAP is a cooperative approach to restoring and protecting water quality in which Federal, State and local governments work with stakeholders and interested citizens to (1) identify watersheds not meeting clean water and other natural resource goals, and (2) work cooperatively to focus resources and implement effective strategies to solve these problems. CWAP calls for State environmental-agency leaders and State conservationists to work together and to involve a full range of appropriate parties (P. Massicot, MD DNR, CWAP Technical Workgroup, written commun., 1998). As part of developing unified watershed assessments, restoration priorities and restoration action strategies, all components of a watershed related to aquatic systems must be considered, including biological, chemical, and physical characteristics. Stream gages are the key component to understanding the physical and chemical characteristics of a watershed because (1) streamflow affects the geomorphic form and processes of the stream channel and (2) determination of contaminant loads transported by streams and rivers requires knowledge of both water quantity and chemical concentrations.

The State of Maryland has identified twelve Category 1 priority watersheds where restoration is required, and five Category 3 watersheds where protection is required as part of CWAP (figure 5). Of the twelve Category 1 watersheds, 5 are currently ungaged. These watersheds are (1) Deep Creek Lake, (2) Mattawoman Creek, (3) Upper Elk River, (4) Wye River, and (5) Lower Pocomoke River. Although the Lower Pocomoke River is ungaged, the Upper Pocomoke River watershed has 2 gaged subwatersheds. Another of the priority watersheds, Upper Monocacy River, has partial coverage that needs improvement for understanding the aquatic system on a watershed level (figure 6). There are 3 gaged subwatersheds in the Monocacy River Basin. The mainstem of the Upper Monocacy River (Station 01639000, Monocacy River at Bridgeport, Md.) is gaged. Two other subwatersheds (Piney Run and Bennett Creek) are also gaged. Monocacy River at Jug Bridge near Frederick, Md. (Station 01643000) is also an active gage; however, it is not shaded because the size of the drainage area (817 mi^2) would give a false impression of the adequacy of the spatial gage coverage in the basin. The smaller triangles denote 13 discontinued stream gages in the Monocacy watershed. Although Big Pipe Creek is located in the Monocacy River Basin and is gaged, the creek has its own 8-digit HUC and is therefore excluded from the Monocacy River group.

Of the other 6 priority watersheds, Gwynns Falls has the most coverage with 4 active gages on the mainstem and 2 on its tributaries as of November 15, 1999. The Upper North Branch Potomac River, Georges Creek, and Antietam Creek each have a stream gage that covers 98 percent, 98 percent, and 96 percent of their watersheds, respectively. The Lower Monocacy River has a stream gage that covers 84 percent of the overall watershed. Seneca Creek has a stream gage that covers 78 percent of its watershed.

Five Category 3 watersheds related to surface-water reservoirs are also considered high priority. These include (1) Prettyboy Reservoir, (2) Liberty Reservoir, (3) Loch Raven Reservoir, (4) Brighton Dam at the Triadelphia Reservoir, and (5) Rocky Gorge Dam at the T. Howard Duckett Reservoir. Current network coverage includes stream gages at Brighton Dam and Rocky Gorge Dam. Prettyboy Reservoir, Liberty Reservoir, and Loch Raven Reservoir do not have stream gages at their outlets.

No active stream gages currently cover any of the inflow into Prettyboy Reservoir. The 80 mi^2 of drainage from Prettyboy Reservoir is included in the 160 mi^2 covered by the active stream gage on Gunpowder Falls at Glencoe, Md. This gage, however, includes too much additional drainage area to solely reflect outflow from the reservoir.

The drainage area on the North Branch Patapsco River at Liberty Dam is approximately 164 mi^2. Three active stream gages above the reservoir cover about 98 mi^2, or 60 percent of the drainage area contributing to the inflow into the reservoir.

The drainage area of Gunpowder Falls at Loch Raven Dam is about 303 mi^2. Three active stream gages above the reservoir cover about 241 mi^2, or 80 percent of the drainage area contributing to the inflow into the reservoir.

Pfiesteria and Harmful Algal Blooms

Harmful algal blooms, such as *Pfiesteria*, are a continuing concern in the Chesapeake Bay and the Potomac River, especially in the sub-estuaries. These blooms are fueled in part by nutrients in the streams that discharge into the sub-estuaries. To evaluate nutrient loadings, streamflow information is combined with water-quality data. In Maryland, 27 gages in the Coastal Plain are active as of

November 15, 1999 (figure 7), down from 51 in operation in previous years. As a result, there are significant gaps in stream-gage coverage, especially on the Eastern Shore. Re-activation of 7 stream gages is recommended to improve coverage of the sub-estuaries. In addition, a new station is to be activated in the St. Martins River watershed in December 1999. A second new station is also recommended in the Ocean/Coastal area of the Eastern Shore, on Trappe Creek.

Nontidal Core/Trends Monitoring Network

The present nontidal core/trends monitoring network concentrates on the Piedmont East, Piedmont West, Blue Ridge, and Valley and Ridge Provinces (figure 3). As the network expands into the Coastal Plain East and West Provinces, it can build on the existing stream-gaging network (currently 27 stream gages), re-activation of stream gages, and establishment of new stream gages.

Droughts and Long-Term Stream Gages

Long-term stream gages are crucial for understanding droughts because: (1) they provide data on inflows into water-supply reservoirs, (2) they can provide a long-term perspective on how wet or how dry any particular year or period of years has been at that station, (3) they provide data that may indicate trends in water quantity or availability over time, and (4) a network of long-term stream gages identifies the local, regional, or statewide nature of a drought.

The 12 active stream gages with continuous record dating back to the 1930–31 drought should

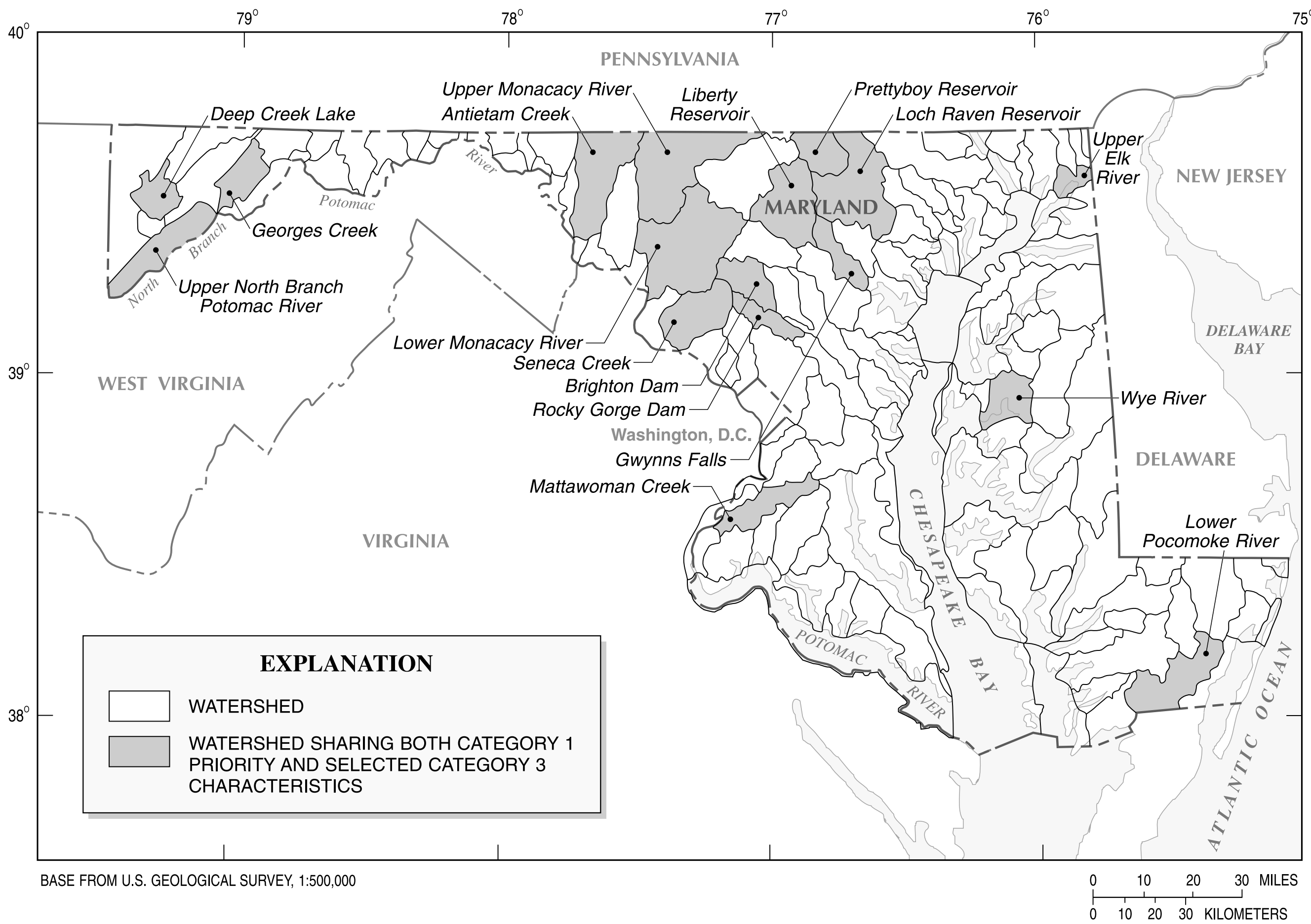


Figure 5. Clean Water Action Plan priority watersheds in Maryland (modified from Clean Water Action Plan Technical Workgroup, 1998).

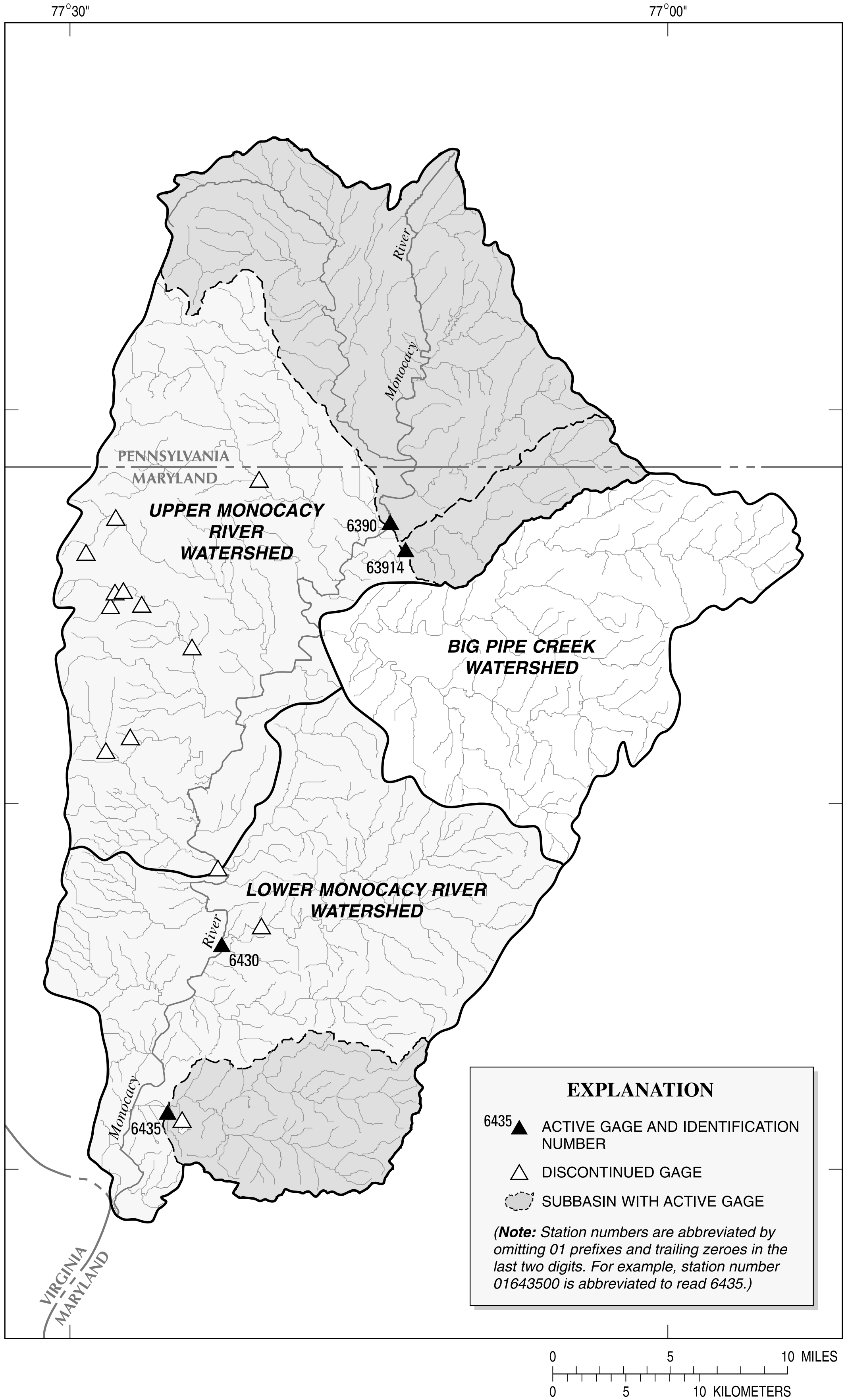
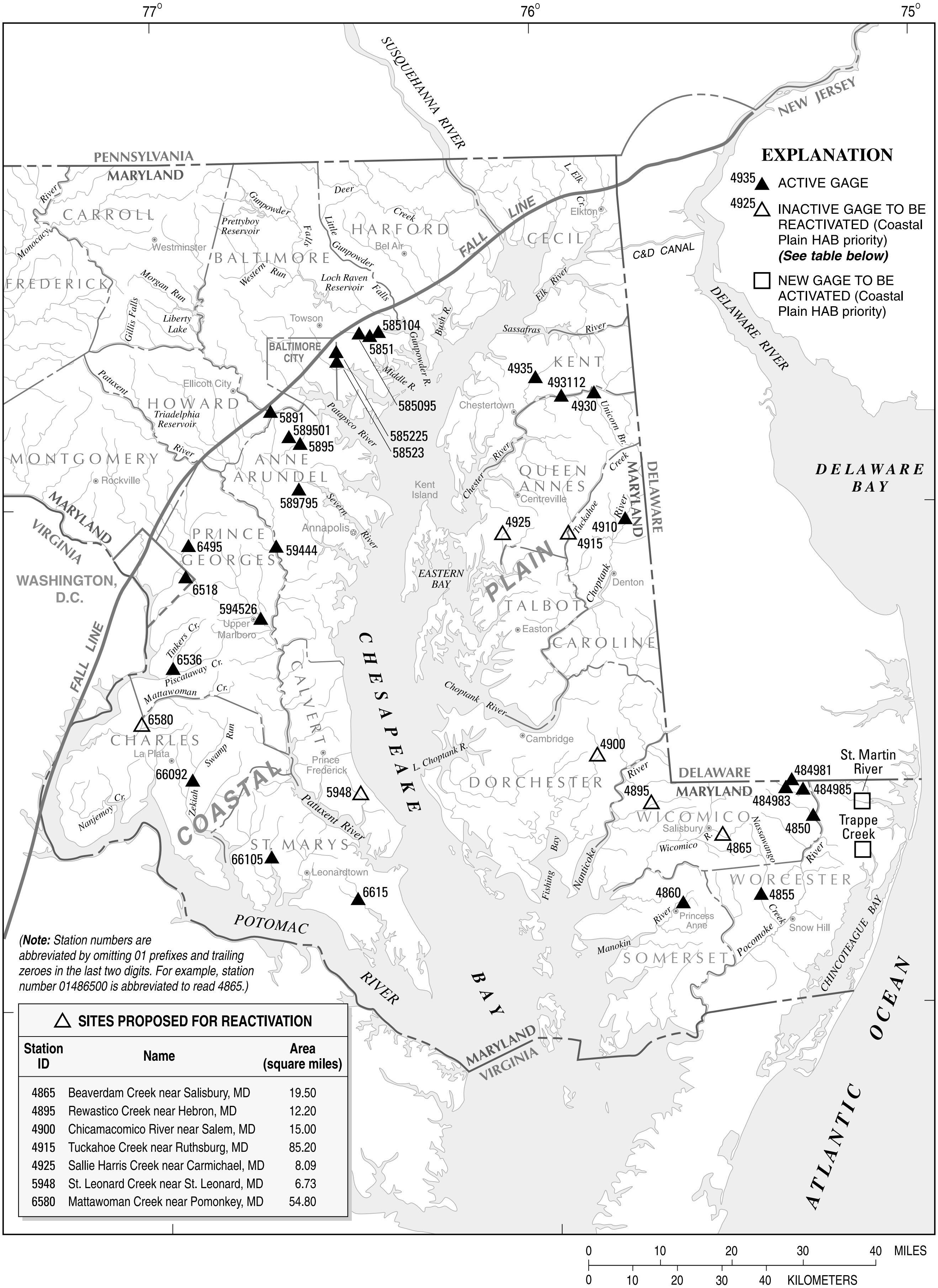


Figure 6. Stream-gage coverage in the Monocacy River watershed, water year 1999.



(**Note:** *Station numbers are abbreviated by omitting 01 prefixes and trailing zeroes in the last two digits. For example, station number 01486500 is abbreviated to read 4865.)*

△ **SITES PROPOSED FOR REACTIVATION**

Station ID	Name	Area (square miles)
4865	Beaverdam Creek near Salisbury, MD	19.50
4895	Rewastico Creek near Hebron, MD	12.20
4900	Chicamacomico River near Salem, MD	15.00
4915	Tuckahoe Creek near Ruthsburg, MD	85.20
4925	Sallie Harris Creek near Carmichael, MD	8.09
5948	St. Leonard Creek near St. Leonard, MD	6.73
6580	Mattawoman Creek near Pomonkey, MD	54.80

Figure 7. Gaging stations in the Coastal Plain of Maryland, water year 1999.

be maintained to provide long-term perspective on future droughts. Of the other 38 active stream gages with continuous record dating back to the 1965–1966 drought, as many as possible should also be maintained. Often stream gages are discontinued due to shifting funding priorities during extended periods of time when flows remain within the normal range. This practice should be carefully evaluated because discontinuing stream gages ensures that data will be unavailable during hydrologic extremes when it is most needed, and assessment of trends and conditions of water resources during drought situations will be compromised.

Ungaged Watersheds

Many of the problems with existing stream-gage coverage are associated with ungaged watersheds. Although there are many watersheds and subwatersheds with little or no stream-gage coverage, eight principal watersheds where coverage is severely lacking include: (1) the Nanticoke River Basin, (2) the Choptank River Basin, (3) the Chester River Basin, (4) the Elk River Basin, (5) the Bush River Basin, (6) the Lower Potomac River Basin (Coastal Plain West below Washington, D.C.), (7) the Upper Potomac River Basin (tributaries to Potomac River in Washington County and Allegany County, Md.), and (8) the Ocean/Coastal region of Maryland's Eastern Shore (table 3).

Other Stakeholder Needs

Many attendees from the MWMC Stream-Gaging Workshop and respondents from the data-users questionnaire expressed the need for more stream gages on small watersheds and urban watersheds. Others reiterated the problem of insufficient coverage in many of Maryland's physiographic provinces. Selected attendees outlined specific needs for stream-gage data and specific streams where active stream gages would enhance ongoing or planned projects.

Several examples of various needs for stream-gage data by network stakeholders are presented below. MDSHA and the USFWS are currently involved in a statewide project to develop regional curves of bankfull-channel geometry characteristics by physiographic region for Maryland. These curves are intended for use in river-restoration efforts and for designing bridges and culverts that are less likely to create geomorphic problems for stream channels. The key to development of these curves is availability of stream-gage data from active stations of various watershed sizes that can be used in field calibration of the bankfull stage and discharge. MDSHA and the USFWS have expressed a need for a minimum of 20 active stream gages in watersheds in each major physiographic region that are unregulated, predominantly undeveloped, and representative of a range of drainage areas up to about 100 mi^2. Because this network criterion does not exist on a statewide level, and cannot be addressed in the project's time frame, the USGS is working in cooperation with MDSHA and the USFWS to redevelop stage-discharge ratings on a short-term basis at selected discontinued stations to help accomplish the goals of this study. Restoration of streams and rivers across Maryland can be considered an ongoing and long-term objective, however. Meanwhile, Maryland's landscape continues to change as a result of population growth and urban development. Enhancement of Maryland's core network, the addition of stream gages in currently ungaged watersheds, and overall statewide coverage are critical for quantifying these landscape changes and ensuring availability of necessary streamflow data for restoration efforts.

The Frederick County Planning Commission indicated that they use all active stream gages in Frederick County and western Carroll County for various purposes including regional/area assessments, river classification and restoration, flood and drought analysis, research, trend analysis, evaluation of current conditions, planning, watershed management, water supply, evaluating impacts, and water-quality investigations. They also indicated that their mission would be enhanced by restarting the discontinued stream gages on (1) Little Catoctin Creek at Harmony, Md., (2) Catoctin Creek near Jefferson, Md., (3) Toms Creek at Emmitsburg, Md., (4) Hunting Creek near Foxville, Md., (5) Hunting Creek near Thurmont, Md., (6) Hunting Creek near Jimtown, Md., (7) Fishing Creek near Lewistown, Md., and (8) Linganore Creek near Frederick, Md. Suggested streams for the addition of new stream gages included Bush Creek and Ballenger Creek.

The Natural Resources Conservation Service and Allegany Soil Conservation District both use the stream gage on Georges Creek at Franklin, Md., for flood-related issues. They stated that available data was not sufficient to meet their current needs and that more stations are needed on additional streams. They indicated the need for multiple stream gages along Georges Creek, re-activation of the stream gage on Town Creek near Oldtown, Md., and the addition of new stream gages on Braddock Run and Jennings Run.

The Baltimore City Water-Quality Management Section uses all active stream gages in the Liberty Reservoir and Loch Raven Reservoir watersheds for various purposes including research, problem assessment, trend analysis, modeling, evaluating current conditions, watershed management, forecasting, baseline flow and water-quality data, and water supply. They also indicated use of stream-gage data from two small, urban stations for compliance with National Pollutant Discharge Elimination System (NPDES) permitting. Suggested network improvements included Fall Line stream gages on Jones Falls, Herring Run, and the Patapsco River.

St. Mary’s County Department of Planning and Zoning uses data from stream gages on Killpeck Creek, St. Clements Creek, and the St. Mary’s River for regional assessments, watershed management, and planning. Suggested improvements to the network included re-starting of the stream gage on Killpeck Creek, which was discontinued in 1998. They also suggested new stream gages on Breton Bay and McIntosh Run due to the presence of an endangered species (the dwarf wedge mussel) near a significantly developed area.

The Washington Suburban Sanitary Commission (WSSC) uses data from stream gages in the Patuxent River watershed that are critical to water supply at Triadelphia Reservoir above Brighton Dam, and T. Howard Duckett Reservoir above Rocky Gorge Dam. Suggested network improvements included new stations on Big Branch, Nichols Branch, and Hackette Branch, which are small tributaries to the Triadelphia Reservoir. Big Branch was of the highest priority to WSSC because the stream runs through several farms that use pesticides.

The MD DNR Coastal Bays Program indicated a need for data in the St. Martin River and Trappe Creek watersheds because of water-quality and potential *Pfiesteria* concerns. No stream gages are in operation in the Coastal Bays area, and no continuous-record stream gages have ever been operated in this region. Recent investigations by MD DNR have identified dormant *Pfiesteria*-like organisms in sediment samples from the St. Martin River, as well as unknown dormant *Pfiesteria*-like organisms in sediment samples from Trappe Creek.

In addition to these locations in the Coastal Bays region, the Wicomico River, Lower Pocomoke River, Chicamacomico River, and Big Annemessex River were also identified by MD DNR as having dormant *Pfiesteria*-like organisms in bed-sediment samples. None of these locations have active stream gages on their mainstems. Historical data is available only for the Chicamacomico River (1951–80), and for Beaverdam Creek (1930–32; 1938–75), which is a tributary to the Wicomico River.

RECOMMENDATIONS

Stream-Gage Prioritization

The MWMC Stream-Gage Committee’s recommendations for the stream-gaging network in Maryland are based on the goals of Federal, State, and local government agencies that were identified from the data-users questionnaire. The goals and uses of streamflow information fall into two general categories: evaluation of current conditions and trends, and watershed management and planning. Current condition issues include accounting for and tracking distribution of streamflow, regional and area assessments, water-quality, ecosystems and aquatic living resources, recreation, and flood hazard warning. Watershed management and planning requires streamflow information for issues concerning stream protection and restoration, water quality,

Table 10. Stream-Gage Committee subnetwork priorities

Priority rank	Priority issues
1	Coastal Plain Harmful Algal Blooms
2	Small watersheds
3	Core network
4	Ungaged 6- and 8-digit Hydrologic Unit Code watersheds
5	Clean Water Action Plan
6	Flood hazard (Garrett, Allegany, Washington, and Frederick Counties)
7	Core/Trend water-quality network
8	Unmet spatial coverage
9	Unmet physical matrix categories

watershed-pollution modeling, flood and drought forecasting, and living resources/ecosystems.

To address these management goals and uses, the stream-gaging network was analyzed in terms of spatial coverage and physical matrix gaps. Subsequently, subsets of the stream-gaging network were evaluated: the core network; small watersheds; overall coverage of watersheds; gaged and ungaged watersheds; nontidal core/trends network; CWAP priority watersheds, which includes water-supply watersheds; hazards network; and Coastal Plain HABs.

Based on analysis of the existing stream-gaging network in Maryland and the multiple management goals and issues, it was concluded that operation of all 97 active stream gages should be continued. A major concern in this regard is the continuing dynamic character of the network, with some gages being discontinued and others being added. A second concern focuses on stream gages with long-term record and the need to ensure their continued operation.

In developing recommendations for additions to the network, the Committee prioritized the subnetworks (table 10). Discontinued stream gages that should be re-activated were identified on the basis of these priorities. Because any specific stream gage may meet a need for more than one use, filling a need for a high-priority subnetwork may also fill a gap in a lower priority subnetwork.

In the spring of 1999, MGS was asked to identify stream gages for re-activation that meet three MD DNR management objectives: Coastal Plain HABs, small watersheds, and CWAP priority watersheds. Based on management needs, 22 stream gages were recommended for re-activation. Of the 22 stream gages, 21 meet the core-network criteria; 21 fill gaps in spatial coverage, and 16 fill gaps in selected physical matrix categories. These multiple uses of stream-gage data reinforce a major finding of the data-users questionnaire, indicating that each stream gage serves multiple uses.

Over the long term, the Committee recommends that the stream-gaging network in Maryland be expanded to a total of 157 gages, an increase of 60 over the current 97 gages. In considering subnetworks and the multiple uses the data from each stream gage may serve, 8 gages should be added to address the Coastal Plain HAB priority (7 re-activated and 1 new); 21 gages should be added in small watersheds (11 re-activated and 10 new); 22 gages should be added to the core network (20 re-activated and 2 new); 2 new gages should be added to address CWAP priorities; and 5 gages should be added to address the flood-hazard priority (2 re-activated and 3 new) (table 11).

Table 11. Stream gages recommended for addition to the network in Maryland according to subnetwork priorities

[HAB = Harmful Algal Bloom; HUC = Hydrologic Unit Code; TBD = Proposed new streams; station no. to be determined]

Station no.	Stream name	Physiographic province	SUBNETWORK PRIORITIES								
			Coastal Plain HAB	Small watershed	Core network	Clean Water Action Plan	Core Trend	Flood hazard	Ungaged 6- or 8-digit HUC	Unmet spatial coverage	Unmet physical matrix
01486500	Beaverdam Creek	Coastal Plain East	X		X			X	X	X	X
01489000	Faulkner Branch	Coastal Plain East			X				X	X	
01489500	Rewastico Creek	Coastal Plain East	X		X					X	
01490000	Chicamacomico River	Coastal Plain East	X		X				X	X	
01491500	Tuckahoe Creek	Coastal Plain East	X		X				X	X	
01492000	Beaverdam Branch	Coastal Plain East			X				X	X	
01492500	Sallie Harris Creek	Coastal Plain East	X		X	X			X	X	
01494000	Southeast Creek	Coastal Plain East			X					X	
01494500	Jacobs Creek	Coastal Plain East			X				X	X	
TBD	Trappe Creek	Coastal Plain East	X	X					X	X	
01495500	Little Elk Creek	Piedmont East			X				X	X	
01495800	Long Creek	Coastal Plain East		X		X			X	X	X
01496000	Northeast Creek	Piedmont East			X			X	X	X	
01496200	Principio Creek	Piedmont East			X				X	X	
01579000	Basin Run	Piedmont East			X				X	X	

Table 11. Stream gages recommended for addition to the network in Maryland according to subnetwork priorities—Continued

Station no.	**Stream name**	**Physiographic province**	**SUBNETWORK PRIORITIES**								
			Coastal Plain HAB	**Small watershed**	**Core network**	**Clean Water Action Plan**	**Core Trend**	**Flood hazard**	**Ungaged 6- or 8-digit HUC**	**Unmet spatial coverage**	**Unmet physical matrix**
TBD	Swan Creek	Piedmont East		X					X	X	
TBD	Broad Creek	Piedmont East		X					X	X	
TBD	Little Deer Creek	Piedmont East		X						X	
01583000	Slade Run [A]	Piedmont East		X	X						X
01585300	Stemmers Run	Coastal Plain West		X	X			X		X	X
01585400	Brien Run	Coastal Plain West		X	X			X		X	
01587500	South Branch Patapsco River	Piedmont East			X				X	X	
TBD	Gillis Falls	Piedmont East		X					X	X	
01590000	North River	Coastal Plain West			X			X	X	X	X
TBD	Big Branch	Piedmont East		X		X					
TBD	Deep Run	Piedmont East								X	
01594600	Cocktown Creek	Coastal Plain West		X	X					X	X
01594670	Hunting Creek	Coastal Plain West			X					X	X
01594710	Killpeck Creek	Coastal Plain West		X	X					X	
01594800	St. Leonard Creek	Coastal Plain West	X		X					X	X

Table 11. Stream gages recommended for addition to the network in Maryland according to subnetwork priorities—Continued

Station no.	Stream name	Physiographic province	SUBNETWORK PRIORITIES								
			Coastal Plain HAB	Small watershed	Core network	Clean Water Action Plan	Core Trend	Flood hazard	Ungaged 6- or 8-digit HUC	Unmet spatial coverage	Unmet physical matrix
01595500	North Branch Potomac River [A]	Appalachian Plateau					X	X		X	
01600000	North Branch Potomac River [A]	Valley and Ridge					X	X			
01609000	Town Creek	Valley and Ridge			X		X	X	X	X	
01609500	Sawpit Run	Valley and Ridge		X	X				X	X	X
01612500	Little Tonoloway Creek	Valley and Ridge			X			X	X	X	X
01618000	Potomac River [A]	Valley and Ridge					X	X			
TBD	Conococheague Creek	Valley and Ridge						X		X	
TBD	Little Conococheague Creek	Valley and Ridge		X				X	X	X	
TBD	Licking Creek	Valley and Ridge						X	X	X	X
TBD	Tonoloway Creek	Valley and Ridge						X	X	X	
TBD	Fifteen Mile Creek	Valley and Ridge						X	X	X	X
TBD	Evitts Creek	Valley and Ridge						X	X	X	
TBD	Braddock Run	Valley and Ridge		X				X		X	X
01637000	Little Catoctin Creek	Blue Ridge			X			X		X	X
01639375	Toms Creek	Blue Ridge			X	X		X		X	X

Table 11. Stream gages recommended for addition to the network in Maryland according to subnetwork priorities—Continued

Station no.	Stream name	Physiographic province	SUBNETWORK PRIORITIES								
			Coastal Plain HAB	Small watershed	Core network	Clean Water Action Plan	Core Trend	Flood hazard	Ungaged 6- or 8-digit HUC	Unmet spatial coverage	Unmet physical matrix
01640000	Little Pipe Creek	Piedmont West			X	X				X	X
TBD	Little Bennett Creek	Piedmont West				X				X	
01640965	Hunting Creek	Blue Ridge		X	X	X				X	X
01640970	Hunting Creek Tributary	Blue Ridge		X	X	X				X	X
01640980	Bear Branch	Blue Ridge		X	X	X				X	X
TBD	Broad Run	Blue Ridge								X	
01641000	Hunting Creek	Piedmont West			X	X				X	X
01641500	Fishing Creek	Piedmont West			X	X				X	X
01641510	Fishing Creek Tributary	Piedmont West		X	X	X				X	X
01658000	Mattawoman Creek	Coastal Plain West	X		X	X			X	X	X
01661000	Chaptico Creek	Coastal Plain West			X				X	X	
TBD	McIntosh Run	Coastal Plain West		X					X	X	
TBD	Mill Dam Run	Coastal Plain West		X						X	
TBD	Deep Creek Lake Outlet	Appalachian Plateau				X			X		
TBD	Little Youghiogheny River	Appalachian Plateau		X				X	X		

[A.] Station currently being operated as a crest-stage partial-record station.

If these needs are met, many of the gaps in the ungaged 6- and 8-digit HUCs, unmet spatial coverage, and unmet physical matrix categories will be filled. To fill the remaining gaps, the Committee recommends adding 2 new stream gages (1 in the Piedmont East Province, and 1 in the Blue Ridge Province) (table 11).

Funding Options

The stream-gaging network in Maryland is operated and maintained by the USGS. The network is partly funded through the USGS Federal-State Cooperative Program, in which up to 50 percent of the cost of each stream gage is funded by USGS, and 50 percent or greater is funded by State or local cooperators. When matching funds are not available, or if a stream gage is deemed not to be in the Federal interest, then the Cooperating agency pays 100 percent of the costs of operation and maintenance.

At present, there is no uniform strategy for funding stream gages. User objectives and available funds determine which gages will be funded and operated. This situation will continue into the future unless Federal, State, and local agencies join in support of a stream-gaging network strategy and a long-term funding commitment. Events of the recent past clearly illustrate this situation. In 1985, there were 95 active stream gages, and in 1995, the number of active gages decreased to 76. In 1998, 82 gages were active; in 1999, 3 gages were discontinued and 18 were re-activated or newly installed.

Just as the number of stream gages has varied over time, so have the funding sources that pay for the network (table 7). Federal support has declined as the U.S. Army Corps of Engineers has shifted some priorities away from stream gages. State agency support has shifted from MD DNR to MDSHA. Regional, county, and municipal support varies depending on management needs and changing fiscal resources.

The Committee recommends that future stream gage costs be shared on the basis of need and interest—Federal, State, and county/municipal (table 12). Federal interest focuses on basin-scale (6-digit HUCs) and regional trends and conditions related to water-quality assessment. Such stream gages should be funded 100 percent by the Federal Government. Shared Federal, State, and county/municipal interests focus on representative 8-digit HUCs, CWAP watersheds, water-supply reservoirs, flood-drought hazards, and small watersheds. Stream-gage costs for these priorities should be shared by Federal (50 percent), State (25 percent), and county/municipal interests (25 percent). The Federal cost share may be allocated in part by the USGS Federal-State Cooperative Program or from other Federal agencies, depending on the specific priorities. In locations where gaps remain in the spatial coverage and physical matrix categories, the Committee recommends that cost sharing be split between State or county/municipal sources and the U.S. Geological Survey Federal-State Cooperative Program, pending availability of such funds.

Cost sharing is recommended because of the way in which streamflow information is used. The USGS, FEMA, USFWS, U.S. Army Corps of Engineers, and the Chesapeake Bay Program make significant use of stream-gage data. Consequently, Federal cost sharing in most of the network is appropriate. In the same manner, State agencies such as MDE, MD DNR, and MDSHA use information from all of the stream gages, and should also share in the funding of the entire network. These uses include monitoring of water quality, evaluating regional trends and current conditions, recreation, highway and bridge design, flood-hazard mitigation, and water rights. County and municipal agencies should share in the costs of those gages within their jurisdictions—the Committee suggests a 25 percent cost share. County and municipal data uses include water-supply reservoirs, multi-disciplinary studies and restoration of small watersheds, monitoring of water quality (trends and conditions, regulations), and recreation.

Table 12. Recommended funding responsibilites for the stream-gaging network in Maryland

[HUC = Hydrologic Unit Code]

WATER-RESOURCES MANAGEMENT GOALS AND COMMITTEE SUBNETWORK PRIORITIES	PERCENTAGE OF FUNDING ALLOCATION			
	Federal	U.S. Geological Survey Federal-State Cooperative Program *	State	County/ municipal
1. Water budgets				
A. Distribution of streamflow, basin scale--6-digit HUCs	100	0	0	0
B. Regional and area assessments--core network	0	50	25	25
2. Water-quality assessments				
A. Regional trends/conditions	100	0	0	0
B. Representative 8-digit HUCs	0	50	25	25
C. Clean Water Action Plan priority watersheds	50	0	25	25
D. Coastal Plain Harmful Algal Blooms	0	50	50	0
3. Water-supply reservoirs	0	50	25	25
4. Flood/drought hazard	50	0	25	25
5. Small watersheds	0	50	25	25
6. Spatial coverage/physical matrix (Gaps not met by priorities 1–5)	0	50	25	25

* Pending availability of these funds.

In Review

Analysis of the Maryland stream-gaging network by the Maryland Water Monitoring Council Stream-Gage Committee indicates that the network does not meet current management objectives, either at the Federal, State, or county/municipal level. The Committee recommends expansion of the network from its current 97 gages (as of November 15, 1999) to 157 gages. It is recognized that such a major expansion must be done incrementally, but an enlarged network is needed to address the water-resources management goals of Federal, State, and county/municipal agencies, and to meet the growing needs of recreational users.

The Committee also recommends that funding of the stream-gage network be stabilized, and that major government agency users commit to long-term funding of the network. The recommended cost shares are a significant departure from the current situation, and long-term commitments may conflict with the realities of government budgeting processes. To ensure that streamflow data required for multiple management objectives (both current and future) is available, the Committee believes that both the expanded stream-gage network and recommended funding options are goals worth achieving.

ACKNOWLEDGMENTS

Maryland Water Monitoring Council Stream-Gage Committee:

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Michele Dobson	Harford County Department of Public Works
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Steve Stewart	Baltimore County Department of Environmental Protection and Resource Management
Sue Veith	St. Mary's County Department of Planning and Zoning
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- The attendees of the MWMC Stream-Gaging Workshop in October 1997. Their input and ideas helped set the course for the Committee's work.
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REFERENCES CITED

Bowen, S., 1994, Quality assurance/quality control plan, section 106, ambient water quality monitoring, core monitoring: Annapolis, Md., Maryland Department of the Environment, Chesapeake Bay Watershed Management Administration, Water Quality Monitoring Program, 15 p.

Clean Water Action Plan, Technical Workgroup, 1998, Maryland Clean Water Action Plan, Final 1998 Report on Unified Watershed Assessment, Watershed Prioritization, and Plans for Restoration Action Strategies: accessed January 25, 1999 on the World Wide Web at *http://www.dnr.state.md.us/cwap.htm*

Doheny, E.J., 1998, Evaluation of the stream-gaging network in Delaware: Delaware Geological Survey Report of Investigations No. 57, 54 p.

Garrison, J.S., 1996, Maryland water quality inventory, 1993–1995: Annapolis, Md., Maryland Department of Natural Resources, 312 p.

Governor's Flood Mitigation Task Force, 1997, Governor's Flood Mitigation Task Force for Western Maryland, Final Report: accessed April 9, 1999 on the World Wide Web at *http://www.mema.state.md.us/western.htm*

Maryland Department of the Environment, [n.d.,] Flood Hazard Mitigation: Baltimore, Md., Maryland Department of the Environment pamphlet, 6 p.

Mason, R.R., Jr., and Weiger, B.A., 1995, Stream gaging and flood forecasting: U.S. Geological Survey Fact Sheet FS 209–95, 4 p.

Preston, S.D., 1997, Evaluation of the stream-gaging network in Maryland, Delaware, and Washington, D.C.: U.S. Geological Survey Fact Sheet 97–126, 4 p.

U.S. Department of Labor, Bureau of Labor Statistics, 1999, (Consumer Price Index, Monthly Statistics and Yearly Summary, 1913—Present): accessed January 25 1999 on the World Wide Web at *http://ftp.bls.gov/pub/special.requests/cpi/cpiiai.txt*

U.S. Geological Survey, 1999, Water-resources data, Maryland and Delaware, water year 1998, volume 1, surface-water data: U.S. Geological Survey Water Data Report MD–DE 98–1, 362 p.

APPENDIXES

Appendix 1. Active stream gages in Maryland by watershed size, physiographic province, and development condition

Key no.	Station no.	Location
1.	01485000	Pocomoke River near Willards, Md.
2.	01485500	Nassawango Creek near Snow Hill, Md.
3.	01486000	Manokin Branch near Princess Anne, Md.
4.	01491000	Choptank River near Greensboro, Md.
5.	01493000	Unicorn Branch near Millington, Md.
6.	01493500	Morgan Creek near Kennedyville, Md.
7.	01495000	Big Elk Creek at Elk Mills, Md.
8.	01578310	Susquehanna River at Conowingo, Md.
9.	01580000	Deer Creek at Rocks, Md.
10.	01581700	Winters Run near Benson, Md.
11.	01582000	Little Falls at Blue Mount, Md.
12.	01582500	Gunpowder Falls at Glencoe, Md.
13.	01583100	Piney Run at Dover, Md.
14.	01583500	Western Run at Western Run, Md.
15.	01583600	Beaverdam Run at Cockeysville, Md.
16.	01583980	Minebank Run at Loch Raven, Md.
17.	01584050	Long Green Creek at Glen Arm, Md.
18.	01585090	Whitemarsh Run near Fullerton, Md.
19.	01585095	North Fork Whitemarsh Run near White Marsh, Md.
20.	01585100	Whitemarsh Run at White Marsh, Md
21.	01585200	West Branch Herring Run at Idlewylde, Md.
22.	01585225	Moores Run Tributary at Todd Avenue at Baltimore, Md.
23.	01585230	Moores Run at Radecke Avenue at Baltimore, Md.
24.	01585500	Cranberry Branch near Westminster, Md.
25.	01586000	North Branch Patapsco River at Cedarhurst, Md.

Appendix 1. Active stream gages in Maryland by watershed size, physiographic province, and development condition—Continued

Key no.	Station no.	Location
26.	01586210	Beaver Run near Finksburg, Md.
27.	01586610	Morgan Run near Louisville, Md.
28.	01589300	Gwynns Falls at Villa Nova, Md.
29.	01589440	Jones Falls at Sorrento, Md.
30.	01589500	Sawmill Creek at Glen Burnie, Md.
31.	01589501	Sawmill Creek Tributary at BWI Airport near Ferndale, Md.
32.	01589795	South Fork Jabez Branch at Millersville, Md.
33.	01591000	Patuxent River near Unity, Md.
34.	01591400	Cattail Creek near Glenwood, Md.
35.	01591610	Patuxent River below Brighton Dam near Brighton, Md.
36.	01591700	Hawlings River near Sandy Spring, Md.
37.	01592500	Patuxent River near Laurel, Md.
38.	01593500	Little Patuxent River at Guilford, Md.
39.	01594000	Little Patuxent River at Savage, Md.
40.	01594440	Patuxent River near Bowie, Md.
41.	01594526	Western Branch at Upper Marlboro, Md.
42.	01594670	Hunting Creek near Huntingtown, Md. (Discontinued during 1998)
43.	01594710	Killpeck Creek at Huntersville, Md. (Discontinued during 1998)
44.	01594930	Laurel Run near Wilson, Md.
45.	01594936	North Fork Sand Run near Wilson, Md.
46.	01594950	McMillan Fork near Fort Pendleton, Md.
47.	01595000	North Branch Potomac River at Steyer, Md.
48.	01596500	Savage River near Barton, Md.
49.	01597500	Savage River below Savage River Dam near Bloomington, Md.
50.	01598500	North Branch Potomac River at Luke, Md.

Appendix 1. Active stream gages in Maryland by watershed size, physiographic province, and development condition—Continued

Key no.	Station no.	Location
51.	01599000	Georges Creek at Franklin, Md.
52.	01601500	Wills Creek near Cumberland, Md.
53.	01603000	North Branch Potomac River near Cumberland, Md.
54.	01610000	Potomac River at Paw Paw, W. Va.
55.	01613000	Potomac River at Hancock, Md.
56.	01614500	Conococheague Creek at Fairview, Md.
57.	01617800	Marsh Run at Grimes, Md.
–	01619320	Albert Powell Fish Hatchery Spring at Beaver Creek, Md. (Discontinued during 1998)
58.	01619500	Antietam Creek near Sharpsburg, Md.
59.	01637500	Catoctin Creek near Middletown, Md.
60.	01638500	Potomac River at Point of Rocks, Md.
61.	01639000	Monocacy River at Bridgeport, Md.
62.	01639140	Piney Creek near Taneytown, Md.
63.	01639500	Big Pipe Creek at Bruceville, Md.
64.	01643000	Monocacy River at Jug Bridge near Frederick, Md.
65.	01643500	Bennett Creek at Park Mills, Md.
66.	01644600	Great Seneca Creek near Quince Orchard, Md.
67.	01645000	Seneca Creek at Dawsonville, Md.
68.	01646500	Potomac River at Little Falls near Washington, D.C.
69.	01648000	Rock Creek at Sherrill Drive at Washington, D.C.
70.	01649500	Northeast Branch Anacostia River at Riverdale, Md.
71.	01650500	Northwest Branch Anacostia River near Colesville, Md.
72.	01651000	Northwest Branch Anacostia River near Hyattsville, Md.
73.	01651800	Watts Branch at Washington, D.C.
74.	01653600	Piscataway Creek at Piscataway, Md.
75.	01660920	Zekiah Swamp Run near Newtown, Md.

Appendix 1. Active stream gages in Maryland by watershed size, physiographic province, and development condition—Continued

Key no.	Station no.	Location
76.	01661050	St. Clements Creek near Clements, Md.
77.	01661500	St. Mary's River at Great Mills, Md.
78.	03075500	Youghiogheny River near Oakland, Md.
79.	03076500	Youghiogheny River at Friendsville, Md.
80.	03076600	Bear Creek at Friendsville, Md.
81.	03078000	Casselman River at Grantsville, Md.
82.	01583570	Pond Branch at Oregon Ridge, Md.
83.	01589100	East Branch Herbert Run at Arbutus, Md.
84.	01589330	Dead Run at Franklintown, Md.
85.	01484981	North Fork Green Run near Whitesville, Del. (located in Md.)
86.	01484983	South Fork Green Run near Whitesville, Del. (located in Md.)
87.	01484985	Green Run near Careytown, Md.
88.	01589197	Gwynns Falls near Delight, Md.
89.	01589180	Gwynns Falls at Glyndon, Md.
90.	01584500	Little Gunpowder Falls at Laurel Brook, Md.
91.	01589352	Gwynns Falls at Washington Blvd. at Baltimore, Md.
92.	01610155	Sideling Hill Creek near Bellegrove, Md.
93.	01589340	Rognel Heights Storm Sewer Outfall at Baltimore, Md.
94.	01493112	Chesterville Branch Tributary near Crumpton, Md.
95.	01581500	Bynum Run at Bel Air, Md.
96.	01585104	Honeygo Run near White Marsh, Md.
97.	01581940	Mingo Branch near Hereford, Md.
98.	01581960	Beetree Run at Bentley Springs, Md.
99.	01583580	Baisman Run at Broadmoor, Md.

Appendix 1. Active stream gages in Maryland by watershed size, physiographic province, and development condition—Continued

[Note: stations in **"Bold"** have been in operation for 10 years or greater. Refer to pages 44–47 for listing of individual stream gages and station numbers; < = less than; > = greater than; -- = no data available]

Station type	**Area (in square miles)**	**Land use (in percent)**	**Coastal Plain East**	**Coastal Plain West**
Small	<5	Rural (< 11% Impervious)	**3**, 85, 86	32
Small	<5	Suburb (11-30% Impervious)		**30** [B], 96
Small	<5	Urban (> 30% Impervious)		19, 22, 23, 31, 73, **83**
Intermediate #1	5–25	Rural (< 11% Impervious)	**5** [A], **6**, 87, 94	**76**, **77** [A]
Intermediate #1	5–25	Suburb (11-30% Impervious)		**20** [A]
Intermediate #1	5–25	Urban (> 30% Impervious)		
Intermediate #2	25–50	Rural (< 11% Impervious)	**2**	**74**
Intermediate #2	25–50	Suburb (11-30% Impervious)		
Intermediate #2	25–50	Urban (> 30% Impervious)		
Large #1	50–150	Rural (<11% Impervious)	**1, 4** [B]	**75** [B]
Large #1	50–150	Suburb (11-30% Impervious)		**41**, **70** [A]
Large #1	50–150	Urban (> 30% Impervious)		
Large #2	150–500	Rural (< 11% Impervious)		
Large #2	150–500	Suburb (11-30% Impervious)		**40** [A]
Large #2	150–500	Urban (> 30% Impervious)	--	--
Regional sites	>500	Rural (< 11% Impervious)		
Regional sites	>500	Suburb (11-30% Impervious)		
Regional sites	>500	Urban (> 30% Impervious)	--	--

A. Indicates some type of regulation (low flow, reservoir, dam).

B. Indicates stations that are affected to some extent by flow diversions.

Piedmont East	**Piedmont West**	**Blue Ridge**	**Valley and Ridge**	**Appalachian Plateau**	**Station type**
82, 97, 99	**24** [B]			**45**, **46**	Small
16, 88, 89					Small
18, **21**, 93					Small
13, **17**, **26**, **34,** 98			**57**	**44**	Intermediate #1
15, **29**, **71**, **95**					Intermediate #1
84					Intermediate #1
10, **27**, **33**, **36, 90**	62			**48**, **80**	Intermediate #2
28, **38** [A], **72**					Intermediate #2
					Intermediate #2
7, 9, 11, 14, 25 [B], **35** [A], **37** [A]	**63** [B]**, 65**	**59**	**92**	**47, 49** [A]**, 51** [B]**, 78, 81**	Large #1
39, **66** [B] **67** [B], **69** [A]					Large #1
91					Large #1
12 [A]	**61** [A]		**52** [B], **56** [A], **58** [B]	**50** [A], **79** [A]	Large #2
					Large #2
		--	--	--	Large #2
8 [A], **68** [A, B]	**60** [A], **64** [A]		**53** [A], **54** [A], **55** [A]		Regional sites
					Regional sites
--	--	--	--	--	Regional sites

Appendix 2. Data-Users Questionnaire and Cover Letter

MWMC

MARYLAND WATER MONITORING COUNCIL

March 23, 1998

Dear Colleague

The streamflow-gaging station network in Maryland is a major component of many hydrologic investigations, including (1) water-resources design, (2) model calibration, (3) regional flood prediction, warning, and flood plain mapping, (4) water-supply evaluation and prediction, (5) ecosystem stability and diversity analysis, (6) stream classification and restoration, (7) basin land-use studies, (8) water-quality evaluation, (9) contaminant-load estimation, and (10) watershed analysis. To facilitate and enhance such studies and uses in the future, the network must be stable for the long term and be representative of all regions in Maryland. Due to significant shifts in support and changing funding priorities over the last 10 to 15 years, there are now serious questions as to whether an adequate number of long-term record stations are still in operation across Maryland, and whether the full range of geographic and hydrologic conditions are adequately represented.

To address this issue, a workgroup from the Maryland Water Monitoring Council (MWMC) is conducting an extensive analysis of the streamflow-gaging-station network in Maryland. The work group consists of representatives from U.S. Geological Survey, Maryland Geological Survey, Maryland State Highway Administration, Maryland Department of the Environment, Baltimore County, Harford County, St. Mary's County, Alliance for the Chesapeake Bay, and the Natural Resources Conservation Service.

The goals of the analysis are to:

(1) define geographical gaps and overlaps in the current network,
(2) develop recommendations for improving network coverage,
(3) summarize needs for the data, and
(4) seek long-term financial support for the network

This analysis may result in reactivation of some discontinued stations, activation of selected new stations, upgrading gage recorders, or discontinuing certain stations where continued operation and maintenence cannot be justified.

This analysis focuses on data uses and needs for streamflow-gaging-station data in the water resources community, as well as addressing geographical gaps in coverage. The most effective way to maintain support for streamflow-gaging stations is to demonstrate to decision makers that the data are needed by a variety of users for a wide range of purposes. Your input on uses of data from current stations and needs for additional streamflow-gaging station data is extremely important to future data availability and funding issues related to the network.

If you or others in your organization currently use data from streamflow-gaging stations, or have needs for streamflow data, please take a few minutes to fill out the enclosed questionnaire. The compiled results of data needs, uses, and users will aid in making management decisions regarding network improvement, and to maintain support for the continued operation of stations.

Please mail all responses to Edward Doheny at:

U.S. Geological Survey,
Water Resources Division
8987 Yellow Brick Road
Baltimore, MD 21237
or send by fax: (410) 238-4210

Responses may also be e-mailed to (*ejdoheny@usgs.gov)*.

The questionnaire may also be accessed and responded to online at (*http://md.usgs.gov/MWMC/)*.

We would appreciate receiving all responses by May 1, 1998. All colleagues who participate in the survey will receive a summary of the network analysis, including tables of all compiled basin characteristics and data uses for all active streamflow-gaging stations in Maryland. Please indicate in your response if you would prefer to receive a paper copy of the analysis, or notification when the results are posted on the Internet.

Thank you very much for your participation in this survey.

MARYLAND STREAMFLOW-DATA USERS QUESTIONNAIRE

(**Please feel free to reproduce this document and give to any parties you know with an interest in streamflow-gaging stations)**

On-line response and submission of questionnaire can be made at *http://md.usgs.gov/MWMC/*

Background Information

Name: ____

Title: ____

Affiliation: ____

Phone and Fax Numbers:____

E-Mail Address: ____

Questions

1a. Do you use streamflow data from gaging stations in your work? ____________________

1b. If yes, do you collect your own streamflow data? ____________________

1c. If you don't collect your own streamflow data, who collects the data that you use in your work?
____

2a. What is the longest period of streamflow-gaging-station record that you need for your work? Please check the longest that applies

_____ Short term (<3 years) _____ Moderate (3-10 years) _____ Long term (>10 years)

2b. Is the data that is currently available sufficient for your needs? ____________________

3. If the number of streamflow-gaging-stations in your jurisdiction were reduced, or completely eliminated, what impact would it have on your agency or firm? (Please check one)

_____ Severe _____ Moderate _____ Slight _____ No Impact

4. Who do you think should fund the streamflow-gaging-station network in Maryland and at what percentages? Please fill in percentages for categories listed below such that the sum of the percentages totals 100%. (For example, in your opinion, should federal agencies be funding 35% of the network, State agencies funding 35% of the network, local agencies 30%?).

_____ a. Federal agencies
_____ b. State agencies
_____ c. Local governmental agencies
_____ d. Industry
_____ e. Other (Please Specify) ____

100% = Total of above percentages

5. If an agency or firm is a primary user of streamflow data from a station, do you believe that it should share in the cost of operating and maintaining the station?________________

6a. Is there a stream or river where having a streamflow-gaging station would be important to you? If so, where?____
____
____
____

6b. Do you know of any other organizations/agencies that may have interest in streamflow-gaging stations? If so, please elaborate. ________________________________
____
____

7. In what form do you prefer to receive streamflow data? (Please check those that apply)

_____ Internet _____ Hard copy publication _____ Computer disk/CD-ROM
_____ Other (Please Specify) ____

8. The term "real time" in reference to accessing current streamflow data on the Internet can be misleading because there is a lag time of several hours to one day. What is the longest lag time that would meet your requirements for accessing real-time data?

_____ 1 hour _____ 1-8 hours _____ 8-12 hours _____ 12-24 hours

Please mail or fax all responses to:

Edward Doheny
U.S. Geological Survey
Water Resources Division
8987 Yellow Brick Road
Baltimore, MD 21237

Phone: (410) 238-4235; Fax: (410) 238-4210
E-Mail: ejdoheny@usgs.gov

For real-time data, access the U.S. Geological Survey "Home Page" at: *http://md.water.usgs.gov/realtime/*

An inventory of active streamflow-gaging stations in Maryland, historical daily streamflow, and peak flows can be accessed at: *http://md.water.usgs.gov/historical.html*

The purpose of the list below is to determine the variety of uses of streamflow data at each specific USGS gaging station that is currently in operation. If you use streamflow data at any active USGS gaging station, please indicate the stream/river name and location of the station (or station number, if available) and check all data uses that apply. If you use need more space, please reproduce this sheet to fill out for additional stations. If you use data from several stations for the same purposes, you may list the stations and check the applicable data uses once.

Name of Gaging Station ____

_____ Regional/Area Assessment	_____ Evaluating Current Conditions	_____ Evaluating Impacts
_____ River Classification/Restoration	_____ Watershed Management	_____ Design
_____ Effects of Floods/Droughts	_____ Forecasting	_____ TMDL Tracking
_____ Research	_____ Baseline Water Quality Data	_____ Baseline Flow Data
_____ Problem Assessment	_____ Fishkill Investigations/Pfiesteria	_____ Planning
_____ Trend Analysis	_____ Water Supply	_____ Legal Obligations
_____ Modeling/H & H Analysis	_____ Recreation	

Other (Please list) ____

Name of Gaging Station ____

_____ Regional/Area Assessment	_____ Evaluating Current Conditions	_____ Evaluating Impacts
_____ River Classification/Restoration	_____ Watershed Management	_____ Design
_____ Effects of Floods/Droughts	_____ Forecasting	_____ TMDL Tracking
_____ Research	_____ Baseline Water Quality Data	_____ Baseline Flow Data
_____ Problem Assessment	_____ Fishkill Investigations/Pfiesteria	_____ Planning
_____ Trend Analysis	_____ Water Supply	_____ Legal Obligations
_____ Modeling/H & H Analysis	_____ Recreation	

Other (Please list) ____

Name of Gaging Station ____

_____ Regional/Area Assessment	_____ Evaluating Current Conditions	_____ Evaluating Impacts
_____ River Classification/Restoration	_____ Watershed Management	_____ Design
_____ Effects of Floods/Droughts	_____ Forecasting	_____ TMDL Tracking
_____ Research	_____ Baseline Water Quality Data	_____ Baseline Flow Data
_____ Problem Assessment	_____ Fishkill Investigations/Pfiesteria	_____ Planning
_____ Trend Analysis	_____ Water Supply	_____ Legal Obligations
_____ Modeling/H & H Analysis	_____ Recreation	

Appendix 3. Data uses and users of stream-gage data in Maryland

KEY NO.	STREAM-GAGE DATA USERS IN MARYLAND
1.	U.S. Geological Survey Water Resources Division—Maryland-Delaware-District of Columbia District
2.	U.S. Geological Survey Water Resources Division— Pennsylvania District
3.	National Weather Service
4.	Federal Emergency Management Agency
5.	U.S. Fish and Wildlife Service—Chesapeake Bay Field Office
6.	National Park Service—Chesapeake & Ohio Canal National Historical Park
7.	National Park Service—Antietam National Battlefield
8.	Maryland Geological Survey
9.	Susquehanna River Basin Commission
10.	Susquehanna River Basin Commission—Future Load Calculations
11.	U.S. Army Corps of Engineers—Baltimore District
12.	U.S. Army Corps of Engineers—Pittsburgh District
13.	Maryland Department of Natural Resources—Watershed Modeling and Analysis Section
14.	Maryland Department of Natural Resources—Fisheries Service
15.	Maryland Department of the Environment—Water Rights Division
16.	Maryland Department of the Environment Technical and Regulatory Services Administration—Compliance Monitoring Division
17.	Maryland State Highway Administration—Division of Bridge Design
18.	Maryland State Highway Administration—Division of Highway Hydraulics
19.	Baltimore County Department of Environmental Protection and Resource Management
20.	Anne Arundel County Department of Public Works
21.	Frederick County Planning Commission
22.	Harford County Department of Public Works
23.	Montgomery County Department of Environmental Protection
24.	Prince Georges County Department of Environmental Resources
25.	Allegany Soil Conservation District
26.	Talbot Soil Conservation District
27.	Natural Resources Conservation Service
28.	Baltimore City Department of Public Works—Water Quality Management Section

Appendix 3. Data uses and users of stream-gage data in Maryland—Continued

KEY NO.	STREAM-GAGE DATA USERS IN MARYLAND
29.	St. Mary's County Department of Planning and Zoning
30.	Washington Suburban Sanitary Commission—Water Resources Planning Section
31.	Washington Suburban Sanitary Commission—Operations
32.	Washington Suburban Sanitary Commission—Engineering Support Division
33.	Severn River Association
34.	Interstate Commission on the Potomac River Basin
35.	Upper Potomac River Commission
36.	St. Mary's College—Biology Department
37.	Frostburg State University—Center for Environmental and Estuarine Studies
38.	Maryland National Capital Park and Planning Commission
39.	Dewberry and Davis Consulting Engineers, Fairfax,Virginia
40.	Private Citizen(s)—Boating, Wading, and Fishing in Conococheague Creek, Washington County, Maryland
41.	Metropolitan Washington Council of Governments
42.	Brightwater Consulting
43.	Maryland Department of the Environment—Flood Hazard Mitigation Section
44.	Baltimore City Reservoir Natural Resources Office
45.	University of Maryland—Wye Research and Education Center
46.	American Society of Civil Engineers—Design Improvements/Restore Monocacy Aqueduct
47.	Deer Creek Watershed Association
48.	Maryland Department of the Environment—Water Management Administration-Compliance Program
49.	Maryland Department of the Environment—Environmental Permits
50.	Washington Suburban Sanitary Commission—Systems Control
51.	Caroline County Department of Public Works
52.	Maryland Department of the Environment—Nontidal Wetlands and Waterways Division
53.	Maryland Department of the Environment—Water Management Administration, Surface Discharge Permits Division
54.	Monocacy Canoe Club

Appendix 3. Data uses and users of stream-gage data in Maryland — Continued

[There are 20 categories associated with each station number in this appendix. The U.S. Geological Survey collects and analyzes stream-gage data, and the data users interpret the stream-gage data for their specific purposes. Please refer to the appendix key on pages 56-57 to see the range of Federal, State, and local agencies, private companies, and private citizens who rely on these data.]

Station Number	Regional Area Assessment	River Classification Restoration	Floods and Droughts	Research	Problem Assessment	Trend Analysis	Models or Hydrology/ Hydraulics	Evaluate Current Conditions	Watershed Management	Forecasts
01485000	1, 15, 17, 53	17	1, 4, 15, 17, 43	15, 17, 45	15, 16, 43	16, 43	4, 15, 16, 17, 43, 51, 52, 53	15, 16, 17, 53	15, 16	
01485500	1, 15, 17, 53	17	1, 4, 15, 17, 43	15, 17, 45	15, 16, 43	16, 43	4, 15, 16, 17, 43, 51, 52, 53	15, 16, 17, 53	15, 16	
01486000	1, 15, 17, 53	17	1, 4, 15, 17, 43	15, 17, 45	15, 16, 43	16, 43	4, 15, 16, 17, 43, 51, 52, 53	15, 16, 17, 53	15, 16	
01491000	1, 15, 17, 26, 45, 53	17	1, 4, 15, 17, 43, 45	15, 17, 45	1, 15, 16, 43	16, 43	4, 15, 16, 17, 43, 51, 52, 53		15, 16, 26, 45	
01493000	1, 15, 17, 53	17	1, 4, 15, 17, 43	15, 17, 45	15, 16, 43	16, 43	4, 15, 16, 17, 43, 51, 52, 53	15, 16, 17, 53	15, 16	
01493500	1, 15, 17, 53	17	1, 4, 15, 17, 43	15, 17, 45	15, 16, 43	16, 43	4, 15, 16, 17, 43, 51, 52, 53	15, 16, 17, 53	15, 16	
01495000	1, 15, 17, 53	5, 17	1, 4, 15, 17, 43	5, 15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01578310	9, 15, 17, 53	17	2, 15, 17, 43	15, 17	1, 15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	1, 9, 15, 16, 17, 53	15, 16	
01580000	1, 15, 17, 53	5, 17	1, 4, 15, 17, 43, 47	5, 15, 17, 47	15, 16, 22, 43	16, 43, 47	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 47, 53	15, 16, 22, 47	
01581700	1, 15, 17, 53	5, 17	1, 4, 15, 17, 43	5, 8, 15, 17	8, 15, 16, 22, 43	16, 43	4, 15, 16, 17, 43, 52, 53	8, 15, 16, 17, 53	15, 16, 22	
01582000	1, 15, 17, 44, 53	5, 17	1, 15, 17, 43	5, 15, 17, 28	15, 16, 28, 43	16, 28, 43, 44	15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 44, 53	15, 16, 28, 44	28
01582500	15, 17, 44, 53	17	15, 17, 43	15, 17, 28	15, 16, 28, 43	16, 28, 43, 44	15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 44, 53	15, 16, 19, 28, 44	28
01583100	15, 17, 49, 53	5, 17	15, 17, 43	5, 15, 17, 28, 49	15, 16, 28, 43, 49	16, 28, 43, 49	15, 16, 17, 28, 43, 49, 52, 53	15, 16, 17, 28, 49, 53	15, 16, 19, 28, 49	28
01583500	1, 15, 17, 44, 53	5, 17, 19	1, 15, 17, 43	5, 15, 17, 28	15, 16, 28, 43	16, 28, 43, 44	15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 44, 53	15, 16, 19, 28, 44	28
01583600	1, 15, 17, 53	5, 17	1, 4, 15, 17, 43	5, 15, 17, 28	15, 16, 28, 43	16, 28, 43, 44	4, 15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 44, 53	15, 16, 19, 28, 44	28
01583980	15, 17, 53	17, 19	15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16, 19	
01584050	1, 15, 17, 53	5, 17	1, 15, 17, 43	5, 15, 17	15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16, 19	
01585090	15, 17, 53	17	15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16, 19	

Baseline Water Quality Data	Fishkills/ Pfiesteria	Water Supply	Evaluate Impacts	Design	Total Maximum Daily Load Tracking	Baseline Flow Data	Planning	Legal Obligation	Recreation	Other	Station Number
53	16	15	15, 16, 17, 51, 52, 53	17, 51, 52	16, 53	1, 15, 16, 17, 53	15, 17, 51	15, 17, 53	16		**01485000**
53	16	15	15, 16, 17, 51, 52, 53	17, 51, 52	16, 53	1, 15, 16, 17, 53	15, 17, 51	15, 17, 53	16		**01485500**
53	16	15	15, 16, 17, 51, 52, 53	17, 51, 52	16, 53	1, 15, 16, 17, 53	15, 17, 51	15, 17, 53	16		**01486000**
1, 45,53	16	15	1, 15, 16, 17, 45, 51, 52, 53	17, 51, 52	16, 53	1, 15, 16, 17, 53	15, 17, 51	15, 17, 53	16		**01491000**
53	16	15	15, 16, 17, 51, 52, 53	17, 51, 52	16, 53	1, 15, 16, 17, 53	15, 17, 51	15, 17, 53	16		**01493000**
53	16	15	15, 16, 17, 51, 52, 53	17, 51, 52	16, 53	1, 15, 16, 17, 53	15, 17, 51	15, 17, 53	16		**01493500**
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		**01495000**
1, 2, 53	16	15	1, 15, 16, 17, 52, 53	17, 52	16, 53	1, 2, 9, 15, 16, 17, 53	15, 17	15, 17, 53	16	10	**01578310**
47, 53	16	15	15, 16, 17, 22, 47, 52, 53	17, 52	16, 53	1, 15, 16, 17, 47, 53	15, 17	15, 17, 53	16		**01580000**
53	16	8, 15	8, 15, 16, 17, 22, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		**01581700**
28, 44, 53	16	15, 28		17, 52	16, 53	1, 15, 16, 17, 28, 44, 53	15, 17, 19	15, 17, 53	16		**01582000**
19, 28, 44, 53	16	15, 28		17, 52	16, 53	1, 15, 16, 17, 28, 44, 53	15, 17, 19	15, 17, 53	16		**01582500**
19, 28, 49, 53	16	15, 28	15, 16, 17, 49, 52, 53	17, 52	16, 53	1, 15, 16, 17, 28, 49, 53	15, 17, 19	15, 17, 53	16, 49		**01583100**
19, 28, 44, 53	16	15, 28	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 28, 44, 53	15, 17, 19	15, 17, 53	16		**01583500**
19, 28, 44, 53	16	15, 28	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 28, 44, 53	15, 17, 19	15, 17, 53	16		**01583600**
19, 53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 19	15, 17, 53	16		**01583980**
19, 53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 19	15, 17, 53	16		**01584050**
19, 53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 19	15, 17, 53	16		**01585090**

Appendix 3. Data uses and users of stream-gage data in Maryland — Continued

Station Number	Regional Area Assessment	River Classification Restoration	Floods and Droughts	Research	Problem Assessment	Trend Analysis	Models or Hydrology/ Hydraulics	Evaluate Current Conditions	Watershed Management	Forecasts
01585095	15, 17, 53	17	15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16, 19	
01585100	15, 17, 53	17, 18, 19, 42	1, 4, 15, 17, 43	15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 18, 43, 52, 53	15, 16, 17, 53	15, 16, 19	
01585200	15, 17, 53	17, 19	1, 15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 19, 43, 52, 53	15, 16, 17, 53	15, 16, 19	
01585225	15, 17, 53	17	15, 17, 43	15, 17, 28	15, 16, 28, 43	16, 28, 43	15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 53	15, 16, 28	
01585230	15, 17, 53	17	15, 17, 43	15, 17, 28	15, 16, 28, 43	16, 28, 43	15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 53	15, 16, 28	
01585500	15, 17, 53	5, 17, 42	1, 4, 15, 17, 43	5, 15, 17, 28	15, 16, 28, 43	16, 28, 43	4, 15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 53	15, 16, 28	28
01586000	1, 15, 17, 44, 53	5, 17	1, 4, 15, 17, 43	5, 15, 17, 28	15, 16, 28, 43	16, 28, 43, 44	4, 15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 44, 53	15, 16, 28, 44	28
01586210	1, 15, 17, 44, 53	5, 17	1, 15, 17, 43	5, 15, 17, 28	15, 16, 28, 43	16, 28, 43, 44	15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 44, 53	15, 16, 28, 44	28
01586610	1, 15, 17, 44, 53	5, 17	1, 15, 17, 43	5, 15, 17, 28	15, 16, 28, 43	16, 28, 43, 44	15, 16, 17, 28, 43, 52, 53	15, 16, 17, 28, 44, 53	15, 16, 28, 44	28
01589300	15, 17, 53	17	1, 4, 15, 17, 43	15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16, 19	
01589440	15, 17, 53	5, 17	1, 4, 15, 17, 43	5, 15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16, 19	
01589500	1, 8, 15, 17, 53	17, 18	1, 8, 15, 17, 43	15, 17	8, 15, 16, 43	16, 43	8, 15, 16, 17, 18, 43, 52, 53	15, 16, 17, 53	15, 16	
01589501	15, 17, 53	17, 18	15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 18, 43, 52, 53	15, 16, 17, 53	15, 16	
01589795	15, 17, 53	17, 20, 33, 42	15, 17, 43	15, 17, 20	15, 16, 20, 43	16, 20, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 20, 53	15, 16	
01591000	1, 15, 17, 31, 50, 53	5, 17	1, 4, 15, 17, 32, 43, 50	5, 15, 17	15, 16, 43	16, 32, 43	4, 15, 16, 17, 31, 32, 43, 52, 53	15, 16, 17, 50, 53	15, 16, 32, 50	50
01591400	1, 15, 17, 31, 50, 53	5, 17	1, 4, 15, 17, 32, 43, 50	5, 15, 17	15, 16, 43	16, 32, 43	4, 15, 16, 17, 31, 32, 43, 52, 53	15, 16, 17, 50, 53	15, 16, 32, 50	
01591610	15, 17, 31, 53	17	15, 17, 43, 50	15, 17	15, 16, 43	16, 43	15, 16, 17, 31, 43, 52, 53	15, 16, 17, 50, 53	15, 16, 50	
01591700	1, 15, 17, 31, 50, 53	5, 17	1, 15, 17, 32, 43, 50	5, 15, 17	15, 16, 43	16, 32, 43	15, 16, 17, 31, 32, 43, 52, 53	15, 16, 17, 50, 53	15, 16, 32, 50	
01592500	15, 17, 31, 53	17	1, 4, 15, 17, 43, 50	15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 31, 43, 52, 53	15, 16, 17, 50, 53	15, 16, 50	

Baseline Water Quality Data	Fishkills/ Pfiesteria	Water Supply	Evaluate Impacts	Design	Total Maximum Daily Load Tracking	Baseline Flow Data	Planning	Legal Obligation	Recreation	Other	Station Number
19, 53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 19	15, 17, 53	16		01585095
19, 53	16	15	15, 16, 17, 52, 53	17, 18, 52	16, 53	1, 15, 16, 17, 53	15, 17, 19	15, 17, 53	16		01585100
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 19	15, 17, 53	16		01585200
28, 53	16	15	15, 16, 17, 28, 52, 53	17, 52	16, 53	1, 15, 16, 17, 28, 53	15, 17	15, 17, 53	16		01585225
28, 53	16	15	15, 16, 17, 28, 52, 53	17, 52	16, 53	1, 15, 16, 17, 28, 53	15, 17	15, 17, 53	16		01585230
28, 53	16	15, 28	15, 16, 17, 52, 53	17, 42, 52	16, 53	1, 15, 16, 17, 28, 53	15, 17	15, 17, 53	16		01585500
28, 44, 53	16	15, 28	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 28, 44, 53	15, 17	15, 17, 53	16		01586000
28, 44, 53	16	15, 28	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 28, 44, 53	15, 17	15, 17, 53	16		01586210
28, 44, 53	16	15, 28	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 28, 44, 53	15, 17	15, 17, 53	16		01586610
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 19	15, 17, 53	16		01589300
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 19	15, 17, 53	16		01589440
53	16	8, 15	15, 16, 17, 52, 53	17, 18, 52	16, 53	1, 8, 15, 16, 17, 53	15, 17	15, 17, 53	16		01589500
53	16	15	15, 16, 17, 52, 53	17, 18, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01589501
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01589795
1, 53	16	15, 31, 32, 50	15, 16, 17, 50, 52, 53	17, 50, 52	16, 53	1, 15, 16, 17, 53	15, 17, 50	15, 17, 53	16		01591000
50, 53	16	15, 31, 32, 50	15, 16, 17, 50, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01591400
53	16	15, 31, 50	15, 16, 17, 52, 53	17, 52	16, 53	15, 16, 17, 52, 53	15, 17	15, 17, 53	16		01591610
50, 53	16	15, 31, 32, 50	15, 16, 17, 50, 52, 53	17, 52	16, 53	1, 15, 16, 17, 50, 53	15, 17	15, 17, 53	16		01591700
50, 53	16	15, 31, 50	15, 16, 17, 52, 53	17, 50, 52	16, 53	1, 15, 16, 17, 53	15, 17, 50	15, 17, 53	16		01592500

Station Number	Regional Area Assessment	River Classification Restoration	Floods and Droughts	Research	Problem Assessment	Trend Analysis	Models or Hydrology/ Hydraulics	Evaluate Current Conditions	Watershed Management	Forecasts
01593500	1, 15, 17, 53	5, 17	1, 4, 15, 17, 43	5, 15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01594000	1, 15, 17, 53	17	1, 4, 15, 17, 43	15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01594440	15, 17, 53	17	1, 4, 15, 17, 43	15, 17	1, 15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	1, 15, 16, 17, 53	15, 16	
01594526	15, 17, 24, 53	17	15, 17, 24, 43	13, 15, 17, 24	15, 16, 24, 43	16, 24, 43	13, 15, 16, 17, 24, 43, 53	13, 15, 16, 17, 24, 53	13, 15, 16, 24	13, 24
01594670	1, 15, 17, 53	17	1, 15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01594710	1, 15, 17, 53	17	1, 15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01594930	1, 15, 17, 53	17	1, 15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01594936	1, 15, 17, 53	17	1, 15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01594950	1, 15, 17, 53	17	1, 15, 17, 43	15, 17	15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01595000	1, 15, 17, 53	17	1, 4, 15, 17, 34, 43	15, 17, 37	15, 16, 43	16, 34, 43	4, 15, 16, 17, 34, 43, 52, 53	15, 16, 17, 34, 53	15, 16	34
01595500	15, 17, 53	17	1, 3, 4, 15, 17, 34, 43	15, 17, 37	15, 16, 43	16, 34, 43	4, 15, 16, 17, 34, 43, 52, 53	3, 15, 16, 17, 34, 53	15, 16	3, 34
01595800	15, 17, 53	17	1, 4, 15, 17, 34, 43	15, 17, 37	15, 16, 43	16, 34, 43	4, 15, 16, 17, 34, 43, 52, 53	15, 16, 17, 34, 53	15, 16	34
01596500	1, 15, 17, 53	14, 17	1, 3, 4, 14, 15, 17, 43	14, 15, 17, 37	14, 15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	3, 14, 15, 16, 17, 53	14, 15, 16	3
01597500	15, 17, 53	17	1, 4, 15, 17, 43	15, 17, 37	15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01598500	15, 17, 53	17	1, 3, 4, 15, 17, 34, 43	15, 17, 37	15, 16, 43	16, 34, 43	4, 15, 16, 17, 34, 43, 52, 53	3, 15, 16, 17, 34, 53	15, 16	3, 34
01599000	1, 15, 17, 48, 53	17	1, 3, 4, 11, 15, 17, 25, 27, 43, 48	15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	3, 15, 16, 17, 48, 53	15, 16	3, 48
01601500	1, 15, 17, 53	17	1, 3, 4, 6, 11, 15, 17, 43	15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 52, 53	3, 15, 16, 17, 53	15, 16	3
01603000	15, 17, 48, 53	17	1, 3, 4, 6, 11, 15, 17, 34, 43, 48	15, 17, 37	15, 16, 43	16, 34, 43	4, 15, 16, 17, 34, 43, 52, 53	3, 15, 16, 17, 34, 48, 53	15, 16	3, 34, 48
01610000	15, 17, 53	17	1, 3, 4, 6, 11, 15, 17, 34, 43	15, 17	15, 16, 43	16, 34, 43	4, 15, 16, 17, 34, 43, 52, 53	3, 15, 16, 17, 34, 53	15, 16	3, 34

Baseline Water Quality Data	Fishkills/ Pfiesteria	Water Supply	Evaluate Impacts	Design	Total Maximum Daily Load Tracking	Baseline Flow Data	Planning	Legal Obligation	Recreation	Other	Station Number
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01593500
1, 53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01594000
1, 53	16	15	1, 15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01594440
1, 13, 24, 53	16	15	13, 15, 16, 17, 24, 52, 53	17, 24, 52	16, 24, 53	1, 13, 15, 16, 17, 24, 53	13, 15, 17, 24	15, 17, 53	16		01594526
1, 53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01594670
1, 53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01594710
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01594930
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01594936
1, 53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01594950
53	16	15, 34	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 34	15, 17, 53	16		01595000
53	16	11, 15, 34	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 34	15, 17, 53	16, 54		01595500
53	16	11, 15, 34	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 34	15, 17, 53	16, 54		01595800
53	16	14, 15	15, 16, 17, 52, 53	17, 52	16, 53	1, 14, 15, 16, 17, 53	15, 17	14, 15, 17, 53	16		01596500
53	16	15, 35	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16, 54		01597500
53	16	11, 15, 34, 35	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 34	15, 17, 53	16, 54		01598500
53	16	15, 48	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		01599000
53	16	11, 15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16, 54		01601500
53	16	11, 15, 34, 48	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 34	15, 17, 53	16		01603000
53	16	11, 15, 34	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 34	15, 17, 53	16, 54		01610000

Station Number	Regional Area Assessment	River Classification Restoration	Floods and Droughts	Research	Problem Assessment	Trend Analysis	Models or Hydrology/ Hydraulics	Evaluate Current Conditions	Watershed Management	Forecasts
01613000	15, 17, 53	17	1, 3, 4, 6, 11, 15, 17, 34, 43	15, 17	15, 16, 43	16, 34, 43	4, 15, 16, 17, 34, 43, 52, 53	3, 15, 16, 17, 34, 53	15, 16	3, 34
01614500	15, 17, 53	17	1, 3, 4, 6, 15, 17, 43	15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	3, 15, 16, 17, 53	15, 16	3
01617800	1, 8, 15, 17, 53	17	1, 4, 15, 17, 43	8, 15, 17	15, 16, 43	16, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01619320	14, 15, 17, 53	17	14, 15, 17, 43	15, 17	14, 15, 16, 43	16, 43	15, 16, 17, 43, 52, 53	14, 15, 16, 17, 53	15, 16	14
01619500	7, 8, 15, 17, 53	7, 17	1, 3, 4, 6, 7, 15, 17, 43	7, 8, 15, 17	7, 15, 16, 43	7, 16, 43	4, 15, 16, 17, 43, 52, 53	3, 7, 15, 16, 17, 53	7, 15, 16	3, 7
01637500	1, 15, 17, 21, 53	17, 21	1, 4, 15, 17, 21, 43	15, 17, 21	15, 16, 43	16, 21, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 21, 53	15, 16, 21	
01638500	15, 17, 21, 50, 53	17, 21	1,3,4,6,11, 15, 17, 21, 34, 43, 50	15, 17, 21	15, 16, 43	16, 21, 34, 43	4, 15, 16, 17, 34, 39, 43, 52, 53	3, 15, 16, 17, 21, 34, 50, 53	15, 16, 21, 50	3, 34, 50
01639000	1, 15, 17, 21, 53	17, 21	1, 4, 15, 17, 21, 43	15, 17, 21	15, 16, 43	16, 21, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 21, 53	15, 16, 21	
01639140	15, 17, 21, 53	5, 17, 21	15, 17, 21, 43	5, 15, 17, 21	15, 16, 43	16, 21, 43	15, 16, 17, 43, 52, 53	15, 16, 17, 21, 53	15, 16, 21	
01639500	1, 15, 17, 21, 53	5, 17, 21	1, 4, 15, 17, 21, 43	5, 15, 17, 21	15, 16, 43	16, 21, 43	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 21, 53	15, 16, 21	
01643000	15, 17, 21, 53	17, 21	1, 3, 4, 6, 15, 17, 21, 43, 46	15, 17, 21	15, 16, 43	16, 21, 43	4, 15, 16, 17, 39, 43, 52, 53	3, 15, 16, 17, 21, 53	15, 16, 21	3
01643500	1, 15, 17, 21, 53	5, 17, 21	1, 4, 15, 17, 21, 43	5, 15, 17, 21	15, 16, 43	16, 21	4, 15, 16, 17, 39, 43, 52, 53	15, 16, 17, 21, 53	15, 16, 21	
01644600	15, 17, 23, 53	17	15, 17, 43	15, 17	15, 16, 43	16	15, 16, 17, 43, 52, 53	15, 16, 17, 23, 53	15, 16	
01645000	1, 15, 17, 50, 53	5, 17	1, 3, 4, 6, 15, 17, 34, 43, 50	5, 15, 17	15, 16, 43	16, 34	4, 15, 16, 17, 34, 39, 43, 52, 53	3, 15, 16, 17, 34, 53	15, 16, 50	3, 34
01646500	15, 17, 53	17	1, 3, 4, 6, 11, 15, 17, 34, 43	15, 17	1, 15, 16, 43	16, 34	4, 15, 16, 17, 34, 39, 43, 52, 53	1, 3, 15, 16, 17, 34, 53	15, 16	3, 34
01648000	1, 15, 17, 41, 53	17	1, 3, 4, 15, 17, 43	15, 17	15, 16, 41, 43	16	4, 15, 16, 17, 43, 52, 53	3, 15, 16, 17, 41, 53	15, 16	3
01649500	1, 15, 17, 24, 53	17	1, 4, 15, 17, 24, 43	15, 17, 24	15, 16, 24, 43	16, 24	4, 15, 16, 17, 24, 43, 52, 53	15, 16, 17, 24, 53	15, 16, 24	24
01650500	15, 17, 23, 38, 53	5, 11, 17, 23, 38	1, 4, 15, 17, 43	5, 15, 17	15, 16, 43	16	4, 15, 16, 17, 38, 43, 52, 53	15, 16, 17, 53	11, 15, 16, 23, 38	
01651000	1, 15, 17, 24, 53	17	1, 4, 15, 17, 24, 43	15, 17, 24	15, 16, 24, 43	16, 24	4, 15, 16, 17, 24, 43, 52, 53	15, 16, 17, 24, 53	15, 16, 24	24

Baseline Water Quality Data	Fishkills/ Pfiesteria	Water Supply	Evaluate Impacts	Design	Total Maximum Daily Load Tracking	Baseline Flow Data	Planning	Legal Obligation	Recreation	Other	Station Number
53	16	11, 15, 34	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 34	15, 17, 53	16, 54		**01613000**
1, 53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16, 40		**01614500**
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		**01617800**
14, 53	16	14, 15	14, 15, 16, 17, 52, 53	17, 52	16, 53	1, 14, 15, 16, 17, 53	15, 17	14, 15, 17, 53	16		**01619320**
53	16	7, 15	7, 15, 16, 17, 52, 53	7, 17, 52	16, 53	1, 7, 15, 16, 17, 53	7, 15, 17	15, 17, 53	7, 16, 54		**01619500**
21, 53	16	15, 21	15, 16, 17, 21, 52, 53	17, 52	16, 53	1, 15, 16, 17, 21, 53	15, 17, 21	15, 17, 53	16		**01637500**
21, 53	16	11, 15, 21, 34, 50	15, 16, 17, 21, 52, 53	17, 39, 50, 52	16, 53	1, 15, 16, 17, 21, 53	15, 17, 21, 34, 50	15, 17, 53	16		**01638500**
1, 21, 53	16	15, 21	15, 16, 17, 21, 52, 53	17, 52	16, 53	1, 15, 16, 17, 21, 53	15, 17, 21	15, 17, 53	16, 54		**01639000**
21, 53	16	15, 21	15, 16, 17, 21, 52, 53	17, 52	16, 53	1, 15, 16, 17, 21, 53	15, 17, 21	15, 17, 53	16		**01639140**
21, 53	16	15, 21	15, 16, 17, 21, 52, 53	17, 52	16, 53	1, 15, 16, 17, 21, 53	15, 17, 21	15, 17, 53	16		**01639500**
1, 21, 53	16	15, 21	15, 16, 17, 21, 52, 53	17, 39, 46, 52	16, 53	1, 15, 16, 17, 21, 53	15, 17, 21	15, 17, 53	16, 54		**01643000**
21, 53	16	15, 21	15, 16, 17, 21, 52, 53	17, 39, 52	16, 53	1, 15, 16, 17, 21, 53	15, 17, 21	15, 17, 53	16		**01643500**
23, 53	16	15	15, 16, 17, 30, 52, 53	17, 30, 52	16, 53	1, 15, 16, 17, 30, 53	15, 17	15, 17, 53	16		**01644600**
53	16	15, 34, 50	15, 16, 17, 52, 53	17, 39, 52	16, 53	1, 15, 16, 17, 50, 53	15, 17, 34	15, 17, 53	16, 50		**01645000**
1, 53	16	11, 15, 34	1, 15, 16, 17, 52, 53	17, 39, 52	16, 53	1, 15, 16, 17, 53	15, 17, 34	15, 17, 53	16, 54		**01646500**
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		**01648000**
24, 53	16	15	15, 16, 17, 24, 52, 53	17, 24, 52	16, 24, 53	1, 15, 16, 17, 24, 53	15, 17, 24	15, 17, 53	16		**01649500**
53	16	15, 23	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		**01650500**
24, 53	16	15	15, 16, 17, 24, 52, 53	17, 24, 52	16, 24, 53	1, 15, 16, 17, 24, 53	15, 17, 24	15, 17, 53	16		**01651000**

Appendix 3. Data uses and users of stream-gage data in Maryland — Continued

Station Number	Regional Area Assessment	River Classification Restoration	Floods and Droughts	Research	Problem Assessment	Trend Analysis	Models or Hydrology/ Hydraulics	Evaluate Current Conditions	Watershed Management	Forecasts
01651800	15, 17, 53	17	15, 17, 43	15, 17	15, 16, 43	16	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01653600	1, 15, 17, 53	17	1, 4, 15, 17, 43	15, 17	15, 16, 43	16	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01660920	1, 15, 17, 53	17	1, 15, 17, 43	15, 17	15, 16, 43	16	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
01661050	1, 15, 17, 29, 53	17	1, 15, 17, 43	15, 17	15, 16, 43	16	15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16, 29	
01661500	1, 15, 17, 29, 53	17	1, 4, 15, 17, 43	15, 17, 36	15, 16, 43	16	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16, 29	
03075500	1, 15, 17, 53	17	1, 4, 15, 17, 43	15, 17, 37	15, 16, 43	16	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	
03076500	15, 17, 53	17	1, 3, 4, 15, 17, 43	15, 17, 37	15, 16, 43	16	4, 15, 16, 17, 43, 52, 53	3, 15, 16, 17, 53	15, 16	3
03076600	1, 15, 17, 48, 53	17	1, 4, 15, 17, 43, 48	15, 17	15, 16, 43	16	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 48, 53	15, 16	48
03078000	1, 15, 17, 53	17	1, 4, 15, 17, 43	15, 17	15, 16, 43	16	4, 15, 16, 17, 43, 52, 53	15, 16, 17, 53	15, 16	

Baseline Water Quality Data	Fishkills/ Pfiesteria	Water Supply	Evaluate Impacts	Design	Total Maximum Daily Load Tracking	Baseline Flow Data	Planning	Legal Obligation	Recreation	Other	Station Number
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		**01651800**
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		**01653600**
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	16		**01660920**
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 29	15, 17, 53	15, 16		**01661050**
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17, 29	15, 17, 53	15, 16		**01661500**
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	15, 16, 54		**03075500**
53	16	12, 15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	15, 16, 54		**03076500**
53	16	15, 48	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	15, 16, 54		**03076600**
53	16	15	15, 16, 17, 52, 53	17, 52	16, 53	1, 15, 16, 17, 53	15, 17	15, 17, 53	15, 16, 54		**03078000**

Appendix 4. Maryland stream-gage costs in comparison to the Average National Consumer Price Index (CPI), 1975–present

[CPI numbers in **bold** are projected based on a 10-year average, 1990–99; –, not applicable]

Year	Annual cost for stream gages	Percent change	Average National Consumer Price Index	Percent change
1975	$2,860	–	53.8	9.1
1976	$3,150	10.1	56.9	5.8
1977	$3,460	9.8	60.6	6.5
1978	$3,720	7.5	65.2	7.6
1979	$4,000	7.5	72.6	11.3
1980	$4,300	7.5	82.4	13.5
1981	$4,620	7.4	90.9	10.3
1982	$4,600	-0.5	96.5	6.2
1983	$4,950	7.6	99.6	3.2
1984	$5,250	6.1	103.9	4.3
1985	$5,500	4.8	107.6	3.6
1986	$5,740	4.4	109.6	1.9
1987	$5,900	2.8	113.6	3.6
1988	$6,200	5.1	118.3	4.1
1989	$6,450	4.0	124.0	4.8
1990	$6,800	5.4	130.7	5.4
1991	$7,110	4.6	136.2	4.2
1992	$7,400	4.1	140.3	3.0
1993	$7,770	5.0	144.5	3.0
1994	$8,160	5.0	148.2	2.6
1995	$8,570	5.0	152.4	2.8
1996	$8,900	3.9	156.9	3.0
1997	$9,200	3.4	160.5	2.3
1998	$9,600	4.3	163.0	1.6
1999	$9,500	-1.0	166.6	2.2
2000	$9,500	0	**171.6**	**3.0**
Inflation Factor	–	3.322	–	3.190

Appendix 5. Active core network stream gages in Maryland, water year 1999

[mi^2 = square miles; period of record indicates water years]

Station no.	Station name	County	Physiographic Province	Drainage area (mi^2)	Period of continuous record
01485000	Pocomoke River near Willards, Md.	Worcester	Coastal Plain East	60.5	1949–present
01485500	Nassawango Creek near Snow Hill, Md.	Worcester	Coastal Plain East	44.9	1949–present
01486000	Manokin Branch near Princess Anne, Md.	Somerset	Coastal Plain East	4.80	1951–71, 1974–present
01491000	Choptank River near Greensboro, Md.	Caroline	Coastal Plain East	113.0	1948–present
01493000	Unicorn Branch near Millington, Md.	Queen Annes	Coastal Plain East	19.7	1948–present
01493500	Morgan Creek near Kennedyville, Md.	Kent	Coastal Plain East	12.7	1951–present
01495000	Big Elk Creek at Elk Mills, Md.	Cecil	Piedmont East	52.6	1932–present
01580000	Deer Creek at Rocks, Md.	Harford	Piedmont East	94.4	1926–present
01581500	Bynum Run at Bel Air, Md.	Harford	Piedmont East	8.52	1944–1951, 1955–1970, 1999–present
01581700	Winters Run near Benson, Md.	Harford	Piedmont East	34.8	1967–present
01582000	Little Falls at Blue Mount, Md.	Baltimore	Piedmont East	52.9	1944–present
01583100	Piney Run at Dover, Md.	Baltimore	Piedmont East	12.3	1982–1988, 1996–present
01583500	Western Run at Western Run, Md.	Baltimore	Piedmont East	59.8	1944–present
01583600	Beaverdam Run at Cockeysville, Md.	Baltimore	Piedmont East	20.9	1982–present
01584050	Long Green Creek at Glen Arm, Md.	Baltimore	Piedmont East	9.40	1975–present

Appendix 5. Active core network stream gages in Maryland, water year 1999—Continued

Station no.	Station name	County	Physiographic Province	Drainage area (mi^2)	Period of continuous record
01584500	Little Gunpowder Falls at Laurel Brook, Md.	Baltimore	Piedmont East	36.1	1927–1970, 1998–present
01585095	North Fork Whitemarsh Run near White Marsh, Md.	Baltimore	Coastal Plain West	1.34	1992–present
01585200	West Branch Herring Run at Idlewylde, Md.	Baltimore	Piedmont East	2.13	1957–1965, 1966–1987, 1996–present
01586000	North Branch Patapsco River at Cedarhurst, Md.	Carroll	Piedmont East	56.6	1945–present
01586210	Beaver Run near Finksburg, Md.	Carroll	Piedmont East	14.0	1982–present
01586610	Morgan Run near Louisville, Md.	Carroll	Piedmont East	28.0	1982–present
01589100	East Branch Herbert Run at Arbutus, Md.	Baltimore	Coastal Plain West	2.47	1957–1989, 1998–present
01589300	Gwynns Falls at Villa Nova, Md.	Baltimore	Piedmont East	32.5	1957–1988, 1996–present
01589330	Dead Run at Franklintown, Md.	Baltimore	Piedmont East	5.52	1959–1987, 1998–present
01589440	Jones Falls at Sorrento, Md.	Baltimore	Piedmont East	25.2	1966–1988, 1996–present
01589500	Sawmill Creek at Glen Burnie, Md.	Anne Arundel	Coastal Plain West	4.97	1944–1952, 1983–present
01591000	Patuxent River near Unity, Md.	Montgomery	Piedmont East	34.8	1944–present
01591400	Cattail Creek near Glenwood, Md.	Howard	Piedmont East	22.9	1978–1983, 1983–present
01591700	Hawlings River near Sandy Spring, Md.	Montgomery	Piedmont East	27.0	1978–present
01593500	Little Patuxent River at Guilford, Md.	Howard	Piedmont East	38.0	1932–present

Appendix 5. Active core network stream gages in Maryland, water year 1999—Continued

Station no.	Station name	County	Physiographic Province	Drainage area (mi^2)	Period of continuous record
01594000	Little Patuxent River at Savage, Md.	Howard	Piedmont East	98.4	1939–1958, 1975–1980, 1985–present
01594526	Western Branch at Upper Marlboro, Md.	Prince Georges	Coastal Plain West	89.7	1985–1989, 1992–present
01594930	Laurel Run near Wilson, Md.	Garrett	Appalachian Plateau	8.23	1980–present
01594936	North Fork Sand Run near Wilson, Md	Garrett	Appalachian Plateau	1.91	1980–present
01594950	McMillan Fork near Fort Pendleton, Md.	Garrett	Appalachian Plateau	2.30	1986–present
01595000	North Branch Potomac River at Steyer, Md.	Garrett	Appalachian Plateau	73.0	1956–present
01596500	Savage River near Barton, Md.	Garrett	Appalachian Plateau	49.1	1948–present
01599000	Georges Creek at Franklin, Md	Allegany	Appalachian Plateau	72.4	1905–1906, 1929–present
01601500	Wills Creek near Cumberland, Md.	Allegany	Valley and Ridge	247.0	1905–1906, 1929–present
01610155	Sideling Hill Creek near Bellegrove, Md.	Washington (Allegany)	Valley and Ridge	102.0	1967–1977, 1999–present
01617800	Marsh Run at Grimes, Md.	Washington	Valley and Ridge	18.9	1963–present
01637500	Catoctin Creek near Middletown, Md.	Frederick	Blue Ridge	66.9	1947–present
01639000	Monocacy River at Bridgeport, Md.	Frederick (Carroll)	Piedmont West	173.0	1942–present
01639140	Piney Creek near Taneytown, Md.	Carroll	Piedmont West	31.3	1990–present
01639500	Big Pipe Creek at Bruceville, Md.	Carroll	Piedmont West	102.0	1947–present

Appendix 5. Active core network stream gages in Maryland, water year 1999—Continued

Station no.	Station name	County	Physiographic Province	Drainage area (mi^2)	Period of continuous record
01643500	Bennett Creek at Park Mills, Md.	Frederick	Piedmont West	62.8	1948–1958, 1996–-present
01645000	Seneca Creek at Dawsonville, Md.	Montgomery	Piedmont East	101.0	1930–-present
01649500	NE Branch Anacostia River at Riverdale, Md.	Prince Georges	Coastal Plain West	72.8	1938–present
01650500	NW Branch Anacostia River near Colesville, Md.	Montgomery	Piedmont East	21.1	1924–1983, 1997–present
01651000	NW Branch Anacostia River near Hyattsville, Md.	Prince Georges	Piedmont East	49.4	1938–present
01653600	Piscataway Creek at Piscataway, Md.	Prince Georges	Coastal Plain West	39.5	1965–present
01660920	Zekiah Swamp Run near Newtown, Md.	Charles	Coastal Plain West	79.9	1983–present
01661050	St. Clements Creek near Clements, Md.	St. Mary's	Coastal Plain West	18.5	1968–present
01661500	St. Mary's River at Great Mills, Md.	St. Mary's	Coastal Plain West	24.0	1946–present
03075500	Youghiogheny River near Oakland, Md.	Garrett	Appalachian Plateau	134.0	1941–present
03076600	Bear Creek at Friendsville, Md.	Garrett	Appalachian Plateau	48.9	1964–present
03078000	Casselman River at Grantsville, Md.	Garrett	Appalachian Plateau	62.5	1947–present