Municipal Wastewater Treatment in the National Capital Region

November 17, 2005

About COG

The Metropolitan Washington Council of Governments (COG) is a regional organization composed of 20 local governments surrounding our nation's capital, plus area members of the Maryland and Virginia legislatures, the U.S. Senate, and the U.S. House of Representatives.

COG provides a focus for action and develops sound regional responses to such issues as the environment, affordable housing, economic development, health and family concerns, human services, population growth, public safety, and transportation.

Founded in 1957, COG is an independent, nonprofit association. It is supported by financial contributions from its participating local governments, federal and state grants and contracts, and donations from foundations and the private sector. Policies are set by the full membership acting through its board of directors, which meets monthly to discuss area issues.

The National Capital Region

The National Capital Region consists of 20 Washington area local governments and comprises the single largest urban area in the Chesapeake Bay watershed – about 4.6 million people – or 25% of people living in the Bay watershed and 80% of the people living in the Potomac River watershed. Fifteen major wastewater treatment plants are located within the National Capital Region, including the largest treatment plant in the entire Chesapeake Bay watershed – Blue Plains. These municipal point sources are the largest source of nutrient loadings for the region.

The tidal section of the Potomac River, a central feature of the region, is affected by many sources of pollution, primarily from non-point source runoff at the fall line and effluent discharges from municipal wastewater treatment plants in the National Capital Region. With rapid population growth in the National Capital Region over the past century, the Potomac River has faced water quality problems such as bacterial contamination, low dissolved oxygen, and nuisance algal blooms. The implementation of secondary and advanced wastewater treatment in the National Capital Region has resulted in significant improvements in water quality and ecological conditions in the Potomac Estuary, including healthy dissolved oxygen levels, reduced nuisance algal blooms, and the return of important living resources such as large mouth bass and submerged aquatic vegetation (SAV). The reductions in wastewater pollutant loadings and improvements in water quality and ecological conditions in the Potomac Estuary represent a major environmental success story.

Wastewater Treatment Leads the Way

In the National Capital Region, 13 major wastewater treatment plants presently discharge effluent into the Potomac Estuary. These facilities serve more than 4 million people and discharge a total of about 680 million gallons per day of treated wastewater.

The 370 MGD Blue Plains wastewater treatment plant is the largest advanced WWTP in the world and comprises a majority of the total effluent discharged to the Potomac Estuary.

COG Region Wastewater Capacity (mgd)

Alexandria – 54 mgd

Arlington – 40 mgd

Blue Plains – 370 mgd

Ballenger Creek – 6 mgd

Broad Run – 10 mgd

Dale City – 4 mgd

Frederick – 8 mgd

H.L. Mooney – 18 mgd

Leesburg – 5 mgd

Noman Cole – 67 mgd

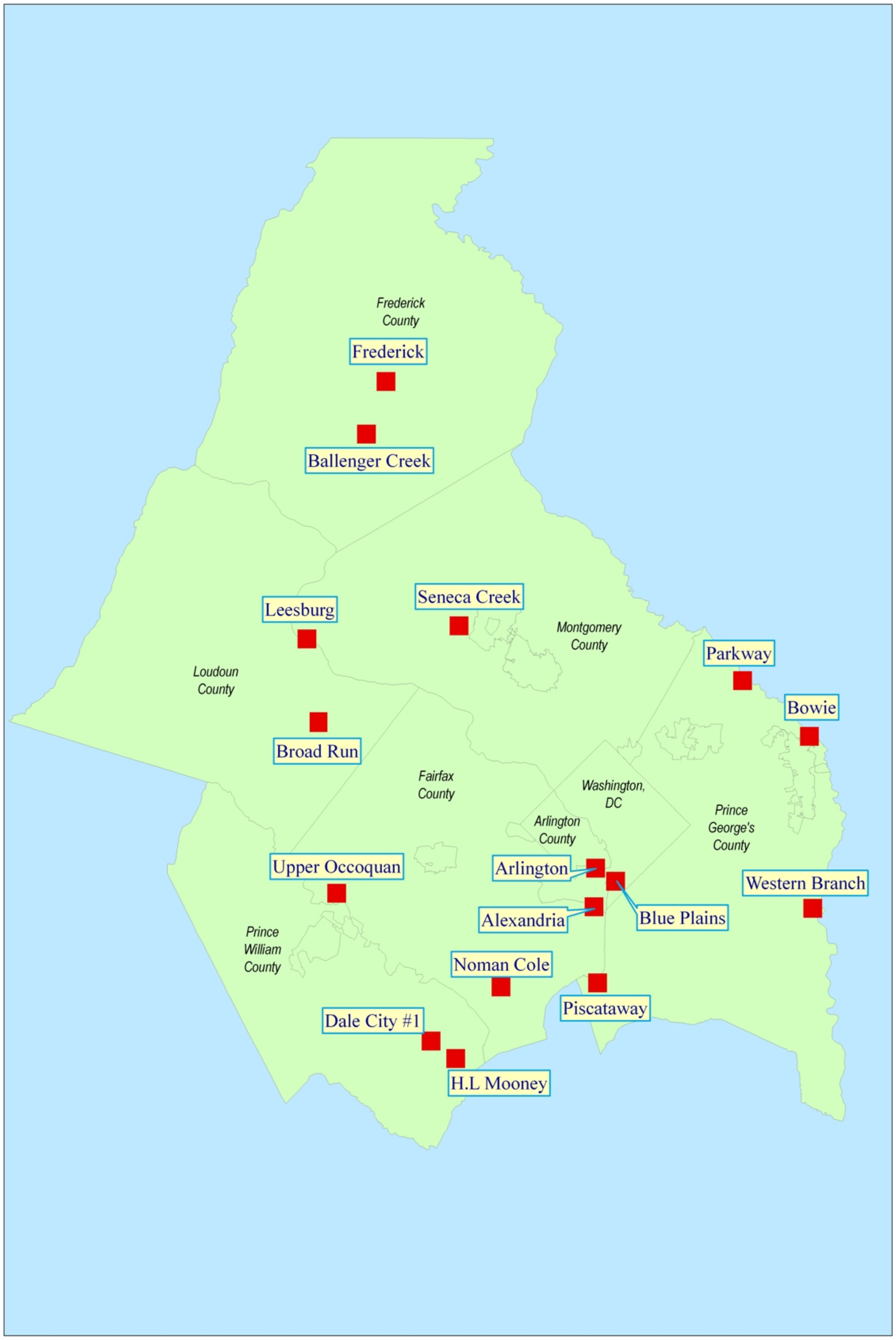
Piscataway – 30 mgd

Seneca Creek – 20 mgd

UOSA – 54 mgd

TOTAL – 686 mgd

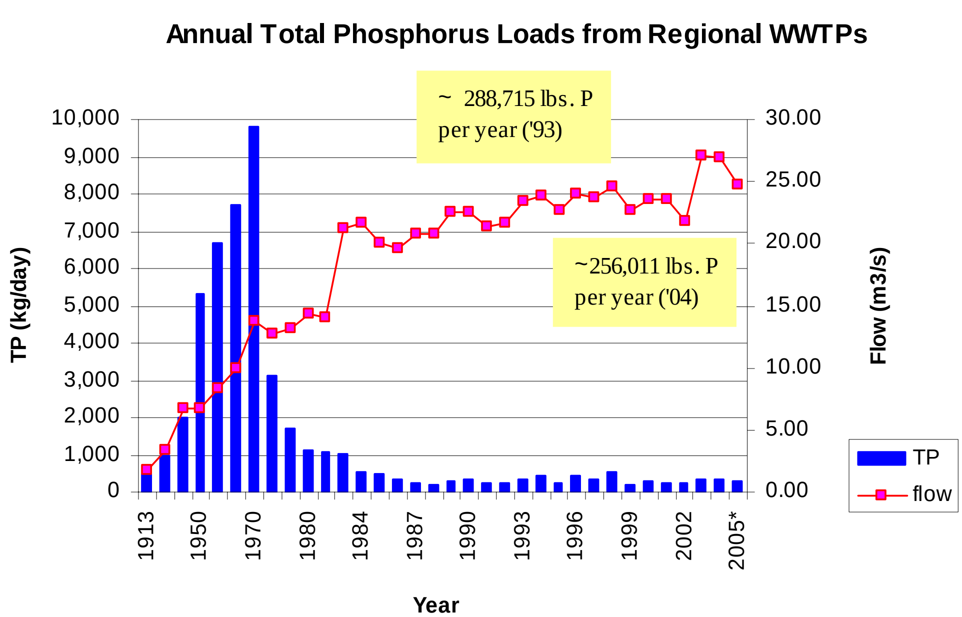
Metropolitan Washington Region Major Wastewater Treatment Plants (>2MGD)



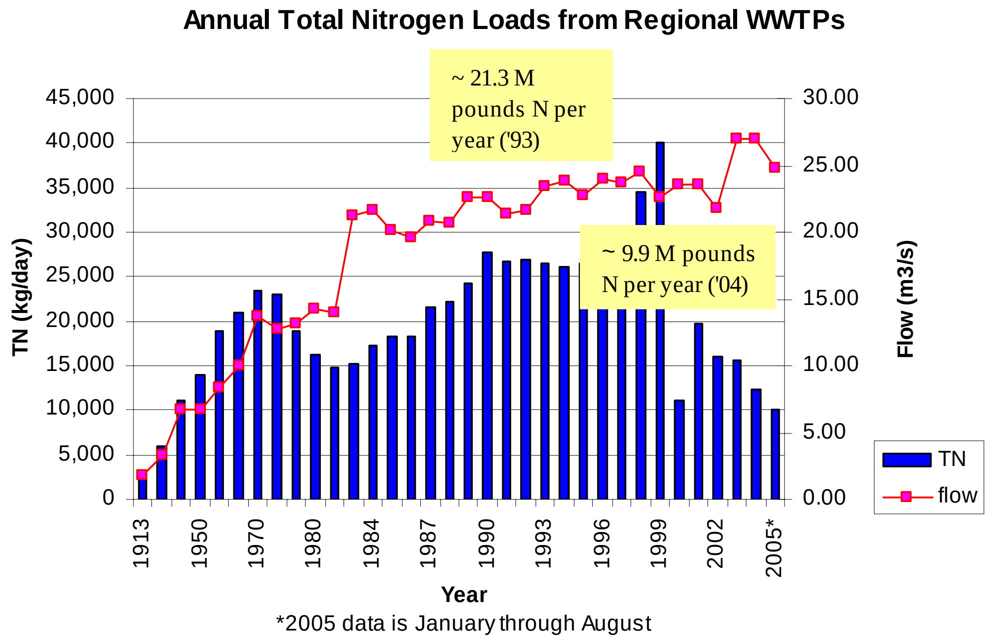
Major pollution reduction efforts began in 1959 with the implementation of secondary treatment at Blue Plains and at other facilities from 1960 to 1980. Since the early 1970s, WWTP phosphorus loadings have been reduced approximately 96% as limit of technology phosphorus controls were implemented at all of the major wastewater facilities in the region to reduce nuisance algal blooms, increase oxygen levels, and alleviate other eutrophication problems in the Potomac estuary. Since the 1990s, advanced biological nutrient removal has also been implemented, reducing WWTP total nitrogen loads by about 44%.

Enhanced Nutrient Removal

Presently, all of the major wastewater treatment plants in the National Capital Region use a process called Biological Nutrient Removal (BNR) to remove nitrogen. The BNR process removes more than 90% of pollutants and achieves concentrations below 8 mg/l total nitrogen. Recognizing that more needs to be done, both Maryland and Virginia are planning to require additional upgrades to the region's major wastewater treatment plants with enhanced nutrient removal (ENR) technologies. Using ENR technologies, these plants are expected to reduce nitrogen and phosphorus in their wastewater down to 3 mg/l total nitrogen and 0.1 mg/l total phosphorus, approximately a 50% reduction in already low discharge levels. Other pollutants will continue to be reduced by more than 90%. The cost of these upgrades is estimated to be $1.5 billion.



* 2005 data is January through August

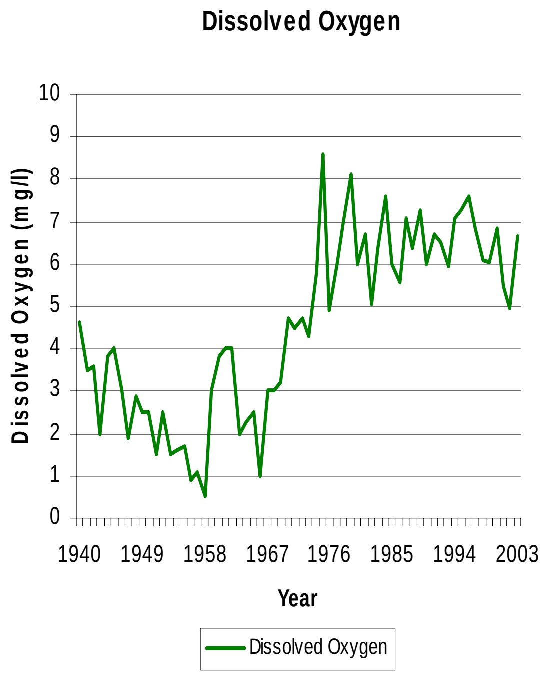


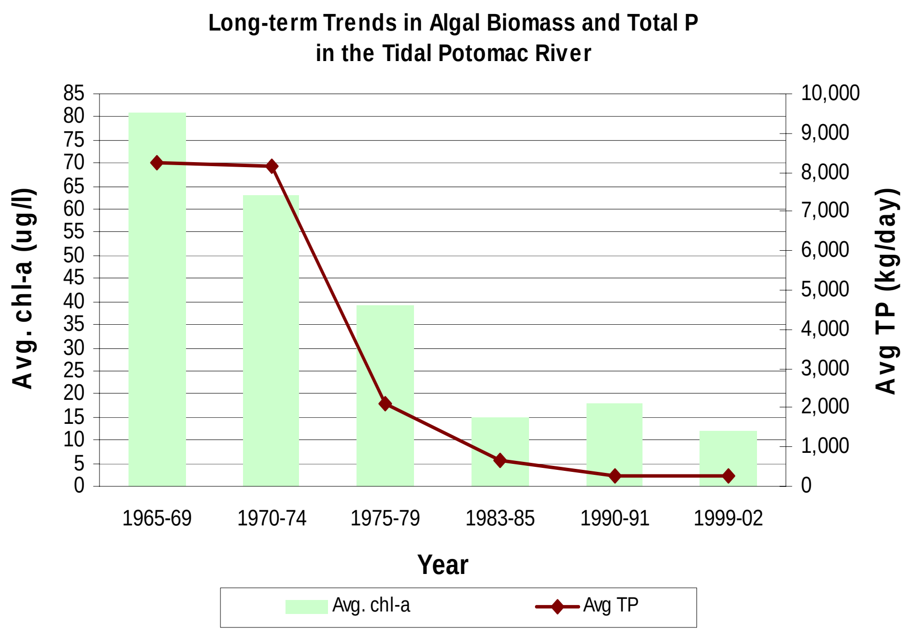
Ecological Benefits of Advanced Treatment

Water quality and biological resource data from the Potomac Estuary clearly show a link between significant reductions in wastewater loadings of nutrients and other pollutants and improvements in the river. Dissolved oxygen, needed by fish and crabs to survive, has historically been depleted by excess nutrients. However, as pollutant loads from regional wastewater treatment plants have declined, dissolved oxygen levels in the river have increased to levels that allow the Potomac's aquatic creatures to thrive. For example, the Potomac Estuary now supports one of the top largemouth bass fisheries in the country.

Long-term trends in summer DO levels on the Potomac River near the Wilson Bridge (mile PMS-44).

Data for 1940-1981 is averaged for June-September from USEPA (STORET) data. Data from 1982-2003 is averaged for July-September from MWCOG data, 2005.





Long-term trends in algal biomass and total phosphorus in the tidal Potomac River.

Data source: MWCOG, 2005; USEPA, 1992.

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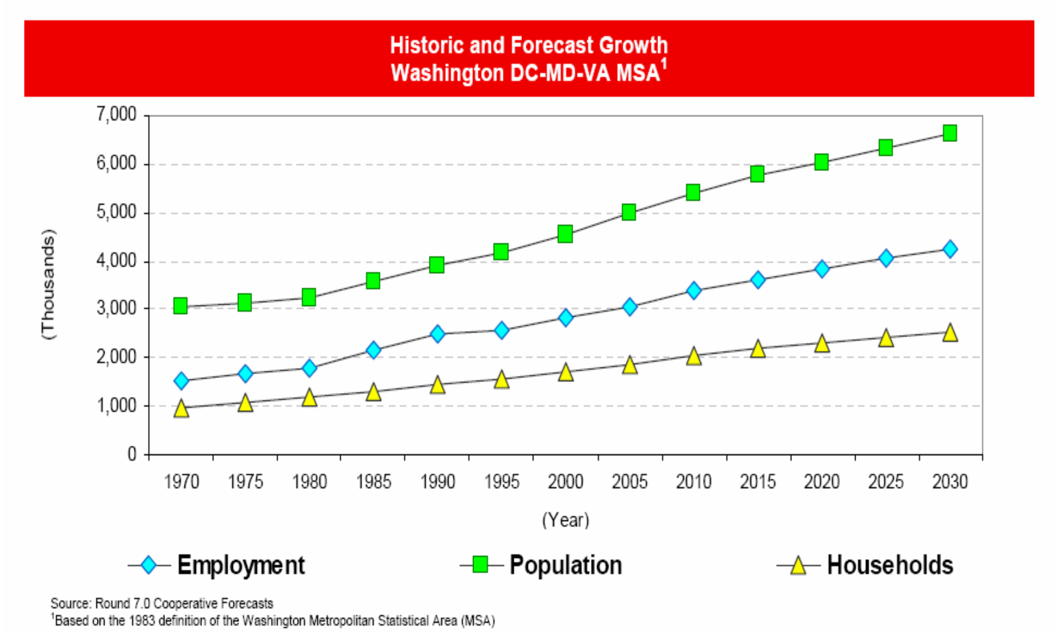
Observed concentrations of nitrogen have decreased significantly and algal blooms do not have the intensity or the magnitude they once had, primarily because of large phosphorus reductions. A resurgence of submerged aquatic vegetation in the Potomac starting in the 1980s has been directly related to improvements in water clarity resulting from reductions in nutrient and suspended solids loadings from regional wastewater treatment plants, and subsequent reductions in ambient algae, phosphorus, and nitrogen (Carter and Rybicki, 1990 and 1994).

Population Trends

From the 1940s to 2000, the region's population nearly quadrupled with the population reaching nearly 4.6 million residents. Regional forecasts reveal dramatic increases in employment, households, and population by 2030, the end of the forecast period. Under the intermediate scenario, regional employment would total more than 4.2 million jobs by 2030, a 50 percent increase over the 2000 employment base of 2.8 million jobs. Also, under this scenario, households would reach nearly 2.5 million, a 48 percent increase. Regional population is forecast to increase by 45 percent during the forecast period, reaching nearly 6.6 million in 2030. This will add greater than 2 million people by 2030, which is half a million more people than were added during the previous 30-year period. As the region's population grows, wastewater flows will increase, placing an even greater demand on regional treatment plants to reduce pollution and maintain water quality.



Potomac River Monitoring Program at Chain Bridge

Metropolitan Washington Council of Governments **August 2007**

Quick Facts

The Chain Bridge monitoring station is operated by Virginia Tech's Occoquan Watershed Monitoring Laboratory with funding from the Metropolitan Washington Council of Governments.

The Chain Bridge station is part of a historical data set. Since data collection began in 1983, there have been nearly 25 years of water quality data collected for the fall line of the Potomac River. Because long-term water quality trends can only be established when taken in the context of decades and the broader watershed, it is important for this monitoring to continue.

The Potomac River is the 2nd largest tributary to the Chesapeake Bay, contributing about 17% of the Bay's fresh water.

Data collected at the fall line allows for comparison of upstream nutrient loads versus downstream (e.g., urban, wastewater) nutrient loads.

Why Monitor Water Quality at Chain Bridge?

In 1983, the Metropolitan Washington Council of Governments (COG) established an automated fall line monitor at the Chain Bridge on the Potomac River.

Photo courtesy of Virginia Tech's OWML

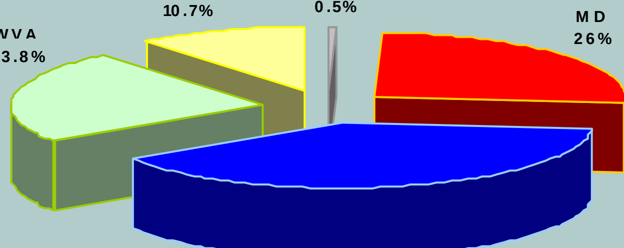
Due to the number of streams discharging into the Bay watershed, and the changing composition of runoff due to storm events, it is challenging to monitor an individual river's nutrient and sediment contributions to the Bay. However, with careful selection of sampling locations and times it is possible to characterize pollutant inputs from a segment of the Potomac over a range of conditions.

The Chain Bridge station is part of a comprehensive Chesapeake Bay Program monitoring network. The network of rivers being monitored were selected to encompass runoff from as much of the Bay watershed as possible, covering a range of different run off sources to the Bay and its tributaries.

Since the fall line designates the transition from the Potomac River's free flowing to its tidally influenced section, monitoring at the Chain Bridge location allows estimation of the quality and quantity of upstream nutrient and sediment loads to the Potomac estuary and the Chesapeake Bay.

Topography

Before reaching Chain Bridge, the Potomac River flows through the rolling terrain of the Piedmont with an average slope of 1.2 feet per mile. Great Falls of the Potomac marks the boundary between the Piedmont and the coastal plain where the Potomac River drops 120 feet before it reaches Chain Bridge.



The Potomac drainage area runs through portions of Maryland, Virginia, West Virginia, Washington, DC, and Pennsylvania. While only 0.5% of the Potomac watershed is in DC, 26% is in Maryland and 39% is in Virginia.

Monitoring Station Description

The monitoring station on the Potomac River (PR01) is located at Chain Bridge at the end of Virginia State Highway 123, in Arlington County, VA (Hydrologic Unit 02070010). The sampling station receives stream-flow from 80% of the 14,670 square mile Potomac River basin. Samples are collected weekly (biweekly from December to March) for non-storm conditions, and for all storm events.

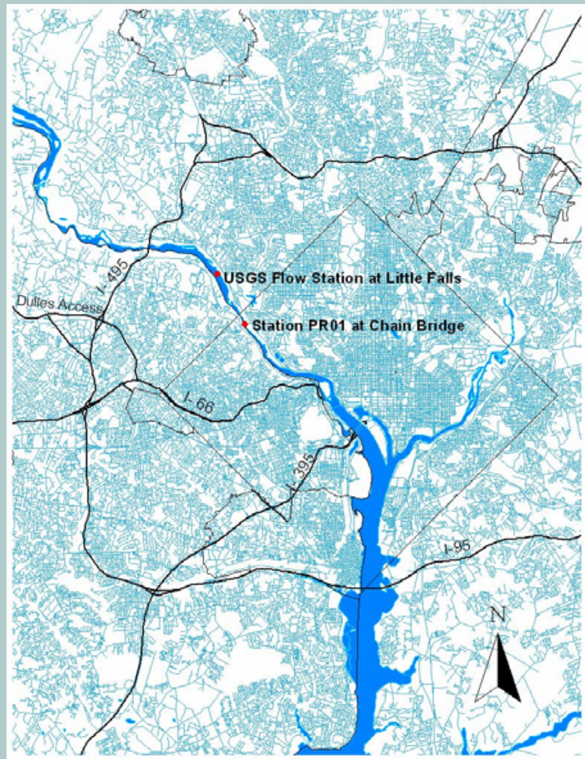


Figure 1: Chain Bridge Monitoring Station

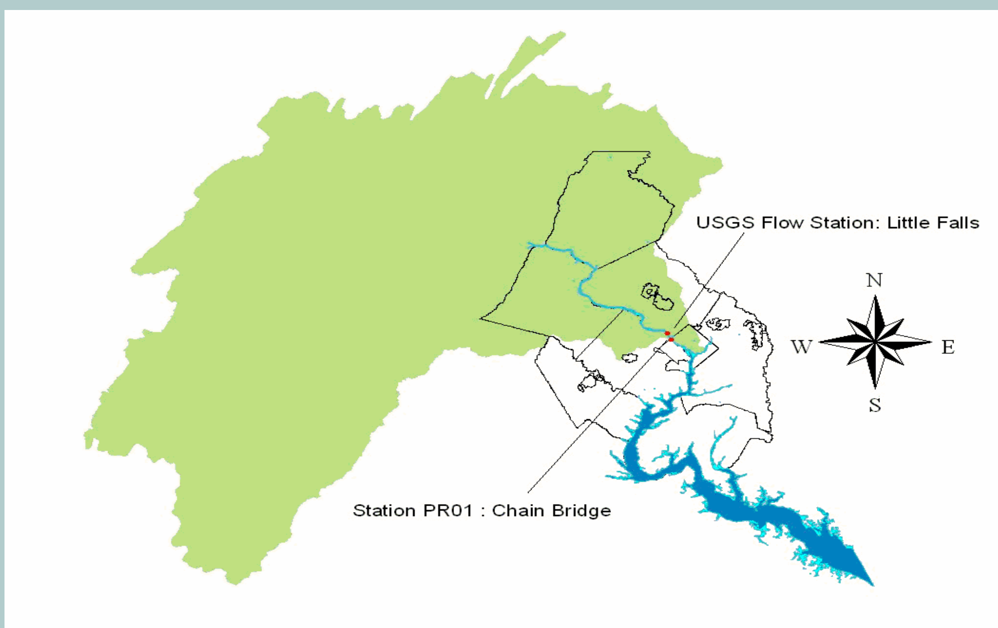


Figure 2: Potomac River Watershed above Chain Bridge.

What is Monitored? Water quality problems in the Potomac River are caused both by direct inputs of pollutants and indirectly by changes to the land and air that surround and interact with the river. Routine monitoring of river quality includes the following parameters: Total nitrogen (TN), total phosphorus (TP), suspended solids (TSS), total organic carbon, dissolved silica, and other parameters.

Water Quality Indicators

Total Suspended Solids (TSS) - Suspended solids are organic and inorganic particles (colloidal particles) that instead of dissolving remain suspended in water. In high concentration, TSS reduces sunlight penetration in water and cause turbidity in surface water. Particles from stream bank erosion, construction sites and farms all contribute to the TSS load in the Potomac.

Total Nitrogen and Total Phosphorus (TN and TP) - Nitrogen and phosphorus are primary nutrients for algae, plants, and organisms to sustain growth. However, too much nitrogen and phosphorus can cause excessive growth of algae, which shades out beneficial aquatic plants and becomes an oxygen demanding material when it dies and decays. The primary sources of nitrogen and phosphorus are domestic wastewater, agricultural runoff, and atmospheric deposition.

Flow

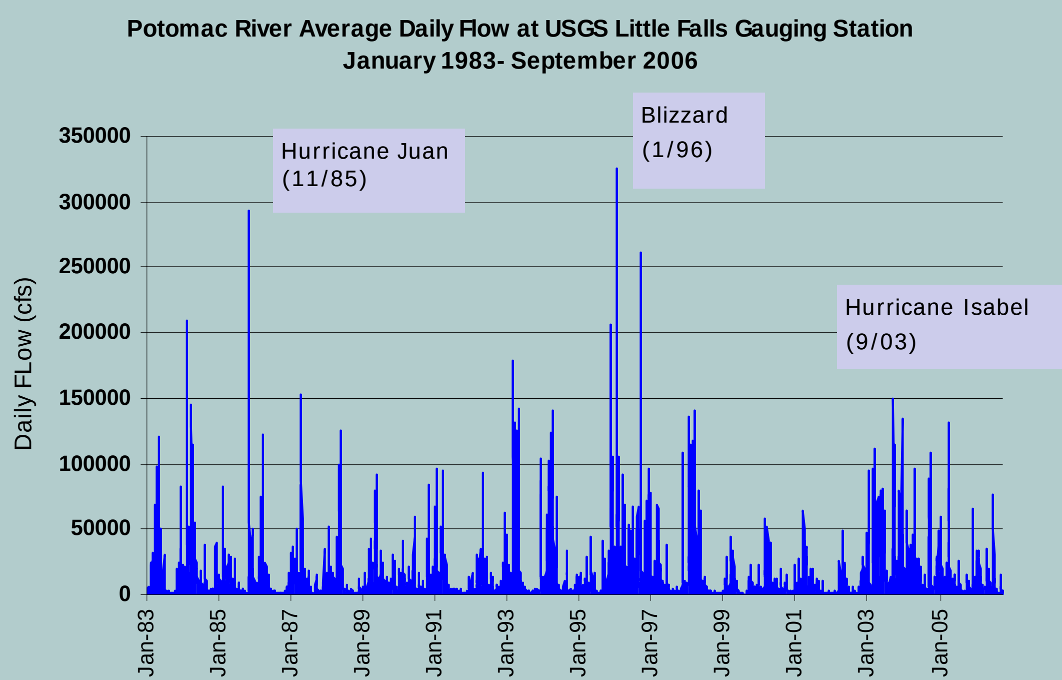
River flows can generally be divided into two basic categories, non-storm flow (dry weather data) and storm events (wet weather data). Under non-storm flow conditions, water in the river comes mainly from groundwater, resulting in relatively stable water quality characteristics and volume. During a storm event, non-storm flow is supplemented and overwhelmed by direct run-off of rainfall, causing both the volume of water flowing in the river and the concentrations of pollutants in the water to increase.

The Potomac River has a mean annual discharge of about 12,660 cubic feet per second (cfs) at the Little Falls Dam gauging station. This average is based on the daily mean flow reported by USGS. By contrast, hurricane Juan in 1985 resulted in an increase in the daily peak average with a maximum of 293,000 cubic feet per second. Likewise in 1996, 23 inches of snow was reported at Dulles Airport in the month of January during the Blizzard of 1996. Higher temperatures and 1 to 3 inches of rain resulted in snowmelt that caused major floods in the Potomac River. This was ranked the fifth largest flood in the history of the Potomac around the metropolitan region.

Because the pollutant loads carried during storm events are much larger than loads carried by non-storm flow, accurate estimates of storm flows and loads are critical in order to characterize pollutant loadings to the Potomac estuary. It is therefore necessary to take several samples during the course of a particular storm to get an accurate estimate of the pollutant load.

A series of discrete samples, taken incrementally at equal river flow volumes throughout a storm, can be used for evaluating a storm event. An automated monitor samples the Little Falls river stage and simultaneously takes direct samples at Chain Bridge, 1.5 miles downstream. These discrete samples are combined into a composite for lab analysis.

The flow graph below shows three major storms events in 1985, 1996 and 2003 that caused major flooding. Runoff from these storm events resulted in high nutrient and sediment loads.

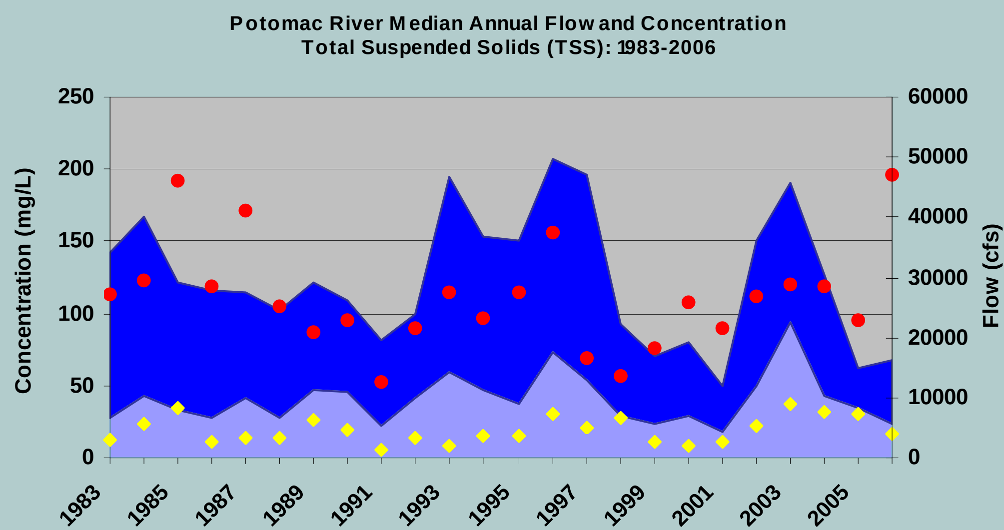


Graphs of TSS and TP Concentration Relative to Non-storm and Storm Flows

What Does the Data Tell Us?

Water quality data collected at Chain Bridge and flow records reported by USGS show a link between runoff and TSS, TP, and TN concentrations . An increase in precipitation, and the consequential runoff, result in increased nutrient loads in the Potomac, as depicted in these graphs.

Flow is measured as cubic feet per second (cfs) and concentrations as milligrams per liter (mg/L).



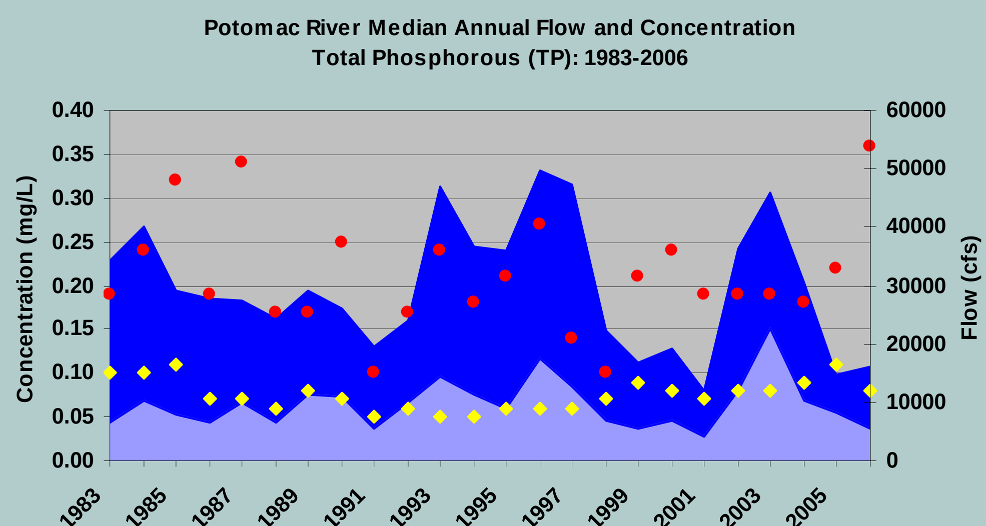
Legend for TSS, TP, TN graphs:

Median flow non-storm

Median flow storm

Median observed non-storm concentration of TSS, TP or TN

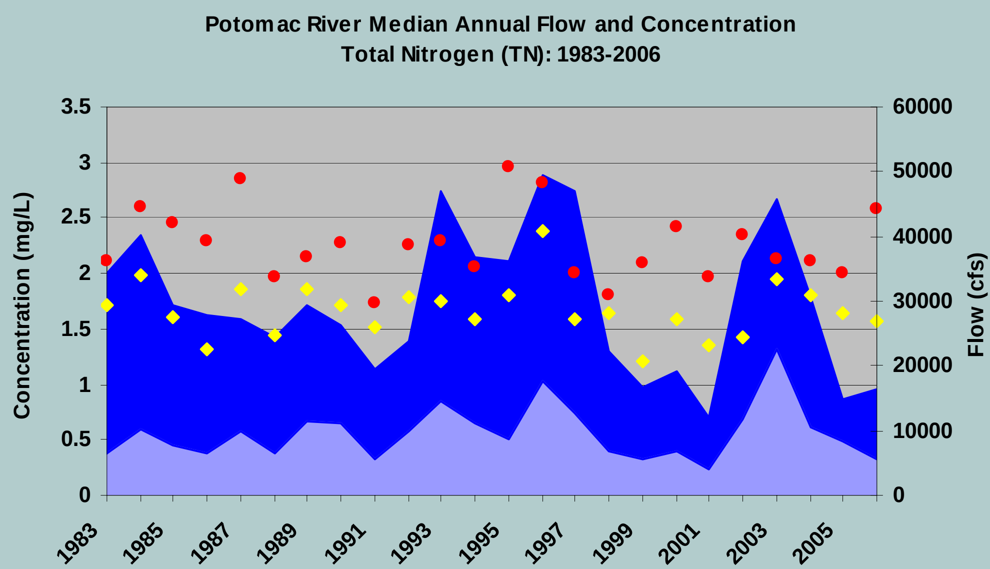
Median observed storm concentration of TSS, TP or TN



Note: In 1983 there was a major algal bloom, which spurred the implementation of a phosphate detergent ban.

Graph of TN Concentration Relative to Non-storm and Storm Flows

As was the case for TSS and TP (previous page), the Total Nitrogen concentration at the Potomac fall line increases during storm events.



Total suspended solids, total phosphorous, and total nitrogen are a major source of Potomac and Bay water quality impairment. The table below summarizes the water quality trends for TSS, TP, and TN at the Chain Bridge Station.

Annual Trends in Pollutants	Total Measured (Storm and Non-Storm combined)	Non-Storm	Storm
Suspended Solids	Upward	No trend	Upward
Phosphorus	Upward	No trend	Upward
Nitrogen	Downward	Downward	No trend

What do these trends tell us about seasonal flow and annual change?

What do they tell us about water quality above and below the fall line?

The data collected at Chain Bridge is a critical measure of whether management techniques are working to reduce pollution in the Potomac watershed as well as the Chesapeake Bay. In samples taken at the Chain Bridge Monitoring Station, the quantities of TSS and TP have increased over time. During the same period, TN has declined.

Regional goals agreed to by the Chesapeake Bay Program call for major reductions in all three types of pollutant loads. Reducing and slowing run off from impervious parking lots, driveways, roads and rooftops through storm water management, low impact development (LID) and green roofs, can work to decrease pollutant loads resulting from population growth and urban development.

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Summary & conclusions

The Chain Bridge station is part of a comprehensive data set necessary to evaluate nutrient reduction to the Bay. Since Chain Bridge data collection began in 1983, there have been 24 years of water quality data collected at the fall line of the Potomac River, and roughly 1,600 nutrient and sediment samples collected. Continued collection of data at Chain Bridge is essential to assess the effectiveness of long-term management actions in the Potomac River watershed.

Photo courtesy of Virginia Tech's OWML

COG wishes to thank Virginia Tech's Occoquan Laboratory for its operation of the Chain Bridge monitoring station. COG'S relationship with Occoquan Laboratory spans nearly 30 years, starting with the National Urban Runoff Program (NURP) in 1978. Occoquan Laboratory has partnered with COG on a number of collaborative water quality studies in the National Capital Region. These have included long-term monitoring programs on the Potomac and Anacostia Rivers and a number of other shorter-duration studies.

For more information about the Chain Bridge Monitoring Program, please contact COG's Department of Environmental Programs.

Photo courtesy of Virginia Tech's OWML

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