Virginia Water Central

Virginia Water Resources Research Center Blacksburg, Virginia June 2003 (No. 26)

May 2003 was one good month for ducks! See the Water Status Report. *Photo by Heidi Clark.*

INSIDE THIS ISSUE

The **Feature Article** looks at recent developments and findings on nutrients in the Chesapeake Bay, other Virginia watersheds, and the nation.

Nitrogen, phosphorus, Chesapeake Bay, Gulf of Mexico, wastewater plants, groundwater...This nutrients business is a big story.

In **Science Behind the News**, an excerpt from a publication by the University of Florida's LAKEWATCH program explains the concept of *nutrients as limiting factors*. Other sections discuss why nitrogen and phosphorus are so important and list the U.S. EPA's recommended levels for these nutrients in lakes and streams.

"Limiting factor...productivity...trophic state.... This nutrients story gets pretty deep."

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY

FEATURE ARTICLE

Nutrients in the Water and in the News

If you follow water-quality issues, you've most likely read or heard a lot about two **nutrients**: **nitrogen** and **phosphorus**.

You may have heard about work with farmers to keep cattle out of streams, or about concerns with storage and disposal of manure from poultry and hogs (please see the box, "Action on Nutrients in the 2003 Virginia General Assembly"). Or you may have seen information encouraging urban and suburban homeowners to refrain from applying excessive fertilizer to their lawns. Or you may have heard about, or even participated in, projects to replant streamside areas with vegetation that will help stop sediment and nutrients in runoff water from reaching waterways. Or you may have read about efforts in Virginia or other states to provide funds for wastewater treatment plants to improve their capacity for removing nitrogen from their effluent (please see the box, "Action on Nutrients in the 2003 Virginia General Assembly"). Finally you

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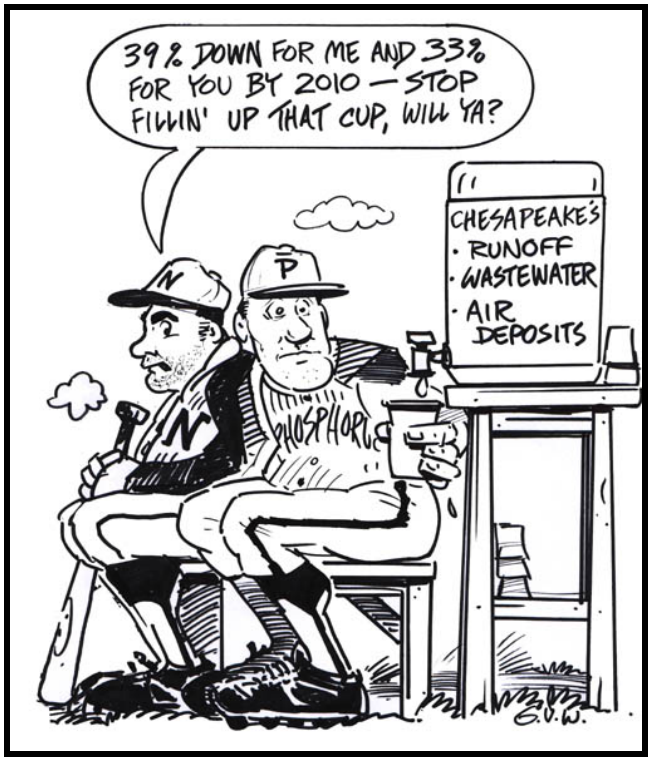


Action on Nutrients in the 2003 Virginia General Assembly

SB 896, Confined Animal Feeding Operations—This bill authorizes the State Water Control Board to develop regulations requiring operations of a certain size to have Virginia Pollution Discharge Elimination Permits, which are used to comply with Section 402 of the Clean Water Act. This state action is necessary following a February 2003 federal regulation on such operations. The federal regulation, stating that "a considerable portion of manure nutrients generated at larger animal production facilities exceeds crop nutrient needs," requires large animal-feeding operations to get a discharge permit and to develop a nutrient-management plan as a condition of the permit.

SJ 424, Nitrogen Reduction in the Chesapeake Bay—Stating that "nitrogen pollution [is] the most serious problem facing water quality in the [Chesapeake] Bay today," and that "upgrading sewage treatment plants [that] currently contribute 61 million pounds of nitrogen annually to the Bay is one of the most cost-effective steps…to significantly reduce nitrogen pollution," this resolution called on the 108th Congress (which began in January 2003) to adopt legislation to fund nitrogen-reduction technology at wastewater plants.

Other bills in the 2003 session may also have direct or indirect effects on the issue of nutrients in water resources, and in past sessions the General Assembly has passed a number of bills related to various aspects of this issue. To learn more about General Assembly action on nutrients and water quality, visit the Legislative Information System Web-site at legis.state.va.us/LIS/Sessions.htm, where you can search each session's legislation by topic; contact your local state senator or delegate; or contact the Virginia Department of Environmental Quality (DEQ) (the Virginia toll-free phone number for the DEQ's Central Office in Richmond is [800] 592-5482).

Sources: Virginia Legislative Information System, legis.state.va.us/LIS/Sessions.htm, 6/20/03; and *Federal Register*, February 12, 2003, pp. 7179-7180.

Continued from page 2

may have heard scientists or government officials talk about two general sources of nutrients: **point sources**, such as a wastewater treatment plant; and **nonpoint sources**, such as agricultural, forestry, or urban land uses.

Statewide, the Virginia Department of Environmental Quality (Va. DEQ) in 2002 reported that nutrients were the cause for 1,500 lake acres and 1511 square miles of estuary being considered "impaired"—that is, not supporting "designated uses" under the Clean Water Act.[1]

In the Chesapeake Bay watershed, reducing nutrients entering the Bay and its tributaries has been an official goal of the federal government and several Bay states since 1987. In April 2003, the Chesapeake Bay Program (the multi-state partnership that manages Bay-restoration efforts) announced new nutrient-reduction goals for 2010. The new goals call for reducing nitrogen and phosphorus entering the Bay by 39 percent and 33 percent, respectively, compared to the levels in 2000.[2] Such reductions are estimated to cost billions of dollars. Table 1 shows the estimates of the amounts of nitrogen and phosphorus originating in the watersheds of Virginia's tributaries to the Bay in 1985 and 2000, compared to the new goals for 2010.

Table 1. Estimates of Nitrogen and Phosphorus Reaching the Chesapeake Bay from Virginia.

	1985	2000	2010 Goal
Nitrogen (lbs. per year)	92.2 million	78.1 million	51.4 million
Phosphorus (lbs. per year)	13.5 million	9.6 million	6.0 million

Source: Alliance for the Chesapeake Bay's *Bay Journal*, April 2002, p. 13.

Virginia is not alone, of course, in facing large-scale water-quality problems due to nutrients. Consider the Gulf of Mexico. In the northern Gulf each summer, an area of several thousand square miles experiences **dissolved oxygen levels** too low to support most aquatic life. Known scientifically as an area of **hypoxia**, the area is known popularly as the Gulf's "dead zone." A May 2000 report by the National Science and Technology Council on the northern Gulf's problem stated, "Scientific investigations indicate that oxygen stress in the northern Gulf of Mexico is caused primarily by excess nutrients delivered to Gulf waters from the Mississippi-Atchafalaya River drainage basin, in combination with the stratification [summertime development of layers] of Gulf waters."[3]

Nationwide, studies of 20 major river basins between 1991 and 1996 by U.S. Geological Survey (USGS) scientists found that amounts of nitrogen and phosphorus "commonly [exceeded] levels that can contribute to excessive plant growth in streams."[4] More recently, the 2000 *National Water Quality Inventory* from the U.S. Environmental Protection Agency (EPA) stated that nutrients were the cause of impairment for about 20 percent of the assessed river miles that did not meet standards and 50 percent of the assessed lake acres not meeting standards.[5]

Why do nitrogen and phosphorus garner so much attention? The main reasons are the following:

1) Both substances are essential for life and are so are found widespread in nature;

[1] Virginia Department of Environmental Quality, *2002 305(b) Water Quality Assessment Report*, p. 3.3-5.

[2] Karl Blankenship, "Bay Officials Agree to Slash Nutrient Inputs Almost 50% from '85 Levels," *Bay Journal,* April 2003, p. 1.

[3] National Science and Technology Council, *An Integrated Assessment of Hypoxia in the Northern Gulf of Mexico* (May 2000), p. 19.

[4] U.S. Geological Survey, *The Quality of Our Nation's Waters: Nutrients and Pesticides*, by Gregory J. Fuhrer, *et al.*, USGS Circular 1225 (Reston, Va., 1999), p. 6.

[5] This report summarizes year 2000 water-quality reports that the 50 states, the District of Columbia, five territories, four interstate commissions, and five tribes provided to the EPA under Section 305(b) of the federal Clean Water Act.

2) Having too much of either substance in aquatic systems can lead to serious ecological impacts;
3) Nitrogen is a potential health risk in drinking water (please see the box below, "Nitrogen as a Drinking-water Issue"); and
4) Human activities generate and move large amounts of both substances.

On the following pages, *Water Central* presents three items to help readers deal with the large, complicated issue of nutrients and water quality. First is an excerpt from "Chesapeake Bay Assessment and Program Initiatives" in the Va. DEQ's 2002 water-quality report. The second item summarizes nutrient-related findings from three USGS publications on water quality in Virginia watersheds that do not drain to the Chesapeake.[6] The third item, a "Science Behind the News" installment, is an edited excerpt from a University of Florida publication on the concept of limiting nutrients, which is a key to understanding how large inputs of nitrogen or phosphorus to aquatic systems can have harmful results. A list of key references for further reading follows the Science article.

(Readers who are unfamiliar with the general concepts of nutrients in aquatic systems may want to read the Science Behind the News article first.)

Ha! Extra space for a notice!

The Water Center's Small Water Systems Web-site, first developed in 2000, provides online assistance and current information for owners and managers of small water systems. The Water Center has recently redesigned the site; please visit it at www.vwrrc.vt.edu/sws.

[6] Much of Virginia is in the Chesapeake Bay watershed: the basins of the Potomac, Rappahannock, James, and York rivers, plus the smaller coastal basins around Hampton Roads and on the Eastern Shore. In southwestern Virginia, the basins of the New and the Tennessee-Big Sandy rivers drain toward the Mississippi River and ultimately the Gulf of Mexico. In southern Virginia, the basins of the Roanoke and Chowan rivers drain to Albemarle Sound on the North Carolina coast.

Nitrogen as a Drinking-water Issue

The focus on nitrogen and phosphorus in the Chesapeake Bay, Gulf of Mexico, and other large water bodies concerns the impact of these nutrients on the growth of algae, and the consequences if excessive nutrients stimulate excessive algal growth. Another issue with nitrogen is the potential for contamination of drinking water by **nitrate**, one of several chemical compounds containing nitrogen that is found in nature and living things.

Under the federal Safe Drinking Water Act, the U.S. EPA has set a "**maximum contaminant level**" (MCL) of 10 milligrams per liter (mg/l) of nitrate-nitrogen. Nitrate levels above 10 mg/l carry an increased risk to infants, who may become ill with "blue baby syndrome," in which the blood's oxygen-carrying capacity is impaired, potentially fatally. There is also some concern about potential cancer-causing effects of nitrates in drinking water even at levels below the MCL.

Concerns about nitrate in drinking water focus mostly on areas with intensive use of nitrogen fertilizers, on areas with porous groundwater geology, and on shallow or improperly constructed wells. In its studies of 33 major groundwater aquifers from 1991 to 1996, the USGS found considerable nitrate contamination (15 percent or more of groundwater samples exceeding the MCL) in four aquifers; most of the high-nitrate samples were from groundwater sources less than 100 feet deep.

Kent Mountford, writing in the December 2002 *Bay Journal*, related the following interesting story about nitrate and drinking water in Paris, France. Since the 1880s, nitrate samples have been taken from the River Seine upstream of the city, where the city's drinking-water intake is located. Data published by French scientist Gilles Billen showed that by the 1990s nitrate values had increased by a factor of 10. "The sharpest upswing appeared after a lag in World War II and paralleled the exponential increase in nitrogen fertilizer application in France," wrote Mountford.

In Des Moines, Iowa, the water system operates the "world's largest" nitrate-removal system. Much of the city's water comes from the Des Moines River, which is affected by nitrogen from intensive cropland fertilization.

Sources: *Inside EPA's Water Policy Report*, May 7, 2001; U.S. Geological Survey, *The Quality of Our Nation's Waters: Nutrients and Pesticides*, 1999; *Leopold Letter*, Iowa State University, Winter 2002.

Nutrients in Virginia's Chesapeake Bay Assessment and Program

The following two pages are an excerpt from Chapter 3.5 of the Virginia Department of Environmental Quality's *2002 305(b) Water Quality Assessment Report*, dated September 30, 2003. That report is available on-line at www.deq.state.va.us/water/reports.html. For a printed copy, visit a state depository library (a larger library, such as at a university), or contact the Va. DEQ at (800) 592-5482 (toll-free in Virginia).

Bolding and information in brackets [ ] have been added to the original.

Chesapeake Bay Program

In 1983, Virginia, Maryland, Pennsylvania, the District of Columbia, the Environmental Protection Agency, and the Chesapeake Bay Commission formally agreed, by signing a Chesapeake Bay Agreement, to undertake the restoration and protection of the Bay using a cooperative Chesapeake Bay Program approach. This approach established specific mechanisms for its coordination among the Program participants. Recognizing the need for an expanded and refined commitment to the Bay's restoration, [the partners signed] a new Bay Agreement…in 1987. The new agreement contained goals and priority commitments in six areas: Living Resources; Water Quality; Population Growth and Development; Public Information, Education, and Participation; Public Access; and Governance.

A key water-quality goal established by the 1987 Agreement was to reduce, by the year 2000, the **annual nutrient load** of nitrogen and phosphorus entering the Bay from controllable sources **by 40 percent**. The starting point, or "baseline," for this reduction effort was the sum total of 1985 point source loads (discharges from municipal and industrial treatment plants) and non-point source loads (runoff from agricultural, forested, and urban areas) in an average rainfall year. Achieving this 40-percent reduction was expected to improve dissolved oxygen levels and water clarity conditions in the Bay, which in turn would help improve the habitats and health of living resources.

In 1992, the nutrient-reduction goal was reevaluated using information from a variety of sources, most notably water-quality monitoring and modeling programs. As a result, the Bay Program reaffirmed its commitment to the 40-percent goal in a set of 1992 Amendments to the Bay Agreement. The Amendments also directed that **tributary-specific nutrient reduction strategies** be developed to achieve and maintain the goal, as well as to protect and improve aquatic habitats within those rivers.

On June 28, 2000, the Chesapeake Executive Council signed *Chesapeake 2000*…. *Chesapeake 2000* outlines 93 commitments detailing protection and restoration goals critical to the health of the Bay watershed…. At the same time Bay Program partners were developing the new Bay Agreement, the Chesapeake Bay and many of its tidal tributaries were placed on the "impaired waters" list. This action is normally followed by the development of a "total daily maximum load" (TMDL) through a regulatory process.

Chesapeake 2000 seeks to avoid regulatory approaches by achieving water-quality improvements prior to the time frame when a Bay-wide TMDL would need to be established. To accomplish this goal, Chesapeake Bay Program partners are developing a new process for setting and achieving nutrient and sediment load reductions necessary to restore Bay water quality. This process requires Bay Program partners to continue to build on previous nitrogen and phosphorus reduction goals, but instead of measuring improvement against broad percentage-reduction goals, they must now establish and meet **specific water-quality standards**. This new process will also incorporate elements traditionally found in the regulatory TMDL process, such as criteria, standards, and load allocations, but also would be developed and applied through a cooperative process involving six states, the District of Columbia, local governments and involved citizens. For the first time, Delaware, New York, and West Virginia are formally partnering with EPA, the Bay states and the District to improve water quality [across the Bay watershed].

In Virginia, the Department of Environmental Quality (DEQ) has primary responsibility for point-source discharge issues…. The Department of Conservation and Recreation (DCR) has the lead for nonpoint-source control programs. Other state agencies that provide vital support include Game and Inland Fisheries, Forestry, Health, Chesapeake Bay Local Assistance, Marine Resources Commission, Agriculture and Consumer Services, …Virginia Institute of Marine Science, and Old Dominion University.

Virginia's Tributary Strategy Program

…Tributary strategies are water-quality plans that are cooperatively developed with stakeholders in each river basin. Agencies under the Secretary of Natural Resources work closely with local governments, Planning District Commissions, Soil and Water Conservation Districts, sanitation and wastewater

authorities, conservation and river-user groups, and others to develop strategies that are practical, equitable, and cost-effective. Reduction goals are established based on the best available scientific information and water-quality model results, and management practices are identified which will help achieve those goals. These point-source and nonpoint-source practices are then eligible for cost-share funding through Virginia's Water Quality Improvement Fund (WQIF)….

Details on the tributary strategy program can be found in *2001 Annual Report on Implementation of the Chesapeake Bay Agreement, Status of the Tributary Strategies, and Status of Water Quality for Virginia's Chesapeake Bay and Tributaries*. [This report is available on-line at www.deq.state.va.us/water/reports.html.)

Shenandoah-Potomac Tributary Nutrient Reduction Strategy

In December of 1996, Virginia completed the Shenandoah and Potomac River Basin Tributary Nutrient Reduction Strategy…. The Strategy outlines point and nonpoint source management actions that were needed to achieve the 40-percent nutrient-reduction goal for this river basin by the deadline of December 31, 2000. Implementation rates for these practices have been very high in response to the cost-share program that was established under the Water Quality Improvement Act….

Point Source Nutrient Reduction Actions in the Shenandoah/Potomac Basin

Progress continues to be made on point-source nutrient-reduction projects under the provisions of 17 signed Water Quality Improvement Fund grant agreements in the Shenandoah and Potomac River basins. These projects account for approximately $75.54 million in cost-share (50 percent) for the design and installation of nutrient-reduction systems. To date, over $57 million has been reimbursed to these grantees for work accomplished. Once operational, these systems will remove an estimated 7,407,000 pounds of nitrogen and 241,300 pounds of phosphorus per year.

Nonpoint Source Nutrient Reduction Actions in the Shenandoah/Potomac Basin

Non-point implementation activities identified in the Shenandoah-Potomac tributary strategy were completed in December of 2000. Based on the sign-up through December 2000 for cost-share to install nonpoint-source Best Management Practices (BMP's), a 40.9-percent reduction in annual controllable nitrogen loads and a 40.7-percent reduction of the controllable phosphorus load were achieved.

The principal nonpoint source components of the strategy included agricultural BMP's and agricultural nutrient-management planning. The agricultural BMP's were implemented through Virginia's Cost-Share Program, which is administered locally by the Soil and Water Conservation Districts. Nutrient-management planning was accomplished through a combined effort of Department of Conservation and Recreation nutrient management staff, local soil and water conservation district staff, and private certified nutrient-management planners.

Nutrient and Sediment Reduction Strategies for Virginia's Lower Chesapeake Bay Tributaries

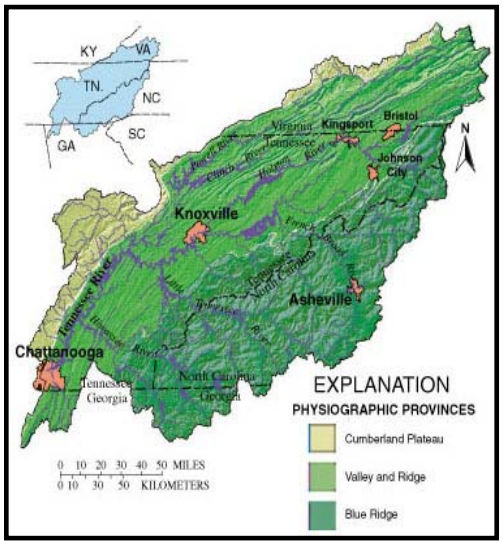
The reevaluation of the Bay wide nutrient-reduction goal, conducted in 1991-92, which lead to the adoption of the 1992 Amendments, yielded an important finding about Virginia's lower Bay tributaries and their impact on the Bay's water quality. It was determined that the nutrient loads from the Potomac River basin and basins to the north have the greatest influence on conditions in the mainstem Bay, whereas the southern tributaries—the Rappahannock, York, James and small coastal basins–contribute little, if any, to the mainstem Bay's water-quality problems in terms of excess nutrient impacts. These southern Bay tributaries, however, have [their own] water-quality problems [that] need to be addressed. Thus the goal-setting process and the final reduction goals for each of the lower tributaries reflect both the unique water-quality and habitat conditions of each tributary, as well as the characteristics of each tributary basin.

[The strategy goals for nutrients for Virginia's lower Bay tributaries, as of 2002, are as follows:
Rappahannock: reduce nitrogen load by 33 percent, phosphorus load by 29 percent;
York: reduce nitrogen load by 30 percent, phosphorus load by 44 percent;
James: reduce nitrogen load by 32 percent; phosphorus load by 39 percent.
Eastern Shore: reduce nitrogen load by 33 percent, phosphorus load by 43 percent.]

Implementation of Virginia's lower Bay tributary strategies has begun. Point-source nutrient-reduction projects are proceeding under eight signed WQIF agreements awarding $23.5 million in cost-share. Once on-line, these systems will remove about 6.29 million pounds of nitrogen and 1,400 pounds of phosphorus annually.

Nutrients in the Upper Tennessee, New, Roanoke, and Chowan Basin Areas of Virginia

Since 1991, the U.S. Geological Survey's National Water Quality Assessment (NAWQA) program has studied surface-water and groundwater quality in more than 50 river basins and groundwater aquifers across the United States. Five study units covered parts of Virginia: Albemarle-Pamlico Basin; Delmarva Peninsula; Kanawha-New River Basin; Potomac River Basin; and Upper Tennessee River Basin. This page and the next present nutrient-related excerpts from the three NAWQA reports addressing parts of Virginia *not* contained in the Chesapeake Bay watershed. For copies of the reports, visit the Web-sites identified below or the NAWQA home page at water.usgs.gov/nawqa/, or contact the NAWQA program at USGS, 413 National Center, Reston, VA 20192; (703) 648-6693; nawqa_whq@usgs.gov.



Upper Tennessee River Basin

Map Source: water.usgs.gov/pubs/circ/circ1205/, 6/23/03.

The report for this study unit is *Water Quality in the Upper Tennessee River Basin—Tennessee, North Carolina, Virginia and Georgia, 1994-98* (Circular 1205, 2000), available on-line at water.usgs.gov/pubs/circ/circ1205/.

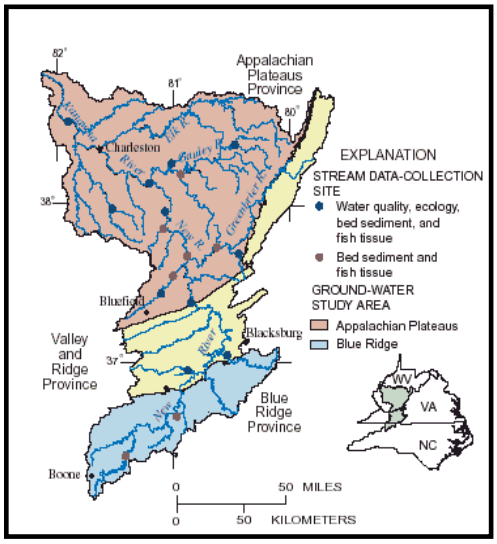
This study area includes about 21,400 square miles, with 3,130 square miles in Virginia. The basin population in 1990 was about 2.4 million. Tennessee River tributaries in Virginia include the Clinch and Holston rivers.

Summary of significant findings on nutrients

•"Inputs from urban and agricultural land uses have increased nutrient levels in streams. Yields of total nitrogen in streams are correlated to agricultural inputs, such as animal waste and fertilizer applications, whereas yields of total phosphorus are correlated with wastewater discharges. Reservoirs serve as effective sinks for both nitrogen and phosphorus species in the basin" [that is, areas that retain nutrients]. (p. 1)

•"Because of water-treatment improvements, nitrogen and phosphorus levels for most of the streams in the Upper Tennessee River Basin remained unchanged or decreased from 1970 to 1993. Nitrogen concentrations, however, increased significantly for many streams in the Blue Ridge physiographic province [geographic area] because of nonurban residential development and aquaculture." (p. 2)

•"Nitrate was present in all domestic wells and springs but usually in concentrations well [below] the federal drinking-water standard. Five of 30 monitoring wells that were installed adjacent to burley tobacco fields contained nitrate concentrations exceeding the drinking-water standard." (p. 2)



Kanawha-New River Basin

Map Source: water.usgs.gov/pubs/circ/circ1204/, 6/23/03.

The report for this study unit is *Water Quality in Kanawha-New River Basin—West Virginia, Virginia, and North Carolina, 1996-98* (Circular 1204, 2000), available on-line at water.usgs.gov/pubs/circ/circ1204/.

This study area covers over 12,000 square miles in North Carolina, Virginia, and West Virginia. The basin population in 1990 was about 870,000. The New River, which starts in North Carolina and flows into the Kanawha River in West Virginia, has a Virginia watershed of 3070 square miles.

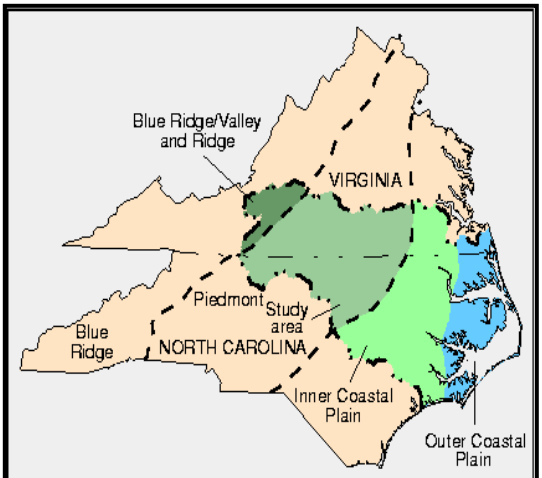
Kanawha-New River Basin, cont.

Summary of significant findings on nutrients

• "In streams, all samples in the study had nutrient concentrations "less than health-related national guidelines for drinking water…and [less than] a national goal for preventing excess algal growth." (p. 2) "[Average] concentrations of nutrients…were at or below national background levels." (p. 19)

•"Differences in nutrient concentrations were found among sites because of differences in land use/land cover and physiography [land forms]. Generally, basins with more agriculture produced [higher average concentrations of] nitrogen than did forested basins." (p. 19)

•In groundwater, only one out of 88 wells sampled had a nitrate concentration above the U.S. EPA standard for drinking water. Findings of low nutrient concentrations "are consistent with national findings…in groundwater of forested areas, and the Kanawha-New River Basin is about 80 percent forested." (p. 19)



LOCATION OF STUDY AREA AND PHYSIOGRAPHIC PROVINCES IN NORTH CAROLINA AND VIRGINIA

Albemarle-Pamlico Drainage Basin

Map source: water.usgs.gov/pubs/circ/circ1157/, 6/23/03)

The report for this study unit is *Water Quality in the Albemarle-Pamlico Drainage Basin—North Carolina and Virginia, 1992-95* (Circular 1157, 1998), available on-line at water.usgs.gov/pubs/circ/circ1157/.

The Albemarle-Pamlico Drainage Study Unit includes about 28,000 square miles in four major river basins, the Chowan, Roanoke, Tar-Pamlico and Neuse. The basin population in 1990 was about three million. No parts of the Tar or Neuse river basins are in Virginia. The Virginia watershed of the Chowan River covers about 3,560 square miles; the Virginia watershed of the Roanoke River, about 6,300 square miles.

Summary of significant findings on nutrients

•"Of four river basins studied in the Albemarle-Pamlico Drainage Basin—the Chowan, Roanoke, Tar, and Neuse—highest nitrogen and phosphorus yields occurred in the highly agricultural and urbanized Neuse Basin [in North Carolina]; lowest nutrient yields occurred in streams of the forested Chowan Basin." (p. 2)

•"Permitted point sources of nitrogen and phosphorus from municipal wastewater-treatment plants and industry account for less than six percent of the nitrogen source inputs and 16 percent of the phosphorus source inputs in all basins. However, nutrients from these point sources go directly into streams and may constitute more than 40 percent of the instream nutrient load." (p. 2)

•"Phosphorus and nitrogen concentrations in streams generally have declined since 1980 in all four basins. This decrease is probably the result of improved agricultural practices, a phosphate detergent ban in North Carolina and Virginia in 1988, and enhanced wastewater-treatment practices." (p. 2)

•"Nitrate concentrations in shallow ground water in the Coastal Plain of the Albemarle-Pamilico Drainage Basin were among the lowest nationally." (p. 25)

•"Highest nitrate concentrations in shallow ground water are in well-drained, sandy soils in combination with intensive agricultural activity, such as crop or livestock production." (p. 2)

•"Water in about four percent of 49 shallow monitoring wells randomly placed in agricultural areas of the Coastal Plain exceeded the 10 mg/L drinking-water standard for nitrate." (p. 2)

—By Alan Raflo

Ha! Extra space for a notice!

"Protecting Public Health: Water and Wastewater Solutions for a New Era" will be held July 29—August 1, 2003, in Morgantown, West Virginia. Sponsored by the National Environmental Training Center for Small Communities. Training on utility security, decision making, financial management, and more. For more information: (800) 624-8301, or smiller2@mail.wvu.edu.

SCIENCE BEHIND THE NEWS

The Concept of Nutrients as Limiting Factors

This article is an edited excerpt from *A Beginner's Guide to Water Management—Nutrients* (Information Circular #102), published in 2000 by Florida LAKEWATCH at the University of Florida's Department of Fisheries and Aquatic Sciences. Large additions by *Water Central* are in "boxes"; shorter additions are in brackets [ ]. Some sections not pertinent to Virginia have been omitted. *Water Central* gratefully acknowledges permission granted by LAKEWATCH to reprint this information.

[The following information on limiting nutrients concentrates on **algae**. Algae (plural; the singular is "alga") are single-celled, mostly aquatic organisms that make food through photosynthesis. Algae are often called plants, but most modern classifications no longer group algae with true plants. Algae are a natural component of all water bodies, but excessive nutrients reaching water bodies typically cause problems by stimulating *excessive* growth of algae.]

A limiting nutrient is a chemical necessary for plant growth but available in smaller quantities than needed for algae to increase their abundance. Once the limiting nutrient in a body of water is exhausted, the population of algae stops expanding. If more of the limiting nutrient is added, larger algal populations will result until their growth is again limited by nutrients or by other limiting environmental factors.

It's helpful to know if there is a limiting nutrient (or some other limiting factor) in your lake [or other water body], as an increase of the limiting nutrient could affect change in the lake.

There are many potentially limiting nutrients. For example, silica is sometimes known to limit the growth of diatoms [a type of algae]. Although scientists may debate which nutrient is the limiting factor at any given time, phosphorus and nitrogen are most often the limiting nutrients in Florida water bodies [and Virginia waters].

Why Nitrogen and Phosphorus Are So Important

Three words tell most of the story: **DNA**, **proteins**, and **energy**.

Both nitrogen and phosphorus are components of DNA, the substance that contains and transmits genetic information. Nitrogen is the key element in proteins, a large class of substances that form biological structures and regulate biochemical reactions. Phosphorus is the key element in a series of compounds and reactions that store and release energy in cells. Because every living thing needs DNA (or a related substance, RNA), proteins, and energy, every living thing needs nitrogen and phosphorus. In turn, because all living things use these elements, at times or in some places *usable* nitrogen or phosphorus is insufficient relative to other substances that plants and algae need to grow. In that case, nitrogen or phosphorus become *limiting factors*.

(For more detail on DNA and proteins, please see the April 1999 *Water Central* article on genetics and water, p. 8).

About Phosphorus

Phosphorus is an element (chemical symbol **P**) that, in its different forms, stimulates the growth of algae in water bodies. Phosphorus compounds [phosphorus combined with other elements] are also found naturally in many types of rocks and soils. In fact, phosphorus is mined in Florida and other parts of the world for a variety of agricultural and industrial uses. In most freshwater lakes in Florida, the limiting nutrient is believed to be phosphorus rather than nitrogen. [But see the box later in this article, "Importance of Nitrogen in Coastal Waters."]

In water bodies, phosphorus occurs in two forms: **dissolved** and **particulate**. Dissolved phosphorus is defined based on its size, as that which is small enough to pass through a 0.45 micron filter [a micron is one millionth of a meter]. It includes phosphorus forms like soluble reactive phosphorus and soluble organic compounds that contain phosphorus. Particulate phosphorus is too big to pass through a 0.45-micron filter. It is formed when phosphorus becomes incorporated into particles of soil, algae, and small animals that are suspended in the water.

Both dissolved and particulate phosphorus can change from one form to another very quickly (called **cycling**) in a water body, and there is ongoing scientific inquiry about when, where, and how often these specific forms of phosphorus are found in water bodies. This is important because *algal cells and plants can only use phosphorus in certain forms*. [The same is true for nitrogen.]

Understanding the relationship between algae and phosphorus is further complicated by the fact that an algal cell's ability to use specific forms of phosphorus is strongly influenced by several factors, including pH, water hardness (caused by the presence of calcium and/or magnesium), the amount of dissolved oxygen in the water, and thermal stratification (layers of water having different temperatures).

This process of phosphorus cycling makes it difficult to measure dissolved or particulate phosphorus in a water body at a given time. However, **total phosphorus** concentrations (abbreviated TP), which include both dissolved and particulate forms, can be used to gain an estimate of the amount of phosphorus in a system….

There are many ways in which phosphorus compounds find their way into water bodies. Some of the more common pathways are as follows:

- Some…parts of the world have extensive phosphate deposits in the soils. In these areas, rivers and water seeping or flowing underground can become phosphorus enriched and may carry significant amounts of phosphorus into water bodies.
- Sometimes phosphorus is added intentionally to water bodies as a management strategy to increase fish production by fertilizing aquatic plant and algal growth.
- Phosphorus can enter water bodies inadvertently as a result of human activities like landscape fertilization, crop fertilization, wastewater disposal, and stormwater runoff from residential developments, roads, and commercial areas.

Total Phosphorus and Biological Productivity

One major task…in water-quality management is assessing the **biological productivity** of a water body—and determining whether it's changing over time. Biological productivity is the amount of algae, aquatic plants, fish, and wildlife that a water body can produce and sustain. However, overall biological productivity is difficult to measure in a water body because it involves measuring many different parameters over a period of time. Such an approach would be prohibitively expensive and time consuming.

Because of [the time and expense of measuring biological productivity directly], many aquatic scientists use **total phosphorus** measurements, often alone, as an indirect [measurement of productivity]. [Scientists often measure phosphorus because it is] one of the main nutrients that can limit the biological productivity of a water body.

However, this is *not always* the most accurate way to assess the biological productivity of a water body. Other factors may also limit biological productivity, such as availability of light.

Trophic State

While discussing…biological productivity with aquatic scientists, you may hear the term **trophic state**. Trophic state is just another way of saying biological productivity. The **Trophic State Classification System** is one method scientists use to quickly and easily describe the biological productivity of a water body. [Trophic state is relevant to nitrogen and well as phosphorus.]

The Trophic State Classification System classifies lakes and other water bodies into one of four trophic states:

•water bodies with low productivity are called **oligotrophic**;
•those with moderate productivity are called **mesotrophic**;
•moderate-to-highly productive waters are called **eutrophic**;
•and highly productive waters are called **hypereutrophic**.

Phosphorus As A Limiting Nutrient

Because phosphorus is frequently the limiting nutrient in the growth of free-floating algae in lakes, it is strongly believed in the scientific community that water bodies with *higher* phosphorus levels will have *higher* levels of algae and water bodies with *low* phosphorus concentrations will have *lower* levels of algae. This belief is based in part on surveys of lakes, both in Florida and throughout the world, and on results of whole-lake experiments….

Consequently, aquatic scientists almost always recommend the manipulation of phosphorus, called phosphorus control, as a primary management strategy for controlling algal biomass. …However, *phosphorus is not always the limiting nutrient* and phosphorus removal may not be the best management approach to controlling algal biomass. [We turn, therefore, to the other frequently limiting nutrient, nitrogen.]

About Nitrogen

Nitrogen [chemical symbol for this element is **N**] is also a necessary nutrient for the growth of algae and aquatic plants.

Various forms of nitrogen can be found in water, including **organic** and **inorganic** forms. Organic forms of nitrogen are derived from living organisms and include…proteins [and the amino acids that make up proteins]. Inorganic forms are composed of materials other than plants or animals (i.e., mineral based) and include **nitrate**, **nitrite**, **ammonia** [which also takes various forms depending on how many hydrogen atoms are attached], and **nitrogen gas**.

Total nitrogen (abbreviated **TN**) is a measure of all the various forms of nitrogen (except nitrogen gas) found in a water sample. Not all forms of nitrogen can be readily used by algae; especially unavailable is nitrogen bound with particulate organic matter. In general, algae and aquatic plants directly utilize inorganic forms of nitrogen such as nitrates, nitrites, and ammonia.

[Nitrogen reaches aquatic environments from both natural and human-created sources, including many of the same sources as phosphorus. Two key differences between nitrogen and phosphorus sources, however, are the following:

•Nitrogen can come from the air naturally, as bacteria associated with plants and algae "fix" nitrogen, or pull nitrogen out of the air in its gaseous form and convert it to a form that plants and algae can use;
•Air deposition of nitrogen from human sources—such as power plants—is a significant source of nitrogen to water bodies in the eastern United States, including the Chesapeake Bay.]

Nitrogen As A Limiting Nutrient

…In some cases, an inadequate supply of nitrogen in water bodies [limits the growth of algae]. Nitrogen limitation…occurs most commonly when the *ratio of total nitrogen to total phosphorus is less than 10*; in other words, when the total phosphorus concentration is more than 10 percent of the total nitrogen concentration. [For more on

nitrogen vs. phosphorus limitation, please see the following box, "The Importance of Nitrogen in Coastal Waters."]

The Importance of Nitrogen in Coastal Waters

"Excessive aquatic plant growth and eutrophication in freshwater generally result from elevated phosphorus concentrations (typically greater than 0.1 milligram per liter). In contrast, nitrogen is typically the limiting nutrient for aquatic plant growth in saltwater and coastal waters."—U.S. Geological Survey, *The Quality of Our Nation's Waters—Nutrients and Pesticides*, 1999, p. 8.

"Nitrogen is the most significant nutrient controlling algal growth in coastal waters, while phosphorus is the most significant nutrient in fresh water."—National Science and Technology Council, *Integrated Assessment of Hypoxia in the Northern Gulf of Mexico*, 2000, p. 12.

"In 1978-79, while I worked at the Chesapeake Biological Laboratory, Chris D'Elia and Jim Sanders did definitive experiments to show that nitrogen was the limiting nutrient in the Patuxent River estuary [a Bay tributary in Maryland]. They did these in the face of EPA protests that phosphorus control was sufficient to manage algal blooms in natural waters."—Kent Mountford, *Bay Journal*, December 2002.

Determining The Limiting Nutrient in a Water Body

Aquatic scientists routinely recommend nutrient (phosphorus and nitrogen) control to manipulate algae populations in a water body. Controlling nutrients as a way of manipulating algae is one strategy for managing fisheries, water clarity, and wildlife populations. This strategy, however, only works if phosphorus or nitrogen is *in fact* the environmental factor limiting algal abundance….

As mentioned earlier in this article, nutrients like silica can be limiting in some…water bodies. In addition, **micronutrients** that are also necessary for the growth of plants and algae (such as molybdenum and zinc) may be in limited supply in some circumstances. (The term **micronutrient** indicates that plants and algae need only tiny amounts of this nutrient. Contrary to its name, a micronutrient is of no smaller importance than a nutrient.) Tests to evaluate these substances as potential limiting nutrients are sometimes recommended. The tests are relatively expensive, so they should only be considered if phosphorus and nitrogen are eliminated as possibilities.

In addition, nutrients are not always the limiting factor. Other environmental factors, such as highly colored water, [light, physical structures, and the presence of algae-eating animals] can also influence the abundance of algae in a water body.

References and Further Reading

•Alliance for the Chesapeake Bay. *Bay Journal*. Published bimonthly in Seven Valleys, Penn., phone (717) 428-2819, e-mail bayjournal@earthlink.net; available on-line at www.bayjournal.com. Useful issues on nutrients include January 2001 (nutrient levels and sources), October 2002 (overview of the nutrient issue), and April 2003 (recent policy developments). For the connection between fertilizer use and water quality, see the following articles by Kent Mountford: "Growing Population Fed Desire to Improve Soils with Fertilizers," November 2002; and "Ability to 'Fix' Nitrogen Led to Explosive Growth of Fertilizer Use," December 2002.

•Florida LAKEWATCH. *A Beginner's Guide to Water Management—Nutrients*. Information Circular #102. Gainesville: University of Florida, Department of Fisheries and Aquatic Sciences, 2002.

•National Science and Technology Council. *Integrated Assessment of Hypoxia in the Northern Gulf of Mexico*. Washington: NSTC, 2000.

•U.S. Environmental Protection Agency. *National Water Quality Inventory—2000*

Report. EPA-841-R-02-001. Washington: U.S. Environmental Protection Agency, 2002.

•U.S. Geological Survey. *The Quality of Our Nation's Water—Nutrients and Pesticides*. by G. J. Fuhrer, *et al.*, Circular No. 1225. Reston, Va.: U.S. Geological Survey, 1999.

Further Reading About Nutrients on the Web

•U. S. Environmental Protection Agency, "Water Quality Criteria-Nutrients," at www.epa.gov/waterscience/standards/nutrient.html.

How Much Nitrogen or Phosphorus is Too Much?

Between 2001 and 2003, the U.S. EPA released 29 "**ecoregional nutrient criteria**" documents. These criteria identify nutrient **concentrations** (the amount of a substance in a given volume of water) in natural waters that are believed to represent water quality conditions…minimally impacted by human activities…." The criteria are based on "reference ecological conditions that are characteristic of a given geographical region." States may use these criteria to set legally enforceable nutrient standards. The guidance documents and criteria information are available at www.epa.gov/waterscience/standards/nutrient.html.

Virginia contains areas in three ecoregions: IX, Southeastern Temperate Forested Plains and Hills, including the Virginia Piedmont; XI, Central and Eastern Forested Uplands, including western Virginia; and XIV, Eastern Coastal Plain, including Tidewater Virginia and the Eastern Shore.

Below are the EPA criteria for lakes/reservoirs and rivers/streams in the Virginia's three ecoregions. All values are in **milligrams per liter**, equivalent to **parts per million**.

	Region IX (Piedmont)	**Region XI (Mountains)**	**Region XIV (Coastal Plain)**
Lakes/Reservoirs			
Total Phosphorus	0.02	0.008	0.008
Total Nitrogen	0.36	0.46	0.32
Rivers/Streams			
Total Phosphorus	0.037	0.01	0.031
Total Nitrogen	0.69	0.31	0.71

For comparison, Florida LAKEWATCH classifies the **trophic state** of Florida lakes using the following average concentrations of total phosphorus (TP) and total nitrogen (TN):
Oligotrophic (very low biological productivity): TP<0.015 mg/l, TN <0.4 mg/l;
Mesotrophic (moderate biological productivity): TP = 0.015—0.025 mg/l, TN = 0.5—0.6 mg/l;
Eutrophic (moderately high biological productivity): TP = 0.025—0.1 mg/l, TN = 0.6—1.5 mg/l;
Hypereutrophic (very high biological productivity): TP >0.1 mg/l, TN >1.5 mg/l.

To get a perspective on milligrams per liter (mg/l), consider this example: If a stream has a nitrogen concentration of one mg/l, then 450,000 liters or about 120,000 gallons of the stream water would contain one *pound* of nitrogen.

Sources: www.epa.gov/waterscience/criteria/nutrient/faqs.htm, 1/30/03; *Federal Register*, 1/6/03, pp. 557-560.

—Article compiled by Alan Raflo

VIRGINIA WATER STATUS REPORT

This section of *Water Central* presents recent and historical data on Virginia's precipitation, stream flow, and groundwater levels (one topic per issue, rotating among the three topics).

Precipitation in Virginia, May 2002—May 2003

The chart below shows precipitation (in *inches*) recorded at six National Weather Service observation sites in Virginia for each month from May 2002 through May 2003. The top number for each site/month is the total precipitation, including the equivalent amount of water contained in any snowfall or other frozen precipitation. These values were found at "Climate" sections of the Web-sites of the National Weather Service offices in Blacksburg (www.erh.noaa.gov/er/rnk), Sterling (www.erh.noaa.gov/er/lwx/), and Wakefield (www.erh.noaa.gov/er/akq/) (as of 6/11/03). The bottom number (in parenthesis) is the **departure from normal:** the amount above (+) or below (-) the average monthly precipitation over the period 1971—2000, according to the National Climatic Data Center, *Climatography of the United States No. 81* (accessed at www5.ncdc.noaa.gov/climatenormals/clim81/VAnorm.pdf on 6/25/03). The monthly amounts shown here are classified as "preliminary data" by the National Weather Service.

For more information or data on Virginia's climate, visit the Web-site of the State Climatologist's office, climate.virginia.edu, or phone that office at (434) 924-0548. That office's latest *Virginia Climate Advisory* (#03/03, issued 6/13/03) discusses how May 2003 set records for the number of rainy days in one month in Virginia.

	Blacks-burg	Lynchburg (Municipal Airport)	Norfolk (Internat. Airport)	Richmond (Byrd Airport)	Roanoke (Woodrum Airport)	Wash.-Dulles Airport
May 02	5.06 (+0.67)	4.16 (+0.05)	Not available	Not available	2.67 (-1.57)	4.75 (+0.53)
June 02	5.29 (+1.36)	0.72 (-3.07)	Not available	Not available	1.46 (-2.22)	3.61 (-0.46)
July 02	2.38 (-1.79)	4.64 (+0.25)	3.59 (-1.58)	1.63 (-3.04)	3.09 (-0.91)	2.65 (-0.92)
August 02	0.88 (-2.80)	1.77 (-1.64)	4.27 (-0.52)	3.18 (-1.00)	2.21 (-1.53)	2.92 (-0.86)
Sept. 02	4.37 (+0.98)	2.46 (-1.42)	6.69 (+2.63)	2.88 (-1.10)	3.54 (-0.31)	2.84 (-0.98)
Oct. 02	4.54 (+1.35)	4.62 (+1.23)	6.55 (+3.08)	6.09 (+2.49)	5.31 (+2.16)	5.04 (+1.67)
Nov. 02	5.11 (+2.15)	5.39 (+2.21)	4.92 (+1.94)	4.28 (+1.22)	4.24 (+1.03)	4.14 (+0.83)
Dec. 02	3.81 (+0.94)	4.04 (+0.81)	4.16 (+1.13)	3.45 (+0.33)	3.92 (+1.06)	3.61 (+0.54)
Jan. 03	1.19 (-2.18)	1.53 (-2.01)	2.34 (-1.59)	2.18 (-1.37)	1.45 (-1.78)	2.69 (-0.36)
Feb. 03	6.30 (+3.28)	5.75 (+2.65)	5.25 (+1.91)	4.21 (+1.23)	5.80 (+2.72)	6.27 (+3.50)
March 03	3.09 (-0.74)	4.17 (+0.34)	2.91 (-1.17)	5.92 (+1.83)	3.52 (-0.32)	3.71 (+0.16)
April 03	4.77 (+0.94)	5.32 (+1.86)	6.39 (+3.01)	4.38 (+1.20)	5.02 (+1.41)	2.71 (-0.51)
May 03	6.50 (+2.11)	8.19 (+4.08)	4.66 (+0.92)	8.59 (+4.63)	10.13 (+5.89)	8.72 (+4.52)

—By Alan Raflo

IN AND *OUT OF* THE NEWS
Newsworthy Items You May Have Missed

The following summaries are based on information in the source(s) indicated in parentheses, usually at the end of each item. Selection of this issue's items ended June 6, 2003. Unless otherwise noted, all localities mentioned are in Virginia and all dates are in the year 2003.

In Virginia…

•**Current research at the Virginia Institute of Marine Science (VIMS)** ranges from the *intensive* to the *expansive*. On the intensive side is the "Dataflow" system, by which researchers can take a series of water-quality measurements every two to four seconds from a boat traveling up to 25 knots, generating a data point every 40 to 60 years. Researchers are using this data to produce detailed maps of water-quality conditions in tidal portions of the James and York rivers. The monitoring is part of efforts to restore submerged aquatic vegetation (SAV) in the Chesapeake Bay and its tributaries. Dataflow data is available on-line through the Chesapeake Bay Program's Web-site at www.chesapeakebay.net.

On the expansive side is VIMS' participation in a census of the **diversity and abundance of zooplankton**—microscopic animals of many kinds, generally floating and drifting with currents—in the Sargasso Sea, a two-million-square-mile area in the western North Atlantic Ocean. In this first-ever attempt at a complete census of Sargasso Sea zooplankton, VIMS is collaborating with Woods Hole Oceanographic Institute in Massachusetts, the Russian Academy of Sciences, and the Smithsonian Institution. The two-year, $380,000 project is part of a national initiative to develop the Ocean Biogeographic Information System, an on-line database of marine animal and plant life. An international Census of Marine Life is also underway. (VIMS newsletter *The Crest*, Winter 2003)

•In March, the SAIF Water Committee in Burgess (Northumberland County) and three partner churches received a Jessie Ball DuPont Fund **grant to study potential health risks of shallow residential** wells in Lancaster and Northumberland counties. The study will monitor bacteria, nitrate, pH, and phosphate in 40 wells per year for three years; 10 of the wells will also be monitored for pesticides, and assessment for other potential contaminants may also occur. The Southeast Rural Community Assistance Project in Roanoke is also supporting the project. More information about the SAIF Water Committee is available on-line at www.saifwater.org or by phone to (804) 580-2079. (SAIF Water Committee press release, 3/5/03)

•By mid-July, the former Virginia Beach **landfill known as Mt. Trashmore is to have a new cap to prevent leakage**. Mt. Trashmore is an 800-foot landfill first closed and capped in the early 1970s. Eventually rainwater and buried fluids began to leak through the cap's hillside. Work began in January to remove the old cap and add four new layers. The new hill will rise 62 feet, two feet higher than the original cap. The finished site is to contain stairways, terraced seating, a special-events area with stage, and re-built basketball courts. (*Virginian-Pilot*, 3/26/03)

•In Spring 2003, **Smith Mountain Lake** (bordered by Bedford, Franklin, and Roanoke counties) suffered double trouble: **debris from floodwaters and loss of state funding for water-quality monitoring.** Remarking on the flood-borne debris, one resident said there were so many boards in his cove that "it [looked] like a lumber yard." Meanwhile, the 2003 Virginia General Assembly eliminated a grant that had supported a monitoring program by nearby Ferrum College since 1987. In March, the Smith Mountain Lake Association (SMLA) formed a committee to explore new debris-removal options, and in April the group suggested creation of a special tax district through which lakefront owners could provide funds for debris removal, water-quality monitoring, and aquatic-plant management. (*Roanoke Times*, 3/27 and 4/19/03)

•On another big Virginia impoundment, **Philpott Lake** (bordered by Franklin, Henry, and Patrick counties), the U.S. Army Corps of Engineers and the Boat U.S. Foundation are collaborating this summer to provide **free loaner life jackets for children** to families who need them. (*Roanoke Times*, 5/30/03)

•In southwestern Virginia's **New River, signs of health accompany signs of trouble**. A healthy sign was the record Smallmouth Bass (8 pounds, 1 ounce) caught on March 12 by a Giles County resident. Perhaps even more encouraging were

the efforts of the angler, his friends, and a state game biologist to sustain the fish and get it certified quickly so that it could be released back to the river. Notably, two weeks later the same fish was *again* caught, measured for a replica mount, and released. (*Roanoke Times*, 4/8/03)

On the troubling side of the New, a difficult search continues for the **source of polychlorinated biphenyls (PCBs)** that caused the state to issue a health advisory in 2001 for 52 river miles. According to the Virginia Department of Environmental Quality (DEQ), which is conducting the search for the PCB source(s), 81 industrial facilities along the river section may have leaked PCBs. The agency has about $95,000 for the search, including staff time, supplies, and tests—enough to fund only about 50 water, soil, or sediment samples. A citizens' committee is helping the DEQ conduct the search. The DEQ will ultimately pass their findings on to the U.S. Environmental Protection Agency (EPA) for possible action. (*Roanoke Times*, 5/11/03)

•**PCB contamination** is also the cause of **two new, and one newly modified, health advisories** by the Virginia Department of Health (VDH) for **three far southwestern Virginia streams**. On May 15, the VDH issued new fish-consumption advisories for Knox Creek in Buchanan County and for Beaver Creek in Washington County and the City of Bristol. The VDH also modified its 1999 health advisory for 12 miles of Levisa Fork in Buchanan County. With the two new advisories, the state now has 14 fishing restrictions or health advisories in effect—one for kepone, three for mercury, and 10 for PCBs. Information about these restrictions and advisories is available on-line at www.vdh.state.va.us (click on "Health Topics," then scroll down to "Fishing Advisories"). This information is also contained in the annual fishing regulations published by the Department of Game and Inland Fisheries. (VDH Web-site noted above, 6/13/03)

•In March, the **U.S. Army Corps of Engineers** added **restrictions to the non-native oyster project** for the Chesapeake Bay that the Virginia Marine Resources Commission approved in February. (Please see the March 2003 *Water Central*, p. 24, for a previous item.) The Corps tightened rules on placement of oyster bags (to minimize the chance of reproductive oysters coming into contact); required more specific oyster-removal plans in case of severe weather; required posting of a bond by owners to cover costs in case of oyster escape; set an earlier end-date for the project (June 2004 instead of April 2005, subject to extension if monitoring shows little risk of oyster reproduction); and required a full environmental impact statement at the end of the trial period. (*Bay Journal*, April 2003)

•From March to May, the **Chesapeake Bay Program**—the regional Bay-restoration partnership including Maryland, Pennsylvania, Virginia, the District of Columbia, the Chesapeake Bay Commission (a tri-state legislative body) and the U.S. EPA—completed setting **goals for sediment reduction, nutrient reduction, and submerged aquatic vegetation (SAV) improvement** in the Bay and its tributaries. For the entire Bay watershed, the goals for 2010 are as follows: reduce sediments to 4.15 million tons/year (from 5 million tons/year in 2000); reduce nitrogen to 175 million pounds/year (from 285 million pounds in 2000); reduce phosphorus to 12.8 million pounds/year (from 19.1 million pounds in 2000); and increase SAVs to 184,888 acres (from 85,000 acres in 2001). (*Bay Journal*, April, May, and June 2003 issues)

•The August 2002 *Water Central*, p. 8, described efforts by the U.S. Department of Agriculture, the Virginia Department of Agriculture and Consumer Services, and Virginia Tech to **monitor wooden pallets and other items at Virginia ports for non-native longhorned beetles and bark beetles**. Establishment of breeding populations of these insects in Virginia (they are already established in North Carolina and other states) would likely result in costly forest damage and management programs. Fortunately, the 2002 sampling found none of the species in question. Sampling continues in Summer 2003. (Virginia Tech Dept. of Entomology, 4/9/03)

•On April 28, the **U.S. Supreme Court** announced that it would **hear arguments in Virginia's dispute with Maryland** over use of Potomac River water. (Please see the December 2002 *Water Central*, p. 16, for a previous item.) Maryland objects to the December 2002 finding by the Supreme Court's special master, Ralph Lancaster, that Virginia does have "the right, free of regulation by Maryland, to construct improvements in the Potomac [adjoining] the Virginia shore and to withdraw water from the Potomac." Fall 2003 is the earliest the Court is likely to hear the case. (*Washington Post*, 4/29/03)

•**Boating accidents in Virginia continue to decrease even as the number of registered boats continues to increase**. (Please see the April 2001 *Water Central*, p. 15, for a previous

report of the same trend.) Between 1997 and 2002, the number of registered boats increased from 232,936 to 246,910; in the same period, annual boating accidents decreased from 227 to 154. Personal watercraft continue to be disproportionately involved in accidents: in 2002, such boats were about 10 percent of all registered boats, but they were involved in over 28 percent of accidents. (*Virginia Wildlife*, May 2003)

•In May, Newport News Waterworks' 15-year effort to build a **reservoir in King William County** received a **serious, unexpected setback**. On May 14, the Virginia Marine Resources Commission (VMRC) voted to deny Newport News a permit to build an intake pipe for withdrawal of 75 million gallons per day from the Mattaponi River. The Mattaponi River water would be used to fill a reservoir that would be built on Cohoke Creek, a tributary of the Pamunkey River. A key consideration by VMRC members apparently was the potential impact that the intake would have on American Shad populations. The Commission heard from a large number of speakers at an eight-hour public hearing on April 22—so many that the hearing was continued on May 14. The city and its partners in the Regional Raw Water Study Group could appeal the decision in circuit court. (*Bay Journal*, April 2003, and *Richmond Times-Dispatch*, 5/15/03.) (Please see the December 2002 *Water Central*, p. 16, for a previous item.)

•The **Old Cape Henry Lighthouse in Virginia Beach** is one of five lighthouses featured in a new **navigation-theme stamp series** issued by the U.S. Postal Service in June. Built in 1792, the Cape Henry lighthouse was the first built by the U.S. government; the 1792 structure was replaced in 1881. The other stamps will depict Cape Lookout Light, Beaufort, N.C.; Morris Island Light, Charleston, S.C.; Tybee Island Light, Savannah, Ga.; and Hillsboro Inlet Light, Pompano Beach, Fla. (*Bay Journal*, June 2003)

…and Outside of Virginia

•The following are brief descriptions and the legislative status (as of June 5) of **several water-related bills under consideration by the 108th Congress** (which began in January 2003). Abbreviations: H.R. = House of Representatives bill; S. = Senate bill. Information on the bills is from the Library of Congress Web-site, thomas.loc.gov/. For more information about these bills, visit this Web-site or contact your senators or local House member.

••**H.R.20/S.170—Clean Water Infrastructure Financing Act of 2003.** H.R.20: Introduced Jan. 8; currently in Subcommittee on Water Resources and Environment. S.170: Introduced Jan. 15; currently in Committee on Environment and Public Works. Both bills would authorize appropriations for state water-pollution-control revolving funds and for other purposes, and would make revisions concerning uses of funds for innovative technologies, administrative expenses, assistance to small systems, and financially distressed communities.

••**H.R.1560—Water Quality Financing Act.** Introduced Apr. 2; currently in Committee on Transportation and Infrastructure. Would authorize appropriations for state water-pollution control revolving funds, and for other purposes.

••**H.R.866—Wastewater Treatment Works Security Act.** Introduced Feb. 13, passed May 7; introduced May 8 to Senate and referred to Senate Committee on Environment and Public Works. A similar Senate bill, **S.1039**, with same title as House bill, was introduced May 12 and referred to the same Senate committee; on May 15 the committee ordered the bill to be reported. Would provide $215 million for vulnerability assessments and increased security measures for wastewater-treatment facilities.

••**H.R.1080—National Aquatic Invasive Species Act.** Introduced Mar. 5; currently in House Resources and House Transportation and Infrastructure committees. Would "reauthorize and improve" the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990.

••**H.R.1081—Aquatic Invasive Species Research Act.** Introduced Mar. 5; referred to four committees: Science, Transportation and Infrastructure, Resources, and House Administration; on Jun. 4, ordered to be reported by Science Committee. Would authorize additional money to support research and education concerning the prevention and eradication of aquatic invasive species.

••**H.R.135—Twenty-First Century Water Commission Act.** Introduced Jan. 7; currently in House Resources and House Transportation and Infrastructure committees. Would establish the "Twenty-First Century Water Commission," which would make recommendations for a 50-year national water-supply strategy.

•In February the White House released its ***National Strategy for Physical Protection of Critical Infrastructures and Key Assets***. The report is available on-line at www.whitehouse.gov/pcipb/physical.html. Drinking water facilities are included in the strategy, and one recommendation

is for the EPA to work with drinking water officials to implement "broad-spectrum" monitoring for contaminants. Broad-spectrum monitoring refers to technology that can identify several contaminants simultaneously and quickly, without the time needed for laboratory analysis of samples. Such technology is not widely used *commercially* at this time. Research laboratories, however, use more advanced technology, so people involved with the issue have called for more cooperation between university researchers and the drinking-water industry to develop the technology and make it commercially available. (*Inside EPA's Water Policy Report*, 2/2/03)

•The International Association of Hydrogeologists is conducting a mapping project to determine the **extent and volume of large aquifers** around the world. Of particular interest are aquifers underlying more than one country, such as the Guarani aquifer underlying Argentina, Brazil, Paraguay, and Uruguay. Delineating the aquifers is one step toward potential agreements about use among the countries sharing the resources. (*Washington Post*, 3/10/03)

•The **EPA is facing challenges to its oversight of state enforcement**. A 2001 report by the General Accounting Office found that enforcement was not consistent across the EPA's 10 regions nationwide (Virginia is in Region III). Then on February 3, 2003, an audit by the EPA Inspector General reported inadequate oversight by EPA Region VI of Louisiana's environmental programs under the federal Clean Water Act and other laws. (EPA Region IV, headquartered in Dallas, includes Arkansas, Louisiana, New Mexico, Oklahoma, and Texas.) The audit was prompted by petitions from third-party groups asking the EPA to remove Louisiana's authority to implement federal programs, including the Clean Water Act's National Pollution Discharge Elimination System (NPDES). The EPA grants to 45 states the authority to manage NPDES programs, by which states regulate and grant permits for wastewater discharges to natural waters. Similar third-party petitions have now been filed in 12 states. In one response to the Louisiana situation, the EPA opened in New Orleans a new enforcement office that will double the number of environmental-crime investigators focused on Louisiana. (*Inside EPA's Water Policy Report*, 2/24 and 3/24/03)

•What are the **"waters of the United States"**? Interpreting this term has long been a major challenge in implementing the federal Clean Water Act, and a broad debate is now occurring over the **regulatory definition** of the term. In January, the U.S. EPA issued an "**Advanced Notice of Proposed Rulemaking** on the Clean Water Act Regulatory Definition of 'Waters of the United States'" (January 15 *Federal Register*). The notice solicited "early comment on issues associated with the scope of waters that are subject to the Clean Water Act"; the comment period ended April 16. The EPA received comments from industry groups arguing that clarification of CWA jurisdiction is needed, from environmental groups concerned that certain waters could receive less protection, and from state-regulatory groups concerned about how CWA changes could affect state programs.

The proposed rulemaking is part of the impact of the 2001 U.S. Supreme Court decision—*Solid Waste Agency of Northern Cook County [Illinois vs. U.S. Army Corps of Engineers*, known as the SWANCC case—in which the Court held that the Army Corps of Engineers was wrong to apply CWA jurisdiction to isolated, intrastate wetlands on the basis of their use by migratory waterfowl. (Please see the June 2001 *Water Central*, p. 14, for a previous item on this case.) According to the Jan. 15 notice, the comments received will be used to determine the issues and the approach for a "future proposed rulemaking addressing the scope of CWA jurisdiction." (*Federal Register*, 1/15/03; Inside EPA's *Water Policy Report*, 4/21/03)

•The omnibus appropriations bill approved by Congress in February for the fiscal year ending September 30, 2003 (H.J.Res.20; became Public Law 108-7) included **$150 million to improve the nation's flood-hazard maps**. The funds will support updating flood-hazard data for all flood-prone areas nationwide; putting all maps and data in digital format; improving federal-state-local collaboration; improving processes for updating maps; and improving public access to maps and other flood-hazard information. The legislation is available at federal depository libraries or on-line at thomas.loc.gov. (*Natural Hazards Observer*, May 2003)

•**Finally**, here's some **perspective on the news** from **David Brinkley**, the long-time television journalist who died June 11. "The only way to do news on television is not to be terrified of it. Most of the news isn't very important. In fact, very little of it is." (*New York Times*, as reprinted in *Roanoke Times*, 6/13/03)

—By Alan Raflo and Heidi Clark

N O T I C E S

State Meetings and Hearings

The Virginia Department of Environmental Quality (DEQ) posts notices of regulatory action, public hearings and meetings, and other events on-line at www.deq.state.va.us/info/ (click on "Public Calendar" or "Public Notices"). The DEQ Coastal Program posts events and other notices on-line at www.deq.state.va.us/coastal/calendar.html. Following are some recent and upcoming water-related public meetings; we include past events in case readers wish to enquire about what occurred at a given meeting. To reach the listed contact people by e-mail, go to the Public Calendar Web-site listed above, find the event, and click on the respective name. To reach the contact person by phone, call the DEQ's Central Office in Richmond at (800) 592-5482 (toll-free in Virginia).

6/10, Charles City, and 6/11, Warsaw: Public meeting on suspended sections of regulation for transport of solid and medical wastes on state waters. For more information, contact John Ely.
6/11, Arlington: Public meeting on proposed total maximum daily load (TMDL) for bacteria for Four Mile Run in Arlington and Fairfax counties, and Falls Church and Alexandria. For more information, contact Katherine Bennett.
6/17, Richmond: Limited impact development task force. For more information, contact Kathy Frahm.
6/19, Richmond: State Water Control Board. For more information, contact Cindy Berndt.
6/23, Tazewell: Public meeting on proposed TMDL for benthic impairment for Clinch River in Tazewell County. For more information, contact Nancy Norton.
6/24, Roanoke: Public meeting on proposed TMDL for bacteria for parts of Tinker, Glade, Laymantown, and Carvin creeks and Lick Run, in Roanoke and Vinton. For more information, contact Jason Hill.
6/24, Broadford: Public meeting on proposed TMDL for benthic impairment for North Fork Holston River in Smyth County. For more information, contact Nancy Norton.
6/25, Bristol: Public meeting on proposed TMDL for benthic and bacteria impairments for Beaver Creek in Washington County and Bristol. For more information, contact Nancy Norton.
6/26, Honaker: Public meeting on proposed TMDL for benthic impairment for Lewis Creek in Russell County. For more information, contact Nancy Norton.
7/1, Winchester: Public meeting on proposed TMDL for benthics for Abrams Creek and Lower Opequon Creek in Winchester and Frederick County. For more information, contact Gary Flory.
7/2, Richmond: Advisory committee on proposed Virginia Pollution Discharge Elimination Systems (VPDES) general permit on storm water discharges for construction activities. For more information, contact Burt Tuxford.
7/8, Winchester: Public meeting on proposed TMDL for bacteria for Abrams Creek, Upper Opequon Creek and Lower Opequon Creek in Winchester and Frederick County. For more information, contact Gary Flory.
7/9, Richmond: Advisory committee on proposed VPDES general permit on storm water discharges for industrial activities. For more information, contact Burt Tuxford.
7/11, Suffolk and 7/15, Roanoke: Notice of intended regulatory action public meeting for proposed designation of various exceptional resource waters. For more information, contact Jean Gregory.
7/14, 8/18, and 9/11, Richmond: Water policy technical advisory committee. For more information, contact Scott Kudlas.
7/15, Richmond: Ground Water Protection Steering Committee. For more information, contact Mary Ann Massie.
7/22, Heathsville: Public meeting on proposed TMDL for fecal coliform impairment in Coan River and Little Wicomico River in Northumberland County. For more information, contact Chester Bigelow.

Conferences and Other Gatherings

•**Taking Marine Education By Storm.** Jul. 20—24, 2003, Wilmington, N.C.; sponsored by the Mid-Atlantic Marine Education Association. For more information: Andy Wood at awood@audubon.org; Web-site: www.marine-ed.org/nmea2003.

•**Water Security in the 21st Century.** Jul. 30—Aug. 1, 2003, Washington D.C.; sponsored by the Universities Council on Water Resources, the National Institutes for Water Resources, and the American Society of Civil Engineers. The Water Center's Tamim Younos, is the program chair.

For more information: (618) 536-7571 or ucowr@siu.edu; Web-site: www.vwrrc.vt.edu/pdf/UCOWR%202003%20Conf.pdf.

•**Watershed Restoration Institute.** Sept. 22—26, 2003, Reisterstown, Md.; sponsored by the Center for Watershed Protection and River Network. For more information: Jack Tawil at (410) 461-8323; Web-site: www.cwp.org.

•**National Conference on Farm Bill Conservation Opportunities.** Nov. 12—14, 2003, St. Louis, Mo.; sponsored by The Conservation Technology Information Center and the National Association of Conservation Districts. For more information: Gerald Talbert at (410) 247-1973 or gtalbert@comcast.net.

Publications

•***Banks and Fees: The Status of Off-Site Wetland Mitigation in the United States.***
This report (Environmental Law Institute, 2002, 195 pp.) examines mitigation banking and in-lieu-fee mitigation activities taking place nationwide. Not available on-line; to order a print copy (cost is $24.99), call (202) 939-3800; e-mail: law@eli.org; or visit www2.eli.org/wmb/index.htm. (*Please note:* The November 2000 issue of *Water Central* discussed wetland mitigation in Virginia.)

•**Environmental Impact Statement (EIS) on the Mountaintop Removal Method of Mining**.
The U.S. EPA released this report on May 29, 2003. The EIS and associated materials are available on-line at www.epa.gov/region03/mtntop/eis.htm. Print copies may be requested by calling EPA Region III, toll-free, at (800) 228-8711. The public comment period for this draft EIS closes on August 29, 2003.

Recent U.S. Geological Survey Reports of Interest to Virginia

To request any publication listed, phone **(888) ASK-USGS** or go on-line to **mapping.usgs.gov/esic/to_order.html** (unless otherwise noted below).

All Resources

•*Proceedings of the USGS Appalachian Region Integrated Science Workshop*, Oct. 22-26, 2001. Publication OF 01-4006. Over 70 reports on water resources, biology, mineral resources, and other aspects of the Appalachian natural and human environments, including several papers on Virginia specifically or by Virginia scientists.

Groundwater

•*Apparent Chlorofluorocarbon Age of Ground Water in the Shallow Aquifer System, Naval Weapons Station, Yorktown, Virginia.* $4. Publication WRI 01-4179, 2001.

Surface Water

•"Pharmaceuticals, Hormones, and Other Organic Wastewater Contaminants in U.S. Streams." Publication FS 0027-02, 2002. Available on-line at toxics.usgs.gov/pubs/FS-027-02/index.html.

•*Geochemical Characterization of Drainage Prior to Reclamation at the Abandoned Valzinco Mine, Spotsylvania County, Virginia.* $13. Publication OF 02-0360, 2002. Available on-line at pubs.usgs.gov/of/2002/of02-360/.

•*Dissolved Organic Carbon and Disinfection By-produce Precursors in Waters of the Chickahominy River Basin, Virginia, and Implications for Public Supply*. $4. Publication WRI 00-4175, 2000.

Also Out There…

(Information on recent, detailed articles on various subjects)

•"Invasive Exotic Vegetation – An Important Consideration of Ecological Restoration Projects."—Discusses potential damage by kudzu and multiflora rose to stream-restoration sites. *NWQEP Notes*, Feb. 2003; NCSU Water Quality Group, Raleigh, N.C.; (919) 515-7448; available on-line at www5.bae.ncsu.edu/programs/extension/wqg/issues/Default.htm.

•"Transforming Chesapeake Bay." – Explains techniques used to increase oyster populations. *Virginia Marine Resource Bulletin*, Spring 2003; Sea Grant Communications, Gloucester Point, Va.; (804) 684-7167, mills@vims.edu; available on-line at www.vims.edu/GreyLit/SeaGrant.html.

•"Clean Water: An Agent for Change."—Provides information on international water issues. *Choices: The Human Development Magazine*, March 2003; United Nations Development Program, New York, N.Y.; (212) 906-5325, choices@undp.org; available on-line at www.choices.undp.org/.

•"Health Risks Associated with Consumption of Untreated Water from Household Roof Catchment Systems."—Summarizes research on microbiological issues of rainwater "harvesting" (with a valuable reference list). *J. Amer. Water Res. Assoc.*, Oct. 2002; AWRA, Middleburg, Va.; (540) 687-8390; info@awra.org; AWRA Web-site www.awra.org.

Notices at the Water Center

To reach the Water Center, phone (540) 231-5624; e-mail: water@vt.edu; or visit www.vwrrc.vt.edu.

The Water Center invites everyone—specialists and non-specialists alike—to the **2003 Virginia Water Research Symposium**, October 8—10 in Blacksburg. You can see southwestern Virginia's fall colors, fish or float the New River, enjoy a college-town atmosphere, and catch up on the latest in Virginia water research. For more information, contact Jane Walker at (540) 231-4159, or janewalk@vt.edu.

•**Statewide Advisory Board.** On March 27, 2003, Governor Warner announced appointments to the Water Center's Statewide Advisory Board (SAB). The newly constituted SAB met for the first time on May 13 in Charlottesville; its next meeting will be August 14. The members and affiliations are as follows (* = returning member):

Chair: Terry Reid*, Wiley and Wilson Engineers, Lynchburg;
Vice-chair: Ward Staubitz*, Virginia office of the U.S. Geological Survey, Richmond;
Marty Farber* of Richmond, General Assembly's Division of Legislative Services, Richmond;
Jack Frye, Department of Conservation and Recreation's Division of Soil and Water Conservation, Richmond;
Jay Gilliam, Virginia Save Our Streams, Raphine;
Brig. Gen. Robert Green (Ret.)*, Virginia Military Institute, Lexington;
Larry Land, Virginia Association of Counties, Richmond;
Stephanie Martin, Virginia Association of Soil and Water Conservation Districts, Hanover;
Jerry Peaks of Chesapeake, Department of Health's Division of Drinking Water, Chesapeake;
Allen Pollock, Department of Environmental Quality, Richmond;
Sandra Riggs, former state assistant attorney general, Appalachia;
Mary C. Terry, Southeast Rural Community Assistance Project, Roanoke;
Dennis Wanless* Control Equipment Co., Inc., Charlottesville;
Jud White, Dominion Virginia Power, Richmond.

For more information about the SAB, including meeting minutes, please contact Tamim Younos at (540) 231-8039 or tyounos@vt.edu.

•**New Water Center Publication**
Cooperative Infrastructures For Small Water Systems: A Case Study, by Micki Young (SR22-2002). This 71-page study examines the potential formation of a cooperative for small water systems in Carroll County, Virginia. Available on-line only at www.vwrrc.vt.edu/publications/recent.htm.

•**Published Research by Water Center Staff**
"Integrating Service-Learning into Watershed Management Programs: Opportunities and Challenges," by Tamim Younos *et al.*, in *J. Amer. Water Res. Assoc.* (39)1:1-5 (Feb. 2003). Reprints are available from the Water Center.

•**Watershed-management Minor at Virginia Tech.** An interdisciplinary watershed-management minor was recently added to the undergraduate curriculum in the Virginia Tech Department of Urban Affairs and Planning curriculum. The program will address water-management issues that face many future government employees and private sector businesses. A certificate from the Water Center will recognize completion of the program, and a notation of this concentration will be recorded on students' transcripts. Faculty from the several participating departments and the director of the Water Center will oversee the program. More information about the minor is available at www.uap.vt.edu/academics/, or by calling the Urban Affairs and Planning Department at (540) 231-5485.

—By Heidi Clark and Alan Raflo

FOR THE RECORD
Sources for Selected Water Resources Topics

Wetlands Information Sources

This topic was covered in the October 1999 *Water Central*, p. 15. Except as noted in the "Updated Information" section, the information in that issue is still correct (as of 5/30/03).

Updated Information

•U.S. Army Corps of Engineers

The Web-site for the Norfolk District of the Corps (listed incorrectly in the earlier issue) is www.nao.usace.army.mil/. The phone number is now (757) 441-7500. The Corps **Regulatory Branch** is responsible for wetlands permitting under Section 404 of the Clean Water Act.

•U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI)

This inventory of information and maps on the characteristics, extent, and status of wetlands and deepwater habitats can be accessed on-line at www.nwi.fws.gov. Users can create and print customized maps of wetland data. For specific questions, contact NWI Regional Coordinator (for Region 5, containing Virginia), Ralph Tiner at (413) 253-8620.

Status and Trends of Wetlands in the Conterminous United States 1986-1997 and other publications on wetlands' status are available at the NWI Web-site (click on "Publications").

•Va. Association of Wetlands Professionals

The Web-site for this organization is now www.vawp.org. Their newsletter is available on-line but to members only.

•Va. Department of Conservation and Recreation/Natural Heritage Division

The contact information has changed to the following: Va. DCR/Natural Heritage Div., 203 Governors Street, Suite 213, Richmond, VA 23219-2094; (804) 786-1712; Web-site: www.dcr.state.va.us/index.htm.

•Va. Institute of Marine Science (VIMS)

The general phone number for VIMS is (804) 684-7000. The VIMS Wetlands Program's Web-site, at www.vims.edu/ccrm/wetlands.html, includes information on tidal and non-tidal wetlands management, impacts of permitted activities, and VIMS' wetland-education programs. *Virginia Wetlands Report* is on-line at www.vims.edu/ccrm/vwrs.html. VIMS' Technical Report series on wetland plants is on-line at www.vims.edu/ccrm/wetlands/flora.html.

•Va. Marine Resources Commission

The agency's Web-site is now www.mrc.state.va.us/index.htm.

•Va. Native Plant Society

This organization now has an office at the State Arboretum in Boyce: VNPS, 400 Blandy Farm Lane, Unit 2, Boyce, VA 22620; (540) 837-1600. The Web-site is now www.vnps.org.

•***National Wetlands Newsletter***, published by Environmental Law Institute (ELI).

The Web-site for information about the newsletter is www2.eli.org/nwn/nwnmain.cfm. ELI also offers a free listserv forum on wetland issues, which can be joined by sending a message to wetlands-subscribe@igc.topica.com.

New Sources

•U.S. Environmental Protection Agency

EPA's **Wetlands Division** is an excellent starting point for learning about environmental and regulatory aspects of wetlands and for finding resources for wetlands education. The Division's Web-site is www.epa.gov/owow/wetlands, and the Division operates a **Wetlands Information Hotline** at (800) 832-7828.

Natural Resource Conservation Service (NRCS)

The NRCS (formerly the Soil Conservation Service) is an agency within the U.S. Department of Agriculture. NRCS' **Wetland Science Institute** provides information and training on current scientific wetland-management tools. The Institute's Web-site, at www.pwrc.usgs.gov/wli/, offers information on wetland delineation, assessment, restoration, and training. Wetland Science Institute, Patuxent Wildlife Research Center, Building #109, 12311 Beech Forest Road, Laurel, MD 20708; (301) 497-5938.

NRCS also manages the **Wetlands Reserve Program**, which provides technical and financial resources for landowners who wish to protect or restore their wetlands on their property. The NRCS contact for this program is Leslie Deavers, (202) 720-1067; e-mail: leslie.deavers@usda.gov.

The program's Web-site is www.nrcs.usda.gov/programs/wrp/.

National Wetlands Research Center

The center functions as a clearinghouse for wetlands-related scientific research. U.S. Geological Survey, National Wetlands Research Center, 700 Cajundome Boulevard, Lafayette, LA 70506; (337) 266-8500; www.nwrc.usgs.gov/.

Association of State Wetland Managers, Inc.

This national association provides members with biweekly news updates and a quarterly newsletter. The Web-site has information on federal, state, and local wetland programs. ASWM, P. O. Box 269, Berne, NY 12023; (518) 872-1804; www.aswm.org/propub/index.htm.

Other Useful Publications

•***Volunteer Monitor*—"Monitoring Wetlands"**

The Spring 1998 issue of *Volunteer Monitor* focused on wetlands and wetlands monitoring by volunteer groups. The newsletter is available on-line at www.epa.gov/owow/volunteer /vm_index.html (note underscore between "vm" and "index"), or request a paper copy (for a nominal charge) from *The Volunteer Monitor*, 211A Chattanooga Street, San Francisco, CA 94114-3411; (415) 695-0801; e-mail: skvigil@yahoo.com.

Constructed Wetlands Bibliography

The bibliography, provided by the Water Quality Information Center of the National Agriculture Library in Beltsville, Md., contains more than 600 citations. The records are available at www.nal.usda.gov/wqic (click on "water and Agriculture, then "Constructed Wetlands Bibliography").

—By Heidi Clark

Upcoming "For the Record" Schedule

Aug. 2003: Water Law and Rights
Oct. 2003: State Water Regulations
Dec. 2003: Federal Water Regulations
Feb. 2004: Aquatic Life
Apr. 2004: Water Maps

Schedule subject to change

TEACHING WATER
Especially for Virginia's K-12 teachers

This Issue and the Virginia Standards of Learning

Below are suggested Virginia Standards of Learning (SOLs) supported by this issue's Feature, Science Behind the News, and For the Record sections. The SOLs listed below are from Virginia's 2003 Science SOLs and 2001 Social Studies SOLs; *Water Central* issues through March 2003 referred to Virginia SOLs issued in *1995*. Abbreviations: BIO=biology; CE= civics and economics; ES=earth science; GOV = Va. and U.S. government; LS=life science; WG = world geography.

Feature Article—Nutrients in the News
Science: 4.8, 6.7, 6.9, LS.7, LS.11, LS.12, ES.7, ES.9, ES.11, BIO.9.
Social Studies: CE.7, WG.2, WG.7, WG.11, GOV.9.

Science Article—Nutrients as Limiting Factors
Science: 6.7, 6.9, LS.4, LS.7, LS.11, LS.12, ES.7, ES.9, BIO.3, BIO.9.

For the Record—Wetlands Information Sources
Science: 4.8, 6.7, LS.10, LS.12, ES.7, ES.9, BIO.9.
Social Studies: WG.7, GOV.16.

Virginia's Water Resources: A Tool for Teachers

Clean Virginia Waterways, located at Longwood University in Farmville, is offering water-resources workshops this summer for K-12 teachers. These *free*, one-day workshops (lunch provided) will enhance teachers' knowledge of Virginia's watersheds and water-quality issues and will introduce new classroom and field activities correlated to water-related SOLs. Teachers will receive a copy of the newly printed *Virginia's Water Resources: A Tool for Teachers* (this book will also be available in Summer 2003 on the Clean Virginia Waterways' Web-site, web.longwood.edu/cleanva). **Sixth-grade teachers** are especially encouraged to attend, although all K-12 teachers can benefit. Three workshop dates are available: Aug. 11, Charlottesville area; Aug. 12, Charlottesville area; Aug. 14, Longwood University.

To register or for more information, contact Katie Register at (434) 395-2602 or cleanva@longwood.edu.

Virginia Water Central

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You can find *Water Central* on the Internet at **www.vwrrc.vt.edu**. If you prefer to read the newsletter there, instead of receiving a paper copy, please send an e-mail requesting this to water@vt.edu, and we will notify you whenever a new issue is posted.

Please notify us at (540) 231-5463 or araflo@vt.edu if your address has changed or if you no longer wish to receive the newsletter.

Thank you!

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YOU GET THE LAST WORD

Please answer the following questions to let us know whether the newsletter is meeting your needs. Please mail this page to the Water Center address listed in the box to the left, or e-mail your responses to water @vt.edu. Thank you.

1. Would you rate the content of this issue as good, fair, or poor?

2. Would you rate the appearance as good, fair, or poor?

3. Would you rate the readability of the articles as good, fair, or poor?

4. Is the newsletter too long, too short, or about right?

5. Do the issues come too frequently, too seldom, or about right?

6. Please add any other **comments** you wish to make.

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