

Virginia Water Central

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FEATURE ARTICLE

Groundwater Issues in Virginia, 2002

Droughts have the effect of greatly focusing one's attention on water resources. Accordingly, as the widespread and deep drought that began in 1998 has increased the number of failures of wells, springs, and other water supplies, Virginians have been taking a much keener interest in their water sources.

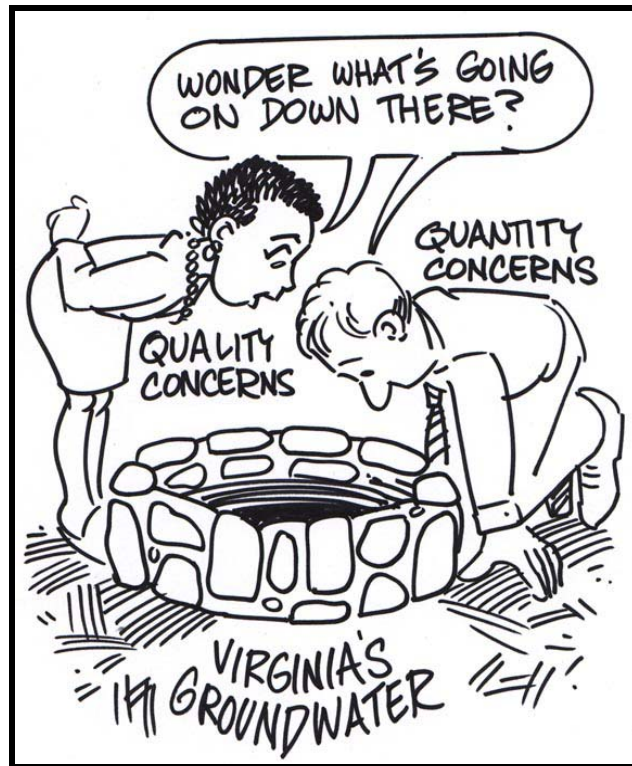
This issue of *Water Central* focuses on one of the state's largest freshwater sources—*groundwater*. While "Science Behind the News" (p. 9) deals with the language and concepts of groundwater science, the Feature Article examines current groundwater-related issues, as identified and described by state officials and other water professionals. We explore their perceptions of how groundwater issues have evolved in Virginia as the four-year drought continues to affect groundwater levels, and as increased development in some areas of the state places greater demands on groundwater sources.

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VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY



A Resource Strained by Drought and Demand

Here are some recent facts from the Virginia Groundwater Protection Steering Committee (see the box on page 2 for a description of this committee):

- Thirty-eight of Virginia's 95 counties are completely dependent on groundwater for public water supplies. Fifty-five counties draw half or more of their public water from groundwater.
- Of Virginia's 2,500 public water supply systems, groundwater is the source for 2,300, many of which are small, remote, and have no alternative to groundwater.
- In 60 Virginia counties, most households obtain water from their own private wells.
- In 52 counties, wells are growing in importance; that is, the number of households served by private wells is increasing faster than the number added to public systems.

Keeping those facts in mind, take a look at another set, provided by Virginia's Drought Monitoring Task Force.¹ On October 21, 2002, the Task Force reported the following in its monthly survey of drought conditions around the state:

- Groundwater-based public water supplies west of Interstate 95 have reported dropping groundwater levels or reduced yields.
- The Va. Dept. of Health issued over 4000 replacement permits for private wells that have failed since July 1, 2002.
- Groundwater levels showed little improvement from rainfall between September 1 and mid-October; periodic and consistent rain throughout the fall and winter months is needed.

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¹ The Drought Monitoring Task Force, coordinated by the Va. Dept. of Environmental Quality, includes several state and federal agencies. Its reports on state drought conditions, updated and published each month, can be found on-line at www.deq.state.va.us/info/drought.

Virginia Groundwater Protection Steering Committee

The Virginia Groundwater Protection Steering Committee is a consortium of ten state agencies, and one federal, that regularly exchange information about groundwater issues in Virginia, and make that information available to the public through a Web-site and annual published reports. Member agencies include the following:

- Va. Dept. of Environmental Quality
- Va. Dept. of Health
- Va. Chesapeake Bay Local Assistance Department
- Va. Cooperative Extension Service
- Va. Dept. of Business Assistance
- Va. Dept. of Agriculture & Consumer Services
- Va. Dept. of Conservation & Recreation
- Va. Dept. of Housing & Community Development
- Va. Dept. of General Services (Consolidated Laboratory)
- Va. Dept. of Mines, Minerals and Energy
- U.S. Geological Survey

The committee is chaired by the Va. Dept. of Environmental Quality and coordinated by Mary Ann Massie, phone (804) 698-4042, e-mail: mamassie@deq.state.va.us. The committee's Web-site address is www.deq.state.va.us/gwpsc/.

Continued from page 2

Clearly, groundwater is vital to the state's freshwater needs. Just as clearly, the drought is taxing this resource. But beyond restricting groundwater use, the drought is raising basic questions about Virginia's groundwater: how much is available, how to protect and conserve it, and how best to monitor the impacts of use on the supply?

Difficult to Know What Lies Below

Such questions are difficult to answer because of groundwater's very nature: the resource isn't easy to observe even when it's abundant. As an example, the Institute of Agriculture and Natural Resources at the University of Nebraska has estimated that, if all of Nebraska's groundwater were brought to the surface, the Cornhusker State would be covered by water 40 feet deep.² But you couldn't know that about Nebraska just from looking at the land surface.

In an interview in October 2002, Dr. Thomas Burbey, an assistant professor of geology at Virginia Tech, discussed the problem of knowing about groundwater. Nebraska knows its groundwater resources in great detail, Burbey said, because a well-defined and studied aquifer—the Ogallala—underlies most of the state. There are “probably thousands” of testing wells scattered throughout the state that allow for comprehensive monitoring of groundwater levels. In Virginia, the U.S. Geological Survey (USGS) and the state Department of Environmental Quality (DEQ) collectively monitor groundwater levels at some 270 observation wells; the monitoring frequency is quarterly for most wells, with some wells monitored monthly or weekly.³

In addition, not enough research has been done for people to understand clearly Virginia's relatively complicated **hydrogeology**.⁴ Even among groundwater professionals—academics, government agency staff, and water-utility operators—there are many groundwater unknowns.

² Information taken from the Institute's Web-site, www.watercenter.unl.edu, 10/2/02.

³ The USGS annually reports results from this monitoring network. The most recent report (as of October 2002) is R. K. White, *et al.*, *Water Resources Data—Virginia—Water Year 2001*, U.S. Geological Survey Water-Data Report VA-01-2.

⁴ Hydrogeology the interactions of geologic materials (soils and rocks) with water and its movement.

Dr. Burbey, for example, who has focused on the state's hydrogeology since coming from Nevada in 1994, said he is fascinated, if also frustrated, by the groundwater puzzle in Virginia. "Nearly two-thirds of Virginia lies on top of fractured rock and **karst**," Burbey said.⁵ "That makes studying the hydrogeology very, very challenging. It's difficult to know where water goes in such regions, how it flows, and where it is stored."

Adding to the difficulty, Burbey said, is that the state has not in the past applied a lot of resources to solving the puzzle. Why? Because Virginia has always been presumed to be "groundwater rich," according to Burbey. "Traditionally, you could sink a well almost anywhere and find water, without going down too far, and that leads to a kind of complacency. People figure it's always going to be there, so why worry? It's understandable, but times are changing now. Groundwater is growing in importance, and it seems important, at least to me, for someone to really try to determine how much of it we have and where it is."

To illustrate at least one difference he has noted in attitudes about groundwater in Nevada—as a representative dry, western state—and in Virginia, Burbey added that Nevada has a state groundwater engineer to regulate the establishment and abandonment of all wells. In Virginia, the entity that tracks such activity is the state Department of Health, through its county offices. These offices accept applications for new wells and for the abandonment of those that have gone dry or been contaminated, but this information in the past was almost never transmitted to a central state authority.

"That's information the state never bothered to collect because it wasn't viewed as being important," Burbey said. But an effort to get that kind of data, though it would be expensive, "would help us start building a historic record of groundwater fluctuations in areas we know almost nothing about at the moment." Now under drought conditions, Burbey noted, the Drought Monitoring Task Force has been keeping track the number of replacement wells (for example, the information from the Task Force presented earlier), because it provides a clue to what's happening with groundwater reserves.

David Nelms, a groundwater specialist for the Virginia District of the USGS, agreed with Dr. Burbey about the need for more information on Virginia's groundwater. In an interview, he maintained that much is unknown about the geology and groundwater characteristics in the fractured rock and karst areas of Virginia—"everything west of I-95," as he put it. He added that even in the comparatively simpler geology of the Coastal Plain, which his organization has mapped and studied for years, there's still much to be learned about the movement of groundwater. (The box on the following page describes four current USGS studies of groundwater in Virginia's Coastal Plain.)

As an example of the kind of work needed, Nelms pointed to a USGS project begun in 2000 in Frederick County. There, according to the project's Web-site (va.water.usgs.gov/projects/va134.html), an effort is under way to "better characterize the carbonate aquifer system in the Northern Shenandoah Valley and provide relevant hydrogeologic information that can be used to guide the development and management of this important water resource." The four-stage project will consider the flows, storage, and quality of the groundwater. Around the county, more than 30 wells and a dozen stream and spring gaging stations are being monitored. Nelms is eager for the cumulative, long-term information the project will yield. "I've got city and county planners, water utility managers, and developers calling me all the time asking questions about groundwater capacity in the Shenandoah Valley," he said, "and it's going to be nice to be able to give them some solid information for a change, once this project is complete."

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⁵ Karst is a subsurface terrain consisting of limestone and other fairly porous rock that has been deformed and eroded by water, leading to many fissures, caves, and sinkholes. Beyond its implications for groundwater *quantity*, karst presents significant challenges for groundwater *quality*. The existence of sinkholes, and other characteristic features make karst-area groundwater supplies very susceptible to contamination by activities on the land surface.

U.S. Geological Survey (USGS) Groundwater Studies in Virginia's Coastal Plain

The **Virginia Aquifer Susceptibility Study** (statewide)—In cooperation with the Va. Dept. of Health, the USGS is using groundwater age-dating techniques to determine how sensitive Virginia's major aquifers are to contamination from surface activities.

Polecat Creek Watershed Study—In cooperation with the Chesapeake Bay Local Assistance Dept., the USGS is studying the potential for groundwater to transport nutrients to streams that flow into the Bay.

Virginia Beach Shallow Aquifer Study—The USGS is assessing the overall hydrogeology of this groundwater system.

Chesapeake Bay Impact Crater Study—In cooperation with the Va. Dept. of Environmental Quality and the Hampton Roads Planning District Commission, the USGS is seeking to understand better how the impact crater (formed by a meteorite thousands of years ago) affects regional groundwater flow and quality.

Source: Virginia Groundwater Protection Steering Committee, *2001 Annual Report*, p. 4.

Continued from page 3

In 2002, the USGS began similar efforts in Clarke and Warren counties, also in the Shenandoah Valley. Nelms expects an even clearer picture of the upper Shenandoah Valley's groundwater characteristics to emerge as a result. "These kinds of studies are needed in a lot more areas than just the Shenandoah," Nelms said, "but it's a good start. [P]art of what they're doing in these projects is amassing and correlating information that already exists. There are lots of little databases out there, but not a lot of coordination. Once a network is established, though, all those databases can be fed into it, and that'll be another big help in forming a realistic picture of the hydrogeology in this huge portion of the state where we know so little right now."

Some localities have taken their own steps to compile local groundwater information. For example, since 1987 Loudoun County has been compiling information from "GW2 Forms" that well-drillers must file with the Va. Dept. of Health whenever a well is established or abandoned. To date, according to Glen Rubis, an engineer with the county's Building and Development Department, Loudoun has assembled information on more than 14,000 private wells. The filed reports vary in how much detail they provide, but they include the depth to groundwater, and this information gives Loudoun a base of knowledge about groundwater levels countywide.

Hard to Manage the Unknown

The relative lack of information about groundwater in Virginia is one factor in there being relatively little *management* of the state's groundwater resources. The state has two Groundwater Management Areas (GMAs), both in the Coastal Plain: one covers the two Eastern Shore counties, and the other includes the area bounded by the Chesapeake/Atlantic coast on the east, the York River on the northeast, and the fall line on the west. In GMA's, which the Va. DEQ administers, by the Va. DEQ, permits are required for groundwater withdrawals of 300,000 gallons or more per month (with certain exemptions).⁶ The DEQ has the authority to establish GMAs anywhere in the state, but there are some excellent reasons why only two exist at this time, according to Terry Wagner, Director of Water Resources Management at the DEQ.

⁶ The legislature first gave DEQ the power to regulate groundwater use in GMAs in 1973; the 1973 act was revised and amended in 1992. The current law is in the *Virginia Code* at Title 62.1, Chapter 25 (62.1-254 through 62.1-270).

“For one thing,” Wagner said in a September telephone interview, “in the coastal GMAs we do have, there are lots of users of groundwater and a real danger that if they draw too much fresh water from the ground it will invite the intrusion of brackish or salt water into those aquifers. That’s hard to combat once it occurs, so it pays to require permits and limit what some users can remove from the ground to keep that from happening.” For another thing, he added, the geology of the Coastal Plain region is both better known and more easily mapped than the more complex geology in other parts of Virginia. “We know how water acts in these areas,” he said. “Thanks to the simplicity of the geology and a long-term commitment to study it, we know what’s there and how it responds. That makes the job of managing it possible.”

The long-term commitment Wagner referred to was made by the federal government—through the USGS—in the 1940s and 1950s, as the military was locating several bases and ports in the coastal area. The federal government wanted assurance there would be water enough for its bases, as well as for the swelling populations and manufacturing operations that often accompany military installations. The USGS studied the geology and hydrogeology of the region thoroughly, and that has provided a dependable base of knowledge for the state DEQ and the coastal GMAs, said David Nelms, the USGS groundwater specialist.

Are other GMAs needed? Wagner said the question is difficult to answer. He ventured a guess, however, that the Shenandoah Valley would be at the top of the list of possible future GMAs. “The legislature gave DEQ the power to establish a management area when the State Water Control Board requests one, or when a local government in the proposed area requests it, *and* when factors suggest groundwater reserves are being seriously challenged.... I think people in the Shenandoah Valley are starting to worry about [such] factors, so I wouldn’t be surprised if somebody asked us soon to step in.”

Policy-makers Recognizing the Information Needs

Va. Tech’s Burbey, the USGS’ Nelms, and the DEQ’s Wagner all stressed that more money and more time are needed to develop a comprehensive picture of the state’s groundwater reserves. Is the state moving in that direction? Somewhat. Both the General Assembly and the Warner Administration have indicated support for better water-resource information in general.

In the legislature’s case, a joint resolution (HJ202) passed in March 2002 directed the State Water Commission (SWC) to study the effectiveness of the Commonwealth’s water policies and report back by 2004. The resolution states that the SWC is to consider “the role the state should play in data collection, water supply planning, water allocation, dispute resolution, and water development,” in addition to studying the state’s role in “watershed planning to provide quality raw water, both surface and groundwater, for water supplies.” The SWC’s Administration’s Advisory Committee met October 24, 2002, to consider HJ202.

This directive came on the heels of one passed in the 2000 General Assembly (HJ161) that established a joint committee (five legislators and two non-legislators) specifically to study *karst* groundwater monitoring and protection in the Shenandoah Valley. The group submitted its findings to the 2002 General Assembly.

On the administration’s side, it has identified the following two water-resource management initiatives: “Develop [a] statewide water policy regulating surface and ground water withdrawals,” and “Work with state and local agencies on long-term water supply planning.”⁷

⁷ Virginia Secretary of Natural Resources Web-site, www.naturalresources.state.va.us, 10/28/02.

Groundwater Rules Unclear, Too

Another murky aspect of Virginia's groundwater is unresolved legal questions surrounding its use.

Jesse Richardson, an attorney as well as an assistant professor in the Department of Urban Affairs and Planning at Virginia Tech, has taken on several cases in this area. "Essentially," Richardson said in a recent interview, "[in the United States] there are two legal approaches to groundwater issues. One is called the English Rule, the other the American Rule. [Generally] for most of our history, most states east of the Mississippi operated under the English Rule, while most of those west [of the river] operated under the American Rule, although that's changing."

Under the English Rule, Richardson said, property owners—individuals as well as businesses, corporations, and utilities—enjoy a fairly free hand in the consumption of groundwater beneath their property. Groundwater can be used for virtually any purpose and virtually any amount can be consumed, regardless of the impact substantial withdrawals may have on groundwater quantity or quality for property owners nearby. Richardson characterized the English Rule as "archaic," having originated at a time when it was assumed that the flow and the characteristics of underground water reserves were unknowable—bordering, as Richardson put it, almost on the "occult." Legal authorities thought groundwater was so mysterious that there was no fair way to control or apportion its use, so they didn't even try.

The American Rule, on the other hand, resulted from early struggles over groundwater in the American west. There it was clear from the first stages of use and development in the 19th Century that water was precious and in limited supply—whether on the surface or below the ground. Fairly quickly, Richardson said, an ethic arose that called for apportioning water resources. Individuals as well as enterprises were granted a certain amount of surface water use per year, and they were restricted to "reasonable" use of groundwater. In other words, groundwater could be used for personal enterprises on one's property, but could not be withdrawn in "unreasonable" amounts for off-property use (such as for irrigation of property owned by others).

According to Richardson, the limited water supplies in the arid American west—a limit not faced in Britain when the English Rule was gaining acceptance—led to firmer legal rules for the consumption of such a vital resource as groundwater. The same thing is likely to happen in Virginia, he said. That's why he was glad to have a recent case in Frederick County, Va., in which he represented a private individual who sued the water utility of Frederick County. The citizen claimed the utility's groundwater use had caused her wells and springs to run dry and a sinkhole to form.

"I was sure we could force the Virginia Supreme Court to finally decide which rule the state follows in deciding how ground water can be used," Richardson said. We haven't known since a Supreme Court case in the 1930s how the legal community views groundwater rights—it was so thorny even then that the court refused to make a ruling. But eventually it has to be decided, because the pressures and conflicts are only going to increase." The Frederick County case, however, was settled out of court, so it never came before Virginia's highest court.

Drought May Dissipate, But Unresolved Groundwater Issues Won't

Jesse Richardson's observations help sum up many of the groundwater issues considered in this article. In the past, groundwater has attracted less attention than other water resources in Virginia, either because groundwater was presumed to be in great supply or because it presented complex scientific and legal questions. As occurred with groundwater *quality* several years ago, however, groundwater *quantity* is now attracting considerably more attention. Researchers, regulators, and developers want to know more about how much groundwater there is, where it collects, where it flows, and how it should be protected and consumed.

The drought certainly is adding pressures to learn more about this resource, but there are many reasons besides the drought for doing so. Because of its importance as a water supply,

increasing demand for its use, its vulnerability to contamination, its interaction with surface water supplies, and unresolved legal issues, Virginia's groundwater should continue to get more attention, even when rainfall in Virginia returns to normal.

—By David Mudd

Some Past Chapters in Virginia's Groundwater Story

To accompany *Water Central's* look at *current* groundwater issues in Virginia, the following table looks at groundwater issues making news in Virginia over the *past* 15 years. The table lists groundwater-related articles in editions of *Water News* (the *Water Central* predecessor) from July 1987—April 1994 and in editions of *Water Central* from June 1998—August 2002.

Water News	Groundwater Issue
Jul. 1987	Development of <i>A Groundwater Protection Strategy for Virginia</i> and formation of the Virginia Groundwater Protection Steering Committee (GWPSC).
Nov. 1988	State Water Control Board (SWCB) hearing on proposed amendments to state groundwater standards, following recommendations of the 1987 groundwater protection strategy.
Feb. 1990	Proposed revisions to state sewage-handling regulations to increase distance between septic-system drainfields and the water table in Tidewater.
Sep. 1990	New Va. Dept. of Health regulations for constructing private wells.
Jan. 1991	An update from the state's GWPSC, identifying septic tanks, landfills, pesticides and fertilizers, underground storage tanks, and waste lagoons as contaminant priorities.
May 1991	SWCB requested the State Water Commission to review Va.'s Groundwater Act of 1973, especially the Eastern Va. Groundwater Management Area; concerns included the impact of "grandfathered" withdrawal rights on the aquifer and the potential for saltwater intrusion.
Sep. 1991	Wellhead-protection examples from Clarke County, Botetourt County, and Eastern Shore.
Oct. 1991	Report from the Wellhead Protection Advisory Committee of the GWPSC, with recommendations for state and local actions.
Dec. 1991	Revisions to VDH private well regulations.
Feb. 1992	HB 488 in the General Assembly amending the 1973 Groundwater Act to authorize stricter SWCB limits on withdrawal permits.
Mar. 1992	James City County well regulations.
May 1992	Notice of U.S. EPA funds for wellhead-protection demonstration projects.
Aug. 1992	SWCB proposed regulations to implement the Groundwater Act of 1992.
Sep. 1992	Proposed transfer of groundwater from New Kent County to Newport News; impacts of the Groundwater Act of 1992.
Dec. 1992	Nitrate levels in well water, as reported in EPA nationwide study and in Va. Cooperative Extension studies in four Virginia counties.
Mar. 1993	<i>Wellhead Protection: A Handbook for Local Governments in Virginia</i> released by the GWPSC.
Mar. 1994	Va. General Assembly bills to modify the Groundwater Management Area program.
Apr. 1994	"National Town Meeting on Groundwater Protection" broadcast as a nationwide teleconference by the League of Women Voters.

Water Central	Groundwater Issue
Dec. 1998	1. Impacts on groundwater of the 1996 amendments to the Safe Drinking Water Act; 2. Federal underground storage tank regulation took effect in December 1998; about 32,000 tanks in Virginia needed attention.
Jun. 1999	Bedford County testing groundwater on a farm for leachate from an old county landfill.
Aug. 1999	1. Alternatives to unacceptable or unavailable groundwater in Va.'s coalfield counties; 2. Smyth County seeking funds to improve drinking water for residents currently being served by contaminated springs or wells.
Oct. 1999	New state regulations on separation of drainfields from water table.
Dec. 1999	Loudoun County study of groundwater supply and potential impacts of development.
Feb. 2000	Statewide study of how Va. citizens dispose of used oil and antifreeze.
Apr. 2000	Methyl tertiary butyl ether (MTBE) contamination of public wells in Loudoun County; scope of problem in neighboring states and nationwide; Va. General Assembly bill requiring water systems to test for MTBE.
Jun.-Aug. 2000	1. EPA researching technologies to clean up MTBE-contaminated soil and water; Congressional bill to ban use of MTBE. 2. "Robowell"—a robotic groundwater monitoring system.
Nov. 2000	USGS study of effect on groundwater of 56-mile wide crater under Chesapeake Bay.
Jun. 2001	Reports of lowered groundwater levels in Bedford County.
Feb. 2002	Court case in Loudoun County on the impacts of development on groundwater nitrate levels.
Apr.-Jun. 2002	1. Residents of Campbell County community looking for alternatives to dry wells. 2. Maryland study of declining water levels in aquifers serving parts of Virginia and Maryland.
Aug. 2002	Drought affecting groundwater levels; reports of well failures.

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 (p. 1) and Science Behind the News (p. 9) sections. Abbreviations: ES=earth science; LS=life science.

Feature Article—Groundwater Issues

Science SOLs: LS.12, ES.7.

Social Studies SOLs: 7.4, 7.5, 10.15, 12.6, 12.8, 12.9.

Science Article—Groundwater Terms and Concepts

Science SOLs: LS.12, ES.6, ES.7, ES.8, ES.9.

Social Studies SOLs: 10.2, 10.9, 10.15

SCIENCE BEHIND THE NEWS

Into the Saturated Zone

“Water is strange. You never know where it is going to be.”—Joe Renner, superintendent of the Stuart M. Perry, Inc., quarry in Clarke County, Va., quoted in “Water Flowing in Clarke Quarry,” *Winchester Star*, 9/20/02

One might amend the quote above to say, “You never know where *groundwater* is going to be.” This seems especially true during the current drought that Virginia and other parts of the United States have been experiencing to some degree since 1998, because wells have been going dry in much larger numbers than usual. Dry wells and other drought impacts have heightened many Virginians’ need to know about groundwater.

This edition of “Science Behind the News” seeks to help Virginians become more familiar with the state’s groundwater resources and better able to examine groundwater-related issues. It covers the basic terms and concepts of groundwater *quantity*—what it is, where it’s found, and how it moves. The article is an extended excerpt (with some revisions) from a 1997 Water Center publication, *A Guide to Virginia’s Ground Water*; the complete publication is available on-line at www.vwrrc.vt.edu, and in print by contacting the Water Center at (540) 231-5624 or water@vt.edu.

The publication from which this article is adapted also includes sections specifically on groundwater *quality*; those sections are not included here. For the groundwater quality information, please see the original publication as well as another Water Center publication, *A Guide to Protecting Virginia’s Valuable Resource: Ground Water*, which is also available both in print and on-line.

Words in **bold** when first used are defined in the Glossary on the last page of this article.

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GROUNDWATER MYTHS

Above ground, water is readily visible in many forms—clouds, rain, snow, fog, lakes, streams, oceans, and polar icecaps. Because groundwater is out of sight, our understanding of it has been hindered by the difficulty of observing and measuring its properties and extent. As a result, over time ideas have developed about groundwater that are based more on folklore and fantasy than on fact. Some of the myths that have developed about groundwater are the following:

- all groundwater occurs as vast underground lakes and rivers.
- water rushes so rapidly underground that its presence can be detected by listening.
- groundwater migrates thousands of miles through the earth.

See if you can find information in this article to correct these myths!



Groundwater's Importance

With the exception of ocean water, groundwater makes up almost 50 percent of the world's water supply. Groundwater is widely distributed beneath the earth's surface; most people are surprised to learn that there is more fresh water underground than exists in rivers, streams, and lakes.

Virginians use groundwater to drink, wash, irrigate crops, manufacture food and clothing, and perform many other tasks. The following box (next page) shows groundwater use, relative to surface water use, for various activities in Virginia.

Water Use in Virginia, 1995

According to the U.S. Geological Survey, Virginians in 1995 used 358 million gallons per day (mgd) of groundwater, compared to 5110 mgd of surface water. Domestic supplies (that is, residential use *not* supplied by a public water supply) were virtually all from groundwater.

Table 1. Estimated freshwater withdrawals in Virginia, 1995 (million gallons/day)

Activity	Surface Water	Groundwater
Public Supply	704	82
Domestic	0	125
Commercial	13	28
Irrigation	24	5.6
Livestock	28	7.8
Industrial	410	107
Mining	37	2.6
Thermoelectric	3890	0.4
Total	5110*	358

*The total does not equal the sum of the categories because of rounding within categories.

Source: U.S. Geological Survey, *Estimated Use of Water in the United States in 1995*.

One Part of the Hydrologic Cycle

The hydrologic (or water) cycle is the constant movement of water—as a solid, liquid, or gas—over, in, and through the earth. There is no beginning or end to the hydrologic cycle. The water we use today may have evaporated from an ocean, traveled through the atmosphere, fallen back to the earth's surface, gone underground, moved through the ground to streams, and returned to the ocean. In fact, much of the water we use has followed such a path many times.

Groundwater is one component of the hydrologic cycle. Some of the water that falls to the earth as precipitation **infiltrates** into the ground (other water evaporates or runs off the land surface to water bodies). Depending on land use, soil type, and the intensity and duration of precipitation, infiltration rates vary widely. The time water remains underground also varies greatly: water may be underground for as little as days or weeks, or for as long as 10,000 years. In contrast, water remains within a river typically about two weeks.

Groundwater Zones

Underground water occurs in two different zones (see Figure 1, next page). First is the **unsaturated zone**, where soil pores are filled partly with air and partly with water. In most areas, this zone is directly beneath the earth's surface. Underneath the unsaturated zone is the **saturated zone**, where all interconnected openings are full of water. The saturated zone provides the groundwater that supplies wells and springs; water in the saturated zone is what is commonly referred to as groundwater. Water **percolating** through the unsaturated zone **recharges** the saturated zone.

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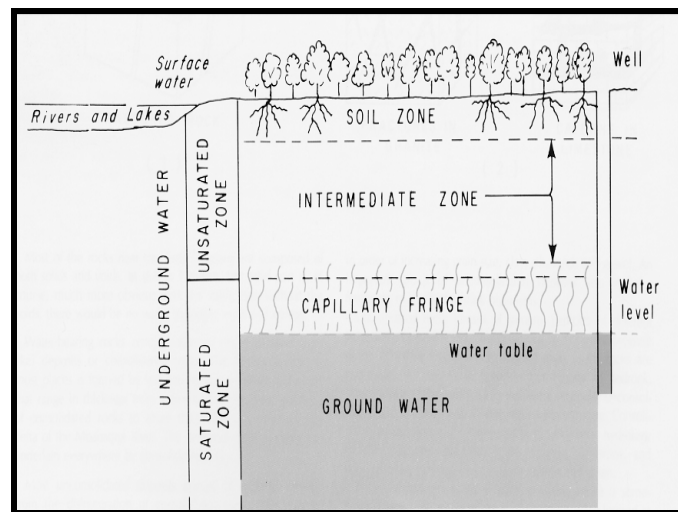


Figure 1. Underground water zones.

Source: R. C. Heath, *Basic Ground Water Hydrology*, 1983.

The unsaturated zone is in turn divided into three sections: the soil zone, the intermediate zone, and the upper part of the capillary fringe. The *soil zone* extends from the land surface to a maximum depth of a meter or two. This zone supports plant growth and is crisscrossed by live and decayed plant roots and by animal and worm burrows. Bacteria, fungi, and insects are also found in the soil zone. The *intermediate zone* is beneath the soil zone and varies in depth depending on the soil type and capillary fringe thickness. The *capillary fringe* is situated between the unsaturated and saturated zones, beginning at the lowest part of the unsaturated zone. The **water table** is found at the lower boundary of the capillary fringe and the upper boundary of the saturated zone.

Water flows downward (percolates) through the unsaturated zone into the saturated zone, where all pores are filled with water. When water enters the saturated zone, the water table rises. Conversely, the water table falls (at least temporarily) when water is pumped from the saturated zone. Groundwater continues its movement downward and outward to hillside springs, stream beds, lakes, or oceans where evaporation takes place and the hydrologic cycle is continued.

Aquifers

Geologic deposits largely govern the distribution and movement of groundwater. Groundwater occurs in many types of geologic formations; only those formations that will yield water in usable quantities to wells or springs are known as **aquifers**.

Types of Aquifers

Aquifers occur most commonly in loose sands and gravel, in permeable sedimentary rocks, such as sandstone and **dolomite**, and in heavily fractured rocks. For practical purposes, aquifers are categorized as **unconfined** and **confined** (see Figure 2, next page). The water table forms the upper boundary of an *unconfined* aquifer. Water levels in wells drilled in unconfined aquifers indicate the position of the water table in the surrounding aquifer. In unconfined aquifers, the water table depth is an important factor influencing land use. For example, a shallow water table may limit the ability to install an on-site sewage disposal systems in a residential development due to an inability to install an on-site sewage disposal system, or it may limit excavation work during construction and development of industrial sites.

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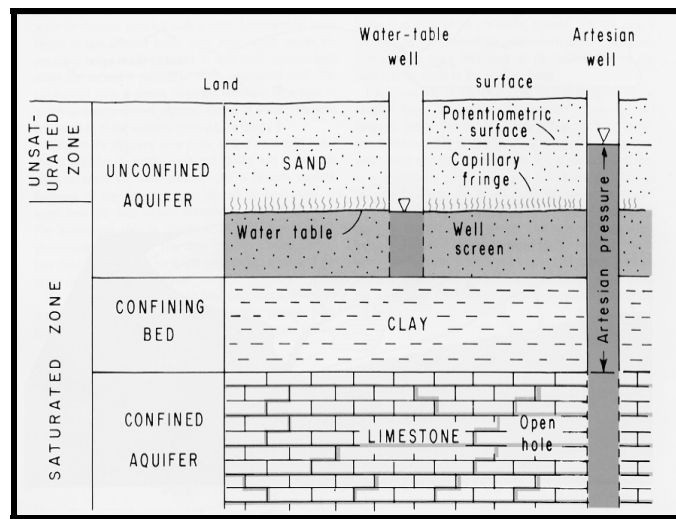


Figure 2. Aquifers and confining beds.

Source: R. C. Heath, *Basic Ground Water Hydrology*, 1983.

A *confined*, or **artesian**, aquifer is confined between two **aquitards** (layers of very low **permeability**, such as clays, shales, and dense rocks). Aquitards do store and slowly transmit groundwater, but the yield of water is insufficient to develop functional wells. Some water leaks through aquitards into the aquifer, so most confined aquifers are “leaky” aquifers. If a cased well is drilled into a confined aquifer, pressure in the aquifer causes the water level to rise above the top of the aquifer; the level to which the water rises is called the **potentiometric surface**. If the water level in the well rises above the ground surface, the well is called a *flowing artesian well*. Confined aquifers are found at greater depths than unconfined aquifers.

Groundwater in Unconsolidated Geologic Deposits

A common misconception is that groundwater occurs in the form of underground lakes and rivers, such as the lakes and rivers on the earth’s surface. In fact, water under the earth’s surface collects in numerous pores (open spaces) between loose particles of sand, gravel, rock and soil. The loose particles are also called **unconsolidated geologic deposits**. Unconsolidated deposits are formed from the disintegration of consolidated rocks and range in thickness from a few centimeters to more than 12,000 meters.

One way to picture groundwater in an unconsolidated deposit is to think of a glass fishbowl full of wet gravel and half full of water (see Figure 3, next page). The pores between the gravel particles in the bottom half of the bowl are filled with water, representing the saturated zone. The pore spaces between the gravel particles in the top half of the bowl contain some air and some water, representing the unsaturated zone. The boundary between the top and bottom halves represents the water table.

An unconsolidated geologic deposit also resembles a household sponge. Water in a sponge is held in open spaces between the sponge’s fibers in the same way that groundwater fills the open spaces that exist between particles of rock, sand, gravel, and soil in an aquifer. Virginia’s Coastal Plain is underlain by shallow aquifers that closely resemble this sponge model.

Groundwater in Consolidated Geologic Deposits

In addition to collecting in networks of pores in unconsolidated deposits, groundwater also occurs in **consolidated geologic deposits**. Consolidated geologic deposits are solid rock masses. There are three general classes of consolidated rocks: **igneous**, such as granite and basalt; **metamorphic**, such as slate; and **sedimentary**, such as sandstone and shale.

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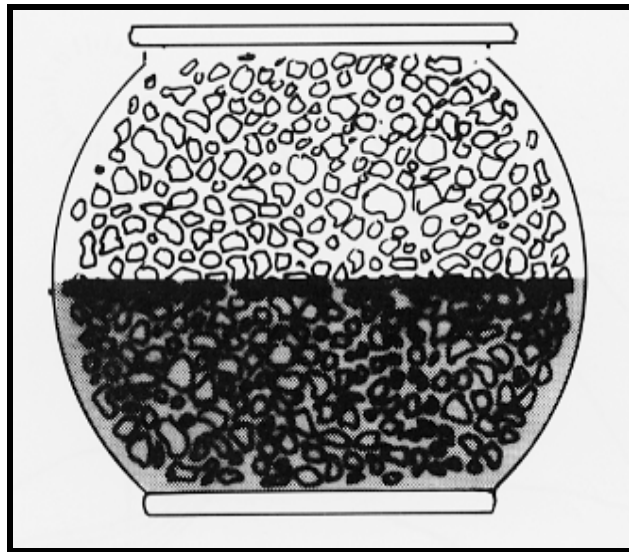


Figure 3. Groundwater in an unconsolidated geologic deposit, represented by a fishbowl of gravel half-filled with water.

Groundwater occurs in pores, cracks, fissures, and channels in consolidated deposits. Fissures and cracks are created by shifts and movements within the earth and by weathering at or near the earth's surface. The size and number of fissures and cracks and the degree to which cracks intersect to form networks vary locally and regionally among geologic formations.

In certain types of rock, cracks and joints become significantly enlarged over time by the water's dissolving action and become **solution channels**. Limestone and dolomite are particularly susceptible to this dissolving action. Rock dissolution produces irregular land surfaces known as **karst terrain**. Karst terrain is usually formed on limestone and dolomite but can also develop on gypsum or rock shale. Depressions known as **sinkholes** are formed. Large areas of the Valley and Ridge region in western Virginia exhibit karst terrain. The size, number, and interconnections of solution channels vary among deposits and from region to region. Once solution channels have developed, they function essentially like pipes, rather than like sponges, in conveying groundwater.

Recharge and Discharge

The process by which water—from rainfall, snowmelt, and other sources such as streams and rivers—flows into a water-bearing geologic formation is known as recharge. The land surface from which a particular geologic formation is recharged is known as that formation's **recharge area** or **zone**. Recharge to the saturated zone occurs as water percolates through the unsaturated zone. The condition of the unsaturated zone can affect both the quantity and the quality of water that eventually reaches and recharges the saturated zone.

In Virginia, the locations at which recharge occurs and the rates of recharge depend on a number of factors: topography of the land surface, geology under the surface, thickness of the existing saturated zone, amount and intensity of precipitation, temperature, and land use. Recharge areas tend to occur where the unsaturated zone is relatively thick (that is, the water table is not close to the land surface). It is generally assumed that recharge occurs in areas of relatively higher elevation (hilltops instead of valleys), but *in many settings this may not be the case*, due to one or more of the factors just mentioned. (See also "losing streams," below.)

Recharge rates among Virginia's various geologic settings vary from about 5 to about 500 millimeters per year.⁸

Discharge areas are where groundwater flows toward the surface and escapes as springs, seepage into stream channels, lakes, or wetlands, and by evaporation from the upper part of the capillary fringe. Discharge areas typically are in areas of low elevation. In discharge areas, the unsaturated area is much thinner (that is, the water table is close the land surface). In general, discharge areas are much smaller than recharge areas.

Connections Between Groundwater and Surface Water

As part of the hydrologic cycle, water moves between aquifers and surface water bodies. Aquifers do not act solely as water receivers nor are they "dead ends" in the hydrologic cycle. Streams, lakes, springs, and wetlands receive naturally occurring groundwater discharge from aquifers. A *gaining stream* is one that receives groundwater; a *losing stream* is one that recharges groundwater. For example, when a stream floods, the water table near the stream banks is temporarily raised by inflow from the stream. Seasonal streamflow fluctuations can produce large variations in the amount and direction of local groundwater flow. During extended dry periods, groundwater discharge may be the only contributor to a stream's flow. Understanding surface and groundwater interactions, and identifying discharge and recharge areas, are important considerations in water resources management. Figure 4 (next page) illustrates these interconnections and several of the terms described so far.

GROUNDWATER IN VIRGINIA

A region of similar geologic structure and climate that has a characteristic set of landforms is called a **physiographic province**. In Virginia, five such regions are recognized (see Figure 5, second page following); moving west to east, they are the Cumberland Plateau, Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain. The following sections describe in general the groundwater resources found in each region.⁹

Cumberland Plateau

The Cumberland Plateau province includes the southwestern tip of Virginia. This area is underlain by sandstone, shale, and coal. Groundwater is used mostly for domestic purposes and processing coal. Wells generally yield 10—50 gallons a minute (gpm), with maximum yields of a few hundred gpm. Groundwater quality in the Cumberland Plateau varies with location and depth. Water obtained from bedrock above the stream level is generally of the best quality. The first 100 feet of rock below stream level often contains water with high concentrations of sulfate, sulfite, nitrate, iron, and carbon dioxide. Better quality water is found at depths of 150—300 feet below stream level.

Valley and Ridge

The Valley and Ridge province, to the west of the Blue Ridge Mountains, is underlain by consolidated sedimentary rocks that were deposited beneath ancient seas and have been intensely folded. Limestone, dolomite, shale, and conglomerate are the common rock types in the Valley and Ridge region. Limestone and dolomite occur beneath lowlands, such as the Shenandoah Valley,

Continued after figure on next page

⁸ R. C. Heath, "Hydrologic Setting of Regions," in William Back *et al.*, *Hydrogeology* (Boulder, Colo.: Geological Society of America, 1988), p. 22.

⁹ These descriptions combine information found in *A Guide to Virginia's Ground Water* and in the Water Center's 1997 publication, *A Guide to Protecting Virginia's Valuable Resource: Ground Water*.

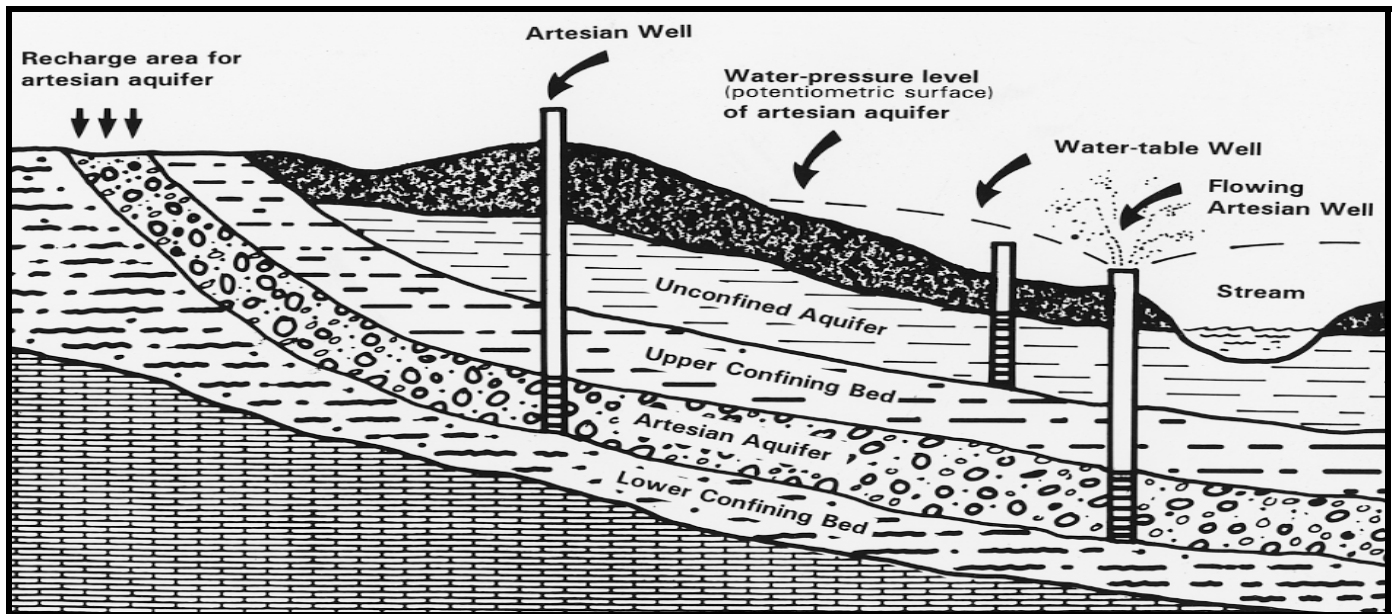


Figure 4. Unconfined and confined aquifers. When a well is drilled in an unconfined (water-table) aquifer, water will only rise to the top of the aquifer. A confined (artesian) aquifer, between confining beds (aquitards), is under greater pressure; when a well is drilled in such an aquifer, the pressure is sometimes great enough to force water all the way up to the earth's surface. The figure also illustrates recharge (upper left) and the connections between the stream and groundwater (both recharge and discharge possible).

where they consistently form the most productive aquifers in Virginia's consolidated rock formations. Karst terrain features, such as **sinkholes**, caves, and springs, are found in the Valley and Ridge province.

Where limestone dominates, ground water yields may be as high as 3,000 gpm. Ridges and upland areas are often underlain by sandstone and shale, which yield substantially less. Groundwater quality is affected by the chemical composition of rock formations. For example, limestone contributes to the "hardness" of the water in this province.

The relationship between ground water and surface water is easily recognized here. In limestone areas, sizable surface streams disappear into underground channels and, conversely, some large springs emerge to become the headwaters for rivers. Groundwater pollution potential is very high in this region, because sinkholes and solution channels can transport water rapidly from the surface without extensive filtration.

Blue Ridge

Extending northeasterly across Virginia from the North Carolina border, the Blue Ridge province is a relatively narrow zone of mountains (4—25 miles wide) with the highest elevations in the state. The bedrock is near the surface, beneath a thin soil layer and weathered rock zone. Rocks below the weathered zone are relatively impervious and contain water primarily in joints, fractures, and fault zones. Igneous and metamorphic rocks are most common in the eastern flank of the Blue Ridge; sedimentary rocks are found on the western flank. The most favorable areas for groundwater accumulation are the lower slopes of the mountains. In general, well yields are low (less than 20 gpm). Springs are common and are often used for private water supplies.

Piedmont

The Piedmont, Virginia's largest physiographic province, extends from the fall zone to the Blue Ridge Mountains. The fall zone marks the area where Virginia's rivers descend from the

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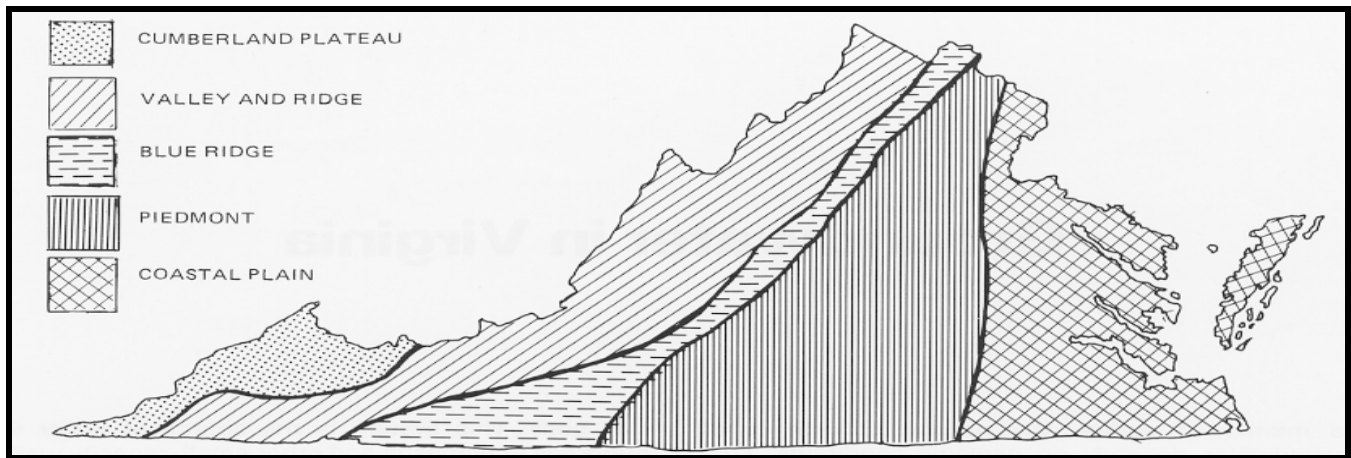


Figure 5. Groundwater availability varies among the five physiographic provinces of Virginia.

uplands of the Piedmont to the coastal lowlands (the boundary between the Piedmont and the Coastal Plain).

The Piedmont's subsurface geology is diverse, resulting in wide variations in ground water quality and well yields. The region has mostly igneous and metamorphic rocks, with some areas of sedimentary rocks. In areas dominated by hard, crystalline rocks, most ground water is found in faults and fractures within a few hundred feet of the surface. Well yields are commonly 3—20 gpm; yields in excess of 50 gpm are considered exceptional in this area.

Coastal Plain

The Coastal Plain extends inland about 110 miles, from the Atlantic coast to the fall zone. Geologically, the Coastal Plain is an underground wedge—thickening toward the coast—with 10 aquifers alternating between 11 confining layers. The subsurface consists primarily of sand, gravel, clay, shell rock, and other unconsolidated geologic deposits.

Deep, artesian aquifers are the principal sources of groundwater in the Coastal Plain. The principal recharge area for these aquifers is the land around the fall zone. Recharge to these aquifers also occurs through “leaks” in the confining beds above them, which are overlain by unconfined aquifers.

Toward the coast, these aquifers become thicker and lie deeper underground. The thickness and extent of the aquifers gives them their enormous groundwater storage capacity. These aquifers store more groundwater than the aquifers of any other physiographic province in Virginia, and almost half of the state's groundwater use occurs in the Coastal Plain. Pumping has modified the original aquifer conditions, however, and caused a general lowering of the level to which artesian wells rise.

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Further Reading on World Wide Web

The “Ground Water Information Pages” of the U. S. Geological Survey, at water.usgs.gov/ogw/, has links for data, publications, state information, field techniques and groundwater models, groundwater programs, and selected issues.

Glossary

- Aquifer**—A water-bearing layer of permeable rock, sand, or gravel that can yield usable quantities of water to a well or spring.
- Aquitard**—A rock or clay layer that is not permeable enough to yield usable quantities of water to a well or spring.
- Confined or artesian aquifer** —A water-bearing layer between two impermeable layers, where the groundwater is under pressure.
- Consolidated geologic deposits**—Solid or hardened rock masses.
- Discharge areas**—Areas where groundwater flows toward the land surface and either evaporates or escapes into springs, streams, lakes, or wetlands.
- Dolomite**—Rock composed of calcium or magnesium carbonate.
- Igneous**—Rocks formed by solidification of molten rock material (magma) within the earth.
- Infiltration**—The movement of water from the land surface into the soil.
- Karst terrain**—A landscape underlain by rocks containing solution channels and other features cause by dissolving action of groundwater.
- Metamorphic**—Rock that has been changed to a more compact and crystalline form by intense heat and pressure within the earth.
- Percolation**—Seeping of water or other fluids through permeable material such as soil.
- Permeability**—A measure of a material’s ability to transmit water or other fluids.
- Physiographic province**—A region of similar geologic structure and climate with a characteristic set of landforms.
- Potentiometric surface**—The level to which water will rise in a cased well drilled into a confined aquifer.
- Recharge**—The movement of water from the land surface to an aquifer.
- Recharge area (zone)**—The area of land surface from which water seeps into the ground to recharge a particular aquifer.
- Saturated zone**—The area below ground surface in which all available pore spaces are filled with water.
- Sedimentary**—Rock formed deposition (sedimentation) of particles by water, wind, or ice.
- Sinkhole**—A depression, usually in a limestone area, that is often connected to an underground channel.
- Solution channel**—An underground opening or passage formed by the dissolving action of water on rocks such as limestone or dolomite.
- Unconfined aquifer**—A water-bearing layer whose upper boundary is the water table.
- Unconsolidated geologic deposits**—Loose earth materials or sediments.
- Unsaturated zone**—The area below ground surface in which the pore spaces are filled partially with water and partially with air.
- Water table**—The upper boundary of the saturated zone (see above).

Comparing Groundwater and Surface Water Terms

Aquifer vs. Water body—An aquifer is an underground area that can economically provide a water supply, while a water body is a surface water feature that may or may not provide a water supply. An aquifer does *not* typically resemble a lake, stream, or other surface-water body.

Recharge area of an aquifer, vs. drainage area (or watershed) of a water body—A recharge area for an aquifer is the land surface area from which water returns to the aquifer. A drainage area of a water body is the land surface over which water flows to that water body.

Infiltration/percolation vs. Runoff/stream flow—Infiltration is the movement of water into the soil, the first step in water becoming groundwater. Percolation is the movement of groundwater among soil and rock particles. These two terms are analogous, respectively, to runoff of water across the land surface and to the flow of water within a stream channel.

Water Central thanks Thomas Burbey, Virginia Tech Dept. of Geology, for reviewing this article.

IN AND OUT OF THE NEWS

Newsworthy Items You May Have Missed

The following summaries are based on information in the source(s) indicated at the end of each item. Selection of this issue's items ended October 14, 2002 (updates through October 24). Unless otherwise noted, all localities mentioned are in Virginia and all dates are in the year 2002.

Drought-Related News

•On August 30, declaring that the “potential effects of this drought constitute a natural disaster wherein human life, public and private property, and the environment are imperiled,” **Governor Mark Warner used Executive Order 33 to proclaim a state of emergency** throughout the Commonwealth. The order required executive branch agencies and institutions to abstain from watering lawns, washing vehicles, and other unnecessary water use as well as to reduce water usage by at least 15 percent. The order also prohibited households that utilize surface water or groundwater in the Shenandoah, James, Rappahannock, Chowan, York, and Roanoke river basins from watering lawns, washing vehicles, filling swimming pools, and irrigating golf courses. The Executive Order is available on-line at www.governor.state.va.us/Press_Policy/ (please note underscore between Press and Policy).

Exemptions were later announced for commercial car washes, watering shrubs and vegetables, filling indoor swimming pools, filling new or repaired outdoor pools to ensure their stability, and watering new lawns or golf-course fairways. (*Roanoke Times*, 9/5/02)

•On October 21, the **Va. Drought Monitoring Task Force** issued the ninth of its series of drought status reports. (The reports are available on-line at www.deq.stae.va.us/info/drought.html.) The report overview included the following points:

*Drought conditions improved somewhat due to above average rainfall since September 1; statewide, rainfall for the first half of October was 158 percent of the average for this period. As of the report date, however, most of Virginia was experiencing moderate to extreme drought conditions.

*The September-October precipitation did little to improve groundwater levels. Above-average precipitation during the fall and winter is essential for overall improvement.

*Levels of large reservoirs—Lake Moomaw, Smith Mountain Lake, Kerr Reservoir, and Philpott Reservoir—were stabilizing or improving due to recent rainfall and variances to allow water releases below the minimum normally required by their operating licenses.

*Public water supplies based on groundwater west of Interstate 95 reported dropping ground water levels or reduced yields.

*The Virginia Department of Health issued over 4000 replacement permits for private wells that failed during July and August.

•For detailed information about the drought's impact in **Maryland**, see the Md. Dept. of the Environment Web-site, at www.mde.state.md.us/drought/. A good source for information on the drought in **North Carolina** is the *Raleigh News & Observer* archive of articles, available on-line at www.newsobserver.com/drought/.

•**We're not dry alone:** Summer 2002 brought the lowest rainfall in 100 years to western **Russia**. (*Christian Science Monitor*, 9/6/02)

Other News in Virginia...

•A recent Virginia Institute of Marine Science (VIMS) article estimated that **recreational saltwater fishing trips** in 2001 had a **total economic impact of over one billion dollars**. An estimated 4.1 million saltwater fishing trips took place in 2001, according to the Marine Recreational Fisheries Statistics Survey (MRFSS). The VIMS article derived the billion-dollar estimate using information gathered in two previous studies, one in 1994 by VIMS and the other in 1998 by MRFSS. In 1994, VIMS had estimated the total economic impact of saltwater fishing as \$477.2 million. In 2002 dollars, this is worth \$579 million, so

the \$1 billion estimate in 2001 represents nearly a 75 percent increase in seven years. (*The Crest*, VIMS, Summer 2002)

•A new Virginia law (SB554, passed by the 2002 General Assembly) that took effect on July 1, 2002, clarifies the authority of the Va. Dept. of Environmental Quality (**DEQ**) to **review the environmental impacts of proposed electric generating facilities**. The DEQ is to provide the State Corporation Commission (SCC) with a list of all environmental permits and approvals required for a proposed facility and it to specify any environmental issues “not governed by those permits or approvals or...not considered by the Department or other participating governmental entity in issuing such permits or approvals.” The SCC, which under Sec. 56-46.1 of the *Va. Code* is to consider the environmental impact of proposed facilities, is to defer to and not duplicate review activities already conducted by the DEQ. As of September 1, SCC applications were pending for 11 proposed power plants in the counties of Brunswick, Buckingham, Charles City, Cumberland, Fauquier, Fluvanna, Henry, James City, Pittsylvania, Warren, and Wythe; and five plants had been announced, but with no application to the SCC as yet, in the counties of Isle of Wight, Prince William, Smyth, Surry, and Sussex. (SCC News Release 6/26/02; and information provided by the SCC, 9/10/02)

•On July 29, 2002, the U.S. EPA announced the **2002 Chesapeake Bay Small Watershed Grants**. This year’s grants provide \$2.5 million to 66 organizations and local governments from across the Bay watershed. The grants fund projects that are designed to improve water quality or restore biological habitat within the Bay basin. The Virginia organizations that that received grants for 2002 are as follows:

Elizabeth River Project	\$100,000
Friends of the Rappahannock	\$100,000
Ducks Unlimited	\$50,000
Eastern Shore SWCD ¹⁰	\$50,000
Goose Creek Assoc.	\$50,000
Potomac Conservancy	\$50,000
Thomas Jefferson SWCD	\$50,000
Yorktowne Square Condominium Assoc.	\$50,000
Arlingtonians for a Clean Environment	\$49,200
James River Assoc.	\$45,000
Alexandria Seaport Foundation	\$40,000
Westmoreland County	\$30,000
Monacan SWCD	\$28,000
Loudoun Co. Dept. Building and Dev.	\$25,000
Piedmont SWCD	\$20,000
Potomac Conservancy	\$20,000
Chesterfield County	\$19,700
Valley Conservation Council	\$17,000
City of Lexington	\$10,000
Friends of Lake Anna State Park	\$4,000

(Bay Program Press Release, 7/29/02, and Web-Site, www.chesapeakebay.net, 9/30/02. More information about funded projects is available at this Web-site or by calling Jennifer Caddick at [410] 267-5756.

•In August, the Ocean Studies Board of the National Academy of Science named 11 experts to form a **panel to review the use of *Crassostrea ariakensis*, or the Asian Suminoe Oyster, in the Chesapeake Bay**. In previous studies, this non-native oyster has grown faster and been more resistant to diseases than the native *C. virginica*, or Eastern Oyster. The panel’s main focus is to examine the potential effects on native species, water quality, habitat, and the spread of diseases that introducing the alien oyster -- either in sterile form or in a form capable of reproducing -- to the Bay. The panel’s report should be completed by Summer 2003. Funds for the \$310,000 study came from the EPA, the National Oceanic and Atmospheric

¹⁰ SWCD stands for Soil and Water Conservation District.

Administration, U.S. Fish and Wildlife Service, Maryland Department of Natural Resources, Virginia Sea Grant, Maryland Sea Grant, and Connecticut Sea Grant. (*Bay Journal*, Sept. 2002; information regarding the panel and its meetings is available at the National Academy of Sciences Web-site, www.nationalacademies.org/osb)

- At its October 24 meeting, the Virginia Department of Game and Inland Fisheries Board voted to **ban the import, possession, and sale of the Northern Snakehead fish from Virginia**. The Board's action follows the discovery, containment, and removal of a population of the fish in a pond in Crofton, Maryland, close to the Little Patuxent River. Snakeheads, native to China, are capable of surviving long periods of drought and flooding, can live for days out of the water, and can prey voraciously on native fish. (*Washington Post*, as reprinted in *Roanoke Times*, 8/21/02; VDGIF Web-site, www.dgif.state.va.us, 9/27/02; and VDGIF director's office, 10/30/02)

- In September 2002, the National Park Service (NPS) launched a **study** to recommend whether or not to create a **national park that focuses on the Chesapeake Bay**. NPS officials sought public opinion through workshops in September about what resources and places a Bay unit of the National Park system might include. Congress requested a "special resources study," which will recommend whether the Park Service can "tell a broader story about the Bay" than existing state, federal, and nonprofit museums and natural reserves. A final report is expected for submission to Congress by Summer 2003. Legislation passed by Congress and signed by the president is required for a new NPS unit to be created. (*Bay Journal*, Sept. 2002; information regarding the study is available on-line at www.chesapeakestudy.org, or by calling Jonathan Doherty at 800-968-7229, x725)

- Like other state agencies, the **Virginia Institute of Marine Science** is feeling the effects of the state budget cuts (for more on budget cuts, please see the special section beginning on page 22). One specific project recently cancelled is **research buoys** in the Chesapeake Bay (mentioned in the February 2002 issue of *Water Central*, p. 10). The buoys were designed to measure currents, wave action, water quality and the presence of marine plants in the Bay in "real time" via the Internet. (*Roanoke Times*, 9/3/02)

- A recently discovered well at Jamestown has much historic potential**. The location of the new discovery suggests to historians that the fort built by the first permanent English settlers in 1607 was twice as big as previously believed. In addition, the well may contain remains of 17th-Century plants, insects, and microorganisms (preserved by being submerged) that could help researchers learn about the environment and disease risks of the time. (*Roanoke Times*, 9/4/02)

- In early September, "a large population" of **Zebra Mussels was found in a freshwater pond in Prince William County**. The non-native species has caused much ecological and economic damage in the Great Lakes and other areas since arriving in ship ballast water in the 1980s. This is the first reported discovery of the species in the Potomac River drainage: the pond is located a quarter mile from Broad Run, a tributary of the Occoquan River, which drains into the Potomac. It is unlikely that the mussels could spread beyond the pond on their own because the pond has no outlets or inlets. But Va. Dept. of Game and Inland Fisheries officials were concerned that the mussels could attach to equipment of recreational divers using the pond. Officials were considering poisoning or draining the pond to eradicate the mussels.

In a related development, a Chesapeake Bay Program panel began meeting in October to devise a plan that can be put in place by next spring to prevent further expansion of the mussel within the Bay watershed. (*Virginian-Pilot*, 9/7/02; *Bay Journal*, Oct. 2002) (For more on the issue of non-native aquatic nuisance species, please see Aug.-Sept. 2001 *Water Central*, pp. 7-20.)

- Virginia will receive **\$17.2 million for eight water projects** as a result of the **2002 federal farm bill**. Smyth County, for example, was awarded \$772,000 (\$338,000 in loan funds and a \$434,000 grant) from the U.S. Dept. of Agriculture for construction of 49,000 feet of new water lines for six residential areas. Nationwide, the bill is providing \$703 million to help fund 377 projects. (*Smyth County News and Messenger*, 9/9/02)

- In September, the U.S. Army Corps of Engineers submitted to the Virginia Beach City Council a study of the **environmental health of the Lynnhaven River**. Congress funded the \$100,000 analysis of the river, a tributary of the Chesapeake Bay. The study documented several problems: poor water quality; loss of

shoreline wetlands; loss of most submerged aquatic vegetation (underwater “grasses”); shellfishing prevented by bacterial contamination; and sediments polluting the river and decreasing its depth. The council expressed support for the Corps to conduct another, more detailed study of ways to clean up and restore the river. The city will pay half of the \$2-million bill for that study, which is to be completed by 2006. (*The Virginian-Pilot*, 9/12/02; the Corps’ report can be viewed at www.nao.usace.army.mil/CurrentP.html)

•In the **northern Shenandoah Valley**, the Regional Water Resources Committee (formerly the Regional Water Supply Committee) is beginning to do **long-range planning for water supplies**, especially from the Shenandoah River. The Committee is part of the Northern Shenandoah Valley Regional Commission (covering the counties of Clarke, Frederick, Page, Shenandoah, and Warren and the City of Winchester). The regional commission will invite all these jurisdictions to be part of the new planning group. In addition, a Water Summit Meeting is to be organized soon with the Central Shenandoah Valley Planning District Commission (covering the counties of Bath, Highland, Rockbridge, and Rockingham and the cities of Buena Vista, Harrisonburg, Lexington, Staunton, and Waynesboro), which has also been investigating issues affecting the Shenandoah River. (*Winchester Star*, 9/20/02)

•**Update on *Pfiesteria* toxin debate** (please see the August 2002 *Water Central*, p. 6, for a previous item): Virginia scientists are involved in a continuing scientific debate over whether the marine alga *Pfiesteria* attacks fish by means of a toxin that can also be harmful to humans. Three recent scientific papers challenged the hypothesis that *Pfiesteria* uses a toxin to prey upon fish; the lead author of one article was Wolfgang Vogelbein of the Va. Institute of Marine Science (VIMS). That hypothesis has been put forth most prominently by JoAnn Burkholder of North Carolina State University, with support from other scientists, including Harold Marshall at Old Dominion University. Other scientists at VIMS and ODU are also involved in studies attempting to answer questions about *Pfiesteria*’s predatory mechanisms and its life cycle. For more information on this debate, please see the well-done and thorough article in the October 2002 issue of *Bay Journal*, published by the Alliance for the Chesapeake. (*Raleigh News & Observer*, 9/23/02; and *Bay Journal*, Oct. 2002)

•**Mosquitoes** have been in the news recently for spreading the **West Nile virus** that had caused 182 deaths this year across the country, including two in Virginia, as of Oct. 23. On Sept. 25 and Oct. 2, mosquitoes were found that carried another serious disease, **malaria**, in Loudoun County and Fairfax County, respectively. After the Fairfax discovery, “aggressive larviciding”—applying pesticides to kill mosquito larvae—took place within a one-mile radius of the site.

There are 166 species of mosquitoes found in North America, and water is essential for their life cycle. Mosquito larvae can live almost everywhere there is still water; adults lay eggs either directly on the water or in places that become wet or flooded later. Eggs of some species can survive for months or years in dry materials, then hatch when water returns.

During frost-free weather, the following actions—recommended by the federal Centers for Disease Control (CDC)—will reduce mosquito-breeding areas:

- *once or twice a week, empty water from flowerpots, pet food and water dishes, birdbaths, swimming pool covers, buckets, barrels, and cans;
- *clean out debris from rain gutters;
- *remove discarded tires and trash that could collect water (check for containers or trash in places that may be hard to see, such as under bushes). (Associated Press, 9/30/02 and 10/3/02; CDC Web-site, www.cdc.gov/ncidod/dvbid/westnile/index.htm, 10/24/02; and *A Guide to Common Freshwater Invertebrates of North America*, by J. R. Voshell, 2002)

•**Congress has reserved \$20 million** in the 2003 Defense Appropriations Bill to **scrap about ten of the environmentally dangerous ships in the James River Reserve Fleet**, also known as the “Ghost Fleet.” The reserve fleet was created in 1925 off Fort Eustis in Newport News and designed to hold government ships that might be used again in time of national crisis. Ninety-seven ships are in the fleet, 71 of which are obsolete and have no chance of returning to service. Altogether, the “Ghost Fleet” holds an estimated 7.7 million gallons of oil, as well as lead paint and other toxins. Most of the \$20 million will be used to pay American shipyards to take the vessels and scrap them. The U.S. Maritime Administration estimates the cost of scrapping one ship at \$2.5 million, so officials expect to scrap as many as ten of the

most deteriorated ships in the fleet next year. An excellent article on the reserve fleet is available at the *Virginian-Pilot* Web-site, www.pilotonline.com/special/ghostfleet. (*Virginian-Pilot*, 10/11/02)

...and Outside of Virginia

- A new report by the National Research Council (NRC) breaks down the **origins of the 29 million gallons of oil that reach North American ocean waters** annually from **human activity**. Oil and gas extraction activities account for only about 3 percent; less than 8 percent comes from tanker and pipeline spills; and almost 85 percent comes from land-based runoff, polluted rivers, airplanes, and small boats and personal watercraft. More than half of the oil originating in land-based activities comes from the coastal area between Virginia and Maine. Besides the oil resulting from human activity, another **47 million gallons** reach ocean waters through **natural seepage** from the ocean floor. The report, *Oil in the Sea: Inputs, Fates and Effects*, is available on-line at www.nap.edu. Printed copies are available for purchase from the National Academy Press, (800) 624-6242. (Univ. of North Carolina *WRI News*, Jul./Aug. 2002)

- An estimated **forty percent of the world's people**, especially in North Africa and West Asia, **may face a serious shortage of safe water** by 2025, according to a United Nations study released August 13. The report was prepared for the World Summit on Sustainable Development that convened in Johannesburg, South Africa, in August. (*Chicago Tribune*, as carried in *The Roanoke Times*, 8/14/02)

- The drought in Summer 2002 brought huge **forest fires** to a number of states. Besides containing the fires, firefighters also had to take steps to contain **the possible spread of forest tree diseases** being carried by humans, equipment, or water. Rivers used as a water source to fight a 377,000-acre fire in Oregon, for example, contained spores of a fungus-like pathogen that is fatal to Port Orford Cedars, which are found in northern California and southern Oregon coastal areas. Another tree disease in southern Oregon, "sudden oak death," was also a concern. Precautionary measures taken to prevent disease transmission included washing vehicles daily and treating river water with bleach before using it in helicopter drops. On the other hand, the Oregon fire had the potential to reduce Port Orford Cedar disease, because prolonged heat kills the organism and infected trees destroyed in the fire can be replaced with a disease-resistant variety. (Associated Press, as carried in *Roanoke Times*, 8/14/02)

- The Pennsylvania Fish and Boat Commission confirmed in July that the **Flathead Catfish** (*Pylodictis olivaris*) has entered the **Susquehanna River**. The predatory fish can grow to over 100 pounds and is an aggressive breeder, so officials are fearful that the Flathead will out-compete locally indigenous species for food. Pennsylvania officials encouraged anglers to kill all Flathead Catfish caught in the Susquehanna or its tributaries. (Associated Press, in *Bay Journal*, Sept. 2002)

- On September 8, **California** Governor Gray Davis signed a **bill requiring state residents to replace older clothes washers with more water-efficient models** by 2007. The law requires washers to use no more than 9.5 gallons to wash one cubic foot of laundry; in contrast, the average washer sold in 1994 used 13.3 gallons, according to the Consortium for Energy Efficiency. Supporters of the law claim it will save about one billion gallons annually, along with reducing energy used for washing and drying; opponents have cited the cost to citizens of buying a replacement appliance. (*Christian Science Monitor*, 9/12/02)

- As of late September, U.S. House and Senate bills to increase **federal funding for water and wastewater infrastructure** seemed unlikely to pass before the end of the current Congress. H.R.3930 in the House and S.1961 in the Senate, were introduced in February and March, respectively, but stalled because of opposition to certain eligibility requirements—such as a requirement that utilities pay locally prevailing wages on funded projects—and other rules that would accompany the new funding.
 New infrastructure funding might come from other federal legislation. In a speech on Sept. 18, the chair of the White House Council on Environmental Quality said that funds for water infrastructure might be available in pending homeland security legislation. In addition, funds from the bioterrorism law (H.R.3448, the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, signed by the president on June 12) might be applied to infrastructure projects that improve the security of water-treatment facilities. (Inside EPA's *Water Policy Report*, 3/25, 7/15, and 9/23/02) (Please see a related item on water infrastructure at the end of this section.)

•In September, the **Commission on Ocean Policy released its “mid-term report,”** stating that the nation’s coastal waters face significant water-quality problems—worse, in fact, than 30 years ago when the federal Clean Water Act and Coastal Zone Management Act were passed. The report cited population increases, farming practices, urban runoff, and air pollution deposition as key contributors to ocean pollution. Following a requirement of the Oceans Act of 2000, President Bush appointed the Commission in June 2001. The Commission’s final report, due to Congress by June 2003, is to include recommendations for a comprehensive federal ocean policy. The Commission has its own Web-site, at www.oceancommission.gov, and the mid-term report is available there. (Inside EPA’s *Water Policy Report*, 10/7/02)

•And a final note: This is **not exactly why Honest Abe is considered our greatest president.** In a Sept. 30th speech, U.S. EPA Administrator Christine Todd Whitman said that the cost of needed improvements to the nation’s water and wastewater infrastructure could exceed current spending levels by \$535 billion over the next 20 years. Attributing much of the cost to the age of the infrastructure, she said, “There are cities in America still using pipes that were laid when Lincoln was president.” (*Washington Post*, 10/1/02)

—By Alan Raflo and John Yowell

John Yowell, a junior English major at Virginia Tech, served an internship at the Water Center in Fall 2002.

Fall 2002 State Budget Cuts for Agencies with Water Resource Programs

On October 15, Gov. Mark Warner announced **budget reductions for state agencies** designed to cover \$857 million of the \$1.5 billion shortfall projected for the 2003—2004 biennial state budget. The following table shows the reductions for the current biennial budget period for the agencies most involved with Virginia's water resources. (Please see the April 2001 issue of *Water Central*, pp. 1—5, for an introduction to state agency spending for water resources.) Agency abbreviations: CBLAD = Chesapeake Bay Local Assistance Dept.; DCR = Dept. of Conservation and Recreation; DEQ = Dept. of Environmental Quality; DOF = Dept. of Forestry; DGIF = Dept. of Game and Inland Fisheries; VDH = Dept. of Health; HCD = Dept. of Housing and Community Development; VIMS = Institute of Marine Science; VMRC = Marine Resources Commission; DMME = Dept. of Mines, Minerals, and Energy; VPA = Port Authority.

	FY03 Base	FY03 Cut	FY04 Base	FY04 Cut	FY's 03 & 04 Base	FY's 03 & 04 Cut	FY's 03 & 04 % Cut
CBLAD	1,488,837	80,499	1,512,378	137,216	3,001,215	217,715	7.3
DCR	34,362,621	4,198,457	32,814,656	4,853,468	67,177,277	9,051,925	13.7
DEQ	34,371,432	4,037,688	35,426,171	3,933,723	69,797,603	7,971,411	11.4
DOF	14,678,683	813,020	15,076,617	2,010,399	29,755,300	2,823,419	9.5
DGIF	14,420,427	2,048,840	14,506,967	2,048,840	28,927,394	4,097,680	14.2
VDH	90,014,864	8,388,961	92,075,261	7,942,597	182,090,125	16,331,558	9.0
HCD	22,807,915	2,189,153	27,661,111	3,488,366	50,469,026	5,677,519	11.2
VIMS	16,309,358	1,724,029	16,453,073	1,809,838	32,762,431	3,533,867	10.8
VMRC	8,837,722	1,024,609	8,882,836	894,814	17,720,558	1,919,423	10.8
DMME	6,133,797	260,263	8,958,724	765,582	15,092,521	1,025,845	6.8
VPA	7,113,275	1,066,991	8,164,245	122,4636	15,277,520	2,291,627	15.0

The dollar figures come from the Va. Department of Planning and Budget's 10/15/02 "Summary Table of Budget Reduction Plans for the 2002-2004 Biennium," accessed on-line at www.governor.state.va.us/Initiatives/Budget/BudgetReductionSummary.pdf, 10/17/02.

The Dept. of Planning and Budget also provided a "Summary of Budget Reduction Plans," dated 10/16/02 (accessed on-line at www.governor.state.va.us/Initiatives/Budget/AgencyReductionPlans.pdf, on 10/17/02). This document includes comments about the agency reductions. Here are the comments pertinent to the water-related programs of the agencies listed above.

CBLAD: "The Chesapeake Bay Local Assistance Department will eliminate a management position, use turnover and vacancy, reduce operating expenditures and eliminate competitive grant funding to localities for implementation of the Chesapeake Bay Preservation Act."

DCR: "The Department of Conservation and Recreation will [do the following]:

- *Eliminate or reduce general fund support by about 26 percent (\$2.0 million) for the development of Total Maximum Daily Load implementation plans, Shoreline Erosion Advisory Service program, and Conservation Reserve Enhancement Program. All of these programs help reduce nonpoint source pollution and assist in the clean up of the Chesapeake Bay and other waters of the Commonwealth. These cuts will put Virginia's ability to remove these waters from the impaired waters list more at risk;
- *Reduce pass-through grants to the Soil and Water Conservation Districts by about 2.5 percent (\$214,615), the Virginia Outdoors Foundation by 10 percent (\$120,000), and Breaks Interstate Park by 13.5 percent (\$62,500);
- *Consolidate regional offices; and
- *Increase fees at state parks by 10 percent for the rental of cabins and campsites at state parks."

DEQ: "The Department of Environmental Quality will [do the following]:

- *Consolidate management activities, complete the elimination of a layer of management in the regional

offices, and reassign staff to save \$2.1 million;

- *Consolidate regional operations and close a satellite office;
- *Reduce pollution prevention and small business compliance programs by about \$600,000; and
- *Eliminate or reduce certain pass-through payments, grants, and other matching funds, including payments to Smith Mountain Lake Volunteer Water Quality Monitoring Project), Izaak Walton League of America, Chesapeake Bay Foundation, and competitive grant awards from the Litter Control and Recycling Fund.”

DOF: “The Department of Forestry will [do the following]:

- *Consolidate area offices and co-locate one office;
- *Reduce general fund support for the reforestation of timberlands;
- *Eliminate an educational outreach program; and
- *Eliminate various non-fire safety positions, resulting in 19 layoffs.”

DGIF: “The Department of Game and Inland Fisheries will [do the following]:

- *Close a fish hatchery;
- *Reduce by over \$2.1 million the use of 139 wage personnel in all programs including secretarial support, field work for wildlife biologists, assisting with fish production, and boat titling and registration; and
- *Stop development of the on-line computer system for licenses to save \$1.3 million.”

VDH: “The Virginia Department of Health will [do the following]:

- *Reduce a portion (\$1.1 million) of the excess Drinking Water State Revolving Fund (DWSRF) matching dollars. The federal EPA grant that supports the DWSRF totals about \$11 million and does not require the full \$4.5 million in general fund support currently appropriated as matching dollars (a 20 percent match of \$2.2 million is required);
- *Reduce administrative and management staffing through a combination of vacancy opportunities and management consolidation....”

HCD: “The Department of Housing and Community Development will [do the following]:

- *Reduce the indoor plumbing program (eight percent in FY 2003 and five percent in FY 2004)....”

VIMS: “The Virginia Institute of Marine Science will utilize turnover and vacancy savings, reduce research programs, eliminate 12 positions (11 layoffs), attempt to secure additional nongeneral funds to support research programs, reduce supplies and travel expenses, sell surplus research vessels, and furlough all employees up to seven days.”

VMRC: “The Marine Resources Commission will eliminate almost \$800,000 in general fund support and use only nongeneral funds for oyster replenishment activities. The agency will refinance equipment purchases through the master equipment lease plan for seven instead of three years. In addition, the agency will use vacant positions to save additional funds.”

DMME: “The Department of Mines, Minerals and Energy will reduce a pass-through grant (Solar Photovoltaic Incentive Grant Program) by 15 percent, supplant general fund support with non-general funds, and eliminate several positions, with three layoffs.”

VPA: “The Virginia Port Authority will reduce grants to local ports by 15 percent in FY 2004, reduce funding for maintenance of its facilities, reduce advertising and travel funding, and defer equipment replacement.”

Major exemptions from the current budget reductions in these agencies included the following:

- *Fire fighting programs in Department of Forestry;
- *Mine safety in the Department of Mines, Minerals and Energy;
- *Game Protection Fund in the Department of Game and Inland Fisheries;
- *Statewide water quality monitoring;
- *Virginia Petroleum Storage Tank Fund and Waste Tire Trust Fund in the Department of Environmental Quality;
- *Dam Safety Program in the Department of Conservation and Recreation.

SPECIAL DROUGHT COMMENTARIES

From Virginia

“Management of Water Resources for Drought Conditions” (part of U.S. Geological Survey Water Supply Paper 2375) was written in 1989 by William Walker, then director of the Va. Water Center, along with Margaret Hrezo and Carol Haley. It includes valuable sections on traditional approaches to drought management, obstacles to effective drought planning, frameworks for state-level drought planning, and a synopsis of state programs related to drought existing at the time. The article is available on-line at the Water Center’s Web-site, www.vwrrc.vt.edu (click on “Publications/Videos,” then “Other Publications”).

From North Carolina

“Managing Drought Risk” was written by Dr. Stuart Schwartz, senior research scientist at the Water Resources Research Institute of the University of North Carolina, for that institute’s July/August 2002 *Newsletter*. It is reprinted here with permission (edited slightly for space, with bolding added).

The persistent drought intensifying over central North Carolina and southern Virginia provides a renewed focus on understanding and managing drought risk. Though familiar to many, the ubiquitous presence of the current drought tends to blur important distinctions [among] drought definitions, impacts, and risks. Droughts can be characterized in many different ways. Most commonly, drought is described by the departure of accumulated precipitation from long-term seasonal averages or climatology. These observed statistical anomalies are referred to as **meteorological drought**. Over varying time scales, unregulated rivers and streams naturally respond to meteorological drought with unusually low streamflows. **Hydrologic drought** refers to the departure of streamflows from their long-term averages. Meteorological drought and hydrologic drought refer to the frequency, duration, and magnitude of unusual dry anomalies in the hydrologic cycle.

The persistence of meteorological drought and hydrologic drought can lead to shortfalls between available water and the demand for moisture...used by natural vegetation, aquatic ecosystems, cultivated crops, and by man. For non-irrigated agricultural lands, the shortfall between moisture supply (from precipitation and soil moisture) and crop needs is referred to as **agricultural drought**. **Water supply drought** portends the potential shortfall between supply (from surface water, groundwater, and reservoir storage) and demand in water systems serving our cities, municipalities, and suburbs.

We can do little more than quantify the intensity, duration, and spatial extent of meteorological and hydrologic droughts. We can however plan for and manage the impacts of agricultural and water supply drought through actions, investments, and behavioral choices that alter both the supply and the demand for water. Long-term strategic planning and short-term tactical response to drought must be based on the management of drought risk. That risk consists of the probability of meteorologic and hydrologic drought, and the consequences of agricultural and water supply drought.

We know that “more extreme” drought conditions are always possible and in fact have occurred. Proxy climate data clearly record historical droughts in North Carolina that were substantially more extreme than those observed in the 20th Century. Climate measures reconstructed from tree rings record persistent dry conditions from 1746—1764 that are unprecedented in modern meteorological records. Using centuries old Bald Cypress trees, David Stahle and his colleagues at the University of Arkansas Tree Ring laboratory have reconstructed proxy measures of moisture availability during the growing season in tidewater Virginia and North Carolina, back to the late 12th Century. The most severe three-year drought...in their 800-year reconstruction occurred in the late 16th Century—coinciding precisely with the disappearance of the Lost Colony on Roanoke Island. The probability that severe meteorological droughts will occur is beyond our control. We can however exert considerable control over the risk and associated impacts from agricultural and water supply droughts, through **drought management**.

Fundamentally, drought management is the management of risks and reliability—such as the risk of imposing water use restrictions; or the reliability with which water for essential potable use, sanitary needs, and firefighting services will be provided. Like all risk management activities, drought management

involves tradeoffs among, for example, the probability of satisfying unrestricted demands; the distribution and mitigation of impacts when demands cannot be fully met; and the costs to reduce, diversify, and mitigate undesirable outcomes when they inevitably occur. Thoughtful risk-based drought plans that integrate costs, risks, and impacts are essential tools in the effective management of water supply reliability.

Not all drought management plans integrate these risk-based tradeoffs. Some drought plans arbitrarily link familiar indexes of climatic drought with generic targets (e.g., 10 percent, 15 percent, etc.) for water use reductions, without any explicit consideration of risk. When such one-size-fits-all drought management plans are uncritically adopted—with the best of intentions—they result in a plan that has little likelihood of effectively mitigating the impacts of drought. During the 1999 mid-Atlantic drought, ad-hoc drought triggers—decoupled from system-specific drought risk—were used to implement water use restrictions in Maryland and Pennsylvania. Drought “declarations” were uniformly applied to both small community systems dependent on shallow wells (especially sensitive to modest meteorological droughts), and large municipalities protected by major reservoir systems. Confusing inconsistent messages resulted, in which water systems serving Pittsburgh and the Maryland suburbs of Washington, D.C., were placed under water use restrictions—creating very real economic losses—despite the high reliability and low risk (achieved through substantial capital investment) designed into those...systems.

The 2002 drought provides [an]...opportunity to interpret current experiences through the lessons learned—and rediscovered—in national [studies], such as the U.S. Army Corps of Engineers’ National Study of Water Management During Drought and findings of the National Drought Policy Commission. These studies identified critical elements common to successful drought plans. Foremost among them is the need for every drought plan to identify clearly and unambiguously meaningful, measurable objectives. For example, water use restrictions can be an essential instrument to achieve drought plan objectives, but “reducing water use” per se is not an *objective* of drought planning. Developing good planning objectives may be the most important and, paradoxically, the most often ignored step in the planning process.

National experience with prolonged drought, such as the 1987—1992 California drought, reinforces the conclusion that the success of drought response plans should be gauged by the minimization and equitable redistribution of the *impacts* of water shortages, not by the shortages themselves.

The overriding lesson from drought response planning throughout the United States is that the most effective tool in managing drought response is the confidence and cooperation of water users. This requires active stakeholder involvement and public education. Public participation is essential in both identifying clear management objectives, and evaluating credible consistent strategies to achieve those objectives.

No drought plan can anticipate all of the possible impacts of severe droughts. The stresses and disruptions associated with the next drought will differ from any previously observed. Drought management plans therefore need to be dynamic, incorporating mechanisms to exercise, update, and revise the plan during non-drought conditions. Deficiencies in drought plans are best-identified and corrected under non-drought conditions, in the constructive atmosphere of a drought preparedness exercise. Like fire drills and war games, regular drought preparedness exercises maintain and improve readiness, and build the institutional knowledge and working relationships that are essential for successful drought management. This is standard practice in *all other* emergency management planning. The most effective plans for drought management maintain preparedness by treating drought operations as one of the normal modes of water system operations—albeit a mode of operation that occurs infrequently.

As we tighten our belts and wait for the most severe drought in recent memory to come to an end, we can confidently predict that an even more severe drought will occur sometime in the future. Water supply systems throughout the country have developed remarkably diverse solutions to the challenge of managing drought risk. Our challenge is to embrace the lessons learned from the drought of 2002, and incorporate them in the continual improvement of drought management plans that integrate and balance the risks, costs, and impacts of drought.

N O T I C E S

Virginia Office of Land Conservation

This office was formed within the Va. Dept. of Conservation and Recreation (DCR) in 2001. Its purpose is to support public and private land conservation efforts and it is also charged with coordinating Virginia's land-conservation commitments under the Chesapeake 2000 Agreement. For more information, contact Matt Bley, (804) 225-2048 or mrbley@dcr.state.va.us.

TMDLs Web-site: www.tmdla.net

America's Clean Water Foundation and the Association of State and Interstate Water Pollution Control Administrators have created this Web-site of information on the Total Maximum Daily Loads (TMDL) process. The site includes basic information, example TMDLs, links to relevant state Web-sites, and other features.

CSO

Creative Stock Options? Channel for Sports Only? No, CSO stands for **combined sewer overflow**: discharge of untreated wastewater from a combined storm-sewer/sanitary-sewer system. The EPA's Dec. 2001 report to Congress, *Implementation and Enforcement of the Combined Sewer Overflow Control Policy* (EPA 833-R-01-003) describes progress made and problems remaining from CSO policy set in 1994. A link to the report is available at cfpub.epa.gov/npdes/.

Status of Virginia's Water Resources

This Oct. 2001 report by the Va. Dept. of Environmental Quality discusses Virginia's water-supply planning activities. Available on the Water Center's Web-site, www.vwrrc.vt.edu; click on "Publications/Videos," then "Other Publications." You may be able to find a printed copy at larger libraries (state depository libraries).

State of the Chesapeake Bay

This annual report from the Bay Program is available on-line at www.chesapeakebay.net. To request a printed copy, phone (800) 968-7229.

Local Stream Protection

A Stream Corridor Protection Strategy for Local Governments is a 63-page handbook from the U.Va. Institute for Environmental Negotiation. Available on-line at www.virginia.edu/~envneg/ien_projects_featured.htm. For a printed copy (\$8), call (434) 924-1970.

Workshops for Dam Owners

The Va. Dam Safety Education Fund provides workshops on maintenance, emergency action plans, and other topics pertinent to Virginia's 1400 regulated dams. For information, contact the Dam Safety Education Fund at (888) 957-3036, or Jon Phillippe, Va. DCR Dam Safety Program, at (804) 786-2886.

Also Out There...

Here are titles of some recent, detailed articles on various subjects:

- “**Sediment Happens**”—The water-quality effects of excessive sediments in the Chesapeake Bay. *Bay Journal*, July-August 2002; Alliance for the Chesapeake Bay, Seven Valleys, Penn., (717) 428-0273; on-line at www.bayjournal.com.
- “**The Horseshoe Crab...200 Years of Existence, 100 Years of Study**”—Description of this animal's biology and its importance to ecosystems, fishing, and medicine. *Reviews in Fisheries Science*, 10(1): pp. 39—73; look for this in a larger library.
- “**Take Me Out to the Carwash**”—Ways to reduce the effects of car washing on nonpoint-source pollution. *Stormwater*, May 2002; Forester Communications, Santa Barbara, Calif., (805) 681-1312; on-line at www.forester.net.

•“**SWANCC and the States**”—Articles on responses by four states, including Virginia, to recent restrictions on the federal government’s jurisdiction over wetlands. *National Wetland Newsletter*, Jul.-Aug. 2002; Env. Law Institute, Washington, (202) 939-3800, law@eli.org.

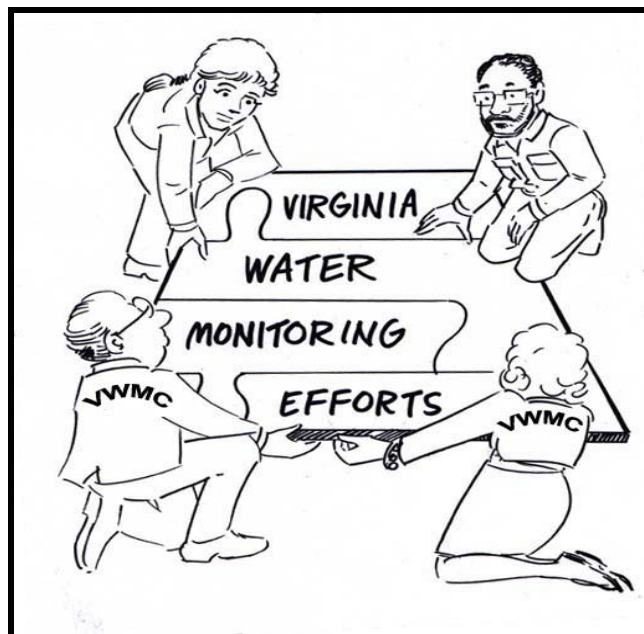
•“**All About Arsenic**”—A wide-ranging look at this substance and the issues surrounding its regulation. *On Tap*, Summer 2002; National Drinking Water Clearinghouse, Morgantown, W.Va., (800) 624-8301; available on-line at www.nesc.wvu.edu/ndwc/.

CORRECTION FROM THE PREVIOUS ISSUE OF *WATER CENTRAL*

•On page 15, Aug. 2002 issue: The item on the Va. State Climatology Office omitted that office’s phone number. The number is (434) 924-0548.

THE VIRGINIA WATER MONITORING COUNCIL

Have you heard of the Virginia Water Monitoring Council? Do you know its purpose? The Virginia Water Monitoring Council was established *to promote and facilitate coordination of water-monitoring programs throughout the Commonwealth of Virginia.*



Each year, many public and private organizations collect large amounts of water-monitoring data of various types (chemical, physical, and biological). The data are being collected for many different reasons and rarely are shared with other water monitors and decision makers. Differences in monitoring design, protocols, data analysis, and data management have made it difficult to exchange water-monitoring data.

Protecting and restoring our waterways and watersheds, however, depend upon having high-quality data that are widely and easily available as well as understandable by non-scientists. The Virginia Water Monitoring Council is working for the goals that adequate and reliable water resources information will be available to Virginians, that they will know the conditions of the states’ waters, and that they will be able to make informed decisions on the use and protection of those waters.

The Virginia Water Monitoring Council was formed in November 1999 and is modeled after the National Water Quality Monitoring Council, which was established in 1997. The National Council

coordinates efforts and provides guidance for developing consistent and scientifically sound water-quality monitoring methods and strategies nationwide. The National Council promotes collaboration, coordination, and communication among water-quality monitoring agencies and groups.

Membership in the Virginia Water Monitoring Council is open to any person or organization with responsibility for, or interest in, water monitoring in Virginia. Examples of organizations with representation in the Council include Citizens for Water Quality, Virginia Institute of Marine Science, Virginia Agribusiness Council, American Water Works Association, Virginia Department of Health, Virginia Department of Environmental Quality, and the U.S. Geological Survey. In all, approximately 150 members belong to the Council and represent about 100 different organizations.

The activities of the Virginia Water Monitoring Council are primarily implemented through four committees: operations, inventory, needs assessment, and communications. The Council's committees are currently working to develop a **water-monitoring inventory** and complete a **needs-assessment survey**. The inventory is an on-going project, gathering information on each water-monitoring program in the state, including contact information for a person who can address inquiries about the monitoring program. The inventory also requests information on how data are documented and used. The needs-assessment survey will ask groups about their need for information about monitoring protocols, networking opportunities, public education activities, or other services. The inventory and a summary of the needs assessment will be posted on the Council's Web-site later this year.

Members Wanted! The Council is always looking to broaden its membership. Please consider becoming an active member. To learn more about the Virginia Water Monitoring Council, visit the Council Web-site at www.vwrrc.vt.edu/vwmc, or contact Jane Walker (VWMC Administrative Assistant) at (540) 231-4159, e-mail: vwmc@vt.edu; or Katie Register (VWMC Steering Committee Chair) at (434) 395-2602, e-mail: cleanva@longwood.edu.

By Jane Walker. Jane is a research associate at the Water Center.

Virginia Water Central

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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 araflo@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.