Virginia Water Central

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FEATURE ARTICLE

An Introduction to Urban Stormwater

"Stormwater. [It's] a scary issue...This is going to be one of [our] largest expenses."

So said Mayor Robert Stebbins of Lewisville, North Carolina—population 7,700—when asked recently about his concerns for his town's future (*Winston-Salem Journal*, Nov. 4, 1999).

Here in Virginia, the staff at the Hampton Roads Planning District Commission—serving jurisdictions as large as Norfolk, with over 261,000 people—might agree with Mayor Stebbins. Back in 1991, the cover of their report "A Stormwater Management Financing Strategy for Hampton Roads" showed a mock Federal Reserve Note, with a stormwater pipe in place of George Washington's portrait and "Millions" in place of "One Dollar."

Stormwater management refers to any practice designed to control the effects of water flows due to rainfall (or other precipitation) in developed, or urbanized, areas. These effects can include flooding of buildings, water over roadways (called "road overtopping,"), increased erosion of stream banks, water-quality degradation, and damage to aquatic habitats.

This article takes an introductory look at stormwater impacts, institutional responses to reduce those impacts, and methods for implementing stormwater control.

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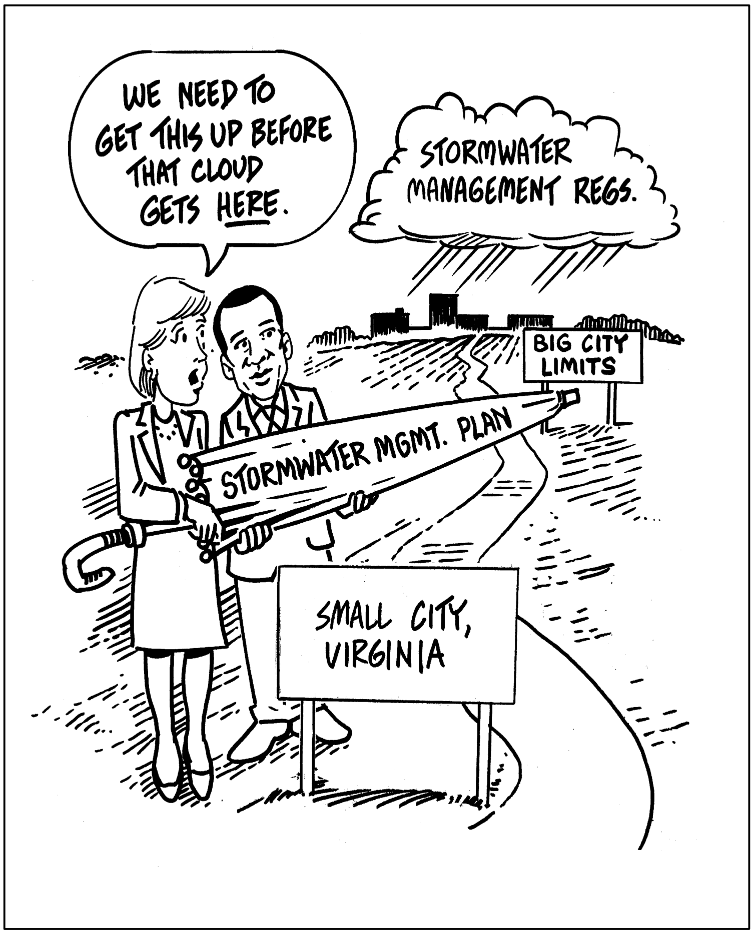

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AND STATE UNIVERSITY

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Stormwater Impacts

Stormwater **runoff** is the overland flow of rainfall-generated water into streams or stormwater collection systems, such as storm sewers or ditches. Runoff occurs when the land surface is incapable of accepting all of the rainfall. In undeveloped areas, runoff occurs either because the soil is saturated—all of the soil's water-holding spaces are filled—or because the rain is falling faster than the rate at which the surface water can **infiltrate**, or move into the soil. As a long-term average, 5-15 percent of rainfall in undeveloped areas becomes surface runoff. The remaining 85-95 percent evaporates, is taken up by plants, or infiltrates to become groundwater.

As urbanization and land development occur, the relationship between rainfall and stormwater runoff changes. Urbanization adds **impervious surfaces**—surfaces that do not allow rainfall to infiltrate into the soil. Paved roads, parking lots, and buildings are all impervious surfaces. On average for impervious surfaces, 85-95 percent of rainfall will be converted to runoff, with evaporation accounting for the remaining 5-15 percent. Both the *volume* of runoff and the *speed* at which the water moves overland can increase as the percentage of impervious surface increases.

Increased stormwater runoff from urbanized areas increases the potential for flooding and road overtopping. After significant land development, a rainfall that was contained within a stream channel when the upstream drainage area was undeveloped may now overflow the channel, possibly flooding buildings near the channel. Similarly, a roadway culvert that was large enough to carry the largest storm flows from an undeveloped landscape may not be able to do so when the drainage area is developed. The additional flow then goes over the roadway, with possibly serious consequences for safety, convenience, and the road-maintenance budget.

Increased stormwater flow from developed areas may also cause problems for **receiving waters**—the streams and lakes that eventually receive the flow. More water, moving at higher speed, can increase erosion, transport, and deposition of soil (known as **sedimentation**) within the receiving waters. While erosion and sedimentation are natural processes, increased stormwater flows can accelerate these processes well beyond their normal rate. Ultimately, this can degrade water quality and aquatic-life habitat.[1]

Besides its *physical* impacts from erosion, stormwater can also affect *chemical* water quality. Stormwater runoff from urbanized areas carries pollutants such as nutrients[2], oil and grease, heavy metals[3], and residues from pesticides. Runoff from developed lands can have pollution loads many times greater than those from undeveloped lands: as much as 20 times greater for nutrients, and as much as 50 times greater for some toxic substances, such as heavy metals.

Institutional Responses to Reduce Stormwater Impacts

Developments up to 1999

Stormwater management methods have evolved substantially over the past 50 years. Before that time, stormwater management focused on moving water off of developed areas as rapidly as possible, with little or no regard for impacts on the receiving waters. In the 1950s and 1960s, some jurisdictions

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[1] For instance, excessive sediment in streams can cover areas of the stream bottom that certain fish require for reproduction.

[2] Nutrients are substances that stimulate plant growth. Primarily compounds containing nitrogen and phosphorus, these substances become pollutants when they are in large enough amounts to cause excessive growth of algae in water bodies. Excessive algal growth leads to various undesirable water-quality conditions.

[3] Some 80 of the naturally-occurring elements are metals. Heavy metals are those above a certain density. Some heavy metals, such as copper and iron, are essential for life, but only in very small amounts, above which they can become toxic. Cadmium and mercury are examples of toxic heavy metals with *no* known biological function.

began to consider off-site water-quantity impacts, primarily flooding. As stormwater-quantity control evolved further in the 1970s and 1980s, jurisdictions began to require on-site **detention** of runoff from new developments. Detention methods—such as ponds—were intended to hold water in place temporarily in order to reduce peak flows, flooding, streambank erosion.

Interest in stormwater *quality* was spurred by the Federal Water Pollution Control Act Amendments of 1972 (Public Law 92-500) (commonly known as the Clean Water Act), which recognized the significance of nonpoint source pollution. Section 208 of the Act required the development and implementation of area-wide pollution-management plans including both point-source and nonpoint-source programs. As part of Virginia's statewide 208 planning, the state developed a set of **best management practices (BMP)** manuals in the late 1970s. The manuals provided guidance on selection and design of BMPs, as well as information on regulatory authority, incentives, and sources of federal, state, and local support. The state did not develop regulations requiring BMP implementation, relying instead on voluntary compliance and local action to implement BMPs.

In 1987, Congress amended the Clean Water Act to require the implementation of a comprehensive program addressing stormwater discharges. Phase I, promulgated in 1990, requires National Pollution Discharge Elimination System (NPDES) permits for stormwater discharges from major stormwater sources. Those regulated under Phase I include "municipal separate storm sewer systems"[4] serving populations of 100,000 or more, several categories of industrial activities, and construction sites exceeding five acres.

In Virginia, the Department of Environmental Quality (DEQ) administers the NPDES program, here known as the Virginia Pollutant Discharge Elimination System (VPDES). A stormwater discharger is required to develop and submit a permit application to the DEQ for its review. If the application is acceptable, DEQ issues the discharger a VPDES permit, typically for five years. The permit usually specifies activities—such as refinements to the stormwater management program—to be completed during the permit period.

Even before the advent of federal regulation of stormwater, a number of jurisdictions in Virginia and elsewhere had identified the need to protect receiving waters from stormwater pollution. Many Virginia jurisdictions require BMPs (such as detention ponds) as part of their stormwater-drainage requirements. Some jurisdictions have developed manuals to assist developers in selecting appropriate BMPs based on a development's size, density, soils, and other factors.

The Virginia Department of Conservation and Recreation (DCR) is responsible for managing the statewide nonpoint-source pollution program, part of which is stormwater management. The DCR's stormwater authority comes from the Virginia Stormwater Management Act (*Va. Code* 10.1-603.1 *et seq.*), passed in 1989 and most recently amended in 1994; and from state stormwater management regulations (4VAC3-20-10 through 4VAC3-20-251), most recently amended in 1998. The state legislation and regulations specify the "minimum technical criteria and administrative procedures" for stormwater-management programs by state agencies and localities. The stormwater management law and regulations require that programs also follow the requirements of the Virginia Erosion and Sediment Control Law (*Va. Code* 10.1-560 *et seq.*), passed originally in 1973 and most recently amended in 1996.

New Developments

The most recent institutional action on stormwater management is Phase II of the federal stormwater regulations. The final rule (published by the U. S. Environmental Protection Agency [EPA] in the December 8,

[4] These are frequently referred to as "MS4s" in regulatory and planning documents.

1999, issue of the *Federal Register*[5]) expands the program to smaller urban municipalities with populations of less than 100,000, as well as to construction sites of one-to-five acres.

Phase II focuses on the nonpoint source pollution impact of stormwater. As the Phase I regulations did for larger municipalities, the Phase II rule requires smaller municipalities to implement the following "minimum measures" for controlling stormwater pollution:

- **public education and outreach** on stormwater impacts and the steps necessary to reduce stormwater pollution;
- **public involvement and participation** in implementing stormwater management;
- **an illicit-discharge detection and elimination program**, including ordinances prohibiting illicit sewer connections or discharges (including dumping), creation of sewer maps, and public education on the hazards of illicit discharges;
- **a construction-site stormwater runoff control program** for construction activities on land disturbances of one-to-five acres;
- **post-construction stormwater management program** for new developments and redevelopment; and
- **pollution prevention/ "good housekeeping" program for municipal operations**.

The Phase II regulations will not require any substantial activity on the part of the newly regulated entities for several years. EPA will first prepare a "model" permit as guidance to cities and towns on how to comply with the new regulations; the deadline for this model permit is October 2000. In addition, EPA will issue a menu of appropriate BMPs for stormwater control, which also has a deadline of October 2000. Review of the BMPs, as well as of a guidance document on measurable goals for communities covered under Phase II, is due by October 2001. Actual permit applications for the newly regulated entities will not be required until January 2003.

[5] Internet users can read the rule at **www.epa.gov/owm/sw/phase2**.

Stormwater Management Practices and Implementation

Peak Flows and Design Storms

In planning and engineering for control of stormwater, jurisdictions typically require that a development not increase the **peak flow** above the pre-development level for one or more **design storms**. Design storms are used to predict *how much rainfall* is statistically likely in a given *location*, in a certain *amount of time* (one hour, six hours, 24 hours, and so forth), and with what *frequency* (every year, every two years, every ten years, and so forth). (Please see the following page on "How to 'Design' a Storm.") Stormwater engineers and planners then determine the expected peak flow from such as storm, given the existing (pre-development) land uses. Finally, they use design calculations and computer modeling to determine the detention storage needed to maintain the peak *post*-development flow rate at the pre-development level. For flooding and road overtopping, 10-year and 25-year design storms are typically used, but in some cases 50-year and even 100-year storms are used. The two-year design storm is often used for streambank-erosion control.[6]

Though these requirements may protect against stormwater impacts locally, they may not fully protect downstream receiving waters. For a single development site, one effect of reducing the post-development peak flow rate to pre-development levels is to increase the time during which the runoff rate is at or near the pre-development peak. Consequently, the time during which receiving streams experience relatively high flows also increases. Furthermore, when a stream receives stormwater flow from *several*

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[6] The selection of the two-year design storm for erosion control is based on research indicating that the bankful condition for streams in rural areas is typically related to a storm of 1.5 to 2 years. The assumption is made that maintaining post-development flow at pre-development peak for a 2-year design storm will not increase the frequency of bankful conditions, and therefore will not significantly increase the *natural* rate of erosion.

How to "Design" a Storm

Long-term data on rainfall depth, rainfall duration, and distribution of the rainfall over the duration of the event are used to develop **design storms**. For example, the table below shows the largest rainfall likely (based on historical averages) to occur in a 24-hour rainfall in Virginia within any given 2-year, 10-year, or 100-year period. These amounts and recurrence periods, however, indicate only the *average* frequency of the given storm; a given storm of any size could occur in *any* year.

Maximum expected rainfall amounts in 24 hours for given recurrence periods in Virginia

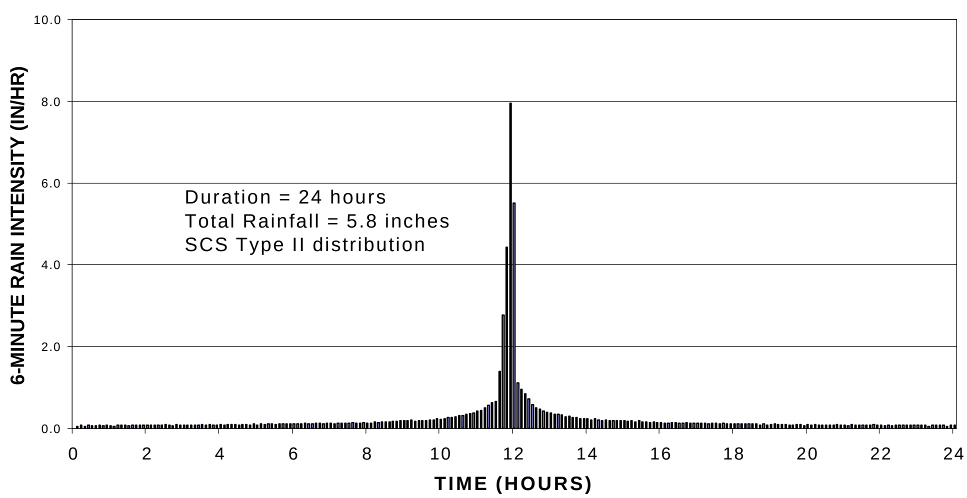
	2-year recurrence period	**10-year recurrence period**	**100-year recurrence period**
Range[1] of rainfall amounts (approximate)	3—4.5 inches	4.5—6.5 inches	5.5—9 inches

[1]Generally the maximum expected amount increases from west to east across the state, although parts of the state's western mountains also average higher amounts.

Source: *Rainfall Frequency Atlas of the United States*. 1961. U. S. Weather Bureau (now National Weather Service) Technical Paper 40, Washington, D. C. Cited in A. T. Hjelmfelt, Jr., and J. J. Cassidy, 1975, *Hydrology for Engineers and Planners*, Iowa State University Press, Ames, pages 66-70.

The *amount* of rainfall is not the only important aspect in a design storm; the *timing* of the rainfall is just as important. The amount of rainfall in a given time is known as rainfall **intensity**. Intensity is not constant during a storm, so long-term data have been used by the Soil Conservation Service (now the Natural Resource Conservation Service, or NRCS) to predict rainfall **distributions** for given storms. The graph below shows a predicted distribution for a rainfall of 5.8 inches over 24 hours. Virginia's stormwater-management regulations (4VAC3-20-60) call for the use of NRCS-recommended rainfall distributions in specifying design storms.

EXAMPLE OF DESIGN STORM



The design-storm information is used to identify the *expected peak flow* from a storm of a given *duration*, at a given *location*, and with a given *recurrence period*. Because they are based on available records (which are sometimes incomplete) and on averages, design storms are not perfect predictors. Nature often operates at the extremes.

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development sites, the peak instream flow will probably increase, even though the stormwater requirements were met on the *individual* sites.

For these reasons, some jurisdictions have developed alternative design-storm requirements. The state of Maryland, for example, requires the control of runoff from the *one*-year storm. Meanwhile, the Metropolitan Washington Council of Governments estimated in 1987 that bankful flows could occur two-to-eight times per year in urbanized areas using the typical two-year design storm requirement. The agency therefore recommended stormwater managers use a one-*inch* design storm for streambank-erosion control.

Best Management Practices (BMPs)

Anyone who has passed by a construction job in progress has probably seen a silt fence: black plastic stretched out at the bottom of a slope to stop soil from being carried to a nearby waterway. Silt fences are commonly used (though not always very effectively) as an erosion-control BMP. The term "BMP" refers to a broad range of such activities designed to reduce the impact of land uses on water resources.

BMPs include both "structural" activities—such as ponds constructed to hold stormwater—and "non-structural" activities. **Non-structural BMPs**, according to the *Federal Register* notice on the Phase II stormwater rule (page 68760), are "preventative actions that involve management and source controls," such as policies that require vegetative buffers along streams or educational programs on how to reduce water-quality impacts. The Phase II rule (pp. 68759) states that regulated small stormwater systems should implement "a combination of structural and/or non-structural…BMPs" to manage stormwater from new developments.

Virginia's stormwater regulations (VAC3-20-71) list 13 "appropriate BMPs" to protect water quality, including vegetated filter strips, grassed swales, constructed wetlands, detention basins, and structures to increase infiltration. The regulation also allows "innovative or alternative BMPs not included in [the regulation]…at the discretion of the local program administrator or [the DCR]."

Mostly a Local Job

Traditionally, stormwater management programs have been implemented by local jurisdictions through storm-drainage and BMP requirements for new developments. The developer submits a plan for meeting the local requirements, and development cannot proceed until the plans have been approved by the jurisdiction. This approach presumes that downstream quantity and quality impacts will be minimal if the requirements are met. If adverse impacts do occur downstream, in spite of the on-site controls, the jurisdiction is responsible for mitigating those impacts, provided that the on-site controls have been properly designed, constructed, and maintained.

Some jurisdictions have chosen a "master-plan" stormwater approach instead of the more piecemeal process of isolated on-site controls. This approach emphasizes the evaluation of stormwater impacts on a *watershed* basis, which is encouraged by the new Phase II stormwater rules from EPA. Computer modeling can be used to characterize existing and future conditions in the watershed, to evaluate the cumulative impacts of development, and to evaluate alternatives for minimizing stormwater impacts on receiving waters. For example, a watershed approach lends itself to regional stormwater facilities that can offer several benefits, including fewer individual structures to maintain.

Who Pays?

Alternatives for financing stormwater management can generally be divided into two categories: *participatory* and *non-participatory*. Participatory mechanisms allocate costs based on usage—that is, on contribution to stormwater runoff. Examples of participatory mechanisms include impact fees, stormwater utilities, special assessments, and developer financing for on-site controls. Non-participatory mechanisms, by contrast, do not allocate the costs based on usage; examples are using a jurisdiction's general fund or long-term borrowing.

Traditionally, on-site controls for stormwater quantity and quality have been financed by developers. In a residential development, the cost of constructing a stormwater facility would be included in the sale price of the new residences. Maintenance costs are borne by the party responsible for the facility, typically a homeowners' association for residential property or the property owner for commercial or industrial properties.[7]

One financing strategy gaining popularity is the stormwater utility. These utilities set up a dedicated funding source and administrative structure for managing stormwater, thereby increasing the likelihood that stormwater planning and implementation will be funded and completed. Property owners pay a monthly or quarterly fee that can cover both the construction and maintenance of stormwater management facilities. Typical monthly charges are $2 to $6 per month for single family residential land uses, with commercial and industrial charges based on the amount of increased impervious surface. Virginia jurisdictions with stormwater utilities include Prince William County and the cities of Chesapeake, Hampton, Newport News, Norfolk, Portsmouth, and Virginia Beach.

Conclusion

Stormwater management practices are designed to control the impacts of stormwater runoff from developed areas. Stormwater management is typically done on a local level, but federal and state law and regulations since 1990 have set minimum requirements for large municipalities, construction sites larger than five acres, and industries.

By the year 2003, localities serving as few as 1000 people will be joining their large-population colleagues in the federal and state "climate" of required stormwater management. In preparing their stormy-weather plans, smaller localities might do well to consider a stormwater master-plan approach applied on a watershed basis. They might also want to examine the stormwater-utility experiences of their big-city neighbors. The stormwater-regulation "cloud" is coming, but smaller localities have some time to put their rainy-day plans in place.

By Rich Wagner, environmental engineer at Camp Dresser & McKee in Annandale, Va.

The opinions expressed in the article do not necessarily reflect those of Camp Dresser & McKee. Water Central *thanks Melanie Pesola, of the Norfolk Division of Environmental Stormwater Management, for providing information for this article.*

For More Information

•"When Best Management Practices Become "Bad Management Practices." By Jerald S. Fifield, in *Land and Water*, Sept.-Oct. 1999, Fort Dodge, Iowa. This article discusses how BMPs can be used more effectively.

•The *Virginia Stormwater Management Handbook*, intended to be a comprehensive document for local governments beginning a stormwater program, is available from the Va. DCR for $45.00. Approximately 900 pages in two three-ring binders. To order: Va. DCR/Div. Soil/Water Cons., Att. Cashier, 203 Governor Street, Suite 402, Richmond, 23219; make check or money order to Treasurer of Va.; no cash, please!

•*Methods for Measuring and Assessing Nonpoint Source Pollution Control at a Regional Stormwater Management Facility*, published by the Water Center in 1998, has a good introduction to stormwater management issues and facilities. Single copies are free to Virginia residents while the supply lasts; there is a small charge for out-of state residents. To request a copy: (540) 231-5624; e-mail: water@vt.edu.

•The Va. DCR Stormwater Management Program Web-site is www.state.va.us/~dcr/sw/stormwat.htm.

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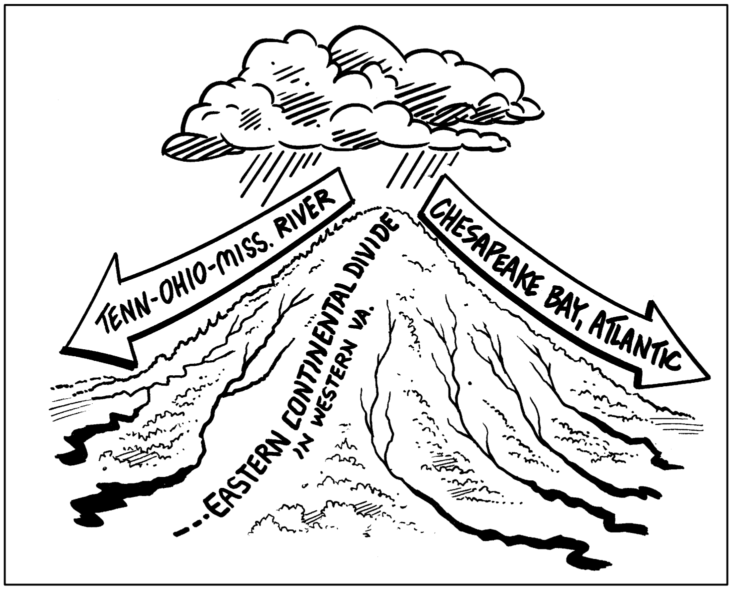
[7] Virginia's stormwater regulations state that "All stormwater management facilities shall have a maintenance plan which identifies the owner and the responsible party for carrying out the…plan." (4VAC3-20-60)

SCIENCE BEHIND THE NEWS

Divide and Confluence

If your child came home from school talking about "adopting a watershed," how much would you know about your potential new "pet"? According to a 1998 survey of 2000 people, 41 percent of U. S. adults would know that a **watershed** is "an area of land that drains into a specific body of water."[8] Many people might also know that watersheds are also called **basins**, **catchments**, or **drainage areas**. A few would even know that in England and Canada, the word "watershed" means the mountain ridge or other and feature that separates water flow between adjacent basins—that is, what in the United States is generally called a **divide**.



Despite this trans-Atlantic disagreement, it's not so hard to define "watershed" in a general way. But any *specific* watershed has its own particular features. Moreover, just as one stream joins another at the streams' **confluence**, so too does the larger stream's watershed incorporate the features of the smaller stream's basin.

Watersheds are a complex mix of components and interactions occurring between divides and points of confluence.

Many Components Make for Variety and Complexity

Components related to land, water, air, and organisms (including, of course, humans) are the ingredients for any given watershed. Differences among watersheds and complexity within individual watersheds result not only from great variety existing among the basic components, but also from countless *interactions* of these components over time. The following subsections use these four basic components to describe the variety and complexity found in watersheds.

Land

A watershed's land features start with an area's **geology**: rocks, minerals, soils, and underground structures. Over millions of years, geological processes combine with climate to create an area's **topography**, the elevations of the land surface. Topographical divides determine a watershed's boundaries and consequently its size. Another key topographical feature is the location and gradient of slopes, which in turn affect such things as the size of flood plains and the location of swampy lowlands.

A watershed can be quite small (such as a few square miles in a small stream basin) or very large, such as the one-million-plus square miles in the Mississippi River Basin. The area of the 14 large-river watersheds within Virginia range from 118 square miles of the Yadkin River Basin (only a small part of which is in the state) to over 10,000 square miles in the James River basin (which is entirely within Virginia). For comparison, Virginia as a whole covers 42,777 square miles.

Water

All surface-water features exist within a watershed. Virginia's surface-water features include rivers and streams; lakes (including reservoirs created by dams) and ponds; coastal and estuarine waters, such as the Chesapeake Bay; marine waters (in the Atlantic Ocean Basin); and the water in seasonal and perennial wetlands. Groundwater is a complicating factor. It interacts significantly with surface waters, and the pattern of groundwater flow can be quite different from the surface-flow patterns of the watershed(s) directly above.

The watershed of a given body of water includes the watersheds of all the tributaries to that body of water. The James River Basin, for

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[8]*National Report Card on Environmental Knowledge, Attitudes and Behaviors.* National Environmental Education and Training Foundation, Washington, DC, December 1998.

Who's Talking about Watersheds?

•"Watersheds. You rarely heard about them before, but now [the word's] there, somewhere, almost every week." *Drinking Water—Understanding a Resource*, published by the University of Nebraska in 1999.

•"The Secretaries of the Departments of Agriculture, Interior, Commerce, and Defense, and the Administrator of EPA, in cooperation with states and tribes, will convene a National Watershed Forum to coordinate watershed assessment, restoration, and protection." Federal Clean Water Action Plan, 1998.

•"Many factors are converging to cause citizens, scientists, resource managers, and government decision makers to [use] watershed management as an approach for addressing a wide range of water-related problems." National Research Council, 1999.

•"Thousands of people are working to protect and restore their watersheds. As of October 20, 1999, this database [contained] 5,527 groups…." U. S. EPA's "Adopt-a-Watershed" Web-site, February 2000.

•"There is a tremendous amount of watershed-based activities in Southwest Virginia, though much more is needed." "Watershed Protection Strategies," at the Southwest Virginia Water Symposium, October 1998.

•"[The Department assists] with the establishment and support of community-based committees in watersheds having water-quality problems from nonpoint pollution sources." Virginia Department of Conservation and Recreation Web-site, February 2000.

•"An 18-item Watershed Action Plan has been developed by [the Virginia Department of Environmental Quality] in cooperation with the Elizabeth River Project, a private partnership of citizens, businesses, and local governments." Va. DEQ Web-site, February 2000.

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example, has about 120 **sub-watersheds** large enough to have a Hydrologic Unit Code, or HUC (please see the "Identifying Watersheds by Numbers" box on the following page). The Appomattox River, a main tributary of the James, has 17 sub-watersheds itself. Overall, Virginia has 53 numbered watersheds, with many more sub-watersheds too small to be numbered (but not too small to be of local importance). There are 2262 numbered watersheds in the United States.

Air

Through climate and weather, the atmosphere is the ultimate source of all water within a watershed. This fundamental relationship may seem obvious, but it carries a less-obvious consequence. Not only does the atmosphere affect the *quantity* of water in a watershed, it also can significantly affect what the water contains—that is, the water *quality*. Air deposition of chemicals is a significant part of at least two current watershed issues in Virginia: acidification of streams in western Virginia and excess nitrogen in the Chesapeake Bay.

Flora and Fauna

Watersheds are different in part because of their inhabitants: plants, animals, algae, bacteria, fungi, and other living things. The converse is also true for many organisms: communities of living things are different in part because of the watershed that surrounds them. Living things are adapted to a set of local environmental conditions, but those local conditions are affected by conditions elsewhere in the watershed. The 1999 report from the National Research Council, *New Strategies for America's Watersheds*, provides an example:

> "Over geologic time periods, fish populations evolved in response to prevailing watershed conditions, including seasonal variations in flow, sediment concentrations, streambed particle sizes, riparian vegetation, and water chemistry." (Page 27)

Some watersheds contain unusual natural environments and rare, even unique, biological communities. Three examples follow, from the Web-site of the Va. Natural Heritage Program.

•Bald Cypress-Water Tupelo *swamps* along southeastern Virginia rivers, such as Blackwater Run, Nottoway River, and Meherrin River (all in the Chowan/Albemarle Sound Basin). "[They] contain some of the *largest and most impressive trees*…in the eastern United States."

•The rivers of the Upper Tennessee Basin (in the Tennessee-Ohio-Mississippi Basin) in southwestern Virginia are "home to one of the world's richest concentrations of *freshwater mussels*…."

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Identifying Watersheds by Number

Hydrologic Unit Codes, or HUCs, are a nationwide system used by the U. S. Geological Survey and other water-resources professionals to designate watersheds. Within the United States are 21 watershed **regions**, 222 **sub-regions**, 352 **accounting units**, and 2262 **cataloguing units**. An HUC consists of two digits for each level. A six-digit accounting unit and an eight-digit cataloguing unit generally refer to a basin and sub-basin, respectively. Here's an example:

02070001 is the HUC for the South Branch of the Potomac River in West Virginia.
02 = Mid-Atlantic Water Resource Region;
07 = sub-region;
00 = Potomac River Basin, or accounting unit, within the sub-region;
01 = sub-basin, or cataloguing unit, within the Potomac River Basin.

Source: U. S. EPA "Surf Your Watershed" Web-site: www.epa.gov/surf3/; February 2000.

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•"Virginia's few remaining *wet prairies* are located primarily along the floodplain of the South River in Augusta County (in the Shenandoah-Potomac Basin)…These fascinating marshy communities are more typical of the Midwest than the East."

Humans

Besides water and land themselves, people are, of course, the dominant feature of all of Virginia's watersheds. People use and affect land, water, air, and biological resources—all the other components of watersheds. Certain human activities, though, relate more directly than others to watersheds. The following watershed issues relate to people's reliance on watersheds, attempts to understand them, or need to manage them:

water supply; water quality; floodplains; urban stormwater; wetlands; surface-water recreation; fisheries; rare and endangered species; agricultural and forestry practices; and scientific research.

A number of relatively intangible human factors are also significant components of watersheds. Publications about watershed programs mention such influences as local history and culture, attitudes about the use of land and water resources, and knowledge of the watershed. Perhaps the most important intangible factor is the degree to which people living in the same watershed recognize a shared predicament.

Measuring Components to Describe Watershed "Health"

As mentioned above, watershed components interact and that interaction contributes to making watersheds both complex and different. But most people probably don't care too much about whether their watershed is complex or different. They're more likely interested in the watershed's "health."

A valuable Internet resource for learning about watersheds and their relative health is the U. S. EPA's "Surf Your Watershed" Web-site, at www.epa.gov/surf3/. At this site, a person can find information and data on land, water, air, and people within their own watershed. A prominent part of the information is the **Index of Watershed Indicators**, or **IWI**. The IWI is a process for describing the health of the aquatic resources in a watershed. The IWI rates watershed health based on current *conditions* within the watershed and the *vulnerability* of the watershed to pollution or other activities.[9]

Using available data (the Web-site identifies the sources used for each component), the various components are incorporated into formulas for the overall IWI. The IWI scale ranges from 1 ("better water quality/low vulnerability") to 6 ("more serious water-quality problems/high vulnerability"). The table below gives three examples of IWI ratings for Virginia watersheds.

Va. Watershed (with HUC)	IWI Rating
Middle Potomac-Catoctin Creek (02070008)—No. Va./So. Md.	4 = "less serious problems/high vulnerability"
Middle Roanoke (03010102)—Central Va. and N. C.	1 = "better quality/low vulnerability"
Lynnhaven-Poquoson (02080108)—SE Va.	3 = "less serious problems/low vulnerability"

[9] Condition components include state water-quality data; fish/wildlife advisories; source-water-quality indicators; contaminated sediments; and wetland loss index. Vulnerability components include aquatic or wetland species at risk; pollutant measurements above limits; urban-runoff potential; agricultural-runoff potential; population change; hydrologic modifications; estuarine-pollution susceptibility; and atmospheric deposition.

Triple-A for Watershed Work

This article has tried to answer the question of what one finds in watershed. A considerably more complicated question is, "What *happens* in a watershed?" Answering that question is a geological, hydrological, biological, and sociological challenge.

A somewhat easier question is, "What are people doing about watersheds?" From the sources used for this article, three themes emerge:
- *assessment*—monitoring water-quality, estimating the impacts of land uses, and other ways to determine watershed conditions;
- *awareness*—everything from teaching about watersheds in K-12 education to efforts to inform stakeholders of public policy developments;
- *action*—the range of activities by agencies, industries, Adopt-a-Watershed groups, and others to protect, restore, or manage better the land and water resources within a watershed.

Coordinating these three areas is part of the challenge of managing land and water resources on a watershed basis. Water-related news will continue to reflect such challenges posed by complex and distinctive watersheds.

References and More Information

National Research Council. 1999. *New Strategies for America's Watersheds*. National Academy Press, Washington, D.C. 311 pages.

"The Rappahannock River." *Virginia Explorer*, Summer 1999, Va. Museum of Natural History, Martinsville/Blacksburg/Charlottesville.

The James River in 21st Century: Proceedings of a conference held in November 1996; and *Southwest Virginia Water Symposium*: Proceedings of a conference held in October 1998.

Both are Water Center publications. Single copies are free to Virginia residents while the supply lasts; there is a small charge for out-of state residents. To request a copy: (540) 231-5624; e-mail: water@vt.edu.

Virginia "River of Words" Program booklet. Includes basic information on watersheds, with correlation to Virginia's Standards of Learning for grades 3-6. For a copy, call (800) 592-5482.

"Elements of Water and Soil Management." A 21-video series produced by Cornell University. To enquire: A-V Resource Center-WR, 7 Cornell Business & Technology Park, Ithaca, NY 14850; (607) 255-2090;
e-mail: Dist_Center@cce.cornell.edu.

The Water Center has two videos from the Cornell series : "Watershed Management in Virginia" (1995) and "Watershed 1996" (with segments on watersheds in Rhode Island, Wisconsin, Idaho, and Texas). To borrow a videotape for a two-week period: 540) 231-5624; e-mail: water@vt.edu. No fee, but the borrower is responsible for the return postage.

TEACHING WATER
For Virginia's K-12 teachers

This Issue and the Virginia Standards of Learning

In this section, *Water Central* suggests Virginia Standards of Learning (SOLs) that the Feature and Science parts of this issue may support. We welcome readers' comments on whether the articles actually do, in fact, help teachers with the standards listed or with others.

Abbreviations: **BIO**-biology, **ES**-earth science, **LS**-life science.

Feature Article—Urban Stormwater
Science SOLs: ES.9 ; BIO.9.
Social Studies SOLs: 10.2, 10.8, 10.10, 12.6, 12.8, 12.9, 12.16.

Science Behind the News—Watersheds
Science SOLs: 4.8, 6.9, LS.7, LS.12, ES.7, ES.9, BIO.9.
Social Studies SOLs: 10.2, 10.9, 10.15.

Virginia Watersheds Poster

Virginia's Watersheds, a well-done and colorful map poster, is available from the Virginia Department of Conservation and Recreation (DCR). The two sides of the 34"x 22" poster show different views of Virginia's major watersheds. One side, useful for water-resources professionals, has a detailed, color-coded depiction of 14 large watersheds and their sub-watersheds. The other side also color-codes the watersheds, but it is less detailed and more appropriate for students and a general audience. The map includes a list of related Virginia Standards of Learning. For a free copy, call the DCR, toll free, at (877) 42-WATER (that's 429-2837).

IN AND *OUT OF* THE NEWS

Newsworthy Items You May Have Missed

The following summaries are based on information in the source or sources indicated at the end of each item. Selection of this issue's items concluded February 1. Unless otherwise noted, all localities mentioned are in Virginia. If you have access to the Internet, you can follow water-related news with the "Daily News Update" at the Water Center's Web site (www.vwrrc.vt.edu).

In Virginia...

•**Only 15-30 percent of people changing their own automobile oil in Virginia recycle the oil**, according to a study by the Northern Virginia Planning District Commission (NVPDC) in Annandale. The study, conducted for the Va. Department of Environmental Quality (DEQ), estimated that 3-4.5 million gallons of used oil and about one million gallons of used antifreeze are improperly disposed of annually. The study recommended re-establishment of a state-wide oil-recycling program. At the 2000 General Assembly, the Senate carried over until 2001 a bill (SB 704) that would require the DEQ to implement some oil-recycling promotion activities.

The NVPDC has also been investigating **laundry-brightener monitoring**, an inexpensive screening tool to detect wastewater contamination in stormwater. Cotton is used to absorb water at a stormwater outfall; if brighteners—which are invisible to the naked eye—are present, they show up under an ordinary black light. Their presence indicates that wastewater has entered the stormwater system, rather than being restricted to the sanitary-sewer system. (NVPDC's *NVironment* newsletter, Summer/Fall 1999).

•In December 1999, the DEQ identified the BGF Industries **fiberglass plant in Altavista** (Campbell County) as a **likely source of polychlorinated biphenyl (PCB) contamination in the Staunton River**. A DEQ staff member said that there were probably also many other sources of the contamination. The Va. Department of Health (VDH) fish-consumption advisory for the river now covers an 80-mile segment beginning at the Leesville Dam upstream of Altavista. (VDH press release, 12/2/99, and *Lynchburg News & Advance*, 12/22/99)

•The **Virginia Supreme Court will hear a right-to-farm case** brought in December by Amelia County farmers. The farmers had obtained Va. Health Dept. permits to apply treated sewage sludge—also called "biosolids"—on their cropland, but the county board of supervisors passed ordinances preventing land application of treated sludge. (*Va. Farm Bureau Federation News*, Dec./Jan. 1999).

•Va. Governor James Gilmore has begun an **environmental-education initiative** called Virginia Naturally 2000. The initiative was announced in the governor's State of the Commonwealth speech on January 12. It got underway with forums in January and February to outline the program to a large number of environmental educators. A House joint resolution (HJR 301) in the 2000 Va. General Assembly would designate the program as "the Commonwealth's official environmental education initiative." The initiative will be coordinated by the Virginia Resource-Use Education Council. People interested in participating in the initiative should contact the Council chair, Ann Regn, at (804) 698-4442; e-mail: amregn@deq.state.va.us.

•On December 8, 1999, the executive council of the Chesapeake Bay Program released the first public draft of **Chesapeake 2000**, by which the Bay Program partners seek to renew the 1987 Chesapeake Bay Agreement. The public comment period on the draft agreement runs until March 31. For more information or to comment, call the Bay Program, toll-free, at (800) 968-7229; or use their Web-site at www.chesapeakebay.net. (*Bay Journal*, Jan.-Feb. 2000)

•As part of the Chesapeake Bay restoration effort, participating states are to develop **tributary strategies**: plans for reducing nutrients and sediments in the rivers that flow to the Bay. Virginia's plan for the **James River** was presented by the Department of Conservation and Recreation (DCR) in a series of public meetings in January and February 2000. A public comment period runs until March 10. For more information or to comment, contact Mark Bennett at the DCR, (804) 371-7485; e-mail: mbennett@dcr.state.va.us. The James River document is available on-line at www.state.va.us/~dcr/sw/index.htm. (*Richmond Times-Dispatch*, 1/24/00)

•**Inadequate oversight of some small wastewater facilities** is attracting state-level attention. In September 1999, untreated sewage contaminated a Henry County creek after the electricity to a small sewage-treatment facility (serving 160 homes) was cut off for non-payment. Now, State Sen. Roscoe Reynolds of Henry County has sponsored a bill (SB 117) that would require owners of small sewage-treatment facilities (less than 40,000 gallons/day) to have a plan to prevent any contamination if the facility ceases operation, and to assume financial responsibility for correcting failures. As of February 1, the bill had passed the Senate and was in committee in the House of Delegates. (*Roanoke Times*, 1/25/00; and Va. Legislative Information System)

…and Elsewhere

•**Sea-level rises** in Maine, Maryland, and Hawaii currently average about 0.1 inch per year (close to one foot per century). Is this a lot, historically? Is the yearly rise increasing due to global warming? These questions are being hotly debated, and we certainly don't have the answers! But the December 1999 issue of *Coastlines* has an informative introduction to the topic and the related issue of coastal erosion. The bimonthly newsletter is published by the Urban Harbors Institute, UMass-Boston; (617) 287-5570; e-mail: coastline@umb.edu.

•A Wisconsin state court approved a $1.5 million settlement in a citizen lawsuit against **Milwaukee** and a private company following the **1993 outbreak of the microbial pathogen *Cryptosporidium*** in the city's drinking water. Over 100 people died and about 400,000 became ill. The city has spent $90 million to install ozone disinfection, which is more effective against the microbe than chlorine-based disinfection. (*Inside EPA's Water Policy Report*, 12/9/99)

•**Lobster-catch rates in Long Island Sound** have decreased some 90 percent since Summer 1999. A parasitic disease is suspected. New York is the country's 3rd-largest lobster-production area, behind Maine and Massachusetts. (*Associated Press*, 12/10/99)

•A new alien aquatic species, the "**fishhook flea**" has become established in Lake Ontario, Lake Michigan, and New York's Finger Lakes. The "fleas" are small fishhook-shaped crustaceans with a tail-spine several times the length of their body. The species is native to the Caspian Sea, Black Sea, and other Central Asian waters. They apparently reached Lake Ontario in August 1998 in a ship's ballast water. They can be spread from one water body to another relatively easily because they can attach to ducks. Occurring in large numbers, the animals foul fishing lines and nets; scientists also fear they could compete with young fish for food. Fishhook fleas are only a part of the large problem of alien aquatic species, which cause an estimated $123 million in damage annually. (*Washington Post*, 1/17/00) [**For a previous item on alien aquatic species, please see the December 1999 *Water Central*, p. 8**]

•The **Maryland oyster harvest** increased from 80,000 bushels in 1993-94 to 423,000 bushels last season. At one time, the Maryland harvest averaged over two million bushels, but two parasitic diseases have drastically reduced oyster populations in Maryland and Virginia both. The recent improvement is evidence that Bay oysters *may be* starting to overcome the diseases, at least in Maryland's waters. (*Washington Post*, 1/18/00)

•Since October 1, 1999, all wastewater collection and treatment systems in **North Carolina** must report all **sewage spills and overflows**. This may lead to additional scrutiny not only of wastewater facilities but also of what people put down their household drains. Many of the overflows—up to 50 percent in the Charlotte area, for example—are due to grease blockages resulting from oil and grease from household drains. (*Charlotte Observer*, 1/23/00)

•**Water resources** are apparently not a high priority for the more than **140 presidential candidates** (that's right—over 140 candidates have officially filed with the Federal Election Commission). The non-profit organization Project Vote Smart has compiled a database of over 1000 major public speeches and other public statements from about 60 of these candidates; our search for "water resources" on February 9 generated **only three references**. The searchable database is updated daily and is available via the Internet at **www.vote-smart.org**. People without Internet access can request a database search by calling the Voter's Research Hotline, toll-free, at (888) 868-3762.

•Finally, here's **a Roanoke resident's witty opinion** on the local water-supply situation, as quoted in *The Roanoke Times*, 12/17/99: "[I]f everybody rushes out and goes crazy [using water] and we don't get the rain and snow we need this winter, we'll be back in the same boat—or *no boat at all* because there won't be any water."

N O T I C E S

On the Public Calendar

•**March 21**—Groundwater Protection Steering Committee meeting, 9 a.m., Va. Department of Environmental Quality Central Office, Richmond. For more information: Mary Ann Massie, (804) 698-4042; e-mail: mamassie@deq.state.va.us.

William & Mary School of Law's Environmental Symposium

The focus of this fourth-annual symposium will be "Water Rights and Watershed Management: Planning for the Future." **March 31—April 1** in Williamsburg. For more information: Sarah Richardson or Brian Perron, (757) 221-3802; e-mail: envlaw@wm.edu.

Environment Virginia 2000

The 2000 version of this annual conference will be held **April 5-6** at Virginia Military Institute in Lexington. For more information: Ron Erchul, (540) 464-7331; →www.vmi.edu/ev.

State of the Chesapeake Bay Report

This is an annual report from the Chesapeake Bay Program. This year's 58-page report, issued in January 2000, is available from the Bay Program at (800) 968-7229; →www.chesapeakebay.net.

Remember Hurricane Bonnie?

The impact on Virginia and North Carolina of this August 1998 storm is described in a "Quick Response Report" (QR112) by the Natural Hazards Center in Boulder, Colorado. Other quick-response reports, as well as many other natural-hazard publications, are also available. For more information: NHC, Campus Box 482, University of Colorado, Boulder, CO 80309-0482; (303) 492-6818; e-mail: hazctr@colorado.edu; →www.colorado.edu/hazards/.

At the Water Center

•A $40,000 grant has been received from the Virginia Tech *ASPIRES* Program for "Developing an Outdoors Watershed Research Laboratory: **The Stroubles Creek Initiative**." The project's goal is to develop an on-campus watershed laboratory for research and demonstrations. For more information: Tamim Younos, (540) 231-8039; e-mail: tyounos@vt.edu.

•**Funding Opportunities for Year 2000:**
1. Seed Grants;
2. Competitive Grants;
3. William R. Walker Graduate Research Fellowship Award.

The deadline to apply for all of these programs in **March 30**. For more information: Tamim Younos, (540) 231-8039; e-mail: tyounos@vt.edu; → www.vwrrc.vt.edu.

•**Service Training for Environmental Progress (STEP)**. Each summer, STEP places college students (this year's juniors, seniors, and graduate students) in Virginia communities for 8-week, water-related projects. This year, STEP hopes to place six students in three communities June 12—Aug. 3. Students receive wages and a work-expense budget; communities provide housing, food, and local supervision. Student applications due **March 31**; community requests for projects due **April 3**.

For more information: Alan Raflo, (540) 231-5463; e-mail: araflo@vt.edu; →www.vwrrc.vt.edu (click on "Student Opportunities").

•**Call for Papers**—for the **National Water Research Symposium 2000**: Advances in Water and Land Monitoring Technologies and Research for Management of Water Resources. Nov. 8-10, 2000, at Virginia Tech in Blacksburg. Submit abstracts (500-750 words) by May 30 to Tamim Younos, 10 Sandy Hall (0444), Blacksburg, VA 24061; Fax: (540) 231-6673, e-mail: tyounos@vt.edu. For more information: →www.vwrrc.vt.edu.

CORRECTIONS FROM PREVIOUS ISSUES OF *WATER CENTRAL*

1) December 1999, p. 9: The correct address for the Small Water Systems Web-site is **www.vwrrc.vt.edu/sws**.

2) December 1999, p. 11: The correct e-mail address to request a "Benthic Macroinvertebrates" poster is **mcjudd@deq.state.va.us**.

FOR THE RECORD
Sources for Selected Water Resources Topics

Following the Virginia General Assembly

This page describes how to follow General Assembly legislation and the state budget process. The sources listed contain useful information *all year long*, not only during the legislative session. The 2000 session is scheduled to conclude on March 11; the legislators will reconvene on April 19 to reconsider any bills vetoed by the governor.

Phone-number Formula for Members of the Virginia General Assembly

Delegates' Numbers = (804) 698-10 plus the House district number. For example, Del. Morgan Griffith, 8th District → (804) 698-1008.

Senators' Numbers = (804) 698-75 plus the Senate district number. For example, Senator Madison Marye, 39th District → (804) 698-7539.

Tracking Legislation in General

Citizens can get a copy of any bill or resolution from the Legislative Bill Room, (804) 786-1895 (you will need to know the bill or resolution *number*). Internet users can find legislation easily. For every bill, the Legislative Information System (→leg1.state.va.us) provides the full text, a summary, and a complete record of action on the bill; bills are indexed by subject, number, and committee.

Tracking the Budget Process

In even-numbered years—the first session of a two-year cycle—the General Assembly considers the state's **biennial budget** and **appropriations**. The process begins in the December prior to the session, when the governor submits a proposed budget to the legislature. At the start of the session in January, the House of Delegates and State Senate each begin considering identical **budget bills**, or **appropriation acts**, which make appropriations for the upcoming two-year period. In the 2000 session, those bills are HB30 and SB30 in the House and Senate, respectively. As with other legislation, the work on budget bills occurs primarily in committees: the Appropriations Committee in the House and the Finance Committee in the Senate. Eventually each house will pass a version of the budget bill; the two versions must be reconciled in conference committee and then passed again in each house.

Internet users can read the current budget (and previous years' budgets) and follow the progress of the budget bill at the Legislative Information System Web-site noted above (→leg1.state.va.us).

People without Internet access: don't despair! You can get a copy of the budget from the Bill Room (see phone number above), or at one of the 13 state-depository libraries; call the Library of Virginia in Richmond at (804) 692-3562 to learn the location of your nearest state-depository library. You can follow the budget bill (or other legislation) by calling the Legislative Information *Office* at (804) 698-1500 for the House, (804) 698-7410 for the Senate.

To identify budget items related to a *particular topic* (such as "water"), Internet users can go to the Legislative Information System Web-site, select "State Budget," and type in the specific search topic. Again, people without Internet access can request such information by calling the Legislative Information Office, where staff members can do such a search for you.

People who wish to *register their opinion* with a delegate or senator on the budget or other current legislation can do so by calling (800) 889-0229, toll-free, Monday-Friday from 7 a.m. to 7 p.m. during the General Assembly session.

When all else fails, ask for help from the legislative office of your local delegate or senator (see the phone-number-formula box above).

Water Central thanks Jo Evans, assistant to Delegate James Shuler, and the Library of Virginia for providing information for this section.

Upcoming "For the Record" Schedule

2000

April – Following State Water Regulations
June – Following Federal Water Regulations
August – Water Maps: Types and Sources
October – Drinking-water Information Sources
December – Water-quality Information Sources

2001

February – Water-quantity and Hydrologic Information Sources

Schedule subject to change

Virginia Water Central

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Attention Web-crawlers!

Water Central is available on the Water Center's Web site, **www.vwrrc.vt.edu**. If you prefer to read the newsletter there, *instead of* receiving a paper copy, please send your e-mail address to water@vt.edu, and we will notify you when a new issue is posted.

YOU GET THE LAST WORD

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

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

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

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

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

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

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

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