

Virginia Water Central

Virginia Water Resources Research Center Blacksburg, Virginia

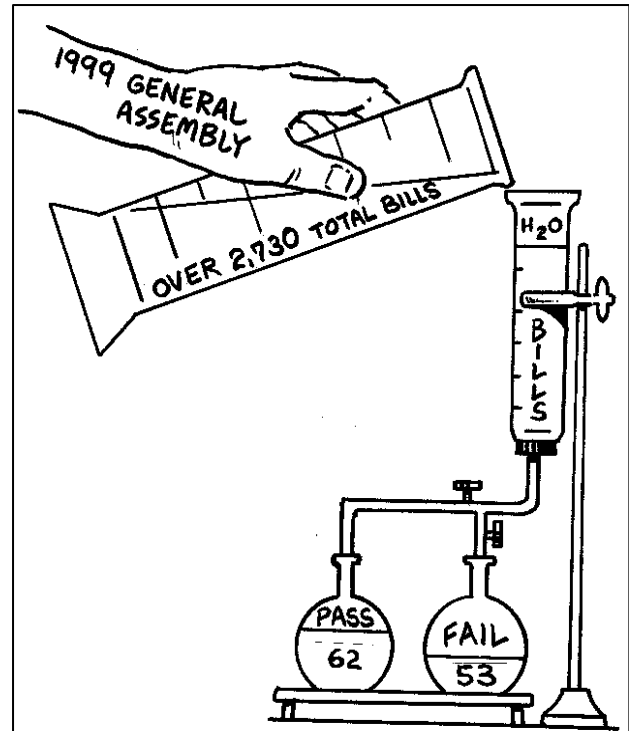
April 1999

FEATURE ARTICLE

The Volume of Water Bills in the 1999 Virginia General Assembly

The Virginia General Assembly held its 1999 session from January 13 to February 27. During the regular session, lawmakers considered 2,735 bills and resolutions, compared to 2945 measures considered in the longer 1998 session. Of the more than 2,700 bills and resolutions that legislators debated in 1999, 115 were in some way water-related; that is, their provisions would have had some impact on water resources or on water-related activities, such as boating and fishing.

To identify these water-related bills, we used the Internet site of the General Assembly's Legislative Information Service (<http://leg1.state.va.us/>). Using the system's subject index, we checked first the two categories under which most water-related bills fall: "Waters of the State, Ports and Harbors" and "Water and Sewer Systems." We then searched under several other relevant categories, which are identified in the list of bills that begins on page 2.



Our list includes solid-waste bills because water quality is a key issue in current solid-waste discussions. Due to space, however, the list does not include 14 measures dealing with land conservation or taxation, although these measures may eventually affect water resources. Nor does the list include the final budget bill, HB 1450, which of course determines any water-related funding, such as in the budgets of natural-resource agencies.

One passed water-related bill, HB 2272 (Impact of piers on oyster grounds, listed on page 2), was vetoed by the governor.

INSIDE THIS ISSUE

Science Behind the News: Genetics and Water	8
In and Out of the News.	12
Notices	14
Learning Resources: For the Record, and Teaching Water	15
You Get the Last Word.....	16

Water Legislation in the 1999 Virginia General Assembly

The bills are grouped by whether they passed or failed, and then by the indexing topics. Abbreviations used in the list are as follows: **HB** = house bill (introduced in the House first); **HJ** = house joint resolution; **SB** = senate bill (introduced in the Senate first); **SJ** = senate joint resolution; **SCC** = State Corporation Commission; **DEQ** = Va. Dept. of Environmental Quality; **VMRC** = Va. Marine Resources Commission; **VIMS** = Va. Institute of Marine Science; **VDH** = Va. Dept. of Health; **DCR** = Va. Dept. of Conservation and Recreation; **SWCB** = State Water Control Board; **SAV** = submerged aquatic vegetation; and **etc.** = other provisions in the bill not noted here.

PASSED

Conservation

HB 2471 Solid waste management and enforcement: Prohibits the issuance of permits for the siting of new municipal solid waste landfills in certain environmentally sensitive areas; **etc.**

HB 2557 Solid waste management: Expands the required review by DEQ when it considers permit applications related to solid waste management facilities and the siting of new landfills, including prohibiting new landfills in seven types of environmentally or geologically sensitive areas; **etc.**

Fisheries and Habitat of Tidal Waters

HB 1634 Commercial fishery grants: Establishes the Fishery Resource Grant Fund. The Graduate Marine Science Consortium will award grants, based on the advice of a seven-member Fishery Resource Grant Advisory Board; **etc.**

HB 2266 Submerged aquatic vegetation: Requires the VMRC, in consultation with VIMS, to develop criteria to aid in (i) defining existing beds of SAV and (ii) delineating potential areas for SAV restoration.

HB 2269 Public trust in subaqueous lands: Directs the VMRC to exercise its authority to protect the public right to use and enjoy the sub-aqueous lands held in trust by the Commonwealth; **etc.**

HB 2272 Impact of piers on oyster grounds: Requires the Commissioner of Marine Resources to find that a proposed private pier will not have an adverse impact on commercially productive oyster grounds before the exemption from permit requirements for private piers applies; **etc. VETOED.**

HB 2279 Crab and peeler pots: Allows the VMRC to establish the appropriate size for the mesh in crab pots and peeler pots; **etc.**

HB 2306 VMRC member qualifications: Requires that appointees to the VMRC have earned their livelihoods for at least five years by working on Virginia waters, and are licensed and registered as commercial fishermen.

HB 2514 Saltwater recreational fishing licenses: Clarifies that a saltwater recreational fishing license purchased by a charterboat or headboat captain for his customers also covers the vessel's captain and mate.

HB 2601 Recreational saltwater fishing: Authorizes the VMRC to establish a fishing guide license for charterboat and headboat captains.

SJ 397 Study; winter crab dredging: Requests the Secretary of Natural Resources to establish a task force to study the effects of winter dredging on the long-term sustainability of the blue-crab fishery.

Game, Inland Fisheries, and Boating

HB 1455 Personal watercraft rentals: Makes it a Class 4 misdemeanor for a renter or leaseholder of a personal watercraft to falsify information on the rental agreement; **etc.**

HB 1484 Recreational boats; saltwater recreational fishing licenses: Allows boat licenses, which cover all of the boat's passengers, to be issued to boat operators instead of just the boat's owner.

HB 1485 Saltwater recreational fishing licenses: Allows any individual to apply for a lifetime saltwater recreational fishing license from the VMRC.

HB 2292 Private pleasure watercraft; optional uninsured coverage: Requires insurers to offer limits of liability for optional uninsured private pleasure watercraft insurance that are equal to the liability limits of the private pleasure watercraft policy; **etc.** HB 2622 was incorporated into this bill.

SB 979 "No wake" buoys: Allows a person to apply to a local governing body for the removal of "no wake" buoys; **etc.**

SB 1134 Personal property tax on certain small boats and watercraft: Adds new classifications, for personal property tax purposes, for watercraft under 18 feet, either motorized or nonmotorized; **etc.**

Passed, cont.

SJ 413 Reciprocal fishing agreement: Requests the Virginia Department of Game and Inland Fisheries and the Virginia Economic Development Partnership to work with their counterpart agencies in Tennessee to develop a reciprocal fishing license agreement for the South Holston reservoir.

Public Service Companies

HB 2443 Regulated land-disturbing activities: Permits annual filings of Erosion and Sediment Control Plans, by certain utilities, with the DCR. This bill extends to natural gas utilities the same treatment that railroads, and electric and telephone utilities are afforded; **etc.**

HB 2748 Sanitary districts; relocation of utility lines to underground: Permits such districts to provide for burying above-ground distribution lines for electricity, telephone, cable television, and similar services and utilities.

Waste Disposal

HJ 706 Solid waste flow control: Urges Congress to enact legislation that would establish the authority of local governments to adopt "flow control" ordinances and thereby more effectively control the movement of solid waste generated within their jurisdictions.

SB 1201 Caps on landfill disposal: Caps the amount of municipal solid waste that may be disposed of in a landfill at 2,000 tons per day or the average amount disposed of in 1998, whichever is greater; **etc.**

Water and Sewer Systems

HB 1965 Liens for water and sewer charges: Adds Petersburg and Stafford County to localities allowed to provide that taxes or charges for water or sewer service shall be a lien on the real estate served.

HB 2242 Water Supply Assistance Grant Fund: Establishes the Water Supply Assistance Grant Fund to allow the State Board of Health to provide grants to help provide safe drinking water; **etc.**

HB 2337 Health; sewage system permits: Extends from July 1, 1996, to July 1, 2001, the "grandfather" date for certified professional soil scientists to be deemed onsite soil evaluators for the purposes of adoption of regulations for the program; **etc.**

HB 2432 Water Facilities Revolving Fund: Allows loans from the fund to private wastewater treatment facilities, if permitted by federal law.

HB 2455 Water and Waste Authorities Act; exempt from Utility Facilities Act: Exempts from the operation of the Utilities Facilities Act (§ 56-265.1 et seq.), an authority, or any subsidiary thereof, organized pursuant to the Virginia Water and Waste Authorities Act to operate a refuse collection and disposal system that, pursuant to statute, is specifically authorized to include in the system (i) facilities for processing solid waste as a fuel, and (ii) facilities for generating steam and electricity for sale; **etc.**

HB 2598 Liens for water and sewer charges: Adds the City of Richmond to localities authorized to place a lien on real estate for unpaid water and sewer charges.

HJ 662 Study; wastewater reclamation and reuse: Requests the DEQ to study ways to encourage, promote, and regulate the reclamation and reuse of wastewater.

SB 739 Virginia Water and Waste Authorities Act: Provides that the governing body of a locality can stop an authority's power of eminent domain by condemning land where a designated historic landmark, building, structure, district, object, or site is located.

SB 963 Health; onsite sewage evaluations: Requires—for subdivision review, permit approval, and issuance of letters for residential development—that the Board, Commissioner, and VDH accept private site evaluations and designs in compliance with the Board's regulations for septic systems and other onsite sewage systems; **etc.**

SB 1062 Health; private wells: Adds Powhatan County to localities that may, by ordinance, establish standards consistent with state standards for the location and testing of water from private wells.

SB 1202 Virginia Water and Waste Authorities Act; exemption from Utility Facilities Act: Similar to HB 2455, which also passed, listed above.

SB 1254 Liens for water and sewer charges: Adds the Cities of Richmond, Newport News, and Petersburg to localities authorized to place a lien on real estate for unpaid water and sewer charges.

Passed, cont.

SB 1273 Public utilities; Water and Waste Authorities Act: Exempts from regulation under the Utilities Facilities Act authorities created pursuant to the Water and Waste Authorities Act that sell landfill gas from a solid waste management facility permitted by the DEQ and operated an authority.

SB 1312 Taxation of well drilling equipment: Equalizes the taxation of well-drilling machinery and mining machinery.

Waters of the State, Ports and Harbors

HB 814: Specifies minimum public participation requirements in the development of guidelines describing eligibility requirements, priorities, and criteria for Water Quality Improvement Fund grants; **etc.**

HB 1207 Poultry waste management in Chesapeake Bay watershed: Requires the SWCB to establish a regulatory program for poultry waste management in the Bay watershed.

HB 1582 Dam safety: Authorizes the Director of the DCR to order the lowering or complete draining of an earthen impoundment if it has been determined that the impoundment structure is unsafe; **etc.**

HB 1859 Petroleum storage tank fee: Changes the threshold amount that has to be maintained in the Virginia Petroleum Storage Tank Fund before the fee on motor and heating fuels can be decreased.

HB 1860 Oil facility financial assurance: Requires that operators of oil facilities annually demonstrate financial responsibility for containment and cleanup as may be required by SWCB regulations.

HB 1968 Regulation of personal watercraft rentals: Authorizes localities with a population greater than 390,000 to adopt ordinances regulating businesses that offer personal watercraft for rent; **etc.**

HB 2014 Petroleum Storage Tank Fund; fees: Clarifies who is liable to the Department of Motor Vehicles for the payment of fees on the sale of certain fuels; **etc.**

HB 2220 Regulating mooring and anchoring: Authorizes Hampton to enact an ordinance to control the mooring and anchoring of vessels in the City's waters.

HB 2221 Removal of property from waters; penalty: Makes it a Class 3 misdemeanor for the owner of a vessel to allow his boat to be abandoned, left in danger of sinking, or left in disrepair for more than a week after notification by the VMRC or a law enforcement official; **etc.**

HB 2267 Tributary plans; sediments and suspended solids: Adds sediment and suspended solids as pollutants in tributary plans.

HB 2268 Suspended solids; Water Quality Improvement Act Grants: Includes suspended solids in the non-exclusive list of pollutants covered by water quality protection efforts funded by nonpoint source pollution-related Water Quality Improvement Act Grants.

HB 2318 Educational Institution Water Quality Improvement Fund: Specifies that higher education institutions are eligible for Water Quality Improvement Fund grants.

HB 2401 Estuarine and Coastal System: Creates the Virginia Estuarine and Coastal Reserve System.

HB 2430 Regulation of wastes transported on water: Adds to the directives on the regulations to be developed for containers carrying certain wastes by ship, barge, or other vessels on Virginia waters; **etc.**

HB 2556 Water transport of wastes: Provides for the prohibition of the commercial transport of certain types of solid and medical wastes by ship, barge, or other vessel on the navigable waters of the Commonwealth; **etc.** HB 2454, Transportation of wastes on water, was incorporated into this bill.

HB 2574 Surface water management area voluntary agreements: Provides control to voluntary agreements among water users in a surface water management area, in lieu of a permit issued by the SWCB, when the board finds that the agreement complies with the area law; **etc.**

HB 2590 Permanent easement in James River: Authorizes the VMRC to grant a permanent easement to the U. S. Forest Service for 0.76 acres of sub-aqueous land in the James River in Amherst and Bedford Counties; **etc.**

HJ 660 Study; bottomland uses, submerged aquatic vegetation: Requests the Virginia Delegation to the Chesapeake Bay Commission to examine issues that may have potential impacts to SAV; **etc.**

HJ 704 Study; additional "inland ports": Requests the Secretary of Transportation to study the desirability and feasibility of establishing additional intermodal transfer facilities to aid in reducing long-haul truck traffic on Virginia's highways.

SB 582 Wetlands mitigation banks: Allows compensation for adverse impacts to wetlands to be done using wetlands mitigation bank credits; **etc.**

SB 1147 Virginia Water Facilities Revolving Loan Fund: Allows the SWCB to loan money from the Fund to several newly defined categories of recipients; **etc.**

Passed, cont.

- SB 1308 Water transport of wastes:** Prohibits the commercial transport of certain types of solid wastes, by ship, barge, or other vessel, on the Rappahannock, James and York Rivers; **etc.**
- SB 1310 Virginia Resources Authority:** Allows the Virginia Resources Authority to issue bonds not backed by the moral obligation of the Commonwealth.
- SJ 330 Commemorative postage stamp:** Requests the U. S. Postal Service to issue a stamp commemorating the 200th anniversary of the U. S. naval shipyards, the oldest and largest of which is the Norfolk Naval Shipyard.
- SJ 436 Study; Shipbuilding Industry:** Continues the Joint Subcommittee Studying Economic Incentives to Promote the Growth and Competitiveness of Virginia's Shipbuilding Industry.
- SJ 483 Commemorative postage stamp:** Similar to SJ 330, which also passed, listed above.

FAILED*Agriculture, Horticulture, and Food*

- HB 2053 Specialty fertilizer:** Would have required retail businesses that sell specialty fertilizer for lawn use to provide the purchaser written information on the water-quality effects of over-application; **etc.**

Counties, Cities and Towns

- HB 1029 Subdivision Ordinances:** Would have allowed localities to require applicants for major water-consuming projects to demonstrate that sufficient water was available to serve the proposed project without harming existing water users; **etc.**

Conservation

- HB 1089 Water Quality Improvement Act point source grants:** Would have removed a restriction that point source grants from the Water Quality Improvement Fund first go to installation of biological nutrient removal at publicly-owned sewage treatment plants; **etc.**
- HB 2069 Water Quality Improvement Act funding calculation:** Would have clarified that required payments into the Revenue Stabilization Fund were not to be included in the calculation of the 10 percent of any unreserved general fund balances remaining at the end of each fiscal year, which are to be deposited into the Water Quality Improvement Fund; **etc.**
- HB 2650 Non-tidewater locality water quality assistance:** Would have allowed local governments outside of the area designated as "Tidewater Virginia" to receive assistance in developing and implementing a voluntary program, approved by the Chesapeake Bay Local Assistance Board, to incorporate protection of the quality of state waters into their comprehensive plans, zoning ordinances and subdivision ordinances; **etc.**
- HB 2735 Agricultural Stewardship Act:** Would have conformed the definition of pollution in the Agricultural Stewardship Act to the definition of pollution in the State Water Control Law.
- SB 1133 Non-tidewater locality water quality assistance:** Same as HB 2650, which also failed, listed above.

Dangerous or Hazardous Substances or Chemicals

- SB 1274 Pesticide application:** Would have required commercial applicators and registered technicians applying any herbicide to a privately-owned lake, pond, or impoundment to give at least 48 hours notice to residents of adjacent property and those within one-quarter mile of the application.

Drainage, Soil Conservation, Sanitation and Public Facilities Districts

- HB 1875 Highway signs; soil and water conservation districts:** Would have required the Commonwealth Transportation Commissioner to develop standards for signs indicating soil and water conservation districts.
- HB 2225 Erosion and sediment control recovery fund:** Would have allowed localities, in lieu of existing security for performance requirements set forth in the erosion and sediment control law, to establish an erosion and sediment control recovery fund; **etc.**
- HB 579 Oyster and clam aquaculture:** Would have ensured that riparian landowners in Virginia Beach have a 50-foot zone from mean low water for oyster and clam aquaculture.
- HB 598 Fishery regulations:** Would have required that all fishery regulations, except for emergency regulations, promulgated by the VMRC remain effective for one year, without being amended.

Failed, cont.

Fisheries and Habitat of Tidal Waters

- HB 671 Fishery Resource Grant Program; created:** Would have established the Fishery Resource Grant Program to award grants to commercial fishermen for the following: new fisheries equipment, environmental pilot studies, aquaculture of marine-dependent species, or seafood technology; **etc.**
- HB 1471 Commercial fishermen fees:** Would have reduced the annual registration fee for commercial fisherman under the age of 70 from \$150 to \$100, and for those 70 or older from \$75 to \$50.
- HB 1472 VMRC emergency regulations:** Would have required the Secretary of Natural Resources to make a determination that an emergency exists before any emergency regulations adopted by the VMRC could be submitted to the Registrar of Regulations or become effective.
- HB 1473 Oyster reefs:** Would have prohibited the construction of oyster reefs on state bottomlands and in the Baylor Survey area; **etc.**
- HB 1838 Fishing license, registration or permit revocation:** Would have clarified that any person engaged in commercial fishing who has had their license, permit, or registration revoked cannot serve as a mate or assistant on vessels of other licensed commercial waterman during the period of the revocation; **etc.**
- HB 2304 Oyster Fund:** Would have required general fund money that has been appropriated for oyster replenishment be deposited in the Public Oyster Rocks Replenishment Fund.
- SB 329 Disposal of vegetative waste:** Would have exempted disposal of vegetative waste on agricultural or forestal land in Bedford County from the requirement for a solid-waste management facility permit.
- SB 392 Restrictions on taking crabs:** Would have required any size and catch restriction on peeler and soft crabs to be identical.
- SB 393 Gray trout; management:** Would have required any regulation of the commercial gray trout fishery to apply the same limit to every method of catch.
- SB 395 Restrictions on crab dredging:** Would have prohibited crab dredging on Sundays; **etc.**
- SB 1080 Taking of certain crabs:** Would have prohibited the taking of peeler crabs less than three inches and soft crabs less than three and one-half inches across.

Game, Inland Fisheries and Boating

- HB 40 Hunting and fishing license fee adjustments:** Would have authorized the Board of Game and Inland Fisheries to increase the cost of basic hunting, fishing, and big game licenses; **etc.**
- HB 160 Personal watercraft; age increased for operation:** Would have increased the minimum age to operate a personal watercraft from 14 to 16.
- HB 765 Boating; life jackets for children:** Would have required a child 12 years of age or younger to wear a personal flotation device while in a motorboat.
- SB 1208 Safe boating:** Would have required persons operating motorboats to have a safe boating reference card on board their boat while it was in operation; **etc.**

Waste Disposal

- HB 1466 Clean-up and closure of landfills:** Would have allowed landfills authorized under HB 1205 (1993), which do not meet modern requirements for liners and leachate collection systems, to continue operating. As introduced, the bill required closure of the "HB 1205" landfills.
- HB 1677 Medical waste penalties:** Would have specified that it is a felony to knowingly transport regulated medical waste to an unpermitted facility; **etc.**
- HB 2486 Solid waste management:** Would have provided that permits for new sanitary landfills should only be issued to counties, cities, or towns and that the locality must own the landfill.
- SB 1182 Regulation and management of solid waste:** Would have capped the amount of municipal solid waste that may be disposed of in a landfill at 2,000 tons per day, or the actual amount disposed of in 1998, whichever is greater; **etc.**

Water and Sewer Systems

- HB 739 Small water or sewer public utilities; rate changes:** Would have prohibited small water and sewer companies from imposing rate increases or other changes in rates, fees, and charges prior to public hearings and approval by the SCC; **etc.**
- HB 2025 Health; water works:** Would have provided that no owner shall establish a waterworks system without providing sufficient standby power to treat and distribute the water during power failures.

Failed, cont.

- HB 2066 Water Quality Improvement Fund Grant uses:** Would have clarified that these grants are not for the purpose of enabling the recipient to comply with permit requirements.
- HB 2627 Orphaned wells:** Would have allowed oil and gas operators to obtain permits for investigating the redevelopment of an orphaned well.
- HB 2727 Tributyltin standard:** Would have modified the effective date for a water quality standard for tributyltin found in the SWCB's regulation.
- SB 1268 Water permit fees:** Would have removed the caps on the amount the SWCB could charge for processing applications for various types of water permits.
- SB 1292 Tributyltin standard:** Similar to HB 2727, which also failed, listed above.

Waters of the State, Ports and Harbors

- HB 473 Water Quality Improvement Fund; utilization of:** Would have expanded the eligible uses of the Water Quality Improvement Fund to include the installation of nutrient-removal technology at private wastewater treatment plants; **etc.**
- HB 818 Prohibition on water transport of wastes:** Would have prohibited the transport of solid and medical wastes by any vessel on state waters to the extent not inconsistent with the U. S. Constitution.
- HB 823 Chesapeake Bay Byway Program; created:** Would have established the U. S. Route 3 Chesapeake Bay Byway Program as a special transportation program for the Northern Neck area; **etc.**
- HB 1348 Shipbuilding industry tax credit:** Would have created credits against employee income tax withholding for contributions by a qualified shipbuilder for a carrier platform integration center; **etc.**
- HB 1924 Confined swine feeding operations:** Would have imposed a moratorium on the permitting and construction of such operations for the period between July 1, 1999, and July 1, 2001; **etc.**
- HB 1803 Illegal gambling; promoting gambling aboard ships; penalty:** Would have prohibited any person from knowingly advancing or profiting from gambling activity on vessels on Virginia waters; **etc.**
- HB 2017 Virginia Port Authority; Board of Commissioners:** Would have added three members to the Board of Commissioners: one resident of Newport News, one resident of Norfolk, and one resident of Portsmouth, appointed by the respective city councils.
- HB 2282 Property conveyance in Rappahannock River:** Would have authorized the VMRC to convey a causeway and a manmade island in the Rappahannock River in Middlesex County to a private party.
- HB 2448 Confined animal feeding operations:** Would have required the owners of such operations that are required to obtain coverage under a general permit issued by the SWCB to provide evidence of financial responsibility for closing the operation's liquid manure collection and storage system.
- HB 2481 Illegal gambling; promoting gambling aboard ships; penalty:** Similar to HB 1803, which also failed, listed above.
- SB 49 Water Quality Improvement Act:** Same as HB 814, which passed, listed above.
- SB 597 Water permit fees:** Would have required the SWCB to recover the total costs of administering the water permit program through the imposition of annual fees on water permits; **etc.**
- SB 656 Regulation of water transport of wastes on James River:** Would have prohibited, to the extent allowable under the federal constitution, the transport of solid and medical wastes by ship, barge, or other vessel on the James River.
- SB 802 Illegal gambling; promoting gambling aboard ships; penalty:** Similar to HB 1803 and HB 2481, which also failed, both listed above.
- SB 951 Virginia Port Authority:** Would have required that, beginning with persons appointed or reappointed to the Authority's Board of Commissioners on or after July 1, 1999, at least one must be a Portsmouth resident.

–By Lisa Garcia

More to Come on Water and the General Assembly

The feature article in the June 1999 *Water Central* will examine the bills that are receiving attention from Virginia's water-resource and public-policy professionals. A summary of how to track Virginia General Assembly legislation is planned for the February 2000 issue.

SCIENCE BEHIND THE NEWS

Dolly the Sheep and Dolly Varden the Trout

(Please note: Items in bold are defined in the box on page 2.)

The cloning of Dolly the sheep in 1998 made news worldwide on **genetic engineering** and the possibility of human cloning. Other examples of genetic engineering—from sources of new drugs to better-testing tomatoes—have become well-established, even routine. Use of DNA for positive identification has become a key element in the justice system. And similar scientific and technological developments are having significant impacts on how humans study and manage water resources.

These developments derive largely from two sciences: *genetics*, the study of how organisms inherit and express biological characteristics; and *molecular biology*, the study of **molecules** in living cells. In the 20th Century, these sciences have revolutionized our ability to identify, understand, and utilize the unique traits of Earth's living things.

Although no Dolly Varden trout will ever be as famous as Dolly the cloned sheep, the same basic genetic principles bind mammals to fish and to all other life on Earth. This article explains these basics, and then shows some ways that water resources are involved in or affected by fast-developing knowledge in genetics and molecular biology.

Exploring Questions Basic to Life

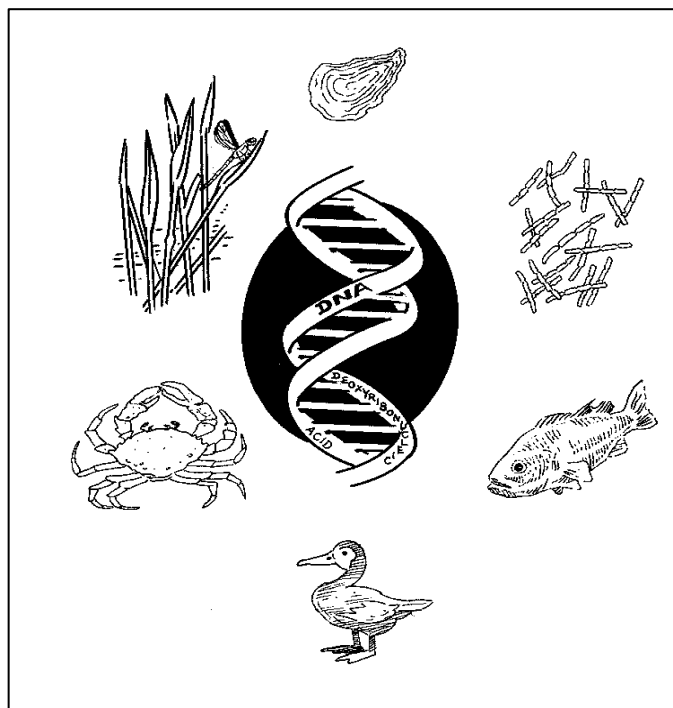
Geneticists and molecular biologists historically have investigated some of the life sciences' most fundamental questions. One of the most challenging was finding a biological basis for the great variety of living things. Scientists wondered both about the variety among different species and about the variation of traits within a species. Inherent in the question of what determined different traits among organisms was the question of how traits are passed on from one generation to the next.

As more was learned about the complexity of living things and about visible patterns of inheritance¹, scientists debated how the information needed for development, regulation, and reproduction of such complexity could reside within cells or in any given biological substances. In 1915, for example, the English scientist William Bateson (1861-1926)—who coined the term “genetics”—found it inconceivable that any one substance could contain all of this information. But in 1953 the “inconceivable” became quite conceivable, when the mystery of the *DNA molecule* was unraveled.

Fundamentals of DNA

Many people have heard that the structure of DNA (short for deoxyribonucleic acid) is a *double-helix*. To visualize a double-helix, think of a railroad track stretching far off into the distance; now imagine the rails

(Cont. p. 2)



The Chemical Tie that Binds

¹ Gregor Mendel's work with garden peas in the 1850s—1860s showed regular patterns of inheritance. Mendel's general principles of heredity, now known as Mendel's laws of inheritance, are a foundation of the science of genetics.

Definitions

(Please note: Terms defined on this page are printed in bold text when first used in the article.)

Amino Acids—The “building blocks” of proteins. Twenty amino acids commonly found in all living things: alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, and valine.

Base—The nitrogen-containing part of a DNA molecule. Bases can vary along a DNA strand, and they are matched with bases on a complementary DNA strand to make **base pairs**. Human-cell chromosomes (see next definition) consist of approximately three billion base pairs; that of the smallest bacteria, about 800,000 base pairs. Single genes (see definition below) vary in size from about 1000 to about 2 million base pairs.

Chromosome—The structures in cells that contain DNA. Genes are sections of DNA along the chromosome. Pioneering work on the gene—chromosome relationship was done in the Columbia University lab of Thomas Hunt Morgan (1866-1945), a native of Lexington, Virginia.

Gene—A portion of a DNA strand that determines a certain hereditary trait. Genes regulate the production of proteins (see definition below). A very high percentage of the DNA (an estimated 99 percent) in most kinds of organisms does not contain functional genes; this is often referred to as “junk DNA.”

Genetic Code—The complete set of associations between DNA’s four nitrogen-containing bases (symbols A, C, G, and T) and the amino acids for which they code. Triplets of the bases code for one amino acid; for example, UGG codes for tryptophan. There are 64 possible combinations of the bases, which code for 20 amino acids (with some duplication). The code is nearly universal (that is, common to nearly all organisms).

Genetic engineering—A form of biotechnology that involves manipulation of genes. Genetic engineering may involve the transfer of one or more genes from one species to another; the recipient is then called a **transgenic** organism. The goal is for the recipient organism to produce the protein coded for by the donor’s gene. For example, through gene transfer a bacterium can produce *human* insulin in commercial quantities.

Genome—All of the genes of a given organism. The **Human Genome Project** is identifying the chromosome location and the base-pair sequences of all of the estimated 100,000 human genes.

Molecule—A basic unit of matter, consisting of two or more atoms bound together by electrical forces. Water consists of molecules made up of two atoms of hydrogen (symbol H) and one of oxygen (symbol O), hence the formula H₂O. Biological molecules—such as DNA—are much more complex.

Protein—A type of biological molecule. Proteins have three basic types of functions: first, as part of an organism’s structure; second, in transporting other important substances; and third, in regulating biochemical reactions.

Recombinant DNA—A new DNA sequence in an organism, produced by genetic engineering.

(Cont. from p. 1)

spiraling around one another, with the crossties unbroken. A double-helix configuration, along with the specific substances that make up the molecule, gives DNA its ability to contain the chemical information needed to regulate living things’ activities and to transfer that information to subsequent generations. *DNA does this by regulating the chemistry in living things.*

All of life’s processes—plants using the sun’s energy to make food, animals digesting a plant, a fish moving a muscle—depend on chemical reactions, more correctly referred to as *biochemical* reactions. Biological differences among species or individuals of the same species result from differences in

biochemical reactions: that is, in the substances involved and in the rate at which the reactions occur.

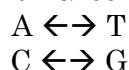
*DNA controls biochemistry by controlling the production of **proteins**.* Relatively familiar proteins include keratins, which form hair, fur, scales, and other protective coverings in many organisms; hemoglobin, which carries oxygen in blood; and insulin, which regulates the blood’s sugar level. One very important group of proteins are *enzymes*, which regulate the location and rate of biochemical reactions.

Proteins are made up of **amino acids** linked together in a chain. The amino acids have different “side chains” that allow them to bond to biological substances in different

ways, giving proteins the capacity to affect reactions between substances. A single protein molecule may have from 50 to several thousand amino acid links. With 20 different kinds of amino acids, there are millions of possible combinations to make the great variety of proteins seen in nature. *DNA, therefore, controls the production of proteins by determining what amino acids will be used to build the proteins.*

Let's return to the spiraling railroad track analogy to see how DNA does this. Imagine John Henry comes along to build some new tracks. Lacking a blueprint, but being a *big* man, he unwinds the spiral and pulls the two rails apart right in the middle of the crossties, so he has two identical rails with half-crossties attached. He can now use the two rails as models to build complementary rails, with new half-crossties matching up with the old ones. The DNA double-helix functions in an analogous way to transfer information to make proteins.

It gets more complicated, however, when you consider the *form* of the information—that is, what the “language” is. Once more our railroad track can illustrate this. Imagine that four colors have been used to paint the crossties; let's say the colors are Amber, Chартreuse, Green, and Teal. Each tie is painted half one color and half another, with the colors matched as follows: Amber is *always* matched with Teal, and Chartreuse is *always* matched with Green:



Now, when John Henry splits the track and takes one side off to build another side, the half-crosstie colors on the *existing* rail tell him what complementary colors to put on the half-crossties of the *new* rail.

In DNA, the “rails” are strands made up of a sugar (deoxyribose) and a chemical group called phosphate (containing phosphorus). The “crossties” are combinations of substances called nitrogenous (containing nitrogen) **bases**. Just as with the crosstie colors, there are four nitrogenous bases in DNA: Adenine, Cytosine, Guanine, and Thymine. To make the “crossties,” adenine always matches with thymine ($A \leftrightarrow T$) and cytosine always

matches with guanine ($C \leftrightarrow G$) to form **base pairs**. These four bases are the “letters” of the **genetic code**. The sequence of bases along the DNA strand determine the “words” of the code, with each “word” having three “letters”—AAA, ATA, CCC, GGG, and so forth, with 64 possible combinations.

What do the “words” mean? They are code for the 20 amino acids that make up proteins. A **gene** is a section DNA that codes for a particular protein. DNA strands are located in **chromosomes** and are found in all living cells, except the red blood cells of mammals.

Following the discovery of the structure of DNA in 1953, deciphering the genetic code meant identifying the sequences of bases that correspond to given amino acids. Completed by 1966, this accomplishment allowed scientists to begin identifying various organisms' genes and the specific substances or reactions they controlled. These advances have led to revolutionary new ways of identifying species and individuals; of understanding how organisms function, especially in response to their environment; and of using genetic information to make products humans need (the whole world of genetic engineering). Water resources and aquatic organisms are by no means being left out of the revolution.

Aquatic Genetics

How does genetics relate to water resources? One answer can be found in the proceedings of the 1992 “Genetics and Evolution of Aquatic Organisms” conference in Wales. The reports from that conference, filling a book of 528 pages, involved nine broad subject areas, including the following that help reveal the scope of genetics' applications to water:

- Know genetic variation relates to adaptation to environments;
- Know DNA technology and fish classification;
- Know genes change in response to pollutants;
- Know genetic markers for tracking fish; and
- Know genetic improvement of traits, such as disease resistance, in economically important fish and shellfish.

Here are some examples of aquatic genetics affecting Virginia's water resources:

•**Identifying drinking-water and water-resource contaminants**—Genetic techniques are being developed and improved to identify bacteria, viruses, and other contaminants in water supplies. Successful techniques are frequently faster, cheaper, and more specific than traditional methods.

•**Identifying sources of bacterial contamination in Virginia waters**—Genetic techniques are being used to distinguish sources of fecal bacteria (bacteria in mammals' feces) in various waters, including the following: Chesapeake Bay streams being studied by Virginia Tech biologist George Simmons; the Four Mile Run watershed in northern Virginia (proposed); and in three streams—Accotink Creek (Fairfax Co.), Christians Creek (Augusta Co.), and Blacks Run (Rockingham Co.)—in a U. S. Geological Survey study. (**Please note:** The October 1999 issue of *Water Central* will discuss the different technologies being used to identify bacterial contamination in water).

•**Fisheries genetics**—Virginia Institute of Marine Sciences scientists study variations in the gene structure of various marine organisms—such as Chesapeake Bay sport fishes—to help determine environmental tolerances that can affect potential food sources for humans.

•**Seeking genetic solutions to malaria**—A mosquito-borne microscopic parasite causes malaria, which in recent years has reemerged as a serious problem in some parts of the world. Shirley Luckhart, a Virginia Tech biochemist, seeks to enhance the mosquitoes' own immune response to the parasite. Her approach involves trying to manipulate mosquito gene(s) that affect the parasite's life cycle, then introducing the modified gene(s) into the mosquito population. Because mosquitoes require water to breed, this type of pest management could not only improve human health but also reduce the amount of insecticides reaching aquatic systems.

•**Clones probably nearby!**—Some organisms can clone themselves naturally. Many Virginia ponds and streams contain

hydra, sponges, and other organisms that can reproduce by cloning. These creatures offer a natural window onto the principles behind news-making genetic developments.

DNA is All Alike—Only Different

DNA's vital function, its basic structure, and the genetic code are common to nearly all living things. But small differences in DNA produce different proteins and different biochemistry, leading to *big* differences in traits. For example, different kinds of amphibians (frogs, toads, salamanders) differ in the *amount* of their DNA by about 0.7 percent; and human DNA differs from and chimpanzee DNA by an estimated 1 percent.

Now, how can you tell Dolly from a Dolly Varden? That's easy: Dolly's Not Aquatic.

References and Further Reading

- Aldridge, Susan. 1996. *The Thread of Life: The story of genes and genetic engineering*. Cambridge Univ. Press, Cambridge, England.
- Baumont, A. R., ed. 1994. *Genetics and Evolution of Aquatic Organisms*. Chapman & Hall, London.
- Borell, Merriley. 1989. *Album of Science—The Biological Sciences in the Twentieth Century*. Charles Scribner's Sons, New York.
- Carter, Gordon R. and Stephen M. Boyle. 1998. *DNA, Genes and Genetic Engineering—A Concise, Comprehensive Outline*. Charles C. Thomas Publisher, LTD., Springfield, Illinois.
- Dickerson, Richard E. and Irving Geis. 1969. *The Structure and Action of Proteins*. Harper & Row, New York.
- Magner, Lois N. 1994. *A History of the Life Sciences*. 2nd ed. Marcel Dekker, Inc., New York.
- Winston, Judith E. 1998. "Clonal Creatures of Pond & Stream." *Virginia Explorer*, Winter 1998. Virginia Museum of Natural History, Martinsville.

Need help remembering how DNA works?

Try this formula:

DNA Purpose = Double-strands → Nitrogen bases → Amino acids → Proteins.

—Alan Raflo, *Water Central* editor

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 March 18, 1999 (with two items updated April 6).

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 (the Web address is listed on the last page of this newsletter).

•To protect **drinking water for about 600,000 residents of Charlotte and Gastonia, N.C.**, several non-profit groups, government agencies, and foundations are proposing that \$20 million be spent over five years to protect water quality in 125 streams feeding into Mountain Island Lake. The money would be used to purchase land or work out agreements to limit development in the streams' watersheds. (*Charlotte Observer*, 1/26/99)

•Despite the January—July 1998 drought, the 1990s might turn out to be the **wettest decade on record for the Chesapeake [Bay] watershed**, with flood of January 1996 and several wet springs (1993, 1994, and 1998). Abnormally high flows pose additional challenges for Bay restoration: More rains result in more runoff and ultimately more contaminants or excessive nutrients reaching the Bay. (*Bay Journal*, Jan.—Feb., 1999, pp. 1, 3)

•“**Chesapeake Milk**” is being test-marketed in some Maryland grocery stores. Its containers bear an Environmental Quality Initiative mark, indicating that five cents of the price will go to an Environmental Quality Stewardship Fund. The fund is to provide incentives to farmers to implement water-quality-protection practices. (*Bay Journal*, Jan.—Feb., 1999, p. 3)

•A \$3.8-million grant, from the North Carolina Clean Water Management Trust Fund, will begin a project to **recycle wastewater from the Johnston County, N.C., sewage-treatment plant** to golf courses, tree farms, pastures, etc. Ultimately the project is expected to cut 30,000 pounds annually from the amount of nitrogen discharged into the Neuse River through treated sewage. The project's total cost is an estimated \$13.3 million. (*Raleigh News & Observer*, 1/30/99)

•**Zebra Mussels** have invaded their 19th state, Connecticut. The small freshwater mollusks, native to Asia, arrived in the United States in the late 1980s, apparently in ship-ballast water. Since their arrival, Zebra Mussels have spread throughout southern Canada, the Great Lakes,

and parts of the southern and eastern United States. Infestations cost utility companies and other raw-water users about \$69 million between 1989 and 1995. (*Coastlines*, U. of Mass. Urban Harbors Institute, February 1999; and *Great Lakes Information Network Web Site*, 3/25/99)

•In one possible approach to the problem of **chicken-manure disposal**, the governors of Maryland and Delaware are considering a joint project to burn manure in a Maryland power plant. This process is already being used elsewhere, for example in England, where a London utility reportedly has three power plants burning 700,000 tons of manure a year. (*Baltimore Sun*, 2/9/99)

•Several thousand acres of **non-tidal wetlands in North Carolina and Virginia have been drained** since a June 1998 federal Court of Appeals decision removed the U. S. Army Corps of Engineers' oversight of sand mining, land clearing, and ditching in such wetlands. (The ruling did not affect tidal wetlands, such as salt marshes.) North Carolina began in March to require state approval for such activity. In Virginia, where officials have not taken steps to impose state regulation, an estimated 1,680 acres have been drained in Chesapeake, and federal officials have said that another 4,300 acres may be drained in the future, possibly affecting the Great Dismal Swamp. (*Raleigh News & Observer*, 3/7/99; *Associated Press*, 3/12/99; *Hampton Roads Daily Press*, 3/17/99)

•**Fauquier County** officials and residents are trying to combine state and local funds to develop **sewage treatment facilities for the villages of Calvert and Catlett**. The system, estimated to cost \$3.5 million to \$4 million, could serve up to 110 homes in each community. Studies indicate that possibly only five percent of the homes in these areas have properly functioning septic systems. Some citizens in these villages have been lobbying for sewage systems for 30 years. (*Fauquier Citizen*, 2/18/99)

•The U. S. EPA may declare tributaries of the New River as "impaired" bodies of water, which could require expensive anti-pollution measures. Members of the New River Valley Planning District Commission (located in Radford) are asking the federal agency not to add these southwestern Virginia waters to the Va. Dept. of Environmental Quality's 1998 "TMDL list"—this would begin the lengthy process of establishing a Total Maximum Daily Load (TMDL) plan to reduce runoff into the river. (See the Oct. 1998 *Water Central* for an explanation of TMDLs.) (*Roanoke Times*, 2/27/99)

•In Honolulu, citizens are involved in a **community-based effort to control pollution in the city's Ala Wai Canal**. Just as in many continental U. S. cities, non-point source pollution—contaminants that wash into waterways from many locations, rather than a from single point of discharge—is considered to be one of Honolulu's most difficult water-quality problem. (*Honolulu Star-Bulletin*, 2/27/99)

•Virginia-based **Smithfield Packing Company reached agreement with the North Carolina Division of Water Quality** to pay a \$29,500 fine for pollution of the Cape Fear River. The company will also limit its Tar Heel, N.C., plant to about 7.5 million hogs per year (the same number it is currently permitted to slaughter). The company could have been fined \$500,000 for violations of previous permits. (*Raleigh News & Observer*, 3/6/99)

•On March 9, Vice President Gore announced a comprehensive **federal strategy to reduce runoff from large livestock operations** and its impact on water resources. The "Unified National Strategy for Animal Feeding Operations" was developed jointly by the U. S. Department of Agriculture and the EPA. The plan has the following elements:

—nutrient-management plans must be in place for all animal-feeding operations by 2009;

—Clean Water Act permits will be required for operations with more than 1,000 animals, those that discharge directly into a waterbody, and those that contribute to the impairment of a waterbody (about five percent of the estimated 450,000 operations nationwide); and

—large companies, known as integrators, that contract with individual farmers to raise animals will have to share responsibility for meeting regulations pertaining to raising the animals.

The administration's Fiscal Year 2000 budget requests \$100 million to help farmers implement measures called for by the national strategy. To

request a copy of the plan, call the EPA at (202) 260-7786; or see it at www.epa.gov.owm. (*U.S. Newswire*, 3/9/99)

•The U. S. EPA hopes to expand nationwide its **Peer Review program, a drinking-water compliance initiative**, after a successful trial in Georgia. Under the program, volunteers (usually water-system managers) help the staff at small water systems comply with the Safe Drinking Water Act. The program is being developed in several other states, including Virginia. (*Inside EPA's Reinvention Report*, 3/10/99)

•"**The Drinking Water Supply in the Washington Metropolitan Area**" was recently released by the League of Women Voters of the National Capital Area. Another study of the area's water supply, by regional water utilities, will be done in 2000, using updated population and water-use projections. The League report can be viewed at www.lwv-fairfax.org/water.htm. (*Washington Post*, 3/11/99)

•The Metropolitan Water District of Southern California—one of the world's largest providers of treated drinking water—is supporting federal and state legislation aimed at **eliminating the additive MTBE from gasoline**. MTBE (methyl tertiary butyl ether), added to reduce air emissions, is listed by the U. S. EPA as a possible carcinogen. MTBE has resulted in cleaner air in California, but it has also contaminated various water resources there. In Virginia, MTBE was found in well-water samples in Loudoun County in Summer 1998, resulting in a Va. Dept. of Health order either to shut down or clean up the wells. (*Business Wire*, 3/12/99; and *Washington Post*, 8/13/99) **UPDATE:** California's governor has ordered that the use of MTBE be phased out in the state. (*Los Angeles Times*, 3/26/99)

•In March, Maryland state biologists spotted the **first Brook Trout in almost a decade to hatch** in the Right Fork of the Jabez Branch in Anne Arundel County. As of 1990, acidic drainage, hot-water runoff, and the construction of Interstate 97 had eliminated the trout. The return of trout to the Jabez Branch took eight years of restoration efforts and more than \$1 million. The director of fisheries for the state's Department of Natural Resources said that the success on this stream is a guide for helping restore or protect thousands of miles of other Maryland streams that ultimately drain into the Chesapeake Bay. (*Baltimore Sun*, 3/14/99)

•As of March 15, the city of **Roanoke's primary drinking-water source, Carvin's Cove Reservoir, was at a record low for this time of year.** Typically full in early spring, this year the reservoir was 21 feet below capacity. The record low for any time of year is 24.2 feet below capacity, in December 1981. The current level is low enough that the city is considering asking

residents to conserve water voluntarily; mandatory restrictions might be necessary if the level were to drop much further, according to the city's utility director. (*Roanoke Times*, 3/16/99)
UPDATE: The Roanoke city council has asked residents to conserve water voluntarily. (*Roanoke Times*, 4/6/99)

—Compiled by Su Clauson-Wicker

N O T I C E S

New River Watershed Conference

The New River Watershed Conference will be held on **May 17—18, 1999**, at New River Community College in Dublin, Virginia. The event is co-sponsored by the Va. Dept. of Conservation and Recreation, the Va. Association of Soil and Water Conservation Districts, and the New River-Highlands Resource Conservation and Development Council. The conference will include information on the New River's status as an American Heritage River. For more information, phone Charlotte Burnett at (540) 674-2937.

Groundwater Protection Steering Committee

The committee's next meeting will be **May 18, 9 a.m.**, at the Va. Dept. Environmental Quality central office in Richmond. For more information, contact Mary Ann Massie, (804) 698-4042 or mamassie@deq.state.va.us.

Citizens for Water Quality

This collaboration of citizen water-monitoring groups in Virginia will be holding its "Annual Summit" on **June 12** in Charlottesville. The group is also seeking watershed representatives from the Atlantic/Small Coastal, Clinch/Powell, James, and New river basins of Virginia. For more information, contact Stacey Brown, (800) 592-5482 or stbrown@deq.state.va.us; or Jay Gilliam, (540) 377-6170 or strmiwla@cfw.com.

Center for Chesapeake Communities

This new non-profit organization seeks to provide technical, financial, and networking assistance to local governments' efforts to protect water quality. Currently the Center is a partner in offering "Small Watershed Grants"—up to \$35,000—to watershed organizations, educational institutions, and local governments for environmental restoration and protection. Application deadline is **May 15, 1999**. For more information, call (410) 267-8595 or (800) 826-5359.

Adopt-A-Stream

This program, similar to Virginia's Adopt-A-Highway program, is a litter-education and cleanup campaign seeking both to reduce litter in Virginia's waterways and to promote citizen stewardship of water resources. For more information, call (804) 786-2064, or send your name, address, and phone number to Adopt-A-Stream, Va. Dept. Cons./Recreation, 203 Governor St., Richmond 23219.

At the Water Center

•Jane Walker has joined the Water Center staff as a research associate. Jane, who formerly was with Virginia Cooperative Extension, is primarily working on ways to increase the reach and impact of the Center's Web-based information.

•Service Training for Environmental Progress (STEP) places college students in Virginia communities for summer internships to research perceived environmental problems. STEP is seeking requests—by **May 3**—from communities or community groups for two projects (two students each) to be conducted in Summer 1999. The community sponsor is responsible for providing housing and food for the two students. For more information or to apply, contact Alan Raflo, (540) 231-5463 or araflo@vt.edu.

•The Water Center has received a grant from the U. S. Army Corps of Engineers to evaluate wetlands-mitigation banking programs in Florida and other states. The work is to be completed by December 1999.

•The Virginia Water Research Symposium date has been changed to **November 14—16, 1999**. The meeting will be held in Richmond at the Holiday Inn, Koger Conference Center. To be added to the mailing list for the conference, contact Judy Poff, at (540) 231-8030, fax (540) 231-6673, or jupoff@vt.edu.

FOR THE RECORD

Sources for Selected Water Resources Topics

Weather and Climate

Useful Publications

Data Resources for Local Water Resources Management (1992), describes weather and climate data available for Virginia. Contact the Va. Tech College of Arch. and Urban Studies, 202 Cowgill (0205), Blacksburg 24061; (540) 231-6416; Web-site: www.arch.vt.edu.

Virginia Agricultural Statistics Bulletin, published annually, includes the past year's measurements and the long-term averages from 96 weather/climate observation stations in the state. Contact the Va. Agric. Statis. Service, P. O. Box 1659, Richmond 23218-1659; (800) 772-0670; e-mail: nass-va@nass.usda.gov; Web-site: www.nass.usda.gov/va.

Agencies

•**National Weather Service**—Eastern Region Office of Public Affairs, 630 Johnson Avenue, Bohemia, NY 11716; (516) 244-0166; e-mail: robert.chartuk@noaa.gov. Web-site: www.nws.noaa.gov.

The National Weather Service is the source and the gateway to volumes of weather and climate information and data.

•**National Climatic Data Center**, Federal Building, 151 Patton Avenue, Asheville, NC 28801-5001; (828) 271-4800; Web-site: www.ncdc.noaa.gov/.

"The world's largest active archive of weather data," according to its Internet home page. The Web-site is linked to regional and state climate centers (see below).

•**Southeast Regional Climate Center**, So. Carolina Dept. of Natural Resources/Water Resources Division, 1201 Main Street—Suite 1100, Columbia, SC 29201; (803) 737-0800; Web-site: water.dnr.state.sc.us/climate/sercc/.

This center serves Alabama, Florida, Georgia, North and South Carolina, Puerto Rico, Virginia, and the U. S. Virgin Islands.

•**Virginia State Climatology Office**, Clark Hall, UVA, Charlottesville 22903; (804) 924-0549. Web-site: www.people.Virginia.edu/climate/.

The state office has records and forecasts for temperature, precipitation, sun and moon phases, lightning, and even fall foliage.

Especially for Mariners

•**Dial-A-Buoy** provides wind and wave measurements taken within the last hour at 65 buoy and 54 Coastal-Marine Automated Network stations in U. S. coastal waters and in the Great Lakes. **(228) 688-1948** (touch-tone or cell phone).

Upcoming "For the Record" Schedule

1999

June – Water Uses
August – Water Maps
October – Wetlands
December – Water Law

2000

February – Following the Va. General Assembly
April – State Water Regulatory Processes

Schedule subject to change

TEACHING WATER

For Virginia's K-12 teachers

This Issue and the Virginia Standards of Learning

Water Central welcomes comments on the applicability of articles to the standards listed or to others not listed.

Abbreviations: **BIO**-biology, **ES**-earth science, **LS**-Life science; **CH**-Chemistry

Feature Article

Science: 6.11, LS.12, ES.9, ES.11

Social Studies: 7.4, 12.6, 12.8, 12.13

Science Behind the News

Science: 5.5, LS.2, LS.3, LS.13, BIO. 3, BIO.4, BIO.6, BIO.7, BIO.8, CH.6
Social Studies: NONE

For the Record

Science: 2.6, 3.9, 4.6, 5.6, ES.11, ES.12, ES.13
Social Studies: 10.2, 10.8
Computer/Technology: 5.3, 8.4

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YOU GET THE LAST WORD

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

1. Would you rate the content of this issue as good, fair, or poor?
2. Would you rate the appearance as good, fair, or poor?
3. Would you rate the readability of the articles as good, fair, or poor?
4. Is the newsletter too long, too short, or about right?
5. Do the issues come too frequently, too seldom, or about right?
6. Please add any other **comments** you wish to make.

Reminder!! *Water Central* will be posted on the Water Center's web site (www.vwrrc.vt.edu/vwrrc/vwrrc.htm). 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.

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