Virginia Water Central Newsletter

Virginia Water Resources Research Center Blacksburg, Virginia December 2017 (No. 68)

Webb Branch of Stroubles Creek inlet to the Virginia Tech Duck Pond in Blacksburg, December 9, 2017.

IN THIS ISSUE

VIRGINIA TECH

Virginia WATER RESOURCES Research Center

S^2 on H_2O

Courtesy of Gloria Schoenholtz.

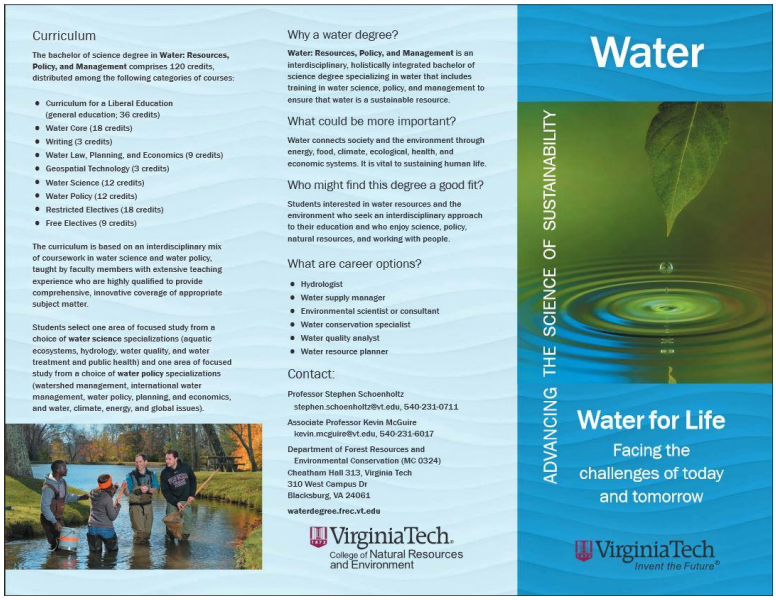
Continuing and Growing the Work with Students

By Stephen Schoenholtz
Director, Virginia Water Resources Research Center

This issue of the *Virginia Water Central Newsletter* features several exciting updates on our recent activities involving student training, a key component of the mission of the Virginia Water Resources Research Center. We offer training opportunities to both undergraduate and graduate students through internships, research assistantships, and seed grants for research projects. The Water Center also coordinates Virginia Tech's undergraduate minor in watershed management and a graduate certificate program in watershed management.

As I noted in a column for our August 2016 newsletter, the newest and largest aspect of our work with students is coordination of the **interdisciplinary undergraduate degree program, "Water: Resources, Policy, and Management,"** which enrolled students for the first time in fall 2015. This innovative, first-of-its-kind program is designed to provide core training in the fundamentals of water science and water policy. Once courses in core training are completed, students can then design individualized curricula to specialize in the study of aquatic ecosystems; water quality, water treatment, and public health; hydrology; watershed management; water policy, planning, and economics; or water, climate, energy, and global issues. The program also offers student support, with water scholarships and water research fellowships provided through generous donor contributions to an endowment fund. The program has grown rapidly, from the 36 students I reported in this space last year to 56 students enrolled in Fall 2017. We expect the program to continue to expand in response to rapidly growing appreciation of the importance of water by the current generation of high school and college students and to blossoming career opportunities in diverse water-related professional fields. (*Ed. note:* For more information on the undergraduate water degree, visit http://waterdegree.frec.vt.edu/; for the associated scholarship, visit http://waterdegree.frec.vt.edu/scholarships-and-research-fellowships/.)

Developing the human resource to manage our water resources sustainably is essential to our future. The Virginia Water Resources Research Center is proud to help promote this development at Virginia Tech and other universities throughout the Commonwealth. We look forward to continued growth of our water education mission to help meet the needs of our water students, our society, and the planet.



Brochure in 2017 for Virginia Tech's Water: Resources, Policy, and Management undergraduate degree program, available online at http://waterdegree.frec.vt.edu/.

FEATURE ARTICLE

Where is the Water at Virginia Tech?

By Eryn Turney. In the spring 2017 semester at Virginia Tech, Ms. Turney, of Dalveville, Va., served as the second student in an internship program begun in 2016 by the Virginia Water Resources Research Center. In May 2017 she graduated with a B.S. degree in Natural Resources Conservation from Virginia Tech's Department of Fish and Wildlife Conservation.

As a student in the College of Natural Resources and Environment, I was exposed to many realms of environmental study. This experience included witnessing the establishment of my department's newest major, Water: Resources, Planning, and Management—the first of its kind nationwide. If an incoming student were to express interest in studying water, they would likely be pointed in this direction. This program has a unique, interdisciplinary design that is easily adapted to student interest. Its design initially sparked my curiosity about how far the study of water reaches at Virginia Tech.

So, as a student interested in pursuing a career in the field of water resources, I began to explore the question, "Where is the water at Virginia Tech?" I used this to uncover opportunities and interests to which I had not previously been exposed, as well as to see how Virginia Tech is working cooperatively to help invent the future for water. From exploring various fields of study and talking to many professionals, I have found the short answer to this question: water is *everywhere*.

In reflecting on that experience in this article, I hope to provide a resource for individuals both within and outside of a university setting (Virginia Tech or otherwise) to understand the many directions water research and education are going, and why it matters. Undoubtedly, there will be areas of work I have neglected. This is simply meant to provide a stepping stone for those who have questions about water resources as a field of study, a career path, or both—as I do.

One Person's Piece in the Puzzle

To begin understanding the scope of water in our everyday lives, consider a concept called the "water footprint." As defined by the Water Footprint Network, a water footprint "…measures the amount of water used to produce each of the goods and services we use."

Understanding the concept of a water footprint helps bring to light the many ways humans use water. Showers, washing dishes, and watering our plants are obvious ways water is used on a daily basis; however, water used to grow and produce food, clothes, and electricity may be less conspicuous and more often taken for granted.

A Water Tour at Virginia Tech

Because water is the center of life, humans are all connected through the utilization, conservation, and exploration of this resource. Virginia Tech is working towards understanding and educating the public on a large scope of characteristics related to water by the many ways humans use it, affect it, and are affected by it. To begin to see the scope of where water can be found at Virginia Tech, I will take you on a tour.

We begin at Cheatham Hall, where posters line the hallways and the stairways are emblazoned with colorful murals. This is the home of the Departments of Fish and Wildlife Conservation, Forest Resources and Environmental Conservation, and Sustainable Biomaterials. These departments—along with the Department of Geography, which is not located in Cheatham—make up the College of Natural Resources and Environment. Some examples of what people here are working on include watershed management, wetland and stream ecology, aquatic toxicology, climate change effects on meteorology, effects of land management/development on water quality, and hillslope hydrology.

Next, walk down a hill to Seitz Hall. It's easy to get lost in the labyrinth of hallways through this building, where one corridor even ends within another building. Seitz is the home of Biological Systems Engineering, part of the College of Agriculture and Life Sciences. Here, you will find people studying and teaching hydrologic and water quality modeling, non-point source pollution, public health impacts, and stream/wetland restoration.

Beyond the doors of Seitz, look across the Drillfield to the Burruss Hall, an iconic image of Virginia Tech; to the right is Patton Hall. Among Patton's wood-paneled halls and pictures of alumni is the home of Civil and Environmental Engineering. In this department, there's work on drinking water quality, fluid mechanics, water quality monitoring and modeling, groundwater and pollution transport, hydrology, water infrastructure, and wastewater treatment.

Coming out of the North side of Patton, walk down a hill zig-zagging amongst buildings until you reach the distinct Derring Hall. Derring Hall, the one building on campus rumored to have been designed by a University of Virginia architect, appears to be made up of endless hallways with haphazardly numbered classrooms separated by swinging double doors. This building is the home of Biological Sciences and study of the influence of hydrology on biogeochemical cycling, the effect of landscape disturbance on stream ecosystems, and eutrophication (nutrient enrichment of water bodies).

Within these buildings, many faculty members shared with me some insights about what they do, why they do it, and how they believe their work fits into the bigger picture of working for change at Virginia Tech as applied to the world outside.

Let's consider how these different academic areas are approaching one given water subject: wetlands. While I, as a student, learned about forested wetland ecosystem functions and values, a civil engineer is focused specifically on the point of where groundwater and surface water interact. While a chemist is concerned with the rate of denitrification that occurs in this same wetland, a biologist studies the variance in benthic macroinvertebrate structure in response to human disturbance of this land. A forester studies how best management practices are affecting the forest structure of the area, while a wildlife toxicologist is concerned with how individual amphibians respond to various levels of pollutants in the water. An economist or policymaker is concerned with determining a monetary value for a natural environment, while a social scientist works to understand how different people prefer to utilize the same area.

In the examples, notice there is not only a difference in *focus* amongst disciplines but also one of *scale*. Some see from a bird's eye view an ecosystem function or issue, while others take a pinpointed view to understand the driver of a particular issue.

How the Pieces Fit

In speaking with people from each of these different departments, I kept waiting for research topics, studies, and interests to overlap. While the core of water resources work for many is improving water systems for the future, specifics of the work typically did not cross over. This is encouraging. Through collaboration, scientists across various disciplines are working towards improvement across a wide array of problems that can become large-scale contributions to society.

Collaboration allows individuals to utilize the knowledge and experiences of others, making it possible to understand the drivers of specific problems and to consider more solutions, and eliminating the need for any one person or group to know "everything." This allows busy individuals to avoid the extended effort involved in coming to a basic understanding of something on which someone else may be an expert. At its best, collaboration among water specialists allows individual interests to fit together as pieces of a larger puzzle, revealing the many relationships water has to life around us.

The more faculty members I spoke to, the more I began to hear about this cohesion among disciplines, where relationships between individuals led to communication and collaboration. I received the general impression that collaboration is very beneficial, but I also learned that it's not always a perfect solution to understanding a situation. For example, one professor described to me a project where individuals from varied interests and expertise attempted to collaborate, but the project became disorganized and ultimately failed. According to the professor, the problem in this case was a failure to establish a common mission or goal. Without that focus, synthesis within the group as a whole didn't occur.

Water Beyond the Classroom

As a land grant university, Virginia Tech's three primary goals and responsibilities are teaching and learning, research and discovery, and outreach and engagement.[1] So far, I have described my experience learning from professors about their teaching and research. In accordance with Virginia Tech's motto "*Ut Prosim*" ("That I May Serve"), water is also found in the third part of this mission, in outreach and engagement, and collectively serves individuals far beyond the university.

For one, I started all of this exploration at the Virginia Water Resources Research Center, which is housed on campus in Cheatham Hall within the College of Natural Resources and Environment. The Water Center collaborates with many other state and national organizations dedicated to providing the general public with information.

Other organizations and programs that I visited on campus concerned with water resources study and sustainability included the following: Virginia Cooperative Extension; Global Change Center; Virginia Water Monitoring Council; Virginia Household Water Quality Program; Stream Research, Education, and Management (StREAM) Lab within Biological Systems Engineering; and Virginia Tech Research Team for Flint, Michigan. Organizations like these provide information, services, employment, events, and other opportunities to learn about water resources to citizens locally, statewide, nationwide, and worldwide.

Tech in the Larger Puzzle

Water is everywhere, and it's a resource everyone relies on every day. Water quantity and quality stresses in response to human and climatic changes call for individuals everywhere to be stewards of these resource.

The depth of the water resources field is immense. In the words of the person I spoke to the most about this exploration, "…like a river, [it is] wide and deep." Though I dove into many places, I missed many others including management, tourism, international studies, human health and medical study, recreation, agriculture, horticulture, architecture, and urban affairs. In one particularly humorous omission, I forgot to include Ocean Engineering, an incredibly obvious area considering that oceans contain the majority of earth's water.

Take that oversight from an undergraduate student as an example: there is always more to discover. What is going on at Virginia Tech serves as an example, but only one, of what is being done across the world. From that though, get excited, because there is more to be done, and lots of places to do it. Ask questions and explore, and your understanding and curiosity will only grow with time. From one student exploring this immense puzzle a little more each day to you, I hope this article has helped to open your eyes to the boundless, unique opportunities that exist in the realm of water resources, and that it's shown reasons to care about why it's all happening in the first place.

Acknowledgements

A special thanks to those faculty members who shared some of their time with me in making sense of this larger picture, as well as answering my many questions in exploring the opportunities available in this field of study and work.

The College of Agriculture and Life Sciences
Durrelle Scott – Biological Systems Engineering Department/Household Water Quality Program;
Cully Hession – Biological Systems Engineering Department/StREAM Lab.

The College of Engineering
Marc Edwards – Civil and Environmental Engineering/Virginia Tech Research Team for Flint, Mich.;
Erich Hester – Civil and Environmental Engineering.

The College of Natural Resources and Environment
Mike Aust – Forest Resources and Environmental Conservation Department;

[1] Virginia Tech Mission Statement, retrieved May 2, 2017, from https://www.president.vt.edu/about-the-office/mission-vision/index.html

Mark Ford – Fish and Wildlife Conservation Department and Virginia Cooperative Fish and Wildlife Research Unit;
Bill Hopkins – Fish and Wildlife Conservation Department and Global Change Center;
Luke Juran – Geography Department and Virginia Water Resources Research Center;
Kevin McGuire – Forest Resources and Environmental Conservation Department and Virginia Water Resources Research Center;
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Inga Solberg –Virginia Water Resources Research Center;
Jane Walker – Virginia Water Resources Research Center and Virginia Water Monitoring Council.

The College of Science
Fred Benfield – Biological Sciences Department.

Though not included specifically in this list, another big thank you to my many professors from the past four years across various departments, as well as my advisor, for your time, effort, and passion for growing the next generation of curious, eager Hokies.

TEACHING WATER
Especially for Virginia's K-12 teachers

This Issue of *Water Central* and the Virginia Standards of Learning

Below are suggested Virginia Standards of Learning (SOLs) that may be supported by items in this issue. The SOLs listed are from Virginia's 2010 Science SOLs and 2008 Social Studies SOLs. Abbreviations: BIO = biology; CH = chemistry; ES = earth science; LS = life science; WG = world geography.

Newsletter Section	Science SOLs	Social Studies SOLs
Feature/Water Center Intern's Report	6.7, 6.9, LS.11, ES.2, ES.8	WG.2
At the Water Center/Competitive Grants Program Summary Reports		
Report 1: Bacteria, chemical Taxis, groundwater, and bioremediation	6.9, LS.11, ES.2, ES.8, BIO.4, BIO.8, CH.6	WG.2
Report 2: Headwater stream patterns in response to storms	6.7, ES.2, ES.8, LS.11	WG.2
Report 3: Chesapeake Bay plastic pollutants, bacteria, and public health	6.7, 6.9, LS.9, ES.2, ES.10, BIO.4, BIO.8	WG.2

AT THE WATER CENTER

To reach the Virginia Water Resources Research Center: phone (540) 231-5624; FAX (540) 231-6673; e-mail water@vt.edu; Web site www.vwrrc.vt.edu.

Virginia Water Resources Research Center's Student Grant and Fellowship Award Winners for 2017-18

Between February and June 2017, the Water Center conducted its two annual competitions for recognizing and supporting students studying water resources at colleges or universities in Virginia. Here are the recipients for 2017-18.

William R. Walker Graduate Research Fellow Award

Established to honor the late William Walker, the founding director of the Virginia Water Resources Research Center, this award has been given since 1999 to recognize and support graduate students in water resources who are pursuing work in a field different from their undergraduate study, or who have returned to school following a period of professional work.

The Walker Award winner for 2017-18 is **Jacob Diamond**, Ph.D. student, Department of Forest Resources and Environmental Conservation, Virginia Tech.

The application period for the Walker Award typically runs from March to May. More information about this program is available online at http://www.vwrrc.vt.edu/walker-award/.

Jacob Diamond, winner of the 2017-18 William R. Walker Graduate Research Fellow Award. *Photo courtesy of Jacob Diamond.*

Competitive Grants

Under the **Competitive Grants Program**, the Water Center awards grants of up to $5000 to support research by students at Virginia colleges or universities. This year's grants, which are for the period June 1, 2017 to May 31, 2018, were awarded to the following students and projects.

Stephanie Houston, Ph.D. student, Department of Biological Systems Engineering, Virginia Tech. **Project title**: "A renewable filtration system for the removal and reuse of pollutants from retention ponds."

Mary Lofton, Ph.D. student, Department of Biological Sciences, Virginia Tech. **Project title**: "Simulating storms to predict phytoplankton community responses to future climate change: a whole-ecosystem mixing experiment."

Brendan Player, M.S. student, Department of Environmental Science, Christopher Newport University. **Project title**: "Nutrient uptake in degraded and restored sections of urban streams across project age gradients."

The application period for competitive grants typically runs from February to March or April. More information about this grant program is available online at http://www.vwrrc.vt.edu/grant-opportunities/competitive-grants/.

Water Center Competitive Grants Program Reports for 2016-17

On the following three pages are **summary reports for the three grants awarded in 2016**, for work done between June 2016 and May 2017. The reports were written by the respective student principal investigators, with editing in some places by the *Water Central Newsletter* editor for space, clarity, or format, including bolding and italics.

2016-17 Report 1. Bacterial Chemotaxis: A Promising Method for Enhancing Bioremediation of Oil Contaminants.

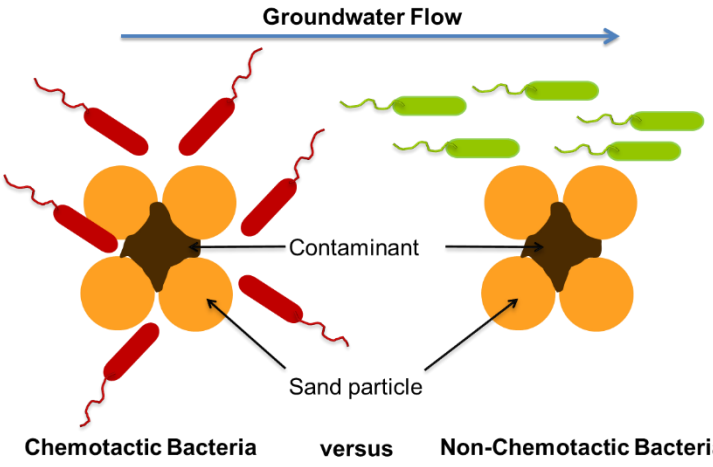
Student Principal Investigator: Joanna Adadevoh ; Faculty Co-Principal Investigator: Roseanne Ford; Department of Chemical Engineering, University of Virginia, Charlottesville, Va.

Chemotaxis is a phenomenon in which microorganisms possess the capability to detect the presence of a chemical and move preferentially towards (i.e., positive taxis) or away from (i.e., negative taxis) a region of increasing chemical concentration. Chemotaxis holds promise for enhancing the bioremediation of contaminated aquifers due to the preferential migration of pollutant-degrading microorganisms towards the sources of contamination. [*Ed. note*: **Bioremediation** is the use of living organisms (bacteria, plants, and others) to break down or remove contaminants from soil, groundwater, or other environments.]

In this study, we experimentally investigated the positive taxis of bacterial cells towards non-aqueous phase liquid (NAPL) contaminants in a laboratory-scale sand chromatography column. [*Ed. note*: **Non-aqueous phase liquid** refers principally to liquid hydrocarbons do not dissolve in water.] The main metric of interest was cell retention within the contaminated media. It was hypothesized that while chemotaxis was occurring, cells would migrate preferentially towards the NAPL attractant sources and remain in the vicinity of those sources, such that the overall retention of chemotactic cells within the sandy media would be enhanced. Our experimental results were consistent with our hypothesis.

Here are more details about the experimental procedure. The NAPL attractant source was naphthalene dissolved in 2,2,4,4,6,8,8-heptamethylnonane (HMN); HMN is a model NAPL and naphthalene is an attractant source for the chemotactic bacteria *Pseudomonas putida* G7. For control experiments, the *non*-chemotactic mutant strain, *Pseudomonas putida* G7 Y1, was used. NAPL contaminants were irreversibly trapped as oil globules in sandy soil within a chromatography column; then, chemotactic and non-chemotactic bacterial cells were introduced simultaneously into the sandy media at the column inlet. Prior to column injection, the chemotactic and non-chemotactic cells were labelled with fluorescent markers of different colors to aid differentiation. Additional control experiments were conducted as follows: (1) HMN containing no dissolved naphthalene trapped within the sandy media, and (2) no HMN or naphthalene within the sand. As the experiment progressed, cell samples were collected with time from the column effluent and enumerated. A major experimental result was an increased retention of chemotactic cells within the sandy media, due to preferential positive taxis of the cells towards the NAPL attractant sources trapped within the sand grains; the enhanced retention of chemotactic cells was shown by a 45-percent decrease in cell recovery from the column, compared to control experiments.

An increased retention of pollutant-degrading cells at the site of contamination may lead to improved oil pollutant accessibility and biodegradation, and hence more rapid biorestoration of contaminated aquifers.



Report 1 diagram: Two scenarios to illustrate differences in the migration of chemotactic bacteria (colored red and oriented diagonally in the diagram) and non-chemotactic bacteria (colored green and oriented horizontally in the diagram) in the presence of a contaminant trapped among sand grains. Adapted from Adadevoh, J. S., *et al.*, 2016, "Chemotaxis increases the residence time of bacteria in granular media containing distributed contaminant sources," *Environ. Sci. Technol.* Vol. 50, pages 181−187. *Diagram courtesy of Joanna Adadevoh.*

2016-17 Report 2. Sensors Reveal the Timing and Pattern of Stream Flow in Headwaters after Storms.

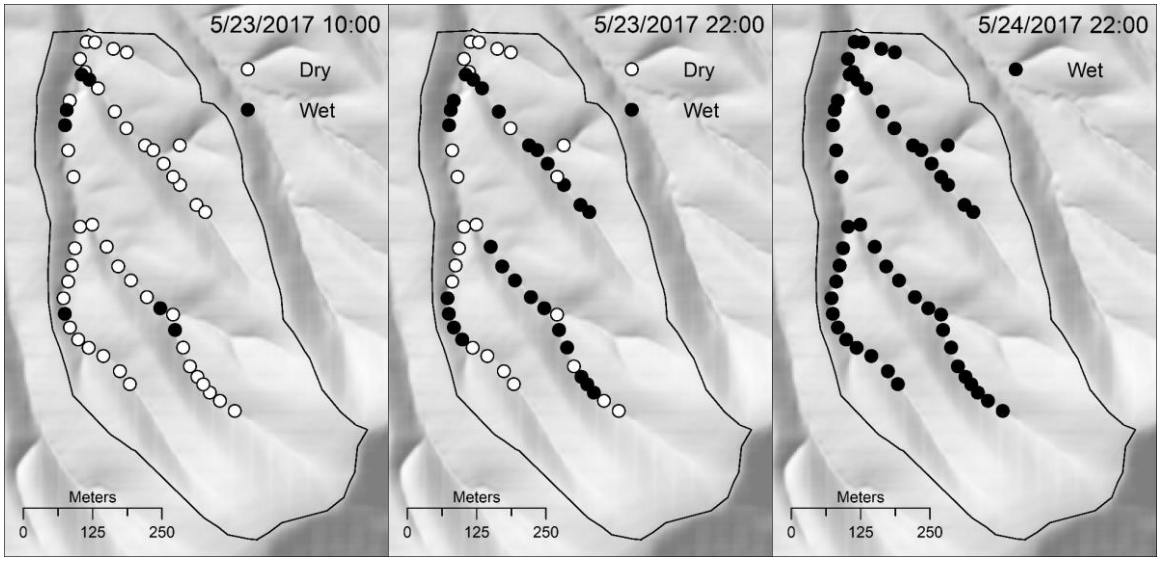
Student Principal Investigator: Carrie Jensen; Faculty Co-Principal Investigator: Andrew Dolloff; Department of Forest Resources and Environmental Conservation, Virginia Tech, Blacksburg, Va.

We installed 50 **stream-intermittency sensors** that detect the presence or absence of water along the stream network of a small headwater catchment in the Valley and Ridge physiographic province of southwest Virginia. [*Ed. note*: **Catchment** is another term for watershed or drainage area, typically applied to relatively small areas.] We had previously mapped the "wet," or active, flowing stream length several times by walking the network at different flow conditions. Mapping the catchment in this manner, however, requires several hours and, as a result, doesn't permit the simultaneous observation of stream length on the rising limb, peak, and falling limb of storm events along the entire network. [*Ed. note*: **Limb** refers to the rising or falling parts of a **hydrograph**, that is, a graph of stream flow over time during a storm.] The stream intermittency sensors facilitate the examination of stream length dynamics during storms by recording the presence or absence of water every 15 minutes.

We are keeping the sensors in the catchment for one year to determine the spatial pattern and timing of stream wetting and drying across different seasons and precipitation rates. One primary question is whether the stream network is longer for the same discharge on a storm's falling limb than on the same storm's rising limb.

Results thus far indicate that flow duration in response to storms is spatially variable throughout the catchment. Interestingly, the onset of flow following rainfall occurs at approximately the same time across many of the sensors, but the duration of flow after the storm ends differs considerably. Reaches with a wide, sediment-filled valley floor carry water for far shorter periods of time than [do] confined channel segments with steep valley side slopes. During our earlier field surveys, we observed flow in a few of the tributaries only for the wettest conditions mapped; the sensors now show that these tributaries actually flow more frequently during much smaller storms, but they flow only for brief periods of time. The high temporal sampling resolution of the sensors allows a more accurate estimate of flow duration in these ephemeral streams, which we otherwise risk underestimating with only field surveys.

Headwater streams carry water, sediment, organic matter, and pollutants to downstream waterways. Much of this transmission occurs episodically during storms when stream levels are high. Storm events are difficult to study in headwaters, as the rise and fall of stream flow occurs rapidly in these small catchments. Stream intermittency sensors help assign an accurate flow duration to headwater reaches, which is not always possible with field surveys. We hope to use the sensor data—in conjunction with terrain metrics like valley width and drainage area—to help predict where and when streams in similar settings will carry flow for a given storm. Such information would aid watershed management efforts.



Report 2 diagram: Dry/wet status of flow intermittency sensors indicating the expansion of stream length during a storm in May 2017. *Diagram courtesy of Carrie Jensen.*

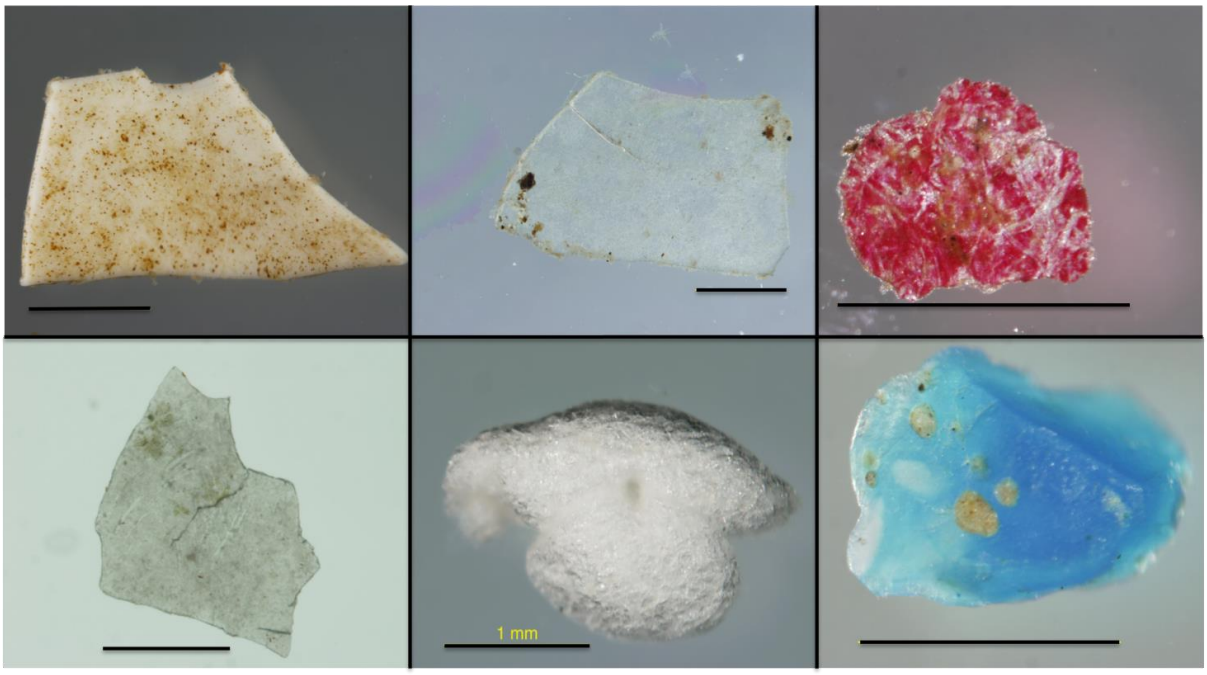
2016-17 Report 3. Plastic Pollution as a Vector for Bacteria and Human Pathogens.

Student Principal Investigator: Amanda Lavety; Faculty Co-Principal Investigator: Fred Dobbs; Department of Ocean, Earth & Atmospheric Sciences, Old Dominion University, Norfolk, Va.

Since plastics degrade very slowly, they remain in the environment for much longer time than most natural substrates. As a result, they can provide a novel habitat for **colonization by bacterial communities**. The full spectrum of relationships between plastics and bacteria, however, is little understood. Ingestion of microplastics by marine metazoans has generated concern for transfer of toxic chemicals; ingestion may also increase exposure to pathogens and associated antibiotic resistances. [*Ed. note*: **Metazoan** refers to multicellular animals.] This exposure could pose a public health issue as it increases the probability of plastics, toxins, harmful bacteria, and antibiotic resistance entering and possibly moving through the food web. Given the environmental ubiquity and persistence of plastics, it is imperative to understand the public-health implications of these floating, dispersible habitats.

The objective of this study was to examine marine plastic pollution as a substrate for bacteria, with particular focus on *Vibrio* species of bacteria, including the human pathogens, *Vibrio cholerae*, *V. parahaemolyticus*, and *V. vulnificus*. We set up experiments in a tributary of the lower Chesapeake Bay to follow *Vibrio* species colonization and total bacterial community composition over time. We also collected microplastics and paired seawater samples to determine the presence, abundance, and antibiotic-resistance profiles of the *Vibrio* species harbored in the plastics and in the water. We examined *Vibrio* isolates' response to six antibiotics and found no differences between the antibiotic susceptibilities of vibrios isolated from plastics compared to those from the surrounding water column. There was, however, a significant difference in antibiotic susceptibility between isolates from colonization experiments and microplastics, with more resistance overall seen in the former.

In every instance examined, we found vibrios to be enriched on plastics by at least two orders of magnitude compared to those from paired seawater samples. Bacterial colonization was detected with DNA sequencing as early as day 2, and plastic communities were consistently distinct and more diverse than surrounding seawater. Colonization rates and community structure varied over time and among substrate types, suggesting that numerous factors should be considered when characterizing microbial communities on plastic. This study demonstrates that plastic pollution serves as a habitat for *Vibrio* species and confirms that plastics may serve as a vector for these and other potentially pathogenic bacteria.



Report 3 images: Photographs of potential microplastics collected in a lower tributary of the Chesapeake Bay. The black lines represent one millimeter. *Photos courtesy of Amanda Laverty.*

N O T I C E S

*For an online list of Virginia water-related **government meetings** (updated weekly), please see the Virginia Water Central News Grouper posts at https://vawatercentralnewsgrouper.wordpress.com/?s=Virginia+Water-related+Government+Meetings.*

*For an online list of Virginia water-related **conferences and other events** (updated at least monthly), please see the Virginia Water Central News Grouper's "Quick Guide to Virginia Water Events," at http://vawatercentralnewsgrouper.wordpress.com/?s=Quick+Guide.*

*For an online list of water-related **conferences and meetings outside of Virginia** (updated quarterly), please see the Virginia Water Central News Grouper's "Water Conference Sampler from around the United States and Elsewhere," at http://vawatercentralnewsgrouper.wordpress.com/?s=Water+Conference+Sampler.*

*If you would like to receive **regular e-mail notifications** about meetings, reports, and other items related to water quality and water monitoring, you may do so by joining the **Virginia Water Monitoring Council**; contact Jane Walker at (540) 231-4159 or janewalk@vt.edu.*

All Web sites listed in this section were functional as of 12/7/17.

2018 Virginia General Assembly Preview and Tracking Information

The 2018 General Assembly convenes on January 10 and is scheduled for 60 days; this is a so-called "long session," which is held in all even-numbered years. The reconvened ("veto") session will be held in April. During long sessions, the Commonwealth's budget for the upcoming two years is set; amendments to the current biennial budget may be considered both in long and short sessions. Live video streams of floor sessions are available at http://virginia-house.granicus.com/ViewPublisher.php?view_id=3 for the House and http://virginia-senate.granicus.com/ViewPublisher.php?view_id=3 for the Senate. Information about all standing committees as of June 2018—including membership, meeting times, and legislation being considered—is available online at http://lis.virginia.gov/181/com/COM.HTM.

The General Assembly's Web site, http://virginiageneralassembly.gov/index.php, offers several useful features, including member lists, session calendars, live video of floor sessions, and information on legislative processes. The Legislative Information System (LIS) Web site, http://lis.virginia.gov/lis.htm, provides lists and summaries of all bills, searchable by topic, member, committee, etc. The organization Open Virginia's Richmond Sunlight Web site, at https://www.richmondsunlight.com/, also offers tools for following the General Assembly and for learning about Virginia law.

To express an opinion on legislation, citizens are requested to contact their respective delegate of senator. If you do not know your representatives or their contact information, you can use the online "Who's My Legislator" service, available at http://whosmy.virginiageneralassembly.gov/.
You can find members' contact information at these links:
House of Delegates, at http://virginiageneralassembly.gov/house/members/members.php;
State Senate, at https://apps.senate.virginia.gov/Senator/.

If you know the numbers of your legislative districts, you can also use the **following code to identify your representatives' Capitol phone numbers**: for delegates, (804) 698-10 + district number (for example, 698-1003 for the District 3 delegate); for senators, (804) 698-75 + district number (for example, 698-7510 for the District 10 senator).

The **Lobbyist-In-A-Box** subscriber service also offers free tracking for up to five bills, and it offers tracking of more than five bills for a fee; visit http://lis.virginia.gov/h015.htm. For assistance, phone Legislative Automated Systems at (804) 786-9631.

Mid-Atlantic Water Resources Conference in October 2017 Presentations Available

On October 12-13, 2017, at the National Conservation Training Center in Shepherdstown, West Virginia, the West Virginia Water Research Institute (WVWRI) hosted the 2017 Mid-Atlantic Regional Water Conference.

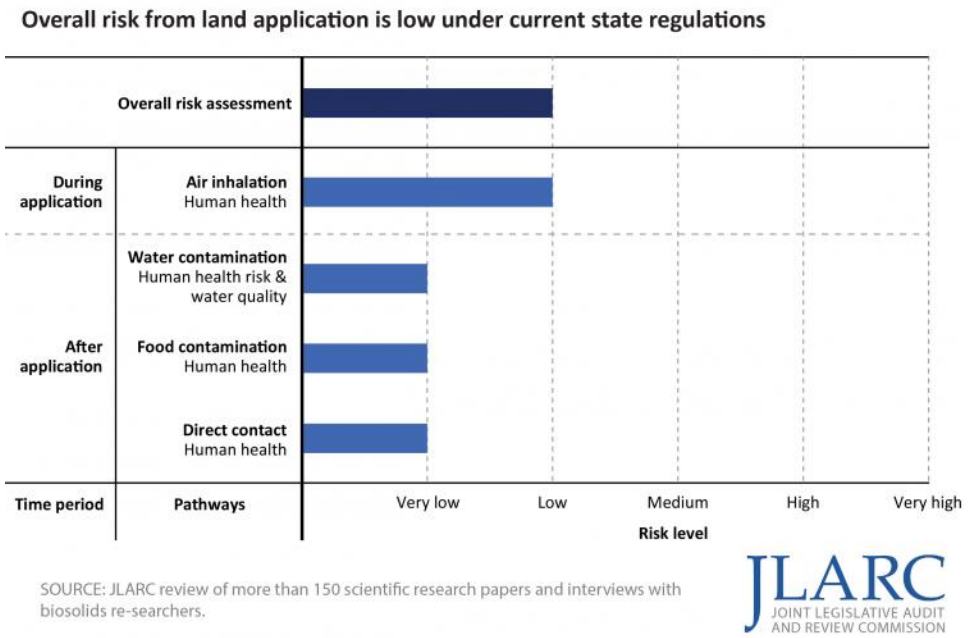
Conference presentations are available online at http://midatlanticwrc.org/event-info/agenda/; to view the abstracts and presentations, click on a given talk's title within the conference agenda table.

The conference was a collaborative effort of Delaware Water Resources Center (at the University of Delaware), the Pennsylvania Water Resources Research Center (at Penn State), the Virginia Water Resources Research Center (at Virginia Tech), and WVWRI (at West Virginia University).

For questions or more information about the conference, visit http://midatlanticwrc.org/, or contact the conference coordinator at the WVWRI by e-mail at wvwaterconference@mail.wvu.edu or by phone at (304) 293-7009.

Biosolids Study by JLARC Released in October 2017

On October 20, 2017, Virginia's Joint Legislative Audit and Review Commission (JLARC) released "Land Application of Biosolids and Industrial Residuals," a 101-page report called for by the 2016 Virginia General Assembly (HJ 120, online at http://leg1.state.va.us/cgi-bin/legp504.exe?161+sum+HJ120). The full report, a summary, and the list of recommendations are available online at http://jlarc.virginia.gov/landing-biosolids-2017.asp.



Overview of risk from biosolids application, according to the findings in Virginia's Joint Legislative Audit and Review Commission's "Land Application of Biosolids and Industrial Residuals," online at http://jlarc.virginia.gov/landing-biosolids-2017.asp.

Well Closure is Well Worth Discussing on the 30th Anniversary in 2017 of "Baby Jessica" in Texas

On October 16, 1987, 18-month-old Jessica McClure was rescued from an abandoned water well in Midland, Texas. The October 2017 issue of *The Cross Section*, from the High Plains Underground Water Conservation District in Lubbock, Tex., recalls the "Baby Jessica" story as a cautionary tale for the proper closure and sealing of wells that will no longer be used—a task of importance not only for safety for humans and animals but also for groundwater protection. The newsletter is available online at http://www.hpwd.org/the-cross-section/; or contact the District at 2930 Avenue Q, Lubbock, TX 79411-2499l (806) 762-0181. Following are some **Virginia information resources related to well abandonment and sealing**.

- Virginia law on sealing temporarily or permanently abandoned wells is online at https://law.lis.virginia.gov/admincode/title12/agency5/chapter630/section450/.
- Water well tips for karst areas from the Virginia Department of Conservation and Recreation are available online at http://www.dcr.virginia.gov/natural-heritage/lokwaterwell.
- "Proper Permanent Well Abandonment for Virginia Coastal Plain Wells," from the Virginia Department of Environmental Quality and Department of Health, is available online (as a PDF) at http://www.deq.virginia.gov/Portals/0/DEQ/Water/GroundwaterPermitting/DocumentsandForms/2017/DEQFactsheet-WellAbandonment2014.pdf?ver=2017-03-23-123639-840.

●Enquire with your local Soil and Water Conservation District (the District Directory is available online at http://vaswcd.org/district-directory). Also, some Virginia local governments provide information on proper well abandonment.

Virginia Oyster Month in November 2017

On November 6, 2017, Virginia Gov. Terry McAuliffe designated November as Virginia Oyster Month. The Governor's Office Nov. 6, 2017, news release with the announcement is "Governor McAuliffe Announces November as Virginia Oyster Month," online at http://governor.virginia.gov/newsroom/newsarticle?articleId=21692. The designation is intended to call attention to the role of the oyster industry in the Virginia's current economy and the long heritage of oyster-based communities and cultural events. In recognition of Virginia Oyster Month, following are some information resources on oysters in Virginia, the Chesapeake Bay, and elsewhere.

●Artisans Center of Virginia, "Virginia Oyster Trail," online at http://www.virginiaoystertrail.com/.
●Chesapeake Bay Program, "Eastern Oyster," online at http://www.chesapeakebay.net/fieldguide/critter/eastern_oyster.
●Alice Jane Lippson and Robert L. Lippson, *Life in the Chesapeake Bay*, Johns Hopkins University Press, Baltimore, Md., 2006.
●Maryland Sea Grant, "Oysters," online at http://www.mdsg.umd.edu/topics/oysters/oysters.
●Clyde L. McKenzie, Jr., "History of Oystering in the United States and Canada, Featuring the Eight Greatest Oyster Estuaries," *Marine Fisheries Review*, Vol. 58, No. 4, 1996.
●Partnership for the Delaware Estuary, "Delaware Bay Oysters," online at http://delawareestuary.org/oysters.
●Patricia Samford, Jefferson Patterson Park and Museum/Maryland State Museum of Archeology, "Oyster Wars," 7/9/13, online at https://jeffersonpatterson.wordpress.com/2013/07/09/oyster-wars/.
●Smithsonian Marine Station at Fort Pierce, "*Crassostrea virginica*/Eastern Oyster," online at http://www.sms.si.edu/irlspec/Crassostrea_virginica.htm.
●Virginia Institute of Marine Science (VIMS), "Oysters @ VIMS," online at http://www.vims.edu/research/topics/oysters/.

Public Lands Day in Virginia Started in September 2017

The first Public Lands Day in Virginia took place September 30, 2017. According to a September 26, 2017, news release from the Virginia Governor's Office, "[t]he newly instituted Virginia Public Lands Day was established during the 2017 General Assembly session [on the last Saturday in September each year] and encourages conservation and stewardship through special events around the Commonwealth. Virginia Public Lands Day will be led by The Nature Conservancy, the Virginia Department of Conservation and Recreation, the Virginia Tourism Corporation, and conservation organizations across the Commonwealth. Numerous events will take place across the state, including guided hikes, paddling trips, and volunteer cleanups in some of Virginia's most treasured natural areas." Public lands in Virginia include national parks and monuments under the National Park Service, state parks and natural area preserves under the Virginia Department of Conservation and Recreation, state forests under the Virginia Department of Forestry, wildlife management areas under the Virginia Department of Game and Inland Fisheries, open space lands under the Virginia Outdoors Foundation, local and regional parks, and private lands made available for public use. ***Sources***: "Governor McAuliffe Announces Partnership with REI to Promote Virginia Public Lands Day; Inaugural Virginia Public Lands Day will take place September 30, 2017," Virginia Governor's Office News Release, 9/26/17, online at http://governor.virginia.gov/newsroom/newsarticle?articleId=21360; Virginia's United Land Trusts, "Virginia Public Lands Day," online at https://vaunitedlandtrusts.org/events/virginia-public-lands-day/; Virginia General Assembly 2017, (House Joint Resolution 640, online at http://lis.virginia.gov/cgi-bin/legp604.exe?171+ful+HJ640ER.

Adapt Virginia Web Portal on Climate Change Adaptation Released in Summer 2017

In Summer 2017, the Adapt Virginia Web portal on climate adaptation was announced by the Virginia Institute or Marine Science's Center for Coastal Resources Management; the Web site is http://adaptva.com/. According to that site, Adapt Virginia (AdaptVA) "is a gateway to information for individuals, local programs, and agencies engaged in climate adaptation. AdaptVA focuses on the physical and social vulnerabilities by integrating the best available science, legal guidance, and planning strategies. Visitors

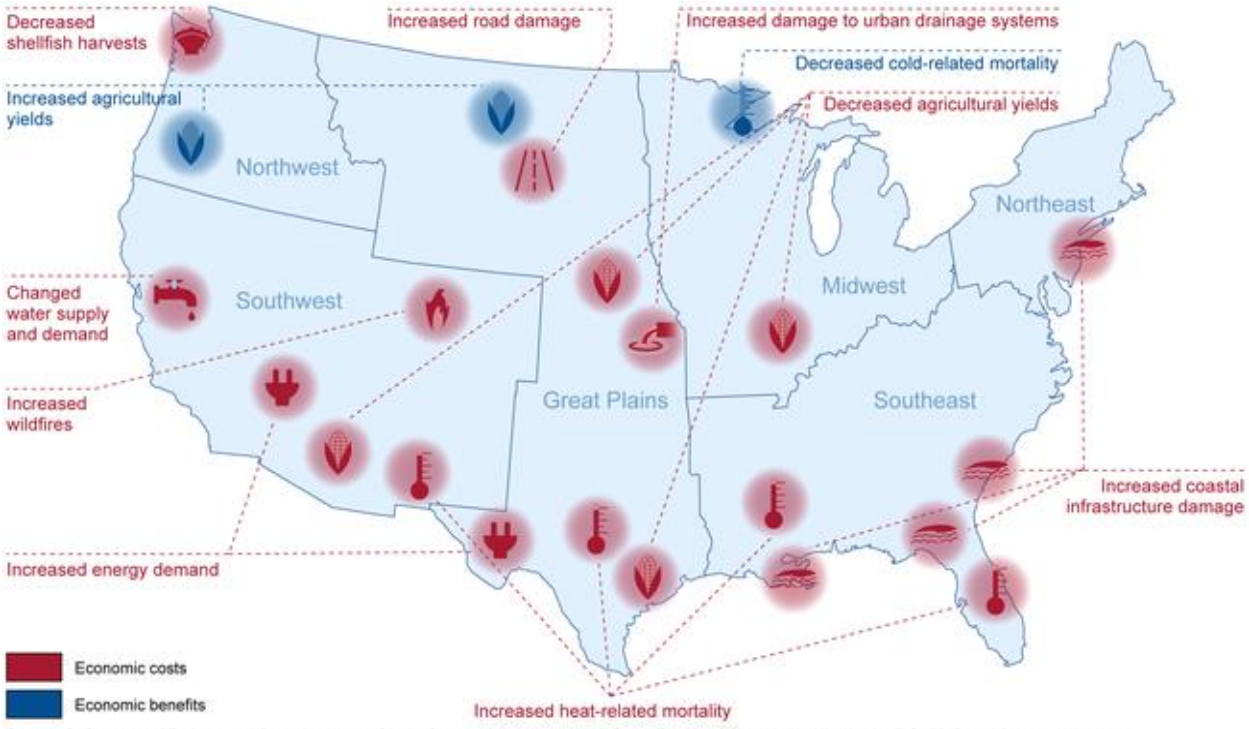
will find legal and policy resources, stories that explain adaption through maps and pictures, a searchable web catalogue, and mapping tools that address short and long-term predictions for rising water levels." The site's content currently covers forecasts, adaptations, tools, maps and data, and planning and policy.

An Overview of Efforts to Capture Wave Energy, from Hawaii to Virginia

On November 12, 2017, the PBS NewsHour broadcast "Scientists work to harness power from Hawaii's waves," available online at https://www.pbs.org/newshour/show/scientists-work-to-harness-power-from-hawaiis-waves#audio. Focusing on work being done in Hawaii, the 8 min./6 sec. segment examines efforts by scientists and entrepreneurs to develop technology that can generate electricity from ocean waves at an economically viable, commercial scale. The report includes comments on the challenges of capturing wave energy from George Hagerman, a senior research associate with Virginia Tech's Center for Energy and the Global Environment.

Climate Change Economic Costs Evaluated in GAO Report Published in September 2017

In September 2017, the U.S. Government Accountability Office (GAO) published "Climate Change: Information on Potential Economic Effects Could Help Guide Federal Efforts to Reduce Fiscal Exposure." The full report (45 pages), along with "Fact Facts" and "Highlights" documents, is available online at https://www.gao.gov/products/GAO-17-720. Following is an excerpt from the Highlights document: "Over the last decade, extreme weather and fire events have cost the federal government over $350 billion, according to the Office of Management and Budget. These costs will likely rise as the climate changes, according to the U.S. Global Change Research Program. …This report examines (1) methods used to estimate the potential economic effects of climate change in the United States, (2) what is known about these effects, and (3) the extent to which information about these effects could inform efforts to manage climate risks across the federal government. GAO reviewed 2 national-scale studies available and 28 other studies; interviewed 26 experts knowledgeable about the strengths and limitations of the studies; compared federal efforts to manage climate risks with leading practices for risk management and economic analysis; and obtained expert views. …The two available national-scale studies that examine the economic effects of climate change across U.S. sectors suggested that potential economic effects could be significant and unevenly distributed across sectors and regions." Below is Figure 2 from the study, showing the kinds of economic impacts that may occur as a result of climate change.



Sources: GAO analysis of Environmental Protection Agency, *Climate Change Impacts in the United States: Benefits of Global Action* (Washington, D.C.: 2015), and Solomon Hsiang et al., "Estimating Economic Damage from Climate Change in the United States," *Science*, vol. 356 (2017); Map Resources (map). | GAO-17-720

Aquifer Recharge, Storage, and Recovery Examined in Three Water Newsletters in 2017

Managed aquifer recharge, storage, and recovery—that is, the intentional recharge of groundwater aquifers with surface water or wastewater, for storage and potential future recovery—was examined in detail in three water newsletters in 2017.

"Arizona Water Banking, Recharge, and Recovery," by Noah Silber-Coats and Susanna Eden, is the feature article in the **2017 issue of *The Arroyo***, an annual newsletter from the University of Arizona Water Resources Research Center. The 16-page article examines in detail Arizona's program of recharging groundwater aquifers with surface water (particularly Colorado River water from the Central Arizona Project) and the complicated legal and management arrangements involved. The publication is available online at https://wrrc.arizona.edu/publications/arroyo, or contact the Arizona center at (520) 621-9591, or e-mail: wrrc@cals.arizona.edu.

The concept, history, and current examples of managed aquifer recharge in the United States and beyond are the focus of the **September 2017 issue of *Water Resources Impact***, published by the American Water Resources Association (AWRA; headquartered in Middleburg, Va.). The publication is available online at http://www.awra.org/impact/; or contact AWRA at P.O. Box 1626, Middleburg, VA 20118-8390; (540) 687-8390; info@awra.org.

"Aquifer Storage and Recovery" is the theme of the **July/August 2017 issue of *Colorado Water***, from the Colorado State University Water Center and the Colorado Water Institute. The 42-page newsletter builds upon a symposium on subsurface water storage held at Colorado State University in November 2016. The issue is available in the newsletter archive online at http://www.cwi.colostate.edu/newsletters.asp; or contact the Colorado Water Institute at 1033 Campus Delivery, Fort Collins CO 80523-1033; (970) 491-6308; cwi@colostate.edu.

Safe Wastewater Use in Agriculture is Focus of 2016 United Nations Publication

Safe Use of Wastewater in Agriculture: Good Practice Examples was published in 2016 by the United Nations (UN) University Institute for Integrated Management of Material Fluxes and of Resources. The book presents 17 case studies of good practices from Africa, Asia, and Latin America. The book is available online at http://collections.unu.edu/view/UNU:5764.

Also Out There…

Brief descriptions of some interesting articles *Water Central* has discovered.

•"**Explore lesser-known preserves on Virginia's Northern Neck**," *Bay Journal*, 11/29/17. This article by Leslie Middleton focuses on two natural preserve areas on the Northern Neck peninsula between the Potomac and Rappahannock rivers: the 135-acre Bush Mill Stream Natural Preserve Area in Northumberland County and the 235-acre Hickory Hollow Natural Preserve Area in Lancaster County. The article is available online at http://www.bayjournal.com/article/explore_lesser_known_preserves_on_virginias_northern_neck, or contact *Bay Journal* at (717) 428-2819. More information about all of Virginia's natural preserve areas is available online at http://www.dcr.virginia.gov/natural-heritage/natural-area-preserves/, or by contacting the Department of Conservation and Recreation in Richmond at (804) 786-6124. The online site for Bush Mill is http://www.dcr.virginia.gov/natural-heritage/natural-area-preserves/bushmill; for Hickory Hollow, http://www.dcr.virginia.gov/natural-heritage/natural-area-preserves/hickory.

•"**Roanoke County teen apprentices get a hands-on look at the valley's waterworks**," *Roanoke Times*, 11/14/17. This article describes the Western Virginia Water Authority's apprenticeship program for Roanoke County high school students. The article is available online at http://www.roanoke.com/news/education/roanoke-county-teen-apprentices-get-a-hands-on-look-at/article_3534b9e8-030b-5959-909d-48405cbc7e16.html, or contact the paper at (800) 346-1234; e-mail: customer@roanoke.com.

•**"New Technologies—Driving Advances in Coastal Science"** was the focus of the Spring 2017 issue of *Coastal Heritage*, from the South Carolina Sea Grant Consortium. This 11-page feature discussed technological developments over the past 25 years that have given scientists much greater capacity to record, measure, and process information, and how that capacity is being applied to coastal erosion, stream runoff, issues with nanoparticles, species identification, and ocean exploration. The magazine is available online at http://www.scseagrant.org/Sections/?cid=82, or contact the S.C. Sea Grant Consortium at (843) 953-2078; e-mail: joey.holleman@scseagrant.org.

YOU GET THE LAST WORD

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

4. What **length** of publication is about right for you?

5. What **frequency** of publication is about right for you?

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

Virginia Water Central Newsletter

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Thank you for your interest in the waters of the Commonwealth of Virginia.

Virginia WATER RESOURCES Research Center