

2012 Annual Report

The Future of Water Starts Here



The Moorhead Environmental Complex earns the highest honor in green building design from the U.S. Green Building Council: LEED Platinum.

Photo: Dave Arscott



2012 AT A GLANCE

- A. John Briscoe, Ph.D., received the Stroud Award for Freshwater Excellence at The Water's Edge, the Center's annual gala at Longwood Gardens, in October. This prestigious award is given for outstanding achievement to those who contribute broadly to the conservation and protection of fresh water. Briscoe, the Gordon McKay Professor of the Practice of Environmental Engineering and Professor of the Practice of Environmental Health at Harvard University, directs the Harvard Water Security Initiative. His distinguished career has focused on the issues of water, other natural resources, and economic development. Photo: Yeda Arscott
- B. In 2012 Stroud Water Research Center began the Stroud Seminar Series, which is designed to inform the general public about issues and hot topics in watershed research and education and the work conducted at the Center. Scientists and educators presented on topics such as "Why do we need wetlands, and does the Clean Water Act protect them?" Photo: Anthony Aufdenkampe
- C. Stroud Water Research Center scientists and educators are working in and around Puerto Maldonado, Peru, in partnership with the Amazon Center for Environmental Education and Research (ACEER). ACEER and the Center are working to create a comprehensive water quality baseline along the new road from Cusco to Puerto Maldonado. It's part of the new Transoceanic Highway, which connects the interior of Brazil to Peru's Pacific Ocean ports. The 2,600kilometer highway has opened previously remote parts of the interior to rapid population growth, development, and resource extraction, the impacts of which could have worldwide consequences. Photo: David H. Funk
- D. International leaders involved in water management and associated fields toured the Center as part of a Department of State exchange program. The goal of the program is to build understanding between professionals in the U.S. and other countries. The Center welcomed visitors from Argentina, Finland, Hong Kong, India, Kuwait, Mexico, Nepal, Oman, Pakistan, Palestinian Territories, Russia, Saudi Arabia, Uzbekistan, Venezuela, and Vietnam. Photo: Kay Dixon

- E. Students and faculty of the Christina River Basin Critical Zone Observatory (CRB-CZO) collected soil and rock cores during the summer at the Laurels Preserve. By drilling wells, they were able to sample groundwater, soils, and rocks to a depth of 70-90 feet in a 100-percent forested area and take depth, temperature, and conductivity measurements. A number of new technologies were piloted including a mini-sonic Geoprobe drill rig and a multiport flute liner. The CRB-CZO is one of six National Science Foundation–supported environmental observatories focusing on how water, atmosphere, ecosystems, and soils interact and shape the Earth's surface. Photo: Anthony Aufdenkampe
- F. As super storm Sandy moved up the East Coast, the Center's scientists used real-time remote sensors to collect stormwater samples from the White Clay Creek in the Christina River Basin. By analyzing the samples and adding the data to the Center's record that spans longer than 40 years, they'll help determine how different land uses affect streams and also what role big storms play in determining what happens to the cycling of carbon. Photo: Anthony Aufdenkampe
- G. Director Bern Sweeney traveled to San Jose, Costa Rica, to give a presentation at the First Latin American Congress on Aquatic Macroinvertebrates. His presentation, "Ecology and Natural History of Macroinvertebrates in Pristine and Polluted Tropical Streams," highlighted the Center's research involving macroinvertebrates in Costa Rica and South America.
- H. At age 104, Dr. Ruth Patrick cuts the ribbon to the Ruth Patrick Education Lab in the Moorhead Environmental Complex. On June 18, friends and family of Ruth Patrick and Joan Milliken Stroud gathered together for an intimate luncheon at the Complex to honor these two women for their instrumental roles in the Center's establishment and years of success. Photo: Kay Dixon



The future of water starts here.

Bern Sweeney is ready to collect insects from a stream near Palquella, Peru. Photo: David H. Funk

Message FROM THE DIRECTOR

A small spring, which the locals call Sawmill Spring, runs not far from where I write. It and a dozen or so other nearby springs collectively give birth to the White Clay Creek, which flows past Stroud Water Research Center and across the Delaware line, growing ever wider and deeper until it becomes the primary source of drinking water for the city of Newark.

Here at the Center, that image inspires us to create new knowledge that will flow, like the White Clay, from our laboratory to our region, to our nation and to the world. Our scientists and educators work tirelessly to produce a continual supply of ideas, models, and data on streams, rivers, and watersheds. Our goal is to ensure a sustainable future for the clean fresh water on which life depends. In that sense, the future of water really does start here.

So it is no accident that one of the major breakthroughs in environmental education in the last decade has been our WikiWatershed program, which is comprised of three major pieces: Model My Watershed, Monitor My Watershed, and Manage My Watershed. In 2012 we tested Model My Watershed in schools in the region, and we are now developing both Monitor My Watershed and Manage My Watershed for classroom use.

Based on rigorous science, these innovative programs were the result of constant conversations between our scientists and educators, and they employ the Center's state-of-the-art scientific instrumentation and field protocols. In this report, we touch on just some of our science, such as our metaecosystems project, which employs sophisticated technology to unravel the mystery of changes in the organic chemistry of water and the species composition of bacterial communities that co-occur in a downstream direction from the headwaters to the mouth of a river system. These details are critical for government officials and water managers to develop policies ranging from determining a stream's suitability for swimming to certifying its purity for drinking.

Since the opening of our Moorhead Environmental Complex last fall, we've reached more than 1,000 people through our education programs, most of whom were students, teachers, and other visitors who came to the Center to learn first hand about our science and programs. Those visitors, as well as others who use our research and implement our programs around the world, have learned that fresh water is the lifeblood of the planet, and that the future of water starts here at the Center — on the banks of the White Clay Creek.

Bul a Su



Students get their feet wet at the Moorhead Environmental Complex, the Center's new green building that's LEED certified to the Platinum level.



First Fall at the Moorhead Environmental Complex: EDUCATING THE NEXT GENERATION OF WATER STEWARDS

It's a bright and brisk fall morning in a wooded neck of the Pennsylvania Piedmont. The trees have begun to lose their splendor, as they do every year around this time, and the White Clay Creek gathers the lost trimmings along its banks. There's a peacefulness here among the stately trunks, which reach heavenward and toward a blue sky. The only sounds a musical mix of gently flowing stream waters and a woman's voice in the distance. The warm sun softens the air's cool bite.

A stone's throw away, a group of about 25 students wearing wading boots huddles together. Christina Medved, Stroud Water Research Center's education programs manager, engages her young audience with enthusiastic questions and explanations accented by lively gestures.

"How many of you know what a wetland is?" she asks.

The students stare blankly back at her in response. A few timidly raise their hands.

She points to two wetland cells behind the Moorhead Environmental Complex and says, "You see these plants? These are wetland plants, and they filter pollutants, including nitrates from waste, out of the water before we allow it to infiltrate back into the groundwater and ultimately the stream. Essentially, they are cleaning the water." She goes on to explain how the wetlands and other features on site help to manage wastewater and mitigate stormwater runoff.

"What are those?" one student asks, pointing to the sunshades on the building's windows.

"Have you ever worn a sun visor before? Those are like visors for the windows. They allow light to come into the offices without causing a huge glare on computer screens, and they also minimize the heat the light brings in, helping to reduce our energy use."

The students are participating in the Center's Stream Study Program. About four hours long, this hands-on program gets students out into the fresh air and fresh water as they explore the physical, chemical, and biological characteristics of streams. The morning begins with an orientation, and soon students are getting their boots wet in the stream, observing how the stream meanders, testing the water, collecting macroinvertebrates, discovering what causes erosion, and learning why trees and the riparian zone are so important.

Getting Their Feet Wet

"The students get really excited to go mucking about in a stream," said Kevin Reigel, a biology teacher at Kennett High School in Kennett Square, Pa., who brings his advancedplacement (AP) science class to the Center every year for the Stream Study Program.

It's the kind of hands-on learning opportunity that changes the way students understand science and relate to their outdoor environment. Medved explained, "We're taking abstract concepts and making them real. Instead of just an idea, they can see it — and they can literally get their hands dirty. That makes all the difference. For example, they may have learned about the concept of a watershed in their textbooks and they might know the definition, but they don't fully understand it. When they come here, and we do a sort of show-and-tell, then they get it."

And they benefit from learning about and seeing the innovative "green" features of the LEED certified (Platinum level) Moorhead Environmental Complex that enable wise water and energy use. "Solar panels, rain barrels, green roofs, these are all things my



Students from The Tatnall School gather around Center educators Christina Medved and Libby Gregg for an orientation that includes a show-andtell of some of the green features of the LEED certified (Platinum level) Moorhead Environmental Complex.



Westtown School students identify the bugs they collected earlier in the day from the White Clay Creek.

AP students are reading about, but most of them haven't seen these things," Reigel said.

Vivian Williams, a consulting education programs manager, echoed, "Most of us are strongly visual in our learning. We need to either see or imagine concrete examples of concepts." In the fall, Williams led a training at the Complex for Pennsylvania Master Naturalists, who, she said, were able to take home tangible ideas from visiting the Center's expanded campus and "apply the ecological story of stream health to their personal landscapes."

The Moorhead Environmental Complex is the new home for the Center's education department. In addition to two teaching labs with tools students need like microscopes and knee-high rubber boots, the Complex has educational signage throughout that explains many of its features. These include a stormwater management system, a rooftop rainwater capture system, a green roof, composting toilets, and a wetland waste treatment and drip irrigation system. Outside, students and other visitors can see rain gardens, pervious surfaces, and landscaping using native vegetation.

Since opening the doors of the Complex in September of 2012, the Center welcomed more than 1,000 students, teachers, and other visitors who learned about how "getting the water right" — the guiding principle behind the design and construction of the Complex — means mimicking Earth's natural water cycle.

"Typically, we bring two to four classes per year," said Ron Smith of Haddonfield Memorial High School in Haddonfield, N.J. He's brought his students for about 18 of the 20 years he's been teaching. "I can't think of a more appropriate place to have a LEED certified green building. So much of the message that Stroud is communicating focuses on water conservation, and this kind of building exemplifies that message."

The Future of Our Water

It's a message Medved takes with her wherever she goes. For the last few years, she's been invited to give a presentation to West Chester University students majoring in communication studies who are taking a course on conflict and resolution; she cites the New York City drinking water supply as a case study. When water needs exceed the local supply, what happens? New York City decided to collect its water from the Catskill Mountains — about 125 miles away. "But who owns that water?" Medved asks. "That would be like West Chester getting its water from Alexandria, Va." The New York City drinking water case study is a concrete example of speaking about real conflict-and-resolution issues to these students. Many of them were not aware of these issues before the presentation even though most have traveled to New York City, given its proximity to West Chester.

Asking questions is what science is all about, and whether Medved is presenting at workshops or schools or hosting visitors at the Center, she wants others to think about water in a different way and ask important questions like "Whose water is it, anyway?" What's especially enticing about bringing students to the Center, said Smith, is the diversity of experiences. "It's not only the quality of the program — the fact that they use real field data and get to practice their science — but most times that we've come, my students were able to interact with real scientists."

Students who visit the Center today may one day walk in the footsteps of the scientists they meet, or they may become policymakers, teachers, landowners, or architects, but most certainly they will become community members who make decisions determining the future of our water.

"I think it is important there is always a presence of youth here at the Center," said Medved, "because if you are not teaching the next generation how to be good watershed stewards, where does that leave us with the future of a healthy water supply?"





All ecosystems on Earth rely upon microbial processes to sustain life.

The Promise of Microbes and Molecules: LIFTING THE VEIL ON MICROBIAL COMMUNITIES AND ORGANIC MOLECULES

In 1676 a 44-year-old Dutchman named Antoni van Leeuwenhoek took a small single lens he had ground, then polished it with such precision that he could magnify an object some 200 times. With a passion like that displayed among researchers at Stroud Water Research Center today, van Leeuwenhoek then took a drop of ordinary pond water and placed it under that lens. He peered curiously down to behold a stunning landscape never before seen by man — a sea of living organisms invisible to the naked eye.

Van Leeuwenhoek's discovery of microorganisms opened the door to a new frontier of scientific investigation that ultimately

led to discoveries such as pasteurization, sterilization, antibiotics, and a breadth of other things that have benefited humankind, changing the way we live.

Building on discoveries from yesterday, passionate researchers at the Center continue to unravel amazing mysteries about microorganisms, thanks to state-of-the-art technologies that van Leeuwenhoek could never have imagined. Together, in collaboration with researchers around the world, the Center's multidisciplinary approach to research advances yet a more sophisticated frontier of scientific investigation. Center scientists, led by stream ecologist Lou Kaplan, in collaboration with microbial ecologist Jinjun Kan and postdoctoral associate Jen Mosher, recently completed the first year of a three-year project funded by the National Science Foundation (NSF) to understand the influence of dissolved organic matter on bacterial communities in streams. "This project cuts across several disciplines, including molecular microbial ecology, organic geochemistry, and stream ecosystem science," says Kaplan. "The fact that we are examining both the streambed microbes and the stream water chemicals at a molecular level is a core strength of this collaboration."

According to Kaplan, the research involves looking throughout a river network, following the flow of energy, materials, and organisms across the boundaries from one stream reach to another. The theoretical framework involves a relatively new term — metaecosystems. This is closely related to the idea of the River Continuum Concept (RCC) that the Center's first director, Robin L. Vannote, proposed in the 1980s. The RCC is really a metaecosystem approach to studying streams. It's an older theory, but one that is now in vogue with present research.

"What is significant is that our preliminary findings are providing new insights and a test of the hypotheses Robin Vannote presented 30 years ago. Because of tools available today, we are beginning to collect data unavailable to stream ecologists 30 years ago. This work is important because all ecosystems on Earth rely upon microbial processes to sustain life. We are lifting the veil to better understand the fundamental properties of microbial communities."

Three River Systems

Center researchers chose three river systems for this study:

- the Río Tempisquito, near the Maritza Biological Station a field station in the Guanacaste Conservation Area in Costa Rica,
- the Neversink River in the Catskill Mountains in New York, and
- the White Clay Creek, alongside the Center, in Pennsylvania.

Kaplan says that he and his team will visit each of the three sites eight different times, collecting microbial communities

from biofilm on rocks and riverbed sediment, as well as biodegradable dissolved organic molecules (DOM) that serve as a rich array of food for microorganisms in the stream.

"These rivers were chosen for a number of reasons," Kaplan says. "First of all, they are forested rivers, and they are on protected land. They also offer real differences in plant communities. Since most organic materials in streams come from land plants, that's a nice variable to have. Furthermore, most of the organic matter passes to the stream through soils and is modified by soil processes. All three river systems have different soils, so this creates a nice contrast as well. Finally, all three have different temperature regimes."

Another reason for using the White Clay Creek and the site in Costa Rica, however, is to answer some key questions using bioreactors colonized by stream bacteria, which require being fed by filtered stream water continuously. The fact that stream water flows into wet labs at the Center and at the Maritza Biological Station facilitates those studies. The bioreactors allow Kaplan and his team to separate the DOM being eaten by bacteria into those molecules used quickly and others used slowly and to identify the molecular composition of each group.

The Neversink River is another good choice because the Center already has some preliminary data from a six-year study they did there for the state of New York. The Frost Valley YMCA's environmental science group and students from the State University of New York (SUNY), New Paltz, have provided help in maintaining bioreactors there as well.

New Tools in the Toolbox

Jen Mosher, who wears a number of hats as a molecular microbial ecologist and organic geochemist for this project at the Center, is the go-to person for getting all the samples ready for analyses.

She sends extracted DOM to the NSF-supported National High Magnetic Field Laboratory at Florida State. There, they are processed by an ultra-sensitive mass spectrometry technique to help the team determine the atomic formulas of molecules in DOM. Mosher also sends extracted, amplified, and purified



Electricity generated by microorganisms (modified from Nielsen et al. 2008)

microbial DNA to the University of Pennsylvania School of Medicine for pyrosequencing — a powerful tool that allows microbial ecologists to identify the microorganisms in a sample without the need to isolate individual species in cultures.

"We do know from our chemical analyses that the DOM in stream water is composed of at least 5,000 distinct organic molecules," says Kaplan, "and we are beginning to see that the microbial communities are equally, if not more, complex. Our idea is that the quality of the carbon influences the structure of the microbial community — but that the structure of the community also influences the assemblage of carbon molecules. These are massive data sets that require powerful statistical analyses."

Fortunately for the team, Mosher also has a strong background in statistical analyses, which is another essential skill required for this research. Mosher has been working with Drs. Tom Battin and Katharina Besemer from the University of Vienna Limnology Department to get up to speed on an open-access software program called *R*, which will facilitate these analyses.

Finally, the research team works with Dr. Robert Findlay, the Bishop Professor of Freshwater Biology at the University of Alabama, who looks at microbial samples from the perspective of their bacterial lipids. "Lipids provide our best opportunity to get quantitative data on the biomass of bacteria and the different functional groups within a community," says Kaplan.

Reading the Metabolic Fine Print

Collecting stream samples from each of these sites is a laborintensive task involving Kaplan, Mosher, and research technicians Mike Gentile and Sherman Roberts. "Based on our preliminary data, we are seeing a subtle shift in DOM from upstream sites to downstream sites and a dramatic change in the composition of the bacterial communities," says Mosher. "Our bioreactor data will help us understand whether the DOM changes influence the function of these communities."

Ecologists measure the richness of a community based on the total number of distinct populations within the community — that is, the total number of separate species. The research team is finding bacterial richness greatest at the top of the river network in the first-order streams, with a gradual decline in second- and third-order streams, Kaplan adds. Curiously, about 5 percent of the total genera of bacteria identified are common to all three river systems.

Applications in the Spotlight

Microbial communities offer countless potential applications from bioremediation, to medical research, to clean energy tools such as microbial fuel cells (MFCs) — devices that capture electrical power generated by microbes and harvest it to power remote batteries or sensors. In fact, Kan designed three such units in the fall of 2012. He placed one indoors in the artificial stream channel, one in the White Clay Creek outside the lab, and one in the pump house.

"We want to know which microbes work best," says Kan. "What is their physiology? How exactly do they generate power? How much can they generate? And how can we optimize this process?"

For Kaplan, the application to clean drinking water is most compelling. "There is a direct connection to what we are doing and to methods used to provide safe, clean drinking water. What we understand about the ability of microbes to utilize organic matter can help a drinking water treatment plant operator fine-tune the biological treatment system."

The New Frontier

"We are using advanced techniques to get at all these answers," Kaplan points out. "Robin Vannote's River Continuum Concept included hypotheses about microbial community changes along rivers, as well as organic matter changes, but he did it in 1980. That predates the molecular revolution in microbial ecology, as well as the advanced analytical techniques in organic geochemistry. Even though he hypothesized something about the downstream changes, his predictions were untestable — not because of his ideas but because we didn't have techniques to perform the tests then.

"Now we do!"

Links

- To learn more about the River Continuum Concept, go to: http://www.stroudcenter.org/about/portrait/continuum.shtm
- For another article on metaecosystems, go to: http://www.stroudcenter.org/newsletters/2011Fall/ metaecosystems.shtm



MICROBIAL FUEL CELLS A KEY TO CLEAN ENERGY

Blink, blink, blink, blink A tiny red LED light in the artificial stream channel inside Stroud Water Research Center blinks on every two seconds, powered by the respiration of bacteria buried in sediments below.

That certain bacteria could transport electrons to solid metal in an oxygen-depleted environment was a stunning discovery scientists made in the early 1980s, says Jinjun Kan, Ph.D., microbial ecologist at the Center. The electron flow can be detected, monitored, and harvested by means of microbial fuel cells (MFCs) and used to power some devices.

"What is unique about our research is that people have been working with MFCs in lakes and oceans, but until now, nobody has been working in streams."

Kan rigged this demo MFC for the Center in November 2012 and is now holding a meter in his hand. "We get a stable 0.5 volts of electricity from this demo," he says, grinning.

The MFCs that Kan designed are not enclosed boxes, like a car battery, but are instead two open platforms. Each platform is made with a piece of inexpensive graphite or carbon cloth, wrapped around a flat piece of plastic. The cloth provides a big and flexible surface to which bacteria easily attach.

One platform — called the anode — is buried in stream sediment where no oxygen exists.

The other platform — called the cathode — floats freely near the surface of the richly oxygenated stream water of the White Clay Creek.

The two platforms are connected by copper wire. In the biochemical process of cellular respiration, the anaerobic bacteria attached to the anode in the oxygen-free streambed consume the organic matter and transfer electrons to the copper wire. The cathode attracts the electron, passing the power on to the little red light.

"Microbial fuel cells provide a very unique platform for studying microbial ecology and microbial physiology," Kan says.

"It's too early to charge your car with this amount of power, but eventually we hope to power the sensors we have in the White Clay Creek to monitor pH, temperature, and things like that," says Kan.

"That would be a really cool application."

Research Projects

Water quality impacts of the interoceanic highway in the Eastern Andes Amazon headwaters region

Funded by: Blue Moon Fund

This collaborative project with the Amazon Center for Environmental Education and Research (ACEER) involves conducting a comprehensive assessment of water quality impacts for streams and rivers intersected by South America's first transcontinental highway, which bisects the Amazon basin from the Atlantic Ocean in Brazil to the Pacific Ocean in Peru. The assessment also includes testing the efficacy of Stroud Water Research Center's Leaf Pack Experiment Kit to evaluate water quality in tropical systems.

Principal Investigators: Bernard W. Sweeney, John K. Jackson, and David H. Funk

Collaborators: Roger W. Mustalish (ACEER) and Wills Flowers (Florida A&M University)

Restoration of upland forest using experimental fencing systems to protect seedlings from deer browse

Funded by: Point Lookout Farmlife and Water Preserve Foundation This project involved creating a four-acre experimental area for testing the efficacy of short fences (arranged strategically around seedling planting areas) to improve seedling growth and survivorship. **Principal Investigator:** Bernard W. Sweeney

Excluding deer using low-cost exclosures to improve water quality in the Brandywine Creek watershed

Funded by: Point Lookout Farmlife and Water Preserve Foundation and the PA DEP TreeVitalize program

Four large field experiments in both forested and deforested habitat were created to test the importance of fence height for protecting young seedlings (natural regeneration and/or nursery stock) from herbivory by deer.

Principal Investigators: Bernard W. Sweeney and Charles L. Dow **Collaborator:** Luca Barnabei (University of Pennsylvania)

Water quality assessment in California using DNA barcoding

Funded by: Southern California Coastal Water Research Project (SCCWRP)

This pilot study was designed to test how the use of a new technology called DNA barcoding can improve water quality assessment in California streams by enabling researchers to identify to species level macroinvertebrate larvae collected from the field. SCCWRP will use the study results to decide if this new technology can and should be applied more widely in their monitoring program of both inland and coastal waters.

Principal Investigators: Bernard W. Sweeney and John K. Jackson **Collaborators:** Peter Miller and Paul Hebert (University of Guelph), Eric Stein (SCCWRP), Erik Pilgrim (USEPA)

Long-Term Research in Environmental Biology (LTREB): Dynamics of stream ecosystem responses across gradients of reforestation and changing climate in a tropical dry forest

Funded by: National Science Foundation DEB 0516516 Stroud Water Research Center has expanded on 20 years of research on tropical streams near the Maritza Biological Station in northwest Costa Rica, which provides the framework of this study, to include sites near Santa Rosa and Rincón de la Vieja in an effort to study a wider range of environmental conditions. Scientists are examining stream responses to the large-scale reforestation of tropical dry forests as well as to the natural moisture gradients (i.e., wet versus dry seasons and rainy versus dry forest sites) that define much of the character of the Guanacaste Conservation Area.

Principal Investigators: John K. Jackson, Louis A. Kaplan, J. Denis Newbold, Thomas L. Bott, Anthony K. Aufdenkampe, and David H. Funk

Collaborators: Julio Calvo (Instituto Tecnológico de Costa Rica Escuela de Ingeniería Forestal, Costa Rica)

Parthenogenesis (virgin reproduction) and hybridization in mayflies

Funded by: Pennswood No. 2 Research Endowment and Stroud Water Research Center

Stroud Water Research Center's multiyear focus on the mayfly *Centroptilum triangulifer* has been expanded to include a number of related and unrelated mayfly species in the White Clay Creek as well as in streams throughout eastern North America. This effort has increased our understanding of parthenogenesis (i.e., virgin reproduction) and hybridization in mayflies, confirmed the biological integrity of species that are morphologically cryptic (i.e., those that are genetically distinct but morphological keys currently give them the same name), and led to the development of valuable laboratory techniques for mating and rearing aquatic insects.

Principal Investigators: David H. Funk, Bernard W. Sweeney, and John K. Jackson

Ecotoxicity study for mayflies exposed to ambient stream water from the upper Delaware basin and to produced water from natural gas drilling

Funded by: Delaware River Basin Commission

The production of natural gas from the Marcellus shale in Pennsylvania results in water that travels up through the well bore. This water generally has high concentrations of various salts and other dissolved substances, as well as a variety of other compounds. This project measures lethal and nonlethal responses of mayflies exposed to produced water diluted with water from the White Clay Creek and another exceptional value stream in northeastern Pennsylvania. It builds on our experience in rearing the parthenogenetic mayfly *Centroptilum triangulifer* in the laboratory by comparing responses of *C. triangulifer* from the White Clay Creek with responses of two mayfly species that commonly co-occur with *C. triangulifer* in small streams of eastern North America.

Principal Investigators: John K. Jackson and Bernard W. Sweeney

Microbial population dynamics of periphyton biofilms in the White Clay Creek

Funded by: Stroud Water Research Center

Starting in the summer of 2011, Center scientists deployed glass slides (periphytometers) to enrich biofilms in three reaches of the White Clay Creek with distinct streamside land uses (mature forest, restored but immature forest, and meadow from upstream to downstream). Molecular DNA fingerprints of small subunit ribosomal RNA gene demonstrated both spatial and temporal variations of biofilm population structures. In-depth community structures will be characterized using the high-throughput sequencing platform at the University of Pennsylvania.

Principal Investigator: Jinjun Kan

Sediment microbial fuel cells (MFCs)

Funded by: Space and Naval Warfare Systems Command (SPAWAR) and Stroud Water Research Center

Two streambed sediment microbial fuel cells have been deployed in the White Clay Creek, and a sweeping test is underway. One demo unit has been installed in the in-house stream channel, and an LED light is connected to demonstrate the power generation from the respiration of bacteria buried in the indoor stream sediments. Data are being collected.

Principal Investigator: Jinjun Kan

Collaborator: Y. M. Arias-Thode (SPAWAR)

CZO research: The role of metals in nitrogen cycling of soils and streams

Funded by: National Science Foundation EAR 1024545

A collaboration with researchers at Princeton University will leverage the exceptional sensor and geochemistry data from our CZO project developed by Center scientists to explore the importance of a number of trace metals in the nitrogen fixation and denitrification transformations of nitrogen within our flood plain soils and sediments.

Principal Investigators: Anthony K. Aufdenkampe; Anne Kraepiel and Francois Morel (Princeton University)

Consequences of erosion and deposition in the Fly River, Papua New Guinea, on carbon cycling and climate change

Funded by: National Science Foundation

This three-year research project on the Fly River in Papua New Guinea, one of the more dynamic sediment delivery systems in the world, aims to determine whether the combined effects of mountain erosion and deposition in flood plains and estuaries have important local or global consequences for carbon cycling and climate.

Principal Investigator: Anthony K. Aufdenkampe

Collaborators: Miguel Goni (Oregon State University), Rolf Aalto (University of Exeter, United Kingdom), Wes Lauer (Seattle University), and Bill Dietrich (University of California, Berkeley)

Earthworm invasion: Investigating changes in soil chemistry and carbon sequestration

Funded by: U.S. Department of Agriculture

Human activities over the last 100 years have introduced exotic earthworms into many pristine northern forests. These earthworm invasions are moving north at 15-30 feet per year, bringing with them radical changes to forest ecology and soil chemistry. Our study is designed to examine whether earthworms increase or decrease carbon storage in forest soils, with consequences to greenhouse gases and climate change.

Principal Investigator: Anthony K. Aufdenkampe **Collaborators:** Kyungsoo Yoo (University of Minnesota) and Cindy Hale (University of Minnesota, Duluth)

The first assessment of Congo River organic matter chemistry and reactivity

Funded by: Stroud Water Research Center

The Congo River is the second largest river in the world, but little is known about it because regional conflict has made its study logistically difficult.

Principal Investigator: Anthony K. Aufdenkampe

Collaborators: Rob Spencer, Peter Hernes, Johan Six (University of California, Davis), Aron Stubbins (Old Dominion University), and Robert Holmes (Woods Hole Research Center)

Christina River Basin Critical Zone Observatory (CRB-CZO): Quantifying carbon sequestration resulting from human-induced erosion

Funded by: National Science Foundation EAR 0724971

In collaboration with the University of Delaware, Center scientists established one of six Critical Zone Observatories in the U.S. and began to establish the sensor and data infrastructures required to test a set of hypotheses about the connections between land use and climate change. The study aims to determine whether large-scale, human-induced soil erosion might transport, bury, and sequester carbon in flood plain and coastal sediments, modifying greenhouse gas emissions from the landscape.

Principal Investigators: Anthony K. Aufdenkampe and Louis A. Kaplan; Donald L. Sparks (University of Delaware)

Collaborators: J. Denis Newbold, David B. Arscott, Charles L. Dow, and Susan E. Gill; Kyungsoo Yoo (University of Minnesota), Jim Pizzuto (University of Delaware), Rolf Aalto (University of Exeter, United Kingdom), and George Hornberger (Vanderbilt University)

MRI: Acquisition of a high-sensitivity light stable isotope mass spectrometer for Critical Zone studies

Funded by: National Science Foundation 1126627

This grant supports the acquisition of a high-sensitivity stable isotope ratio mass spectrometer (IRMS) at the Center, which will provide enhanced capabilities and greater sensitivity analyses than currently available at the Center. The new IRMS system will be put to use in several funded projects.

Principal Investigator: Anthony K. Aufdenkampe Collaborators: J. Denis Newbold and Louis A. Kaplan



Testing a proxy of historical nutrient status using diatom-bound nitrogen isotopes

Funded by: The American Chemical Society, Petroleum Research Fund Climate science relies on interpreting proxies of past environmental conditions in dated sediment and ice cores. This study will develop a rapid approach to analyzing the stable isotopes of proteins within the glass shells produced by diatom algae, which is likely to be an improved proxy for historical nutrient status because of its uniform biological source. Although the researchers will initially apply the results of their studies to studies of ocean sediments, the technique will be transferable to lakes, ponds, and rivers.

Principal Investigator: Anthony K. Aufdenkampe Collaborator: Katharina Billups (University of Delaware)

Restoration of streamside forest for improving water quality

Funded by: White Clay Creek Wild & Scenic Rivers Management Committee Program

This project involved planting trees as a best management practice for keeping pollutants out of a stream and improving its health. In collaboration with the Brandywine Conservancy and Dansko, Inc., the Center planted about 600 trees along a portion of the headwaters of the east branch of the White Clay Creek, which is part of a Pennsylvania-designated exceptional value watershed, and installed 600 tree shelters on two acres of riparian land.

Principal Investigator: Bernard W. Sweeney



Evaluating threats to humans and aquatic ecosystems posed by agriculture around the Río Sierpe, Costa Rica

Funded by: Blue Moon Fund

Stroud Water Research Center biologists completed a project to better understand the threat of contaminants from agriculture entering the fish and drinking water supplies around the Río Sierpe and Río Grande de Térraba in southwest Costa Rica, the site of the largest intact mangrove forest on the Pacific coast of Latin America. Rice is one of the major crops in the area, along with banana and oil palm. Fish from a few locations are contaminated with legacy pesticides that may pose a health risk, but overall pesticide restrictions are being followed. Fish kills in association with pesticide application continue to occur periodically, and impacts should be evaluated. The Rainforest Alliance will consider these results when developing standards for rice that could be applied worldwide to certify farms as environmentally, economically, and socially sustainable.

Principal Investigators: William H. Eldridge and David B. Arscott **Collaborators:** Chris Wille, Oliver Bach, and Adriana Rodriguez Retana (Rainforest Alliance)

The snail the dinosaurs saw or an introduced species? Using genetic data to untangle the history of a snail that is new to Pennsylvania

Funded by: Stroud Water Research Center

In 2012 a University of Pennsylvania master's in environmental science student confirmed and located nine populations of *Plueocera proxima* in Chester County, Pa., a species of snail that has never been recorded north of the James River in Virginia. She also evaluated stream and

terrestrial habitat characteristics preferred by snails and conducted DNA barcoding to determine the origin and evaluate population structure. **Principal Investigator:** William H. Eldridge **Collaborator:** Saras Windecker (University of Pennsylvania)

Fish dispersal across a riparian habitat gradient

Funded by: Stroud Water Research Center

In 2012 Stroud Water Research Center biologists continued a study started in 2010 to measure fish dispersal along a two-kilometer stretch of White Clay Creek spanning a meadow, recovering forest, and mature forest. The study aims to evaluate the effects of riparian habitat on stream fish.

Principal Investigator: William H. Eldridge Collaborator: Eli Gurarie (NOAA Fisheries)

Azavea summer of maps

Funded by: Azavea

A summer intern with Azavea combined GIS data collected by Center scientists from above and below the surface of the White Clay Creek to generate a complete terrestrial and aquatic map covering two kilometers and quantified the spatial distribution of stream geomorphological characteristics across a transition between more than 150-year-old woods, more than 20-year-old woods, and a meadow.

Principal Investigators: William H. Eldridge, David B. Arscott, and Anthony K. Aufdenkampe

Collaborators: Angela Sakrison, Tamara Manik-Perlman, and Daniel McGlone (Azavea)

Origin of striped bass collected in the Delaware River for toxics in biota monitoring

Funded by: Stroud Water Research Center

In 2012 the Delaware Department of Natural Resources and Environmental Control (DNREC) collected striped bass (*Morone saxatilis*) from the Delaware River for toxics in biota monitoring. Center scientists used DNA analysis to determine if the fish are from the Delaware River population or were strays from the larger Hudson River or Chesapeake Bay populations. Further work with additional DNA markers will be necessary to confirm the origin of the individuals.

Principal Investigator: William H. Eldridge

Collaborator: Richard Greene (DNREC)

AMD remediation and stream ecosystem function

Funded by: Pennsylvania Department of Environmental Protection This study was designed to determine the impact of abandoned mine drainage (AMD) on stream ecosystem functions, such as algal growth, nutrient spiraling, litter decay, and enzyme function, as well as on macroinvertebrate communities. It will also aid in the assessment of the effectiveness of AMD remediation efforts. This research broadens our understanding of the scope of concerns generated by AMD pollution, considered the most extensive pollution problem in terms of stream miles affected throughout Pennsylvania, and it has the potential to lead to greater support for remediation efforts.

Principal Investigators: Thomas L. Bott, Bernard W. Sweeney, J. Denis Newbold, and John K. Jackson

Collaborators: Matthew McTammany (Bucknell University) and Steven Rier (Bloomsburg University)

Long-Term Research in Environmental Biology (LTREB): Trajectory for the recovery of stream ecosystem structure and function during reforestation

Funded by: National Science Foundation DEB 1052716

Stream restoration in the U.S. is a multibillion-dollar industry, but longterm monitoring of it is virtually nonexistent. Center scientists initiated a study to follow restoration within the White Clay Creek that involves the reforestation of meadows or pastures with native deciduous trees and the removal of invasive plant species. As the planted forest matures, researchers will characterize the changes in the aquatic biological communities and their associated activity. Teachers will be trained in the use of long-term environmental data as a means to enhance teachers' and students' math skills, analytical abilities, and environmental knowledge.

Principal Investigator: Louis A. Kaplan

Collaborators: Anthony K. Aufdenkampe, John K. Jackson, Jinjun Kan, J. Denis Newbold, William H. Eldridge, David B. Arscott, Charles L. Dow, Susan E. Gill, and Bernard W. Sweeney

Metaecosystems and the upstream legacy: Influence of dissolved organic matter on the structure and function of streambed bacterial communities

Funded by: National Science Foundation DEB 1120717

Organic carbon, in the form of dissolved molecules transported in stream water, is processed for energy by microorganisms that live on the streambed. Looking out over a drainage network, investigators explore how the quality of the organic molecules changes with distance downstream and how those changes influence the composition of the communities of streambed microbes using that food resource. Research sites will range in size from small streams to small rivers within temperate and tropical forests. The research goals include advancing knowledge of stream ecosystems across drainage networks and forging a broad model of stream ecosystems in the global carbon cycle.

Principal Investigator: Louis A. Kaplan

Collaborators: Jinjun Kan, Susan E. Gill, and Jennifer J. Mosher; Robert H. Findlay (University of Alabama) and David C. Richardson (SUNY New Paltz)

Macroinvertebrate monitoring at sites in White Clay Creek, Pa., Flint River, Ga., Mississippi River, Mo., Susquehanna River, Pa., and Delaware River, Pa.

Funded by: Various public and private sources

These projects use aquatic macroinvertebrates such as mayflies, stoneflies, and caddisflies to provide assessments of current water quality in these streams and rivers. Where long-term data are available, the most recent conditions are interpreted with the invaluable perspective of conditions observed 5, 10, 20, or 30 years ago. **Principal Investigators:** John K. Jackson and Bernard W. Sweeney

Comparative life cycle and toxicity testing of multiple mayfly species across a gradient of total dissolved solids, with methods development for native species in the Central Appalachian coal fields

Funded by: United States Environmental Protection Agency

Many water quality standards for pollutants in streams are based on laboratory toxicity tests that rely on macroinvertebrate species that are easy to handle in the laboratory. Unfortunately, these standard test species generally do not live in streams, and their sensitivity relative to most native stream species is unknown. This project measures lethal and nonlethal responses of mayflies exposed to water from streams flowing out of valleys filled with mountaintop mining overburden in West Virginia and Kentucky. It builds on our experience in rearing the parthenogenetic mayfly *Centroptilum triangulifer* in the laboratory by comparing responses of *C. triangulifer* from the White Clay Creek with responses of five mayfly species collected from small streams in West Virginia.

Principal Investigators: John K. Jackson, David H. Funk, and Bernard W. Sweeney

Macroinvertebrate assessment of environmental conditions in four tributaries on the Red Clay Reservation

Funded by: Red Clay Reservation

Stroud Water Research Center scientists sampled stream macroinvertebrates (i.e., primarily insects, crayfish, and worms) and baseflow water chemistry to assess stream condition as a cumulative measure of the effects of land and water use in four small tributaries on the Red Clay Reservation. The stream assessments are being used in support of the restoration and management efforts to increase and protect plant and animal biodiversity throughout this 500-acre private land trust near Hockessin, Del.

Principal Investigator: John K. Jackson

EarthCube Domain End-User Workshop: Engaging the Critical Zone community to bridge long-tail science with big data

Funded by: National Science Foundation EAR 1252238

This workshop served two objectives: (1) to engage approximately 45 cyber-literate Critical Zone scientists in the EarthCube process and (2) to inform about 20 of EarthCube's cyberscientists of the diversity of needs of Critical Zone science. The overall goal of the workshop was to develop a set of unifying requirements for the integration of "long tail" data and "big data" and to develop an interactive community of domain scientists and cyberscientists to pursue solutions.

Principal Investigator: Anthony K. Aufdenkampe

Collaborators: Christopher Duffy (Penn State University) and Gregory Tucker (University of Colorado Boulder)



Integrated data management system for Critical Zone Observatories

Funded by: National Science Foundation EAR 1332257

The objective of the project is to develop a comprehensive, integrated data management system for the Critical Zone Observatory (CZO) program, called CZOData. The overall goal for CZOData is to support, empower, and broaden the impact of CZO science and maximize the return on investment of the CZO program by transforming capabilities to easily share, integrate, analyze, and preserve the wide range of multidisciplinary data generated within and across CZOs. **Principal Investigator:** Anthony K. Aufdenkampe

Developing a community information model and supporting software to extend interoperability of sensor- and sample-based Earth observations

Funded by: National Science Foundation EAR 1224638

This two-year project was designed to develop a community information model and related software to enable Web-based interoperability of Earth observations derived from sensors and samples that span now discrete data and informatics initiatives for multiple communities. The system would target specific existing Web service data repositories in order to demonstrate how the information model can support federation of Earth observations data across multiple data publication systems. The model would incorporate international standards for data description and publishing utilizing Open Geospataial Consortium standards and domain-specific markup languages. It is hoped that the results will feed directly into the larger EarthCube cyberinfrastructure initiative.

Principal Investigator: Jeffery Horsburgh (Utah State University) **Collaborators:** Anthony K. Aufdenkampe; Ilya Zaslavsky (University of California San Diego), Kerstin Lehnert (Columbia University), and Emilio Mayorga (University of Washington)

Education Projects

From classroom to creek

Funded by: Stormwater Programs for the City of Newark, Del. Stroud Water Research Center educators visited several elementary schools within the city of Newark to introduce students to the concepts of watersheds and how to minimize stormwater runoff in their communities. Students learned where water goes during a precipitation event, that storm drains are meant for water only, and how trees throughout a watershed not only help filter water but also help minimize the amount of water traveling to storm drains.

Project Lead: Christina Medved

The science of water through the world of art

Funded by: Point Lookout Farmlife and Water Preserve Foundation This program at Point Lookout Preserve gives students and teachers new ways of thinking about stream ecosystems and stewardship through the creative processes of art and science. Elementary through high school students from Delaware and Pennsylvania participated in programs that combined watershed science, artistic exercises, canoeing, and introductions to the art of the Brandywine Valley with a focus on the art of the Wyeth family. **Project Lead:** Vivian Williams

Consortium for Scientific Assistance to Watersheds (C-SAW)

Funded by: Consortium for Scientific Assistance to Watersheds Stroud Water Research Center educators provided technical assistance to county conservation districts, municipal environmental advisory committees, watershed associations, and citizen action groups as part of a partnership of nine organizations across Pennsylvania whose goal is to teach conservation groups how to conduct effective watershed assessments and restoration efforts.

Project Lead: Christina Medved

Integrating the carbon and water cycles within an ecosystem esthetic approach to landscapes

Funded by: National Science Foundation

Stroud Water Research Center educators and scientists developed and began implementation of Your Livable Landscape: Cultivating an Ecosystem Esthetic, a collaborative education program that builds on the landscape practices of Longwood Gardens and the science of Stroud Water Research Center. Through a lecture series and a website, the program taught Longwood visitors the connections among landscape practices, stormwater runoff, and the mobilization and mineralization of carbon. Through the program, visitors to Longwood Gardens learned about beautiful landscaping techniques that allow rainwater infiltration, reduce stormwater runoff, and sequester carbon.

Principal Investigators: Susan E. Gill, Louis A. Kaplan, Anthony K. Aufdenkampe, and J. Denis Newbold

Collaborators: Michele Adams (Meliora Design), Muscoe Martin (M2 Architecture), and Rick Darke (Rick Darke LLC)

Model my watershed

Funded by: National Science Foundation

Stroud Water Research Center educators and scientists launched Model My Watershed, an innovative, three-year program to develop, test, and disseminate a watershed-modeling tool set for Philadelphia-area secondary schools. The goal of the program is to engage and excite students about the diverse science, technology, engineering, and mathematics (STEM) careers needed to address environmental issues. Using an interactive, hydrologic modeling tool set, students make real-world decisions based on real scientific data and models and learn to predict how environmental changes in their watersheds affect the hydrologic cycle.

Principal Investigators: Susan E. Gill, Anthony K. Aufdenkampe, and J. Denis Newbold; Robert Cheetham (Azavea), Dana Tomlin (University of Pennsylvania), and Nanette Dietrich (Millersville University)

Collaborators: Michele Adams (Meliora Design) and Steve Benz (OLIN)

Critical zone geoscience education

Funded by: National Science Foundation

Stroud Water Research Center educators and scientists are teaching the principles and processes of the earth's Critical Zone to teachers, informal educators, and academically at-risk youth. This program is based on the research of the Christina River Basin Critical Zone Observatory. Educators worked with students at Greenwood Elementary School and Kennett Middle School in afterschool programs and with youth at the Garage Center and through 4-H.

Principal Investigators: Susan E. Gill; Gary Coutu (West Chester University)

Stroud Seminar Series

Funded by: Cockayne Fund, Inc.

Stroud Water Research Center educators and scientists presented their work through a series of lectures. These lectures covered topics such as the challenges in STEM education; whether environmental laws are protecting our streams and rivers; how emerging tools and approaches enable scientists to confront major environmental challenges; connecting with nature in the Digital Age; the science behind your livable landscape; and why we need to protect wetlands.

Watershed education for Plain sect communities

Funded by: Marshall Reynolds Foundation

In collaboration with Penn State Cooperative Extension and the Chesapeake Bay Foundation, Center and Extension educators taught students in four Mennonite schoolhouses in Lancaster County. The lessons specifically focused on teaching them the links between stream health, healthy farms, and rural communities; teaching them simple and effective tools to improve stream health, particularly utilizing forested riparian zones to protect stream water quality; and emphasizing a collective community responsibility for environmental stewardship and connections between their communities and other natural resources in the Chesapeake Bay watershed. Students were taught at their schools and also attended a field trip to the Center. One school participated in a tree planting of a riparian buffer at a local farm. They planted more than 100 trees, and over the years they will monitor the growth and survivorship of those trees.

Project Lead: Christina Medved

Stream school for New Jersey Department of Environmental Protection (NJ DEP)

Funded by: NJ DEP

For several years now, Center educators have provided two-day stream ecology trainings for Americorps volunteers and citizen water quality monitoring volunteers. NJ DEP utilizes volunteer data, at the state level, for assessing the health of its water bodies. Annually, this program trains its new Americorps staff and acts as a refresher for citizens. Many new volunteers also attend this course.

Project Lead: Christina Medved

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Your gift to the 2012 Annual Fund enabled us to continue the freshwater research and watershed education programs that are helping to protect, preserve, and restore fresh water everywhere. With loyal support from you, the Friends of Stroud Water Research Center, our work will continue for many years to come.

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Special Gifts

Stroud Water Research Center gratefully acknowledges these special gifts used to enhance areas not covered by the annual fund or the capital campaign.

Hearne Hardwoods John Lazarich Foundation and Mr. Peter Kjellerup and Mrs. Amanda C. Cabot Mr. and Mrs. Stephen M. Stroud

Generous donation of a stunning walnut table that was custom designed for the Joan Milliken Stroud Conference Room Ongoing support for marketing and communications efforts

Funds to support operations at the Maritza Station in Costa Rica, Wetland WWTP monitoring, and the Costa Rica Leaf Pack Network $^{\otimes}$

Educational Incentive Tax Credit

The education department gratefully acknowledges these businesses for their support through Pennsylvania's EITC program. These dollars are used specifically to subsidize costs associated with field trips from local Pennsylvania public schools.

DNB First Banking – Downingtown Susquehanna Bancshares, Inc.

Many thanks to everyone who supported our achievement of a green building for environmental education and public outreach that is LEED certified to the Platinum level!

Charles and Karen Dow

Sponsors and Volunteers



Moorhead Environmental Complex Dedication

GIFTS IN KIND

Acme Giant Philly Pretzel Factory Wawa

Stroud Seminar Series

Gunnip & Company Northern Trust Co. of Delaware Susquehanna Bank

Sustainable Feast PRESENTING SPONSOR

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Wild & Scenic Film Festival

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Dogfish Head Craft Brewery Exelon Patagonia Trail Creek Outfitters SIW Vegetables

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Francine Covelli of FarmTable Gathering Triple Fresh Catering

The development department gratefully acknowledges the following volunteers who generously gave their time to do such glamorous tasks as stuffing envelopes, running errands, and sharing creative talents: Franny Abbott, Yeda and Dave Arscott, Jan Battle, Laura Borecki, Lauren and Mike Broomall, Eliot Dalton, Laurie de Grazia, Evie Dutton, Abbie and Willy Eldridge, Libby Gregg, Anne Hannum, Rosanne Lisi, Katharine Maroney, Allison Masci, Alicia McGlade, Barbie Riegel, Winden Rowe, Trish Scott, Donnan Sharp, Andrea Spahr, Stephanie Speakman, Boo Stroud, and Vivian Williams. *Thank you! Your commitment and dedication is greatly appreciated!*

WELCOME TO NEW DEVELOPMENT DIRECTOR KRISTINE C. LISI



Kristine C. Lisi, Stroud Water Research Center's development director, joined the Center's staff in December 2011. Hailing from Westtown School, Lisi brings a wealth of creative ideas and experience to the table. In her first year at the Center, she raised Annual Fund giving to its highest level ever. She's also aided in successfully organizing six events, including The Water's Edge in October 2012, which netted its highest profit since 2003.

Much of her success is owed to her tenacity, enthusiasm, and cheerful personality. Kay Dixon, the Center's associate director of development, said of working with Lisi, "Kristine is always thinking of ways to expand our development efforts, and thereby she's helping to advance our mission. She's articulate, smart, and high-energy, and her sense of humor and upbeat personality make her a joy to be around."

Prior to serving as Westtown School's director of gift planning, she held development positions with the Delaware Valley Association for the Education of Young Children, Peter Nero and the Philly Pops, the University of Pennsylvania, the University of Pennsylvania Medical Center, and Blair Academy.

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Financials

Operating Statement for the year ended December 31, 2012

Revenues & Support

Expenditures

		Total Expenditures	5,067,582
Total Revenues & Support	5,067,582	Communications	37,297
		Other	304,729
Reserves	177,630	Education	306,728
Other Contributions & Income	281,732	Development/Outreach	309,828
Education/Public Programs	295,553	Information Services	346,786
Annual Fund	404,674	Facilities	438,229
Endowment	1,558,269	Administrative	655,207
Research Programs (Grants & Contracts)	\$ 2,349,724	Research	2,668,778

Financial Information

Stroud[™] Water Research Center is a 501(c)(3) nonprofit organization registered with the Pennsylvania Bureau of Charitable Organizations. Gifts to Stroud Water Research Center are tax deductible on a U.S. return as allowed by law.

The Stroud Water Research Center Employer Identification Number (EIN) is 52-2081073.

The fiscal year is January 1 to December 31.

The annual audit is performed by Gunnip & Company.

Investment assets are managed by New Providence Asset Management and Passive Capital Management. The Center is also the beneficiary of the Morris W. Stroud 3rd Pennswood No. 2 Trust managed by the Glenmede Trust Company.

Privacy Statement

Stroud Water Research Center donor records are not sold, bartered, leased, exchanged, or otherwise provided to any outside organizations.

SECURING THE FUTURE

For 45 years, Stroud Water Research Center has advanced the knowledge and stewardship of fresh water through research and education.

Your continued generosity through annual, endowed, and planned gifts is vital to our research and education programs. Below is a brief list of ways you can make a tax-deductible gift:

ONLINE

Visit www.stroudcenter.org and click on "Donate Now."

CASH OR CHECK

Please mail donations to: Stroud Water Research Center, 970 Spencer Road, Avondale, PA 19311

CREDIT CARD

Stroud Water Research Center accepts VISA, Mastercard, and American Express. Credit card gifts can be made as a one-time gift or as a monthly or quarterly contribution.

STOCK

Gifts of appreciated securities are an outstanding way to avoid 15 percent capital gains tax. Prior to transferring assets, please contact Stroud Water Research Center Development staff, since no name will be attached to the deposit of funds. Your broker can use this information: Charles Schwab & Co.; DTC Clearing Number: 0164 – Code 40 Account name: Stroud Water Research Center; Account number: 1749-3778

Stroud Water Research Center Development Staff

WIRE TRANSFER

Funds may be wired directly to the Stroud Water Research Center financial institution. Please contact the development department for instructions.

PLANNED GIVING

A planned gift can meet your short-term or long-term charitable and financial goals. Planned gifts include, but are not limited to, bequest intentions, charitable gift annuities, IRA payments, retirement plan assets, insurance policies, and other various trusts to fit your needs.

CORPORATE MATCHING GIFT

Several companies match an employee's personal charitable contribution. Double your gift by simply asking your company's HR person if your company participates in a gift-matching program.

MEMORIAL AND HONOR GIFTS

Remember a friend, neighbor, or loved one with a gift in his/her name. All tributes will be listed in the annual report, and, when an address is provided, a letter will be sent on your behalf.

Kristine C. Lisi, Director of Development, klisi@stroudcenter.org, 610-268-2153, ext. 304 Kay D. Dixon, Associate Director of Development, kdixon@stroudcenter.org, 610-268-2153, ext. 303

Staff

Administration

Bernard W. Sweeney, Ph.D. President, Director, and

Senior Research Scientist David B. Arscott, Ph.D. Vice President, Assistant Director, and Research Scientist

John D. Pepe Controller and Treasurer

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Rebecca Duczkowski Executive Administrative Assistant (as of Dec. 2012) Shelby J. vonTill Executive Administrative Assistant (retired as of December 2012) Jane Sowden Grant and Contract

Biogeochemistry

Administrator

Louis A. Kaplan, Ph.D. Senior Research Scientist

STAFF

Michael D. Gentile Research Tech III Jennifer Mosher Post-Doctoral Associate Jean Peirson Laboratory Assistant (now deceased) Sherman L. Roberts Research Tech III

GRADUATE STUDENT

Christine McLaughlin Ph.D. Candidate, University of Pennsylvania

INTERNS

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VOLUNTEER Collin McCallum-Cook

Communications and Marketing

Diane Huskinson Consultant, Huskinson Communications

Development

Kristine C. Lisi Director of Development and Secretary to the Board of Directors

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Kay D. Dixon Associate Director of Development

Ecosystems

STAFF Sara R. Geleskie Research Tech III

VOLUNTEER

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Education Programs Manager Vivian L. Williams Education Programs

Manager and Program Design Specialist

Alicia McGlade

Entomology

John K. Jackson, Ph.D. Senior Research Scientist

S T A F F

Juliann M. Battle Research Tech IV Michael C. Broomall Research Tech III

David H. Funk Research Tech V William L. Milliken, Jr. Field Assistant Sally Peirson Research Tech III Roberta M. Weber

Research Tech III

Andrew Kluge

Facilities

David H. Funk Director of Facilities

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Salomon Romero Woodlot Tech Javier Tinoco

Woodlot Tech

Fish Molecular Ecology

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STAFF Laura Borecki

Research Tech III

Saras Windecker MES Candidate, University of Pennsylvania

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Andrew Anderson

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Charles L. Dow, Ph.D. Director of Information Services and Research Scientist

STAFF

Melanie L. Arnold Data Analyst

Heather P. Brooks Data Analyst and Web Designer Elizabeth S. Gregg Systems Administrator

Maritza Station^{*} Costa Rica

Rafael A. Morales Station Manager and Research Tech

STAFF

Cristian A. Collado Research Tech

Microbiology

Jinjun Kan, Ph.D. Assistant Research Scientist

STAFF Laura K. Borecki Research Tech III

GRADUATE STUDENT

Madeline Stone Ph.D. Candidate, University of Pennsylvania

VOLUNTEERS

Peter Sulaiman Ho Yet Tom

Organic Geochemistry

Anthony K. Aufdenkampe, Ph.D. Associate Research Scientist

STAFF

* The Maritza Biological Station staff is employed by the Asociación Centro de Investigación Stroud, a non-governmental organization in Costa Rica

that serves as the umbrella organization for all of the Center's research and education activities in Central and South America

Stephanie A. Dix Research Tech III Sara R. Geleskie Research Tech III Steven D. Hicks

Research Engineer

Diana Karwan, Ph.D. Post-Doctoral Associate Olesya Lazareva, Ph.D. Post-Doctoral Associate, University of Delaware David S. Montgomery Research Tech III Carl Rosier, Ph.D. Post-Doctoral Associate University of Delaware Erika Vazquez

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PART-TIME TEMPS

Naomi Hicks, Ph.D. Hydrology and GIS Consultant Justin Olexy Computer Programming Consultant

VOLUNTEERS

Francisco Barrera

Watershed Installations

David S. Montgomery Manager



Research Scientists Emeritus

Thomas L. Bott, Ph.D. Senior Research Scientist Emeritus J. Denis Newbold, Ph.D. Research Scientist Emeritus

Adjuncts

Rolf Aalto, Ph.D. Adjunct Scientist,

University of Exeter William C. Anderson Adjunct Researcher.

Unionville High School Teacher Retiree Barry M. Evans, Ph.D.

Adjunct Research Scientist, Penn State University Nanette Marcum-

Dietrich, Ph.D. Adjunct Education Faculty, Millersville University

NEW IN 2013 THE WATERSHED RESTORATION GROUP AT STROUD WATER RESEARCH CENTER!



Matt Ehrhart

David Wise

In January 2013, Matt Ehrhart and David Wise joined Stroud Water Research Center as director of watershed restoration and watershed restoration manager, respectively. The new Watershed Restoration Group aims to develop, research, implement, and monitor watershed restoration programs that

 connect landowners, stakeholders, and the general public with Best Management Practices for conserving, restoring, and protecting watersheds.

help provide the

and global scale.

To learn more about the

Group, please go to: www. stroudcenter.org/restoration

Watershed Restoration

Photos: Dave Arscott

infrastructure on the

ground for sustaining

sources of clean fresh

water at a local, regional,

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2012

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OUR MISSION

Stroud[™] Water Research Center seeks to advance knowledge and stewardship of fresh water through research, education, and global outreach and to help businesses, landowners, policymakers, and individuals make informed decisions that affect water quality and availability around the world.



Every effort has been made to produce this report in a responsible manner. This piece is printed on process chlorine-free Mohawk Options, 100% PC, which is made with 100% post-consumer recycled fiber. Mohawk Fine Papers purchases enough Green-e certified renewable energy certificates (RECs) to match 100% of the electricity used in their operations. This paper is also certified by Green Seal. All inks are soy and vegetable based. Paper-based environmental savings are:

 6,884 gallons wastewater flow saved762 lbs. solid waste not generated

- 1,500 lbs. net greenhouse gases prevented
- 5 11,478,400 BTUs energy not consumed



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