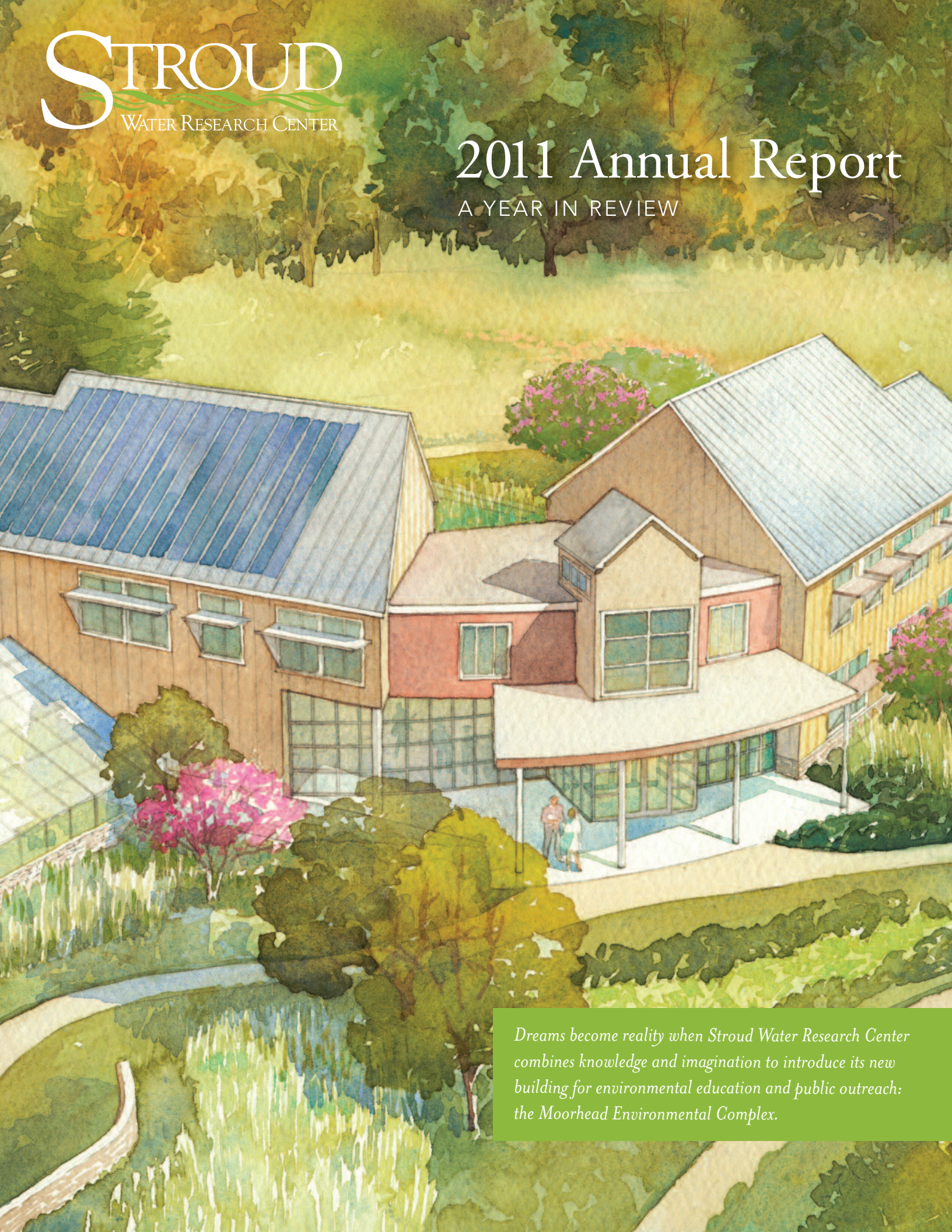
STROUD
WATER RESEARCH CENTER

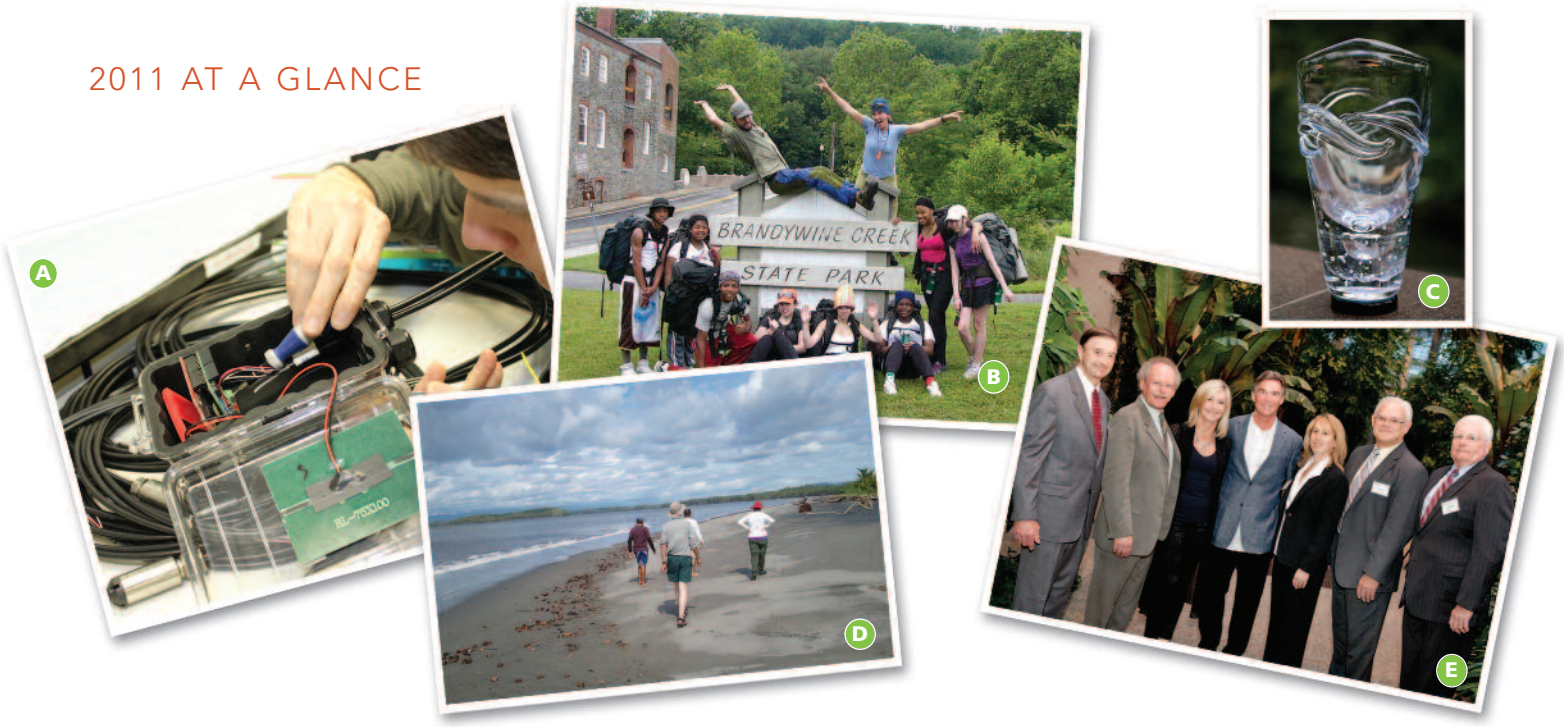
2011 Annual Report

A YEAR IN REVIEW



Dreams become reality when Stroud Water Research Center combines knowledge and imagination to introduce its new building for environmental education and public outreach: the Moorhead Environmental Complex.

2011 AT A GLANCE



A. At the 11th Annual Conservation District Watershed Specialist Training Meeting in State College, 58 attendees learned about the Center's use of emerging technologies and saw a demonstration for building sensors to monitor water using inexpensive open-source equipment. Photo: Kay Dixon

B. In June, the Center led students from Coatesville-area high schools on a nearly weeklong trek down the Brandywine River. The multidisciplinary experience combined science, history, art, math, communications, and collaborative learning. Students learned about the importance of their river and how it connects all the diverse communities through which it flows. Photo: Christina Medved

C. Stroud Water Research Center presented its first Stroud Award of Freshwater Excellence to Olivia Newton-John and her husband, John Easterling for their unwavering commitment to rainforest conservation in the Amazon River basin. The glass sculpture, designed by Simon Pearce, appropriately resembles the Center's logo. Photo: Andrea Monzo

D. Center scientists headed to the Río Sierpe and Grande de Térraba watersheds in Costa Rica to identify contaminants as well as contaminated fish and shellfish species that threaten humans who consume them. The research findings may offer additional insight into how agriculture impacts streams and rivers, and in turn, human health, in Pennsylvania as well as in Costa Rica. Photo: David B. Arscott

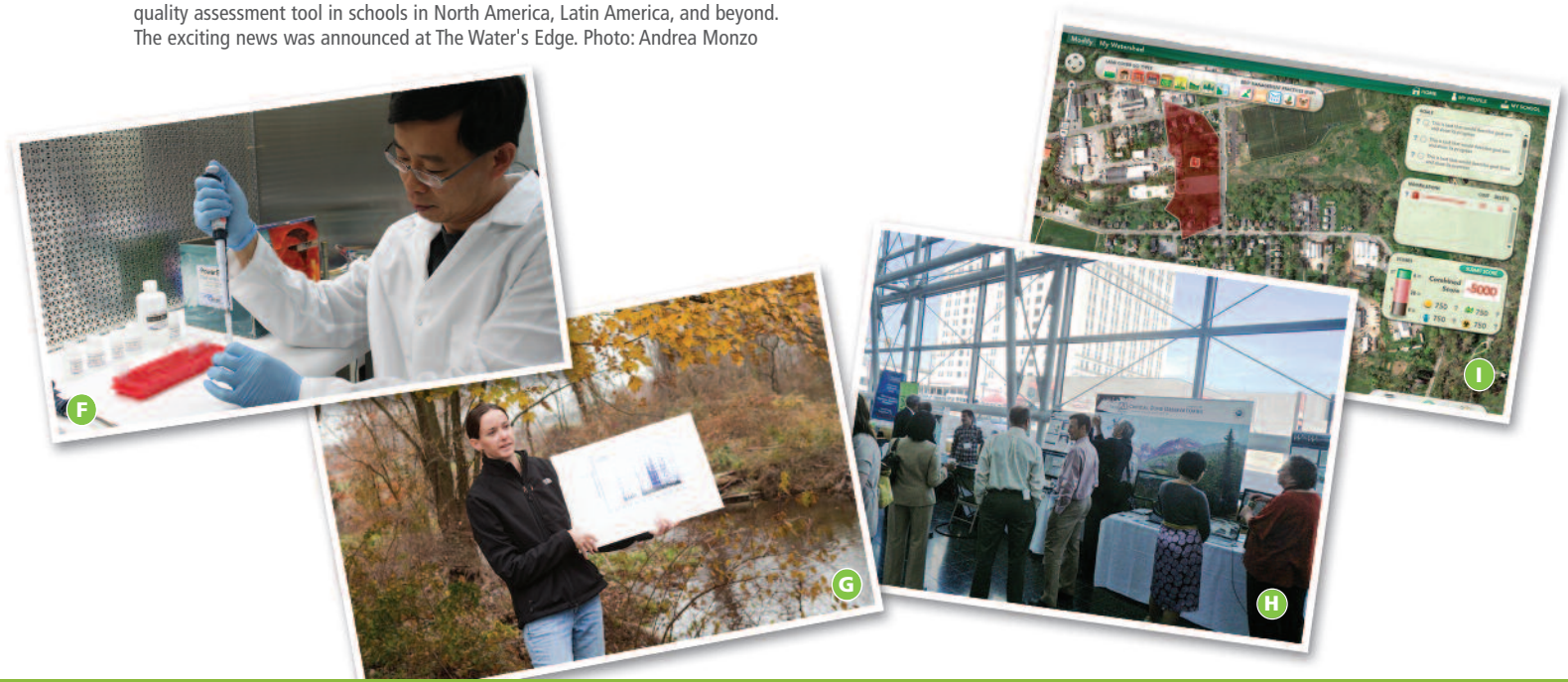
E. Stroud Water Research Center initiated memorandums of understanding (MOUs) with the National Wildlife Federation and the Amazon Center for Environmental Education and Research Foundation. The MOUs set a plan in motion to further expand and market the Center's Leaf Pack Experiment Kit as a teaching and water-quality assessment tool in schools in North America, Latin America, and beyond. The exciting news was announced at The Water's Edge. Photo: Andrea Monzo

F. Center scientists were awarded a grant to conduct a three-year study of metaecosystems using the River Continuum Concept (RCC) as a springboard. The RCC was published in 1980 and brought worldwide attention to the Center, pioneering the idea that from headwaters to mouth a river changes in its physical characteristics, which causes changes in the river biology. Photo: Kay Dixon

G. Stroud Water Research Center hosted a watershed field tour as part of a three-day conference in November on Critical Zone Observatory (CZO) research. About 80 water research scientists from Europe, North America, China, and Australia visited the Center to learn about Christina River Basin (CRB) CZO research. Photo: Ambre Alexander

H. Two Center projects — Model My Watershed and CRB-CZO — were among 31 featured at the STEM Smart congressional event in Philadelphia. The event introduced a publication by the National Research Council (NRC) on successful Science, Technology, Engineering, and Math (STEM) education and highlighted examples of successful STEM education initiatives. Photo: N. Scatina

I. The Center's Education Department shared recent developments in the National Science Foundation–funded project Model My Watershed at a handful of Science, Technology, Engineering, and Math (STEM) education events across the country. The project is a place-based modeling tool that uses an online, hydrologic, visual model and authentic data that allow students to see how runoff impacts their neighborhoods and watersheds. Image: www.wikiwatershed.org



Message
FROM THE DIRECTOR

"If you have built castles in the air, your work need not be lost; that is where they should be. Now put the foundations under them."

— HENRY DAVID THOREAU

Dreaming Big in 2011

Henry David Thoreau's words, written more than 150 years ago, could serve as Stroud Water Research Center's motto for 2011 — figuratively, to be sure, but also literally.

At Stroud Water Research Center, we have dreamed for years about building a physical foundation to support our education and public outreach programs, as well as to free up vital laboratory space for our growing team of scientists. But buildings, particularly one as special as ours, are expensive, and we had little money on hand. So we went to work, we made plans, we broke ground, we asked for your support — and our environmental education and public outreach building, the Moorhead Environmental Complex, will have its grand opening on May 30th.

We dreamed of ways to collect the massive amounts of data we need to answer critical questions about protecting fresh water around the world. The equipment that existed was both inadequate to our needs and too expensive for our budgets to replace. So we invented extraordinary sensors built from ordinary parts that you can easily buy on the Internet — and we are now deploying hundreds of high-quality and inexpensive sensors to track water-quality changes in real time, and we are sharing our open-source designs and our data with the rest of the world.

We dreamed of creating education programs that would inspire students to get involved in their own watersheds and to have fun doing so — and we developed Model My Watershed, which will enable students of all ages to record on their laptops what is happening in their local streams and watersheds.

We are still dreaming in 2012 — and our dreams today, as they have been for the past 45 years, are all variations on one big dream: how to unlock the secrets of fresh water. We want to understand its structure and function, to protect its sources, and to ensure its availability for future generations. But we do more than dream; we work every day to turn those dreams into reality. The support of our friends over the years has been the lifeblood of our work. You have encouraged us to dream, and you have helped us make so many of those dreams a reality.

So, thank you for your past support and your ongoing interest. We will continue to do everything in our power to dream big dreams and — with your help — to make those dreams come true.

Photo: Rafael A. Morales

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2011

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Stroud Water Research Center is getting the water right with its new LEED-certified building for environmental education and public outreach.

From the Ground Up:

A FRESHWATER FOUNDATION FOR ENVIRONMENTAL EDUCATION AND PUBLIC OUTREACH

Not Just a Dream

Science and art allow us to dream big. Consider those like Hubble and Galileo, who studied the cosmos, Van Gogh, who painted the stars, and Michelangelo, the heavens. The senses of wonder, curiosity, and creativity they shared with the world have given all of us a better understanding of life on Earth and beyond.

As our world becomes more complicated, the need to still better understand how to satisfy the competing needs of business, industry, community, and the environment also grows.

Since its founding in 1967, Stroud™ Water Research Center has played a critical role in using solid science to help shed light on these issues by studying freshwater streams and rivers. The Center's scientists and educators have dared to let loose their imaginations. No dream is too big, no microorganism too small.

While demystifying the complexity and interconnectedness of freshwater ecosystems, they have discovered how to better ensure water quality and availability.

So when the Center most recently outgrew its facilities, which have been expanded and renovated several times since its founding, a new dream began to unfold. Rather than simply adding on, it was decided to design an entirely new, "green" building for environmental education and public outreach that would model sustainable practices for managing water.

"Part of our mission is to share our knowledge through education and conservation, and with this new building, we can do that by modeling best practices," said Director Bern Sweeney.

Fresh water is a limited resource. There's no more water today than when far fewer than 7 billion people roamed the earth, and its availability and quality is a growing concern. The World Economic Forum's *Global Risks Report 2012* ranked both the likelihood and the impact of a water crisis as the No. 1 societal risk in the next 10 years.

Sandy Wiggins says the answer is localization. "We often hear about reducing our environmental footprint and sustainable practices," he said. Wiggins is principal of Consilience LLC and the Center's representative during the building process and former chairman of the U.S. Green Building Council. "In terms of water, that means restoring the earth's natural hydrological cycle. We want to value water as a precious resource, use it conservatively, and ideally, use only water obtained from rainfall on the site and then treat it so that it is as clean or cleaner than it was when it fell from the sky. We call that net zero water."

Getting the Water Right

Getting the water right became the guiding principle for the new building. To do it, the Center assembled a team of designers, engineers, and builders to create a LEED-certified building that blends form with function, beauty with smart design.

Together they came up with a plan. They added bioswales, rain gardens, pervious surfaces, and landscaping using native vegetation to increase infiltration and reduce stormwater runoff as well as related nonpoint source pollution.

"This project has actually further restored the hydrologic health of the site. Most building projects do just the opposite," Wiggins said.

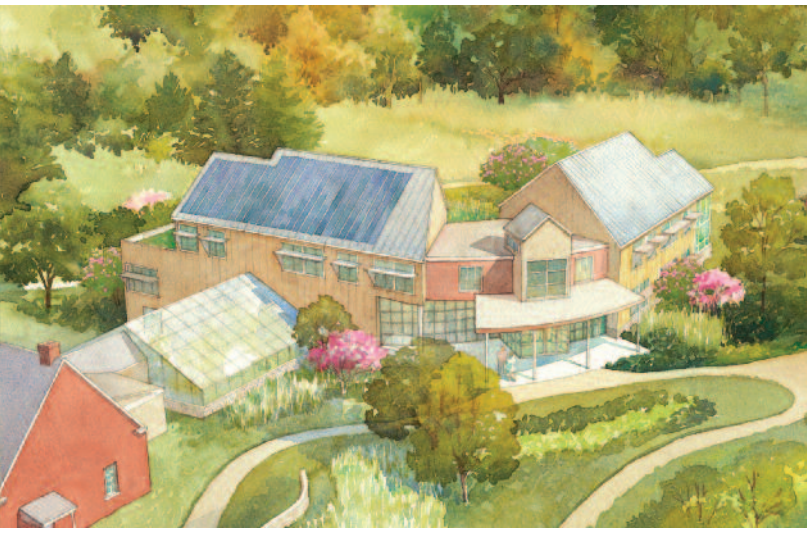
The stormwater management system works together with a rooftop rainwater capture system, a green roof, composting toilets integrated with a water-reuse system, and a wetland waste treatment and drip irrigation system to mimic nature's natural water cycle. Add it all up and you have — balance. Fans of *The Lion King* may recall Mufasa's teaching: "When we die, our bodies become the grass, and the antelope eat the grass. And so we are all connected in the great Circle of Life." Disney had the right idea.

Here's how it works. Rain falling on the landscape is either absorbed into the ground, taken up by plants, or channeled to one of the infiltration strategies like the rain gardens. Rain falling on the roof of the building is collected into large cisterns. Water in the cistern then goes through an advanced water treatment system that uses charcoal filters and ultraviolet light instead of chemicals. It's then distributed throughout the building. Once that water is used and flushed down the drain, it travels to a septic tank and then to the constructed wetlands.

The Center's new LEED-certified building for environmental education and public outreach will be named the Moorhead Environmental Complex in honor of Board Co-chairman Rodman W. Moorhead III for his generous gift and longtime support and leadership. The dedication ceremony will be held May 30th at 4 p.m.

Assistant Director Dave Arscott of Stroud Water Research Center explained, "The wetlands remove the nutrients or pollutants of primary concern — for example nitrate-nitrogen or dissolved organic matter. There are microbes and plants in the wetlands that process nitrogen and metabolize organic carbon. The water that finally comes out of the wetland cells is pumped into a drip irrigation system where the ground can further purify the water and recharge the aquifer."

Although initially the rainwater will only be used for flushing toilets and for research, the building has been designed so that eventually the rainwater can be used as a source of potable water with the flip of valve.



Artist illustrations depict the front (pictured left) and back (pictured right) of the new LEED-certified building for environmental education and public outreach: the Moorhead Environmental Complex.

"Right now, that's not possible in the United States," Wiggins said. "There's no regulatory framework for using captured rainwater for potable drinking water unless you are willing to follow the very costly regulatory protocols of a big municipal water system like New York City or Philadelphia. This project has been a catalyst for changing the regulatory environment. It's started a national dialogue, and the building will serve as a pilot. Progress is being made in Washington."

"It's a great opportunity for us to monitor how and to what degree these systems affect water quality in and around one of Pennsylvania's most valued streams," said Arscott. The new building stands adjacent to the meetinghouse alongside White Clay Creek, a Pennsylvania-designated exceptional value watershed and a part of the National Wild and Scenic Rivers system.

The building is doing double duty as part education and public outreach center and part science experiment. "It's a research tool. We plan on monitoring wells in the ground near the drip irrigation system and around the existing drain field. We'll sample wells for nitrate-nitrogen and dissolved organic carbon and other chemical signatures of the water to see if we can see a change in the shallow groundwater."

The Department of Environmental Protection (DEP) was so impressed with the wetland waste treatment and roof rainwater capture systems that it awarded the Center a grant of more than $239,000 through Growing Greener to help fund their construction, $30,000 of which is to monitor the effectiveness of the wastewater system.

Watershed Manager for DEP Kevin B. Munley commented, "We are proud to be part of this exciting project. Most remarkable is that Stroud Water Research Center — this world-renowned center of freshwater science — is not only using the building as a teaching tool for the public, but also monitoring how well the integrated water use and treatment system actually works. That kind of information will be valuable for creating water treatment and use guidelines."

Classroom to Creek

All research at the Center — including monitoring the water management systems — helps feed education and public outreach. The first building is housing all the scientists and researchers so they have room to collaborate under one roof, and their close proximity to the Education Department, now relocated to the new building, makes it possible to easily share findings and tailor education programs so that students can learn from cutting-edge science.

Director of Education Susan Gill said, "Because we're close to the science, when our scientists learn something new, we can bring that into the classroom."

The Education Department has two new classrooms in the building. "It's a place where students and teachers from all over, as well as local community members and groups, come to participate in our programs," said Gill.

"Our stream programs are an important part of what we do. We teach students about water quality by assessing

macroinvertebrates, invasive species, the pH of water, and turbidity, and they have been well received because of the quality of our science. With the expanded space, we are even better able to serve as an educational resource for our community. On occasion, we used to have to find off-site locations to have demonstrations and workshops, but now we can do more of these events right on site — close to the science and White Clay Creek."

Really, the entire building is a classroom. Educational signage around the building will explain how Stroud Water Research Center is getting the water right and highlight some other key features of the LEED-certified design: overall energy efficiency, recycled and locally sourced materials, and environmentally sensitive indoor materials and design.

Muscoe Martin, principal of M2 Architecture and the design team leader, says that when visitors walk into the building, he hopes they'll be inspired by more than the innovative approach to water and energy use. "We tried to creatively design the building to communicate about water in an architectural way. The slopes and angles, the way water moves." And right above the entryway, bathed in sunlight from surrounding windows, is a library. "In a symbolic way, it says this is a place where discoveries are made and knowledge is shared."

Links

- To help fund the Center's new building for environmental education and public outreach, make a donation here: www.stroudcenter.org/donate
- To find upcoming events at the Center's expanded facilities, check out: www.stroudcenter.org/events
- To learn more about the Center's facilities, go to: www.stroudcenter.org/about/tour/index.shtm
- To learn more about the Center's education programs, go to: www.stroudcenter.org/education/index.shtm
- To learn more about the U.S. Green Building Council's LEED certification program, go to: www.usgbc.org/LEED
- To read the World Economic Forum's Global Risks Report 2012, go to: www.weforum.org/reports/global-risks-2012-seventh-edition

LEED PROJECT CHECKLIST HIGHLIGHTS

Innovation and Design Process

- ✓ Educational Components
- ✓ Water Use Reduction
- ✓ Innovative Wastewater and Stormwater Treatment
- ✓ LEED-Accredited Professionals

Water Efficiency

- ✓ Water-Efficient Landscaping
- ✓ Innovative Wastewater Technologies
- ✓ Water Use Reduction

Energy and Atmosphere

- ✓ Optimized Energy Performance
- ✓ Green Power (Solar PV and Geothermal)

Sustainable Sites

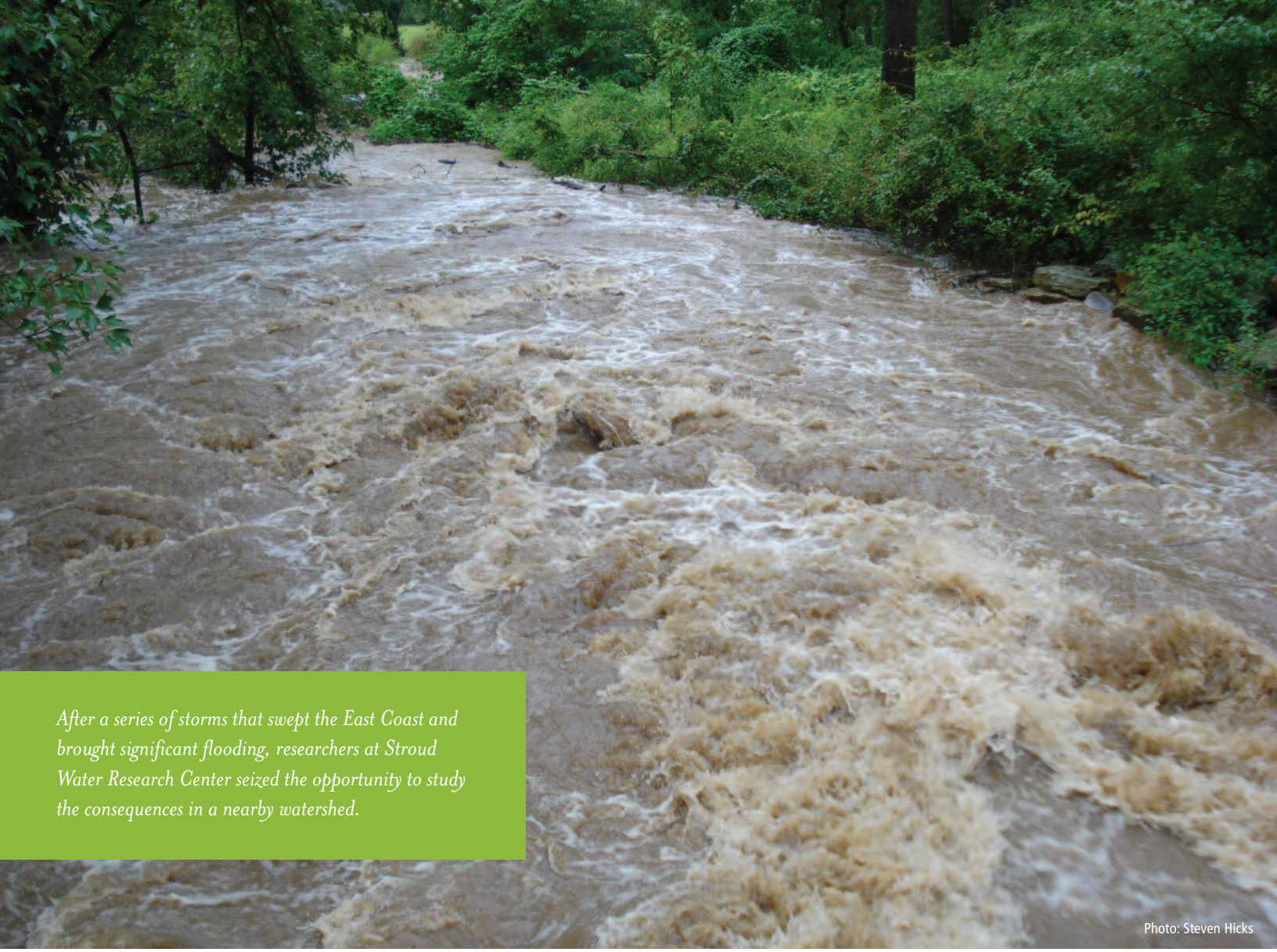
- ✓ Habitat Protection and Restoration
- ✓ Stormwater Management
- ✓ Bicycle Storage and Fuel-Efficient Vehicles
- ✓ Heat Island Reduction via Green Roof

Materials and Resources

- ✓ Recycling of Construction Waste
- ✓ Reuse of Materials and Recycled Content
- ✓ Sustainably Grown Timber

Indoor Environmental Quality

- ✓ Outdoor Air Delivery Monitoring
- ✓ Low-Emitting Materials
- ✓ Lighting and Heating Control



After a series of storms that swept the East Coast and brought significant flooding, researchers at Stroud Water Research Center seized the opportunity to study the consequences in a nearby watershed.

Photo: Steven Hicks

Chasing Storms and Carbon

IN THE CHRISTINA RIVER BASIN CRITICAL ZONE OBSERVATORY

The Storm(s)

When Hurricane Irene hit, the team was ready. Scientists at Stroud™ Water Research Center had been preparing for months for a storm big enough to provide unique insights into the movements of carbon and sediments through the Christina River watershed. The best time to track these movements is during storms, whose high winds and heavy rains erode soil, scour streambeds, and transport massive amounts of solid materials.

Because storms move so much carbon — soil, leaves, trees, and so on — in such a short time, they present unparalleled opportunities for research. "All erosion of consequence happens as a result of floods," said Associate Research Scientist Anthony Aufdenkampe. "Last summer was a big deal.

"Because we are focused on how landscapes transport materials, particularly during big storm events," said Aufdenkampe, "we were completely ready for Irene," which was fortunate because Irene hit hard. One of the most destructive hurricanes in memory, Irene dumped almost six inches of water in eight hours on a watershed already soggy from earlier August rains.

In preparation for the hurricane, Center scientists went well beyond their typical storm protocols, said Diana Karwan, a hydrologist, postdoctoral fellow, and self-described "storm

chaser." They set up monitoring equipment at nine sites, from the headwaters of White Clay Creek to below the city of Newark, Del. On the larger streams, at Avondale and Newark, they co-located their equipment on U.S. Geological Survey sites, and elsewhere they deployed an assortment of devices to gather data from both land and water.

How did they do?

"We nailed it," said Aufdenkampe, "in a way we never had before."

Ten days later, Tropical Storm Lee hit. Unlike Irene, which moved up the coast and roared ashore near the Chesapeake Bay, Lee came out of the Southwest and was weakening when it entered Pennsylvania. "We had no idea it was going to be so big," said Aufdenkampe of a storm that delivered seven inches of water to already-oversaturated ground — the last two inches in 45 minutes. "It was an insane downpour."

The two storms probably transported 80-90 percent of the sediment moved during the entire year, said Karwan. "Storms can completely change the conditions of a watershed."

Neither Irene nor Lee came close to being the biggest storm in the 40-plus years the Center has kept records — Irene produced the 18th largest peak flows, and Lee ranked eighth. But the combination of two coming so close together, coupled with Lee's final deluge, produced flooding that closed roads, left thousands without power, and turned Chester County into a federal disaster area.

While the storms brought unique opportunities for research, the life-threatening conditions also presented a variety of collection problems. The hazards were especially significant for Karwan, who requires such large amounts of sediment for her analyses that she collects them in 55-gallon drums. Clearly, Irene and Lee were not times for her to be in waders with a rope around her waist. So with the help of Steve Hicks, the staff inventor, and Dave Montgomery, a veteran research technician who is known for creative on-the-spot solutions, Karwan oversaw the design and construction of "dial-a-pump," a technological innovation that enables her to "call" sensors and pump switches from her cell phone and instruct them to collect data and samples.

The CZO

One reason that so much equipment and attention could be focused on the storms was the ongoing partnership between Center scientists and their colleagues at the University of Delaware on the Christina River Basin Critical Zone Observatory (CRB-CZO). The primary mission of the joint effort is to understand the processes that move and mix carbon and minerals throughout the watershed, and what effect those processes have on net carbon sequestration — and ultimately on the earth's climate.

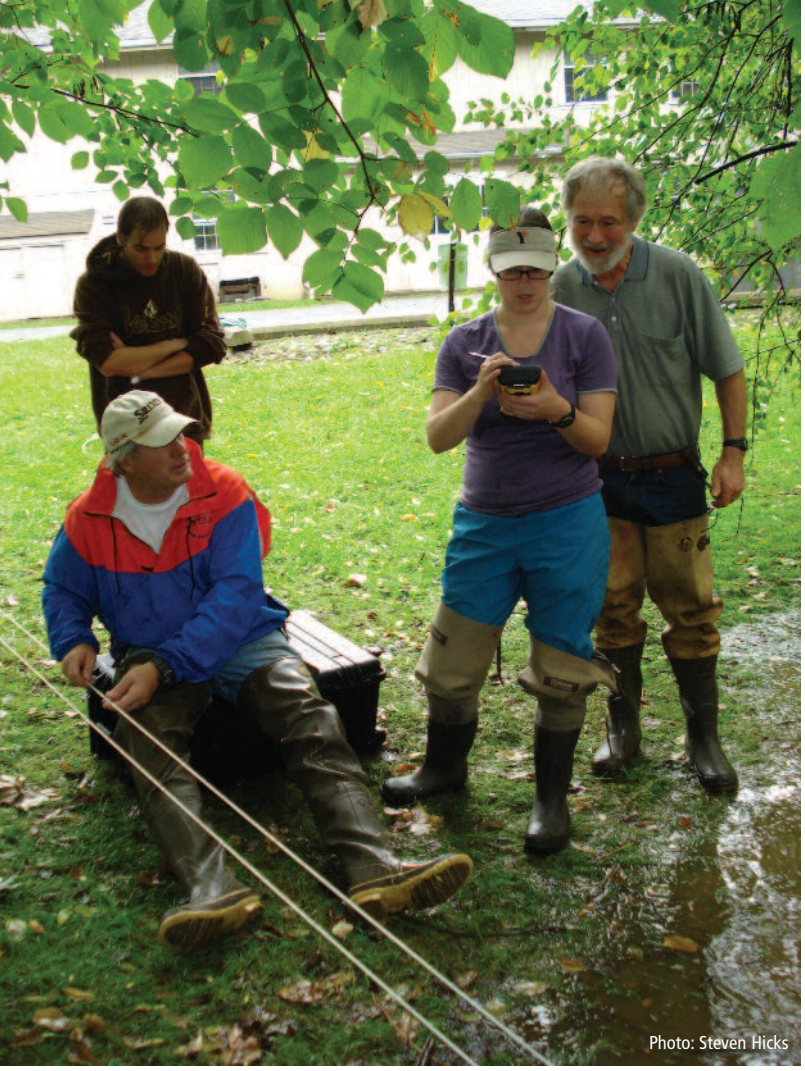
"The Critical Zone extends from the bottom of the active aquifers to the lower boundary of the atmosphere," said Aufdenkampe. "It is critical to all life," and studying it requires collaboration among scientific disciplines that have historically had little communication with each other and whose practitioners have grown increasingly specialized over the years. The CZO brings together researchers from the biological, chemical, geophysical, and even the social sciences with the common goal of understanding the interactions among the carbon, mineral, and water cycles across the watershed.

The Christina River Basin collaboration is one of six multiyear, multidisciplinary, multimillion-dollar CZOs funded by the National Science Foundation across the country. It is, said Aufdenkampe, the only one situated in a historically "human-modified landscape," the only one to incorporate the ecological footprint of humans into its fundamental questions, and the only one "that has a primary question specifically related to greenhouse gases."

The Missing Carbon

By analyzing the movement of carbon through the watershed, the research team hopes to shed light on the "missing carbon sink" and to understand its significance for global climate change.

For a long time, scientists believed that most of the carbon that washed into inland waterways ended up in the ocean, where it was either buried at sea or returned to the atmosphere. The problem was that atmospheric and oceanic studies could not account for up to a third of the carbon that should have been in either one place or the other. Consequently, in the 1990s



From left: Bill Anderson (volunteer, seated), Fred Shaw (intern), and Sara Geleski and Denis Newbold of Stroud Water Research Center measure stream flows using a new Acoustic Doppler Current Profiler (ADCP), which they are towing across the surface of the stream on a cable pulley system.

scientists began to look more closely at rivers, focusing initially on the Amazon, where mammoth floods come roaring down the Andes carrying billions of tons of sediment with them. The researchers, including a young Anthony Aufdenkampe, discovered that, far from channeling all that carbon to the ocean, rivers "outgassed" most of it directly into the atmosphere or buried it in the flood plains.

A similar process on a smaller scale occurred during the flooding last summer. Karwan, who studies chemical alterations in the stream's sediment, noted that the composition of the sediment changed significantly as the two storms passed through the watershed. Because the ground had already been saturated by Irene and earlier thunderstorms, Lee, in particular, carried material into the stream that would not have been there under less severe conditions.

Big storms do more than erode large volumes of carbon-laced soil and carry it into the stream. By removing topsoil, they also expose clay that has been so deeply buried that it contains no carbon at all. One question that the CZO team is asking from different perspectives is: What implications does that lifeless, mineralized ground have for carbon sequestration?

One answer is that the newly exposed minerals are suddenly available to bind with carbon and create new soil. This means that erosion may actually sequester carbon — both by bringing to the surface minerals that can remove it from the air and by burying carbon under layers of flooded ground. Yet erosion also releases carbon — through increased outgassing from rivers and the ocean. Understanding how those processes impact the fate of carbon should provide important insights into the global carbon cycle.

While storms the size of Irene and Lee bring enormous disruptions to the lives of many people, they also have much to tell the scientific community about the basic processes of the ecosystem. More than six months after the two events, Center scientists continue to analyze the massive amounts of data they collected last summer. Meanwhile, they prepare for the next storms in the hope — and the belief — that future events will reveal more insights into the processes that connect the lives of every organism in the watershed and may ultimately affect the fate of the earth.

Links

- To learn more about how the Center is creating custom solutions to scientific problems, go to: www.stroudcenter.org/newsletters/2011Summer/hicks.html
- To read more about the Center's CZO work, including Hurricane Irene storm sampling, go to: www.stroudcenter.org/research/projects/czo/news.shtm

How are emerging tools and approaches enabling scientists to confront major environmental challenges that threaten our world?
Find out the answer to this question and many others in Stroud Water Research Center's ongoing science and education seminar series: **Wide-Angle View.** For dates and topics, go to: www.stroudcenter.org/events

Research Projects

Microbial population dynamics of periphyton biofilms in White Clay Creek

Funded by: Stroud Water Research Center

From the summer of 2011, glass slides to collect algae and bacteria (periphytometers) were deployed in three reaches of White Clay Creek with different types of streamside landuse (mature forest, restored but immature forest, and meadow). Molecular DNA fingerprints of marker genes will be used to monitor how species of algae and bacteria vary during the year in each reach.

Principal Investigator: Jinjun Kan

Marine sediments microbial fuel cells (MFCs)

Funded by: Space and Naval Warfare Systems Command (SPAWAR)

This project focuses on the molecular DNA characterization of microbial species colonizing the anodes and cathodes of microbial fuel cells. The goal is to screen potential bacteria to improve the efficiency and kinetics of electricity yield in marine sediments.

Principal Investigator: Jinjun Kan

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

Collaborative 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 (Stroud Water Research Center), 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. In 2011 Center scientists analyzed the carbon contents and geochemical fingerprints of samples collected during the 2010 expedition.

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. In 2011 the Center hosted graduate student Amy Lyttle from the University of Minnesota, training her on sample preparation and analysis techniques.

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. In 2010 Center scientists prepared a second paper for publication.

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. In 2011 the large project team continued an exceptionally high level of activity — deploying dozens of environmental sensing nodes, presenting scientific findings dozens of times at national and international meetings, and co-hosting a workshop on the development of an international CZO network, including an all-day field tour of CRB-CZO sites.

Principal Investigators: Anthony K. Aufdenkampe, Louis A. Kaplan (Stroud Water Research Center), and Donald L. Sparks (University of Delaware)

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

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. In 2011 the Center completed its method development and sample analyses and submitted its first paper of results.

Principal Investigator: Anthony K. Aufdenkampe

Collaborator: Katarina Billups (University of Delaware)

Unless otherwise noted, principal investigators are from Stroud Water Research Center.

Hydrologic regulation of dissolved organic matter biogeochemistry from forests through river networks

Funded by: National Science Foundation EAR 0450331

This collaborative proposal will generate the mathematical models that simulate stream flow in White Clay Creek and the movement of water carrying dissolved organic carbon from soils to the stream. Standing on the stream bank, scientists have been looking both upslope and downstream, focusing on the interactions of water movement and organic carbon supply and investigating processes within the hillslope soils, individual stream reaches, and the entire river network.

Principal Investigator: Louis A. Kaplan

Collaborators: J. Denis Newbold, Anthony K. Aufdenkampe (Stroud Water Research Center), and George M. Hornberger (Vanderbilt University)

The application of scaling rules to energy flow in stream ecosystems

Funded by: National Science Foundation DEB 0516516

Scientists have grown young deciduous trees in an atmosphere enriched with the stable isotope of carbon so as to follow the fate of those organic molecules in small laboratory reactors, microcosms, and through whole stream releases of these molecules in first- through fifth-order streams. Investigations have involved working in the forested Neversink River watershed of New York.

Principal Investigator: Louis A. Kaplan

Collaborators: Peter Miller and Paul Hebert (University of Guelph), Eric Stein (SCCWRP), and Erik Pilgrim (USEPA)

Restoration of streamside forest for improving water quality

Funded by: Pennsylvania Department of Environmental Protection TreeVitalize Program

Planting trees along the stream corridors is a best management practice for keeping pollutants out of streams and improving their health. This collaborative effort with the Brandywine Conservancy involved the proactive planting of 6,935 trees on 22 acres of land involving six different landowners.

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 are working 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. The Rainforest Alliance is interested in 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

Center biologists are determining the local distribution of a species of snail that has never been recorded north of the James River in Virginia until Center researchers discovered it in three first-order streams in southeastern Pennsylvania in 2010.These new populations will help researchers evaluate a controversial hypothesis that some snail species have not moved between neighboring watersheds for over 60 million years. This species could also help validate DNA barcoding for species identification because individuals of this species may diverge more in their DNA sequence than two distantly related mayfly species.

Principal Investigator: William H. Eldridge

Fish dispersal across a riparian habitat gradient

Funded by: Stroud Water Research Center

In 2011 Stroud Water Research Center biologists continued a study started in 2010 to measure fish dispersal along a two-kilometer stretch of the 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)

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 McTammay (Bucknell University) and Steven Rier (Bloomsburg University)

Long-Term Research in Environmental Biology: 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 rain 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, and Anthony K. Aufdenkampe

Collaborator: Julio Calvo (Escuela de Ingeniería Forestal del Instituto Tecnológico de Costa Rica)

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 long-term monitoring of it is virtually nonexistent. Center scientists initiated a study to follow restoration within 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 (Stroud Water Research Center)

Collaborative research: 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, Jennifer J. Mosher (Stroud Water Research Center), Robert H. Findlay (University of Alabama),David C. Richardson (SUNY New Paltz)

Spatial and temporal variation in water quality among major tributaries of the Schuylkill River

Funded by: William Penn Foundation

This research, education, and outreach project continues efforts with local watershed groups to monitor macroinvertebrates in streams throughout the Schuylkill River Basin, which is located in the Northern Piedmont and the Ridge and Valley ecoregions. Work during 2011 focused on evaluating long-term change and environmental variation among the 19 sites on the major tributaries of the Schuylkill River that were sampled annually between 1996 and 2010.

Principal Investigator: John K. Jackson

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

Effects of elevated and fluctuating temperature regimes on macroinvertebrates and fish in Pennsylvania's warm water streams and rivers

Funded by: Pennsylvania Department of Environmental Protection

This laboratory project investigates macroinvertebrate and fish responses to artificial changes in water temperature. Thermal regimes are warmer than normal and approach or exceed physiological and regulatory limits. Daily temperature changes emulate patterns characteristic of plant operations that discharge warm effluents.

Principal Investigators: John K. Jackson, William H. Eldridge, and Bernard W. Sweeney (Stroud Water Research Center)

Algal and macroinvertebrate responses to elevated phosphorus concentrations in Pennsylvania streams

Funded by: Pennsylvania Department of Environmental Protection

This project took advantage of the unique facilities of Stroud Water Research Center as a field station with first-rate laboratory facilities in an Exceptional Value Watershed and the experience of the research programs and personnel that allows for experimental manipulations impossible to conduct elsewhere. Phosphorus is a major pollutant of fresh waters, historically turning streams, rivers, lakes, and reservoirs green with excess algae. These experiments were designed to look at algal responses of elevated phosphorus and how macroinvertebrates responded to these changes in algae.

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

Collaborator: Hunter J. Carrick (Penn State University)

Comparative lifecycle 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.

Principal Investigators: John K. Jackson 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 base flow 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

Water quality monitoring in White Clay Creek watershed, 1991-2008

Funded by: White Clay Wild & Scenic Management Committee, White Clay Creek Watershed Association, Pennswood No. 2 Research Endowment, and Stroud Water Research Center

Scientists combined data collected by the White Clay Creek Stream Watch Program (Pennsylvania and Delaware) and Stroud Water Research Center to provide an assessment of current conditions across 18 locations throughout the watershed and an additional nine sites around Avondale, Pa. They also documented long-term changes and variations at sites with multiple years of data. Comparable data from sites in the Schuylkill River Basin provided an invaluable perspective.

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

Dynamics of organic particles in river ecosystems

Funded by: National Science Foundation DEB 0543526

Suspended organic particles are important to river food webs and in the transfer of organic carbon from land to ocean. In an experiment conducted in the Center's streamside flumes, researchers verified that biofilms — algae and microbes that coat streambed surfaces — continually trap and release organic particles, thereby controlling their rate of downstream migration. The results of this and other experiments from this project are being used to model the influence of headwater streams on the downstream river network. In 2011 Center scientists completed this project and submitted another paper for publication and the final report.

Principal Investigators: J. Denis Newbold, Anthony K. Aufdenkampe, Louis A. Kaplan (Stroud Water Research Center), Aaron I. Packman (Northwestern University), and James N. McNair (Annis Water Research Institute)

Education Projects

From Classroom to Creek

Funded by: Stormwater Programs for the City of Newark, Delaware

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

The Science of Water Through the World of Art

Funded by: Point Lookout Farmlife and Water Preserve Foundations

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.

Consortium for Scientific Assistance to Watersheds (C-SAW)

Funded by: Consortium for Scientific Assistance to Watersheds (C-SAW)

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.

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. The program teaches Longwood visitors the connections among landscape practices, stormwater runoff, and the mobilization and mineralization of carbon. Through the program, visitors to Longwood Gardens will learn 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: Michelle 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 math (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, J. Denis Newbold (Stroud Water Research Center), Robert Cheetham (Azavea), Dana Tomlin (University of Pennsylvania), and Nanette Dietrich (Millersville University)

Collaborators: Michelle Adams (Meliora Design) and Steve Benz

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 after-school programs and with youth at the Garage Center and through 4-H.

Principal Investigators: Susan E. Gill (Stroud Water Research Center) and Gary Coutu (West Chester University)

Brandywine Trek

Funded by: Marshall-Reynolds Foundation, Brandywine Health Foundation, and Franny and Franny Abbott

Eight high school students from Coatesville set off on a journey that took them from the headwaters of the Brandywine River in Honey Brook, Pa. to its mouth in Wilmington, Del. They hiked and canoed the length of the river, camped under the stars, and lived simply on the land. Along the way, they met with scientists, conservationists, historians, park rangers, and farmers — both to learn more about the river and to report on what they found. Their goal was to become the spokespeople for the Brandywine and to bring public attention to the importance of protecting its water and the land that feeds it.

Watershed Citizenship Learning Community, Cabrini College

Funded by: National Science Foundation

In collaboration with faculty from Cabrini College, Stroud Water Research Center educators developed and taught courses in watershed ecology and watershed citizenship to nonscience majors. These courses used the watershed as a vehicle to instill lifelong interest in watershed stewardship and an understanding of the science associated with the preservation and conservation of freshwater resources.

Principal Investigator: Susan E. Gill

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2011

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Your gift to the 2011 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 was honored to receive a very generous estate gift from a longtime and loyal donor, **Caroline Schutt Brown**. To her friends, she was known simply as **Cookie**. Over the years, she was seen regularly at most of our events and scientific lectures. Her unrestricted gift was used to purchase education and conferencing technologies in the Center's new education and public outreach facility to monitor our wastewater quality changes as we transition to a new wetland waste treatment system. It also helped us complete chemical analyses of stream water collected from research sites in Costa Rica near the Center's Maritza Biological Station. Her presence and enthusiasm for the work that we do will be sorely missed.

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

First Cornerstone Foundation, Inc.	A grant to create a video promoting the Center
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Restrooms Remembered

Sunny Girl Farm

Talula's Table

Va La Vineyard

Waywood Beverage

Environmental Film Festival

Trail Creek Outfitters

Patagonia

The Education Department gratefully acknowledges **DNB First** and **1N Bank** for its support through the State's Educational Improvement Tax Credit (EITC) Program. These dollars are used to subsidize costs associated with field trips for students from local Pennsylvania public schools.

Financials

2011

Operating Statement
for the year ended December 31, 2011

Revenues & Support

Research Programs (Grants & Contracts)	$ 1,864,100
Endowment	1,350,519
Education/Public Programs	592,342
Other Contributions & Income	418,585
Annual Fund	392,649
Reserves	226,549
Total Revenues & Support	**4,844,744**

Expenditures

Research	2,516,604
Administration	595,037
Education	563,357
Facilities	359,330
Information Services	318,293
Other	223,286
Development/Outreach	223,201
Communications	45,636
Total Expenditures	**4,844,744**

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 federal tax id number 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 more than 40 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 educational 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
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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

WIRE TRANSFER
Funds may be wired directly to the Stroud Water Research Center financial institution. Please contact the Development Department for instructions.

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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.

Stroud Water Research Center Development Staff

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Kay D. Dixon, Associate Director of Development, kdixon@stroudcenter.org, 610-268-2153, ext. 247

Staff, Interns, and Volunteers

2011

Administration

Bernard W. Sweeney, Ph.D.
President, Director and Senior Research Scientist

David B. Arscott, Ph.D.
Vice President (as of Dec. 2011), Assistant Director, and Research Scientist

John D. Pepe
Controller and Treasurer

STAFF

Shelby J. vonTill
Executive Administrative Assistant

Jane Sowden
Grant and Contract Administrator

Biogeochemistry

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

STAFF

Michael D. Gentile
Research Tech III

Christine McLaughlin
Ph.D. Candidate, University of Pennsylvania

Jean Peirson
Laboratory Assistant

Sherman L. Roberts
Research Tech III

INTERNS

Ceili Bachman
Mara Frelich
Emily Gray

Communications and Marketing

Diane Huskinson
Consultant, Huskinson Communications

Development

Lynn Biddle
Director of Development and Secretary to the Board of Directors

Kristine C. Lisi
Director of Development and Secretary to the Board of Directors (as of Dec. 2011)

STAFF

Kay D. Dixon
Associate Director of Development

VOLUNTEERS

Juliann M. Battle
Lauren and Michael C. Broomall
Evie Dutton
Abbie Eldridge
Elizabeth S. Gregg
Julia Keane
Julia Loving
David S. Montgomery
Trish Scott

Ecosystems

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Research Scientist

STAFF

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Research Tech III

Frank Klein
Research Tech, DuPont Chemist Retiree

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Susan Roche
Erika Vazquez

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STAFF

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Vivian L. Williams
Education Programs Manager

Entomology

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Senior Research Scientist

STAFF

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Michael C. Broomall
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David H. Funk
Research Tech V

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Field Assistant

Carly S. Nagle
Intern

Sally Peirson
Research Tech III

Roberta M. Weber
Research Tech III

INTERNS

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Ashley Wilmont

Facilities

David H. Funk
Director of Facilities

STAFF

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Maintenance Mechanic

Tonya Prigg
Janitor

Salomon Romero
Woodlot Tech

Javier Tinoco
Woodlot Tech

Fish Molecular Ecology

William H. Eldridge, Ph.D.
Assistant Research Scientist

STAFF

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Research Tech

Laura Borecki
Research Tech III

Information Services

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

STAFF

Melanie L. Arnold
Data Analyst

Heather P. Brooks
Data Analyst & Web Designer

Elizabeth S. Gregg
Education Programs Assistant

Maritza Station* Costa Rica

Rafael A. Morales
Station Manager & Research Tech

STAFF

Cristian A. Collado
Research Tech

Microbiology

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Emeritus Research Scientist

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Assistant Research Scientist

STAFF

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Research Tech III

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Post-Doctoral Associate University of Delaware

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Heili Lowman
Alfred Shaw

** The Maritza Station staff is employed by the Asociación Centro de Investigación Stroud, a non-governmental organization in Costa Rica which serves as the umbrella organization for all the Center's research and education activities in Central and South America.*

STROUD™
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