Nonpoint Source
News-Notes
August 2005, #76

The Condition of the Water-Related Environment
The Control of Nonpoint Sources of Water Pollution
The Ecological Management & Restoration of Watersheds

Notes on the National Scene

Many Paths Lead to Adoption of Low Impact Development

Like the rapid growth of cities and suburbs that preceded it, low impact development is quickly spreading across the nation. More and more communities are recognizing that low impact development (LID) is a critical component of effective programs to reduce stormwater runoff and treatment costs, protect waterways, maintain aesthetics, and, in many cases, lower stormwater management costs. As with any innovation, widespread adoption takes time. In the following three locations across the United States, three very different types of organizations have led the charge toward incorporation of LID principles into their local developments.

LID from the Bottom-Up: Adoption Can Start at the Grassroots Level

Thanks in large part to one nonprofit watershed group, LID adoption in eastern Virginia is spreading quickly. When the LID movement was just beginning in the late 1990s, the Friends of the Rappahannock (FOR) recognized it for its potential environmental protection benefits. At that time, FOR began working with Stafford County, a rapidly growing area located about an hour's drive south of Washington, D.C., to educate county staff and elected officials about LID and build consensus for the need to amend building codes.

"Look! Up in the sky! It's … the EPA's Coastal Crusader! See article on page 5."

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Many Paths Lead to Adoption of Low Impact Development (continued)

In June 2003, thanks in large part to the efforts of FOR, Stafford County became the first county in Virginia to adopt regulations requiring use of low impact development (LID) principles whenever possible. The Stafford County Board of Supervisors amended the local development codes, waiving previous requirements like curb, gutters, and sidewalks; permitting the use of rain gardens and permeable pavers to reduce stormwater runoff; and facilitating the use of other LID practices. To support developers' efforts to comply with the new code, the County revised its *Stormwater Management Design Manual* (http://co.stafford.va.us/code/Stormwater_Management) to describe LID practices and how to incorporate them into site design.

The FOR has earned statewide and national attention for its efforts, and has been expanding its LID advocacy program to other counties and local governments in the area. FOR is currently working with Spotsylvania County (just south of Stafford County) to modify its existing codes. With support from a National Fish and Wildlife Foundation Small Watershed Grant, the FOR helped the small Town of Warsaw adopt a LID ordinance in 2003. While other localities in Virginia make LID use optional, or provide incentives to encourage LID use, the Town of Warsaw was the first locality in Virginia to require that LID techniques are used in any new development. FOR continues to reach out to its watershed community through demonstration projects and teaching tools. For more information about FOR's LID program, see www.riverfriends.org, or call the FOR office at 540-373-3448.

LID Can Trickle-Down: Intergovernmental Partnership Spreads LID Throughout Puget Sound

In Washington State's Puget Sound region, a diverse intergovernmental team is taking LID into the mainstream. Formed in 1996 by the Washington State legislature, the Puget Sound Action Team (Action Team) defines, coordinates, and implements Washington State's environmental agenda for the Puget Sound watershed—an area that includes 12 counties, 115 cities, and the lands of 17 tribes. The 17-member Action Team includes directors from 10 state agencies, representatives from three federal agencies, one representative of tribal governments, two representatives of local governments (city and county), and a chairperson appointed by the governor. The Action Team has a staff of more than 25 that provide professional and technical services. The 12-member Puget Sound Council, with representation from business, agriculture, the shellfish industry, environmental organizations, local and tribal governments, and the legislature, provides advice and guidance to the Action Team.

What is Low Impact Development?

In traditional stormwater management, water from a development site is moved away as quickly as possible to a centralized location, such as a pond or a local stream. When it rains, the large volumes of water that move through these systems can cause erosion and ecosystem degradation. In short, traditional approaches treat stormwater as a liability. By treating stormwater as an asset, LID is philosophically different. LID reduces runoff volumes by attempting to re-create the drainage patterns that were present before development. By incorporating practices such as rain gardens, green roofs, bioretention cells, cisterns, swales, and porous pavements, developers can increase runoff infiltration, storage, filtering, evaporation, and detention onsite. For more information about LID, including lists of available educational and technical resources, see the Low Impact Development Center Web site at www.lowimpactdevelopment.org or EPA's LID Web site at www.epa.gov/nps/lid.

The Action Team recognized the benefits of LID in the late 1990s and has worked with local jurisdictions throughout Puget Sound to encourage acceptance and adoption of LID practices. The Action Team has educated more than 800 planners, developers, engineers, and others at LID conferences and regional workshops throughout the Puget Sound region. The Action Team and numerous partners have worked together to develop an assortment of educational and technical support materials on the subject, including three technical memoranda detailing: (1) types of LID techniques, (2) analysis and recommendations for the use of LID techniques in Puget Sound, and (3) how to adapt the Washington stormwater management manual to include benefits of LID techniques. In 2005, the Action Team and Washington State University Extension released *Low Impact Development Technical Guidance Manual for Puget Sound*, the region's first technical guidance detailing the appropriate use of LID techniques in the region. These publications can be downloaded from the Action Team's Web site at www.psat.wa.gov/Programs/LID.htm.

The Action Team's outreach efforts are paying off. LID is spreading across the region, initiated in new places sometimes by the influence of just a few people involved in, or educated by, the Action Team. Thirteen of 38 municipalities (33 percent) that responded to an Action Team stormwater survey in 2004 indicated that they have adopted or revised ordinances to allow for LID. The Action Team knows of even more

LID-using localities that either didn't respond or were not surveyed. The Action Team is currently helping 11 cities and counties in the Puget Sound basin revise their stormwater and development regulations to better incorporate the LID approach and techniques.

For examples of how these localities and others are implementing LID throughout the region, see *Natural Approaches to Stormwater Management* (www.psat.wa.gov/Publications/LID_studies/LID_approaches.htm). This 2003 publication highlights a range of LID applications in local government ordinances, individual sites, residential subdivisions, and new state road construction. For more information on LID activities in the Puget Sound region, contact the Action Team at 360-725-5444.

LID from the Top-Down: City Government Leads by Example

In Chicago, the City's government can take much of the credit for introducing widespread LID practice implementation. The City calls its efforts "green building" and "green infrastructure" rather than LID, but the practices are one and the same. Practices such as rain gardens, permeable paving, roof top gardens, and others help the city reduce the volume of runoff reaching the sewer and help counteract Chicago's significant urban heat island effect.

Going Green in Chicago

Chicago's green building and water management efforts are just two parts of a much larger campaign called "Conserve Chicago Together," which also includes air, land protection, solid waste, and energy initiatives. Mayor Richard Daley is promoting these initiatives in his quest to make Chicago the "most environmentally-friendly city in the world."

Why did Chicago decide to be so proactive about stormwater management? For years, Chicago had been plagued by combined sewer overflows and severe flooding problems on streets and in basements. Chicago's government leaders began to realize that they could only hope to successfully manage stormwater by incorporating upgrades into the "built" infrastructure (sewer lines, etc.) with new "green" infrastructure and practices.

And so Chicago's LID movement was born. In recent years, in addition to upgrading water and sewer lines, the City has been actively implementing LID practices. Some of the City's efforts include:

- disconnecting public buildings' downspouts if they lead to the sewer system;
- installing new permeable pavement alleys that detain stormwater and encourage infiltration over time;
- adding rain gardens and bioswales along roads and other public areas to capture and filter runoff;
- planting rooftop gardens on public buildings to help capture rain water;
- replacing hardscape with landscaped medians and parkways along major roadways; and
- creating campus parks adjacent to public schools.

The City also looks to its residents and businesses to help conserve water and reduce stormwater runoff. The City actively encourages homeowners to disconnect their downspouts from the sewer system and direct the water instead to their yards or gardens. They reach out to residents using public service announcements, community meetings, instructional videotapes, brochures, and discounts on materials for downspout disconnection. A recent rain barrel initiative by the City encouraged homeowners to go a step further and capture and reuse their stormwater to maintain their landscape.

Chicago leaders are stimulating demand for green buildings and green roofs by creating policies and incentives targeted to developers, building owners and managers, homeowners, insurance providers, and the financial community. The City has instituted a policy that encourages and, in some cases, requires green roofs and adherence to green building standards in any development, public or private, that receives public assistance from the City. For developments that do not rely on public assistance, the City offers incentives such as allowing more floor area or greater density for development projects that incorporate LID practices. Trained City staff work with developers to incorporate green design and infrastructure into their site plans.

Although the costs for green building can be greater than traditional building methods, Chicago is coming out ahead in many ways. In a 2004 speech, Mayor Richard Daley explained that, during his

Many Paths Lead to Adoption of Low Impact Development (continued)

more than 15-year tenure as mayor, "we've learned that protecting the environment makes sense both economically and politically. We've learned that we can actually save money on taxes and on household and business expenses by paying attention to the environment. At the same time, we enhance our quality of life, which builds pride in our City and helps us attract new employers, residents, tourists and conventions—all the ingredients of a strong local economy."

For more information about Chicago's myriad environmental programs, see http://egov.cityofchicago.org and click on "environmental initiatives" in the right column.

The Future of LID

As the previous case studies indicate, communities need not follow any pre-ordained path in their efforts to better manage stormwater and protect the environment. People from all walks of life, from the concerned citizen to the mayor of a big city, can, and do, make a difference.

EPA Releases New Forestry National Management Measures Document

EPA has just published *National Management Measures to Control Nonpoint Source Pollution from Forestry*, a technical guidance and reference document designed to help state, territory, and authorized tribal managers, as well as the public, implement nonpoint source (NPS) pollution management programs in forest settings. The new guidance enhances and updates the technical information contained in the *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*, published by EPA in January 1993 under section 6217(g) of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA). Whereas the 1993 guidance was regulatory within designated coastal areas, this document does not set new or additional standards for either CZARA section 6217 or Clean Water Act section 319 programs.

The new guidance contains information on the best available, economically achievable means of reducing NPS pollution that can result from forestry activities. The guidance is equally applicable to inland as well as coastal areas and provides background information about NPS pollution related to forestry activities, the broad concepts of assessing and addressing water quality problems on a watershed level, and up-to-date technical information about how to reduce forestry NPS pollution. Because the guidance is national in scope, it does not address all practices and techniques specific to local or regional soils, climates, or forest types. For more information about the guidance or to download the document, see www.epa.gov/owow/nps/forestrymgmt/. You can receive a free printed copy of this guidance by contacting the National Service Center for Environmental Publications via phone at 1-800-490-9198 or via the Web at www.epa.gov/ncepihom/ (request Publication # EPA 841-B-05-001).

Why is the Forestry Guidance Needed?

Forestry activities can generate significant NPS pollution, particularly in the form of sediment. In a forested watershed, logging has the effect of both compacting and loosening soils due to the construction and use of roads, use of heavy machinery, logs being dragged over the ground or otherwise transported to collection areas, and vegetation being removed. Roads and road ditches, ruts on the ground, and areas cleared of leaf litter or other soil coverings create opportunities for water channeling and flow diversion, which, if not properly controlled and directed, can generate erosive flows. The potential for sediment delivery to streams is a long-term (beyond two years) concern from almost all forest harvesting activities and from forest roads regardless of their level of use or age (i.e., for the life of the road).

Other pollutants of significance, including nutrients, temperature, toxic chemicals and metals, organic matter, pathogens, herbicides, and pesticides, can also be generated by timber harvesting and related activities. Problems associated with most of these other pollutants from forestry activities generally do not extend beyond two years from the time of harvest, or are associated with a specific activity, such as an herbicide application. Temperature pollution may remain much longer than two years because the riparian area must grow tall enough to shade the stream to keep temperatures down. All of these pollutants have the potential to affect water quality and aquatic habitat, and minimizing their delivery to surface waters and groundwater deserves serious consideration before and during forestry activities. The new guidance document helps managers identify and prepare for these potential sources of forestry-related NPS pollution before the activity begins. For more information about controlling NPS impacts from forestry, see www.epa.gov/owow/nps/forestry.html.

EPA Acts to Reduce Bacteria Threats at Beaches

On November 8, 2004, EPA issued a final rule aimed at further protecting the health of the nation's beaches on coastal and Great Lakes waters. The rule establishes more protective health-based federal bacteria standards for those states and territories bordering Great Lakes or ocean waters that have not yet adopted standards in accordance with the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000 (see box). The Act required coastal states and states bordering the Great Lakes to adopt bacteria standards by April 2004 to better protect beach bathers from harmful pathogens. For states that have not yet adopted more protective standards, the Act required EPA to establish standards for them.

What is the BEACH Act?

The Beaches Environmental Assessment and Coastal Health (BEACH) Act, signed into law on October 10, 2000, amended the Clean Water Act (CWA) to incorporate provisions to reduce the risk of illness to users of the Nation's recreational waters. Section 406(b) of the CWA, as amended by the BEACH Act, authorizes the U.S. EPA to award program development and implementation grants to eligible states, territories, tribes, and local governments to support microbiological testing and monitoring of coastal recreation waters that are adjacent to beaches or similar points of access used by the public. BEACH Act grants also support development and implementation of programs to notify the public of the potential exposure to disease-causing microorganisms in coastal recreation waters.

Of the 35 states and territories that have coastal or Great Lakes recreational waters, 14 have adopted water quality standards that are as protective of health as EPA's recommended criteria for all their coastal recreation waters, five have adopted the criteria for some of their coastal recreation waters, 13 states are in the process of fully adopting the criteria, and three have not begun the process. Although the agency has established federal standards through this final rule, any state that adopts its own standards that are as protective as EPA's and receives approval will be removed from these federal requirements. These federal water quality standards are part of the Administration's Clean Beaches Plan, which also includes grants to states and territories for beach monitoring and public notification programs, technical guidance, and scientific studies.

EPA is committed to ensuring continued monitoring of the nation's beaches and public notification of beach closures and advisories; therefore, EPA will continue to grant funding to all BEACH Act states and territories regardless of their compliance status. During the past four years, EPA has provided nearly $42 million in grant money to 35 coastal states and territories. For more information about the new criteria and the rule, see www.epa.gov/waterscience/beaches/bacteria-rule-final-fs.htm. For general information about beaches and EPA's activities to protect them, see www.epa.gov/beaches/.

Has your state adopted its own standards? To find out, visit www.epa.gov/waterscience/beaches/bacteria-rule.htm.

News from States, Tribes, and Localities

Helicopter Monitoring Program Protects Beachgoers

The EPA's Coastal Crusader helicopter monitors water quality to protect public health.

Sun- and surf-loving beachgoers in New York and New Jersey are accustomed to periodic visits by a low-flying helicopter that hovers over the water just offshore. This aircraft, rather than flying the customary boardwalk shop ad banner, is a U.S. EPA beach water surveillance helicopter. True to its name, "Coastal Crusader," it takes on a heroic responsibility—protecting human health by monitoring coastal water quality and watching for floating debris.

The EPA first began using a helicopter to collect water samples off the coasts of New York and New Jersey in 1977, after a massive algae bloom caused a large fish kill. The program has continued to expand since then. Currently the helicopter flies six days a week during beach season—from late May through early September—taking water samples and visually monitoring for floating debris. The pollution

problems it targets, waterborne microorganisms and trash, are largely caused by nonpoint sources such as combined sewer overflows and urban runoff.

Assessing What's in the Water

EPA scientists and/or interns on the helicopter take weekly samples at more than 120 ocean stations along 180 miles of New Jersey and New York shoreline. They obtain a water sample by lowering a Kemmerer sampling device through a hatch cut through the floor of the specially adapted TwinStar helicopter. The Kemmerer sampling device is an open tube with locking end caps. The bottle is lowered to a particular depth while the water flows through until the desired depth is reached. Then a weight, called a messenger, is sent down the line holding the tube. The weight hits the all-angle locking trip head, allowing the end caps to close. The sampler is then retrieved with the desired sample of water being uncontaminated by water from other depths.

EPA intern Rob Livingston practices lowering the Kemmemmer sampling device through the helicopter floor.

Within hours, EPA staff brings the water samples to EPA's Edison, N.J. laboratory, where the samples are analyzed for dissolved oxygen concentration and counts of fecal coliform and enterococcus bacteria. As the summer grows hotter, low dissolved oxygen in the ocean can sometimes be a problem, so the helicopter periodically travels up to nine miles off the coastline to take samples. Low dissolved oxygen can impact the health of the ocean fish and other organisms, explained Helen Grebe, BEACH Program Coordinator for EPA's Region 2 office, so "we monitor the dissolved oxygen to identify trends from year to year."

EPA analyzes many samples for fecal coliform and enterococcus bacteria counts to protect people from illnesses that may be contracted from surface waters contaminated by fecal pollution. Although these bacteria typically do not cause illness directly, they serve as scientifically accepted indicators of more harmful pathogens that are more difficult to detect.

EPA staff members also send some water samples to the NJ Department of Environmental Protection to be analyzed for phytoplankton identification and quantification. The samples provide an early warning of noxious algae blooms that threaten water quality and other sea life. A new chlorophyll sensor recently fitted on the helicopter will be part of a pilot study this year—providing visual data on phytoplankton levels that can be compared to data gathered from the water sample analysis.

Assessing What's on the Water

In addition to taking water samples, the EPA staff members aboard the Coastal Crusader spend a significant portion of every day looking for floating debris or evidence of other pollution (oil slicks, etc.). This part of the monitoring effort began in 1989 after trash (including medical waste) washed onto southern Long Island and New Jersey beaches during the summers of 1987 and 1988, causing extensive beach closures. The beach closures lasted between several hours to several days and had significant economic and social impacts. The State University of New York Waste Management Institute estimated that the beach closures caused an economic loss of up to $4 billion in New Jersey and up to $2 billion in New York.

At that time, local, state, and federal officials determined that monitoring and cleanup of floating debris was necessary to protect human health and the local beach areas' economies. Under EPA's lead, the partners developed the Floatables Action Plan (FAP), which includes helicopter and vessel surveillance, a communications network to report sightings of floatable debris, coordinated clean-up response, and routine clean-ups conducted by skimmer vessels in the New York/New Jersey Harbor area.

Since the program began, the U.S. Army Corps of Engineers Drift Collection Vessels have collected 16,698 tons of floatable debris on scheduled "floatables days" (three days every new and full moons to coincide with tidal extremes), and an estimated 91,549 tons at other times throughout the year. Other local and state agencies, nonprofit organization, and civic groups conduct coastal cleanups of

For more information about bacteria in coastal waters, see EPA's *Draft Implementation Guidance for Ambient Water Quality Criteria for Bacteria* at www.epa.gov/waterscience/criteria/bacteria/.

their own, and have collected more than 62,000 tons of debris during the past 15 years. The U.S. Army Corps of Engineers estimates that 90 percent (by volume) of its collection total consists of wood debris. Tires, plastic waste, cardboard, seaweed, sewage-related materials, and street runoff-related materials constitute the remaining 10 percent. For more information about the FAP and the successes achieved to date, see www.epa.gov/region2/water/action_plan/.

Communication is Key

EPA shares its water quality and floatables monitoring results with state, and local agencies to help local authorities decide whether there is any need to close the beaches. EPA issues immediate alerts to state and local officials when a pollution problem is detected. For example, in 2004, EPA's analysis showed that two out of 767 samples collected exceeded the standard for densities of enterococcus bacteria—one each in New Jersey and New York. In both cases, EPA immediately notified the local authorities, explained Grebe. "Then they decide whether to close the affected beach." If no pollution problems are detected, EPA sends a weekly data summary throughout the summer to keep the officials informed. All of EPA's data is maintained in STORET, so the detailed data is always publicly accessible through the Internet if it is needed.

EPA's data supplements the comprehensive beach water quality monitoring already performed by the localities. "New York and New Jersey have long-standing comprehensive monitoring programs," notes Grebe. "The helicopter monitoring program complements their programs by collecting additional samples to help fulfill state commitments."

Extending its Reach

The Coastal Crusader offers a helping hand for other environmental causes as well. The helicopter allows scientists to perform wetland delineations from the air, assess and visually monitor superfund sites, and to respond to environmental emergencies such as oil spills.

The Crusader also serves as an ever-present, very visible environmental education beacon, noted Grebe. "Beachgoers see the big EPA letters on the side and know what we are doing—they always wave." Most local people have heard about the program through EPA's annual press conferences or the resulting television and newspaper coverage. Every time beachgoers see the Crusader it reminds them that good water quality is not something to be taken for granted. Everyone must pitch in to keep local beaches clean and safe.

[For more information, contact Helen Grebe, MS220, U.S. EPA Facilities, Raritan Depot, 2890 Woodbridge Avenue, Edison, NJ 08837-3679; Phone: 732-321-6797; E-mail: grebe.helen@epa.gov; Web: www.epa.gov/r02earth/water/oceans/copter.htm.]

Nonpoint Source Pollution Still Plagues the Coastline

Although implementation of the Floatables Action Plan (FAP) has greatly reduced the need for beach closures due to debris, nonpoint source pollution problems still exist. Floatable debris continues to make its way to open water—the FAP partners are just very good at finding and removing it before it washes on shore. The principal sources of floatable debris and other nonpoint source pollutants (such as bacteria) in the area include 737 combined sewer overflow points discharging to the open waters of the NY/NJ Harbor or to its tributaries, hundreds of stormwater discharge points, construction activity, and highway drainage. Other sources include littering, poor landfill and marine transfer practices, decaying shoreline structures, sunken vessels, and vessel discharges. The FAP includes elements that continue to reduce the overall amount of floatable debris derived from these sources. New York and New Jersey both have active programs to combat other sources of nonpoint source pollution. For more information see: www.dec.state.ny.us/website/dow/bwam/ (New York), or www.state.nj.us/dep/watershedmgt/nps_program.htm (New Jersey).

Philadelphia Looks to Vacant Land to Control Stormwater

Philadelphia is a historic city—and an impervious one. During the past 300 years, Philadelphia changed from a New World settlement into one of the most densely built cities in the United States. The many impervious surfaces associated with this development, including buildings, roads, and parking lots, have led to large volumes of stormwater runoff and many combined sewer overflow events. Pollution was taking its toll on local rivers and streams—and something had to be done.

To address the problem, the Philadelphia Water Department (PWD) has embraced a comprehensive watershed management program that fosters regional cooperation and looks beyond traditional infrastructure projects as a solution to stormwater management and combined sewer overflow

Philadelphia Looks to Vacant Land to Control Stormwater (continued)

mitigation. A key part of PWD's new program seeks to incorporate low impact development (LID) practices throughout Philadelphia watersheds whenever possible.

Vacant Land Offers Opportunity

During the past 50 years, Philadelphia's population has steadily declined because of migration to developing suburbs and the loss of many manufacturing jobs, among other factors. The result has been widespread property vacancy and abandonment—vacant lots or buildings cover approximately 2,600 acres. While the extent of disinvestment is daunting, the City has chosen to view its vacant lands as an opportunity to radically change its approach to stormwater management.

Philadelphia Water Department

The Philadelphia Water Department, one of the oldest municipal water departments in the United States, is an integrated drinking water, wastewater, and stormwater utility that serves the nation's fifth-largest city, with a population of over 1.4 million. Its massive sewer system network includes 1,600 miles of combined sewers, 1,200 miles of separate sanitary and storm sewer lines, 150 miles of intercepting sewers, 169 combined sewer regulating chambers, 85,600 manholes, and 75,000 stormwater inlets.

Most of the City's vacant land and buildings are located within areas served by combined sewers. By incorporating LID and site-specific infrastructure projects that detain stormwater runoff during storm events, or keep it out of the combined sewers entirely, PWD hopes to alleviate combined sewer overflows and minimize the scale and necessity of future large infrastructure projects. Furthermore, PWD believes that LID designs can effectively balance development costs and water pollution controls with projects that enhance community aesthetics, quality of life, sustainability, and environmental education.

Recognizing that LID design strategies are new to most people in the Philadelphia area, PWD has undertaken efforts to educate people and lead by example. With financial assistance from the Pennsylvania Department of Environmental Protection (DEP), PWD has provided conceptual design services to many institutional and nonprofit partners, and has undertaken LID demonstration projects of its own.

For more information about low impact development (LID), and to learn about how other localities are incorporating LID into their planning processes, see the article on page 1.

Vacant Land Serves as Educational Asset

The first demonstration project designed and implemented by PWD was the conversion of an overgrown, trash-strewn vacant lot into an outdoor classroom in West Philadelphia. The site was designed to mimic the transformation of a watershed from "natural" to "man-made," with the back planted with trees and bushes and the front paved with concrete. The hard surface area supports benches and serves as a clean gathering place for visiting children. Stormwater reaches the site as direct rainfall and from the downspout of a neighboring property. A rain barrel collects the initial roof runoff to provide a watering source for the onsite vegetation. The runoff overflow is allowed to drain across the site.

To provide on-site stormwater storage, PWD excavated a four-foot deep infiltration trench in the middle of the lot, added an impervious liner, inserted perforated PVC pipe for drainage, and backfilled it with layers of gravel and sand. PWD graded the lot so it directs the water to the middle of the lot, above the infiltration trench. Three small check dams on the surface above the trench slow the water, allowing it to puddle and infiltrate down through the mulch, soil, sand, and gravel.

Vacant lot is transformed into outdoor classroom.

Vacant Land Manages Stormwater While Waiting for New Life

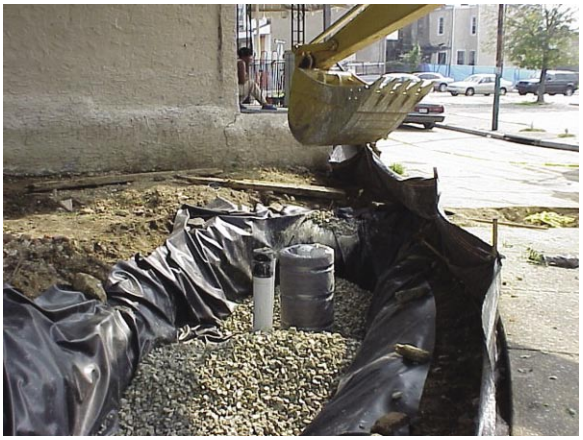
While the project above transformed a vacant lot into a productive use (outdoor classroom), PWD felt that the intensity of the project is not appropriate for most vacant lot stabilization projects. The City of Philadelphia is pursuing an aggressive policy of demolishing derelict vacant structures and reclaiming the land, and decided to use many of these sites to demonstrate how minimal LID designs can help reduce stormwater runoff. For example, PWD has partnered with the Pennsylvania

Horticultural Society's Philadelphia Green program to re-grade several vacant lots to direct runoff into strategically placed swales and depressions. PWD performs infiltration tests on lots prior to beginning re-grading work to ensure the site will drain within 48 hours. After grading is complete, the sites are planted with trees and shrubs and fenced to prevent dumping. PWD now views sites like this as assets—while these properties are awaiting development, most runoff is directed into small depressions and allowed to infiltrate, easing the burden on the City's combined sewer system.

Vacant Land Offers Natural Retreat

Not all of Philadelphia's vacant land is awaiting development. To improve neighborhoods, the City has transformed many vacant lots into long-term open space, often as community pocket parks or gardens. PWD's demonstration of this kind of project targeted a small corner lot at the end of a block. Although this parcel had been developed as a community pocket park several decades ago, deferred maintenance had essentially rendered the park unusable, except for the most unsavory of activities. Given the location of this lot at the bottom of a downward-sloped block, it was a logical choice for demonstrating how bioretention and sub-surface storage can be easily incorporated into a neighborhood. PWD cleared the lot, installed a gravel storage system, and planted a small bioretention garden along the perimeter of the lot. Trees, benches, and a new porous walkway completed the park-like setting. Currently, only runoff from the parcel itself is managed by the bioretention garden. In the future, PWD hopes to install a storm drain that will carry roof runoff from nearby properties and direct it to the subsurface storage available at the site.

Water collects in a large depression on a vacant lot along 8th Street.



LID pocket park under construction.

PWD has undertaken many additional innovative and significant demonstration projects on vacant lots, schoolyards, parking lots, recreation courts, rooftops, and large scale redevelopment efforts. For detailed descriptions and photographs of many of these LID demonstration projects, see *New Thinking in an Old City: Philadelphia's Movement Towards Low-Impact Development* (www.ncsu.edu/waterquality/issues/notes112.pdf). PWD recognizes the widespread benefits of LID practices, and will continue to use them as a key tool in the fight against the City's combined sewer overflow problem.

[For more information, contact Glen J. Abrams, Urban Watersheds Planner, Philadelphia Water Department, Office of Watersheds, 1101 Market St., 4th floor, Philadelphia, PA 19107; Phone: 215-685-6039; E-mail: Glen.Abrams@phila.gov. This article was adapted and updated with permission from the North Carolina State University Water Quality Group's NWQEP Notes *Newsletter, February 2004, Issue 112.*]

What are Combined Sewer Overflows?

Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and in some cases, industrial wastewater in the same pipe. The vast majority of these systems are relics from our oldest cities that predate separate sewer systems. Most of the time, combined sewer systems transport all of their wastewater to a sewage treatment plant, where it is treated to discharge permit standards and then discharged to a water body. During periods of heavy rainfall or snowmelt, however, the wastewater volume in a combined sewer system can overwhelm the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies. These overflows, called combined sewer overflows (CSOs), contain not only stormwater but also untreated human and industrial waste, toxic materials, and debris. They are a major water pollution concern for the approximately 772 cities in the U.S. that have combined sewer systems, including Philadelphia. For more information, see www.epa.gov/npdes/cso/.

Karuk Tribe's Ecosystem Restoration Effort Still Going Strong

In July 2000, News-Notes Issue #61 featured an article describing the Karuk Indian Tribe's innovative efforts to restore its degraded watershed. Five years later, we now revisit the Tribe to see how its restoration program has fared.

For years, the tribal lands of the Karuk Tribe of California, located in Northern California near the Oregon state line, had been honeycombed with roads for mining (gold, gravel, and quartz) and timber harvesting. Almost all of the Karuk's ancestral land is located in the Klamath and Six Rivers National Forests, which had opened most of the area to natural resource removal. By 1997, the mines and forests—and associated jobs—were nearly depleted, and the Karuk people found themselves in a critical situation—they were out of work and left with a severely degraded watershed. Showing remarkable resilience, however, the Tribe devised a plan that began to boost their economy and restore the land that had been their ancestral home for thousands of years.

For more information about the decommissioning process, and to view pictures, see the Karuk Ecosystem Restoration Program: 2002 Final Report, available at www.karuk.us/dnr/pdf/wsdocuments/KarukWatershedFinalReport02.pdf.

As the mines and logging operations shut down, funding cuts had prevented the national forests from completing restoration of the damaged watersheds in a timely manner. The Tribe had to take matters into its own hands. In 1996, the Tribe entered into a Memorandum of Understanding (MOU) with the Klamath and Six Rivers National Forests. The MOU established a framework for the partners to jointly identify, plan, and accomplish mutually beneficial projects. The projects identified included watershed restoration, job training opportunities, and community economic development.

A few years later, the Tribe developed a Comprehensive Watershed Restoration Training and Implementation Program for tribal members and staff. The training program provided participants with a thorough foundation in the technicalities underlying watershed restoration. All trainees serve an on-the-job apprenticeship in completing critical restoration work on projects throughout the Karuk lands. The program has created a highly skilled local workforce that has a vested interest in protecting water quality and other natural resources while earning decent wages.

Tribe is Still Making Progress

When News-Notes last visited the Tribe in 2000, it had just established its restoration program and had successfully decommissioned 2.2 of 7.2 miles of Steinacher Road, an old logging road that contributed a large amount of sediment to the Klamath River basin. Since then, the Tribe has made much progress. It secured funds from a variety of federal and state sources and completed the Steinacher Road project in 2002. The Tribe has since moved its efforts to roads in the East Ishi Pishi Road area, which includes a number of severely impacted watersheds.

In December 2004, with funding from an EPA Section 319 grant, the Tribe completed the decommissioning of a portion of a road complex in the East Ishi Pishi Unit's Irving Creek watershed. In 64 days, working between 4 and 10 hours a day, the Tribal Restoration Division staff removed approximately 28,889 cubic yards of fill material from almost five miles of the road and moved it to stable road locations. Due to the erosive nature of soils in this area, project staff immediately incorporated post-project erosion control measures. Road decommissioning work within the Irving Creek Watershed should be complete by the end of 2005.

The Karuk Tribe and its partners have identified approximately 64 miles of road as candidates for future decommissioning, 36 miles of which already have decommissioning plans in place. The proposed actions will take more than eight to 12 years to complete, depending on funding availability. Without stable revenue, continuation of the restoration program is uncertain. If the past ten years is any indication, the Karuk Tribe will be successful in their continuing quest to restore the health of their sacred ancestral territory and the well-being of the Tribe.

Program Helps Tribal Members

Kevin Wilder, who has worked for the Karuk Tribe's Watershed Program since 1999, is pleased with the success of the program and hope it continues. He supports a family of nine and is sending a daughter to college this year. "I live in the Orleans area where there is very limited opportunity for employment, so I feel very fortunate to have such a well-paying job." The program has provided him with knowledge that he can apply for the rest of his life, Wilder adds. "I have been able to learn valuable skills—surveying stream crossings, designing road decommissioning prescriptions, and operating an excavator and a dozer."

Why Excavate the Sediment?

When logging and mining roads were originally constructed, sediment was used to fill in around stream crossings and to build up the downslope portion of roads (this is called sidecast). The decommissioning efforts require the removal of road fill from stream crossings, swales, and unstable sidecast areas that threaten waterways and downstream salmonid habitat. Stream crossings are excavated either to original width, depth, and slope to expose natural channel armor and buried topsoil or to achieve stable engineered dimensions for maximum cost-effectiveness. Sidecast fill material, with high failure potentials affecting watercourses, is excavated to reduce erosion hazard and expose buried topsoil. Excavated material is moved to stable road locations and then shaped to specific slope and compaction requirements.

Referred to as "sediment savings," the sediment that the tribe removed would otherwise have entered salmon streams as culverts failed and road runoff continued unabated. Since the inception of this program, the tribe has removed approximately 270,000 cubic yards of fill material. To visualize this, imagine 27,000 dump trucks of fill material lined bumper-to-bumper for 102 miles.

[For more information, contact Earl Crosby, Karuk Tribe of CA, Watershed Restoration Coordinator, P.O. Box 282, Orleans, CA 95556; Phone: 530-469-3454; E-mail: ecrosby@karuk.us.]

Notes on Watershed Management

Siphoning Out a Legacy of Phosphorus Pollution in Devil's Lake

Once the bathtub water is polluted, how do you clean it? That was the question faced by scientists from the Wisconsin Department of Natural Resources (WDNR) in the mid-1980s when they began studying the causes of nutrient enrichment and other water quality problems in Devil's Lake, the 372-acre centerpiece to Wisconsin's most popular state park. Devil's Lake was formed during the Ice Age roughly 10,000 years ago and has no natural surface water outlet—the lake loses water only through evaporation and seepage. Sewage inputs from a variety of human sources had contributed nutrient pollution to the lake from the mid-1800s through the 1980s. Since then, the pollution has been trapped, cycling back and forth between the water, the organisms, and the lake's bottom sediments. In the end, WDNR's solution again brings to mind a bathtub—wait until the dirty water builds up in the bottom, and then pull the plug.

History of Pollution in Devil's Lake

Phytoplankton (free-floating algae) blooms first started appearing in August and September during the late 1970s—generating concern among state officials and the public that Devil's Lake, a lake known for its exceptional water clarity, was in trouble. Richard Lathrop, a limnologist at the Wisconsin Department of Natural Resources (WDNR), began studying the lake and its problems in 1986. A 2-year comprehensive study conducted by Lathrop and other WDNR scientists revealed that the lake contained a large amount of phosphorus (P) that was feeding the algae. The researchers also found that the high populations of algae, once dead, sank to the bottom and were broken down by decomposers, causing oxygen in the deeper parts of the lake to become depleted by mid-summer. These anoxic conditions allowed P that was temporarily bound to insoluble hydrous iron oxide compounds in the sediments to be released into the overlying water as the iron was reduced and made soluble. The P that built up in the lake's bottom waters (the hypolimnion) was then distributed throughout the lake as the lake destratified in late summer, culminating with complete lake "turnover" in mid-October (for more information on lake stratification, see www.waterontheweb.org/under/lakeecology/05_stratification.html). In subsequent years, as Lathrop continued studying the lake, the water clarity loss problem lessened slightly as free-floating algae blooms gave way to unsightly growths of filamentous algae and periphyton (attached algae) near the shore.

Picturesque Devil's Lake is surrounded by quartzite bluffs and talus boulder fields.

Siphoning Out a Legacy of Phosphorus Pollution in Devil's Lake (continued)

The sources of P that feed these algae growths actually no longer enter the lake. As far back as the late 1860s, people built resorts and cottages along the shoreline of Devil's Lake. Some of the outhouses and septic tanks built to serve these residences likely leaked pollution into the lake. Four resorts and over 60 cottages were gradually removed after the state park grew from its inception in 1911. Additional pollution leaked into the lake from a broken park sewer main that the state discovered in the late 1970s and repaired by the early 1980s. Current P inputs to the lake are minor, coming from the lake's small, mostly forested watershed. Yet, the legacy of this P pollution remains in the lake because there is no natural outlet to gradually flush it out.

No Outlet? Create One!

WDNR decided to pull the plug. After much monitoring and investigation, Lathrop convinced WDNR managers and administrators that the best way to remove P was to siphon out water from the deepest part of the lake at the end of the summer, when P concentrations were highest there. This bottom withdrawal method has been used in other lakes (and reservoirs), most notably in Europe, but never before in a large seepage lake like Devil's Lake. In drainage lakes with outlets, systems can be designed to withdraw water from the bottom of the lake instead of the surface; and inflowing rivers and streams can naturally replace the withdrawn water. In the case of Devil's Lake, it was necessary both to find a stream to receive withdrawn water, and to find a source of clean replacement water to maintain lake levels. Providentially, an intermittent stream called Babbling Brook was nearby. In fact, Devil's Lake residents previously excavated a ditch in the 1890s to divert snowmelt water from Babbling Brook into Devil's Lake when lake levels dropped due to dry conditions earlier in the year. A buried metal culvert replaced the ditch in the early 1960s, but it hadn't been used since the early 1970s due to higher lake levels.

WDNR determined that the P-laden anoxic water siphoned from the bottom of the lake could be discharged into the lower part of Babbling Brook from late August or early September until lake turnover occurred around mid-October during a period when the stream was usually dry and without aquatic life. Babbling Brook eventually discharges into the Baraboo River, but WDNR determined that the P from Devil's Lake would not cause negative impacts in the downstream river for two reasons: (1) the withdrawn P would represent less than 0.001 of the Baraboo River's annual P load; and (2) the water would be released after the summer growing season. In years when Devil's Lake water levels were low, WDNR could replace the withdrawn water by diverting relatively clean snowmelt and rain runoff water from Babbling Brook primarily during late winter and early spring.

Will it Work?

WDNR expects that the reduction of P will result in the decline of all three types of algae: phytoplankton, filamentous, and periphyton. WDNR also anticipates two additional water quality benefits. First, reduction of P might indirectly reduce mercury (Hg) levels in fish. Currently, the excess algae can be indirectly linked to elevated Hg levels in the lake's fish population, ultimately reaching levels of public health concern in large sport fish such as walleye. Sulfate-reducing bacteria that thrive only in the anoxic (oxygen-depleted) bottom waters and underlying sediments in late summer convert the relatively harmless inorganic Hg (mainly from atmospheric deposition) to the toxic methyl-mercury (Me-Hg) form. Me-Hg builds up in the anoxic bottom waters until the lake mixes at fall turnover, when Me-Hg is readily taken up by phytoplankton and concentrated as it passes up the food chain to fish. By decreasing the duration and extent of bottom-water anoxia that allows sulfate-reducing bacteria to grow, the build-up of Me-Hg in the lake's bottom waters could be reduced and Hg concentrations in fish should decline.

Second, WDNR hopes that a reduction in P levels will reduce the prevalence of swimmer's itch, which has become so troublesome that fewer people visit the lake in summers when parasite infestation problems are high. The excess periphyton algae are feeding an overabundance of snails, some species of which are intermediate hosts to a parasite that causes swimmer's itch. The amount of periphyton would be expected to decrease as the P in the lake declines, thus decreasing the major source of food for snails. By starving the snails, their densities should decline dramatically, thereby reducing the number of free–swimming parasites in the water.

Putting the Plan into Action

The plan to reduce P levels in Devil's Lake by siphoning P-rich bottom water from the lake is certainly no quick fix, given the legacy of P stored in the bottom sediments. WDNR expects to operate the system in September and early October for approximately 15 years. Because of the extended time frame of the project, the bottom withdrawal siphon design was ideal for Devil's Lake because it would require no maintenance and no electricity to run it—a huge cost savings on such a long-term restoration project. Additional savings during the system's installation were realized by WDNR performing land surveys and completing other preparations such as ordering materials. Despite these savings, WDNR still had to find an estimated $300,000 to install the system.

Fortunately, WNDR and other interested organizations found a way to fund the project. The Friends of Devil's Lake State Park applied for and was awarded a $200,000 State Lake Protection Grant. An EPA Clean Lakes Grant provided another $100,000, and an additional $5,000 came from a Friends of Wisconsin State Parks grant that was matched by the local Friends group, providing a total of $310,000. WDNR hired a consulting firm to conduct the engineering design work, which was underway by mid-February 2002.

How Do you Build a Giant Siphon?

A local contractor began constructing the bottom withdrawal siphon system in July 2002. The contractor fused 50-foot sections of 20-inch diameter plastic pipe to eventually make a giant straw 5,500 feet long. The 4,150-foot long lake portion of the siphon required 320-pound concrete weights to be attached every 12 feet to counteract the pipe's buoyancy. By the end of July, the pipe with 55 tons of attached weights was floating in place over the deepest part of the lake. After the contractor trenched the near-shore lakebed on the day of sinking, the 50-foot pipe intake was towed to the middle of the lake and attached. Two fire trucks on shore began filling the pipe, causing it to slowly sink—a process that took more than four hours. By the end of the day, the pipe lay on the lake bottom with the intake holes positioned eight inches above the sediments at the lake's deepest spot—46 to 50 feet depending on lake levels.

The next day the contractor began trenching the land section of the siphon pipe. A manhole was placed at the high point of the siphon where a flow meter and an air evacuation system were located and where a portable vacuum pump could be connected to prime the siphon (i.e., evacuate the air, causing lake water to fill the pipe)—a process that takes nearly six hours. The main flow valve was located near the siphon end, which is submersed in a manhole that drains via a short pipe to Babbling Brook. The difference in water levels between the terminal manhole and the lake surface creates a pressure head difference that determines the flow rate of the siphon. (Head differences of five to nine feet, depending on lake levels, produce flow rates of four to six cubic feet per second in the siphon).

Concrete weights attached to the pipe keep it on the lake bottom.

A barge helps position the pipe intake at the deepest part of the lake.

Siphoning Out a Legacy of Phosphorus Pollution in Devil's Lake (continued)

By mid-August 2002, the 1,350-foot land section of pipe was joined to the lake portion. On August 29th, the main valve was opened and bottom water from Devil's Lake started pouring out. Average flow rates that year were 5.3 cubic feet per second (2,380 gallons per minute) during the seven-week run until it was shut down for the season when cooler weather naturally "turned over" the lake water on October 17th. By then, 981 pounds of phosphorus had been removed from the lake, far exceeding the initial goal of about 350 to 400 pounds. Because of high lake water levels, no water was diverted from Babbling Brook the following spring.

The pipe was buried underground from the lake to the discharge point.

However, 2003 turned out to be a drought year, which shortened the time the siphon was used. The system still managed to remove 377 pounds of P that season. In November 2003, runoff water from Babbling Brook began replacing water siphoned off earlier in the fall. Rainfall and snowmelt also added to the water in the lake during the late winter and early spring months of 2004. In fact, heavy rains caused so much flooding later in the spring of 2004 that WDNR administrators authorized the siphon to be activated for four weeks in early summer as a flood mitigation measure. In late summer 2004, Lathrop reactivated the siphon system for eight weeks and removed 1,300 pounds of P. Lake levels remained high enough that again no water needed to be diverted from Babbling Brook.

Monitoring Underway

Lathrop operates the bottom withdrawal siphon and water diversion systems each year, and directs the monitoring effort to evaluate the lake restoration project's success. P levels in the bottom withdrawal outfall water are determined from daily composite samples obtained by an automated sampler; other constituents including methyl and total mercury are periodically sampled by grab sampling at the outfall. Lake monitoring is conducted at the deepest spot in the lake approximately bi-weekly beginning each spring and continuing until early November, after fall turnover has occurred. Lathrop monitors a variety of constituents and water quality characteristics in the lake; including temperature and dissolved oxygen profiles, water clarity (Secchi disk), phosphorus and chlorophyll levels in the surface waters, and zooplankton. During the stratified season, phosphorus, iron, and sulfate levels are determined from samples collected at various depths in the lake bottom waters. Periphyton growth rates are also monitored in lake shoreline waters during the summer. Finally, each spring Lathrop collects mimic shiners—a variety of minnow—and has the tissues analyzed for mercury.

Water from Devil's Lake is released into Babbling Brook.

Because the project solution is so peculiar, the process of gaining acceptance and approval for it was difficult. Lathrop invested years of his career leading the research and project planning. Now Lathrop must be content to monitor the lake and wait to see if his efforts pay off as expected. Lathrop points out that the siphon project is a long-term one, but he hopes to start seeing improvements after seven or eight years of withdrawals. Lathrop adds that, as a career scientist for WDNR, he has been involved in many lake and watershed studies. "This one is special," he notes. "I feel like I have been a part of something that will really make a difference."

Siphoning Out a Legacy of Phosphorus Pollution in Devil's Lake (continued)

[For more information, contact Dr. Richard C. Lathrop, Wisconsin Dept. Natural Resources c/o Univ. Wisconsin-Madison Center for Limnology, 680 N. Park St., Madison, WI 53706; Phone: 608-261-7593; E-mail: rlathrop@wisc.edu. Information for this article was taken from: Restoring Devil's Lake from the Bottom Up, Wisconsin Natural Resources*, June 2004, 28:4-9, and from: Lathrop, R.C. et al., 2005. Restoration of a Wisconsin Seepage Lake by Hypolimnetic Withdrawal.* Verh. Internat. Verein. 2q3. *29: (in press).]*

Beating Acid Mine Drainage in Pennsylvania's Swatara Creek

After decades of impairment from acid mine drainage (AMD), Swatara Creek is gaining a new lease on life. In 1990, Swatara Creek, a tributary of Pennsylvania's Susquehanna River, was found to be "fishless" in its headwaters because of acidic, metal-laden inflows from abandoned anthracite coal mine operations. Since then, federal, state, and local organizations have worked together to repair the creek by implementing numerous passive-treatment and surface-stabilization projects. Their efforts are paying off. Water quality monitoring and ecological surveys on Swatara Creek have indicated better water quality and increasing numbers of fish and other aquatic organisms. The partners are continuing to monitor Swatara Creek, gathering data that will help them determine which passive-treatment systems are most promising for successful long-term application in Swatara Creek and other similar watersheds.

What is Acid Mine Drainage?

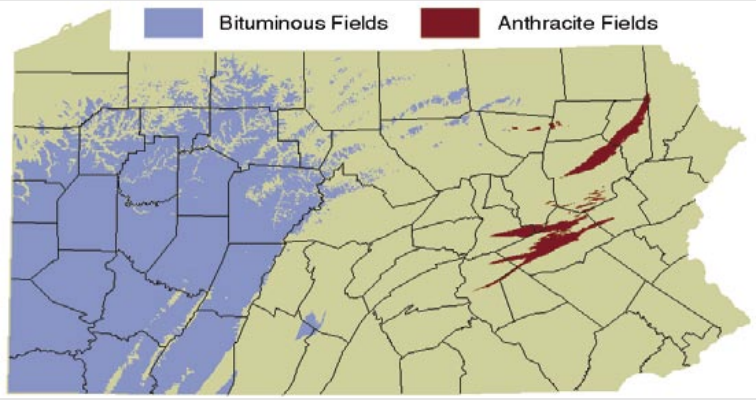
Coal and surrounding rocks contain pyrite, an iron-sulfide mineral also known as "fool's gold." A complex series of chemical weathering reactions are spontaneously initiated when surface mining activities expose the coal and surrounding rocks to an oxidizing environment. The pyrite mineral assemblages are not in equilibrium with the oxidizing environment and almost immediately begin reacting and transforming. The mineral transformation process can release damaging quantities of acidity, metals, and other soluble components into any water that comes into contact with the rocks. The polluted water that results is also known as acid mine drainage (AMD). Most aquatic organisms and plants cannot survive in AMD—the water is unfit for drinking or swimming, and structures such as bridges can be corroded or encrusted. As the AMD flows downstream and is diluted with fresh water, the dissolved metal ions can precipitate on to submerged objects, forming solid metal hydroxide particles that build rusty coatings on the streambed and stain the water reddish brown.

Addressing a Pervasive Problem

Most of the coal mines in the Swatara Creek Watershed were abandoned before 1960. Many of the abandoned underground mining tunnels have since flooded and collapsed, causing localized subsidence. Thinly vegetated piles of mined rock and coal waste continue to be sources of sediment, acidity, sulfate, iron, aluminum, and other metals in surface runoff. Surface water also can run off into subsidence pits and mine openings to the underground mines where it becomes contaminated with acidity, sulfate, and metals. In downstream reaches, the contaminated water resurfaces as AMD that discharges to Swatara Creek and its tributaries.

Pennsylvania Coal

Coal is a readily combustible rock whose composition consists of more than 50 percent by weight of carbonaceous material. Coal forms when layers of plant and animal matter accumulate in an oxygen-poor environment (such as a swamp), become covered with sediment, and are compacted and chemically altered by heat and pressure over geologic time.



Coal fields underlie portions of Pennsylvania.

Pennsylvania is underlain by fields of anthracite coal in the east and bituminous coal in the west. Anthracite coal is formed during mountain-building periods when compaction and friction subject the rocks to extremely high temperatures. Anthracite is typically composed of between 86 and 98 percent carbon. Most of the anthracite reserves in the United States are found in 11 counties in eastern Pennsylvania. Bituminous coal is formed at a lower temperature than anthracite and has a carbon content of between 45 to 86 percent. Bituminous coal, which underlies most of western Pennsylvania, is the most plentiful form of coal in the United States. For more information about coal, see http://energy.er.usgs.gov/coal.htm.

Beating Acid Mine Drainage in Pennsylvania's Swatara Creek (continued)

The Pennsylvania Department of Environmental Protection's (PaDEP) Bureau of Mining and Reclamation, the U.S. Geological Survey (USGS), and Skelly and Loy Engineering Consultants collected water quality data from throughout the Swatara Creek basin beginning in 1975 and continuing through 1988. These data were used to help document stream conditions and identify problem areas prior to the development of a watershed restoration plan or the installation of passive treatment systems. Data from these previous investigations included analysis of typical AMD, metals, major ions, acidity, and alkalinity.

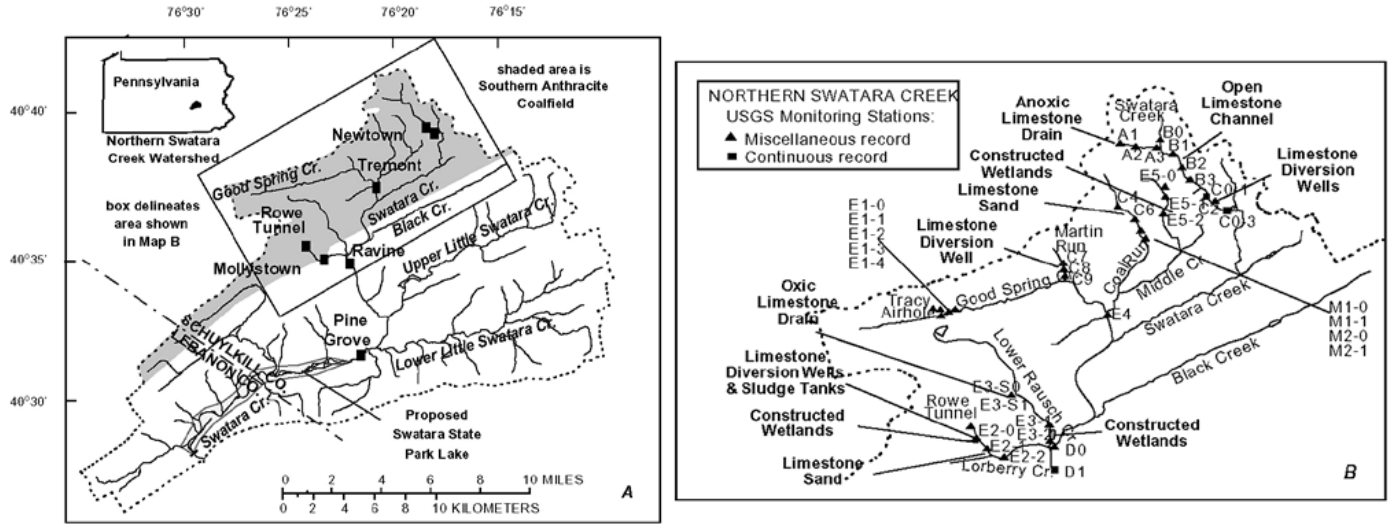
In the mid-1990s, the PaDEP developed a watershed remediation plan to restore Swatara Creek and its tributaries to their designated recreational and fishable uses. Several groups have helped implement the plan, including the Northern Swatara Creek Watershed Association and fishing and sportsman's groups. The Schuylkill County Conservation District (SCCD) has coordinated the implementation of passive-treatment measures for the AMD, and has led nutrient management and streambank stabilization efforts in the farming areas. Schuylkill County's Waste Management Coordinator has funded some of the stream improvement projects. Local coal companies and limestone quarries have donated supplies and services.

Implementation of Passive Treatment Projects

During 1995 through 1998, PaDEP and volunteers, with technical assistance from the USGS, constructed limestone-based passive-treatment systems at several major pollution sources in the Swatara Creek headwaters. These treatment systems were designed to raise the pH, which facilitates the precipitation of dissolved iron, aluminum, and associated metals. The systems include limestone-sand dosing, open limestone channels, anoxic limestone drains, and limestone diversion wells. Each passive-treatment system has different advantages and disadvantages; however, all suffer from possible complications associated with variability in flow rates, chemistry of the AMD and stream water, and from uncertainties about efficiency and longevity of the treatments. For more information about passive treatment systems, see box on next page.

Monitoring Shows Success

Since 1996, the USGS, in cooperation with the PaDEP and SCCD, has conducted water-quality monitoring to evaluate the effectiveness of specific implementation projects and their cumulative effects on a watershed scale. The Swatara Creek Project was accepted into the EPA's Section 319 National Monitoring Program in 1998, adding to the resources available to support the project. The total cost for the project for 1999-2002 was $670,000, and the estimated total cost of the project for 2003-2007 is $967,340. The USGS, SCCD, and PaDEP share costs, with EPA providing both technical resources and funding to PaDEP.



Map of project area showing locations of passive treatment systems and monitoring stations.

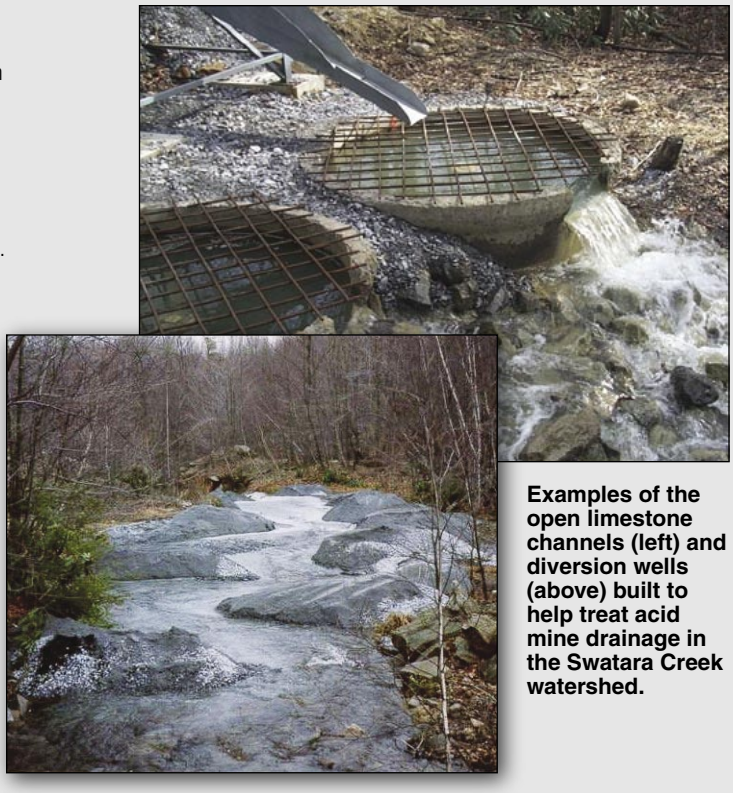
Passive Treatment Options for Acid Mine Drainage

Active chemical treatment of acid mine drainage (AMD) to remove metals and neutralize acidity is often an expensive, long-term process. Fortunately, many passive-treatment systems are now available that do not require continuous chemical inputs and that take advantage of naturally occurring chemical and biological processes to cleanse contaminated mine waters. The primary passive technologies include constructed wetlands, anoxic limestone drains, successive alkalinity-producing systems, limestone ponds, open limestone channels, diversion wells, and bioremediation.

Constructed Wetlands. Constructed wetlands promote precipitation of metal ions to hydroxides, which are retained in the wetland where they can be removed. In an anaerobic wetland, oxygen is excluded as water moves slowly through an organic layer above a crushed limestone bottom. The limestone raises the water's pH and metal is precipitated out and retained in the wetland. Microbial action also raises pH, and plant materials adsorb soluble metals and metal precipitates. The plant material eventually becomes saturated with metals and must be excavated and replaced.

Anoxic Limestone Drains. Acidic ground water can be channeled through anoxic limestone drains, which are buried trenches of limestone. The limestone dissolves, increasing pH and adding alkalinity. Under anoxic conditions, most dissolved iron does not precipitate until water pH approaches neutrality, thus the limestone does not become coated with iron hydroxides.

Successive Alkalinity Producing Systems. These systems combine the use of an anoxic limestone drain and an organic substrate. In some situations, dissolved oxygen concentrations are so high that oxygen must be removed from the water before it can be introduced into an anoxic limestone bed. In that case, water ponds over a layer of organic compost that is underlain by crushed limestone. Oxygen is consumed in the compost while the limestone raises the water's pH. Drainpipes below the limestone carry the water to an aerobic pond where metals are precipitated.



Examples of the open limestone channels (left) and diversion wells (above) built to help treat acid mine drainage in the Swatara Creek watershed.

Limestone Ponds. Limestone ponds are constructed on top of a spring that is discharging acid mine drainage. Crushed limestone is placed on the bottom of the pond and the water flows upward through it. Recently, such systems have incorporated automatic siphon flushing systems to remove solids that precipitate within the limestone bed.

Open Limestone Channels. Open limestone channels introduce alkalinity to surface water. The limestone is brought in and placed in the channel. These are more effective on a slope greater than 20 percent as the turbulence keeps the precipitates in solution and cleans precipitates from the limestone. They are often used with other passive systems to convey water to various treatment cells and to maximize treatment.

Diversion Wells. Diversion wells are wells constructed with a layer of crushed limestone on the bottom. Acidic water is introduced into the bottom of the well through a vertical pipe and flows upward through the limestone. The higher pH water and metal flocs flow out the top of the well and the metal can be precipitated in a downstream pond.

Bioremediation. Bioremediation involves the use of microorganisms to remediate contaminated sites. Different organisms can raise pH and remove metals from acid mine drainage solutions.

The physical and chemical characteristics of each mine drainage needs to be known before a restoration team can choose the remediation system that is most likely to be effective. The passive systems noted above work well and are relatively inexpensive, but all need monitoring for adjustments or limestone replenishment over time. For more information, and to view pictures of each type of system, see the following Web sites:

- www.dep.state.pa.us/dep/deputate/minres/reclaimpa/reclaimpahome.htm
- http://geology.er.usgs.gov/eastern/environment/drainage.html
- www.wvu.edu/~agexten/landrec/passtrt/passtrt.htm

The monitoring data have shown improvements in water quality. For example, the team found that the anoxic limestone drain at the Buck Mountain discharge near the headwaters of Swatara Creek has had a great benefit on a watershed scale, producing measurable improvements in pH and alkalinity for several miles downstream. The original limestone dissolved so quickly that the team had to add an additional 100 tons of limestone to the treatment system in January 2002. They also found that the diversion wells have the greatest potential to treat stormflow, which generally is more acidic than baseflow; however, these systems require maintenance to ensure that they contain sufficient limestone through the duration of a stormflow event and that they do not become clogged with debris. The data also showed that wetlands installed at various locations on tributaries and at coal mine discharge sources are effective at reducing metals transport to the main stem of Swatara Creek.

Section 319 National Monitoring Program

Swatara Creek is designated as a Section 319 National Monitoring Program project. These projects comprise a small subset of NPS pollution control projects funded under Section 319 of the Clean Water Act. The goal of the program is to support 20 to 30 watershed projects nationwide that meet a minimum set of project planning, implementation, monitoring, and evaluation requirements designed to lead to successful documentation of project effectiveness with respect to water quality protection or improvement. For more information on this and other National Monitoring Program projects, see www.bae.ncsu.edu/programs/extension/wqg/319index.htm.

Data collected on Swatara Creek at the outlet of the project area indicate the combination of treatment systems has significantly improved water quality in Swatara Creek. Because minimum values of pH have increased to near neutral over the study period, the fish community in this location has rebounded from nonexistent in 1990 to 400 fish, representing 25 species, in 2002. Another good sign of improving health of the stream is an increased abundance of aquatic insects that are intolerant of pollution. Nevertheless, substantial transport of dissolved and suspended metals persists in Swatara Creek because of the long-term accumulation of iron hydroxide, aluminum hydroxide, and associated materials in the streambed during normal flows, and the scour and transport of accumulated metal-rich streambed deposits during stormflow events. The long-term performance of the individual treatment systems and continued recovery of the aquatic ecosystem remain uncertain. Ultimately, the project data and interpretations will be used to resolve uncertainties about the optimum designs and appropriate uses of these systems for long-term implementation in Swatara Creek and elsewhere.

[For additional information, contact: (1) Jane Earle, PA Dept. of Environmental Protection, Bureau of Conservation, PO Box 8555, Harrisburg, PA 17105-8555; Phone: 717- 787-7007; E-mail: jearle@state.pa.us; (2) Daniel Koury, PA Dept. of Environmental Protection, Bureau of Mining and Reclamation, 5 West Laurel Blvd, Pottsville, PA 17901-2454; Phone: 717-621-3118; E-mail: dkoury@state.pa.us; or (3) Charles Cravotta, U.S. Geological Survey, 215 Limekiln Road, New Cumberland, PA 17070; Phone: 717-730-6963; E-mail: cravotta@usgs.gov.]

Technical Notes

Satellite Data Open a New View on Water Quality

States in the Great Lakes Region are leading the country in the use of satellite data as a means for assessing the health of lakes. Minnesota, Michigan, and Wisconsin together are home to more than 30,000 lakes larger than 10 acres in area. The quality of each lake varies depending on its proximity to different land uses and pollution sources. Although each state has a number of agencies and volunteer organizations collecting monitoring data, the number of lakes far outstrips the monitoring resources available. Now, a handful of additional monitors—satellites—have joined the scene. These satellites collect and share statistically reliable data on an unprecedented scale.

Keeping up with the Science

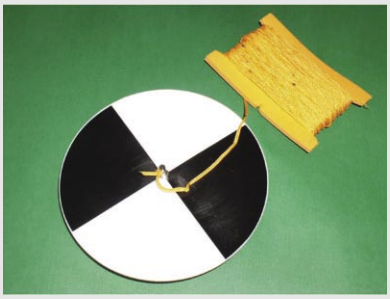
For updated information on the rapidly advancing use of satellite data for lake monitoring in the Great Lakes region, visit The Regional Earth Science Applications Center (RESAC) Web site at http://resac.gis.umn.edu. RESAC was established by NASA as a consortium of universities, state and federal natural resource management agencies, and industry partners who are developing satellite remote sensing products, geospatial analysis methods, and biophysical process models to meet regional decision-making needs.

Satellite Data Open a New View on Water Quality (continued)

Researchers from Minnesota, Michigan, and Wisconsin have embraced the use of satellite data as a tool for assessing water quality. In 2003, they unveiled a Web site for their joint Regional Water Clarity project, an effort to compare satellite data and ground-based monitoring to assess lake water clarity across the Great Lakes region (for more information see http://resac.gis.umn.edu/water/regional_water_clarity/regional_water_clarity.htm). The researchers found that analysis of certain wavelengths of visible light in the satellite data correspond closely with that of on-the-ground Secchi disk readings, allowing accurate estimates of lake clarity for thousands of otherwise unmonitored lakes. Researchers are also mapping water clarity with archived satellite data enabling them to go back into the past and look at historical trends. This type of visual information helps resource managers identify and target problem areas and enables systematic ground-based monitoring of inland lakes.

What is a Secchi Disk?

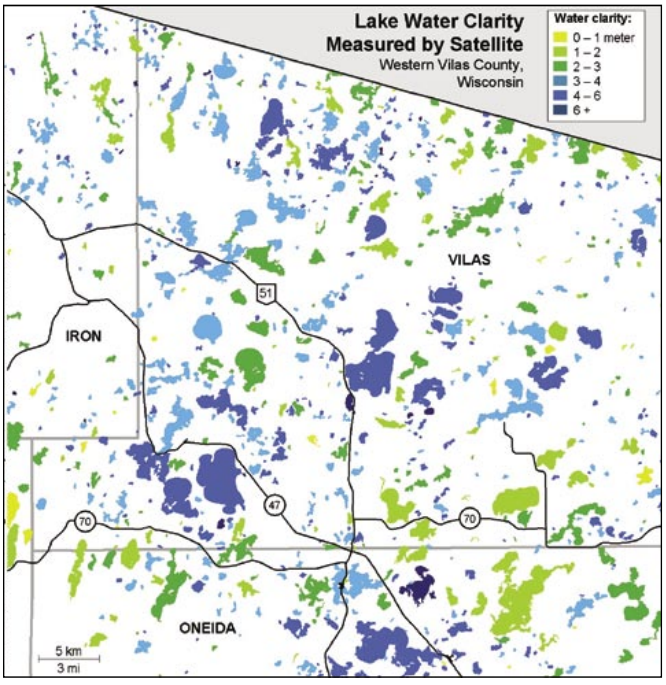
Resembling an oversized CD with a bold black-and-white pattern on top, a Secchi disk is lowered by rope into the water until it is just deep enough to disappear from sight. At that point, the user records the depth. The water clarity is then expressed in terms of Secchi depths.



Example of a typical Secchi disk (photo courtesy of Wildlife Supply Company (Wildco)).

Wisconsin's Story

Wisconsin completed its portion of the Regional Water Clarity Project in January 2003. "We couldn't have completed this project without the help of our statewide volunteer monitors," explained Thomas Lillesand, Director of the University of Wisconsin-Madison's Environmental Remote Sensing Center. As part of the Wisconsin Department of Natural Resources' Self-Help Citizen Lake Monitoring Program, volunteers across Wisconsin routinely measure the clarity of their local lakes with Secchi disks. To aid in Wisconsin's part of the Regional Clarity Project, Self-Help volunteers took Secchi readings on lakes beginning in 1999. The volunteers adhere to a strict monitoring time schedule that allows their measurements to occur just as the Landsat satellite passes overhead and gathers corresponding electronic images of these and other lakes. This coordinated data collection effort continues today.



Example of a lake clarity map generated using satellite data (map courtesy of the Environmental Remote Sensing Center at the University of Wisconsin-Madison).

Back at University of Wisconsin-Madison, researchers correlated the conventional water-clarity data with the corresponding Landsat data through 2001. Lillesand says in this way, Secchi readings from fewer than 400 lakes made it possible to estimate the clarity of all other lakes in the satellite's images without sampling each of them by hand. "Our research aims to integrate satellite data into the state's day-to-day lake management programs," he explained. "This won't eliminate the need for conventional water quality monitoring, but it will greatly increase the benefits of ground-based sampling."

Sharing Results with the Public

In January 2003, the University of Wisconsin-Madison researchers and their cooperators released a Web-based, interactive mapping resource (www.lakesat.org) for the state of Wisconsin. The map allows users to view the whole state or zoom in on a particular region or lake to see satellite data maps and maps depicting water clarity. The Web site was an instant success. "We had so many hits the first few days that it overwhelmed our server," Lillesand recalled. The site has received more than 20,000 visitors since January 2003.

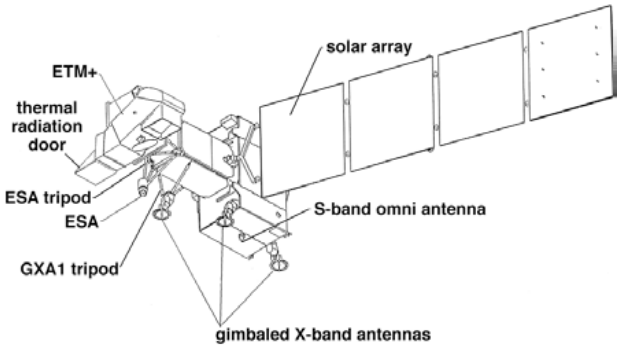
Satellite Data Open a New View on Water Quality (continued)

The researchers have discovered that a wide variety of people use the resources for different reasons. "Fishermen look for prime fishing spots, researchers and lake associations check the status of lakes, teachers use it to provides hands-on education, and more," explained Lillesand. "We have also noticed that the project is generating more interest in water quality protection. When people see that other nearby lakes are in better shape than theirs, they tend to want to get involved so they can do something about it." The number of volunteers in the state's lake monitoring program

Thirty Years of Satellite Data

The NASA Landsat program launched its first satellite into the earth's orbit in 1972. The satellite carried a television camera and a sensor called the Multi-Spectral Scanner, which collected data in four spectral bands and had a coarse resolution (one pixel to 80 square meters). The resolution refers to the level of detail available, which is determined by the fixed width represented in each square pixel of the satellite's digital composite image. This same sensor was aboard the next three Landsat satellites launched during the 1970s. Landsat 4 (1982) and Landsat 5 (1984) were equipped with an improved sensor, the Thematic Mapper, which provided greater resolution in the visible and near-infrared regions (30 meters versus 80 meters) and three additional spectral bands. Landsat 6 (1993) failed to reach orbit after launch.

Landsat 7, launched in April 1999, was equipped with an Enhanced Thematic Mapper-Plus sensor. The improved instrument has eight bands sensitive to different wavelengths of visible and infrared radiation, has better resolution in the thermal infrared band than the instruments carried by Landsats 4 and 5, and is also far more accurate. Every 16 days, the Landsat 7 system collects and archives high-quality multi-spectral data for the entire globe. The repeating, extensive coverage of Landsat 7 is excellent for observing seasonal changes on continental and global scales, and Landsat's fine resolution is ideal for perceiving important detail in land surfaces.



Schematic drawing of Landsat 7.

The Landsat 7 system offers the unique capability to seasonally monitor important small-scale processes on a global scale, such as the annual cycles of vegetation growth; deforestation; agricultural land use; erosion and other forms of land degradation; snow accumulation and melt and the associated fresh-water reservoir replenishment; and urbanization. The other systems affording global coverage do not provide the resolution needed to observe these processes in detail, and only the Landsat system provides a 26-plus year record of these processes.

Also in 1999, NASA launched the first Earth Observing System (EOS) satellite, called Terra, carrying five remote sensors. NASA launched a second EOS satellite, Aqua, in 2002. The most comprehensive EOS sensor is MODIS, the Moderate-resolution Imaging Spectroradiometer (http://modis.gsfc.nasa.gov). MODIS offers a unique combination of features: it detects a wide spectral range of electromagnetic energy; it takes measurements at three spatial resolutions; it takes measurements all day, every day; and it has a wide field of view. This continual, comprehensive coverage allows MODIS to complete an electromagnetic picture of the globe every two days. MODIS's frequent coverage complements other imaging systems such as Landsat's Enhanced Thematic Mapper Plus, which reveals the Earth in finer spatial detail, but can only image a given area once every 16 days—too infrequently to capture many of the rapid biological and meteorological changes that MODIS observes.

Landsat Problems Raise Scientists' Concerns

In May 2003, the scanning system on Landsat 7 began to malfunction, creating gaps in the sensor's coverage. Researchers at the University of Wisconsin say that the impact of these gaps on their lake monitoring program has not been as severe as originally feared, since most targeted lakes are at least partially covered by the satellite. But these data gaps may cause smaller lakes to be missed, and they may be more of a problem for other studies.

The aging of Landsat 5 (which is now sixteen years past the end of its five-year design life), combined with the scanning malfunction on Landsat 7, have left scientists feeling uncertain over the current status and future direction of the satellite program. These concerns increased last year when the proposed Landsat Data Continuity Mission was scrapped and plans for future satellites were sent back to the drawing board. A new plan calls for a replacement sensor called the Operational Land Imager to be carried on a series of standard weather satellites beginning in 2010. Response from the scientific community has been cautiously optimistic over the prospect of a long-term commitment to maintain a Landsat-like sensor on the weather satellites, combined with concern about the possibility of a gap between the likely end of operation of Landsats 5 and 7 and the launch of the new satellite series. For more information about the Landsat program, see http://landsat.usgs.gov.

jumped dramatically after this resource came out—from about 650 volunteers statewide in 2000 to more than 1300 volunteers in 2004.

Looking Beyond Lake Clarity

"Demonstrating that lake clarity can be estimated over very large areas via satellite data at this level of detail is just the beginning of our research," said Lillesand. "We want to be able to answer such questions as how lake clarity has changed over time, where lake management activities might be most useful, and which lakes will be most subject to change in the future due to such factors as changes in land use and climate."

Can I Use Satellite Data in My Watershed?

In early 2005, the U.S. EPA Office of Wetlands, Oceans, and Watersheds' Monitoring Branch awarded a grant to the North American Lake Management Society (NALMS) to conduct a comparative study of different methods and sensors for lake management applications of remote sensing. Researchers from University of Wisconsin-Madison, the University of Minnesota, and the University of Nebraska-Lincoln will conduct studies on lakes in the Midwest region and produce a report that compares the capabilities, accuracy, and costs of all the various approaches. The report will serve as a guidance document for lake managers in the Midwest region who are considering whether and how to use remote sensing in their own work. Researchers expect the project to be completed within two years.

Under the sponsorship of the NASA Affiliated Research Center (ARC) program, Lillesand and his colleagues have also looked beyond Landsat to other satellite data to help them monitor lake water quality. Lillesand says that a new imaging system aboard NASA's state-of-the-art Terra and Aqua satellites, called MODIS, has a much wider field of view and can provide coverage nearly every day (see box "Thirty Years of Satellite Data" for more information on Terra, Aqua, MODIS, and Landsat). Although MODIS data are coarser in resolution, revealing far less detail than Landsat's, MODIS' broad coverage area and frequency permits scientists to monitor the clarity of large water bodies like Lake Winnebago and Green Bay daily except when clouds obscure them. "We are using MODIS data to monitor sediment plumes and nuisance algae blooms," explained Lillesand. "We hope to get a better idea of where the hot spots are so we can more accurately target the sources of the problems."

[For more information, contact Thomas Lillesand, Environmental Remote Sensing Center, University of Wisconsin-Madison, 1225 W Dayton St, Floor 12, Madison, WI 53706. Phone: 608-263-3251; E-mail: tmlilles@facstaff.wisc.edu; Web: www.ersc.wisc.edu.]

UNH Center Compares Stormwater Treatment Technologies

In a new regulatory environment, stormwater managers are often pushed to take a leading-edge approach to new stormwater treatment technologies that mitigate urban nonpoint source pollution. But which technologies are best suited for the different watershed conditions? Managers hesitate to invest large amounts of public funds in an innovative technology for fear they would be held accountable if the technology fails. Now, a new research facility at the University of New Hampshire (UNH) is helping to take some of the risk out of their decision-making.

Providing Answers to Tough Questions

In urban settings, stormwater has historically been piped away from buildings, city streets, and parking lots into outlets leading to nearby streams and rivers. Yet increasingly, under National Pollutant Discharge Elimination System (NPDES) Stormwater Phase II regulations, local stormwater managers are responsible for spending public dollars to formalize stormwater management programs and install treatment systems to control stormwater pollution.

Selecting a stormwater treatment system involves site-specific considerations on installation space and configuration, budgets, and desired outcomes. Ultimately, the questions that public officials want to answer with some degree of confidence—particularly if public tax revenue is at stake—is, "Will the treatment work here?" and "Will it improve water resources?"

Empirical data of treatment system performance would increase confidence, but those data are often narrow, limited, or are published by vendors themselves along with marketing pitches for their product's performance. Newer stormwater treatment systems like low-impact development (LID) techniques backed by widely accepted theory may meet resistance to implementation because there are few installation sites and little monitoring data that offer "proof" that they work in practice.

So, if you are a municipal official ready to install innovative stormwater treatment for your town—and are wondering how to select an optimal system within the constraints of a tight budget and particular rainfall regime—you'll be happy to learn about UNH's Center for Stormwater Technology Evaluation and Verification (CSTEV).

A New Approach

Researchers at CSTEV conduct field-tests of multiple stormwater treatment technologies. Their mission is to fill the gap—of data, and the data's credibility—by monitoring and analyzing different technologies under the same control conditions. As a third party, independent research center, its sole focus is the testing, effectiveness, and nuances of each stormwater treatment technology. The lab has been operational since July 2004.

CSTEV's "experimental-laboratory" is in fields that skirt the perimeter of a nine-acre campus parking lot. Principal Investigator, Dr. Tom Ballestero, refers to this as an "ultra-urban watershed," with 99 percent impervious surface. All parking lot runoff flows to one location, and from there the water flows by gravity to different treatment systems. So, each system sees essentially the same runoff hydrograph and the same runoff water quality. At the site, 15 different treatment systems are installed side-by-side. Outflow hydrographs from each system are monitored as well as the outflow water quality. For a given storm, researchers collect and compare data on flow volume influent and effluent, time measurements, and pollutant removal efficiency for a suite of water quality parameters across all of the technologies. The availability of this type of data has long been on stormwater managers' wish lists. Now, when deciding which treatment technology to choose, the manager doesn't have to worry about the varying conditions that might have affected stormwater data reported for different technologies under different study conditions.

Director of the CSTEV, Dr. Robert Roseen, groups the 15 technologies under testing into three classes: conventional structural systems, manufactured devices, and low impact development treatment systems (see box). He estimates that 95 percent of stormwater treatment systems now used across the country are conventional structural systems like retention systems and vegetated swales, while less than one percent are LID techniques such as bioretention systems or gravel wetland systems. The manufactured devices under testing were provided by vendors themselves, following a widely cast solicitation by CSTEV.

Stormwater treatment systems studied at CSTEV*

Conventional Structural Systems	Manufactured Devices	Low-impact Development Systems
• Retention Pond • Vegetated Swale	• ADS Treatment Unit: Water Quality and Storage • Aqua Swirl and Aqua Filter Systems • Storm Drain Manhole Refit Systems • VortSentry™ Hydrodynamic Separator • Structural Stormwater Treatment System • Continuous Deflective Separation	• Surface Sand Filter • Porous Asphalt Pavement • Tree Box Filter • Bioretention Unit • Gravel Wetland Unit

**Fact sheets providing more information on each system are available at www.unh.edu/erg/cstev/fact_sheets.*

A Storm-by-Storm Analysis is Not Enough

A typical gauge of a treatment technology's effectiveness is to measure its removal efficiency—through a yardstick known as the event mean concentration (EMC). In effect, the EMC is the mass

of the contaminant (flowing into or out of the system), and the removal efficiency is the percent of the mass (of a pollutant) removed from influent stormwater as it flows out of the technology. This number captures the result of one test, at one time, from one rainfall event. "Even repeating the event mean concentration test five or six, or ten times, in one summer, is a narrow measurement of the technology's effectiveness," says Ballestero. Instead, at CSTEV, Ballestero focuses on replicating how the technology works in practice over time.

Ballestero considers how a technology functions at different times during its operation: at the start-up phase, in different seasons, and after some acclimation such as vegetation growth and wildlife introduction around the technology. "A minimum period of measurement is one year," he says, while pointing out that ground frost penetration—which can affect different technologies—has differed by more than four feet in the previous two years in New Hampshire.

Measuring a series of responses to storms over the course of at least a year, he says, allows researchers to synthesize various factors into a probabilistic analysis of a technology's effectiveness. A distribution teases out slight variations in the technology's performance and can offer a better way to compare different technologies. For example, he says, "We might be able to say that Device X removes total suspended solids (TSS) to a benchmark level or better 75 percent of the time but has notable severe exceedances, but Device Y removes TSS slightly above a benchmark level 95 percent of the time. This information is exactly what managers need to figure out what would work for their waterbodies. This is ultimately more useful information than a removal efficiency ratio of a technology based on limited testing."

But … Will This Improve My Receiving Water?

CSTEV's extensive data collection and analysis may be just the bridge that managers need to cross over from research to real-world application. Ballestero stresses that the receiving water is usually a critical factor but may be overlooked in a manager's decision-making. An extended-period, probabilistic data analysis would better support matching an appropriate technology with waterbody or watershed goals. For example, if a receiving water's uses cannot support an occasional overload of a pollutant, but can more easily support a steady, moderate-level of pollutant, that is important to factor into a technology selection decision.

Beyond the focus on urban pollutants, CSTEV also examines what happens to the stormwater in the treatment technology itself. Exposure to air in some technologies and no exposure in others affects the quality of the stormwater. Some technologies are good at cleaning our urban pollutants, but they yield anaerobic water that could be problematic if discharged to a receiving water with low dissolved oxygen. Alternatively a technology with a surface expression, such as a pond, can generate water with high levels of microbes, which might pose problems for receiving waters that have existing high-microbe levels.

This bioretention unit is one of the low-impact development systems currently being tested at CSTEV.

Price Tag for Multiple Beneficiaries

The independent status of the UNH researchers makes their research attractive both to the user community and to vendors who get high-credibility, in-depth testing of their system at no cost. To run a lab like this takes a large budget. "Larger," says, Ballestero, "than any single town or community, or even state should have to pay." NOAA provided grant funding to cover $400,000 in design and construction for the fifteen different treatment systems, and $300,000 to cover the monitoring equipment.

Pollutants Monitored

Being judicious about the parameters that are monitored is critical, says Ballestero, because it's easy to spend up to $100,000 on monitoring a single storm across fifteen different technologies. CSTEV monitors for the following pollutants, which are consistently above detection levels as they enter the treatment systems:

- Diesel range organics
- Zinc
- Chlorides
- Cyanide
- Nitrate/ammonia (depending on aerobic or anaerobic systems)
- TSS
- Enterococci (family of bacteria)

These data can be used to represent the likely behavior of entire classes of pollutants, such as microorganisms, metals, nutrients, organics, and sediment.

NOAA and UNH's Cooperative Institute for Coastal and Estuarine Environmental Technology, whose mission is to promote the use of technology to reverse estuarine degradation, also grant annual operational funding to the tune of $0.7 million.

Widely Applicable

The New Hampshire location places CSTEV at a unique advantage to generate data on technology effectiveness in cold-climates with heavy snowpacks, deep ground frost, and urban cold-weather management practices such as sand and salt applications. Yet New Hampshire still enjoys all four seasons and receives moderate rainfall, which allows the data to be applicable in warmer climates as well.

EPA Contributes to Technology Verification

In 1995, the U.S. EPA established its Environmental Technology Verification (ETV) Program. The ETV Program's mission is similar to that of the University of New Hampshire's CSTEV—to provide third party, quality-assured performance data on technologies that address problems that threaten human health and the environment. Unlike the CSTEV, the EPA's ETV Program evaluates treatment technology mostly in-situ at real world installation sites. Because ETV's tests for stormwater technologies are performed in different places under different conditions, developing a ranking of similar treatment technologies is not feasible. However, side-by-side comparison is not the goal of the ETV program testing; instead, ETV aims to verify that the technology performs in practice, and to gauge how well it performs its intended functions for particular circumstances.

The ETV Program operates as a public-private partnership through agreements between EPA and private testing and evaluation organizations. ETV now operates six centers and one pilot program that, in total, cover a broad range of environmental technology categories, including air, water, pollution prevention, and monitoring. At its Water Quality Protection (WQP) Center in Edison, New Jersey, ETV works in partnership with NSF International, a Michigan-based non-profit research organization, to evaluate wastewater and stormwater treatment devices. The ETV and NSF partnership will be in place until July 2007, at which time the ETV will cease to provide base level funding for verification projects at the WQP Center. Instead, the WQP Center will become self-sufficient and begin relying on full funding of the verification process by the participating vendors and other sources.

ETV's WQP Center and NSF are currently in various stages of testing and reporting on a number of commercial-ready treatment, control, and rehabilitation technologies, including decentralized wastewater treatment systems for residential nutrient reduction, watershed protection technologies (e.g., animal waste treatment), high-rate UV disinfection technologies, stormwater treatment, high-rate solids separation, and runoff collection models, among others. The WQP Center is also working with the U.S. Coast Guard and other federal agencies to develop testing protocols for ship ballast water treatment technologies designed to mitigate proliferation of aquatic invasive species. These technologies are similar to those used for advanced wastewater and stormwater treatment.

Information on the WQP Center, such as testing activities, final verification reports and statements, meeting announcements, and a current list of vendors participating in the program, may be found on the NSF and EPA ETV Web sites: www.nsf.org/business/ETV_EPA_NSF/ and www.epa.gov/etv.

[For more information, contact Ray Frederick, U.S. EPA Water Quality Protection Center, 2890 Woodbridge Ave., MS 104, Edison, NJ 08837; Phone: 732-321-6627; E-mail: frederick.ray@epa.gov.]

UNH Center Compares Stormwater Treatment Technologies (continued)

Outreach and Public Access

A large function of the CSTEV, Roseen says, is to demonstrate new or different technologies. At 12 nominal-fee workshops run annually, attended by about 30 people each time, he says, "municipal officials go through our site, see first hand the footprint and configuration of systems they have heard, or read about, and get an evaluation of their cost, and their water quality performance." Many workshop participants are seeing LID technologies in practice for the first time. CSTEV's demonstration workshops have had "an overwhelming positive response," says Roseen, "where we are just keeping pace with the demand for more tours, individual follow-up questions, and information requests."

The outreach mission of CSTEV continues to expand, adds Roseen. "We continually analyze the data we collect, and present it at workshops and conferences." Roseen and Ballestero are waiting to collect a full year's worth of data before publishing a major scientific paper, accompanied by non-technical fact sheet publications for non-scientists. In the meantime, CSTEV maintains a comprehensive program Web site (www.unh.edu/erg/cstev/) to educate the public and provide updated information. An interactive site map shows where each system is located and offers detailed engineering diagrams of each. Supplemental fact sheets describe the specifications of each installed treatment technology. Monitoring data collected to date are presented within slide presentations available for download. Web site visitors can even enjoy a short virtual tour, thanks to a streaming video segment produced by a local cable access channel.

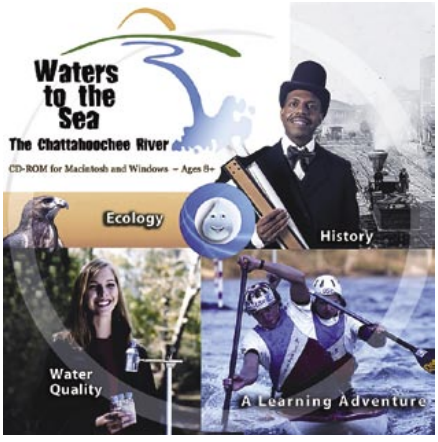
[For more information, contact either (1) Dr. Thomas P. Ballestero, Phone: 603-862-1405; E-mail: tom.ballestero@unh.edu; or (2) Dr. Robert M. Roseen, Phone: 603-862-4024; E-mail: robert.roseen@unh.edu; Mail: UNH Stormwater Center, Environmental Research Group, University of New Hamphire, Durham, NH 03824. Web site: www.unh.edu/erg/cstev]

Software Spotlight

Award-Winning Multimedia Software Takes Students Down the Chattahoochee River

Students are going on a virtual adventure along the Chattahoochee River via the new award-winning CD-ROM, *Waters to the Sea: The Chattahoochee River.* Produced by Hamline University's Center for Global Environmental Education (CGEE), this educational resource is designed to help Georgia students in grades 4-8 learn about their local waterways, the Chattahoochee River system, the water cycle, ecosystem concepts, and relevant local history concepts. Video, animation, and interactive segments teach students about the history of the area and motivate them to take action to protect the river and associated ecosystems.

The CD-ROM has caught the attention of people far and wide. In fact, CGEE earned the 2004 Panda Award—the world's top award for environmental multimedia—at the biannual Wildscreen Festival (www.wildscreenfestival.org) in England in October 2004. Wildscreen is the largest and most prestigious festival for environmental media. CGEE shared the award with the British Broadcasting Company (BBC), winning against many of the world's other top wildlife and nature production entities, such as the National Geographic Society, Discovery Channel, and Public Broadcasting Service (PBS).



The CD-ROM's cover portrays the wide variety of topics addressed.

CGEE developed the CD-ROM in partnership with the Upper Chattahoochee Riverkeeper, a river advocacy group in Atlanta, Georgia, and Columbus State University's Oxbow Meadows Environmental Learning Center in Columbus, Georgia. Coca-Cola North America, Georgia Power, the Robert Woodruff Foundation, and Georgia's Sustainable Forestry Initiative provided funding. Copies of the CD-ROM are available for $39.95 (see http://cgee.hamline.edu/waters2thesea/Chattahoochee).

Award-Winning Multimedia Software Takes Students Down the Chattahoochee River (continued)

Series Will Expand Across the Nation

Waters to the Sea: The Chattahoochee River is the second in the *Waters to the Sea* series. The program's format is adaptable to any watershed region and serves to educate users about people's relationship to regional watersheds throughout history. The first CD-ROM in the series, *Waters to the Sea: The Upper Mississippi River*, took users on three virtual river journeys from prehistoric times up to the present, through the prairie, deciduous forest, and coniferous forest ecoregions of the river basin. CGEE has embarked on a series of educational multimedia products they hope will provide an overview of the nation's major river basins and the issues they each face. Additional regional installments are planned for the Colorado River and rivers of Southern California, the Rio Grande and the rivers of Texas, the Chesapeake Bay region, and rivers of the northeast and northwest.

Users of *Waters to the Sea: The Chattahoochee River* are guided through the CD by one of three historic guides from different eras who provide historic perspective on the watershed's environment. For example, one of the historic guides on the watershed tour is Mary Musgrove, a Creek Indian who was a tribal leader at the time of early European settlement in the Southeast. She leads users through two interactive modules concerning the Creek and Cherokee Indians and the many traditional uses of deer and river cane (American bamboo) within tribal subsistence culture.

Each *Waters to the Sea* installment has four to five hours of interactive content that strategically uses multimedia technology to enrich learning and inspire stewardship. Rich storytelling that weaves extensive video, landscape panoramas, audio, and original music complements fun, thought-provoking interactive segments that explore and reinforce science and social studies concepts. Importantly, modules are developed in alignment with state and national science education standards to assist educators. CGEE and its partners provide Web-supported study guides for teachers that provide hands-on, project-based learning experiences applicable in the classroom and in the field that augment standard curricula. Teachers also have access to orientations, workshops, online training, and graduate-level courses to help them integrate the program into their classrooms and use the product to its fullest potential.

[For more information, contact Tracy Fredin, Center for Global Environmental Education, Hamline University, 1536 Hewitt Ave., MS-A1760, St. Paul, MN 55104-1284; Phone: 651-523-3105; E-mail: tfredin@hamline.edu; Web: http://cgee.hamline.edu/waters2thesea.]

Notes on Education

Minnesota Elementary School Sees Green by Meeting LEED Standards

A school building that improves the capacity for learning and is friendly to the environment? Westwood Elementary School, a 75,000-square foot school located on 26 acres in Zimmerman, Minnesota, does just that. In August 2004, Westwood Elementary became one of only four K-12 schools in the country and the first building in Minnesota to earn the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) certification, a widely recognized standard for developing high-performance, sustainable buildings that are good for people and gentle on the environment.

What is a LEED Certificate?

The LEED Green Building Rating System represents the U.S. Green Building Council's effort to provide a national standard for what constitutes a "green building." Through its use as a design guideline and third-party certification tool, the LEED rating system aims to improve occupant well being, environmental performance, and economic returns of buildings using established and innovative practices, standards, and technologies. Members of the U.S. Green Building Council, representing all segments of the building industry, developed LEED and continue to contribute to its evolution.

A project submitted for LEED certification is assessed by one or more third-party accredited professionals with building industry experience, demonstrated knowledge of green building practices and principles, and familiarity with LEED requirements, resources, and processes. The third party rates the project based on six categories of performance: sustainable sites, energy and atmosphere, water efficiency, indoor environmental quality, materials and resources, and innovation in design.

To become certified, a project must earn at least 26 out of 69 possible points. Depending on the number of points achieved, a project receives either standard certification (26 to 32 points), or higher certification ratings—silver (33 to 38 points), gold (39 to 51 points), or platinum (52 points or more). Once LEED-certified, a project becomes a physical demonstration of the values of the organization that owns and/or occupies it. For more information about LEED certification, see www.usgbc.org.

LEED-certified Westwood Elementary protects the health of children and the environment.

Westwood is Gentle on the Environment

The Westwood Elementary School project, designed by KKE Architects, earned 28 LEED certification points for a variety of initiatives that reduce energy and water use, reduce solid waste, minimize impact on the land, and protect indoor air quality. For example, the bathrooms are equipped with low-flow and infrared-controlled fixtures to reduce water use. Photocell and motion sensors automatically turn off lights in unoccupied rooms or when rooms are sufficiently illuminated with natural light. During construction, a waste management plan spared 60 percent of would-be waste materials from the landfill.

Several building initiatives at Westwood reduce the potential for nonpoint source pollution, including: a two-story design that minimizes the school's impervious footprint and maximizes pervious ground cover; the placement of the school close to an existing road to further reduce the need for additional pavement; the use of ponds to capture and treat stormwater runoff; and the preservation of a wetland on school property. The wetland and other outdoor features are available for use as an outdoor environmental classroom and schoolyard habitat.

Westwood is Friendly to the Students

Marie Norman, principal of Westwood, says that although she doesn't have hard data to prove that her students perform better in the green building, studies have shown that exposure to natural light encourages better attendance and higher test scores. At Westwood, daylight reaches 84 percent of the two-story building's interior spaces because of super-sized windows—offering almost everyone a clear view of the outside.

Fresh air also helps keeps students healthy, adds Norman. "You can tell right away that the air is different; it is clean. Everything is filtered. Does it make people want to come to school? I think so." A displacement ventilation system delivers conditioned air into a room near ground level. The warmth of the occupants heats the air, which causes it, and airborne contaminants, to rise to the ceiling to exhaust ducts. An energy recovery system takes the exhaust air from the building and uses it to heat incoming outside air without mixing the two. Only fresh air is pumped back into the school.

Westwood is Easy on the Pocketbook

The building's $12 million cost compares favorably with traditional construction costs. In fact, the project was completed under budget—even though the budget had been established before the school district decided to build a green building. Elements such as minimizing both the size of the building's footprint and the amount of impervious surfaces contributed to cost savings. Westwood's construction will continue to provide cost savings over time. School officials expect to save $45,000 per year in energy costs compared with a more traditional building.

Westwood has had many people visit the school since it opened in the fall of 2003, adds Norman. "We've had busloads of teachers, administrators, school board members, and citizens from towns that are building new K-12 schools come to look." It may be an idea whose time has come.

[For more information, contact Lee Meyer, KKE Architects, Inc., 300 First Avenue North, Minneapolis, MN 55401; Phone: 612-336-9639; E-mail: lmeyer@kke.com. For more information about Westwood School, see http://westwood.elkriver.k12.mn.us.]

Reviews and Announcements

Book Explores a Century of Forest and Wildland Watershed Lessons

The Society of American Foresters offers a new book summarizing the findings and lessons learned from key forest and watershed studies of the past century. *A Century of Forest and Wildland Watershed Lessons* provides information on studies across the United States. This book is only available in hard copy. To order, see http://store.safnet.org or contact the Society of American Foresters, 5400 Grosvenor Lane, Bethesda, Maryland 20814; Phone: 301-897-8720.

EPA Issues National Coastal Condition Report II

In January 2005, EPA released the National Coastal Condition Report II (NCCR II). The report is the second in a series of environmental assessments of U.S. coastal waters and the Great Lakes. NCCR II is based on analysis of coastal monitoring data, offshore fisheries data, and assessment and human health advisory data gathered by a variety of federal, state, and local sources between 1997 and 2000.

The report indicates that the overall condition of the nation's coastal waters is fair, which is essentially the same as the first report in 2001. This rating is based on five key indicators of ecological health: water quality, coastal habitat loss, sediment quality, benthic community condition, and fish tissue contaminants. For each of these five key indicators, EPA assigned a score of good, fair, or poor to each coastal region. EPA then averaged these ratings to create overall regional and national scores. Consistent with the recent Oceans Commission report (www.oceancommission.gov), this report sends a clear message about the serious challenges facing our nation's ocean and coastal resources. To download a free copy of NCCR II, see www.epa.gov/owow/oceans/nccr/2005.

EPA Releases Compliance Assistance Guide for the Construction Industry

EPA's Office of Compliance has just published the Managing Your Environmental Responsibilities: A Planning Guide for Construction and Development (the MYER Guide). This assistance tool reflects significant input from stakeholders and is a product of joint effort by the industry, states, other federal agencies, non-governmental organizations and EPA.

The MYER Guide contains two different sets of checklists and detailed discussion/case studies on major environmental areas (including stormwater) affecting the construction industry. It is designed to help the construction industry understand which environmental regulations apply to them, and can be used during different phases of a construction project. The industry can use the Guide at the pre-bid phase to learn about the applicable environmental requirements, so appropriate costs can be taken into consideration early. The industry can also use the responsibility-assignment checklist during the pre-construction phase to facilitate allocation of environmental responsibilities to all parties before breaking ground. Readers will find answers to many environmental questions and can conduct self-audits by using checklists during the construction phase. The MYER Guide is designed so that each of the checklists and chapters can be pulled out and used in the field. An electronic copy of the guide may be downloaded at www.cicacenter.org/links/. A hard copy is available at no cost from the National Service Center for Environmental Publications (NSCEP) at 800-490-9198 (document number EPA305-B-04-003).

New NEMO Report Released

NEMO recently released *Putting Communities in Charge* (2005), a 34-page report dedicated to the work of the NEMO Program in Connecticut. This report describes the origin, objectives, and progress of the NEMO program and includes overviews of a number of recent initiatives. The report also highlights case studies of towns that have worked with NEMO, and the ways that these towns are taking charge of their community's future development patterns. Profiled towns and areas

include: Old Saybrook, Waterford, Woodstock, Salem, Central Naugatuck Valley, Watertown, East Haddam, Candlewood Lake Authority, and Stonington. The profiles of the towns are available for download at http://nemo.uconn.edu/publications (look under "CT Impact Reports").

Southeast Watershed Forum Offers Restoration Guide

The Southeast Watershed Forum's (SWF) *Return of the Natives: A Community Guide for Restoration of Fish and Aquatic Species* is a 20-page, full-color guide featuring case studies of various groups' efforts to protect native aquatic organisms. SWF wrote the guide to increase regional awareness of the importance of native species and implementation of land use practices that will protect the habitat and water quality essential to biological diversity. The guide is available at www.southeastwaterforum.org/pdf/newsletters/Return_of_Natives.pdf.

Technical Guidance on CAFOs Now Available

EPA recently released *Managing Manure Guidance for Concentrated Animal Feeding Operations* (CAFOs), a technical guidance designed to supplement the *NPDES Permit Writers' Guidance Manual and Example NPDES Permit for CAFOs.* This guidance provides additional technical information for owners, operators, technical service providers, consultants, and permit authorities on how to carry out EPA's revised regulatory requirements for NPDES permitting of CAFOs. It also provides information on voluntary technologies and management practices that may both improve the production efficiency of CAFOs and further protect the quality of the nation's waters. This document assumes that readers have a basic understanding of the CAFO regulations. The guidance is available for download at http://cfpub.epa.gov/npdes/afo/info.cfm#manure.

Updated Conservation Easement Handbook Available

The Land Trust Alliance and the Trust for Public Land recently released the second edition of their *Conservation Easement Handbook*, originally published in 1988. Intended for attorneys, land trusts, and conservation professionals developing easement programs, the thoroughly revised and expanded handbook offers 21 chapters (555 pages) containing information about drafting easements and managing an easement program. It provides how-to tips and checklists for land trust staff and board members; detailed drafting guidelines for attorneys; and a CD-ROM containing many sample documents. For more information, and to review the introduction and first chapter, see www.lta.org/publications. The handbook can be ordered for $49.95.

Urban Subwatershed Restoration Manual #4 Released

The Center for Watershed Protection recently released the *Urban Subwatershed Restoration Manual #4, Urban Stream Repair Practices*, which focuses on the practices used to enhance the appearance, stability, structure, or function of urban streams. The manual offers guidance on three broad approaches to urban stream repair: stream cleanups, simple repairs, and more sophisticated comprehensive repair applications. The manual explains the natural and man-made forces that influence urban streams, and presents guidance on how to set and meet appropriate stream restoration goals. It outlines methods to assess stream repair potential at the subwatershed level, including basic stream reach analysis, more detailed project investigations, and priority screenings. Finally, the manual offers practical advice to help design, permit, construct, and maintain stream repair practices in a series of more than 30 profile sheets. Thanks to a grant from the EPA Office of Wastewater Management, users may download this manual free for a limited time at www.cwp.org.

Recent and Relevant Periodical Articles

Advances in Porous Pavement

The March/April 2005 Issue of *Stormwater Magazine* features this article by Tara Hun-Dorris. Hun-Dorris reviews the currently available types of porous pavement and discusses examples of their durability and effectiveness. See: www.stormh2o.com/sw_0503_advances.html.

Municipal Use of Stormwater Runoff

The May/June 2005 issue of *Stormwater Magazine* features this article by Peter C. Hall. Hall explores the potential for municipalities to capture and use stormwater runoff as a supplemental water supply source. He features examples of how the process could benefit two Texas cities: Lubbock and Austin. See: www.stormh2o.com/sw_0505_municipal.html.

Paved Paradise?

The September 4, 2004 (Vol. 166, No. 10, p. 152) issue of *Science News Online* features this article by Sid Perkins. Perkins examines what contributes to imperviousness and discusses how impervious surfaces can negatively affect a region's hydrology, water quality, ecosystems, and climate. See: www.sciencenews.org/articles/20040904/bob8.asp.

Web Sites Worth a Bookmark

EPA's National Menu of Best Management Practices for Stormwater Phase II

www.epa.gov/npdes/menuofbmps. The EPA developed this online menu to help regulated small MS4s select the types of practices they could use to develop and implement their stormwater management programs.

EPA's Water Use Efficiency Program Web Site

www.epa.gov/owm/water-efficiency. This site provides information on EPA's new national program to promote water-efficient products to consumers. A broad spectrum of stakeholders, from homeowners to state governments, can find information here that can help them become more water-efficient.

Hydrologic Cycle

http://ga.water.usgs.gov/edu/watercycle.html. This new U.S. Geological Survey Web site provides in-depth, illustrated discussions about the hydrologic cycle. Available in 37 languages, the site provides educational discussion on each of 15 primary areas of the cycle, including condensation, runoff, storage, springs, flow, and more.

North Carolina's Stormwater and Runoff Pollution Web Site

www.ncstormwater.org. North Carolina's new stormwater management Web site offers educational material ranging from novice to expert, children's activities, research, news, events, and a toolkit of outreach resources for local governments. Although developed for North Carolina, the site contains stormwater education information applicable to a wide audience.

Google Earth

http://earth.google.com. Google recently released a free utility for PC Windows that combines satellite imagery and aerial photos with other Google mapping tools. The program allows users to conduct flyovers of the Earth, and zoom in on particular addresses and locations. This amazing mapping resource, available to anyone with a computer and a fast connection, can serve as a useful watershed planning and outreach tool.

Calendar

August 2005

18-19 Petroleum Hydrocarbons and Organic Chemicals in Ground Water: Prevention, Assessment, and Remediation Conference, Costa Mesa, CA. For more information, see www.ngwa.org/e/conf/0508175040.shtml.

28-31 Technology 2005 – 2nd Joint Specialty Conference for Sustainable Management of Water Quality Systems for the 21st Century: Working to Protect Public Health, San Francisco, CA. For more information, see www.wef.org/conferences/.

29-Sep 2 International Conference on Ecology and Transportation, San Diego, CA. For more information, see www.icoet.net.

31-Sep 2 Animal Agriculture and Processing: Managing Environmental Impacts, St. Louis, MO. For more information, see www.awma.org/events/confs/Animal.

September 2005

6-9 2005 Annual Conference of the Floodplain Management Association, Sacramento, CA. For more information, see www.floodplain.org.

14-16 Ecotourism in the United States, Bar Harbor, ME. For more information, see www.ecotourism.org.

19-22 13th National Nonpoint Source Monitoring Workshop, Raleigh, NC. For more information, see www.bae.ncsu.edu/programs/extension/wqg.

19-23 Oceans 2005, Washington, D.C. For more information, see www.oceans2005.org.

October 2005

12-13 Pennsylvania Stormwater Management Symposium, Villanova, PA. For more information, see www.villanova.edu/vusp.

17-20 National Conference on Nonpoint Source and Stormwater Pollution Education Programs, Chicago, IL. For more information, visit www.epa.gov/npdes/stormwater and select the "Trainings and Meetings" link on the right side box, or contact Bob Kirschner at the Chicago Botanic Garden by e-mail: bkirschn@chicagobotanic.org.

25-28 Eighth Annual Wetlands and Watersheds Workshop: Aquatic Systems and Water Quality, Atlantic City, NJ. For more information, see www.wetlandsworkgroup.org.

31-Nov 2 2005 Sustainable Beaches Conference, St. Petersburg, FL. For more information, see www.cleanbeaches.org.

November 2005

1-3 North Carolina Stream Restoration Institute's River Course: Stream Restoration Design Principles, Raleigh, NC. For more information, see www.bae.ncsu.edu/programs/extension/wqg/sri/RiverCourse.htm.

2-3 2005 Great Lakes Beach Association Annual Conference, Green Bay, WI. For more information, see www.great-lakes.net/glba/2005conference.html.

7-9 California 2005 Nonpoint Source Conference, Sacramento, CA. For more information, see www.swrcb.ca.gov/nps/fall2005.html.

15-16 Workshop: Integrated Restoration of Riverine Wetlands, Streams, Riparian Areas, and Floodplains, Amherst, MA. For more information, see www.aswm.org/calendar/integratingrest/integratedrest.htm.

17-18 Nature at Your Service – 2005 National Conference on Urban Ecosystems, Charlotte, NC. For more information, see www.americanforests.org/conference.

Contribute to Nonpoint Source News-Notes

Do you have an article or idea to share? Want to ask a question or need more information? Please contact NPS News-Notes, c/o Carol Forshee, by mail at U.S. EPA, Mail Code 4503-T, 1200 Pennsylvania Ave., NW, Washington, DC 20460, by phone at 202-566-1208, or by e-mail at forshee.carol@epa.gov.

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