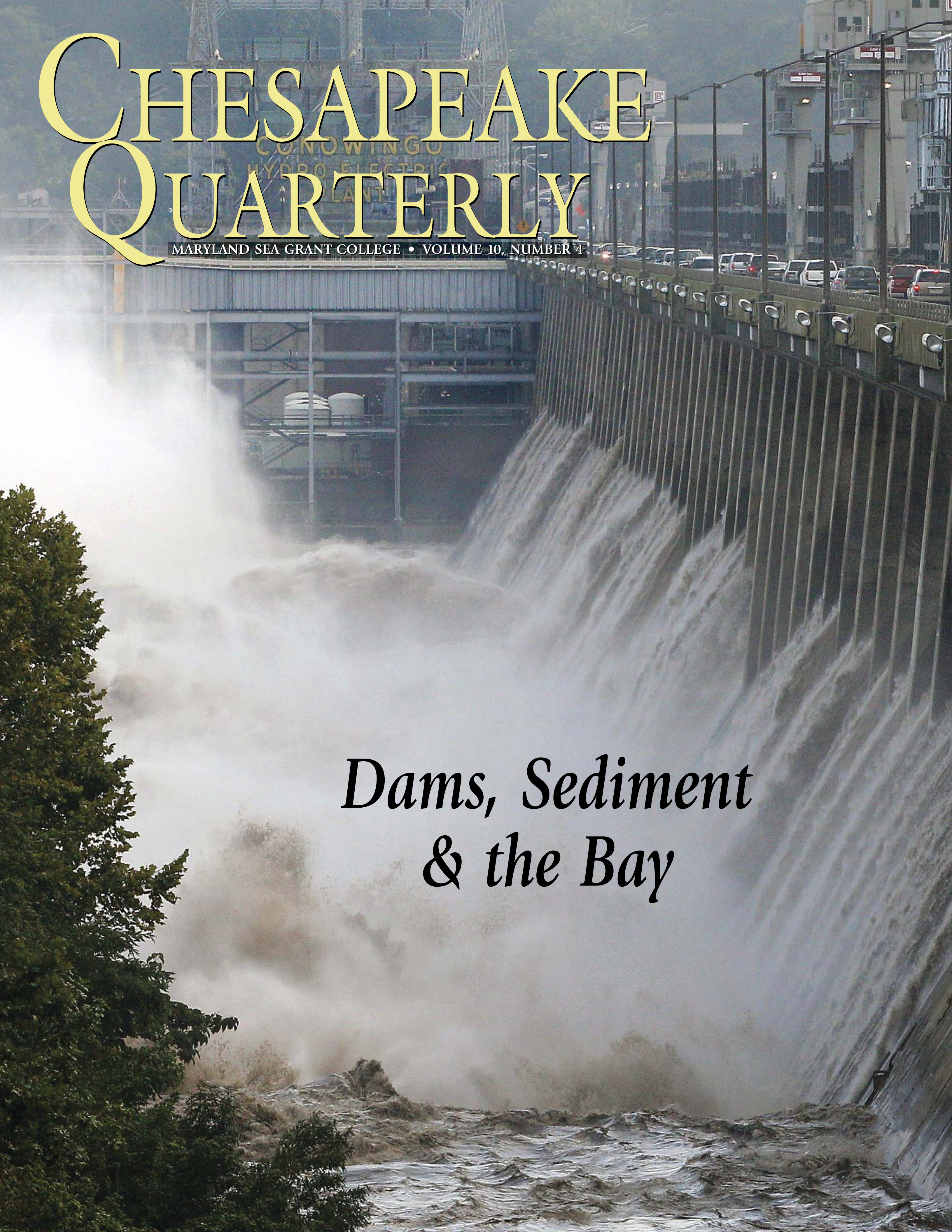
Chesapeake Quarterly

MARYLAND SEA GRANT COLLEGE • VOLUME 10, NUMBER 4



Dams, Sediment & the Bay

contents

Volume 10, Number 4

CHESAPEAKE QUARTERLY December 2011

Chesapeake Quarterly explores scientific, environmental, and cultural issues relevant to the Chesapeake Bay and its watershed.

This magazine is produced and funded by the Maryland Sea Grant College Program, which receives support from the National Oceanic and Atmospheric Administration and the state of Maryland. Assistant Director for Communications, Jeffrey Brainard; Editor, Michael W. Fincham; Production Editor and Art Director, Sandy Rodgers. Send items for the magazine to:

Maryland Sea Grant College
4321 Hartwick Road, Suite 300
University System of Maryland
College Park, Maryland 20740
301.405.7500, fax 301.314.5780
e-mail: mdsg@mdsg.umd.edu
www.mdsg.umd.edu

***Cover photo:** The Conowingo Dam opened its gates to alleviate flooding on September 9, 2011, as Tropical Storm Lee swept through the area.* PHOTOGRAPH BY PATRICK SEMANSKY / ASSOCIATED PRESS. ***Pages 2 and 3:** Tropical storms Irene and Lee delivered a one-two punch to the Chesapeake Bay in August and September 2011. They washed detritus such as boards, tree branches, and even propane gas containers into the Bay and later deposited them along miles of Bay shoreline, including here at Sandy Point State Park near Annapolis, Maryland.* PHOTOGRAPH BY DAVID HARP.

BIG YEAR FOR STORMS BAD YEAR FOR

Tropical Storm Lee flushed sediment into the Bay, but scientists question its effect

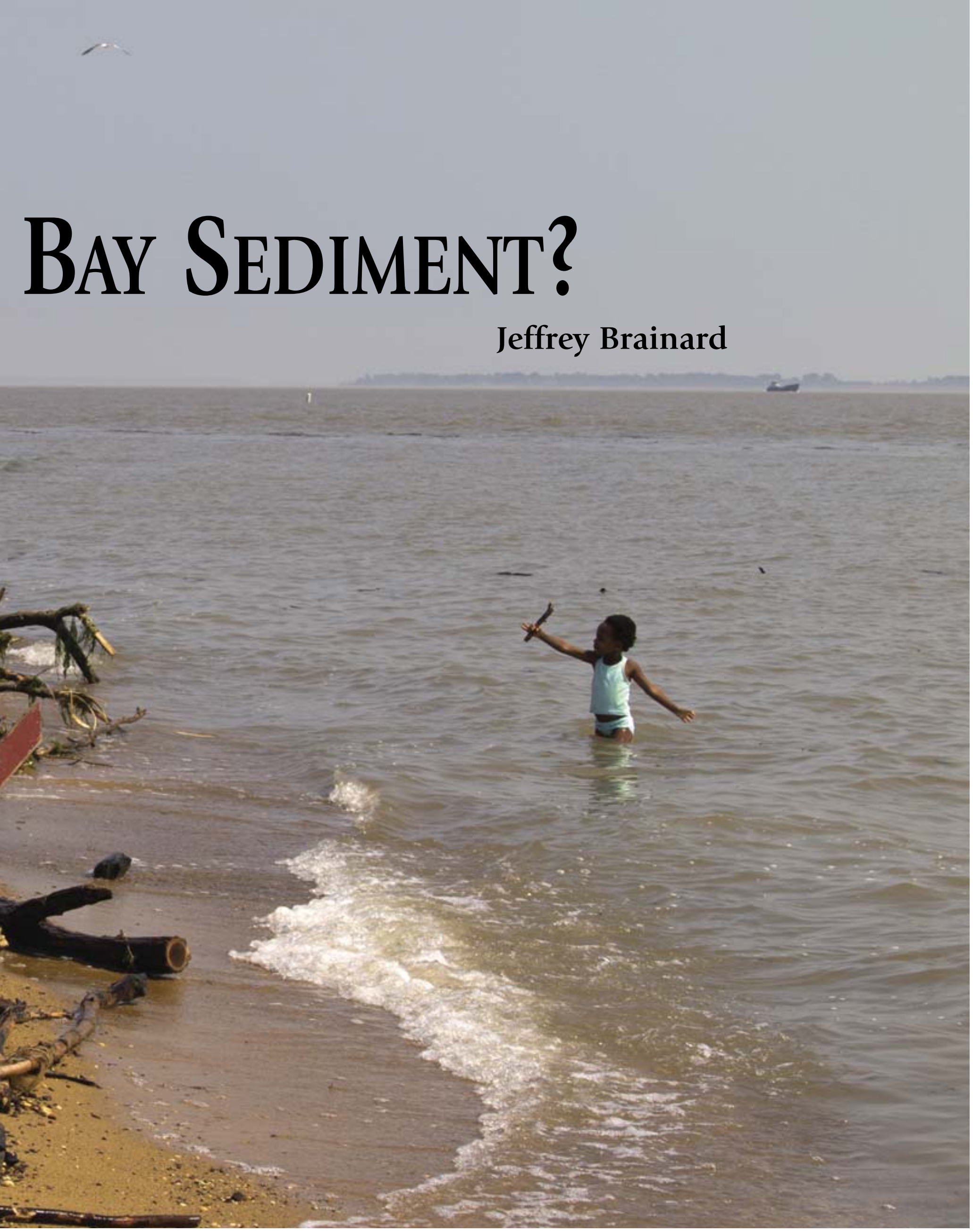
Jeffrey Halka and Larry Sanford watched as the coring tube disappeared over the side of the *RV Kerhin*, a research vessel on station in the northern Chesapeake Bay. The tube held a heavy weight that would help the core sink quickly and burrow into the Bay's bottom four meters below.

They worked under a September rain, a reminder that 2011 was turning into one of the wettest years on record. Two big tropical storms, Irene and Lee, had blown over the Chesapeake a few weeks earlier, dumping torrential rain on the region. The Bay's water was still brown.

As they worked, the two scientists had an older, more famous storm in mind. Halka is director of the Maryland Geological Survey and Sanford is a professor at the Horn Point Laboratory, part of the University of Maryland Center for Environmental Science. Both had studied the history of Tropical Storm Agnes, the 1972 storm that caused the greatest flooding in the Chesapeake in modern times. Halka and Sanford were taking

Bay Sediment?

Jeffrey Brainard



sediment samples that September day from the same area of the upper Bay, near Aberdeen Proving Ground, where researchers had found some of the thickest deposits of sediment following Agnes. That sediment onslaught is seen as an important reason for a big die-off in the following years of oysters and underwater grasses.

Halka and Sanford hoped the samples would show how much new sediment was deposited by Lee on the Bay's bottom. They knew that the tropical storm had caused the second-largest water flow since Agnes in the lower Susquehanna River, the Chesapeake's largest tributary. Had a new layer of life-smothering mud flushed into the Bay?

Their preliminary findings, and those of other researchers, offer hope for optimism. But they also underscore how little is known about the effects of big storms on the Bay's ecology.

One for the Record Books

After Agnes hit in 1972, scientists produced a thick bound report about its effects. The volume contains some startling numbers illustrating why that storm remains a historic benchmark and case study. During a three-day period in late June, the tropical storm (which started as a hurricane on the Gulf Coast) dumped up to 18 inches of rain in pockets of the Susquehanna River watershed and, across all of it, an average of 8 inches. The watershed was already soggy from heavy spring rainfall.

The result was an epic torrent. For the 10-day period after the start of the rains, the flow averaged 15 times normal, and peaked at 30 times normal. This in turn sent a huge slug of sediment into the Chesapeake Bay: an estimated 30 million tons. Today, the average annual flow of sediment from the Susquehanna is only about 1.5 million tons. It was more sediment than had been discharged from the Susquehanna during all of the preceding 10 years and perhaps a quarter-century. The flood acted like a time machine: in only two weeks, the upper Bay had aged the equivalent of 10 to 25 years in geologic terms.

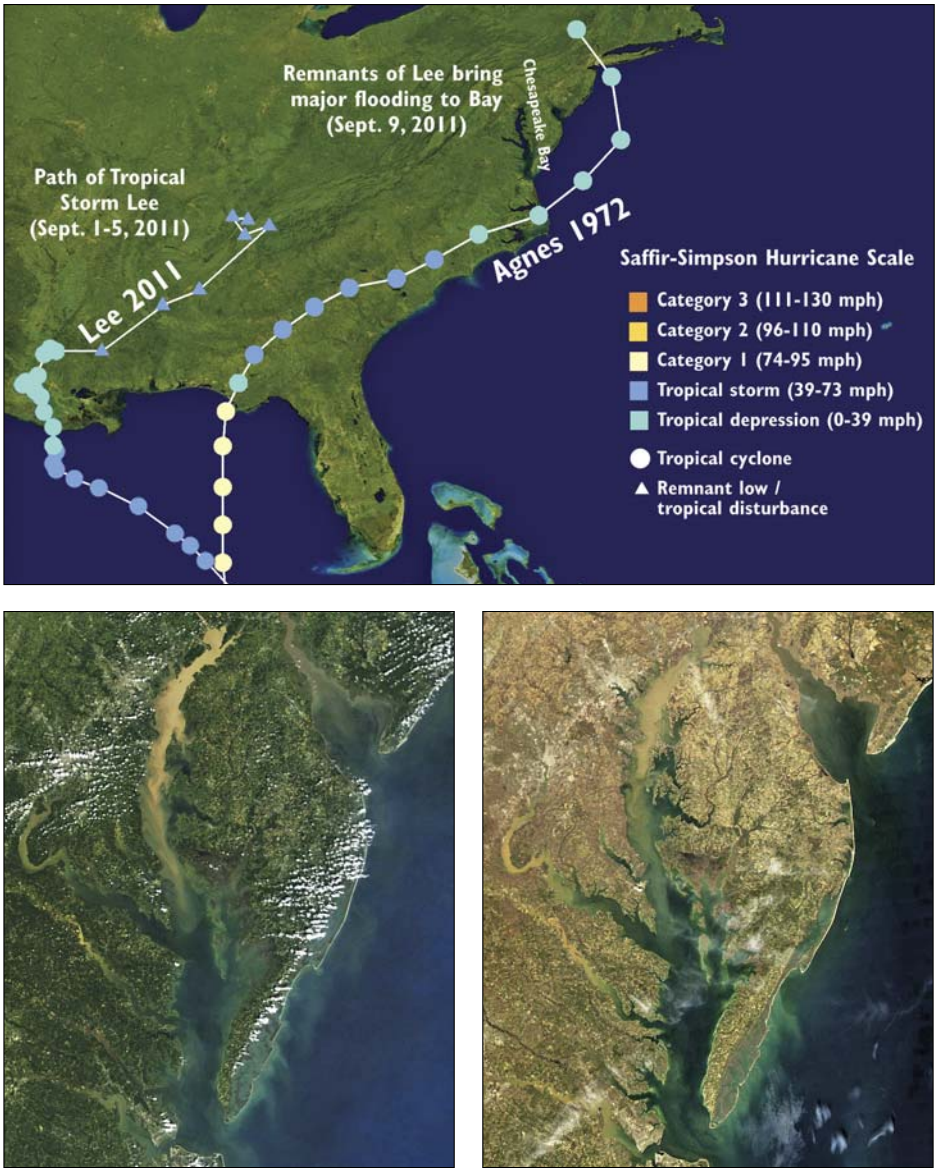
The sediment — which is essentially river mud, made up of sands, silts, and clays — came from riverbanks and runoff from fields and lawns. The post-Agnes scientific report estimated that nearly a foot of new sediment was deposited at points in the upper Bay, north of the Bay Bridge, between Turkey Point and Tolchester Beach, Maryland. Up to one meter went into the shipping channel in that area.

The scientific assessment also found that the impacts of this deluge were especially severe around the Susquehanna Flats, the shallow area at the mouth of the Susquehanna River. The underwater grasses, also called submerged aquatic vegetation, lay directly in the path of inundation. The assessment estimated that the volume of vegetation declined by 67 percent. A year before the study, aquatic plants covered 29 percent of the area measured; a year later, they covered only 10 percent.

Agnes's timing could hardly have been worse because June is when underwater grasses are just sprouting. The grasses are important in the Bay's ecology because they provide habitat for juvenile fish and enhance water clarity by trapping and removing sediment from the water.

Sediment from the Dams

Even during normal conditions, sediment flow from the Susquehanna has a big



Tropical Storm Lee *turned the Chesapeake Bay brown (bottom left, satellite photo from September 2011) as silt and clay from the Susquehanna River and other sources swept in. Tropical Storm Agnes, in June 1972, caused the biggest single load of sediment on record. As shown by their tracks (top), neither storm was a hurricane by the time it reached the area — but both generated loads of rain. Sediment also muddies the Bay each spring when it is swept in with snow melts (bottom right, satellite photo from April 2011) and from winter storms, like the unnamed one in January 1996 responsible for the second-largest sediment dump from the Susquehanna River.* *SOURCE: STORM TRACKS, NATIONAL HURRICANE CENTER; SATELLITE IMAGES, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.*

influence on the upper Bay. The river is the Bay's largest single nontidal source of sediment, contributing about a quarter of the total. Tides sweep additional amounts of sand from the Atlantic Ocean and deposit it in the lower Bay.

But under the abnormal conditions of a big storm, the flow of sediment from the Susquehanna to the Bay is magnified. That's because the lower Susquehanna is home to three hydroelectric dams that are holding back millions of tons of sediments that have been trapped behind them during their decades of operation (see "Countdown for the Conowingo," p. 8). High river flows can scour out several million tons in just a few days, more than the 1.5 million tons reaching the Bay in an entire year.

In earlier decades when it was healthier, the Chesapeake's ecosystem was better able to withstand a storm-driven pulse of river mud. Aquatic vegetation bounced back in as little as two to three years after a series of big storms hit the Bay in the mid-1950s, research indicates. (They were Hurricane Hazel, in 1954, and tropical storms Connie and Diane, in August 1955.) Agnes was unusual in that the vegetation declined precipitously and then stayed low for years after. It didn't help that levels of nitrogen and phosphorus in the Bay continued to rise after Agnes. Nutrients remain high today and continue to make the Bay more vulnerable to the effects of big storms than it otherwise would be.

Lee, which hit the region in early September 2011, was mercifully far smaller than Agnes. (Irene dumped high rainfall on the Eastern Shore in late August but less in the Susquehanna watershed.) The U.S. Geological Survey estimated that the Susquehanna delivered less than half as much water to the Bay after Lee than it did post-Agnes. Lee also brought less sediment, about 4 million tons, compared with Agnes's 30 million. Even so, the flow after Lee ranks ahead of most other storms on record for river flow in the lower Susquehanna. That's why scientists were curious about the storms' effects on aquatic vegetation in the upper Bay, including the beds at the Susquehanna Flats. Researchers had recorded a resurgence of growth there during the past five years. Had Lee brought sediment on anything like the scale of Agnes?

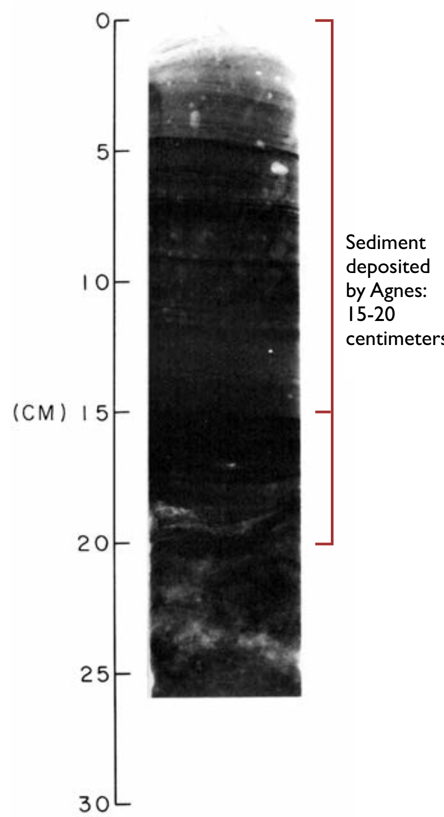
During their trip in September on the *Kerhin*, Halka and Sanford obtained a series of eight cores, or meter-long samples, of sediments, following a north-south line in the upper Bay. While the research is still incomplete, the researchers found evidence of a sediment dump that was modest in comparison with that from Agnes. In the same location where researchers had identified 20 centimeters of new sediment from Agnes, Sanford and Halka found a surface layer, measuring about 5 centimeters, of what appeared to be new sediment. The light-brown, soft

Significant Storms over the Susquehanna River Watershed

Storm	Year	Month	Peak flow (cubic feet per second)	Average recurrence of storm that size*	Sediment scoured from Conowingo Dam (million tons)*
unnamed	1936	March	798,000	~100 years	n/a
Hurricane Agnes	1972	June	1,130,000	~300 years	20
Hurricane Eloise	1975	September	710,000	~50 years	5
unnamed	1993	April	442,000	~10 years	2
unnamed	1996	January	909,000	~200 years	12
Hurricane Ivan	2004	September	620,000	~30 years	3
unnamed	2011	March	487,000	~10 years	2
Tropical Storm Lee	2011	September	778,000	~30 years	4

**Estimates subject to margins of error.*

***Large storms can threaten** the Bay's ecology by dumping large amounts of sediment and nutrients into the Bay, choking off submerged aquatic vegetation. But as the table at left shows, most of the largest storms to hit the Bay came during the winter or fall, when those plants are dormant or near the end of their growing season. Tropical Storm Agnes was a devastating exception, hitting in June 1972 at the beginning of the growing season. The sediment core below measured some 15-20 centimeters of sediment dumped by Agnes in one location. Scientists like Larry Sanford (left, with sediment core) predict that if the reservoir behind the Conowingo Dam on the lower Susquehanna River fills up with sediment, the amount scoured out by big storms and sent to the Bay will increase.* SOURCE: TABLE, U.S. GEOLOGICAL SURVEY AND EXELON CORPORATION; SEDIMENT CORE GRAPHIC, COURTESY OF THE CHESAPEAKE RESEARCH CONSORTIUM. PHOTOGRAPH BY JACK GREER.



material contrasted with grayish sediment beneath that was probably older. It made sense, Sanford says, that the layer identified from Agnes measured about four times the depth of the one found after Lee. Estimates are that Agnes scoured about four times as much sediment from behind the Susquehanna dams as did Lee.

However, the scientists found only 1 to 2 centimeters of apparently new sediment at other spots around the upper Bay that day and during a separate cruise in October south of the Bay Bridge. It was déjà vu for Halka, who had done similar testing for sediment after a big, unnamed storm in January 1996. He had found no evidence then of sediment attributable to that storm.

The apparent lack of sediment this year is "surprising," says Halka. "We're still scratching our heads about how sediment is delivered to the Bay [during a storm] and what happens to it once it gets there."

The Art of Measurement

The science of measuring and tracking sediments around the Bay's bottom, it turns out, involves some tricky sleuthing. Researchers who study them have used a variety of methods.

Visually inspecting the cores can be deceptive, Sanford explains. Color is not necessarily an indication of age; certain geochemical processes can make older sediments look light brown, too.

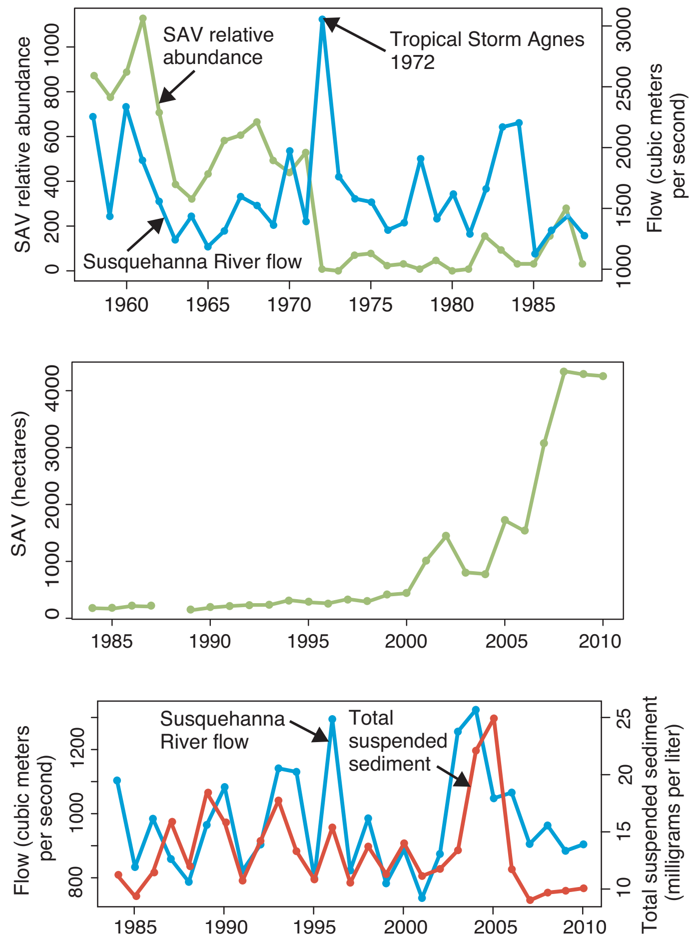
Researchers are examining another line of evidence from X-ray photographs of the cores. This was the primary method used in the 1970s to study sediment deposited after Agnes. However, just as physicians can draw different interpretations of the same X-rays of a human lung, so can geologists when examining X-rays of sediments. Where the earlier scientists reported that one post-Agnes sample showed a sediment layer of up to 20 centimeters, Halka draws a different conclusion: "I'd say there's only one or two," he says. This raises intriguing questions about whether Agnes indeed deposited as smothering a load of sediment as is commonly thought.

One of Sanford's colleagues at Horn Point Lab, assistant professor Cindy Palinkas, is using yet another gauge of age to study the sediments obtained after this year's storms. The method, not available to researchers in the 1970s, uses a radioisotope called beryllium 7. The element becomes attached to sediments when they are above water. The isotope has a half-life of only 53 days (it loses half of its radioactivity in that span), so its presence in bottom sediments suggests that they were recently washed into the Bay. The results of this method indicate that the 5-centimeter layer from the core taken near the Sassafras River was indeed recently deposited there, as were the 1- to 2-centimeter layers in the other samples taken farther south. That suggests that the sediments were deposited there by Lee — but not to the depth that scientists anticipated.

"It's clear that the system isn't operating the way we expect," Palinkas notes. "We expected to see all of the sediment concentrated in the northern part of the Bay. It may be instead that a thinner layer is being spread out over a wider area. From a biological standpoint, SAV [submerged aquatic vegetation] and oysters can do better with a dusting than getting dumped on."

Sanford adds that learning more about where sediments go during storms would require collecting more data from more locations. But it's difficult to finance and organize a short-term research effort like that. Scientists funded by research grants work on long time scales.

"We get these massive events [storms] every once in awhile," Sanford says. "And they remind us that they probably have, although we don't really know, a big impact on the system. But it's so hard to try to organize a research program around unpredictable large storms, that we never really answer that question. And then we wait for the next event."



The abundance of submerged aquatic vegetation *in the Susquehanna Flats area (top, shown in green, on a relative scale) plunged after Tropical Storm Agnes. But data for 1984 to 2010 (middle), which are based on a different method, show a large increase in recent years. The concentration of total suspended sediment (bottom graph, in red) follows closely with flow (blue) from the Susquehanna River.* FIGURES BY CASSIE GURBISZ, UMCES HORN POINT LAB; DATA FROM A VARIETY OF SOURCES.

Another effect of Lee was that the remaining oysters of the upper Bay were decimated, the Maryland Department of Natural Resources announced in November. But biologists add that the oysters were probably done in by high freshwater flows from rainfall earlier in 2011, before the two tropical storms arrived. Sediment may not have played an important role. What's more, the upper-Bay oysters represent only 2 percent of the Bay's remaining population.

One big question mark is Lee's effect on submerged aquatic vegetation. How much sediment the plants can survive — and at what point a survivable dusting of river mud turns into a fatal dump — is among the storm-related questions that scientists haven't studied in depth. But the Susquehanna Flats may provide some clues.

Survival of Aquatic Grasses

Submerged vegetation in the Flats has represented a bright spot in the Bay's recovery. The bed had grown from nearly nothing in 1984 to 8 kilometers wide by 2009. Just as high flow from the Susquehanna has threatened the bed, a drought has seemed to help: its growth accelerated in 2005 after several consecutive years of low flow, says Cassie Gurbisz, a graduate student at Horn Point Lab who has studied the bed. The lower flow,

***An aerial photo** (top) of underwater grasses in the Susquehanna Flats, taken in November 2011, shows abundant vegetation (light areas) and little change from photos taken the previous year. This suggests that this year's storms may have left intact the grass beds, which have grown significantly since 2001 (bottom), when they were scarce.* SOURCE: ANNUAL SUBMERGED AQUATIC VEGETATION MONITORING PROGRAM, VIRGINIA INSTITUTE OF MARINE SCIENCE.

she says, would have resulted in lower delivery of sediments and nitrogen from the river's mouth.

After this year's storms, Gurbisz and other scientists had to hold their collective breath to learn what had happened to the grass beds. Their condition, and that of submerged aquatic vegetation along the length of the Bay, have been charted annually through aerial surveys sponsored by the Virginia Institute of Marine Science. However, Lee blew across the Chesapeake just before the program had planned its annual overflight of that part of the upper Bay. For weeks afterwards, the water was too opaque to justify the cost of an overflight, because sponsors knew they would get no useable images.

The water didn't clear sufficiently until the first week of November, when a flight was finally sent up. The result: it appeared that the flats were largely intact.

"We were pleasantly surprised or even shocked," says Robert Orth, a professor at the Virginia Institute of Marine Science who oversees the overflight program. "Just visually comparing what the Bay looked like a year ago, one would not have known there was a big storm." He adds, "We think the size of the bed played a role in mediating those effects." But next year's growing season will provide more proof, he says.

Some damage to the bed seems likely, says Michael Kemp, a professor at Horn Point Lab and Gurbisz's advisor, who has extensively studied the Bay's aquatic vegetation. The latest photograph may show what is actually "a good bit of dead, standing plant material," he says. "We hope for the best, that the bed is going to come back. I doubt that it will come back like it has been in the previous four or five years." He adds, "We'll surely learn something from [those effects]." But he calls the storms "depressing" because he and his colleagues were planning to conduct further research to better understand the reasons for the bed's resurgence. The storm's effects will likely muddy those results.

Still, the storms could have done more damage had they hit in June, as Agnes did in 1972. The importance of timing was underscored by an analysis published in 2005 by Ping Wang and Lewis Linker of the U.S. Environmental Protection Agency's Chesapeake Bay Program Office. They used a computer model to simulate the impact of storms on submerged aquatic vegetation at different times of the growing season. The model suggested that peak growth of vegetation for the season fell by about half following a July storm but by a smaller amount following a September storm. Storms also weakened the plants so that peak growth remained lower than average the following year.

Another important effect of this year's storms could be the increased loads of nitrogen and phosphorus washed into the Bay. They could drive algae blooms next summer that in turn could result in another record year of hypoxic "dead zones." Scientists plan to conduct more analysis and aerial surveys next year — the 40th anniversary of Agnes — to understand better how this year's storms stack up against that catastrophe.

— *brainard@mdsg.umd.edu*

For More Information

The Effects of Tropical Storm Agnes on the Chesapeake Bay Estuarine System. Chesapeake Research Consortium. 1976. Johns Hopkins University Press. 639 pp.

Bathymetry and Sediment-storage Capacity Change in Three Reservoirs on the Lower Susquehanna River, 1996-2008. Michael J. Langland. 2009. U.S. Geological Survey Scientific Investigations Report 2009-5110. 21 pp.

Sediment Introduction and Transport Study RSP 3.15. Conowingo Hydroelectric Project, Exelon Corporation. May 2011.
Part 1: www.exeloncorp.com/assets/energy/powerplants/docs/Conowingo/Conowingo_RSP_3.15Part1.pdf
Part 2: www.exeloncorp.com/assets/energy/powerplants/docs/Conowingo/Conowingo_RSP_3.15Part2.pdf

The Impact of Susquehanna Sediments on the Chesapeake Bay. Chesapeake Bay Program, Scientific and Technical Advisory Committee, Workshop Report. May 2000. www.chesapeake.org/stac/Pubs/Sediment_Report.pdf

Effect of timing of extreme storms on Chesapeake Bay submerged aquatic vegetation. P. Wang and L.C. Linker. 2005. In K.G. Sellner (ed.), *Hurricane Isabel in Perspective*. Chesapeake Research Consortium, CRC Publication 05-160, Edgewater, Maryland. www.chesapeake.org/pubs/Isabel/Wang%20and%20Linker.pdf

Countdown for the Conowingo

Jeffrey Brainard

The Conowingo Dam keeps sediment from entering the Bay, but for how much longer?

Last year, the federal government directed the communities surrounding the Chesapeake Bay to take on a difficult challenge: improve the Bay's water quality by reducing the overabundance of sediments and nutrients flowing into it by 2025. But that might prove to be an especially big challenge for residents of Pennsylvania and New York if policy makers don't figure out what to do about the Conowingo Dam on the Susquehanna River.

The Conowingo hydroelectric dam, located ten miles upriver from where the Susquehanna meets the Bay, currently offers a boon to the Bay's ecology, but also a potential threat. The beneficial part is that under normal weather conditions, the dam traps more than half the sediment reaching it — sand, silt, and clay washed into the river from fields and construction sites upriver. The trapped sediment would otherwise end up in the Bay.

The downside of the dam, which was built in 1928 and has been accumulating deposits all these years, is that sediment could completely fill its reservoir within 15 years. After that, all of the sediment reaching the dam would flow through it downstream, more than doubling the current amount reaching the Chesapeake and far exceeding the planned reduction in sediment loads. Also worrisome are findings that the more sediment trapped behind the dam, the larger the volume scooped up and sent toward the Bay during large storms.

Like the dam, the sediment results in two kinds of impacts on the Bay, one benign and another alarming. Too much fine-grain sediment suspended in the water can choke off the growth of the submerged aquatic vegetation that improves water quality and provides habitat for fish. But the Bay's marshes need coarser sediments to survive.

So, in theory, pumping some of the larger-grained sediments from the reservoir might yield two benefits at once: increasing the dam's storage capacity and helping marshes downstream. A new study, begun in 2011, will examine that and other ideas for dealing with the Conowingo conundrum.

"Everyone's concerned that we're spending all this time and effort working out how to control nonpoint sources of sediments and nutrients from flowing into the Bay," says Anna Compton, study manager for the U.S. Army Corps of Engineers, which will conduct the study. "But the big unknown remains the sediments trapped behind the dams in the Susquehanna River."

It's Not Easy Being Green

The Susquehanna is the Bay's largest tributary, and one of its largest sources of sediment. At 464 miles, it is also the longest river on the East Coast that drains into the Atlantic Ocean, and one of the most flood-prone.

The nearly-mile-wide Conowingo Dam, in Cecil County, Maryland, is the southernmost and largest hydroelectric dam on the river. Two smaller dams upriver, Holtwood and Safe Harbor, will also be included in the new Corps of Engineers study. The smaller dams' reservoirs have already completely filled with sediment, leaving the Conowingo as the last manmade stopping point for sediment headed toward the Bay.

It's difficult to paint the Conowingo as an environmental threat when one considers the green energy it generates:

***Roiling waters sent** tons of sediment and nutrients through the Conowingo Dam's floodgates (above) following Tropical Storm Lee in September 2011, carrying them down the Susquehanna River (opposite page, at the Cecil County/Harford County line) toward the Chesapeake Bay. During calmer weather, the dam traps about half of all sediment, preventing it from reaching the Bay.* *PHOTOGRAPHS: OPPOSITE PAGE, ED RYBCZYNSKI; THIS PAGE, WENDY MCPHERSON, U.S. GEOLOGICAL SURVEY.*

those 572 megawatts provide enough power for nearly a half-million homes, with no emission of greenhouse gases.

Then there's the sediment trapped behind the dam. Each year more than 3 million tons of sediment reach the dam from upriver, and the dam captures close to 2 million tons, according to estimates by the U.S. Geological Survey. A figure of nearly 2 million tons can be difficult to grasp, but according to estimates by the Susquehanna River Basin Commission, the material would annually fill more than 22,000 railroad hopper cars.

The estimate for when the Conowingo reservoir will fill, according to a 2009 Geological Survey report, is 15 to 20 years. That lifespan could be extended by another five to ten years if people upriver cut the total amount of sediment reaching the dam by about 20 percent. That's the same amount of reduction, as it turns out, that the U.S. Environmental Protection Agency set in 2010 for the entire Chesapeake in its "pollution-diet" plan for reducing sediment and nutrients.

The capacity could be further stretched out, the estimate said, if the Susquehanna gets hit with more big storms. High water flows in the river scour out sediment from the Conowingo's reservoir at predictable rates. For example, rain from Tropical Storm Lee, which socked the region in September, dug out 4 million tons, the Geological Survey estimates. That bought the equivalent of another two years of storage capacity, but at a price to the environment: the pulse of sediment, flowing over just a few days, was larger than what the upper Bay normally receives in an entire year.

Once the dam's reservoir reaches capacity, Conowingo's role as a friend of the Chesapeake could diminish or end. The flow of sediment past the dam would more than double to some 3.3 million tons annually. (Increased amounts of nitrogen and phosphorus would also move downstream.) The 1.8-million-ton increase in sediment would far surpass the magnitude of the decrease that Pennsylvania is required to achieve under the EPA sediment-reduction plan.

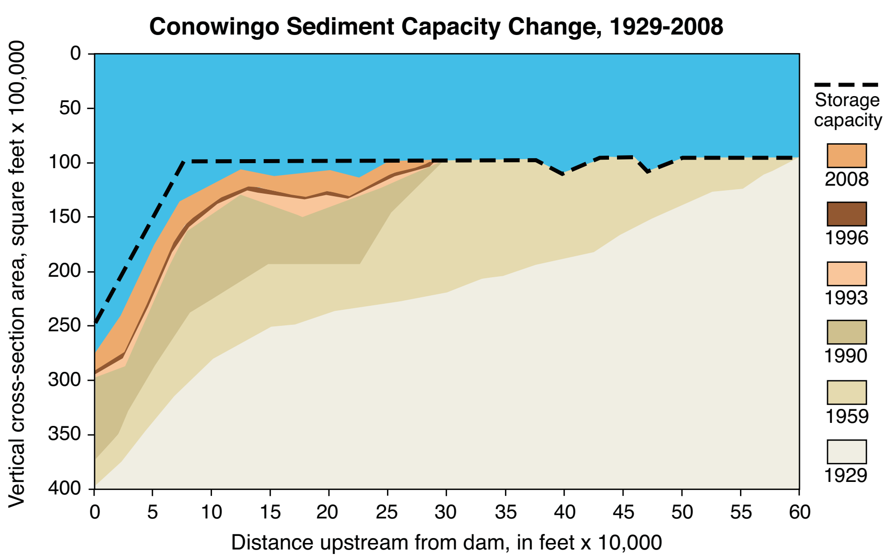
This target is based on the current amount of sediment flowing from the Susquehanna; the plan does not include any exception to the sediment limit if the Conowingo's reservoir fills up. As a result, if the capacity runs out, Pennsylvania would be required to reduce sediments in the river by much more than is called for under the current EPA plan, by greater than 60 percent.

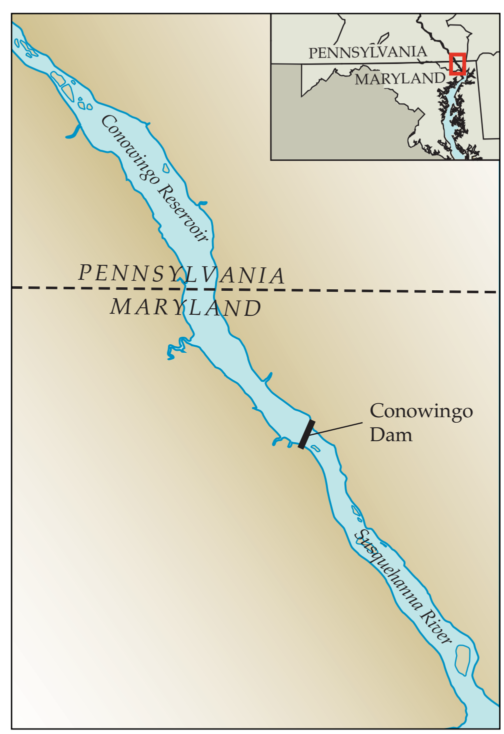
Experts agree this could be extremely difficult to achieve. Reducing sediment would require a variety of land-use restrictions and conservation measures across the Susquehanna's 27,500-square-mile watershed — for example, containing soil that washes off farms and construction sites into streams and storm drains during storms. Residents and elected officials in Pennsylvania and other states have already complained that a 20-percent reduction in sediment looks prohibitively expensive.

That's why federal and state agencies agreed this year that it was time to look for solutions to the concerns raised about the Conowingo Dam.

An Engineering Solution?

The Corps of Engineers announced in September 2011 that it was starting a three-year, $1.4 million study to review possible solutions and their possible costs. Partners include the state of Maryland, the Susquehanna River Basin Commission, and the nonprofit Nature Conservancy.





The Conowingo Dam, *located five miles below the Pennsylvania-Maryland border, is the last dam on the Susquehanna River before it empties into the Chesapeake Bay. The dam's original storage space has shrunk over the years since it was built, as shown in the graph above. The remaining capacity could run out by 2024.* *SOURCE: GRAPH, MICHAEL LANGLAND, U.S. GEOLOGICAL SURVEY; MAP, REDRAWN FROM A U.S. GEOLOGICAL SURVEY MAP.*

The study is intended to provide a more detailed and accurate understanding of sediment flow in the Susquehanna and the role of the three dams in storing the material. The project is expected to provide analysis and estimated cost ranges for management options other than dredging.

The new analysis will differ in several ways from previous studies of the Conowingo. It's the first by the Corps of Engineers, a national leader in projects to dredge sediments. A key player in the study will be the Corps Army Engineer Research and Development Center in Vicksburg, Mississippi, which is known for its expertise in studying the transport of sediments down the Mississippi River to its delta.

It's also the first study to examine how the upper Chesapeake's ecology could be affected by varying quantities of sediment delivered from the dams. The Corps will use a model of the Bay's water quality developed by the Vicksburg lab and used by the EPA's Chesapeake Bay Program Office to calculate the sediment limits.

Besides reexamining dredging, the study will also consider, among other options, a method called sluicing. Sediment could be funneled past the dam in a pipe, but in a controlled procedure meant to minimize the impact on the upper Bay's ecology. Of key importance, the work might occur only during the winter months, when aquatic vegetation is dormant and fish are not spawning.

The sluicing approach has attracted interest from researchers who think it could benefit the Bay's ecosystem. The upper Chesapeake is starved for the kind of sandy, large-grain sediment that makes up much of the material trapped behind the dams, says Michael Langland of the U.S. Geological Survey, who has estimated the dam's remaining storage capacity. The sand deficit resulted because different-sized sediments behave in different ways. Sandy sediments fall to the bottom relatively quickly in rivers, water doesn't carry them as far, and they are more easily trapped behind dams. However, much of the sediment flowing through the dam consists of smaller particles like silt and clay, which settle more slowly and so are carried farther.

The construction of the Conowingo largely blocked the natural movement of the bigger sediments down the Susquehanna and into the Bay. Marshes require fresh supplies of sandy sediment to replace their own stores that are eroded naturally by waves. They need this sandy material to keep pace with sea-level rise in coming years.

Neither sluicing nor the other options under study by the Corps of Engineers is guaranteed to extend indefinitely the Conowingo's capacity to store sediments, Compton says. But some measures could at least extend its capacity by a few additional years, buying more time for policy makers and people living in the Susquehanna watershed to reduce the sediment load.

Paying for It All

A question mark about the Corps of Engineers study is whether Congress will finance the full $1.4 million price tag. So far it has provided only $250,000. However, the project is included in the Corps budget for 2012, and Compton says that the Corps has placed a high priority on it.

Financing the study may prove far simpler than funding any solutions it recommends. Who will pay, and how much? The answer remains to be determined.

The Susquehanna River Basin Commission estimated in 1995 the cost to dredge only the 2 million tons of sediment that is newly trapped behind the dam each year: $48 million, in 2010 dollars. That figure did not include disposing of the material or removing any of the more than 174 million tons that have already accumulated in the reservoir.

For its part, the dam's owner, Exelon Corporation, has been noncommittal on whether it would share in the cost of a fix. In a public document, corporation officials did call dredging "very unlikely" to be viable because of costs and other factors. And the corporation has said that it "cannot bear primary responsibility (both in terms of costs and resources) for addressing the adverse impacts of others," impacts like sediment entering the Susquehanna above the dam.

"[In the river's watershed], there's a lot of people on that land contributing to that 3 million tons, and we're going to need everybody to address that," says Mary Helen Marsh, Exelon's director of environmental operations. "It's a watershed issue; it's not a Conowingo Dam issue."

Exelon's license to operate the dam expires in 2014, and sediment could play a role in the license renewal process now underway. The Federal Energy Regulatory Commission, which controls the license, asked the corporation in 2010 to develop a plan for managing the sediment.

The Corps of Engineers might participate in financing a fix for the sediment problem, Compton says.

If the Conowingo's reservoir is allowed to fill completely and the target level for sediment downstream is exceeded, the consequences could be dire. The EPA has threatened tough enforcement actions, like requiring local governments to adopt and impose new land-use restrictions to control sediment.

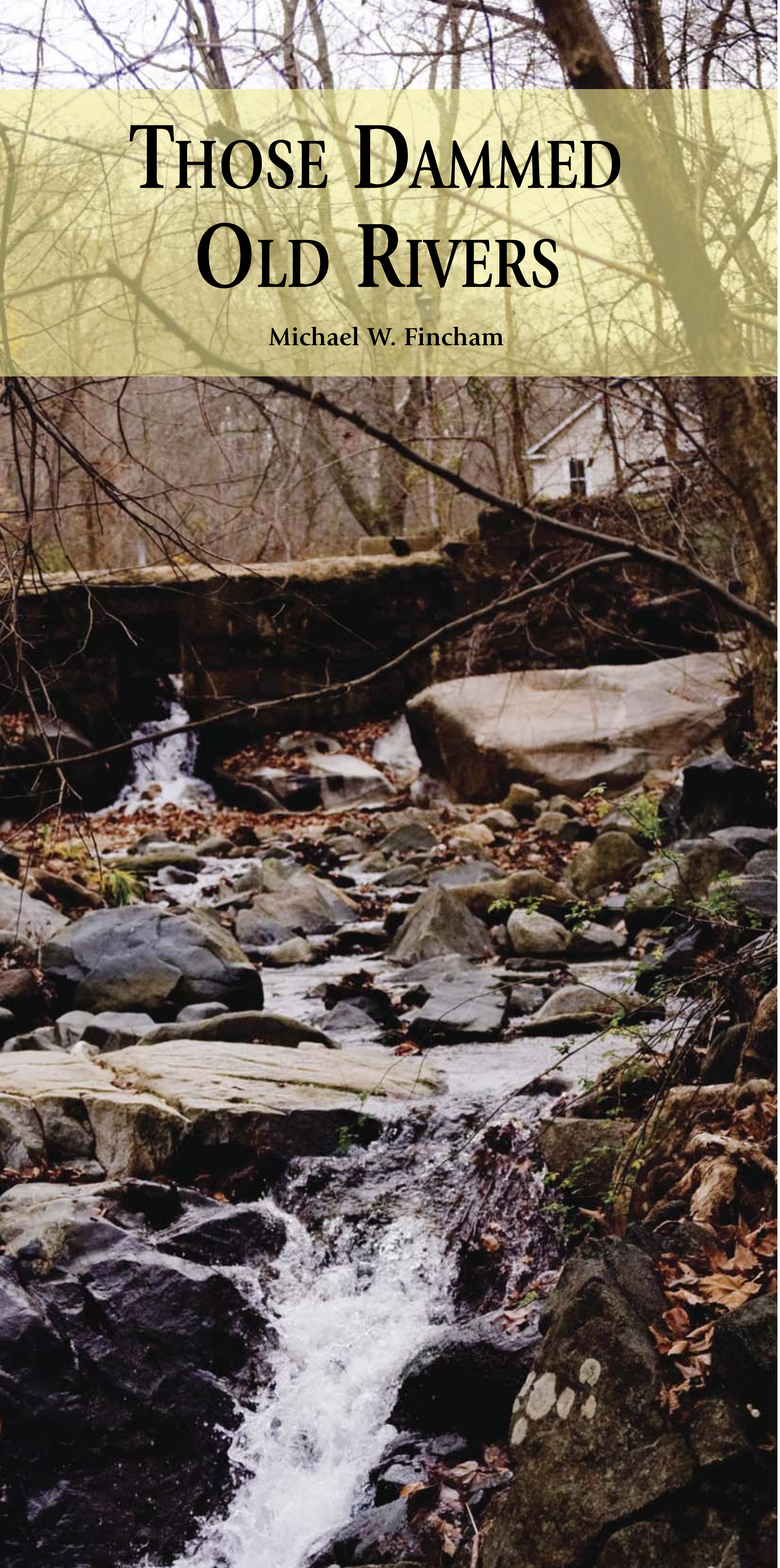
Because the Conowingo sits in Maryland but is affected by residents living upriver in other states, finding an answer to the sediment puzzle will likely require the regional cooperation and leadership that have proven difficult in some efforts to clean up the Bay. The Susquehanna River Basin Commission called attention to sediments in major reports in 1995 and 2002. But action didn't follow, and the reservoir has continued to fill with sediment.

"It seems like there's enough interest to get a study and then as soon as it's complete, the study just drops off, because there's not another mechanism to pick it up," says Michael Langland of the Geological Survey. "There just seems to be at times a lack of somebody to step up and pursue the next step."

— *brainard@mdsg.umd.edu*

Those Dammed Old Rivers

Michael W. Fincham



Michael W. Fincham

In 1761 a business man named John Cornthwaite built a dam along the Patapsco River. Near a bend in the river now known as Ilchester, he had his workers lay a series of logs across the river and wedge them into rock outcroppings along the shore. The dam would supply water power for what seems to have been the first grist mill on the river. For reasons now unknown, it came to be called Dismal Mill.

For building his dam, Cornthwaite likely got help from the colonial Maryland government: in 1669 the general assembly had passed the Maryland Mill Act, an economic stimulus package aimed at encouraging the building of dams and mills. The act empowered Cornthwaite to backflood his millpond right over 20 acres of his neighbors' riverside property. Dam owners also got an 80-year license to use the river water, and this "water privilege," as it was called, could be sold or traded like real estate. For the loss of their land, the neighbors got below-market compensation.

His neighbors weren't the only losers in the deal. The Patapsco is a natural spawning river for species like alewives, American shad, hickory shad, river herring, and white and yellow perch. Unlike salmon these fish are not leapers, and not many would be able to make it over the dam at Dismal Mill. If any did, they would soon butt up against more dams.

Over the next two centuries, a string of dams would go up along the river as the Patapsco became one of the first focal points of the Industrial Revolution in Maryland. Those dams created water power for grist mills, saw mills, paper mills, cardboard mills, textile mills, as well as foundries and forges and hydroelectric plants. Towns would sprout up around the mills at places that came to be called Avalon, Orange Grove, Ilchester, Ellicott City, Oella, Daniels, and Oakland Mills.

Most of those dams and some of those towns are gone now, but migrating fish are still not swimming up the Patapsco, despite several efforts to open passage for them. Dams were abandoned as water power lost importance, then breached and broken as great storms sent famous floods roaring down the narrow river valley. At large concrete dams that survived those floods, fish ladders were erected with much publicity and high hopes for restarting the old fish runs. But not many migrating fish read the press releases, and hardly any of them ever managed to scale the ladders and reclaim their ancient privilege of spawning along the upriver reaches of the Patapsco.


Michael W. Fincham

On the Patapsco River, *Rich Ortt (above) surveys Bloede Dam, currently a candidate for demolition. Decades after it stopped producing electric power, Bloede Dam blocks upriver passage for fish and poses a safety hazard for people. At least six deaths have taken place here in recent decades. This small dam (opposite page) along Bonnie Branch run is a typical legacy of the early industrial era when dozens of dams, large and small, were built along the Patapsco and its small tributaries.*

Rich Ortt says he can see the river start to move right before his eyes. We're walking through a mid-November rain that's falling gently but steadily on the Patapsco River valley, and we're half a mile upstream from Bloede Dam, the last surviving dam on the lower river. The hillsides are russet with dead leaves and wooded with second-growth trees, their bare branches thinning into mist up along the ridge line. The river running through here is only inches deep, but the flow is growing stronger.

Ortt is not worried about water flow. He's focused on the sand-colored sediment along the bottom. "From this little bit of rain, the flow has probably gone up about 50 percent this morning," he says. "If you look at those sand ripples, you'll see the sand can move about two or three feet, and create these little sand bars."

Ortt is watching that shifting sediment along the river bottom because he's an engineer with the Maryland Geological Survey, and his job is to figure out where all this sediment will go if the Bloede Dam downstream is removed. The state has ambitious plans to take down the old dam and finally reopen much of the Patapsco's upriver spawning reaches. Those plans hinge, in part, on Ortt's findings. He points at the sand. "You actually see it moving."

The dam dilemma: tear them down to open fish runs or leave them up to block sediment flows?

What he's seeing raises a dilemma for those dam removal plans. Tearing down Bloede Dam may let fish swim upstream — but it may also let sediment flow downstream towards the Chesapeake Bay, an estuary already loaded and darkened with sediment. When I ask how much sediment's behind the dam, Ortt looks up at the gray heavens and pulls down some large numbers for me. Between 80,000 to 100,000 cubic feet. When that doesn't register with me, he tries an analogy. "Think 10,000 dump trucks full of sediment," he says.

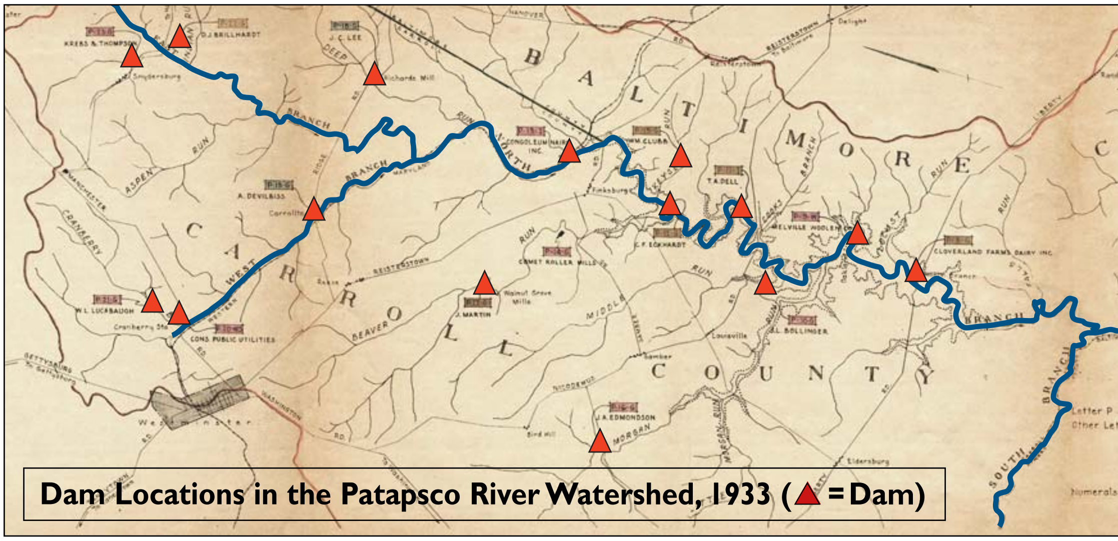
You see the dilemma. Do you make a choice between fish runs and sediment flows? Or do you dig all that sediment out of the river before you tear down the dam?

"It's a real debate in the community," says Serena McClain of American Rivers, the nonprofit organization that's partnered with the National Oceanic and Atmospheric Administration (NOAA) to supply funding and technical assistance for taking dams down along the Patapsco and along dozens of other rivers around the country. Fish passage has been the driving passion behind a national dam removal movement that has helped bring down 470 dams around the country since 1999 — including 7 in Maryland. Sediment storage behind dams, however, is an issue in some proposed dam removals according to McClain, especially in Maryland where water quality is a major concern. "In the Chesapeake Bay watershed," she says, "sediment is a huge dirty word."

In late 2009, giant yellow excavators trundled into the Patapsco River several miles upstream of Ellicott City and began hammering at Union Dam and then loading the rubble into dump trucks. Already breached on one side, Union Dam had little sediment to hoard and what was there was simply released to flow downstream. In 2010 the heavy gear entered the river ten miles downstream near Ilchester and began battering Simkins Dam. Sitting just above Bloede, this private dam held an extensive backlog of trapped sediment. All that sediment was also set free to flow downstream.

Union and Simkins dams were experiments with a technique called "passive sediment release," a technique that may be tried for handling all the sediment now sitting behind Bloede Dam. Simply tear down the dam and let the river — and the sediment — run free. It's a lot cheaper than digging it out and trucking it away.

Early results suggest the experiment has worked — so far — in the stretch of river just below the demolished dam. "The sediment was really made up of this



***How many dams were built along the Patapsco** may never be known. In 1933, engineers for the Office of Water Supply for Baltimore City tried to map all the existing and demolished dams in the Patapsco watershed. They found evidence for 28 licensed dams, many already in ruins, that once supplied water for grist mills, saw mills, cotton mills, woolen mills, water reservoirs, and early hydro-electric power. Many more had already disappeared completely, broken by great floods, like the storm of 1868, which washed away scores of dams from earlier, busier eras of dam building.* CREDITS: LARGE MAP (ADAPTED), COURTESY OF THE MARYLAND GEOLOGICAL SURVEY; SMALL MAP, KARL MUSSER.

sand and gravel and really nice cobble materials," says McClain of American Rivers. Excellent habitat for migrating fish — if they could ever get here.

As a test of passive release, however, Simkins was a limited experiment. Much of its backed-up sediment simply shifted downstream and began massing behind Bloede Dam, just half a mile below. Built in 1907 as the world's first self-contained hydroelectric dam, Bloede is a larger dam where any "passive sediment release" would be a full-scale experiment. There are no more downstream dams between Bloede and Baltimore Harbor some five or more river miles downstream. And the sediment load moving downstream could be more than 10,000 truckloads.

Additional sediment, says Rich Ortt, could start coming off the land. He's now working a low stretch of woods that flank the riverside upstream of Bloede, trying to figure out what's under the ground he's walking on. If the dam comes down, will these woods stay put? Or will they wash away?

A big man, Ortt has broad shoulders and a broad open face that's half hidden under the hood of his red windbreaker as he trudges through the woods. He's leading a crew of three — all hooded or hatted against the rain — and together they look like a sect of monk-like druids performing some mysterious ritual among the trees. They take turns pulling a flat, white sled, and Ortt follows behind bearing a backpack that sprouts a long rod topped off by a disc-shaped antenna. The sled holds a ground-penetrating radar that shoots radio waves into the earth below and records the wave energy that bounces back. The disc antenna connects with unseen satellites to track their wanderings through the wet woods.

"We think this is a sediment bar," says Ortt, referring to this stretch of woodland. "But it could have been just a regular geologic bench." If there's a geologic bench (a bedrock formation) below us, then the land and the trees that have sprouted on the land will probably stay put. If this wooded ground is a sediment bar, however, some of it could end up in the river. Once the dam goes down, the river channel could drop nearly 26 feet below its current level, he says, and this deeper channel could undercut the stream beds, destabilizing the wooded ground where Ortt is working. "If this becomes mobile," he says, "this is more sediment than what's in the river."

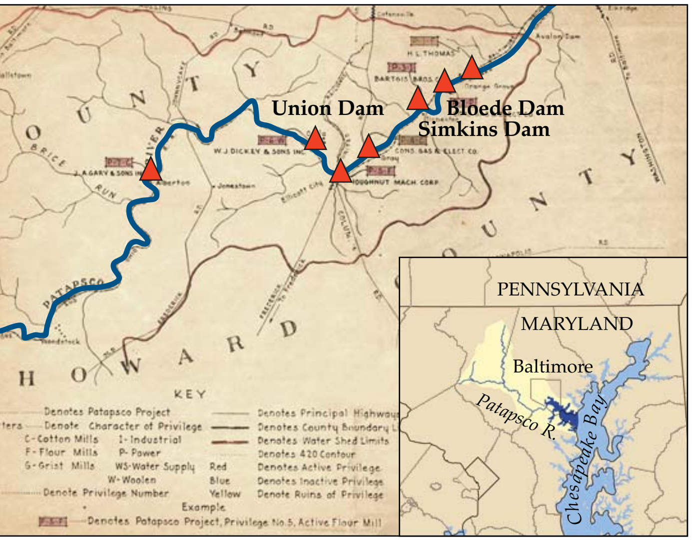
What's the best option for all that Bloede sediment? Dig it up and load it onto trucks? Or try passive release and let it flow downriver towards Baltimore Harbor and the Bay beyond?

Questions like these make for spirited debates, according to those who've worked on the planning for dam removal. That planning process includes scientists from Johns Hopkins University, citizens from Friends of the Patapsco State Park, and experts from American Rivers, NOAA, and the Maryland state agencies responsible for natural resources, the environment, and geological surveys.

The debates can sometimes set biologists (who favor fish passage) against geologists (who worry about sediment loading). And they reflect controversies in the research community over competing theories about how rivers form in the Mid-Atlantic, controversies that set geologists against other geologists. The planners for Bloede Dam, it seems, will have to make a big bet on one theory or the other.

At the heart of the science debate is a newly expanded theory about legacy sediments left behind by old dams. Published in *Science* magazine in 2008, the findings come from Dorothy Merritts and Robert Walter, two geologists from Franklin and Marshall College who surveyed and studied hundreds of creeks, streams, and rivers, most of them in Pennsylvania. They suggest that many of the banks and floodplains bordering many Mid-Atlantic rivers are actually legacy sediment that silted up thousands of old millponds behind thousands of old dams.

Their theory tries to create a new paradigm for explaining how rivers formed in the Mid-Atlantic. In many valleys, the first dams — and there were a lot of them — were strung across marshy wetlands interwoven with small branching rivulets. So many dams were built so quickly that whole valley bottoms were transformed from wetlands to a series of



linked slackwater millponds, lined up one after another. Those millponds filled with sediment, the dams were abandoned or breached, and the undammed water started cutting river channels down through terraces of land built on old millpond sediment. The end result would be the rivers we see today in many places: clearly defined, single strand rivers that meander through landscapes still littered with forgotten millpond sediment.

It's a compelling narrative that may have general implications for dam removals and river restorations. Robert Walter theorizes that the earth eroding off banks and adjacent lands adds up to a major chunk of the annual sediment load entering the Chesapeake Bay, a much larger chunk than previously realized. "The dams that were breached 100 years ago have a long-lived background of erosion that is still occurring," says Walter. "It is not a problem that is going to solve itself simply by blowing out the dams and forgetting about them."

"That article gained a lot of traction," says McClain of American Rivers. "It definitely divided the scientific community." And it did so just when Maryland planners were discussing releasing sediment from Simkins Dam into the Patapsco River. The key finding from Merritts and Walter was radical and important, according to Peter Wilcock, a geologist with Johns Hopkins University and an advisor to the dam removal team. "Nobody realized how much legacy sediment was due to dams that were no longer there," he says.

Some geologists, however, suggest Merritts and Walter may have overextended their theory in an effort to create a regionwide explanation of river formation based primarily on rivers in Pennsylvania. And one result was overreaction, says Wilcock. "People are saying 'Oh my god, legacy sediment, we've got to dig it up. It's a loaded gun pointing to the Bay.' "

In Maryland, however, the dam removal team seems willing to bet against the new theory about legacy sediment. "Not all legacy sediment is dam sediment," says Wilcock. And not all sediment is bad for rivers. The planning team is, so far, making a bet on an older theory that rivers can reach an equilibrium, a theory based largely on rivers in Maryland.

In the 1950s Reds Wolman of Johns Hopkins University and Luna Leopold of the U.S. Geological Survey made numerous observations and measurements along rivers like Seneca Creek and Watts Run and Western Run, bringing a new quantitative rigor to river studies. They watched and measured how alluvial rivers were changing from year to year, how they were eating sediment off banks in certain spots but using it to build up other banks in other spots. Rivers seemed to have their own ways of handling sediment. According to Wolman, they could handle and adjust to slugs of storm-driven sediment that arrived every couple of years.

Their key finding: "The stream was wandering back and forth across the flood plain," says Wilcock. "And somehow it was keeping the same size and shape and slope and length." The river was authoring its own geometry. It was changing, but it was staying (almost) the same — just in a different place. Wolman and Leopold had a name for what the river was doing: it was creating a "dynamic equilibrium."

That's the theory McClain of American Rivers wants to bet on. "Equilibrium — that's what rivers do essentially," she says. "If you put in a dam, you're not allowing the natural transport of sediment. You might actually exacerbate erosion downstream because the river is hungry." A hungry river can start stealing sediment from the nearest shore.

Release the sediment flow? Or dig it up? Doing both, it turns out, is also an option. Most of the dammed sediment is sand that the river, over time, could handle. Sand could flow downriver and probably create new fish habitat. Buried behind the bottom of the dam, however, may be silts and clays, the finer grains that travel further and cause turbidity problems. "You may have to dredge that portion out," says Ortt, who plans on taking deep cores near the bottom of the dam.

With the Bloede Dam decision, whenever it comes, the dam removal movement in Maryland may reach a watershed moment. The funding for the Patapsco tear-downs came from the economic stimulus package of 2008 and from state agencies. In a twist of history, government help for building dams has morphed into help for tearing them down. For demolishing a big dam like Bloede, however, more money will have to be found — and a new stimulus package seems unlikely anytime soon.

If passive release proves too risky, if digging out the sediment proves too expensive, old Bloede Dam could keep aging in place. If it does, then all the work that went into removing those upriver dams won't yield much of a payoff for fish passage. A movement could lose its big moment. And some of its energy.

For now, Bloede remains the last dam holding sediment back from the lower river and the first dam blocking migrating fish from the upper river. Like a locked-up starting gate, it straddles the river near the spot where, in 1761, a businessman named John Cornthwaite first barred fish from racing up the Patapsco by laying down wooden logs to build a dam for his Dismal Mill.

— *fincham@mdsg.umd.edu*

Sea Grant

Maryland Sea Grant College
4321 Hartwick Road, Suite 300
University System of Maryland
College Park, Maryland 20740

Address Service Requested

Non-Profit Org.
U.S.Postage
PAID
Permit No. 04386
College Park, MD

Chesapeake Quarterly is printed on recycled paper, processed chlorine free, using soy-based inks

Jon Kramer Leaves Maryland Sea Grant

Michael W. Fincham

First impressions can be deceiving, but in the case of Jon Kramer they weren't. He came to Maryland Sea Grant in 1998 to interview for an Assistant Director job and took an informal sit down with the communications staff. We were not the search committee, just colleagues curious about a candidate.

What we got straight out of the gate was thoughtful honesty, a candid discussion by a man who was facing a challenge of his own choosing: a career switch from research scientist to science administrator. He knew this job, if he got it, would be a life change, and he let us know what was going on in his head and his heart. He wasn't selling himself, he was revealing himself. In doing so, of course, he sold himself.

Those first impressions held up over his 14-year career at Maryland Sea Grant. And those qualities — honesty, thoughtfulness, and a readiness for new challenges — served him well and his colleagues even better. In 1999 he became Interim Director of the program; in 2000 he became Director.

And in 2011 he chose another challenge. Jon Kramer left Maryland Sea Grant in December to join a new kind of science organization, the National Socio-Environmental Synthesis Center, or SESync for short. The new center is generously funded by the National Science Foundation, and its goal is ambitious: to connect, to bridge the gap between the specialization required for the best research and the multi-disciplinary, interconnected nature of environmental issues. In this brave new world, Kramer will be Director for Synthesis and Interdisciplinary Science.

He prepared well for this kind of job through his years at Maryland Sea Grant. Under his leadership the program pursued its founding mission of developing research focused on regional issues and connecting with all the communities that could use new findings to enjoy, preserve, and profit from our rivers, estuaries, and coasts. The result was top ranking for the program during its periodic five-year reviews by Sea Grant's national office.

While managing Sea Grant, Kramer made synthesis a major part of his work. He organized projects that created teams of scientists to review, evaluate, and apply research findings to complex — and controversial — issues. What did science have to say about the safety of dredge spoil from Baltimore Harbor? About the science value of recent oyster restoration efforts? About the scientific foundations for ecosystem-based fisheries management? He wanted the best science to play a big role in environmental decision making.

His passion for connecting good science with the rest of the world came out in other ways. A typical tactic: the magazine you're reading. *Chesapeake Quarterly* began with his support and guidance and for ten years has committed itself to narrative journalism as a way to tell interesting stories in accessible language about science and scientists. Another tactic: a book series called *Chesapeake Perspectives*. He started it by asking scientists and scholars to write about their work in non-technical terms, to share their best thinking about the ecology and culture of the Chesapeake region.

Those skills and interests did not go unnoticed. Sea Grant directors elected him to head up the National Sea Grant Association, and the Hudson River Foundation and the Center for Watershed Protection both put him on their boards of directors to help with strategic planning.

After first impressions come second impressions, then third and fourth, and many more. These impressions linger: his openness, his fairness, his steady moral compass. Those qualities count in a leader. But in the dailiness and weekliness of work life, so do these: his wide reading, his abiding interest in the newest Nikon cameras, his attention to college basketball. And, of course, his love affair with the Boston Celtics.

— *Michael W. Fincham*

Read our BayBlog, see photo galleries and videos, and send your comments to us at www.chesapeakequarterly.net
For more about books and videos from Maryland Sea Grant, visit, www.mdsg.umd.edu/store