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IMPACT

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**A NEW
PARADIGM FOR
WATER RESOURCES
MANAGEMENT**

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A NEW PARADIGM FOR WATER RESOURCES MANAGEMENT

Joe Berg ~ Guest Associate Editor
jberg@biohabitats.com

The temporal and spatial context of water resource management in North America has limited our understanding and vision for effective conservation, management and restoration of this important resource. Colonial land clearing practices changed stream valley morphologies from broad, shallow streams moving through highly connected wet landscapes that made efficient use of transported materials. Today, the stream valley morphologies generally appear as narrow, deep channels cutting through drier landscapes overloaded with thick deposits of sediment delivered by alluvial and colluvial processes, a result of forest clearing and agricultural production. Add to this situation the extra energy associated with stormwater runoff from developed areas, and our streams are eroding and transporting materials while our receiving waters are the dumping grounds for these materials. This issue documents and addresses this situation and identifies 'new' or rediscovered approaches for more appropriate (and cost-effective) water resource management.

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**Front Cover ... North Grays Bog Restoration,
Anne Arundel County, Maryland, courtesy of
Keith Underwood.**



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THE SOUTH RIVER, LEGACY SEDIMENTS, AND THE FUTURE OF THE RESOURCE

Erik Michelsen

THE PRESENT

In 2008, less than 20% of the nutrient samples (total nitrogen and total phosphorus) collected from the South River passed the Chesapeake Bay Program's thresholds for water quality. Less than 10% of samples showed water clarity as deep as 1 meter, the threshold generally thought to be required to sustain the growth of underwater grasses. Zero acres of underwater grasses were reported on the river in 2008.

After routine rain events, aerial photographs of the river evidence a sediment plume from an opaque brown color near the headwaters to a light mocha swirled with an occasional clean-water wedge through the mid-river, and a more diluted beige as the river's silty payload mixes with the relatively clear waters of the Chesapeake Bay.



Figure 1. The South River After a 3.3-inch Rain Event (two-year storm) in May 2008.

An examination of water quality data over a five-year period shows a clear trend both for decreased water clarity and bottom dissolved oxygen as one moves upriver. According to conventional wisdom, this is somewhat unusual because this area is the least developed segment of the watershed and, according to the Anne Arundel County Department of Public Works is by far the most heavily forested (58%) and least covered with impervious surfaces (9%).

As part of the Riverkeeper's new sampling regime, we have added nutrient sampling to our regular data collection efforts on the river and tributaries. Preliminary data collected through early 2009 shows a similar trend.

Moving upriver, one sees a greater concentration of total phosphorus in the water. Phosphorus is often bound to sediments and can be released as those sediments make their way into tidewater.

THE PAST

In the years between the retreat of the last ice age (about 6,000 years ago) and European colonization, the Chesapeake watershed was almost entirely forested, and when rain fell on the landscape, virtually no sediment runoff was deposited in tidewater (Brush, 2009). Within two centuries of having been firmly established in the region, residents had reduced the forest cover in the watershed to just above 40%.

With this deforestation came the inevitable erosion of millions of tons of agricultural soils as the rain fell on the highly erodible sands and clays found throughout the region. These sediments washed off the landscape and found their way both into the stream valley floodplains, which had once been broad, shallow, slow-moving stream and wetland complexes and tidewater.

There is considerable research to corroborate this series of events, but locally the U.S. Naval Academy has taken soil cores in the headwaters of Church Creek that confirm it. In a recent personal communication, Dr. Andrew W. Miller of the Academy reported that in January 2009, researchers took four soil borings near the Route 665 bridge across Church Creek in Annapolis. Each of the cores showed the same pattern - three to four feet of silt, sometimes banded with sand, overlaying a peat horizon, a vestige of the wetland complex that had once been present at the site. This is consistent with the findings of other researchers in the region (Walter and Merritts, 2008). Presently, an 11-foot wide, single-threaded channel carries much of the stormwater from the developed area above the site where once the system was likely 300 feet+ in width and comprised of acres of high quality wetlands.

Taken cumulatively and viewed through the prism of new research on the massive impacts that colonial land use practices have had on our contributing waterways, our data points to the conclusion that much of the damage to tidewater of the South River that we see today is driven by the legacy land use patterns throughout the watershed.

The impacts of these "legacy" agricultural sediments on the South River are even more dramatically documented where mill dams were present on the landscape.

The South River, Legacy Sediments, and the Future of the Resource . . . cont'd.

During the 18th and 19th Centuries, farmers and landowners living throughout the mid-Atlantic region were heavily dependent on the energy of water-driven mills to saw lumber and grind grains, and the South River watershed was no different. At least seven different mill sites have been identified throughout the headwaters of the river and on Broad and Flat Creeks. Remnants of several of these mills and dams remain in the watershed today.

In the case of several of these mill dams (i.e., Bacon Ridge Branch, Flat Creek, and Broad Creek), we have found several meters of legacy sediment trapped in the area formerly impounded by the mill dam, with a channel carved through these deposits. In each case, deep channels, still actively eroding, carve their way through the silts and deposit tens of thousands of cubic yards of material downstream. This pattern is again consistent with what is being found elsewhere throughout the region in the stream valley systems.

The damage from sediments is by no means constrained to the stream valleys though. Its impacts to tide-water may actually be more pervasive. Take this account from a 1917 publication on the geology and mineral resources of Anne Arundel County:

Anne Arundel County is much freer from tidal marshes than are many regions of the Coastal Plain. Several of the larger rivers the Magothy, Severn, and South River have no marshes of large extent.

Now, each of the headwater tributaries to the river is dominated by tens of acres of tidal marsh. Creeks, such as Glebe, Beards, Broad, and Flat have huge areas of tidal wetlands as well. One survey asserts that ~9%, or 20 hectares (49 acres) of the 230 hectare area of the South River above the Riva Bridge have filled in with marsh since 1846.

Among the recent historical accounts of the river, one that stands apart describes the historical configuration of North River:

Long after the colonial period, local farmers continued to ship their tobacco by water. William P. Doepkens recalls seeing barges loading tobacco in the North River (South Run) near the intersection of Route 450 and Rutland Road as recently as the 1920s.

Anyone who has been in that area recognizes that it would be impossible to get a kayak within several thousand feet of that location, much less a tobacco barge. Marshes like these have been cored elsewhere in the region and have revealed an astonishing rate of sedimentation.

Where these sediments are elevated enough to become colonized by common reed (*Phragmites australis*) or other wetland plants, they become marsh. Prior to that point, and generally downstream of these marsh systems, the sediments remain a thick, anoxic ooze, suffocating the benthic (bottom dwelling) filter feeders that once occupied the Bay and its tributaries. In their place, we have substituted a pelagic-dominated system, where

sediment and nutrients bound in the water column support microorganisms and algae that block light to the bottom and consume oxygen critical to bottom-dwelling life.

THE FUTURE

Taken cumulatively and viewed through the prism of new research on the massive impacts that colonial land use practices have had on our contributing waterways, our data points to the conclusion that much of the damage to tidewater of the South River that we see today is driven by the legacy land use patterns throughout the watershed.

Once acknowledged, the first questions that often come to mind are: "What can be done to fix the problem?" or "Won't this be very expensive to correct?"

Taking the second question first, my answer is that, yes, it will likely be quite expensive to fix. For instance, I would be surprised if, in a watershed the size of the South River, the issue could be seriously tackled with the expenditure of less than \$10 million. We have options, already being explored by the South River Federation, to help take advantage of natural ecosystem services to help defray the cost. For instance, the Federation is conducting an education campaign and working with homeowners in the watershed to facilitate the introduction of American beaver (*Castor canadensis*) into the watershed. In several states, beaver reintroduction is an approved stream restoration practice, and research has shown that beaver impoundment reduce sediment delivery downstream, assist in the processing of nutrients, and provide critical spawning habitat for freshwater dependent fish species.

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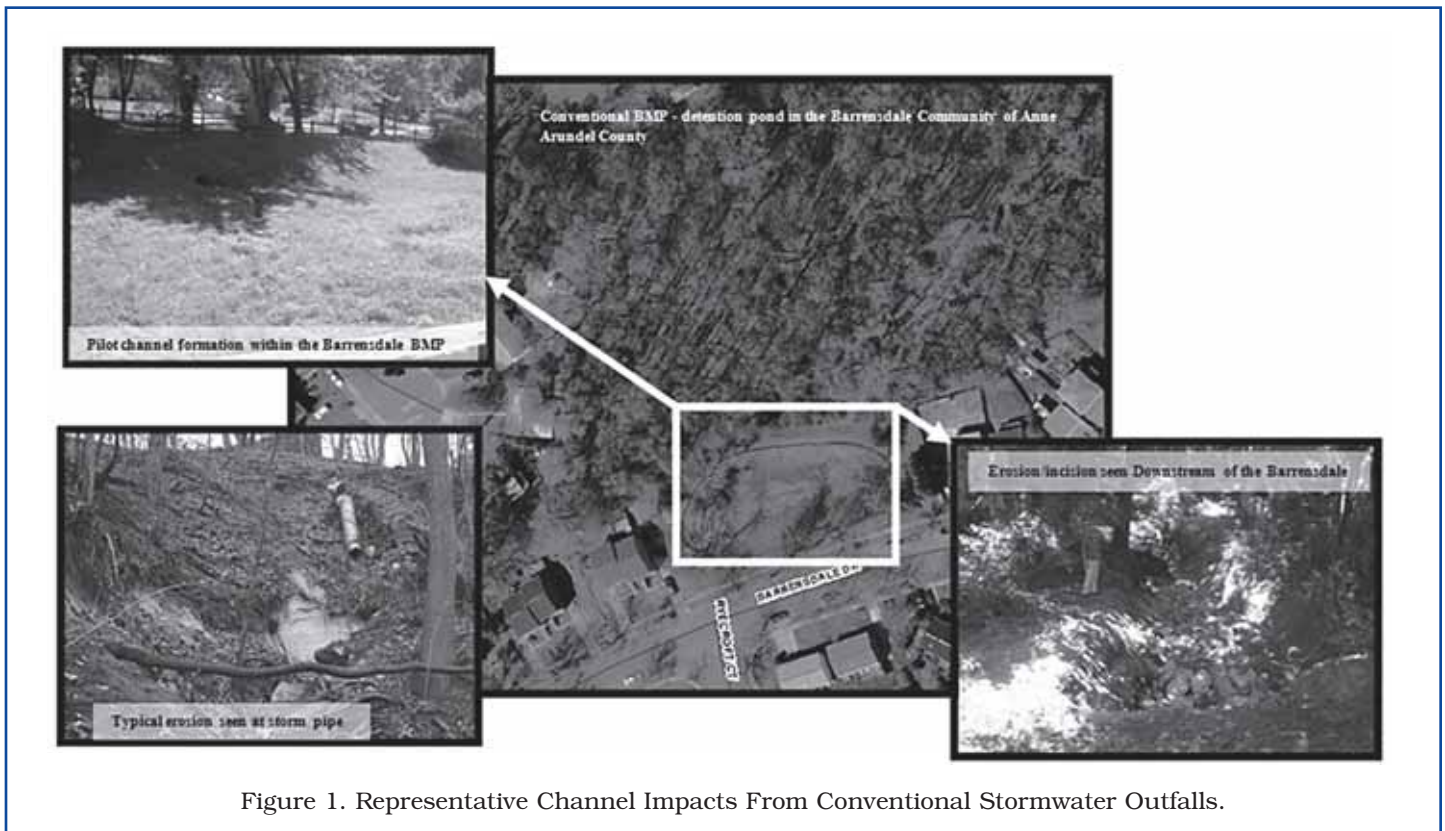
IMPLEMENTING REGENERATIVE STORM CONVEYANCE RESTORATION TECHNIQUES IN ANNE ARUNDEL COUNTY: AN INNOVATIVE APPROACH TO STORMWATER MANAGEMENT

Hala Flores, Janis Markusic, Christopher Victoria, Ronald Bowen, and Ginger Ellis

Municipalities all over the United States are required to comply with a variety of regulatory mandates associated with the restoration of waterbodies within their borders. At the forefront of these mandates is the Federal Water Pollution Control Act, commonly known as the Clean Water Act (CWA). Initially focused on remediating pollution associated with point source discharges through the National Pollution Discharge Elimination System (NPDES) permit process the U.S. Environmental Protection Agency, in 1990, required large municipalities (>100,000 population) to obtain an NPDES permit for discharges delivered through municipal separate storm sewer systems (MS4) under control of these large, local governmental entities. Like the focus on traditional point source discharges, the intent of this program under the CWA is to improve the quality of stormwater runoff from developed areas to "... restore and maintain the chemical, physical, and biological integrity of the Nation's waters." To meet the intent of the CWA through implementation of an NPDES MS4 permit, a municipality needs to develop an effective program for the management and treatment of stormwater generated from its developed lands.

In the mid 1980s, the State of Maryland passed regulations requiring the development of stormwater management (SWM) programs for its counties and municipalities. Prior to this time, "stormwater management" meant that runoff would be rapidly collected from the land and conveyed directly to the nearest stream or river via closed pipe systems. Due to the erosive nature of these stormwater outfalls, stream channels down cut, widened, and/or threaten the stability of adjacent public infrastructure. Municipalities consequently engaged in arming natural channels with rip-rap or replacing them with concrete trapezoidal channels to curb the in-stream erosion. Figure 1 depicts typical problems seen downstream of conventional best management practices (BMPs) and storm pipe outfalls.

Design guidelines for step pool storm conveyance systems are currently under development and will be featured as the preferred solution for stormwater conveyance, energy dissipation at outfalls, flood control, as well as ground water recharge and water quality treatment in future updates to the local Storm Water Management manual



Implementing Regenerative Storm Conveyance Restoration Techniques in Anne Arundel... . . . cont'd.

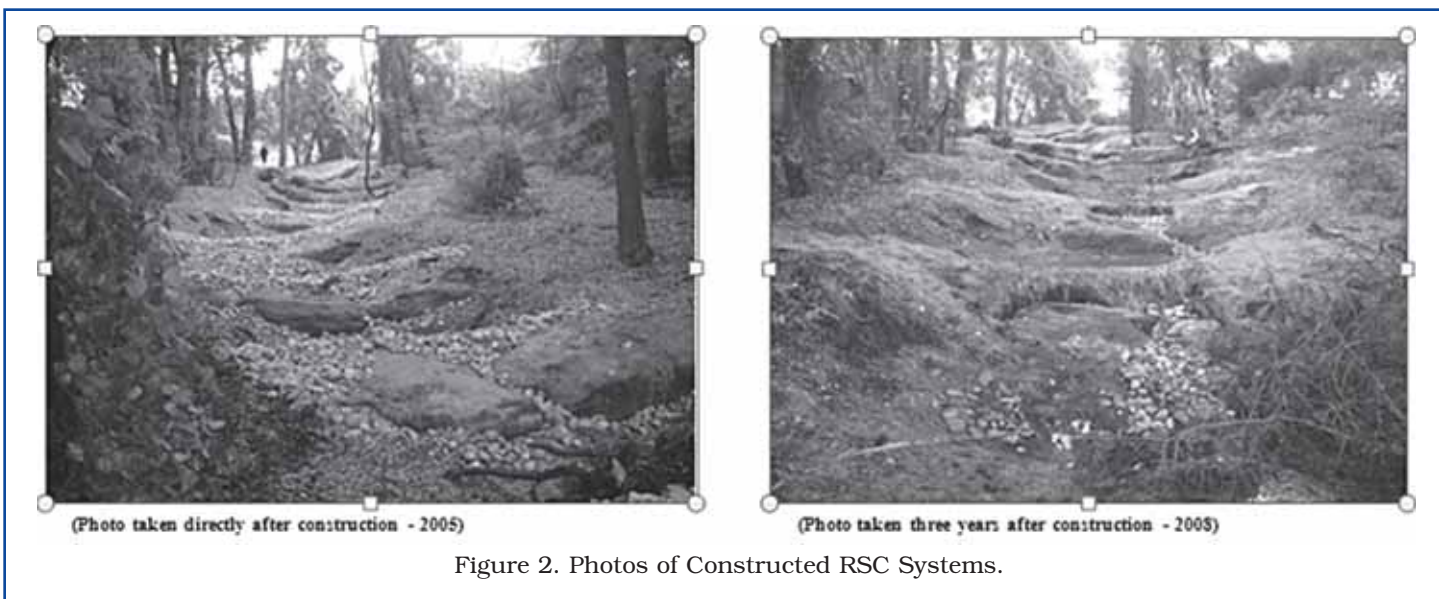
In the late 1990s, recognizing the limitations of its original approaches, Maryland revamped its SWM approach, focusing on controlling storm runoff volumes to approach those necessary to maintain natural rates of erosion and channel adjustment found in stream systems. More recently the state has further refined its stormwater approach, now requiring counties to adopt ordinances and procedures prescribing the use of environmental site design (ESD) to the maximum extent practicable. This new runoff management model requires a different approach regarding both the kinds of best management practices (BMPs) used and the distribution of those BMPs within the watershed landscape. In particular, the developer is encouraged to use alternative approaches to traditional structural BMPs such as minimizing impervious surfaces, developing less of the site, directing sheetflow to buffer areas, using grass swales along roadways to convey stormflows, distributing rain gardens and bioretention devices throughout a site, and directing downspouts to pervious areas to encourage infiltration.

Regenerative Storm Conveyance (RSC) is an ecologically-friendly SWM solution that seeks to safely convey surface water flows while recharging the ground water resources and improving water quality through soil media filtration, floodplain connection, and vegetative measures. These solutions are unique in their reliance on native and natural material to mitigate for SWM impacts and for the retrofit of degraded outfalls and stressed ravines. Shortly after construction, RSC solutions become an indistinguishable part of the environment, making them a truly sustainable environmental restoration alternative.

Step Pool Storm Conveyance (SPSC) are surface conveyance systems that convert and dissipate, through storage pools and sand seepage filters, polluted surface stormwater flow to clean shallow ground water flow. SPSC are primarily composed of a series of shallow aquatic pools, riffles, and cascades formed by native

stones, dense and varied native vegetation adapted to the varied wetness zones, and an underlying water quality sand filter bed. SPSC are considered an edge-of-perennial stream application of the various available RSC restoration techniques, meaning that these systems can be used as the primary conveyance/water quality treatment train from upmost headwater locations and downstream to the connecting perennial stream. Figure 2 shows photographs of a constructed RSC system in Anne Arundel County.

Used as the primary conveyance system on the site, SPSC systems reduce the need for curb and gutter and closed stormdrain infrastructure. Unlike closed storm drains, they have the added benefit of providing habitat for a range of plants, animals, amphibians, and insects. These habitats enhance pollutant uptake and assimilation and provide a natural and native aesthetic to sites. SPSC systems are typically composed of an alternating sequence of pools and riffles. The design is modified to include stone cascades followed by a series of plunge pools for sites with steep longitudinal slopes (i.e., slope exceeds 5 percent and is less than 50%). The geometric cross-section of the SPSC riffle segments is parabolic in shape. The SPSC riffle/cascade segments are hydraulically designed to safely convey flows up to and including the extreme floods (i.e., 100-year return frequency storm events). The depth and spacing of the aquatic pools are designed to dissipate the incoming energies to a level where the design flows within the pools are nonerosive (i.e., less than 4 ft/sec). Storm flows plunge from the riffle/cascade segments to the aquatic pools via sandstone-lined weir structures. The weirs are placed in a curvilinear manner to deflect the hydraulic energy away from the right and left banks and to the center of the channel resulting in ineffective flow areas behind the sandstone boulders where vegetation can take hold to further stabilize these structures. Additional sandstone rocks are used as footer stones in the plunge pools to prevent scour.



Implementing Regenerative Storm Conveyance Restoration Techniques in Anne Arundel... . . . cont'd.

In addition to the stormwater conveyance functions, constructed segments within the SPSC system, with a hydraulic slope less than 5 percent, can provide full water quality treatment and ground water recharge comparable to filtering and infiltration systems as prescribed by the Maryland Department of the Environment (MDE, 2000). The geometric design of the aquatic pools and sand filter bed is formulated to provide filtration of the required water quality volume associated with the first inch of runoff. A secondary benefit provided by the pools and plant material is to reduce flow velocity and enhance the removal of suspended particles and their associated nutrients and/or pollutants. Additionally, uptake of dissolved nutrients by the plant material is expected to yield secondary water quality benefits above and beyond the benefits achieved through the primary filter.

The filter area design equation used for sizing the SPSC filter is (Source: MDE, 2000):

$$A_f = \frac{WQ_v \times d_f}{K(h_f + d_f) t_f}$$

where

- A_f = required sand filter bed area (ft²)
- WQ_v = required water quality volume (ft³)
- d_f = sand filter bed depth (ft)
- K = coefficient of permeability of filter media (ft/day)
- h_f = depth of pool (ft)
- t_f = design filter bed drain time (days)

The SPSC systems are effective flow attenuation/flood control measures. They can successfully be designed as zero surface discharge systems (i.e., all input surface flows are conveyed and converted to shallow ground water flows that discharge as seeps at the receiving stream or wetland). This can be achieved by sizing the pools and voids within the filter bed to accommodate the entire storage volume for the desired design storm. Additionally, the energy dissipation in the plunge pools results in reduced levels of hydraulic power comparable to predevelopment or reference conditions, thus satisfying more directly and effectively the State of Maryland's channel protection requirement. The reduced energy and velocity at the downstream end of these structures result in reduced channel erosion impacts commonly seen between conventional stormwater practice outfalls and ultimate receiving waters.

To ensure the sustainability of constructed SPSC systems, Anne Arundel County requires the restoration of the connecting downstream channel. This is to ensure that any existing downstream channel incision/headcut does not propagate upstream and unravel the stability of the constructed SPSC structure.

The SPSC systems are relatively easy to maintain as compared with other conventional SWM systems requiring, in the first five years, invasive plant management, plant restocking to ensure survivability, and excess

debris removal. As SPSC systems mature, maintenance activity is expected to lessen. Design guidelines for SPSC systems are currently under development and will be featured as the preferred solution for stormwater conveyance, energy dissipation at outfalls, and flood control, as well as ground water recharge and water quality treatment in future updates to the local SWM manual.

Reconnecting our degraded streams to their floodplains has been a major objective of our SWM and stream restoration work over the past five years. As our primary method of choice for the conveyance of concentrated runoff down slopes to our receiving streams, SPSC will be used both in new development and to replace existing piped outfalls. They will be used as a significant component of our restoration and conversion of conventional SWM ponds by providing wetland features with a natural outfall.

While a relatively new application, SPSC systems appear able to withstand large events while providing water quality treatment for smaller storms. Field personnel have witnessed significant surface flow in these systems with no apparent sign of degradation. The management of stormwater quantity and quality achieved through these SPSC systems will contribute significantly to our pursuit of attenuating erosive stormwater flows as well as achieving water quality standards.

Preliminary results from implementing this approach at more than ten sites to date are very encouraging. The majority of these sites have been virtually maintenance free, a significant cost savings over traditional conveyance systems. Anne Arundel County continues to explore innovative applications for utilization of RSC techniques, including SPSC systems.

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SAND SEEPAGE WETLANDS: A KEY TO IMPROVING WATER QUALITY AND SPECIES RECOVERY

Keith Underwood

INTRODUCTION

Current science documents that impairment to the health of the Chesapeake Bay ecosystem is the compromised drainage network, from 0-order headwater streams through estuarine marsh interfaces that historically dominated our watersheds. These systems were degraded/lost over the last 400 years at such a slow rate that these processes went virtually unnoticed. The result has been that our targets for Bay restoration have ignored the most significant problem and the best opportunity for estuary recovery. All of the targeted problems with the Bay's health can now be attributed to these losses. The headwater drainage systems received and processed inputs instead of merely conveying the material downstream. Forested floodplains similarly received water and material inputs and used these inputs to support a variety of ecosystem services. Lower in the watershed approaching the tidal interface, the stream valleys of the past were silica gravel and sand bedded and supported peat forming species. Peat formation occurs in shallow aquatic beds over nutrient deficient substrates. Our most significant wetlands and streams were integrated as one. The bottom line is that essentially all of our stream valleys were frequently inundated and flooded for extended periods.

Colonial land clearing resulted in the removal of most forests by 1750, and by 1850 the forests had all been removed a second time. As a result soils were exposed and the fine grained sediment (silt) eroded into the stream valleys and was subsequently deposited on the floodplains. Simultaneously the flow of open water in these valleys was restricted from a broad flat sheet flow with a large surface area to volume ratio (best for material processing) to a single channel with a large volume to surface area ratio (what we all now think of as a stream). The energy now contained in this channel form has eroded the bottom of the channels further lowering ground water tables. Urban runoff has exacerbated this situation. This negative biofeedback loop explains much of the Bay's problems (i.e., historically dominant organic soils are buried under a layer of nutrient-rich mineral soils, headwater streams are converted to piped or eroded gullies, floodplains are isolated from stream flow, ground water tables are falling with stream incision, nutrients and sediments are released into tidal waters).

The completed project at Howard's Branch is a case study of how to connect the water train from top of watershed to receiving open water. This is an on the ground example of tidal pond to stream valley flood plain recovery.

The creation of a new growth site for Atlantic White Cedar (*Chamaecyparis thyoides*) was the driving force behind this stream stabilization and wetland enhancement

project in Anne Arundel County, Maryland. The Howard's Branch project was designed to create peatland ecosystems in a highly degraded stream valley floodplain by creating a functional seepage wetland supporting a sustainable Atlantic White Cedar (AWC) community. A series of cobble weirs and a network of sand berms were placed over a dry lakebed to simulate the geology and hydrology found in natural Atlantic White Cedar sites. The 2001 construction of the project was completed with the planting of 1,000 Atlantic White Cedars propagated from the 10 remaining stands of the species on the western coastal plain of Maryland. This article reviews the procedures developed for the Howard's Branch project, reports on the status of the constructed wetland, and discusses the relevance of this project to improving water quality in the Chesapeake Bay watershed.

SITE HISTORY

In 1930, a forested stream valley flood plain was flooded to a depth of 4 feet with the construction of an earthen dam across a small stream known as Howard's Branch. Used as a drinking water supply of an adjacent community, the dam failed in 1980 and the lake drained, exposing 50 years of accumulated sediments. The stream subsequently cut through these sediments, transporting them downstream to tidal waters, damaging tidal and subtidal ecosystems and resulting in disturbance regime plants such as common reed (*Phragmites australis*) in the tidal wetlands and Eurasian water-milfoil (*Myriophyllum specatum*) in the adjacent shallow tidal waters. The Howards Branch stream valley floodplain (former impoundment) within the project site is approximately 737 feet long and 120 feet wide. The floodplain ranges in elevation between 10-15 feet above sea level. The drainage area to the project site is a total of 231 acres or 0.4 square miles, and is comprised of a mix of forested open space and low density residential.

Given the recent scientific documentation of the immense benefits provided by peatland ecosystems to tidal estuaries, restoration or establishment of new peatlands in created environments to make up for historic losses takes on a fresh urgency

DESIGN CONCEPT

The creation of a sand seepage wetland using a combination of pools, sand berms, and cobble weirs results in a system of physical features, chemical processes, and biological mechanisms that can have dramatic effects on the hydrology of the site. The physical modifications necessary to establish the sand seepage dynamic result in

the creation of a series of well vegetated stilling pools, sand seepage beds replete with above and below ground biomass, and associated flow paths through low areas dominated by native wetland plants. The physical effect of the pools and their many plant stems is to reduce water velocity and facilitate removal of suspended particles and their associated nutrients and/or contaminants. The cobble weirs set the surface water elevations and establish the head necessary to drive the sand seepage dynamic that supports so many bog species, including Atlantic White Cedar. In addition, the sand seepage bed supports microbes, fungi, and macro invertebrates. Furthermore, the many roots present in the sand take up nutrients and provide sites for microbial attachment, contaminant adsorption, and long-term sequestration in the peat forming layer resulting from annual root formation of the fibric root mat. Similarly, water flowing through the lower areas dominated by peat forming *Sphagnum* are subject to many of the same physical and chemical processes.

The vegetation along the channel and in the bottoms of pools provides an important contribution to project sustainability by tying the system together and increasing the porosity of both the pools and the sand berms.

CONSTRUCTION

Project construction resulted in a three-dimensional wetlands complex integrated into the landscape around it. A series of cobble weirs were constructed across the main stream channel about 100 feet apart in 1-foot lifts as grade controls. Each weir flooded the soils above it. A network of berms, comprised of sand, gravel, and wood chips was combined with the cobble weirs to form a new surface topography that would control surface and sub-surface hydrology. Placement of the sand berms about ten feet from the toe of the adjacent steep slopes flanking the project site resulted in depressions between the tops of the berms and the adjacent side slopes that serves to capture surface water and ground water seepage from the side slopes. This formed long pools (seepage reservoirs) that surrounded most of the site (Figure 1).

The water surface elevation in these moats was designed to be higher than the water surface elevation in the channel so that water captured in the moats would then move laterally and irrigate the sand berms. As water slowly filters through the sand berms to lower elevations, sandy seepage slopes are created similar to those found in other AWC sites.



Figure 1. Completed Project, 2002.

Sand Seepage Wetlands: A Key to Improving Water Quality and Species Recovery . . . cont'd.

White, bank-run silica sand and gravel were used to form the berms and sandstone boulders were used as grade controls for the weirs. Wood chips and Canadian peat were incorporated to provide organics to the sand growing media. In order to preclude the establishment of hardwoods processed white silica sand was placed on the surface of the berms. In April 2001, volunteers planted 1,000 Anne Arundel County native AWC on the sand berms as containerized saplings up to 48 inches in height. Some plant species associated with AWC were subsequently introduced to the site from local native sources.

RESULTS

We converted an eroding wetland dominated by non-native and invasive plant species into a stable seepage wetland complex supporting a number of threatened plant species. The constructed berms and weirs slow and retain baseflow surface waters while allowing a non-erosive course for surface waters generated by storm events. Vegetation growing on the weirs has restricted the channel width over the weirs and created water depths of approximately six inches, which is adequate for passage of local fish species. Surface water flows are directed into a broad, flat, and gentle meandering pattern. Water captured in the moats and retention of water above the weirs serves to both raise and stabilize the ground water table and irrigate the berms. The baseflow of the stream is now slowed and distributed to maximize the irrigation of the sand berms, while energies associated with storm flows are adequately dissipated by the project features to allow the water to pass harmlessly through the site.

In 2003, 177 vascular plant species were identified on the site. Thirty-four percent of the identified species are obligate wetland plants and 72% are facultative or wetter. AWC is now the dominant tree on the project site, and thousands of AWC seedlings have resulted from natural recruitment on the site.

We have observed losses of dozens of peatland species in the Atlantic Coastal Plain. Peatland ecosystems need active management, preservation and restoration and damaged ecosystems such as Howard's Branch provide sites that "could be restored in such a way as to enhance the chances of survival for one or more rare, endangered, or threatened species." Given the recent scientific documentation of the immense benefits provided by peatland ecosystems to tidal estuaries, restoration or establishment of new peatlands in created environments to make up for historic losses takes on a fresh urgency. This novel approach of creating seepage wetlands at Howard's Branch could be used in other geographic areas to improve water quality and enhance the sustainability of other rare species dependent on this geomorphic setting.

CONCLUSIONS

The successful establishment of viable, reproducing populations of several rare wetland species at Howard's Branch is an example of what can be accomplished given the will to act when opportunities present themselves. This three-acre project was achieved at a cost of less than \$350,000. It has demonstrated the feasibility of restoring and enhancing rare ecosystems using a damaged site, created design criteria for the establishment of functional AWC wetland within the historic range, established a viable reproducing population of AWC and associated species (a rare plant community) in a created seepage wetland, and actively engaged the public and promoted education and stewardship. Furthermore, ongoing monitoring of water quality is pointing to this innovative seepage wetland as a highly efficient practical solution for sediment and nutrient removal. It inverts conventional thinking on water management altogether ... we need to focus on **water resource management, not stormwater management.**

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**PRELIMINARY RECONSTRUCTION OF A PRE-EUROPEAN SETTLEMENT
VALLEY BOTTOM WETLAND, SOUTHEASTERN PENNSYLVANIA**

**Mark Voli, Dorothy Merritts, Robert Walter, Erik Ohlson, Katherine Datin,
Michael Rahnis, Laura Kratz, Wanlin Deng, William Hilgartner, and Jeffery Hartranft**

INTRODUCTION

Early accounts of the mid-Atlantic piedmont region by European settlers describe numerous swamps and meadows, abundant springs, and associated wetland plant communities. The Swedish-Finnish botanist Pehr Kalm (1716-1769) described nights in southeastern Pennsylvania as noisy with the sounds of frogs croaking in marshes and meadows, but also noted that settlers converted swamps and meadows to cornfields and pastures (Kalm, 1937). Reports of draining naturally occurring wetlands are frequent in historic literature. Small patches of presettlement wetlands exist today that are remnants of once larger and significantly more widespread naturally occurring wetlands described by early observers.

Since European settlement, numerous anthropogenic impacts accelerated erosion of upland sediment (Jacobson and Coleman, 1986; Langland and Cronin, 2003). Widespread sediment trapping was facilitated by the construction of tens of thousands of low-head milldams during the period of intensive land clearing, farming, and mining of the 18th-19th Centuries (Walter and Merritts, 2008). The slackwater environment of ubiquitous ponds buried and preserved the geologic record of presettlement wetlands, much as volcanic ash preserves an ancient city. The contact between pre-European settlement soils and post-settlement sediment typically is vertically abrupt and laterally continuous, and retains fine pedologic details, such as root structures from plants. The extent and abundance of the naturally occurring presettlement wetlands is long since forgotten, but the evidentiary record remains.

Millponds filled with sediment to the crests of dams and spillways by the late 1800s, but as dams breached throughout the 20th Century the drop in base level resulted in deep incision into the sediment reservoirs (Walter and Merritts, 2008). Incising streams produce three-dimensional views of the buried presettlement landscape, revealing the organic-rich soils.

This study uses macrofossils, specifically seeds extracted from buried organic-rich soils, to identify pre-European settlement wetland vegetation at Big Spring Run, a second-order stream in southeastern Pennsylvania. This report is a precursor to more detailed ecologic, geochemical, and geomorphic analyses that are ongoing in this watershed.

SITE DESCRIPTION

Draining 15 square km of Paleozoic limestone with quartz veins, Big Spring Run begins at several springs and flows north into Mill Creek, a tributary to the Conestoga River in Lancaster County, Pennsylvania (Figure

1). The Conestoga drains into the Susquehanna River, a tributary to the Chesapeake Bay. A wedge of fine-grained sediment that thickens downstream toward a breached milldam buried the Big Spring valley bottom and many of its springs. The study area encompasses two incised headwater tributaries and the main stem about 1.5 km upstream of the breached dam. Many segments of the Conestoga River, including Big Spring Run, are included on the U.S. Environmental Protection Agency (USEPA) 303d impaired water body list for high loads of suspended sediment and nutrients. Land use for the majority of the Big Spring Run watershed is agricultural. Big Spring Run is the location of a multi-year (2008-2011) research investigation by Franklin and Marshall College, Pennsylvania Department of Environmental Protection, the U.S. Geological Survey, and USEPA to assess a floodplain, stream, and riparian wetland restoration approach to ecological restoration.



Figure 1. Sample Sites (dots) at Big Spring Run, Flowing From South to North in This April 2005 Digital Orthophoto.

METHODS

Pre-settlement organic soils were identified and sampled at exposed stream banks along 0.5-km of Big Spring Run (see Figure 1), and macrofossils (seeds) were analyzed following the procedures of Hilgartner and Brush (2006). The light yellowish brown (10 YR 6/4 to 2.5 Y 6/4) post-settlement sediment is laminated and fine-grained (>95% silt and clay) and 0.8-1.2 m thick. The underlying pre-settlement soil (20-50 cm thick) is dark gray to black (10 YR 2/1) silt with fine sand and locally abundant angular quartz gravel derived from long-term weathering of bedrock.

Several techniques were used to constrain the age and depositional style of these deposits, including magnetic susceptibility and isotope geochronology. Identifications are made using multiple seed references. Nomenclature follows Gleason and Cronquist (1991). A Nikon binocular microscope fitted with a digital camera is used to photograph seeds.

As a result of reservoir sedimentation and subsequent incision, a highly unstable channel is migrating rapidly across the valley bottom, eroding both historic sediment and the pre-settlement wetland soil

RESULTS

Radiocarbon dating of wood and seeds from the buried organic-rich soil yielded ages ranging from 690 to 3200 yr BP (dating at Beta Analytic, Inc., Miami, Florida.). Over 300 seeds have been extracted from this stratigraphic unit along Big Spring Run, with typical yields of 10-30 seeds per 30 cm³ of sample. Seeds in greatest abundance were those of *Carex* spp. (including *C. crinita*, *C. stipata*, and *C. stricta*), *Polygonum* spp., *Eleocharis* spp. (including *E. ovata*), and *Scirpus* spp. Additionally, we have found several seeds of *Najas flexilis* (nodding water nymph) and *Brasenia schreberi* (watershield) at a buried spring site located along the southern valley margin. These wetland species are found at all depths of the buried pre-settlement soil.

The majority of the species are those of obligate wetland species, but near valley margins nuts and seeds have been identified from facultative upland species, including *Liriodendron tulipifera* (tulip tree) and *Juglans cinerea* (butternut). Because these nuts and seeds are embedded within dark soil that also contains obligate wetland species, we interpret their occurrence to indicate that they fell into the wetland from an adjacent hillslope.

DISCUSSION

Macrofossil analysis of specimens obtained from buried pre-settlement soils provides a paleoecological record of wetland vegetation across the entire valley bottom of the headwaters of Big Spring Run. Species are representative of plants that grow in organic-rich wetland mucks (i.e., hydric soils) or pools of water, as at springs.

The modern incised stream crosses the valley at several locations (see Figure 1), and no buried stream channel is observed. The buried hydric soil exists at the current level of baseflow – the seasonal ground water level – indicating that the modern hydrology is not substantially altered from pre-settlement conditions.

Species from these buried plant communities can be assigned to wetland classification systems that illuminate the paleo-environment just prior to European-American settlement. The buried Palustrine wetlands at Big Spring Run are best classified as Persistent Emergent Wetlands (Cowardin *et al.*, 1979), and can be subclassified as a wet meadow herbaceous wetland (Fike, 1999).

We conclude that a wet meadow herbaceous wetland existed from at least 3,200 years ago until its burial beneath historic sediment circa 1730 AD. Stream incision began sometime between 1850 and 1930, based on analysis of historic maps and aerial photographs. As a result of reservoir sedimentation and subsequent incision, a highly unstable channel is migrating rapidly across the valley bottom, eroding both historic sediment and the pre-settlement wetland soil. A valued seed bank and record of the pre-settlement landscape are washing downstream along with this sediment.

These results have significant implications for restoration strategies at Big Spring Run and similar sites. The presence of ground water and hydric soil, and the predominance of sedge seeds, indicate that this area was originally a wetland dominated by obligate wetland plant species in or near permanently saturated soil. By contrast, modern plants growing on the surface of the historic sediment fill are predominantly quackgrass (*Agropyron repens*), Canada thistle (*Cirsium arvense*), and orchard grass (*Dactylis glomerata*), species characteristic of mesic wastelands and roadsides. A few isolated patches of obligate wetland species occur near springs at the valley margins. A planting of ~3,000 riparian trees on the historic silt and clay in 2002 had a high mortality rate (>80%). A possible cause of this high mortality is the height of the plant roots above the ground water table (~1 to 1.2 m). A possible implication of this study is that restoring the naturally occurring riparian wetlands buried beneath the historic sediment, rather than stream restoration or riparian tree planting on the historic sediment surface, could be a more effective and sustainable approach to increasing wetland biodiversity and improving riparian habitat and function, while possibly also reducing sediment and nutrient loads downstream.

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BASEFLOW STREAM CHANNEL DESIGN: AN APPROACH TO RESTORATION THAT OPTIMIZES RESOURCE VALUES AND ECOSYSTEM SERVICES

Joe Berg

BACKGROUND

Millions of dollars are spent on stream restoration every year. Society has implemented a variety of agricultural BMPs and stormwater management practices to control sediment and nutrient loadings in runoff from urban, agricultural, and forest lands over the past decades. While we have applied a range of management techniques for runoff control situations, we have a more limited set of tools to meet channel designs in a variety of situations. This article will explore one channel design alternative.

THE STATUS QUO STREAM RESTORATION APPROACH

The prevailing approach for stream restoration is the natural channel design technique popularized by David Rosgen (<http://www.wildlandhydrology.com>) which focuses on designing channels capable of dynamic equilibrium through the use of a bankfull channel designed to be competent with respect to sediment transport. Stream channels designed in this fashion convey a range of flows up to the bankfull flow, which is characterized as the channel-forming discharge and is approximately equivalent to a discharge generated by a storm with a recurrence interval on the order of 1.5 years.

If designed and constructed properly, these streams convey flows delivered to them without significant bank or bed erosion and no net in-channel sediment deposition. However, this approach to stream restoration requires special consideration when working in urban drainages where storm events generate larger volumes with shorter durations, and streams are often sediment starved. In addition, the sediment competence requirement of the bankfull channel design approach limits the opportunity for sediment and material processing.

SUPPORT FOR ALTERNATIVE STREAM RESTORATION APPROACH

Researchers have documented the importance of material processing by streams, particularly in headwater and smaller order streams. Kaushal *et al.* (2008) documented that stream restoration projects that were hydrologically reconnected to their floodplains had increased rates of denitrification relative to restored streams that were not as well reconnected to their floodplains. Higher denitrification rates, a permanent type of nitrogen removal, occur in headwater streams as a function of greater channel surface area to water volume.

As increased impervious area and faster delivery mechanisms associated with ditches, curbs, gutters, and pipe conveyance, produce larger runoff volumes, active

channel adjustment will continue to degrade our resources. This is a negative feedback mechanism, since as the channel enlarges to convey the larger, faster discharges, the channel will be able to contain still larger discharges, resulting in more in-channel energies to support more and faster channel erosion, more complete separation from the stream's floodplain, and loss of those floodplain functions.

An intuitive interpretation of these studies and others indicates that in any larger system context, whether stream, river, lake, or estuary, our stream restoration projects should have goals that include the interruption of sediment and nutrient transport. The nitrogen processing literature points to an integrated stream and riparian zone, where water is slowed along its flowpath, the channel has a large surface area relative to the volume of water it conveys, and plenty of organic material is available to support denitrification.

A resurgence of interest in colonial land clearing practices and the resulting historic changes to watershed morphology and ongoing sediment supply dynamics in our watersheds (i.e., legacy sediments) presented an opportunity to refine our understanding of what constitutes a 'natural' stream. Walter and Merritts (2008) evaluated stream valleys in the mid-Atlantic and found no relict evidence of a stream channel morphology resembling the bankfull channel form now widespread across the landscape and used as a reference for restoration design. Instead, they uncovered stream systems best characterized as swamp systems with baseflow channels. These channels were very well connected to their floodplain, that were documented to have layers of organic rich soil. However, colonial land clearing practices resulted in the delivery of huge volumes of sediment, burying these systems and resulting in our current stream and floodplain morphology.

While different landscapes may require different approaches to stream rehabilitation, the approach suggested here can be especially useful in urban systems as a tool for restoring the ecosystem functions of the stream channel and the adjacent riparian floodplain where basin characteristics will allow it

It appears that the precolonial channel form and its integration with its floodplain is an excellent model for stream restoration in urban areas when floodplain reconnection is possible. A baseflow channel that is well connected with its riparian or floodplain habitat can restore floodplain functions like storm flow attenuation, reduction in channel erosion and sediment transport,

sediment trapping, and other water quality and habitat values.

Another stream valley pattern from the past is the repeating sequence of beaver ponds and dams. These natural forms connected stream flows with the floodplain, maximized material trapping and processing, and delivered other services such as habitat diversity. A repeating series of pools and weirs that increase the connectivity of an incised channel to its floodplain is a type of stream restoration that is more in keeping with the water quality and habitat goals for many of our degraded urban streams, rivers and estuaries.

THE RECOMMENDED APPROACH

This proposed baseflow channel design approach to stream channel design integrates these considerations in a historically appropriate channel form that is highly connected to its floodplain and delivers ecosystem services that are in high demand. If successfully implemented, the baseflow stream channel conveys the 'normal' flow in a channel with a high surface area to volume ratio, a physical relationship associated with effective material processing. With increased discharge associated with stormwater runoff, the increased water surface elevation spills out of the baseflow channel and into the adjacent riparian zone or floodplain. This results in a loss of energy due to a slower, broad, shallow flow with a comparable reduction in the channel adjustment and sediment entrainment, rather than the narrower, deeper, bankfull flow with its increased shear stresses and channel erosion, entrainment, and export of sediment downstream. By reconnecting the channel to the riparian zone or floodplain to deliver the elevated flows to these vegetated systems, society capitalizes on natural floodplain functions critical to ecosystem and societal health, including sediment trapping, material processing, reduction in flood water surface elevation, increase in concentration time of floodwaters, reduction in volumes through infiltration, evaporative losses, and depression storage. Furthermore, channel overflow contributes to ground water recharge and stream baseflow maintenance during periods of summer lowflow, support for wetland and vernal pool hydrology and ecology, suppression of non-native invasive plant species, increased micro-habitat diversity, etc.

The most important element in the baseflow channel design approach is the riffle weir that creates a stream water surface in close proximity to the riparian or floodplain elevation (Figure 1).

Setting this elevation is critical to the project success. For example, in a restoration project with a goal of integrating stream and wetland restoration, it is possible to set the riffle weir at or above the surface of the floodplain, inundating floodplain depressions and initiating the development of a peat-forming system capable of providing important ecosystem services.

This would also be a strategy for restoration of floating leaved and emergent wetlands in the floodplain. Alternatively, in a trout stream watershed, where surface ponding is undesirable due to thermal impacts, the riffle

weirs can be set to elevations close to but below the surface of the floodplain (based on hydrology and hydraulics modeling) to get the reconnection benefits without the risk of thermal impacts. A similar approach could be used to limit flood elevations to below 100-yr flood elevations.



Figure 1. Photo of Constructed Riffle Weir.

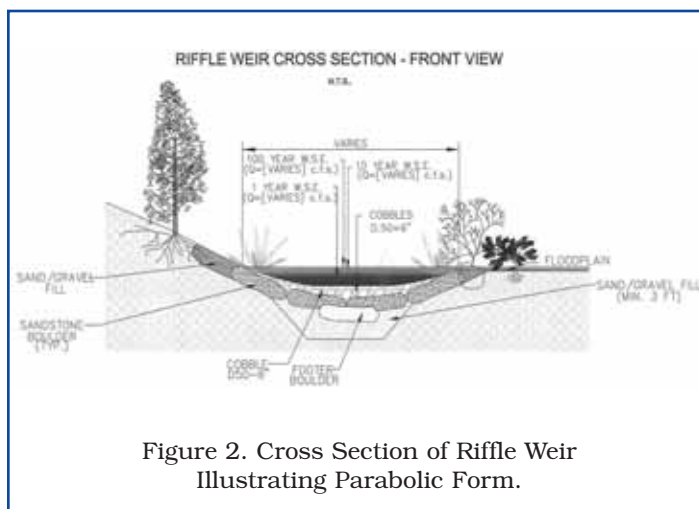


Figure 2. Cross Section of Riffle Weir Illustrating Parabolic Form.

In order to concentrate baseflows in the riffle weirs to support movement of aquatic organisms upstream and downstream of the structure, the riffle weir is designed and constructed with a parabolic form. During periods of high flow, the stream in the controlled weir section gains width faster than depth until sufficient depth in the control sections results in the stream flow spilling out into the floodplain. The riffle weirs also result in the formation of backwatered sections of the channel. This can be of significant value to aquatic life in small streams as the larger, deeper pools are important habitat, serving as summer low-flow refugia habitat. The relative proportion and locations of riffle, pool, and other stream habitat is a design function of project goals, stream and valley slope, and other considerations (e.g., infrastructure elevations, etc.).

CONCLUSION

This approach to stream restoration can be used as one component of an integrated system of water management. While different landscapes may require different approaches to stream rehabilitation, the approach suggested here can be especially useful in urban systems as a tool for restoring the ecosystem functions of the stream channel and the adjacent riparian/floodplain where basin characteristics will allow it. This approach improves connectivity between the stream and its adjacent riparian/floodplain area, a connection known to provide many benefits for water quality, water quantity control (e.g., increased time of concentration, reduced velocity and shear stresses), improved wetland hydrology, and a variety of aquatic and terrestrial habitat values.

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▲ HIGHLIGHTS OF JAWRA TECHNICAL PAPERS • AUGUST 2009 • VOL. 45 • NO. 4

Mansour D. Leh and Indrajeet Chaubey compare two GIS-based approaches to hillslope runoff generation: a topographic index model and a likelihood indicator model.

Norman L. Miller *et al.*, perform a series of drought simulations for the California Central Valley for a range of droughts from mild to severe for time periods lasting up to 60 years.

Peter C. Smiley, Jr. *et al.*, noting protocols designed for monitoring studies are not appropriate for impact assessments, develop guiding principles for designing impact assessments of ecological responses to conservation practices.

Kelli Larson examines public attitudes about an array of resource management efforts in Portland, Oregon. She outlines a conceptual approach for future assessments of environmental attitudes in particular settings while highlighting important value-based dimensions of judgments.

Xuesong Zhang and Raghavan Srinivasan explore a number of spatial interpolation techniques applied to aerial estimation of precipitation in a study area in China. Their results suggest advanced geostatistics methods that incorporate auxiliary information improve spatial precipitation estimation for hydrologic models.

Deepti Puri *et al.*, use the SPARROW model to explore watershed and hydrological characteristics as the probable sources and delivery mechanisms of waterborne pathogens and their indicator (*E. coli*) in Guadalupe and San Antonio River basins in Texas.

Heather E. Golden *et al.*, report on nitrate sampling in mixed land cover watersheds draining to Cayuga Lake. They found a high degree of spatial heterogeneity in catchment response.

Donna B. Schwede *et al.*, present the Watershed Deposition Tool, an important tool for providing the linkage between air and water-quality modeling needed for determining the Total Maximum Daily Load and for analyzing related nonpoint-source impacts on watersheds.

Brooke C. Asleson *et al.*, describe the development and evaluation of three approaches for performance assessment of rain gardens: visual inspection, infiltration rate testing, and synthetic drawdown testing. They found a combination of visual inspection and infiltration rate testing is particularly useful for developing maintenance tasks and schedules.

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JAWRA ~ Journal of the American Water Resources Association

STREAM RESTORATION CAN IMPROVE WATER QUALITY BUT IS FAR FROM BEING THE SILVER BULLET SOLUTION

Solange Filoso and Margaret Palmer

INTRODUCTION

The recent and growing recognition of the importance of headwater streams in controlling the water quality and flow conditions of downstream waters has led to an increasing interest in using stream restoration as a best management practice (BMP). The goal is to reduce downstream pollution and protect water resources. Stream restoration efforts have been particularly focused on urban regions, where impacts such as increased frequency of flooding and peak flow volumes, high sediment loads, loss of aquatic habitats, changes in stream physical characteristics (channel width and depth), decreased baseflow, and increased stream temperatures have reduced the capacity of aquatic ecosystems to deliver services important to humans such as clean water, fishing, and recreational or aesthetic enjoyment (Bernhardt and Palmer, 2007).

In coastal regions of the United States (U.S.) such as the Chesapeake Bay, stream restoration has been of particular interest to local and state governments, and non-governmental organizations (NGOs) who seek to mitigate local problems that enhance pollutants loads to coastal ecosystems. However, until recently, quantitative information on the effectiveness of restoration projects at reducing pollutant loads to downstream waters was largely lacking.

One of the reasons for the lack of information about stream restoration effectiveness is that reliable monitoring can be expensive and has historically been underfunded (Bernhardt *et al.*, 2005). Thus, a comprehensive monitoring program is not always realistic for restoration projects, especially if the projects themselves are associated with low cost and risk. However, if strategic monitoring programs are implemented to measure the effectiveness of stream restoration for specific designs 'categories,' watershed settings, or physiographic regions, information can be collected to that will assist water resources managers in targeting efforts most appropriate for different stream types and restoration objectives.

STREAM RESTORATION EFFECTIVENESS AT REDUCING POLLUTANT LOADS: THE CHESAPEAKE BAY COASTAL PLAIN CASE

The western Coastal Plain of the Chesapeake Bay is one of the fastest developing regions in the U.S. With impervious land covering up to 40% of the catchments adjacent to the Bay, a high number of degraded streams have increased sediment and nutrient loads and peak flow volumes. The proximity of the Coastal Plain catchments to the Bay accentuates the effects of urbanization on aquatic ecosystems because there is less attenuation of nutrient and sediment fluxes compared to catchments upriver that are further from the Bay. Therefore, resi-

dents of highly developed regions adjacent to the Bay such as those in Anne Arundel County, Maryland, hope that stream restoration can serve as an important BMP to mitigate local water quality degradation. County managers also want to reduce the loss of stream and river biodiversity in watersheds with high percentages of impervious area and/or old development, some of which rely on septic systems for their "black water" wastes.

Traditional designs such as the reconfiguration stream channels and armoring of banks to control erosion and sediment export have been used in many restoration projects implemented in the region in the past decade. More recently, innovative designs that take advantage of the low topographic relief of streams near the tidal zone and integrate stream runs, riffles and pools with wide floodplains and wetlands, have been implemented. However, whether or not these newer restoration designs are effective at reducing pollutant loads had never been determined. Further, the effectiveness of one design versus the other had been only speculated. Thus, we saw the situation in Anne Arundel County as a great opportunity to start collecting data on the different stream restoration designs for reducing pollutant loads to downstream waters in a variety of regions and stream types in the Chesapeake Bay region.

We initiated a monitoring program several years ago in streams restored with different designs and implemented either near the headwaters or lower down in the watershed near the tidal area within Anne Arundel County. In each stream, we measured water discharge and concentrations of total suspended solids (TSS) and nitrogen up and downstream of the restored reach to detect changes in loads over time. We also monitored degraded unrestored streams for comparison, and determined concentrations of nitrogen in different forms (e.g., nitrate, ammonia, organic nitrogen) because the potential for nitrogen load reduction along a stream is associated with the dominant forms of the nutrient that enter each stream.

The effectiveness of BMPs such as stream restoration will improve only when monitoring information obtained with well-accepted methods become available for a variety of designs and stream types, and for a wide range of physiographic regions

After two years of collecting data during baseflow conditions, which is when most of the stream flow is derived in Coastal Plain streams of the Chesapeake Bay (Bachman *et al.*, 1998), we observed that the newer and more physically complex (in-stream wetlands and step pools) restored streams were significantly more effective at reducing nitrogen loads moving downstream than

Stream Restoration Can Improve Water Quality But is Far From Being the Silver Bullet... . . . cont'd.

unrestored streams, or streams restored earlier using older designs. For one thing, streams restored with wetlands and step pools were positioned lower in the watershed and usually had higher loads because of higher discharges in comparison to streams positioned near the headwaters. Also, the restored floodplains and wetlands associated with the newer stream restoration design provide more opportunities for nitrogen processing (Craig *et al.*, 2008).

On average, up to 20% of the total nitrogen load moving downstream was reduced in streams restored with floodplains and in-stream wetlands, while the attenuation of nitrogen in dissolved inorganic forms was even higher. We are still investigating how these streams behave during stormflow conditions, but our results from samples collected during just a few storms over entire hydrographs indicate that allowing stormflow water to spill over stream banks into floodplains and wetlands positively affects the quality of water discharged downstream. Our data showed that volume-weighted concentrations of nitrogen decreased between the up and downstream ends of these restored streams during stormflow conditions, especially during the summer. Also the concentrations of TSS decreased several fold between up and downstream sites, while discharges increased only slightly, an indication of load reduction.

Despite the fact that our data showed that most of the restored streams monitored were not effective at reducing nitrogen and TSS loads moving downstream, the results of the newer designs in our case study are encouraging. We believe this indicates that it is critical to carefully link the stream restoration design with the type of stream or physiographic region (i.e., in Coastal Plains regions like our case study, restoration efforts need to be similar to ancient lowland streams that were probably swamp-like). If restoration is designed to represent ancient streams, then stream ecosystem functions such as nitrogen processing and sediment deposition may be enhanced.

However, it is important to keep two things in mind. First, the total amount of nitrogen (e.g., in kg N per unit of stream per time) removed by the project in our case study is very small in comparison to the total load that reaches the Bay each year. Second, much of the nitrogen that enters less impacted forested catchments is actually efficiently processed in the terrestrial ecosystems, including soils and vegetation. Consequently, as nitrogen inputs to catchments continue to increase due to atmospheric pollution, fertilizer application, and human waste, and as forested areas are turned to other uses, catchments will become less capable of processing nitrogen. This means that with high percentages of impervious surfaces, the load of nitrogen entering streams is likely to exceed the capacity of streams to process the nitrogen. These thoughts as well as our extensive work in other areas leads us to believe that increasingly, the solution for reducing pollutant loads in streams and downstream waters should be at the catchment scale, and include well-coordinated efforts to decrease inputs of pollutants to entire watersheds while increasing the effectiveness of

variety of BMPs designed to restore the hydrology and the capacity for pollutant processing in catchments.

The effectiveness of BMPs such as stream restoration will improve only when monitoring information obtained with well accepted methods become available for a variety of designs and stream types, and for a wide range of physiographic regions. In addition, integrated monitoring needs to be adopted in restoration projects so a watershed-scale perspective about the health of a subcatchment can be used to guide future plans.

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APPLICATION OF REGENERATIVE STORMWATER CONVEYANCE WITH OTHER LID ELEMENTS IN APPROACH ZERO DISCHARGE SYSTEMS

Ted Brown

INTRODUCTION

Regenerative stormwater conveyance (RSC) provides enhanced stormwater management by combining features and treatment benefits of swales, infiltration, filtering, and wetland practices into the design. Applicable in new development, retrofit, and restoration scenarios, RSC uses carbon-rich, sand-bed channels, wide parabolic grade control weirs, and shallow pools to collect and convey stormwater runoff (Figure 1). The practice can be used to provide conveyance within a site, to other stormwater treatment practices in a treatment train, or from outfalls into receiving streams. RSC systems are fully consistent with and even expand upon the principles of low impact development and sustainable green infrastructure.

STATUS QUO

Drainage infrastructure, whether it be simply conveyance based or intended for other stormwater management criteria (e.g., detention, channel protection), typically results in the concentration of flows at discrete outfall points. The result seen throughout urbanizing watersheds is impaired habitat, excessive erosion, and transport of sediment and nutrients to downstream sinks (e.g., ponds, lakes, estuaries, etc.), and compromised infrastructure.

BASIC BUILDING BLOCKS

RSC systems are open-channel, sand seepage filtering systems that utilize a series of shallow aquatic pools, riffle weir grade controls, native vegetation, and underlying sand channels to treat and safely attenuate and

convey storm flow, and convert stormwater to ground water through infiltration and below ground seepage.

Cobble weirs set the surface water elevations and establish the hydraulic head necessary to drive the sand seepage system and support the plants. The sand seepage bed, with its 20%-by-volume green mulch, supports microbes, fungi, macroinvertebrates, and processes which remove nutrients and contaminants as they pass through the sand bed while maintaining porosity. The many roots present in the sand take up nutrients and provide sites for microbial attachment, contaminant adsorption, and long-term sequestration in the peat forming layer resulting from annual root formation of the fibric root mat.

Regenerative stormwater conveyance is a new approach to managing site runoff that promotes natural regeneration of stream and wetland ecosystems ...they are unique systems in that they can be located on the front or tail end of a treatment system without the need for flow splitters and still provide water quality and ground water recharge benefits

Once established, these systems are designed to regenerate zero order stream systems that support a broader baseflow regime in first and second order streams. In addition to the hydrologic benefits, RSC restores a range of site ecologies from smaller microhabitat elements to more significant forest floor systems. When designed and constructed properly RSC systems have demonstrated an amazing capacity to regenerate and be mostly self-maintaining.



Figure 1. Photos of RSC.

STORMWATER MANAGEMENT BENEFITS

RSCs are unique in that they have the ability to provide all or some portion of the full range of typical stormwater management criteria, including: ground water recharge, volume reduction, water quality, channel protection, and flood control. They combine features and treatment benefits of swales, infiltration, filtering, and wetland practices, yet are also designed to be stable enough to convey flows associated with events up to and including extreme floods (i.e., 100-year storm) in a nonerosive manner, which results in reduced channel erosion impacts commonly associated with stormwater practice outfalls and receiving waters.

CASE STUDY

The Preserve at Severn is a 156-acre site in Gambrills, Maryland, that was subdivided to form 65 large lots. The subdivision lies in an extremely sensitive area between two branches of Jabez Branch, the only trout stream remaining in Anne Arundel County. The stormwater management design for this subdivision infiltrates the majority of the discharge from up to the 100-year storm using a combination of RSC systems, bioretention areas, and larger constructed sand seepage wetlands.

Overall Design Approach

The design approach for The Preserve at Severn emphasizes the use of RSC systems on both the front and tail end of the treatment system to provide water quality and ground water recharge benefits. Where located on the front end of a treatment train, they provide water quality, ground water, and channel protection treatment while also providing nonerosive flow conveyance that delivers flows to the stormwater quantity control practice – a constructed wetland. This final conveyance and treatment system ensures that flows associated with larger storms are delivered to Jabez Branch either as cooler shallow ground water seepage flows or as nonerosive flows delivered via wide parabolic weirs.

Phase 1 Basis of Design

Drainage Area No. 1 is located in the southeast corner of the subdivision and has a drainage area of 17.9 acres. The underlying soils are mapped as Magothy Formation underlain by the Potomac Group, and are considered as Hydrologic Soils Group B. The stormwater system is designed to meet the water quality, recharge and channel protection volumes all prior to the constructed wetland using the RSC system. Runoff is filtered and infiltrated and allowed to attenuate and dewater in shallow pools.

Water Quality and Recharge Volume

Drainage Area No. 1 was divided into five subareas with 4,470 linear feet of RSC system and two bioretention areas treating stormwater runoff before it enters the

constructed wetland. These devices provide 55,705 cubic feet (cf) of total storage. The required treatment volumes for these devices is 8,053 cf for water quality volume and 2,531 cf for recharge volume. Therefore, subtracting the 8,053 cf from the total storage of 55,705 cf yields a net excess of provided volume of 47,652 cf. This additional volume can be allocated towards meeting the full channel protection volume (18,422 cf), meaning that the channel protection volume is fully captured, detained, and then infiltrated into the shallow sand and cobble seam that in turn will slowly discharge cooler water to Jabez Branch over an extended period of time, which also supports a baseflow regime.

Large Storm Control

Large storm control (e.g., 10-year, 25-year, and 100-year) is typically a rate based analysis where proposed conditions peak flows do not exceed existing conditions peak flows. For this project site, an additional design objective was to provide a near zero surface discharge for events up to the 25-year storm. The site design incorporates a constructed sand seepage wetland to provide storage detention for larger events and to act as a reservoir that slowly releases water to an RSC system that discharges to Jabez Branch. Approximately 3.5 acre-feet of storage are provided by the constructed sand seepage wetland.

While an infiltration loss function was incorporated into the wetland stage-storage-discharge relationship, a similar accounting was not pursued in an explicit manner for the routing of flows through the RSC system. Instead, a simpler and more conservative hydrologic modeling approach was used that routes flows through the system without assuming any infiltration or evapotranspiration losses. Even with this added level of conservative analysis, model output shows that the 25-year discharges will be more than four times less than existing conditions at the wetland outlet. Exit velocities associated with this peak discharge from the wetland will be less than 3 feet per second. Velocities associated with the 25-year event peak flows at the confluence with Jabez Branch are estimated to be 3.4 feet per second (the increase due to the additional 4.4 acres of drainage area) and the flow will be approximately 0.5 feet deep in the outlet weir.

In addition to the stormwater management and ecosystem restoration benefits of the RSC system at the Preserve at Severn, there are significant cost savings realized associated with the stormwater related infrastructure. Initial cost estimates were half as much using the RSC approach versus conventional stormwater management design using storm drain pipe and related drainage infrastructure such as catch basins, headwalls, and endwalls (\$400K vs. \$825K, respectively). Operation and maintenance costs are also expected to be lower than for conventional practices for the RSC system. Finally, the developer is selling these lots for a premium based on the enhanced landscaping elements.

CONCLUSION

RSC is a new approach to managing site runoff that promotes natural regeneration of stream and wetland ecosystems. They are unique systems in that they can be located on the front or tail end of a treatment system without the need for flow splitters and still provide water quality and ground water recharge benefits. Installation of these systems has multiple benefits including, less area of disturbance, lower costs, and opportunities for stakeholder stewardship and participation.

ACKNOWLEDGMENTS

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▲ WATER RESOURCES PUZZLER (answers on pg. 27)

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A SOLAR-POWERED WATER GRAB

Clay J. Landry

A new study by Greenpeace International, the European Solar Thermal Electricity Association and the International Energy Agency indicated that 25 percent of the world's electricity could come from Concentrated Solar Power (CSP) by 2050. Imagine a new and clean energy source that is virtually limitless. Or is it?

According to Boston-based Prometheus Institute, a solar-energy market research firm, the United States (U.S.) will add nearly 12,000 megawatts (12 gigawatts) of solar thermal energy by 2020. The majority of these solar plants are proposed for the southwestern U.S. where heat, sun, and flat landscapes are plentiful. Within the U.S., the Bureau of Land Management has received nearly 160 applications for permits for concentrated solar power plants that would cover more than a 1.0 million acres of federal land with mirrors and reflectors that concentrate the sun's energy. The National Renewable Energy Laboratory has estimated that the majority of CSP electric generation capacity by 2050 will be located in the desert southwest.

While sunshine is abundant in the desert, water is not plentiful. Most commercial CSP facilities use a system of curved mirrors to collect the sun's energy to heat a fluid flowing through tubes. The hot fluid then is used to boil water in a conventional steam-turbine generator to produce electricity. Like conventional thermal power plants, CSP's use water cooling towers to release the heat into the atmosphere through an evaporation process. While air-cooling technology is available, water cooling is generally more economical for CSP plants because it has lower capital costs, higher thermal efficiency, and it operates more consistently through year-round temperature changes.

According to a 2007 report by the U.S. Department of Energy, CSP plants can use up to four times as much water as fossil and nuclear power plants. A typical coal plant or nuclear plant consumes 500 gallons of water per megawatt hour (gal/MWh) of electricity generated. A combined-cycle natural gas plant consumes about 200 gal/MWh. In contrast, most CSP design plants consume about 800 gal/MWh.

The future of CSP facilities in the water-constrained region of the southwest is at a crossroads. The potential cumulative impact of CSP in a region with freshwater constraints has raised questions about whether, and how, to invest in large-scale deployment of CSP. There is still a great deal of uncertainty about the water use impacts of CSP since many of the facilities are still being sited, the selection of the cooling technology has not been finalized, and the technology is continually evolving.

This is not the first time a new and promising power generation technology has encountered problems related to water supply. Touted as a clean source of electricity, more than 200 new natural gas fired power plants were being proposed across the western U.S. by the early

2000s. Like the CSP plants, these plant developers focused on fuel source and transmission and sited their facilities near major natural gas pipelines and transmission power-lines. Water supply was not at the forefront of planning and siting of these gas-fired facilities. Many of the facilities applied for new water rights that were subsequently denied due to lack of water. In fact, Arizona halted plans for two gas-fired power plants in 2002 that would have provided more than 2,500 megawatts of power after the state determined that ground water sources in the region were perilously low. Similarly, Calpine, Cogentrix, and other generation companies shelved numerous projects after running into water supply problems.

Some solar companies are recognizing that water will be vital to their success. For example, Arizona Public Services, the state's largest electric utility, has focused solar development on farmland purchased with existing water rights previously used for growing alfalfa and cotton. The company estimates that the new water cooled CSP facilities will use less water than historically used by the farms.

Total capital investment in CSP is estimated to be \$200 billion by 2020. However, projects slated for public lands may have a difficult time getting financing if they are unable to secure water. Consequently, the demand for existing water rights will likely increase as other companies follow the Arizona Public Services strategy.

Robert Glennon, the author of "Unquenchable: America's Water Crisis and What to Do About It," commented "This reallocation of water – from farming to power generation – offers a lesson for the country as a whole. As the U.S. confronts inevitable water shortages, we need to insist that power companies, developers, and others who need water offset the impact of their new uses by persuading existing water customers to use less."

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PARTY LIKE IT'S 2012

Eric J. Fitch

It's the End of the World as We Know It (And I Feel Fine) – Michael Stipe/R.E.M. Eponymous

Hoban 'Wash' Washburn (Alan Tudyk): This landing is gonna get pretty interesting.

Capt. Malcolm Reynolds (Nathan Fillion): Define "interesting."

Hoban 'Wash' Washburn: [in a deadpan] Oh God, oh God, we're all going to die? - from the film 'Serenity'

On July 22 of this year, the longest total eclipse of this century occurred. The eclipse in totality cut a swath from the Maldives in the Indian Ocean, across south and southeast Asia including India, Nepal, and Bhutan, and terminated its show in Oceania in places such as Kiribati and the Marshalls. At the height of its duration, the sun was in total eclipse for 6 minutes, 39 seconds. A partial eclipse was visible across a much larger geographic area of Asia and Oceania. There will not be another total eclipse of this duration until the year 2132. I believe there are several aspects of this occurrence that we fail to appreciate at our peril. First, the appearance of the eclipse was predicted by astronomers with accuracy and precision undreamed of in most previous cultures. Second, these scientific predictions are considered so commonplace that for many the knowledge became simply another factoid urging them to look up (with the right eye protection) and let nature entertain them. Third, for some the eclipse was a sign of spiritual or supernatural evil, perhaps even a foretaste of the end of the world, as demonstrated by the filling of temples for prayer and at least at one site a stampede of frightened souls and the death of at least one woman who could not move fast enough. A friend of mine cynically observed, it's probably a good thing that we won't have to deal with as "big" an eclipse for more than a century if that's how people are going to act!

This got me thinking about "the end of the world," endtimes and other thing apocalyptic. Hollywood, not to miss a beat, will be bringing out a film this November entitled '2012' (no, it has nothing to do with the Arthur C. Clarke-based movie 2001: A Space Odyssey and its sequels). Instead it is based on the pop cultural premise that according to the ancient Mayan long calendar the world that year will be thrown into chaos and destruction on either December 21 or 23 of the current Gregorian Calendar. Listen to enough conspiracy "experts" long enough and they will express with great sincerity tie-ins (support?) from Numerology to the Book of Numbers to Nostradamus. By the time we actually get to late 2012, I expect there will be a significant number of people expecting the "end of the world" because "that's what they heard."

Part of the great genius of modern society is to elevate the role of the common individual. At least as a society we have agreed that no one is higher or lower in significance because "God made it so." Race, creed, ethnic origins, gender, and other factors that traditionally cause societies to be separated into upper and lower classes have been collectively delegitimized in many countries. Levels of wealth and political power do still create class distinctions, although some talk a good game about these not mattering anymore. However, the greatest social "leveling" seems to be that of opinion. With the elevation of the individual, we have also elevated the value of opinion ("everyone has their right to their opinion").

Unfortunately, we have not accompanied this valuation of opinion with the valuation of intellect or knowledge to defend these opinions. This can be seen almost daily in the "deliberations" of our elected officials. Lack of true deliberative ability can be evidenced by examples such as city councils and county commissions signing on to a hoax petition to ban "dihydrogen monoxide," using Michael Crichton as an "expert witness" before a U.S. Senate Committee hearing on climate change, and using opinion polls to determine the "validity" of scientific theories.

In 1959, C.P. Snow, arguably one of the great intellectuals and polymaths of the 20th Century, gave the annual Rede lecture at Cambridge University. The title of the lecture was "The Two Cultures and the Scientific Revolution," which continues to be published through its 10th edition under the title "The Two Cultures." Snow's premise was both simple and profound: that the academic/intellectual world was fractured into two camps: the literary intellectuals and the natural scientists. He observed that these two sides of the intelligentsia were profoundly suspicious of the other and looked at each other with increasing incomprehension. Snow's lecture threw down a challenge that educators have been trying to deal with ever since. Though the ideal of the pre-industrial Renaissance Man (person), where a person could know all that is worth knowing, is no longer a possibility, higher education does strive to provide students with an appreciation for the fruits of all types of intellectual pursuit, and in doing so may inadvertently exacerbate a larger societal problem. We have produced a generation of leaders who seem to lack of an ability to think critically and objectively with regard to scientific and technical data, and to evaluate relative risks with regard to those data for decision-making.

Some decision makers seem willing to do nothing with regard to climate change, sea level rise, overtaxing water sources to the point where saltwater intrusion, aquifer collapse and myriad other water resource problems occur, and rationalize these decisions by clinging to the idea that all forms of knowledge are "democratically" equal. Worse, some decisionmakers actually understand the science but their political/economic calculus leads them to use these alternate/popular sources to justify their actions to the hoi polloi of their electorate. If one believes what Mooney and Kishenbaum wrote in the book, "Unscientific America: Scientific Illiteracy Threatens Our Future," then these calculated actions may very well work for the purposes of political power. If true, this schism between the few who understand and use scientific knowledge responsibly and those who don't and/or who cynically misuse it may present an even greater threat than Lord Snow illuminated in the halls of Cambridge 50 years ago.

E-MAIL CONNECTION

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JUDICIAL INTERPRETATION AND WATER RESOURCES

J. Brian Smith and Michelle Henrie

Congratulations to our newest U.S. Supreme Court Justice, Justice Sonia Sotomayor. Justice Sotomayor is our first Hispanic Supreme Court Justice, and she is the third woman to serve on the Supreme Court.

The confirmation process for Supreme Court justices has become extremely political and contentious in recent years. Nominees, however, are not labeled Democrat or Republican; rather, they are labeled as “liberal” or “conservative,” or more recently as “activist” judges or as “strict constructionists.” Justice Sotomayor’s critics have expressed concerns that she may prove to be an “activist” judge.

There are no legal definitions or other agreed upon definitions for these terms. Generally, however, an “activist” judge is viewed as a judge who interprets the law broadly, often basing his or her interpretation on currently acceptable societal views, or possibly on their own sense of right and wrong. Critics refer to this broad interpretation of law as “legislating from the bench,” the thought being that the judge is making law rather than just enforcing the law as written. “Activist” judges are generally viewed as being “liberal” in their social views; however, a judge who holds conservative social views could equally promote those conservative views through judicial activism.

A “strict constructionist,” on the other hand, is generally used to refer to a judge who believes in interpreting the law as it is written and as the law was intended by the drafters of the law at the time it was drafted. This judicial philosophy is also referred to as “originalism.” Strict constructionism and originalism are often associated with judges who hold conservative social views. However, a judge with liberal social views could equally promote those views using an originalist interpretation of the law.

Judicial interpretational philosophy generally comes into the national spotlight when a judicial Supreme Court nomination is pending or when the Supreme Court is deciding a constitutional case of national interest. These cases usually center on such constitutional issues as equal rights, the right to abortion, second amendment rights, freedom of speech, and freedom of religion.

However, constitutional interpretational issues can, and often do, arise in water and natural resource related issues. An example is *New York v. United States*, 505 U.S. 144 (1992), a case in which the Supreme Court considered whether the Commerce Clause of the Constitution provided a basis for the federal government to order states to enforce certain federal laws relating to radioactive waste disposal. The Commerce Clause states: “The Congress shall have Power ... To regulate Commerce with foreign Nations, and among the several States, and with the Indian Tribes.” The Supreme Court ruled that the U.S. could not order states to enforce the federal laws. Justice Stevens dissented in that case, arguing: “I see no reason why Congress may not also command the States to enforce federal water and air quality standards or federal standards for the disposition of low-level radioactive

wastes.” Thus, Justice Stevens would have interpreted the Commerce Clause more broadly to allow the federal government the power to order states to enforce environmental laws. Many, no doubt, would view Justice Stevens’ view as an “activist” view. Indeed, the Supreme Court has taken what some might consider an activist approach in the past by using the Commerce Clause to expand federal authority into such areas as federal jurisdiction over all navigable waters, protection of endangered species, and civil rights.

Judicial interpretation also comes into play, not just in constitutional matters, but also in interpreting statutes. In interpreting a statute, judges typically begin with the principle that, when the statutory language is plain, the court must enforce it according to its terms. This seems straightforward enough. Then, however, the courts also apply the principle that the court may consider the specific context in which the language of the statute is used, and the broader context of the statute as a whole. The foregoing provides to the courts a little more latitude in statutory interpretation. Adding additional latitude is the principle that: “if judges are to give meaningful effect to the intent of the enacting legislature, they must interpret statutory text with reference to the statute’s purpose and its history” (Justice Breyer, dissenting, in *U.S. v. RESSAM*, 07-455 [U.S. 5-19-2008]). Thus, even in statutory interpretation, there is ample room for a judge’s particular view on interpretation to come into play.

Issues of judicial interpretation are not limited to the U.S. Supreme Court. Issues of judicial interpretation can arise any time you have a court case with a law that must be interpreted, regardless of whether the court is a local, state of federal court and regardless of whether the law is a constitutional provision, statute, or regulation.

If you are a water resources professional involved in litigation, do you want an “activist” judge or a judge who adheres to a philosophy of strict interpretation? It depends, of course, on your particular case. Most of us at this point would put our politics aside, evaluate our case, and decide which interpretive style, and which judge, is better for our case. If our case is clearly supported by a strict interpretation of a constitutional provision, or by the plain language of a particular statute, then we know we want an “originalist” judge. Conversely, if our case is not clearly supported by existing law and requires going beyond the specific constitutional or statutory provisions, then we are going to want an “activist” judge who may look beyond the four corners of the constitution or statute for historic, societal, or public policy reasons to decide the case in our favor. We cannot always choose our judge, and we do not always know the philosophical leanings of our judges, but a particular judge’s judicial interpretational philosophy is worth considering when the opportunity presents.

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WATER BLOGS: BEST OF AND INTERESTING POSTINGS

Faye Anderson

It seems blogs are referenced everywhere these days – personal blogs, political blogs, company blogs, special topic blogs, etc. The term ‘blog’ evolved from ‘weblog’ and the phrase has stuck – we now have blogs, bloggers, blogging, blogosphere, blogs on blogging, etc. Blogs are a website that you can publish on, a kind of an ongoing newspaper column if you will, or online journal.

The social media savvy see blogs as a nifty Content Management System that allows for easy publishing and managing of text, images, video, links, tags, reader comments, trackbacks, etc. Blogs are interactive communication and their simplicity is part of their draw. Typically set up as a single page with most recent author entries on top, readers can follow along very easily with any new information or updates that their favorite bloggers post.

Many bloggers are devoted enthusiasts and offer their ‘readers’ stories, links, commentary, etc. Check out a list of Top 100 Blogs at Technorati (<http://technorati.com/pop/blogs>). Many bloggers have a special focus to their postings and here we will list just a few interesting water-relevant blogs. Of course, we will assume you have already checked out AWRA’s own blog at <http://awramedia.org/mainblog> and become a subscriber.

Dot Earth

<http://dotearth.blogs.nytimes.com>

DotEarth is the *New York Times* environment blog authored primarily by reporter Andrew C. Revkin and supported by a Guggenheim Fellowship. The blog’s logo is ‘Nine Billion People. One Planet’ and his reporting ranges widely over climate, energy, water, biology, etc., in an effort to examine efforts to balance human affairs with the planet’s resources. This blog is characterized by quality reporting and writing and more in-depth coverage of complex issues.

Water and the World

<http://knight.miami.edu/blogs/joe>

Water and the World is a project of the University of Miami’s School of Communication and the Knight Center for International Media. Water and the World is authored by a former *New York Times* reporter, Joseph Treaster and focuses its attention on national and international water issues and events. He covers policy issues, natural disasters, and major water conferences with a journalist’s eye and provides readers with background and links to further information.

Thirsty in Suburbia

<http://blog.gayleleonard.com>

The Thirsty in Suburbia blog from Gayle Leonard archives funny, offbeat, and insightful happenings related to the vast world of water. As she states “Today, there are many brilliant, thought-provoking and insightful blogs covering the complex issues on the topic of water. This is not one of them.” However, her posts and links are often about the meanings we create around water and the ironies of our water habits. Her posts about water

marketing and advertisements from around the world are very amusing and thought provoking. Besides, she lists AWRA’s Water Resources Blog as Notable.

WaterWired

<http://aquadoc.typepad.com/waterwired>

Michael Campana, aka Aquadoc, truly examines and illuminates all things water – from OSU student projects to western water happenings to breaking national policy issues to international events – and comes up with the very interesting news stories and adds his expert commentary to boot. Something interesting is highlighted every week ... and based on his quality postings, all should note he was crowned ‘The Water King’ by another blogger a few months ago.

Roger Pielke Jr.’s Blog

<http://rogerpielkejr.blogspot.com>

As Roger says, he blogs about science, policy, politics and occasionally some other stuff. He takes complex issues, mostly climate change politics, and tries to make sense of how science is fitting into the mix. His blog posts have caused some measure of controversy in various corners of the blogosphere. Based out of the University of Colorado, his postings illustrate the tough road treaded though and around these complex policy issues ... and the nature of academic discourse when substantial gaps exist in perspectives and research findings.

The Water Blog

<http://www.portlandonline.com/water/index.cfm?c=39678>

The Water Blog comes to readers courtesy of the Portland Water Bureau. In addition to postings updates on local water news, events, and conservation tips for their citizens, the city of Portland, Oregon, is tracking sightings of their *I Only Drink Tap Water* sticker. Check out their tap map and related stories on their water blog.

International Water Law Project Blog

<http://internationalwaterlaw.org/blog>

The IWLP Blog is the work of Gabriel Eckstein, out of Texas Tech, and chronicles his observations on cutting edge developments in international and transboundary water law and policy. His commentary ranges from the latest in ground water law to the role of water in the Middle East peace process to why governments oppose a human right to water. Check out his blog for wide-ranging coverage of international water law issues.

These are just a very small sampling of currently active blogs that water professionals can check out to gain an appreciation for what’s out there. Existing blogs cover all ends of the water cycle and the policy spectrums, and taken as a whole form an important channel for discourse that anyone with an Internet connection can participate in.

E-MAIL CONNECTION

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**▲ HERBERT SCHOLARSHIP AWARD
WINNER FOR 2009-2010 ANNOUNCED**

**GRADUATE STUDENT RECIPIENT
LAURA CHRISTIANSON
IOWA STATE UNIVERSITY
AMES, IOWA**



AWRA congratulates Laura Christianson, the 2009-2010 recipient of the AWRA Richard A. Herbert Memorial Scholarship – Graduate Student Award.

Laura is currently pursuing a doctoral program in agricultural engineering at Iowa State University where her research interests include the study of denitrification bioreactors for agricultural drainage. She is specifically interested in the role biological systems play in water pollution prevention and in conservation, and hopes her research will help landowners worldwide minimize the environmental impacts of their industry.



Solution to Puzzle on pg. 22



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WATER RESOURCES FACULTY POSITION – UNIVERSITY OF MARYLAND

The University of Maryland, Department of Civil and Environmental Engineering, seeks applicants for two (2) tenure-track positions in water resources engineering, hydrology, and hydraulics at the assistant or associate professor level. Appointments at the full professor level will be considered. Candidates are expected to possess strong academic teaching skills, to demonstrate scholarly research, and to obtain funding from competitive external funding agencies. All areas of water engineering and planning will be considered. All applicants must hold a PhD in Civil Engineering or a related field by January 2010 for appointment in spring 2010, or by September 2010 for appointment in fall 2010. For best consideration applications should be received by November 30, 2009, for spring appointment; and by January 31, 2010, for fall appointment, but later applications will be reviewed. Applications should include a cover letter, curriculum vitae, statement of research and teaching interests, and four names of references with contact information, all as a single document attachment labeled "LastName_FirstName_UMDWR_Search09.pdf".

Applications and questions should be referred to:

Ms. Janet Alessandrini
Department of Civil and Environmental Engineering
University of Maryland
College Park, MD 20742, USA
Tel: +1 301-405-1974
Fax: +1 301-405-2585
Email: jalessan@umd.edu

*THE UNIVERSITY OF MARYLAND IS AN EQUAL OPPORTUNITY AND AFFIRMATIVE ACTION EMPLOYER.
WOMEN AND UNDER-REPRESENTED MINORITY CANDIDATES ARE PARTICULARLY ENCOURAGED TO APPLY.*

▲ AWRA'S 2009 ELECTION RESULTS (take office effective January 1, 2010)



PRESIDENT-ELECT
MICHAEL E. CAMPANA

Michael formerly directed the Institute for Water and Watersheds at Oregon State University, where he is now Professor of Geosciences. At the University of New Mexico (1989-2006) He was Professor; Black Professor of Hydrogeology (2003-06); and Director of the Water Resources Program (1997-2006). Prior to UNM he was a hydrologist at the Desert Research Institute and taught in the UN-Reno's Hydrologic Sciences Program (1976-1989). Michael is an academic with a strong practical orientation, initially trained as a ground water hydrologist, but whose interests now include hydrophilanthropy, water resources in developing countries, transboundary water resources, regional hydrogeology, and water resources management and policy. Michael also runs the WaterWired blog and Twitter, and posts often to the AWRA blog, WaterSISWEB, and the Watershed Management Council. His BS is in geology (College of William & Mary) and his MS and PhD degrees are in hydrology (University of Arizona).



SECRETARY-TREASURER
ROBERT J. MORESI

Bob is a Senior Hydrogeologist with more than 35 years of planning, design, assessment, and management experience encompassing all elements of water resources projects. His experience ranges from water supply sustainability to major watershed management projects for flood control. He worked for three of Florida's Water Management Districts for 10 years where he was instrumental in development of their rules and regulations. He has spent the past 26 years in consulting.

Bob has served on organizing committees for water resources conferences, and has authored and presented several publications on water availability, use, protection, and management. He joined the American Water Resources Association in 1971 as a student and has remained active throughout his career.



DIRECTOR
KENNETH CARPER

Kenneth Carper has 30 years of experience as a water resources consulting engineer; he spent the first 20 years of his career in Florida and the last 10 years in North Carolina. As Vice President and Director of Watershed Services for WK Dickson and Co., Inc., a top 500 ENR consulting engineering firm with corporate offices in Charlotte, North Carolina, Ken oversees watershed projects throughout the South

eastern United States. He resides in Raleigh, North Carolina. He has a B.S. in Environmental Engineering from the University of Central Florida in Orlando and a MBA from Florida Metropolitan University. Ken is a registered professional engineer (PE) in Florida and North Carolina, a Certified Floodplain Manager (CFM), and a Certified Professional in Stormwater Quality (CPSWQ). He views AWRA as one of only a few organizations that seems to take pride and a sense of accomplishment at providing opportunities for those with varied technical, professional, and academic backgrounds to come together to collaborate, debate, and implement strategies and solutions that advance water resources management and research.



DIRECTOR
C. MARK DUNNING

Mark Dunning is currently a senior project manager with CDM Federal Programs, responsible for providing support to federal agencies in water resources planning, strategic planning, and socioeconomic evaluation and assessment. Prior to joining CDM, Mark served in the U.S. Army Corps of Engineers for more than 30 years. As Chief of Future Directions in the agency's civil works directorate he led the development and implementation of the Corps' civil works strategic plan that first established integrated water resources management as an agency priority. He also led the Corps' involvement with AWRA in planning and conducting the highly successful and influential National Water Policy Dialogues in 2002 and 2005 and served as a consultant to AWRA for the third policy dialogue held in 2007.

▲ SCHEDULED TOPICS FOR FUTURE ISSUES OF *IMPACT*

NOVEMBER 2009

SPIRITUALITY AND WATER MANAGEMENT

ERIC J. FITCH (ASSOCIATE EDITOR) ~ fitche@marietta.edu

JANUARY 2010

RETURN ON INVESTMENT IN GIS

(SPRING SPECIALTY CONFERENCE)

SANDRA FOX (GUEST EDITOR)

MARCH 2010

ZERO IMPACT DEVELOPMENT

JONATHAN E. JONES (ASSOCIATE EDITOR)

jonjones@wrightwater.com

The topics listed above are subject to change. For information concerning submitting an article to be included in the above issues, contact the designated Associate Editor or the Editor-in-Chief N. Earl Spangenberg at espangenberg@uwsp.edu.

AMERICAN WATER RESOURCES ASSOCIATION MEMBERSHIP APPLICATION – 2009

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