WATER RESOURCES IMPACT

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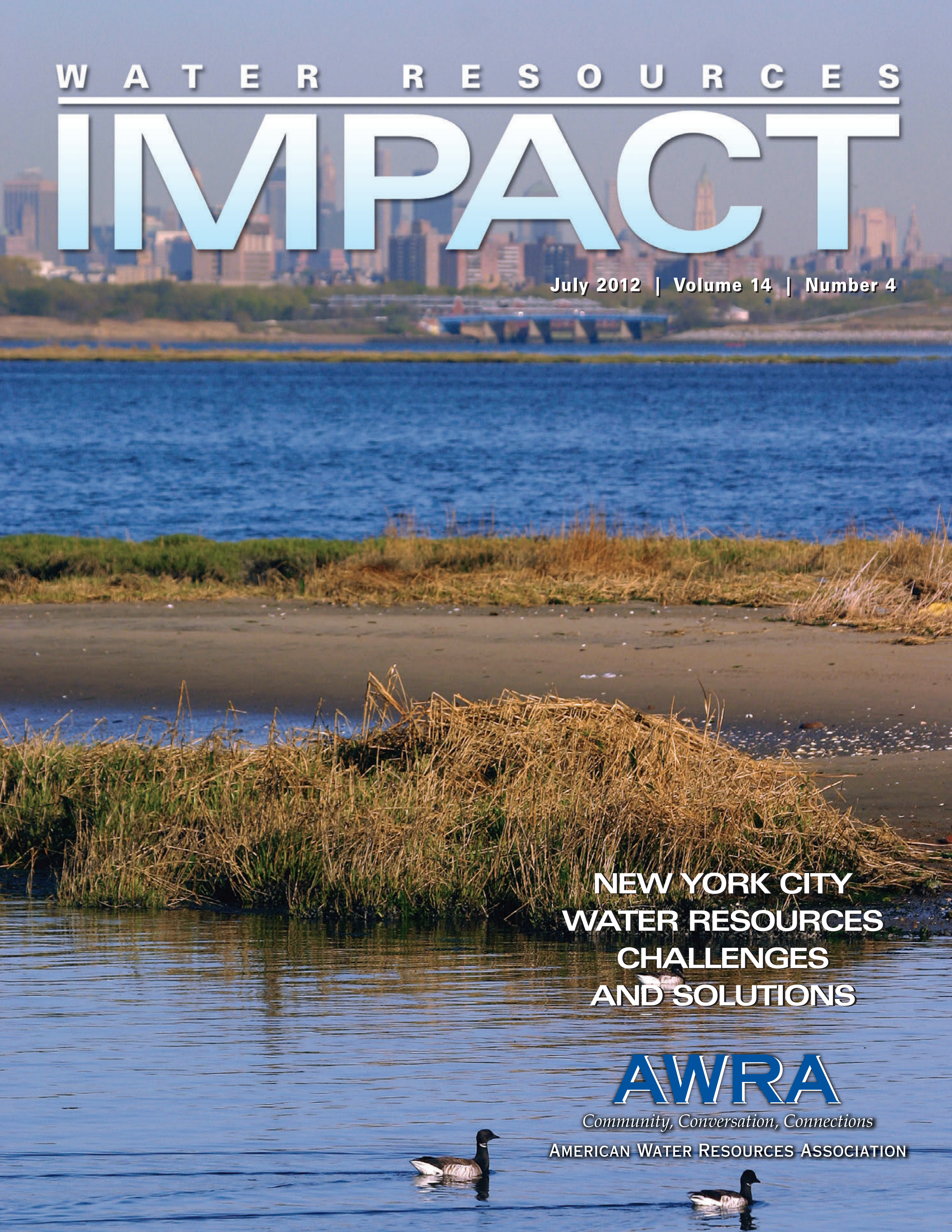

NEW YORK CITY WATER RESOURCES CHALLENGES AND SOLUTIONS

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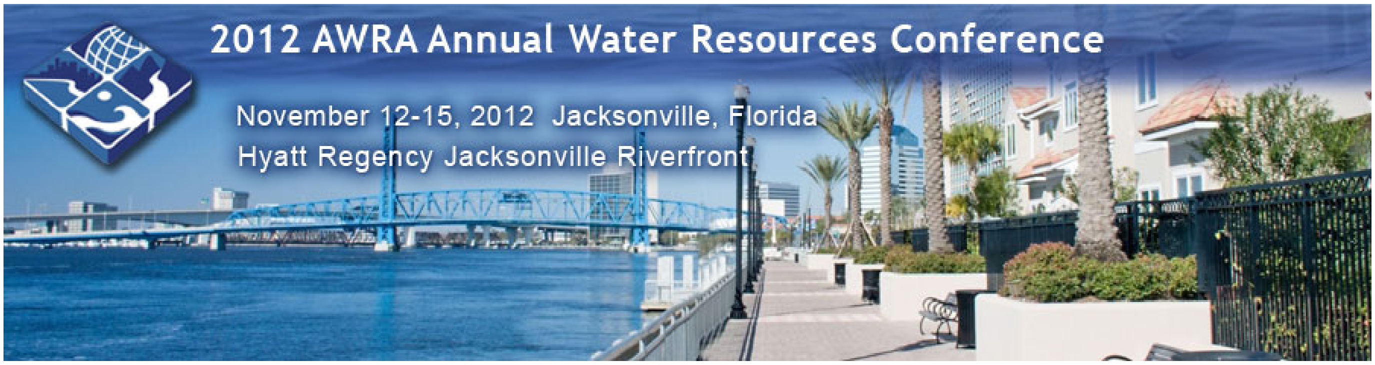

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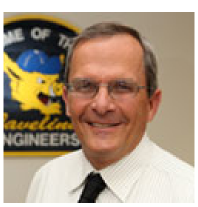

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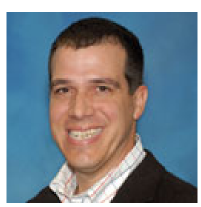

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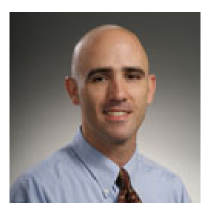

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NEW YORK CITY WATER RESOURCES CHALLENGES AND SOLUTIONS

JOE BERG ~ Associate Editor
jberg@biohabitats.com

This issue of *Water Resources IMPACT* is focused on New York City's efforts to pursue a citywide green infrastructure strategy that includes implementing stormwater retrofit and ecological restoration projects that result in cleaner water, better habitat, and increased awareness. Through a thorough and committed series of pilot projects, the City is taking an adaptive management approach and using lessons learned in the ultra-urban setting to launch broader implementation efforts.

FEATURE ARTICLES

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Other features in this issue ...

(Opinions expressed by our columnists are their own and do not represent the opinion or position of AWRA.)

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American Water Resources Association
4 West Federal Street • P.O. Box 1626
Middleburg, VA 20118-1626
(540) 687-8390 / Fax: (540) 687-8395
E-Mail: info@awra.org • Homepage: www.awra.org

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Cover Photo: Jamaica Bay and New York City Skyline.

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SUSTAINABLE STRATEGY FOR CLEAN WATERWAYS: NEW YORK CITY'S GREEN INFRASTRUCTURE PLAN

Angela Licata

New York City (NYC), the most populated and densely developed urban area in the United States, is surrounded by rivers and bays that are vital to the City and its inhabitants. Due to the ultra-urban environment and expansive impervious surfaces, stormwater runoff poses a threat to the quality of these valuable waterways. Like many other long established urban centers, stormwater throughout much of NYC joins with wastewater flows in a combined sewer system. Under normal conditions, these flows are conveyed to the City's wastewater treatment plants (WWTPs) where they are treated before being discharged into receiving waters. Due in part to the ultra-urban environment and expansive impervious surfaces, during times of intense or prolonged rainfall, flows in excess of the plants' treatment capacities are relieved through combined sewer overflows (CSOs), discharging a combination of untreated wastewater and stormwater into NYC's waterways.

Over the course of many years, NYC has invested billions of dollars to better manage CSOs and improve water quality throughout the City. Traditionally, the City has utilized sewer and treatment plant infrastructure enhancements, commonly referred to as grey infrastructure, for CSO control. These grey infrastructure improvements include treatment plant upgrades, improved CSO regulators, in-line storage, and additional storage and detention options. While these strategies have improved stormwater management and CSO control, remaining opportunities for large-scale grey infrastructure are very expensive and provide few benefits beyond CSO reduction. With substantial wet weather management challenges remaining, NYC sought a long-term plan to cost-effectively and sustainably manage sewer flows, reduce CSOs, and improve receiving water quality. The New York City Green Infrastructure Plan serves as the cornerstone of these efforts, combining smaller-scale, cost-effective grey infrastructure, green infrastructure source controls, and ecological restoration practices.

Green infrastructure stormwater controls manage stormwater runoff near the source by predominantly using natural processes such as infiltration and evapotranspiration. Examples include bioswales that appear similar to street-side tree pits but infiltrate and store runoff within soil and stone layers, blue and green roofs that manage stormwater runoff directly on rooftop surfaces, and pavements that infiltrate runoff through the surface into stone storage and underlying soils. In addition to reducing the rate and volume of stormwater entering the combined sewer system, these green infrastructure source controls can provide an array of additional benefits, including public education, improved aesthetics, reduced energy use, improved air quality, and cooling benefits.

Under the New York City Green Infrastructure Plan, the City is working towards managing runoff from 10% of impervious surfaces in combined sewer areas using green infrastructure over the course of the next 20 years. Already, the City has introduced a new stormwater performance standard for new and expanded development, new stormwater management system guidelines, grant programs, incorporation of green infrastructure into ongoing City infrastructure projects, and direct investment in green infrastructure implementation on public properties within priority CSO areas.

ATS are unique wastewater treatment devices that mimic a stream ecosystem in a constructed environment designed to promote the growth of algae and the removal of pollutants from a portion of the WWTP effluent

Through an adaptive management approach, NYC is applying lessons learned from green infrastructure implementation throughout the City to guide future efforts. This approach provides the flexibility to incorporate the latest and most innovative stormwater controls into ongoing efforts, while continuously refining existing designs, construction techniques, and maintenance protocols. A stormwater retrofit pilot study serves as a key element of this approach. To date, more than 20 source control retrofits have been constructed, including bioretention, street-side bioswales, blue roofs, green roofs, permeable pavement, and subsurface detention and infiltration systems. These pilots have been constructed within street rights-of-way, rooftops, parks, public housing facilities, and parking lots in collaboration with other city agencies and local authorities. Performance monitoring at these pilot locations not only assists in refining designs and evaluating implementation logistics, but also provides critical information to support ongoing green infrastructure modeling, analysis, and planning efforts.

Beyond better runoff management at the source, the NYC Green Infrastructure Plan seeks to improve water quality directly within NYC's surface waters through ecological restoration practices. Specifically, the New York City Department of Environmental Protection (NYCDEP) is leading the effort to implement a range of ecosystem restoration pilot projects within the Jamaica Bay watershed. These pilot projects were identified as part of the Jamaica Bay Watershed Protection Plan, which is focused on cleaning the water of the Bay and reestablishing previously lost ecosystems. A range of projects has been pursued since 2009 including introducing algal turf scrubber (ATS™) technology at a WWTP, installing an oyster bed and oyster reef balls, monitoring the effectiveness of floating islands to slow or prevent further marsh erosion, measuring the filtration capacities of ribbed mussels in situ, and planting eelgrass in the Bay.

ATS are unique wastewater treatment devices that mimic a stream ecosystem in a constructed environment designed to promote the growth of algae and the removal of pollutants from a portion of the WWTP effluent. The microalgae from the ATS are periodically harvested and can be used as a source of biofuel, along with macroalgae harvested from the Bay, creating a sustainable, "green" technology. Oysters, which serve as natural water filters, once thrived in Jamaica Bay, but are no longer found there due to overharvesting and other human disturbances. As part of restoration pilot efforts, installation of an oyster bed and reef balls are evaluating the potential for restoring this habitat. Within Jamaica Bay, preventing the loss of salt marshes and protecting existing shorelines can be a challenge. A pilot project is underway to use a floating wetland as a wave attenuator to potentially control marsh erosion caused by wave energy and potentially create additional habitat. Another pilot is evaluating the use of mussels, which have a well known filtering capacity and are abundant in parts of Jamaica Bay, to treat water in the vicinity of wastewater and CSO discharges. Finally, submerged aquatic vegetation (SAV) beds are important for a number of fish and shellfish species. As part of the ecosystem restoration pilots, eel grass, a type of SAV, is being planted at locations throughout the Bay to better understand how it can be effectively grown in the future.

With substantial stormwater management and water quality improvement challenges at hand, NYC has embarked on an ambitious, yet achievable, approach to address these challenges through the use of innovative and sustainable solutions. The City is making major investments to improve water quality within its waterways through an adaptive management approach that relies heavily upon green infrastructure. Implementation of green infrastructure source controls and ecological restoration practices throughout the City is already underway, providing valuable information on the challenges and benefits of these systems. Utilizing these lessons to expand implementation efforts is expected to provide better management of stormwater and improve the quality of the surrounding waterways, contributing towards a greener and more sustainable NYC.

AUTHOR LINK Angela Licata
Deputy Director
Bureau of Environmental Planning & Analysis, NYCDEP
59-17 Junction Blvd., 11th Floor
Flushing, NY 11373-5108
(718) 595-4458

E-MAIL AngelaL@dep.nyc.gov

Angela Licata is the Deputy Commissioner for Sustainability for the NYCDEP. She brings over 20 years of experience working with the DEP to this role and has had the opportunity to work with all aspects of the operation. In her current position overseeing the Bureau of Environmental Planning and Analysis, Bureau of Environmental Compliance, and the Office of Green Infrastructure she is responsible for more than 25 major initiatives of NYCDEP's strategy 2011-2014.

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▲ HIGHLIGHTS OF JAWRA TECHNICAL PAPERS • JUNE 2012 • VOL. 48 • NO. 3

Wildman and Forde evaluate the viability of an interstate water market in the Colorado River Basin.

Doyle and Shields challenge effectiveness standards for stream restoration programs.

Kenney *et al.*, ask, "Is urban stream restoration worth it?"

Allums *et al.*, analyze nitrate concentrations in four springs that discharge from the Upper Floridan aquifer into the Flint River.

Muñoz *et al.*, present a method for estimating peak flow under a scarcity of hydro-meteorological information.

Mulvihill and Baldigo analyze how various data stratification schemes can be used to optimize the accuracy and utility of regional hydraulic geometry.

Cheng *et al.*, present a multi-step progressive optimality algorithm for short-term hydroscheduling in China.

Andersson *et al.*, compare two approaches to obtain climatic time series and assess the performance of SWAT in simulating discharge and smallholder maize yields in Southern Africa.

Bunte *et al.*, demonstrate how bankward fining and longitudinal differences of pool-tail fines can affect amounts, variability, and accuracy of grid-count results obtained by different sampling schemes.

Dutta *et al.*, add some critical experimental data to the discussion of poultry litter, looking at estrogens and dissolved organic carbon.

Waite *et al.*, compare the performance of models developed using multiple linear regression techniques with models developed using three relatively new techniques.

Stoeckel *et al.*, look at how reservoirs can affect exposure times of downstream organisms.

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JAWRA ~ Journal of the American Water Resources Association

ALGAL TURF SCRUBBER PILOT PROJECT: EVALUATING NUTRIENT REMOVAL AND BIOFUEL POTENTIAL

John McLaughlin, Robert Will, Peter May, and Sarah Roberts

Jamaica Bay is impaired by high nutrient loadings associated with limited tertiary treatment in the wastewater treatment plants discharging to the estuary. Tertiary treatment through physical and chemical or alternate microbial processes is widely used but costly to implement and can be variable in its performance (Randall *et al.*, 1990). Alternative ecologically engineered nutrient removal technologies are emerging as cost effective methods to achieve water quality goals. The use of natural processes in controlled, ecologically engineered systems are designed and managed to do work for society in ways that are less expensive and more ecologically sound than traditional technologies. Algal Turf Scrubber© (ATS™) technology has been shown to be an effective tool for tertiary treatment (Craggs *et al.*, 1996).

In September 2010, New York City Department of Environmental Protection (NYCDEP) completed construction of the Jamaica Bay Algal Turf Scrubber© (ATS™) Pilot Project located at the Rockaway Wastewater Treatment Plant (WWTP) in Rockaway, Queens, New York City (NYC), The purpose of this pilot project is to evaluate the potential effectiveness of the technology for removing nutrients entering Jamaica Bay, thus improving water quality in the Bay. In addition, one of the goals of the ATS pilot implementation is to determine the feasibility and economy of scaling up the system to handle tens of millions of gallons of wastewater per day from one or more of NYC's WWTPs.

An algae-to-biofuel demonstration is also being conducted in conjunction with the ATS. Along with macroalgae harvested from Jamaica Bay, micro-algae harvested from the ATS is being researched to determine its viability as a source of biofuel. Periodic harvesting of the algal turf removes nutrients and pollutants from the system while stimulating continued algal growth and dramatically increasing algal uptake efficiencies (Adey and Loveland, 1991). The algae harvested from the ATS can also be reused as fertilizer; a high protein feed stock for animals, and a source of oil for biodiesel. The additional use of the algae as a beneficial byproduct makes the treatment of wastewater with ATS extremely cost efficient. If current efforts to utilize algae oils for biodiesel production prove effective, the large volumes of algae produced from the ATS could potentially fuel city vehicles such as garbage trucks.

PILOT PROJECT LOCATION

The ATS system is deployed at the Rockaway WTTP on the southern edge of Jamaica Bay, located at the northern end of Beach 108th Street in Rockaway Queens (Figure 1). The initial site for the pilot ATS system was planned for the 26th Ward WTTP but was later changed to the Rockaway WTTP because of the size and space considerations. The Rockaway WTTP, at 22 million gallons per day, is the smallest of the Jamaica Bay WTTPs and was only supporting a secondary level of wastewater treatment. In addition, the Rockaway WTTP had available secure space adjacent to its sludge transfer bulkhead on Jamaica Bay for the ATS pilot implementation

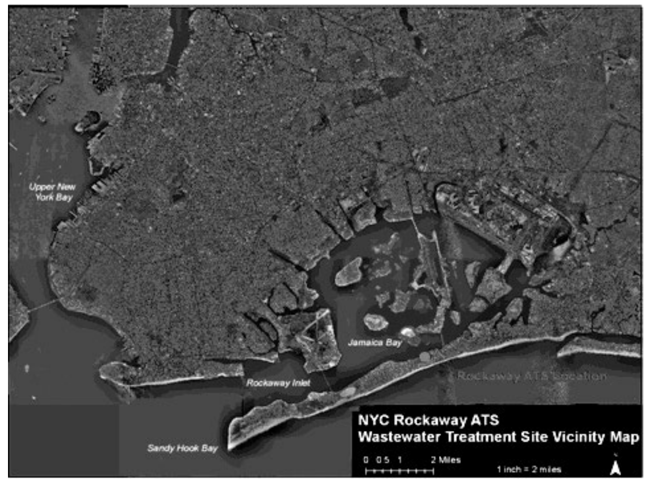

Figure 1. Rockaway ATS Location.

ALGAL TURF SCRUBBER DESCRIPTION

Algal turf scrubbers are a unique water treatment technology that cultures diverse, natural assemblages of attached benthic periphyton, bacteria and phytoplankton on an inclined floway with screen substrate, to remove a variety of nutrients or contaminants from polluted waters (Adey *et al.*, 1993; Adey *et al.*, 1996). The first algal scrubbers were patterned after marine algal mats found on the surfaces of coral reefs. Later versions of the ATS were found to be readily adapted to estuarine and freshwater sources with algae native to those ecosystems. The ATS process is a patented water treatment technology developed by Dr. Walter Adey and held by the Smithsonian Institution, and subsequently licensed to Hydromentia, Inc., a Florida firm that has greatly expanded the use of this technology.

Performance data on ATS systems to date has shown that marine and estuarine systems develop a more robust algal growth than freshwater systems

The ATS, which mimics a stream ecosystem, is designed to promote the growth of beneficial algae which uptake pollutants from water pumped through the floway. The system uses the algae to filter nutrients from wastewater effluent that is pumped into the floway in regular pulses from the Rockaway WTTP. The ATS pilot consists of two inclined floways – long, slightly sloped, shallow troughs made of waterproof materials and raised on a support frame – and screen liners (Figure 2). The two floways are 350 ft x 1 ft (107m x 0.3m) angled at a 0.5 percent slope, which receive pulsed, secondarily treated sewage effluent at two different flow rates. Wastewater effluent is pumped from the Rockaway WTTP clarifiers prior to chlorination to the ATS pilot system.

Figure 2. Dual ATS Floways Looking Upstream From the Effluent Return Tanks.

MONITORING

Started in September 2010, the dual Rockaway ATS systems were operated, maintained, and monitored through December of 2010. Restarted after a winter shutdown period in March 2011, the systems were again operated, maintained, and monitored through the year until being shutdown for the winter in December 2011.

Algal Production and Harvesting

Algal turf communities must be "grazed" or harvested regularly for the community to be kept in a high rate of growth. The algal community is most efficient at removing and metabolizing nutrients and carbon dioxide when the algae are young and growing. To maximize algal production and simultaneously nutrient removal, the two ATS floways were periodically harvested (Figure 3). Collected algae were then transferred by hand to nylon mesh bags and drained. After draining, the algae were weighed and recorded. The recorded weights from each harvest were used to compare algal productivity over the entire monitoring period.

Figure 3. Squeegee Used to Scrape Algae From the Floway Mesh.

Algal Tissue Sampling and Speciation

The production of algae in the ATS represents the major pathway of nutrient uptake and removal. To evaluate the mass of nutrients, carbon and other constituents removed by the algae, algae were collected monthly and sent to a lab for analysis.

Water Quality Sampling

Several types of water quality sampling and analysis were performed during the 2010 and 2011 monitoring such as grab samples, composite samples, and seasonal diurnal sampling. The water samples were analyzed for a wide range of constituents such as nutrients and total suspended solids (TSS) concentrations. At the same time that grab and composite samples were taken, *in-situ* measurements of temperature, dissolve oxygen, pH, and conductivity were made at the start and end of the ATS floway. The purpose of the water quality samples and *in-situ* measurements were to develop a better understanding of the relationship between Rockaway WTTP secondary treated effluent and the performance of the ATS technology for providing additional water quality treatment.

Algal Drying and Biofuel Conversion

To evaluate the potential for algal biomass to be efficiently converted into a usable biofuel, algae collected during harvesting were dried on wire racks in a drying shed. Once dry, algae were shipped to the University of Arkansas, who was contracted to convert ATS-produced algal biomass into biofuel products. The first liter of biobutanol was produced in December 2010.

BENEFITS OF THE ATS

The primary benefit of the ATS system is in providing a cost effective tertiary treatment of contaminated water sources. A level of water treatment can be achieved depending on the level of algal biomass production. In addition, one of the primary goals for the project was to reduce nutrient loadings and to some degree, this has been achieved. A 10% removal of Total Kjeldahl Nitrogen (TKN), the organic nitrogen form preferentially utilized by the algae, was achieved in 2011. Additionally 5% of total phosphorous removal was achieved.

Additional benefits of the ATS system are demonstrated in the various uses of the primary byproduct of the system, algal biomass. The ATS pilot demonstrated that the algae can be converted into biofuels such as ethanol and butanol. Any remaining algal biomass can be utilized as fertilizer. Using the algae to produce the dietary supplement Omega-3 oils has also been demonstrated elsewhere and represents a potential for producing further revenue by creating a commercially desirable product.

For this pilot project, the ATS algae removed on average 30% of the carbon from the source water. In effect, that carbon is sequestered if used as a fertilizer. As an energy source, the algae represent a carbon neutral biofuel as they release the same amount of carbon in combustion as they uptake from the water and atmosphere. Carbon credits through a regional carbon trading effort could be attributed to a scaled up project. Likewise, nutrient credits could be counted should a nutrient trading effort be implemented in NYC as it is being considered in other regions.

Oxygen production is also a significant byproduct of the ATS operation. Algae produce significant quantities of oxygen during photosynthesis, often saturating and super-saturating the source water with oxygen. There may be potential in the use of this highly oxygenated water as a supplement to daytime activated sludge processing that requires significant quantities of oxygen to be diffused during system operations at significant cost.

Should these stacked benefits be realized, they would contribute to offsetting the operation and maintenance costs of an ATS system. While not likely to entirely offset ATS costs, an ATS system operated by a public, nonprofit entity may represent a lower cost water treatment technology while showing some form of economic return in the process.

In addition, one underrealized benefit of the ATS system operation is the demonstration of a green technology that can be incorporated into public school educational programs, and profiled as one of the many tools that NYC is utilizing in striving to achieve a measure of sustainability in its management for the benefit of its residents.

An option that may be considered if the ATS pilot project is operated in the future is application of the bayside ATS to flow from Jamaica Bay source water. Performance data on ATS systems to date has shown that marine and estuarine systems develop a more robust algal growth than freshwater systems. With the high level of nitrogen the possibility exists that direct treatment of Jamaica Bay water may produce an increase in nitrogen load reduction. If successful, future treatment options could include a blend of wastewater and water from the Bay for algal growth enhancement and nitrogen load reduction.

NEXT STEPS

The 2010 and 2011 ATS operation periods were beset by numerous shutdowns of the ATS floways due to a several factors. From an ATS pilot project system evaluation perspective, optimization of algal growth rates provides the greatest opportunity for nutrient removal and reducing water treatment costs. One of the goals in operating the ATS system through the 2012 season will be to determine if the system can operate on a more continuous basis, thereby optimizing algae growth rates and increasing overall algae harvests, while providing increased nutrient removal and water quality improvement.

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AUTHOR LINK
John McLaughlin
Director, Office of Ecological Services
Bureau of Environmental Planning & Analysis, NYCDEP
59-17 Junction Blvd., 11th Floor
Flushing, NY 11373-5108
(718) 595-4458

E-MAIL
JohnM@dep.nyc.gov
RWill@dep.nyc.gov
pmay@biohabitats.com
sroberts@biohabitats.com

John McLaughlin is the Director, Office of Ecological Services, with the NYC Environmental Protection. He has been with NYCEP for 19 years and has been active in the ecological restoration field for over 25 years. He also led the development of the ecological and water quality strategies of the Jamaica Bay Watershed Protection Plan.

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STORMWATER CONTROL IN THE PUBLIC DOMAIN
Green Infrastructure Source Controls in Parks and Public Housing

Julie Stein and Matthew Jones

Implementation of stormwater treatment practices on public property is a major element of New York City's (NYC) ongoing green infrastructure efforts. Parks and public housing facilities are distributed throughout the combined sewer areas of NYC and contain the full range of impervious surface types and configurations, presenting opportunities for unique green infrastructure applications in addition to the street-side and rooftop controls used elsewhere within the City.

Take for example, the Bronx River Houses, a public housing complex located within the Bronx, New York. The Bronx River Houses consists of a central community center, a number of high rise residential buildings, parking lots around the edge of the complex, and concrete sidewalks throughout (Figure 1). This variety of impervious surfaces was conducive to pilot implementation of a blue roof tray system, subsurface stormwater chamber system, subsurface perforated pipe system, and a number of bioretention areas. These source controls were implemented between Spring 2010 and Fall 2011 as part of the Department of Environmental Protection's (DEP's) green infrastructure pilot program.

Given the preliminary installation and monitoring success of the various pilots at the Bronx River Houses, it is clear that public properties like parks and public housing complexes present opportunities to manage stormwater runoff through the use of green infrastructure

Like many public housing complexes in NYC, there are small vegetated areas dispersed between sidewalks, courtyards, and buildings. At the Bronx River Houses, bioretention was implemented throughout these open areas around the central community center. These bioretention areas contain a 6-inch surface depression, approximately 12 inches of an engineered sandy soil, and an 8-inch stone drainage layer with an underdrain connected to existing catch basins. Openings were cut into the existing concrete curbs to allow runoff from the sidewalks to enter the bioretention areas. Flagstone sumps were also installed immediately downstream of these curb cuts to catch debris and consolidate maintenance efforts. As these bioretention areas were in the general vicinity of larger existing trees, they were designed with low lying shrubs and vegetation, rather than trees, which are commonly used in NYC street-side bioswale and bioretention applications.

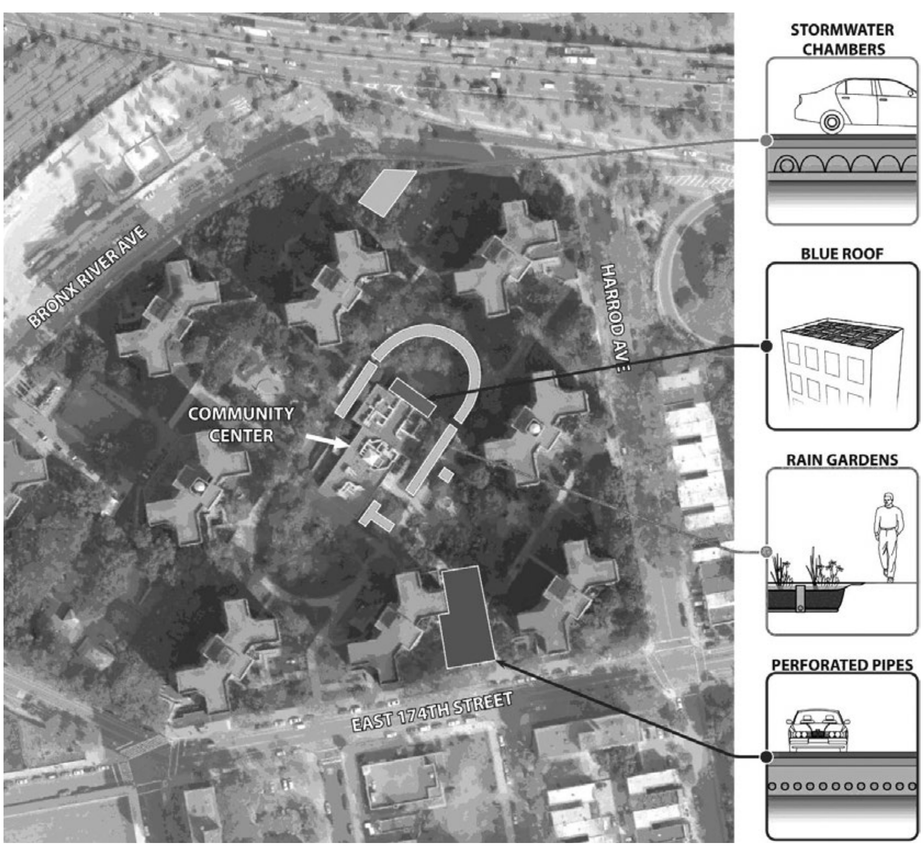

Figure 1. Overview of Green Infrastructure Implemented at the Bronx River Houses.

Both quantitative and qualitative monitoring activities are underway at these bioretention areas to evaluate their overall performance and specifically, their effect on runoff flow rates and volumes. During the 2011 monitoring period, these bioretention areas were effective at managing runoff from smaller storm events, retaining the majority of runoff for storms with less than one-inch of rainfall. Even with this high level of retention, these bioretention areas drained rapidly, with complete water drawdown often occurring before a storm ended. These evaluations in combination with additional on-site performance assessments suggest that most of the runoff these controls receive is seeping into the underlying soils.

A similar trend was observed during the first monitoring season for the open bottom, subsurface detention facilities installed under two of the parking lots at the Bronx River Houses. Both subsurface systems incorporate a pretreatment baffle structure to consolidate removal of oils, sediments, and debris. An orifice plate at the outlet of each system restricts 10-year storm flows to 0.25 cubic feet per second (cfs), in accordance with NYC's new stormwater performance standard. The two systems differ in how they provide void space for detention. At one parking lot, stormwater chambers increase void space, while a series of perforated pipes are used at the other location (Figure 2). In both cases, stone surrounds these structures, increasing storage capacity. These systems were designed with an open bottom, providing direct contact with underlying in-situ soils, in order to allow seepage losses and improved retention.

Figure 2. Subsurface Perforated Pipe System Under Construction.

Although the stormwater chamber system was designed primarily for detention, the system retained runoff from most storms during the 2011 monitoring period, only generating outflow during large or intense storms. Evaluations of monitoring data and on-site assessments indicate that runoff is seeping into the underlying soil, preventing flows from reaching the combined sewer system. As the perforated pipe system was constructed more recently, performance evaluations at that source control are ongoing.

Given the preliminary installation and monitoring success of the various pilots at the Bronx River Houses, it is clear that public properties like parks and public housing complexes present opportunities to manage stormwater runoff through the use of green infrastructure. Due to the varied nature of parks and housing facilities, there are opportunities for a variety of different green infrastructure controls which incorporate numerous different design elements. Ongoing monitoring activities as part of DEP's pilot program continue to provide valuable information on the performance, maintenance requirements, and general functionality of these controls, and will undoubtedly be used in the future to improve green infrastructure design elements at other public facilities and thereby alleviate combined sewer overflows throughout the City.

AUTHOR LINK Julie Stein
Director, Office of Stormwater Management Planning
Bureau of Environmental Planning & Analysis, NYCDEP
59-17 Junction Blvd., 11th Floor
Flushing, NY 11373-5108
(718) 595-4397

E-MAIL JulieS@dep.nyc.gov
mjones@hazenandsawyer.com

Julie Stein is the Director of Wet Weather Planning and Water Quality Policy within NYCDEP Sustainability. She currently directs the planing and public participation activities for the development of DEP's Long Term Control Plans (LTCPs) as well as related technical evaluations of green infrastructure and climate resiliency alternatives.

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Water Resources IMPACT is in its 14th year of publication and we have explored a lot of ideas. We hope we have raised some questions for you to contemplate. "Feedback" is your opportunity to reflect and respond.

We want to give you an opportunity to let your colleagues know your opinions ... we want to moderate a debate ... we want to know how we are doing. For this issue send your letters by e-mail to:

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Please share your opinions and ideas. Please limit your comments to approximately 350 to 400 words. If published, your comments may be edited for length or space requirements.

ROOFTOP CONTROL OF STORMWATER: A SUSTAINABLE SOURCE CONTROL STRATEGY IN NYC USING BLUE ROOF AND GREEN ROOF APPLICATIONS

Julie Stein, John McLaughlin, and Laura Bendernagle

THE CHALLENGE OF STORMWATER MANAGEMENT IN AN URBAN ENVIRONMENT

The water cycle is a staple of most grammar school science classes. Evaporation, condensation, precipitation, then transport to the ocean – the basic cycle. What we often overlook is how the water cycle has changed due to anthropogenic influences like urban development. Notably, in natural environments, most rainwater infiltrates or is absorbed by plants. Runoff may account for only 10-20% of rainfall depending on soil type. In contrast, urban centers like New York City (NYC) contain large swaths of impervious surfaces which prevent infiltration, and runoff oftentimes will comprise more than 55% of rainfall (USEPA, 1993).

In 2010, the Department of Environmental Protection (DEP) published the Green Infrastructure Plan and launched a green infrastructure pilot program. While many green infrastructure practices are being tested through the pilot program for design, performance, and maintenance in NYC's urban environment, two pilot practices – blue roofs and green roofs – are especially suited for rooftop runoff management. Rooftops represent approximately 28% (NYCDEP, 2010) of impervious surfaces in the City, and therefore present a significant opportunity for green infrastructure implementation. Furthermore, rooftops are often unused space with limited public access, and could be especially useful in areas where ground-level space for source controls is limited. In order to better understand the functionality of blue and green roofs alike, DEP has developed two key rooftop green infrastructure pilots – one at a DEP warehouse on Metropolitan Avenue in Brooklyn, and one at an elementary school (PS 118) in Queens.

BLUE ROOFS FOR STORMWATER MANAGEMENT

Blue roofs are a relatively new stormwater management practice, and consist of structures that provide temporary storage capacity during and immediately after rain events, as well as some opportunity for stormwater volume reduction through storage and evaporation. Various blue roof types include modified inlets, check dams, and trays, all of which are currently being testing at the Metropolitan Avenue blue roof pilot site, constructed in Fall/Winter of 2010 (Figure 1). In each of the four sections being monitored, drain inserts are used to measure outflow rates for comparison of the effectiveness of the different blue roof types. In addition, a weather station was installed to measure site-specific rainfall, wind, evaporation, and solar radiation.

The modified inlet at the Metropolitan Ave. pilot site surrounds an existing roof drain and incorporates a weir with an orifice to restrict water flow into the drain. Rainwater therefore ponds across this portion of the roof.

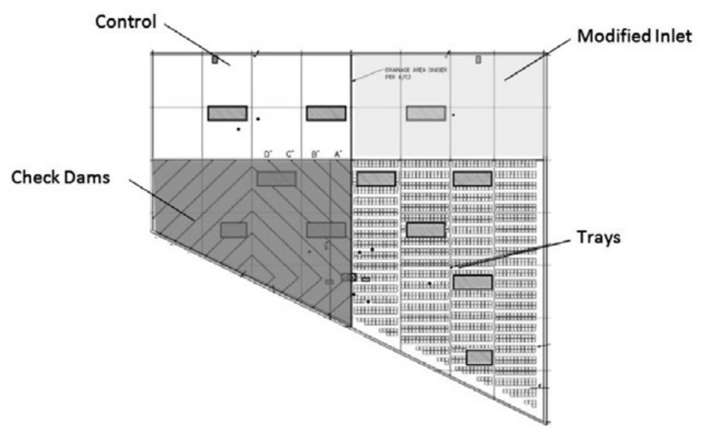

Figure 1. The Four Roof Quadrants at the Metropolitan Avenue Blue Roof Pilot Are Used to Directly Compare the Effectiveness of Three Types of Blue Roofs.

Check dams surround another roof drain at the Metropolitan Avenue pilot. The dams are short barriers made of 1-inch high angle aluminum with orifice holes drilled at regular intervals. Loose gravel is piled behind the dams to further delay water transport to the roof drain and prevent clogging of the dam orifices. The barriers create added storage across the roof and slow the movement of water to the drain as the water must overtop or seep through the dams.

While stormwater and water quality challenges remain, blue roofs and green roofs will likely contribute to the City's spectrum of innovative solutions to CSOs

Likewise, the modular trays provide added rooftop storage, with water slowly seeping through a layer of filter fabric and small weep holes in the bottom of the trays. The trays are 2 feet by 2 feet, 3-4 inches high, and filled with stone ballast to prevent wind uplift. A distinct advantage of a tray configuration over the modified inlet and check dam roof types is the ability to limit water retention and ponding to specific portions of a roof. As such, pathways and areas with lower structural loading capacity can be kept free of standing water after a storm event.

The main advantage of blue roof practices in general is that they are typically among the most cost effective of green infrastructure practices to design, install and maintain. Routine maintenance includes removal of debris and unclogging of roof drains. Common concerns involve mosquito breeding. However, if the blue roof is properly designed to drain in 30 hours after a rain event and maintained to prevent clogging, mosquito eggs will not have the opportunity to hatch.

GREEN ROOFS FOR STORMWATER MANAGEMENT

Another important DEP, green infrastructure rooftop pilot site is PS 118 in Queens, New York. This roof is divided into three sections – a blue roof, a green roof, and an uncontrolled reference section – each approximately 3,200 square feet in size. Similar to the monitoring setup at Metropolitan Avenue, a full weather station, water level loggers, v-notch weirs, and drain inserts are used to monitor conditions and provide a comparison for the green and blue roof pilots. Green roofs differ from blue roofs in that they incorporate a greater focus on retention and evapotranspiration through the use of an engineered, porous soil media, drainage cores, and vegetation (Figures 2 and 3). Typical vegetation includes hardy, drought resistant plants such as sedum. The green roof at PS 118 is one continuous installment, however modular, pre-vegetated green roof tray systems are also commercially available.

In addition to providing stormwater benefits, green roofs provide a number of notable ancillary benefits. For instance, studies by Columbia University researchers at the Con Edison Learning Center facility in Queens, New York, have shown that green roofs reduce building energy use for heating and cooling through increased insulation and evaporative cooling effects. While blue roofs have yet to be tested, they may show similar, if reduced, energy benefits. Green roofs also provide extra protection for the roof membrane and reduce large heat swings in roof temperature, both of which enhance membrane durability and longevity. Lastly, green roofs provide aesthetic benefit and increased property values by brightening and refreshing the urban landscape.

ROOFTOP PILOT PRELIMINARY STORMWATER RESULTS

While results are still being collected from the PS 118 and the Metropolitan Avenue pilots, certain preliminary trends have already been identified. For example, the green roof generally retains 60% of rainfall for storms smaller than one inch, while the retention performance of the blue roofs is more varied. All Metropolitan blue roof types evaluated, including the uncontrolled quadrant, provide some level of retention and detention, and all drain within an adequate timeframe to avoid prolonged ponding and to provide storage capacity for the next storm event. However, in general, the tray and check dam systems appear to provide a greater level of detention than the modified inlet and uncontrolled roof.

In all, monitoring of the blue and green rooftop pilots in NYC will continue for approximately one more year, at which time more conclusive performance results will be released. However, while stormwater and water quality challenges remain, blue roofs and green roofs will likely contribute to the City's spectrum of innovative solutions to Combined Sewer Overflows.

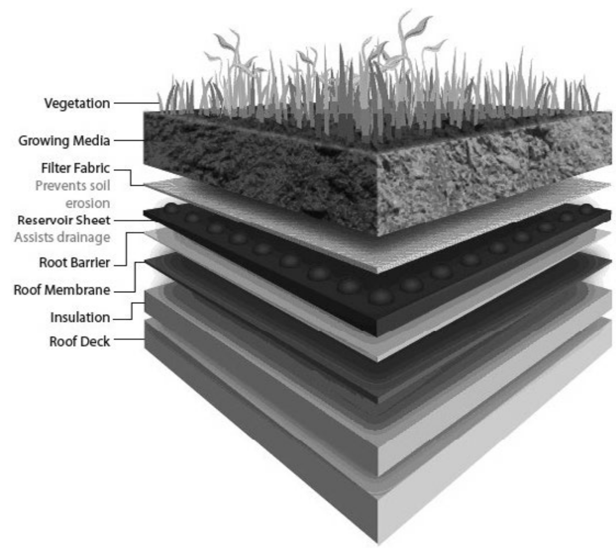

Figure 2. Green Roofs Are Typically Composed of Layers That Encourage Retention and Evaporation.

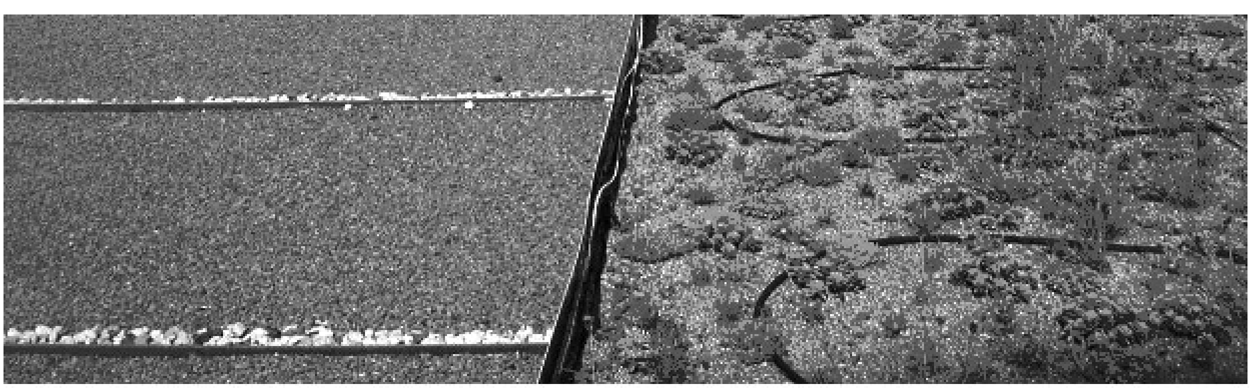

Figure 3. At PS 118, Two Rooftop Source Controls – A Green Roof and Blue Roof – Were Installed and Are Currently Being Monitored.

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E-MAIL

Julie Stein
Director, Office of Stormwater Management Planning
Bureau of Environmental Planning & Analysis, NYCDEP
59-17 Junction Blvd., 11th Floor
Flushing, NY 11373-5108
(718) 595-4397

AUTHOR LINK

JulieS@dep.nyc.gov
JohnM@dep.nyc.gov
LBendernagel@hazenandsawyer.com

Julie Stein is the Director of Wet Weather Planning and Water Quality Policy within NYCDEP Sustainability. She currently directs the planing and public participation activities for the development of DEP's Long Term Control Plans (LTCPs) as well as related technical evaluations of green infrastructure and climate resiliency alternatives.

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SCHEDULED TOPICS FOR FUTURE ISSUES OF IMPACT

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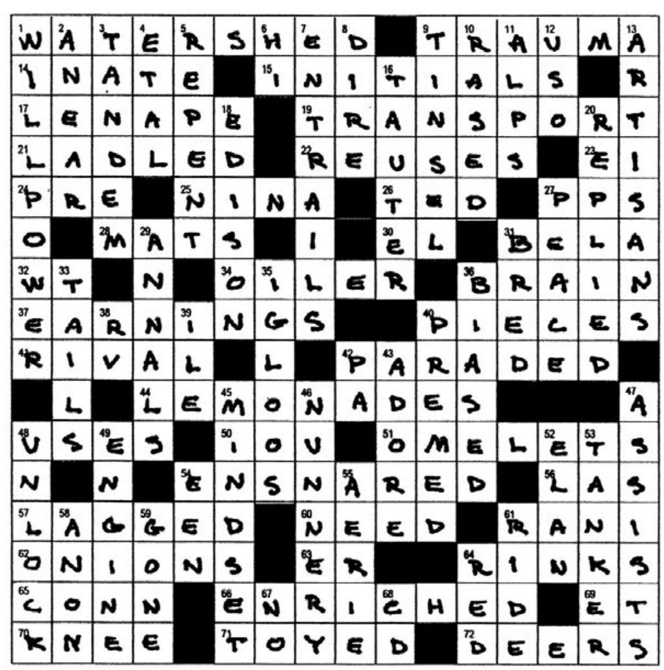

WATER RESOURCES IMPACT

STREET-SIDE SOURCE CONTROL OF STORMWATER IN NEW YORK CITY
A Performance Analysis of Infiltration and Subsurface Storage in an Ultra-Urban Environment

John McLaughlin and Zhongqi Cheng

Streets and adjacent sidewalks provide essential transportation corridors for the inhabitants of New York City (NYC), but are also responsible for generating large amounts of stormwater runoff. Within the combined sewer areas of NYC, these impervious right-of-way areas cover approximately one quarter of the total land area. In these locations, runoff flows along contiguous curb lines until it is collected by catch basins, often located at street intersections. This configuration results in the direct flow of stormwater into the combined sewer system, but also makes it feasible to divert concentrated runoff flows for management through green infrastructure.

Street-side bioswales are a key component of right-of-way runoff management in NYC. Bioswales are installed within the sidewalk, immediately adjacent to the street, and consist of a shallow vegetated basin constructed from engineered soil with a relatively high infiltration rate (Figure 1). Bioswales function by diverting runoff from the street curb-line, where it is temporarily stored and used by the plants or infiltrated into the underlying soil. These mechanisms are collectively known as bioretention, a common stormwater management practice. The adaptability, relatively small footprint, and location in the right-of-way of these source controls facilitate implementation at numerous sites throughout the City.

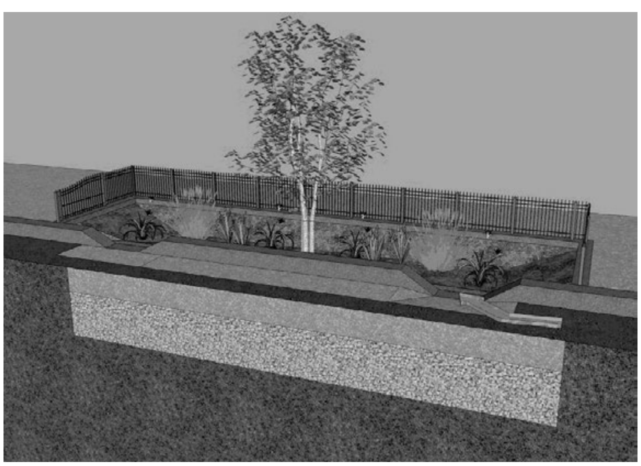

Figure 1. Illustration of a Typical Enhanced Tree Pit.

Bioswales divert runoff from the street through the use of a depression cut into the concrete curb. A curb cut is also installed at the down slope end of the system to drain excess water back to the street. Where feasible, bioswales are installed just upstream of existing catch basins in order to maximize runoff flow to the bioswale, and allow for bypassed flows to drain into sewers.

Two types of bioswales were designed and constructed as part of the New York City Department of Environmental Protection's (DEP) initial stormwater pilot implementation efforts. These variations are known as enhanced tree pits and street-side infiltration swales and represent the first fully permitted, first-generation green infrastructure installations within NYC. Both of these systems include a 3-inch surface depression that is mulched and generally contains a tree in addition to other smaller vegetation. Underneath this depression are several feet of a sandy, engineered soil media, designed to have a high infiltration rate. Within street-side infiltration swales, this engineered soil extends down through the full 5-foot depth of the system. Enhanced tree pits contain approximately 3 feet of engineered soil over a 2-foot layer of crushed stone or glass for increased storage capacity. These two bioswale variations also differ in size, with enhanced tree pits covering a 5-foot by 20-foot area, while street-side infiltration swales are 5 feet by 40 feet. A variety of factors influence the design and implementation of these facilities, including street and sidewalk geometry and drainage patterns, surface and subsurface utilities, and underlying soil properties.

On-site evaluations have demonstrated that grassed swales conveying runoff from the curb cuts and pipe outlets to the bioretention areas are retaining runoff themselves, improving stormwater management

During a storm event, runoff enters the bioswale through the curb cut, flowing into the surface depression. The surface depression provides temporary storage and allows runoff to infiltrate into the engineered soil, where it can be retained and later evaporated, beneficially used by plants, or infiltrated into the underlying soil. In each case, the water that is managed by the bioswale is not conveyed to the combined sewer system.

Beginning in 2011, eight enhanced tree pits and street-side infiltration swales were implemented and monitored throughout Brooklyn and Queens as part of DEP's pilot green infrastructure program (Figure 2). During the 2011 monitoring period, these source controls were generally effective at managing stormwater runoff, frequently retaining runoff from storm events with 1-inch of rain or less. Many lessons were learned during the course of implementation and monitoring. For example, initial enhanced tree pits and street-side infiltration swale curb cuts utilized a steel curb frame to maintain consistent lines along the top of the curb. Evaluations of pilot performance revealed that these curb cuts frequently became blocked and clogged by litter and other debris. When this occurred, the stormwater management benefits of these bioswales were greatly diminished, as runoff could not effectively flow into the surface depression. Retrofits at these initial bioswales and subsequently developed designs utilized open-top curb cuts to improve performance and better facilitate maintenance. Ongoing evaluations at these initial bioswales and others throughout the City are providing valuable information to improve designs and better understand the challenges and benefits of these systems.

Figure 2. Enhanced Tree Pit Implemented and Evaluated Throughout the Green Pilot Program.

While relatively small green infrastructure source controls like enhanced tree pits and street-side infiltration swales can be distributed throughout NYC, there are also opportunities to manage right-of-way runoff with larger green infrastructure installations. An example of this type of green infrastructure implementation is a pair of bioretention areas constructed within a highway median in Queens, between North and South Conduit Avenues. Such bioretention areas can be constructed within the low point of the grassed median and manage runoff from the surrounding streets and sidewalks. A variety of drainage infrastructure retrofits, including simple curb cuts, concrete flumes conveying runoff under existing sidewalks, retrofits to existing catch basins, and new catch basins, are used to divert runoff into the median. Once runoff enters the median, vegetated swales convey runoff to the bioretention areas for treatment.

The example bioretention areas referenced above consist of a 6-inch surface depression, 2-feet of a sandy engineered soil media, and a 1-foot stone drainage layer with an underdrain. The surface storage layers are connected through an overflow channel, and an overflow structure in the eastern bioretention area drains runoff flows exceeding the surface storage capacity of the bioretention areas. The underdrain system connects to the overflow structure, which conveys flows to the downstream combined sewer system. A stop log structure restricts outflow from the system by requiring water to build up within the subsurface stone and soil layers before leaving the system as outflow, effectively allowing for performance testing of various underdrain configurations. The bioretention surface is vegetated with a variety of trees, shrubs, and smaller plants.

The effect of these bioretention areas on runoff flow rates and volumes, water quality, and a variety of qualitative aspects like maintenance requirements and general performance are being investigated through ongoing evaluations. During the 2011 monitoring period, these bioretention areas fully retained runoff from storm events of up to two inches of rainfall, preventing that water from reaching the combined sewer system. On-site evaluations have demonstrated that grassed swales conveying runoff from the curb cuts and pipe outlets to the bioretention areas are retaining runoff themselves, improving stormwater management. At the same time, curb cuts are not fully effective at capturing runoff flows, hindering the management capacity of these systems.

Within NYC, there is a need for green infrastructure source controls to manage runoff from the variety of impervious surfaces that cover the City. With streets and sidewalks covering large portions of the City, and often directly connected to the combined sewer system, street-side green infrastructure like bioswales and bioretention are expected to provide valuable stormwater management benefits. Already, preliminary implementation and monitoring evaluations demonstrate that these practices can provide valuable runoff retention benefits. In addition, prior evaluations and ongoing investigations are providing important information on the benefits and challenges associated with these stormwater source controls. The interpretation of all this information will allow for design improvement and ultimately enhanced understanding of the potential role street-side bioretention practices will play in DEP's strategy to manage stormwater within the ultra-urban environment of NYC.

AUTHOR LINK
John McLaughlin
Director, Office of Ecological Services
Bureau of Environmental Planning & Analysis, NYCDEP
59-17 Junction Blvd., 11th Floor
Flushing, NY 11373-5108
(718) 595-4458

E-MAIL
JohnM@dep.nyc.gov
ZCheng@brooklyn.cuny.edu

John McLaughlin is the Director, Office of Ecological Services, with the NYC Environmental Protection. He has been with NYCEP for 19 years and has been active in the ecological restoration field for over 25 years. He also led the development of the ecological and water quality strategies of the Jamaica Bay Watershed Protection Plan.

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RIBBED MUSSELS AS WATER FILTERS TO CLEAN JAMAICA BAY

Robert Will, Terry Doss, and Justin Bowers

Overharvesting and degrading water quality led to the loss of bivalve populations in the New York-New Jersey Harbor by the early 20th Century. While scattered populations of oysters and other mollusks, including mussels, can be found in the harbor estuary, there are no longer enough to significantly improve the harbor's water quality. The discharge from combined sewer overflows and other point sources contains organic particulates, nutrients, and undesirable chemical contaminants. Filtration of these discharges by mussels could potentially remove substantial quantities of these constituents. The filtering capacity of mussels is well known, but it is unclear if that capacity could be adapted to the practical application of filtering discharges to improve water quality. To once again reap the benefits of these natural biofilters, New York City (NYC) has been investigating the capabilities of mussels to determine to what extent these mollusks can be used and in what densities to observe an appreciable improvement in water quality.

Ribbed mussels currently occur in nearby Jamaica Bay and are abundant in some locations, thus they are a local species that can tolerate the similarly degraded conditions in dead-end basins and Jamaica Bay. They also have the desirable feature that they are not sought after by humans for food, so there is minimal risk of poaching. The primary challenge for using ribbed mussels for filtration is to create conditions near targeted points of pollution discharge (e.g., combined sewer overflows (CSO) and discharges from Wastewater Treatment Plants (WWTP) to support a large concentration of mussels to carry out effective filtration.

MUSSEL BIOFILTRATION PILOT PROJECT

The goals of the mussel filtration pilot study are to test the effectiveness of ribbed mussels to remove nutrients and particulate organic matter from a CSO discharge, test alternative techniques to grow mussels in a CSO tributary, and provide baseline information for further development of mussel filtration within Jamaica Bay. To achieve these goals, it was determined that several substrates would be constructed for the growth of ribbed mussels within a selected discharge tributary of Jamaica Bay. Once the structures were put into place, the project would rely on natural colonization of the substrates. The substrates are then to be monitored for mussel growth, while collecting continuous water quality data.

The concept of using natural biofiltration to improve water quality is an appealing idea but practical application of this concept to bivalves in an estuarine environment has not been demonstrated in this area. This pilot study is an initial attempt to test the concept and obtain basic information to determine if a practical application can be developed.

PILOT PROJECT SITE LOCATION

Fresh Creek was selected as the location for the mussels structures based on several favorable characteristics: Fresh Creek has a CSO discharge and a number of stormwater outfalls, but is free of other obvious potential pollution sources; the creek currently supports ribbed mussels and there is a wetland edge over most of its length; and the creek has little boating activity so that substrate structures placed in the water will have little interaction with navigation.

A narrow section near the middle of Fresh Creek was selected for installation of the structural substrates. The primary factor in selecting this location is the control it applies to flows in the creek. This narrow, straight segment will ensure that tidal flows will be concentrated in the area of the mussel structures, which, in turn, will enhance the chances of detecting water quality differences across the array of substrates. Depth is sufficient to permit access for boats and a small work barge to place (and remove) the structures, and the location can be easily accessed from the shoreline for monitoring purposes. Human activity within the adjacent Fresh Creek Park is low.

The spring and summer of 2012 will serve as important monitoring periods to determine the effectiveness of various substrates at supporting mussel growth

SUBSTRATE STRUCTURES

The selection of substrate material was based on the potential acceptability of substrate as habitat by ribbed mussels, the maximization of surface area for mussel attachment, the overall cost of the substrate structures and installation/removal, the ease of installation, and the durability of the materials.

Mussels have been observed to grow on hard surfaces such as rope and metal surfaces like shopping cart wire. As a result, two substrates are being tested on five structures: large diameter cargo netting which provides substantial surface area in a relatively small space strung between posts driven into the creek bottom; and, expanded metal grating which provides a large surface area and flow through, bolted to posts driven into the creek bottom (Figure 1). Both substrates are attached within the intertidal range, off of the sediment floor, and intermixed on each structure across the channel. The five structures were placed so as not to interfere with existing mussel beds and wetland vegetation. The structures are slightly offset to the tidal flow to minimize buildup of debris.

Figure 1. Ribbed Mussel Substrate Structures in Fresh Creek.

MONITORING

There are two primary components in monitoring this pilot study. The first is the performance of the structural substrates for growing a concentration of ribbed mussels at the study site. The second is the water quality effects of the mussel filtration system over the study period. The first component is needed to obtain information that could be used to refine the project, to evaluate alternative structural substrates, and to provide quantitative data to be used to scale-up the concept. The second component will provide quantitative information on the magnitude of the water quality benefit, which would then be integrated with the structural evaluation to estimate the sizing of future applications to achieve a selected level of water quality benefit.

The structures were placed in Fresh Creek in July of 2011, and have been monitored on a monthly basis to determine whether or not mussel growth occurs on the substrates. No mussel set was observed in the summer or fall of 2011, and as of mid-May 2012 no new mussel spat has been observed; however, ribbed mussels are expected to begin spawning in late spring, or early summer so no ribbed mussel spat is expected to be observed before July 2012.

In addition to the array structures, spat settlement bags were placed in Fresh Creek and in five other areas around Jamaica Bay through July and August 2011 to observe whether or not bivalve spat set within the bags. Spat settlement bags had been shown to capture spat settlement when used in a confined tank set with bivalve spat. However, within Fresh Creek and the five other areas around Jamaica Bay, no ribbed mussel spat was observed.

During monitoring, a variety of species other than ribbed mussel were observed settling on the arrays. *Ulva lactuca* (sea lettuce) appeared soon after completion of construction, predominantly visible on the lower quarters of the arrays. It grew in modest patches, primarily on the rope surfaces, but never overwhelmed the structures. Blue crabs (*Callinectes sapidus*) were frequently observed on the arrays during the summer months, but were not observed after September. Common shrimp (*Crangon crangon*) and common barnacles (*Semibalanus balanoides*) were also observed upon the arrays. The barnacles are established primarily in the lower quarter of the arrays, and appear to favor the metallic surfaces of the structures over the rope surfaces.

As the first season of monitoring was conducted prior to any observed mussel growth on the arrays, the data gathered from this monitoring will be considered baseline information that will aid in the interpretation of monitoring data once mussels are established on the arrays.

WATER QUALITY DATA

Continuous water quality data was logged using a data sonde. Water quality parameters included temperature, dissolved oxygen (DO), turbidity, chlorophyll, depth, pH and salinity. The sonde was anchored at the midpoint of the third structure supporting substrates. Discrete samples from a handheld probe were also taken directly adjacent to the installed sonde. The sonde data was collected at approximately 30-day intervals.

Monitoring results for the period between July 2011 and December 2011 show both seasonal trends in water quality data and event driven trends linked to rainfall and stormwater discharge.

The sonde data (Table 1) indicate that while some of the environmental parameters follow expected patterns (temperature decreases as the months progress, pH and salinity remain at relatively consistent mean levels), other variables such as DO and turbidity appear to experience large variations.

Fresh Creek is categorized by the NYS Department of Environmental Conservation as a Class I water, which requires a DO standard of at least 4.0 milligrams per liter (mg/l) at all times to be considered healthy. The DO results presented in Table 1 shows that while on average Fresh Creek exceeded these standards, at some points during the monitoring period, it also experienced periods of anoxia (late summer and early fall).

Evaluation of specific rain events revealed water quality response patterns resulting from stormwater discharge. An analysis of dissolved oxygen, turbidity and precipitation data for the September 6-8, 2011 period, indicate that dissolved oxygen and turbidity reacted significantly to stormwater discharge events. During this period, over five inches of precipitation fell within a three day period, the highest single event total since monitoring at Fresh Creek began.

DO in particular fell precipitously following the storm, dropping from between 5-10 mg/l beforehand to between 0-5 mg/l afterward. DO remained at low levels for several days following the rain before climbing back towards previous levels. The average DO prior to the rain event was 6.24 mg/l. During and immediately following the storm, the average fell to 2.59 mg/l. Several days after the event, the DO average climbed back to 5.87 mg/l, still short of the average prior to the storm.

Table 1. Summarized Water Quality Data, September 2011-February 2012.

		Temp (C)	Salinity	Depth (ft)	pH pH	Turbidity	Chlorophyll	DO (percent)	DO (mg/L)
9/2-9/21/11	Mean	22.78	20.36	4.78	7.45	20.54	25.25	64.37	4.91
	Max	26.73	22.05	8.76	8.45	221.00	123.70	265.80	19.14
	Min	19.19	6.01	1.26	6.82	1.30	2.30	-0.10	0.00
9/21-10/26/11	Mean	19.00	20.56	4.54	7.51	443.59	34.38	74.59	6.16
	Max	24.05	22.76	9.21	8.46	1175.60	162.00	250.00	19.84
	Min	14.59	2.94	0.20	7.05	2.20	6.30	0.10	0.00
12/8-2/3/12	Mean	5.80	24.66	1.16	7.73	44.51	15.46	90.86	9.71
	Max	10.71	26.27	2.67	8.44	601.50	264.30	148.00	15.64
	Min	-1.93	1.03	-0.15	7.32	1.60	0.30	54.10	5.32

The turbidity during the same event showed an even more pronounced spike. The turbidity of the water increased sharply after the first three inches of rain had fallen in 24 hours, rising from roughly 2.1 nephelometric turbidity units (NTU) to over 40 NTU in a matter of hours, and then returning to average levels nearly as quickly. Due to the amount of rainfall and the pronounced nature of the spike, it is likely the response to a CSO discharge. The turbidity spike also coincided with low tide (based on the instrument depth readings), which suggests that the relatively low volume of water in the creek provided less dilution capability.

NEXT STEPS

Removal of a significant percentage of the nutrients and organic particulate matter from CSO and other discharges using ecological systems could improve water quality in Jamaica Bay, particularly in combination with other actions to reduce nutrient levels and improve habitat conditions for aquatic life. This ribbed mussel pilot study will provide baseline information on the practicality of this concept and help identify next steps to advance this approach. The spring and summer of 2012 will serve as important monitoring periods to determine the effectiveness of various substrates at supporting mussel growth. If successful, then the next step will be to correlate mussel growth and biofiltration capacity with water quality conditions.

AUTHOR LINK Robert Will
Research Scientist
NYCDEP
Bureau of Environmental Planning & Analysis
Office of Ecological Services
59-17 Junction Blvd. (11th Floor)
Flushing, NY 11373-5108
(718) 595-3185 / Fax: (718) 595-4479

E-MAIL RWill@dep.nyc.gov
tdoss@biohabitats.com
jbowers@biohabitats.com

Robert Will is a marine biologist at the NYCDEP, working on habitat restoration and ecologically-based improvement of water quality in the estuaries of NYC. Specifically, he is a project manager for the restoration of eelgrass and oysters, the use of mussels for water purification, the harvesting of algae for nutrient reduction and biofuel production, and the reduction of salt marsh erosion in Jamaica Bay, New York. He is also a project manager on several BMP storm water management projects that reduce the volume of water and load of nutrients to the NYC sewer system.

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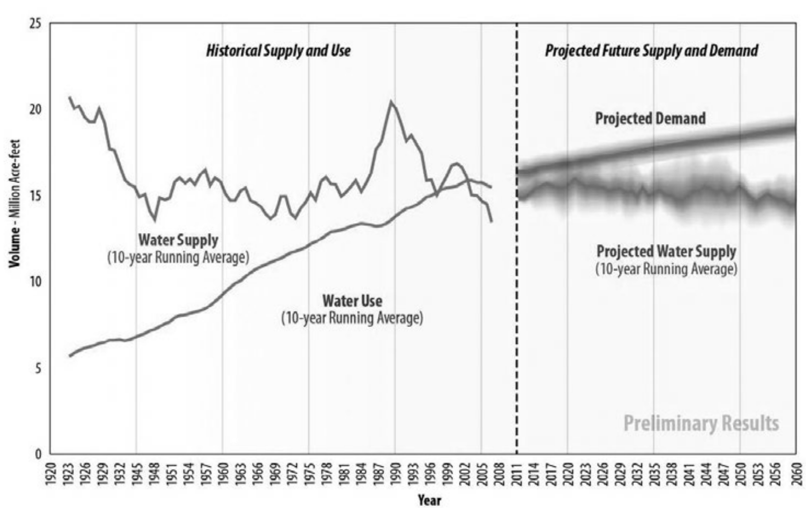
INTERSTATE WATER MARKET AND THE COLORADO RIVER BASIN

Clay Landry and Jackson Reed

Earlier this year, the Journal of the American Water Resources Association published an article titled "Management of Water Shortage in the Colorado River Basin: Evaluating Current Policy and the Viability of Interstate Trading." In this paper, authors Wildman and Forde identify Colorado River supply and demand issues, and explore options for how to mitigate future supply imbalances. The report cites Australia's Murray-Darling Basin (MDB) as a relevant case study for how basin wide water scarcity and regional water shortages can be overcome through interstate water trading. According to the authors, an interstate water market within the Colorado River Basin (CRB) that redistributes water efficiently may be the solution to preventing a water shortage in the Lower Basin (Wildman and Forde, 2012).

The threat of significant water shortages within the CRB continues to grow. In 2003, the basin's water use exceeded the ten-year average supply for the first time. With markedly low levels of runoff and rapidly depleting reservoirs, one recent projection forecasted a 50% chance of total reservoir storage depletion by as early as 2021 (Barnett and Pierce, 2008). The figure below summarizes historical supply and use in the CRB and then projects future supply and demand.

The threat of a water supply shortage is of particular concern to Nevada and Arizona because a significant portion of their population relies on the CRB's most junior water rights. Should total deliveries be reduced by 500,000 acre-feet/year, Arizona and Nevada would receive 17.1% and 6.7% reductions respectively, while California and the other states would still be entitled to their full allocation. The U.S. Bureau of Reclamation (USBR) instituted a set of guidelines in case of Lower Basin shortages, but as Wildman and Forde point out, these guidelines are short-sighted and serve only as a stopgap solution. Instead, an adequate solution to managing CRB water must protect users during long periods of drought.



Historical and Projected CRB Water Supply and Demand (USBR, 2011)

An interstate water market may offer the best alternative for managing water supplies in the CRB. Australia's MDB water market serves as a successful model for redistributing available water supplies throughout the basin amidst long periods of drought. The MDB water market is credited with preventing a water crisis during the extremely dry 2008-2009 growing season when the State of South Australia purchased almost all of its municipal water through the interstate trading program (*SA Water*, 2009). Rather than adopt the USBR's guidelines, which as a final response simply leave the seven CRB states to hold a meeting, a water market similar to the MDB's could efficiently address Colorado River shortages by reallocating water to its highest-value uses. A comprehensive over-view of Australia's water markets can be found in R. Quentin Grafton's article in the September 2011 issue of *IMPACT* (Grafton, 2011).

For a CRB interstate water market to be feasible, the seven basin states would need to agree upon a central authority to oversee the management of the supply. Currently, fear of a lower basin "water grab" creates general skepticism and wariness amongst upper basin water managers to negotiate any type of interstate water transfer agreement. This opposition to transferring water out-of-state may remain until Nevada and Arizona are forced to issue a state of emergency because of a water shortage. Until the CRB states can implement a model for water reallocation similar to the MDB's, let's hope that current conservation efforts are enough to prevent a shortage on the Colorado River.

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E-MAIL CONNECTION

landry@waterexchange.com
reed@waterexchange.com

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AGE OF AGES

Eric J. Fitch

Man is the most intelligent of the animals -- and the most silly . . . Diogenes of Sinope
We are all in the same boat in a stormy sea, and we owe each other a terrible loyalty . . . C.K. Chesterton

Ah, the overwhelming joy of a presidential election year where Politicians, Pundits, and other professional Bloviators make multiple exaggerated claims straight through to outright lies before breakfast is served. At least we can be comforted that it's nothing new. In the 4th Century B.C. (or B.C.E. if you prefer), Diogenes of Sinope aka Diogenes the Cynic was what I like to call a "stunt philosopher." He embarrassed everyone from Plato (not an easy task) to Alexander (not an easy task to walk away from alive) largely to show them the folly of their self or other imposed importance. He begged for a living, slept in a tub and did things like go around carrying a lamp in the daylight. When asked what he was doing he told the inquirers that he needed the extra light because he was involved in a difficult task: he was trying to find an honest man. Though considered a pest in his day, his philosophy did gain adherents and was later formalized into two useful strains to help us survive election years: cynicism and stoicism.

Many who have access to the media have been making much of the term "American Exceptionalism" while largely misinterpreting the concept. Tracing its way back to the French political philosopher and historian Alexis de Tocqueville, the concept of American Exceptionalism is the idea that there is something unique about the American Character/Spirit that keep us striving to promote liberty and equality at home and abroad. Lipset and others have hypothesized that this comes about from being the first nation created by a revolution that led to democracy. Some incorrectly interpret this concept as meaning America is better than other nations and as an excuse to view ourselves as above the laws that constrain the behaviors of other lands. It is the later tendency that has brought trouble aplenty to the field of water and other natural resources as commons to be managed.

Objections primarily from the conservative end of the American political spectrum have put the United States (U.S.) in a difficult position with the community of nations on several international treaties and conventions which the U.S. has chosen to stand apart from. One that, as Sen. Corker of Tennessee remarked is having a "Lazarus" moment is the most current addition to the Law of the Sea conventions. Thirty plus years ago at Montego Bay, Jamaica, UNCLOS (U.N. Convention on Law of the Seas) was signed and sent out for ratification. It received the 60 necessary signatures in a little over a decade and went into force. Today, 164 nations have signed and ratified the treaty; including most of the Developed and Developing Nations of the World and most of the U.S.' allies. Sixteen nations have signed but not ratified including such world powers as Afghanistan, Bhutan, the UAE and my personal favorite Lichtenstein. Eighteen countries have neither signed nor ratified, the most prominent of which is the U.S., but also with the company of Syria, Turkey, The Stans (Turkmenistan, Uzbekistan, Kazakhstan, Kyrgyzstan, etc.) and little San Marino. A quick search of the internet of reasons for the U.S. not signing are that it would surrender U.S. sovereignty, have corporations which extract minerals from international waters pay royalties into a fund to be distributed to the developing world, and that technologies/patents may have to be shared. (Oh, and then we get into the theories about the national origin of President Obama and the 'black helicopters of the one world conspiracy').

What would be gained by the U.S. signing and ratifying the treaty? Well ideally, a world in which the Oceans as common resources are managed sustainably, where national/international boundaries are clearly delineated, where those breaking international laws on the seas can be jointly pursued and prosecuted and where mechanisms exist (legal, political, scientific, rational) to resolve conflicts without resorting to the force of arms. These are all things that for the last 30 years the U.S. has tried to accomplish by informally following the contents of this convention we are so afraid of.

For good or ill, our American experiment in democracy and our position in the world community is foundering in a system where a relative few can block actions/votes that favor the well being of the many for the greed and ego of a few (yes, I am talking about the U.S. Senate). At least UNCLOS is not alone. All international attempts to deal with climate change as a matter of international law have been similarly blocked largely by the same group. As have biodiversity agreements, forest protections, and on and on. At least here I can take some comfort in knowing what age I'm in. We may not be in the American Century, we may not be in the Era of the Seas, but we have certainly moved into the Anthropocene: The age where the atmosphere and nature as a whole are being shaped by human actions and not to the good. So, I'm off to pick up my lantern and maybe do what Diogenes failed to do (but, maybe not).

E-MAIL CONNECTION

fitche@marietta.edu

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THE FAILURE OF IMAGINATION

Laurel E. Phoenix

It has been two years since the BP Gulf oil spill, and no doubt many have forgotten about it if they didn't lose their jobs or health or property values to it, or didn't witness the dead, dying, or sickly animals washing up on the shore then and now. Humanity may cover the globe, but individuals only perceive and partially understand a minute part. I still wonder: is it because most citizens don't live on the Gulf Coast that we don't find the risk of deepwater drilling, much less the greater risk of oil dependence, salient?

As a geographer, I have always been aware of the importance of scale. Maps help somewhat in conceptualizing those things that are beyond our vision, like the one in Figure 1, marking hundreds of oil and gas platforms in the Gulf. We need maps to convey that which is beyond human sensibility, since our imaginations are limited. As Wendell Berry put it,

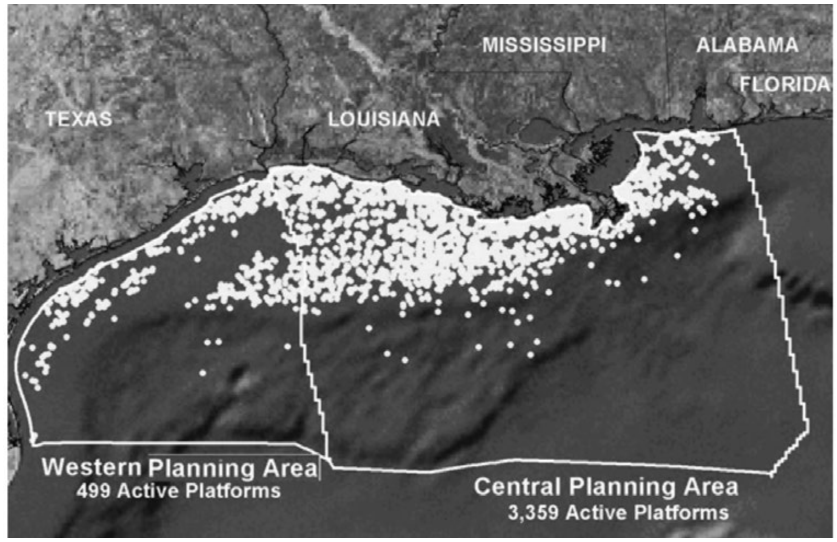

Figure 1. Map of the Northern Gulf of Mexico Showing the Nearly 4,000 Active Oil and Gas Platforms (http://oceanexplorer.noaa.gov/explorations/06mexico/background/oil/media/platform_600.html).

> *I will say, from my own belief and experience, that imagination thrives on contact, on tangible connection. For humans to have a responsible relationship to the world, they must imagine their places in it. To have a place, to live and belong in a place, to live from a place without destroying it, we must imagine it. By imagination we see it illuminated by its own unique character and by our love for it. By imagination we recognize with sympathy the fellow members, human and nonhuman, with whom we share our place.*

Although Berry always writes about love for a place and community, and knows we cannot survive without a land ethic, it struck me that his words apply equally to the waters and seas upon which we depend. And yet we must stretch our imaginations to understand that what is at stake is far greater than the price of filling your tank.

> *In this age so abstracted and bewildered by technological magnifications of power, people who stray beyond the limits of their mental competence typically find no guide except for the supposed authority of market price. "The market" thus assumes the standing of ultimate reality. But market value is an illusion, as is proven by its frequent changes; it is determined solely by the buyer's ability and willingness to pay.*
>
> *By now our immense destructiveness has made clear that the actual value of some things exceeds human ability to calculate or measure, and therefore must be considered absolute. For the destruction of these things there is never, under any circumstances, any justification. Their absolute value is recognized by the mortal need of those who do not have them, and by affection. Land, to people who do not have it and who are thus without the means of life, is absolutely valuable. Ecological health, in a land dying of abuse, is not worth "something;" it is worth everything. And abused land relentlessly declines in value to its present and succeeding owners, whatever its market price.*
>
> Wendell E. Berry Lecture
> "It All Turns on Affection"
> http://www.neh.gov/about/awards/jefferson-lecture/wendell-e-berry-lecture

What is the Gulf worth to us once it is ruined? Or, for that matter, what is the Arctic worth? Maybe these are the questions we should ponder as we fill our gas tanks.

E-Mail Connection

phoenixl@uwgb.edu

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UPDATE OF PRECIPITATION FREQUENCY ESTIMATES FOR ALASKA

Deborah Martin, Guest Author

Knowing the amount and frequency of heavy precipitation is important to everyone from civil engineers to water resource managers. However, precipitation frequency estimates from the 1960s and 1970s continued to serve as the de-facto standards for a wide variety of design and planning activities under federal, state, and local regulation until recently. In 2004, the Hydrometeorological Design Studies Center (HDSC), within the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service, Office of Hydrologic Development, began publishing updated estimates in Volumes of *NOAA Atlas 14, Precipitation-Frequency Atlas of the United States.* The latest release is Volume 7 for the State of Alaska (Perica *et al.*, 2012).

The volume for Alaska was funded by NOAA's Climate Program Office, the Alaska University Transportation Center, and the Alaska Department of Transportation and Public Facilities, but other Volumes have been almost entirely funded using State resources. Published volumes cover the semiarid southwestern United States, Ohio River basin and surrounding states, Puerto Rico and the U.S. Virgin Islands, Hawaii, selected Pacific Islands, and California. The next volumes, due out in 2013, will include the following southeastern states: Alabama, Arkansas, Georgia, Florida, Louisiana, and Mississippi, and the following midwestern states: Colorado, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Oklahoma, South Dakota, and Wisconsin.

Precipitation frequency estimates are essential in the design of highways, culverts, bridges, parking lots, etc. For example, hydrologic and hydraulic engineers use them to design storm water-runoff facilities, to estimate the volume of detention basins and size detention-basin outlet structures, and to estimate the volume of sediment or amount of erosion. They are also used to delineate floodplains and regulate the development in floodplains for the National Flood Insurance Program. If precipitation frequency estimates are overestimated (i.e., the estimated value is higher than the true value), it can cause unnecessary cost to taxpayers or developers. However, if an estimate is too low, it can cause destruction of property and loss of human life.

Precipitation frequency estimates are calculated based on the statistical analysis of historical precipitation data. For Volume 7, HDSC partnered with the University of Alaska, Fairbanks' Water and Environmental Research Center to collect and quality control the data. The new, updated estimates benefit from denser gauge networks with longer periods of record, the use of state-of-the-art methods in statistical hydrology and the use of the latest techniques for spatial interpolation and mapping. The updated estimates are much more accurate than those previously available, especially in areas of complex terrain. They are available at very high spatial resolution making them locally relevant across all of Alaska.

NOAA Atlas 14 is an on-line document that can be accessed through a unique data portal, the Precipitation Frequency Data Server (PFDS), at hdsc.nws.noaa.gov/hdsc/pfds. The interface allows for quick access to the estimates for precipitation durations from five-minutes to 60-days for average recurrence intervals from 1 to 1,000 years including upper and lower bounds for the 90% confidence interval. The PFDS provides a Google Maps"-based interface to help identify a location of interest, or a user can enter location coordinates or select a gauged location (station) from a list. Estimates and their 90% confidence bounds can be viewed (and printed) on-the-fly in a tabular or graphical form or users can download grids of the estimates for use in their own applications. Cartographic maps are also available for selected recurrence intervals and durations along with other supplementary information such as temporal distributions of heavy precipitation and an analysis of seasonality. Since the release of Volume 6 for California in 2011, the PFDS has served around 25,000 requests for information per month. The PFDS has been well received by the profession. For instance, one user commented, "…I really enjoy the interface. Very straightforward and gives all the data you could be looking for."

Details on progress and schedules for current projects can be tracked through quarterly reports available on the HDSC web page. HDSC also maintains a list server to distribute occasional announcements and to invite stakeholders to review projects in progress. Please visit HDSC's web page for more information (www.nws.noaa.gov/ohd/hdsc).

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AUTHOR LINK Deborah Martin
Hydrometeorological Design Studies Ctr.
Hydrologic Science and Modeling Branch
Office of Hydrologic Development
NOAA's National Weather Service
301-713-1669 x108

E-MAIL Deborah.L.Martin@noaa.gov

Deborah Martin is an atmospheric scientist with Science Applications International Corporation (SAIC) and has worked as a contractor in the Hydrometeorological Design Studies Center (HDSC) in NOAA's National Weather Service's (NWS) for the past 12 years. She holds degrees from the University of Virginia – a B.A. in Environmental Science and an M.S. in Atmospheric Science.

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JAWRA: NAVIGATING THE FUTURE

Jennifer Lynch

As the American Water Resources Association navigates the future for its journal, it is important that you the members contribute to the conversation. One of the more imminent issues is the move to online only publication. Institutional subscribers have increasingly opted for electronic access to a journal over print, accelerating the digital transformation of our business. We believe that digital formats allow us to offer more value to readers, in terms of availability, discoverability, and the integration of our publishing into their research, learning, or professional practice. Researcher surveys have shown that journal loyalty is trumped by search engine results, and our ability to track and report on heavily (or lightly) used and cited articles comes from the virtue of the online environment. The chart below shows the preferences of our institutional subscribers. While some disciplines are holding to print, preference among life science journals is over 70%; the *Journal of the American Water Resources Association* (*JAWRA*) is at 72%. The remaining 28% still have online access, but have opted for print in addition.

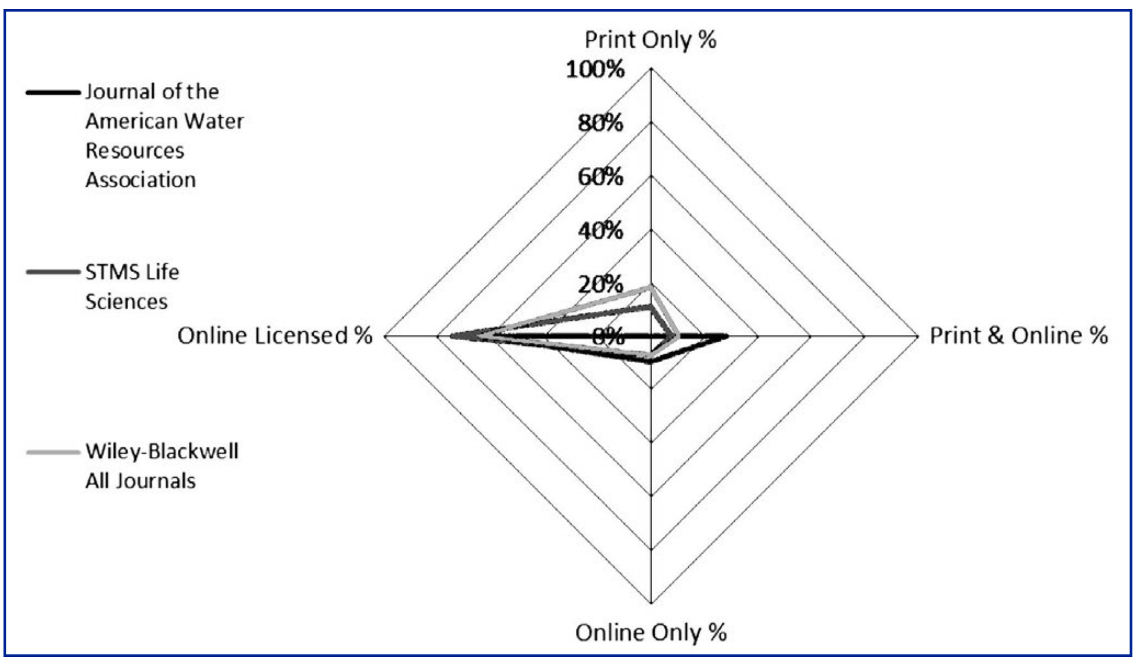
One of the more frequent questions posed by journal readers is "how is online content protected/archived?" Wiley participates in the CLOCKSS (Controlled Lots of Copies Keep Stuff Safe) program. This is publisher-wide collaborative archive that comprises geographically dispersed nodes located at 15 major research libraries. Access to content is locked unless a "trigger event" occurs, at which time access is restored to the affected title. More information about this initiative can be found at http://www.clockss.org/clockss/Home.

Other concerns that we hear from members regard reaching developing world researchers, the preference for browsing journals in remote or access free areas (such as an airplane), and the nostalgia for paper copies. Internet access is far more reliable than local postal service in some parts of the world. The carbon footprint of distributing hard copy journal issues and the erratic costs of shipping make the move to online only publication very attractive from both an environmental and cost perspective. And finally, we are currently looking to reconfigure the way articles are presented so that they render on ALL devices – phones, tablets, etc. Please keep feeding us suggestions, and we will strive to make *JAWRA* accessible to you in the ways that you prefer.

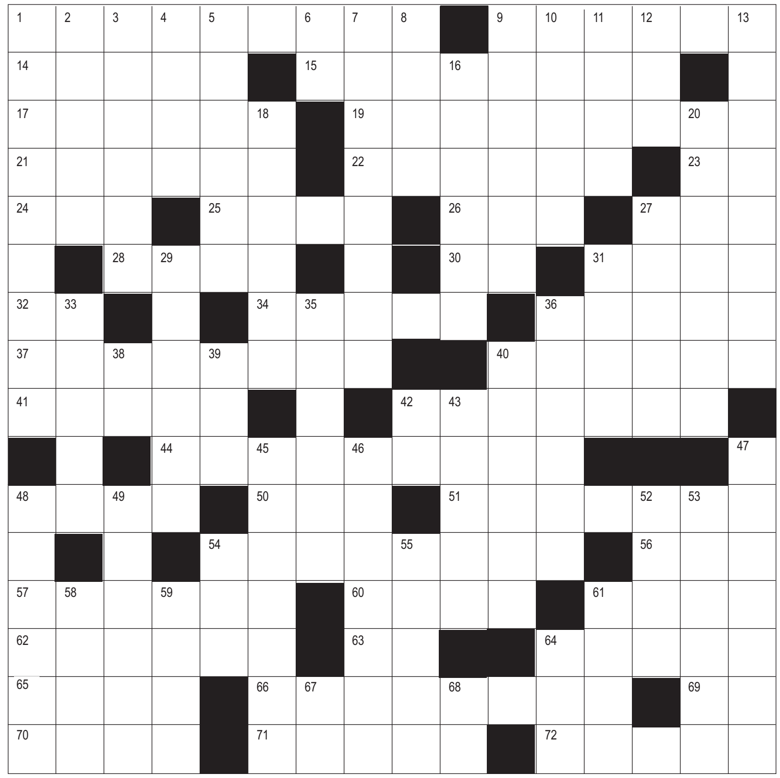
Jennifer Lynch, Editor
Wiley-Blackwell

E-MAIL CONNECTION

jlynch@wiley.com



WATER RESOURCES PUZZLER (answers on pg. 12)



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53 oiler
54 even (poet.)
55 high nest
58 again
59 left
61 to ridicule
64 followed by light or lips
67 question response
68 banking option

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▲ MESSAGE FROM THE PRESIDENT … William A. Battaglin, 2012

Sure it's fun! But skiing the last of the snowpack in March in shorts is not how it should be in Colorado. Snowpack was thin in most of the US this year (can you guess where the exception was?). No snow in the Western US means more than a bad year for the ski areas. Winters like 2011-2012 can potentially cause problems for millions of water users in Colorado, Utah, Arizona, and California.

One way AWRA helps solve the water problems of the future is to support the students of today. That support comes in many forms: direct scholarships given to deserving students by both the National organization and many AWRA State Sections; student-professional networking events; and student activities with plenty of opportunities to hone their presentation skills at AWRA conferences. One of my "Presidential" actions has been to change the way AWRA National handles your donations to the Herbert Scholarship fund. In the past all donations to this fund went into an endowment account and only the interest on that account was available for scholarship. But now the account has grown large enough so that we can safely provide both the interest money and a portion of your donations directly to the students. So please show your support for AWRA's mission of supporting education by making a donation this year to the Herbert Scholarship fund.

I want to take a moment to highlight two educational opportunities in Colorado for students who are interested in water resources. Dr. Jörg Drewes at Colorado School of Mines runs AQWATEC (the Advanced Water Technology Center). This research center provides students with the opportunity to do cutting edge research in support of the Center's mission that is to advance the science of water treatment processes for potable and non-potable water supplies. Dr. Tom Cech at Metropolitan State Collage of Denver runs the One World One Water Center for Urban Water Education and Stewardship. This new program (starts this Fall) will help students become urban water stewards through course work, co-curricular events, and applied learning activities that blend science, engineering, and the arts.

Two more nominations for the AWRA list of points of Hydrologic Interest.

- **Eaglecrest Ski Area, Juneau, Alaska –** "the exception" in the photo above. Great skiing just 15 minutes from Juneau. With about 400 inches of snow near the top when I skied there in March, this area was deep in hydrologic resources!

- **Coopers Landing, Coopers Landing, Missouri –** Where else can you enjoy a sunset over a wild and scenic portion of the Missouri River, while enjoying beer and wine, great Thai food; bluegrass music, Bones the tambourine juggling percussionist, and cultural features such as BoatHenge.

Cheers, Bill

E-MAIL CONNECTION

wbattagl@usgs.gov

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Learn more about the Richard H. Herbert Memorial Educational Scholarships on AWRA's website: info@awra.org

▲ AWRA'S 2012 SPRING SPECIALTY CONFERENCE STUDENT PRESENTER COMPETITION

Congratulations to the Student Presenter Competition winner of AWRA's 2012 Spring Specialty Conference on *GIS and Water Resources VII* that was held during the conference in New Orleans, Louisiana, March 26-28. Twenty-three students participated and were scheduled throughout the 40 sessions and the poster session. Conference attendees were given the opportunity to judge the students during their scheduled session. The following criteria was used for all competitors:

- Efficient use of allotted presentation time or poster space.
- Quality of responses to audience questions in oral or poster sessions.
- Effective integration of audio-visual materials.
- Perceived preparedness.
- Logic and understandability of material (problem, methods, results, conclusions).
- Adequate description of context for material – conveyed purpose of paper, identified relevant literatures, etc.
- Overall style and presence; effective communicator – enthusiasm or persuasiveness
- Suitability for AWRA/professional audience.
- Significance and originality of the material presented.

Again, our congratulations on a job well done to all those students who were in the competition and we wish them all the best in their future endeavors. We look forward to hearing more from everyone at future AWRA conferences!

Everyone did a terrific job and made the decision difficult. However the following individual was selected as the outstanding winner:

ERIC S. HERSH
Center for Research in Water Resources
Dept. of Civil, Architectural, and
Environmental Engineering
The University of Texas at Austin
Austin, Texas

A Chain-of-Custody Approach to Managing Arctic Marine Observations Data
(Co-authors: Harish Sangireddy and David Maidment)

ERIC S. HERSH
The University of Texas at Austin
Austin, Texas

Eric S. Hersh is a graduate research assistant and doctoral candidate at The University of Texas at Austin Center for Research in Water Resources. Eric works to develop tools and systems to leverage existing hydrologic information to solve water resource problems, particularly those relating to the integration of physical, chemical, and biological observations of the water environment. Eric has applied this work near and far, from environmental flow analysis in Texas to the Arctic shelf ecosystem in the Chukchi Sea, Alaska. Eric holds a bachelor's from Tufts University in Civil Engineering and Environmental Studies and a master's degree from the University of Texas at Austin in Environmental and Water Resource Engineering. Prior to graduate school Eric consulted on water resources in Boston and he is a registered professional engineer in Massachusetts.

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AMERICAN WATER RESOURCES ASSOCIATION
4 West Federal St., P.O. Box 1626
Middleburg, VA 20118-1626 USA
Telephone: (540) 687-8390

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