Horizons
Engineering Excellence in Meeting Environmental Challenges
HAZEN AND SAWYER
Environmental Engineers & Scientists
Winter 2007

Nutrient Pollution: Trends, Challenges and Solutions

Over the past several decades, nutrient pollution has become a serious environmental problem in the United States. When discharged into our waterways, nutrients such as nitrogen and phosphorus often cause excessive algae growth, which can kill both plant and animal life by exhausting the available oxygen.

The effects of nutrient pollution are cumulative, and, as populations and wastewater discharges have increased, the problem has grown worse — especially in waters adjacent to high population areas, such as the Long Island Sound and the Chesapeake Bay.

BNR/ENR: How it Works

Since much nutrient pollution originates from the discharge of treated wastewater, a concentrated effort has been made in recent years to stem the problem at the source and many municipalities have now implemented Biological Nutrient Removal (BNR) measures at their treatment plants.

BNR removes nutrients (primarily nitrogen and phosphorus) through the creation of aerobic, anoxic, and anaerobic areas in the secondary treatment process. This encourages the growth of bacteria that, ultimately, convert the nutrients into inert nitrogen gas and other byproducts.

Enhanced Nutrient Removal (ENR) takes this technology an extra step, usually by adding a carbon source and/or filtration to the treatment process, which has the effect of lowering nutrient levels even further.

Although adding BNR/ENR technology to existing facilities can be complicated, it's also quite effective. In Maryland, for example, BNR measures have reduced nitrogen levels to about 8 milligrams per liter (mg/l), from a pre-BNR average of 18 mg/l. The state is now working to further reduce nutrient levels by adding ENR technology to its wastewater treatment plants.

The Henrico County Water Reclamation Facility (shown above during construction and now completed) is a 75-mgd wastewater treatment plant located southeast of Richmond, VA. An initial upgrade, designed by Hazen and Sawyer, increased capacity, simplified the treatment process, and added BNR. We are now working with Henrico County to further reduce nutrients as part of the Chesapeake Bay ENR program.

Implementation Challenges

One of the main challenges to implementing BNR/ENR on a large scale is cost. Each facility must be upgraded to add necessary equipment and retrofits can easily run into the tens of millions of dollars.

Utilities are studying how they can most efficiently and cost-effectively meet more stringent nutrient removal requirements — in many cases with facilities that aren't designed for it.

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Inside

Hazen and Sawyer Happenings

Architecture, Engineering Projects Tapped for Exhibition and Awards

Newtown Creek, North Battery: This upgrade to New York City's largest wastewater treatment plant — a Joint Venture of Hazen and Sawyer, Greeley and Hansen, and Malcolm Pirnie — won the Concrete Industry Board's 2006 Award of Merit with Special Recognition.

In related news, two recent study projects — **Rye Lake** and **Catskill Aqueduct** — won awards from ACEC-NY, and two architectural design projects were included in the American Institute of Architect's "Going Public 2" exhibition. For more information, please see the back page.

New Technologies, Regulations Focus of Water Process Group

Hazen and Sawyer's Water Process Group has been working on a range of issues including UV disinfection, disinfection byproduct control, membrane technologies, and limiting distribution system corrosion.

The group is also focusing on optimizing existing facilities to meet more stringent regulations and on creating innovative designs to reduce the footprint of new facilities.

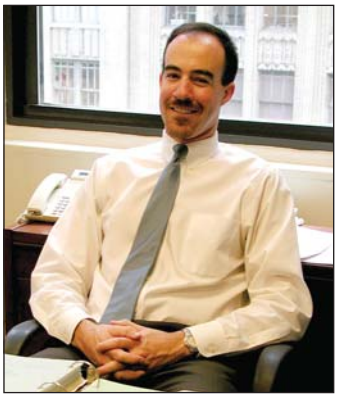
One example now under construction: New York City's 290-mgd Croton WTP. By using Computational Fluid Dynamics modeling and careful process selection, the group was able to fit New York's first filtration plant in a tight, underground envelope.

For more info: Please contact Mark Bishop at mbishop@hazenandsawyer.com or Bill Becker at wbecker@hazenandsawyer.com

New Boston Office Opens to Serve New England

Hazen and Sawyer has opened a new Boston office to better serve the New England area.

"New England faces a range of challenges — from aging water and wastewater infrastructure to new regulatory standards — and I am honored and excited to be able to help communities in and around my home state of Massachusetts meet these challenges," said Matthew Valade, P.E., a Senior Associate and water treatment process specialist, who is head of the new office.



Matthew Valade

Located in downtown Boston, the office is working on range of projects for the region, including the design of a new water treatment plant for the City of Portsmouth, New Hampshire.

For more info: Please contact Matthew Valade at mvalade@hazenandsawyer.com

Hazen and Sawyer Forms Program Management/ Construction Management Group

Program management (PM) and construction management (CM) are certainly not new to Hazen and Sawyer; we've been providing these services since the firm's inception. In fact, our revenue from PM/CM-related work totaled $21.8 million in 2005, placing us among the top 50 firms in the US.

What is new, however, is the consolidation of the firm's PM/CM resources into one cohesive workgroup, which will help ensure that our customers are receiving the best service available in the industry.

As a full-service engineering firm with both PM/CM and environmental expertise, Hazen and Sawyer knows how to design, develop, construct, and manage the most challenging assignments.

We also have some unique skills to offer, such as resident engineering and inspection of underwater pipelines, deep-well injection, and oversight of critical infrastructure projects.

For more info: Please contact Joe Ramaglia at jramaglia@hazenandsawyer.com

Viewpoint: Modeling Comes of Age with BioWin

By Dr. Paul Pitt, P. E., Vice President

With wastewater treatment plants subject to increasingly stringent effluent limits, sophisticated process modeling is becoming more common. Several models exist, and, over the past 10 years, Hazen and Sawyer has developed a state-of-the-art, site-specific approach to process modeling, design, and optimization using the BioWin simulator.

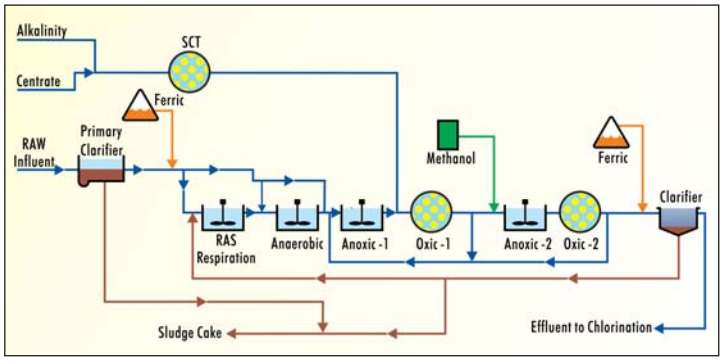
Paul Pitt

This approach — which has been used to model 50 different facilities, including several with treatment standards at the limits of technology — ensures that our clients get the most cost effective, flexible, and robust solution for their needs.

BioWin: How it Works

BioWin provides a powerful interface for interactive steady-state and dynamic simulation of wastewater treatment systems. BioWin can simulate a wide range of process elements — including primary settling tanks, aerobic, anoxic and anaerobic bioreactors, IFAS bioreactors, final settling tanks, filtration digesters, and thickening and dewatering elements — to create an accurate model of a plant.

The model is also able to simulate the addition of different chemical treatments, such as carbon (e.g. methanol), alkalinity, and metal salts. The figure below depicts a typical wastewater treatment plant process, as it appears in BioWin.



Typical BNR Wastewater Treatment Plant Setup in BioWin.

Experience Critical to Success with Modeling

While process modeling is an extremely useful engineering tool, the model must be carefully calibrated and verified to the site-specific influent characteristics, kinetics, ambient conditions, and the plant's operational approach before it can provide meaningful results.

An accurate understanding of a facility's influent, effluent, and operating characteristics is key to proper modeling. In the photo above, Hazen and Sawyer's Ron Latimer takes samples at JEA's Arlington East Water Reclmation Facility, Jacksonville, Florida.

Hazen and Sawyer's modeling staff have extensive professional experience, which allows us to model and interpret the results from a real-world, treatment-plant perspective.

With over a decade of modeling using BioWin, Hazen and Sawyer has developed a large database on plant performance from which we can pull various kinetic and stoichiometric fractions. Our extensive understanding of the BioWin model allows us to rapidly asses the impacts of specific influent parameters and/or operational changes on the performance of a plant. In addition, Hazen and Sawyer conducts rigorous field sampling to obtain site specific data relevant to the wastewater properties and characteristics of the plant.

This unique blend of theoretical knowledge and practical experience allows us to produce flexible designs that achieve current and future effluent standards, typically through a phased approach that optimizes the use of existing infrastructure.

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To keep our skills sharp, BioWin users from all regions meet on a regular basis to discuss BioWin projects and issues, and perform quality control checks on all BioWin projects.

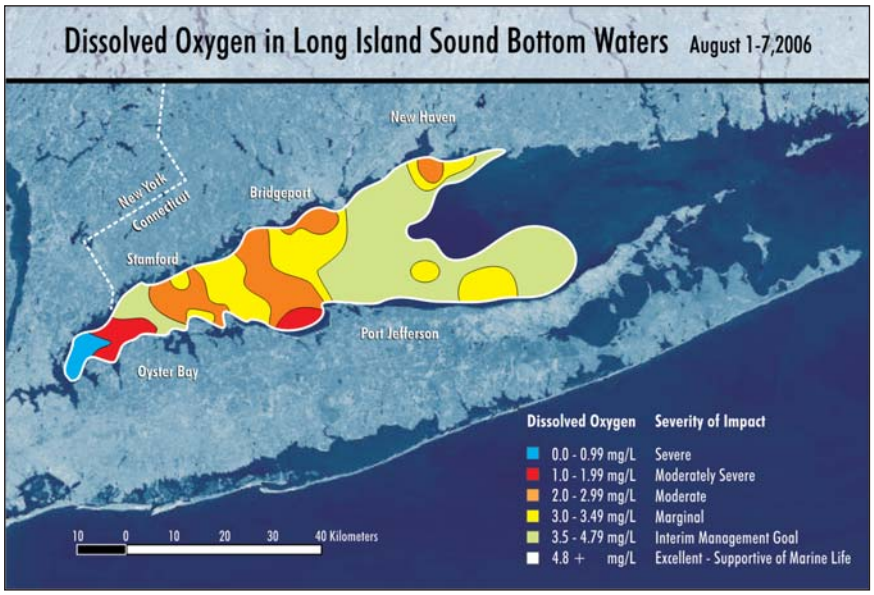
Partnership Making Progress Protecting Long Island Sound—

By Paul D. Saurer, P.E., Vice President and Richard Panchyk, N.E. Marketing Manager

Located between the north shore of Long Island and the south shore of Connecticut, the Long Island Sound is a unique estuary. Roughly 1,320 square miles in area, more than 20 million people live within 50 miles of the Sound, and the area contributes over $5 billion a year to the local economy through tourism and recreation.

The Long Island Sound is also an important habitat for thousands of species of birds, fish, and other wildlife. The mixing of salt water from the ocean and fresh water draining from the land serves as a breeding, feeding, and nursery area for several sensitive and threatened species. The federal government officially designated Long Island Sound as an "estuary of national significance" in 1987. However, water pollution from the highly urbanized tri-state area threatens the Sound.

The good news is that there are practical solutions to these problems, and Hazen and Sawyer and its clients are at the forefront of efforts to clean up Long Island Sound. From initial research into the nature of the Sound's water quality issues, to selection of Biological Nutrient Removal as the key technology — and culminating with the management and oversight of over $640 million in capital construction — the firm has been, and will continue to be, a leader in nutrient removal.



Although water quality in the Long Island Sound has been improving, dissolved oxygen levels crept back up this summer as treatment plants are being upgraded. Data used with the permission of the Connecticut Department of Environmental Protection, Long Island Sound Water Quality Monitoring Program.

Long Island Sound's Hypoxia Crisis

Most aquatic species require dissolved oxygen in the water for respiration, but nitrogen — from both point sources (such as wastewater treatment plants) and nonpoint sources (such as stormwater runoff) — can deplete dissolved oxygen.

Excessive nitrogen in the water provides a food source for algae growth. When the algae die, the decomposition of this organic matter by bacteria consumes available dissolved oxygen, limiting what's available for fish and other higher forms of marine life. This depletion of available dissolved oxygen in the water is most evident during the warm summer months, when the rate of consumption of oxygen can be greater than that at which it is replenished.

Low dissolved oxygen levels (or hypoxia) cause immobile species to die off and others to avoid the hypoxic waters, transforming what should be a thriving ecosystem into a depleted waterbody.

Through the 1970s and 1980s, nitrogen discharges from both point and nonpoint sources to Long Island Sound were unregulated and increased at an alarming rate through the continued development of surrounding communities, exacerbating hypoxic conditions in the Sound.

Partnership Works Towards Solutions

To address this issue, a bi-state partnership called the Long Island Sound Study (LISS) was authorized by Congress and founded in 1985. The partnership of user groups, federal, state, and local agencies, and other organizations and individuals, undertook an extensive examination of the various environmental issues confronting the Sound and developed nitrogen reduction goals for the surrounding municipalities.

The LISS determined that more than half of the nitrogen in the Sound was attributable to effluent from nearby wastewater treatment plants — there are 105 wastewater treatment plants in Connecticut and New York that, according to 2006 estimates, discharge roughly 160,000 pounds of nitrogen into the Sound daily.

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Pennsylvania's Chesapeake Bay Tributary Strategy

By William G. Richards, P.E., Vice President

Although separated from the Chesapeake Bay by Maryland, many of Pennsylvania's waters flow to the Bay, and thus have an impact on the Chesapeake's health.

As part of a national program to improve its water quality, the Pennsylvania Department of Environmental Resources (PA-DEP) published their Chesapeake Bay Tributary strategy in December 2004. Its provisions apply to the Susquehanna and Potomac River drainage areas within the state, and the program includes both nonpoint and point source dischargers.

As originally proposed, Pennsylvania's point source program would have required all dischargers with a design flow greater than 0.4 mgd to meet Total Nitrogen (TN) and Total Phosphorus (TP) loads based on effluent concentrations of 8 mg/L TN and 1 mg/L TP at the projected year 2010 flow rate.

These load limitations, written into the discharger's next permit renewal (on a five-year cycle) and providing three years to comply, would be enforced through the National Pollutant Discharge Elimination System (NPDES). Dischargers would have to meet these annual load limitations regardless of their actual flows. In addition, there is no provision for new dischargers in the watershed or for increasing existing capacity beyond existing design flows, except for buying/trading nutrient credits or implementing wastewater reuse, so the program as proposed will severely limit growth.

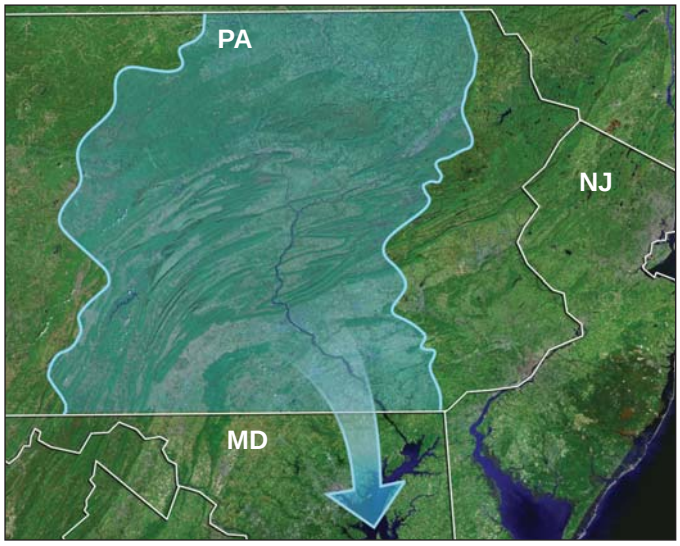
Pennsylvania's wastewater utilities and their Authority Engineers have been negotiating with PA-DEP for changes in the implementation of the program, while trying to maintain the overall objective of reducing the amount of nutrients that flow to the Chesapeake Bay.

A compromise program has proposed loads for significant dischargers based on design flow, 6 mg/L TN and 0.8 mg/L TP, and a three-phased implementation period extending over 10 years. PA-DEP has initially accepted these provisions, but the Environmental Protection Agency has expressed concerns over phasing and its impact on the Bay's 2010 nutrient reduction goals. We will continue to monitor these discussions.

The Hazen and Sawyer Approach

From our experiences in the lower Chesapeake Bay (and other sensitive areas such as the Long Island Sound), Hazen and Sawyer has developed unequalled expertise in the design and implementation of nutrient reduction technology for municipal dischargers.

Since the unveiling of Pennsylvania's nutrient reduction program for the areas of the Chesapeake Watershed within the Commonwealth, we have been participating in the planning and education process for utilities that will need to comply with these regulations.



As the map above shows, much of central Pennsylvania drains into Chesapeake Bay — making nutrient reduction efforts as important here as they are in adjacent states.

In assisting Pennsylvania municipalities, we have:

- Made technical presentations on nutrient removal at Pennsylvania wastewater conferences (see page 7);
- Attended PA-DEP workshops and meetings;
- Engaged Authority Engineers in strategy discussions;
- Kept informed and up-to-date on PA-DEP's implementation schedule and their reaction to dischargers' recommendations for compromise;
- Developed process models to assist in design and system optimization (see page 3 article on modeling).

We can provide engineering expertise to Authority Engineers, recommend cost-effective nutrient reduction technologies, and carry through with design, construction, and operational assistance. And we have designed and implemented numerous reclaimed water applications.

As Pennsylvania meets the challenge of helping the Chesapeake Bay thrive, we look forward to helping engineer the solutions.

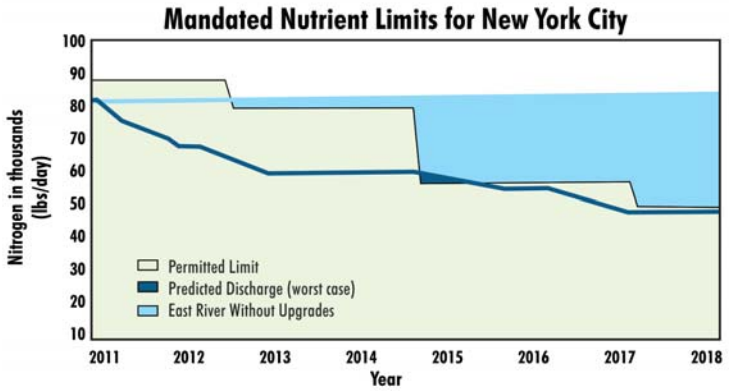
"Partnership Making Progress" Continued from Page 4

Considering this, the Group determined that reducing discharges from these treatment plants was essential to improving water quality in the Sound.

In 1998, after over a decade of research and the development of a water quality model that correlates levels of nitrogen removal with their impact on dissolved oxygen and water quality, the LISS mandated a 58.5 percent reduction, from peak levels, of nitrogen discharges. This multi-phase, bi-state plan, to be implemented over 15 years, was approved by the Environmental Protection Agency in 2001.

New York Chooses Biological Nutrient Removal

The New York City Department of Environmental Protection (NYCDEP), the agency responsible for operating New York City's 14 Water Pollution Control Plants, studied multiple nitrogen removal pathways, including chemical treatment, biological treatment, and fixed media before choosing Biological Nutrient Removal (BNR) as the most effective and proven large-scale technology. Plants slated for BNR upgrades range in size from 80 to 275 mgd, and the total capital construction cost for this set of plant upgrades is expected to exceed $640 million.



Local regulatory agencies applied their own policies and standards according to the circumstances of their treatment plants. The New York State Department of Environmental Conservation adopted an interim "no net increase" policy for the Sound, and implemented a "nitrogen cap" through modification of permits for the Westchester County plants.

Additionally, the New England Interstate Water Pollution Control Commission established the Connecticut River Nitrogen Project Workgroup — recognizing that some nitrogen in the river (whose outlet is the Long Island Sound) originates in states north of Connecticut.

Once future limits on nitrogen discharges were established, the daunting task of designing and implementing upgrades to treatment plants began. Since the 1990s, Hazen and Sawyer has provided comprehensive program management to the NYCDEP overseeing the construction of BNR upgrades at five major wastewater plants. And we've also designed and provided construction management services for several BNR upgrades in New York and Connecticut to improve water quality in the Long Island Sound.

As BNR upgrades in New York City moved from the conceptual to the design phase, the Advanced Wastewater Treatment program (AWT) led by Hazen and Sawyer (as part of a joint venture) issued design guidance to engineers tasked with plant-specific designs. This ensured a uniform standard across the plants and sufficient process infrastructure to meet the stringent, new discharge standards.

The AWT team considered potential impacts of BNR on the NYCDEPs other programs, including water conservation, combined sewer overflow control, and floatables reduction.

During construction of several New York City BNR upgrades, modeling played a key role. The BioWin process model was used to calculate the impacts of various construction-related changes on plant operations to ensure that overall nutrient levels would not climb too high during the upgrade process — saving the client more than half a billion dollars in unnecessary and redundant construction.

Nutrient Reduction Efforts are Helping the Sound

Progress is being made and overall water quality is improving, according to the 2006 Sound Health report issued by LISS.

Since the early 1990s, there has been a 20 percent reduction in end-of-pipe discharges of nitrogen from sewage treatment plants into the Long Island Sound. Compared to 1994, this translates into 47,000 fewer pounds of nitrogen entering the Sound each day.

Though the challenges of implementation are ongoing, the commitment of local and federal regulatory agencies, coupled with the nitrogen reduction plans of plant owners and their engineers, is making a difference. By reducing nitrogen levels through good planning and new technology, we hope to protect the ecological value of Long Island Sound and ensure a safe place for recreation, fishing, and tourism for many years to come.

"Nutrient Pollution" Continued from Page 1

The most cost-effective solution involves optimizing existing infrastructure before adding additional facilities. To do this, a calibrated wastewater treatment plant model is often quite useful. Hazen and Sawyer has in-depth experience with modeling software (see article on page 3) and extensive experience with BNR retrofits.

Future Trends: Technology and Cooperation

To protect threatened waters, strict effluent limits are being imposed across the country — often via State Pollution Discharge System Permits and court-mandated consent decrees. Some states are looking forward to even tougher restrictions and are upgrading their facilities to the strictest current standard: limit of technology (LOT).

The ecologically-rich Chesapeake Bay and Long Island Sound are two good examples of waterbodies that are benefiting from the concerted work of multi-state groups of stakeholders to lower nutrient levels.

The expectation is that other states and municipalities will follow suit, though reaching the strictest standards may be a multi-step process. Municipalities that have BNR measures already in effect can proceed most effectively to LOT, while for other municipalities, reducing nutrients via BNR/ENR is an important first step.

There are many benefits to reducing the amount of nutrients flowing into our waters. In some cases, the improvement can get waters delisted from the "impaired waters" list. And, more broadly, when our rivers, bays, and coasts return to health, their ecological value improves, as do opportunities for recreation and commerce. The good news is that we have the technology to help our threatened waters. But to reap the greatest benefit, towns, cities, states, and regions must all work together to achieve the desired water quality improvement.

Papers and Presentations

Below is a select list of recent papers. For a full list, please visit our website's Publications page at www.hazenandsawyer.com.

WEFTEC, 10/21-10/25/06, Dallas, TX:

- C. Michael Bullard, "A Tale of Three Cities – Different Approaches to Class A Biosolids Management," (coauthors R. Bonne, R. Brice, B. Lassiter).
- Robert E. Fergen, "Metals Site Specific Criteria Development at Twelve Mile Creek WWTP, Union County, NC," (coauthors J. Struve, L. Shealy, M. Tye).
- Laurissa Hoyle, "Investigation Steam Application for Reducing Foaming in Activated Sludge Systems," (coauthors F.L. de los Reyes III, P. Pitt, A. Stone).

AWWA/WEA Conference, 11/12-11/15, Greensboro, NC:

- Dan Edwards, "Fundamentals of Control Systems for Water and Wastewater Operators Lake Mackintosh Marina Clubhouse – Burlington, NC," (coauthor V. Madrid).
- Mark Bishop, "Water Plant Recycle – Good Design Practice and Management," (coauthor M. Mann).
- C. Michael Bullard, "Design, Permitting and Start-Up Considerations for the Town of Cary Dewatering and Thermal Drying Facility," (coauthors R. Bonné, C. Martin, A. Russell, T. Rorrer).
- Frank Qiao, "A New Way to Simulate Rainfall Dependent Inflow and Infiltration (RDII)," (coauthors H. LU, K. Derr, M. Wang).
- Ronald L. Taylor, "Designing for Reliable, Cost Effective, Nutrient Removal: Lessons Learned," (coauthors J. Carroll, P. Pitt).

William Becker, 9/16, "Corrosion: Just When You Thought it was Under Control," NYAWWA Edwin C. Tift Water Supply Symposium, Liverpool, NY.

T.J. Wang, 9/12, "Infoworks CS Application on the Design of Miami-Dade County South District Wastewater Treatment Plant High Level Disinfection System and 450 mgd Plant Expansion — A Case Study," Walingford Software Users Conference, UK.

William G. Richards, 9/11, "Prioritization of Collection System Improvements by Sewer Assessment Programs," Pennsylvania Municipal Authorities Conf., Hershey, PA.

Damann Anderson, 8/29, "Nitrogen: The Need for Integrated Watershed Management," at the National Onsite Wastewater Association Annual Conference, Denver, CO.

William G. Richards, 8/9, "Development of an Ongoing Sewer Cleaning and Inspection Program for an Urban Collection System," (coauthors C. Roumbas, D. Sparks), Water Environment Federation's Collection Systems Conference 2006, Detroit, MI.

PennTec Conference, 7/16-7/19, State College, PA:

- Mark Bottin, "Designing for Nutrient Removal: Lessons Learned," (coauthors P. Pitt, R. Taylor and J. Carroll).
- Ron Latimer, "Optimization of Biological Nutrient Removal Facilities Utilizing the BIOWIN Process Simulation Software," (coauthors P. Saurer and P. Pitt).
- Chris Roumbas, "Development of an Ongoing Sewer Cleaning and Inspection Program for an Urban Collection System," (coauthors D. Sparks and B. Richards).

Roopesh Joshi, 6/2, "The Design of the Upgrade and Expansion of the Stamford Water Treatment Plant" at the New York State Society of Professional Engineers Annual Meeting, White Plains, NY.

Janeen M. Wietgrefe, 4/25, "Groundwater Treatment," (coauthor M. Bishop) at Florida Atlantic University.

Awards and Exhibits

Sustainable Designs on Display at NY Architecture Show

Two Hazen and Sawyer architectural design projects, the Manhattan Pump Station and the Warnerville Pump Station, were recently on display as part of the American Institute of Architect's "Going Public 2: City Snapshot(s) and Case Studies of the Mayor's Design and Construction Excellence Initiative."

The Manhattan Pump Station, which also received a Design Excellence Award from the New York Arts Commission, was commissioned by New York's Department of Environmental Protection (NYCDEP).

The Warnerville Pump Station, also commissioned by NYCDEP, is to be located near Kennedy Airport and was inspired by local aviation history.

The Warnerville Pump Station, to be located near Kennedy Airport, will play an important role in New York City's CSO system.

"For both structures, we are emphasizing sustainable design strategies to maximize energy efficiency and minimize impacts on surrounding buildings," explained Michael Stallone, AIA, LEED AP, and Hazen and Sawyer NYC Director of Architecture.

"We are very pleased to see the American Institute of Architects and New York City supporting this kind of innovative work," added Tommaso Nardone, AIA, LEED AP, and Warnerville Project Architect.

For more information, please visit AIA online at: http://www.aiany.org

Concrete Industry Board Gives Newtown Creek, Staten Island Bluebelt Awards

A joint venture project to upgrade Newtown Creek WPCP, New York's largest wastewater control plant, was given the Concrete Industry Board's Award of Merit with Special Recognition in late 2006. The Lenevar Avenue riser box, part of the Staten Island Bluebelt designed by Hazen and Sawyer, was given an Award of Merit.

"Excellence in engineering and satisfied customers are what drive us — but winning awards is always gratifying," said Robert Smith, P.E., Vice President and Northeast Regional Manager, "and we thank the Concrete Industry for these honors."

NYACE Engineering Excellence Awards for Rye Lake Water Treatment Studies, Catskill Aqueduct Pressurization Study

At the 2006 ACEC-NY Engineering Excellence awards banquet in April, Hazen and Sawyer received a Diamond Award (first prize) for the Rye Lake Water Treatment Studies, completed for the Westchester Joint Works. The project was also chosen as one of ACEC-NY's entries in the national Engineering Excellence competition. Hazen and Sawyer (in joint venture with CDM) also received a Gold Award for the Catskill Aqueduct Pressurization Study, completed for NYCDEP.

Both studies are laying the groundwork for important updates to New York's drinking water infrastructure. For the Catskill Study, Hazen and Sawyer is helping NYCDEP evaluate alternatives to convey water to the 2-bgd ultraviolet light (UV) disinfection facility the City is building for the Catskill/Delaware supply. For the Rye Lake project, we are assisting the Westchester Joint Water Works with site selection, treatment process evaluation, pilot plant testing, and conceptual design of their planned facility.