Compendium of Abstracts

Presented at the

1st Annual New York City Watershed Science and Technical Conference

September 11-12, 2003

The Watershed Approach
A Comprehensive Strategy for the Management of Watersheds

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1st Annual New York City Watershed Science and Technical Conference

The Watershed Approach: A Comprehensive Strategy for the Management of Watersheds

Holiday Inn 503 Washington Avenue
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September 11-12, 2003

Sponsored by:

NYS Department of Environmental Conservation

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INTRODUCTION AND ACKNOWLEDGMENTS

The historic 1997 New York City Watershed Agreement put in motion unparalleled efforts and resources devoted to understanding the science of the New York City Watershed. Central to these efforts by New York State, New York City, the United States Environmental Protection Agency, Watershed municipalities and partnership agencies has been an unprecedented array of Watershed protection and water quality monitoring measures.

The Watershed Protection and Partnership Council completed a review of the Agreement on its fifth anniversary, and recommended that there be an annual opportunity to bring scientists together with Watershed stakeholders and the public, to technically inform, exchange ideas, and present information collected to date with regard to the protection of the nation's largest unfiltered surface water supply.

Thus, the first Annual New York City Watershed Science and Technical Conference was created to achieve this important objective. It is our hope that by bringing scientists together to publicly present new research findings and data, the conference will also serve to enhance technology transfer and increase coordination among the array of entities working with Watershed science.

Earlier this year, a Call for Abstracts was made to all agencies and stakeholders in the NYC Watershed. Submitted abstracts were reviewed by the Watershed Protection and Partnership Council's Technical Advisory Committee. Eighteen abstracts were selected for presentation at the Conference and are included in this compendium.

To the conference participants, and to all who submitted their scientific endeavors for review - please accept our many thanks. With your help and continued participation, we will together advance our insight into the science of protecting the drinking water for 9 million New Yorkers.

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Through Protection to Prevention: Balancing Microbial Risks and Disinfection Byproducts Formation in New York City Water Supply

Irina Birman, Ph.D. and Roger Sokol, Ph.D.

ABSTRACT: Waterborne outbreaks may result in simultaneous infection of a high proportion of the community and thus, the importance of safe and reliable drinking water cannot be overemphasized. When first used as a drinking water disinfecting technique, chlorination resulted in enormous public health improvement. Economically beneficial and effective in inactivating the vast majority of pathogens, chlorination is still the most frequently used drinking water disinfecting technique. However, in addition to inactivating disease-causing organisms, chlorine interacts with natural organic matter in waters to form a class of compounds collectively known as disinfection byproducts. Epidemiological and laboratory animal study data demonstrate that there are potential public health risks associated with disinfection byproducts. These risks forced the scientific and water supply communities to search for ways to balance the microbial inactivation benefit of chlorination with the risk of disinfection byproducts formation. This is of particular importance in water supplies such as New York City, which have been granted a Filtration Avoidance Determination (FAD). Numerous programs have been and are being implemented in the City's watershed to ensure drinking water safety and to maintain its FAD status. Without undermining the importance of conventional water treatment processes, this presentation will emphasize how source water protection provides an effective public health safeguard. Watershed management strategies, which improve overall water quality and reduce the potential for disinfection byproducts formation will be discussed.

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Paired Watershed Study to Evaluate Effects of Agricultural Best Management Practices on Water Quality

Patricia L. Bishop, W. Dean Hively, Jery R. Stedinger, Jay A. Bloomfield, Michael R. Rafferty, Jeff L. Lojpersberger

ABSTRACT: Reduction of nutrient losses, particularly phosphorus (P), from dairy farms is an environmental management priority in catchment areas draining to Cannonsville Reservoir, a New York City drinking water supply. In 1993 a paired watershed study was established to evaluate changes in nutrient and sediment loading attributable to extensive best management practice (BMP) implementation on a 160-ha, upland dairy farm in the Cannonsville basin. The small watershed scale and headwater location was appropriate for evaluation of changes in P loading processes across the entire farm landscape. Control for inter-annual environmental variability was provided by matched data from a nearby 83-ha forested watershed. Monitoring stations at both sites continuously logged precipitation and stream discharge and automatically collected stream-water samples during runoff events. More than 3,800 samples were analyzed during a two-year pre-treatment period (PRE-BMP), and a four-year post-treatment period (POST-BMP). Documentation of changes in land use and farm management resulting from BMPs helped to explain observed changes in water quality. As expected, PRE-BMP event mean concentrations and unit loading rates of nutrients and sediments were much greater at the farm than at the control site. Results of multivariate regression and ANCOVA (analysis of covariance) analyses indicate reductions in farm P event loads consistent with BMPs installed on the farm, especially winter storage and improved management of manure. Event load reductions in the winter, spring and summer seasons were estimated at 43, 40, and 49 percent for total dissolved phosphorus (TDP) and 48, 41 and 48 percent for particulate phosphorus (PP). Overall, a 39 percent reduction in TDP event loads and a 34 percent reduction in PP event loads were estimated in the POST-BMP period. Respective TDP and PP event loading rates for the farm watershed were estimated to be 247 g/ha/yr and 731 g/ha/yr under PRE-BMP conditions, and 163 g/ha/yr and 513 g/ha/yr under POST-BMP conditions.

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Reducing Phosphorus Through Feed Management on Dairy Farms

P. E. Cerosaletti, D.G. Fox and L.E. Chase

ABSTRACT: A study of four dairy herds in the Cannonsville reservoir basin in Delaware County, NY was conducted to determine current levels of phosphorus (P) feeding in commercial dairy herds typical of the basin as well as to investigate and implement forage and feed management strategies to reduce dairy cattle dietary P intakes, manure P excretions, and feed P imported onto dairy farms. Mean P intakes in the herds ranged from 107% to 165% of requirement before implementing feed management changes. Much of the excess P intake was due to P content of forage grown on the farm, which was higher than average forages for New York State. By intervening in the diets of two herds, P intakes were lowered by an average of 24.5% without decreasing animal performance. Measured mean fecal P concentrations in both herds decreased 33% ($p < .001$) after dietary adjustments. Improved homegrown forage production allowed greater utilization of homegrown nutrients and less reliance on imported feed nutrients. Purchased feed costs were reduced up to $70 per cow per year. Whole farm mass P balances (amount of P remaining on the farm) were reduced 50% on average as a result of dietary changes, with both herds achieving less than 45% of imported P remaining on the farm. If similar results could be obtained on all lactating dairy cows in the Cannonsville basin, purchased feed P imports and manure P excretions could be reduced by more than 60,000 kg annually.

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Creating and Implementing A Water Quality Protection Plan For Multiple Levels of Government

Sabrina D. Charney

ABSTRACT: Westchester County's Comprehensive Croton Watershed Water Quality Protection Plan uses extensive analysis of land use, impervious surfaces, water quality conditions, development potential and local environmental regulations to outline approximately 100 actions that can be taken by federal, state and local governments, other organizations and watershed residents to protect and improve water quality. These include physical projects, outreach and education strategies, legislation and other programs.

The Croton Watershed encompasses 40% of Westchester County (177 square miles) with land in parts of ten municipalities. The Plan needed to balance home rule interests with statutory planning requirements of the historic Memorandum of Agreement (MOA) to Protect New York City's Drinking Water Supply. The Westchester County Planning Department took the lead in preparing the plan, working closely with the municipalities and the New York City Department of Environmental Protection.

Technology played a ground-breaking role in the analysis of critical environmental variables to determine land use impacts on water quality. Extensive analysis included the use of low-level aerial photography for impervious surface measurements and site specific land use and tax assessment data for determining development potential.

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Municipal Stormwater and Highway Management in Delaware County, NY

Delaware County Planning Department and Department of Public Works

ABSTRACT: Since signing the 1997 Watershed Agreement, Delaware County has taken a proactive, interdisciplinary approach in addressing watershed management. Through the Delaware County Action Plan (DCAP), the Delaware County Planning Department (DCPD) and the Department of Public Works (DPW) have teamed to develop a variety of stormwater management programs to minimize the impacts of nonpoint source pollution throughout the County.

DCPD has been working on an inventory and assessment of stormwater sources and infrastructure throughout the County. The goal is identify all point and nonpoint sources of stormwater in the village and hamlet areas that may produce stormwater pollution and manage them to reduce their impact on water quality. An example is the creation of a GIS database enabling characterization and cross-reference of stormwater sources with the location of existing municipal stormwater infrastructure in the County's watersheds.

Through its Town Planning Advisory Service, DCPD will work with municipalities to develop local initiative regarding water quality protection through stormwater management and to demonstrate the role of water quality in relation to economic development. Each municipal strategy will develop a prioritized plan to meet current and future needs for repair, expansion, and management of local stormwater infrastructure. Maintenance programs will also be developed to continually assess the condition of the stormwater system, track sediment by volume and type removed, and reduce the likelihood of flooding due to clogged or broken collection and conveyance systems. For example, DCPD produced a comprehensive stormwater report for the Village of Margaretville using GIS and TR-55 runoff modeling to leverage an additional $200,000 in funding to complete stormwater retrofits and BMPs throughout the Village.

DPW completed an assessment of highway stormwater impacts in 1999 and continues to maintain a comprehensive highway inventory and assessment program. This program has been recently expanded to fully document, using GIS methods, the location, maintenance, and management of roadway and stormwater infrastructure of the County. As part of the program, all major drainage features such as culverts, swales, catchbasins, and bridges have been inventoried, mapped and assessed. Efforts to minimize negative water quality impacts include both capital construction projects (stormwater retrofit for County Route 6 in Bovina) and ongoing management practices (sediment removal with Vactruck, culvert stabilization and control of the use of deicing material). DPW also proposes to extend the highway management program to towns to address inventory and assessment of town roads, identification of priority stormwater management practices (SMPs), capacity building through the provision of expertise and training to Town Highway Superintendents for the SMP management practices and installations, and evaluation and monitoring of these SMPs.

Other DPW projects include: 1) research with SUNY ESF to evaluate the potential use of tire chips for the removal of dissolved phosphorus in stormwater – initial results indicate a potential dissolved phosphorus removal rate upwards of 50%; 2) construction of a 2-acre wetland called the Oxbow Hollow Wetland Bank. Twenty acres of new wetland creation is planned for the area, which provides important environmental enhancements and a training ground for equipment operators and facility designers.

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Stormwater Best Management Practices For Pollutant Removals

Dale Borchert

ABSTRACT: The City of New York Department of Environmental Protection (DEP) has implemented a Kensico Reservoir watershed management and protection plan that targets the control of fecal coliform bacteria and turbidity that could enter the reservoir from its watershed. Among other practices, DEP has constructed nine Best Management Practices (BMP) with extended detention basins (with plans for a 10th) on streams that discharge into Kensico Reservoir.

With the construction of these BMPs, DEP developed a stormwater monitoring program to evaluate the effectiveness of these structures in reducing loads of fecal coliform, total suspended solids, turbidity (a quasi-load) and total phosphorus. Between 2000 and 2007, DEP intends to monitor at least one year's worth of storm events at each of these extended detention basins to quantify their ability to reduce loads of the above analytes.

As part of this program, DEP monitored BMP Facility 12 between March 2000 and September 2001. During this period, sufficient data were collected to calculate storm loads of fecal coliform during 11 events, total suspended solids during 13 events and turbidity and total phosphorus during 14 events. The Regression of Loads technique (Martin and Smoot, 1986) was used to calculate load removal efficiencies. This technique calculates the regression between the input loads and output loads, where 1 minus the slope of the regression line (constrained through the origin) is assumed to be the percent reduction of analyte load. Based on this analysis, BMP Facility 12 was found to remove 49% of the fecal coliform loads, 73% of the total suspended solids loads, 51% of the turbidity quasi-loads and 54% of the total phosphorus loads.

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THMs in the Croton System

Gerard Marzec

ABSTRACT: Disinfection by-products (DBPs) are compounds that are formed when organic matter in raw water reacts with chlorine during the disinfection process. One group of these compounds, which DEP monitors, is the trihalomethanes (THM), of which chloroform is the main constituent. The USEPA has set limits on THM and other DBPs, such as the haloacetic acids (HAAs), because they are potential carcinogens.

Trihalomethane levels are typically higher in the Croton System and, as a result, have been the subject of recent research. The sources of precursors for disinfection by-products in New Croton Reservoir have been assessed via monitoring of trihalomethane formation potential (THMFP) in the reservoir and in its major tributaries from 1992 through 1998. As a result of this initial work, DEP undertook a multi-objective study of THMFP sources in 1999. In 2002, draft compilation report was completed and the highlights of this study were:

- THMFP in New Croton appears to originate primarily from upstream terrestrial sources,
- Four upstream reservoirs (Amawalk, Croton Falls, Cross River and Diverting) acted as sinks of THMFP precursors. Titicus was undergoing dam rehabilitation during this study. The low reservoir elevation may have caused the reservoir to act like a source of precursors, but the cause is not clear.
- Wetlands and, at times WWTPs, proved to be significant sources of the THMFP concentrations in the streams, and
- THMFP concentrations in New Croton Reservoir were linked to potential THM levels at Jerome Park Reservoir.

Regular monitoring of the distribution system THM compliance monitoring sites provides the status of THM levels compared to EPA limits. The Catskill/Delaware and Croton systems are below the historical 100 $\mu g\ L^{-1}$ MCL as well as the 80 $\mu g\ L^{-1}$ MCL which became effective in 2002.

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Croton Watershed Strategy Project

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ABSTRACT: In December 2002, DEP concluded the Croton Watershed Strategy project. This project was a two year effort to develop an integrated watershed management plan for the Croton System. The primary goal of this project was to allow DEP to optimize management efforts and focus limited resources on critical areas to achieve maximum water quality benefit.

For the Croton Watershed Strategy, DEP retained the services of Malcolm Pirnie, HydroQual and LimnoTech to:

- Conduct a watershed assessment for four critical indicator variables: total phosphorus, total suspended solids, pathogens, and toxic chemicals;
- Implement the methodology in a Decision Support Tool to allow DEP to continue to update the watershed assessment; and
- Recommend watershed management alternatives for DEP's consideration.

For this analysis, the twelve Croton reservoir basins were divided into 74 smaller subbasins. The watershed assessment examined both existing conditions in the watershed and potential future impacts to water quality associated with further development of the watershed. A separate assessment methodology was developed for each water quality variable based on available data and current understanding of the watershed sources. The methodology focuses on impairment from terrestrial sources; it does not consider in-reservoir sources or contributions from upstream basins and aqueduct discharges. The assessment was not intended to predict actual levels or concentrations of water quality variables in the reservoirs and does not include any actual monitoring data. Instead, the analysis identifies each subbasins' relative potential to impair water quality compared to other subbasins.

Individual reports were developed for each of the reservoir basins. The Basin Reports provide: potential point and nonpoint water quality impairment sources for each variable ("Areas of Concern"); subbasin scores that indicate the relative potential for water quality impairment from each source and each subbasin; and basin-specific management recommendations. Background information on the physical, environmental, and demographic characteristics of each basin are also included in the reports.

A final, watershed-wide analysis was also conducted as part of the project. The analysis compares subbasins and Areas of Concern across the watershed objectively, prioritizing the recommendations based on several factors including: reservoir operations, 60-day travel time, phosphorus restricted basins, trout streams, and wetlands/sensitive environments. Management recommendations were grouped into five general areas: wastewater, stormwater, open space preservation, road drainage improvement and agriculture.

The Croton Watershed Strategy project has provided a more detailed and comprehensive watershed analysis than was previously available. This will be valuable in a wide variety of DEP activities. The Decision Support Tool will also allow DEP to update this analysis as new data is developed.

Additional work is planned for the Croton Watershed Strategy project in 2003. This work includes the development of a Tracking Tool which will track implementation of projects by basin, estimate reductions of phosphorus based on existing or proposed implementation projects, estimate increases of phosphorus based on new development, and generate basin status reports. Additional critical watershed analyses, field verification and outreach efforts are also planned during 2003.

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Improved Recovery of *Cryptosporidium* oocysts in High Turbidity Matrix Spike Samples Using a Dual Immunomagnetic Separation and a Sodium Hexametaphosphate Procedure with Method 1623HV

K.A. Alderisio and L.A. Blancero

ABSTRACT: Fifty liter samples were spiked with clay sediment, *Giardia* spp. cysts and *Cryptosporidium* spp. oocysts in the laboratory to determine the potential effect of this matrix on (oo)cyst recovery during storm events. Sample filtration data resulted in high turbidity and high filter pressure mimicking local storm event measurements. Cyst and oocyst recoveries from these samples were significantly low compared to recoveries attained from less turbid samples. A dual IMS procedure and sodium hexametaphosphate wash were introduced, both independently and in combination, to attempt to improve the recovery of the (oo)cysts. The initial average oocyst percent recovery using the 1623HV method (12%) was increased by the dual IMS procedure (58%), and the sodium hexametaphosphate wash (66%). Results from two additional trials combining both method improvements demonstrated the most significant *Cryptosporidium* oocyst recovery (81%). The recovery of *Giardia* cysts did not improve significantly with either of the tested methods. Data suggest that these procedures may also improve the recovery of *Cryptosporidium* oocysts from other difficult matrix samples.

Researchers have endeavored to improve the recovery of protozoa from water samples for several years. In this quest, there has been much emphasis on both laboratory analytical procedure and field sample collection. With the improved time saving steps of US EPA Method 1623 compared to the ASTM and ICR methodologies, there has been increased focus on the ability to process more quality control samples in a protozoan laboratory than ever before. This is particularly true in the area of matrix spike testing. Although the methods have not yet reached 100 % recovery of *Giardia* cysts and *Cryptosporidium* oocysts, laboratories are able to qualify data with the addition of more matrix spike samples in their quality assurance sampling plans. This information is helpful when performing data analysis and when comparing occurrence data for these pathogenic protozoa at different locations throughout various watersheds.

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DEP's Waterfowl Management Program to Reduce Coliform Bacteria in Reservoirs

Christopher Nadareski and Michael Usai

ABSTRACT: DEP's Wildlife Studies Section is responsible for the development and implementation of the Waterfowl Management Program (WMP) at Kensico Reservoir, which includes monitoring and managing goose, gull, duck, cormorant and other duck-like bird populations roosting and breeding on the reservoir. Through presence-absence studies, correlational analysis and microbiological studies, DEP has identified waterbirds as a major source of fecal coliform bacteria in New York City's drinking water reservoirs. Federal and state approved wildlife management techniques are used to maintain significantly lower fecal coliform bacteria levels during the autumn and winter when bacteria levels were traditionally elevated. Roosting bird population surveys consisting of censusing all waterbirds roosting on the water are conducted daily from August through March and weekly from April through July at Kensico Reservoir. Waterbird roosting population surveys are conducted at Croton Falls Reservoir and Cross River Reservoir on a biweekly basis and are conducted weekly at source reservoirs to Kensico (West Branch, Rondout, and Ashokan). Bird censuses and management are also conducted at the two distribution reservoirs (Hillview and Jerome Reservoirs). Overhead wires to preclude bird activity on the surface of the reservoirs are maintained by DEP's Operations staff for all of Hillview Reservoir and the north basin of Jerome Reservoir. Waterbird populations remained low enough to forestall active harassment and not impact water quality at these locations. Egg-depredation to control Canada Goose (*Branta canadensis)* gosling production is conducted at Kensico, Jerome, West Branch, and Rondout Reservoirs. DEP's Waterfowl Management Program have been highly effective at reducing waterbird populations roosting on the reservoirs and the egg-depredation has been greatly reduced productivity and almost eliminated the molting goose population at Kensico Reservoir. The Waterfowl Management Program has averted bird- related seasonal increases in fecal coliform bacteria.

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Modeling Watershed Management Effects On Phoshorus Loads To Cannonsville Reservoir

Elliot M. Schneiderman, Mark S. Zion, Margaret W. Gitau, David G. Lounsbury, and William J. Gburek

ABSTRACT: The effectiveness of New York City's (NYC) watershed management programs to control phosphorus (P) loads to the Cannonsville water supply reservoir was evaluated using the Generalized Watershed Loading Functions (GWLF) model, a watershed- scale hydrologic and water quality model. Four watershed management programs addressing both point and non-point sources were evaluated: wastewater treatment plant upgrades; agricultural best management practices (BMPs); urban stormwater BMPs; and septic system rehabilitations. A calibrated GWLF model for the Cannonsville watershed was used to estimate P loads under pre-management, or baseline, conditions. Phosphorus reductions due to each watershed management program were then estimated from BMP implementation and effectiveness data. These reductions were incorporated in the baseline model in a management scenario to estimate the effects of the four watershed management programs on P loading to the reservoir. Estimated reductions in P loading due to implementation of the four watershed management programs were substantial, exceeding 25% for both dissolved and particulate P. Reductions in total watershed loads depend on a combination of the effectiveness of the management program, the rate of implementation, and the watershed- wide contribution of the managed P sources under baseline conditions. Urban stormwater management provided small reductions in both dissolved and particulate P due to the small amount of urban land use areas in this watershed. Wastewater treatment plant upgrades and the implementation of agricultural BMPs provided most of the estimated loading reductions.

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Modeling to Assess Different Strategies to Achieve the TMDL for Cannonsville Reservoir

Mark S. Zion and Elliot M. Schneiderman

ABSTRACT: The purpose of this study is to use modeling to assess how different phosphorus loading reduction strategies, each consistent with the TMDL, affect reservoir algal biomass and trophic state (measured as chlorophyll.) Different phosphorus loading reduction strategies influence both the nature and timing of nutrient availability for algal growth in a reservoir. Therefore, different strategies (that result in the same TMDL) may have different impacts on algal biomass and reservoir water quality. Modeling results may be used to assess the effects of different strategies, and phosphorus loading reductions targeted on a seasonal basis, or from specific sources and land uses, may be evaluated for their ability to reduce algal biomass (chlorophyll.) Modeling assessments may be used to select watershed management strategies that will be most effective in minimizing the algal response to a given TMDL.

New York City Department of Environmental Protection (DEP) has developed a Nutrient Management Eutrophication Modeling System to examine how the timing and sources of phosphorus loads affect the reservoir water quality. The modeling system uses the Generalized Watershed Loading Functions (GWLF) model to generate a long-term time series (30+ years) of watershed flow and nutrient loads under a prescribed set of watershed management conditions and utilizing historical meteorologic forcings for input. These watershed model results are then input into the reservoir model, which generates an in-lake growing season chlorophyll a concentration for each year of the simulation. A probability density function of the annual growing season chlorophyll a concentration is formed, and provides a signature of reservoir eutrophication potential.

For this study, various watershed management scenarios are designed such that phosphorus loads to the reservoir are reduced to levels consistent with the annual TMDL requirements. Watershed management scenarios which consider seasonal changes in loads and changes in loads due to different sources, land uses, and management programs are identified. Each scenario is input to the modeling system to simulate a new time series of watershed loads, generating a chlorophyll frequency distribution and, thus, providing a signature for reservoir eutrophication potential. Comparison of these reservoir eutrophication signatures for different management scenarios reveals the range of effects of implementing the current annual total phosphorus TMDLs on reservoir eutrophication.

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Enhanced Monitoring in Source Watersheds for NYC Drinking Water: Relating Stream/Reservoir Health and Function to Watershed Conditions

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ABSTRACT: The Stroud Water Research Center has been conducting a multi-year monitoring project since 2000 to assess the ecological health of streams draining the New York City drinking water-supply area. The project was designed as a six year study, split into two, three-year phases. We report here the basic design and general findings from the first phase involving a total of 60 stream sites and 8 reservoirs. Inorganic chemistry, dissolved organic carbon [DOC], biodegradable DOC, suspended solids, molecular tracers (e.g. caffeine, fragrances, fecal steroids), and macroinvertebrates were monitored once annually (spring for macroinvertebrates; summer for all other measures) at the 60 stream sites under baseflow conditions. A subset of the 60 sites were also sampled during winter baseflow for molecular tracers. Measures of ecosystem function (inorganic nutrient and organic carbon spiraling; ecosystem metabolism) were made once annually at 10 of the 60 sites, also during the summer. Storm sampling for inorganic chemistry, DOC/BDOC, suspended solids, and tracers was conducted at three of the 60 sites. The three sites were chosen to represent one of three major land –use influences found in the NYC watershed area: forest, agriculture, and urban/suburban. A total of three storms were sampled over the three-year phase at each of the storm-sampling sites. Primary productivity, assessed during summer months, was measured in the reservoirs.

Watershed characteristics, including land use/cover, wastewater treatment plant influences, and human population characteristics can be used to separate the stream sites along the geographic separation of the sites provided by the Hudson River (i.e. East [EOH] or West [WOH] of the Hudson River). WOH sites were defined primarily by the relative extents of forest and agricultural areas, while EOH sites were defined primarily by nonagricultural human influences. In-stream measures also tended to parallel this geographic separation, with unique responses found between selected watershed characteristics and specific water-quality measures observed in the two defined regions. For instance, certain macroinvertebrate indices were related to variability in imperviousness and wastewater treatment plant (WWTP) effluent in the WOH region, but were unrelated to any EOH watershed characteristics. Likewise, certain chemical markers explained some variability in imperviousness and WWTP effluent in the WOH region, while a very different set of chemical markers explained some variability in these watershed-level characteristics in the EOH region. Initial results have also lead to a suggested link between ecosystem function (e.g. community respiration, metabolism, nutrient spiraling, etc) and selected physical, chemical, and biological factors that characterize stream responses to watershed conditions. The reservoir primary productivity results have shed some light on the extent to which tributaries to the reservoirs (major or minor) affect conditions within the reservoirs.

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Monitoring, Research, and Modeling to Evaluate Effectiveness of BMPs at Farm and Watershed Scales: The Town Brook Research Group Effort

W.J. Gburek

ABSTRACT: Phosphorus (P) loss from agriculture within the New York City (NYC) water supply watersheds is a major concern; for instance, the Cannonsville Reservoir was previously designated as P-restricted. The Watershed Agricultural Council of the New York City Watersheds (WAC) oversees implementation of best management practices (BMPs) intended to mitigate P loss within these watersheds. While there is a substantial database of BMP effectiveness at the local scale, there is minimal data quantifying aggregate BMP effectiveness at farm and/or watershed scales. The Town Brook Research Group (TBRG), consisting of scientists from USDA-ARS, Cornell University, USGS, and the NYC-DEP, working cooperatively with the WAC, farm planners, and local farmers, was formed in 1999 to address these latter needs. Based on an interdisciplinary farm- and watershed-oriented research program that combines laboratory and field work with monitoring and modeling, the TBRG has developed a series of integrated research projects directed toward the needs of the WAC and watershed planners, providing for the development of sustainable and economically viable agriculture within the NYC water supply watersheds. To reach these goals, the TBRG has developed a variety of approaches to quantify farm- and watershed-scale impacts of the WAC's current BMP strategies, as well as develop alternative BMPs and BMP implementation strategies for future application. These BMP strategies address the immediate problem of P loss from current agricultural practices, as well as the longer term problems associated with P imbalances at the farm and watershed scales. This presentation describes the overall objectives of the TBRG, its research efforts and findings to date, potential impact of the research on the WAC's program, and future initiatives.

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East-of-Hudson Watershed Agricultural Program: History, Current Conditions, and Future Program Direction

Michael J. Saviola

ABSTRACT: Farming in the New York City water supply watersheds presents a complicated environmental management problem. Farm practices are a potentially significant source of nonpoint source pollution and present a risk of pathogen introduction. Farm practice pollution control is critical for meeting the City's anti-degradation objectives and the filtration avoidance criteria of the federal Surface Water Treatment Rule. Conversely, well-managed agriculture is recognized as a preferred land use, with significant long-term environmental benefits. In order to achieve water quality protection goals of the MOA, preserve the economic viability of agriculture, maintain the existing land use patterns and preserve open space in the Croton watershed, the Watershed Agricultural Program has been expanded from the west of Hudson (Cat/Del) watersheds to include eligible agricultural enterprises within the City's east of Hudson Croton watersheds. The foundation of the concept of maintaining well-managed agricultural lands in a populated, rural landscape is a superior way to protect water quality. In light of ever increasing development pressures on lands within the Croton watershed, this initiative is strengthening the agricultural producers' ability to operate in a manner which will foster the development of local and regional farm-related economies, and provide water quality benefits which far outweigh those of residential or other less preferred land uses.

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Data-Based Modeling and Future Forecasts of Phosphorous Loading to the Cannonsville Reservoir

Christine A. Shoemaker and Bryan Tolson

ABSTRACT: This talk will discuss modeling and data analysis of phosphorous transport in the Cannonsville Basin, a 1178 km^2 watershed consisting of primarily agricultural (dairy farming) and forested land. We have used the USDA model SWAT2000 (Soil and Water Assessment Tool) to model hydrology, sediment, and phosphorous movement over the watershed and into the reservoir. The model is part of the US Environmental Protection Agencys BASINS 3.0 software package for managing watersheds.

The occurrence of eutrophic conditions in the Cannonsville reservoir, due to excessive phosphorus (P) loading, has resulted in restrictions on future economic growth in the watershed when the growth directly or indirectly increases P loadings. Phosphorus related inputs that were assigned based on available basin specific data included wastewater treatment plant (WWTP) phosphorus discharges, spatially distributed groundwater soluble phosphorus concentrations, cattle population estimates, manure production factors, manure phosphorus characteristics and initial soil phosphorus levels. Agricultural management practices were also specified based on generalized management practices representative of Delaware County. Atmospheric deposition rates of P were assigned based on the average of data collected from multiple locations across the Northeast US. The largest phosphorus load applied to the basin soils or rivers from the above sources is by far from dairy cattle manure. Manure inputs, as well as all other phosphorus inputs in the model, are described in detail in Tolson and Shoemaker (2002).

Excellent calibration and independent validation results were obtained for model results for hydrology, sediment, and for dissolved and particulate phosphorous, based on over 20,000 data points collected over a number of years by several government agencies. These results will be reported.

The model was used to look at future scenarios. The current results indicate phosphorous loadings will increase in future decades even if economic activities and phosphorous management programs do not change. Since this result has very serious policy implications, we also performed a mass balance of phosphorous in the watershed. The calculations for the mass balance were independent of the data input and model used in the SWAT analysis. The results of the mass balance also supported the prediction that phosphorous loading to the reservoir will increase over time.

Additional future phosphorous management scenarios were considered, including the use of precision feeding (to reduce phosphorous levels in manure) and further reductions in the number of cows in the watershed. These changes in practices did have an immediate effect in lowering phosphorous loading to the watershed. However, in the long term, the phosphorous levels continued to increase according to the model results. The reasons for these results (including the build-up of phosphorous in the soil) will be discussed in order to assess the possible uncertainties associated with these current model predictions and their interpretation in terms of policy planning for protection of the Cannonsville Reservoir against eutrophication.

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Applying Lawn Fertilizer that Contains No Phosphorus, in the NYC Watershed

Charles D. Silver, Ph.D.

ABSTRACT: Phosphorous is the primary nutrient implicated in the occurrence of algae blooms in the drinking water reservoirs of the New Croton Watershed, which serve approximately 900,000 residents of New York City and Westchester County. Algae blooms in a drinking water supply can generate offensive tastes and odors, deplete oxygen, and threaten public health by increasing the potential for the formation of hazardous by-products after disinfection. All of these impacts can be attributed to eutrophication, which can be defined as the input of excess nutrients to an aquatic system. Eutrophication is a natural process that can be enhanced and accelerated by human land use activities such as agriculture, urbanization, and home lawn/turfgrass management.
Few landscapers and even fewer homeowners know how much fertilizer is needed for "their" lawn. As a result, landscapers often depend on "tried and true" practices while consumers rely on product labels, staff from local garden centers or stores that sell fertilizers, and local agricultural extension offices. However, soils generally contain enough phosphorous to grow healthy lawns and meet plant demand without the addition of phosphorous in fertilizer. For example, soil tests in New Jersey found phosphorous levels adequate for grass growth in 80 percent of the residential lawns tested. In addition, in Westchester and Putnam Counties, New York, 66 percent of soil samples submitted to Cornell Cooperative Extension for analysis contained an "adequate" level of phosphorous for lawn maintenance.

So, how do we convince landscapers and homeowners in the NYC Watershed to test "their" lawn soil before adding fertilizer? And if phosphorus is present in abundance, how do we convince landscapers and homeowners in the NYC Watershed to apply fertilizer that does not contain phosphorus? Scientists and planners representing Putnam and Westchester Counties, NYCDEP, NYSDEC, NYSDOH, NYSOAG, USEPA, Cornell Cooperative Extension, academia, the NYS Turf and Landscape Association, and Bartlett Tree Research Laboratories have been meeting periodically to answer these questions. Some of the issues that have been identified and resolved or are in the process of being resolved include:

- identifying how phosphorus migrates from lawn soils to reservoirs.
- determining the costs, procedures, and turn-around-times associated with testing soil for phosphorus.
- comparing phosphorus results from different phosphorus extraction test methods to one another (modified Morgan to Bray to Mehlich).
- researching how other states classify "low, medium, and high" phosphorus levels in lawn soil.
- determining how often lawn soils that are being fertilized by "zero" phosphorus fertilizer should be tested, so they do not become phosphorus deficient.
- contacting fertilizer manufacturers to determine whether zero phosphorus fertilizer is available to landscapers and homeowners.
- developing strategies to educate both landscapers and homeowners about: 1) phosphorus and water quality; 2) soil testing; and 3) applying zero phosphorus fertilizer to lawns when appropriate.

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New York City Reservoir Sediment Document Review

Charles D. Silver, Ph.D.

ABSTRACT: The New York State Department of Environmental Conservation (NYSDEC) published two reports dated June 2000 and November 2000 entitled "NYC Watershed Protection Program - Core and Surficial Sediment Sampling". These documents presented sediment sampling results from five of the nineteen reservoirs (Cannonsville, Kensico, Neversink, New Croton, and Rondout) that supply unfiltered drinking water to nine million people in New York City and Westchester County.

Sediment samples were collected and analyzed for metals, pesticides, polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and dioxins. In addition, acute toxicity tests with sediments were performed at all five reservoirs. Sediment guidelines were compared to the reservoir sediment data to evaluate its potential effects to human health or aquatic organisms. Based on the information provided in these previous reports, assessing the sediment in terms of potential human health impacts was greatly limited because tissue analysis was not performed on organisms inhabiting the reservoirs.

New York State sediment guidelines were exceeded at all five reservoirs. However, the water in all five of these reservoirs is of very high quality, which indicates that the sediment is not adversely impacting it. This evaluation identifies which contaminants were measured at elevated concentrations in the reservoirs being investigated. Toxicity tests were conducted on nine sediment samples collected at the five reservoirs. The only sediment sample that exhibited toxicity to bottom-dwelling organisms was collected from the Kensico Reservoir. Samples from this reservoir and the New Croton Reservoir, which are both located east of the Hudson River, exceeded NYSDEC sediment guidelines far more often than the Cannonsville, Neversink, and Roundout Reservoirs, which are located west of the Hudson River. In addition, sediment guidelines that are based on the combined effects of metals, PAHs, and PCBs were predictive of the toxicity observed in the Kensico sediment sample. These sediment guidelines also suggest that none of the other twenty-four reservoir sediment samples being investigated were contaminated to a level that would be expected to be toxic to sediment-dwelling organisms.

We recommend that the following additional studies be conducted, particularly in the Kensico and New Croton Reservoirs: 1) to define or further characterize the effects of sediment resuspension; 2) to analyze tissues for bioaccumulation and risk assessment purposes; and 3) to further identify specific sources of sediment contamination. In addition, the majority of pesticides measured in the sediments are no longer being sold in the United States and reflect historic use. As a result, an inventory of currently applied pesticides needs to be generated and monitored. Finally, dioxin levels in the sediment need further evaluation.

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