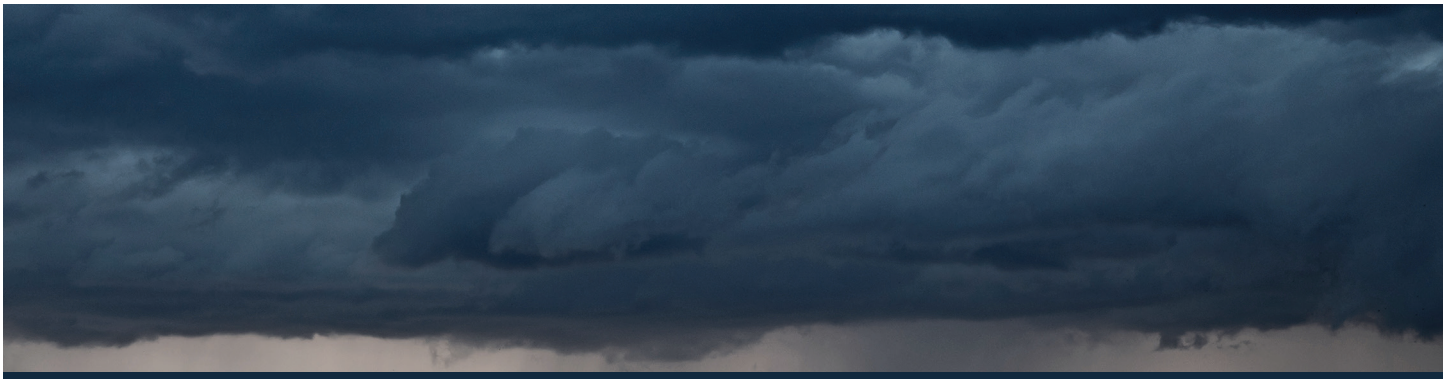

Clean Water Through Protection and Partnership

NYC Watershed Science and Technical Conference

September 12, 2019

Diamond Mills Hotel, Saugerties, NY

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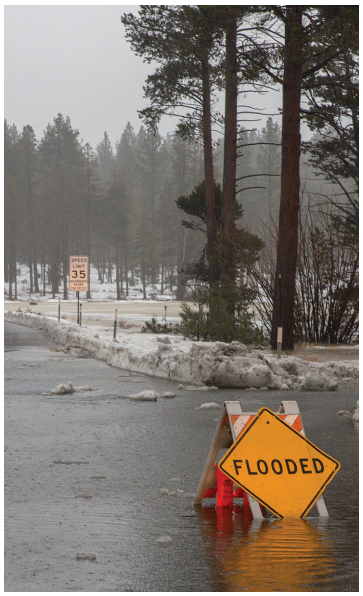

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Cover photo courtesy of NYWEA

INTRODUCTION AND ACKNOWLEDGMENTS

Dear Conference Participants,

In 1997, the signatories to the historic New York City Watershed Agreement formed an enduring partnership to protect and enhance the City's Watershed and the scores of communities living within it.
Underlying this complex social and political undertaking has been an unprecedented technical initiative among scores of local, State and Federal agencies with one common goal: to advance the science of watershed protection.

The Watershed Science and Technical Conference was created as an annual opportunity to bring scientists, professionals, and other experts together with watershed stakeholders and the public, to technically inform, exchange ideas, and unveil new information regarding the protection of the nation's largest unfiltered surface water supply.

Each year, this conference showcases the most current trends, technologies and scientific developments in the arena of watershed protection and management. The conference continues to punctuate the multiple longstanding themes that remain central to the business of caring for a watershed:

- Stormwater control,
- Wastewater treatment,
- Stream health,
- Emerging contaminants and microconstituents,
- Monitoring and modeling,
- Pathogens, nutrients, and turbidity,
- Recreational use, forestry, agriculture, and more.

The Conference Call for Abstracts was made to agencies and stakeholders in and beyond the New York City Watershed. The resulting responses were reviewed by the Watershed Technical Program Committee for technical merit and interdisciplinary utility, as well as temporal and substantive relevance. Those chosen by the Committee for presentation at this year's Conference are included in this Compendium.

In addition to our esteemed presenters and all those who submitted their scientific endeavors, we wish to thank the many agencies, professional organizations, and individuals who contributed to the success of this conference. It is our hope that all who attend will be edified by the scientific data presented, and inspired by the dedication and hard work of those who, each day, advance our insight into the science of protecting the drinking water for nine million New Yorkers.

Respectfully,

Lisa Melville

Lisa Melville
NYC Watershed Programs Coordinator
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Watershed Protection and Partnership Council

For the Conference Organizers and Sponsors:

The Watershed Protection and Partnership Council
The New York Water Environment Association, Inc.
The New York State Department of State
The New York State Department of Environmental Conservation
The New York State Department of Health
The New York City Department of Environmental Protection
The Catskill Watershed Corporation
The Watershed Agricultural Council
The United States Geological Survey
The New York State Environmental Facilities Corporation

A Sudden and Sustained Increase in Giardia Cysts at New York City's Rondout Reservoir - A Case Study

Kerri Alderisio, Christian Pace, Kurt Gabel and Chris Nadareski, NYC Department of Environmental Protection

In November of 2018, an increase in the number of Giardia cysts was observed at the Delaware inflow to Kensico Reservoir. The increase was traced to the upper end of the Delaware Aqueduct at the Rondout Reservoir outflow. Concentrations of cysts were several times higher than normal for this time of year at Rondout, with a maximum of 29 cysts 50L-1 in December, while historical data show concentrations only in the single digits. Several different areas of investigation were explored to identify the source(s) and transport of the Giardia cysts. Initial review of other water quality data included fecal coliforms, turbidity, and other physical parameters, as well as a review of precipitation, runoff, and stream flows. Supplemental water samples were collected at streams, at various depths in the reservoir, and at different aqueduct elevations to narrow down locations of the Giardia. With regard to sources, waterbird population counts, wildlife surveys and trapping were performed in order to test scat samples for the presence and types of Giardia in the animal populations around the reservoir. Samples positive for Giardia were sent to the Center for Disease Control and Prevention in Atlanta, Georgia, (CDC) to attempt to identify the species and subtypes of Giardia that were recovered from the water and the wildlife. Results from the typing were helpful in identifying potential sources of the cysts, and determining if the types recovered were types capable of causing disease in humans.

This presentation will review the various efforts undertaken by the Water Quality Directorate in response to this event and share the sample results and conclusions to date.

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Holistic Reservoir Management: Ecological Engineering to Suppress Harmful Algae Blooms and Improve Raw Water Quality

David Austin, Jacobs Engineering Group

Harmful algae blooms (HAB) are products of complex dynamics within lakes and reservoirs. Control of watershed nutrient inputs is typically necessary to ensure basin water quality but is often insufficient to prevent HAB or excessive primary productivity. Drinking water utilities are concerned with taste and odor production as well as HAB. In general, HAB impairs recreation and habitat. Experience of reservoir management reveals that strong suppression of HAB is commonly feasible and practical. Dosing so requires considering lakes/reservoirs holistically as biogeochemical systems driving ecosystem dynamics.

Elimination of anoxia is critically important. Mobilization of phosphorus and iron from sediments typically drives HAB formation. Deep (hypolimnetic) injection of pure oxygen has proven to be a successful water quality remediation method, with approximately 45 projects operating since the mid-1990s. Dissolved oxygen concentrations achieved in deep waters are typically over 50% saturation where strong anoxia had previously prevailed. By sequestering phosphorus and iron in sediments, this nutrient denial strategy radically reduces T&O and HAB events in deep reservoirs.

Oxygen may not be enough. It is often necessary to inject small quantities of iron or aluminum salts to bind phosphate if lake/reservoir geochemistry is iron-deficient. Shallow reservoirs present special challenges. Intermittent stratification and anoxia may make deep oxygen injection inapplicable. Destratification aeration is not consistently effective for fundamental reasons. In shallow lakes/ reservoirs injection of soluble doses of aluminum salts at concentrations below chronic toxicity is proving to be an effective means of reducing total phosphorus concentrations that drive HAB. Additionally, hydrodynamics controls on HAB via destratification are effective within some basins. The presentation will discuss mechanisms and present experience from projects in managing HAB drivers and HAB.

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Extreme Flood Risk From Rain Events and Rain On Snowpack

Mark Bartlett, Ph.D., Emery Myers and Glenn Muckley, Stantec Consulting Services Inc.

The risk of extreme flood events typically is based on the risk of extreme rainfall as projected by NOAA. Differently, in many regions, rainfall on snowpack and the resulting meltwater are a primary pattern associated with extreme flood events. However, such extreme flooding is not represented by the typically approach of considering extreme rainfall alone. Here, for a watershed area, we introduce a method for calculating extreme moisture inputs from both rainfall and snowpack meltwater for typical NOAA storm recurrence intervals (100yr, 500yr, etc.). The presented method for extreme moisture input is consistent with both the Army Corps of Engineers estimates of snowmelt and the extreme rainfall projections by NOAA. When snowpack is always zero, the moisture inputs default to the NOAA extreme rainfall values. In addition, the new approach accounts for present and projected climate

variability and associated temperature fluctuations that may exacerbate the risk of rain on snow events. The approach was recently applied to FEMA flood estimation in the Cities of Carlin and Wells, NV. We further demonstrate the approach for select watersheds in NY for both present and future climate conditions. By accounting for both rainfall and snowmelt dynamics, watershed managers may improve estimates of the extreme flooding risk used to plan operations and infrastructure improvements.

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A Case Study in Watershed-Based Nutrient Management Strategies for Wastewater Utilities

Megan Bender, Jacobs Engineering Group

With only increasing competition for public funds, wastewater utilities will need new and innovative tools to protect water quality. This presentation provides an innovative watershed-based approach used by utilities in Wisconsin to manage nutrients in their surrounding watersheds. The State of Wisconsin has enacted legislation that allows point sources to partner with other stakeholders to implement basin-wide strategies to meet total maximum daily loads (TMDLs) promulgated under Wisconsin Pollutant Discharge Elimination System (WPDES) Permits. These strategies have been shown to provide more cost-saving opportunities when compared to traditional point source treatment approaches. NEW Water, the brand of the Green Bay Metropolitan Sewerage District's (GBMSD) venture into watershed collaboration for TMDL compliance, started with a pilot project. NEW Water and Jacobs have been leading stakeholders within local watersheds to pilot test adaptive management for TMDL compliance for GBMSD's wastewater treatment facilities. The success of these efforts has led many Wisconsin utilities to formally include adaptive management for meeting nutrient limits stipulated in their WPDES Permits. The presentation will discuss the following aspects of a successful Adaptive Management program: baseline watershed characterization, enhanced nutrient management approaches to reduce watershed phosphorus loads, the decision framework used to evaluate non-point source controls versus removal through treatment plants, the tools developed to plan the work and verify progress, including paperless mobile applications, and water quality improvements observed to date.

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Wetland Delineation: *NYSDEC* vs. *USACE* Regulatory Program

Kevin Bliss, Ph.D., TRC

This talk explores the regulatory definition of freshwater wetlands as applied by both the New York State Department of Environmental Conservation and the US Army Corps of Engineers. Accepted characteristics of wetland hydrology, hydric soils, and hydrophytic vegetation, will be provided, along with an explanation of how these features are determined in the field. The distinctions between these two regulatory agency approaches, and the ramifications of those differences, will be discussed.

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K9 Detective Pilot at Kensico

Allison Dewan and Lori Emery, NYC Department of Envrionmetnal Protection

The Bureau of Water Supply's Research Application Section was formed in late 2017 to lead the Bureau's efforts to understand and apply state-of-the-industry water utility research and methods as it strives to implement best practices and anticipate future challenges. In researching innovative methods for detecting contaminants in the watershed, Research Application staff noted an increasing number of newspaper articles and reports related to training dogs to detect pollution, invasive species and endangered species.

For example, in 2011, a research team from Santa Barbara, California collaborated with Environmental Canine Services (ECS) on a pilot-scale project that was funded and published by the Water Environment Research Foundation. This study demonstrated that canine scent tracking, by canine helpers Sable and Logan, was an effective means for pinpointing the source of raw sewage that had been entering a storm drain in Santa Barbara, California. ECA made the news again in 2015 when their Jack Russell named Crush helped personnel from Clinton County Conservation District in Michigan identify areas with failing septic systems. ECS also worked with Clean Ocean Action in New Jersey to identify several areas in the Navesink River where fecal contamination is a problem. And it's not all dirty work! Working Dogs for Conservation (WDC), an organization based out of Montana, trains dogs that work all around the world on additional concerns such as ecological monitoring, poaching, aquatic and invasive species detection.
After learning that other utilities, including the New Jersey Department of Environmental Protection's Division of Fish and Wildlife, use canines for scent detection, BWS Research Application began exploring options for a pilot

study in the Kensico Watershed. One area of interest was Kensico Site N5-1. Following an extensive water quality investigation in that area during 2016 and 2017, a broken sewer line was located and repaired. Despite that repair, microbial source tracking data continue to show the presence of human waste.

Staff from BWS Research Application, Water Quality and Watershed Protection Programs worked with Environmental Canine Services to carry out a three-day pilot study in June of 2019. Samples were also collected for traditional microbial source tracking analyses for comparison to the canine response. This pilot assisted BWS in determining whether to conduct additional pilots to determine whether canine scent detection should become part of our source tracking toolbox, either through contract or with in-house resources.

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Microbiologically Induced Corrosion in Water Systems

Glenn Edgemon and Scott Davis, HDR, Inc

The term microbiologically induced corrosion (MIC) designates corrosion due to the presence and activities of microorganisms including microalgae, bacteria, and fungi. Corrosion occurs in environments that can support the growth of microorganisms, including environments where corrosion would not be predicted (e.g., low chloride waters) and the rates can be exceptionally high. Problems with MIC have been reported in most every major industry, particularly in systems that contain stagnant water, with reports going back to at least the early 1900s. Essentially all cooling water and process water applications may be susceptible to MIC. Further, biological fouling, which is always a precursor to MIC, can reduce the efficiency of heat exchangers, fluid distribution systems, and other water-based processes. This presentation describes common MIC mechanisms, commercially available test procedures, monitoring tools, and disinfection/treatment options.

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Cybersecurity for Water Sector Critical Infrastructure

David Espy, Jacobs Engineering Group

This course covers the current cyber threats to critical infrastructure Industrial Control Systems (ICS), the need to be security aware, and the current cybersecurity standards and guidelines for ICS in the water sector. The speaker will delve into the specifics of security practice for ICS covering the main security concepts and how to apply them so at the conclusion of the presentation participants should be able to:

- Understand current threats to critical infrastructure ICS systems.
- Understand the human factor in ICS cybersecurity.
- Understand basic cybersecurity concepts for protecting ICS.

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Assessment of Climate Change Impacts on New York City Water Supply System using Operations Support Tool: CCIMP Phase II

Rakesh Gelda,Ph.D., Adao H. Matonse, Jerry Mead and Emmet M. Owens, NYC Department of Environmental Protection

In 2008, New York City (NYC) Department of Environmental Protection (DEP) initiated Climate Change Integrated Modeling Project (CCIMP), with the goals of evaluating the impacts of future climate change on the quantity and quality of NYC's water supply, and as a consequence, how these impacts could influence the operation of reservoirs within the supply system. The CCIMP was designed to be carried out in multiple phases. The first phase of CCIMP completed in 2013, was based on relatively simple methods of generating climate scenarios from 3 global climate models (GCMs) and without any consideration of climate variability. Water quality impact assessment was limited to turbidity in Schoharie Reservoir and eutrophication in Cannonsville Reservoir. In this study, a part of Phase II of CCIMP, we adopt the latest climate projections (CMIP5; Coupled Model Intercomparison Project Phase 5) from 20 GCMs, use rigorous statistical downscaling and temporal disaggregation methods to generate climate scenarios, and use state-of-the-art modeling software system, including DEP's Operations Support Tool (OST) to evaluate climate change impacts.

Compared with the current climate, future (mid-century) annual average air temperature (T) is expected to increase by 2.7 °C, and precipitation by 5%. Significant trends in several climate indices, e.g., number of frost days, snowpack, and extreme rainfall events are also projected. Approximately, 20% reduction in snowfall and 50% reduction in snowpack (March 15) is expected in the watershed. Under these climate conditions, mean annual inflow to the Catskill/Delaware system is expected to

increase by 6%, with greater increases (~ 25%) during December-February and a reduction (~ 10%) during April-June, lessening the overall seasonal variability. Annual average T of Schoharie and Esopus creeks could rise by 1.4 °C with a lesser increase (1 °C) in Shandaken Tunnel T. Although annual average turbidities in Rondout, Schoharie and Esopus creeks are projected to increase by < 1 NTU, extreme levels of turbidities could increase by > 50% and such high turbidity events could be more frequent in the future. The largest increase in diversion turbidity is simulated to occur during August-September at Shandaken Tunnel Portal and Ashokan Release Channel. Overall, the use of alum at Kensico Reservoir may increase from 1.5 days/year for the baseline conditions to 1.8 days/year in the future. No relationship was found between the alum use and change in T or change in precipitation.

Under the projected future climate and current operating rules and assumptions, OST simulations also suggest that the average number of days the NYC water supply system is in drought conditions would remain unchanged. Furthermore, these simulations demonstrate high resiliency, high reliability, and low vulnerability of the water supply system.

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Hydrological and Temperature Variations Between 1900 and 2016 in the Catskill Mountains

Petra Kelly-Voicu and Allan Frei, CUNY Hunter, Department of Geography, Institute for Sustainable Cities

In this study, we identify a set of stations in this region that are appropriate for climatological analysis, and examine variations in precipitation, streamflow, and temperature, between 1900 and 2016. We find that the most significant hydroclimatic events on record include the cold drought of the 1960s which was a year-round phenomenon, and the wet period between the late 1990s and 2012 which was primarily a warm season phenomenon. We also find increasing temperatures since the mid-20th century, in particular daily minimum temperatures, which vary with season and elevation. As a result, diurnal temperature ranges have tended to decrease in this region, particularly during the warm season and at lower elevations. Cyclic behavior is found more in hydrologic than in temperature variables, and more during the cold season where periodicity peaking at 28 years is identified. These results are consistent with previous studies based on station-records as well as paleoclimate studies, and in the context of millennial scale variations suggest that some aspects of these recent fluctuations may be unusual in the climatological history of this region.

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Developing a Regional Curve for Estimating Bank Erosion Rates in the Ashokan Watershed, New York

Matthew Lajoie, Stantec Consulting Services Inc.

Stream bank erosion contributes considerable sediment loads to downstream areas, and turbidity is a major concern for New York City's primary drinking water source in the Ashokan Reservoir. Stantec has partnered with the Ashokan Watershed Stream Management Program to develop a predictive model that will estimate sediment contributions from streams within the Ashokan watershed and the associated reductions that can be expected from restoration and stabilization efforts. Methodologies developed by Dave Rosgen in Colorado, and implemented in the Chesapeake Bay region, have been adapted to develop a preliminary regional curve based on empirical stream monitoring data. Other predictive curves are scarce and have not been developed in the Northeast; therefore, this new model will likely have applications beyond the Ashokan watershed. Such models, once established, are useful tools for planning and prioritization of watershed management strategies and can be applied efficiently where monitoring-based evaluations are extremely time intensive and costly. We will discuss model development methods and considerations, applications for BANCS, and lessons learned during the process.

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Addressing Taste & Odor Complaints

Eldi Lico and Michelle Rissolo, NYC Department of Environmental Protection

The increase in musty taste and odor complaints from Manhattan and the Bronx, areas served by the Croton Filtration Plant, occurred October 5, 2018 through October 15, 2018. The event was caused by seasonal water quality characteristics within our source water reservoir. As the complaints peaked, the Bureau of Water Supply shutdown the Croton Filtration Plant, reconfigured our source water

draft locations, blended water from the Catskill Aqueduct before restarting the Croton Filtration Plant and adjusted treatment. Our ability to monitor consumer complaints, increase monitoring within the system, and blend water from different sources allowed our treatment operations team to successfully manage the issue and mitigate taste and odor concerns. Our operational flexibility was the key to our successful mitigation of the continued complaints.

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Clean Water Through Protection and Partnership

Michael Liu, Carla Glaser, Salome Freud and Steven Schindler, NYC Deparment of Environmental Protection

In order to make the Lead and Copper Rule (LCR) more effective at protecting public health and ensure effective implementation by regulators, the EPA is considering Long Term Revisions (LTR) to the rule. Utilities will be impacted as they may be required to:Make improvements to corrosion control treatment by re-optimizing treatment or possibly establishing minimum doses of orthophosphateMeet a new health based benchmark or a decreased Action Level Enhance sampling protocols by changing the type or number of samples, timing or location for samplingDevelop proactive Lead Service Line (LSL) replacement programs.

New York City Department of Environmental Protection (NYC DEP) has taken a proactive approach and has commenced a number of studies to further optimize corrosion control, better understand lead exposure, and help prepare for the LTR LCR as summarized in sections below.

Initiative 1: Piloting an increased orthophosphate dose

In an effort to further optimize corrosion control treatment, DEP will pilot an increased orthophosphate dose in an isolated area of the distribution system. DEP currently adds orthophosphate (PO4) at an operational maintenance dose of 2 ppm, and adjusts pH using sodium hydroxide to control the corrosion of lead from plumbing into drinking water. Doses of 3 to 4 ppm PO4 will be piloted in City Island, Bronx, beginning in July 2019. City Island was selected as the pilot location as it is very small – less than 0.5 square miles – and its drinking water supply is fed by two trunk mains, both of which run through an existing, but inactive, chlorine booster station designed to feed the island. The chlorine booster station was retrofitted to be a phosphoric acid booster station for this pilot project. The effect of the increased dose will be studied by collecting profile samples from private homes with different types of service lines, and from two (2) pipe loops which were installed on the island for this study. Study results will inform DEP whether corrosion control treatment needs to be adjusted for re-optimization, and allow DEP to assess the feasibility of meeting a lower lead Action Level.

Initiative 2: Scale analysis of lead service lines

DEP has been extracting lead service lines from different areas of the distribution system, and performing lead scale analysis via x-ray diffraction (XRD) and Scanning Electron Microscopy (SEM) to identify the lead corrosion products that have formed over time. The goal is to understand the solubility of lead and the potential for its release in different areas of the distribution system. This information will help us gain confidence in our corrosion control treatment, and could be used to set priorities for LSL replacements.

Initiative 3: Profile sampling of homes

To better understand the effectiveness of NYCs corrosion control program in preventing premise plumbing lead from entering the drinking water, and to evaluate the time of highest lead exposure, DEP has been conducting, and continues to conduct, profile lead sampling at numerous homes. Results indicate that first draw samples collected at-the-tap do not always capture the worst case scenario or the highest exposure, as lead levels often peak after the first draw sample. Results also showed that lead concentrations observed at-the-tap fluctuate constantly depending on water use, stagnation time, water flow rate, and random particulate release from lead sources. This knowledge is important for DEP as it can be used to educate the public and to update sampling protocols upon the implementation of the LCR LTR.

Initiative 4: Analysis of post construction activities on effect of lead

DEP manages a Free Residential (FR) lead test kit program for NYC residents. Through this program, customers can request free lead testing for their water. On average, DEP receives about 10,000 requests per year generating a large amount of data which is mined constantly for different insights. In 2016, DEP added a question to the lead kit request form asking customers to indicate whether there has been any recent construction at or near their home that may have disturbed their service line. At the same time water shut-off notices provided to residents as part of water main replacement projects were revised to provide information regarding lead exposure and the availability of free lead testing. A subset of data was extracted and analyzed to study the effect construction activities may have in disturbing LSLs, on increasing lead levels and raising the exposure risk.

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Retrofitting Long-Term Reference Wetland Monitoring with Current Condition Assessment Methodologies in the New York City Water Watershed

Laurie Machung, NYC Department of Environmental Protection

The New York City Department of Environmental Protection's (DEP) Wetlands Protection Program incorporates wetland mapping and assessment to inform watershed management. To this end, DEP has been monitoring 18 reference wetlands throughout the New York City Watershed for over 15 years. These data have provided a benchmark for wetland creation and restoration and for future change analyses. The New York State Natural Heritage Program (NYNHP) has recently developed tools for a statewide wetland condition assessment that may also benefit implementation of DEP's Wetlands Program. NYNHP's protocol includes landscape, buffer, and plot level metrics for assessing wetland condition. DEP is exploring the feasibility of integrating these protocols into its wetland monitoring and management program. DEP calculated NYNHP landscape level metrics for its reference wetlands, and found landscape scores to vary among drainage basins within the water supply watershed. DEP also calculated NYNHP site level metrics such as Floristic Quality Assessment Indices and mean coefficients of conservatism, and explored the influence of different sampling strategies on metric values. This study will enable DEP to determine the feasibility of retrofitting previously collected data to current NYNHP methodology and to adapt its monitoring protocols to achieve standardization and comparability with statewide wetland assessment methodology.

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Chloride Trends in West of Hudson Streams

Jim Mayfield and Richard Van Dreason, NYC Department of Environmental Protection

Increasing trends in chloride concentrations in water bodies in the northeastern United States have been well documented by numerous studies. Recent studies (*e.g.* Smith et al 2018, Swinton et al 2015, Godwin et al 2003) show that this trend has also been observed in New York State. Elevated chloride concentrations may have a deleterious effect on aquatic ecosystems and may also mobilize metals in the environment and increase corrosion rates of vehicles and infrastructure, and even lead to corrosion of water distribution pipes. While roads salts are generally the largest source of chloride to water bodies, other contributors may include wastewater treatment plants, septic systems, agricultural practices, water softeners, and dust suppressants for unpaved roads. In addition to chloride, these sources may also cause increases in sodium, calcium, potassium, and magnesium, depending on the chemical compounds being used. In this presentation trends in chloride concentrations in the NYC Water Supply West of Hudson streams will be examined. Other related analytes will also be evaluated for trends. Both traditional trend analysis techniques, i.e. non-parametric Seasonal Kendall Test, and a more recent method, Weighted Regressions on Time, Discharge, and Season (WRTDS) will be used in this effort. Potential causes for observed increase will be discussed. In addition to trends, comparisons of results among watersheds of varying land use will be made. While the chloride concentrations in the West of Hudson steams are generally well below the New York State ambient water quality standard of 250 mg/L of chloride for A and AA class waters, it is still important to monitor chloride concentrations and try to minimize the potential impacts of elevated chloride through reductions in salt usage.

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From Watershed to Reservoir Effluent: Data Exploration to Gain Insights on Disinfection By-Product Precursors

Karen Moore, Ph.D., Chrisitian Tiani, NYC Department of Environmental Protection and Alfred Theodore NK Kpodonu City University of New York

Disinfection by-products (DBPs) form in drinking water when organic matter originating from watershed and reservoir sources is chlorinated. Although only a fraction of the organic matter pool forms DBPs, New York City is taking a proactive approach to monitor DBP precursors in the headwaters of its supply system to inform water management. Using a variety of methods drawing from traditional statistics and innovative methods in data analytics, we explore field and laboratory data from an ongoing study of Cannonsville and Neversink Reservoirs and their associated watersheds. The Cannonsville watershed has the most agricultural land in the NYC water supply system, while Neversink is forest-dominated, providing a contrast in DBP precursors and system behavior. We explore relevant data, including results from fixed-frequency sampling at reservoir and stream sites, storm event sampling at stream sites, and high frequency monitoring at reservoir buoys and stream stations using

optical sensors. Analytes include temperature, conductivity, turbidity, chlorophyll and phycocyanin fluorescence, fluorescent dissolved organic matter (fDOM), absorbance at 254 nm (UV254), dissolved organic carbon (DOC), and DBP formation potential. DBP formation potential gives an indication of a worst-case scenario for DBP sources, but is costly and time-consuming to measure. We explore relationships for surrogate indicators of DBP formation potential with the ultimate goal of developing a predictive model to assist in making operational decisions to minimize the presence of DBP precursors in water conveyed to the drinking water distribution system.

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Shoreline Stabilization for MS4 Chesapeake Bay TMDL Compliance

Glenn Muckley, Stantec Consulting Services Inc.

Stream restoration using Natural Channel Design (NCD) principles has become a useful watershed-based tool in improving water quality, particularly with regard to pollutant reductions in order to satisfy an established Total Maximum Daily Load (TMDL). However, a significant amount of sediment and nutrients enter receiving waters directly from other mass wasting sites and eroding shorelines. Control of these sources has been historically underutilized in many locales. The potential environmental benefits from living shoreline solutions can be immense – prevention of habitat loss, new habitat creation, water quality improvement, and pollutant load reductions. Even further, the landowner / stakeholder solutions can be felt even more tangibly through the prevention of property loss and the protection of critical infrastructure.

In 2013, an Expert Panel was formed by the Urban Stormwater Workgroup to review shoreline best management practices (BMPs) and recommend pollutant load reductions for the practices. We will review aspects of the Recommendations of the Expert Panel to Define Removal Rates for Shoreline Management Projects (amended June 2017) and the advantages of using shoreline stabilization BMPs for Municipal Separate Storm Sewer System (MS4) Chesapeake Bay TMDL compliance.

We will also discuss a GIS-based approach for screening shoreline stabilization BMP opportunities on a large scale and the optimization approach used to target areas of greatest potential for sediment and nutrient reduction. We will share lessons learned from early desktop screenings, as well as design considerations to optimize practices for MS4 crediting purposes, which may be applicable to New York watershed improvement initiatives, project evaluations, and quantification of benefits.

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Water Quality Responses to Future Climate in a Water Supply Watershed

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Excessive loading of nutrients, and resulting eutrophication of waterbodies is a global water quality problem. Water quality impacts include harmful algal blooms, cyanobacterial toxins, formation of precursors of disinfection byproducts, and taste and odor problems in drinking water. Land management practices along with climate change and climate variability can influence nutrient loading into waterbodies. The New York City Department of Environmental protection (NYC DEP) is investigating the potential impacts of climate change on the quantity and quality of drinking water in the NYC water supply system that serves over 9 million consumers. The current study is a follow-up to our recent work where we developed future climate scenarios for the study region, developed and tested a modified version of the SWAT hydrological and water quality model (SWAT-HS), and investigated the impact of climate change on streamflow and stream turbidity. The focus of this study is on the impact of climate change and the resulting changes in the seasonal pattern of runoff on nutrient loading in the Cannonsville watershed. While there is evidence that management practices have reduced nutrient loading in the Cannonsville watershed, the impact of climate change and the resulting changes in streamflow on nutrient loading is not clear. We assume stationary land use and management practices to assess the change in nutrient loading from baseline (2001-2010) to middle of the century (2051-2060) period due to a change in climate. Preliminary results from SWAT-HS simulations indicate that loading of dissolved forms of nutrients (N and P) will decrease or will have no change under future climate whereas particulate forms of nutrients and sediment loading will increase due to an increase in the frequency of large storm events.

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Correlation of Stream and Reservoir Giardia Concentrations with Precipitation Based on Corresponding Monthly, Seasonal, or Annual Time Scales

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Precipitation events are known to mobilize microbial contaminants in watersheds, transporting them from land surfaces into streams and rivers, potentially creating issues for drinking water suppliers. Giardia and Cryptosporidium are two protozoan pathogens of concern for the New York City water supply and are monitored at points throughout the watershed at varying frequencies. Protozoan samples are collected on a fixed frequency basis (ex. weekly, monthly, etc.). While this sampling strategy captures a wide array of conditions over time, it can also create challenges and add to the complexity of analysis, especially when attempting to link results with environmental processes. DEP has 17 years of protozoan data and this affords DEP a very large dataset (over 12,000 samples) which can be used to investigate correlations between environmental conditions and protozoan concentrations. Common summary statistics (mean, median, etc.) for protozoan data from WOH streams and reservoir outflows were assessed for statistical correlation with rainfall amounts during corresponding time periods (weeks, months, seasons, and years). Environmentally appropriate time lags between the variables were also investigated to best represent the field conditions and reservoir residence times, when applicable.

This presentation will review the fundamental methods for data analysis used to compare protozoan concentrations with precipitation, and discuss factors which influence the analysis, including the type of summary statistic, length of time interval, percentage of non-detects, and the type of site. The strongest correlations will be highlighted, along with potential factors which may have helped strengthen the relationship.

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Optimizing Coagulant Dosing Using Machine Learning Methods

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Under current drinking water regulations, minimum percentage removals of total organic carbon (TOC) are required of water treatment facilities in order to mitigate taste and odor issues, formation of disinfection by-products, and microbial growth-supporting substrate. Removal of TOC is accomplished using chemical coagulants, such as aluminum sulfate (Al2(SO4)3) which facilitates agglomeration of TOC into larger “flocs” that can then be physically removed from the water. This coagulation process is a function of water temperature, pH, and type and quantity of TOC. Jar testing has been the industry standard for determining coagulant dose, where plant treatment processes are replicated in a scaled down, laboratory-sized system. However, jar testing results may be subject to potential sampling artifacts due to temperature and pH changes over the course of testing. In addition, the procedure is labor- intensive and thus unable to allow operational coagulant dose changes on timescales less than ~ 1 day. A machine learning modeling approach, relying on historical plant water quality and operations data collected at high frequency over a long time period for the entire range of physico-chemical conditions observed in the plant, may offer possible solutions to the inherent drawbacks of jar testing. We propose using a hybrid approach, consisting of both feed-forward (i.e., raw water quality parameters) and feed-backward (i.e., treated water quality parameters) model inputs, with the goal of using raw water quality and desired treated water quality to optimize coagulant dosing. If successful, benefits may include reduced cost of operation, real-time dose control, and enhanced TOC removal.

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Results From a Comparison/Contrast Study Between Foamstream and Conventional Herbicides: A Study On Efficacy

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NYCDEP has been investigating alternatives to commonly used chemical herbicides for managing herbaceous weeds on City-owned property. FoamstreamRcreated by WeedingTech, Ltd. is one of these alternatives. Foamstream is composed of superheated water surrounded by a proprietary foam product that insulates the water's scalding properties. Foamstream is applied under pressure via a wand directly onto the herbaceous plant, scalding the leafy structure above ground. DEP designed a study to test the efficacy of Foamstream, and its usefulness as a weed management tool, compared to two conventional herbicides: glyphosate (e.g. Roundup) and glufosinate ammonium (Finale). The study was conducted from June 2018 to September 2018, and was initiated with the application of Foamstream and the herbicides at five upstate DEP sites. Results showed that Foamstream eradicated leafy plant tissue immediately due to cell lysis but regrowth was seen at

all sites within one month. Roundup and Finale were slower to act but their efficacy lasted much longer with only minimal growth seen at sites even into the latter part of the study. It was determined that Finale was the best of the three application materials used for both length of time of control and overall species control.

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Batavia Kill Watershed District Dams- Response During Tropical Storm Irene and Post-Storm Repairs to Three HIgh Hazard Dams in the Town of Windham

Kathryn Serra, C.T. Male Associates

Dam failure were activated at their highest threat level- imminent failure- for the three high hazard dams owned by the Batavia Kill Watershed District in the Town of Windham. These dams provide flood control on the Batavia Kill, a major tributary of the Schoharie Reservoir. C.T. Male prepared the EAP's in 2008 and staff was called to assess catastrophic damage of the largest dam in the watershed, Maplecrest Dam, during the storm. This presentation will discuss storm damage to the dams and the Batavia Kill as well as impacts to the NYC Watershed. The presentation will also outline lessons learned from responding to calls from local emergency responders, assessment of severe damage of the dams as a result of the storm, and repairs to the auxiliary spillways at all three high hazard dams.

Outline:

Introduction.Description of Dams. Type of construction, location, size, etc.EAP activation August 28, 2011. Discussion of trip to Windham, road closures, damage, etc. Photos of damage to Maplecrest Dam.Photos of post-storm damage to all three dams.Discussion of damage. How severe? Design of Repairs:LiDAR survey of spillways. Comparison to original design plans.Hydrologic analysis.Modeling of auxiliary spillways. Pass the ½ PMF without erosion to spillways.Stabilization of spillways. Grading of spillways. Ultimate final design. Discussion of construction.

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Legionella spp. Monitoring in New York City's Water Distribution System

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The Legionella spp. Monitoring in New York City's Water Distribution System (LMINDS) is a study aimed at investigating the prevalence and geographic distribution of Legionella spp. in New York City's (NYC's) water distribution system. Legionella, most often Legionella pneumophila serogroup 1, is the causative organism for legionellosis (Legionnaires' disease and Pontiac fever) and has received increased attention as a result of several highly publicized outbreaks of Legionnaires' disease in NYC. In the United States, cases of legionellosis reported annually have increased by approximately 550% since 2000, with 7,458 cases reported in 2017. Legionellosis accounts for 79% of all waterborne disease outbreaks in the United States. Legionella spp. are ubiquitous in aquatic systems, and have been shown to be present in source and distribution waters. The presence of Legionella spp. in NYC's drinking water distribution system has not been systematically investigated. Therefore, the NYC Department of Environmental Protection (DEP) and NYC Department of Health and Mental Hygiene (DOHMH) are in the process of conducting a joint longitudinal study broken down in two phases to investigate the prevalence and distribution of Legionella spp. in NYC source water and the distribution system and develop baseline data.

During Phase 1, twelve monthly sampling events took place at 19 sampling locations between November 2017 and November 2018. A total of 230 water samples were collected from 19 locations representing water from NYC two surface water sources: Catskill-Delaware and Croton watersheds. Samples from different stages of water treatment were tested, including untreated source water, prefinished water, samples from distribution entry points, and from various distribution sites including those with historically low residual chlorine levels and longest residence times. Biofilm samples were collected during the installation of wet tap connections at an additional seven locations. During the ongoing Phase 2 of the study, all of the 281 compliance Revised Total Coliform Rule sampling locations will be sampled at least once between January 2019 and November 2019. Thirty-three physiochemical and metal water parameters (e.g. pH, temperature, residual chlorine, iron, and copper) are measured with each sample collection. Recovered samples are subjected to microbiological analysis to assess the presence of E. coli, coliforms, and heterotrophic bacteria. Legionella detection is conducted using polymerase chain reaction (PCR) and by culture on selective media to detect and enumerate Legionella spp. Presumptive Legionella colonies were then identified using matrix-assisted laser desorption/ionization time of flight mass spectroscopy (MALDI-TOF MS).

During Phase 1, all water samples met applicable (EPA and NYS) water quality guidelines for physiochemical and microbiological parameters, and. Legionella spp. were infrequently detected by culture. Legionella spp. DNA was detected in all (47/47) source and pretreated water samples, but Legionella DNA detection in distribution water and biofilm samples was variable. In total, 87% (206/237) of the water and biofilm samples had detectable Legionella spp. DNA, which is unsurprising given Legionella spp. are ubiquitous in aquatic environments. Despite frequent detection of Legionella DNA throughout the distribution system, only 2.5% (6/237) of samples were culture positive. Legionella bozemanii (50 CFU/100 mL) was recovered in the same source water site on two occasions and Legionella pneumophila (1 - 20 CFU/100 mL) was recovered from the same distribution site on four occasions. This site continues to be sampled during Phase 2. Preliminary results did not indicate a correlation between Legionella pneumophila recovery and physicochemical changes within the distribution system. However, the positive distribution site was in the midst of an ongoing massive new main replacement and street construction project. Although Legionella DNA were detected throughout the distribution system, the lack of recoverable Legionella in samples collected in this study suggest these Legionella are non-viable and that the current disinfection practices are effective in protecting against the presence of Legionella spp. in New York City's water supply.

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Monitoring Disinfection Byproduct Surrogates in the NYC Water Supply

Rich Van Dreason, NYC Department of Environmental Protection

Notable increases in disinfection byproducts (DBPs) occurred in the NYC drinking water distribution system post Tropical storms Irene and Lee in the summer of 2011. As a result, the New York City Department of Environmental Protection (NYCDEP) increased its monitoring of DBP surrogates (dissolved organic carbon (DOC) and UV254) to weekly at all reservoir keypoints (i.e. reservoir connections to tunnels) in January 2012. DBP concentrations are strictly regulated because some studies have indicated that certain DBPs may pose adverse effects to human health. Starting in July 2018, coinciding with frequent rain events, notable increases in distribution system DBPs and source water DBP surrogates were again apparent.

In this presentation, we will discuss the factors involved in the increase as well as operational changes taken to manage DOC concentrations before the water is delivered to the distribution system. Regional, seasonal and temporal patterns of DOC and UV254 in the upstate water supply will also be presented.

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How You Present Your Water Quality Data Can Be As Important As the Water Quality Data Itself

David Van Valkenburg and David Van Valkenburg, NYC Department of Environmental Protection

To protect the drinking water supply of over 9.5 million customers, the New York City Department of Environmental Protection (DEP) monitors analytes for water quality at frequencies that range from once per year to every five minutes at more than 475 upstate sampling locations. This large amount of data can be difficult to convert into actionable information that can assist DEP in providing guidance toward the best water quality for our customers or perform more targeted monitoring. To facilitate the generation of actionable information, understanding the source data is critical and influences how the data has to be interpreted. In addition to understanding the data, the medium by which the information is presented as well as consideration for the intended audience of that information is also important. This presentation will focus upon key water quality analytes, e.g. turbidity, temperature, and other automated in-situ sensor data, by examining various graphical and statistical techniques to express stream, reservoir, or aqueduct results in a clear and understandable fashion. Through this examination, relationships and patterns, not previously considered, can become apparent and lead to new insights for data analysis consideration.

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Predicting Source Water Quality in NYC Reservoirs Using Satellite Observations of Watershed Characteristics

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Despite the strong influence of watershed conditions on source water quality, most water utilities and water resource

agencies do not currently have the capability to monitor watershed sources of contamination with great temporal or spatial detail. Typically, knowledge of source water quality is limited to periodic grab sampling; automated monitoring of a limited number of parameters at a few select locations; and/or monitoring relevant constituents at a treatment plant intake. While important, such observations are often not sufficient to inform proactive watershed or source water management at a monthly or seasonal scale. Satellite remote sensing data on the other hand can provide a snapshot of an entire watershed at regular, sub-monthly intervals, helping analysts characterize watershed conditions and identify trends that could signal changes in source water quality.

As part of a NASA-funded applied research project, the authors are evaluating correlations between satellite observations of watershed characteristics, as described by various vegetation indices and land use products, and surface water quality. Water quality parameters under investigation include nitrogen, phosphorus, organic carbon, chlorophyll-a, and turbidity. Case studies for this project include NYC DEP's Catskill and Delaware System reservoirs as well as 50 lakes across New York State for which in situ water quality data are available. Results demonstrate strong correlations between satellite-based watershed observations and subsequent water quality at lag times of 3, 6, and 12 months, indicating the potential to predict water quality conditions up to a year in advance, depending on the water quality parameter, to help guide watershed management and in situ monitoring efforts.In this paper, we will describe the statistical, mixed effect modeling approach and present results for the Catskill and Delaware reservoirs and State lakes. We will further describe the data acquisition and analytical tools that were developed for this project and discuss potential future stakeholder applications.

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The Tale of Two Storm Strategies on the Same Project

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More often than not, the design and function of storm management features are governed by spatially similar site conditions, e.g., soil characteristics, depth of bedrock and/or groundwater, site grades. Though less common, extreme spatial variation in site conditions warrants a combination of different approaches for managing stormwater. However, few examples and little guidance exists on leveraging various stormwater management strategies for extremely different conditions across the same project site. Here, for vastly different site conditions, we outline two concurrent storm water management strategies for a mixed-use project on 45 acres in Malta, Saratoga County, NY. The site is split by a stream and wetland corridor with one side of the corridor containing Hydrologic Group A soils with relatively deep groundwater and the other side of the corridor containing Hydrologic Group C/D soils with high groundwater. Our approach demonstrates how two different strategies are successfully applied to achieve project and regulatory goals. More specifically, we show how Group A soil conditions were best suited to an approach based on porous asphalt pavement supplemented by underground storm water rechargers, as well as drywells in areas with restrictions on slope and porous pavement. In contrast, for the Group C/D soils with shallow slopes and high groundwater, the best approach involved multiple stormwater management areas to allow treatment close to the source and close to the stream/wetland corridor and water quality treatment in surface sand filters that allow a greater depth of collected runoff as compared to bioretention areas and a thinner soil treatment layer. We anticipate that this approach may be compatible with watershed sites within Saratoga County, NY and may guide future stormwater projects that must adapt to different soil characteristics, groundwater levels, and slope grades–all within the same project site.

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