New York City Department of Environmental Protection

Filtration Avoidance Annual Report

for the period January 1 through December 31, 2018

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Cover Photo by DEP Photographer Kristen Rendler
Neversink Intake Chamber

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List of Acronyms

APHIS	Animal and Plant Health Inspection Service
ATU	advanced treatment unit
AUV	autonomous underwater vehicle
AWSMP	Ashokan Watershed Stream Management Program
BMP	best management practice
BWS	Bureau of Water Supply
C&D	construction and demolition
CAT/DEL	Catskill/Delaware
CATUEC	Catskill Upper Effluent Chamber
CC	compliance conference
CCD	Croton Consent Decree
CCE	Cornell Cooperative Extension
CCEUC	Cornell Cooperative Extension of Ulster County
CDUV	Catskill/Delaware Ultraviolet Disinfection Facility
CE	conservation easement
CMC	Catskill Mountain Club
CP	Forest Management Plan Conservation Practices
CREP	Conservation Reserve Enhancement Program
CRISP	Catskill Regional Invasive Species Partnership
CRP	Conservation Reserve Program
CSBI	Catskill Streams Buffer Initiative
CT	contact time
CUNY	City University of New York
CWC	Catskill Watershed Corporation
CWMP	Community Wastewater Management Program
DCPD	Delaware County Planning Department
DCSWCD	Delaware County Soil and Water Conservation District
DEIS	Draft Environmental Impact Statement
DEM	Digital Elevation Model
DEP	New York City Department of Environmental Protection
DFIRM	digital flood insurance rate map
DMAP	Deer Management Assistance Permit
DOE	New York City Department of Education
DOHMH	New York City Department of Health and Mental Hygiene
DPR	New York City Department of Parks and Recreation
DSEIS	Draft Supplemental Environmental Impact Statement
DUA	Day Use Area
EAB	emerald ash borer
EAF	Environmental Assessment Form
ECLRS	Electronic Clinical Laboratory Reporting System

ED/RR	Early Detection and Rapid Response Plan
EFC	New York State Environmental Facilities Corporation
EIS	environmental impact statement
ELTP	Enhanced Land Trust Program
EOH	East of Hudson
EOHWC	East of Hudson Watershed Corporation
EWP	Emergency Watershed Protection
FAD	Filtration Avoidance Determination
FDNY	New York City Fire Department
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FHMP	Flood Hazard Mitigation Program
FITT	Forestry Interdisciplinary Technical Team
FMP	New York City Forest Management Plan
GCSWCD	Greene County Soil and Water Conservation District
GI	gastrointestinal illness
GIS	Geographic Information System
GPS	Global Positioning System
GWLF	Generalized Watershed Loading Function
HAA5	haloacetic acid five
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HEFS	Hydrologic Ensemble Forecast Service
HEV	human enteric virus
HHC	New York City Health and Hospitals Corporation
HMGP	Hazard Mitigation Grant Program
HPC	Heterotrophic Plate Count
IAR	inactivation ratio
IRSP	individual residential stormwater permit
ISAC	Invasive Species Advisory Committee
ISC	New York State Invasive Species Council
ISWG	Invasive Species Working Group
JV	Joint Venture
LAP	Land Acquisition Program
LFA	Local Flood Analysis
LFHMIP	Local Flood Hazard Mitigation Implementation Program
LiDAR	Light Detection and Ranging
LIMS	Laboratory Information Management System
MAP	Management Assistance Program
MFO	Master Forest Owner
MCL	Maximum Contaminant Level
MGD	million gallons per day
MMI	Milone & MacBroom, Inc.

MOA	New York City Memorandum of Agreement
MRO	Modification of Reservoir Operations
MSM	Men who have sex with men
MST	Microbial Source Tracking
NAS	National Academies of Science
NASEM	National Academy of Sciences, Engineering and Medicine
NHD	National Hydrography Dataset
NMP	nutrient management plan
NOV	Notice of Violation
NRCS	Natural Resources Conservation Service
NTU	nephelometric turbidity unit
NWI	National Wetlands Inventory
NYC	New York City
NYCFFBO	New York City-Funded Flood Buyout Program
NYNJTC	New York-New Jersey Trail Conference
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
O&M	Operation and maintenance
OIT	Office of Information Technology
OST	Operations Support Tool
PAA	Public Access Area
PCR	polymerase chain reaction
PFM	precision feed management
PRISM	Partnership for Regional Invasive Species Management
RBAP	Riparian Buffer Acquisition Program
RCMP	Riparian Corridor Management Plan
REP	Regulatory and Engineering Programs
RFP	Request for Proposals
RNSP	Rondout/Neversink Stream Program
ROV	remote operated vehicle
RTCR	Revised Total Coliform Rule
RWBT	Rondout-West Branch Tunnel
SAFARI	Shandaken Area Flood Assessment and Remediation Initiative
SAP	Streamside Acquisition Program
SBR	sequential batch reactor
SCSWCD	Sullivan County Soil and Water Conservation District
SDE	Spatial Database Engine
SDEIS	Supplemental Draft Environmental Impact Statement
SEIS	Supplemental Environmental Impact Statement
SEQRA	State Environmental Quality Review Act

SFI	Stream Feature Inventory
SMIP	Stream Management Implementation Program
SMP	Stream Management Program
SPDES	State Pollutant Discharge Elimination System
SSMP	Septic System Management Program
SSTS	subsurface sewage treatment system
SUNY	State University of New York
SWAC	Schoharie Watershed Advisory Committee
SWAT-HS	Soil Water Assessment Tool – Hillslope
SWCD	Soil and Water Conservation District
SWPPP	stormwater pollution prevention plan
SWTR	Surface Water Treatment Rule
TCR	Total Coliform Rule
TFS	Team Foundation Server
THM	trihalomethane
TKN	total kjeldahl nitrogen
TSI	timber stand improvement
TTHM	Total trihalomethane
UCSWCD	Ulster County Soil and Water Conservation District
UFI	Upstate Freshwater Institute
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
WAC	Watershed Agricultural Council
WaLIS	Watershed Lands Information System
WAP	Watershed Agricultural Program
WCDEF	Westchester County Department of Environmental Facilities
WDRAP	Waterborne Disease Risk Assessment Program
WECC	Watershed Enforcement Coordination Committee
WFMP	Watershed Forest Management Plan
WFP	whole farm plan
WOH	West of Hudson
WQSP	Water quality stream projects
WRF	Water Research Foundation
WR&R	New York City Watershed Rules and Regulations
WSP	Water Supply Permit
WSPS	Water and Sewer Permitting System
WWQMP	Watershed Water Quality Monitoring Plan
WWTP	wastewater treatment plant
WWTPCI	Wastewater Treatment Plant Compliance and Inspection

1. Introduction

In 2018, New York City continued to implement a broad array of initiatives as part of the City's source water protection program. Since the first Filtration Avoidance Determination (FAD) was issued in early 1993, the New York City Department of Environmental Protection (DEP) has undertaken programs which are based on one simple premise: It is better to keep water clean at the source than allow it to get contaminated and have to clean it up. The result is that New York City consumers continue to enjoy affordable, high quality water.

The success of the program is the result of a considerable investment by the City of funding and countless staff hours, intended to sustain the pristine quality of the source waters of the Catskill and Delaware watersheds. DEP's programs have become a national and international model. Each year, water and public health professionals come from around the world to study the City's source water protection strategies. A key element of the success of the program has been the development of strong relationships with watershed communities; locally-based organizations; environmental groups; and federal, state, and local government agencies.

The cornerstone of DEP's source water protection program is extensive research by DEP scientists into existing and potential sources of water contamination. As part of DEP's source water monitoring program, tens of thousands of samples are collected annually throughout the watershed. Each year DEP performs hundreds of thousands of laboratory analyses. Based on the information collected through its monitoring and research efforts, DEP has crafted a watershed protection strategy that focuses on implementing initiatives that address current potential pollution sources and prevents the creation of new sources.

DEP's most recent FAD was issued in December 2017 and covers a full 10-year period, including comprehensive program plans through 2027. The latest FAD builds on previous accomplishments and continues many of the programs that have been at the core of the water quality protection effort since the early 1990s. In addition, the City's protection strategy continues to evolve, accounting for its achievements, changing watershed conditions and the latest thinking in water quality science and modeling. These program refinements ensure that DEP proactively addresses current and future threats to water quality.

This annual report covers the period January 1, 2018, through December 31, 2018, and is compiled to satisfy the requirements of the 2017 FAD. Material in this report is organized to parallel the sections of the FAD.

While the report focuses primarily on the efforts of New York City, it is important to recognize that DEP works in partnership with many agencies, organizations, and communities throughout the region to achieve its goals (Figure 1.1 and Figure 1.2). These partnerships are vital to the continued success of the source water protection program and recognize the need to strike a balance between protecting water quality and the fact that the watershed is home to tens of thousands of people. The contributions of many of these groups are acknowledged throughout

this report. The other private, governmental, community, academic, and non-profit entities sharing a role in this complex effort are too numerous to list. However, DEP gratefully acknowledges their ongoing help and support.

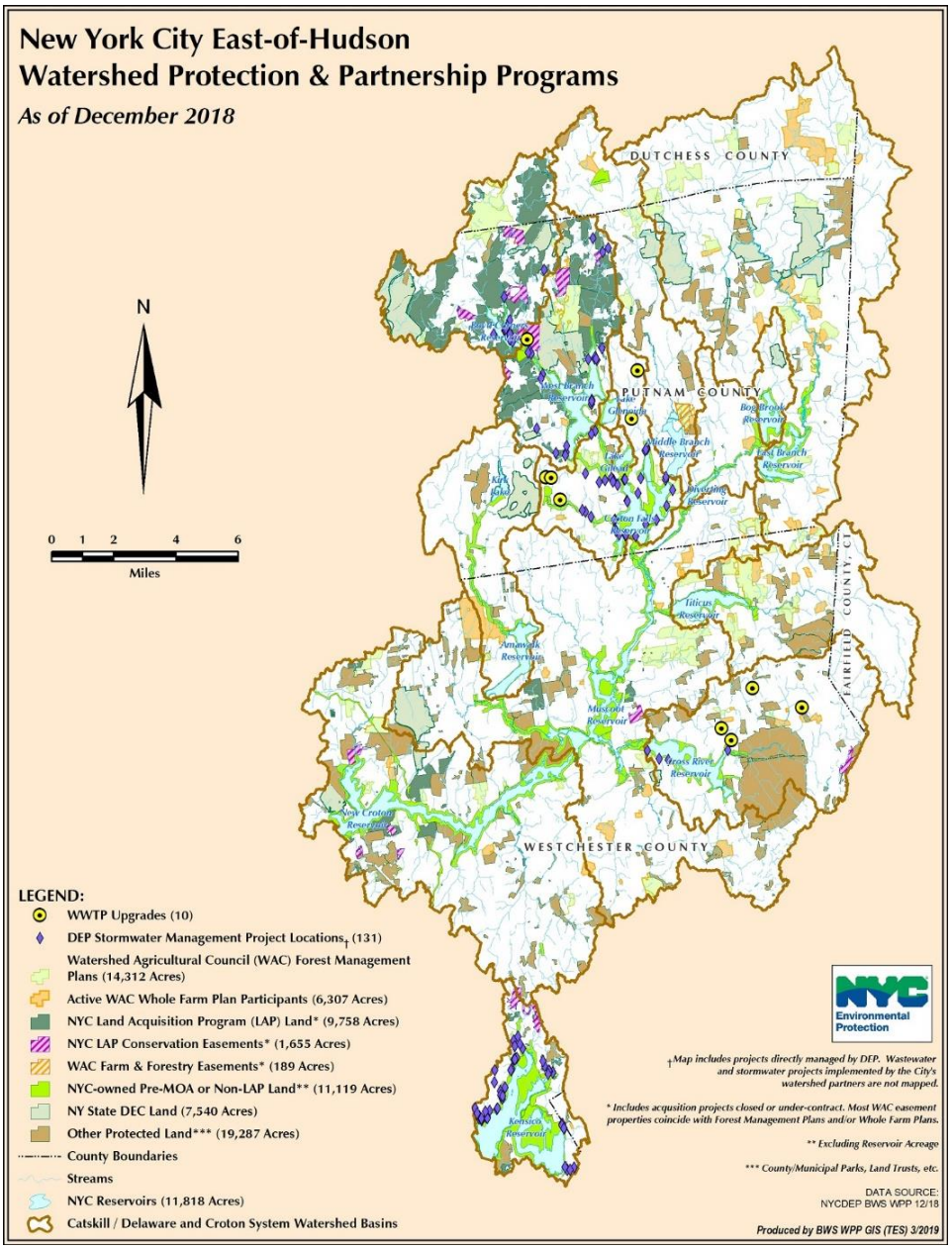


Figure 1.1 New York City East-of-Hudson watershed protection and partnership programs as of December 2018.

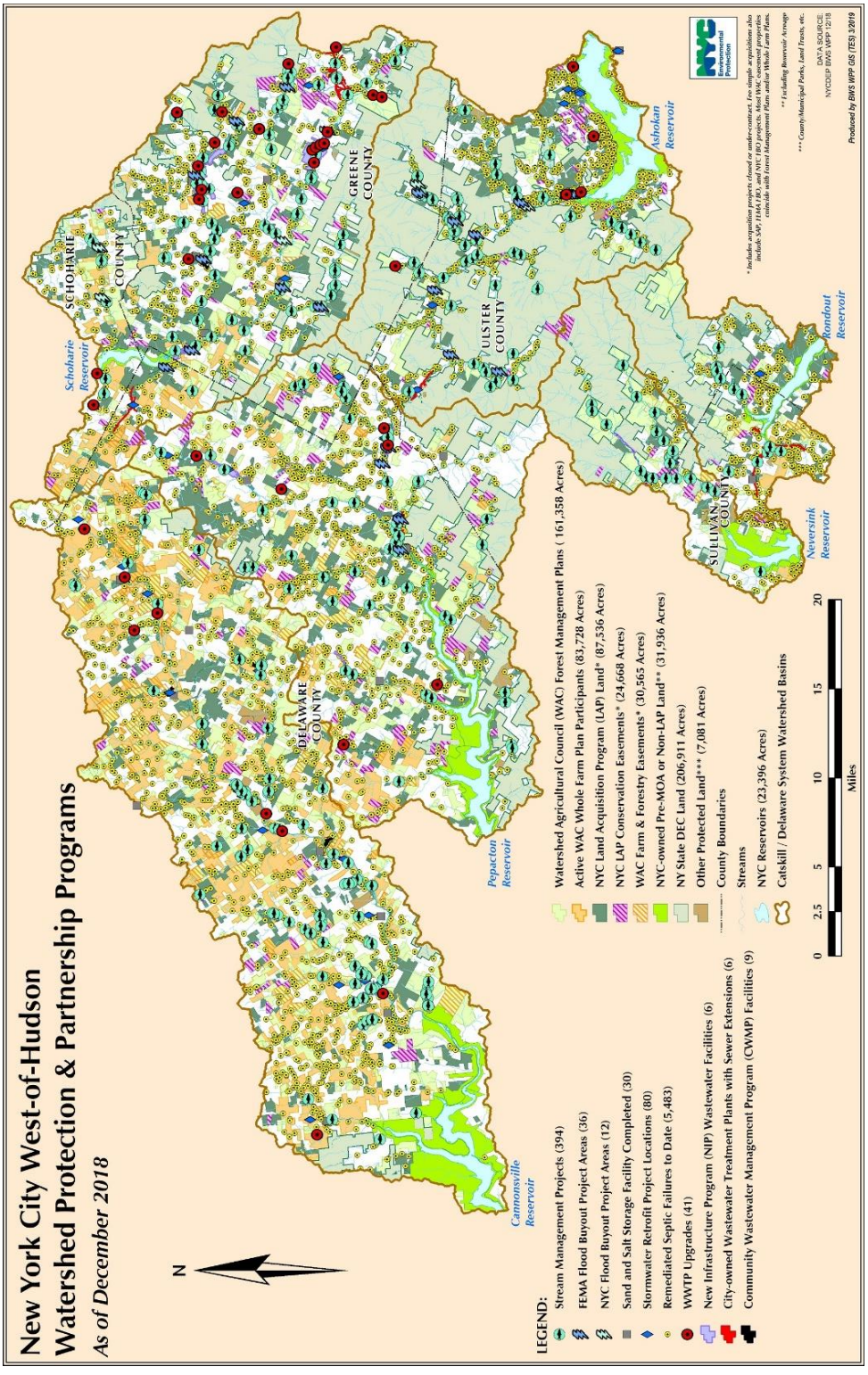


Figure 1.2 New York City West-of-Hudson watershed protection and partnership programs as of December 2018.

2. Federal and State Objective Water Quality Compliance

During 2018, DEP continued its comprehensive water quality monitoring efforts. New York City's sampling program is far more extensive than is required by federal or state law. Each year, the City collects tens of thousands of samples in the watershed and in the distribution system. In 2018, DEP collected 53,265 samples and conducted 654,041 analyses. Of these, 37,549 samples were collected and 414,684 analyses were completed within the City. Once again, the results were notable: The City complied with the objective criteria of the Surface Water Treatment Rule (SWTR) (USEPA 1989).

On the tenth of every month, DEP provides both the U.S. Environmental Protection Agency (USEPA) and the New York State Department of Health (NYSDOH) with the results of its extensive monitoring program via the monthly Water Quality Report, which is issued in compliance with the requirements of the SWTR and other federal regulations in effect since 1991. The City, as an unfiltered surface drinking water supplier, must meet the SWTR specified objective criteria and demonstrate this in the monthly Water Quality Report. The information provided below summarizes compliance monitoring conducted during 2018.

2.1 Surface Water Treatment Rule Monitoring and Reporting

SWTR monitoring includes raw water monitoring for fecal coliform concentrations, turbidity, and disinfection/contact time (CT) values; entry point monitoring for chlorine residuals; distribution system monitoring for chlorine residuals and coliform bacteria levels; and quarterly monitoring in the distribution system for trihalomethanes and haloacetic acids. In 2018, all monitoring samples complied with thresholds defined by the SWTR.

2.1.1 Raw Water Fecal Coliform Concentrations (40 CFR Section 141.71 (a)(1))

In 2018, the Catskill Aqueduct south of Kensico Reservoir was offline. Therefore, no Catskill Aqueduct effluent fecal coliform samples were collected for the year. The Delaware Aqueduct effluent from Kensico Reservoir exhibited fecal coliform concentrations in water prior to disinfection at levels less than or equal to 20 fecal coliforms $100ml^{-1}$ in at least 90% of the samples collected during the year, as calculated by six-month running percentages. In fact, the running percentage of samples for the Catskill/Delaware System never fell below 97.81.

As shown in Figure 2.1, in 2018 the highest six-month running percentage of positive raw water fecal coliform samples at the Delaware Aqueduct effluent from Kensico Reservoir was 2.2%, well below the maximum percentage of positive samples allowed under the SWTR.

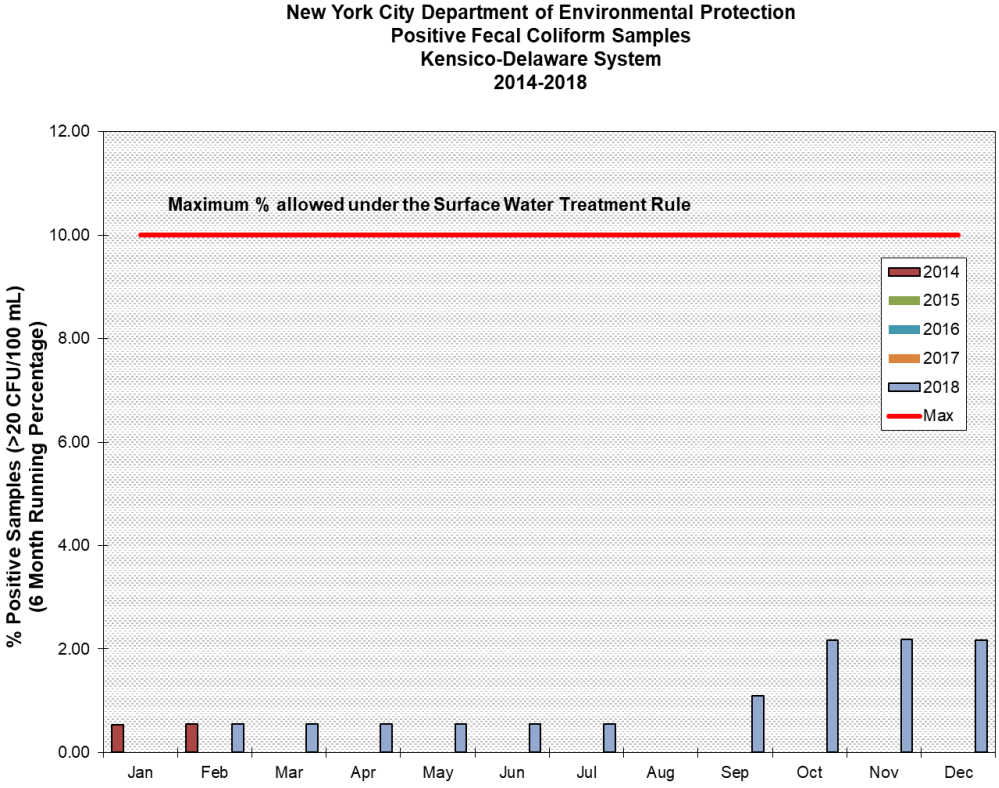


Figure 2.1 Positive fecal coliform samples, Kensico-Delaware System, 2014-2018.

2.1.2 Raw Water Turbidity (40 CFR Section 141.71(a)(2))

The Delaware Aqueduct effluent from Kensico Reservoir exhibited turbidity levels less than or equal to 5 NTU in water prior to disinfection for the entire 2018 calendar year (Figure 2.2). No samples were collected from the Catskill Aqueduct in 2018 because the Catskill Aqueduct south of Kensico Reservoir was offline.

2.1.3 Raw Water Disinfection/CT Values (40 CFR Sections 141.71(b)(1)(i) and141.72(a)(1))

CT values recorded each day during the year for the Catskill and Delaware systems produced net inactivation ratios (IAR) greater than or equal to 1.0. The first segment of the Catskill Aqueduct was offline from Kensico to Eastview, so the net IAR was measured using the IAR from the first segment of the Delaware Aqueduct from Kensico to Shaft 19 at the Catskill/Delaware UV Treatment Plant (CDUV), and adding the IARs from the CDUV to Hillview on each aqueduct (second segments). The actual lowest net IAR in 2018 was 1.9 for the Catskill Aqueduct and 2.0 for the Delaware Aqueduct.

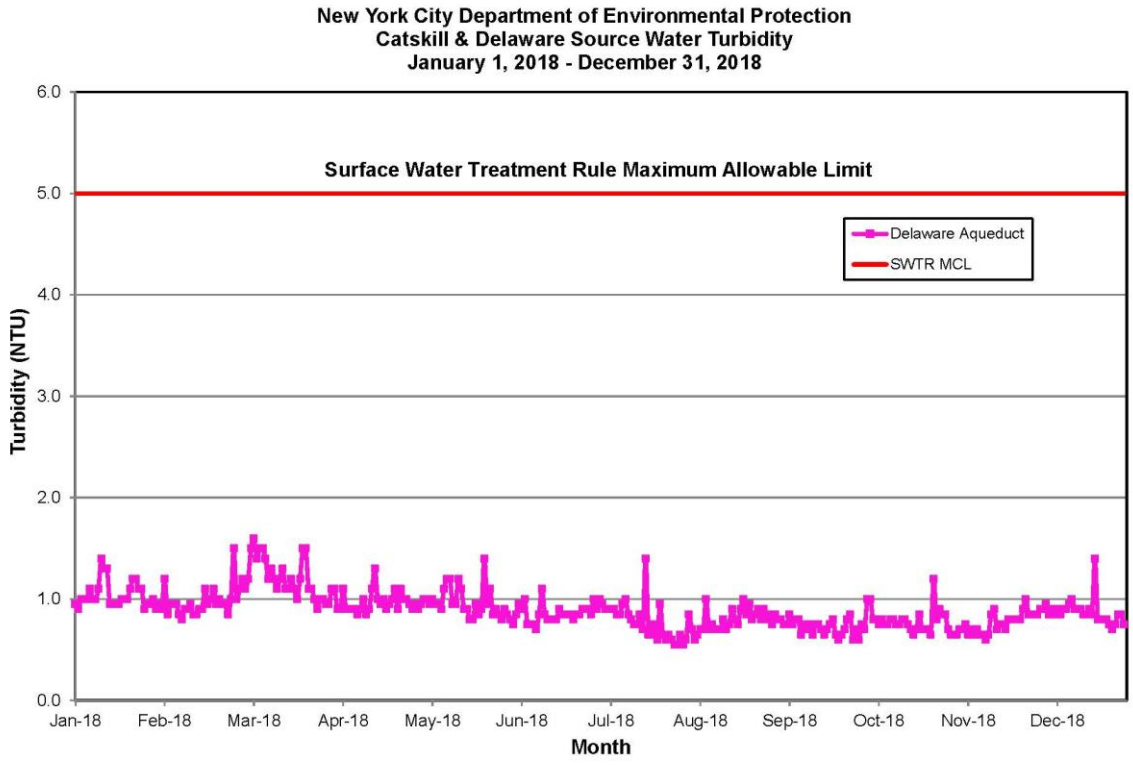


Figure 2.2 Delaware source water turbidity, January 1, 2018-December 31, 2018.

2.1.4 Entry Point Chlorine Residual (40 CFR Sections 141.71(b)(1)(iii) and 141.72(a)(3))

As required, continuous monitoring for free chlorine residual was maintained at the distribution entry points throughout 2018; chlorine residuals were maintained at or above 0.20 mg L^{-1} at all distribution entry points during the year. The lowest chlorine residual measured at an entry point was 0.27 mg L^{-1}.

2.1.5 Distribution System Disinfection Residuals (40 CFR Sections 141.71(b)(1)(iv) and 141.72(a)(4))

Of the 16,026 samples measured for residual chlorine within the distribution system during 2018, all were greater than or equal to 0.01 mg/L, except for seven samples that equaled 0.00 mg/L.

2.1.6 Trihalomethane Monitoring (40 CFR Section 141.71(b)(6)) and HAA5 Monitoring (40 CFR Section 141.171)

The analysis for trihalomethanes in 2018, performed on a quarterly basis, resulted in a maximum total trihalomethane (TTHM) value of 60 µg L^{-1}. The analysis for haloacetic acids, also performed on a quarterly basis, resulted in a maximum haloacetic acid five (HAA5) value of 66 µg L^{-1}.

The highest TTHM quarterly running annual average during 2018, recorded during the fourth quarter, was 38 µg L^{-1}, a level below the regulated level of 80 µg L^{-1}. The highest HAA5 quarterly running annual average, recorded during the fourth quarter, was 43 µg L^{-1}, a level below the regulated level of 60 µg L^{-1}.

2.2 Total Coliform Monitoring

2.2.1 Monthly Coliform Monitoring (40 CFR Section 141.71(b)(5))

Within the distribution system, coliform monitoring indicated monthly levels of total coliforms below 0.7% for all 12 months of 2018 (Figure 2.3). The number of compliance samples analyzed for total coliforms was 9,754, of which 25 were total coliform positive, and one was *E. coli* positive for 2018. The annual percentage of compliance samples that were total

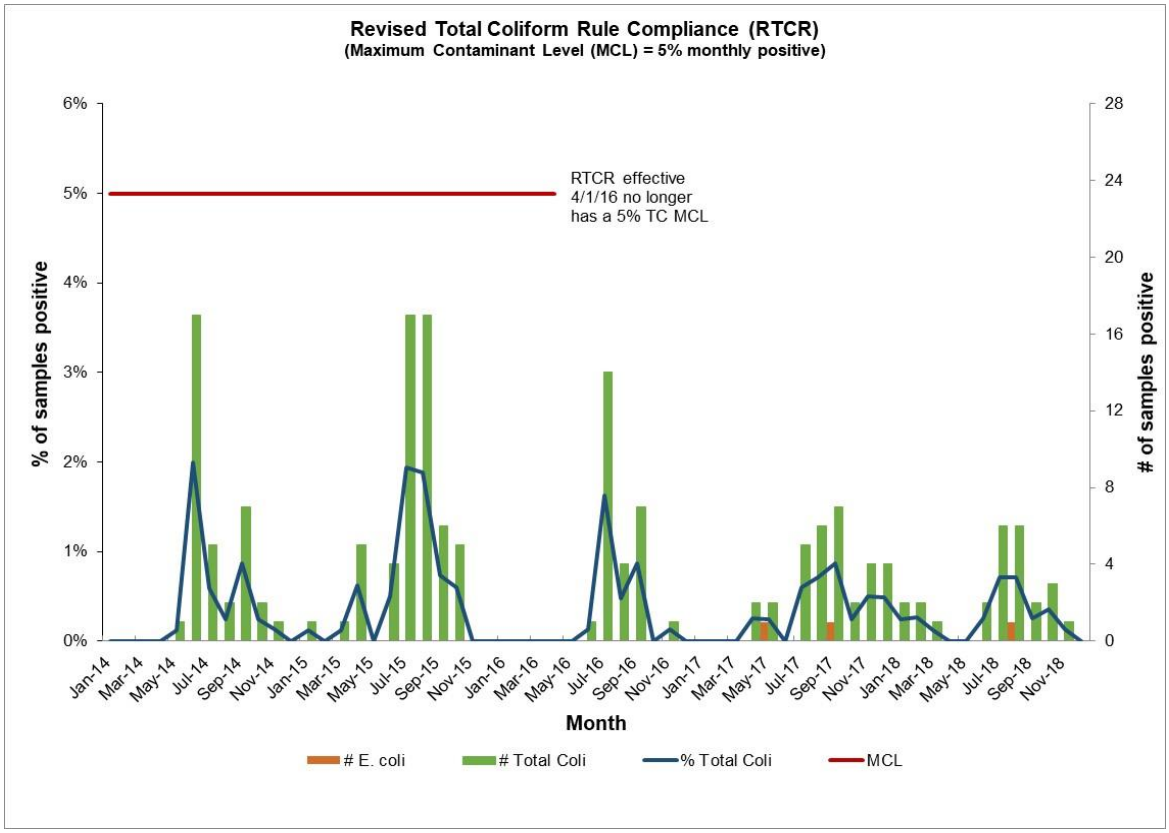


Figure 2.3 Positive total coliform samples, NYC distribution system, 2014-2018.

coliform positive was 0.3%. Since 1995, DEP has collected 248,969 coliform compliance samples, and only 17 of them have tested positive for *E. coli*.

In 2018, heterotrophic plate counts (HPC) were all ≤500 CFU mL^{-1}, equivalent to a measurable free chlorine residual. Zero percent of the samples had an undetectable free chlorine residual or HPC >500 CFU mL^{-1}. This meets the requirements that a free chlorine residual be maintained at representative points in the distribution system, and that no more than 5% of the free chlorine residual samples be undetectable in any two months.

2.2.2 Chlorine Residual Maintenance in the Distribution System

During 2018, DEP continued a number of programs to ensure adequate levels of chlorine throughout the distribution system, including maintaining chlorination levels at the distribution system's entry points, conducting spot flushing when necessary, and providing local chlorination booster stations at remote locations. Two permanent chlorination booster stations were operated during 2018 to improve the chlorine residual levels for the Fort Tilden, Roxbury, and Breezy Point areas (Rockaway Peninsula) in Queens; and for Staten Island. As a result of these steps, detectable chlorine residuals were maintained throughout the distribution system in 2018.

3. Environmental Infrastructure

3.1 Septic Programs

3.1.1 Septic Rehabilitation and Replacement Program

Since 1997, DEP has committed over $100 million to rehabilitate, replace, and upgrade over 5,500 septic systems serving single- or two-family homes in the West of Hudson (WOH) watershed. The Septic System Rehabilitation and Replacement Program is managed by the Catskill Watershed Corporation (CWC). CWC in 2018 completed 197 projects in the following sub-programs: Priority Area Program (191 systems completed), Hardship Program (one system completed), and Reimbursement Program (five systems completed). Program eligibility under the Priority Area Program was expanded to include the entire WOH watershed in 2018.

3.1.2 Septic Maintenance Program

The Septic Maintenance Program is intended to reduce septic system failures through the subsidizing of regular pump-outs and maintenance. In 2018, the program subsidized 308 septic tank pump-outs. The program has funded 2,283 septic tank pump-outs since its inception.

3.1.3 Other Septic Programs

The Small Business Septic System Rehabilitation and Replacement Program funds the repair or replacement of failed septic systems serving eligible small business owners in the WOH watershed. In 2018, CWC expanded program eligibility to include the entire WOH watershed and reimbursed one business owner for a septic repair or replacement. CWC has funded the repair or replacement of 20 failing septic systems for small business owners to date.

The Cluster Septic System Program pays for the planning, design, and construction of cluster systems in 13 WOH watershed communities. CWC contacts communities about their eligibility for the program when failures are identified. No communities opted to participate in this program during 2018. DEP has committed to provide operation and maintenance (O&M) funds in case cluster systems are built. Funding will be included in the forthcoming septic agreement with CWC.

In May 2018, DEP provided CWC with suggested modifications to the Cluster System Program Rules that mirrored language in the 2017 FAD about potential program modifications. CWC prefers to wait until the parties finalize the successor septic contract (Septic V) and amend the governing septic contract (Septic III) before proposing changes to the Cluster System Program Rules.

3.2 Community Wastewater Management Program

The Community Wastewater Management Program (CWMP) provides funding for the design and construction of community wastewater management solutions. To date, the CWMP

has completed projects in Bovina, DeLancey, Bloomville, Hamden, Boiceville, Ashland, Trout Creek, Lexington, and South Kortright.

The five remaining CWMP projects include Shandaken, West Conesville, Claryville, Halcottsville, and New Kingston. Draft preliminary engineering reports for each of these communities have all been completed. Project highlights for 2018 are below.

- Shandaken – DEP approved a block grant of $6.77 million in May 2017 for a septic maintenance district. The project remains in the design phase for the initial round of septic system remediations. In December 2018, the Shandaken Town Board passed resolutions to move forward with public hearings to establish the sewer district and sewer use law.
- West Conesville – DEP approved a block grant of $8.41 million in July 2017 for a community septic system. In 2018, the Town of Conesville worked toward adopting a Sewer Use Law, creating the sewer district, acquiring the necessary land and easements, and completing design. The preconstruction phase is anticipated to be completed in spring 2019.
- Claryville – DEP approved a block grant of $8.65 million in April 2017 for septic maintenance districts in the towns of Denning and Neversink. Denning created the district and adopted a sewer use law. Neversink anticipates creating the district in early 2019. Pump-outs and inspections of individual septic system within Neversink's hamlet of Claryville were completed in 2018. Designs for the initial round of septic system remediations were submitted to DEP in 2018. Construction is anticipated to commence in spring 2019.
- Halcottsville – DEP approved a block grant of $8.95 million in September 2017 for pump stations, a sewer collection system, and a force main connection to the City-owned Margaretville WWTP. The preconstruction phase is anticipated to be completed in August 2019.
- New Kingston – DEP approved a block grant of $5.2 million in November 2018 for a community septic system with 28 connections. CWC and the town are working to secure a site for the community septic system.
- Shokan – In 2018, DEP negotiated the terms of contract with CWC for this project. The contract is expected to be registered in early 2019. CWC and the Town of Olive entered into a program participation agreement and the town in August 2018 passed a resolution to proceed with the project's study phase.

3.3 Sewer Extension Program

The Sewer Extension Program funded the design and construction of wastewater sewer extensions connected to City-owned wastewater treatment plants (WWTPs) in the WOH

watershed. This program concluded prior to the 2017 FAD with the completion of all the sewer extensions. As a result, DEP no longer intends to report on this program in future annual reports unless directed otherwise.

3.4 Stormwater Programs

3.4.1 Stormwater Cost-Sharing Programs

DEP pays for incremental costs associated with stormwater measures incurred as a result of the New York City Watershed Rules and Regulations (WR&R) to the extent they exceed the costs of complying with state and federal requirements. Funding can cover the design, construction, and maintenance of stormwater pollution prevention plans and individual residential stormwater plans for new construction after May 1, 1997, through two separate programs: the WOH Future Stormwater Controls Program administered by the CWC and the Future Stormwater Controls Paid for by the City Program. Funding for eligible projects can be paid completely from the WOH Future Stormwater Controls Program (municipalities and large businesses) or completely from the Future Stormwater Controls paid for by the City Program (low-income housing projects and single-family home owners), or it can come 50% from each program (small businesses). In 2018, DEP entered into a contract with CWC to administer the Future Stormwater Controls Paid for by the City Program on behalf of DEP. This will allow CWC to begin making all future stormwater payments to new applicants starting in 2019.

DEP provided $31.7 million to the CWC to administer the WOH Future Stormwater Controls Program. From this allotment, CWC has reimbursed approximately $7 million to program applicants and transferred over $17 million to other eligible watershed protection programs. The fund balance was approximately $13.8 million at the end of 2018. Table 3.1 summarizes projects approved for funding under both programs in 2018.

Table 3.1 Future stormwater controls projects in WOH approved for funding in 2018.

Applicant	Project	CWC Funding	Percent Funding CWC/DEP
Full Moon Resort	Additional funds for stormwater measures associated with pavilion	$36,478.78	50% CWC
Benjamin Dates	Design costs for SWPPP for residence	$12,500.00	100% CWC
Full Moon Resort	Additional funds – swale, gutters	$12,147.50	50% CWC
Prattsville Medical Clinic	Additional funds – soil erosion controls	$16,009.86	50% CWC

Applicant	Project	CWC Funding	Percent Funding CWC/DEP
Putt Putt VanWinkle	Design costs for SWPPP for mini-golf course	$16,145.00	100% CWC
Bear Pen Mountain Sports	Design costs for SWPPP for tubing facility	$6,600.22	50% CWC
Fromm Realty	Design costs for SWPPP – fifteen lot subdivision	$23,440.00	50% CWC
Full Nelson, LLC	Design costs for SWPPP for gas station	$15,500.00	50% CWC
Scribner's Catskill Lodge	Design and implementation of stormwater controls associated with garbage shed	$2,760.00	50% CWC
Windham Manor, LLC	Design of stormwater controls for sports facility	$5,500.00	50% CWC
Scribner's Catskill Lodge	Additional funds	$106.88	50% CWC
Hunter Ski Bowl	Design/implementation of stormwater controls for trails, parking lot, ski lift	$790,563.00	100% CWC
O'Connor Hospital	Additional funds for implementation of stormwater controls	$97,660.05	100% CWC
Greene County Bike Path	Design costs for variance	$20,227.00	100% CWC
South Kortright Central School	Design costs for stormwater controls associated with impervious surfaces	$34,618.10	100% CWC
John Shlonsky	Design/implementation of stormwater controls for new house	$275,582.50	100% CWC

Applicant	Project	CWC Funding	Percent Funding CWC/DEP
Masserson Holdings, LLC	Additional funds – implementation of stormwater controls	$40,910.20	50% CWC
Full Nelson, LLC	Implementation of stormwater controls associated with gas station	$219,204.00	50% CWC
Lisa Zocchia Waage	Implementation of stormwater controls for residence	$12,592.50	100% CWC
Windham Manor, LLC	Implementation of stormwater controls for new barn, parking lot	$42,000.00	50% CWC
Full Moon Resort	Additional funds – additional design work associated with pond – outflow, overflow	$44,330.20	50% CWC

3.4.2 Stormwater Retrofit Program

DEP and CWC jointly administer the Stormwater Retrofit Program, which includes a construction grants component, a maintenance component, and a planning and assessment component. The program funds the design, permitting, construction, and maintenance of best management practices to address existing stormwater retrofit runoff in concentrated areas of impervious surfaces.

Through 2018, 91 stormwater retrofit projects have been completed, including 75 capital projects and 16 planning and assessment projects. These numbers reflect an updated accounting of the projects completed through the program and a correction of program numbers following a review conducted by CWC and DEP.

Presently, there are five open construction projects and three open planning and assessment projects. Capital projects completed in 2018 are presented in Table 3.2 and summaries of open projects are presented below in Table 3.3 and Table 3.4.

Table 3.2 Stormwater retrofit capital projects completed in 2018.

Applicant	Project description	Approval	Project cost
Delaware County	VAC truck	12/2016; 3/2017	$446,755.00
South Kortright Central School	Stormwater collection, conveyance, and treatment structures	6/2016; 4/2017; 6/2017	$731,744.01
Village of Delhi	Street Sweeper	11/2017	$220,174.00

Table 3.3 Status of stormwater retrofit construction projects still open in 2018.

Applicant	Project description	Approval	Status
Town of Shandaken	Hamlet of Pine Hill stormwater collection, conveyance, and treatment	2/2010	Design
The Onteora Club	Onteora Club stormwater collection, conveyance, and treatment	12/2015	Design
Village of Margaretville	Main Street stormwater collection, conveyance, and treatment	12/2015	Open
Village of Delhi	Riverwalk Phase II stormwater collection, conveyance, and treatment	3/2017	Construction
Delaware Academy	School stormwater collection, conveyance, and treatment	3/2017	Design

Table 3.4 Summary of planning and assessment projects still open in 2018.

Applicant	Grant amount	Funding Date
Town of Windham	$46,625	2015
Village of Fleischmanns	$46,875	2015
Town of Walton	$50,000	2017

4. Protection and Remediation Programs

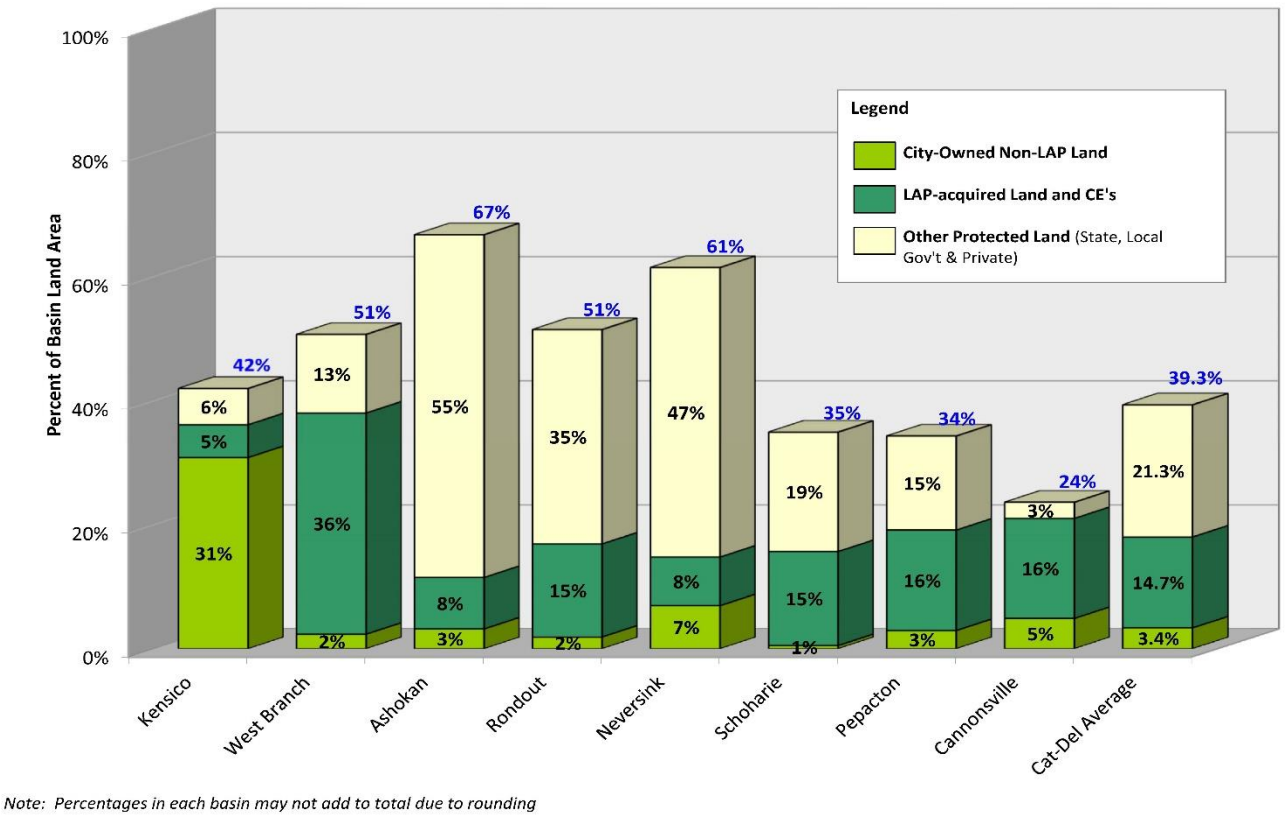
4.1 Waterfowl Management Program

For information on the Waterfowl Management Program, see the Waterfowl Management Program Annual Report, which will be available on the DEP website after its submittal on October 31, 2019. (http://www.nyc.gov/html/dep/html/watershed_protection/fad.shtml).

4.2 Land Acquisition

Through 2018, the Land Acquisition Program (LAP) has protected 152,000 acres in the Catskill/Delaware watershed, the majority in fee simple but also through conservation easements (CEs) acquired by the City and the Watershed Agricultural Council (WAC). This represents more than a four-fold increase in the amount of City-owned land since 1997, all based on voluntary transactions spanning more than 1,750 signed purchase contracts.

In many reservoir basins, City land holdings have increased dramatically compared with pre-1997 ownership patterns (Figure 4.1). In the Rondout basin, which is comprised entirely of Priority Areas 1A and 1B, the City has increased the number of protected acres by almost 800%.



Note: Percentages in each basin may not add to total due to rounding

Figure 4.1 Percent of land protected in each Catskill/Delaware basin by real estate type.

In the West Branch/Boyd Corners basins, acreage under City control has increased by 1,500%, while Schoharie basin acreage has increased by 2,900%. Overall, City-controlled land in the Catskill/Delaware watershed has increased to over 185,000 acres, including CEs secured by DEP and WAC and all deals yet to close. In 1996, the City owned just over 3% of the Catskill/Delaware watershed while another 21% was protected by New York State and others. Today, roughly 18% is City-controlled, representing more than 45% of all permanently protected land. See Section 4.7 for a summary of stream buffers and wetlands protected by real property interests acquired by the City.

4.2.1 Solicitation/Resolicitation

The 2017 FAD requires solicitation of 350,000 acres over the seven-year period, 2018-2024. During 2018, DEP and its program partners solicited 41,213 acres towards this FAD goal, with 21,213 acres by DEP and the remaining 20,000 acres being the maximum credit available as a result of solicitations by WAC Farm and Forest CEs (39,512 acres), Streamside Acquisition Program (1,010 acres), and the New York City-Funded Flood Buyout Program (26 acres). Since 1997, DEP has solicited over 480,000 acres against the overall program-wide requirement of 445,050 acres.

4.2.2 Purchase Contracts in the Catskill/Delaware System

As depicted in Table 4.1, during 2018 DEP and its LAP partners signed 56 purchase contracts comprising 5,538 acres. These contracts include seven WAC Forest CE properties, eight WAC Farm CE properties, 10 Streamside Acquisition Program (SAP) properties, and 11 New York City-Funded Flood Buyout Program (NYCFFBO) properties. As depicted in Table 4.2, DEP and its LAP partners closed on 39 purchase contracts comprising 3,083 acres in 2018. Table 4.3 depicts land acquired by Priority Area for 2018 and prior.

Table 4.1 Contracts signed in the Catskill/Delaware watershed during 2018 by real estate type.*

Type	Contracts	Acres	Average Size	Price
City CE	0	0	0	$0
NYCFFBO	11	40	4	$2,179,100
City Fee	20	1,459	73	$4,098,086
SAP	10	79	8	$404,840
WAC Farm CE	8	1,312	163	$2,187,423
WAC Forest CE	7	2,649	378	$2,488,875
Totals	**56**	**5,538**	**99**	**$11,358,324**

* *Apparent errors in the "Totals" row are due to rounding/averaging.*

Table 4.2 Contracts closed in the Catskill/Delaware watershed during 2018 by real estate type.*

Type	Contracts	Acres	Average Size	Price
City CE	0	0	0	$0
NYCFFBO	0	0	0	$0
City Fee	31	2,326	75	$8,509,417
SAP	4	12	3	$152,000
WAC Farm CE	2	422	211	$911,208
WAC Forest CE	2	323	161	$405,793
Totals	**39**	**3,083**	**79**	**$9,978,418**

* *Apparent errors in the "Totals" row are due to rounding/averaging.*

Table 4.3 Contracts and acres closed/signed in the Catskill/Delaware watershed by Priority Area.

Period	Priority Area	Contracts Executed	Acres	Price (millions)
1997-2017	1A	132	5,084	$ 34.3
2018	**1A**	**0**	**0**	**$ 0**
Subtotal		132	5,084	$ 34.3
1997-2017	1B	333	17,540	$ 135.4
2018	**1B**	**3**	**1,192**	**$ 1.0**
Subtotal		336	18,732	$ 136.4
1997-2017	2	187	11,630	$ 35.1
2018	**2**	**9**	**99**	**$ 1.6**
Subtotal		196	11,729	$ 36.7
1997-2017	3	401	41,194	$ 89.9
2018	**3**	**14**	**1,315**	**$ 2.6**
Subtotal		415	42,509	$ 92.5
1997-2017	4	652	71,811	$ 175.6
2018	**4**	**30**	**2,928**	**$ 6.2**
Subtotal		682	74,739	$ 181.8
Grand Totals		**1,761**	**152,793**	**$ 481.7**

Through 2018, all LAP initiatives have resulted in 1,761 signed purchase contracts comprising 152,793 acres throughout the Catskill/Delaware watershed at a cost of $481.7 million, plus additional supporting ("soft") costs that include appraisals, surveys, etc., of about $42 million (excluding WAC and SAP programs). Figure 4.1 illustrates the status of protected land through the Catskill/Delaware basins, and Figure 4.2 illustrates acres secured to contract by each program annually.

Figure 4.3 shows a property signed to contract in 2018 by DEP.

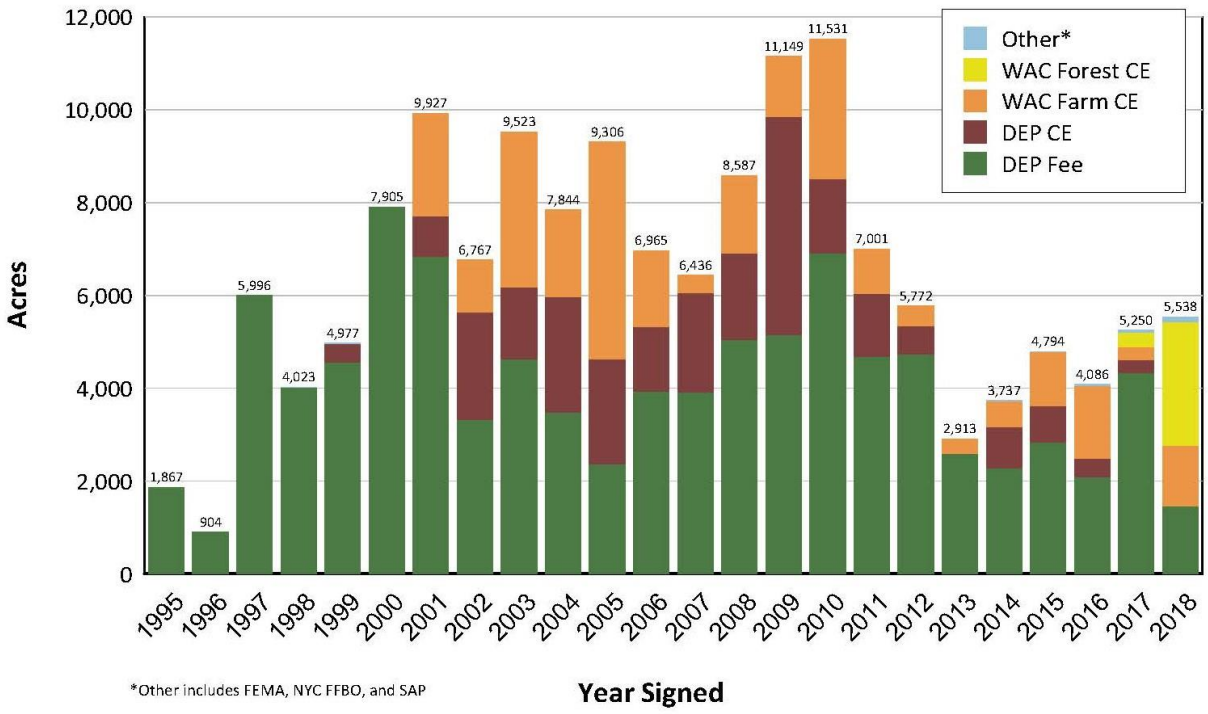


Figure 4.2 Acres in executed contracts by year and real estate type in the Catskill/Delaware watershed.

4.2.3 Transfer of Conservation Easements on Fee Acquisitions to New York State

DEP is required to convey CEs to the state on all lands acquired in fee simple using City funds. During the reporting period, DEP conveyed nine CE deeds covering 113 properties and 8,344 acres to the state. To date, DEP has conveyed to the state a total of 85 CEs on 1,112 properties comprising 74,716 acres. Of these, 68 have been recorded by the state and the remaining 17 are being processed.

4.2.4 New York City-Funded Flood Buyout Program

The NYCFFBO continues to make significant advances. In 2018, DEP ordered seven appraisals for a program-to-date total of 25. By the end of 2018, there were 13 accepted offers, one pending offer, 11 contracts executed, and four refused offers (three of these are commercial

or municipal ventures that lacked additional monies to relocate). Eight additional landowners are interested in the program with resolutions already passed by the respective towns, resulting in a total of 33 interested landowners (including those in process or closed, though there were no closings in 2018).

Nine towns in four watershed counties have passed resolutions in support of these 32

Figure 4.3 A half mile of stream meanders through this 200-acre property in the Pepacton basin signed to contract by DEP in 2018.

projects. Appraised values to date total nearly $3.9 million, with projects falling into the categories of Local Flood Assessment, Stream Projects, and Erosion. Some program activities on properties slated to be municipally-owned (including contract execution and closings) were impacted by yet unresolved discussions to finalize the model CE covering municipally-owned properties, which involves a monitoring agreement between CWC and the New York State Department of Environmental Conservation (NYSDEC) for these town-owned properties. A summary of the 13 projects program-to-date with a signed contract (including two which have closed) is provided in Table 4.4 below.

Per 2017 FAD requirements, DEP submitted the first evaluation report on the NYCFFBO in June 2018. That report determined the NYCFFBO successfully achieved its goals to date and recommended it continue.

4.2.5 Streamside Acquisition Program

DEP funds the pilot Streamside Acquisition Program (SAP) through a contract with the Catskill Center for Conservation and Development. The SAP closed on its first four projects during 2018. During 2018, 14 appraisals were ordered and 10 contracts were executed (80 acres)

including offers from prior years. Since 2015, the program has conducted 42 appraisals which resulted in 16 executed contracts (121 acres). Of those 121 acres, 68% are within the 300-foot stream buffer and/or the 100-year FEMA floodplain.

The 2017 FAD requires DEP to work with stakeholders and develop incentives to increase landowner participation in the SAP. During 2018, DEP organized four meetings with stakeholders and three subcommittee meetings to address this deliverable, which is due March 31, 2019.

4.2.6 Water Supply Permit

DEP's 2010 Environmental Impact Statement (EIS), which supported the 2010 Water Supply Permit (WSP), evaluated potential impacts watershed-wide, and for 20 WOH towns, of LAP acquisitions and determined there would be no adverse socioeconomic impacts to the supply of developable land in each municipality. The 2010 WSP authorized the LAP to acquire up to 106,712 acres in the Catskill/Delaware system through 2025, beyond the 102,287 acres that had been acquired as of January 1, 2010.

Table 4.4 Status of executed and/or closed projects under the NYCFFBO as of December 31, 2018.

Municipality	Prop ID	Expected Owner	Acres Executed	Acres Closed
Delaware County				
Walton	9123	Town	1.3	0.0
County Subtotal	**1**		**1.3**	**0.0**
Greene County				
Hunter	8847	NYC	22.0	0.0
	9243	NYC	1.2	0.0
Jewett	8883	NYC	4.8	4.8
County Subtotal	**3**		**28.0**	**4.8**
Schoharie County				
Conesville	8884	NYC	0.6	0.6
	8963	Town	0.6	0.0
	9306	NYC	3.3	0.0
County Subtotal	**3**		**4.5**	**0.6**
Ulster County				
Olive	9309	Town	1.3	0.0
	9315	Town	0.3	0.0
	9374	NYC	1.3	0.0

Municipality	Prop ID	Expected Owner	Acres Executed	Acres Closed
Shandaken	4988	NYC	6.0	0.0
	9393	NYC	1.5	0.0
County Subtotal	**6**		**11.4**	**0.0**
Subtotal Ownership	**9**	**NYC**	**41.7**	**5.4**
	4	**Town**	**3.6**	**0.0**
Grand Total	**13**		**45.3**	**5.4**

Between January 1, 2010, and December 31, 2018, DEP and its partners signed contracts on 50,349 acres (47% of the total 106,712-acre limit), leaving a balance of 56,363 acres for potential acquisition pursuant to the WSP. DEP completed a study in 2017 updating the analysis of levels of potential acquisition and the associated impacts in 21 WOH towns and again determined that there would be no adverse socioeconomic impacts.

. DEP convened three stakeholder meetings in 2018 to discuss this study in relation to LAP's solicitation goals. In April 2018, DEP submitted a proposal to NYSDOH to modify its solicitation plans per a 2017 FAD deliverable. Until DEP's proposal is formally approved, DEP continued to limit outgoing solicitations in a number of WOH towns during 2018, while continuing to accept inquiries from interested landowners.

4.2.7 Federal Emergency Management Agency 2012 Buyout Program

By the end of 2017, DEP completed all Federal Emergency Management Agency (FEMA) buyout acquisitions in Greene and Ulster counties and had received reimbursement for eligible expenses from FEMA for these. In Delaware County, 28 properties were originally identified for acquisition as part of the FEMA Buyout Program. Six of these properties required a 25% local match and, of these, Delaware County (with continuing City involvement) eventually closed on five properties while one was offer refused. DEP procured and paid for early-stage site services on another 22 properties, after which Delaware County requested they be removed from the County-City FEMA buyout list. Delaware County proceeded to close on 21 of these properties by the end of 2018 without City involvement (one additional project became offer refused). Once Delaware County receives funds from FEMA, the City expects to be reimbursed for all of its eligible expenses on all 28 properties.

4.2.8 Cooperative Activities with Land Trusts

Throughout 2018, there was no activity within the five towns (six eligible properties) that opted into the Enhanced Land Trust Program (ELTP) in 2011. DEP does not expect this program to result in any projects at least through 2021, when towns will have a third opportunity to elect in or out of ELTP. With the exception of the SAP and WAC CE programs, no properties were

acquired or paid for by the City that involved land trusts or non-governmental organizations during 2018.

4.2.9 Farms in Transition

The 2017 FAD required DEP to work with stakeholders in 2018 to explore the feasibility of a program that will protect the majority of each transitioning farm (agricultural land that is at risk of foreclosure or farms with retiring farmers). DEP convened several stakeholder meetings and reported in June 2018 that there is currently no consensus among stakeholders for a new program.

4.2.10 EOH Stream Buffers

The 2017 FAD required DEP to evaluate in 2018 the need, opportunities, and options for enhancing riparian buffer protection efforts in Kensico and EOH FAD Basins. DEP undertook a multidisciplinary, metrics-based analysis and submitted the required report in September 2018, concluding sufficient protections and programs already exist for EOH stream buffers and no new initiatives are needed.

4.2.11 Use of LAP-Acquired Land by Local Communities

The 2017 FAD required DEP to report in 2018 on progress of a workgroup convened to assess opportunities to use LAP-acquired lands to help relocate development out of the floodplain. Because local communities did not convene any meetings with DEP on this topic, there is no progress to report for 2018.

4.3 Land Management

The City has made a significant investment in purchasing water supply lands and conservation easements (CEs). To manage these lands for water quality protection, including beneficial uses, DEP has developed a comprehensive, long-term plan for land management. Primarily focused on City lands, land management activities fall into two major categories:

- Property management of City water supply lands and CEs
- Beneficial use

4.3.1 Management of Water Supply Lands and Conservation Easements

Property Management of City Lands

The City now manages 175,071 acres of land and reservoirs it holds in fee simple; this includes reservoir buffer lands (pre-Memorandum of Agreement (MOA)), MOA lands, and land along aqueducts. While the average size of parcels acquired under the MOA since 1997 is 67 acres, assemblages of acquired land have reached up to 2,862 acres.

Inspections

All City lands owned in fee simple are inspected as per the DEP Fee-land Monitoring Policy (DEP 2010), which outlines procedures for property inspections and boundary maintenance on City lands. Property inspections are divided into three types: standard inspections, focused inspections, and aerial inspections. The type of inspection a property receives depends on its priority, which is assigned based on its location, number of adjacent properties, the various uses conducted on the property (e.g., recreation, land use permit) and any history of trespass or encroachments.

Standard inspections are performed on "standard priority properties," those on which little or no trespass or encroachments have been observed, or which have little road frontage or no or low public use. These properties receive a boundary inspection at least once every five years. Five-year boundary inspections are the most comprehensive type of inspection and include a traverse of all property boundary lines as well as the interior of the property; this ensures proper survey monumentation and maintenance of boundary lines over the long term.

Focused inspections are performed on "high priority properties." These are parcels on which recreational use is high, where there is a history of encroachments or repeated trespass, where there are active land use permits or other projects, or where there are many adjacent landowners. Focused inspections are performed annually.

DEP can change a property's inspection priority at any time depending on changing circumstances (such as the discovery of encroachments) or perform additional site visits as needed. All inspections and site visits, along with journal notes, photos, encroachments, and observations, are recorded in DEP's Watershed Lands Information System (WaLIS). Inspections are also scheduled using WaLIS.

All City lands are posted as appropriate. Signage includes "Posted," "No trespassing," and for recreation areas "Public Access Area," "Day Use Area," or "Entry by Permit." Other types of signs may be utilized as site-specific conditions dictate.

Encroachments

DEP works diligently to cure encroachments when they are discovered on City lands. DEP Police and Operations staff are often the ones to identify potential encroachments during the routine inspections mentioned above and property stewardship activities. Once a potential problem is identified and categorized (minor, major, or criminal), DEP staff coordinate the appropriate response with other entities including DEP Legal Affairs, NYC Law Department and DEP Police as necessary.

In 2018, several significant encroachments on City watershed lands were resolved through the coordinated actions of several Bureau of Water Supply (BWS) directorates, DEP Legal, and DEP Police. In Bovina, for example, a neighbor was charged with property damage and trespass following documentation of all-terrain vehicle use on City MOA lands that caused

severe rutting and erosion. The landowner was taken to court and fined. The fine will be used to restore the City property in 2019. Another encroachment in the Village of Brewster that was discovered during a property inspection was resolved through discussion with the adjoining property owner who removed fencing and equipment and materials being stored on City lands. In 2018, the City entered into a court-ordered settlement with a neighbor in the Town of Yorktown who had been encroaching on and illegally using adjoining City lands that are part of the New Croton Aqueduct.

Conservation Easement Stewardship

DEP

At the end of 2018, DEP had 175 closed CE properties totaling just over 26,000 acres in the Catskill, Delaware, Kensico, and Croton watersheds. DEP conducts two annual inspections of all easements in compliance with MOA's terms. DEP continues to perform annual aerial inspections of CEs since they provide an efficient alternative for inspecting properties, especially the larger ones. Potential violations that could have serious water quality impacts, such as land clearing, construction, and bridge or road building, are clearly visible using aerial inspections. Combined with a fall on-the-ground inspection (or a ground check if problems are observed), aerial inspections provide a high level of protection for the City's investment.

Eight easement properties were sold to new owners in 2018 and we have learned another eight easement properties are currently listed for sale. Potential sales to new owners require significant stewardship resources in order to explain the easement restrictions, answer questions about allowed activities, and share the deed and maps with potential buyers. Once a sale of a CE property occurs, DEP's policy is to meet the new owners at the CE property, provide copies of the baseline documentation, and answer any questions about the easement restrictions and activity approvals. This provides an important opportunity to introduce DEP staff and establish a good landowner relationship. DEP has made contact with all the new owners in 2018 and is setting up site meetings with them.

Two categories of CE violations occurred in 2018. The first involved two instances of intra-family property conveyances in which the conveyance deed did not reference the conservation easement as required by the easement deed. The second category of violations was discovered during DEP field inspections. Violations included one forest harvest performed without prior approval or oversight; one case of fill placed in a riparian area adjacent to a Class A watercourse just outside of a building envelope; and a minor grading violation where a neighbor took stone from a channel of the Esopus Creek. Out of the five new violations, one was resolved in 2018 and the others are currently being addressed.

A violation discovered in 2017 for wetland grading at the completion of a forest harvest was closed in 2018 after the landowner successfully installed mitigation plantings requested by the NRD Wetlands Program.

DEP reviewed several requests for "prior approval" as required by the easement deed. This included three stream work projects (two were denied) and two accessory structure requests (one denied, one still under review). A dozen farming and livestock activity approvals are being extended. Approximately six forest harvest projects were reviewed and approved in 2018 and another six are in the planning stage for 2019.

Watershed Agricultural Council (WAC) Conservation Easements and Stewardship

At the end of 2018, the WAC had 185 easement properties totaling 28,274 acres in the Catskill, Delaware, and Croton watersheds. WAC performed all MOA-required inspections of their easements in 2018, including aerial inspections.

DEP is a voting member of the WAC Easement Committee, which is responsible for interpreting and enforcing WAC easement deeds and adopting guidelines stewardship staff can apply when questions arise.

In 2018, WAC adopted an enforcement policy and guideline called for in the DEP-WAC contract. DEP has also requested that WAC develop a waiver policy (before any more waivers are granted) and update its waste guideline. WAC discovered six violations in 2018 and resolved four of them. Four of the violations were for improper debris storage and two involved the installation and rental of rustic commercial campsites with waste storage.

4.3.2 Beneficial Use

Recreation

DEP provides outstanding public recreational opportunities at 19 reservoirs and two controlled lakes and on thousands of acres throughout the Catskill, Delaware, and Croton watersheds.

Through its land protection efforts, DEP has been able to significantly increase the acreage available to the public for recreation. Not only does this provide outdoor opportunities for watershed residents, but it also plays an important role in strengthening local economies and eco-tourism based businesses.

Recreational access also expands the stewardship constituency for the water supply system and the lands that protect water quality. With an increasing portfolio of recreational lands, managing the stewardship of these areas becomes an ever more challenging task that will benefit from assistance provided by the watershed community. Regular recreational interactions with the natural environment can engender a sense of respect and ownership by the user. This can complement DEP's protection goals and allow for a more engaged recreational user. Combining this with outreach, volunteer opportunities, and trainings will increase awareness and extend the reach of DEP to better manage, inspect, and improve its recreational land holdings.

Some of the activities enjoyed by residents and tourists are deep water and in-stream fishing, ice fishing, boat fishing, hunting, hiking, cross-country skiing, and other similar low-

impact activities. Areas open to the public have increased in recent years due to DEP's purchases of additional lands and attempts to allow expanded recreational opportunities in the City's watershed. DEP's management priority is to allow and enhance those recreational activities compatible with water quality protection.

In 2018, DEP opened an additional 2,952 acres of land for recreation, bringing the total lands and reservoirs available for public use to 136,800 acres. DEP continued to open WOH watershed lands as Public Access Areas (PAAs). Users of these lands may hunt, hike, fish, or trap without a DEP Access Permit. Figure 4.4 provides a breakdown of the acres of land, by category, opened for recreation since 2008 — which continues the upward trend that began in

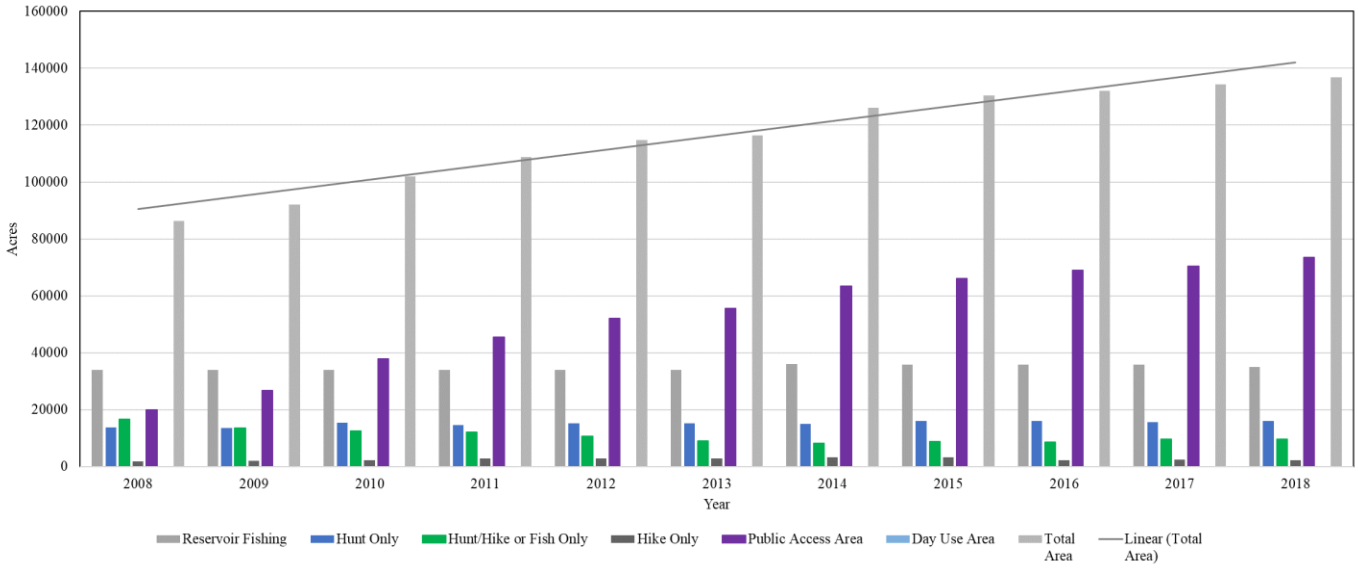


Figure 4.4 Acres of DEP land open for recreation since 2008.

2003. In 2018, DEP opened two new Day Use Areas on the Pepacton Reservoir (Pepacton Cemetery and Dunraven). These areas are open to the public without the need for a DEP Access Permit.

DEP has provided revocable land use permits to several partners for recreation projects on City land. DEP now has eight trails totaling approximately 31 miles with many trail partners, such as the Catskill Mountain Club, NY/NJ Trail Conference, and The Finger Lakes Trail Conference.

In 2018, DEP continued to work with Ulster County on advancing the Ashokan Rail Trail. This includes an 11.5-mile-long former rail bed along the northern shore of the Ashokan Reservoir. Ulster County has completed all track and tie removal of the old rail line and has been working on several infrastructure improvement projects, such as culvert replacement and addressing drainage issues (Figure 4.5)

DEP also issued land use permits for hiking trails to the Catskill Mountain Club (Ashokan Quarry Trail) and to the Town of Hunter (Kaaterskill Path). Both trails will be constructed in 2019.

DEP finalized a trail policy to help provide better guidance and criteria for locating and constructing trails as well as provide transparency to those who wish to propose trail on City land. Hiking trails are routed to avoid natural resources, such as wetlands, and constructed to not create erosion and sedimentation. Use of these trails also provides an opportunity to educate visitors about DEP watershed protection efforts.

DEP worked with the Catskill Mountain Club and the Catskill Regional Invasive Species Partnership to install a boot-brush station at the Shavertown Trail. Hikers can now brush off their boots before and after the hike to reduce the spread of invasive plants through seed transfer.

In 2018, DEP worked on revising its "Rules for the Recreational Use of Water Supply Lands and Waters." This effort will extend into 2019. Primary changes include the following: the ability to designate Public Access Areas in the East of Hudson region; eliminating sailboats as a recreational boating vessel; enabling DEP to have better control over fishing boats stored on City lands; prohibitions on mountain bikes, horses, and smoking; and the ability to waive Access Permit requirements for events such as family fishing days.

DEP continued to develop its program to allow NYS-licensed guides to take clients on DEP lands and waters for hunting, fishing, hiking, and other allowable activities. Permits were issued to one additional guide in 2018, for a total of 35 approved guides. Other activities to enhance recreational opportunities included three public Family Fishing Days (Ashokan and Pepacton reservoirs and Lake Gleneida). Almost 300 people participated.

DEP and several partner organizations again held a clean-up day on nine reservoirs. Some 410 volunteers filled 346 garbage bags with 4,650 pounds of debris during the one-day cleanup. Debris collected included 4,702 glass, plastic or metal beverage containers; 1,554 food wrappers; 5,041 small pieces of foam, glass or plastic; 1,117 cigarette butts; 489 yards of fishing line; 872 grocery bags; 1,079 disposable cups and plates; 1,302 bottle caps; 977 take-out food containers; and 16 tires.

Fishing Boat Program

DEP has provided for the traditional use of fishing boats on DEP reservoirs. Individuals must register their boats and obtain a permit from DEP to store their fishing boat on a reservoir. Prior to storage, all boats must be steam cleaned and they must remain on their assigned reservoir. Currently, DEP has more than 13,000 fishing boats permitted throughout the watershed. Boat owners must renew their registration every two years and abide by DEP safety and storage regulations.

In 2018, DEP began to increase the renewal period on many boat tags to every four years. DEP regulates the number of allowable boats for each reservoir, limiting numbers and closing reservoirs or boat storage areas to new boats when they reach capacity. These limits are based on the DEP Boat Area Rapid Assessment, which utilizes several factors, including safety, erosion, buffer health, and other natural indicators, to establish healthy limits. The fishing boat program is a very popular public resource and provides for a safe and diverse use of DEP reservoirs.

Recreational Boating Program

In 2018, DEP issued 1,660 recreational boat tags (canoes, kayaks, sailboats, sculls) for the reservoirs covered by the program: Cannonsville, Pepacton, Neversink, and Schoharie. These numbers are particularly impressive as 2018 was a very rainy summer. Kayaks easily remain the most popular vessel used, followed by canoes. Canoe and kayak rental vendors rented 935 vessels. The intention of the rental program is to increase recreational boating participation by

Figure 4.5 A section of the former rail bed that will become the Ashokan Rail Trail.

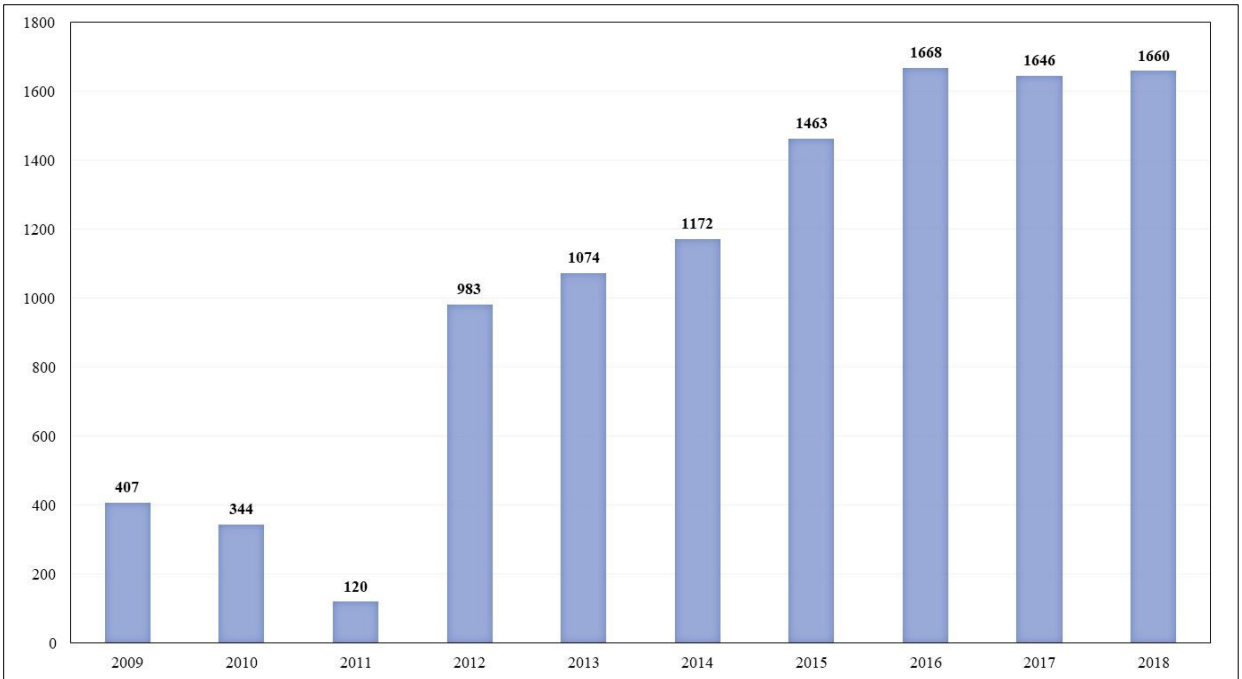


Figure 4.6 Total recreational boat usage, rentals plus boat tags, 2009-2018.

making vessels easily available to those who do not have their own or do not want to transport them. Since its initial year in 2009, the program has seen a steady increase in participation. (Figure 4.6). Year after year, the rental program grows while individual boat tags numbers decrease. This trend reflects the easy access provided by the rental boat program, which has the additional benefit of boosting the region's economic growth.

The recreational boating program caused very little, if any, interference with boaters who store their rowboats on the reservoirs for fishing. No serious safety issues were encountered. Only a few vessels were put into reservoirs without being properly steam cleaned. Both DEP staff and concerned recreational users approached the violators and informed them of the program requirements. DEP continues to increase outreach to boaters and has updated signs at boat launch sites, where needed, to prevent impact to the reservoirs. In coming years, DEP hopes to enhance the program by extending the recreational boating season (Figure 4.7).

Watershed Stewards

In 2016, DEP launched its Watershed Land Steward Program to engage recreational users as volunteers to assist with the protection and improvement of DEP watershed lands. At Kensico and Pepacton reservoirs, stewards collected trash, made sure boats were stored properly, and talked with their fellow anglers and boaters. The participants functioned as ambassadors for their respective reservoirs.

In 2018, this program expanded to cover most East of Hudson reservoirs. Additionally, in partnership with the Croton and New York City chapters of Trout Unlimited, DEP expanded the program to cover streams flowing into and out of City reservoirs.

Figure 4.7 Kayakers enjoy a spring paddle on Pepacton Reservoir.

DEP provides training to volunteers on important watershed issues including watershed protection, invasive species, and the DEP Recreation Program. Stewards submitted monthly reports to DEP, which are then followed up on by DEP staff.

This past year, DEP initiated a notification system to relay issues identified by the stewards to boat owners on the reservoirs. The stewards notified DEP about 36 damaged boats, 88 improperly stored boats, 17 boats in the water, 50 expired boat tags, three unsecured boats, and one case of illegal dumping. DEP plans to grow this program to include more volunteers and broaden its reach, both in geography and scope, to address watershed issues throughout its water supply lands. While focus now is primarily on reservoirs, the potential exists to replicate this model to target land-based recreation on DEP's 130,000+ acres of watershed lands open to the public.

Universal Access

To expand recreation to more users, DEP has increased its focus on Universal Access. While most of DEP's recreational properties are managed as open space without improvements, DEP realizes that heavily used areas, such as Day Use Areas (DUAs), provide an opportunity to incorporate accessibility improvements that will enable more users to explore and enjoy DEP lands and waters. DEP has completed several evaluations of DUA properties and identified possible improvements that can increase universal accessibility. In the short term, DEP is working to ensure all portable restroom facilities meet or exceed ADA accessibility standards, evaluating paved surfaces for ease of access, and making improvements to parking areas with signage. DEP has also completed several designs on future recreational projects that will focus on Universal Access.

DEP is also committed to making recreational opportunities more accessible to aging users. This includes identifying opportunities where distance to recreational areas is a challenge. In 2018, DEP completed the construction of a dedicated angler parking area at the popular Chimney Hole fishing area on Ashokan Reservoir. This significantly reduces the distance anglers need to travel to reach the shoreline.

Agricultural Use

DEP allows its land to be used for agricultural activities through a landowner-lease program, but sets certain conditions on landowners who choose to farm. These can include minimum buffers along all streams and wetlands, a prohibition on spreading raw manure during frozen or snow-covered conditions, and, if fertilizers will be used, an approved nutrient management plan.

In 2018, DEP worked with WAC to revise DEP's policy on agricultural leases and increased the minimum 25 foot buffer to 35 feet. Most of the farmers using City lands are enrolled in WAC's Whole Farm Plan Program. These farmers adopt whole farm plans, which helps ensure good farming practices are utilized. These plans are generally developed for private land but can be adapted for use on City lands and include various agricultural best management practices (BMPs), such as soil stabilization techniques. Some of the agricultural lands the City purchases under the Land Acquisition Program (see Section 4.2) have Conservation Reserve Program (CRP) and/or Whole Farm Plan BMPs already installed on them, such as fencing and tree planting. The City, as landowner, must maintain these BMPs.

The most common agricultural use on City land is the harvesting of hay. In 2018, DEP approved nine new projects covering 187 acres. This made a total of 140 projects in 26 different towns covering 3,170 acres. Most project areas were inspected in 2018 and no major issues were observed. On projects where no riparian area existed prior to City purchase (they were being farmed right up to the streambank), the streamside vegetation is reestablishing itself and will form an effective buffer area in a few years.

4.4 Watershed Agricultural Program

The Watershed Agricultural Council (WAC) administers the Watershed Agricultural Program (WAP) using DEP-provided funds and technical assistance provided by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), Delaware County Soil and Water Conservation District (DCSWCD) and Cornell Cooperative Extension (CCE). The USDA Farm Service Agency provides technical and financial assistance for the federal Conservation Reserve Enhancement Program (CREP).

To date, the WAP has developed 450 Whole Farm Plans (WFPs), including 372 West of Hudson (WOH) farms and 78 East of Hudson (EOH) farms. At the end of 2018, 330 of these WFPs (73%) remained active, including 262 WOH farms (71%) and 68 EOH farms (87%). By comparison, 331 WFPs were active at the end of 2017.

During 2018, the WAP developed one new WFP on a WOH farm, one WOH farm became inactive, and one WOH farm withdrew from the program. WAC anticipates developing new WFPs for seven prospective participants within the next 18 months. For the 331 active WFPs at the end of 2017, the WAP conducted 318 annual status reviews (96%), which exceeds the 90% FAD metric. The WAP also completed 92 WFP revisions during 2018.

In 2018, the WAP implemented 329 BMPs on all active farms at a total cost of approximately $3.4 million. These figures include 299 BMPs on WOH farms ($3.1 million) and 30 BMPs on EOH farms ($0.3 million). These figures also include the repair or replacement of 54 BMPs on WOH farms and four BMPs on EOH farms. To date, more than 7,800 BMPs have been implemented on all watershed farms at a cost exceeding $64.6 million; these figures include 7,128 BMPs on WOH farms ($57.8 million) and 764 BMPs on EOH farms ($6.8 million).

In 2019, the WAP anticipates designing and/or implementing approximately 274 BMPs on WOH farms at an estimated cost of approximately $5 million and approximately 30 BMPs on EOH farms at an estimated cost of nearly $400,000.

Pursuant to the 2017 FAD, the WAP is required to achieve a new BMP implementation metric intended to reduce by 50% an existing backlog of BMPs on WOH farms (identified prior to January 1, 2017) while limiting the potential backlog of new BMPs identified after January 1, 2017. The backlog metric covers “new” (not yet implemented) BMPs in WFP pollutant categories I-VI, as well as previously implemented BMPs (regardless of pollutant category) needing repair or replacement.

In 2017, DEP and WAC developed an official BMP backlog list to serve as a baseline for measuring FAD-mandated backlog reductions. This official BMP backlog list includes 1,754 BMPs at a total estimated cost of $35.8 million, including 1,410 “new” BMPs (estimated cost of $28.1 million) and 344 repair and replacement BMPs (estimated cost of $7.7 million). Through 2018, the WAP has implemented 146 “new” backlog BMPs (21% of FAD metric) and 163 repair or replacement backlog BMPs (95% of FAD metric). These statistics include 137 backlog BMPs

implemented during 2018 (74 "new" BMPs and 63 repair and replacement BMPs) out of the 299 total BMPs implemented on all WOH farms. In other words, 46% of all WOH BMPs implemented during 2018 were attributed to the backlog, while 54% were BMPs newly identified since January 1, 2017. Since the official BMP backlog was established, the WAP has planned an additional 681 new BMPs since January 1, 2017, with an estimated cost of over $8.7 million.

During 2018, the WAP completed 75 new or updated nutrient management plans (NMPs) on 68 active WOH farms and seven active EOH farms. In the WOH watershed, 234 active farms are following NMPs, of which 92% are current (developed within the last three years). In addition, 132 of currently eligible WOH farms (96%) participated in the WAP's Nutrient Management Credit Program in 2018, an increase of five participants from the 2017.

The WAP implemented its third full year of the Precision Feed Management (PFM) Program, completing 14 new Feed Management Plans in 2018. The PFM Program now has 44 active participants with Feed Management Plans, including 43 dairy farms (32 in the Cannonsville basin, six in the Pepacton basin, and five in the Schoharie basin) and one beef farm in the Cannonsville basin.

In 2018, the WAP signed 18 CREP contracts covering 130.8 acres of riparian forest buffers; this includes eight new contracts (37.7 acres) and 10 re-enrolled contracts (93.1 acres). In 2018, 13 CREP contracts expired (74.2 acres) and those landowners chose not to re-enroll. There are currently 179 active CREP contracts with 136 different landowners that contain 1,809.9 acres of riparian forest buffers.

The WAP conducted 21 farmer education programs in 2018 attended by 737 participants, of which 53% were watershed farmers, 21% were other farmers, and the remainder were students, agribusinesses or agency staff. An estimated 50% of all WAP participants attended at least one farmer education program during 2018, with highlights including the annual Catskill Regional Agricultural Conference, a Nutrient Management Credit Workshop, and several other tours and events covering topics such as livestock production, soil health, and pasture management.

Finally, the WAC Economic Viability Program continued to implement the Pure Catskills Campaign, reaching more than 50,000 people through its annual print guide, e-newsletters, and marketing website (purecatskills.com). In 2018, WAC initiated an economic viability micro-grants program to enhance the economic viability of watershed farm and forest businesses. WAC also attended or sponsored over 12 events promoting the diversity of agricultural and forest-based products from the Catskill region. Using DEP funds, WAC also launched a new business planning program for watershed farm and forestry businesses, with results from this new program expected in early 2019.

4.5 Watershed Forestry Program

The Watershed Forestry Program is a partnership among DEP, WAC, and the U.S. Forest Service (USFS). The partnership supports and promotes well-managed working forests through stewardship planning (forest management plans), the Management Assistance Program (MAP), the implementation of BMPs, professional training for loggers and foresters, and educational programs for landowners and school-based audiences.

In 2018, WAC funded the development of 43 forest management plans covering 8,991 acres. Four of these plans resulted in the new enrollment of 851 acres in the NYS Forest Tax Law (480-a tax abatement program), while the remaining 39 plans (8,140 acres) represented re-enrolled properties. A landowner who enrolls in the 480-a tax abatement program agrees to restrict development, limit subdivision, and commit to a schedule of forest stewardship activities for a rolling 10-year period. In this capacity, the 480-a program protects water quality by essentially functioning as a term easement preventing conversion of forestland to other less protective uses, while still being utilized for timber production.

WAC also funded the completion of 34 MAP projects including 18 timber stand improvement projects, 11 wildlife improvement projects, four invasive species control projects, and one tree planting project. To date, the program has funded 620 MAP projects on 5,189 acres of forestland, with timber stand improvement and wildlife improvement representing 76% of all completed projects. The number of completed MAP projects increased slightly in 2018 compared to the 33 projects in 2017, but was still below the annual goal of 45 projects. This was despite an 83% increase in MAP project approvals in 2018. Late snow in spring 2018 followed by an unusually wet summer and fall contributed to a second consecutive year of fewer-than-expected completed projects. Additionally, a significant increase in the size of timber harvest projects that required BMP funding also contributed to the low MAP completion rate as further described below.

In 2018, WAC funded the completion of 45 road BMP projects which included six stream crossing projects on active timber harvesting sites. Despite a 10% decrease in the number of participating timber harvests (50 to 45 projects from 2017 to 2018), the size of these harvests was 30% larger as measured by the total length of roads and trails cost-shared (134 to 187 miles). This increase, which required a greater investment of WAC staff time to administer BMP funding, consequently affected MAP completion rates. In 2018, WAC also loaned out five portable bridges, distributed 27 free BMP samples, and completed nine Croton Trees for Tribs projects. These latter projects included 432 trees and shrubs planted on one acre along 931 linear feet of streams.

Since 2015, WAC has supported an interactive website called MyWoodlot.com that educates forest landowners through online modules and helps them create customized plans with personalized goals and management activities. The website contains 55 goals, 221 activities, 571 pieces of how-to information, and 149 blogs and feature stories available as educational content

for interested landowners. In 2018, 51 landowners created MyWoodlot profiles for a total of 229 profiles to date; 18 of these profiles (8%) belong to staff, committee members and partners. Website diagnostics suggest that over 3,500 unique users visited MyWoodlot.com during 2018, a 59% increase over 2017.

In collaboration with the NYS Trained Logger Certification and Cornell Cooperative Extension, the Watershed Forestry Program sponsored 10 professional logger training workshops during 2018 attended by 136 participants. Approximately 138 loggers working in the Catskill/Lower Hudson region remained "Trained Logger Certified" during 2018.

WAC and its program partners sponsored several forest landowner education programs in 2018, including 58 workshops reaching more than 2,078 participants. The Cornell Master Forest Owners Program conducted 47 landowner visits. In 2018, 44 master forest owners served the Catskill region, of which 16 are based in the watershed.

The Watershed Forestry Program implemented the following school-based education programs in 2018: Green Connections School Partnership Program, Watershed Forestry Institute for Teachers, and Watershed Forestry Bus Tour Grants Program. Green Connections engaged 155 students via three partner schools (six classrooms), while 23 teachers attended the Watershed Forestry Institute held at the Taconic Outdoor Education Center in Putnam County. WAC sponsored 25 bus tours attended by approximately 252 adults and over 1,360 students (primarily New York City residents), including Trout in the Classroom field trips, Green Connections field trips, Croton Trees for Tribs planting events, and educational visits to a watershed model forest.

Finally, the watershed model forests continued to host diverse educational programs and outreach events that reached thousands of youth, landowners, loggers, and water consumers. In 2018, the four model forests hosted 104 events for 12,865 participants. The Lennox Model Forest educated 118 campers with forest-based programs such as wilderness survival and nature hikes, while the Frost Valley Model Forest attracted 9,787 campers and visitors. The Siuslaw Model Forest hosted more than 37 youth and adult programs, covering topics such as beekeeping, invasive species, mushroom cultivation, stream protection, and forest ecology. The Clearpool Model Forest reached 2,224 students from the East of Hudson region and New York City.

4.6 Stream Management Program

Throughout 2018, the Stream Management Program (SMP) continued to work closely with watershed communities to restore and protect stream system stability and ecological integrity by promoting the long term stewardship of watershed streams and floodplains. Community participation expanded considerably in the Flood Hazard Mitigation Program as the planning phase was almost finished and applications for implementation funding rose considerably. The SMP completed an additional 12 stream projects (Figure 4.8) for a total to date of 394 projects treating nearly 45 miles of stream. The SMP also conducted stream feature inventories (SFIs) on 19.4 miles of priority waterways and delivered a broad base of stream

Figure 4.8 Location of SMP projects, 2018.

management educational programming, professional engineering and technical assistance. The following sections summarize progress within the major functional program categories of Water Quality Stream Projects, Flood Hazard Mitigation, Stream Management Plan Implementation, and Stream Studies. The Catskill Streams Buffer Initiative (CSBI) is reported in Section 4.7.2.

4.6.1 Water Quality Stream Projects

Water quality stream projects (WQSPs) prioritize improvements in water quality and are approved by NYSDOH toward fulfilling this FAD requirement. While SMP projects serve multiple objectives and all projects can benefit water quality, each project has a principal goal and associated funding category within the SMP. Other project categories include Local Flood Analysis (LFA), Stream Management Implementation Program (SMIP), and the CSBI.

The 2017 FAD requires the completion of 24 WQSPs based on SFIs that support project prioritization. DEP met with the SMP partners in 2018 to review available water quality analyses and discuss using a water quality basis for informing selection and prioritization of streams for SFIs and WQSPs. Meetings included an overview on linking WQSPs to SFI findings and known water quality impairments associated with stream conditions; a review of past SFIs in each basin; presentations on water quality status and trends in each basin using DEP water quality monitoring data; a discussion on whether the DEP information could inform the focus of SFI and WQSPs selection; and a discussion on near-term SFI plans and the approach for targeting WQSPs. A summary report on each basin's approach will be submitted in June 2019.

The SMP each year nominates WQSPs for NYSDOH approval towards the 2017 FAD deliverable of 24 projects. The first project was completed in 2017. In 2018, a second project was completed: Bush Kill at Watson Hollow in the Ashokan basin (Figure 4.9 and Figure 4.10).

Two new projects were approved in 2018: West Branch Neversink River at Clothes Pool in the Neversink Basin and the Hillslope Stabilization Project at Bull Run in the East Branch Delaware River Basin. Table 4.5 summarizes the 2017 FAD WQ Projects completed and approved to date.

Figure 4.9 Bush Kill at Watson Hollow before construction.

Bush Kill at Watson Hollow Restoration Project

The Bush Kill is a direct tributary to the Ashokan Reservoir; as a result, unstable reaches that generate turbidity can be a priority for treatment. The Ashokan Watershed Stream

Management Program (AWSMP) worked with the Ulster County Department of Public Works to restore stability to this reach of the Bush Kill directly adjacent to Watson Hollow Road. The slope failure led to a collapse of Watson Hollow Road. Channel incision into clay-rich, fine sediments undermined the hillslope stability. This created new erosion sources and degraded water quality. The restoration project included relocating the channel away from the hillslope; constructing grade control features to prevent incision into the streambed; installing a floodplain bench in front of the bank to dissipate stream energy; installing a drainage system on the slope to prevent storm water from oversaturating and destabilizing the steep slope; and applying herbaceous seed mixes and live willow staking. Total construction cost was $394,955.

Figure 4.10 Bush Kill at Watson Hollow after construction.

Table 4.5 Status of WQ Projects towards fulfillment of the 2017 FAD requirement.

Project Name	Status	Length (feet)	Basin
Batavia Kill at Kastanis	Completed	3,800	Schoharie
Bush Kill at Watson Hollow	Completed	250	Ashokan
Batavia Kill at Red Falls Phase 1	Approved	2,700	Schoharie
Batavia Kill at Red Falls Phase 2	Approved	4,400	Schoharie
West Branch Neversink River at Clothes Pool	Approved	800	Neversink
Hillslope Stabilization at Bull Run	Approved	300	Pepacton

Woodland Creek at Woodland Valley Landowner's Association Restoration Project

In 2018, DEP also fulfilled its obligation under the Revised 2007 FAD to complete seven WQSP Projects in the Ashokan basin with completion of the Woodland Creek at Woodland Valley Landowner's Association Restoration Project. Figure 4.11 and Figure 4.12 illustrate the project, and Table 4.6 details the seven Ashokan projects that treated 1.6 miles of unstable stream in the Stony Clove, Beaverkill and Woodland Creek tributaries over six years in fulfillment of the Revised 2007 FAD requirements.

Following an SFI by the Ulster County Soil and Water Conservation District (UCSWCD) in 2015, DEP and UCSWCD prioritized the unstable and turbidity-producing reaches of Woodland Valley Creek. This 1,300-foot reach, located in the Town of Shandaken and the

Figure 4.11 Woodland Creek before construction.

Esopus Creek headwaters, was eroding extensively through lacustrine clay and identified for full channel restoration. Restoration included realignment of the channel away from two bank failures; removal and disposal of exposed clay; installation of engineered rock grade controls; and creation of vegetated floodplain benches using willow stakes and native trees and shrubs. Total construction cost was approximately $1 million.

4.6.2 Flood Hazard Mitigation Program

Figure 4.12 Woodland Creek after construction.

The Flood Hazard Mitigation Program supports the Local Flood Analysis (LFA) process which identifies flood hazards in West of Hudson population centers through hydraulic models. LFA-recommend projects are then funded and implemented through the SMP LFAs, Catskill Watershed Corporation (CWC) Local Flood Hazard Mitigation Implementation Program (LFHMIP), or the New York City-Funded Flood Buyout Program (NYCFFBO). Projects completed by the SMP in 2018 are listed in Table 4.7. A full list of completed LFAs can be found at www.Catskillstreams.org\LFA.

Table 4.6 Ashokan Basin WQ Projects completed towards the Revised 2007 FAD requirement of seven completed projects by 2018.

Project Name	Year Completed	Length (feet)	Cost
Stony Clove at Chichester – Sites 2/3/4	2013	1,650	$1,547,182
Warner Creek – Site 5	2013	800	$495,465
Stony Clove at Wright Road	2015	2,675	$1,802,985
Stony Clove Creek Hillslope Stabilization	2016	650	$1,221,771
Beaverkill at Van Hoagland Road Project 1	2018	600	$638,496
Beaverkill at Van Hoagland Road Project 2	2018	700	$744,912
Woodland Creek/Woodland Valley Assoc.	2018	1,350	$1,002,526
Total		8,425	$7,453,337

Table 4.7 Summary of LFA projects completed in 2018.

Basin	Type of Project	Name of Project	Length (feet)
Delaware	Floodplain Restoration	Mill Street Floodplain Restoration	800
Neversink	Streambank Stabilization	Denning Town Hall	700
Neversink	Full Channel Restoration	Blue Hill Lodge	750

SMP LFAs and LFA Projects

In 2018, six LFAs were completed in Delhi, Andes, Tannersville, Hunter, Ashland, and Shandaken/Allaben, while three LFAs remain ongoing in Roxbury, Halcott and Grahamsville. To date, 29 population centers have completed LFAs, marking substantial completion of the LFA process. DEP committed a total of $1.65 million to the development of LFAs through 2018. Figure 4.13 depicts the locations and status of LFAs in the WOH watershed.

Through the SMP, several towns made progress towards implementing LFA-recommended projects. In 2018, the SMP funded 11 LFA projects at a cost of $3.5 million. These 11 projects are counted toward the 50 LFA projects required by the 2017 FAD. Through 2018, $6.4 million has been spent or committed out of the $10.1 million funding requirement that was part of the Revised 2007 FAD and remains a deliverable in the 2017 FAD.

Three LFA projects were completed in 2018 (Table 4.7). The DCSWCD completed construction of the Mill Street floodplain restoration in Fleischmanns and substantially completed construction of the Water Street floodplain restoration in Walton. The Sullivan County Soil and Water Conservation District addressed flood hazards in Claryville (Town of Denning) by treating failing hillslopes and channel instability at the Blue Hill Lodge and Town Hall sites. These sites were contributing an excessive amount of sediment and eroded trees. The Claryville LFA identified sediment and wood from these sites as possibly increasing flood elevations and reducing floodwater conveyance through the hamlet.

In Greene County, the Greene County Soil and Water Conservation District (GCSWCD) and CWC advanced a streambank stabilization and floodplain restoration project in the hamlet of Conesville to mitigate flooding on Schoharie Route 990V. In 2018, CWC funded demolition of a private property acquired through the NYCFFBO and GCSWCD substantially completed the design for this project which will proceed in 2019.

Figure 4.13 Location and status of LFA projects, 2018.

CWC Local Flood Hazard Mitigation Implementation Program

In 2018, CWC initiated a property protection initiative by funding elevation and flood-proofing of floodplain structures. Feasibility studies are a critical first step before undertaking these measures. CWC in 2018 awarded 18 grants to support studies in Walton (four businesses and one critical facility), Boiceville (one business), Margaretville (two commercial properties), and Prattsville and Lexington (several residential properties). CWC funded the first elevation of a residential structure in Prattsville. Also in 2018, CWC approved 15 fuel tank anchoring projects to address pollutant sources in flood-prone areas. To date, CWC has funded the anchoring of 38 propane tanks (12,700 gallons) and 14 fuel oil tanks (3,900 gallons).

New York City-Funded Flood Buyout Program

In 2018, DEP supported Ulster County and the Town of Shandaken with the New York State Department of Transportation's (NYSDOT) replacement of the state Route 28 bridge over the Esopus Creek by preparing and submitting a successful application to FEMA for use of past flood buyout properties for new potential LFA project implementation.

4.6.3 Implementing Stream Management Plans

In 2018, DEP and its SMP partners continued to deliver comprehensive basin-scale programming including stream assessments; project selection, design, and construction; LFA support; and education and technical training of stakeholders. The SMP partners met throughout the year with their advisory councils and working groups to implement the recommendations made in stream management plans, track status and progress via annual action plans, and administer their Stream Management Implementation Program (SMIP).

Locally-driven projects are those funded by the SMP partners through the application-based SMIP. Table 4.8 summarizes the total SMIP awards in 2018 and to date. For the 245 SMIP grants awarded to date, 157 are complete (64%), 57 are in process (23%), and 31 are in the design phase (13%). In 2018, the SMP began to track flood hazard mitigation projects separately as LFA Projects to be consistent with the 2017 FAD requirements. The 11 LFA projects funded in 2018 are reported in Section 4.6.2. Basin-specific accomplishments are reported below and SMIP projects completed in 2018 are reported in Table 4.9. Additional project descriptions can be found at http://catskillstreams.org/smip/.

Ashokan Basin

Through DEP's partnership with CCE of Ulster County and the UCSWCD, the AWSMP advanced numerous initiatives in 2018. In addition to the previously described WQSPs, these included funding nine SMIP projects totaling $648,912; installing four CSBI projects; monitoring eight previously constructed stream restoration projects; and SFIs on Hatchery Hollow and Lost Clove totaling 3.3 miles.

Table 4.8 Number of SMIP awards by category for 2018 and totals to date (2009-2018).

SMIP Category	2018	Total
Education and Outreach	4	60
Recreation and Habitat Improvements	6	20
Stormwater and Critical Area Seeding	0	7
Highway/Infrastructure	8	50
Landowner Assistance/Streambank Restoration	5	39
Planning and Research	5	42
Flood Hazard Mitigation	0	27
Total	**28**	**245**

The AWSMP also advanced flood hazard mitigation projects recommended through LFAs in Boiceville/West Shokan and Shandaken/Allaben. Education and outreach highlights included the 2018 Catskill Environmental Research and Monitoring Conference; a public Woodland Creek Stream Management Plan presentation; several floodplain management trainings; and the Esopus Creek Newsletter in print and digital format. The AWSMP website (ashokanstreams.org) continues to provide an excellent resource for news, publications, and events.

Delaware Basins

In partnership with DEP and the Delaware County Planning Department, the DCSWCD progressed with recommendations in the East and West Branch Delaware River Action Plans by approving funding for 13 SMIP projects, completing one LFA project and substantially advancing another, and installing five CSBI projects. DCSWCD also completed six SMIP projects (Table 4.9) including a full channel restoration on an East Brook farm to enable CREP re-enrollment. DCSWCD completed an SFI on the Little Red Kill in the Town of Middletown (a tributary to the East Branch Delaware River) and accomplished the seeding and mulching of 26.3 acres through the roadway seeding program.

Table 4.9 Summary of locally-driven SMP projects completed in 2018.

Basin	Type of Project	Name of Project	Length (feet)
Delaware	Full Channel Restoration	Phoenix Farm CREP	1,900
Delaware	Streambank Stabilization	Beers Brook Grade Control	200
Delaware	Streambank Stabilization	Town Brook	200
Delaware	Streambank Stabilization	East Brook	200
Delaware	Stormwater/Infrastructure	Grant Brook Wall Repair	180
Delaware	Stormwater/Infrastructure	O'Dell Lake Rd. Culvert Replacement	50
Rond./Nevsk.	Full Channel Restoration	Frost Valley Road Stabilization	800

Rondout and Neversink Basins

The Rondout Neversink Stream Program (RNSP), led by Sullivan County Soil and Water Conservation District, approved eight SMIP projects totaling $823,158. The program completed two LFA projects, three CSBI projects, and one locally-driven project to improve flood resiliency through the stabilization of Frost Valley Road and restoration of the adjacent floodplain in the Town of Neversink. The RNSP completed SFIs on Trout Creek and Sugarloaf Brook (both Rondout Reservoir tributaries) and Conklin Brook (a Neversink Reservoir tributary), as well as a reference reach validation survey at the Frost Valley Model Forest. The RNSP awarded significant research grants to the U.S. Geological Survey (USGS) to update fish population and habitat studies and to Colorado State University to examine the role of large wood accumulations in stream channels. The RNSP accomplished the seeding and mulching of 0.75 acres through the roadway seeding program; coordinated the fourth annual Angler's Symposium; and funded education projects with Tri-Valley High School, Sullivan BOCES, and Time and the Valleys Museum. Additional information about the RNSP can be found at www.rondoutneversink.org.

Schoharie Basin

In 2018, the GCSWCD and the Schoharie Watershed Advisory Committee advanced several stream management plan recommendations, including funding nine SMIP projects totaling $610,321; completing three CSBI projects and two SFIs for 15 miles of the West Kill and Gooseberry Creeks; substantially advancing the design of several projects for 2020 construction; the annual monitoring of 11 former stream restoration projects; and seeding and mulching 13.8 acres through the roadway seeding program. Education and outreach efforts included the 12th Annual Schoharie Watershed Summit and the 9th Annual Schoharie Watershed Month events. GCSWCD held a public SMIP information session to promote project funding opportunities and visited local schools to conduct demonstrations using the EnviroScape Watershed/Nonpoint Source Model, the Augmented Reality Sandbox, and the Emriver Stream Table. The GCSWCD biannual newsletter was distributed in both print and digital formats.

4.6.4 Stream Studies

The SMP continued to provide scientific support to stream management activities. The primary effort in 2018 was advancing the second full year of the 10-year collaborative research effort led by the USGS and DEP, with support from the AWSMP.

USGS collected continuous turbidity data at all Esopus Creek watershed and Stony Clove watershed monitoring sites. USGS also collected continuous stage-discharge data and storm event suspended sediment samples at 14 locations throughout the study area. With consultant support, DEP continued geomorphic monitoring at selected suspended sediment source reaches in the Stony Clove watershed. An additional geomorphic monitoring site was added in 2018. SFI mapping of erosional suspended sediment sources in the Stony Clove watershed every five years

is part of the study design and this mapping was repeated in 2018. This data will be compared with similar data collected in 2013.

During 2018, DEP worked with USGS to analyze the range of mean daily turbidity levels and flood event turbidity levels for the 20 monitoring stations in the Stony Clove watershed covering USGS Water Years 2017 and 2018. The analysis will be used to inform the selection of three sediment turbidity reduction project sites for treatment in 2020-2021 to help evaluate the impact of restoration on mitigating turbidity. Turbidity monitoring in Stony Clove Creek and the upper Esopus Creek watershed continues to support a 2016 USGS report's findings that sediment turbidity reduction projects constructed between 2012 and 2015 have reduced turbidity levels and modified the turbidity-discharge relationship for low to moderate flood events.

Also during 2018, USGS and DEP presented interim study results at two regional conferences (NYC Watershed Science Technical Conference and Catskill Environmental Research Monitoring Conference) and one national conference (American Geophysical Union Conference).

4.6.5 Watershed Emergency Stream Response and Recovery Plan

The 2017 FAD directed DEP to participate in and report on progress made by a working group to be convened by the NYSDEC to develop an Emergency Stream Response and Recovery Plan. The plan would outline instream and riparian emergency recovery activities traditionally needed both immediately and during the longer recovery period following flood events. The working group did not meet in 2018 and, as a result, the plan has not advanced.

4.7 Riparian Buffer Protection Program

Protecting riparian buffers is a critical component of DEP's Long-Term Watershed Protection Strategy. Privately owned lands contain approximately 64% of the total riparian buffer acreage in the Catskill/Delaware watershed, with many of these buffers protected to some degree by various watershed programs described in Section 4.4 and Section 4.5. This section highlights the protection of riparian buffers on publicly owned or controlled lands and the progress of the Catskill Streams Buffer Initiative (CSBI), including a pilot partnership with the federal Conservation Reserve Enhancement Program (CREP) on fallow agricultural land.

4.7.1 Activities on City-owned or Controlled Land

DEP's Land Acquisition Program (LAP) includes 300-foot buffers on either side of a watercourse as a principal eligibility requirement under the "natural features criteria" set forth in the MOA. Through 2018, approximately 39.3% of the entire Catskill/Delaware watershed was protected by public ownership or conservation easements held by DEP, WAC, NYSDEC, or other entities such as municipalities and land trusts. Within the Catskill/Delaware watershed, 35.8% (89,637 acres) of all stream buffers are protected, including 17.9% protected via City ownership. Through the Streamside Acquisition Program (SAP), DEP executed 10 contracts in 2018 to acquire 80 acres containing streams and buffers within the Schoharie basin.

DEP carefully considers the presence or absence of riparian buffers when it reviews requests from outside parties for projects on City-owned lands. For example, when allowing agricultural use of City-owned lands, DEP requires a minimum 35-foot buffer between farming activities and the stream. Proposals maintaining a larger buffer receive extra points in their rating. DEP reviews all land use permits and proposed projects, including stream crossings, for potential impacts to riparian buffers. Where needed, DEP provides suggestions on how to avoid or mitigate these impacts. DEP secures stream crossing permits as required by NYSDEC and takes extra measures during forestry operations to select best management practices, such as temporary bridges or arch culverts, to minimize impacts on streams and buffers.

4.7.2 Catskill Stream Buffer Initiative

The CSBI is an integral component of DEP's Stream Management Program (SMP) and a cornerstone of the City's efforts to protect and enhance riparian buffers in the WOH watershed. The CSBI works to enhance the extent of riparian buffers through vegetation mapping, riparian corridor planning, buffer restoration, invasive plant removal, and extensive education and outreach. It is worth noting that the 2018 Riparian Buffer Working Group annual meeting focused on learning about new landowner outreach techniques.

Plants are essential to natural stream bank stability, and providing plant materials that are local genotypes of Catskill native species continues to be one of the unique aspects of the CSBI. The CSBI supplies Catskill native plant material through contracts with the Greenbelt Native Plant Center and One Nature, LLC, and carefully considers plant selection, propagation and grow-out techniques. In 2018, DEP and its partners received 5,000 gallon-sized trees and shrubs. Since program inception in 2009, over 59,500 gallon-sized trees and shrubs from locally collected seed have supported planting efforts.

DEP works with five county Soil and Water Conservation Districts (SWCDs) whose CSBI coordinators help participating landowners develop Riparian Corridor Management Plans (RCMPs). These serve to guide project design and educate landowners about their buffers. Since 2009, coordinators have completed 136 RCMPs, including five new RCMPs in 2018.

In 2018, the CSBI completed 15 riparian buffer restoration projects on 4.01 acres of streamside property and over 4,292 feet (0.8 miles) of stream length (Table 4.10). These projects installed 2,042 native Catskill plants and included over 1,802 feet of bioengineering treatments consisting of native willow species mostly harvested from within the watershed.

Table 4.10 Summary of CSBI projects completed in 2018.

Project name	County	Basin	Stream Length (feet)	Area (acres)
Russ Planting	Greene	Schoharie	570	0.53
McWilliams Planting	Greene	Schoharie	210	0.25
Potter Planting	Greene	Schoharie	245	0.23

Project name	County	Basin	Stream Length (feet)	Area (acres)
Aiden Brook/ Brittenham Planting	Sullivan	Neversink	120	0.03
Toohey Planting	Sullivan	Neversink	293	0.25
Route 55 Hydroseeding	Sullivan	Rondout	115	0.09
Pantherkill Planting	Ulster	Ashokan	448	0.47
Degenaars Planting	Ulster	Ashokan	115	0.05
Miller Planting	Ulster	Ashokan	280	0.12
Meislan Planting	Ulster	Ashokan	446	0.09
Hobbs Planting	Delaware	Cannonsville	350	0.26
Siegel Planting	Delaware	Cannonsville	450	0.42
Castellito/ Old Herrick Rd Planting	Delaware	Pepacton	200	0.55
Manhattan Country School Farm Planting	Delaware	Pepacton	250	0.25
SUNY Delhi Outdoor Education Center #3 Planting	Delaware	Cannonsville	200	0.42
Total			**4,292**	**4.01**

Since 2009, the CSBI has completed 212 projects spanning 112.4 riparian acres and over 17.8 miles of stream length (Figure 4.14). These projects installed over 38,220 gallon-sized trees

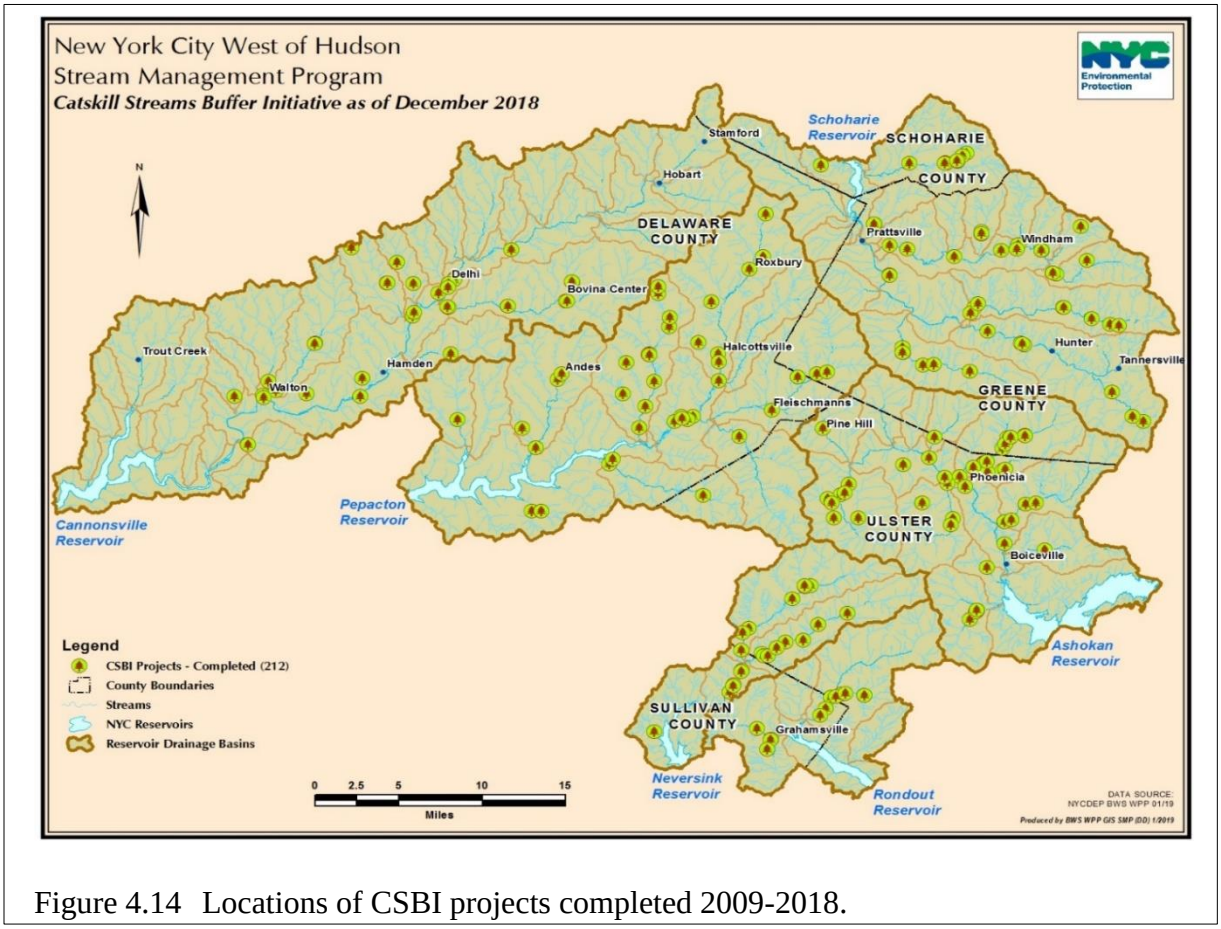


Figure 4.14 Locations of CSBI projects completed 2009-2018.

and shrubs, in addition to plugs, tubelings, and cuttings from willow and dogwood species (all native Catskill species). In 2018, riparian planting activities also took place on nine non-CSBI stream restoration projects, which planted roughly 6,300 feet.

Following installation, county CSBI coordinators monitor projects for five years to document plant survival and growth rates, assess the effectiveness of installation techniques, understand the factors affecting project success, and design follow-up maintenance interventions. The five county CSBI coordinators monitored 50 sites in 2018, 13 for the first time. Coordinators actively monitor 93 sites in total with assistance from summer interns hired through partnerships with Ulster County Community College and the State University of New York.

The first full year of the CREP/CSBI pilot program began in 2018 with outreach to prospective landowners. In Greene and Schoharie counties, CSBI coordinators prioritized parcels and began to solicit landowner interest. In Sullivan County, CSBI coordinators identified few parcels as strong candidates for the pilot based on a GIS assessment, so they did not solicit landowners. Ulster County plans to assess parcels starting in 2019. In Delaware County, four landowners signed contracts for plantings on 19.5 acres, and plantings will begin in 2019.

Additionally, WAC and the Delaware County Soil and Water Conservation District (DCSWCD) distributed a survey to 489 landowners to gauge interest in the pilot program. The survey was returned by 187 respondents, and 72% of these respondents (135 landowners) indicated interest in the program or stated they wanted more information before deciding their level of interest. In 2019, WAC and DCSWCD will follow up with many of these landowners.

Finally, in 2018 the CREP/CSBI Working Group collaborated with NYSDOH and USEPA to develop metrics to evaluate pilot program progress in Delaware County.

4.8 Ecosystem Protection Program

4.8.1 Wetlands Protection Program

DEP aims to safeguard wetlands and the multiple functions they provide to help maintain the high quality of surface waters in the watershed. Implemented in 1996, the Wetlands Protection Strategy was updated in 2018 to reflect current programmatic goals. DEP collects information on the status of wetlands in the watershed and leverages wetlands protection through regulatory means, land acquisition, and multiple stewardship programs.

Regulatory Review

DEP receives notification of applications filed in the watershed under Article 24 of the NYS Environmental Conservation Law, Section 404 of the Clean Water Act, and Connecticut town wetland regulations (Conn. Gen. Stat. Sec. 22a-42f). A subset of NY towns within the EOH watershed voluntarily forward filed wetland permit applications to DEP for review. DEP reviews all of these submittals and provides comments when alternatives that would avoid, minimize, or

mitigate wetland and water quality impacts are identified. DEP's comments often lead to project plan modifications, resulting in less impact and/or improved mitigation than originally proposed.

In 2018, DEP reviewed four NYS Article 24 wetland permit applications for activities within FAD Basins. All of these were for proposed activities within the regulated adjacent area and included no direct wetland impacts. DEP reviewed an additional 19 wetland permit applications in Croton System basins, including nine Article 24, one Section 404, and nine town permit applications (Figure 4.15). The majority of activities reviewed (74%) were for disturbance

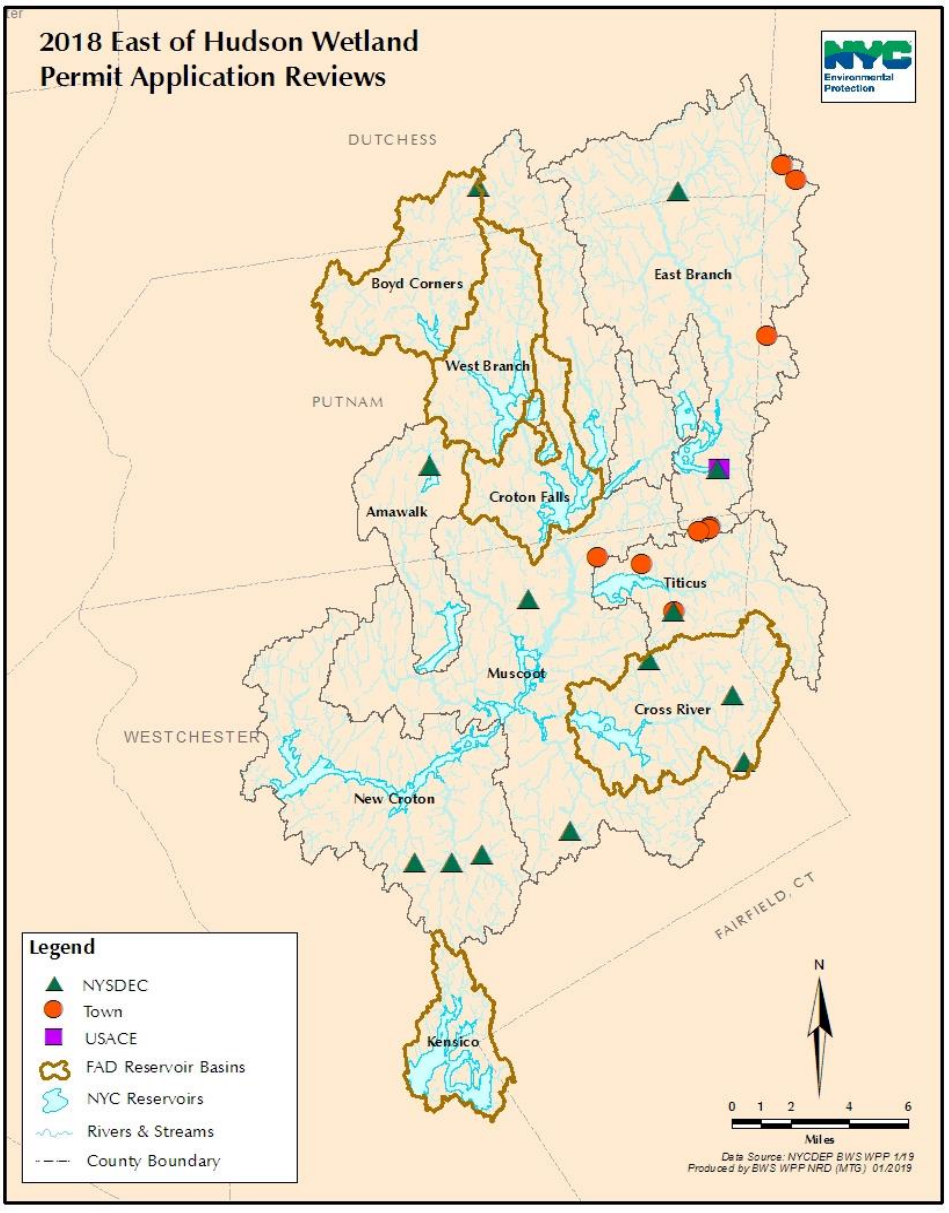


Figure 4.15 Locations of wetland permits reviewed in 2018.

within the adjacent area only. Only three of these permit applications (13%) were for permanent encroachments, each less than 0.05 acre.

In 2018, DEP also provided comments for an *amici curiae* brief submitted to the U.S. District Court for the Southern District of New York by the City and Nassau County in support of the plaintiff's challenge of the 2017 rule to delay the effective date of the 2015 Clean Water Rule. DEP provided comments on the significant functions and extent of wetlands within the watershed that rely on federal regulations for their protection. DEP also reviewed and provided comments on proposed modifications to a NYSDEC Region 4 General Permit for certain activities under Article 15, Article 24, and Section 401 of the Clean Water Act.

Land Acquisition

According to the National Wetlands Inventory (NWI) and NYSDEC Freshwater Wetland maps, there are approximately 15,190 acres of wetlands in the Catskill/Delaware (CAT/DEL) watershed. Since 1997, DEP has protected 2,964 acres or 19.5% of these wetlands through its Land Acquisition Program, 70 acres of which were acquired in 2018 (See Section 4.2 for details of the Land Acquisition Program). In the CAT/DEL watershed, pre-MOA DEP lands contain an additional 973 acres (6.4%) of wetlands, with an additional 1,275 acres (8.4%) of wetlands located on state or other protected lands. This amounts to roughly 34% of wetlands in the CAT/DEL watershed being located on protected lands. Figure 4.16 shows a wetland acquired in

Figure 4.16 Forested wetland on a parcel acquired in the Town of Kent in 2018.

the Town of Kent in 2018. Table 4.11 summarizes the number and acreage of wetlands protected through acquisition for both the CAT/DEL and Croton watersheds.

Table 4.11 Wetlands acquired or protected by the NYC Land Acquisition Program in the Catskill/Delaware and Croton systems as of December 31, 2018.

Description	*Acres*	*% of Total Watershed Acreage*	*% of Total Land Acquired*	*% of Total Wetlands or Deepwater Habitats in System*
For Catskill/Delaware (Ashokan, Schoharie, Rondout, Neversink, Pepacton, Cannonsville, West Branch, Boyd Corners, Kensico basins):				
Total Acreage of Entire Watershed	1,048,660			
Total Acreage of Wetlands (both NWI and DEC-regulated) in Entire Watershed (excluding Deepwater Habitats**)	15,190	1.45%		
Total Acreage of Deepwater Habitats in Entire Watershed	28,335	2.70%		
Total Acreage of Wetlands and Deepwater Habitats in Entire Watershed	43,526	4.15%		
Total Lands Under Contract or Closed by NYCDEP as of 12/31/18†*:	149,626	14.27%		
Within those total lands under contract or closed:				
Total Acreage of Wetlands (both NWI and DEC-regulated, excluding Deepwater Habitats**)	2,964		1.98%	19.51%
Total Acreage of Deepwater Habitats**	194		0.13%	0.69%
Total Acreage of Wetlands and Deepwater Habitats**	3,158		2.11%	7.26%
For Croton:				
Total Acreage of Entire Watershed	212,700			
Total Acreage of Wetlands (both NWI and DEC-regulated) in Entire Watershed (excluding Deepwater Habitats**)	20,025	9.41%		
Total Acreage of Deepwater Habitats in Entire Watershed	10,808	5.08%		
Total Acreage of Wetlands and Deepwater Habitats in Entire Watershed	30,834	14.50%		
Total lands under contract or closed by NYCDEP as of 12/31/18†*:	1,984	0.93%		
Within those total lands under contract or closed:				
Total Acreage of Wetlands (both NWI and DEC-regulated, excluding Deepwater Habitats**)	97.1		4.89%	0.48%
Total Acreage of Deepwater Habitats**	1.6		0.08%	0.02%
Total Acreage of Wetlands and Deepwater Habitats**	98.7		4.97%	0.32%

** Source: WLCP GIS, December 31, 2018. Note: Acres are calculated directly from areas of GIS polygons and therefore may not match exactly other acreage totals submitted by DEP. Watershed statistics calculated from LiDAR-derived 1m basin boundaries updated in 2014.*

*** Categories considered "Deepwater Habitats" include reservoirs or large lakes (L1), unconsolidated bottom (L2UB), riverbeds (RUB & RRB) or streambeds (RSB). Categories considered wetlands include Palustrine Systems and exclude the Deepwater Habitats classes as well as all upland (U), and unconsolidated shore (L2US).*

† Includes fee, conservation easements, and farm easements. Excludes non-LAP and pre-MOA land.

Wetland Mapping

In 2018, DEP developed bid specifications to expand the Light Detection and Ranging (LiDAR) wetland mapping pilot study (DEP 2015) to the entire watershed as required by the 2017 FAD. The pilot study demonstrated that incorporating LiDAR-derived datasets and high resolution aerial photography in object-based image assessment increases the completeness and accuracy of wetland mapping. The pilot also developed methods to improve detection and mapping of connections between wetlands and stream features in the National Hydrography Dataset. Improving the accuracy and completeness of wetland maps will benefit the implementation of many watershed programs, from providing better base maps for reviewing wetland permit applications and other land use proposals to identifying parcels with significant wetlands for acquisition. These data will also provide a new baseline for wetland trends analyses.

Wetland Monitoring

DEP gains information on the characteristics and functions of watershed wetlands through its long-term reference wetland monitoring program. DEP has collected vegetation, soils, and hydrologic data from reference wetlands comprising 117 acres throughout the CAT/DEL watershed for over a decade. These data provide reference standards to guide wetland protection and management efforts.

The 2018 Wetlands Protection Strategy includes a goal to evaluate and refine this monitoring program to ensure the extent and types of reference wetlands reflect the distribution of wetland types in the watershed. To this end, DEP began to evaluate its water table monitoring protocols. DEP initially installed over 30 wetland water table monitoring wells in 18 wetlands between 2004 and 2005. These wells measure water levels at 6-hour intervals and provide baseline hydrographs for various wetland types that can inform wetland establishment and restoration projects. They also serve as a benchmark for assessing long term trends in wetland hydrology due to succession, climate, changes in land use or other unforeseen factors.

In 2018, DEP examined the data from its 31 well locations across 18 wetlands to evaluate whether additional collection was warranted. DEP opted to continue deployment of wells where the long term record was not subject to significant gaps due to equipment malfunction, vandalism, or other disturbances, as complete long term data are most beneficial for long-term trend detection. DEP also sought to retain wells representative of major cover types including emergent, scrub-shrub, hemlock-hardwood forested, and hardwood-forested wetlands, while assessing if any of these cover types are more than adequately represented to avoid redundant data collection. Through this process, DEP identified 11 wells that could be decommissioned. Eight of the 11 wells were decommissioned from forested wetland types, which were found to be over-represented through this and previous analyses.

Decommissioning redundant or failing wells will enable DEP to reallocate resources to other wetland types possibly underrepresented in the program. In 2018, DEP installed a well in a previously unmonitored peat swamp on City lands in the Cannonsville basin, which was found to

be underrepresented in the reference wetlands monitoring program (DEP 2014). DEP has also expanded its monitoring program to include 11 seasonal pools, including two new sites added in 2018. Monitoring wells are installed in four of the seasonal pool sites.

DEP also tested new monitoring well technology in 2018, as the currently deployed Ecotone® brand has been discontinued. The new loggers record water levels by measuring pressure, rather than the copper wire-electrode capacitance system of the Ecotone® model. New loggers were installed immediately adjacent to older wells in three reference wetlands and synchronized to record every six hours (Figure 4.17). The goal is to determine whether there are significant differences in the recorded water levels between the two methods, and whether correction factors need to be applied to either data set to ensure comparability.

Figure 4.17 New water level logger installed between two older loggers in a reference wetland site in the Pepacton Reservoir basin.

In all, DEP collected 6-hour-interval water level data from 28 wells located in reference vegetated wetland and seasonal pool monitoring sites throughout the CAT/DEL watershed in 2018 (Figure 4.18). DEP also collected water quality data (pH, dissolved oxygen, temperature, and specific conductivity) from seasonal pool sites during 14 sampling runs throughout the 2018 growing season. Spring adult breeding amphibian and invertebrate surveys, and amphibian egg mass counts were also conducted at seasonal pool sites. Long-term monitoring of seasonal pool wetlands will provide information on the functions of these important and biodiverse ecosystems

that currently lack federal and state protection. The monitoring may also provide early detection of trends in amphibian populations due to environmental factors or disease.

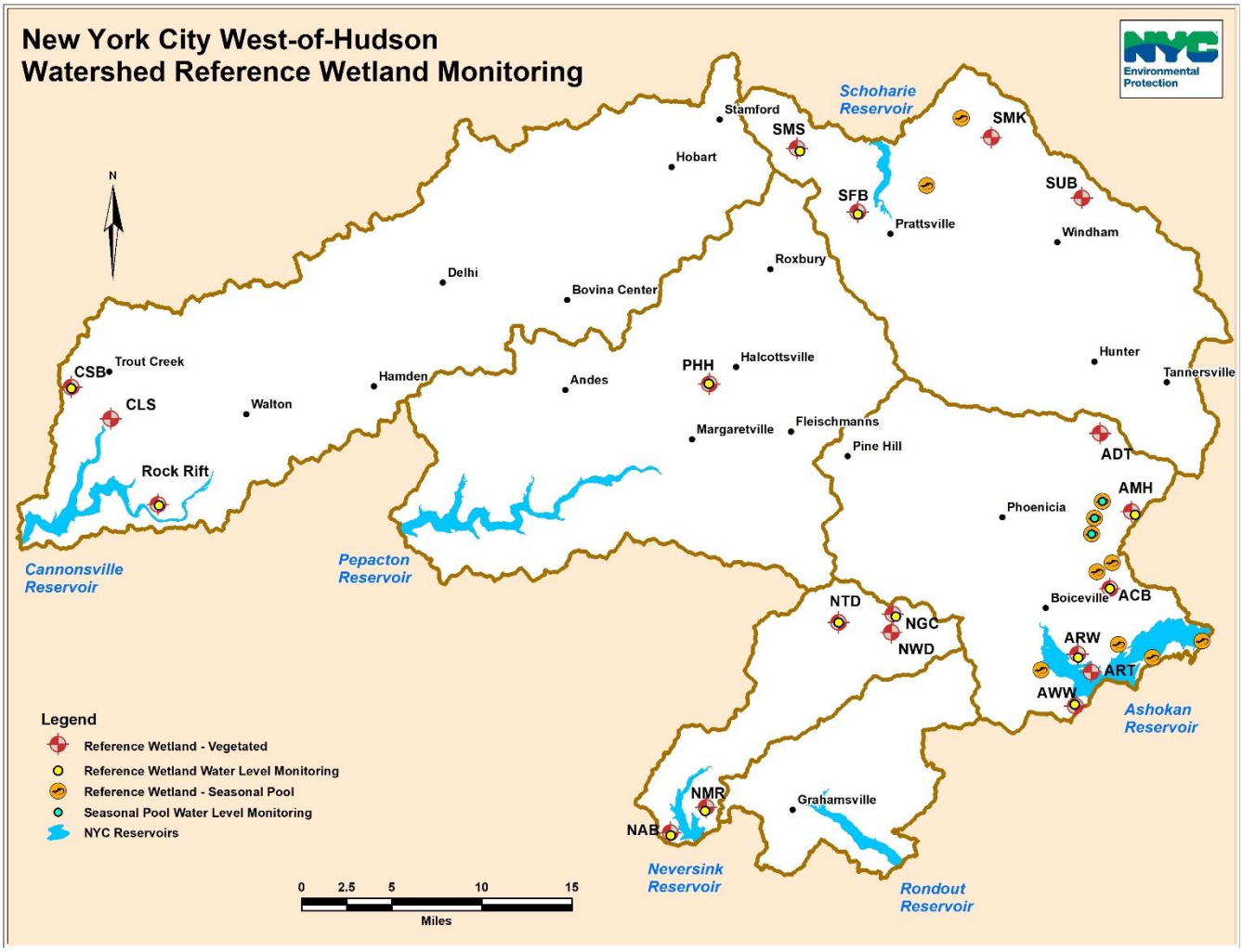


Figure 4.18 Reference wetland monitoring locations in the CAT/DEL watershed. Some study sites have multiple wells installed.

DEP Forest Management Program

DEP conducts an interdisciplinary review of its proposed forest management projects to ensure long-term responsible stewardship of natural and cultural resources on City lands. As part of this review, DEP wetland scientists delineate on-site wetlands, which are treated as exclusion zones in which no disturbance is permitted under normal circumstances. Moreover, the 100-foot-wide area surrounding wetlands is considered a special management zone, within which tree removal and equipment operation are limited. In 2018, DEP delineated 58 wetlands comprising 60 acres at nine proposed forest management projects on City lands. These delineations also

provide DEP with field-scale data on the characteristics of wetlands on City lands and inform remote wetland mapping efforts.

Education and Outreach

Wetlands program staff conducted numerous educational programs for the public and watershed stakeholders. DEP issued a press release for National Wetlands Month in May and included an article on historic wetlands near the Ashokan Reservoir in its recreation newsletter. DEP hosted a wetlands pop-up educational event at Ashokan Reservoir. More than 40 visitors stopped by the display to learn about wetlands in the watershed and speak with staff (Figure 4.19). Wetlands program staff also presented at the annual conference of the New York State Wetlands Forum, participated in the joint Meeting of the New England and Mid-Atlantic Biological Assessment Wetlands Workgroup, and attended the World Fishing & Outdoor Exposition at Rockland Community College, where the DEP's educational pamphlet on wetlands in the watershed was distributed.

Figure 4.19 DEP staff engaging the public at an outreach event at Ashokan Reservoir to celebrate National Wetlands Month.

4.8.2 Forest Management

DEP has an active Forest Management Program staffed by 11 geographically based foresters, a forest resources planner and a program manager. The program manager position is currently vacant due to a retirement in June 2018 and the position is planned to be filled by mid-

2019. Six of the 11 forester positions were added to the organization in the fourth quarter of 2017. The forest planner position was filled and started in May 2018. The additional positions support the growing forest management workload resulting from continued land acquisition and the ongoing implementation of the 2011 Watershed Forest Management Plan.

The program is responsible for the scientific assessment and active management of forest resources on City land. Most of these projects are timber harvests. Salvage, stewardship and restoration projects are involved as well. The overall goal is to promote forest vigor, resistance, and resiliency to protect and enhance water quality over the long term.

In 2018, the program successfully awarded five new forest management projects. Table 4.12 lists each project, its respective basin, and area of the project in acres.

Table 4.12 2018 Awarded Forest Management Projects.

Project Name	Basin	Acres
Torino Cove	Ashokan	80
Yagerville	Rondout	83
Cannon Hollow	Cannonsville	106
Turkey Mountain	New Croton	145
Road X	Neversink	307
Total		721

The program also substantially completed the planning and internal review of five additional projects that will be bid out in early 2019. (Table 4.13)

Table 4.13 2018 Forest Management Projects – Internal Review Complete.

Project Name	Basin	Acres
Conklin Ledges	Neversink	152
Ulster Heights	Rondout	57
Bear's Den	Cannonsville	161
Heavy Nettle	Cannonsville	95
Damsite	Ashokan	148
Blind Miller	Ashokan	137
Total		750

Finally, substantial program time in 2018 was spent developing an Out-year Plan (a rolling, five-year plan of priority projects including target bid dates), revamping WaLIS to help manage an increased project workload, developing regional strategies, and formulating a list of program initiatives to create a blueprint for program activities and future priorities.

The emerald ash borer (EAB), a non-native invasive insect, continued to spread westerly through the Catskill/Delaware system and affect all ash trees, which comprise 7% of City-owned forestland. Due to the rate of EAB spread, DEP continues to implement a mitigation strategy as

opposed to management. The strategy focuses on identifying dense stands of ash, and reducing the safety risk posed by dead and dying roadside and recreation area ash trees on City lands. To this end, DEP has been implementing ash harvests in the western part of the Ashokan basin and similar projects in the Pepacton basin.

One of these projects, the Snake Pond Forest Management Project (awarded 2017) is still ongoing. Snake Pond in the Pepacton basin is a popular recreation area along the Shavertown Trail. The ash in this area is still EAB-free and this project is part of DEP's efforts to get ahead of the insect where possible. Since this area is popular for recreation, this project has also provided a unique opportunity for outreach and education (Figure 4.20). An interpretive sign was designed and posted at the recreation area along with an invasive species boot brush station.

Figure 4.20 On the left, pre-salvage of white ash on the Snake Pond Forest Management Project to improve forest health in the Pepacton basin. On the right, interpretative sign at Snake Pond.

In June, the program awarded CAT-467, Watershed Forest Inventory and Analysis for NYC Water Supply Lands, to LandVest, Inc. This $449,500 supply and service contract involves conducting forest inventory and analysis on LAP fee lands acquired between from 2009 through 2016. A total of 3,025 inventory plots will be sampled across 29,894 acres of acquired properties. Between June and October, LandVest completed inventory of 575 plots representing

5,719 acres of City land. Inventory will resume in the spring when understory vegetation is developed enough for accurate identification. A deliverable of this contract will be a series of reports summarizing forest conditions on new lands and will be used to revise the Watershed Forest Plan in 2027. The last plan update was completed in 2017, as required by the FAD.

In 2018, the Forestry Program continued working on a contract to improve the condition of City-owned pre-MOA forest land in the EOH watershed. Activities undertaken will include forest thinning aimed at commercial and non-commercial timber, mechanical and chemical control of invasive species, tree and shrub enrichment planting and reforestation, and deer-herbivory control. Work in 2018 focused on identifying the field sites and necessary treatments for the first two years of work under the contract. Initial efforts will be focused on 260 acres of degraded forest along the New Croton Reservoir, the terminal reservoir of the City's Croton System. The goal of the stewardship work is to improve the ability of the City's watershed foresters to contribute to water quality protection through improved forest condition and to pilot stewardship contracting in anticipation of future contracts. Work is planned to commence in summer 2019.

Continuous Forest Inventory

Since 2002, the Forest Science Program unit of NYCDEP's Ecological Research and Assessment section has been establishing and measuring permanent forest plots across City water supply lands to collect data to deepen our understanding of forest health, diversity and productivity; and changes that occur over time. This data contributes to development of data summaries, formulae and models that accomplish the following:

- Enable prediction of forest growth, mortality and recruitment of new seedlings into the forest over time.
- Allow estimation of merchantable tree heights or timber volumes from diameter measurements.
- Improve generation of acceptable construction project seed mixes and plant palettes based on regional vegetation patterns.
- Increase understanding of forest-habitat relationships.
- Verify whether applied silviculture techniques are contributing to achieving goals of increasing diversity in and among stands related to species, size classes, ages, etc.

Such long-term ecological assessment studies are necessary to guide decisions that will ultimately lead to healthy, managed, resilient, diverse forests that best protect water quality.

In 2018, plots were added on MOA lands in the Pepacton basin. At present, 417 permanent plots have been established watershed-wide, with all plot locations mapped with GPS and each tree on every plot documented with numbered tags. Plot establishment on MOA lands in the Cannonsville basins remain to be completed over the next year or two. With two

measurements at different times available on over 100 plots and varying ages available across the watershed, DEP can soon begin developing growth, mortality and recruitment models. These models can be further developed into management models to forecast results of different applied strategies in the years to come.

4.8.3 Invasive Species

In 2018, DEP continued to implement the Invasive Species Management Strategy submitted as a FAD deliverable at the end of 2016. The strategy outlines actions to prevent new introductions of invasive species; detect new infestations early and respond to them rapidly; control and manage existing populations to support specific projects; mitigate the impacts of species that cannot be otherwise managed; and restore sites to prevent further impacts. This work is predominantly accomplished through intra-agency collaboration and partnerships.

Intra-Agency Collaboration

The Invasive Species Working Group (ISWG) was formed within DEP in 2008 to develop and implement a science-based, comprehensive plan to identify, prioritize, and address invasive species threats to the water supply. The ISWG met three times in 2018 and formed new sub-committees to address monitoring for invasive mussels and to develop a policy for drafting from reservoirs for firefighting operations. The ISWG discussed ongoing projects and updates, the use of drones for invasive species monitoring, and the agency's response to the detection of zebra mussel (*Dreissena polymorpha*) veligers in the Muscoot River and Amawalk Reservoir.

Partnerships

New York State Invasive Species Advisory Committee

DEP has a seat on the New York State Invasive Species Advisory Committee (ISAC), created through state legislation in 2007 to provide information, advice, and guidance to the New York State Invasive Species Council (ISC) on invasive species impacts, prevention, regulation, detection, and management in the state. In 2018, DEP's representative served as vice chair of the committee. The ISAC covered topics including the planned state agency response to spotted lanternfly (*Lycorma delicatula*), biocontrol development for swallow wort (*Cynanchum* spp.) and other species and the new NYS Invasive Species Comprehensive Management Plan. DEP attended four ISAC meetings in 2018.

Catskill Regional Invasive Species Partnership

DEP continued to work regionally with partners on invasive species management in the Catskill region. In 2018, DEP worked with the Catskill Regional Invasive Species Partnership (CRISP) to finalize the five-year strategic plan and develop metrics to measure progress. DEP participated in CRISP quarterly meetings, served on the steering committee, helped prioritize a species list, and aided in decision-making on project funding.

Lower Hudson Partnership for Regional Invasive Species Management (PRISM)

DEP continued to partner with the Lower Hudson PRISM and NYSDEC to survey for giant hogweed (*Heracleum mantegazzianum*) within the watershed. Due to the risk of serious injury and blindness, the state has been working to eradicate giant hogweed since 2008. No plants were found for the first time in 10 years on City lands in the Croton Falls Reservoir basin in the Town of Carmel. These sites will now be monitored for three years before achieving an eradication designation. DEP and the Lower Hudson PRISM are also partnering on the removal of silver vine (*Actinidia polygama*), an early detection species for New York State that crosses City and private lands. DEP serves on the Steering Committee for the PRISM and facilitates the working groups for capacity building tasks.

Prevention and Pathway Risk Management

Policies are one tool DEP employs to prevent the introduction of invasive species. In 2018, DEP BWS Emergency Planning Section drafted a Wildland Firefighting Dipping/Scooping Operations Policy to guide the use of City waterbodies as sources for aerial firefighting support. The policy contains a decontamination protocol for aircraft to prevent the introduction of new species. Traditional firefighting operations were also identified as another potential vector through drafting of water for tankers. A sub-committee of the ISWG was formed to explore a policy to address this. That effort is ongoing.

Internal protocols are another way DEP minimizes the risk of introduction and spread of invasive species. In 2018, DEP sought to formalize a more effective protocol for flushing the internal compartments on all boat engines. DEP also revised a policy to limit field staff from moving downstream of Amawalk Reservoir without decontaminating gear due to the presence of zebra mussel veligers in that reservoir.

To minimize the risk posed by watershed recreation users, DEP shares prevention messages through education and outreach activities. In 2018, DEP installed a boot brush station at the Shavertown Trail Head in the Pepacton Reservoir basin to help eliminate the movement of invasive plant seeds on hikers' boots. The station includes an informational sign and a set of mounted boot brushes with a gravel catchment pad underneath (Figure 4.21).

DEP and CRISP held a ribbon cutting ceremony for the station during the annual statewide Invasive Species Awareness Week and garnered some media attention that helped amplify this message. DEP also conducted table outreach at the Cold Spring and Pakatakan farmers markets and published an article in DEP's recreation e-newsletter as part of the week's activities.

Early Detection and Rapid Response

In addition to the giant hogweed and silver vine responses that DEP continued to work on, DEP initiated several other rapid response efforts to attempt to eradicate early detection species.

In 2018, DEP began treating the infestation of *Hydrilla* in New Croton Reservoir. This pilot effort targeted populations in two isolated coves distant from intakes and employed a granular formulation of fluridone herbicide (Sonar H4C) designed for use around potable water intakes. Early results show success in reducing the population with limited dispersal of the herbicide in the reservoir, but there is still a great deal of plant material in the reservoir that needs to be managed. DEP also continued to collaborate with NYSDEC on downstream management efforts in the Croton River.

Figure 4.21 Boot brush station at the Shavertown Trail Head near Pepacton Reservoir.

DEP Water Quality staff identified a very small, new infestation of water chestnut (*Trapa natans*) in New Croton Reservoir just below the Muscoot dam. The entire infestation was hand pulled in an afternoon by interns from Ulster Community College with support from DEP Water Quality and Operations staff.

DEP staff and Ulster Community College interns surveyed a large forest stand near Titicus Reservoir and identified over 100 Amur cork trees (*Phellodendron amurense*) as a rapid assessment of this emerging species. Plans are underway for a response in the coming years.

Control and Management

DEP continued to manage priority invasive species on City lands in 2018 through manual and mechanical removal, herbicide applications, and biological control. Cornell University released 1,020 tooth-necked fungus beetles *(Laricobius nigrinus*), the second biological control agent for hemlock woolly adelgid (*Adeliges tsugae*) introduced to the watershed, at two sites on City lands around Schoharie and Pepacton reservoirs. Cornell will continue to survey for the silver flies (*Leucopis* spp.) they released in 2016 and 2017 and study their impacts on hemlock woolly adelgid populations. They may augment these populations in 2019 with additional releases.

Mitigation of Impacts

DEP participated in a new project to identify lingering ash trees in 2018. The Ecological Research Institute designed the Monitoring and Managing Ash project with researchers from the US Forest Service. They trained 30 DEP staff and partners on the project and the protocols for

identifying and surveying ash trees that may hold some resistance to emerald ash borer (*Agrilus planipennis*). DEP staff and Ulster Community College interns set up four ash mortality monitoring plots throughout the WOH watershed. More information about this project is available at: www.monitoringash.org.

Zebra mussels are another species that can have a significant negative impact on the water supply. DEP first received reports of mussels present in Lake Mahopac, an upstream lake that feeds the Muscoot River and Amawalk Reservoir, in 2015. In 2018, DEP surveyed the river and found attached adults. Veligers were collected in both Amawalk Reservoir and the Muscoot River below Amawalk Dam. This discovery propelled an exploration of alternatives to mitigate the impacts to the system through infrastructure improvements and other initiatives. DEP staff are collaborating across directorates to stay on top of this infestation through expanded monitoring efforts and upgrades to water supply systems.

Restoration

DEP staff continue to give attention to the reforestation project at Kensico Reservoir where Superstorm Sandy left large blowdowns in close proximity to the reservoir. Invasive species management of Japanese angelica tree (*Aralia elata*) and mile-a-minute weed (*Persicaria perfoliata*) supports the success of tree plantings (Figure 4.22). Ultimately, the goal is to achieve

Figure 4.22 Superstorm Sandy blowdown reforestation project plantings with Japanese angelica tree control.

a canopy of native tree species. But this requires several years of management including invasive species suppression efforts.

4.9 East of Hudson Non-Point Source Pollution Control Program

The EOH Nonpoint Source Pollution Control Program seeks to address wastewater-related and stormwater-related nonpoint pollutant sources in the four EOH Catskill/Delaware basins: West Branch, Croton Falls, Cross River, and Boyd Corners.

4.9.1 Wastewater Programs

Septic Reimbursement Program

DEP provides support to Westchester and Putnam counties in their efforts to reduce the potential impacts of improperly functioning or maintained septic systems. Westchester County, Putnam County, and their respective municipalities continue to implement the septic requirements of the NYSDEC MS4 General Permit. As required by the permit, municipalities and counties continue to implement programs for the inspection, maintenance, and rehabilitation of septic systems.

DEP also continues to implement the Septic System Rehabilitation Reimbursement Program in the West Branch, Boyd Corners, Croton Falls, and Cross River basins in partnership with the New York State Environmental Facilities Corporation (EFC). In 2018, DEP worked with EFC to expand program eligibility so that septic systems located in basins upstream or hydrologically connected to the Croton Falls Reservoir will be eligible in 2019.

During 2018, EFC issued reimbursement payments to eligible homeowners for seven septic repairs. In April, EFC directly mailed eligible residents a letter describing the program and providing contact information. As required by the 2017 FAD, DEP submitted a report on methods to increase awareness and program participation. Following the report, DEP undertook additional education and outreach initiatives. As part of this effort, DEP contacted local officials and key staff (e.g. town supervisors, engineers, planners, MS4 coordinators, local health officials) to describe the program and provide information. DEP also distributed program literature at applicable public places such as town halls and libraries.

Community Wastewater Planning Grant Program

During the reporting period, DEP entered into discussions with the New England Interstate Water Pollution Control Commission to assist with the development and implementation of a new EOH Community Wastewater Planning Grant Program that is required by the 2017 FAD. Discussions have focused on the scope of services to be provided by the commission and the structure of the resulting grant program.

4.9.2 Stormwater Retrofit and Remediation

DEP continues to advance two nonpoint source pollution reduction projects for Maple Avenue (Town of Bedford, Westchester County) and Drewville Road (Town of Carmel, Putnam

County). DEP has completed designs for both projects and construction will proceed under one contract. During 2018, DEP made significant progress toward securing the contract needed for construction, which was awarded to R. Pugni & Sons, Inc. DEP held the pre-award meeting in May, registered the contract in October and issued the Notice to Proceed in November. The contractor anticipates mobilization to occur in the first half of 2019.

4.9.3 Stormwater Facility Inspection and Maintenance

DEP developed the Facility Inspection and Maintenance Program to ensure that previously constructed stormwater remediation facilities continue to function as designed through routine inspections. New facilities are added to the program and maintenance is completed under the warranty in each facility's construction contract during the first year and under DEP's maintenance contract thereafter. Inspection and maintenance follow procedures contained in the maintenance contract. During 2018, DEP inspected all facilities approximately three times each, with 38 facilities requiring vegetation removal, 28 requiring sediment and debris removal, 20 requiring stone riprap repairs, and two requiring fence repairs. All stormwater facilities are functioning as designed.

4.9.4 Stormwater Retrofit Grant Program

DEP previously established a $20 million grant program funded through the EOH Watershed Corporation (EOHWC) for eligible municipalities to construct the stormwater retrofits needed to satisfy permit obligations of EOH municipalities under Section IX.A.5.b of the NYSDEC MS4 General Permit. All of these funds were expended on stormwater retrofit projects. The 2017 FAD requires DEP to provide the EOHWC with another $22 million to support the construction of additional stormwater retrofits in the EOH FAD basins. During 2018, DEP completed contract negotiations with EOHWC for this new funding and issued the Notice of Award in December. DEP anticipates registering the contract by September 2019.

4.10 Kensico Water Quality Control Program

4.10.1 Wastewater-Related Nonpoint Source Pollution Management Programs

Septic Reimbursement Program

DEP implements the Kensico Septic System Rehabilitation Reimbursement Program through a contract with EFC. The program reimburses homeowners a portion of the costs to rehabilitate eligible failing septic systems or connect those systems to an existing sewage collection system. During 2018, EFC mailed the annual reminder letter to eligible residents and issued one septic reimbursement to an eligible homeowner. As required by the 2017 FAD, DEP submitted a report on methods to increase awareness and program participation. Following the report, DEP undertook additional education and outreach initiatives. As part of this effort, DEP contacted local officials and key staff (e.g. town supervisors, engineers, planners, MS4 coordinators, local health officials) to describe the program and provide information. DEP also distributed program literature at applicable public places such as town halls and libraries.

West Lake Sewer

The West Lake Sewer Trunk Line, owned and maintained by the Westchester County Department of Environmental Facilities (WCDEF), conveys untreated wastewater to treatment facilities located elsewhere in the county. DEP previously funded the installation of a sanitary sewer remote monitoring system for the trunk line to provide real-time detection of problems such as leaks, system breaks, overflows, and blockages. To date, there have been no overflows or concerns and the units appear to be working well. In 2018, DEP conducted an annual visual inspection of the trunk line to assess the condition of exposed infrastructure and routine partial inspections throughout the year related to ongoing maintenance of Kensico stormwater BMPs near the line. DEP noted no defects or abnormalities.

4.10.2 Stormwater-Related Nonpoint Source Pollution Management Programs

BMP Construction, Inspection and Maintenance

DEP has constructed 47 stormwater management and erosion abatement facilities throughout the Kensico watershed to reduce pollutant loads to the reservoir. DEP and its contractor inspected and maintained these facilities, shown in Figure 4.23, throughout 2018, according to the O&M guidelines. Maintenance consisted of grass mowing, vegetation removal, tree removal, and sediment and debris removal. All BMPs are performing as designed.

Wildlife Sanitary Surveys

DEP conducts wildlife sanitary surveys to prevent wildlife excrement from washing into the Kensico Reservoir and potentially elevating levels of fecal coliform bacteria. DEP has identified sampling locations based on proximity to the Delaware Aqueduct Shaft 18 water intake location, which are surveyed approximately 24 to 48 hours prior to significant precipitation events. DEP developed a system of locating, identifying, and removing wildlife excrement as a proactive effort to reduce fecal coliform bacteria and other pathogens from potentially entering the water supply.

During 2018, DEP and its contractor conducted eight wildlife sanitary surveys in advance of significant precipitation events at Kensico Reservoir (Table 4.14). Of the 372 fecal samples collected, 55% were attributed to white-tailed deer (*Odocoileus virginianus*), 16% to eastern cottontail rabbits (*Sylvilagus floridanus*), 5% to opossum (*Didelphis marsupialis*), 4% to raccoons (*Procyon lotor*), and less than 4% to other mammals. Avian species excrement included 7.5% from Canada geese (*Branta canadensis*) and 5% from passerine bird species.

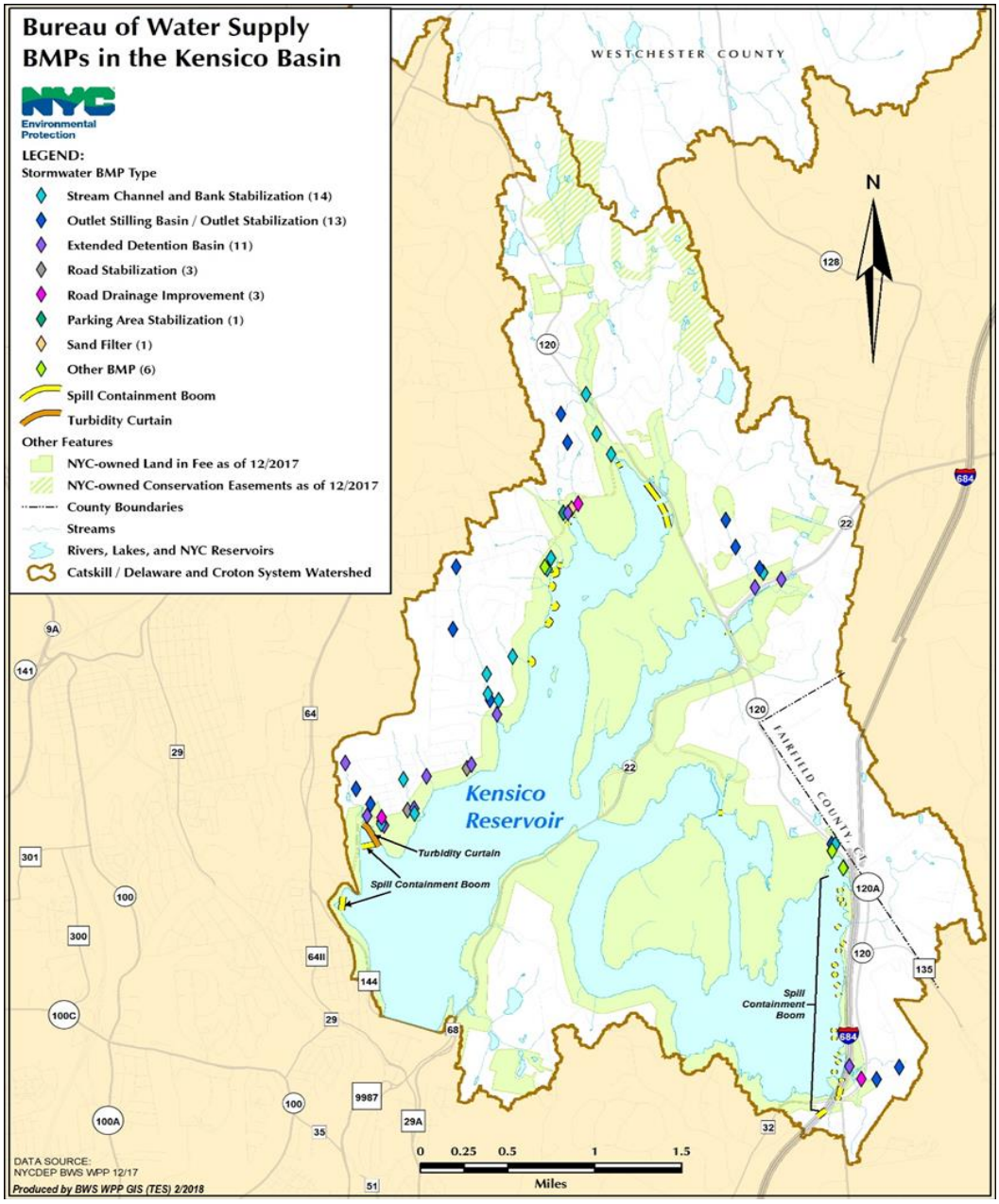


Figure 4.23 BMPs within the Kensico Reservoir Basin.

Spill Containment Facilities

DEP maintains spill containment facilities in and around Kensico Reservoir to improve spill response and recovery, and to minimize water quality impacts in case of a spill. In 2018, DEP conducted routine maintenance at the spill boom sites to ensure they are available in the event of a spill. There were no spills that required the deployment of booms. However, in

December there was a release of 2 gallons of motor oil into a Kensico tributary. The oil was contained and removed using hydrocarbon absorbents.

Table 4.14 Kensico Reservoir 2018 wildlife sanitary surveys.

Species	3/1	9/17	10/10	10/26	11/1	11/9	12/14	12/20	Total
White-tailed deer	6	7	11	26	31	46	40	37	204
Rabbit	22	4	13	0	5	15	0	1	60
Canada goose	24	1	0	0	1	0	2	0	28
Opossum	0	0	0	1	0	16	3	0	20
Passerines	0	6	0	3	0	7	3	1	20
Raccoon	5	0	1	1	0	5	0	1	13
Mink	0	0	0	2	0	0	0	4	6
Striped skunk	0	2	0	0	0	0	2	0	4
Coyote	0	1	0	1	0	0	0	0	2
Domestic dog	1	0	0	0	0	0	0	0	1
Unknown Mammal	1	2	0	0	0	0	11	0	14
Totals	**59**	**23**	**25**	**34**	**37**	**89**	**61**	**44**	**372**

Shaft 18 Shoreline Stabilization

Since the Catskill/Delaware Ultraviolet Disinfection Facility (CDUV) began operating, all water in the Kensico Reservoir flows through the Delaware Effluent Chamber at Shaft 18 on the reservoir's southeast shore. Increased reliance on Shaft 18, together with changing weather patterns, necessitates shoreline stabilization measures near the effluent chamber to maintain turbidity levels in compliance with state and federal water quality standards. Stabilization measures will include approximately 700 feet at the western shoreline and approximately 475 feet at the cove area. In 2018, DEP awarded the contract to H&L Construction, issued the construction Notice to Proceed and held the preconstruction meeting. DEP anticipates mobilization will commence in the first half of 2019.

4.10.3 Other Kensico Management Programs

Turbidity Curtain

DEP continues to monitor the extended primary curtain and the back-up turbidity curtain that are designed to direct flows from Malcolm and Young brooks farther into the body of Kensico Reservoir. DEP inspected both turbidity curtains during 2018 to ensure they are properly functioning. No immediate repair work was required and the curtains appear to be functioning as intended.

Effluent Chamber Dredging

DEP continues to evaluate the potential need for dredging in relation to the construction of the connection between Kensico Reservoir and the CDUV. As noted in previous FAD reports, DEP anticipates completing this evaluation in 2020.

Westchester County Airport

DEP continues to review any activities proposed at or in relation to the Westchester County Airport due to its proximity to Kensico Reservoir, including the Park Place development project. DEP is currently reviewing a revised Stormwater Pollution Prevention Plan that was submitted in October 2018 for the proposed 980-space parking garage.

In June 2018, DEP attended a public hearing on airport operations led by Westchester County Executive George Latimer. More than 200 people attended and allowed Westchester County to gather feedback on issues relating to flight paths, noise pollution, ground and surface water pollution, and future airport expansion.

Pursuant to the state's emerging contaminants program, NYSDEC continues to investigate an uncapped landfill located on airport property. In April 2018, NYSDEC conducted water sampling at the base of the landfill where accumulated iron flocculent is noted and within an unnamed tributary to Kensico Reservoir. It is DEP's understanding that NYSDEC and Westchester County officials are reviewing those sampling results in consideration of a potential remediation plan.

4.11 Catskill Turbidity Control

4.11.1 Implementation of Catskill Turbidity Control Alternatives

Due to the nature of its underlying geology, the Catskill watershed is prone to elevated levels of turbidity in streams and reservoirs. High turbidity levels are associated with high flow events, which can destabilize stream banks, mobilize streambeds, and suspend the glacial clays beneath the streambed armor. The design of the Catskill System considers local geology and provides for settling within Schoharie Reservoir, Ashokan West Basin, Ashokan East Basin, and the upper reaches of Kensico Reservoir. Under normal circumstances, the extended detention time in these reservoirs is sufficient to allow the turbidity-causing clay solids to settle out and the system easily meets the SWTR turbidity standards (5 NTU) at the Kensico effluent. Occasionally after extreme rain/runoff events in the Catskill watershed, DEP has used aluminum sulfate (alum) as chemical treatment to control high turbidity levels.

Since 2002, DEP has undertaken several studies and implemented significant changes to its operations to better control turbidity in the Catskill System. Many of these measures have been implemented pursuant to the 2002 and 2007 FADs and the Shandaken Tunnel and Catalum State Pollutant Discharge Elimination System (SPDES) permits. A comprehensive analysis, the Catskill Turbidity Control Study, was conducted by DEP with the Gannett-Fleming-Hazen and Sawyer Joint Venture in three phases between 2002 and 2009. Based on the results of this study,

DEP implemented several alternatives: a system-wide Operations Support Tool (OST) that allows DEP to optimize reservoir releases and diversions to balance water supply, water quality, and environmental objectives; an interconnection of the Catskill Aqueduct at the Delaware Aqueduct Shaft 4 to improve overall system dependability; and structural improvements to the Catskill Aqueduct stop-shutter facilities. The interconnection and the stop-shutter facilities projects achieved functional completion in 2016.

Operations Support Tool

The Operations Support Tool (OST) couples computer models of reservoir operating rules and water quality; assimilates near real-time data on stream flow, water quality, and reservoir levels; and ingests streamflow forecasts to predict reservoir levels and water quality up to a year into the future. It is a decision-support system: water supply managers make decisions based on guidance from OST in combination with other forecast information; knowledge of system infrastructure status and other conditions; water supply BMPs; and years of experience operating the system. DEP uses OST daily for operational decisions, as well as planning and policy evaluation purposes.

During 2018, OST was updated to reflect the 2017 Flexible Flow Management Program (2017FFMP) agreement as well as the 2016 USGS new bathymetry survey for the West of Hudson reservoirs. In addition, OST was enhanced with the capability for, alternatively, simulating using previous Decree Party Delaware river basin release agreements. During 2018, the focus continued to be on using the system to support operational decision-making and planning, including the simulation and analysis of the Catskill Aqueduct outage to support daily operations during the shutdown. Standard modeling practices, such as ongoing evaluation of model performance, forecast verification, and fine-tuning of model code and algorithms, were performed. New software was developed to visualize and export model output, making the use of OST more efficient and providing additional information to support system managers, including during Catskill Aqueduct shutdowns. Over 1,750 model runs were executed in 2018, an increase of 46% compared to 2017 and underscoring the value and purpose of OST for water supply operations and management.

National Academies Expert Panel review

In September 2016, the National Academies of Sciences, Engineering and Medicine (NASEM) commenced a two-year project to conduct an expert panel review of the City's use of OST for water supply operations and identify ways the City can more effectively employ OST to manage turbidity. The expert panel had several goals:

- Evaluate the effectiveness of the City's use of OST for water supply operations and identify ways in which the City can more effectively apply OST to manage turbidity.

- Evaluate the performance measures/criteria the City uses to assess the efficacy of the Catskill Turbidity Control Program and recommend additional performance measures if necessary.
- Review the City's proposed use of OST in evaluating the suggested modification to the Catalum SPDES Permit as well as the alternatives to be considered in the environmental review of those proposed changes.
- Review DEP's existing studies of the potential effects of climate change on the City's water supply to help identify and enhance understanding of potential future concerns in the use of OST.

The last meeting of the expert panel was held on April 5-6, 2018, and the final report was released on September 25, 2018 (https://www.nap.edu/catalog/25218/review-of-the-new-york-city-department-of-environmental-protection-operations-support-tool-for-water-supply). The expert panel strongly endorsed OST for guiding the operation of NYC's water supply, managing risks such as droughts and turbidity events, and planning for the future effects of climate change. Recommendations were included to improve and maintain OST in the years ahead. DEP is carefully reviewing the recommendations and will meet with NYSDOH, NYSDEC, USEPA and the watershed inspector general in early 2019 to discuss the findings.

Catalum Consent Order and Environmental Review

Rain events in October and December 2010 caused elevated turbidity levels in the Ashokan Reservoir. In addition to alum at Kensico, DEP also utilized the Ashokan Release Channel as part of a strategy previously approved by NYSDOH and EPA to ensure all drinking water standards were met. Using the release channel raised concerns from communities along the Esopus Creek downstream of the reservoir.

In February 2011, NYSDEC commenced an administrative enforcement action against the City for alleged violations of the Catskill Aqueduct Intake Chamber Catalum SPDES Permit (NY0264652) regarding operation of the Ashokan Release Channel and alum addition. NYSDEC and DEP negotiated a consent order to resolve the alleged violations, which took effect in October 2013. The consent order included penalties, environmental benefit projects, a schedule of compliance, and an Interim Release Protocol for the release channel's operation.

Consistent with the consent order, DEP in June 2012 requested a modification to the Catalum SPDES Permit to incorporate turbidity control measures in water diverted from Ashokan Reservoir and to postpone dredging of alum floc at Kensico Reservoir until completion of certain infrastructure projects. The proposed modification is subject to environmental review under the State Environmental Quality Review Act (SEQRA), for which NYSDEC is lead agency. NYSDEC released a draft scope for the Catalum environmental impact statement (EIS) for public comment from April 9, 2014, to August 29, 2014. Over 900 comments were received from over 550 commenters. The Final Scope was issued on March 22, 2017, and it takes into

consideration feedback from the public review process and includes responses to the comments received. The EIS is underway, and a draft DEIS will be submitted to DEC by May 31, 2019.

5. Watershed Monitoring, Modeling, and GIS

5.1 Watershed Monitoring Program

5.1.1 Routine Water Quality Monitoring

To ensure the delivery of high quality drinking water, DEP conducts extensive water quality monitoring encompassing all areas of the watershed, including sites at aqueducts and water supply intakes (keypoints); streams; reservoirs; and wastewater treatment plant (WWTP) facilities. DEP's monitoring objectives for 2018 are documented in the Watershed Water Quality Monitoring Plan (WWQMP) (DEP 2017) and its associated addenda, which are designed to meet the broad range of DEP's regulatory and informational requirements. The overall goal is to establish an objective-based water quality monitoring network providing scientifically defensible information regarding the protection and management of the New York City water supply.

The plan's objectives have been defined by the requirements of those who ultimately require the information, including DEP program administrators, regulators, and other external agencies. The plan prescribes monitoring to achieve compliance with all federal, state, and local regulations; meet the terms of the Revised 2007 FAD (NYSDOH 2014); enhance the capability to make predictions of watershed conditions and reservoir water quality; and ensure delivery of the best water quality to consumers through ongoing surveillance. Many specific objectives fall within each of these major areas.

Compliance: The compliance objectives are focused on meeting the regulatory monitoring requirements for the New York City watershed. This includes the Surface Water Treatment Rule (SWTR) (USEPA 1989) and its subsequent enhancements, the New York City Watershed Rules and Regulations (WR&R) (DEP 2010), administrative orders, and State Pollutant Discharge Elimination System (SPDES) permits. The sampling sites, analytes, and frequencies are defined in each objective according to each permit, rule, or regulation.

FAD program evaluation: The USEPA specified many requirements in the 2007 FAD (USEPA 2007) meant to protect public health and NYSDOH has continued to specify requirements in the Revised 2007 FAD. These requirements have continued in the 2017 FAD promulgated in December 2017. These requirements form the basis for the City's ongoing assessment of watershed conditions, changes in water quality, and any modifications to the strategies, management, and policies of the Long-Term Watershed Protection Program (DEP 2016b). The City also conducts a periodic assessment of the program's effectiveness using DEP's water quality monitoring data. Program effects on water quality are reported in the Watershed Protection Program Summary and Assessment reports (e.g., DEP 2016c), which are produced every five years.

Modeling support: Modeling data are used to meet the long-term goals for water supply policy and protection and to provide guidance for short-term operational strategies when unusual

water quality events occur. These objectives are achieved through implementation of watershed and reservoir model improvements based on ongoing data analyses and research results; ongoing testing of those models; updating of data necessary for the models' development; and development of data analysis tools to support modeling projects.

Stream, reservoir, aqueduct, and meteorological data are all needed to develop, calibrate, and validate models. Data acquired through stream monitoring include both flow and water quality data. Aqueduct monitoring provides flow and reservoir operations data to support reservoir water balance calculations. The water balance and reservoir water quality data are needed to test, apply, and further develop DEP's one- and two-dimensional models. The meteorological data collection provides critical input necessary to meet both watershed and reservoir modeling goals. The modeling program's 2018 activities are summarized in the Watershed Water Quality Annual Report (see Section 5.2 for details on accessing the report).

Surveillance monitoring: The surveillance monitoring chapter of the WWQMP contains several objectives that focus on aqueduct monitoring to guide the short-term operation of the water supply system. Other objectives relate to developing a baseline understanding of potential contaminants (trace metals, volatile organic compounds, and pesticides) and summarize how DEP monitors for zebra mussels. Zebra mussel monitoring is meant to trigger actions to protect the infrastructure from becoming clogged by these organisms if they are found. The remaining objectives pertain to recent water quality status and long-term trends for reservoirs, streams, and benthic macroinvertebrates in the Croton System. It is important to track the reservoirs' water quality to be aware of developing problems and to proactively pursue appropriate actions.

5.1.2 Additional Water Quality Monitoring

In addition to routine monitoring, events or incidents may occur that necessitate additional water quality monitoring. Almost 1,400 additional watershed samples were collected for special investigations during 2018, including 110 stream samples, 966 reservoir samples, and 77 pathogen samples.

These special investigations (SIs) include monitoring related to the activation of the Croton Water Filtration Plant and blending of Croton and Catskill waters; testing effectiveness of an ultrasonic algal control project; implementation of an invasive species control project; activation of the Cross River Pumping Station; and other smaller, less intensive monitoring events. The major 2018 SI efforts are outlined below.

Special Investigation: Croton activation and Croton/Catskill blend

To help minimize the drawdown of Kensico and West Branch reservoirs, the Croton Water Filtration Plant (CFP) began delivering water to the City's distribution system in October. Some consumers began registering taste and odor complaints with DEP, describing a musty odor. DEP addressed this by shutting the CFP down to assess the situation. The plant was then restarted with a blend of Catskill and Croton water. Enhanced water quality monitoring of the

Croton keypoints at the Croton Lake Gatehouse (mid-basin) and Gatehouse 1 (dam), as well as increased limnological monitoring of New Croton Reservoir provided data for identification of the optimal tap and operation of the system during the blend. Through this enhanced monitoring effort and tracking of consumer complaint calls, DEP was able to gradually scale back the proportion of Catskill water used, and eventually returned to full use of Croton water with the consumer complaints remaining at baseline levels.

Special Investigation: Ultrasonic Control of Algae

DEP initiated a pilot project in 2018 to study the potential for controlling algal blooms with ultrasonic technology. The study targeted Croton Falls Reservoir for phase one (deploy an ultrasonic buoy prior to any observed blooms) and New Croton Reservoir for phase two (deploy the second buoy after visible blooms were observed).

Each study area consisted of four sites: a treatment site with the ultrasonic buoy, a control site outside of the range of the ultrasonic probes, and two transect sites in-between them. A YSI EXO water quality sonde outfitted with a total algae probe was deployed at both treatment and control sites and logged data every 15 minutes throughout the project. Samples were collected weekly at all sites for phytoplankton, chlorophyll a, total phosphorus and total dissolved phosphorus analyses at 1 meter below the surface and 1 meter off of the bottom. Dissolved oxygen profiles were also collected weekly at each site. Twice monthly zooplankton tows were collected at each site and algal toxin samples were collected monthly. DEP sent zooplankton and algal toxin samples to independent contract labs for analysis.

The study was inconclusive and a draft report was sent to NYSDEC in February 2019.

Special Investigation: Invasive Species Control

DEP opened a special investigation to evaluate the fate and transport of an applied chemical herbicide in New Croton Reservoir for the treatment of the aquatic invasive plant *Hydrilla*. A contractor applied fluridone (trade name Sonar Genesis) at two selected treatment areas in the reservoir from May through November 2018. Seven New Croton reservoir sites were selected to quantify the presence and extent of fluridone transport in the reservoir before, during, and after application. In addition, two keypoint sites were also monitored for the presence of this chemical. DEP collected grab samples weekly and shipped them to a contract lab. Reservoir samples were taken at the thermocline if present, so temperature profiles were taken to identify the thermocline at each site. Due to trace levels of fluridone persisting past the end of application, weekly samples were collected until December when samples from all sites returned non-detect results.

Special Investigation: Cross River Pump Station Activation

Due to the shutdown of the Catskill Aqueduct, a plan was in place to use the Cross River pump station in fall 2018 to supplement the water supply. The activation of this pump station requires preliminary sampling to determine water quality and subsequent approval by NYSDOH.

This sampling is performed a minimum of two weeks prior to the actual activation of the pump station. This enhanced monitoring consists of daily grab sampling at the pump station, weekly pathogen sampling and weekly limnological sampling at two sites in Cross River Reservoir. Additionally wastewater treatment plant inspection sampling increased during the preliminary monitoring and the use of the pump station. In 2018, this extra sampling was needed for 45 days to support operational decisions.

The Cross River Pump Station was operated from October 29-October 31, 2018, and an after-action report was issued on January 3, 2019.

Special Investigation: Kensico Stream (N5) Turbidity

In mid-September 2018, contractors cleaning the flow control structure at a tributary to Kensico Reservoir noticed a cloudy white discharge coming from upstream. The flow control structure was turned off and samples were taken that day. The milky discharge persisted for several days and it was determined that a broken water main was eroding surrounding soils consisting of gray-colored clay sediment. After repair of the main, the water in the flow control structure was slowly released into the reservoir and contained with a turbidity curtain in the receiving cove. Field sampling crews helped deploy the turbidity curtain and collected daily turbidity profiles and samples near the curtain and farther out in the reservoir to confirm that reservoir water quality was not impacted. The enhanced sampling was conducted for 17 days to monitor and confirm that water quality in Kensico remained unaffected.

Robotic Monitoring

DEP utilizes a Robotic Water Quality Monitoring Network (RoboMon) as part of its routine monitoring program. High-frequency data obtained by the network are critical for ensuring effective water supply management during storm events, providing early warning of water quality conditions, and helping to formulate management actions guiding the water supply system's operation. It also provides data essential for model development. The network includes fixed-depth buoys (including two under-ice buoys), profiling buoys, and several stream installations. The RoboMon network made over 1.3 million measurements in the watershed in 2018.

5.1.3 Wastewater Treatment Plant Protozoan Monitoring

WWTP protozoan monitoring in Filtration Avoidance watersheds seeks to demonstrate that microfiltration and technologies deemed equivalent continue to perform well with respect to protozoan removal from the effluents of the plants. In 2018, DEP collected 41 protozoan samples from 10 wastewater treatment plants throughout the NYC watershed. Eight plants were monitored in the WOH basins and two plants in the EOH basins (Figure 5.1 and Figure 5.2). FAD monitoring is scheduled on a quarterly basis at these 10 plants. An exception in 2018 was the Grahamsville plant, which was sampled five times. An extra sample was added in January 2018 to make up for a missed sampled in the fourth quarter of 2017. This sample was reported

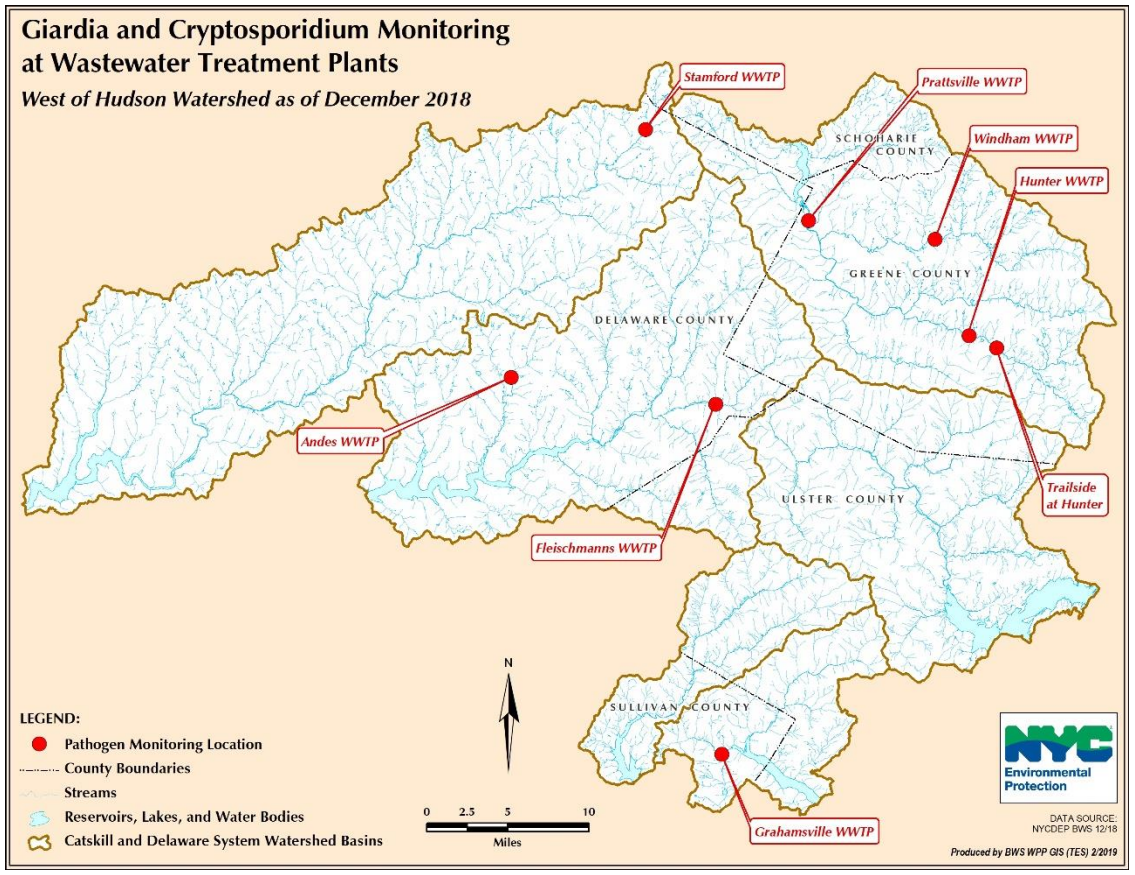


Figure 5.1 Wastewater treatment plants monitored for *Giardia* and *Cryptosporidium* in 2018 in the WOH watersheds.

with data from 2017 in the FAD Annual Report for that year, and will not be discussed further in this report.

Each sample for *Cryptosporidium* and *Giardia* involved the field filtration of 50 liters of water from the plant's effluent or a similar tap location after disinfection. Samples were analyzed by DEP according to USEPA Method 1623.1 (USEPA 2012). Three samples were positive for *Giardia* at WOH plants (Trailside at Hunter LLC, Hunter, and Windham), and one of those samples (Windham) was also positive for *Cryptosporidium* oocysts. Each of these three positive samples, and relevant plant conditions at the time of sampling, are discussed below.

On January 23, a sample was taken at Hunter WWTP and found to have one *Giardia* cyst in the 50.0L filtered sample. The facility operator was contacted to obtain background information on plant operations during the time of the sample. The operator noted flow for the day was 345,000 gallons due to 1.5 inches of rain along with warm weather causing snowmelt. The rain event followed a busy ski weekend. Plant storage tanks were full and the plant was processing 300 GPM when the protozoan sample was taken that day. Operators had been

experiencing coagulant and flocculent issues that day and they switched the sand filters (from sand filter #3 to #2) after the sample was taken. The maximum turbidity reached on that day was 0.50 NTU but only for an instant. Despite the sand filter change, effluent turbidity still continued to run up to 0.49 NTU at 5:00PM. A follow-up inspection was conducted on February 1 and the

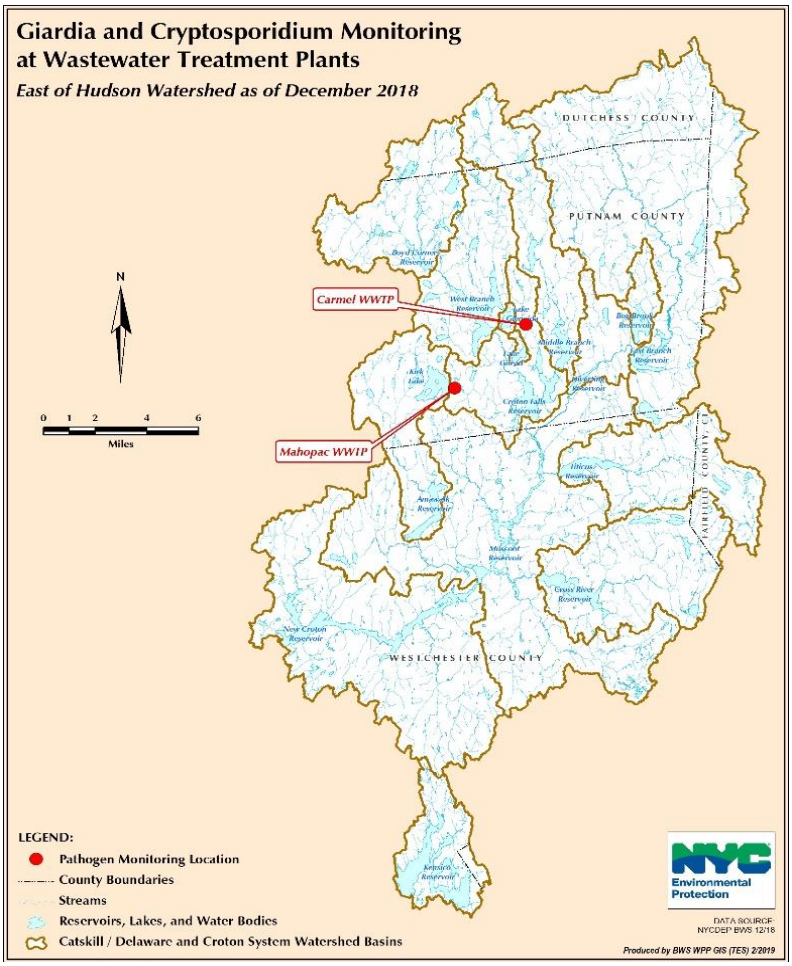


Figure 5.2 Wastewater treatment plants monitored for *Giardia* and *Cryptosporidium* in 2018 in the EOH potential FAD watersheds.

continuous backwash upflow dual sand filters were working well. The filters have been air lanced quarterly, and prior to the sample, were most recently air lanced at the beginning of January. The #3 filter unit was air lanced again following the positive sample result.

On February 27, a protozoan sample taken at the Trailside at Hunter LLC wastewater plant was found to have 73 *Giardia* cysts in the 52.8L sample (equivalent to about 69.1 *Giardia* cysts $50.0L^{-1}$). After the positive result, plant operators were asked about any operational issues or process abnormalities. Operators noted higher than normal turbidity going into the sand filters

due to strainers clogging upstream of the sand filters, which caused the poly aluminum chloride to overdose. Overdoses of poly aluminum chloride are known to bind up the filter media and operators suggest this may have caused the higher than normal *Giardia* level. A new supervisory control and data acquisition system is planned for this plant, which would control dosages and turbidities more efficiently.

As follow-up, DEP inspectors visited the Trailside at Hunter plant on March 6 and made the following suggestions for the interim period: avoid draw-down of the equalization lagoon so low that it pulls in detritus, increase the basket pore size, put the second filter train online and perhaps use that to test alternate coagulant doses, and work with their chemical supplier to determine the most effective coagulant and dose.

On September 12 a protozoan sample taken at Windham wastewater treatment plant was found to have one *Giardia* cyst and four *Cryptosporidium* oocysts in the 50.0L sample. DEP inquired with plant operators about any abnormal processes around the time of the sample. The operator indicated they had recently switched filter beds and may have stirred something up. No other process abnormalities were noted.

All EOH FAD quarterly samples were collected at the Carmel and Mahopac wastewater treatment plants in 2018 and all were negative for *Giardia* or *Cryptosporidium*.

5.2 Multi-Tiered Water Quality Modeling Program

DEP's Water Quality Modeling Program uses models to quantify the impact of climate change, land-use changes, components of the watershed protection program, the water supply system's operation, and water demand on the quantity and quality of water delivered to the City. A detailed description of water quality modeling progress and activities in 2018 will be included in the Watershed Water Quality Annual Report, which will be available on the DEP website after its submittal on July 31, 2019. (http://www.hyc.gov/html/dep/html/watershed_protection/fad.shtml).

A brief summary of these activities is provided here.

In DEP's multi-tiered approach, climate models are used to provide meteorological inputs to watershed, reservoir, and system operation models. Climate models generate time series of weather conditions and, particularly, the occurrence of extreme events under both current and future climate conditions.

In 2018, a regionalization analysis of historic precipitation data in the WOH watersheds was completed. This analysis identified contiguous regions where observed precipitation magnitude and occurrence were similar. The analysis then formed the basis for a stochastic weather model to estimate rainfall magnitude and occurrence at ungauged sites in the watersheds during the recent past.

Also in climate modeling, DEP identified that downscaled future climate data for areas in the United States including the Catskill Mountain region is available from several major universities and government research centers. After reviewing alternative sources, DEP selected the Multivariate Adaptive Constructed Analog datasets of downscaled Global Climate Model forecasts (https://climate.northwestknowledge.net/MACA/) for further analysis.

Combining the downscaled forecasts with the stochastic weather generator DEP developed in 2016-17, future time series of weather conditions, containing extreme events not captured in historic observations, were generated. These weather forecasts were used as input to the Generalized Watershed Loading Function (GWLF) hydrologic model to evaluate streamflow in each of the West of Hudson watersheds under future climate conditions. A similar approach was taken to generate future time series of weather conditions for the Esopus Creek watershed draining to Ashokan Reservoir. In this analysis, the GWLF model's streamflow predictions were used to generate predictions of stream turbidity using an empirical turbidity-streamflow relationship developed using a quantile regression approach.

In 2018, the Water Quality Modeling section continued the application and testing of the Soil Water Assessment Tool – Hillslope (SWAT-HS) model to watersheds draining to Cannonsville Reservoir. A paper describing the effect of input data complexity and resolution on the accuracy and uncertainty in SWAT-HS predictions for runoff quantity was published in 2018. Another paper under review describes the validation of streamflow predictions of SWAT-HS for seven sub-watersheds in the Cannonsville watershed for which USGS stream gaging is available.

In addition, the predictions of dissolved and particulate phosphorus loading for the West Branch Delaware River inflow to Cannonsville Reservoir were validated against measurements. The model was applied to predict the impacts of wastewater treatment plant upgrades and agricultural nonpoint source management on phosphorus loading. Also, application and testing of the Regional HydroEcologic Simulation System model for the Biscuit Brook and Shelter Creek watersheds draining to Neversink Reservoir concluded. Similarly, progress was made on the application of the General Lake Model/Aquatic EcoDynamic to Cannonsville Reservoir.

Lastly, the second annual progress meeting with regulators to discuss water quality modeling results was held on October 10, 2018, at DEP's Kingston office. Representatives of the NYSDOH and USEPA attended. DEP staff gave an overview of modeling activities during the previous year, with questions, answers, and follow-up discussion between DEP and regulatory agency staff.

5.3 Geographic Information System

DEP utilizes its Geographic Information System (GIS) for multiple purposes: to support numerous FAD and MOA programs; to manage the City's interests in water supply lands and facilities; to display and evaluate the efficacy of watershed protection through maps, queries, and analyses; and to support watershed, reservoir, and operational modeling efforts. Primary GIS

resources include a centralized geodatabase (the GIS library), the Watershed Lands Information System (WaLIS), and Global Positioning System (GPS) technology. This report summarizes GIS technical support for programs and modeling applications; the completion or acquisition of new GIS data layers; improvements to GIS infrastructure; and dissemination of GIS data.

5.3.1 GIS Technical Support

In 2018, DEP continued to use its GIS to perform technical support and data development for a variety of watershed protection programs and modeling applications. For example, DEP created customized statistical reports and maps depicting land ownership, land cover extent, hydrographic and topographic features, riparian and flood zones, water supply facilities, or program implementation status over particular basins or political boundaries. These analyses were developed for program design and planning, engineering screening, regulatory jurisdiction determination, emergency response, water supply operations, and recreational outreach.

DEP continued using digital elevation models (DEMs) to generate custom sub-basin boundaries for specific water quality sampling locations. DEP also incorporated DEMs into global climate models to generate local predictions of future climate conditions. DEP continues to rely on data sets such as reservoir bathymetry, SSURGO2 soils, land cover, and land use to drive model analyses.

In 2018, DEP analyzed hydrography and land cover GIS layers to target parcels in WOH basins for potential enrollment in the CREP/CSBI pilot program. We used a complex set of criteria based on parcel size, land cover and distance to watercourses. DEP also performed a comprehensive GIS analysis of land cover, land ownership, and wetland types within 300-foot stream buffers for the EOH FAD basins as part of a FAD-mandated assessment report submitted in September (Figure 5.3). DEP used GIS to plan for the expansion of the EOH septic program in basins upstream of Croton Falls and to target and prioritize specific wastewater service areas in the EOH FAD basins for video inspection based on water quality monitoring data, areas of new development, and areas that still require sewer infrastructure mapping (Figure 5.4). DEP also developed GIS data and maps in support of the Ashokan Rail Trail project in partnership with Ulster County.

5.3.2 Completion or Acquisition of New GIS Data Layers and Aerial Products

Under contract with DEP, USGS is using boat-based sonar to conduct bathymetric surveys of all 13 reservoirs and three controlled lakes in the EOH watershed according to the same specifications used for WOH reservoir bathymetry mapping. During 2018, USGS completed survey field work for the remaining five reservoirs not initially surveyed in 2017, and began data clean-up and processing to produce bathymetric surfaces, including identification of data gaps requiring additional field work in 2019.

Also in 2018, DEP obtained the latest version of SSURGO2 soils data from the USDA and numerous other data updates from the NYS GIS Clearinghouse, including transportation

features. DEP edited and updated several existing feature classes and mission-critical data sets, such as county-wide tax parcels, City-owned lands or interests, state-owned lands, water supply facilities, stream restoration projects, septic repairs, and engineering project locations. DEP updated EOH Designated Main Street Areas with information from the Regulatory and

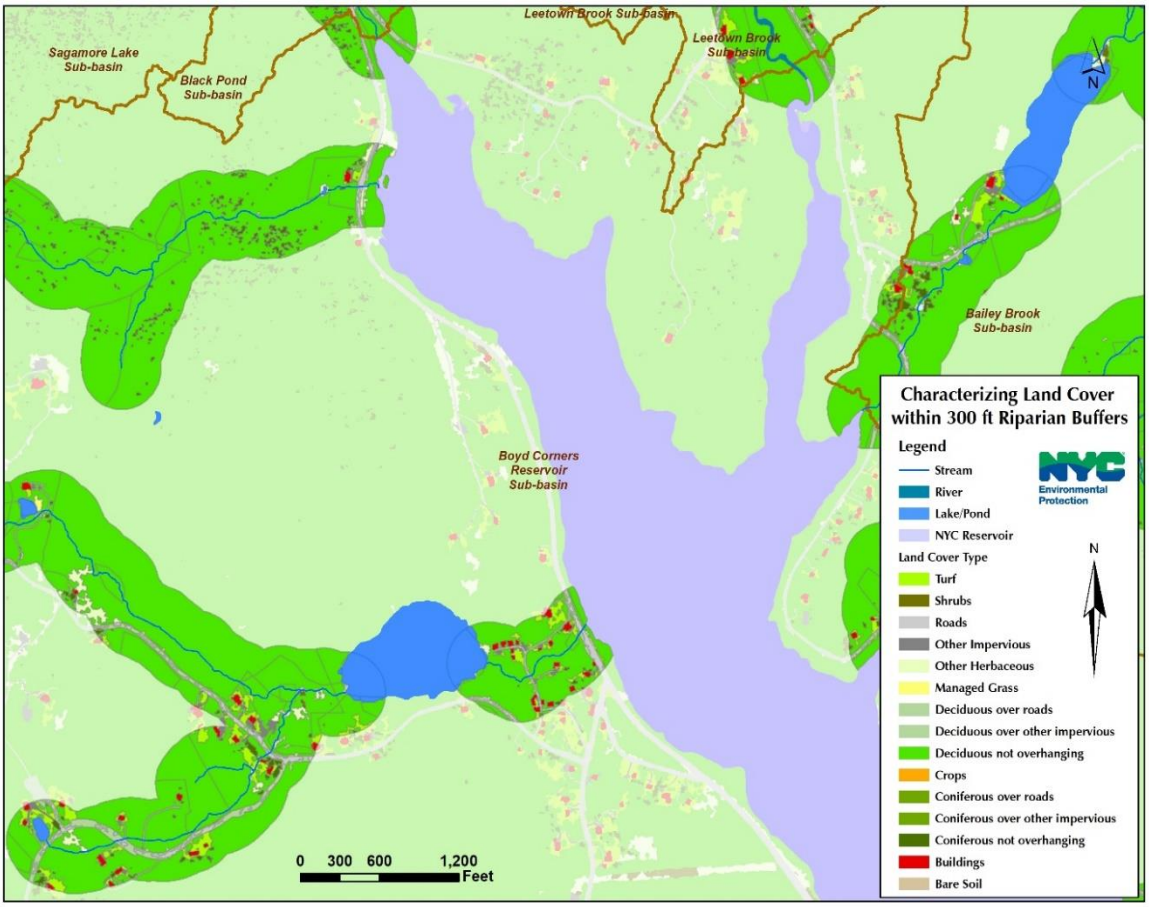


Figure 5.3 Example of land cover composition within 300-foot riparian buffers in the Boyd Corners sub-basin.

Engineering Program. Based on field verification, DEP made annual corrections and additions to National Hydrography Dataset (NHD) mapped water features, including all associated GIS layers that are dependent on hydrography data. DEP also received updated locations of sensitive, threatened, or endangered species on City-owned lands from the New York Natural Heritage Program to supplement data collected by the DEP Wildlife Studies Program.

5.3.3 GIS Infrastructure Improvement

During 2018, DEP migrated GIS and WaLIS databases to new server infrastructure, which resulted in a marked improvement in application speed for WaLIS and GIS due to the faster servers.

DEP continued to maintain its GIS infrastructure by upgrading ArcGIS Desktop software; diagnosing database performance issues; updating schemas and servers to improve database speed; building and testing new geodatabase scripts; evaluating and refining user security levels on servers for different databases; and backing up all databases. DEP continued

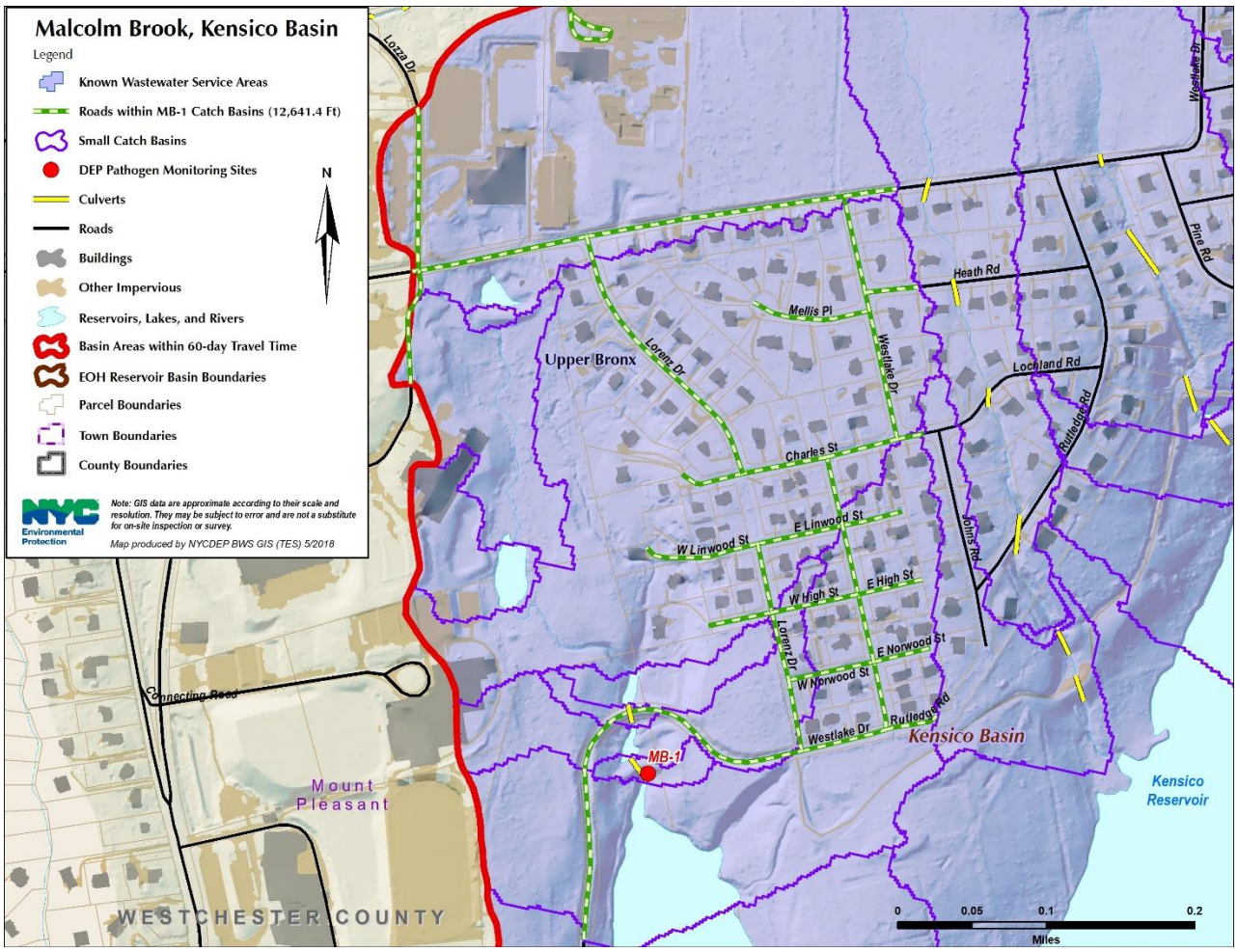


Figure 5.4 Results of an analysis using LiDAR-derived small catchment basins, hydrography, culverts, high-resolution impervious surface cover, road networks, and water quality sampling sites to target areas for sanitary sewer inspection in the Kensico basin.

building an ArcGIS Portal to support web-based mapping capability and enhance data sharing. DEP also monitored and analyzed the performance of GIS and WaLIS software, provided guidance and training to WaLIS users as needed, and performed routine maintenance on GPS units, including updating software and replacing or upgrading GPS hardware.

DEP also continued to upgrade and maintain WaLIS, which currently operates on 234 DEP user workstations. DEP released new versions of WaLIS to address certain issues and provide additional functionality. DEP developed field data collection techniques for the input of logistical information into the emergency response module of WaLIS, including digital photo points and other GPS functionality. DEP continued developing and managing forestry data in WaLIS in preparation for the upcoming forest inventory on City-owned lands. This included developing new GIS methodology and software tools to support overall forestry data cleanup.

5.3.4 Data Dissemination to Stakeholders

Using established in-house data sharing policies, DEP continued to review all outside requests for GIS data and provide these data to watershed partners and interested parties as required. Each year, DEP provides over 50 stakeholders and communities with semi-annual data updates in January and July for newly-acquired and existing City-owned lands. In 2018, DEP also shared its watershed recreation data with the Catskill Center and Ulster County. Throughout 2018, DEP responded to data sharing requests from NYSDOH, NYSDEC, WAC, CWC, Catskill Center, and various counties, towns, and consultants working on DEP-related watershed projects.

6. Regulatory Programs

A primary component of DEP's overall watershed protection strategy is the enforcement of applicable environmental regulations, which include but are not limited to, the New York City Watershed Rules and Regulations (WR&R), the NYSDOH Appendix 75-A Wastewater Treatment Standards, the NYSDEC SPDES General Permit for Stormwater Discharges from Construction Activity, and the New York State Environmental Quality Review Act (SEQRA). Of these, the primary mechanism for protection of the water supply is via administration of the WR&R.

DEP's regulatory efforts are focused on three primary functions: review and approval of land development projects within the watershed; inspection of the following: wastewater treatment plants, new subsurface sewage treatment systems and active construction sites; and, pursuit and resolution of violations of the WR&R.

6.1 Project Review

Land development projects in the City's watershed, including those sponsored by DEP, are reviewed to ensure compliance with the WR&R. Activities that typically require DEP review and approval include wastewater treatment plants (WWTP), sewer collection systems, subsurface sewage treatment systems (SSTS), projects requiring the preparation of stormwater pollution prevention plans (SWPPP), and the construction of certain impervious surfaces. In addition, DEP reviews and issues individual residential stormwater permits (IRSP) and stream crossing/piping/diversion permits for other stormwater-related activities.

DEP also ensures erosion control measures during construction are properly sited and maintained. Post-construction, DEP makes sure projects that require SWPPPs or IRSPs have installed the necessary long-term best management practices. In addition, DEP reviews and offers comments on permit applications submitted to NYSDEC for activities such as mining operations, timber harvesting, industrial activities, landfill closures, stream disturbance and wetland incursions. DEP input is sought in accordance with the DEP/NYSDEC Memorandum of Understanding.

Lists of the new projects received during the previous calendar year in both the select East of Hudson reservoir basins and all West of Hudson basins are included in the Semi-Annual FAD report. The project lists represent all stormwater, variance, and new or repaired intermediate SSTS applications. The semi-annual Project Activities report also includes project summaries and maps reflecting project locations. In 2018, there were 11 new commercial septic applications, two WWTP applications, 17 sewer connection applications, 22 stormwater applications and one variance application. In addition, there were three mining permit reviews, 16 stream disturbance permit reviews, eight timber harvest reviews and five other type projects within the Catskill and Delaware watersheds.

6.1.1 SEQRA Coordination

DEP conducts reviews and provides detailed comments on all SEQRA notices received for land development projects and activities in the City's watershed. DEP's SEQRA Coordination Group tracks all applications, maintains a database of new and amended notices, tracks development trends in the watershed, and coordinates with local, state, and federal entities that regularly act as lead agencies pursuant to SEQRA.

The semi-annual report includes a summary and mapping of all SEQRA reviews performed by DEP during the previous calendar year.

6.1.2 Delegation Agreements

The Westchester and Putnam County health departments review new, modified, and repaired SSTSs in accordance with their respective delegation agreements with DEP. The Ulster County Health Department reviews new SSTSs in accordance with its delegation agreement with DEP.

During 2018, DEP received documentation relative to 66 delegated SSTSs; 20 of these reviews are attributed to subsurface sewage treatment systems in the WOH watershed with the remaining 46 delegated SSTS applications located in the select EOH FAD Basins.

6.2 Enforcement Activities

DEP investigates, documents and issues Notices of Violation (NOV) for a wide variety of errant activities including failing SSTSs, non-compliant SWPPPs, projects that commence construction without prior DEP approval, and pollutant-laden discharges in the watershed. Enforcement actions are prepared with input from both DEP's Bureau of Legal Affairs and Corporation Counsel of the City of New York. In addition to coordinating with NYSDEC, county health departments, municipal code enforcement officers, and the Catskill Watershed Corporation, DEP routinely refers water quality violations to partner agencies where DEP's authority under the WR&R relative to the activity is limited or non-existent. Examples of violations that DEP fully documents and refers to NYSDEC's regional offices are discharges from sites covered by industrial SPDES permits, such as concrete or asphalt manufacturing facilities. In 2018, there were three new NOVs opened, and nine NOVs closed that are detailed in the Semi-Annual Report.

The primary function of the DEP Police with respect to watershed enforcement is regular patrol of the watershed on a daily basis documenting a wide range of potential water quality incursions. Police employees receive over 300 hours of training in environmental law and regulations, provided in part by DEP watershed protection staff, as well as 170 hours of practical field training in water supply infrastructure protection. DEP police have the authority to issue summonses and notices of warning/violation of the state Environmental Conservation Law and the WR&R, as well as other state and local codes. DEP regulatory staff work cooperatively with

the DEP Police to ensure that citizen complaints of potential illicit environmental activity are investigated and addressed in a timely manner.

6.3 Wastewater Treatment Plant Compliance and Inspection Program

DEP's Wastewater Treatment Plant Compliance and Inspection (WWTPCI) Program conducts a quarterly compliance inspection at each surface-discharging WWTP that operates on a year-round basis. A minimum of two compliance inspections per year are conducted during the operating season at seasonal surface-discharging facilities. Similarly, at least two compliance inspections per year are conducted at non-contact cooling water discharges to surface waters, groundwater remediation systems, landfills, and oil/water separators. Treated industrial waste discharges to groundwater, via ground surface application, are inspected four times per year. This does not preclude DEP from performing inspections with greater frequency. DEP may also conduct unannounced facility inspections to manage instances of non-compliance, respond to abnormal or emergency operating conditions, react to mistakes or problems with self- monitoring data or record keeping, discuss DEP laboratory sampling results, oversee modifications or expansions to a facility, and fulfill special requests by internal agency management.

When violations are identified at WWTPs, DEP coordinates enforcement activities with NYSDEC, USEPA, NYSDOH, and the New York State Attorney General's Office through the quarterly Watershed Enforcement Coordination Committee (WECC) meetings. At these meetings, the operational status of watershed WWTPs is discussed and steps are taken to ensure adequate enforcement activities are pursued to achieve compliance.

6.3.1 Facility Compliance in the Catskill/Delaware Watershed

Thirty-one WOH WWTPs were inspected by DEP on a regular schedule in 2018. Of these, 26 are permitted for year-round discharge and five for seasonal discharge. Three of the 31 are wastewater treatment facilities permitted to discharge to groundwater. These are the hamlet of Chichester, Mountainside Farms, and Hanah Country Club. Three other facilities are classified as industrial non-contact cooling water discharges. These are Friesland Campina- DOMO, Kraft Dairy and Saputo Foods. Altogether, DEP conducted 146 scheduled compliance and emergency response inspections in 2018.

Compliance with State Pollution Discharge Elimination System (SPDES) permits continued to improve among WWTPs in the Catskill/Delaware watersheds in 2018, due in large part to the WWTCPI Program. The Village of Hunter experienced five overflows of untreated sanitary sewage at its pump stations between June 2017 and August 2018. Causes ranged from an accumulation of fat, oil and grease within the sewer main to an incomplete transfer from auxiliary power to the pump control panel to a flawed alarm condition at the village's drinking water treatment plant. The NYSDEC issued an NOV on September 11, 2018, with deadline of January 11, 2019, for corrective measures to eliminate the problems. The Village of Hunter took several steps to fix the problems.

- Contracted a septic hauler to vacuum the line and remove the fat, oil and grease.
- Installed a new generator transfer switch.
- Installed a new high capacity pump at the Liftside pump station; several gas powered trash pumps were purchased in the event of excess hydraulic load to the station.
- The water treatment plant programmed a high level alarm to prevent the pumps from sending water to the backwash surge tanks and causing an overflow into the wastewater collection system.
- An inflow and infiltration investigation will be performed to evaluate the integrity of the collection system.

DEP participates in Compliance Conferences (CC) with those facilities that continue to violate their SPDES permit limits and/or monitoring requirements. CCs are usually conducted after repeated attempts by DEP to remediate the problem with the facility owner and/or operator have failed. DEP, in conjunction with NYSDEC and local regulatory authorities, sends out an NOV letter prior to calling for a CC. DEP did not conduct any CCs in 2018. Many problematic and outdated facilities, which used to exceed their permits on a regular basis, have been connected to another upgraded facility, upgraded as a standalone facility, converted to subsurface discharge, or totally abandoned. As a result, the number of failed WWTPs has decreased greatly.

6.3.2 Facility Compliance in the East of Hudson Watershed

The West Branch, Boyd Corners, Croton Falls, Cross River, and Kensico reservoir basins are of special interest because they contribute to the waters of the Delaware System. The following is a summary of the WWTPs and collection systems inspected within the West Branch, Croton Falls, and Cross River basins. There are no WWTPs in the Kensico and Boyd Corners basins. However, DEP does inspect the collection system/pump stations maintained by Westchester County and the towns of North Castle and Harrison within the Kensico basin. In 2018, DEP conducted 77 scheduled compliance and emergency response inspections for the WWTPs in the EOH FAD basins.

There are nine WWTPs in the West Branch, Croton Falls, and Cross River basins. All were in substantial compliance with their SPDES permit discharge limitations in 2018. DEP scheduled the activation of the Croton Falls and Cross River pump stations in fall 2018 to capably supplement the New York City water supply as repairs were undertaken to the Catskill Aqueduct. This required a heightened level of vigilance to protect water quality within the Croton Falls and Cross River Reservoir basins.

Correspondence was sent to the permittees for prompt notification, at all hours, for any upset conditions within the WWTP or wastewater collection system and their components that could impact the aforementioned basins. Weekly reconnaissance inspections were performed until the Cross River pump station was deactivated. The Croton Falls pump station was not used.

For monitoring of the Westlake Sewer Trunk Line, see Section 4.10.1.

DEP performed compliance inspections of the Town of North Castle (Old Route 22, Cooney Hill Road, Route 120/Loudens Cove, New King Street, Old Orchard Street) and the Harrison (Park Lane) pump stations and collection system throughout the 2018 monitoring period. The inspections revealed no abnormal conditions.

6.3.3 Sampling of WWTP Effluents

Wastewater treatment plant effluent results are reported to NYSDOH and USEPA semi-annually in the WWTPCI report as required by the 2017 FAD. Sampling data are also shared regularly with DEP's WWTPCI staff for the purpose of tracking compliance with SPDES-permitted effluent limits.

Sampling of surface-discharging WWTP effluents was conducted by DEP's state-approved laboratories throughout the year. In 2018, grab samples were collected monthly. In addition, composite samples were collected once for the year at non-City owned plants that have composite sample monitoring requirements in their SPDES permits. For City-owned plants, the frequency was biweekly and these plants are listed in DEP's Watershed Water Quality Monitoring Plan (DEP 2018). City-owned WWTPs were also sampled in accordance with SPDES permit monitoring requirements and, in most cases, one sample was collected each month. The samples were a combination of grab and composite sample depending on the parameter and were analyzed by DEP laboratories. Results were reported to NYSDEC in SPDES Discharge Monitoring Reports. Monitoring of non-contact cooling water discharges was discontinued in 2015.

In the Catskill System, there are 17 WWTPs with active SPDES permits. One has no discharge, the Chichester plant in the town of Shandaken in Ulster County. It is an NYC owned and operated, intermediate sized sub-surface sewage treatment system. The other 16 plants with effluents were sampled (including four City-owned and 12 non-City owned) and composite samples were collected from nine (four City-owned and five non-City owned) of these plants which have the composite sampling requirement.

In 2018, 1,915 analyses were performed on 387 effluent and influent samples (as required) from WWTPs in the Catskill System. Of the 387 samples, 240 were collected from City plants and 147 were collected at non-City plants. These samples underwent 1,897 analyses by DEP's Kingston laboratory and 18 analyses by a contract laboratory.

In the Delaware System there were 13 WWTPs with active SPDES permits sampled in 2018 (two City-owned and 11 non-City owned). Composite samples were collected at 11 of the Delaware WWTPs (two City-owned and nine non-City owned). For the Delaware System, 209 effluent samples were collected, with 41 from City-owned plants and 168 from non-City owned plants. These samples underwent 1,438 analyses performed by Grahamsville (666), Kingston (704), and contract (68) laboratories.

In the EOH System, there are 61 WWTPs with active SPDES permits. In this system, 2,723 analyses were performed by the Hawthorne laboratory on 381 WWTP effluent samples. (Mahopac STP is the only EOH plant with composite sampling.) One WWTP is in a FAD basin (Clearpool Camp) and seven WWTPs, located within the Croton Falls and Cross River basins are "potential FAD basins" due to pump stations that can add water from these reservoirs into the Delaware Aqueduct.

In 2017, the sampling frequency of non-FAD basin plants was reduced from monthly to quarterly, with the understanding that WWTPs within the Croton Falls and Cross River basins would be sampled monthly if either pump station were activated. The Cross River Pump Station was activated in 2018 for only three days, so the station was sampled daily. The Croton Falls Pump Station was not activated in 2018.

6.4 Capital Replacement Program

The City is obligated to pay for capital replacement of watershed equipment and methods at eligible WWTPs that are required by the WR&Rs and not otherwise required by federal or state law. In 2018, DEP continued to implement the Capital Replacement Program in partnership with the EFC. However, given that EFC is not interested in administering this program over the long term, DEP is working to partner with New England Interstate Water Pollution Control Commission to administer the program in the future. In 2018, DEP and the commission agreed on the terms of a contract that is anticipated to register in 2019.

During 2018, EFC made no payments to WWTPs for replacement of watershed equipment. Minor equipment (e.g. filter cartridges, pumps) is replaced as needed in order to ensure the facility functions properly and in accordance with the WR&R. DEP is able to directly fund the replacement of minor equipment under established O&M agreements with each WWTP owner.

7. In-City Programs

7.1 Waterborne Disease Risk Assessment Program

New York City's Waterborne Disease Risk Assessment Program (WDRAP) is a joint agency program involving the NYC Department of Health and Mental Hygiene (DOHMH) and DEP. Originally established in 1993, DEP and DOHMH updated and signed an intra-city agreement in 2017 for WDRAP's continuation until 2022.

WDRAP has two major ongoing functions:

- To obtain data on the rates of giardiasis and cryptosporidiosis in the City, along with demographic and risk factor information on cases and patients.
- To provide a system to track gastrointestinal illness (as indicated by diarrhea or vomiting) to ensure rapid detection of any outbreaks.

Active laboratory surveillance began in the City in 1993 for giardiasis and in 1994 for cryptosporidiosis, and continued through 2010. This method of data collection was resource intensive as it involved WDRAP staff members regularly visiting or calling parasitology laboratories. In January 2011, an electronic reporting system replaced active laboratory surveillance which resulted in faster, less resource-intensive surveillance data collection. Electronic reporting of cases and follow-up by DOHMH has been ongoing, and continued through 2018.

Public health epidemiologists handle all confirmed cryptosporidiosis case reported to DOHMH in order to collect additional information. The epidemiologists verify the data provided in the case reports, collect additional demographic and clinical information, and identify possible sources of exposure. Giardiasis cases receive similar attention if the patient works in a high risk setting (e.g. food handler) or attends, or is thought to attend, daycare.

All data from 2018 are preliminary as of this writing, and are subject to change pending the results of confirmatory laboratory testing. In 2018, there were 1,109 cases of giardiasis and 250 cases of cryptosporidiosis reported to DOHMH (counts as of January 2019). Of these cases, epidemiologists completed eight giardiasis patient interviews and 212 cryptosporidiosis patient interviews.

As with all observations, methodologies employed for data collection will have an impact on the recorded results. In recent years, shifts in laboratory techniques have had a notable impact on cryptosporidiosis surveillance in the City and across the U.S. An increase in cases of cryptosporidiosis in NYC first noted by WDRAP staff in late 2015 continued through 2018. The increase was initially observed especially in the area of a university hospital. Further investigation linked many of the early cases to a new type of diagnostic known as a syndromic multiplex panel. These tests can detect the DNA of over 20 enteric pathogens in a single stool

sample. This new diagnostic tool is often ordered for patients who would not previously have been tested for *Cryptosporidium*. A total of 10 laboratories are now using this test in the City.

Though practices are different at each facility, once a laboratory introduces a syndromic multiplex panel, traditional diagnostics like microscopy are rarely used. The proportion of cryptosporidiosis patients diagnosed exclusively by a syndromic multiplex panel at a hospital or commercial laboratory has grown from 20% in 2015 to 75% in 2018. DOHMH is confident that the new diagnostic continues to lead to an increase in detection of cryptosporidiosis cases, and that the case increase observed is not considered reflective of an increase of disease transmission. Similar increases in cryptosporidiosis rates have been observed in several other jurisdictions in the U.S.

As in previous years, adult men (aged 20-59 years) were the most common demographic group among cryptosporidiosis cases in 2018, representing 48% (121/250) of all patients. DOHMH hypothesizes that cryptosporidiosis in NYC is predominately a sexually transmitted enteric infection among men who have sex with men (MSM). MSM are historically at greater risk for cryptosporidiosis, not only because of a higher prevalence of AIDS in this population, but also because of higher risk sexual practices that increase the risk for fecal contact. In the neighborhood of Chelsea (which is known to have an above-average prevalence of MSM), rates of cryptosporidiosis were elevated (10.6/100,000) compared to other neighborhoods in NYC. Chelsea has had consistently elevated cryptosporidiosis rates since surveillance began.

In an effort to reduce the disease burden of not only cryptosporidiosis but other enteric pathogens including giardiasis and amebiasis, DOHMH developed an awareness campaign for the MSM community and their health care providers. A webpage (https://www1.nyc.gov/site/doh/health/health-topics/diarrheal-infections.page) was developed as well as postcards for a specific campaign during Pride Week 2018 (a celebration of gay, lesbian, bisexual, transgender people and their allies). Work on educating MSM about prevention and treatment of enteric parasitic infections will continue in 2019.

In addition to tracking cases of disease, New York City has four syndromic surveillance systems in place to detect outbreaks of gastrointestinal disease:

- Daily, electronic tracking of hospital emergency department logs for chief complaint data (including gastrointestinal illness symptoms).
- Daily, electronic monitoring of over-the-counter or non-prescription anti-diarrheal medications sales.
- Tracking the number of stool specimens submitted to a large clinical laboratories for microbiological testing.
- Monitoring of several sentinel nursing homes across the City for gastrointestinal disease outbreaks.

The above systems are not specifically designed to detect outbreaks of giardiasis, cryptosporidiosis, or waterborne disease, but to more generally detect an increase in gastrointestinal illness regardless of the cause. These systems are useful for rapid and sensitive detection of gastrointestinal illness outbreaks, and alerts from these systems could trigger rapid investigation of potential sources. For example, to assess whether the water supply might be the source of an outbreak, source water quality, watershed conditions, and/or other water system parameters could be examined. All four syndromic surveillance systems listed above continued to be operational in NYC in 2018. There was no evidence of a drinking water-related outbreak in New York City in 2018, consistent with WDRAP findings of prior years.

A WDRAP Annual Report is prepared each year and provides much more detail than is provided here. The annual reports include more complete findings from disease surveillance and case follow-up (including demographic data and case interview results for giardiasis and cryptosporidiosis cases), summary results from syndromic surveillance programs, and WDRAP program implementation information. The WDRAP annual reports are posted at http://www.nyc.gov/html/dep/html/drinking_water/wdrap.shtml.

8. Education and Outreach

DEP collaborates with the Catskill Watershed Corporation (CWC), Watershed Agricultural Council (WAC), Cornell Cooperative Extension, Soil and Water Conservation Districts, Catskill Center, the Catskill Regional Invasive Species Partnership, the Lower Hudson Partnership for Invasive Species Management, Trout Unlimited, and other partners to advance a comprehensive watershed education and outreach program. The goal is to increase knowledge and awareness among key audiences about source water protection, land conservation and stewardship, stream corridor protection, stormwater and wastewater, flood response and preparedness, invasive species, watershed recreation, riparian buffers, and other topics.

One way DEP directly disseminates information to a broad public audience is through its website (nyc.gov/dep) and social media platforms. During 2018, DEP had 10,305 likes on NYC Water Facebook, 2,728 followers on NYC Watershed Facebook, 17,216 followers on NYC Water Twitter, and 1,919 followers on NYC Water Instagram. The Drinking Water section of the DEP website received 61,898 page views, Watershed Protection received 12,285 views, Watershed Recreation received 22,816 views, and Environmental Education received 7,839 views. DEP's NYC Water Flickr Page (https://www.flickr.com/photos/nycwater) continues to be an excellent source of photos for many of the educational programs described in this report.

DEP issued 112 press releases in 2018, many of which focused on water supply topics and publicity for watershed recreation events. One unique press release highlighted that New York City's unfiltered tap water won the New York State Tap Water Taste Test competition at the New York State Fair in August. DEP announced and attended two public hearings in July for the updated Watershed Recreation Rules and four public hearings in late October and early November for the proposed changes to the Watershed Rules and Regulations.

Recreation and stewardship activities on City-owned lands continue to be popular ways that DEP engages target audiences. In 2018, DEP organized family fishing events at three reservoirs that attracted nearly 300 participants and eight reservoir clean-up events that engaged 410 volunteers. DEP also organized several boater safety events attracting 30 participants; a safety and survival hike in collaboration with the DEP Police; a wetlands interpretive program at the Ashokan Reservoir in celebration of American Wetlands Month; a community hike in celebration of National Trails Day; and a boot wash station and interpretive hike associated with New York State Invasive Species Awareness Week. DEP's Watershed Recreation e-newsletter reached an average of 105,000 subscribers throughout 2018.

Every year, DEP's Education Office conducts more than 350 environmental education programs that reach nearly 30,000 students (pre-kindergarten through college), teachers, environmental educators, and adult audiences (primarily water consumers) through classroom visits, guided tours and field trips, professional development workshops, programs at the Visitor Center at Newtown Creek, and Trout in the Classroom. During 2018, DEP's Annual Water

Resources Art & Poetry Contest engaged more than 1,300 students from over 75 schools in the watershed and New York City. DEP sponsored two performances of "City That Drinks the Mountain Sky" for almost 1,000 participants. DEP and the Children's Museum of Manhattan co-hosted educational events in connection with the museum's splashy outdoor water exhibit "Dynamic H2O". DEP continued to enhance and distribute an educational map and study guide that was created in 2017 ("New York City's Water Story: From Mountain Top to Tap") to help students explore the water supply system. Trout in the Classroom engaged over 10,000 students and teachers from more than 150 schools in the watershed and New York City, including nearly 200 participants in the annual Trout in the Classroom Fall Teacher Conference.

Another primary way DEP and its partners directly educate specific audiences is through targeted watershed protection programs. Accomplishments for 2018 include the following:

- The CWC Public Education Program awarded 38 education grants totaling nearly $200,000 to schools and organizations in the watershed and New York City; the estimated audience for all of these programs is more than 20,000 people. To date, CWC has awarded 583 grants totaling just over $3 million. For additional information, please visit the following CWC websites: watersheducators.org or cwconline.org.
- The CWC, in support of its septic system repair and replacement programs for watershed homeowners and businesses, sponsored three septic system design workshops for approximately 62 engineers and professionals in April, September and October.
- The Watershed Agricultural Program conducted more than 21 farmer education programs that were attended by 737 participants. Highlights include the annual Catskill Regional Agricultural Conference (159 participants), the annual WAC Farm Tour (95 participants), and dozens of workshops, tours, pasture walks and seminars covering agricultural topics.
- The WAC continued to promote all of its programs and the importance of working landscapes through its main website (nycwatershed.org), in addition to promoting local farm and forestry products through the Pure Catskills Campaign (purecatskills.com). The annual Taste of the Catskills Local Food Event attracted over 4,000 attendees.
- The Watershed Forestry Program continued to support and expand the MyWoodlot.com website for forest landowners while the watershed model forests continued to host dozens of educational events for all audiences. In 2018, the Forestry Program sponsored 10 logger training workshops for 136 participants and 25 bus tours for 252 adults and over 1,360 students, primarily from New York City. Twenty-three teachers attended the annual Watershed Forestry Institute in July and 155

students participated in the annual 2017-2018 Green Connections School Partnership Program.

- The Stream Management Program continued to sponsor specialized education and training programs for landowners, municipal officials, watershed professionals, and school-based audiences via workshops, interpretive hikes, volunteer planting events, presentations to local flood commissions, and participation in basin-specific stakeholder meetings. Highlights include the Catskill Environmental Research and Monitoring Conference (168 participants), Schoharie Watershed Summit (101 participants), Ashokan Stream Explorers Youth Conference (61 participants), Anglers Symposium (55 participants), Phoenicia Elementary Earth Day (140 participants), Woodstock Elementary Earth Day (130 participants), Leave No Trace Stream Stewardship Education Program at Blue Hole on Rondout Creek (over 1,000 people reached), Bennett Elementary Earth Day (90 participants), Greene County Youth Fair (300 participants), Youth Climate Change Leadership Summit (122 participants), Watershed Scientist in Residence Program (over 130 participants), Erosion and Sediment Control Training Workshops for contractors, and more than a half-dozen highway superintendent meetings. The catskillstreams.org website continued to serve as a repository for various stream stewardship topics.

Finally, DEP and its partners attended numerous community outreach events and speaking engagements throughout the year, primarily in the watershed but also New York City and elsewhere. These opportunities allow DEP and its partners to disseminate informational publications, answer questions from the public, share scientific knowledge, and communicate key messages to a broad audience. Highlights for 2018 include the following: Cannonsville Hydropower public meetings, Catskill Farm exhibit opening, Catskill Forest Festival, Catskill Great Outdoor Expo, Delaware County Fair, Delaware/Otsego Envirothon, Gilboa Career Day, Grahamsville Little World's Fair, Lower Hudson Valley Engineering Expo, Margaretville Cauliflower Festival, New York City Outdoor Expo, New York City Watershed Science and Technical Conference, New York ReLeaf Conference, New York State Floodplain Managers Annual Conference, New York State Wetlands Forum, Olive Day, New York State Woodsmen's Field Days, Rockland Community College World Fishing and Outdoor Expo, Shandaken Day, SPDES Permit Outreach Meetings, Ulster County Fair, and Watershed Jobs Forum.

9. Miscellaneous Reporting Provisions

9.1 Water Conservation/Demand Management

DEP values the role of water conservation and demand management in the responsible long-term management of New York City's water supply. As a result, actual water demand is down more than 30% since the 1990s, despite increasing population (Figure 9.1). However, DEP must consider the increasing uncertainty of climate change — predictions of warmer temperatures and greater precipitation variability — in its management of the City's water supply and the demand for this resource. Further, the leaking of the Delaware Aqueduct and its planned shutdown and repair in 2022 as part of DEP's Water for the Future Program is a near-term certain event that provides an imperative not only to proactively manage but, also, explicitly reduce existing water demand to ensure adequate water supply through this period.

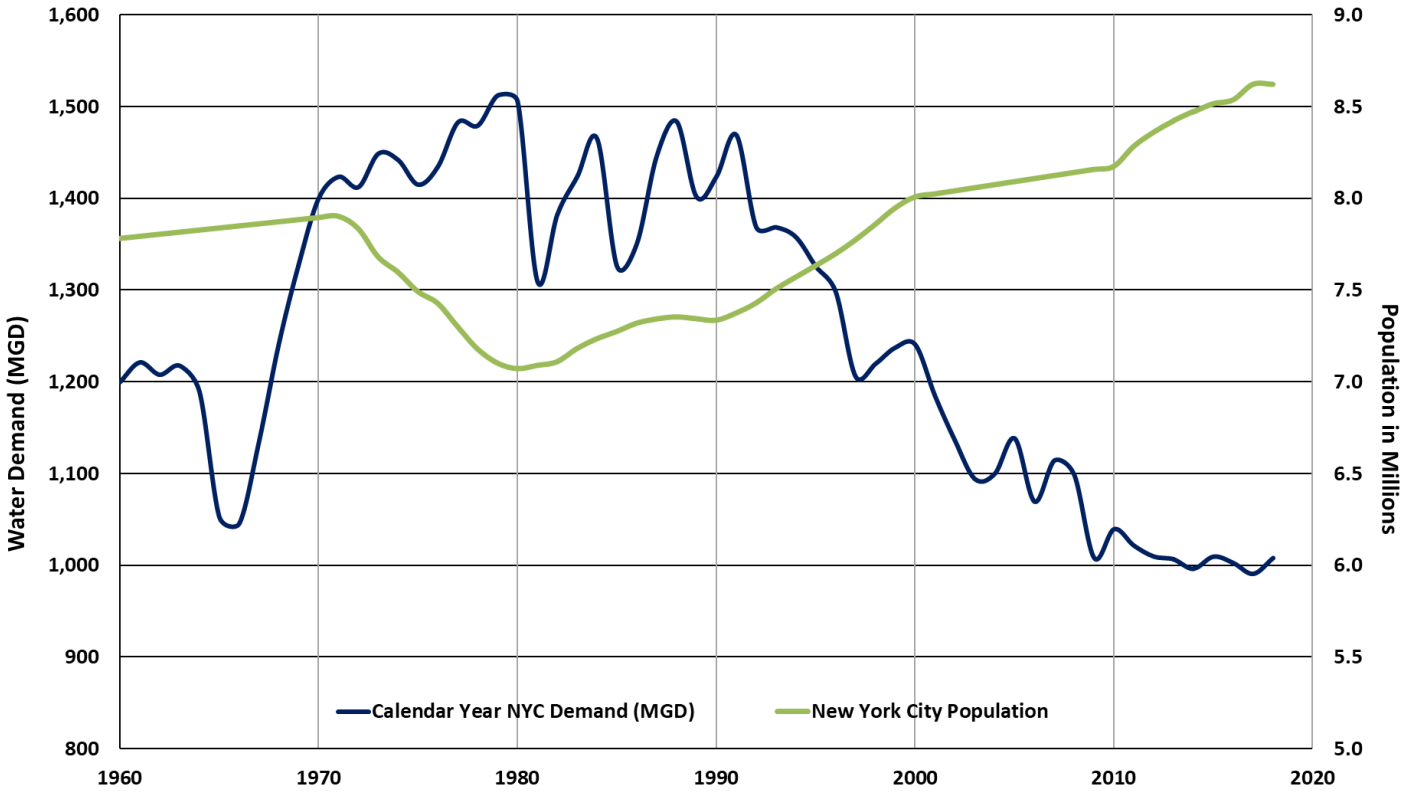


Figure 9.1 New York City water demand and population

9.1.1 Water Demand Management Plan

DEP's water conservation efforts aim to reduce water use in New York City and upstate communities by 20 million gallons per day (MGD) by 2022. This reflects a revised goal from the 2013 Water Demand Management Plan that is detailed in the 2018 Water Demand Management Plan, released on June 1, 2018. The 2018 Water Demand Management Plan (http://www.nyc.gov/html/dep/pdf/conservation/2018-water-demand-management-plan.pdf) sets forth six major strategies DEP continues to implement to reduce water use.

- Municipal Water Efficiency Program: Involves retrofits of city-owned properties.
- Residential Water Efficiency Program: Focuses primarily on the Toilet Replacement Program for multi-family buildings.
- Non-Residential Water Efficiency Program: Collaboration with private sector organizations including restaurants, hotels, hospitals, and universities.
- Water Distribution System Optimization: Entails system repairs and upgrades, managing water pressure, and refining water meter accuracy and leak detection.
- Water Supply Shortage Management: Encompasses the review and revision of plans to prepare for a drought and other water shortages.
- Wholesale Customers Water Demand Management Program: Targets demand management planning and implementation for wholesale customers north of the City.

The following is a summary of DEP's 2018 progress in implementing the above listed strategies.

Municipal Water Efficiency Program

DEP has established partnerships and completed several projects with key municipal agencies and entities to support water efficiency measures in their facilities. Partners include the New York City Department of Education (DOE), the New York City Department of Parks and Recreation (DPR), the New York City Fire Department (FDNY), the City University of New York (CUNY), and New York City Health and Hospitals Corporation (HHC).

Through its ongoing partnership with DOE, DEP funded the replacement of over 34,500 toilets and urinals with high-efficiency models in 402 schools across all five boroughs through 2018.

In July 2018, DEP completed its fourth Water Challenge to Wastewater Treatment Plants (WWTPs) to encourage water reduction in DEP's own facilities. All 14 WWTPs have participated in these challenges, and seven achieved a 10% reduction over the previous year's baseline average. DEP will start a fifth challenge in 2020, encouraging all 14 WWTPs to reduce demand by 5%. DEP also expanded its water hose replacement program by doubling the number of hoses replaced with high-efficiency models used to clean equipment at each WWTP.

Additionally, DEP is currently working to replace inefficient water pumps and other equipment with high-efficiency models at our treatment facilities.

In October 2018, DEP began auditing the three largest WWTPs. Through the auditing process, engineers are completing an extensive review of water use at each plant, and are identifying parts of the water treatment process that could be modified to reduce consumption. To date, DEP has identified several projects that could reduce water consumption, including expanding the use of effluent in place of potable water, retrofitting seal pumps, and reducing the size of hoses used for tank spray downs. Findings from the audits will be compiled into a comprehensive report, and cost-efficient water savings measures will be chosen for implementation by 2022. DEP estimates that 1 MGD of savings could be achieved through these measures.

In 2018, DEP formed a new partnership with HHC and began retrofitting fixtures at Harlem Hospital. Retrofits at the hospital include toilets, urinals, ice machines, faucet aerators, and a commercial dishwasher. DEP will retrofit additional HHC hospitals through 2022. Overall, this partnership with HHC is expected to result in a savings of 1.22 MGD.

Residential Water Efficiency Program

In early 2014, DEP launched the Toilet Replacement Program. Eligible residential building owners who are part of the Multi-Family Conservation Program can receive $125 vouchers to replace old, inefficient toilets with high-efficiency, WaterSense-certified models. DEP manages contracts with four toilet wholesale vendors to accept the vouchers and provide the toilets to consumers through the program's online application tool. Through 2018, the program has replaced over 13,500 toilets.

In addition to establishing the Toilet Replacement Program, DEP directed its contractor, Honeywell, to provide building owners with complimentary household water conservation surveys. The surveys assist building owners with identifying opportunities for water savings and detecting leaks. In 2018, Honeywell conducted surveys in 4,115 individual apartments in 1,993 single-family apartment buildings. Honeywell also surveyed 254 multi-family buildings, and 4,202 individual units within these properties.

Non-Residential Water Efficiency Program

DEP successfully launched three Water Challenges to different commercial sectors: hotels, restaurants, and hospitals. Modeled after the Mayor's Carbon Challenge, participants are encouraged to reduce their annual water consumption by an average of 5% from their baseline year (measured as the 12-month period prior to the beginning of the challenge). DEP prepares monthly reports to help participants track their consumption and their performance against the other participants. DEP also hosts quarterly workshops to help participants learn how to make their facilities more water-efficient.

In 2018, DEP launched a Water Challenge to Universities: https://www1.nyc.gov/html/dep/html/ways_to_sav e_water/nyc-water-challenge.shtml. New York City is home to more university students than any other city in the country and the challenge builds upon ongoing campus sustainability initiatives at each participating university. The six participating universities are Fordham University, Long Island University, New School, Pace University, St. John's University, and Weill Cornell University. This challenge is unique because it engages university staff in implementing permanent water conservation measures, and is also an opportunity to foster a water conservation ethic among university students and administrators alike. Identical to previous Water Challenges, the goal is for the six participants to achieve a 5% reduction in water consumption, which is 42,000 gallons per day.

Water Distribution System Optimization

Water distribution system optimization includes system repairs and upgrades, water pressure management, refining water meter accuracy, and leak detection. In 2018, DEP surveyed 1,793 miles of water mains for leaks.

DEP recently implemented a strategic approach to leak detection. Borough-based teams properly trained in leak detection target specific areas served by older network mains more likely to need preventive and corrective maintenance. These teams can respond rapidly to problems compared to the slower response times when DEP relied on one consolidated resource center.

Leaking and/or vandalized fire hydrants can also result in significant water waste. An illegally opened fire hydrant can release more than 1,000 gallons per minute and drop pressure. In 2018, DEP repaired 7,481 hydrants, replaced 1,164, and provided other maintenance services to 8,531 additional hydrants.

DEP's efforts to achieve universal metering of all DEP water and sewer accounts is motivated by the need to reduce non-revenue water and promote conservation among water users by providing accurate consumption information. The universal metering initiative is also critical to measuring the success of many other demand management strategies. Accurate consumption data enables DEP to determine whether target consumer groups have achieved projected consumption reductions or how demand management strategies may be adapted to improve their effectiveness. DEP replaced 416 large meters in 2018 (i.e., those over 1.5 inches in diameter).

Water Supply Shortage Management

In December 2016, the Mayor's Office of Operations and the City Law Department certified DEP's revisions to the "Emergency Drought Rules." The proposed revised title is "Water Shortage Rules," replacing the narrower focus of the previous title. The proposed revisions address water shortage emergencies due to circumstances other than natural conditions, such as planned and unplanned infrastructure outages and repair that the City may face over the next several years. The proposed revisions also add, remove, and change certain water-use prohibitions during the different stages of water shortage emergencies to better reflect DEP's

current understanding of City water use. DEP anticipates formal adoption of the revised rules prior to the 2022 shutdown.

Wholesale Customers Water Demand Management Program

In 2014, DEP kicked off the demand management program for wholesale customers in upstate watershed communities. These customers make up 10% of the system's current consumption. As of 2018, DEP offers assistance and is working with up to 10 customers (approximately 85% of the total upstate wholesale consumption) to develop demand management plans for their systems with a target 5% reduction in consumption.

Once participating utilities complete their demand management plans, each will work to implement conservation measures identified in their plan. DEP drafted individual intergovernmental agreements for each participating utility in 2018. Each agreement represents a contractual funding obligation from DEP and commitment from the utility partner to implement their demand management plan.

The demand management plan for the Village of Ossining was finalized in May 2016, the agreement was finalized in May 2017, the contract was registered in December 2017, and implementation began in 2018. Five other demand management plans were finalized in 2018, and DEP anticipates finalizing the remaining plans in 2019.

9.2 Updates to Drought Management Plan

In 2018, monthly average precipitation (historical average for the period 1985-2015) was above normal for more than 50% of the year. August was the wettest year of record for Pepacton and Cannonsville reservoirs. The NYC Delaware Basin Reservoir System storage stayed in the "Normal" storage zone (above drought watch) for the entire year. It was not necessary to invoke the City's Drought Management Plan. The probability of refill did not fall below 50% for the Catskill or Delaware Systems.

The Drought Management Plan has three phases — Drought Watch, Drought Warning, and Drought Emergency — that are invoked sequentially as conditions dictate. The Drought Emergency phase is further subdivided into four stages with increasingly severe mandated use restrictions. Guidelines identify when to declare a Drought Watch, Warning, or Emergency and when the appropriate responses should be implemented.

These guidelines are based on prevalent hydrological and meteorological conditions, certain operational considerations and other factors. In some cases, other circumstances may influence the timing of drought declarations.

- Drought Watch - Declared when there is less than a 50% probability reservoirs in either of the two largest systems, the Delaware (Cannonsville, Neversink, Pepacton, and Rondout reservoirs) or the Catskill (Ashokan and Schoharie reservoirs), will fill by June 1, the start of the water year.

- Drought Warning - Declared when there is less than a 33% probability reservoirs in either the Catskill System or Delaware System will fill by June 1.
- Drought Emergency - Declared when there is a reasonable probability that without the implementation of stringent measures to reduce consumption, a protracted dry period would cause the City's reservoirs to be drained. DEP estimates this probability during dry periods in consultation with the New York State Drought Management Task Force and the New York State Disaster Preparedness Commission. The estimation is based on analyses of the historical record, the pattern of the dry period months, water quality, subsystem storage balances, delivery system status, system construction, maintenance operations, snow cover, precipitation patterns, use forecasts, and other factors. Because no two droughts have identical characteristics, no single probability profile can be identified in advance that would generally apply to the declaration of a Drought Emergency.

DEP continues to encourage consumers to conserve water and to observe the City's year-round water use restrictions. These restrictions include a prohibition on watering sidewalks and lawns between November 1 and March 31 and illegally opening fire hydrants.

9.3 Delaware Aqueduct Leak

DEP efforts to repair the Delaware Aqueduct continued in 2018 and included the following major activities:

- Commencement of the bypass tunnel construction.
- Catskill Aqueduct Repair and Rehabilitation (CATRR): Completed design and construction contract registered July 2018.

Tunnel Dewatering Preparation

The 80 million gallons per day pumping station, which is capable of dewatering the Rondout-West Branch Tunnel (RWBT) under any expected conditions, is now ready to operate. Quarterly meetings are held to review status of the monthly testing of the pump station.

RWBT Bypass and Repair—Site and Shafts (BT-1) and Bypass Tunnel (BT-2)

The bypass tunnel contract, BT-2, is underway. The tunnel boring machine began its excavation on January 8, 2018, and has excavated more than 7,000 feet of the 12,500 foot tunnel. Excavation is expected to be complete in fall 2019 and will be followed by the installation of a 16-foot-diameter steel inter-liner and final concrete lining. Upon completion of this effort, the tie-in to the existing RWBT will commence. During the execution of the tie-in, workers will grout the leaks in the Wawarsing area of the tunnel from within the dewatered tunnel. DEP expects the bypass project to be completed in fall 2023.

Hydraulic Investigations of the RWBT

Investigations of the RWBT helped DEP assess the nature and degree of leakage stemming from the aqueduct. Efforts to study the nature of the leak are described below.

- The Tunnel Monitoring Program continued under DEP's DEL-LTA contract. The purpose of this program is to determine if tunnel conditions are changing. DEP routinely monitors tunnel flow rates, operational trends, and surface expressions to confirm the steady-state condition of the RWBT leak. The monitoring efforts resulted in a determination of no substantial change during 2018.
- The DEL-LTA contract supports autonomous underwater vehicle (AUV) and remote-operated vehicle (ROV) flights within the RWBT as needed. No inspections were deemed necessary during 2018.

Catskill Aqueduct Repair and Rehabilitation

The CATRR project focuses on the section of the aqueduct between Ashokan Reservoir in Ulster County and Kensico Reservoir in Westchester County. The project's scope focuses on inspection of the entire aqueduct, repairing deficiencies (including concrete and mechanical components), and removing a biofilm layer on the interior walls to improve the hydraulic characteristics of the tunnel and restore tunnel capacity. CAT-RR construction commenced in August 2018 and the first round of tunnel shutdowns were conducted from October 2018 through January 2019.

Two related projects include building chemical addition facilities at the Ashokan Screen Chamber (CAT-213E) and the Pleasantville Alum Plant (CAT-213F) to deliver chlorination and dechlorination chemicals, respectively. An order to commence work was issued on the CAT-213E and CAT-213F projects in 2018 and construction was started.

9.4 Catskill/Delaware Filtration Plant

History

The 1997 Filtration Avoidance Determination first required the City to produce a preliminary design for filtration facilities for the Catskill/Delaware water supply. The 2002 FAD required the City to provide biennial updates to the preliminary plant design for the Catskill/Delaware (CAT/DEL) system (in addition to constructing an ultraviolet light disinfection facility, which was placed into full service in October 2012). The 2007 FAD continued to require the City to provide a biennial report updating the preliminary design for filtration facilities. In 2013 and 2015, the City and NYSDOH agreed no design changes to the 2009 preliminary plans for the CAT/DEL Filtration Facilities were necessary.

Next Steps

Because the work supporting the preliminary plans is more than 25 years old, the 2017

FAD requires the City to contract for a comprehensive review of filtration methods and technologies, as well as to develop a new conceptual design for a filtration facility(s). This will minimize the overall time to commence filtration in the event the City or NYSDOH determines filtration is necessary.

The design review process will include -

- Bench studies and modeling
- Large scale pilot studies
- Independent review from water treatment experts
- Conceptual design incorporating the latest filtration methods and technologies

In 2018, the City met the milestones specified in the 2017 FAD implemented for the CAT/DEL Filtration Plant Design. DEP advertised the new contract on January 31, 2017, and issued Notice to Proceed as of January 24, 2018, to a consulting engineering firm specializing in water-treatment plant design.

During 2018, DEP staff selected the Catskill-Delaware Interconnection Facility in Gardiner in Ulster County for bench scale pilot testing. This location was chosen due to the availability of both Catskill and Delaware System water.

In 2019, DEP will undertake bench-scale testing of potential treatment technologies.

9.5 Arkville office

DEP has committed to locating staff in a new office being constructed in Arkville, N.Y. by the Catskill Watershed Corporation (CWC). The goal of sharing space is to further improve coordination on joint programs and to enhance accessibility for watershed communities. The FAD requires DEP to assign specific numbers of staff to the new facility in the coming years.

In 2018, Keystone Associates, the design firm hired by CWC in 2017, completed full design of the facility and the construction project was put out to bid by CWC. A contractor was selected and work began at the site in late 2018. In November 2018, CWC delivered a first draft of a lease document to DEP. DEP undertook an internal review of the draft, which included oversight agencies within New York City that will be involved in finalization of the lease.

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