New York City Department of Environmental Protection

Filtration Avoidance Annual Report

for the period January 1 through December 31, 2021

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Bureau of Water Supply

Cover photo of Ashokan Spillway in November 2021.

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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
CAT	Catskill Aqueduct
CAT/DEL	Catskill/Delaware
CATRR	Catskill Aqueduct Repair and Rehabilitation
CATUEC	Catskill Upper Effluent Chamber
CC	Compliance conference
CCE	Cornell Cooperative Extension
CCEUC	Cornell Cooperative Extension of Ulster County
CDUV	Catskill/Delaware Ultraviolet Disinfection Facility
CE	Conservation easement
CFI	Continuous forest inventory
CMC	Catskill Mountain Club
CP	Forest Management Plan Conservation Practices
CPDP	Stream crossing/piping/diversion permits
CREP	Conservation Reserve Enhancement Program
CRISP	Catskill Regional Invasive Species Partnership
CRP	Conservation Reserve Program
CSBI	Catskill Streams Buffer Initiative
CUNY	City University of New York
CWC	Catskill Watershed Corporation
CWMP	Community Wastewater Management Program
DBP	disinfection byproduct precursor
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

EFC	New York State Environmental Facilities Corporation
EIS	Environmental impact statement
EOH	East of Hudson
EOHWC	East of Hudson Watershed Corporation
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
GCM	Global climate model
GCSWCD	Greene County Soil and Water Conservation District
GIS	Geographic Information System
GPS	Global Positioning System
HAA5	Haloacetic acid five
HEC-RAS	Hydrologic Engineering Centers River Analysis System
HEFS	Hydrologic Ensemble Forecast Service
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
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
LRAA	Locational running annual average
MAP	Management Assistance Program
MCL	Maximum Contaminant Level
MFO	Master Forest Owner
MGD	million gallons per day
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

NFC	Natural features criteria
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
NYNHP	New York Natural Heritage 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
OBIA	Object-based image assessment
OEL	Operational evaluation level
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
RWBT	Rondout-West Branch Tunnel
SAP	Streamside Acquisition Program
SCSWCD	Sullivan County Soil and Water Conservation District
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

STRP	Stream turbidity reduction project
SUNY	State University of New York
SWAC	Schoharie Watershed Advisory Committee
SWAT-HS	Soil Water Assessment Tool – Hillslope
SWC	Surface water criteria
SWCD	Soil and Water Conservation District
SWPPP	Stormwater pollution prevention plan
SWTR	Surface Water Treatment Rule
TCR	Total Coliform Rule
THM	Trihalomethane
TSI	Timber stand improvement
TTHM	Total trihalomethane
UCSWCD	Ulster County Soil and Water Conservation District
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
VoPro	Volume projection model
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
WR&R	New York City Watershed Rules and Regulations
WRRF	Water Resource Recovery Facility
WSP	Water Supply Permit
WWQMP	Watershed Water Quality Monitoring Plan
WWTP	Wastewater treatment plant
WWTPCI	Wastewater Treatment Plant Compliance and Inspection

1. Introduction

Starting in the early 1990s, New York City began to develop and implement a multi-faceted program to protect and enhance the quality of the City's drinking water supply. The New York City Department of Environmental Protection (DEP) received the first Filtration Avoidance Determination (FAD) in January 1993. Since that time, DEP has spent or committed more than $2.7 billion to implement programs based on one simple premise: it is better to keep water clean at the source than allow it to be contaminated and clean it up later. 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. Over time, DEP has developed strong relationships with key water supply stakeholders including the watershed communities; locally based organizations; environmental groups; and federal, state, and local government agencies. In addition to the water quality benefits, DEP's water supply operations and protection programs provide significant economic benefits to the watershed region. Through direct and indirect employment, more than a thousand jobs are supported and project funding and tax payments account for more than $200 million annually. In addition, DEP's reservoirs and land holdings are a valuable resource for the local tourism economy.

The cornerstone of DEP's source water protection program is extensive research by DEP scientists into existing and potential sources of water contamination, and the detailed characterization of land use and land cover in the watershed. 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.

In December 2017, the New York State Department of Health (NYSDOH), in consultation with United States Environmental Protection Agency (USEPA), issued a 10-year FAD. The programs identified in the 2017 FAD built on the significant program accomplishments to that time and reflected DEP's continued commitment to long-term watershed protection. The 2017 FAD was the first to include a complete set of program and financial commitments for the full 10-year period. The 2017 FAD demonstrates DEP's ability to continue to implement proven programs, as well as the ability to revise strategies as needed to anticipate and respond to changing conditions. DEP's source water protection program continues to be an international model for sustainable water supply management and public health protection.

In 2018, the National Academies of Science, Engineering and Medicine (NASEM) convened an expert panel to evaluate New York City's source water protection program. This study follows a similar evaluation conducted by NASEM in the early 2000s after the MOA was signed. Over approximately two years, the panel engaged in a comprehensive process, which included eight meetings, dozens of presentations by DEP staff and watershed stakeholders, a number of site visits in the watershed, countless information requests, and hundreds of hours of discussion and drafting. The panel released its final report in August 2020. The report includes a strong endorsement of the work DEP and its partners have undertaken over many years, stating that the programs "have admirably supported water quality" with "strong indications" they will continue to be effective in the future. The report also includes 63 major recommendations, ranging from straightforward and relatively modest program adjustments to out-of-the-box thinking.

During 2021, DEP conducted a review and evaluation of the panel's recommendations and engaged with regulators and watershed stakeholders. In December 2021, DEP submitted a revised Long-term Watershed Protection Plan, which include certain proposed adjustments to the requirements of the 2017 FAD. DEP's plan is expected to be the basis of mid-term modifications to the FAD, which will be issued by NYSDOH in 2022.

Ensuring that DEP's protection strategies are accounting for expected climate change impacts is an important consideration. DEP's modeling group remains on the cutting edge of using and adapting global climate models to assess the range of potential conditions in the watershed region. As part of its protection programs, DEP supported several projects this year that seek to build resilience to climate change. For example, the Maltby Hollow Bridge, located on a critical road for many residences in West Shokan, was redesigned and reconstructed to pass the NYSDOT future projected peak flow (current 100-year storm, plus 20%) and the current 500-year flow. In Shandaken, an undersized bridge crossing the Esopus Creek was upsized to pass the current 100-year flood flow. A local flood analysis (LFA) was launched for the community of Pine Hill, which will use future peak flows in the HEC-RAS model to summarize the future flows and calculate flood elevations, depth of flooding, and bridge overtopping at key locations under various flood stage scenarios.

As part of the watershed regulatory program, DEP administers the current NYSDEC Stormwater Management Design Manual, which allows for the use of the most up-to-date NOAA regional rainfall dataset in the design of stormwater pollution prevention plans. NOAA's current data is based on a denser network of weather stations and a greater period of record than previous data, reflects both seasonal information and the potential effects of climate change, and enables more accurate estimates of peak rates and runoff volumes. Continuing to review and refine climate adaptation measures will be an ongoing priority for source water protection.

As DEP's FAD programs approach the completion of their 30th year, DEP and its partners have built a wealth of knowledge and experience in the protection of water quality in the

CAT/DEL System. There are many instances of collaboration among the many disciplines represented within DEP and its partner organizations. Although examples are too numerous to list, recent collaborations include:

- DEP's stream, health and safety, land management and land acquisition staff, along with external partners including the Catskill Watershed Corporation, Soil and Water Conservation Districts,, and local municipalities, coordinated on projects, policies, and processes in support of the NYC-Funded Flood Buyout Program and Local Flood Hazard Mitigation Implementation Program projects. Six demolitions – and pre-demolition preparations for several more that are planned next year – were completed in 2021. In addition, DEP worked with partners to help Shandaken enter FEMA's Community Rating System program, and supported the Village of Walton in revising its FEMA flood maps to remove 22 structures from the Special Flood Hazard Area and reduce flood elevations at 20 more.
- The Wetlands Program delineates and evaluates wetlands to inform forest management and stream management projects, and to provide field-verified data to confirm wetland presence as requested by the Land Acquisition Program (LAP). In addition, National Wetlands Inventory data is used to screen for wetland presence across a suite of FAD programs, and to summarize wetlands acquired by the LAP.
- Natural resources staff participate in interdisciplinary reviews under SEQRA for projects in the watershed. Subject matter experts from the Wetlands, Wildlife Studies, Forestry, Invasive Species, Aquatics, and Restoration programs review project plans and provide feedback to ensure proposed projects in the watershed appropriately address natural resource issues.
- DEP's Invasive Species Program collaborates with other agencies and organizations whose missions include invasive species management to more efficiently address emerging invasive species concerns within the watershed. By knowledge sharing and leveraging resources, these partnerships are critical to invasive species management at the regional scale. At the state level, DEP's seat on New York State's multi-stakeholder Invasive Species Advisory Committee allows statewide collaboration to further policy changes, legislation, and fostering dialog on larger invasive species initiatives.

This annual report covers the period January 1, 2021, through December 31, 2021, and is compiled to satisfy the requirements of the 2017 FAD. Material in this report is organized to parallel the sections of the FAD. Figure 1.1 and Figure 1.2 depict the impressive level of accomplishment over the past quarter century. The programs, each designed to target potential pollution sources, have touched nearly every corner of the City's vast catchment.

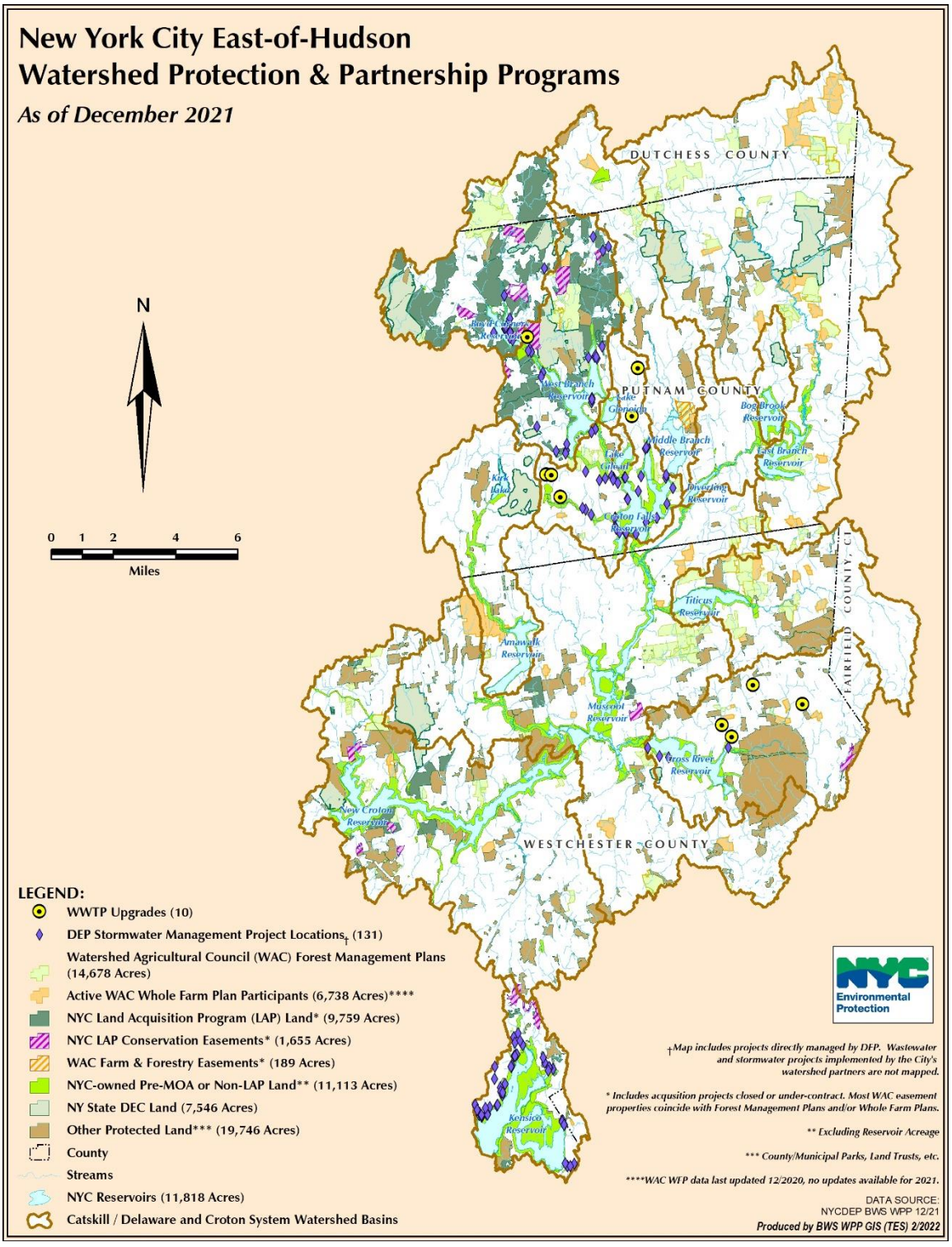

Figure 1.1 New York City East-of-Hudson watershed protection and partnership programs as of December 2021.

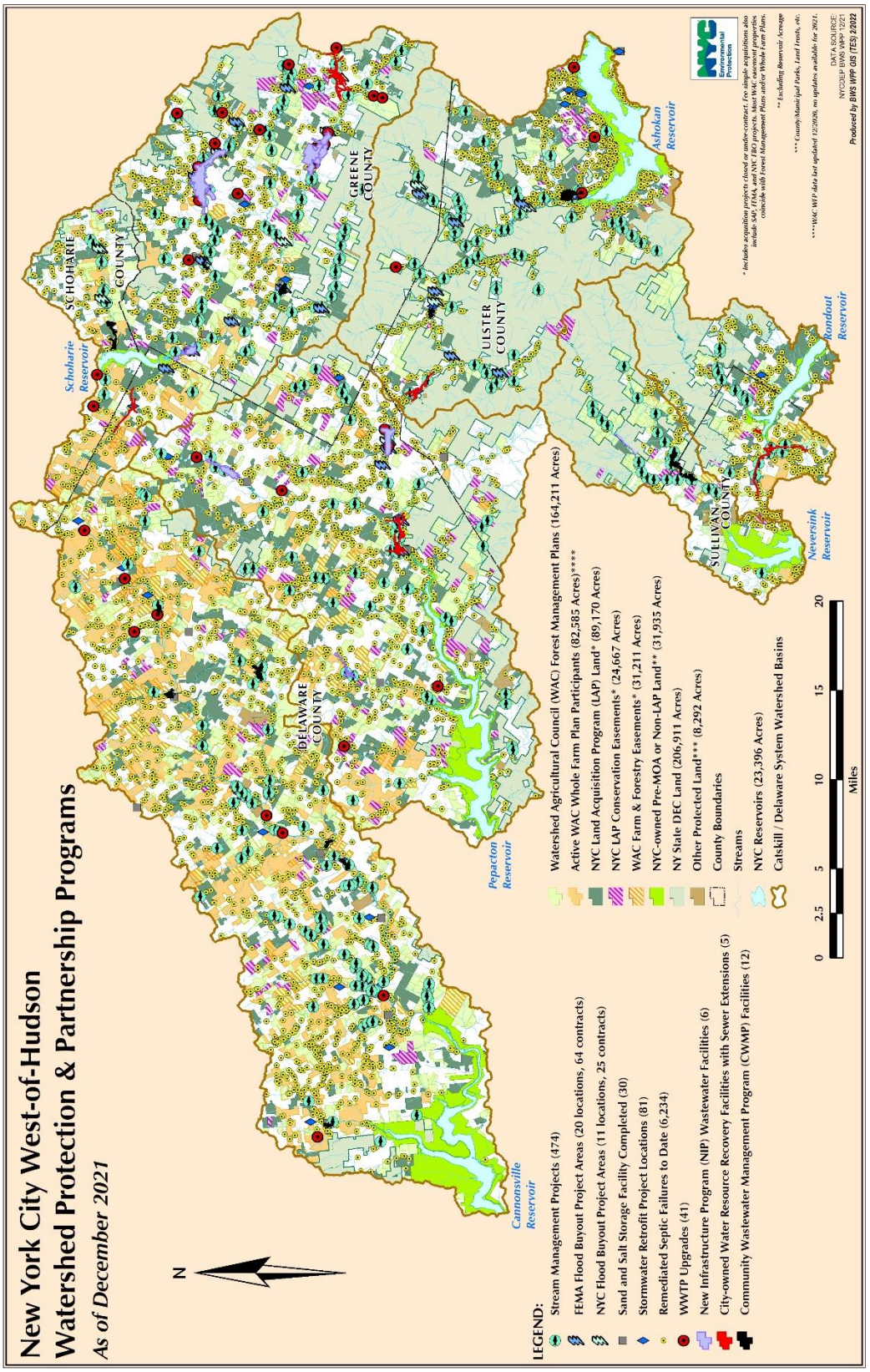

Figure 1.2 New York City West-of-Hudson watershed protection and partnership programs as of December 2021

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. 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 that share a role in this complex effort are too numerous to list. However, DEP gratefully acknowledges their ongoing help and support.

2. Federal and State Objective Water Quality Compliance

During 2021, 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 2021, DEP collected approximately 44,300 samples and conducted 556,100 analyses. Of these, 32,900 samples were collected and 392,000 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. The report 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 2021.

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 (HAA5). In 2021, all monitoring samples complied with thresholds defined by the SWTR, except for fourth quarter exceedances of the calculated locational running annual average (LRAA), and the Operational Evaluation Level (OEL) for HAA5 as detailed in section 2.1.6.

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

In 2021, the Catskill Aqueduct between Kensico Reservoir and the Catskill/Delaware Ultraviolet Light Disinfection Facility (CDUV) 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 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 96.7%.

As shown in Figure 2.1, in 2021 the highest six-month running percentage of positive raw water fecal coliform samples at the Delaware Aqueduct effluent from Kensico Reservoir was 3.3%, well below the maximum percentage of positive samples allowed under the SWTR.

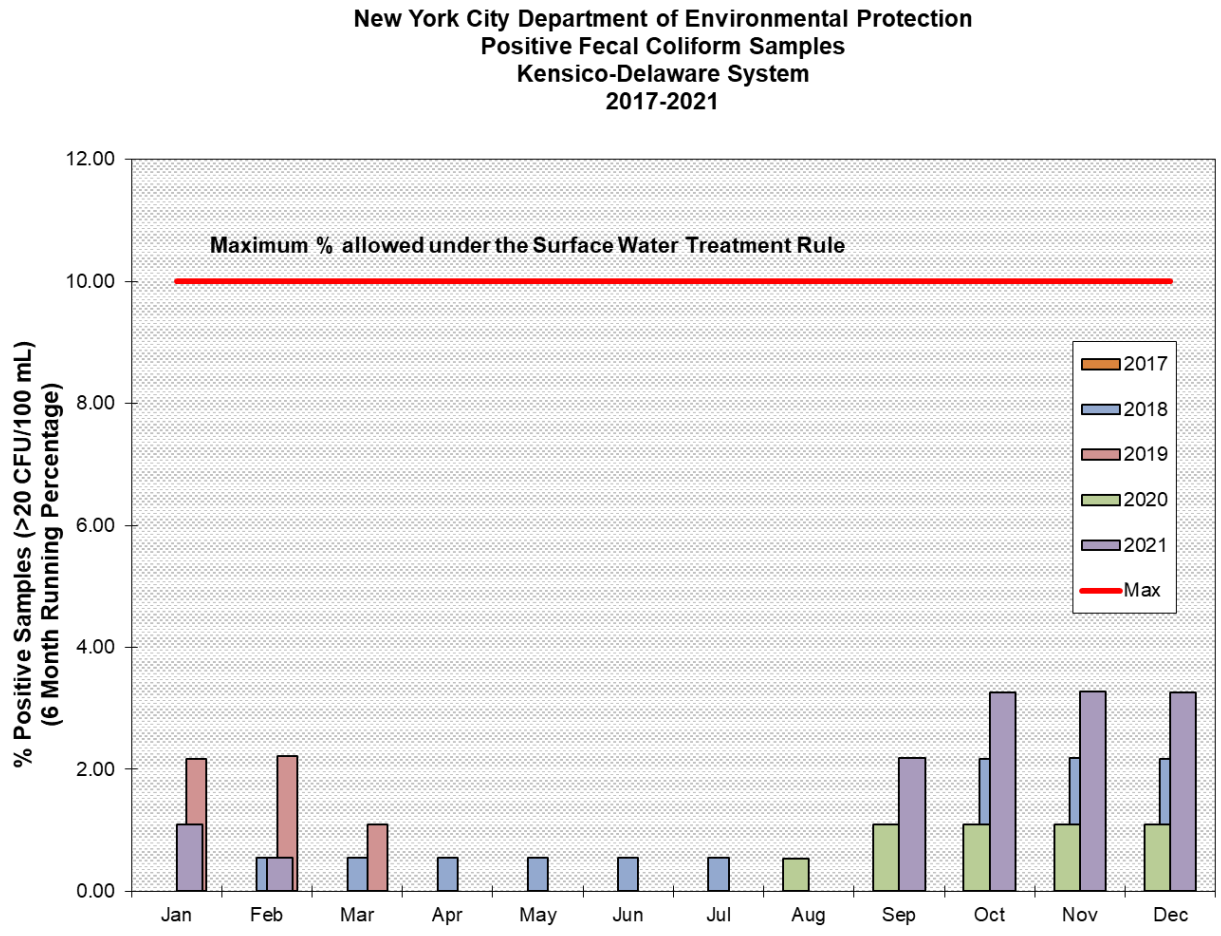

Figure 2.1 Positive fecal coliform samples, Kensico-Delaware System, 2017-2021.

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 2021 calendar year (Figure 2.2). No samples were collected from the Catskill Aqueduct in 2019 because the Catskill Aqueduct south of Kensico Reservoir was offline.

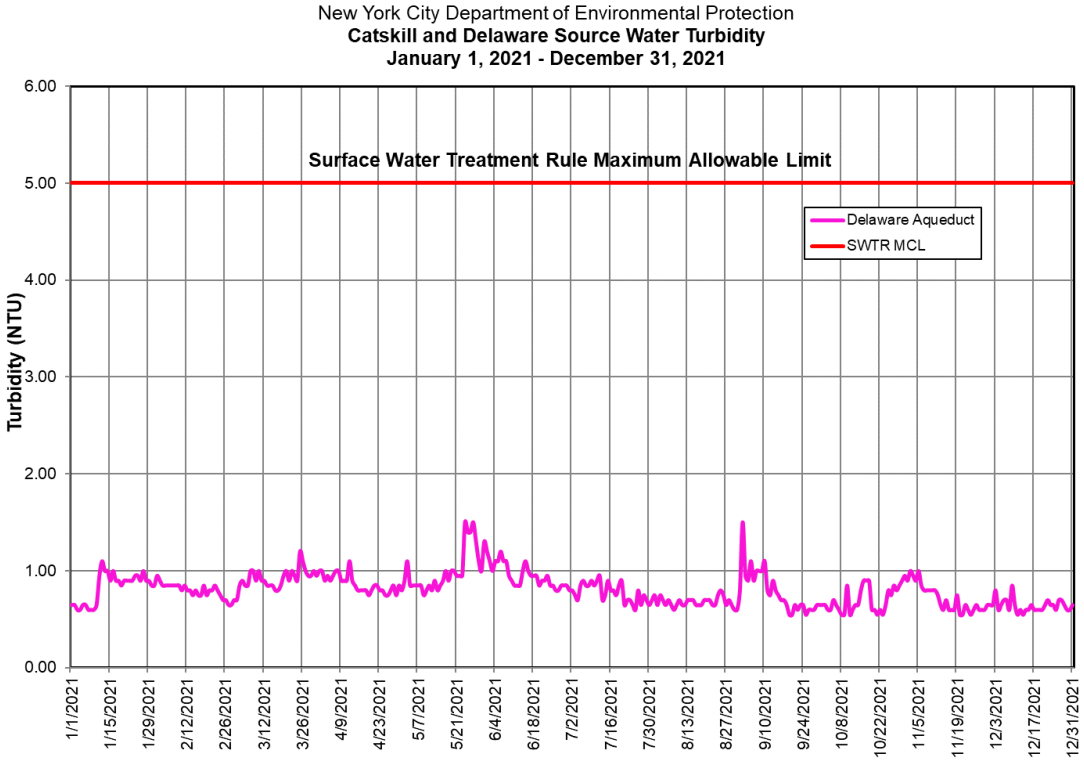

Figure 2.2 Catskill and Delaware source water turbidity, January 1, 2021-December 31, 2021.

2.1.3 Raw Water Disinfection/CT Values (40 CFR Sections 141.71(b)(1)(i) and 141.72(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 Reservoir on each aqueduct (second segments). The actual lowest net IAR in 2021 was 1.8 for the Catskill Aqueduct and 1.3 for the Delaware Aqueduct.

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

As required, continuous monitoring free chlorine residual was maintained at the distribution entry points throughout 2021, and at no time did the concentration fall 0.20 mg/L for more than four hours. All chlorine residuals, except one, were maintained at or above 0.20 mg/L at all distribution entry points during the year. On December 16, 2021, an accidental tripping of the heating element to the online evaporator in Downtake 1 disrupted chlorination to Tunnel 1

resulting in Shaft 3 chlorine residual dropping below 0.20 ppm from 3:15 p.m. to 4:19 p.m. (67 minutes). The lowest chlorine residual measured during the incident at an entry point was 0.01 mg/L.

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

Of the 15,617 samples measured for residual chlorine within the distribution system during 2021, all were greater than or equal to 0.01 mg/L, except for four 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 2021, performed on a quarterly basis, resulted in a maximum total trihalomethane (TTHM) value of 88 µg/L. The analysis for haloacetic acids, also performed on a quarterly basis, resulted in a maximum haloacetic acid five (HAA5) value of 93 µg/L.

The highest TTHM quarterly running annual average during 2021, recorded during the fourth quarter, was 45 µg/L, a level below the regulated level of 80 µg/L. The highest HAA5 quarterly running annual average, recorded during the fourth quarter, was 48 µ/L, a level below the regulated level of 60 µg/L.

The calculated LRAA for the fourth quarter of 2021 exceeded the maximum contaminant level for HAA5 of 60 µg/L at three of the 20 sites sampled on November 3, 2021, and the OEL was exceeded at seven sites, detailed in the table below. DEP became aware of the exceedance on November 29, 2021, and reported it to NYSDOH and the New York City Department of Health and Mental Hygiene. This was a Tier 2 violation of the SDWA, and public notification was made. (Table 2.1)

Table 2.1 Distribution HAA5 Exceedance Sites in the fourth quarter 2021.

Sample Site	Neighborhood	Borough	Zip Code	Result (µg/L)	LRAA (µg/L)	OEL (µg/L)
24350	Brighton Beach	Brooklyn	11235	81	**62**	71
50250	Silver Lake	Staten Island	10301	86	**65**	75
52050	Port Richmond	Staten Island	10302	93	**64**	76
23450	Stuyvesant Heights	Brooklyn	11221	73	54	**61**
45250	Somerville	Queens	11392	70	58	**63**
50850	Bulls Head	Staten Island	10314	72	56	**62**
77650	Bellaire	Queens	11329	77	54	**63**

Note: Bold numbers are exceedance values.

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 0.5% for all 12 months of 2021 (Figure 2.3). The number of compliance samples analyzed in 2021 for total coliforms was 9,874, of which 44 were total coliform positive, and none were *E. coli* positive. The annual percentage of compliance samples that were total coliform positive was 0.4%. Since 1995, DEP has collected 258,688 coliform compliance samples, and only 17 of them have tested positive for *E. coli*.

In 2021, heterotrophic plate counts (HPC) were all ≤500 CFU/mL, equivalent to a measurable free chlorine residual. Zero percent of the samples had an undetectable free chlorine residual or HPC >500 CFU/mL. 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.

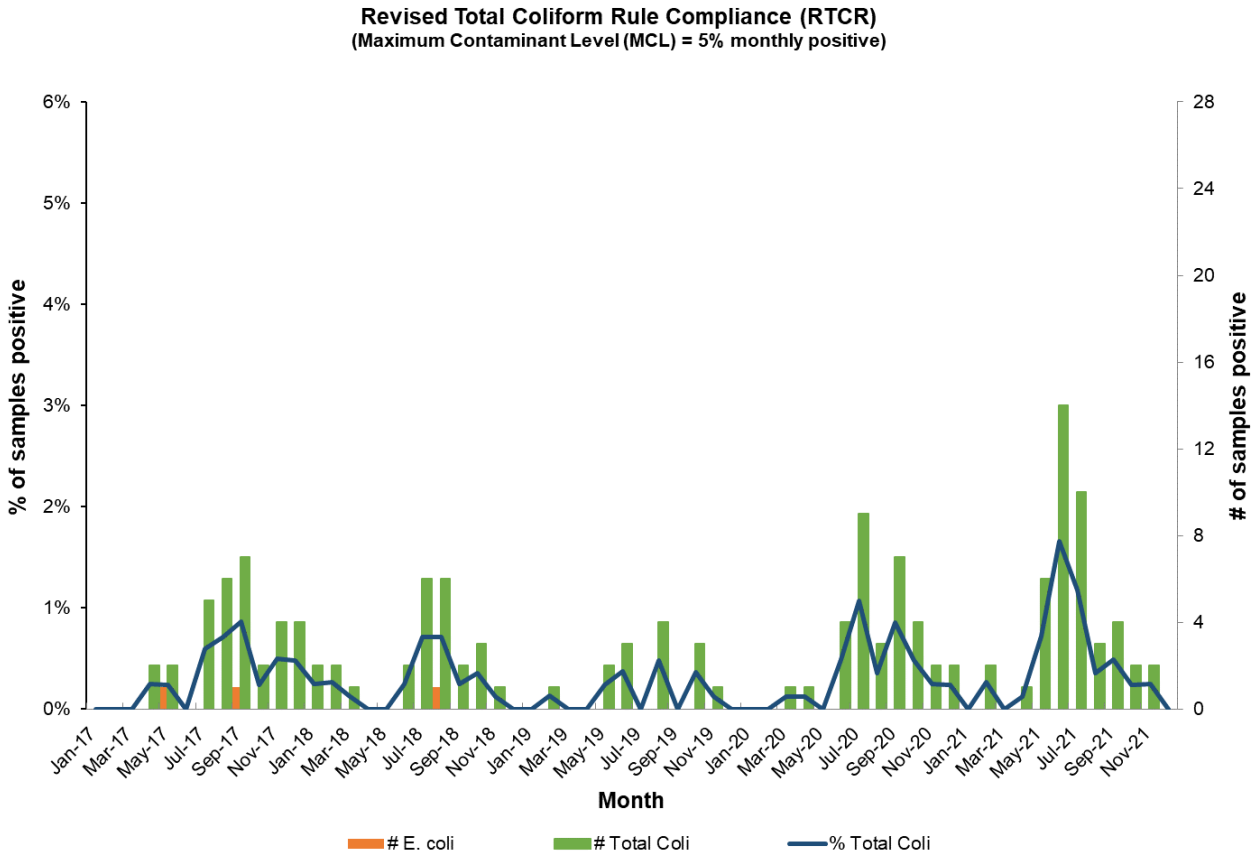

Figure 2.3 Positive total coliform samples, NYC distribution system, 2017-2021.

2.2.2 Chlorine Residual Maintenance in the Distribution System

During 2021, 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 2021 to improve the chlorine residual levels for the Fort Tilden, Roxbury, and Breezy Point areas (Rockaway Peninsula) in Queens, and for Staten Island. Because of these steps, detectable chlorine residuals were maintained throughout the distribution system in 2021.

2.3 Expert Panel Review of the Watershed Protection Plan

In March 2018, the National Academies of Science, Engineering and Medicine (NASEM) commenced a multi-year expert panel review of the City's Long-Term Watershed Protection Plan. The goal was to evaluate the adequacy of the Watershed Protection Programs for addressing water quality, water quality trends, and anticipated future activities that might adversely impact the water supply and its ability to comply with 40 CFR §141.71 and §141.171, and 10 NYCRR §5-1.30. NASEM released the final report digitally in July 2020 (https://www.nap.edu/catalog/25851/review-of-the-new-york-citywatershed- protection-program) and as a hardcopy in December 2020. The report has been downloaded over 1,600 times in 66 countries. It contains 63 major recommendations and numerous suggestions for enhancement, integration, and evaluation of watershed programs.

Following the release of the expert panel report, DEP convened five stakeholder meetings in January, February, and April 2021 to discuss the major recommendations and potential changes to the City's watershed program. DEP used the feedback from these stakeholder sessions along with the recommendations in the report and negotiation discussions with our state and federal regulators to inform the 2021 Long-Term Watershed Protection Plan submitted on December 15, 2021.

3. Environmental Infrastructure

3.1 Septic Programs

Since 1997, DEP has committed over $190 million to rehabilitate, replace, and maintain septic systems in the West of Hudson (WOH) watershed through the following programs managed by the Catskill Watershed Corporation (CWC): Septic Rehabilitation and Replacement Program, Septic Maintenance Program, Expanded Septic System Rehabilitation and Replacement Program (formerly the Small Business Septic Program), and the Cluster System Program.

The Septic Rehabilitation and Replacement Program funds the repair and replacement of septic systems serving single- or two-family residences. In 2021, CWC reimbursed 254 residential septic repairs, including 10 second-time repairs. To date, the program has funded more than 6,100 residential septics throughout the WOH watershed.

The Septic Maintenance Program is intended to reduce septic system failures through the subsidizing of regular pump-outs and maintenance. In 2021, CWC subsidized 604 septic tank pump-outs, for a cumulative 3,731 pump-outs since program inception.

The Expanded Septic System Rehabilitation and Replacement Program funds the repair or replacement of failed septic systems serving eligible governmental entities, not-for-profit organizations, and small business owners in the WOH watershed. In 2021, CWC funded the remediation of 14 septic systems under the Expanded Septic Program, bringing the total repairs or replacements to 43 since program inception.

The Cluster Septic System Program funds the planning, design, and construction of cluster systems in 13 WOH watershed communities; operation and maintenance funding is also available. CWC contacts communities about their eligibility for the program when failures are identified. No communities opted to participate in this program during 2021.

3.2 Community Wastewater Management Program

Administered by CWC, DEP funds the Community Wastewater Management Program (CWMP) to support the design and construction of community wastewater management solutions. To date, the CWMP has completed 12 projects in Bovina, DeLancey, Bloomville, Hamden, Boiceville, Ashland, Trout Creek, Lexington, South Kortright, Claryville, Shandaken, and West Conesville. A community septic system, West Conesville was completed in 2021. For the remaining three CWMP projects still in progress, highlights for 2021 include:

- Halcottsville – DEP approved a block grant of $8.95 million to connect this community to the City-owned Margaretville WWTP in September 2017. In 2021, the Delaware River Basin Commission approved the project's discharge permit; DEP issued SWPPP approval for stormwater controls; NYSDEC issued design approval; and the Town of Middletown bid the project, with the low bid exceeding the

engineering estimate by approximately $2.8 million. The town re-bid the project in December and will open bids in February 2022. DEP is amending the CWMP contract with CWC to provide additional funding to complete this project.

- New Kingston – DEP approved a block grant of $5.2 million for a community septic system in November 2018. In 2021, the engineer finalized design drawings and stormwater controls plans, and NYSDEC issued a notice of complete application and a draft SPDES permit in December. Final design and Stormwater Pollution Prevention Plan (SWPPP) approvals are awaiting issuance of the SPDES permit. Pending design approval, the Town of Middletown expects to bid the project in early 2022. Anticipating bids may exceed the engineer's cost estimate, DEP is amending the CWMP contract with CWC to provide additional funding, if necessary, to complete this project.
- Shokan – DEP approved a block grant of $48.715 million for a wastewater treatment plant serving the hamlets of Boiceville and Shokan in August 2020. The project is now in the pre-construction phase. In 2021, the Town of Olive secured a parcel of land and advanced the project design. Due to higher than expected project costs, DEP is amending the Shokan contract with CWC to provide additional funding to complete construction.

3.3 Sewer Extension Program

The Sewer Extension Program concluded prior to the 2017 FAD.

3.4 Stormwater Programs

3.4.1 Stormwater Cost-Sharing Programs

DEP pays for incremental costs associated with stormwater measures required solely by the City's Watershed Rules and Regulations (WR&R) to the extent they exceed the costs of complying with state and federal requirements. Pursuant to the 1997 MOA, two separate programs are available to offset eligible WR&R compliance costs related to the design, construction, and maintenance of stormwater pollution prevention plans and individual residential stormwater plans: the WOH Future Stormwater Controls Program (MOA-128) and the Future Stormwater Controls Paid for by the City Program (MOA-145). CWC administers both programs.

The MOA-128 Program reimburses municipalities and large businesses 100% and small businesses 50% for eligible WR&R costs. DEP has provided over $36.4 million to CWC for the MOA-128 Program, of which CWC has reimbursed over $9.7 million to program applicants and transferred approximately $17.5 million to other eligible programs.

The MOA-145 Program reimburses low-income housing projects and single-family homeowners 100% and small businesses 50% for eligible WR&R costs. Through 2021, CWC

has reimbursed over $900,000 to MOA-145 Program applicants. Table 3.1 summarizes projects approved for funding under both programs in 2021.

Table 3.1 WOH future stormwater controls projects approved for funding in 2021

Applicant	Project	CWC Funding
Hunter Peaks, LLC	Subdivision	$535,265.60
Getaway Roscoe, LLC	Campsites, cabins	$17,133.92
Michael & Dorian Clara	Residential	$19,529.80
Nigel Koulajian	Residential	$20,690.00
Bennet Gilbert	Residential	$13,502.96
Rosenthal & Buick	Residential	$7,950.00
Macollo, LLC	Parking lot	$23,698.75
Robert Perl	Residential	$285,698.04
Copperhood Property, LLC	Spa redevelopment	$12,419.50
DMK Development-Stamford, LLC	Retail store/parking	$109,476.79
Hudson Forest Gardens, LLC	Subdivision	$9,370.71
Nathan Sleeper	Residential	$23,459.43

3.4.2 Stormwater Retrofit Program

Jointly administered by DEP and CWC, the Stormwater Retrofit Program provides funding for the design, permitting, construction, and maintenance of best management practices to address existing stormwater retrofit runoff in concentrated areas of impervious surfaces.

Through 2021, the program has completed 79 stormwater retrofit projects, and 19 planning and assessment projects. Presently, there are two open retrofit projects, both approved for construction funding in 2020. One project involves a stormwater collection, conveyance, and treatment system for the Delaware Academy in Delhi. The second involves a stormwater collection, conveyance, and treatment system for Lake Street in the Village of Fleischmanns

4. Protection and Remediation Programs

4.1 Waterfowl Management Program

Implementation of the Waterfowl Management Program continued without interruption during 2021. The Waterfowl Management Program Annual Report, submitted on October 31, 2021, summarizes the program's activity from January 1 through July 31, 2021. The period from August 1 through December 31, 2021, will be summarized in the program's annual report to be submitted on October 31, 2022. Reports are also available on the DEP website (https://www1.nyc.gov/site/dep/about/filtration-avoidance-determination.page).

4.2 Land Acquisition

DEP's Land Acquisition Program (LAP) permanently protects high priority sensitive lands in the Catskill/Delaware watershed through fee simple acquisitions and the purchase of conservation easements (CEs). These are both direct purchases by the City and through partnerships with the Watershed Agricultural Council (WAC Farm and Forest CE programs), Catskill Center for Conservation and Development (Streamside Acquisition Program, or SAP), and local municipalities with assistance from the Catskill Watershed Corporation (flood buyout programs).

In 1997, the City owned 3.4% of the land area in the Catskill/Delaware (CAT/DEL) watershed (5.9% including reservoirs), while an additional 21.3% was protected by New York State and others for a total protected status of 24.7%. As of December 31, 2021, 39.7% (41.2% including reservoirs) of the watershed has been permanently protected by the City, state, and others. Table 4.1 and Table 4.2 describe natural resources and features on City-protected lands and conservation easements acquired pursuant to the FAD.

Table 4.1 Catskill/Delaware stream length and riparian buffer summary as of December 31, 2021.

Land Protection Category	Total in CAT/DEL Watershed incl. reservoirs (acres)[1]	% Total CAT/DEL Watershed Area	CAT/DEL Stream Length (miles)[2]	% Total CAT/DEL Stream Miles	CAT/DEL 300 ft. Riparian Buffer (acres)[3]	% Total CAT/DEL Riparian Buffers
Publicly-owned or Controlled lands[7]						
NYC-owned Non-LAP Property (Pre-1997 or facility-related)	61,366	5.9%	105	2.7%	6,887	2.8%
NYC-owned LAP Property (Post-1997, Fee Simple)	95,159	9.1%	380	9.9%	24,289	9.7%
Land Protected by LAP NYC Conservation Easement	25,700	2.5%	103	2.7%	6,450	2.6%
Land Protected by WAC Conservation Easement	28,059	2.7%	119	3.1%	7,385	3.0%
Land Protected by WAC Forest Easement	2,969	0.3%	6	0.1%	413	0.2%
Subtotal NYC Lands and Easements	**213,253**	**20.3%**	**712**	**18.6%**	**45,424**	**18.2%**

Land Protection Category	Total in CAT/DEL Watershed incl. reservoirs (acres)[1]	% Total CAT/DEL Watershed Area	CAT/DEL Stream Length (miles)[2]	% Total CAT/DEL Stream Miles	CAT/DEL 300 ft. Riparian Buffer (acres)[3]	% Total CAT/DEL Riparian Buffers
NY State-owned Land	209,533	20.0%	623	16.3%	42,415	17.0%
Other in Protected Status	9,335	0.9%	47	1.2%	2,831	1.1%
Total CAT/DEL Public Land:	**432,120**	**41.2%**	**1,382**	**36.1%**	**90,670**	**36.2%**
Private Watershed Lands						
Private Land	616,539	58.8%	2,449	63.9%	159,514	63.8%
Total All CAT/DEL Privately-owned Land:	**616,539**	**58.8%**	**2,449**	**63.9%**	**159,514**	**63.8%**
Grand Total All Land in CAT/DEL:	**1,048,660**	**100.0%**	**3,831**	**100.0%**	**250,184**	**100.0%**

Table 4.2 Catskill /Delaware wetland, forest cover, and floodplain summary as of December 31, 2021.

Land Protection Category	CAT/DEL Wetlands & Deepwater Habitats (acres)[4]	% Total CAT/DEL Wetlands & Deepwater Habitats	CAT/DEL Forest Cover (acres)[5]	% Total CAT/DEL Forest Cover	CAT/DEL FEMA-designated Floodplain (acres)[6]	% Total CAT/DEL FEMA-designated Floodplain
Publicly-owned or Controlled lands[7]						
NYC-owned Non-LAP Property (Pre-1997 or facility-related)	27,014	62.1%	31,789	3.8%	2,999	11.0%
NYC-owned LAP Property (Post-1997, Fee Simple)	2,383	5.5%	81,996	9.8%	2,162	8.0%
Land Protected by LAP NYC Conservation Easement	444	1.0%	22,206	2.7%	490	1.8%
Land Protected by WAC Conservation Easement	381	0.9%	14,940	1.8%	1,374	5.1%
Land Protected by WAC Forest Easement	17	0.0%	2,782	0.3%	41	0.2%
Subtotal NYC Lands and Easements	**30,238**	**69.5%**	**153,713**	**18.4%**	**7,067**	**26.0%**
NY State-owned Land	1,268	2.9%	207,282	24.9%	975	3.6%
Other in Protected Status	361	0.8%	7,939	1.0%	525	1.9%
Total CAT/DEL Public Land:	**31,867**	**73.2%**	**368,934**	**44.2%**	**8,566**	**31.6%**
Private Watershed Lands						
Private Land	11,659	26.8%	465,174	55.8%	18,581	68.4%
Total All CAT/DEL Privately-owned Land:	**11,659**	**26.8%**	**465,174**	**55.8%**	**18,581**	**68.4%**
Grand Total All Land in CAT/DEL:	**43,526**	**100.0%**	**834,108**	**100.0%**	**27,147**	**100.0%**

Note: Footnotes apply to both Table 4.1 and Table 4.2.

1. GIS Data Source: NYCDEP BWS, 1/2022. Land ownership acreage categories are calculated directly from areas of GIS polygons and therefore may not match exactly other survey-based acreage totals submitted by DEP. GIS data are clipped to the NYC watershed boundary. CAT/DEL includes all WOH basins plus West Branch, Boyd Corners, and Kensico. Reservoir basin boundaries derived from 1m LiDAR in 2014. Water features are from

local-resolution National Hydrography Dataset (NHD) originally derived from 1m LiDAR in 2013 and last updated by DEP GIS staff in 2020.

2. Includes streams and river centerlines only as a linear measurement, wherever they intersect with the specified land category.

3. Riparian Buffers are calculated as a 300-foot area on both sides of watercourses (streams and rivers only, excludes ponds, lakes, and reservoirs). Any water features within these buffers were excluded from buffer acreages.

4. Includes Wetlands plus Deepwater Habitats. Acres of both are calculated from a combined GIS layer of NWI and DEC-mapped polygons and summarized by categories specified by DEP wetlands scientists, already used for FAD annual reporting purposes. 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). These definitions are distinct from the definition of a natural features criteria qualified wetland under the WSP.

5. Forest features are from land cover classes derived from LiDAR, leaf-off and leaf-on imagery that was acquired by DEP in 2009. Specific classes included are deciduous and coniferous Trees from the land cover dataset, using the query "Landcover IN(1 , 4)".

6. Excludes NYC reservoir acreages. "Floodplains" are defined as 100-year Floodplain, areas with a 1% annual chance of flooding. The query used, "FLD_ZONE IN ('AO' , 'AH', 'AE', 'A', 'VE')", is extracted from published FEMA DFIRM data. Some Wetlands, Floodplains, and Riparian Buffers overlap with each other, so these acreages cannot be added together for a "total water feature" figure.

7. All LAP properties are "Under Contract" or "Closed". "Other in Protected Status" means the land is believed to be under some form of permanent ownership by a land trust or municipal government.

It is worth noting that DEP now owns or controls more stream length (712 linear miles) and roughly the same amount of land within stream buffers[1] (45,424 acres) than are protected in the Catskill/Delaware watershed by all other entities combined, including New York State. In total, 36% of stream length and stream buffers throughout the Catskill/Delaware watershed are under some type of permanent protected status along with 73% of wetlands and deepwater habitats, 65% of floodplains and 44% of forest cover. Overall, this means the proportion of protected water features in the watershed roughly equals or exceeds the proportion of acres protected.

Figure 4.1 depicts protected lands by basin, illustrating that in many high priority reservoir basins the City's land holdings have increased dramatically compared with pre-MOA ownership. In the Rondout, West Branch/Boyd Corners, and Schoharie basins, for example, the City has raised the number of protected acres by almost 800%, 1,500%, and 3,000% respectively. Through 2021, the City owned or controlled a total of 187,205 acres in the Catskill/Delaware watershed, or 18.3% of the land area.

[1] Stream buffers are defined as land within 300 feet of watercourses or 1,000 feet of reservoirs.

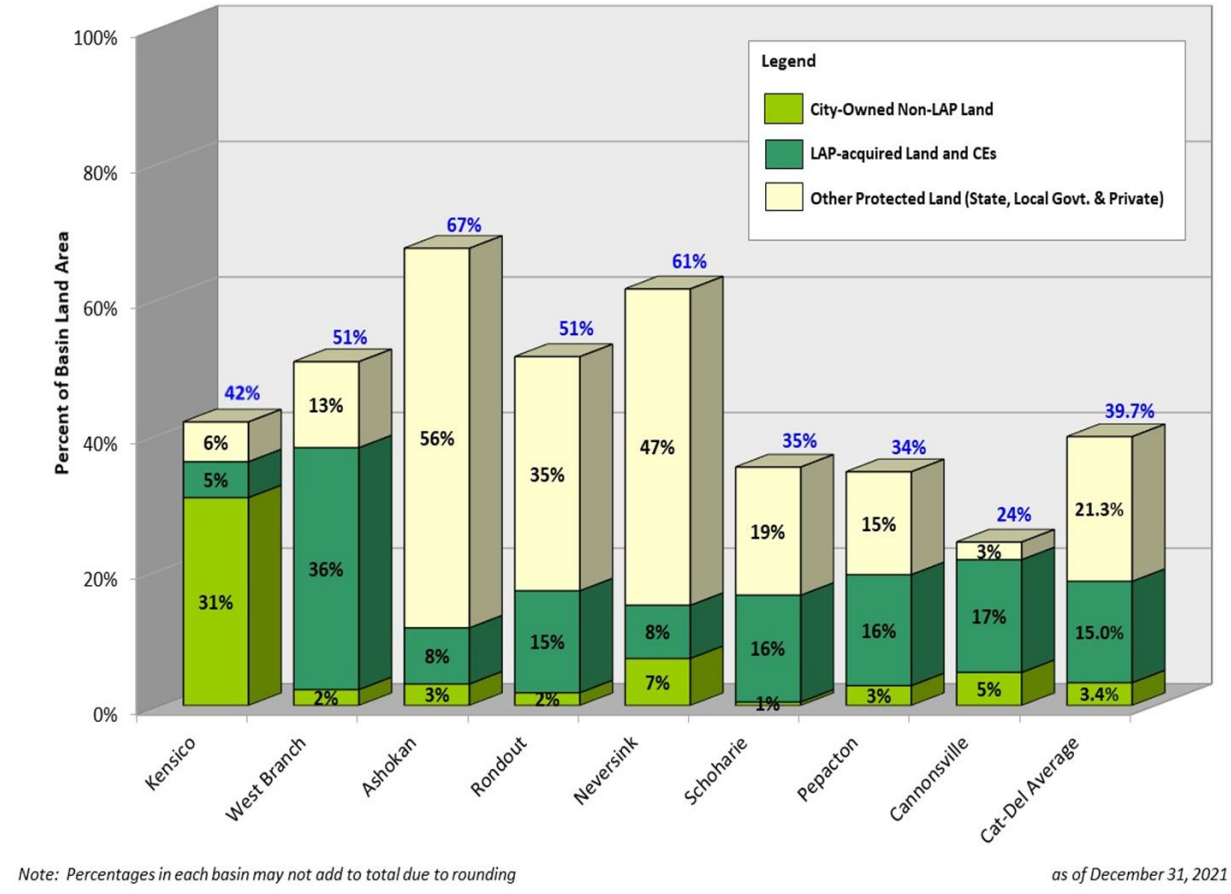

Figure 4.1 Percent of land protected in each Catskill/Delaware basin.

4.2.1 Solicitation Goals

The 2017 FAD requires the LAP to solicit 350,000 acres over the seven-year period 2018-2024. In 2021, DEP and its LAP partners solicited 11,868 acres. DEP was responsible for 10,133 acres; the remainder represented the maximum credit available per the FAD because of 342 acres solicited through the SAP, five acres solicited through the New York City-Funded Flood Buyout Program (NYCFFBO), and zero acres solicited through the WAC Farm and Forest Conservation Easement (CE) programs. Acreage solicited through these partner programs are multiplied by five to yield a total solicitation credit of 1,735 acres for WAC, SAP and NYCFFBO.

Combined with acres solicited since 2018, the LAP has thus far solicited 136,679 acres (39%) toward the 350,000-acre FAD goal. Since 1997, the LAP has solicited over 480,000 total acres, with the vast majority now re-solicitations of previously solicited properties. It is worth noting that throughout 2021, DEP engaged in discussions with stakeholders and FAD regulators

over the future of the LAP, resulting in DEP proposing a revised seven-year solicitation goal of 200,000 acres in its December 2021 Long-Term Watershed Protection Plan.

Overall outcomes of LAP solicitations by basin and county since 1997 are listed in Table 4.3 and Table 4.4, respectively. Relatively high levels of positive responses (measured by contracts executed or in negotiation) are seen among solicited landowners in EOH basins: 41% in Kensico and 68% in West Branch/Boyd Corners; but positive landowner responses in two WOH basins (Ashokan and Schoharie) are also at or above 30%. Similar findings are observed at the county level, with solicitations in Dutchess, Putnam and Westchester resulting in positive landowner responses well above 30%. Landowners in Greene County also responded at that level.

Table 4.3 Status of solicited properties (excluding WAC) in the CAT/DEL System by basin.

Basin	Current LAP Status	Number of Parcels	Acres	% of Basin Acres
Kensico	Signed/Closed	19	356	35%
	Active, Under Negotiation	1	60	6%
	Offer Refused	9	86	9%
	No Response	2	112	11%
	Not Interested	6	351	35%
	Other*	5	39	4%
	Kensico Basin Sub-Totals	**42**	**1,005**	
West Branch	Signed/Closed	207	9,407	67%
	Active, Under Negotiation	4	144	1%
	Offer Refused	41	412	3%
	No Response	42	733	5%
	Not Interested	49	2991	21%
	Other*	29	286	2%
	West Branch Basin Sub-Totals	**372**	**13,972**	
Ashokan	Signed/Closed	240	12,913	30%
	Active, Under Negotiation	7	132	0%
	Offer Refused	80	5,222	12%
	No Response	163	9,712	22%
	Not Interested	175	11,336	26%
	Other*	62	4,387	10%
	Ashokan Basin Sub-Totals	**727**	**43,701**	

Basin	Current LAP Status	Number of Parcels	Acres	% of Basin Acres
Cannonsville	Signed/Closed	271	27,296	20%
	Active, Under Negotiation	15	2,105	2%
	Offer Refused	75	6,686	5%
	No Response	517	46,878	35%
	Not Interested	446	44,962	33%
	Other*	100	7,778	6%
	Cannonsville Basin Sub-Totals	**1,424**	**135,706**	
Neversink	Signed/Closed	28	4,201	19%
	Active, Under Negotiation	4	891	4%
	Offer Refused	10	1,278	6%
	No Response	42	4,413	20%
	Not Interested	49	9,321	43%
	Other*	8	1,751	8%
	Neversink Basin Sub-Totals	**141**	**21,586**	
Pepacton	Signed/Closed	331	31,878	28%
	Active, Under Negotiation	7	835	1%
	Offer Refused	55	6,448	6%
	No Response	277	24,827	22%
	Not Interested	342	47,231	41%
	Other*	70	3,257	3%
	Pepacton Basin Sub-Totals	**1,082**	**114,475**	
Rondout	Signed/Closed	150	8,269	28%
	Active, Under Negotiation	5	188	1%
	Offer Refused	26	948	3%
	No Response	83	4,755	16%
	Not Interested	156	13,866	47%
	Other*	17	1,210	4%
	Rondout Basin Sub-Totals	**437**	**29,236**	

Basin	Current LAP Status	Number of Parcels	Acres	% of Basin Acres
Schoharie	Signed/Closed	381	29,216	32%
	Active, Under Negotiation	18	829	1%
	Offer Refused	97	5,589	6%
	No Response	381	17,985	20%
	Not Interested	311	25,770	28%
	Other*	180	12,508	14%
	Schoharie Basin Sub-Totals	1,368	91,897	
	Total	**5,593**	**451,848**	

* "Other" includes properties solicited and now developed, resolicitation under way (awaiting response) and contract rescinded.

Table 4.4 Status of solicited properties (excluding WAC) in the CAT/DEL System by county.

County	Current LAP Status	Number of Parcels	Acres	% of County
Dutchess	Signed/Closed	26	1,058	47%
	Offer Refused	7	54	2%
	No Response	8	105	5%
	Not Interested	12	1,028	45%
	Other*	3	18	1%
	Dutchess Sub-Totals	**56**	**2,263**	
Putnam	Signed/Closed	181	8,349	71%
	Active, Under Negotiation	4	144	1%
	Offer Refused	34	357	3%
	No Response	34	628	5%
	Not Interested	37	1,962	17%
	Other*	26	269	2%
	Putnam Sub-Totals	**316**	**11,709**	
Westchester	Signed/Closed	19	356	35%
	Active, Under Negotiation	1	60	6%
	Offer Refused	9	86	9%
	No Response	2	112	11%
	Not Interested	6	351	35%
	Other*	5	39	4%
	Westchester Sub-Totals	**42**	**1,005**	

County	Current LAP Status	Number of Parcels	Acres	% of County
Delaware	Signed/Closed	612	58,244	25%
	Active, Under Negotiation	21	2,699	1%
	Offer Refused	133	12,627	5%
	No Response	781	71,741	30%
	Not Interested	776	79,420	34%
	Other*	171	11,518	5%
	Delaware Sub-Totals	**2,494**	**236,249**	
Greene	Signed/Closed	304	25,329	32%
	Active, Under Negotiation	16	862	1%
	Offer Refused	70	4,405	6%
	No Response	326	16,219	21%
	Not Interested	250	22,027	28%
	Other*	150	10,260	13%
	Greene Sub-Totals	**1,116**	**79,102**	
Schoharie	Signed/Closed	70	4,629	26%
	Active, Under Negotiation	3	207	1%
	Offer Refused	25	1,583	9%
	No Response	89	3,370	19%
	Not Interested	75	5,740	33%
	Other*	30	2,130	12%
	Schoharie Sub-Totals	**292**	**17,660**	
Sullivan	Signed/Closed	69	5,133	20%
	Active, Under Negotiation	6	1,022	4%
	Offer Refused	18	1,110	4%
	No Response	66	5,980	24%
	Not Interested	118	9,651	38%
	Other*	12	2,386	9%
	Sullivan Sub-Totals	**289**	**25,283**	

County	Current LAP Status	Number of Parcels	Acres	% of County
Ulster	Signed/Closed	346	20,437	26%
	Active, Under Negotiation	10	188	0%
	Offer Refused	97	6,446	8%
	No Response	201	11,260	14%
	Not Interested	260	35,648	45%
	Other*	74	4,598	6%
	Ulster Sub-Totals	**988**	**78,578**	

* "Other" includes properties solicited and now developed, resolicitation under way (awaiting response) and contract rescinded.

Since 2019, all solicitations have adhered to DEP's proposed modifications approved by NYSDOH. These modifications increased surface water criteria (SWC) requirements in relation to other property characteristics and prohibited outgoing solicitations in towns upon reaching specified acquisition thresholds. LAP cannot undertake outgoing solicitations in Andes, Walton and Delhi. Shandaken also remains unavailable for solicitation under Special Condition 10(c) of the 2010 Water Supply Permit.

4.2.2 Purchase Contracts

As depicted in Appendix A Table 1, DEP and its LAP partners executed 11 purchase contracts in 2021 comprising 452 acres. The average SWC is 49% for these properties, compared to a cumulative average of 28% across all LAP deals to date. Appendix A Table 2 shows that purchase contracts executed in 2021 were valued at $2.4 million. To date, DEP and its LAP partners have signed 1,823 total contracts comprising 154,812 acres at a fair market value of $494.2 million, which does not include partner-operating costs to administer the WAC and SAP programs. DEP spent an additional $42 million on LAP soft costs such as appraisals and surveys.

Figure 4.2 depicts acreage signed to contract annually under core LAP and partner programs since 1995. Calendar years 2020 and 2021 represent the lowest annual number of acres signed to purchase contracts since the start of the program, which is attributable mainly to the pandemic-induced hiatus in all activities during most of this period.

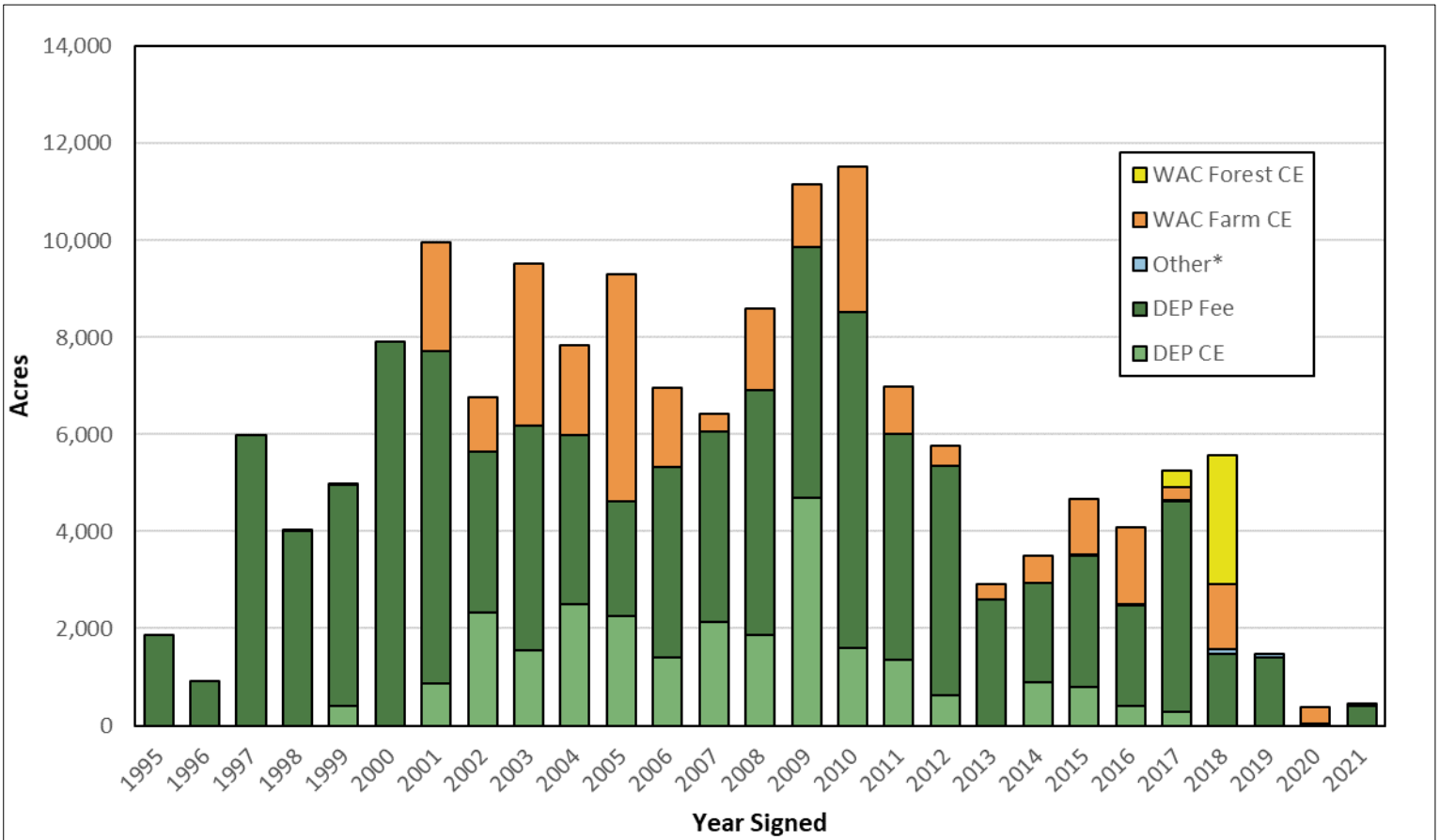

Figure 4.2 Annual acres secured by purchase contracts in the CAT/DEL watershed organized by LAP programs, 1995-2021.

As depicted Appendix A Table 3, DEP and its LAP partners closed on 24 purchase contracts in 2021 comprising 1,512 acres. The average SWC is 28% for these properties, the same as the cumulative average of 28% across all LAP deals to date. Appendix A Table 4 shows that projects closed in 2021 were valued at $5.4 million. To date, DEP and its LAP partners have closed on 1,806 total contracts comprising 153,636 newly acquired acres at a cost of $489.7 million. Appendix A Table 5 summarizes these newly acquired watershed lands by LAP Priority Area.

With the LAP's increasing selectivity toward portions of properties that contain SWC, a higher percentage of projects now require subdivisions. Many subdivisions are purposefully planned and designed at the start of a project to secure desired lands. Some subdivisions, however, are required during the contract phase to solve unexpected encroachments discovered by surveys. Regardless, such projects generally require local subdivision approvals and the seller retaining part of a property. To date, 10 of SAP's 25 closed purchase contracts (40%) and 399 of LAP's 1,359 (29%) closed fee simple purchase contracts (excluding flood buyout projects) have required subdivisions.

The exact number of acres retained by sellers in the aftermath of subdivisions is more difficult to assess. During 2020 and 2021, 36 projects totaling 3,349 acres were active (accepted purchase offers, signed purchase contracts, and/or closed) and required subdivisions, which resulted in sellers retaining 845 acres (20% of total pre-subdivision acreage). However, LAP's tracking system was not designed to maintain information on landowner-retained acreage for more than a few years; this data is periodically lost once updated tax lot data is brought into DEP's proprietary Geographic Information System. Without considerable research and review of 25 years of archived files, the LAP is unable to reliably report on acreage retained by sellers before 2020.

4.2.3 Transfer of Conservation Easements to New York State

DEP is required to convey CEs to New York State on all watershed lands acquired in fee simple. In 2021, DEP did not convey any new CEs to the state. As of December 31, 2021, DEP had submitted 85 CEs covering 1,112 properties (74,716 acres), of which NYSDEC has recorded 81 CEs on 1,065 properties (71,657 acres).

4.2.4 New York City-Funded Flood Buyout Program

In 2019, DEP and its partners finalized the model CE to be applied to municipally owned properties located wholly within 1% return interval flood (100-year base flood) zones. CWC will monitor these CE properties under an agreement with NYSDEC. DEP continues to work with the Coalition of Watershed Towns and NYSDEC toward finalizing other model CEs, including one for municipally owned properties with upland areas outside 1% return interval flood zones.

During 2021, DEP ordered six appraisals through the NYCFFBO, for 42 appraisals (excluding updates) ordered to date. Appraised values for accepted offers to date total $7.7 million, with projects in the categories of local flood analysis, stream projects, erosion and inundation. At the end of 2021, 49 municipal resolutions had been passed (four in 2021) and 23 purchase contracts had been executed, of which 22 have closed (five in 2021; the remaining contract was executed in 2021). A summary of all NYCFFBO contracts executed and closed to

date is provided in Appendix A Table 6. An example of a NYCFFBO property acquired in 2021 is shown in Figure 4.3.

Figure 4.3 This 0.12-acre parcel was acquired by the Village of Hunter in 2021 through the NYCFFBO. Flooding from Schoharie Creek during Tropical Storm Irene damaged this Main Street dwelling

4.2.5 Streamside Acquisition Program

DEP administers the pilot Streamside Acquisition Program (SAP) through an $8 million contract with the Catskill Center for Conservation and Development (CCCD). During 2021, CCCD ordered eight appraisals (including three updates), executed six purchase contracts on 49 acres, and closed on four projects totaling 26 acres. To date, the SAP has ordered and received 69 appraisals (including updates for time) on 64 properties, which has resulted in 31 signed contracts on 247 acres; 76% of this acreage is within 300-foot stream buffers or 100-year FEMA floodplains. To date, the SAP has closed on 25 contracts protecting 198 acres. Figure 4.4 depicts one such acquisition in the Town of Lexington.

Figure 4.4 A cascading stream on a 3.7-acre vacant lot in Greene County acquired in 2021 by NYC through the SAP.

In December 2021, following extensive discussions with watershed stakeholders, DEP submitted a FAD report that summarized proposed incentives intended to increase landowner participation in the SAP. DEP has already implemented some of these incentives.

4.2.6 Farm and Forest Easement Programs

DEP funds the Farm and Forest CE Programs through a $29 million contract with WAC that is extended through December 2022. The City is currently processing a successor contract that includes $11 million for the Farm CE Program and $8 million for the Forest CE Program as

required by the 2017 FAD. During 2021, virtually all WAC CE acquisition activities remained on pause as WAC continued to manage through an internal reorganization process that began in late 2020. No landowners were solicited and no real estate appraisals were ordered, but one farm CE that had been signed to contract in 2020 was closed during 2021 (343 acres in the Town of Stamford). As summarized in Appendix A Table 1 and Appendix A Table 2, WAC has closed on 157 Farm CEs protecting 28,229 acres and nine Forest CEs protecting 2,982 acres.

4.2.7 Water Supply Permit

The 2010 Water Supply Permit (WSP) authorizes the LAP to acquire up to 106,712 acres of land in the CAT/DEL watershed through 2025, beyond the 102,287 acres that had been acquired as of January 1, 2010. Between January 1, 2010, and December 31, 2021, DEP and its LAP partners signed contracts on 52,599 acres (49% of the total 106,712-acre limit), leaving a balance of 54,113 acres for potential acquisition pursuant to the WSP.

4.2.8 Cooperative Activities with Land Trusts

Although five towns (six eligible properties) opted into the Enhanced Land Trust Program in 2011, there has been no activity since then; whether at the project level or with respect to towns changing their participation status (2021 was the most recent five-year review opportunity for towns). DEP expects no future activity and does not plan to report on this effort going forward unless a project arises. DEP continues to contract with two locally based land trusts, WAC and the Catskill Center, to operate FAD-mandated acquisition programs.

4.2.9 Use of LAP-Acquired Land by Local Communities

The 2017 FAD requires DEP to participate in a workgroup convened to assess opportunities to use LAP-acquired lands to relocate development out of floodplains. Local communities have not convened any meetings with DEP on this topic in recent years.

4.3 Land Management

As the City continues to make significant investments in purchasing water supply lands in fee simple and conservation easements (CEs), DEP implements a comprehensive land management strategy. This strategy is focused on the management and stewardship of water supply lands and CEs, and the support and promotion of beneficial uses, such as watershed recreation.

4.3.1 Fee Simple Lands

As of December 31, 2021, DEP owns and manages 181,448 acres of City-owned fee simple lands and reservoirs. This includes pre-MOA reservoir buffer lands, newly acquired properties through the Land Acquisition Program (LAP), and land along aqueducts and shaft sites. As the City acquires new, smaller properties under the Flood Buyout Program and Streamside Acquisition Program, these properties are often isolated from other City-owned

parcels and typically involve active neighbors, which can present an array of property management challenges. The average size of parcels acquired is now 46.2 acres.

Property Inspections

DEP inspects all City-owned water supply lands per a monitoring policy that outlines procedures for property inspections and boundary maintenance. Property inspections are divided into three types: standard, focused, and aerial (although DEP has not conducted aerial inspections yet). The type of inspection a property receives depends on its priority, which is assigned based on its location, number of adjacent properties, various uses conducted on the property, and any history of trespass or encroachments. All City lands are posted with signage as appropriate, whether restrictive ("No Trespassing") or permissive ("Public Access Area").

DEP performs standard inspections on "standard priority" properties, those on which minimal or no trespass or encroachments have been observed, or those which have minimal road frontage and/or 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.

DEP annually performs focused inspections 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. DEP can change a property's inspection priority at any time depending on the circumstances, such as the discovery of encroachments, or perform additional site visits as needed. DEP records all inspections and site visits, along with journal notes, photos, encroachments, and observations, in its Watershed Lands Information System (WaLIS).

Encroachments

DEP strives to cure encroachments when they are discovered on City-owned lands, often during routine inspections of properties and other land management or volunteer stewardship activities. Once an encroachment is identified and categorized as minor, major, or criminal, DEP coordinates the appropriate response with other entities, including the City Law Department and DEP Police as necessary.

In 2021, DEP identified 47 new encroachments on City-owned watershed lands, most were categorized as minor. This was a significant increase from previous years, due largely to DEP developing a new tool in WaLIS that allows staff to more accurately report and track encroachments. In 2021, DEP successfully cured 15 encroachments through internal coordinated actions. Resolutions for other encroachments remain ongoing.

Land Use Permits

DEP issues land use permits (LUPs) to qualified entities seeking opportunities for limited use of City-owned land where no appropriate alternatives exist. LUPs have a term of five years

and may be renewed with approval by DEP. The conditions in LUPs are intended to ensure protection of water quality as well as City-owned property, assets and infrastructure, such as aqueducts and shaft sites. During 2021, DEP issued 32 LUPs and renewed over 800 LUPs.

Agricultural Uses

DEP allows City-owned lands to be used for agricultural activities through a landowner-licensing program that establishes certain operational conditions and land use restrictions. The most common agricultural use of City-owned land is hay harvesting. Most farmers using City-owned lands are enrolled in the Watershed Agricultural Program (WAP) and follow a Watershed Agricultural Council (WAC) Whole Farm Plan that prescribes best management practices (BMPs), such as soil stabilization techniques. Some of the City's agricultural lands have BMPs, such as livestock fencing and riparian buffers, already installed on them through the WAP or Conservation Reserve Enhancement Program (CREP).

In 2021, DEP approved two new agricultural use licenses covering 115 acres, for a total of 137 agricultural use projects in 26 watershed towns covering 3,197 acres. DEP continues to work with the WAP and individual licensees to allow certain low-impact BMPs to be installed on City-owned watershed lands pursuant to a Whole Farm Plan.

4.3.2 Conservation Easements

DEP continues to hold 177 CEs on properties totaling nearly 26,000 acres in the Catskill, Delaware, and Croton watersheds. DEP conducts two annual inspections of all CE properties in compliance with the MOA. One inspection is an on-the-ground visit focused on the margins of the building envelope where violations often occur. DEP also performs one annual inspection of CE properties by helicopter, which is highly efficient for larger properties and allows DEP to inspect over 10,000 acres in one day. Potential violations that could have serious water quality impacts are clearly visible from the air. If problems are observed, on-the-ground inspections can be scheduled to follow up and further document a situation.

During a 2021 aerial inspection, DEP discovered one new CE violation located in the rear of a remote property that would have been difficult to observe from a distance or access on foot. The property owner has agreed to remove debris that was dumped on a steep slope in violation of several CE restrictions. DEP also resolved seven violations in 2021 discovered in prior years; the prohibited activities were terminated and the sites restored.

When a CE property is sold, DEP's policy is to meet the new owners at the property, provide copies of baseline documentation, answer any questions about CE restrictions and activity approvals, and strive to establish good landowner relationships. DEP is aware of seven CE property transfers that took place in 2021, with four CE properties currently listed for sale. These transactions require DEP stewardship attention to ensure potential buyers and new property owners understand the easement restrictions. In 2021, DEP provided maps and deeds to five new CE owners, with site meetings planned during 2022.

DEP approved seven new requests in 2021 for approval of restricted activities: two stream work projects, one surface disturbance request, two farming with herbicide requests, and two requests to locate a rustic structure in a stream setback area. DEP reviewed and approved six new forest harvest project plans in 2021 in addition to performing harvest site inspections at seven CE properties, including three harvests approved in 2020.

WAC performed all MOA-required farm and forest CE inspections in 2021, including aerial inspections. WAC reported three easement violations, all of which were resolved.

4.3.3 Watershed Recreation

One of DEP's land management priorities is to allow and enhance low-impact recreational activities compatible with water quality protection. DEP provides outstanding recreational opportunities at 19 reservoirs, two controlled lakes, and thousands of acres of City-owned land throughout the Catskill, Delaware, and Croton watersheds.

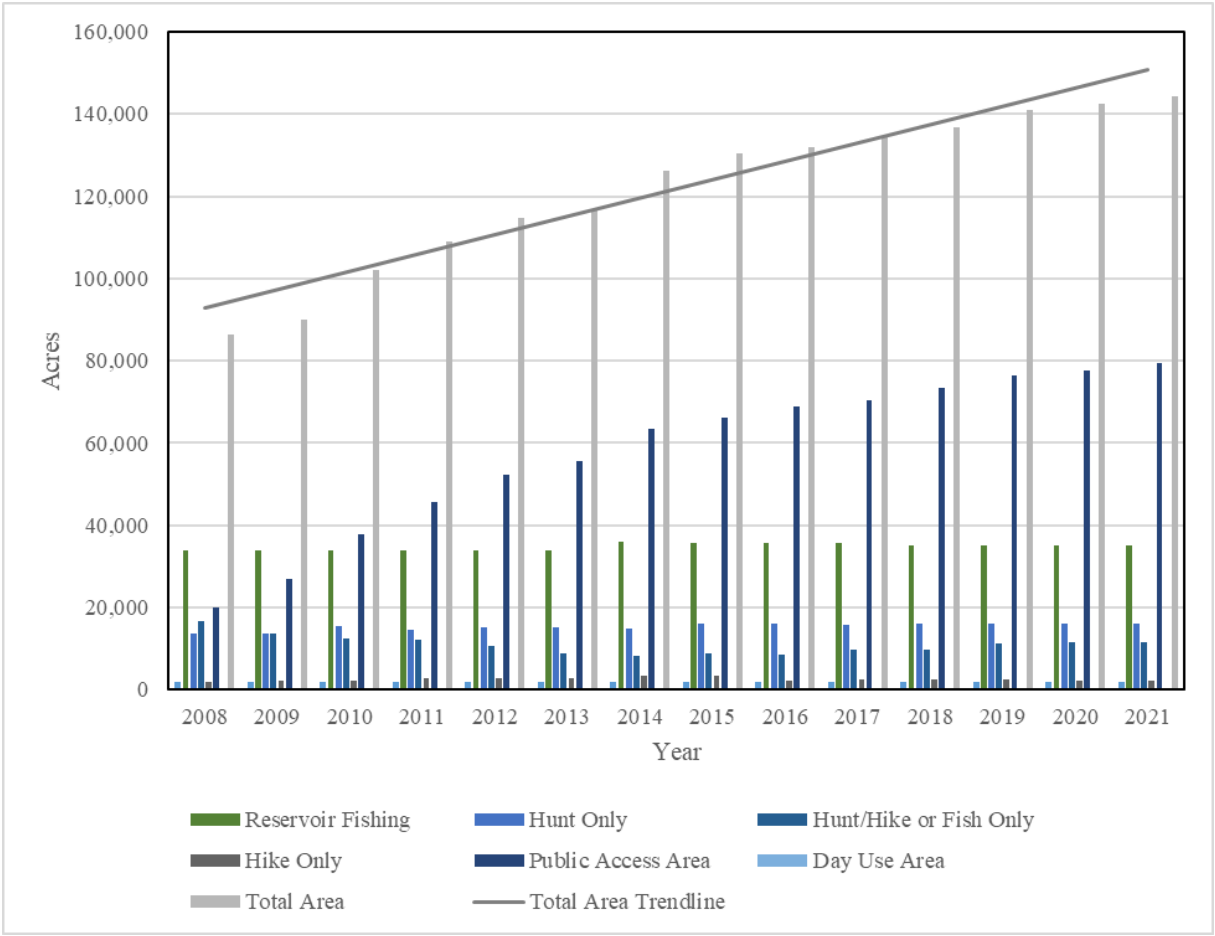

Figure 4.5 Acres of City-owned watershed land and reservoirs open for recreational access since 2008.

DEP continues to increase the acreage of watershed land available for recreation while expanding public access and supporting local economies through eco-tourism. In 2021, DEP opened an additional 1,779 acres of watershed land for recreation, bringing the total lands and reservoirs available for public use to 144,317 acres. DEP continued to open WOH watershed lands as Public Access Areas (PAAs), where users may hunt, hike, fish, or trap without a DEP Access Permit. Figure 4.5 provides a breakdown of the acres of land opened for recreation since 2008, which continues the upward trend that began in 2003.

In 2021, DEP coordinated with Ulster County to manage the 11.5-mile-long Ashokan Rail Trail, which opened to the public in 2019. DEP tracks recreational use with a trail counter installed at each of the three trailheads. Over 165,000 pedestrians and bikers utilized the trail in 2021, with DEP noting very few issues or concerns. Through a partnership with the Woodstock Land Conservancy and NY/NJ Trail Conference, volunteer trail stewards monitor the Ashokan Rail Trail during peak times, assist with enforcing trail rules, and educate recreational users about the importance of source water protection in proximity to the Ashokan Reservoir.

Although no new trails opened on City-owned watershed lands in 2021, DEP continued to assist local partners with planning for future trail projects. DEP also continued to work with existing trail partners, including Catskill Mountain Club, NY/NJ Trail Conference, Finger Lakes Trail Conference, and watershed communities, to host 16 recreational hiking trails spanning approximately 66 miles of City-owned watershed lands. In 2021, DEP issued permits to five state-licensed guides to bring clients onto City-owned lands and reservoirs for hunting, fishing, hiking, and other recreational activities; 47 guides hold permits to date.

DEP allows the traditional use of fishing boats on water supply reservoirs. Individuals must register their boats and obtain a permit from DEP. All boats must be steam cleaned before storage, and they must remain on their assigned reservoir. Boat owners must renew their registration every four years and abide by DEP's recreation rules, which limit the number of allowable boats per reservoir and within specific boat storage areas. In 2021, DEP issued 581 new boat tags and renewed 3,840 expiring boat tags. More than 13,000 fishing boats are currently permitted throughout the Catskill, Delaware and Croton watersheds.

For the first time, DEP's recreational boating program on the Cannonsville, Pepacton, Neversink, and Schoharie reservoirs opened for the full expanded season, starting on May 1 and continuing through October 31, 2021. In cooperation with CWC, DEP also allows certified vendors to rent canoes and kayaks for recreational use on City-owned reservoirs. In 2021, a total of 1,826 canoes and kayaks were registered with DEP or rented from local businesses, representing the most active year of the recreational boating program since it began.

4.3.4 Deer Management

Healthy forests are a cornerstone of DEP's watershed protection efforts, including strategies that promote sustainable forest management, invasive species controls, and forest regeneration. Of significant importance to forest regeneration is the need to manage deer

herbivory, which is why DEP works with state, local, and individual stakeholders to minimize negative deer impacts on City-owned watershed lands. DEP regularly communicates with NYSDEC, regional sporting groups, and members of the hunting community to strategize about deer management tools and hunting opportunities. In 2021, DEP participated in its tenth season of the Deer Management Assistance Program (DMAP) by issuing 423 DMAP permits to local hunters, resulting in 71 harvested deer. Since 2012, DEP has issued 3,074 DMAP permits that resulted in 562 deer being harvested, an 18% success rate.

4.4 Watershed Agricultural Program

The Watershed Agricultural Council (WAC) administers the Watershed Agricultural Program (WAP) using DEP contract 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 (FSA) provides technical and financial assistance for the federal Conservation Reserve Enhancement Program (CREP). The WAP reduces the risk of agricultural pollution through the development of Whole Farm Plans (WFPs) and the implementation of BMPs, along with the establishment of riparian buffers through CREP.

To date, the WAP has developed 456 WFPs on 375 West of Hudson (WOH) farms and 81 East of Hudson (EOH) farms. At the end of 2021, WAC reports that 313 WFPs (69%) remained active, including 247 WOH farms and 66 EOH farms. Of the 247 active WOH farms, 26 are classified as “active, ineligible” because they do not meet the WAP’s current eligibility requirements of five animal units.

During 2021, the WAP did not approve any new WFPs on WOH farms; one new WFP was approved on an EOH farm. Fourteen farms became inactive or “active, ineligible” (two EOH and 12 WOH). The WAP anticipates developing up to three new WFPs within the next 18 months. For the 326 active WFPs reported by WAC at the end of 2020, the WAP conducted 307 annual status reviews (240 WOH, 67 EOH) during 2021, exceeding the 90% FAD metric. The WAP also completed 74 WFP revisions for 68 WOH farms and six EOH farms.

In 2021, the WAP implemented 155 BMPs on all participating farms at a total cost of $1.8 million. These figures include 118 structural BMPs (of which 27 were repair or replacement BMPs on WOH farms totaling $776,839), 30 nutrient management plans on WOH farms and seven, no-cost management BMPs on EOH farms. To date, the WAP has implemented approximately 8,741 BMPs on all watershed farms at a cost exceeding $74 million; these figures include 7,909 BMPs on WOH farms ($67.2 million) and 832 BMPs on EOH farms ($7.3 million). In 2022, the WAP anticipates implementing approximately 200 BMPs on WOH farms at an estimated cost of $3.5 million and approximately 52 BMPs on EOH farms at an estimated cost of $873,000. These projections are subject to change as they are contingent upon WAC’s progress in resolving internal financial accounting issues related to its core DEP funding contracts.

The 2017 FAD requires the WAP to achieve several new BMP design and implementation metrics intended to reduce by 50% an existing backlog of BMPs identified in WOH WFPs prior to January 1, 2017, while limiting the creation of a new backlog of BMPs identified after January 1, 2017. The 50% backlog reduction metric applies to "new" BMPs identified but not yet implemented in WFP pollutant categories I-VI, as well as previously implemented BMPs regardless of pollutant category, in need of repair or replacement.

To serve as a baseline for the FAD metric, DEP and WAC adopted an official BMP backlog list dated January 1, 2017, that is comprised of 1,754 BMPs estimated to cost $35.8 million, including 1,410 priority "new" BMPs not yet implemented in WFP pollutant categories I-VI ($28.1 million) and 344 repair or replacement BMPs ($7.7 million). To achieve the 50% FAD reduction metric, the WAP must design and schedule for implementation at least 705 "new" backlog BMPs and at least 172 repair or replacement backlog BMPs before December 31, 2022. Implementation of these BMPs is required by December 31, 2024.

Between January 1, 2017, and December 31, 2021, the WAP implemented 531 backlog BMPs at a total cost of $9.1 million, including 300 "new" BMPs in pollutant categories I-VI ($5.2 million) and 231 repair or replacement BMPs ($3.9 million). As such, the WAP has reduced the backlog of "new" BMPs by only 21% (43% achievement toward the FAD implementation metric), while reducing the backlog of repair or replacement BMPs by 67% (thus exceeding the FAD metric for this category). During this same period, the WAP completed designs on 401 "new" backlog BMPs (300 implemented and 101 not yet implemented), thus achieving 57% toward the FAD design metric. The WAP also completed designs for 247 repair or replacement backlog BMPs (231 implemented and 16 not yet implemented), thus achieving 143% toward the FAD design metric.

Of the total 118 structural BMPs implemented in 2021, 21 were backlog BMPs (20 "new" and one repair or replacement) costing $967,040 ($717,901 for "new" BMPs and $249,139 for repair or replacement BMPs). To achieve current FAD metric deadlines, the WAP must design an additional 304 "new" backlog BMPs by December 31, 2022, and implement 405 "new" backlog BMPs before December 31, 2024. During 2022, the WAP anticipates designing approximately 312 "new" backlog BMPs for implementation.

Between January 1, 2017, and December 31, 2021, the WAP deleted 444 BMPs (25%) from the backlog list (404 "new" BMPs and 40 repair or replacement BMPs) due to farms becoming inactive, changes in farm operations or practices, or internal data reporting discrepancies. As of December 31, 2021, the WAP's official BMP backlog list included 779 total remaining BMPs, comprised of 706 "new" BMPs and 73 repair or replacement BMPs.

Since January 1, 2017, the WAP has planned or identified an additional 1,652 non-backlog BMPs (including new repair or replacement BMPs) on active WFPs estimated at $21.8 million. Out of these 1,652 newly identified BMPs, the WAP has implemented 393 new (non-backlog) BMPs and 134 non-backlog repair or replacement BMPs totaling $3.4 million. The

non-backlog BMP portfolio, more accurately described as a new backlog of BMPs, is being generated primarily through extensive ongoing revisions to existing WFPs and the planning of new agronomic BMPs such as liming and cover crops; this growing new backlog of BMPs is contrary to the dual goals of the 2017 FAD metric. Since many of these BMPs will not be implemented for years, it is likely that a high percentage will be deleted in the future due to changes in farming operations or farms becoming inactive.

During 2021, the WAP completed 36 new or updated nutrient management plans (NMPs) on 30 active WOH farms and six active EOH farms. In the WOH watershed, 220 participating farms are following NMPs, of which 201 (91%) are current (developed within the last three years). Additionally, 132 WOH farms participated in the Nutrient Management Credit Program in 2021 (a decrease of 10 participants from the prior year); 12 farms left the program because they no longer met the eligibility requirement while two new farms were added to the program.

The WAP also implemented its sixth year of the Precision Feed Management (PFM) Program, completing 16 new or revised feed management plans in 2021. The PFM Program now has 56 active participants, including 38 dairy farms (25 in the Cannonsville basin, eight in the Pepacton and five in the Schoharie basin) and 18 beef farms (13 in the Cannonsville basin, four in the Pepacton basin and one in the Rondout basin).

In 2021, the WAP enrolled two new contracts totaling 11.14 acres in the Delaware County CREP/Catskill Stream Buffer Initiative (CSBI) pilot program, while three CREP contracts were re-enrolled covering 15.74 acres of riparian forest buffers. Four contacts were either terminated or canceled. CREP implements riparian buffers on agricultural lands; CREP/CSBI implements riparian forest buffers on historical agricultural lands that are no longer actively farmed. As of December 31, 2021, there were 125 CREP contracts containing 1,306 acres of riparian forest buffers in the WOH watershed. It should be noted that the USDA's review of CREP contract rental rate payments that began in 2020 was concluded in 2021, with significant impacts on CREP enrollment. Although 117 CREP contract holders accepted a federal rental rate reduction, 46 contract holders terminated their contracts, resulting in a loss of approximately 361 acres from the NYC Watershed CREP between 2020 and 2021. Eleven contract holders had appealed the USDA's decision, and the national appeals division determined that USDA had improperly reduced their rental rate payments, which resulted in 10 contract holders having their rental rates restored to their original amounts and one termination included in the 46 reported above.

The WAP conducted 48 farmer education programs in 2021 attended by 1,750 total participants, of which 563 were watershed farmers. At least 128 individual WAP participants attended at least one farmer education program during 2021, with highlights including the Catskill Regional Agricultural Conference, the annual WAC Farm Tour, a series of lunchtime grazing webinars, a Food, Water and Climate Farm Tour for legislative staff members, and a farm tour for environmental policy graduate students from Bard College.

Finally, the WAC Economic Viability Program reaches thousands of people through its Pure Catskills print guide, e-newsletters, marketing website (Pure Catskills), and support of regional events that promote the sale and marketing of locally sourced watershed products.

4.5 Watershed Forestry Program

The Watershed Agricultural Council (WAC) Forestry Program is a partnership between DEP, WAC, and the United States Forest Service (USFS) that promotes well managed, working forests as a beneficial land use for watershed protection. The WAC Forestry Program combines core DEP contract funds with USFS grant funding to support the development of forest management plans, the implementation of forest stewardship activities through the Management Assistance Program (MAP), the implementation of BMPs on active timber harvest projects, professional training for loggers and foresters, and educational programs for landowners and school-based audiences.

In 2021, WAC funded the development of 35 forest management plans covering 7,718 acres. Two of these plans resulted in the new enrollment of 588 acres in the NYS Forest Tax Law (480-a tax abatement program), while the remaining 33 plans (7,130 acres) represented re-enrolled properties. A total of 59,592 watershed acres are enrolled in 480-a forest management plans funded by WAC. Landowners who enroll in this tax abatement program agree to restrict development, limit subdivision, and commit to a rolling 10-year schedule of forest stewardship activities that help prevent conversion of forestland to other less protective uses.

WAC also funded the completion of 67 MAP projects: 15 timber stand improvement projects, 29 wildlife improvement projects, eight invasive species control projects, one tree planting project, and 14 landowner site visits. To date, the program has funded 811 MAP projects on 6,548 acres of forestland, with timber stand improvement and wildlife improvement representing 77% of all completed projects.

In 2021, WAC funded the completion of 31 road BMP projects, which included seven stream crossing projects on active timber harvest sites. WAC also loaned out two portable bridges and distributed seven free BMP samples. Additionally, WAC completed 18 Croton Trees for Tribs projects that planted 190 trees and shrubs along 310 linear feet of streams.

WAC continues to maintain the interactive MyWoodlot.com website that educates forest landowners through online modules and helps them develop customized goals and management activities for their properties. The website contains 55 goals, 230 activities, 757 pieces of "how-to" information, and 286 blogs and feature stories. In 2021, 72 landowners created MyWoodlot profiles, for 391 profiles to date; 26 of these profiles (6.6%) belong to WAC staff, WAC committee members and partners. WAC reports that 48,258 unique users visited MyWoodlot.com during 2021.

In collaboration with the NYS Trained Logger Certification Program and Cornell Cooperative Extension, WAC sponsored nine professional logger-training workshops during

2021 attended by 81 participants. Approximately 88 loggers working in the Catskill/Lower Hudson region were "Trained Logger Certified" during 2021.

WAC and its partners sponsored numerous forest landowner education programs in 2021, including 25 workshops attended by 416 participants. The Cornell Master Forest Owners (MFO) Program conducted 53 landowner visits while 38 MFOs were available to assist forest landowners in the watershed, primarily the Catskill region.

The Watershed Forestry Program implemented the following virtual and in-person school-based education programs in 2021: Green Connections School Partnership Program, Watershed Forestry Institute for Teachers, and the Watershed Forestry Bus Tour Grants Program. Green Connections engaged 383 students during the 2020-2021 school year, while 21 teachers attended the Watershed Forestry Institute. WAC sponsored 43 virtual bus tours attended by 1,222 participants, primarily New York City students.

Additionally, the four watershed model forests hosted 62 educational programs and outreach events for 2,919 participants including youth, forest landowners, loggers, and water consumers. The Lennox Model Forest educated 840 campers with forest-based programs such as geocaching and nature hikes, while the Frost Valley Model Forest attracted 55 visitors. The Siuslaw Model Forest hosted 677 youth and adult programs, while the Clearpool Model Forest reached 1,347 visitors from East of Hudson and New York City.

Finally, the 2017 FAD required the WAC Forestry Program to evaluate the effectiveness of its forest management planning and landowner education programs using the Conservation Awareness Index (CAI), a survey tool that estimates landowner preparedness to make informed conservation decisions about their land. WAC mailed the CAI survey in both 2015 and 2020 to 3,000 watershed landowners having more than 10 acres of forest, and then compared CAI scores between the two analysis periods based on landowner demographics. DEP submitted a summary CAI evaluation report in December 2021 to fulfill this FAD deliverable.

4.6 Stream Management Program

Throughout 2021, the Stream Management Program (SMP) continued to work with local contract partners to restore and protect stream system stability and ecological integrity by promoting the long-term stewardship of streams and floodplains. Participation in the Flood Hazard Mitigation Program continued to expand as applications for implementation funding increased. The SMP completed an additional 10 stream projects (Figure 4.6), which taken together with 20 Catskill Streams Buffer Initiative (CSBI) projects, resulted in 474 completed projects treating more than 53 miles of stream. The SMP conducted nearly 38 miles of stream feature inventories (SFIs) in support of stream management planning and an additional 11 miles in support of the Esopus sediment studies. In 2021, the SMP continued to deliver a broad base of educational programming, professional engineering services, and technical assistance.

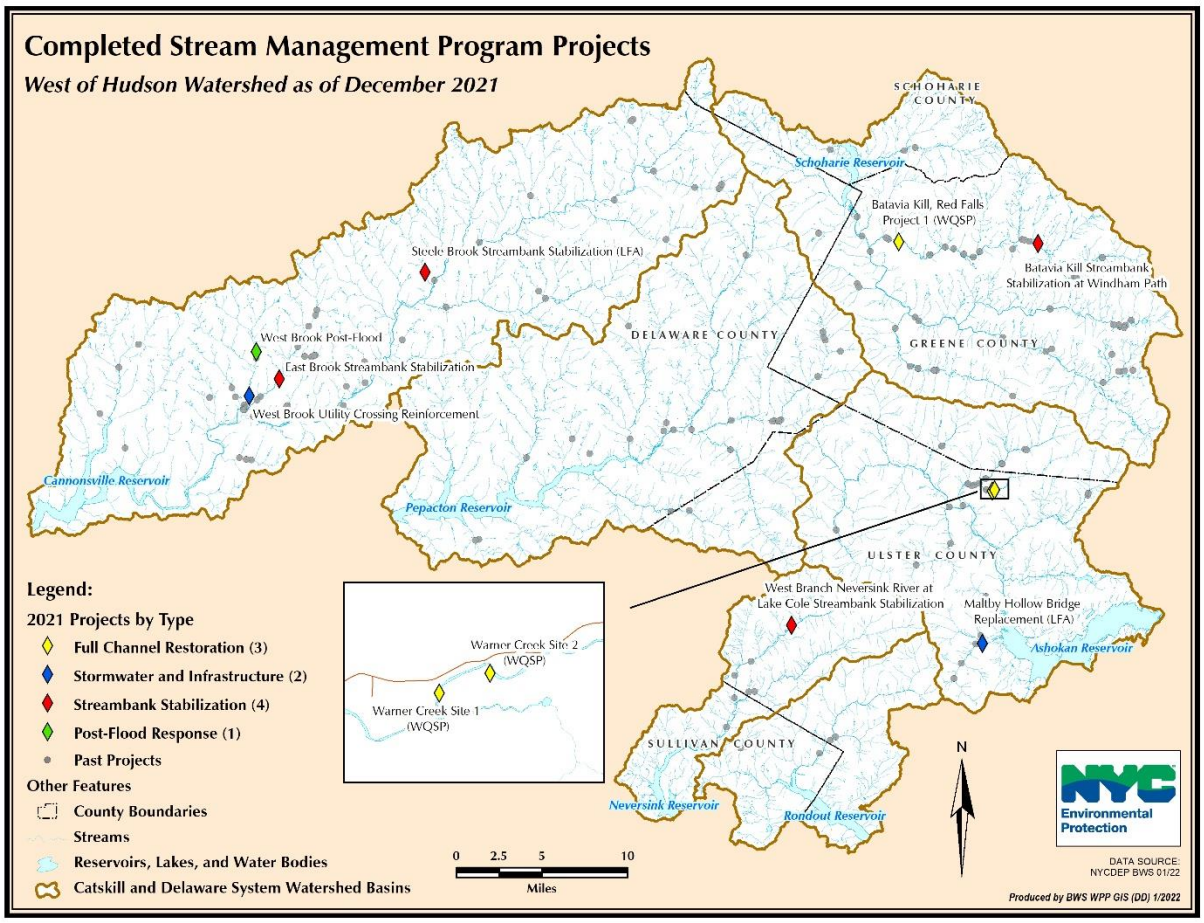

Figure 4.6 Location of SMP projects, 2021.

4.6.1 Water Quality Stream Projects

The 2017 FAD requires the completion of 24 water quality-driven stream projects (WQSPs) that prioritize improvements in water quality and are based on SFIs; at least eight of these projects shall be in the Ashokan basin. 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 latter program is described more fully in Section 4.7 of this report.

Each November, the SMP nominates WQSPs for NYSDOH approval under the FAD. In 2021, NYSDOH approved the Panther Kill Restoration project in Shandaken and the SMP constructed three previously approved projects: Warner Creek Site 1 and Site 2 in Shandaken, and the Batavia Kill at Red Falls, Project 1. To date, 15 projects have been approved (five in

Ashokan) and seven have been completed (three in Ashokan). Table 4.5 summarizes the status of WQSPs at the close of 2021.

Table 4.5 Status of WQSPs toward 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 Project 1	Completed	1,606	Schoharie
Batavia Kill at Red Falls Project 2	Approved	585	Schoharie
West Branch Neversink River at Clothes Pool	Completed	850	Neversink
Hillslope Stabilization at Bull Run	Approved	300	Pepacton
East Kill at Colgate Lake Road	Completed	700	Schoharie
Warner Creek Site 1	Completed	540	Ashokan
Warner Creek Site 2	Completed	560	Ashokan
Stony Clove Above Jansen Road	Approved	1,600	Ashokan
West Kill Above Wolff Road	Approved	1,000	Schoharie
East Branch Delaware River at Ladleton	Approved	1,200	Neversink
West Branch Delaware River at Riverhaven Farm	Approved	2,350	Cannonsville
West Branch Delaware River at Birdsong Farm	Approved	2,000	Cannonsville
Panther Kill Stream Restoration	Approved	700	Ashokan

Red Falls contains the largest and most complex stream segments SMP has addressed to date; the entire project area is approximately 6,000 feet in length and includes multiple large hillslope failures. The Batavia Kill Stream Management Plan prioritized the Red Falls segments based on water quality impacts from excessive erosion into extensive glacial lacustrine clay and till deposits, and mass wasting of steep hillslopes exceeding 50 feet in height. Phase 1 of Project 1, completed in 2020 at a cost of $564,766, prepared the site for Phase 2 and required construction of a 2,900-foot-long access road and a 1,250-foot-long dewatering channel.

Phase 2 restored the stream and created a floodplain along 1,606 feet of channel starting from Red Falls and proceeding upstream. This involved construction of grade controls, including three boulder riffles and a cross vane to prevent further incision destabilizing hillslopes, bank stabilization using rootwads and log revetment, and extensive floodplain grading and revegetation. The final cost of Phase 2 was $1,563,319. Red Falls Project 2 is planned for 2022 and will include an additional 585 feet of stream restoration followed by restoration of the entire 13.5-acre site. Figure 4.7 shows the Red Falls Project 1 prior to and following Phase 2 restoration.

Figure 4.7 Red Falls Project Phase 2 prior to restoration (top) and Phase 2 following restoration (bottom).

4.6.2 Flood Hazard Mitigation Program

The Flood Hazard Mitigation Program supports the development of LFAs, which identify flood hazards in WOH population centers through hydraulic models, followed by the implementation of LFA-recommended projects through the SMP, Catskill Watershed Corporation (CWC) Local Flood Hazard Mitigation Implementation Program (LFHMIP), or the New York City-Funded Flood Buyout Program (NYCFFBO).

The 2017 FAD requires the City to make $15 million available through SMP partner contracts to fund the implementation of 50 LFA-recommended projects, of which DEP committed an initial $7.1 million in five new SMP partner contracts collectively registered during 2019-2020. The 2017 FAD also requires the City to assess the use of $10.1 million in flood hazard mitigation funding that was committed to SMP partner contracts pursuant to the Revised 2007 FAD, as well as the $17 million previously committed to CWC's LFHMIP.

SMP Local Flood Analyses (LFAs) and Recommended Projects

In 2021, the communities of Jewett and Grahamsville substantially advanced LFAs covering six population centers, while Pine Hill initiated the LFA process. To date, DEP has committed a total of $1.92 million to the development of LFAs, with 22 LFAs completed for 36 population centers. Figure 4.8 depicts the locations and status of LFAs. A full list of completed LFAs can be found here.

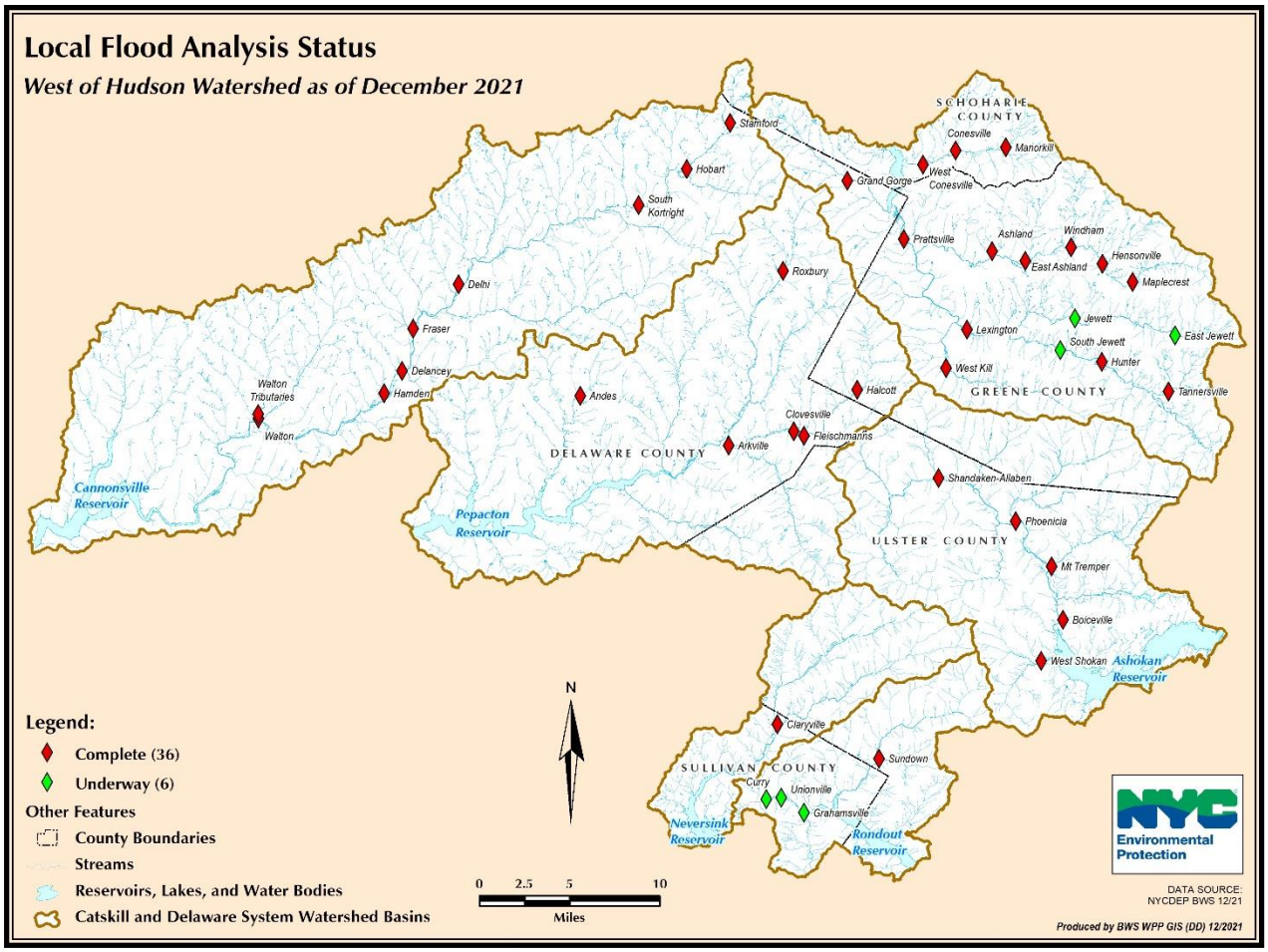

Figure 4.8 Location and status of LFA projects, 2021.

In 2021, the SMP partners awarded five grants totaling $1.2 million to support the implementation of LFA-recommended projects. These grants include design of expanded bridges over the Esopus Creek in Phoenicia and in the Village of Stamford, and stream channel restoration at the Andes Central School. To date, the SMP has awarded 25 grants to support 17 discrete projects per the 2017 FAD requirement. SMP partners completed two LFA-recommended projects in 2021: the Maltby Hollow bridge replacement in Ulster County and the Steele Brook streambank stabilization in Delaware County.

The Olive LFA identified the Maltby Hollow Bridge as being in poor condition, undersized, and posing a significant access vulnerability during and following flood events. Ulster County Department of Public Works designed the new structure to exceed the NYSDOT standard for passing the future projected peak flow of the 100-year flood (defined as the current peak flow increased by 20%) as well the 100-year flow with a modeled 50% flood-debris

blockage and the 500-year flow with no blockages. The total project cost of nearly $2.2 million includes an Ashokan Watershed Stream Management Program (AWSMP) contribution of $230,000 towards design and construction inspection, and a CWC contribution of $750,000 towards construction through the LFHMIP (Figure 4.9).

Figure 4.9 Maltby Hollow Bridge: Top is before replacement; bottom is after replacement.

The Steele Brook Streambank Stabilization Project was identified in the Delhi LFA to address large woody debris and sediment contributing to blockages at the Main Street Bridge that exacerbate flooding in the Village of Delhi. Delaware County Soil and Water Conservation District (DCSWCD) completed construction of the 810-foot-long project at a total cost of $413,203, including a $309,903 contribution from the U.S. Army Corps of Engineers (Figure 4.10).

Figure 4.10 Steele Brook at Reservoir Park before (top) and after (bottom) construction.

In summary, of the original $10.1 million that DEP committed to prior SMP partner contracts under the Revised 2007 FAD, nearly $6.9 million was committed to projects and $6.2 million of that amount was expended prior to those contracts being closed out during 2019-2020. Of the $7.1 million that DEP committed to current SMP partner contracts pursuant to the 2017 FAD, over $3.4 million has been committed to projects and nearly $1.3 million of that amount has been expended.

CWC Local Flood Hazard Mitigation Implementation Program

In 2021, CWC awarded funding to support three property-protection feasibility studies for potential elevation and floodproofing projects. To date, 53 feasibility studies have been approved for funding, of which 52 are completed. CWC contracts with LaBella Associates (formerly Chazen Engineering) to complete these studies.

CWC awarded funding to design two property-protection projects: elevating a residence in Lexington and wet floodproofing a commercial building in Walton. Fourteen property-protection design projects have been approved to date. CWC also approved construction funding to support two property mitigation projects: a residence in Prattsville and a business in Walton. To date, CWC has awarded funding to support eight property-protection construction projects, of which three have been completed.

Additionally, CWC awarded project design funding for Andes Central School to relocate utilities out of the floodplain and for the Village of Walton to properly upsize a critical NYSDOT culvert on NYS Route 10 over Third Brook. The Town of Olive received construction funding to upsize a culvert on a dead-end town road in West Shokan. The Village of Tannersville received funding to construct a streambank stabilization project on Railroad Avenue. The Olive Fire Department received additional construction funding to help relocate the Boiceville fire station to a nearby upland site out of the floodplain.

CWC approved three fuel tank anchoring applications to address pollutant sources in flood-prone areas. To date, CWC has approved 53 applications and funded the anchoring of 47 propane tanks (15,500 gallons) and 18 fuel oil tanks (4,725 gallons).

CWC continued to work with DEP to fund the removal of structures associated with the NYCFFBO. In 2021, six demolitions were completed: four in the hamlet of Boiceville, one in Conesville, and one in Hunter. Pre-demolition work was also completed for another eight properties across six municipalities to be demolished in 2022.

In summary, of the original $17 million DEP committed to CWC's LFHMIP, more than $11.1 million has been committed to projects and $3.9 million of that amount has been expended. DEP and CWC are finalizing negotiations on a new $15-million successor contract to continue funding the LFMHIP through the term of the 2017 FAD.

4.6.3 Implementing Stream Management Plans

In 2021, DEP and its SMP partners (Soil and Water Conservation Districts in Ulster, Sullivan, Delaware and Greene counties, and the Cornell Cooperative Extension of Ulster County) 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 recommendations made in stream management plans, track status and progress via annual action plans, and administer the Stream Management Implementation Program (SMIP) to support locally driven projects.

Table 4.6 summarizes the total number of SMIP grants awarded in 2021 and to date (since 2009). For the 296 SMIP grants awarded to date, 247 are complete (83%), 40 are in process (14%), and 9 are in the design phase (3%). In 2021, the SMP partners committed $1.9 million to 21 new projects and completed five SMIP construction-related projects, which are summarized in Table 4.7. The partners also completed three education and outreach projects and two planning and research projects. Since 2018, the SMP tracks flood hazard mitigation projects separately as LFA-recommended projects to be consistent with the 2017 FAD. Additional information on all SMIP projects can be found here.

Table 4.6 Number of SMIP awards by category for 2021 and totals to date.

SMIP Category	2021	Total
Education and Outreach	3	78
Recreation and Habitat Improvements	0	24
Stormwater and Critical Area Seeding	9	69
Landowner Assistance/Streambank Restoration	6	45
Planning and Research	3	52
Flood Hazard Mitigation	0	28
Total	**21**	**296**

The total reflects new projects as well as accounting for withdrawn projects.

Table 4.7 Summary of locally driven SMP projects completed in 2021

Basin	Type of Project	Name of Project	Length (feet)
Cannonsville	Stormwater and Infrastructure	West Brook Utility Crossing Reinforcement	150
Cannonsville	Post Flood Response	West Brook	350
Cannonsville	Streambank Stabilization	East Brook	740
Neversink	Streambank Stabilization	West Branch Neversink River at Lake Cole	900
Schoharie	Streambank Stabilization	Batavia Kill at Windham Path	294

4.6.4 Stream Studies

The SMP provides scientific investigations to support stream management activities. Priorities include (1) advancing and documenting the status of the 10-year collaborative research effort investigating turbidity dynamics and reduction efforts led by the USGS and DEP, (2) working with consultants to obtain new bankfull channel geometry data for Schoharie Creek, and (3) working with SMP partners on research and assessment initiatives.

The upper Esopus Creek watershed turbidity/suspended-sediment source and treatment monitoring research advanced through the fifth water year of the 10-year monitoring period. DEP submitted the second biennial FAD status report in March 2021 and completed a second round of SFI mapping (11 stream miles) to record erosional connectivity with turbidity source geology in the Stony Clove watershed. The AWSMP constructed two of the three stream turbidity reduction projects (STRPs) in the Stony Clove watershed, and DEP continued high resolution topographic monitoring at a set of eroding stream reaches that are candidates for future STRP applications. In September 2021, the first peer-reviewed journal article documenting a modeling application of the hydrologic, water quality and geomorphology monitoring data was published.

On December 25, 2020, Stony Clove Creek and most of its monitored tributaries experienced a rain-on-snow event that produced a 10-to-15-year recurrence interval flood. The flood was powerful enough to cause extensive channel erosion and increased connectivity with turbidity source geology (glacial legacy sediment) throughout the Stony Clove basin. It took several months before turbidity returned to pre-flood conditions, especially in Hollow Tree Brook, Ox Clove Creek, and Stony Clove Creek. This flood event presented an opportunity to document post-flood conditions and begin testing the hypothesis that floods of this magnitude-frequency result in a watershed scale geomorphic disturbance that produces a period of elevated turbidity at lower streamflow thresholds. DEP spent much of the 2021 field season mapping the Stony Clove watershed fluvial geomorphic response and documenting the new turbidity source conditions. This data, along with the water quality monitoring data, will help inform the conceptual model of turbidity production and potential for reduction in the study area.

DEP and Stantec Engineering advanced the effort to finalize revisions to the Catskill Mountain bankfull discharge and hydraulic geometry regionalized regression relationships (regional curves). The regional curves are tools stream managers use to predict bankfull discharge and associated channel dimensions (width, depth and area) as a function of the stream drainage area. In August 2021, a Schoharie Creek bankfull flood event enabled mapping of the flood stage at the two USGS streamflow stations. Surveys conducted in November at the study reaches will enable DEP to consider their inclusion in the Catskill bankfull regional curves.

4.6.5 Watershed Emergency Stream Response and Recovery Plan

The 2017 FAD requires that DEP participate in a working group to be convened by NYSDEC to develop an Emergency Stream Response and Recovery Plan, and to report on

progress made within 12 months of NYSDEC convening the workgroup. NYSDEC is expected to issue a new Statewide Programmatic General Permit for emergency response post-storm recovery activities that DEP hopes will expedite the issuance of emergency permits and improve the quality of post flood stream work. As of December 31, 2021, the working group has not met.

4.7 Riparian Buffer Protection Program

DEP protects and manages riparian buffers as an essential component of its overall watershed protection program. DEP's Land Acquisition Program (LAP) acquires publicly owned buffers, while privately owned buffers are managed and protected through the Stream Management Program's (SMP) Catskill Streams Buffer Initiative (CSBI), Conservation Reserve Enhancement Program (CREP), and other watershed programs.

4.7.1 Activities on City-owned or Controlled Land

DEP's 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. Within the Catskill/Delaware watershed, 36% (90,670 acres) of all stream buffers are protected by fee simple public ownership or conservation easements held by the City, state, Watershed Agricultural Council (WAC), local municipalities, or land trusts. It is worth noting that DEP now owns or controls more stream length (712 miles) and roughly the same amount of land within stream buffers (45,424 acres) as are protected in the Catskill/Delaware watershed by all other entities combined.

DEP carefully considers the presence or absence of riparian buffers when reviewing requests for projects on City-owned lands. For example, when issuing agricultural use licenses for 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 BMPs, such as temporary bridges or arch culverts, to minimize impacts on streams and buffers.

4.7.2 Catskill Stream Buffer Initiative

The CSBI strives to enhance the extent and functionality of WOH riparian buffers through vegetation mapping, riparian corridor planning, buffer restoration, maintenance and monitoring, invasive plant removal, and extensive education and outreach. DEP works with five county Soil and Water Conservation Districts (SWCDs) whose CSBI coordinators develop Riparian Corridor Management Plans (RCMPs) for participating landowners and guide project design. Since 2009, county CSBI coordinators have completed 162 RCMPs, including 18 new RCMPs in 2021.

One unique aspect of the CSBI is the propagation of local genotypes of Catskill native species. Since 2009, the SMP has contracted with nurseries, including the Greenbelt Native Plant Center and One Nature, LLC, to grow over 70,239 gallon-sized trees and shrubs from locally collected seed. In 2020 and 2021, DEP and its partners received 6,739 gallon-sized trees and shrubs through these contracts.

In 2021, CSBI planting projects took place on three types of sites: the CSBI base program, the CREP/CSBI pilot program, and extensions of existing CSBI projects (Table 4.8). The program added 20 new project sites (18 to the CSBI base program and two CREP/CSBI) and extended the buffer length on two existing CSBI projects. Altogether, the CSBI completed buffer restoration on 22.7 acres of streamside property that span nearly 1.8 miles of stream length. These projects installed 5,001 native Catskill trees and shrubs.

Table 4.8 Summary of CSBI projects completed in 2021 by project type: CSBI base program project site (B), CREP/CSBI (CR), extension of existing CSBI project site (+).

Basin	Project Type	Name of Project	Stream Length (feet)	Area (acres)
Ashokan	B	Ulster County Culvert	150	0.09
Ashokan	B	Griffin	350	0.14
Ashokan	B	Nakitin	275	0.10
Ashokan	B	James	200	0.81
Schoharie	B	Roach Marsi	475	0.59
Schoharie	B	Foreman	150	0.04
Schoharie	B	Wetmore	275	0.10
Schoharie	B	Weisburg	240	0.19
Schoharie	+	Dodson Extension	100	0.28
Schoharie	+	Windham Manor Extension	300	0.06
Schoharie	B	Robinson	150	0.10
Schoharie	B	Blitz	300	0.45
Schoharie	B	Levin	225	0.11
Schoharie	B	Ashland Park	1,200	0.69
Schoharie	B	Tsung	80	0.16
Rondout	B	Rodriguez	186	0.20
Neversink	B	Toohey	100	0.04
Rondout	B	Reichman	95	0.02
Pepacton	CR	Winter Hollow	2,850	12.15
Pepacton	CR	West Terry Clove	1,560	5.38
Cannonsville	B	SUNY Delhi #4	100	0.50
Cannonsville	B	SUNY Delhi #5	100	0.50
Total			**9,461**	**22.70**

Since 2009, the CSBI has completed 268 total projects spanning 182 riparian acres and nearly 24 miles of stream length. These projects installed over 102,000 gallon-sized trees and shrubs, in addition to plugs, tubelings, and cuttings from willow and dogwood species (all native Catskill species). Figure 4.11 depicts the locations of completed CSBI projects. The 2017 FAD requires the CSBI to revegetate a minimum of five streambank miles during 2018-2027. During the initial period 2018-2021, the CSBI achieved 6.9 miles towards this FAD metric.

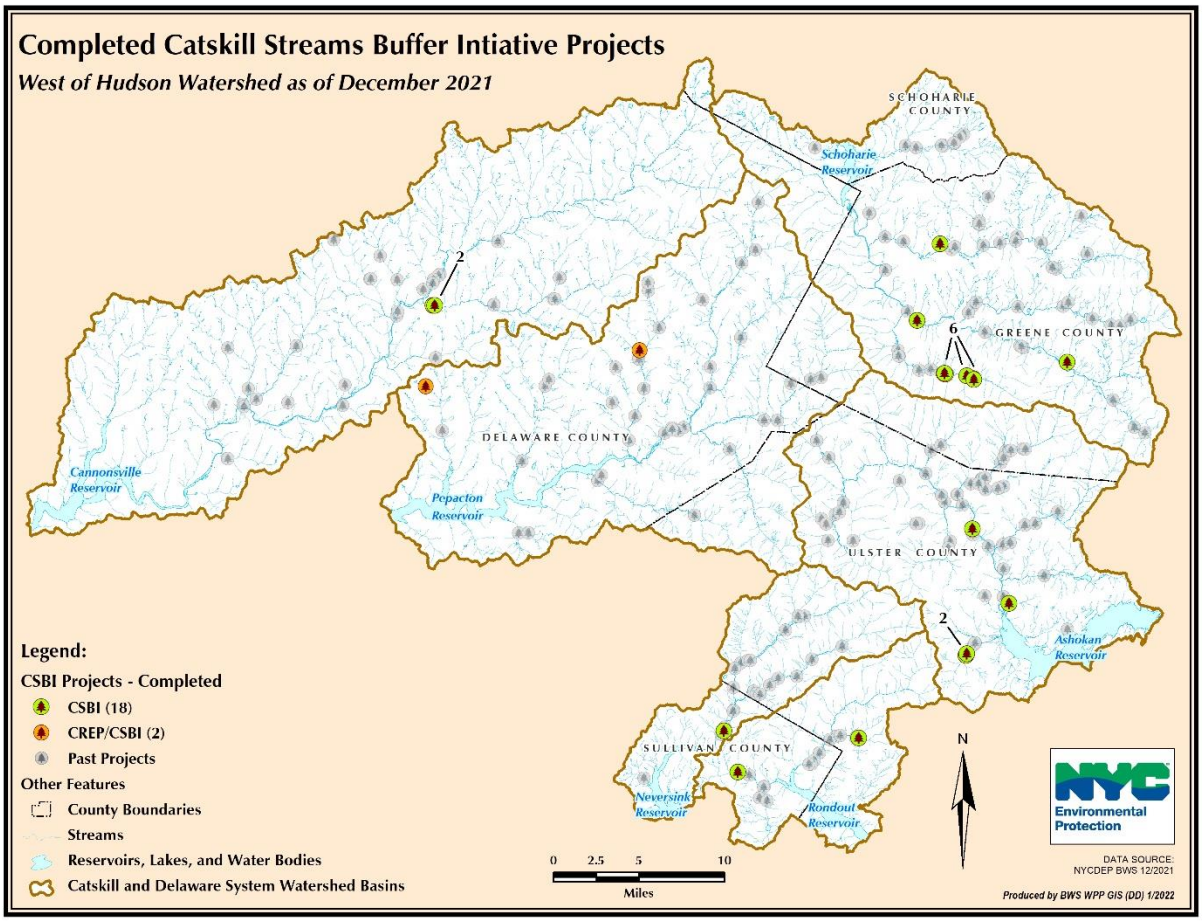

Figure 4.11 Locations of CSBI projects completed 2009-2021.

To understand better the factors affecting project success and design follow-up maintenance interventions, CSBI coordinators monitor projects for five years following installation to document browse pressure, plant survival and growth rates, and to assess the effectiveness of installation techniques. Fifty-seven sites were monitored in 2021.

CREP/CSBI Pilot Program

Pursuant to the 2017 FAD, a CREP/CSBI pilot program is underway to assess the potential for implementing riparian buffer planting projects that combine the benefits of both

programs, including federal incentive payments from CREP and enhanced planting resources from CSBI. In November 2021, DEP submitted a second FAD evaluation report of the CREP/CSBI pilot program that recommended continuation of the pilot into 2025.

Overall, the pilot program has shown promise to increase the rate of buffer establishment, a stated program goal. Six projects to date (four in 2019) have planted 2.5 miles of stream length and revegetated 37.87 acres. This includes two projects completed in 2021, planting 0.8 miles and 17.53 acres. An extension of the pilot program should provide DEP and its partners with ample time to evaluate sustained increases in landowner participation and buffer establishment.

Figure 4.12 depicts the West Terry Clove CREP/CSBI project, located in the Town of Hamden on a tributary to the Pepacton Reservoir, before and after planting. Buffers ranged from 35-100 feet in width, buffering 5.38 acres along 1,560 linear feet of stream.

Figure 4.12 The West Terry Clove Project before (top) and after (bottom) planting.

4.8 Ecosystem Protection Program

4.8.1 Wetlands Protection Program

DEP protects wetlands through regulatory means, land acquisition, and multiple stewardship programs. Wetland mapping and monitoring programs provide baseline information to support these protection efforts.

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 New York towns within the EOH watershed voluntarily forward filed wetland permit applications to DEP for review. DEP reviews 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 2021, DEP reviewed four New York State (NYS) Article 24 wetland permit applications and one U.S. Army Corp of Engineers (USACE) pre-construction notification (PCN) for activities within FAD basins (Figure 4.13). Only one of the five applications in FAD basins involved permanent wetland impacts, which totaled 0.12 acres of disturbance in the Croton Falls basin associated with an Article 24 permit for a wetland crossing in a subdivision. The remaining Article 24 permits reviewed in FAD basins were for treatment of catch basins with larvicide in the Kensico basin, treatment of common reed (*Phragmites australis*) in the Boyd Corners basin, and 0.07 acres of proposed adjacent area disturbance for improvements to a private residence in the Cross River basin. The USACE PCN was for temporary impacts to 0.16 acres of wetlands associated with drainage improvements at the Westchester County Airport.

DEP reviewed an additional 34 wetland permit applications in the Croton System, including 13 NYS Article 24, 7 USACE and 14 town permit applications (Figure 4.13). The majority of these applications did not involve permanent wetland loss as they were for adjacent area impacts, aquatic nuisance species treatments, or minor temporary impacts due to activities such as culvert replacements. Five applications included permanent wetland encroachment, three of which were under 0.1 acres. One NYS Article 24 application in the East Branch basin was for 1.26 acres of wetland disturbance associated with removal of PCB-contaminated sediment and included 2.45 acres of wetland creation as mitigation. Another application (NYS Article 24/USACE PCN) in the Middle Branch basin included 0.5 acres of wetland disturbance offset by 1.54 acres of mitigation.

There was limited activity in review of federal, state, and municipal wetland-related rulemaking in 2021. The City of New York joined with a group of 20 states and municipalities in a preliminary comment to EPA and the USACE, strongly supporting the agencies' decision to

replace The Navigable Waters Protection Rule: Definition of Waters of the United States, which a U.S. District Court vacated in 2021. The City, along with the other states and municipalities, urged the agencies to move expeditiously, and write a broad, protective, and science-based rule.

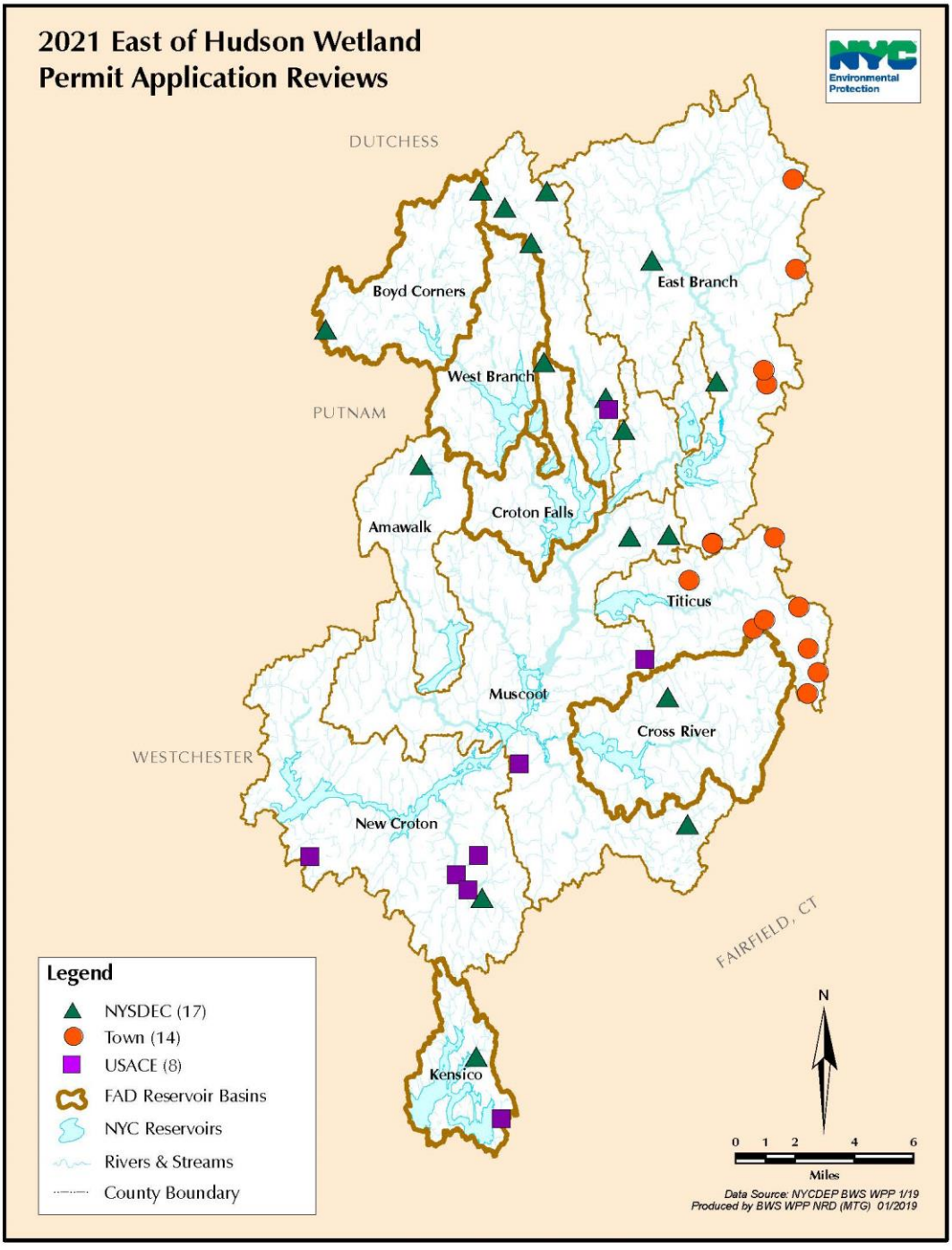

Figure 4.13 Locations of wetland permits reviewed in 2021.

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 3,024 acres or 19.9% of these wetlands through its Land Acquisition Program (See Section 4.2 for details of the Land Acquisition Program). In the CAT/DEL watershed, pre-MOA DEP lands contain an additional 968 acres (6.4%) of wetlands, with an additional 1,316 acres (8.6%) of wetlands located on state or other protected lands. This amounts to roughly 35% of wetlands in the CAT/DEL watershed being located on protected lands. Table 4.9 summarizes the acreage of wetlands protected through acquisition for both the CAT/DEL and Croton watersheds.

Wetland Mapping

Work continued on the contract to expand the light detection and ranging (LiDAR) wetland mapping pilot study to the entire watershed. The pilot study demonstrated that incorporating LiDAR-derived datasets and high-resolution aerial photography in object-based image assessment (OBIA) increased 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 (NHD).

In 2021, DEP contractors developed and implemented protocols to edit manually the output from the OBIA automated feature extraction model completed in 2020. These editing protocols were designed to remove errors of omission and commission and ascribe NWI classifications using repeatable rule-based procedures. The contractors completed manual editing for the East of Hudson watershed and delivered draft data, which DEP reviewed. The contractors also made substantial progress on wetland connectivity assessment West of Hudson. The project is on schedule for completion by the March 31, 2022, FAD deadline. The final product will include NWI-compliant geospatial wetlands data, NHD-compliant data showing wetland connectivity to streams, and reports summarizing methods and results for both mapping and connectivity.

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.

Table 4.9 Wetlands and deepwater habitats acquired or protected by the NYC Land Acquisition Program (LAP) in the Catskill/Delaware and Croton systems as of December 31, 2021*.

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 12/31/21†*:	151,887	14.48%		
Within those total lands under contract or closed:				
Total Acreage of Wetlands (both NWI and DEC-regulated, excluding Deepwater Habitats**)	3,024		1.99%	19.91%
Total Acreage of Deepwater Habitats**	201		0.13%	0.71%
Total Acreage of Wetlands and Deepwater Habitats**	3,225		2.12%	7.41%
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 12/31/21†*:	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, 2021. 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.

Statistics produced by T. Spies, BWS WPP GIS, 1/14/2022

Wetland Monitoring

DEP gains information on the characteristics and functions of watershed wetlands through its wetland monitoring program. DEP has collected vegetation, soils, and long-term hydrologic data from numerous wetlands and seasonal pools throughout the CAT/DEL watershed for over a decade (Figure 4.14). These data provide benchmarks to guide wetland protection and management efforts and identify ecological trends from factors such as surrounding land use, climate change, or invasive species.

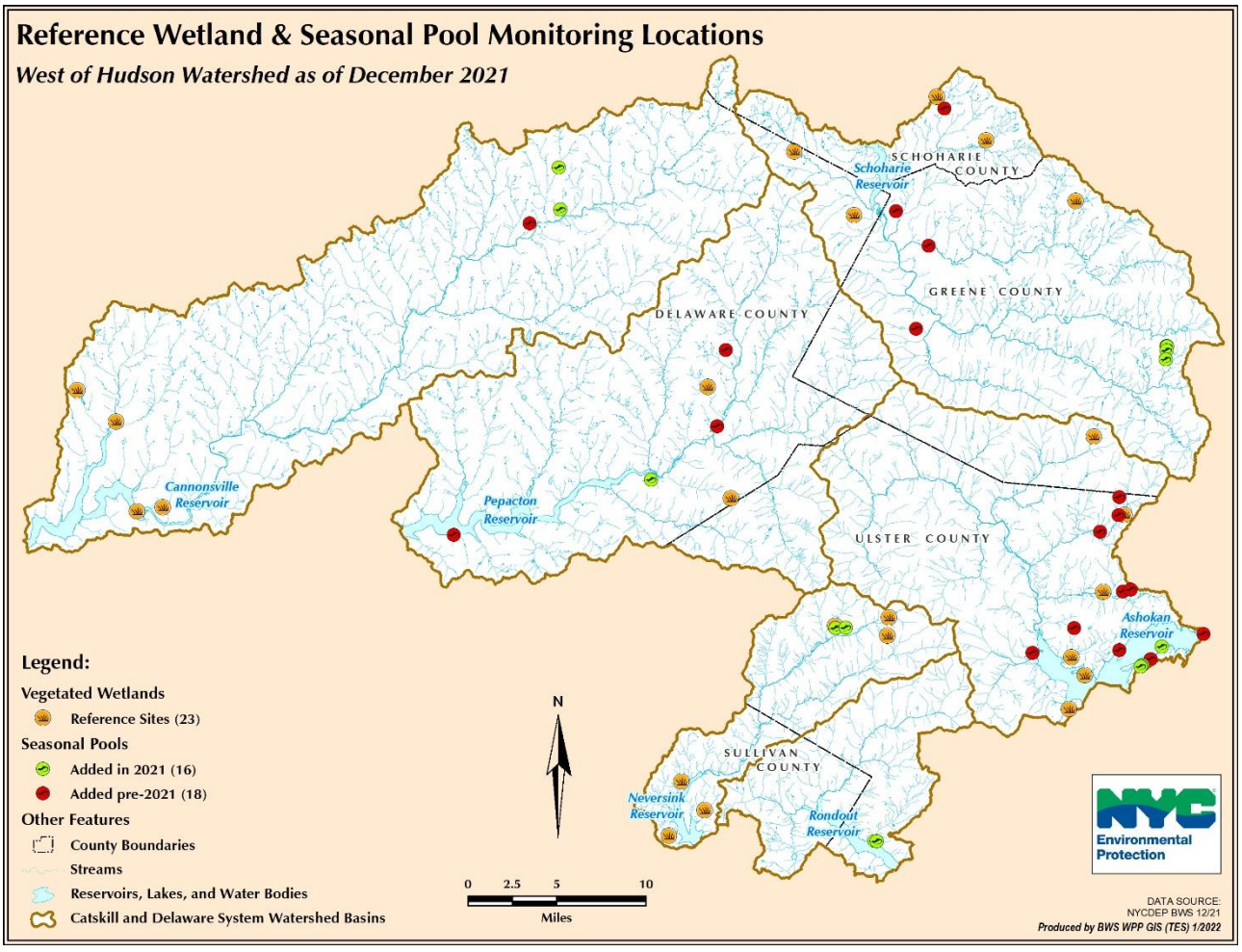

Figure 4.14 Reference wetland and seasonal pool monitoring sites in the CAT/DEL watersheds.

In 2021, DEP added 16 seasonal pool wetlands to its monitoring program, bringing total pools in the program to 34. In addition, DEP conducted kinematic surveys on five seasonal pool wetlands in the Ashokan Reservoir basin. The surveys were done to obtain true bottom elevation

and horizontal profiling to provide information on water storage capacity to assess cumulative hydrologic functions of these important, yet largely unmapped and unregulated systems.

DEP also continued to collect 6-hour-interval water level data from 11 wells located in select reference vegetated wetlands and seasonal pools in 2021. DEP also collected water quality data (pH, dissolved oxygen, temperature, and specific conductivity) from seasonal pool sites throughout the growing season. Spring adult breeding amphibian and invertebrate surveys, and amphibian egg mass counts were also conducted at seasonal pool sites.

In 2021, DEP continued its partnership with New York Natural Heritage Program (NYNHP) to help develop statewide wetland assessment methodology (https://www.nynhp.org/epa-wetland-condition). In 2021, DEP implemented NYNHP's rapid wetland conditional and functional assessment tools and intensive sampling methods at five watershed wetlands (three EOH, two WOH). The wetlands were situated in a range of settings throughout the watershed, from low to relatively high levels of disturbance in their surrounding landscape. Six wetlands were previously sampled as part of this partnership in 2020 (Figure 4.15).

This supports DEP's goal to develop its wetlands monitoring program by using standardized and streamlined sampling and assessment protocols while contributing to NYNHP's database as it further develops tools to guide wetland protection and stewardship. Conditional and functional assessment tools can help prioritize wetlands for enhanced protection, identify restoration opportunities and performance targets, and provide benchmarks for evaluating trends.

Figure 4.15 Minimally disturbed highbush blueberry bog thicket in the Boyd Corners basin sampled in 2021 as part of DEP's partnership with NYNHP.

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 2021, DEP delineated 21 wetlands comprising 54 acres at four 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 two educational programs in 2021. DEP staff led wetland ecology students from Siena College on a tour of a bog in the Schoharie Reservoir basin, and field ecology students from SUNY Ulster to a wetland mitigation site near Ashokan Reservoir. DEP also gave a virtual presentation on carbon storage in watershed wetlands at the annual Watershed Science and Technical Conference. The presentation was based on an analysis of soils data from reference wetlands to estimate carbon storage in wetland soils.

4.8.2 Forest Management

DEP has an active Forest Management program staffed by 11 foresters and a program manager. The goal of the program is to implement the Watershed Forest Management Plan to maintain a healthy, resilient forest on NYC watershed lands that will continue to protect water quality. Much of this work is achieved through commercial timber harvests publicly bid and overseen by project foresters. Considerable time and planning go into the selection, development, and review of Forest Management Plans (FMPs) which includes drawing on in-house expertise through the Forestry Interdisciplinary Technical Team (FITT) process.

In 2021, the program successfully awarded two new FMPs and completed planning on four additional FMPs that will be bid in early 2022 (Table 4.10).

The program also initiated and advanced the planning of nine additional projects that will be bid out in the second half of 2022 (Table 4.11).

Table 4.10 FMPs awarded or planning completed in 2021.

Project Name	Basin	Acres
Southslope	Schoharie	270
Morning Willow	Ashokan	300
Viscomi Road	Rondout	55
Kelly Road	Rondout	88
Bailey Brook	Boyd's Corner	85
Scutt Mountain North	Cannonsville	149
Total		**947**

Table 4.11 FMPs in planning in 2021 for award in 2022

Project Name	Basin	Acres
Neversink Flats	Neversink	121
Hollow Brook	Neversink	327
Shavertown Heights	Pepacton	330
Rocky Knob	Pepacton	63
Upper Meeker Hollow	Pepacton	94
White Pond	Boyd's Corner	182
Church Hill Rd	West Branch	55
Tonche Gap	Ashokan	110
Quarried Coves	Ashokan	179
Total		**1,461**

In addition to planning and bidding out new FMPs, forestry program staff oversaw 14 FMPs that were active during 2021. These projects involved over 1,800 acres of forestland across both the East of Hudson and West of Hudson watersheds. The active projects ranged from a 61-acre thinning and firewood sale in the Town of Hurley along Ashokan Reservoir straddling the Ashokan Rail Trail, to a 161-acre ash salvage and hemlock treatment near the Cannonsville Reservoir in the Town of Tompkins. Also included was an 80-acre ridgetop site in the Town of Kent that included salvage from a 24-acre oak-dominated blowdown.

During the active management phase of FMPs, the project foresters maintain regular contact with contractors, and make frequent site visits to ensure compliance with BMPs incorporated in the harvest plan. Unprecedented rainfall through summer 2021 forced work stoppages on several active projects as certain sites became saturated and heavy equipment would cause excessive rutting and concerns about erosion and sediment control.

The FMPs listed in Table 4.10 include some of the last of the ash salvage projects developed in response to the infestation of the watershed forests by the emerald ash borer (EAB). The Forestry Program has been prioritizing management of forest stands with a high percentage

of ash before it becomes unmarketable following infestation. The value of the ash allows the project forester to include more forest stand improvement work in the overall project.

The Scutt Mountain North FMP, straddling the towns of Stamford and Bovina in the Cannonsville Reservoir basin, is a good example of this type of salvage project (Figure 4.16). The timber volume report for this project identified over 181,000 board feet of harvestable ash, which accounts for over 70% of the total volume of wood in the timber sale. Maintenance of the residual northern hardwood stand in the predictable absence of white ash is a primary goal of this FMP. Some areas will see clusters of removal in groups where ash dominates the overstory. This will replicate a natural disturbance regime creating group canopy openings of variable sizes (.25 to 2 acres) while other areas will see no treatment at all. Variable density thinning will be conducted across other portions of the stand to enable pockets of regeneration amid areas of mature trees, creating a more resilient forest structure that can adapt to a warming climate. In other sections of the project, a seed tree method will be employed: heavy thinning around retained mature hardwoods that will provide seeds to regenerate this area.

Figure 4.16 Looking up to the southern edge of the Scutt Mountain North Forest Management Project.

As part of an effort to protect ecological processes on City lands, forestry program staff incorporate invasive and interfering species control into FMPs. Controlling these species helps to maintain growth of existing native trees and understory vegetation, and to secure recruitment of new seedlings. Control work is conducted both as part of forestry project contracts and by forestry program staff directly. In 2021, forestry program staff directly completed 52 acres of invasive species control across six discrete FMPs.

While the wave of ash mortality has influenced project selection over the past few years, program staff spent a lot of time and effort in 2021 conducting forest inventory work at multiple scales to help inform future management priorities. The Downsville region initiated an intake process involving desktop GIS review of remote imagery followed by ground truthing to prioritize newly acquired lands for inventory. Together with the other regions, they also established hundreds of plots to prioritize forest management work within basins. This work is in addition to project planning inventories conducted to develop silvicultural prescriptions for individual FMPs.

Continuous Forest Inventory

In addition to inventories conducted for regional and project planning, DEP also monitors permanent continuous forest inventory plots (CFI) across New York City Water Supply lands to determine how the watershed forest is changing over time. DEP has collected data from CFI plots since 2002 to improve our understanding of:

- Forest demography
- Tree growth and mortality
- Tree phenology
- Forest structural and compositional attributes and change
- Forest health, including tree pests and diseases, invasive plants, and other factors degrading forest condition.
- Forest carbon distribution and dynamics
- Disturbance effects

Such long-term ecological monitoring is necessary to guide forest management decisions aimed at maintaining or enhancing the health and resilience of the watershed forest to protect water quality.

In 2020 and 2021, DEP undertook an assessment to determine whether the CFI program is fulfilling its objectives. The assessment included an audit of the project structure, as well as desktop and field analyses to detect inconsistencies in measurements and field methods. Foresters visited 144 plots containing 4,288 trees, enabling evaluation of approximately 30% of all existing permanent plots. The analyses identified several inconsistencies in both

measurements and field methods. Because of the audit, the project is currently being redesigned to remedy the inaccuracies and re-orient the project structure to reach its objectives better in the future. We expect the project re-design will be completed in 2022.

4.8.3 Invasive Species

In 2021, 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; to detect new infestations early and respond to them rapidly; to control and manage existing populations to support specific projects; to mitigate the impacts of species that cannot be otherwise managed; and to restore sites to prevent further impacts. This work is predominantly accomplished through intra-agency collaboration and external 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 2021 to discuss ongoing projects and updates, the 2022 update to the Invasive Species Management Strategy, and other policy changes.

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 2021, ISAC covered such topics as the transport of invasive species on construction equipment and topsoil, invasive species prevention regulation changes, and updates on the latest jumping worm (*Amynthas agrestis*) research. DEP attended four ISAC meetings in 2021.

Catskill Regional Invasive Species Partnership

DEP continued to work regionally with partners on invasive species management in the Catskill region. In 2021, DEP worked with the Catskill Regional Invasive Species Partnership (CRISP) to develop a strategic planning survey tool using the Group Concept Mapping program from groupwisdomTM, an anonymous online platform for collecting, rating, and sorting ideas and recommendations from stakeholders. This will result in a report that will generate priorities and recommendations for invasive species management in the Catskills. DEP will use the report to update the Invasive Species Management Strategy and CRISP will use it to update their strategic plan. DEP participated in CRISP quarterly meetings, served on the steering committee and was voted in as chair of the steering committee for 2022.

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 fourth consecutive year on City lands in the Croton Falls Reservoir basin in the Town of Carmel. These sites will continue to be monitored periodically moving forward but are now considered eradicated. DEP and the Lower Hudson PRISM continued to partner on the removal of silver vine (*Actinidia polygama*), an early detection species for New York State that crosses City and private lands in the New Croton Reservoir basin. DEP was voted in for a new term on the steering committee for the PRISM.

Early Detection and Rapid Response

In addition to partnering with the Lower Hudson PRISM on the giant hogweed and silver vine responses, DEP initiated several other rapid response efforts to attempt to eradicate early detection species.

In 2021, DEP began a full-scale treatment of the *Hydrilla* infestation in New Croton Reservoir. Contractors with SOLitude Lake Management treated 250 acres of nearshore area with a granular fluridone herbicide (Sonar H4C and Sonar One). The first year's treatment reduced the population with limited dispersal of the herbicide in the reservoir. Survey results indicate that *Hydrilla* is present at nearly 30% of survey points down from 40% the previous year, and tuber density was drastically reduced to near zero. DEP also continued to collaborate with NYSDEC on management efforts in the Croton River downstream of the New Croton Reservoir dam.

Figure 4.17 This is a circle trap for the spotted lanternfly provided by the NYS Department of Agriculture and Markets. These were deployed at Hillview Reservoir and Ashokan Reservoir in 2021.

For the fourth consecutive year, DEP controlled a small infestation of water chestnut (*Trapa natans*) in New Croton Reservoir just below the Muscoot Dam. Ulster County Community College interns with support from DEP staff hand-pulled the entire infestation in an afternoon. This infestation was slightly larger than 2020 but is remaining relatively small with this minimal investment in removal. Future efforts may involve a return visit to ensure no plants are missed.

The spotted lanternfly (*Lycorma delicatula*) was reported in the watershed for the first time in 2021. This invasive plant pest poses a threat to many hardwood species. DEP worked with NYS Department of Agriculture and Markets to deploy and monitor traps in areas where

individuals have been detected (Figure 4.17). DEP also participated for the second year in a spotted lanternfly multi-agency coordination task force and treatment work group to explore different treatment options for the state. DEP staff caught several adult spotted lanternflies in traps at Hillview Reservoir but could not confirm populations despite reports of adult sightings at Kensico, Neversink, and Ashokan reservoirs.

Tree-of-heaven is the primary host tree for the spotted lanternfly. It is not a common species throughout the WOH watershed. DEP launched a targeted removal effort to minimize the number of stems present on City lands around Ashokan Reservoir to reduce the spotted lanternfly's capability to reproduce in this area. Nearly 500 stems were treated with an herbicide basal bark spray in November and the DEP WOH tree crew cut trees that were hazardous along roadsides.

Control and Management

DEP continued to manage priority invasive species on City lands through manual and mechanical removal, herbicide applications, and biological control in 2021. DEP is contracting with Cornell University to assess and improve the viability of biological control agents for hemlock woolly adelgid control. Cornell will continue to survey for the silver flies (*Leucopis* spp.) they released in 2016, 2017, 2019, 2020, and 2021, and study their impacts on hemlock woolly adelgid populations. Cornell will release additional flies in 2022.

Mitigation of Impacts

DEP continued to participate in a project to identify lingering ash trees in 2021. The Ecological Research Institute designed the Monitoring and Managing Ash (MaMA) project with researchers from the U.S. Forest Service. DEP staff and Ulster County Community College interns monitored four ash mortality plots throughout the WOH watershed. More information about the MaMA project is available at http://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. Veligers were found in the Muscoot River and Amawalk Reservoir in 2018. In 2021, DEP detected adult mussels attached to sampling equipment and rocks within Amawalk Reservoir (Figure 4.18). DEP staff are collaborating across directorates to track this infestation through continued monitoring efforts and upgrades to water supply infrastructure to prevent negative impacts to the water supply system.

Restoration

DEP created a new position in 2019 to oversee a Restoration Ecology Program. This position was filled in 2020 and we have worked through 2021 to draft a framework to identify restoration needs and implement projects across the watershed as needed. Additionally, the Restoration Ecology Program developed a restoration plan for a small dam removal project in

2021. DEP removed the Chia Lin Dam in East Fishkill to address safety concerns and restore stream connectivity. The Restoration Ecology Program developed a plan to restore native vegetation to the former lake impoundment following the dam removal. Establishing a native plant community will stabilize the basin, reduce the spread of invasive plant species, and restore the ecosystem services of a forest system.

Figure 4.18 This adult zebra mussel was collected in Amawalk Reservoir in August 2021.

4.9 East of Hudson Non-Point Source Pollution Control Program

The EOH Nonpoint Source Pollution Control Program seeks to address nonpoint pollutant sources in the four EOH FAD basins: West Branch, Croton Falls, Cross River, and Boyd Corners. The program supplements DEP's existing regulatory efforts and nonpoint-source management initiatives.

4.9.1 Wastewater Programs

Septic Programs East of Hudson

DEP supports 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, which obligates municipalities and counties to implement programs for the inspection, maintenance, and rehabilitation of septic systems.

DEP continues to partner with the New York State Environmental Facilities Corporation (EFC) to implement the Septic System Rehabilitation Reimbursement Program in priority areas of the EOH Catskill/Delaware watershed and basins hydrologically connected to the Croton Falls Reservoir (i.e. Bog Brook, Diverting, East Branch, and Middle Branch). DEP continues to conduct annual direct mailings to eligible residents to promote the program's funding availability and disseminate EFC's contact information. In 2021, the program issued reimbursements for 11 septic repairs; seven were completed in the West Branch and Boyd Corners reservoir basins with the remaining four in the Cross River, Croton Falls, and upstream, hydrologically connected basins.

EOH Community Wastewater Planning Grant Program

The 2017 FAD required DEP to develop and administer a grant program to provide funding to municipalities for preliminary planning of community wastewater solutions for areas in the EOH FAD basins where poorly functioning individual septic systems may impact water quality. DEP contracted with NEIWPCC to administer the program and fund engineering studies and reports to assist identified municipalities in evaluating wastewater treatment options.

The 2017 FAD identified eight study areas: Lake Waccabuc, Lake Truesdale, and Lake Kitchawan in the Cross River Reservoir basin, and Palmer Lake, Lake Gilead, Lake Casse, Lake View Road, and Mud Pond Brook in the Croton Falls Reservoir basin. Participating communities included the towns of Carmel, Kent, Lewisboro, and Pound Ridge. All eight reports were completed by the FAD deadline of December 31, 2021, thus providing a roadmap for the municipalities to seek financing through state or federal funding sources.

Video Sanitary Sewer Inspections

DEP implements an inspection program for targeted portions of the sanitary sewer system located within the West Branch and Croton Falls reservoir basins. These selected areas, identified as possible areas of concern during prior video inspection of sanitary infrastructure, will be submitted as part of a comprehensive summary report anticipated to be completed in the first half of 2022. The contract to perform this service was registered in December 2020, and the contractor completed the work in 2021.

4.9.2 Stormwater Retrofit and Remediation

DEP completed the two nonpoint-source pollution reduction projects at Maple Avenue (Town of Bedford, Westchester County) and Drewville Road (Town of Carmel, Putnam County) in 2020.

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. Maintenance is completed under the warranty in each facility's construction contract during the first year and under DEP's maintenance program contract thereafter. Inspection and maintenance follow procedures contained in the maintenance contract. During 2021, DEP inspected all facilities, with 82 facilities requiring vegetation removal, 70 requiring sediment and debris removal, six requiring seed and mulch, 19 requiring tree removal, and 19 requiring stone riprap repairs. All stormwater facilities are functioning as designed.

4.9.4 Stormwater Retrofit Grant Program

DEP established a grant program funded through the EOH Watershed Corporation (EOHWC) for eligible municipalities to construct the stormwater retrofits needed to satisfy municipal permit obligations under Section IX.A.5.b of the NYSDEC MS4 General Permit. The MS4 Permit mandates that EOH watershed municipalities achieve nonpoint source phosphorous reductions through the construction of stormwater retrofits. As required by the 2017 FAD, DEP contracted with the EOHWC to provide an additional $22 million to support the design and construction of stormwater retrofits in the EOH FAD basins and those basins upstream of the Croton Falls Reservoir. Through 2021, EOHWC expended or committed approximately $5.4 million of the initial payment for retrofit projects in the West Branch, Boyd Corners, Cross River, Croton Falls, and upstream hydrologically connected basins. Since inception, EOHWC's retrofit program has removed an estimated 350 kg P/year from these basins.

4.10 Kensico Water Quality Control Program

Kensico Reservoir in Westchester County is a terminal reservoir that provides the last impoundment of Catskill/Delaware water prior to entering the City's distribution system. As such, DEP prioritizes water quality protection efforts in the Kensico basin.

4.10.1 Septic Reimbursement Program

DEP implements the Kensico Septic System Rehabilitation Reimbursement Program through a contract with New York State Environmental Facilities Corporation (EFC). Through EFC, DEP reimburses homeowners a portion of the costs to rehabilitate eligible failing septic systems or connect those systems to an existing sewage collection system. The program is voluntary, with the goal of encouraging property owners to inspect their septic systems and, if failing, rehabilitate them (Figure 4.19). During 2021, EFC mailed the annual reminder letter

about the program to all eligible residents. EFC issued three septic reimbursements to eligible homeowners.

Figure 4.19 Installation of Eljen system for septic repair near Kensico Reservoir.

4.10.2 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 2021, DEP conducted an annual visual inspection of the trunk line to assess the condition of exposed infrastructure. DEP also conducted routine partial inspections throughout the year related to ongoing maintenance of Kensico stormwater BMPs near the line. DEP noted no defects or abnormalities.

4.10.3 Video Sanitary Sewer Inspection

DEP implements an inspection program for targeted portions of the sanitary sewer system located within the Kensico basin. These selected areas, identified as possible areas of concern during prior video inspection of sanitary infrastructure, will be discussed in a comprehensive summary report anticipated to be completed in the first half of 2022. The contract to perform this service was registered in December 2020 and the contractor completed the work in 2021.

4.10.4 Stormwater BMPs

DEP has constructed stormwater management and erosion abatement facilities throughout the Kensico basin to reduce pollutant loads to the reservoir. DEP and its contractor inspected and maintained these facilities, shown in Figure 4.20, throughout 2021, according to the O&M guidelines. Maintenance consisted of grass mowing, seeding and mulching, vegetation removal, fallen tree removal, fence repair, swale repair, and sediment and debris removal. All BMPs are performing as designed.

4.10.5 Wildlife Sanitary Surveys

DEP conducts sanitary surveys to prevent wildlife excrement from washing into Kensico Reservoir and potentially elevating fecal coliform levels. DEP identified sampling locations based on proximity to the Delaware Aqueduct Shaft 18 water intake location. These 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 2021, DEP and its contractor conducted 31 wildlife sanitary surveys in advance of significant precipitation events at Kensico Reservoir (Table 4.12). Of the 711 fecal samples collected, 52% were attributed to white-tailed deer (*Odocoileus virginianus*), 1% to rabbits (*Sylvilagus* spp), 1% to raccoons (*Procyon lotor*), and approximately 3% to unknown mammals. Avian species excrement included approximately 15% from Canada geese (*Branta canadensis*) and 26% from passerine bird species.

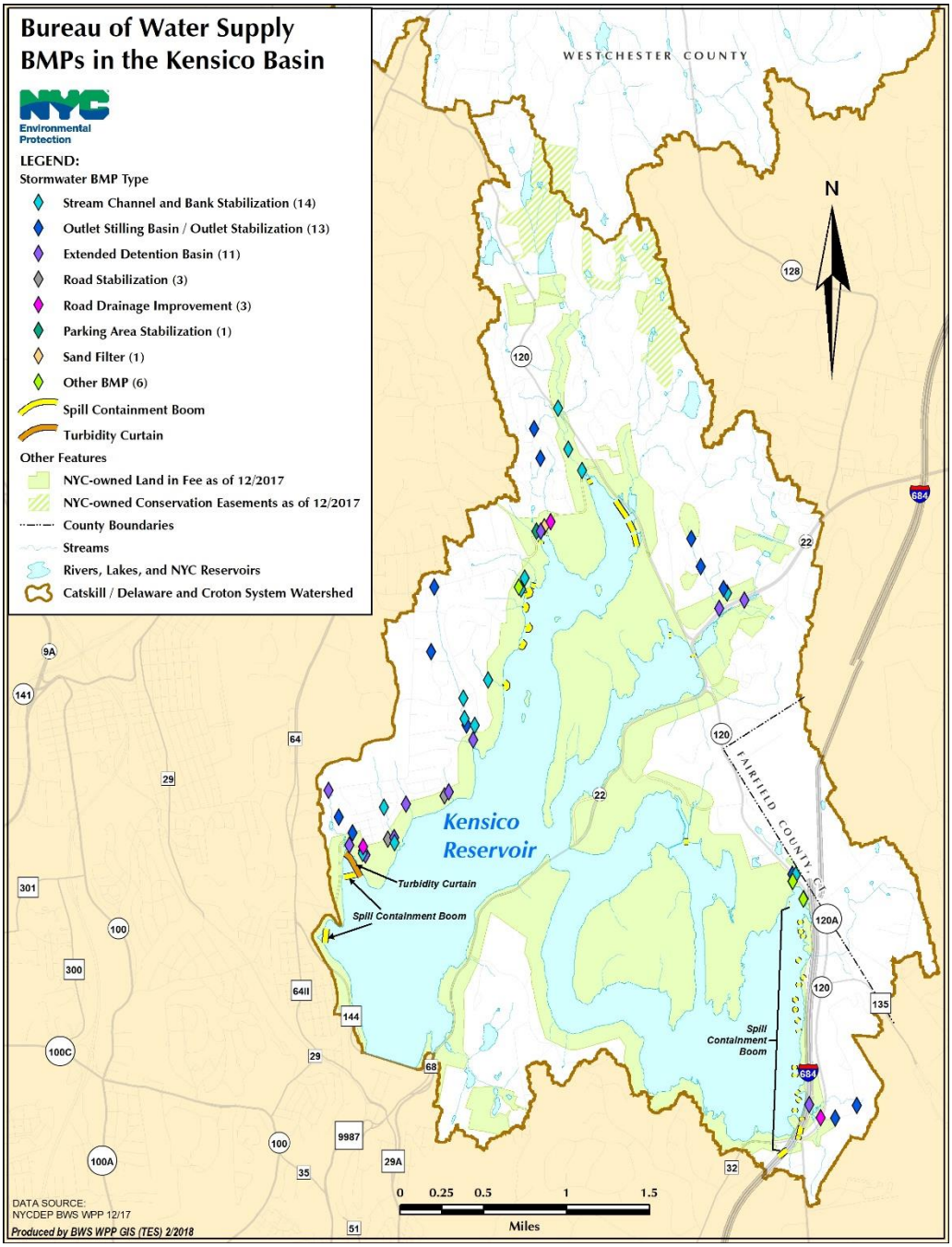

Figure 4.20 BMPs within the Kensico Reservoir Basin

On October 25, 2021, DEP performed two additional wildlife sanitary surveys at stream corridors north of the Shaft 18 Effluent Facility (Table 4.13). Of the 102 fecal samples collected from these surveys, approximately 40% were attributed to white-tailed deer, 55% to raccoons, 3% to coyote, and 2% to unknown mammals.

Table 4.12 Kensico Reservoir 2021 wildlife sanitary surveys.

Date of Survey	White-tail Deer	Raccoon	Rabbit	Canada Goose	Coyote	Mink	Striped Skunk	Passerine (birds)	Domestic Dog	Other/ Unknown Mammal	Total (all species)
1/7/2021	0	0	0	0	0	0	0	0	0	0	**0**
1/15/2021	7	0	1	0	0	0	0	0	0	1	**9**
3/28/2021	16	2	3	8	0	0	0	0	0	2	**31**
4/14/2021	0	0	0	52	0	0	0	0	0	1	**53**
4/21/2021	0	0	0	8	0	0	0	0	0	0	**8**
5/4/2021	0	0	0	14	0	0	0	0	0	0	**14**
5/26/2021	0	0	0	32	0	0	0	43	0	0	**75**
6/9/2021	0	0	0	0	0	0	0	2	4	0	**6**
6/15/2021	0	0	0	0	1	0	0	8	0	0	**9**
6/22/2021	0	0	0	0	0	1	0	25	0	0	**26**
6/30/2021	0	0	0	0	0	0	0	58	0	0	**58**
7/6/2021	0	0	0	0	0	0	0	48	0	0	**48**
7/27/2021	0	0	0	0	0	0	0	3	0	0	**3**
8/2/2021	6	2	0	20	0	0	0	0	0	3	**31**
8/3/2021	52	0	0	0	0	0	0	0	0	0	**52**
8/20/2021	1	0	2	1	0	0	0	1	0	0	**5**
8/31/2021	1	0	0	0	0	0	0	1	0	2	**4**
9/15/2021	0	0	0	0	0	0	0	13	0	0	**13**
9/21/2021	2	0	1	0	0	0	0	18	0	2	**23**
9/22/2021	0	1	0	0	0	0	0	0	0	1	**2**
9/27/2021	15	1	0	0	0	0	0	0	0	0	**16**
10/4/2021	17	0	0	0	0	0	0	0	0	4	**21**
10/9/2021	32	0	2	0	0	0	0	0	0	0	**34**
10/16/2021	1	0	1	0	4	0	1	1	0	1	**9**
10/24/2021	70	0	0	0	0	0	0	0	0	5	**75**
10/25/2021	47	0	0	0	0	0	0	2	0	0	**49**
10/29/2021	15	0	0	0	0	0	0	0	0	0	**15**
11/11/2021	74	1	2	0	0	0	0	2	0	0	**79**
11/18/2021	33	1	1	0	0	0	0	9	0	1	**45**
11/21/2021	36	0	0	0	0	0	0	0	0	0	**36**

Date of Survey	White-tail Deer	Raccoon	Rabbit	Canada Goose	Coyote	Mink	Striped Skunk	Passerine (birds)	Domestic Dog	Other/ Unknown Mammal	Total (all species)
12/17/2021	35	0	0	0	0	0	0	0	0	1	**36**
Total by species	**460**	**8**	**13**	**135**	**5**	**1**	**1**	**234**	**4**	**24**	**885**
Percent by species	**52.0**	**0.9**	**1.5**	**15.3**	**0.6**	**0.1**	**0.1**	**26.4**	**0.5**	**2.7**	**100**

Table 4.13 Supplemental Kensico Reservoir 2021 wildlife sanitary surveys.

Date of Survey	Supplemental Survey locations at Kensico Reservoir	White-tail Deer	Raccoon	Coyote	Other/ Unknown Mammal	Total (all species)
10/25/2021	N5	8	37	0	0	**45**
10/25/2021	Catskill Effluent Cove	33	19	3	2	**57**
Total by species		**41**	**56**	**3**	**2**	**102**
Percent by species		**40.2**	**54.9**	**2.9**	**2.0**	**100**

4.10.6 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 2021, DEP conducted routine maintenance at the spill boom sites to ensure they are available in the event of a spill. There were no spills requiring the deployment of booms in the Kensico Reservoir. One minor event occurred in December when 7 gallons of hydraulic oil was accidentally released at the Delaware Aqueduct Shaft 17 security gate. The oil was removed using hydrocarbon absorbents.

4.10.7 Shaft 18 Shoreline Stabilization Facilities

Since the Catskill/Delaware Ultraviolet Disinfection Facility (CDUV) began operating, all Kensico water flows through the Delaware Effluent Chamber at Shaft 18 on the reservoir's southwest shore. Increased reliance on Shaft 18, together with changing weather patterns,

necessitate shoreline stabilization measures near the effluent chamber to maintain turbidity levels in compliance with state and federal water quality standards. Stabilization measures include approximately 700 feet at the western shoreline and approximately 475 feet at the cove area. Work includes construction of sediment control measures, installation of a sheet pile cofferdam, installation of riprap shoreline protection, and site restoration. DEP completed all work at the cove in 2020 and all riprap shoreline protection at the western shoreline in 2021 (Figure 4.21). Contractors will complete the remaining restoration at the western shoreline in 2022.

Figure 4.21 Aerial photograph showing the stabilization sites at the cove (foreground) and western shoreline (background).

4.10.8 Other Activities

Turbidity Curtain

In 2021, DEP continued to monitor and inspect the extended primary curtain and the back-up turbidity curtain that are designed to direct flows from Malcolm and Young brooks farther out to the main body of Kensico Reservoir. Based on the most recent inspection, no repair work was required. The curtains appear to be functioning as intended.

Dredging Assessment

The Catskill Upper Effluent Chamber (UEC) sits along the shore of a cove in the southwest section of Kensico Reservoir. Since the CDUV began operating, this chamber has been off-line. As part of the Catskill Aqueduct pressurization project, DEP is assessing the intake structure and evaluating the possible need for removing sediment at the effluent chamber. Using new bathymetric data, DEP's consultant used historical operational configurations and data to develop a turbidity transport model. Based on this model and visual inspection from divers, DEP assessed the potential for erosion in the UEC cove under future operational conditions. The work compared shear stress at the sediment-water interface to the critical shear stress for erosion of in situ sediment substrate at various water levels and peak flow. Based on this analysis, DEP may consider dredging approximately 0.17 acres of the channel as part of renewed operation of the UEC. A preliminary estimate of the volume of material to be removed is 1,000 cubic yards.

DEP intends to assess the possible need for sediment removal directly in front of the Shaft 18 intake. In addition to using the revised bathymetric data, DEP will use divers to confirm sediment depths at various locations. However, with Shaft 18 serving as the single intake at Kensico, DEP is unable to shut down the intake to ensure the safety of divers. DEP will defer this diver-supported assessment until the intake can be shut down.

Westchester County Airport

DEP continues to review activities proposed at or in relation to the Westchester County Airport due to its proximity to Kensico Reservoir.

Park Place at Westchester is a private 980-space parking garage proposed at 11 New King Street in the Town of North Castle. DEP has provided comments on the project through the SEQRA process that has been ongoing since 2008. DEP continues to review a SWPPP application required pursuant to the WR&R and awaits resubmission of a revised plan in response to DEP's June 2021 technical comments.

An uncapped landfill was identified at the airport in 2015. Since then, Westchester County has performed sampling and laboratory analysis of groundwater, surface water, landfill soils, and accumulated iron flocculent. Results of soil samples collected from eight test pits excavated within the landfill indicated exceedances for certain metals and mercury. DEP understands that the landfill/soil mound will be addressed through Westchester County's

participation in NYSDEC's Brownfield Cleanup Program as it continues to work cooperatively on a site characterization work plan and, ultimately, a remediation plan.

In accordance with a 2019 NYSDEC Consent Order, Westchester County prepared a site characterization work plan to assess PFOS, PFOA, and other groundwater contaminants both on and near the airport and applied for acceptance into the state's Brownfield Program. In January 2021, NYSDEC responded to DEP's July 2020 technical comments. Also in 2021, First Environment, on behalf of Westchester County, collected soil samples from the north segment of airport property near King Street and submitted the results of the PFAS target compounds to NYSDEC. DEP understands that First Environment will submit a pilot test work plan to NYSDEC for work to be conducted below the uncapped landfill/soil mound in the area of SPDES Outfall 004. The goal is to create a small treatment system capable of reducing PFAS in surface water that may be leaving the airport via an intermittent stream.

4.11 Catskill Turbidity Control

4.11.1 Implementation of Catskill Turbidity Control Alternatives

Due to the nature of the 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. DEP has implemented many of these measures 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 JV in three phases between 2002 and 2009. DEP implemented several alternatives based on the results of this study: 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 Catskill-Delaware Interconnection and the Catskill Aqueduct stop-shutter facilities projects achieved functional completion in 2016.

Operations Support Tool

OST is a software that simulates reservoir levels and water quality up to a year into the future and guides NYC water supply operations. It is a decision-support system linking computer models of NYC water supply reservoir operating rules, real-time data of water quality and quantity, and inflow forecasts provided by the National Weather Services (NWS). DEP uses OST daily for operational decisions support, as well as planning, including climate-change impact assessment and policy evaluation purposes.

During 2021, DEP continued with model enhancements to make OST better reflect current water supply system rules, infrastructure status, and operations and elevate OST flexibility to provide modeling support for various infrastructure outage applications, in particular the Catskill Aqueduct (CAT) and the upcoming Rondout West Branch Tunnel (RWBT) outages. The enhancements included addressing some of the National Academy of Science, Engineering and Medicine (NASEM) OST Expert Panel recommendations, as following:

- During 2021, the NWS through its Northeastern and Middle Atlantic River Forecast centers in collaboration with the NOAA's Office of Water Prediction delivered, for the first time, GEFSv12-based HEFS ensemble forecasts to replace the old (2014) GEFSv10-based HEFS ensembles. GEFSv12 development is using extended meteorological and hydrological data and forcing hindcast ensembles that include the most recent records (through 2019). This was in response to one of the NASEM OST Expert Panel recommendations. In 2021, DEP staff started testing the newly available ensemble forecast to evaluate further its skill while working collaboratively with NWS to address any problem identified during the testing process.
- The new GEFSv12-based ensemble product delivered in 2021 to NYCDEP includes not only the usual raw HEFS forecast but also post-processed ensemble forecast for most of OST forecast locations. The post-processing is based on the NWS Ensemble Post-processor (EnsPost) software tool, which is applied and maintained by the two river forecast centers. This is a significant achievement because it allows DEP staff to fully benefit from existing NWS expertise and be able to shift focus towards other important forecast related areas and software tools to enhance HEFS implementation in OST, such as ensemble forecast diagnostic and verification tools. The first verification of the new EnsPost forecast was completed collaboratively among NYCDEP and NWS scientists.
- We completed new models in 2010 to support thermal release needs at Hancock, Bridgeville and Lordville. During 2021, NYSDEC continued testing these thermal release forecast tools operationally. If approved, these tools will be incorporated in OST.

- In 2021, we further enhanced the OST baseline run to provide better modeling support for the RWBT and CAT outages. The enhancements consisted of new OST updates to better reflect operations and the existing operational flexibility in the Croton system, as well as a better simulation of the turbidity load from Pepacton, Cannonsville, and Neversink reservoirs into Rondout Reservoir using historical and current measures of reservoir turbidity.
- DEP staff continued developing a new version of a Volume Projection (VoPro) model. The VoPro tool is based on mass balance and mechanistically identical to OST, and includes local communities' water demands. This new version of VoPro is specific for the Croton System. Starting with the present status of the system, VoPro allows water supply operators to enter changes in diversion and releases out of reservoirs and receive first indication of the system response in terms of reservoir storage. This screening tool is particularly important, as a compliment to OST, to evaluate quickly short-term OST operations, and to support operations during the RWBT shutdown planned for 2022.

During 2021, the focus was on using OST to support daily operational decision-making, including during the CAT Shandaken Tunnel outages. We also used OST to support planning for the RWBT outage, including preparing staff for daily operations support by testing the model for the shutdown using 2021 hydrological conditions and subsequently briefing management on a regular basis. Standard modeling practices, such as ongoing evaluation of the new HEFS forecast performance, retrospective forecast verification, and fine-tuning of model code and algorithms, were performed. DEP executed over 720 model runs in 2021, underscoring the continued value and purpose of OST in supporting water supply operations and management.

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 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 channel's operation.

Consistent with the consent order, DEP requested a modification to the Catalum SPDES Permit in 2012 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. Below is a timeline for the Catalum environmental impact statement (EIS) development:

NYSDEC released a draft scope for the Catalum EIS for public comment from April 9, 2014, to August 29, 2014. More than 550 commenters submitted more than 900 comments.

- The final scope was issued on March 22, 2017, and it took into consideration feedback from the public review process and includes responses to the comments received.
- A draft DEIS was submitted to NYSDEC on May 30, 2019.
- NYSDEC released the DEIS for public comment on December 16, 2020.
- DEIS public hearings were held on February 4, 2021 and March 3, 2021.
- The public comment period for the DEIS closed on June 16, 2021. Over 1,200 comments were received.

DEP and NYSDEC are currently reviewing comments and discussing options for moving forward.

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 plants (WWTP) and water resource recovery facilities (WRRF). DEP's monitoring objectives for 2021 are documented in the Watershed Water Quality Monitoring Plan (WWQMP) (DEP 2018) 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 2017); 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 2019), 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 continued to specify requirements in the Revised 2007 FAD. These requirements have continued in the 2017 FAD promulgated in December 2017 (NYSDOH 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 2021a). 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 2021b), 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 2021 activities are summarized in the Watershed Water Quality Annual 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 pursue appropriate actions proactively.

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 under normal conditions and 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 2.9 million measurements in the watershed in 2021.

5.1.2 Additional Water Quality Monitoring

In addition to routine and robotic monitoring, events or incidents may occur that necessitate additional water quality monitoring. DEP collected over 1,500 additional watershed samples for special investigations during 2021, including 280 stream samples, 980 reservoir samples, and 11 keypoint samples. In addition to the routine manual profiles conducted on routine scheduled field events, there were over 21,000 manual profile analyses conducted by staff on special limnology surveys.

These special investigations (SIs) include monitoring related to the operation of the Croton Water Filtration Plant and blending of Croton and Catskill waters; implementation of an invasive species control project; potential activation of the Cross River Pumping Station; and other smaller, less intensive monitoring events. The major 2021 SI efforts are outlined below.

Special Investigation: Croton Filtration Plant Operation

Due to both the planned shutdown of the Catskill Aqueduct in October and to help minimize the drawdown of Kensico and West Branch reservoirs, the Croton Water Filtration Plant continued to deliver water to the City's distribution system in 2021.

To support plant operation, enhanced water quality monitoring of Croton system keypoints at the Croton Lake Gatehouse (mid-basin) and Gatehouse 1 (dam), as well as increased limnological monitoring of New Croton Reservoir continued. To assist with the plant's operation, DEP's field and laboratory teams conducted extensive field surveys and laboratory analyses that generated over 1,100 values for target analytes including Geosmin, 3-Methylisoborneol (MIB) and total and dissolved iron and manganese. Geosmin and MIB are naturally occurring compounds that have an earthy/musty taste and odor. In 2021, elevated levels of MIB were detected in late summer and autumn. Manganese is a problematic water column metal for Croton and the selection of water column elevation can minimize the manganese getting to the filter plant. Additionally, two new robotic monitoring buoys were placed at sites near the Croton Lake Gatehouse and Gatehouse 1 to enable near-real-time monitoring and support operation of the Croton Reservoir. DEP deployed these buoys in early spring, and collected temperature, pH, field specific conductivity, dissolved oxygen, and turbidity measurements four times per day. A modem connection relayed the data. The buoys remained on the water and active through the majority of 2021. Based on the field and laboratory data generated, the Croton Filtration Plant was able to avoid a surface manganese maximum in late summer as well as minimize the impact of high levels of manganese at the bottom of the reservoir throughout autumn.

Special Investigation: Tropical Storm Ida

The remnants of Tropical Storm Ida brought 6-10 inches of rainfall over a 24-hour period (September 1-2) with 5.8 inches of rainfall recorded near Kensico Reservoir. The rainfall inundated the Kensico watershed, which had received 4.4 inches of rainfall just 10 days prior from the remnants of Tropical Storm Henri. Stormwater best management practices (BMPs) around Kensico Reservoir experienced high flows and sediment mobilization that led to elevated levels of turbidity and fecal coliform in the reservoir. While turbidity spikes were measured in the reservoir during the height of the storm near Delaware Shaft 18, Kensico was being operated in float mode and turbidity remained in compliance. Following the storm, fecal concentrations were elevated, including four consecutive days with concentrations >20 CFU/mL at DEL18DT. Water quality monitoring was increased at Kensico Reservoir, with limnology sampling occurring two times per week, Kensico tributary sampling occurring weekly, and daily sampling

conducted at Delaware Shaft 17. Monitoring was also increased throughout the watershed at Ashokan, Rondout, West Branch, and New Croton reservoirs. Fecal coliform concentrations returned to baseline at DEL18DT after a period of 10 days. Concentrations, however, remained elevated throughout Kensico Reservoir and, as a result, the reservoir continued to operate in float mode for several weeks until October 18, 2021, when Kensico was placed back into reservoir mode.

Special Investigation: Croton Falls Rinse

In preparation for the Rondout to West Branch Tunnel shutdown, Croton Falls Rinse was conducted to evaluate if water quality within Croton Falls Reservoir could be improved by transferring water from West Branch Reservoir to Croton Falls Reservoir via the West Branch Croton River. The Croton Falls Rinse effectively began on July 29, 2021, with releases from West Branch Reservoir that continued until September 1, 2021, when it was abruptly ended with the arrival of the remnants of Hurricane Ida. In situ specific conductance profile measurements collected at one-meter intervals every two weeks provided the best assessment of water displacement within the main basin of Croton Falls Reservoir. The in situ specific conductance profile measurements near the Croton Falls Dam indicated that water diverted via West Branch Croton River was isolated in the Croton Falls Reservoir above the thermocline, and hence did not completely change water quality throughout the entire water column of the reservoir. Due to this thermocline effect, another rinse operation was initiated in January 2022 to evaluate the Croton Rinse operational objective prior to the establishment of a thermocline.

Special Investigation: Invasive Species Control at New Croton

Water Quality Operations provided sampling to support a larger scale fluridone treatment that showed promise in controlling the aquatic invasive plant *Hydrilla* during a pilot study that began in 2018. DEP continued a special investigation to evaluate the fate and transport of an applied chemical herbicide in New Croton Reservoir for the treatment of *Hydrilla*. Reservoir-wide treatment began in June 2021 and continued through September 2021 on a roughly two-week schedule. Sampling to monitor transport of the herbicide started prior to the first treatment in June 2021 and continued to mid-November 2021. Samples were collected weekly at both keypoint and reservoir sites.

5.1.3 Wastewater Treatment Plant Protozoan Monitoring

Protozoan monitoring at wastewater treatment plants (WWTPs) in the Filtration Avoidance watersheds seeks to demonstrate that microfiltration and technologies deemed equivalent continue to perform well with respect to the removal of *Giardia* spp. and *Cryptosporidium* spp. from the plant effluents. City-owned plants in the watershed are formally known as water resource recovery facilities (WRRFs).

The Watershed Water Quality Monitoring Plan includes quarterly protozoan monitoring at 10 plants each year. However, the NYSDOH approved COVID-19 monitoring reductions and granted DEP relief from this monitoring until the third quarter of 2021. Sampling resumed on

September 7, 2021. In 2021, DEP collected 13 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).

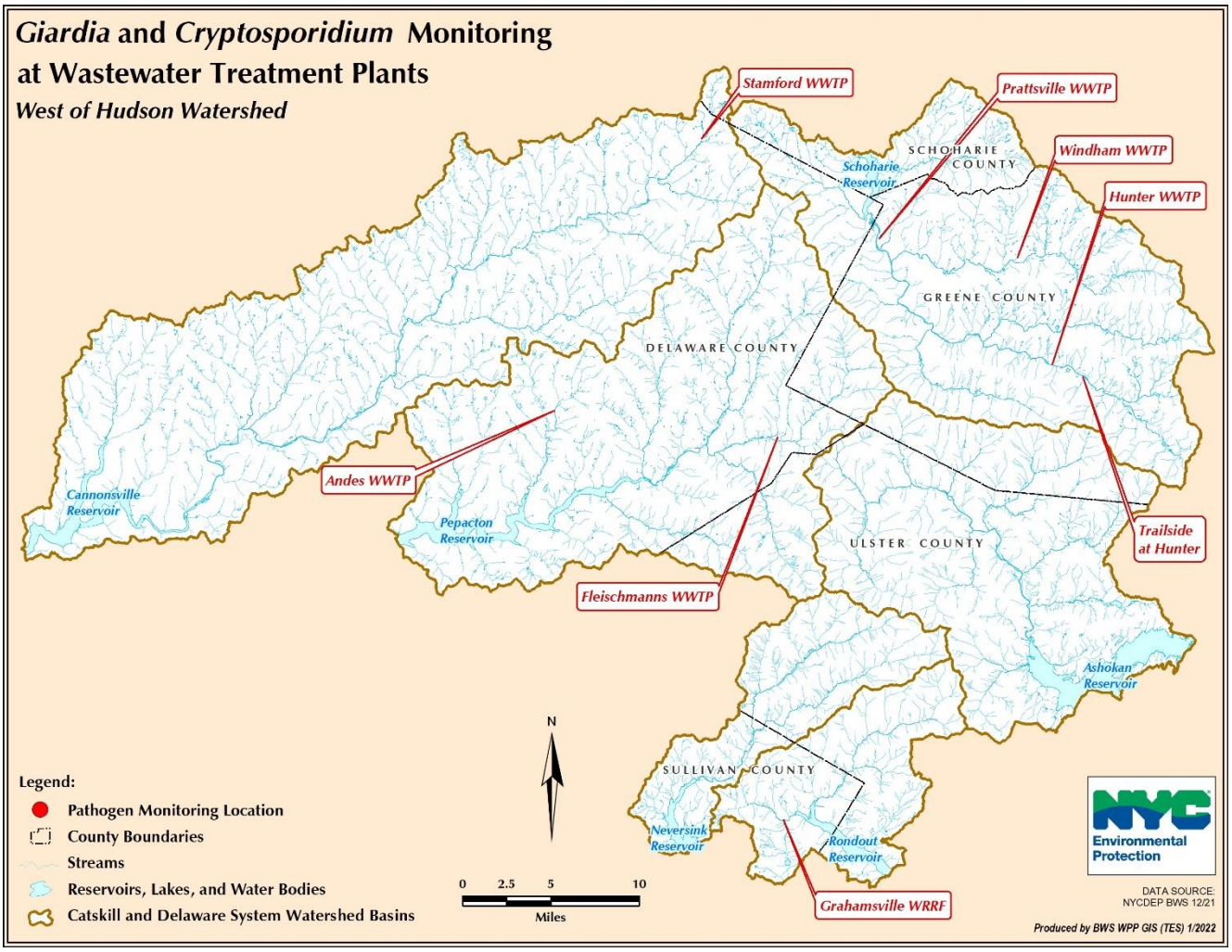

Figure 5.1 Wastewater treatment plants monitored for *Giardia* and *Cryptosporidium* in 2021 in the WOH watersheds.

Since protozoan monitoring resumed in September, and considering other scheduled monitoring requirements, not all WWTPs in the WOH watersheds could be sampled for protozoa in the third quarter (Table 5.1). During the fourth quarter, six of the eight WOH plants were monitored (two were not sampled due to a scheduling oversight). Both EOH plants were monitored for pathogens in the third and fourth quarters of 2021.

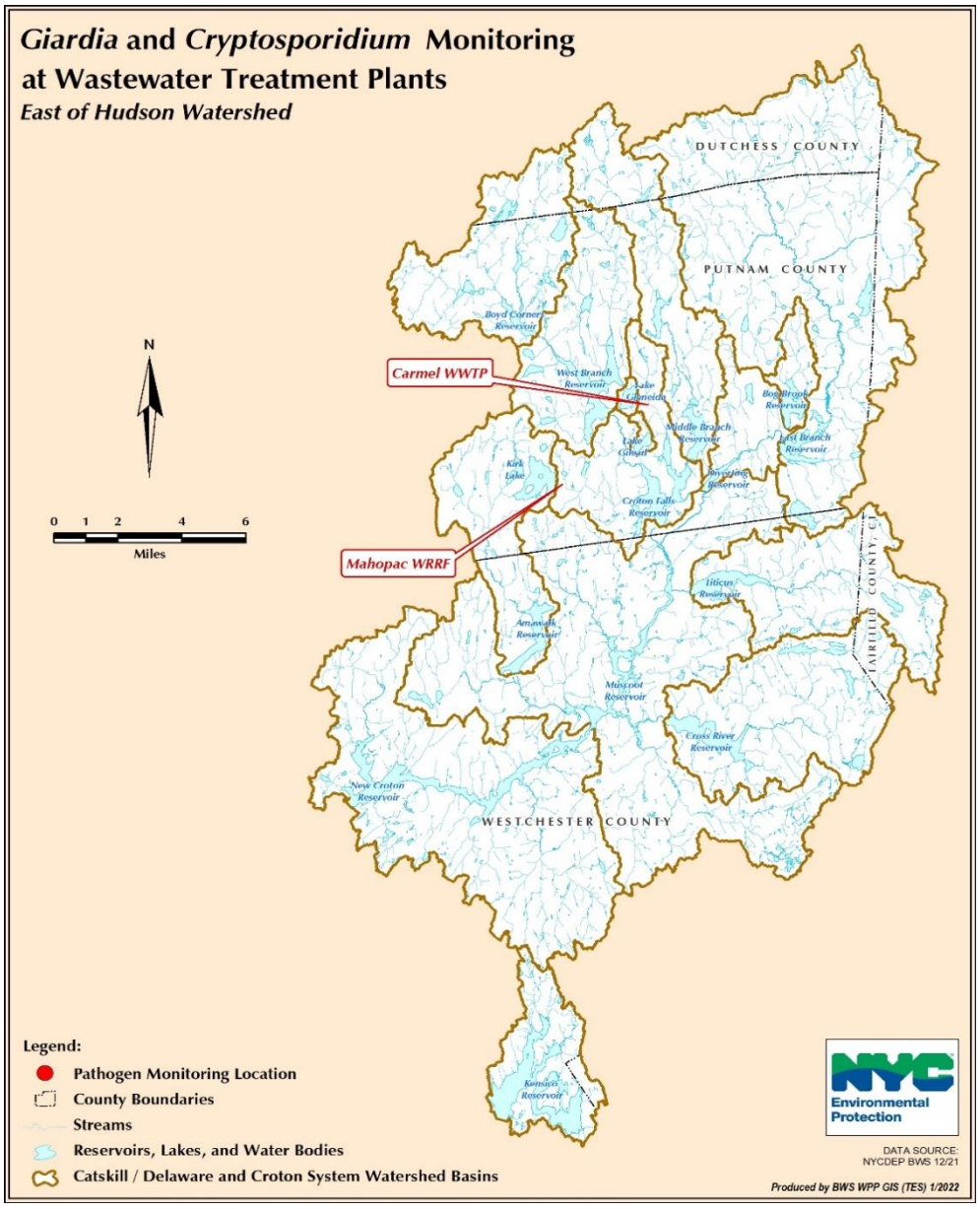

Figure 5.2 Wastewater treatment plants monitored for *Giardia* and *Cryptosporidium* in 2021 in the EOH potential FAD watersheds.

Each sample for *Giardia* and *Cryptosporidium* 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). Of the 13 protozoan samples collected at WWTPs in 2021, none was positive for *Cryptosporidium* or *Giardia* (oo)cysts.

Table 5.1 Status of protozoan monitoring at WWTPs for 2021.

	First Quarter	Second Quarter	Third Quarter	Fourth Quarter
Plants Sampled	None (COVID-19 Monitoring Reduction Plan)	None (COVID-19 Monitoring Reduction Plan)	**WOH** Andes Fleischmanns Stamford **EOH** Carmel Mahopac	**WOH** Hunter Trailside at Hunter Prattsville Grahamsville Stamford Windham **EOH** Carmel Mahopac
Plants Not Sampled	**WOH** Andes Fleischmanns Hunter Trailside at Hunter Prattsville Grahamsville Stamford Windham **EOH** Carmel Mahopac	**WOH** Andes Fleischmanns Hunter Trailside at Hunter Prattsville Grahamsville Stamford Windham **EOH** Carmel Mahopac	**WOH** Hunter Trailside at Hunter Prattsville Grahamsville Windham	**WOH** Andes Fleischmanns

5.1.4 Water Quality Reports

Pursuant to the City's Long-Term Watershed Protection Plan (DEP 2021a) and as a FAD requirement (Section 5.1), DEP produces a Watershed Water Quality Annual Report (WWQAR). This is submitted annually each July to NYSDOH and USEPA (e.g., DEP 2021c). This document covers water quantity (e.g., the effects of droughts or excessive precipitation during the reporting period); water quality of streams and reservoirs; Kensico Reservoir water quality; pathogen monitoring and research; and a summary of the year's major water quality modeling activities. DEP's watershed monitoring effort excluding all automated (robotic) monitoring consists of 409 routinely sampled aqueduct, reservoir, and stream sites, resulting in over 11,000 samples and approximately 92,500 analyses annually. For the 2021 WWQAR report (due July 2022), the document's limnology and hydrology components will draw largely from information obtained from approximately 370 routinely sampled reservoir and stream sites, resulting in

approximately 3,800 samples and almost 38,800 analyses. Limnological profiles conducted during the sampling surveys added over 52,700 analyses. For the pathogen component, 410 routine samples were collected at 26 sampling sites (including keypoints) and analyzed for *Giardia* and *Cryptosporidium*, along with turbidity, pH, and temperature, for over 1,300 analyses.

For operational and surveillance purposes and to provide information to DEP managers and regulators, water quality data are reported frequently and in several different internal and external reports. These include, but are not limited to, the Watershed Water Quality Annual Report (e.g., DEP 2021c), the Drinking Water Supply and Quality Annual Report (e.g., DEP 2021d) and the Filtration Avoidance Annual Report (e.g., DEP 2020), or, every fifth year, the Watershed Protection Program Summary and Assessment (DEP 2021b). All of DEP's watershed water quality data is also available on NYC Open Data (DEP 2021e).

5.2 Multi-Tiered Water Quality Modeling Program

DEP's Water Quality Modeling Program uses models to quantify the impact of climate change, changes in land use, individual and grouped components of the watershed protection program, operation of the water supply system, and water demand on the quantity and quality of water delivered to the City. DEP in 2021 received new bathymetric data for East of Hudson (EOH) reservoirs; tested the use of a 'change factor' method to account for bias in Global Climate models (GCMs) of precipitation; reconstructed stream flow for West of Hudson (WOH) reservoirs using tree ring chronologies; and applied the Soil and Water Assessment Tool (SWAT) model to WOH reservoirs, which included an assessment of uncertainty in flow predictions. Our work also validated DEP's Schoharie and Ashokan turbidity models; examined the efficacy of modeling disinfection byproduct precursors (DBP) using UV-254 for Cannonsville and Neversink reservoirs; executed several OST-W2 runs to support decisions made by BWS operations regarding elevated turbidity issues generated by the Christmas Eve 2020 storm; and enhanced OST-W2 forecasting of turbidity to better support operations after the that 2020 storm. A detailed description of water quality modeling progress and activities in 2021 will be included in the Watershed Water Quality Annual Report, which will be completed on July 31, 2022. This report features a summary of these activities.

EOH bathymetry: The U.S. Geological Survey (USGS), in cooperation with DEP, surveyed the bathymetry of the 16 EOH reservoirs and controlled lakes from 2017 to 2019. A final report and pertinent datasets were released in 2021 (Nystrom et al., 2021). The data included the mapped bathymetric surfaces and contours of the lakes and reservoirs and elevation-area-capacity tables. The bathymetric surfaces and contours are used in water quality models and mapping applications. The elevation-area-capacity tables are used to determine current and available reservoir storage. Future updates of Operations Support Tool (OST) and water quality models will incorporate these data.

Climate models bias correction: GCMs tend to underestimate the multi-year variability of precipitation over some regions, resulting in an underestimation of the magnitudes and/or intensities of prolonged droughts as well as prolonged wet periods. A "change factor" method was proposed to correct for this bias, in which a factor is applied to variability at longer time scales than previous implementations (i.e., multi-year rather than daily or monthly). The method was tested for Ashokan Reservoir basin.

Reconstruction of annual stream flow: Tree ring chronologies were used to reconstruct annual total streamflow at gauges on each of the major inflows to six WOH reservoirs. These paleoclimate streamflow reconstructions extrapolate the existing streamflow records further back in time (AD 1450) using the principal components of local tree-ring data as predictors in a supervised learning model. The reconstructed flows will be used to estimate likelihoods and return periods of low-frequency events, i.e., wet, and dry extremes.

SWAT modeling for WOH reservoirs: DEP is continuing to put significant effort into the application and testing of the Soil and Water Assessment Tool (SWAT) model. In 2021, the application of SWAT was extended to all WOH watersheds. Good streamflow simulations were obtained for all watersheds for the model testing period 2001–2018. Uncertainty analysis was performed using Bayesian model averaging. The analysis showed high level of reliability of the simulation results. The SWAT model was also applied to evaluate watershed management, including agricultural activity that occurred in Cannonsville watershed from early 1990s through 2019. The calibrated model estimated the current sources of stream nutrient loads, assessed loading reductions from point and nonpoint sources achieved over the past 30 years, and simulated scenarios on the impact of various watershed management practices. A comparison of model scenarios of 1990s watershed conditions with that of 2010s representing current watershed conditions showed nonpoint source contributions of dissolved phosphorus have decreased significantly. Upgrades to wastewater treatment plants continue to result in reduced phosphorus loading from point sources compared to early 1990s as reported previously. Additional details can be found in the 2021 summary and assessment report (DEP, 2021b). Ongoing work includes the application of SWAT to make water quality simulations in all six WOH watersheds. This will support the evaluation of watershed protection programs and the impact of climate change on the entire WOH system.

Validation of turbidity models for Ashokan and Schoharie: In the period following 2008, the watershed experienced major pluvial as well as dry conditions, with record precipitation and flooding during Hurricane Irene in 2011 and drought-like conditions in 2015-2016. These wide-ranging conditions offered an opportunity to retest and validate turbidity models for Schoharie and Ashokan reservoirs. In 2021, validation testing of the Schoharie and Ashokan turbidity models was extended for the 2009-2019 interval (not covered in the original validation testing done during Catskill turbidity control studies and OST development) (Gannett Fleming & Hazen and Sawyer 2009). Overall, good performance was achieved and substantiated the continued use of these models in OST.

Testing DBP precursor modeling with UV-254: DEP is working on a multi-year project to develop fate and transport models for DBP precursors, with the goal of predicting concentrations of trihalomethane and haloacetic acid formation potentials (THMfp and HAAfp) in reservoirs, diversions and releases. Since challenges in in-situ and frequent monitoring of THMfp and HAAfp make them difficult for consideration as model state variables, DEP is investigating the accuracy and utility of an optical proxy measurement (UV-254 absorbance). Simple zero-dimensional (i.e., completely mixed reactor assumption) reservoir models were tested for Cannonsville and Neversink reservoirs with data from 2016 through 2020. A first-order decay rate was included to represent net effect of autochthonous production and loss processes. Preliminary modeling results suggest that DBP precursors as represented by UV-254 may degrade in the water column of these reservoirs albeit at a very slow rate.

OST-W2 runs: To guide operations after the Christmas Eve 2020 storm, 109 OST runs were executed between December 24, 2020, and April 14, 2021, that had water quality simulations turned on and were conducted in position analysis mode. Typically, these runs were conducted to determine optimal operation of Cannonsville, Pepacton and Neversink reservoirs for up to four weeks ahead while balancing water supply and water quality; to assess if Ashokan diversion, in conjunction with Shaft 4, could be made while minimizing the impact on Kensico; to assess impact of releases from Ashokan on lower Esopus Creek; and to evaluate dividing weir gates operation at Ashokan.

Enhancements to OST: DEP is continuing to enhance OST as needs for managing reservoir operations under unique and unprecedented situations arise (e.g., Christmas Eve 2020 storm). In 2021, OST was modified to allow (1) inputs of temperature and turbidity for the Rondout W2 model according to historical 50th or 90th percentile patterns, a constant value, or a combination of a constant and a pattern, (2) W2 runs for Kensico only so that a wide range of scenarios for the operation of Catskill and Delaware aqueducts could be evaluated relatively quickly, and (3) time variable scheduling of dividing weir gates opening at Ashokan Reservoir. In addition, a Power BI report was developed to help OST modelers quickly visualize available data and decide which data describe best the initial state of the reservoirs for setting up OST-W2 runs.

Many of these results were presented in detail at the annual progress meeting with regulators held on October 20, 2021. Representatives of the New York State Department of Health and the U.S. Environmental Protection Agency attended this meeting, where DEP staff gave an overview of modeling activities during the previous year, with ample time allowed for questions, answers, and follow-up discussion between DEP and regulatory agency staff.

5.3 Geographic Information System

DEP uses 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 2021, DEP continued to use its GIS to perform technical support and data development, including GPS fieldwork, for a variety of watershed protection programs and modeling applications, via telework and in-office. A core function of the GIS is to create 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. Such analyses were used for program design and planning, engineering screening, regulatory jurisdiction determination, emergency response, water supply operations, and recreational outreach.

Based on data provided in Premium Energy's Ashokan Pump Storage preliminary permit application, DEP used Light Detection and Ranging (LiDAR) topography to estimate inundation areas for each proposed reservoir, and what protected lands they would intersect. Maps were then created of each inundation area for the NYC Law Department to assist in their response to the application. GIS staff designed and created database reports for the Land Acquisition Program (LAP) depicting eligible acres available for solicitation under several different scenarios if the criteria for required percentage of surface water were increased, as well as acres available in different priority areas. DEP used the reports in negotiations with watershed towns regarding solicitation limits. DEP also developed a Watershed Virtual Tour online map using the ArcGIS StoryMap software to support the outreach efforts of the agency.

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.

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

In addition to procuring and maintaining GPS hardware and software year-round, GIS staff process and upload field-collected GPS data into GIS layers that are incorporated into the GIS Library. In the 2021 summer field season, numerous GPS datasets were collected, corrected, checked for quality assurance, and processed into GIS layers related to wildlife and wetland studies, forestry, property management, and land acquisition. Under a current contract with DEP,

a consultant is mapping wetlands at a high resolution with aerial remote sensing techniques. GIS staff met with the consultant to discuss hydrographic connectivity with the newly mapped wetlands and provide classification criteria for how to incorporate regulated streams. Staff then reviewed draft EOH wetlands data and provided specific quality-assurance (QA) data checks to the vendor.

USGS, under an inter-governmental agreement with DEP, completed all sonar-generated bathymetric surveys of the 13 East of Hudson reservoirs and three controlled lakes. The contract concluded in 2021 with the delivery of a final report and data that included raw and corrected survey points, derived topographic surfaces of each reservoir bottom from those points, and 2-foot contours of reservoir depth derived from each topographic surface (Figure 5.3). DEP wrote and ran QA scripts to review all draft deliverables and incorporated the final data into DEP's GIS and modeling databases.

Figure 5.3 Topographic surfaces derived from sonar-generated bathymetry are used to render a 3-dimensional view of the submerged Old Croton Dam near the Croton Lake Gatehouse. USGS developed these high-resolution bathymetry data for each EOH reservoir.

As part of ongoing annual GIS data maintenance, DEP regularly updated or overhauled several existing feature classes. These included mission-critical data for various DEP programs,

such as countywide digital tax parcels, City-owned land or interests, state-owned land, water supply facilities, stream restoration projects, septic repairs, and engineering project locations. Work continued on updating GIS layers for all water quality monitoring sites, biomonitoring sites, snow survey and snow pillow sites, and meteorological stations referenced in the Laboratory Information Management System (LIMS). DEP performed annual hydrography and drainage basin data edits, including a matrix of data dependencies. These annual edits are based on corrections observed in the field from Regulatory and Engineering Programs, Water Quality and other DEP staff, and have been expanded in extent to now include USGS National Hydrography Dataset layers in additional basins outside the immediate water supply region to support DEP's Community Water group. Annual updates on locations of sensitive, threatened, or endangered species on City-owned lands were received from the New York Natural Heritage Program (NYNHP) to supplement data collected by the DEP Wildlife Studies Program. DEP obtained the latest version of SSURGO2 soils data from USDA and numerous other updates from the NYS GIS Clearinghouse, including NYSDOT transportation features and NYSDEC layers.

5.3.3 GIS Infrastructure Improvement

During 2021, 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 maintained GPS units used by various programs by replacing aging units, updating data dictionaries, updating software, and tracking inventory for all GPS hardware and software.

Due to COVID-19 statewide restrictions, non-essential DEP staff continued to telework during much of 2021 by remotely accessing their office computers via virtual private network to run full versions of GIS and WaLIS desktop software. Staff also continued using web-based ArcGIS JavaScript tools implemented to support DEP's GIS and WaLIS needs while teleworking, including the NYC Watershed Viewer and WebWaLIS.

DEP's Bureau of Information Technology began an initiative in early 2021 to implement best practices and upgrade GIS architecture throughout all DEP bureaus in collaboration with the GIS software vendor ESRI. This initiative stemmed from a series of enterprise GIS architecture modernization meetings to evaluate the BWS upstate GIS architecture, network, users, database needs, and other characteristics specific to the size and remoteness of the offices and user base. DEP conducted numerous GIS software timing tests via a virtual desktop in Microsoft's cloud-computing environment (Azure) in addition to other network configurations available at DEP's remote offices. The goal of the testing is to provide remote users with a high-speed GIS and WaLIS experience.

DEP also continued to upgrade and maintain WaLIS, which currently operates on 220 DEP user workstations. DEP's developers provided routine WaLIS support throughout 2021 by

creating custom server reports, customizing the WaLIS interface to resolve mapping or data entry issues, or facilitating and enhancing workflow. Staff also modified workflow assignments and a vast amount of email triggers related to the large number of retirements and other staff attrition. With the end of telework during the latter half of 2021, DEP's goals for WaLIS shifted away from the continued development of web-based resources needed for teleworking, such as the NYC Watershed Viewer and WebWaLIS. DEP's focus turned instead to running WaLIS remotely via cloud-based resources that will provide the full desktop functionality while also better integrating it with the GIS data it relies on, including the latest version of ArcGIS Portal.

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. DEP provided over 61 stakeholders and communities with semi-annual data updates in January and July for newly acquired and existing City-owned lands. DEP shared updated watershed recreation data with Ulster County, WAC, and the Catskill Center for their recreation website mapping applications, and to the NYC Open Data Portal. Throughout 2021, DEP responded to data sharing requests from NYSDOH, NYSDOT, NYSDEC, NHNHP, NYS Office of the Attorney General, WAC, CWC, EOH Watershed Corporation, Catskill Center, FEMA, Westchester Land Trust, Cornell University, City University of New York, NY Power Authority, Hudson Highlands Land Trust, 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 focus 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 (CPDP) for other stormwater-related activities. DEP also ensures that during construction, erosion control measures are properly sited and maintained. For post-construction condition, DEP ensures projects that require SWPPPs or IRSPs have properly 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. NYSDEC seeks DEP's input 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 Semi-Annual Project Activities report also includes summaries and maps reflecting project locations. In 2021, there were four new commercial septic applications, 14 commercial septic repair applications, two sewer collection applications, two sewer connection applications, 25 stormwater applications and two variance applications. There were also three mining permit reviews, 27 stream disturbance permit reviews, two timber harvest reviews, four NYSDOT reviews and four other-type projects within the Catskill and Delaware watersheds.

6.1.1 SEQRA Coordination

DEP 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 Law.

The semi-annual report includes a summary and mapping of all SEQRA reviews performed by DEP during the previous calendar year. There were 40 new SEQRA applications received in FAD basins in 2021.

6.1.2 Delegation Agreements

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

During 2021, DEP received documentation relative to 71 delegated SSTSs; 12 of these reviews are attributed to subsurface sewage treatment systems in the WOH watershed with the remaining 59 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 any activity that results in a pollutant-laden discharge in the watershed. Enforcement actions are prepared with input from attorneys from DEP's Bureau of Legal Affairs and the City Law Department. 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 2021, DEP opened nine new NOVs and closed two existing NOVs. Additional detail regarding these violations is included in the semi-annual report.

The primary function of the DEP Police with respect to enforcement is daily patrol of the watershed documenting a wide range of potential water quality incursions. Officers 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. The police have the authority to issue summonses and notices of warning/violation of the New York State Environmental Conservation Law, the WR&R, as well as other state and local codes. DEP regulatory staff work cooperatively with the DEP Police to ensure citizen

complaints regarding 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. (New York City-owned plants in the watershed are formally known as water resource recovery facilities (WRRF).) 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. DEP inspects treated industrial waste discharges to groundwater, via ground surface application, 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

DEP inspected 31WOH WWTPs on a regular schedule in 2021. 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 162 scheduled compliance and emergency response inspections in 2021.

Compliance with State Pollution Discharge Elimination System (SPDES) permits continued to improve among WWTPs in the Catskill/Delaware watersheds in 2021, due in large part to the WWTCPI Program.

As reported previously, NYSDEC issued a notice of violation (NOV) on February 6, 2019, for collection system overflows and late reporting relative to the Hunter Highlands Wastewater Treatment Plant. On October 28, 2021, EPA issued a significant non-compliance letter to the facility for total suspended solids violations in February and June 2021. NYSDEC

and DEP continue to work cooperatively to seek short and long-term solutions at the Hunter Highlands facility. Final resolution of all outstanding issues will be sought through the issuance of a NYSDEC consent order. A partial list of the most critical items include:

- Insulating and covering the aeration basins.
- Developing an adequate staffing plan (including increasing operator hours).
- SCADA system improvements
- Collection system repairs

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 participate in any CCs in 2021. 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 basins are of special interest because they contribute to 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, but DEP does perform inspections of the collection system/pump stations maintained by Westchester County and the towns of North Castle and Harrison within the Kensico basin. In 2021, DEP conducted 105 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 2021. DEP scheduled the activation of the Croton Falls and Cross River pump stations in autumn 2021 to supplement capably the New York City water supply as repairs were undertaken to the Catskill Aqueduct. The operation of each station required a heightened level of vigilance to protect water quality within the Croton Falls and Cross River basins. Correspondence were 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 in advance of pump activation. However, supplemental water was ultimately not required and activation of the pumps was not necessary

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 2021 monitoring period. The inspections revealed no abnormal conditions.

For monitoring of the Westlake Sewer Trunk Line, see Section 4.10.2.

6.3.3 Sampling of WWTP Effluents

Wastewater treatment plant (WWTP) and Water Resource Recovery Facilities (WRRF) effluent results are reported to NYSDOH and USEPA semiannually in the Wastewater Treatment Plant Compliance and Inspection (WWTPCI) report as required by the 2017 FAD. Sampling data are also shared regularly with DEP's WWTPCI staff for tracking compliance with SPDES-permitted effluent limits.

Sampling and analysis of surface-discharging WWTP effluents was conducted by DEP's state-approved laboratories throughout the year at a reduced frequency due to NYSDOH approved COVID-19 monitoring reductions. In 2021, composite samples were collected once for the year at non-City owned plants that have composite sample monitoring requirements in their SPDES permits. City-owned WRRFs were also sampled in accordance with SPDES permit monitoring requirements. 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.

In the Catskill System, there were 17 WWTPs and WRRFs with active SPDES permits. The Chichester plant in the town of Shandaken in Ulster County has no discharge. It is a City-owned and operated, intermediate sized sub-surface sewage treatment system. The remaining 16 plants are comprised of three City-owned and 13 non-City-owned facilities. In 2021, 2,127 analyses were performed on 352 influent and effluent samples (as required) from WWTPs and WRRFs in the Catskill System. Of the 352 samples, 308 were collected from City plants and 44 were collected at non-City plants. These samples underwent 2,079 analyses by DEP's Kingston Laboratory and 48 analyses by a contract laboratory.

There were 13 WWTPs and WRRFs in the Delaware System with active SPDES permits in 2021 (two City-owned and 11 non-City-owned). For the Delaware System, 248 influent and effluent samples were collected, with 197 from City-owned plants and 51 from non-City owned plants. These samples underwent 1,648 analyses performed by Grahamsville (723), Kingston (854), and contract (71) laboratories.

In the EOH System, there were 62 WWTPs and WRRFs with active SPDES permits. In this system, 2,896 analyses were performed by the Hawthorne Laboratory on 382 WWTP effluent samples. Mahopac is the only EOH plant with composite sampling. Nine WWTPs are located in a FAD watershed, with eight located within the Croton Falls and Cross River watersheds and one within the West Branch watershed.

The sampling of non-FAD basin treatment plants was not conducted from January through October 2021 due to COVID-19 monitoring reductions and was subsequently discontinued from that point forward in a November agreement with NYS DOH. Cross River and Croton Falls are routinely considered non-FAD basins; however, they become part of the FAD system when their pumps are in operation. During these times, WWTP and WRRF samples are required to be collected. In 2021, preparatory sampling was conducted in both basins between October 11 and 24; however, the pumps were not activated.

6.4 Capital Replacement Program

The City is obligated to pay for capital replacement of watershed equipment and methods at eligible WWTPs required by the WR&Rs and not otherwise required by federal or state law. In 2021, DEP worked with NEIWPCC to negotiate a contract amendment to provide additional program funding in future years.

During 2021, NEIWPCC made no payments to WWTPs located in FAD basins for replacement of watershed equipment. DEP provides funding to replace minor equipment (e.g. filter cartridges, pumps, meters) as needed 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

The goal of EPA's Surface Water Treatment Rule is public health protection, and that goal is a core objective in DEP's mission. A program that helps provide assurance that this goal has been met is New York City's Waterborne Disease Risk Assessment Program (WDRAP). Components of WDRAP have evolved over time; but the essential purpose and the core organizational structure have remained consistent over the years. WDRAP is a joint agency program involving the NYC Department of Health and Mental Hygiene (DOHMH) and DEP. Established in 1993, the program has continued under a series of intra-city agreements (ICAs) between these two city agencies. The WDRAP ICA lays out each agency's roles and responsibilities. In 2021, DEP and DOHMH began work on a new ICA, which is to take effect July 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 surveillance began in the City in 1993 for giardiasis and in 1994 for cryptosporidiosis, and has been ongoing since that time. Electronic reporting of cases began in 2011. DOHMH public health epidemiologists follow up on confirmed reported cases of cryptosporidiosis 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, health care worker, childcare worker) or attends, or is thought to attend, daycare.

All data from 2021 are preliminary as of this writing, and are subject to change pending the results of confirmatory laboratory testing and any other needed adjustments. In 2021, there were 810 cases of giardiasis and 278 cases of cryptosporidiosis reported to DOHMH (counts as of January 2022). Of these cases, epidemiologists completed five giardiasis patient interviews (of patients in high transmission risk group), and conducted 196 cryptosporidiosis patient interviews.

A shift in recent years toward the use of syndromic multiplex panels (SMP) has had a notable impact on both giardiasis and cryptosporidiosis surveillance in NYC and across the United States. An increase in the number of cryptosporidiosis cases in NYC first noted by WDRAP staff in late 2015 continued in subsequent years. In 2020 and 2021, the COVID-19 pandemic affected case numbers, resulting in a decrease in case reporting in 2020 and an apparent partial rebound in case reporting in 2021. Approximately 37 laboratories are now using

an SMP test in the City. The proportion of giardiasis patients diagnosed exclusively by an SMP test at a hospital or commercial laboratory has grown from 5% in 2015 to 48% in 2021. Similarly, the proportion of cryptosporidiosis patients diagnosed exclusively by an SMP test at a hospital or commercial laboratory has grown from 20% in 2015 to 78% in 2021.

DOHMH is confident the new SMP diagnostic test continues to lead to an increase in detection of both giardiasis and cryptosporidiosis cases and that the case increase observed is not considered reflective of an increase of disease transmission. Similar increases in giardiasis and cryptosporidiosis rates have been observed in several other jurisdictions in the United States.

COVID-19 had an impact on all diseases reported to DOHMH in 2020. A decline in new cases reported to the health department was observed starting in March 2020 when NYS issued stay at home orders that led to a reduction in visits to doctors and to emergency departments for non-COVID related illnesses. The travel ban, social distancing, and remote work led to a disruption in exposures for many communicable diseases, including exposures associated with giardiasis and cryptosporidiosis. The reporting for both giardiasis and cryptosporidiosis appears to be rebounding in 2021.

In addition to tracking reported cases of giardiasis and cryptosporidiosis, New York City has four syndromic surveillance systems in place to detect outbreaks of gastrointestinal illness:

- Hospital emergency department logs are tracked electronically for chief complaint data (including gastrointestinal illness symptoms). Data from 53 hospitals is received and analyzed on a daily basis.
- Sales of over-the-counter or non-prescription anti-diarrheal medications at major pharmacies are monitored electronically. Data from 470 drug stores is received and analyzed on a daily basis.
- The number of stool specimens submitted to a large clinical laboratory for microbiological testing are tracked.
- Several sentinel nursing homes across the City are monitored 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. All four syndromic surveillance systems continued to be operational in NYC in 2021. There was no evidence of a drinking water-related outbreak in New York City in 2021, consistent with WDRAP findings of prior years.

Each year a WDRAP annual report is prepared which 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), summary results from syndromic surveillance programs, and WDRAP program implementation information. The WDRAP annual reports are a FAD requirement, and are submitted annually to USEPA, NYSDOH, and others as required. These reports are also posted on DEP's website:

- The latest annual report is available at: https://www1.nyc.gov/site/dep/water/waterborne-disease-risk-assessment.page.
- Annual reports going back to 1997 are available at: https://www1.nyc.gov/site/dep/about/document-portal.page.

In terms of additional WDRAP-related activities, in 2021, DEP continued work on its Public Health Surveillance Systems Survey Project. Data collection and compilation for the project was completed and a final report is in preparation. Also in 2021, NYC's Hillview Reservoir *Cryptosporidium* and *Giardiasis* Action Plan was updated, as required.

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 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.

DEP disseminates information to a broad public audience through its website, press releases, and social media platforms. By the end of 2021, DEP was reaching 13,000 followers on NYC Water Facebook, 5,466 followers on NYC Watershed Facebook, 21,288 followers on NYC Water Twitter, and 4,866 followers on NYC Water Instagram. DEP's NYC Water Flickr Page contains over 8,620 photos and archival images.

Recreation and stewardship of City-owned lands remain popular ways that DEP engages with certain audiences, including over 100,000 subscribers to a Watershed Recreation e-newsletter. Due to ongoing COVID-19 safety precautions, DEP did not organize any family fishing days, reservoir clean-ups, or other in-person events on City lands during 2021. DEP continued to collaborate with Ulster County to manage and maintain the Ashokan Rail Trail, which attracted approximately 165,000 visitors throughout 2021.

DEP's Education Office conducted more than 250 environmental education programs in 2021 that reached nearly 30,000 students, educators, and other professionals. Due to ongoing COVID safety precautions, these programs included a combination of virtual field trips and professional learning opportunities, new digital resources such as the NYC Watershed Storymap and NYC's Water Story Curriculum Guide, and modified classroom visits and guided tours at the Visitor Center at Newtown Creek. DEP's 2021 Water Resources Art & Poetry Contest engaged more than 1,300 students from over 90 schools in the watershed and New York City; approximately 100 contest winners were featured in a new exhibit at the Catskill Water Discovery Center in Arkville, Delaware County. Trout in the Classroom engaged over 10,000 students and teachers from approximately 150 schools. DEP sponsored a series of pre-taped virtual performances of the "City That Drinks the Mountain Sky" and continued to collaborate with local museums and community organizations to support educational exhibits related to the water supply and watershed.

The CWC Public Education Program awarded 28 grants totaling $182,479 to schools and organizations in the watershed and New York City; the estimated audience for these programs is 11,180 people. To date, CWC has awarded 677 educational grants totaling more than $3.6 million, including 51 grants for public audiences and 626 grants for school-based audiences.

CWC maintains a networking website for watershed educators and routinely posts press releases and program announcements on its main organizational website.

The Watershed Agricultural Program conducted 48 farmer education programs that were attended by 1,750 total participants via both virtual and in-person events. Highlights included the virtual Catskill Regional Agricultural Conference; the annual WAC Farm Tour; a series of lunchtime grazing webinars; a Food, Water and Climate Farm Tour for legislative staff members; a farm tour for environmental policy graduate students from Bard College; and the 25th annual Delaware County Clean Sweep Chemical Disposal Day. WAC routinely posts program announcements on its organizational website in addition to promoting local farm and forestry products through the Pure Catskills Campaign and posting informational videos on the WAC YouTube channel. The annual Taste of the Catskills local food-tasting event was postponed due to COVID-19 precautions.

The WAC Forestry Program utilized the interactive MyWoodlot website to educate forest landowners and engage them in stewardship activities, while the watershed model forests continued to host educational events for all audiences. MyWoodlot also offers a virtual model forest Storymap tour. In 2021, WAC sponsored nine logger training workshops for 81 participants and conducted 43 virtual bus tours for 1,222 participants, primarily New York City students. Twenty-one teachers attended the annual Watershed Forestry Teachers Institute and 383 students participated in the 2020-2021 Green Connections School Partnership Program.

The Stream Management Program offered a combination of virtual and in-person events throughout 2021 to educate and train streamside landowners, municipal officials, watershed professionals, school-based audiences, and other stakeholders. Highlights for 2021 include: substantive progress on the first of three webinars for municipal officials titled "Stream Process 101"; the virtual Schoharie Watershed Summit; Ashokan Watershed Month (Family Fun & Fish Day in Woodstock and Municipal Officials Day in Phoenicia); Ashokan Stream Explorers Youth Adventure; Glaciers of the Catskills webinar; publication of "A History of Life Along the Upper Rondout Creek" e-book; and completion of the Ashokan Watershed Detectives YouTube video. CatskillStreams.org continues to serve as a comprehensive resource for streamside landowners and local officials, as well as a repository for all stream management plans and local flood analyses completed to date for WOH watershed communities.

Finally, DEP and its partners attend community outreach events where staff communicate key messages directly to the public and distribute information. Although a number of events were postponed during 2021 due to COVID-19 precautions, several events did proceed and were attended by watershed program partners. Highlights include the Delaware County Fair (77,000 attendees), Delhi Harvest Festival, Deposit Lumberjack Festival, Grahamsville Little World's Fair, Greene County Youth Fair, Longyear Farm Day, Margaretville Cauliflower Festival, NYC Watershed Science and Technical Conference (virtual), Olive Day, Phoenicia Farmer's Market, Shandaken Tunnel SPDES Permit Outreach Meeting, and the Ulster County Fair.

9. Miscellaneous Reporting Provisions

9.1 Water Conservation/Demand Management

Because of continued water efficiency measures, water demand is down more than 40% since the 1990s, despite increasing population (Figure 9.1). Since 2009, average daily demand has been below the 1960s drought-of-record (1,045 MGD) and demand in 2020 and 2021 was at a 60-plus-year low, due in part to the COVID-19 pandemic.

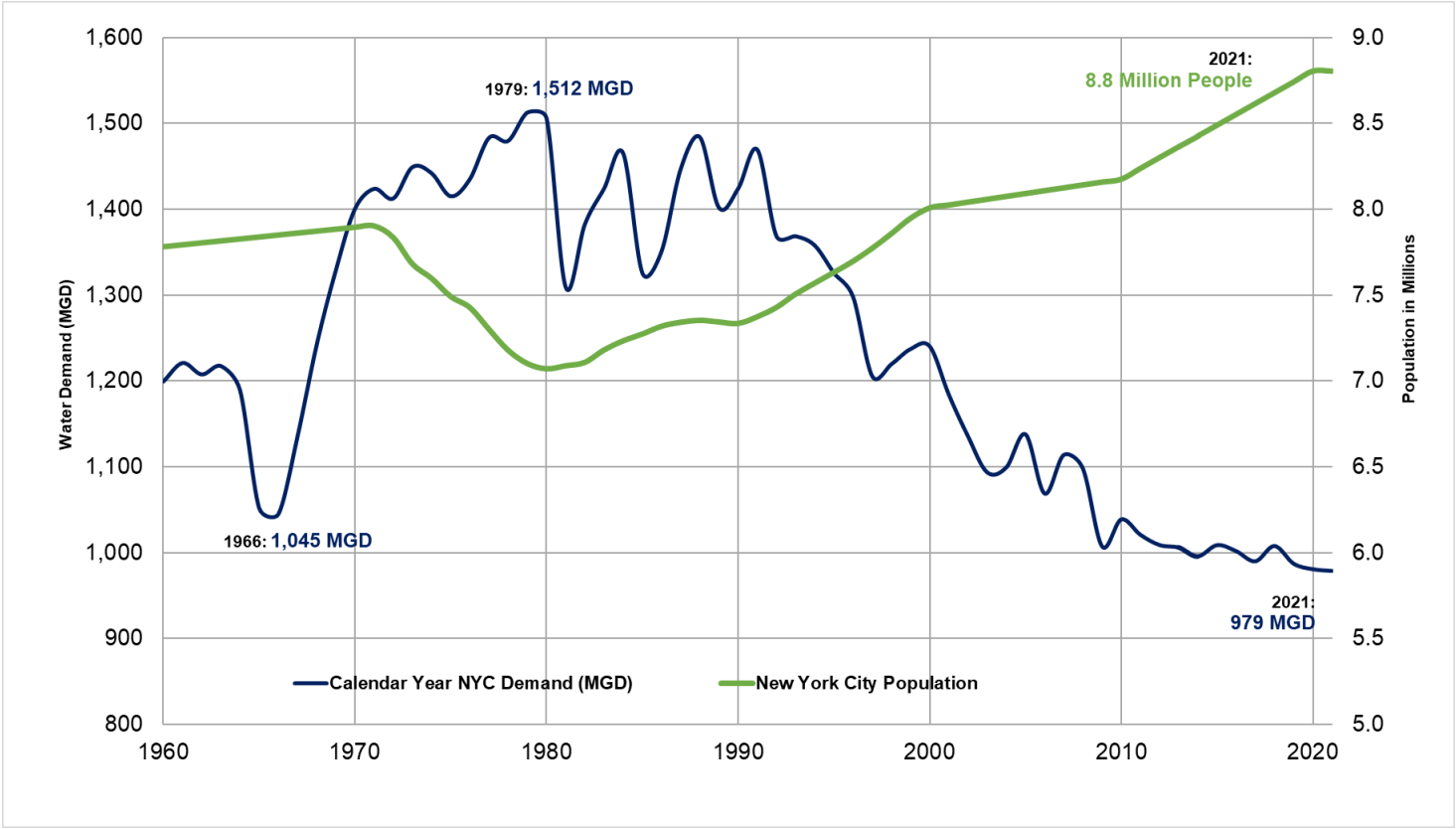

Figure 9.1 New York City water demand and population.

The COVID-19 pandemic changed many water demand trends in New York City, including decreases in non-residential water use as businesses closed, and increases in residential water use when work-from-home protocols and school closures meant more people were spending time in their homes. As New York implemented a phased reopening, as people returned to work and school, and as vaccines became widely available, water trends shifted again, indicating a slow but steady recovery of pre-pandemic water usage trends. DEP's demand management program has continued saving water across the city in preparation for the planned

shutdown and repair of the Delaware Aqueduct. Furthermore, continued water savings will help optimize reservoir water levels during times of drought and reduce the energy and greenhouse gas emissions associated with water and wastewater operations.

9.1.1 Water Demand Management Plan

As described in the 2018 Water Demand Management Plan and subsequent annual updates (https://www1.nyc.gov/site/dep/water/water-conservation.page), DEP is continuing to implement efficiency measures in New York City and upstate communities with the goal of reducing water use by 20 million gallons per day (MGD) by 2022, relative to the 2013 baseline. The plan sets forth six major strategies:

- 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 recent progress in implementing these 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), New York City Health and Hospitals Corporation (HHC), New York City Department of Citywide Administrative Services (DCAS), and New York City Department of Cultural Affairs – Cultural Institutions Group (CIG).

Through ongoing partnership with DOE, DEP has funded the replacement of over 35,600 toilets and urinals with high-efficiency models in 421 school facilities across all five boroughs to date. Despite temporary delays due to the COVID-19 pandemic, in 2020 and 2021, DEP retrofitted 19 schools with 767 toilets and 243 urinals. In total, DOE retrofits are expected to save 4.71 MGD.

DEP's partnership with CUNY has included 780 fixture upgrades at City College for a demand savings of 0.04 MGD. In 2020, DEP and CUNY extended their partnership and executed an interagency agreement to replace inefficient fixtures at Queens College. In total, DEP and CUNY plan on replacing over 600 fixtures across four campus buildings at Queens College for an estimated savings of 0.03 MGD. Due to pandemic-related delays, DEP and CUNY anticipate beginning these upgrades in spring 2022.

In 2021, DEP continued its partnership with DPR and the Central Park Conservancy and Prospect Park Alliance. In Central Park, the North End Recirculation Project will include a pumping and filtration system to recirculate water in the Park's northern waterbodies and reduce flow to the City's combined sewer system. This project is currently in design and is anticipated to save 0.48 MGD. In Prospect Park, DEP continued coordinating with Prospect Park Alliance to replace a valve on the make-up water line for the park's lake system. In spring 2021, Prospect Park Alliance hired an engineering firm to design and construct this project, which is expected to save 0.80 MGD when completed.

In January 2021, DEP completed its fifth Water Challenge to all 14 of the City's water resource recovery facilities (WRRFs) in the five boroughs. All facilities were encouraged to reduce demand by 10% over a two-year baseline average from calendar year 2018 and 2019. Of the 14 WRRFs, eight were able to reduce water consumption by at least 10%. Red Hook WRRF achieved the most savings among WRRFs with dewatering facilities, with a 45% reduction from baseline consumption. Coney Island WRRF achieved the most savings for WRRFs without dewatering facilities, with a 41% reduction from baseline. The WRRF Challenge resulted in a total savings of approximately 0.9 MGD.

DEP is also continuing to partner with HHC after completing retrofits at Harlem Hospital, which saved 0.07 MGD. Due to the COVID-19 pandemic, however, additional HHC retrofit projects were put on hold. DEP and HHC will resume retrofits in 2022. Additional HHC retrofits are expected to result in an overall savings of 1.22 MGD.

In June 2020, DEP completed a partnership project with DCAS that included replacement of 268 restroom fixtures in four buildings: DCAS and Department of City Planning office buildings, Queens Criminal Court, and the Manhattan Civil Courthouse. These replacements achieved an estimated water savings of 0.02 MGD.

Residential Water Efficiency Program

In June 2019, DEP concluded the Toilet Replacement Program after five years of successful implementation. The program retrofitted approximately 13,300 toilets citywide for a savings of 0.63 MGD. Although the Toilet Replacement Program concluded, DEP continues to offer home water saving kits to New Yorkers. In total, DEP has achieved a demand savings of 1.03 MGD through these two initiatives.

DEP and its contractor Honeywell have also provided complimentary household water conservation surveys to building owners across NYC. The surveys aid building owners with identifying opportunities for water savings and detecting leaks. In 2020, Honeywell surveyed 1,533 individual apartment units before surveys were suspended due to the pandemic. Home surveys have saved an estimated 0.4 MGD.

Non-Residential Water Efficiency Program

The DEP Water Conservation and Reuse Grant Pilot Program incentivizes commercial and residential water conservation projects that achieve a minimum water savings of 2,740 gallons per day (1 million gallons per year). In 2020, DEP accepted a project that includes a 400,000 gallon per day water reuse system. Overall, the pilot program is anticipated to save 0.2 MGD by 2023.

DEP has successfully completed several Water Challenges to different commercial sectors: hotels, restaurants, hospitals, and universities. Participants are encouraged to reduce their annual water consumption by at least 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 August 2020, DEP completed its two-year Water Challenge to Universities. Collectively, the six participants—Fordham University: Lincoln Center Campus, The New School, Long Island University: Brooklyn Campus, Pace University, St. John's University, and Weill Cornell Medicine—reduced their monthly average water consumption by 11%, surpassing the 5% Water Challenge goal, for a total savings of 0.12 MGD.

Water Distribution System Optimization

Water distribution system optimization includes system repairs and upgrades, water pressure management, refining water meter accuracy, and leak detection. In 2020 and 2021, DEP surveyed a total of 455 miles of water mains.

Leaking and/or vandalized fire hydrants can result in significant water waste; an illegally opened fire hydrant can release more than 1,000 gallons per minute. In 2020 and 2021, DEP repaired 15,142 hydrants, replaced 2,065, and provided other maintenance services to 31,416 additional hydrants.

DEP continually works to improve maintenance of the pressure zones within the City's water distribution system. In 2020 and 2021, DEP completed 10,459 preventive maintenance inspections/calibrations on pressure regulating valves. DEP also overhauled 50 of the pressure regulating valves in use citywide. In 2021, the number of breaks per 100 miles was 6.23, below the City's 10-year average of 6.8, and well below the accepted industry average of 25 breaks per 100 miles annually.

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. Due to the COVID-19 pandemic, meter replacement operations were paused for several months. However, in 2020 DEP replaced 708 large meters and 3,815 large meters in 2021.

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" and revised the title to "Water Shortage Rules." The 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 revisions also add, remove, and change certain water-use prohibitions during the different stages of water shortage emergencies to better reflect DEP's understanding of City water use. DEP expects to promulgate this rule before the 2022 shutdown.

Wholesale Customers Water Demand Management Program

The Wholesale Customer Water Demand Management Program assisted DEP's seven upstate wholesale customers (utility partners) in developing demand management plans for their systems, with a target 5% reduction in consumption. All seven utility partners developed demand management plans under this program, with a total two-year sustained water demand savings of 5.21 MGD (a 9% decrease from their 2013 baseline). Due to unforeseen circumstances brought on by the COVID-19 pandemic, much of the anticipated funding for implementation of this program was reallocated. However, in 2021 DEP made progress towards executing an agreement with Yonkers that will result in an additional estimated savings of 1.3 MGD.

9.2 Updates to Drought Management Plan

In 2021, monthly average precipitation was above normal for 50% of the year (based on historical average for the period 1989-2021). The NYC Delaware Basin Reservoir System storage stayed above the normal storage level 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 have been established to identify when a Drought Watch, Warning, or Emergency should be declared 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 - Drought Watch is declared when there is less than a 50% probability that 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 - A Drought Warning is declared when there is less than a 33% probability that reservoirs in either the Catskill or Delaware system will fill by June 1.
- Drought Emergency - A Drought Emergency is 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. This probability is estimated 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, which remain in effect. 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 2021 and included the following major activities:

- Completion of the bypass tunnel final concrete lining in October 2021.
- Completion of the fourth and final annual autumn shutdown of the Catskill Aqueduct for the Catskill Aqueduct Repair and Rehabilitation (CATRR) project, which began in 2018.
- Completion of a Delaware Aqueduct Shutdown Management Plan describing water supply operations before, during, and after the Delaware Aqueduct shutdown is

underway. The completed plan document was delivered to the NYSDOH in September 2021.

Tunnel Dewatering Preparation

The 50 million gallons per day pumping station, which is capable of dewatering the Rondout-West Branch Tunnel (RWBT) under the expected conditions, is ready to operate. Quarterly meetings are held to review status of the monthly testing of the pumping station.

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

The bypass tunnel contract, BT-2, continues to make progress. The final concrete lining of the tunnel was completed in October 2021 and the final lining of the access shaft and construction of the superstructures is in progress. The shutdown of the RWBT for the connection of the bypass to the existing RWBT will commence in autumn 2022. During the execution of the connection, 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 during 2023.

Hydraulic Investigations of the RWBT

Investigations of the RWBT help 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 2021.
- The DEL-LTA contract supports autonomous underwater vehicle and remote-operated vehicle flights within the RWBT as needed. No inspections were deemed necessary during 2021.

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. The fourth and final shutdown was carried out between October and mid-December 2021 with significant scope achieved, including the stabilization of the Catskill Influent Weir at Kensico Reservoir, biofilm removal, replacement of valves and several steel pipe siphon locations, and wall and invert repairs in the Reynolds Grade Tunnel.

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 and alum, respectively. CAT-213E reached substantial completion in October 2021; CAT-213F substantial completion is expected in July 2022.

9.4 Catskill/Delaware Filtration Plant

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 that began fully operating 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. In recognition that the work supporting the existing preliminary plans was over 25 years old, the 2017 FAD required the City to contract for a comprehensive review of filtration methods and technologies, resulting in a new conceptual design for a filtration facility or facilities.

DEP completed the initial phase of the design project, which included bench scale studies, in 2020. Following evaluation of the results, DEP initiated phase two of the project in 2021. The second phase includes the design, construction, and operation of large-scale pilot plants; completion of pilot studies and a report; and completion of a full-scale conceptual design. Work commenced on June 21, 2021. The 2021 work included development of a site design for the pilot facilities, initiation of filter train design, and preparation for procurement of vendor services for construction.

9.5 Arkville office

DEP has committed to locate staff in a new office recently 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.

Construction of the new building in Arkville was substantially complete in the spring of 2020. DEP and the City's Department of Citywide Administrative Services (DCAS) negotiated a lease with CWC for the portion of the building to be occupied by DEP. The lease was registered in spring 2020, and initial payments were processed shortly thereafter. DEP staff began to take occupancy of the building in 2020. As of the end of 2021, DEP had 20 full-time employees working in the building. DEP has allocated additional vacant positions to be based in Arkville; those positions will be filled as allowed by the City's hiring process.

References

DEP. 2018. Watershed Water Quality Monitoring Plan. Directorate of Water Quality (issued October 2008, first revision May 2009, second revision May 2016, third revision 2018). Valhalla, NY. 207 p.

DEP. 2019. New York City Watershed Rules and Regulations. 1997, amended November 29, 2019. Rules and Regulations for the Protection from Contamination, Degradation, and Pollution of the New York City Water Supply and its Sources. RCNY Title 15, Chapter 18. https://www1.nyc.gov/assets/dep/downloads/pdf/watershed-protection/regulations/rules-and-regulations-of-the-nyc-water-supply.pdf.

DEP. 2020. New York City Department of Environmental Protection Filtration Avoidance Annual Report. Valhalla, NY. 112 p.

DEP. 2021a. Long-Term Watershed Protection Program Plan. Bureau of Water Supply. Valhalla, NY. 97 p.

DEP. 2021b. Watershed Protection Program Summary and Assessment. New York City Department of Environmental Protection, New York, Valhalla, NY. 389 p.

DEP. 2021c. 2020 Watershed Water Quality Annual Report. Valhalla, NY. 237 p.

DEP. 2021d. NYC Drinking Water Supply and Quality Report - 2020. New York, NY. 18 p. 2020-drinking-water-supply-quality-report.pdf (nyc.gov).

DEP. 2021e. NYC Open Data web platform. NYC Open Data - (cityofnewyork.us).

Gannett Fleming & Hazen and Sawyer. 2009. Catskill turbidity control studies: Phase II Implementation Plan - Updates and Supporting Analyses. Prepared for New York City Department of Environmental Protection, Bureau of Engineering Design and Construction.

Nystrom, E.A., Huston, C.J., and Welk, R.J., 2021, Bathymetry of New York City's East of Hudson reservoirs and controlled lakes, 2017 to 2019: U.S. Geological Survey Scientific Investigations Report 2021–5057, 46 p., https://doi.org/10.3133/sir20215057.

NYSDOH [New York State Department of Health]. 2017. New York City Filtration Avoidance Determination. 120 p.

USEPA [United States Environmental Protection Agency]. 1989. Drinking Water: National Primary Drinking Water Regulations; Filtration, Disinfection; Turbidity, *Giardia lamblia*, Viruses, *Legionella*, and Heterotrophic Bacteria; Final Rule. 54 Fed. Reg. 27486. June 29, 1989. WH-FRL-3607-7. Washington, D.C.

Appendix A: Land Acquisition Program Tables

Appendix A Table 1 Executed purchase contracts with natural features criteria.

Reporting Period: 1995 to 2020

R.E. Type	# of Contracts	Acres	SWC Acres	Avg. % SWC per Project	Slope Acres	Avg. % Slope per Project
City CE	170	25,934	7,155	28%	16,489	64%
City FBO	22	47	47	100%	19	40%
City Fee	1,365	96,893	27,223	28%	58,104	60%
FEMA	64	75	66	87%	15	20%
SAP	25	198	145	73%	80	40%
WAC CE	157	28,229	8,178	29%	15,091	53%
WAC FE	9	2,982	463	16%	2,239	75%
	1,812	**154,358**	**43,275**	**28%**	**92,037**	**60%**

Reporting Period: 2021

City FBO	1	4	4	100%	1	17%
City Fee	4	401	177	44%	241	60%
SAP	6	49	41	85%	28	58%
	11	**454**	**222**	**49%**	**270**	**60%**

Program-to-date Sub-Totals

City CE	170	25,934	7,155	28%	16,489	64%
City FBO	23	51	51	100%	20	39%
City Fee	1,369	97,294	27,400	28%	58,345	60%
FEMA	64	75	66	87%	15	20%
SAP	31	247	186	75%	109	44%
WAC CE	157	28,229	8,178	29%	15,091	53%
WAC FE	9	2,982	463	16%	2,239	75%
Grand Totals:	**1,823**	**154,812**	**43,497**	**28%**	**92,307**	**60%**

-Numbers for acres and percents are rounded.
-Survey acres are used to calculate project acres for closed properties. SWC (Surface Water Criteria) acres are based on GIS and tax parcel acres and may not be as accurate.
-Pursuant to the 1997 Memorandum of Agreement, SWC includes acreage that is within (a) 300 feet of a watercourse, (b) 1,000 feet of reservoirs, (c) areas designated as 1% return interval flood (100 year base flood), and/or (d) wetlands (defined as federal jurisdiction wetlands larger than five acres, or designated by NYSDEC).
-Slope: Acres that are at or greater than 15% grade.

In some cases SWC acres may appear to be greater than project acres; this is because SWC acres are GIS-base and project acres are survey-based. Therefore, they do not always align.

Appendix A Table 2 Executed purchase contracts with cost.

Reporting Period: 1995 to 2020

R.E. Type	# of Contracts	Acres	Avg. Size of Project	Purchase Price
City CE	170	25,934	153	$72,229,274
City FBO	22	47	2	$3,510,069
City Fee	1,365	96,893	71	$369,862,042
FEMA	64	75	1	$453,575
SAP	25	198	8	$1,383,449
WAC CE	157	28,229	180	$41,539,881
WAC FE	9	2,982	331	$2,891,334
	1,812	**154,358**	**85**	**$491,869,625**

Reporting Period: 2021

City FBO	1	4	4	$85,000
City Fee	4	401	100	$1,944,000
SAP	6	49	8	$328,325
	11	**454**	**41**	**$2,357,325**

Program-to-date Sub-Totals

City CE	170	25,934	153	$72,229,278
City FBO	23	51	2	$3,595,069
City Fee	1,369	97,294	71	$371,806,069
FEMA	64	75	1	$453,575
SAP	31	247	8	$1,711,774
WAC CE	157	28,229	180	$41,539,891
WAC FE	9	2,982	331	$2,891,335
Grand Totals:	**1,823**	**154,812**	**85**	**$494,226,950**

Numbers for acres and dollar values are rounded.

Appendix A Table 3 Closed purchase contracts with natural features criteria.

Reporting Period: 1995 to 2020

R.E. Type	# of Contracts	Acres	SWC Acres	Avg. % SWC	Slope Acres	Avg. % Slope
City CE	170	25,934	7,155	28%	16,489	64%
City FBO	17	40	40	99%	17	42%
City Fee	1,345	95,035	26,809	28%	56,835	60%
FEMA	64	75	66	87%	15	20%
SAP	21	172	120	70%	74	43%
WAC CE	156	27,886	8,087	29%	14,855	53%
WAC FE	9	2,982	463	16%	2,239	75%
	1,782	**152,125**	**42,739**	**28%**	**90,524**	**60%**

Reporting Period: 2021

City FBO	5	7	8	109%	2	32%
City Fee	14	1,136	298	26%	767	68%
SAP	4	26	25	96%	7	25%
WAC CE	1	343	91	26%	236	69%
	24	**1,512**	**421**	**28%**	**1,012**	**67%**

Program-to-date Sub-Totals

City CE	170	25,934	7,155	28%	16,489	64%
City FBO	22	47	47	100%	19	40%
City Fee	1,359	96,171	27,107	28%	57,603	60%
FEMA	64	75	66	87%	15	20%
SAP	25	198	145	73%	80	41%
WAC CE	157	28,229	8,178	29%	15,091	54%
WAC FE	9	2,982	463	16%	2,239	75%
Grand Totals:	**1,806**	**153,636**	**43,160**	**28%**	**91,536**	**60%**

-Numbers for acres and percents are rounded.
-Survey acres are used to calculate project acres for closed properties. SWC (Surface Water Criteria) acres are based on GIS and tax parcel acres and may not be as accurate.
-Pursuant to the 1997 Memorandum of Agreement, SWC includes acreage that is within (a) 300 feet of a watercourse, (b) 1,000 feet of reservoirs, (c) areas designated as 1% return interval flood (100 year base flood), and/or (d) wetlands (defined as federal jurisdiction wetlands larger than five acres, or designated by NYSDEC).
-Slope: Acres that are at or greater than 15% grade.
In some cases SWC acres may appear to be greater than project acres; this is because SWC acres are GIS-based and project acres are survey-based. Therefore, they do not always align.

Appendix A Table 4 Closed purchase contracts with costs.

Reporting Period: 1995 to 2020

R.E. Type	# of Contracts	Acres	Avg. Size of	Purchase Price
City CE	170	25,934	153	$72,229,274
City FBO	17	40	2	$2,478,600
City Fee	1,345	95,035	71	$363,906,470
FEMA	64	75	1	$453,575
SAP	21	172	8	$1,211,271
WAC CE	156	27,886	179	$41,204,532
WAC FE	9	2,982	331	$2,891,334
	1,782	**152,125**	**85**	**$484,375,056**

Reporting Period: 2021

City FBO	5	7	1	$1,031,469
City Fee	14	1,136	81	$3,831,832
SAP	4	26	6	$172,178
WAC CE	1	343	343	$335,349
	24	**1,512**	**63**	**$5,370,829**

Program-to-date Sub-Totals

City CE	170	25,934	153	$72,229,278
City FBO	22	47	2	$3,510,069
City Fee	1,359	96,171	71	$367,738,329
FEMA	64	75	1	$453,575
SAP	25	198	8	$1,383,449
WAC CE	157	28,229	180	$41,539,891
WAC FE	9	2,982	331	$2,891,335
Grand Totals:	**1,806**	**153,636**	**85**	**$489,745,885**

Numbers for acres and dollar values are rounded.

Appendix A Table 5 Summary of executed purchase contracts by Priority Area.

Priority Area	1997 - 2020 Contracts	1997 - 2020 Acres	1997 - 2020 Price ($millions)	2021 Contracts	2021 Acres	2021 Price ($millions)	Program-to-Date Totals Contract	Program-to-Date Totals Acres	Program-to-Date Totals Price ($millions)
1A	133	5,145	$34.4	1	6	$0.0	134	5,151	$34.4
1B	338	18,750	$135.3	0	0	$0.0	338	18,750	$135.3
2	202	11,742	$37.7	1	4	$0.1	203	11,745	$37.8
3	425	42,898	$95.3	6	248	$1.8	431	43,146	$97.1
4	714	75,823	$189.1	3	197	$0.4	717	76,020	$189.5
Grand Totals:	**1,812**	**154,358**	**$491.9**	**11**	**454**	**$2.4**	**1,823**	**154,812**	**$494.2**

Note: Acreage and dollar grand totals in red are arrived at by summing the whole number (after rounding) value for the subtotals by Priority Area above.

Appendix A Table 6 Summary of purchase contracts signed under the NYC-Funded Flood Buyout Program.

	ID	Municipality	Expected Owner	Acres	Status
Delaware					
	9316	Fleischmanns (Village)	City	0.2	Acquired by NYC
		County Subtotal	**1**	**0.2**	
Greene					
	9243	Hunter (Town)	City	1.2	Acquired by NYC
	9586	Hunter (Village)	Village	0.1	Acquired by Municipality
	8847	Hunter (Town)	City	21.5	Acquired by NYC
	8883	Jewett (Town)	City	4.8	Acquired by NYC
	8934	Tannersville (Village)	Village	0.5	Acquired by Municipality
	9487	Tannersville (Village)	Village	0.5	Acquired by Municipality
	9486	Tannersville (Village)	Village	0.5	Acquired by Municipality
	9573	Windham (Town)	Town	0.3	Acquired by Municipality
		County Subtotal	**8**	**29.4**	
Schoharie					
	8963	Conesville (Town)	Town	0.6	Acquired by Municipality
	9306	Conesville (Town)	City	2.8	Acquired by NYC
	8884	Conesville (Town)	City	0.6	Acquired by NYC
		County Subtotal	**3**	**4.0**	
Ulster					
	9315	Olive (Town)	Town	0.3	Acquired by Municipality
	9311	Olive (Town)	Town	1.6	Acquired by Municipality
	9309	Olive (Town)	Town	1.3	Acquired by Municipality
	9381	Olive (Town)	City	0.9	Acquired by NYC
	9374	Olive (Town)	City	1.2	Acquired by NYC
	9665	Shandaken (Town)	City	3.4	Contract Executed
	9419	Shandaken (Town)	City	1.2	Acquired by NYC
	9408	Shandaken (Town)	Town	0.5	Acquired by Municipality
	9406	Shandaken (Town)	Town	0.5	Acquired by Municipality
	9393	Shandaken (Town)	City	1.6	Acquired by NYC
	4988	Shandaken (Town)	City	4.4	Acquired by NYC
		County Subtotal	**11**	**16.9**	
		Grand Total	**23**	**50.5**	

Acreage figures are rounded.