*NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION*
*BUREAU OF WATER SUPPLY*

# Annual Report for the Kensico Water Quality Control Program

This report discusses the status of the components the Kensico Water Quality Control Program and the results of water quality monitoring in the Kensico Reservoir and its watershed between January 1 and December 31, 2007.

**January 2008**

*Prepared in accordance with New York City's December 2006 Long-term Watershed Protection Program and Section 4.1.0 Kensico Water Quality Control Program of the New York City Filtration Avoidance Determination, July 2007*

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**Bureau of Water Supply**

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# 1. Introduction to Kensico Watershed Programs

Kensico Reservoir, located in Westchester County, is the terminal reservoir for the City's Catskill/Delaware water supply system. Because it provides the last impoundment of Catskill/Delaware water prior to entering the City's distribution system, DEP has prioritized watershed protection in the Kensico basin to ensure the continued success of past efforts while providing for new source water protection initiatives that are specifically targeted toward stormwater and wastewater pollution sources.

## 1.1 Stormwater Management and Erosion Abatement Facilities

### 1.1.1 BMP Construction, Operation, and Maintenance

DEP constructed 45 stormwater management and erosion abatement facilities throughout the watershed in order to reduce pollutant loads conveyed to the reservoir by stormwater. The facilities, shown in Figure 1.1, were routinely inspected and maintained as needed throughout the year. Maintenance was completed in accordance with the Operation and Maintenance Guidelines (NYCDEP 2000a, revised 2003), which require regular inspections. Table 1.1 shows inspection requirements and typical maintenance needs.

Table 1.1. Inspection checklist for extended detention basins.

| Inspection Guidelines | Minimum Inspection Frequency | Maintenance Guidelines |
|---|---|---|
| Access routes, basin structures, including riprap stabilized outlet, emergency spillway, headwalls, riser boxes, embankments, weirs, handrails and trash racks for cracks, seepage, and settling of embankment. | Four times a year and after heavy storm events for erosion, structural damage, debris accumulation, and vegetative growth. | Report access obstructions, damage to access route, damaged structures, and erosion to Project Manager and repair as advised. Remove debris, clogs, and vegetative growth promptly. Replace or remove debris and sediment accumulation from riprap when clogging becomes apparent. Replace filter fabric when riprap is replaced. Maintain clear access to manholes, gate valves, and catch basins. |
| Inlet/outlets, basins, and maintenance access roads for debris and trash accumulation, obstructions, and clogging. | Monthly and after heavy rain or snowmelt for clogging. | Remove debris, trash, and obstructions promptly using hand tools if tools are needed. |

Table 1.1. (continued) Inspection checklist for extended detention basins.

| Inspection Guidelines | Minimum Inspection Frequency | Maintenance Guidelines |
|---|---|---|
| Vegetation - health of planted vegetation (wetland, embankment, coconut rolls, and seeded areas), erosion of planted areas. | Monthly during growing season. Quarterly during non-growing season. | Replace dead and dying wetland and planted vegetation, repair erosion, and prevent future erosion and reseed and mulch bare areas. Maintain/mow/prune embankment vegetation and remove tree growth from embankment bi-annually. Do not mow wetland vegetation. |
| Nuisances: odors, burrowing pests | Monthly | Identify source and remove nuisance. Report nuisances to Project Manager and address as advised. |
| Gate Valve | Yearly | Check integrity of the valve by fully opening and closing the valve to ensure it is functioning properly. |
| Dams for structural integrity (seepage, settling, and erosion). | Annually | Report damage to Project Manager and repair structures as advised. |
| Sediment depth in forebay and detention basin. Measure sediment depth with marked measuring stick. Once a year, drain pond to measure sediment depth. | Once a year and after significant storms. | Remove sediment from forebay every 5 years and from main basin every 15 years or when depth >50% of the basin depth. If basin does not contain a forebay, remove sediment at least every 15 years. A backhoe will be required to clean out the sediment. Dispose of the removed material in accordance with federal, state, and local regulations. |

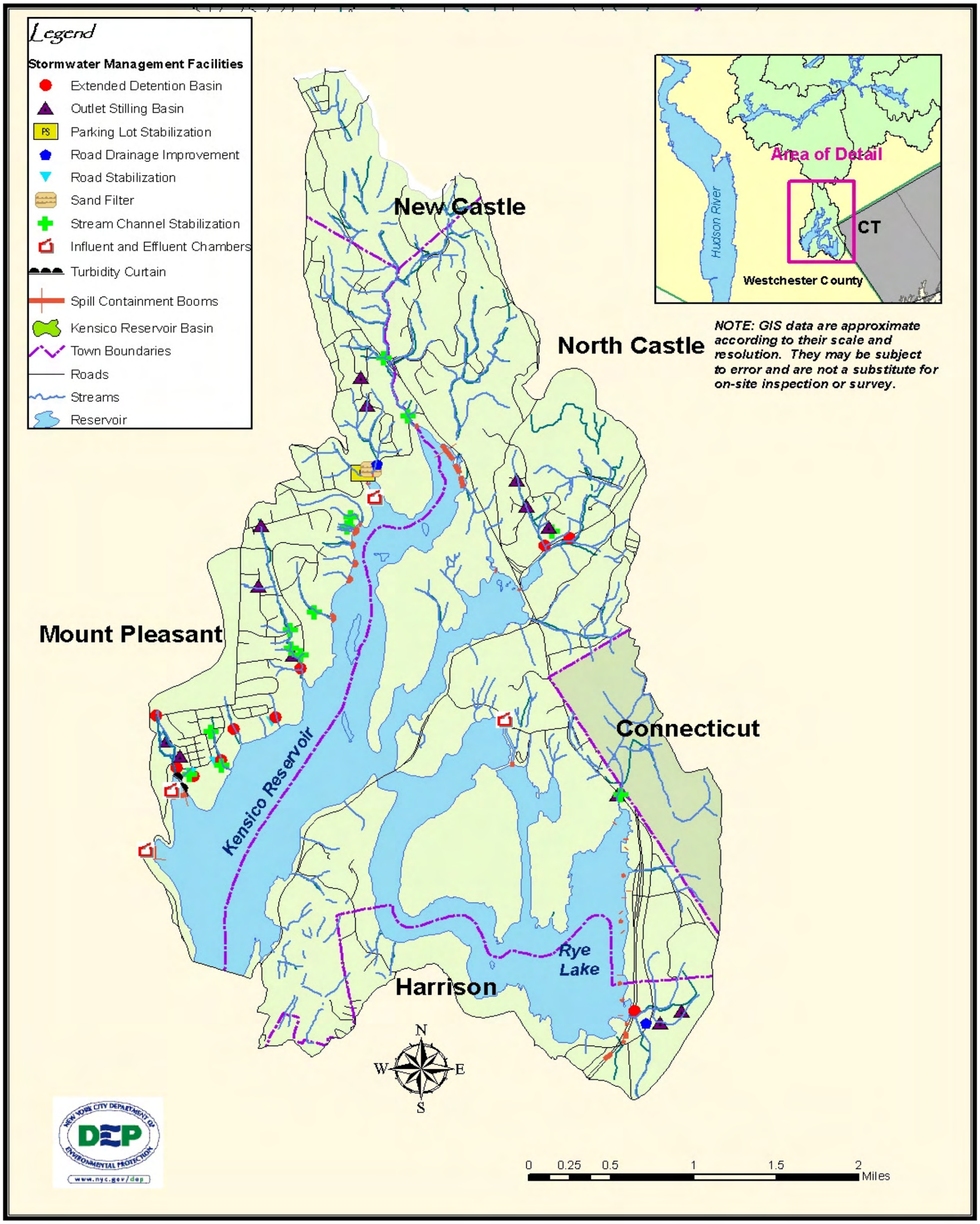


Figure 1.1 Location of stormwater management facilities in the Kensico Reservoir watershed.

Table 1.2. Kensico stormwater and erosion abatement facility construction and completion schedules and maintenance activities.

| Basin | Facility Number and Type | Construction Dates | 2007 Maintenance Activities |
|---|---|---|---|
| Malcolm Brook | 2, extended detention basin | 6/17/00<br>11/21/00 | Weed whacked, debris removal, remove fallen tree |
| | 4, stilling basin | 8/31/99<br>9/13/99 | |
| | 8, drop pipe, velocity dissipation box, outlet stabilization | 6/14/99<br>8/20/99 | Sediment removal (3CY) |
| | 12, extended detention basin | 4/12/99<br>11/5/99 | Weed whacked<br>Debris removal –upstream and down-stream sides<br>Removed 1 clog and 5 CY of debris from forebay riser box – clear trash rack |
| Young Brook | 13, extended detention basin | 3/29/99<br>11/5/99 | Sediment removal (1CY), weed whacked, remove invasive plant (purple loosestrife) |
| Young Brook | 14, 15<br>Road, outlet and channel stabilization | 3/29/99<br>11/5/99 | |
| N2 | 16, outlet stabilization | 10/27/99<br>10/27/99 | |
| N2 | 18, 19, 20, extended detention basin, and road, outlet, and channel stabilization | 9/28/99<br>9/14/00 | Weed whacked, partial washout of road (added 6CY of item 4), debris removal, sediment removal forebay (75CY) |
| N3 | 2A, extended detention basin | 10/12/99<br>9/14/00 | Weed whacked , remove fallen tree |
| N4 | 23, 24, extended detention basin and road stabilization | 12/22/99<br>9/14/00 | Weed whacked, debris removal |

Table 1.2. (continued) Kensico stormwater and erosion abatement facility construction and completion schedules and maintenance activities.

| Basin | Facility Number and Type | Construction Dates | 2007 Maintenance Activities |
|---|---|---|---|
| N5 | 37, 39, and 40, extended detention basin, road stabilization and channel stabilization | 3/27/00<br>9/14/00 | Weed whacked<br>BMP 40 sediment removal (6CY), (34CY)<br>BMP 37 – Debris removal multiple times, remove 2 fallen trees, repair washout on east side of basin, sediment removal from forebay above north weir (48CY) |
| N5 | 5A, drop pipe, manhole and stabilized outlet | 3/27/00<br>4/25/00 | |
| N5 | 35, outlet stabilization | 5/24/00<br>5/25/00 | |
| N5 | 34, stream channel stabilization | 5/23/00<br>5/23/00 | |
| N5 | 31, stream channel stabilization | 10/25/99<br>11/22/99 | |
| N5 tributary | 28, outlet and stream channel stabilization | 10/25/99<br>10/25/99 | Weed whacked, sediment removal (16 CY) (see Figure 1.2), reposition riprap |
| N5 | 25, outlet stabilization | 10/25/99<br>11/12/99 | |
| N6 | 41, stream channel stabilization | 12/8/99<br>12/28/99 | |
| Bear Gutter | 63, outlet stabilization | 4/5/00<br>4/5/00 | |
| Bear Gutter | 64, outlet stabilization | 5/26/00<br>5/26/00 | |
| Bear Gutter | 65, outlet stabilization | 5/27/00<br>5/27/00 | |
| Bear Gutter | 66, extended detention basin | 4/24/00<br>9/14/00 | Weed whacked, remove fallen tree |
| Bear Gutter | 67, extended detention basin | 6/7/00<br>11/8/00 | Weed whacked, replace 2 dead trees |

Table 1.2. (continued) Kensico stormwater and erosion abatement facility construction and completion schedules and maintenance activities.

| Basin | Facility Number and Type | Construction Dates | 2007 Maintenance Activities |
|---|---|---|---|
| Bear Gutter | 8A, stream channel stabilization | 4/18/00<br>4/20/00 | |
| N8 | 43, stream channel stabilization | 12/3/99<br>4/3/99 | This site will be done under the Kensico Action Plan |
| N9 | 44, stream channel stabilization | 4/18/00<br>4/18/00 | |
| N12 | 7A, outlet stabilization | 11/16/99<br>11/17/99 | Sediment removal (1 CY) |
| N12 | 47, outlet stabilization | 11/17/99<br>11/18/99 | Sediment removal (4CY)<br>Added 20 SY of riprap |
| N12 | 57, sand filter<br>58, road drainage improvements<br>59, parking area stabilization | 1/11/00<br>12/15/00 (57)<br>8/2002 (58 & 59) | Weed whacked, debris removal, sediment removal from catch basins that discharge into BMP 57 (5CY), BMP 59 – debris removal |
| Whip | 60, stream channel stabilization | 12/1/99<br>12/3/99 | |
| Whip | 61, stream channel stabilization | 11/29/99<br>12/3/99 | |
| E9 | 68 | 4/10/00<br>4/10/00 | Sediment removal (4CY), debris removal<br>Added 20 SY riprap |
| E9 | 68A | 5/1/04<br>11/28/04 | |
| E11 | 70, outlet stabilization | 4/6/00<br>4/7/00 | |
| E11 | 71, outlet stabilization | 4/7/00<br>4/7/00 | |
| E11 | 74, 75 | 11/6/00<br>11/28/04 | Weed whacked<br>Remove 3 fallen trees |
| Turbidity curtain | | | Damaged sections (around exposed floats and replace missing floats, re-stitch sections together and secure steel anchor cables) were repaired by DEP operations staff |

Figure 1.2 BMP 28. Photo after removal of accumulated sediment.

### 1.1.2 Spill Containment Facilities

DEP installed, and now maintains, spill containment facilities around Kensico Reservoir (see Figure 1.3). The facilities improve spill response, clean up, and recovery, thereby minimizing water quality impacts in the event of a spill.

In 2007, DEP continued to maintain the 39 spill containment facilities installed at the outlets of 26 storm drains along Interstate 684 and Route 120 (see Figure 1.4). Two storage buildings to house emergency response equipment were previously installed at Shaft 18 and Shaft 17. A third building has been installed at the Catskill Influent Chamber.

Although no spills have been reported on Interstate 684 or the roads surrounding Kensico since the booms were installed, the booms have functioned as designed. Temporary booms were located at the end of the boat ramp that can encircle the ramp in the event of a spill. No spills or discharges occurred, nor was boom deployment required.

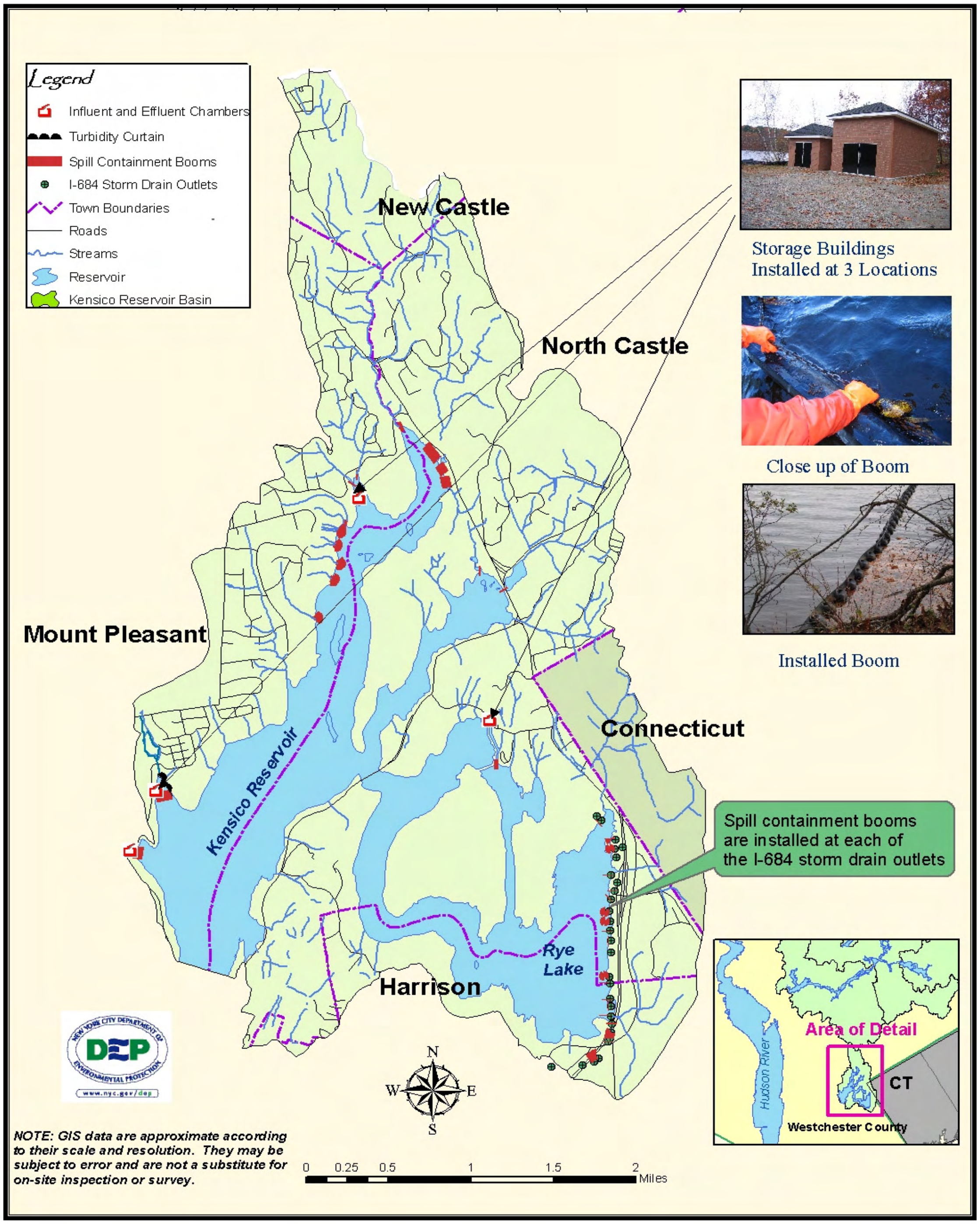


Figure 1.3 Spill containment facilities in Kensico Reservoir.

Figure 1.4 Kensico spill boom – Site 11.

### 1.1.3 Turbidity Curtain

Since its installation in 1995, the 800-foot-long turbidity curtain installed in the reservoir between the Catskill Upper Effluent Chamber and Malcolm and Young Brooks has effectively deflected discharges from the two watercourses away from the effluent chamber. Figure 1.5 shows the location of the turbidity curtain and its flow deflection function.

In 2007, DEP monitored the extended turbidity curtain, and performed the following maintenance tasks:

<u>June 29, 2007</u> – A contractor dive team inspected the turbidity curtain and supports which include all hardware and anchoring points. The dive team identified items on the curtain that required maintenance.

<u>July 24, 2007</u> – Based on the items identified during the dive team inspection, divers added two new anchors, connected the bottom of the curtain to existing blocks, and replaced both sides of the curtain wires.

<u>July 25, 2007</u> – Gaps between some of the curtains have been connected. All wires were replaced with stainless steel wire and crosby clamps.

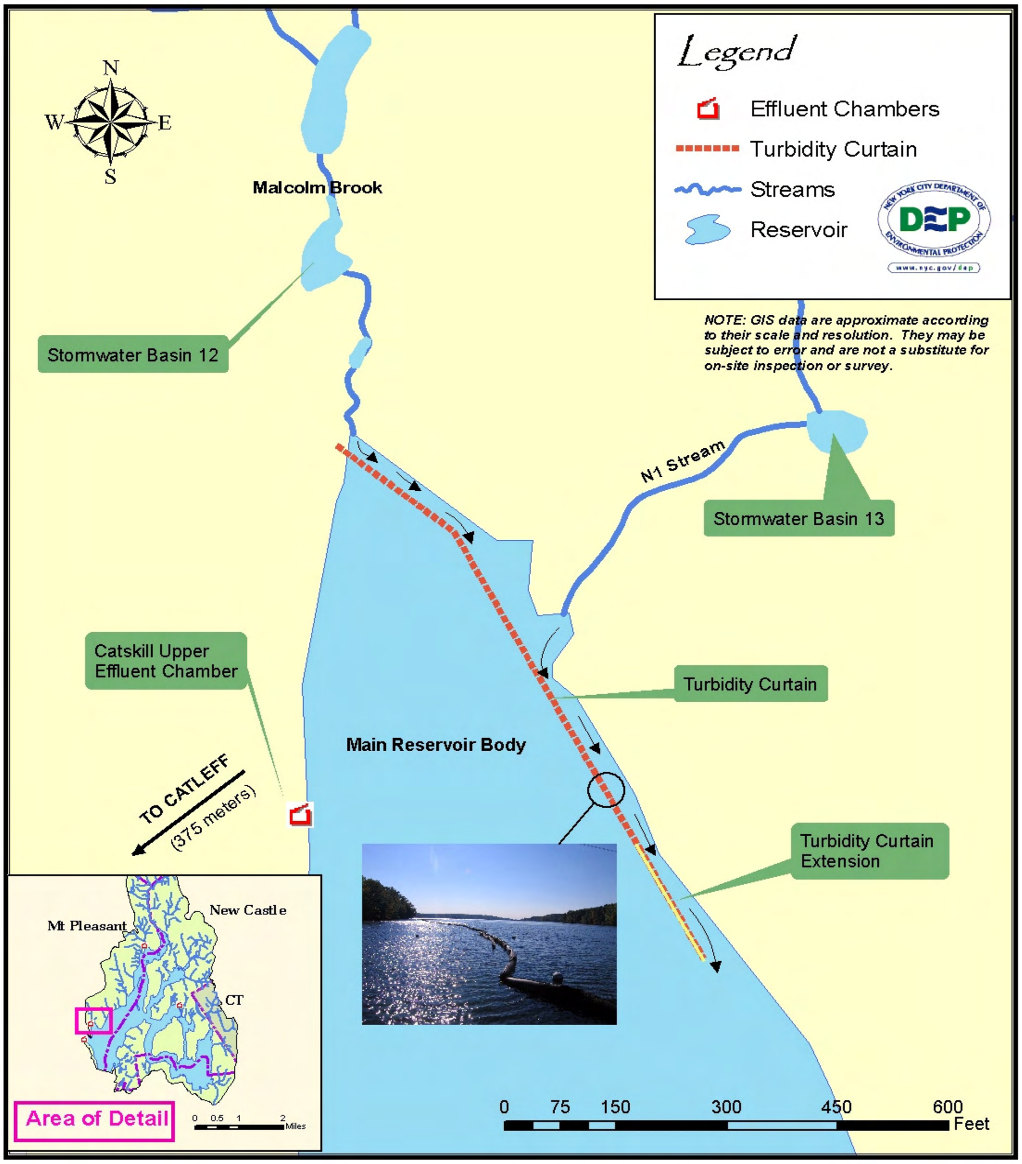


Figure 1.5 Turbidity curtain in Kensico Reservoir.

### 1.1.4 Computer Assisted Facilities Management

A Computer Assisted Facilities Management (CAFM) application has been developed for DEP staff to use to ensure the facilities are inspected and maintained properly. The database and application design have been modified to refine the scheduling and management of inspection, maintenance, construction, and repair activities and the reporting related to those activities. The CAFM application has been delivered in SQL form and is now utilized to track inspection and maintenance of the facilities.

### 1.1.5 BMP Monitoring

Monitoring to assess the pollutant removal rates of the detention basins and sand filter continued in 2007 in accordance with the Monitoring Plan for the Kensico Basins (NYCDEP 2000b, revised 2004). Six events were sampled at BMP Facility 74. This was in addition to the 3 events at this facility that were sampled in 2006. See Section 4.6 for a summary of the monitoring effort. The 2007 monitoring effort concludes the FAD sampling requirement of the Kensico BMPs. As per the 2007 FAD, a more detailed report of the findings will be presented in the 2009 Kensico Programs Annual Report.

To date, monitoring has shown that the detention basins function as designed, to reduce the loads of turbidity and fecal coliform bacteria. Monitoring data in combination with the maintenance program's volume of accumulated sediment removed from each basin confirm that the basins reduce loads of suspended solids conveyed to the reservoir. Similarly, measured accumulations removed from outlet stilling basins confirm that sediment is detained. Inspectors confirm the stability of repaired outlets and streambanks, further ensuring repaired areas do not return to their eroded state and become a source of stormwater borne sediment.

## 1.2 Kensico Action Plan

### 1.2.1 Kensico Action Plan Summary

In early 2006, DEP initiated the development of the Kensico Action Plan in an effort to build on the successful watershed management and protection strategies within the Kensico basin. In March 2006, DEP retained HDR|LMS Engineering Inc. to complete the Kensico Action Plan. DEP submitted the final Kensico Action Plan in August 2007.

Key components of the Kensico Action Plan included the following:

1. Completed a user-friendly library of data and background material on the development of the Kensico Reservoir BMPs.
2. Delineated and re-mapped the Kensico watershed using the most recently available photogrammetric base maps.
3. Modeled the Kensico catchments, using the most recent GIS coverages and subbasin mapping. This modeling exercise estimated the relative volumes, rates, and quality of stormwater discharging from the various Kensico watershed subbasins.
4. Completed a review of the results of the sanitary sewer mapping and video infrastructure inspection program.
5. Prepared four stormwater remediation plans.
6. Completed three water quality risk assessments.
7. Assessed the sediment accumulations in the approach channels to Shaft 18 and CATUEC.

The four stormwater remediation plans consisted of the following proposals:

1. Drainage improvements in the N-1 catchment. Observations during high flows indicated that overland flow that was expected to flow into BMP 13 bypassed this structure and instead discharged into BMP 12. As a result, more runoff than was expected reached BMP 12, causing it to be less effective, and minimal runoff was received by BMP 13, reducing its treatment benefit. The construction of catch basins to intercept this flow and redirect it to BMP 13 is proposed to enhance the performance of both basins.
2. Pipeline System for N7 Sub-basin. A riprap-lined channel in the N7 catchment area receives flow from upgradient impervious surfaces and is not properly stabilized. Stream velocities, compounded by the steepness of the slope, have contributed to the erosion of this channel. The proposed project is to pipe portions of this channel in order to reduce erosive velocities, restabilize the area above the pipe, and install centrifugal sediment traps at the base of the slope.
3. Extended Detention Basin for the N12 Sub-basin. The construction of an extended detention basin on this catchment is proposed for the treatment of stormwater runoff. This extended detention basin will be constructed off-line, allowing baseflows from the stream to by-pass the structure. Only stormwater runoff will be treated by this design.
4. Whippoorwill Stream Stabilization. Several areas of the Whippoorwill stream corridor were identified where streambank erosion contributed to the sediment load to Kensico Reservoir. Several tools are proposed to re-direct streamflow away from these banks, forcing the stream energy to the center of the stream. This design is expected to reduce the sediment load to Kensico Reservoir without the construction of a large-scale basin.

The three water quality risk assessments consisted of the following areas:

1. Westchester County Airport. This review assessed the water quality risks to the reservoir associated with the operation of the Westchester County Airport. The report found that the airport had previously re-plumbed stormwater from airport surfaces so that it would be discharged outside of the Kensico Reservoir watershed. In addition, fuel and de-icing storage facilities are located outside of the Kensico watershed. The report found that the airport’s compliance programs are adequate to ensure that releases of petroleum and hazardous materials from the airport will be addressed properly.
2. Swiss Re Corporate Park. Swiss Re is one of the largest commercial office parks within the Kensico Reservoir watershed. A review of the Swiss Re property found no chemical transport from the property to Kensico Reservoir. In fact, several environmental initiatives have been implemented by the facility, including the elimination of “non-green” cleaning agents, non-organic fertilizers, and all herbicides.
3. Turf Management Chemicals in the N5 Subbasin. Previous DEP water quality data found that the N5 subbasin had detectable levels of common herbicides in runoff. A risk assessment was conducted to determine the source and risk associated with these chemicals. The assessment included the development and implementation of a survey to homeowners and landscapers in the area. Data from this survey were used to quantify chemical treat-

ment within this watershed. These data were then applied to a model to evaluate potential herbicide loading and its impact on water quality within Kensico Reservoir. The modeling work found that less than 0.1% of the applied herbicides are transported to Kensico Reservoir, and the observed concentrations are well below federal water quality criteria.

The Kensico Action Plan also included a summary of the work performed to date, in order to evaluate the potential need for further effluent chamber dredging since sediment was removed from the intake channels at the Catskill Upper Effluent Chamber (CATUEC) and Shaft 18 in May 1999. Based on the results of the sub-bottom profiling, DEP determined there is no need to dredge the channel into Shaft 18 or CATUEC.

DEP is undertaking several projects aimed at further reducing sediment loading within the cove near CATUEC. These include improvements to BMPs 12 and 13 that discharge to the cove, a back-up turbidity curtain, and implementation of projects to reduce turbidity during storm events. DEP will assess the need for further exploration of the channel near CATUEC following the implementation of these projects.

### 1.2.2 Kensico Action Plan Implementation

Following submittal of the Kensico Action Plan in August 2007, DEP evaluated the four proposed pollution remediation practices: 1) a pipeline system and engineering stormwater practice at N7, 2) an extended detention basin at N12, 3) stream stabilization at Whippoorwill, and 4) drainage improvements along West Lake Drive in order to enhance the performance of BMPs 12 and 13. Based on the evaluation of the projects, DEP determined, in December 2007, to move forward with the implementation of all four of the projects and provided an implementation schedule.

In 2007, DEP initiated the work to prepare the necessary bid specifications and to secure a design contractor during the construction phase. Completed project specifications are expected to be submitted by the design consultant, HDR|LMS, in the first half of 2008. Once approved by DEP, the contract documents will be submitted for legal review and advertisement.

## 1.3 West Lake Sewer

The West Lake Sewer Trunk Line, owned and maintained by the Westchester County Department of Environmental Facilities (WCDEF), is 21,864 linear feet of gravity sewer line with 124 manholes located within the Kensico Reservoir basin. The trunk line conveys untreated wastewater to treatment facilities located elsewhere in the county. Given the proximity of the collection system to Kensico Reservoir, potential defects or abnormal conditions within the sewer line and its components could lead to exfiltration or overflows of wastewater. The intent of this program is to work with the County to mitigate risks posed by the line while maintaining the collection system’s location and gravity flow.

### 1.3.1 Sanitary Sewer Remote Monitoring System

DEP has proposed a sanitary sewer remote monitoring system for the West Lake sewer in an effort to track the status of the sewer line and improve the response time in the event an overflow occurrence were to take place. During the reporting period, DEP initiated a discussion with WCDEF. The nature of the discussion was to outline DEP's approach in establishing a contract for the installation of a remote water level monitoring system at key locations on the West Lake Sewer Trunk Line. The WCDEF Director of Maintenance acknowledged the effectiveness of the video inspection and maintenance work already being done on the West Lake Sewer Trunk Line under the DEC Order on Consent. The Director further understood the potential benefit of reviewing the feasibility and implementation of a remote water level monitoring system to reduce the potential of sewage discharge. However, further discussions with the County and additional aspects of the proposal will need to be addressed in 2008. Some issues that will need to be explored are coordinating a mutually acceptable scope of work in order to identify the key monitoring nodes, components and hardware, contract administration, monitoring and response planning, and operation and maintenance costs. DEP anticipates further discussions with WCDEF in the first half of 2008 to discuss the future actions by both parties.

### 1.3.2 Sewer Line Visual Inspection

DEP conducts an annual visual inspection of the trunk line in order to assess the condition of exposed infrastructure, including manholes, for irregularities. The annual full inspection was performed in December 2007. Partial inspections were conducted throughout the year in association with ongoing routine maintenance of Kensico stormwater best management practices in the vicinity of the line. No defects or abnormalities were noted.

## 1.4 Video Inspection of Sanitary Sewers

Select portions of the sanitary sewer system were digitally mapped and video inspected in the Kensico Reservoir watershed. The purpose of the inspection was to evaluate the sewer system and identify defects that may result in exfiltration with the potential to contribute pollutants to the drinking water supply. The project's scope of work included videotaped inspection and digital mapping of segments of previously uninspected sewer lines located within the Kensico watershed. Any pump station failures and defects with the potential to contribute pollutants to the drinking water supply were also located and reported.

Collection of digital map data was essential for collection system assessment and maintenance. The data, collected and stored in DEP's GIS library for multiple user access, included:

- the location, size, age, and material composition of all sewer lines, manholes, pump stations, and any other sewer system components (appurtenances);
- the location of defects that result in exfiltration of wastewater;
- the location of pump station failures and other defects with the potential to contribute pollutants to the drinking water supply; and

- the location of any illicit wastewater connections found during the inspection program.

DEP's contract to video inspect, digitally map, and clean certain sections of the sanitary sewer infrastructure in the Kensico Reservoir watershed was intended to supplement DEP's previous effort under which some 50,000 linear feet of sewer were mapped and inspected. The contract to digitally map and inspect the entire remaining sanitary infrastructure in the Kensico watershed, estimated to be some 40,000 feet, was completed in 2006. The contract reports, completed by Tectonic Engineering Consultant, P.C., were submitted to HDR|LMS as part of the Kensico Action Plan to protect the Kensico basin from point source and non-point source pollutants. Upon review of the inspection reports, HDR|LMS identified several possible areas of concern within the Town of Harrison that required further investigation and remediation. These areas of concern, listed in an evaluation memorandum prepared by HDR|LMS, were submitted to DEP in August 2007. DEP forwarded to the Town of Harrison Engineering Department the aforementioned evaluation memo along with copies of the pipe segment inspection reports and manhole reports for the areas indicated within the evaluation memo. DEP and the Town of Harrison will continue to coordinate any remediation of these conditions to prevent any possible contamination to the drinking water supply.

## 1.5 Septic Repair Program

In 2007, DEP began development of the Kensico Septic System Rehabilitation Reimbursement Program. The program will provide funding to reimburse a portion of the costs to repair, update, or 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 have their septic systems inspected, and if failing, rehabilitated. DEP intends to roll out the program in three priority phases, with those properties located closest to Kensico Reservoir and watercourses given higher priority (see Figure1.6).

During the reporting period, DEP drafted program rules and submitted them for review and approval. DEP is also in the process of merging data from a 2002 house-to-house septic survey with updated tax ID data for property owners, in order to develop a database of properties for inclusion in the program.

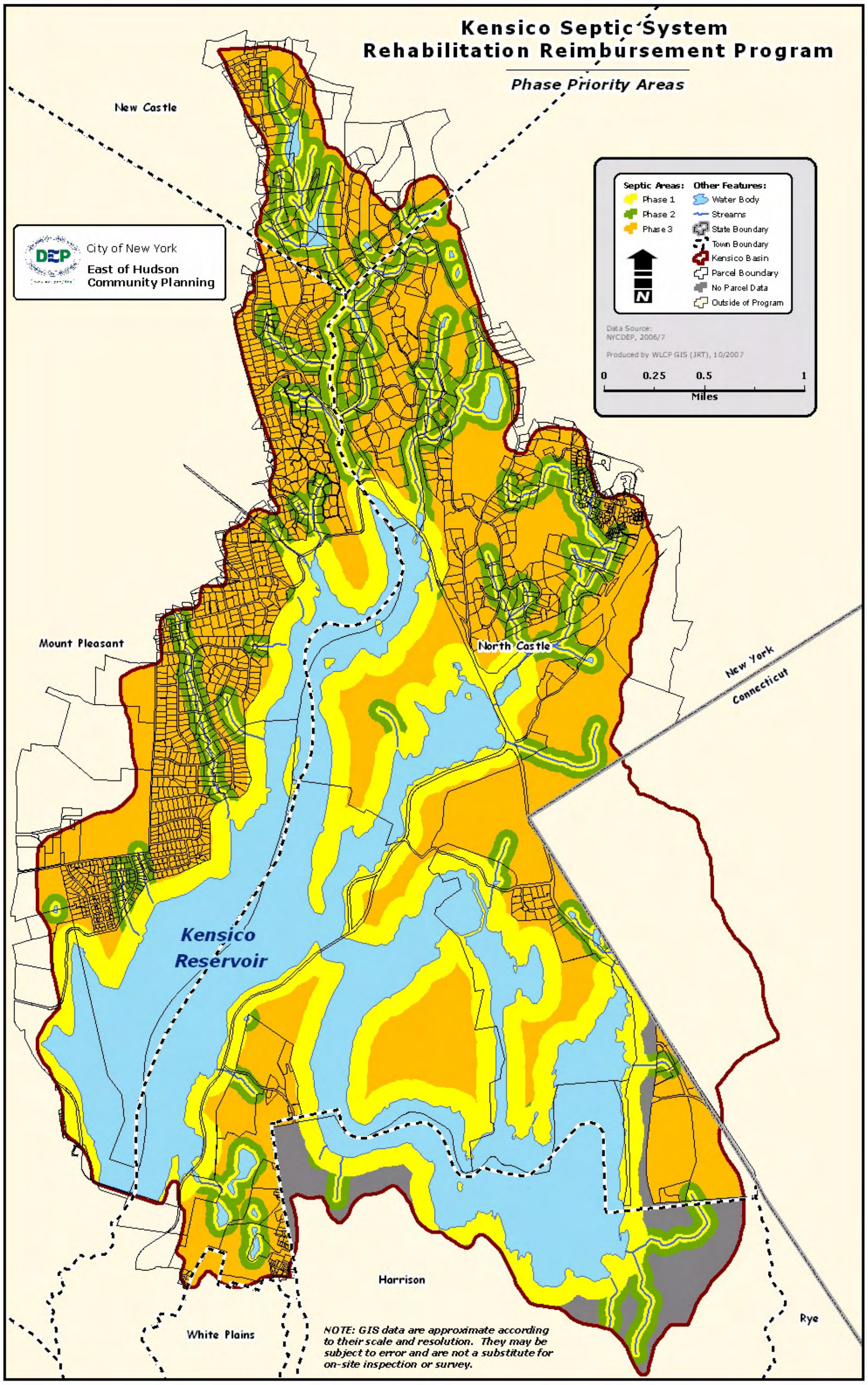


Figure 1.6 Kensico Reservoir Septic Program priority areas.

## 1.6 Turbidity Reduction

The Catskill Upper Effluent Chamber (CATUEC) is situated along the shore of a cove in the southwest section of Kensico Reservoir. The shoreline of this cove trends north to south, so that CATUEC faces east into the cove. The cove then extends south and east into the main basin of the reservoir. Water from Kensico Reservoir enters CATUEC and is transported to the Catskill Lower Effluent Chamber (CATLEC) where the Kensico Reservoir's Catskill Lower Effluent Chamber (CATLEFF) monitoring site is located. To investigate whether wind speed and direction may have an effect on turbidity at CATLEFF, DEP reviewed eight years of data in order to conduct a turbidity assessment. In August 2007, DEP submitted the report *Review of Turbidity, Wind Speed and Direction Data Collected at or near the Catskill Lower Effluent Chamber, Kensico Reservoir* (NYCDEP 2007a).

The report found that winds near CATUEC typically originate from a westerly direction, so that in general winds are blowing away from this shoreline, and surface water is pushed away from CATUEC. Winds in this area are also typically less than 1.0 m/s in strength. Occasionally, weather conditions near Kensico Reservoir change such that the wind will originate from an easterly direction, pushing directly onto the shoreline adjacent to CATUEC. When wind velocities are sufficient to create wave action or have a seiche effect on the shoreline in the cove near CATUEC, sediment in this area may become resuspended and entrained into the Kensico Reservoir effluent that enters CATUEC, resulting in a short-term rise in turbidity values measured at CATLEFF. The report also found that bottom sediments within the cove are too deep to be impacted by this wind induced wave action.

While DEP will continue to assess the turbidity issues at CATUEC, DEP has also determined that a shoreline stabilization project south of the chamber should be implemented to mitigate the erosion and possible resuspension of near-shore materials that may contribute to turbidity at CATUEC during wind events. Design of the shoreline stabilization project has been assigned to Malcolm Pirnie and Gannett Fleming. It is anticipated that design work will commence in the first half of 2008.

## 1.7 Route 120

In 2006, DEP met with the NYSDOT Route 120 Advisory Committee for the Route 120 and I-684 improvement projects. During the 2007 reporting period, NYSDOT submitted to DEP the proposal for resurfacing I-684 and constructing stormwater treatment basins in the I-684 median from just south of the new Lake Street overpass in New York northward to the bridge over Tamarack Swamp in Connecticut. This plan includes resurfacing of all the ramps for Exit 2 of I-684. It is anticipated that this project, which is a portion of the overall corridor project known as Routes 120 and 22/Exits 2 and 3 on I-684/Old Post Road, will begin in the fall of 2008.

## 1.8 Westchester County Airport

The Westchester County Airport is located east of Kensico Reservoir in close proximity to Rye Lake. As such, DEP continues to review any activities that are being proposed at the airport.

Two projects appeared in the SEQRA review venue during 2007. At this time, DEP has not identified serious concerns with the proposals. The activities include the following:

- The relocation of the north perimeter road away from the northern end of Runway 16-34, and the removal of a portion of the existing north perimeter road. The north perimeter road will be relocated approximately 450 feet further north to increase safety at the north end of the runway, pursuant to FAA runway safety requirements. DEP issued a comment letter on the Lead Agency Notification for this proposal in April 2007.
- Proposed improvements to the existing terminal area aircraft deicing system and related improvements. This proposal was initially part of a larger overall Airport Layout Plan modification, now being considered a separate project as requested by the Westchester County Planning Department. DEP issued a comment letter on the Lead Agency Notification for this proposal in August 2007.

# 2. Introduction to Kensico Streams and Reservoir Monitoring Data

The 2007 Filtration Avoidance Determination (Section 4.10, Kensico Water Quality Control Program) calls for semi-annual reporting on the implementation of Kensico protection programs. On an annual basis, the report must also include presentation, discussion, and analysis of water quality monitoring data (e.g., data relating to keypoints, reservoirs, streams, BMPs) as well as the status and application of the Kensico Reservoir model. This additional water quality monitoring information is contained in Part II of this report (Chapters 2-7), which also provides an overview of the results of work carried out in and around Kensico Reservoir for the calendar year 2007.

The Kensico Water Quality Control Program is designed to reduce fecal coliform, toxic chemicals, and turbidity in Kensico Reservoir; therefore, this report emphasizes these analytes, and in addition contains sections on the protozoan pathogens *Cryptosporidium* and *Giardia*, and on human enteric viruses. Because of the importance of complying with the Safe Drinking Water Act's Surface Water Treatment Rule, adherence to the Rule's fecal coliform and turbidity requirements is also addressed.

For the purposes of continuity, the format of this report is very similar to previous Kensico reports delivered to EPA. It should also be noted that much of the data reported are still classed as "provisional", i.e., routine data review has not yet been completed.

When operated in its normal, "on-reservoir" mode, water enters Kensico Reservoir at the Catskill Influent Chamber (CATIC) and at Delaware Shaft 17 (DEL17), and leaves the Reservoir at the Catskill Upper Effluent Chamber (CATUEC) and Delaware Shaft 18 (DEL18) (Figure 2.1). Water can also be diverted through bypass tunnels for water quality or maintenance purposes. In 2007, normal operations were interrupted only once because of water quality issues. On April 15-16, during a period of elevated turbidity due to unusually heavy precipitation, the Catskill Aqueduct was shut down for several hours, preventing the turbid water from being sent to distribution.

During the reporting year, the surface elevation of the Reservoir remained within its normal range.

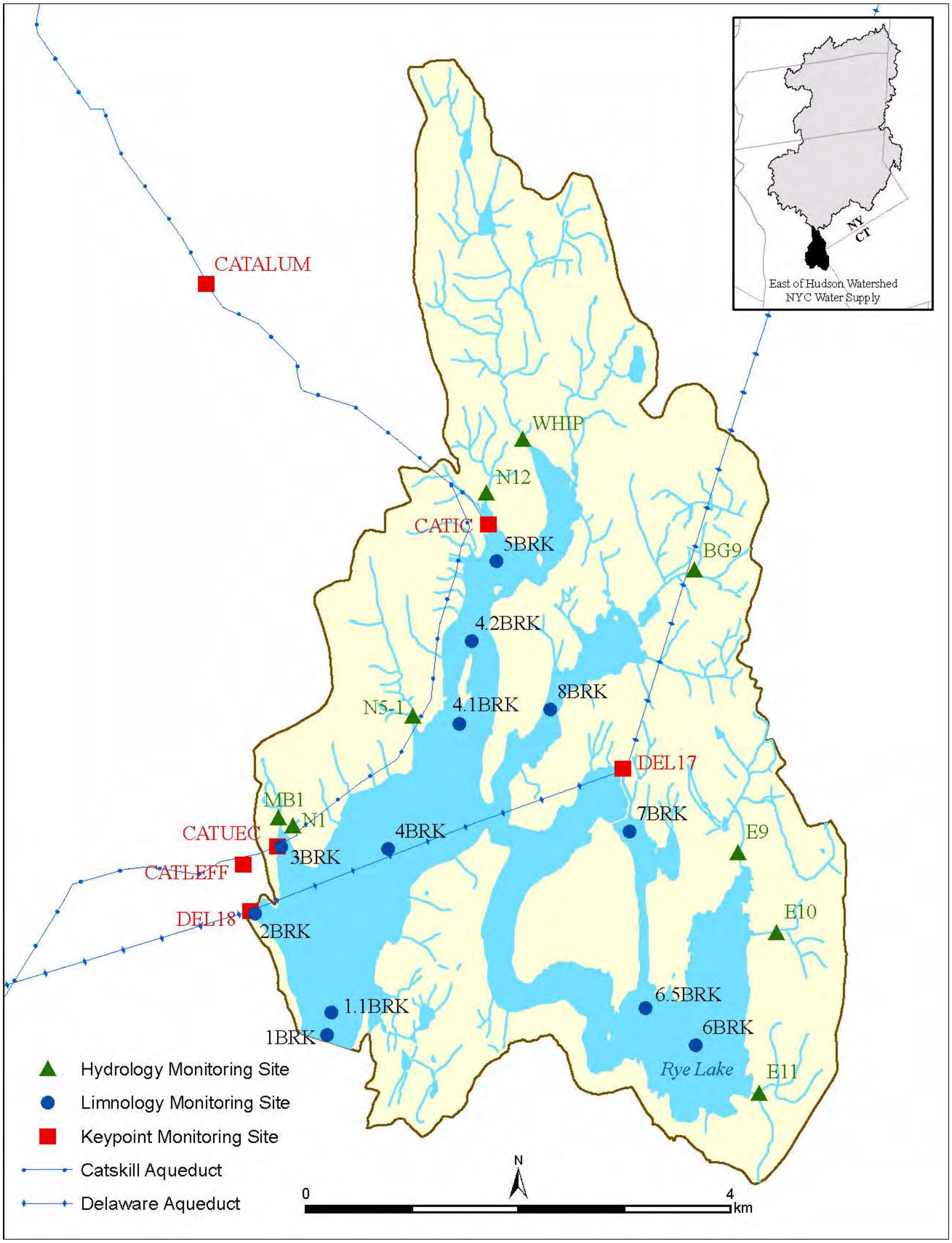


Figure 2.1 Kensico Reservoir, showing limnological and hydrological sampling sites, keypoints, and aqueducts. There is a meteorological station at DEL18.

# 3. Sampling Strategy

## 3.1 Groundwater

The Kensico Groundwater Monitoring Program was implemented in 1995 to determine whether groundwater could be contributing significant levels of coliform bacteria to Kensico Reservoir. Results of this program have been included in subsequent Kensico Reports. By agreement with EPA, as of 2007 DEP has ended the routine groundwater monitoring program. However, DEP will continue to receive and review results of ongoing sampling of Westchester County Airport groundwater monitoring wells by Westchester County DOT.

## 3.2 Volatile and Semivolatile Organic Compounds

DEP annually samples ten (10) upstate reservoir aqueduct keypoints to complement required surveillance of VOCs and SVOCs conducted within the NYC Water Supply distribution system. This keypoint survey includes the sampling of the Delaware (at DEL18) and Catskill (at CATLEFF) aqueducts leaving Kensico Reservoir.

## 3.3 Streams

DEP continues to monitor the hydrology of the Kensico watershed. Samples are collected at eight fixed sampling sites (BG9, E10, E11, E9, MB-1, N12, N5-1, WHIP) as shown in Figure 2.1**.** Routine sampling of Kensico streams was conducted monthly in 2007.

Since completion of FAD Section 307n-1, stream gauges at various sampling sites have been maintained or installed to facilitate the collection of streamflow data for other staff research projects. These stream sites include MB-1, BMP13IN, BMP13OUT, N5-1, BMP57IN, BMP57OUT, N12, E9, and E10; additional datalogging equipment was added at sites WHIP and E11 in 2006. Streamflow data collected from these sites are used for BMP monitoring projects, Pathogens Unit's research projects, and routine sampling reports. Finally, the meteorological station at DEL18 continues to provide daily and hourly meteorological data.

## 3.4 Reservoir

DEP monitors Kensico Reservoir water quality by routinely sampling for a series of physical, chemical, and microbiological parameters. Samples are collected at different depths throughout the water column at fixed sampling locations as shown in Figure 2.1**.** Routine limnological monitoring of Kensico Reservoir was conducted monthly from March 26 through December 5, 2007.

In addition to the routine surveys, additional sampling was required when a water quality issue or concern developed. These additional surveys involved more frequent sampling, sampling at different locations within the reservoir, and/or sampling for additional analytes, as needed.

Additional surveys conducted in 2007 were related to a short-term increase in turbidity in Ashokan Reservoir due to a relatively large storm event in April, and to repairs to the dike located near Delaware Shaft 17 in Kensico Reservoir.  All routine and additional data collected during the sampling period were distributed through weekly water quality reports and source water briefs provided to DEP, EPA, DEC, and City, State, and County DOH.

## 3.5 Reservoir Effluent Chambers

DEP routinely conducts water quality compliance monitoring at aqueduct keypoints, including CATLEFF and DEL18, where Kensico Reservoir water enters the Catskill and Delaware Aqueducts, respectively. These two sample points are located just prior to disinfection. Fecal coliforms are monitored via daily grab samples, and turbidity is measured every four hours.

## 3.6 Protozoa and Human Enteric Viruses

DEP is responsible for performing compliance and surveillance monitoring of protozoan pathogens (*Cryptosporidium* and *Giardia*) and human enteric viruses (HEV) in the New York City watershed.  In 2007, 423 samples were collected and analyzed for *Cryptosporidium* and *Giardia* within the Kensico Reservoir watershed between January 1 and December 24.  This sample set included 208 routine fixed-frequency samples and seven enhanced monitoring samples from four keypoints (Kensico Reservoir influent and effluent aqueducts), and 94 fixed-frequency samples and two enhanced monitoring samples at the eight perennial streams.  In addition, 64 samples were collected for the Water Resource Development Act (WRDA) project and 48 samples were collected to finalize Safe Drinking Water Act (SDWA) project 5.5.  Finally, 208 samples were collected and analyzed for human enteric viruses at the two influent and effluent keypoint locations.

Monitoring for *Cryptosporidium* and *Giardia* involved the collection of 50 L aliquots and analysis according to Method 1623 (USEPA 2001).  Human enteric virus samples involved the collection of 240 L aliquots and analysis according to the ICR method (USEPA 1996).  Occasionally, the sampled water had elevated turbidity (e.g., after storm events), resulting in clogging of the sample filter. When this happened, the targeted sample volume could not be attained.  In these cases, rather than extrapolate, the sample volume attained was considered the sample volume for that particular sample and is reported with the data.  In addition, enhanced monitoring was performed when necessary in response to elevated *Cryptosporidium*, *Giardia*, or other water quality parameters, and data are distinguished as such in the reported results.

# 4. Results and Discussion

## 4.1 Groundwater

The Kensico Groundwater Monitoring Program was implemented in 1995 to determine whether groundwater could be contributing significant levels of coliform bacteria to Kensico Reservoir. Eighteen monitoring wells at thirteen sites were constructed for this task. In addition to coliforms, the wells were also monitored for turbidity, pH, conductivity, total phosphorus, total nitrogen, nitrite, ammonia, alkalinity, and chloride. Over the twelve years that these wells have been sampled, most bacteria detections were for total coliform bacteria. In addition, the detection of coliform bacteria has commonly been found to coincide with precipitation events, indicating surface water intrusion, rather than a chronic problem with groundwater. Also, at all of the wells, nutrient concentrations typically remained within the range of their historical records, that is, there was minimal variation over time, and those nutrients with guidelines never exceeded them. These results have led DEP to conclude that the coliform detections are most likely not related to leaking sewer lines, failing septic systems, or other anthropogenic sources.

In addition to routine groundwater monitoring, in 2001 and 2002 DEP conducted two rounds of split sampling for organic compounds in Westchester County Airport groundwater monitoring wells with Westchester County DOT. DEP included four sentinel wells placed along the western edge (reservoir side) of the Airport property in its split sampling regime. These wells showed no detections during either sampling event. While data indicate that some groundwater contamination remains beneath the Airport, it is not believed that the contamination reflected in the sampling data is a water quality concern for Kensico Reservoir.

By agreement with EPA, as of 2007 DEP has ended its routine groundwater monitoring program. However, DEP will continue to receive and review results of ongoing sampling of Westchester County Airport groundwater monitoring wells by Westchester County DOT.

## 4.2 Volatile and Semivolatile Organic Compounds

Annual surveillance monitoring of Kensico Reservoir effluent keypoints DEL18 and CATLEFF on October 23, 2007 for 67 VOCs and 68 SVOCs resulted in no compounds being detected.

## 4.3 Coliform Bacteria

### 4.3.1 Streams

The routine fecal coliform data for the period January 2007 through December 2007 are plotted in Figure 4.1. All streams, except sites N5-1, had median values less than 200 colony forming units per 100mL (CFU 100mL$^{-1}$). Stream N5-1 had the highest median value at 295 CFU 100mL$^{-1}$, while E9 had the lowest at 45 CFU 100mL$^{-1}$. Fecal coliform values this year were consistent with previous years. The highest values were generally seen on the Sept. 11, 2007 sampling date. This sampling happened to occur shortly after almost 3 inches of rain had fallen in the watershed on September 10-11.

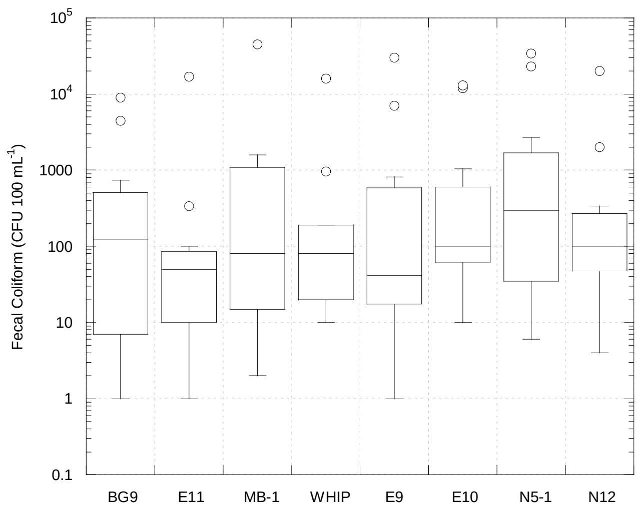


Figure 4.1 Fecal coliform plots for routine Kensico monitoring data, January - December, 2007.

Total coliform data are not plotted here. Instead, New York State DEC Part 703 water quality standards for coliform have been used as a guideline for the comparison of stream water quality, based on DEP's monthly fixed frequency monitoring program. For each stream sampling site, Table 4.1 indicates the number of occurrences during the sampling period that total coliform values were elevated above the 5,000 CFU 100mL$^{-1}$ value. These data confirm that most streams have an occasional occurrence above 5000 CFU 100mL$^{-1}$, which may be associated with a fixed frequency sample being collected during or immediately following wet weather, as is seen in the data collected on September 11, 2007 after the rain event of September 10-11, as mentioned above. However, the occurrences at stream sampling sites MB-1 and N5-1 stand out. These additional occurrences may be attributed to the residential character of the catchments or may be a function of the fact that the BMPs, whose permanent pools attract biological activity throughout the year, are located immediately upstream from the sampling sites.

Table 4.1. Occurrences of total coliform values > 5000 CFU100 $mL^{-1}$ in Kensico perennial streams during 2007, based on fixed frequency monthly sampling.

| Site | n | Total Coliform Value > 5000 CFU 100$mL^{-1}$ |
|---|---|---|
| BG9 | 12 | 2 |
| E10 | 12 | 2 |
| E11 | 12 | 2 |
| E9 | 11 | 1 |
| MB-1 | 12 | 5 |
| N12 | 12 | 2 |
| N5-1 | 12 | 5 |
| WHIP | 11 | 2 |

### 4.3.2 Reservoir

A total of 325 and 329 routine bacteria samples were collected from Kensico Reservoir for total and fecal coliform analyses, respectively, during this reporting period. Total and fecal coliform data from March through December are plotted in Figure 4.2. The results are compared with SWTR drinking water limits of 100 CFU 100$mL^{-1}$ for total coliform and 20 CFU 100$mL^{-1}$ for fecal coliform. Although the SWTR limits apply to raw water quality at the effluent chambers, DEP uses these limits as a guideline to identify potential reservoir water quality impacts before they reach the effluents.

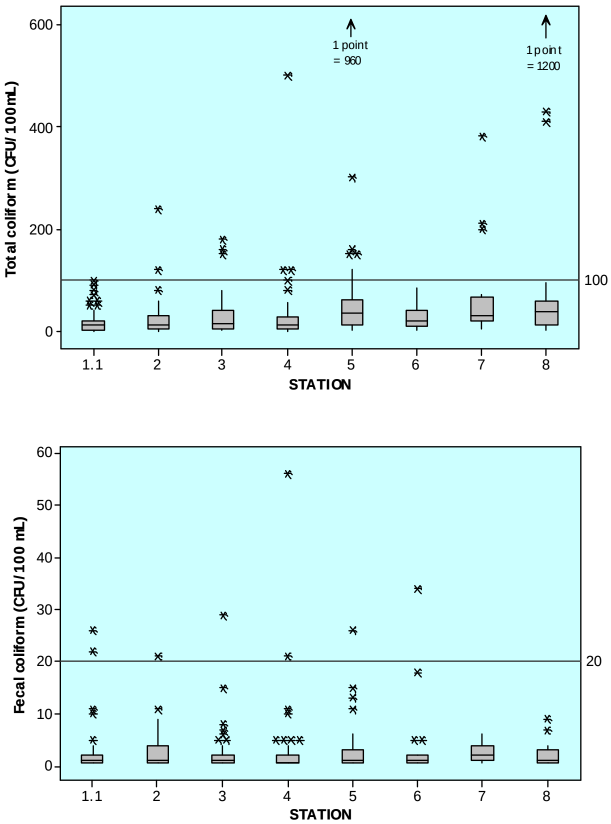


Figure 4.2 Total and fecal coliform plots for routine Kensico monitoring data, March - December, 2007.

During the reporting period, all sites had a median total coliform value less than 100 CFU $100mL^{-1}$. Site 8 had the highest median value (38 CFU $100mL^{-1}$) while sites 1.1, 2, and 4 shared the lowest median value (10 CFU $100mL^{-1}$). There were multiple instances where the reservoir total coliform bacteria levels were greater than the DEP guidelines. These higher values typically occurred in the autumn months. Seasonality of total coliform, with higher values at this time of year, is normal for many of the NYC reservoirs.

During the reporting period all sites from routine surveys had median fecal coliform values less than 20 CFU $100mL^{-1}$. There were only eight instances where the reservoir fecal coliform bacteria levels from discrete samples were greater than the DEP guidelines. Site 1.1 had two instances, one in July and one in September 2007 (26 and 22 CFU $100mL^{-1}$, respectively); Site 2 had one instance in October 2007 (21 CFU $100mL^{-1}$); Site 3 had one instance in June 2007 (29 CFU $100mL^{-1}$); Site 4 had one instance in July (21 CFU $100mL^{-1}$) and one in December (56 CFU $100mL^{-1}$); Site 5 had one in September 2007 (26 CFU $100mL^{-1}$); and Site 6 had one instance in April (34 CFU $100mL^{-1}$ ).

Special surveys during 2007 included monitoring of water quality during dike repairs near Delaware Shaft 17 (January through early March), and monitoring of a short-term turbidity event from Ashokan (April). Two total coliform samples exceeded the guidelines, the bottom of Site 3 on March 2, 2007 (440 CFU $100mL^{-1}$) and the bottom of Site 6 on April 19, 2007 (130 CFU $100mL^{-1}$). Fecal coliform counts only exceeded the DEP guidelines at the Site 3 sample on March 2, 2007 (74 CFU $100mL^{-1}$).

There was also a special survey near the inflow of tributary E10 due to a wastewater discharge into this tributary. The fecal coliform counts for this survey reached a maximum of 18 CFU $100mL^{-1}$ (see Section 6.5). The data from these special surveys were provided through weekly water quality reports and source water briefs.

### 4.3.3 Reservoir Effluent Chambers

Median fecal coliform concentrations measured from January to December 2007 were 1 CFU $100mL^{-1}$ at CATLEFF and 1 CFU $100mL^{-1}$ at DEL18. Mean values were 1.9 and 1.7 CFU $100mL^{-1}$, respectively. During the same period, the regulatory limit of 20 CFU $100mL^{-1}$ was exceeded only once at CATLEFF, and was not exceeded at DEL18 (Figure 4.3). (Eighteen exceedances are permitted in any six-month period at each keypoint.) The one exceedance was associated with precipitation. This continues to support the conclusions of previous DEP studies, which have indicated that almost all fecal coliform problems since the inception of DEP's Waterfowl Management Program (see Section 6.2) occurred following precipitation events.

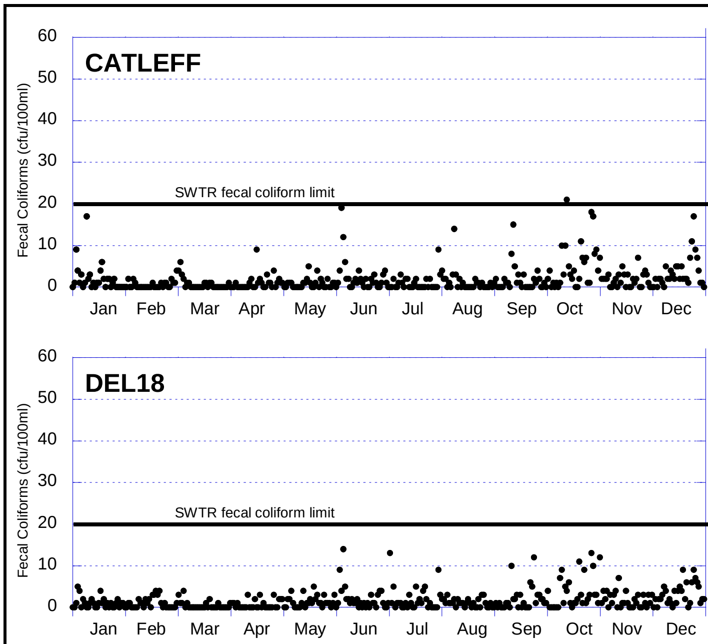


Figure 4.3 Graphs of daily fecal coliform concentrations for the CATLEFF and DEL18 keypoints, 2007. The SWTR fecal coliform limit must be met for at least 90% of samples in a six-month period.

## 4.4 Turbidity

### 4.4.1 Streams

The routine turbidity data for the period January 2007 through December 2007 are plotted in Figure 4.4. Median turbidity data are less than 5 NTU for all streams except N5-1 (6.9 NTU). Turbidity values in 2007 were consistent with data from previous years. As with the coliform data discussed above, the highest turbidity values observed during the routine monthly sampling occurred after rain events, such as the one that occurred on September 10-11. After almost three inches of rain, the turbidity values observed on September 11, 2007 were about an order of magnitude higher than typically observed, with a maximum value of 110 NTU at site N12.

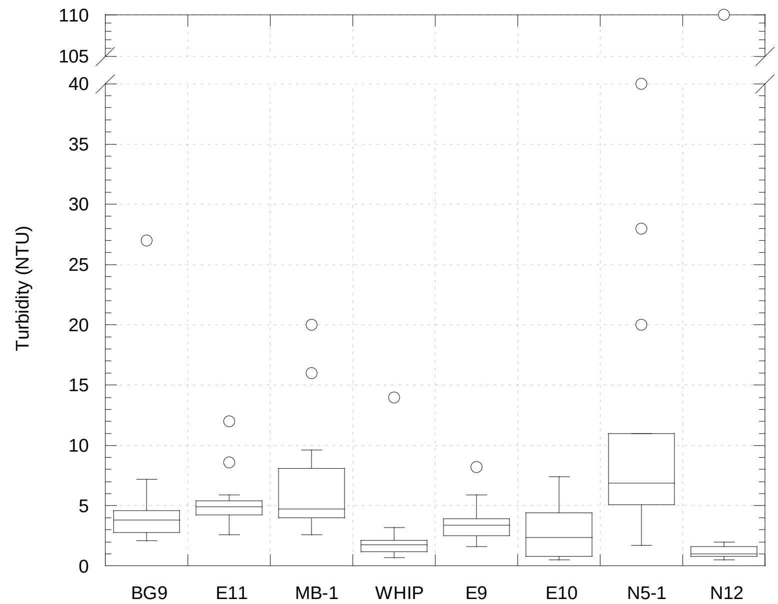


Figure 4.4 Turbidity data for the period January 2007 through December 2007, based on routine monthly monitoring.

### 4.4.2 Reservoir

A total of 346 turbidity samples were collected during routine monitoring of Kensico Reservoir in 2007. A box plot of the results from the routine limnological monitoring from March through December 2007 is presented in Figure 4.5. As in the past, Site 5 showed the highest median turbidity (2.0 NTU). At the sites closest to the effluent chambers (sites 2 and 3) and at sites 1.1, 4, and 6, the turbidity was less than 3.0 NTU for all routine samples. Five samples ranged between 3 and 5 NTU: Site 5 had three samples during a short-lived turbidity event from Ashokan Reservoir in April 2007; Site 7 had one sample in September 2007; and Site 8 had one sample in October 2007 in this range.

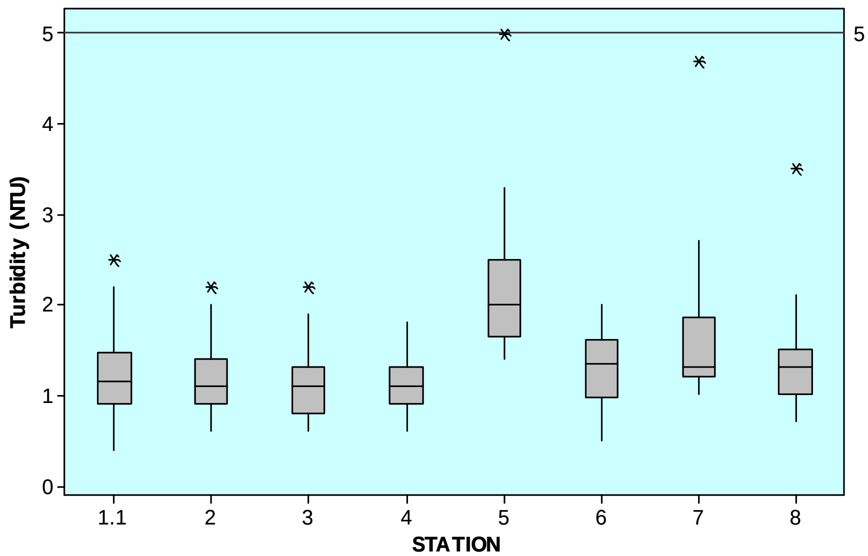


Figure 4.5 Turbidity plots for routine Kensico monitoring data, March - December, 2007.

### 4.4.3 Reservoir Effluent Chambers

Mean turbidity, measured on a four-hour schedule, from January to December 2007 was 1.1 NTU at CATLEFF and 1.0 NTU at DEL18. The SWTR limit of 5 NTU was not exceeded at either keypoint. During this period the maximum four-hour turbidity measurements were 3.4 NTU at CATLEFF and 2.0 NTU at DEL18 (Figure 4.6).

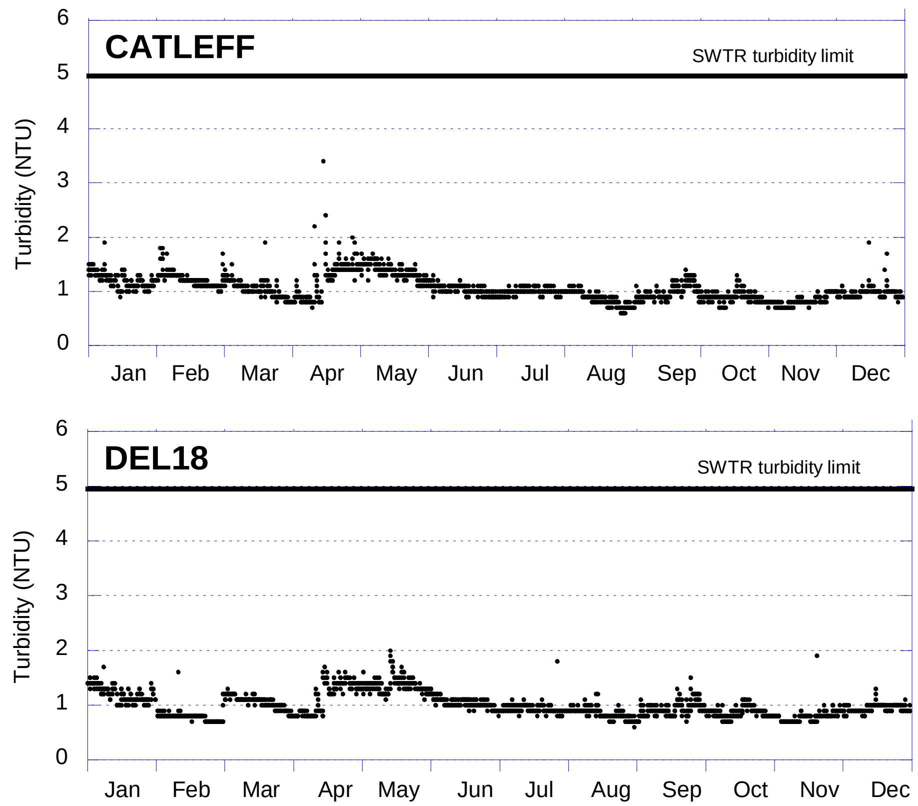


Figure 4.6 Graphs of four-hour turbidity data for the CATLEFF and DEL18 keypoints, 2007.

## 4.5 Protozoa and Human Enteric Viruses

### 4.5.1 Streams

There are eight perennial streams that flow into Kensico Reservoir. Previously, the sampling frequency for *Cryptosporidium* and *Giardia* at seven of the eight streams was monthly, while the sampling frequency at Malcolm Brook was weekly due to its proximity to the Catskill Upper Effluent Chamber location. In June of 2007, the sampling frequency was changed to bimonthly for seven of the eight streams and monthly for Malcolm Brook. Malcolm Brook was also sampled on two additional occasions in December, in response to slightly elevated *Cryptosporidium* oocyst results. Results from both the fixed frequency monitoring and the enhanced sampling for protozoa are presented in Tables 4.2–4.3. No stream samples were collected for HEV analysis in 2007.

Table 4.2. *Cryptosporidium* results from perennial Kensico streams, January 1 – December 24, 2007. Sample volumes in liters (L).

| Sample Date | BG9 (L) | E10 (L) | E11 (L) | E9 (L) | MB-1 (L) | N12 (L) | N5-1 (L) | WHIP (L) |
|---|---|---|---|---|---|---|---|---|
| 03-Jan-2007 | 1 (48.0) | 1 (50.0) | 5 (50.0) | 0 (50.0) | 5 (30.0) | 0 (50.0) | 2 (20.0) | 0 (50.0) |
| 09-Jan-2007 | | ■ | ■ | ■ | 7 (21.0) | ■ | ■ | ■ |
| 17-Jan-2007 | ■ | ■ | ■ | ■ | 0 (50.0) | ■ | ■ | ■ |
| 24-Jan-2007 | ■ | ■ | ■ | ■ | 2 (50.0) | ■ | ■ | ■ |
| 30-Jan-2007 | ■ | ■ | ■ | ■ | 0 (50.0) | ■ | ■ | ■ |
| 07-Feb-2007 | ■ | ■ | ■ | ■ | 0 (50.0) | ■ | ■ | ■ |
| 13-Feb-2007 | 1 (50.0) | 0 (50.0) | 3 (50.0) | 0 (50.0) | 0 (50.0) | 0 (50.0) | 0 (50.0) | 0 (50.0) |
| 21-Feb-2007 | ■ | ■ | ■ | ■ | 0 (50.0) | ■ | ■ | ■ |
| 27-Feb-2007 | ■ | ■ | ■ | ■ | 0 (50.0) | ■ | ■ | ■ |
| 07-Mar-2007 | ■ | ■ | ■ | ■ | 0 (40.0) | ■ | ■ | ■ |
| 13-Mar-2007 | 1 (32.0) | 1 (50.0) | 4 (50.0) | 2 (50.0) | 1 (30.0) | 0 (50.0) | 0 (35.0) | 0 (50.0) |
| 21-Mar-2007 | ■ | ■ | ■ | ■ | 0 (50.0) | ■ | ■ | ■ |
| 28-Mar-2007 | ■ | ■ | ■ | ■ | 1 (40.0) | ■ | ■ | ■ |
| 03-Apr-2007 | 0 (50.0) | 2 (50.0) | 2 (50.0) | 3 (50.0) | 0 (50.0) | 0 (50.0) | 1 (50.0) | 1 (50.0) |
| 10-Apr-2007 | ■ | ■ | ■ | ■ | 0 (50.0) | ■ | ■ | ■ |
| 18-Apr-2007 | ■ | ■ | ■ | ■ | 0 (40.0) | ■ | ■ | ■ |
| 24-Apr-2007 | ■ | ■ | ■ | ■ | 0 (30.0) | ■ | ■ | ■ |
| 01-May-2007 | 0 (48.7) | 0 (50.0) | 0 (50.0) | 2 (50.0) | 0 (40.0) | 0 (50.0) | 0 (50.0) | 0 (50.0) |
| 08-May-2007 | ■ | ■ | ■ | ■ | 0 (35.0) | ■ | ■ | ■ |
| 15-May-2007 | ■ | ■ | ■ | ■ | 0 (50.0) | ■ | ■ | ■ |
| 23-May-2007 | ■ | ■ | ■ | ■ | 1 (50.0) | ■ | ■ | ■ |
| 30-May-2007 | ■ | ■ | ■ | ■ | 0 (46.0) | ■ | ■ | ■ |
| 05-Jun-2007 | 1 (34.0) | 0 (50.0) | 0 (30.0) | 0 (46.0) | 0 (25.0) | 0 (51.0) | 0 (16.0) | 1 (50.0) |
| 10-Jul-2007 | ■ | ■ | ■ | ■ | 0 (24.3) | 0 (50.0) | 0 (30.0) | 0 (50.0) |
| 07-Aug-2007 | 0 (50.0) | 1 (50.0) | 0 (40.0) | 2 (50.0) | 0 (50.0) | ■ | ■ | ■ |
| 11-Sep-2007 | ■ | ■ | ■ | ■ | 2 (25.0) | 0 (18.0) | 0 (20.0) | 2 (20.0) |
| 02-Oct-2007 | 0 (50.0) | 0 (50.0) | 0 (50.0) | n.f. | 1 (50.0) | ■ | ■ | ■ |
| 07-Nov-2007 | ■ | ■ | ■ | ■ | 0 (50.0) | 0 (50.0) | 0 (50.0) | 0 (50.0) |
| 04-Dec-2007 | 3 (50.0) | 3 (50.0) | 4 (50.0) | 0 (50.0) | 8 (50.0) | ■ | ■ | ■ |
| 10-Dec-2007* | ■ | ■ | ■ | ■ | 11 (50.0) | ■ | ■ | ■ |
| 17-Dec-2007* | ■ | ■ | ■ | ■ | 0 (50.0) | ■ | ■ | ■ |

n.f. – no flow; * - enhanced sampling.

Table 4.3. *Giardia* results from perennial Kensico streams, January 1 – December 24, 2007. Sample volumes in liters (L).

| Sample Date | BG9 (L) | E10 (L) | E11 (L) | E9 (L) | MB-1 (L) | N12 (L) | N5-1 (L) | WHIP ( L) |
|---|---|---|---|---|---|---|---|---|
| 03-Jan-2007 | 49 (48.0) | 5 (50.0) | 36 (50.0) | 15 (50.0) | 44 (30.0) | 8 (50.0) | 16 (20.0) | 7 (50.0) |
| 09-Jan-2007 | ▪ | ▪ | ▪ | ▪ | 55 (21.0) | ▪ | ▪ | ▪ |
| 17-Jan-2007 | ▪ | ▪ | ▪ | ▪ | 13 (50.0) | ▪ | ▪ | ▪ |
| 24-Jan-2007 | ▪ | ▪ | ▪ | ▪ | 6 (50.0) | ▪ | ▪ | ▪ |
| 30-Jan-2007 | ▪ | ▪ | ▪ | ▪ | 1 (50.0) | ▪ | ▪ | ▪ |
| 07-Feb-2007 | ▪ | ▪ | ▪ | ▪ | 6 (50.0) | ▪ | ▪ | ▪ |
| 13-Feb-2007 | 28 (50.0) | 1 (50.0) | 131 (50.0) | 42 (50.0) | 2 (50.0) | 5 (50.0) | 8 (50.0) | 19 (50.0) |
| 21-Feb-2007 | ▪ | ▪ | ▪ | ▪ | 7 (50.0) | ▪ | ▪ | ▪ |
| 27-Feb-2007 | ▪ | ▪ | ▪ | ▪ | 0 (50.0) | ▪ | ▪ | ▪ |
| 07-Mar-2007 | ▪ | ▪ | ▪ | ▪ | 1 (40.0) | ▪ | ▪ | ▪ |
| 13-Mar-2007 | 17 (32.0) | 2 (50.0) | 40 (50.0) | 8 (50.0) | 10 (30.0) | 4 (50.0) | 9 (35.0) | 8 (50.0) |
| 21-Mar-2007 | ▪ | ▪ | ▪ | ▪ | 9 (50.0) | ▪ | ▪ | ▪ |
| 28-Mar-2007 | ▪ | ▪ | ▪ | ▪ | 5 (40.0) | ▪ | ▪ | ▪ |
| 03-Apr-2007 | 5 (50.0) | 5 (50.0) | 30 (50.0) | 2 (50.0) | 5 (50.0) | 4 (50.0) | 9 (50.0) | 7 (50.0) |
| 10-Apr-2007 | ▪ | ▪ | ▪ | ▪ | 4 (50.0) | ▪ | ▪ | ▪ |
| 18-Apr-2007 | ▪ | ▪ | ▪ | ▪ | 9 (40.0) | ▪ | ▪ | ▪ |
| 24-Apr-2007 | ▪ | ▪ | ▪ | ▪ | 6 (30.0) | ▪ | ▪ | ▪ |
| 01-May-2007 | 23 (48.7) | 1 (50.0) | 66 (50.0) | 38 (50.0) | 2 (40.0) | 4 (50.0) | 7 (50.0) | 4 (50.0) |
| 08-May-2007 | ▪ | ▪ | ▪ | ▪ | 1 (35.0) | ▪ | ▪ | ▪ |
| 15-May-2007 | ▪ | ▪ | ▪ | ▪ | 1 (50.0) | ▪ | ▪ | ▪ |
| 23-May-2007 | ▪ | ▪ | ▪ | ▪ | 1 (50.0) | ▪ | ▪ | ▪ |
| 30-May-2007 | ▪ | ▪ | ▪ | ▪ | 1 (46.0) | ▪ | ▪ | ▪ |
| 05-Jun-2007 | 10 (34.0) | 3 (50.0) | 8 (30.0) | 3 (46.0) | 5 (25.0) | 3 (51.0) | 8 (16.0) | 1 (50.0) |
| 10-Jul-2007 | ▪ | ▪ | ▪ | ▪ | 0 (24.3) | 11 (50.0) | 5 (30.0) | 4 (50.0) |
| 07-Aug-2007 | 2 (50.0) | 4 (50.0) | 1 (40.0) | 47 (50.0) | 5 (50.0) | ▪ | ▪ | ▪ |
| 11-Sep-2007 | ▪ | ▪ | ▪ | ▪ | 16 (25.0) | 4 (18.0) | 5 (20.0) | 19 (20.0) |
| 02-Oct-2007 | 0 (50.0) | 3 (50.0) | 26 (50.0) | n.f. | 0 (50.0) | ▪ | ▪ | ▪ |
| 07-Nov-2007 | ▪ | ▪ | ▪ | ▪ | 1 (50.0) | 2 (50.0) | 0 (50.0) | 1 (50.0) |
| 04-Dec-2007 | 22 (50.0) | 3 (50.0) | 28 (50.0) | 11 (50.0) | 19 (50.0) | ▪ | ▪ | ▪ |
| 10-Dec-2007* | ▪ | ▪ | ▪ | ▪ | 34 (50.0) | ▪ | ▪ | ▪ |
| 17-Dec-2007* | ▪ | ▪ | ▪ | ▪ | 2 (50.0) | ▪ | ▪ | ▪ |

n.f. – no flow; * - enhanced sampling.

### 4.5.2 Keypoints

Keypoint sampling for Kensico Reservoir is performed at the aqueduct influent and effluent locations of the Reservoir (CATALUM, DEL17, CATLEFF, DEL18) (see Figure 2.1). As in most years, sampling during 2007 included fixed frequency sampling (weekly) as well as some enhanced monitoring (in response to specific water quality results or events).

**Influent Keypoints**

Kensico Reservoir influent keypoints (CATALUM and DEL17) are sampled weekly for *Cryptosporidium* and *Giardia*. The summary results are presented in Table 4.4. *Cryptosporidium* was detected in one and seven samples at low concentrations (maximum = 1 oocyst $50L^{-1}$ for both sites) for CATALUM and DEL17, respectively. This is similar to the 2006 *Cryptosporidium* data which had three positive detections for CATALUM and four positive detections for DEL17, also with a maximum of 1 oocyst $50L^{-1}$ for both sites. *Giardia* was detected in 26 and 35 samples collected at CATALUM and DEL17, respectively in 2007, with maxima of 5 and 7 cysts $50L^{-1}$, respectively. This is also similar to the 2006 results, in which *Giardia* detection occurred in 27 and 32 samples collected for CATALUM and DEL17, respectively, with a maximum of 6 cysts at both sites.

Table 4.4. Weekly Kensico Reservoir influent keypoint results – *Cryptosporidium* and *Giardia* summary, January 1 – December 24, 2007.

| | | CATALUM | DEL17 |
|---|---|---|---|
| *Giardia* $50L^{-1}$ | Number of Samples | 52 | 52 |
| | Number of Positives | 26 | 35 |
| | Mean | 0.71 | 1.54 |
| | Median | 0 | 1 |
| | Maximum | 5 | 7 |
| *Cryptosporidium* $50L^{-1}$ | Number of Samples | 52 | 52 |
| | Number of Positives | 1 | 7 |
| | Mean | 0.02 | 0.12 |
| | Median | 0 | 0 |
| | Maximum | 1 | 1 |

<u>Enhanced Influent Keypoint Monitoring</u>

An enhanced monitoring sample event occurred at DEL17 on April 17 as a result of an approximately six-inch rain event on April 15. The results did not indicate elevated pathogen numbers (Table 4.5).

Table 4.5. Enhanced monitoring results for Kensico Reservoir effluent keypoints – *Cryptosporidium* and *Giardia* summary, January 1 – December 24, 2007.

| Date | Site | *Giardia* 50 $L^{-1}$ | *Cryptosporidium* 50 $L^{-1}$ |
|---|---|---|---|
| 17-Apr-07 | DEL17 | 0 | 0 |

**Effluent Keypoints**

Kensico Reservoir effluent keypoints (CATLEFF and DEL18) are also sampled weekly for *Cryptosporidium* and *Giardia*. The summary results are presented in Table 4.6. *Cryptosporidium* was detected in six and two samples at low concentrations (maximum = 1 oocyst 50$L^{-1}$ for both sites) for CATLEFF and DEL18, respectively. This is slightly less than 2006 *Cryptosporidium* data, which had seven positive detections for both CATLEFF and DEL18, with maxima of 1 and 2 oocysts 50$L^{-1}$, respectively. *Giardia* was detected in 47 and 45 samples collected at CATLEFF and DEL18, respectively in 2007, with maxima of 10 and 8 cysts 50$L^{-1}$, respectively. This is greater than 2006, in which *Giardia* detection occurred in 32 and 28 samples collected for CATLEFF and DEL18, with maxima of seven and six, respectively.

Table 4.6. Weekly Kensico Reservoir effluent keypoint results – *Cryptosporidium* and *Giardia* summary, January 1 – December 24th, 2007.

| | | CATLEFF | DEL18 |
|---|---|---|---|
| *Giardia* 50$L^{-1}$ | Number of Samples | 52 | 52 |
| | Number of Positives | 47 | 45 |
| | Mean | 2.58 | 1.92 |
| | Median | 2 | 2 |
| | Maximum | 10 | 8 |
| *Cryptosporidium* 50$L^{-1}$ | Number of Samples | 52 | 52 |
| | Number of Positives | 6 | 2 |
| | Mean | 0.08 | 0.02 |
| | Median | 0 | 0 |
| | Maximum | 1 | 1 |

Enhanced Effluent Keypoint Monitoring

An enhanced monitoring sample event occurred on February 9 in response to an elevated result on February 6 (1 *Cryptosporidium*, 7 *Giardia*). The result indicated a decrease in the pathogen numbers (Table 4.7), so no further enhanced sampling was performed. In addition, another enhanced monitoring sample event occurred at CATLEFF and DEL18 on April 17, as a result of an approximately six-inch rain event on April 15. The results did not indicate elevated pathogen numbers. Lastly, a third enhanced monitoring sample event occurred on August 3 in response to a special investigation originating from a North Castle Sewage District sewage spill (NYCDEP 2007e) (see Section 6.5). The results indicated no elevated pathogen numbers, so no further enhanced sampling was performed.

Table 4.7. Enhanced monitoring results for Kensico Reservoir effluent keypoints – *Cryptosporidium* and *Giardia* summary, January 1 – December 24, 2007.

| Date | Site | *Giardia* 50 $L^{-1}$ | *Cryptosporidium* 50 $L^{-1}$ |
|---|---|---|---|
| 9-Feb-07 | CATLEFF | 5 | 0 |
| 23-Feb-07 | CATLEFF | 5 | 0 |
| 17-Apr-07 | CATLEFF | 1 | 0 |
| 17-Apr-07 | DEL18 | 3 | 1 |
| 3-Aug-07 | CATLEFF | 1 | 0 |
| 3-Aug-07 | DEL18 | 0 | 0 |

**Human Enteric Virus Monitoring**

The four Kensico Reservoir keypoints (CATALUM, DEL17, CATLEFF, DEL18) (see Figure 2.1) were sampled weekly for human enteric viruses (HEV). A summary of the results is presented in Table 4.8 and Figure 4.7. At the time of this writing, HEV results for December 2007 were not available. Approximately 21% of all samples collected were positive for HEV in 2007. A majority (76%) had concentrations < 3 MPN $100L^{-1}$. Ten samples were > 3 MPN $100L^{-1}$, eight at the Kensico influents (CATALUM = 4, DEL17 = 4) and two at the Kensico effluents (CATLEFF = 1, DEL18 = 1), indicating that HEV detections were higher at influent sites than effluent sites. This in turn suggests that a reduction of viruses occurs while aqueduct water travels through Kensico Reservoir.

Table 4.8. Summary of human enteric virus results at Kensico keypoints, January 1 through November 26, 2007.

| | Human Enteric Viruses* MPN $100L^{-1}$ | | | | |
|---|---|---|---|---|---|
| Keypoint Location | Number of samples | Number of positive samples | Mean** | Median | Max |
| Catskill Influent Keypoint | 48* | 15 | 0.94 | 0 | 20.83 |
| Catskill Effluent Keypoint | 48* | 7 | 0.36 | 0 | 10.25 |
| Delaware Influent Keypoint | 48* | 13 | 0.66 | 0 | 10.13 |
| Delaware Effluent Keypoint | 48* | 6 | 0.13 | 0 | 3.22 |

*HEV results for December 2007 are pending.

**Zero value substituted for non-detect values when calculating mean results.

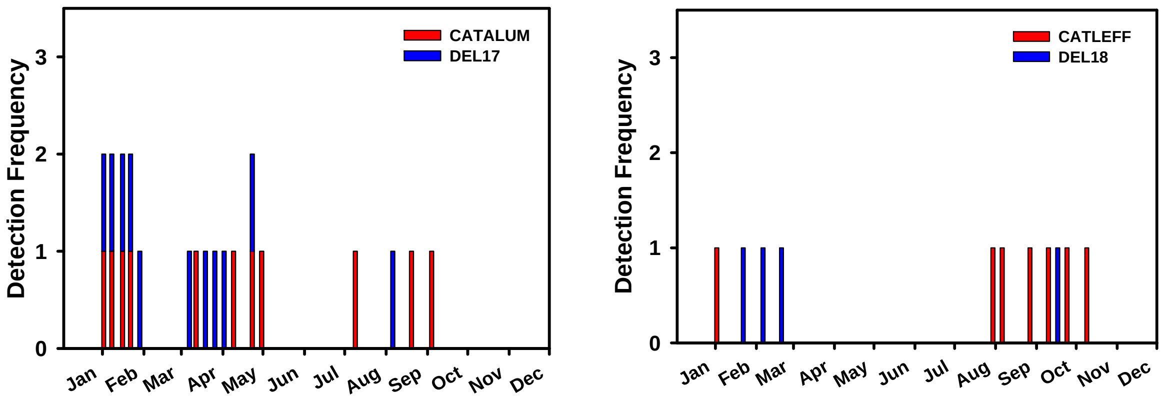


Figure 4.7 Positive detection frequency of human enteric viruses at the four Kensico keypoints, January 1 – November 26, 2007. Stacked bar diagram; 0 = non-detect at both keypoints, 1 = detection at one keypoint, 2 = detection at both keypoints.

### 4.5.3 Development of Event-Based Pathogen Monitoring Strategies of Streams (WRDA Grant)

**Site Development**

The objectives of this study are to develop an automated monitoring strategy for sample collection during storm events, to characterize concentrations of *Giardia* and *Cryptosporidium* during storms, and to provide an estimate of loads from various local landscapes and land uses. The project is funded through the Water Resources Development Act (WRDA) and by DEP. The East-of-Hudson (EOH) portion of this project incorporates the eight perennial tributaries to Kensico Reservoir. In the fall of 2005, sampling equipment was deployed at three sites in the EOH System to facilitate the development of Phase I of the event-based pathogen monitoring program. For each storm event, 48 discrete, 1 L aliquots were collected from stream flow at 30 min intervals into two composite 24 L cubitainers using an ISCO autosampler. These composite samples were subsequently sent to DEP's laboratory for protozoan analysis and the data were used to determine the optimum storm sampling time duration for Phase II, Year 1. These Phase I data were presented at the 2006 Watershed Science and Technical Conference (Alderisio et al. 2006). From June 2005 through May 2006, the remaining sample sites were developed by installing flow monitoring stations associated with autosamplers in order to prepare for WRDA Phase II, which began in the spring of 2006.

**Watershed (Oo)cyst Loading**

During Phase II, Year 1 a total of 197 x 24 L storm composite samples were collected for the Kensico WRDA sample sites. These sites included E9, E10, E11, BG9, WHIP, N12, MB-1, MB-3, MB-4, N5-1, N5-1 MAIN, N5-1 TRIB, and N1 (Figure 4.8). From the Phase II, Year 1 storm sampling, DEP determined that the Kensico Reservoir tributaries make up about 0.5% of the average flow and about 5-10% of the pathogen loading (Table 4.9). During large storm events, the relative stream flow contribution increased to as much as 5%, which potentially significantly increased the relative pathogen contribution.

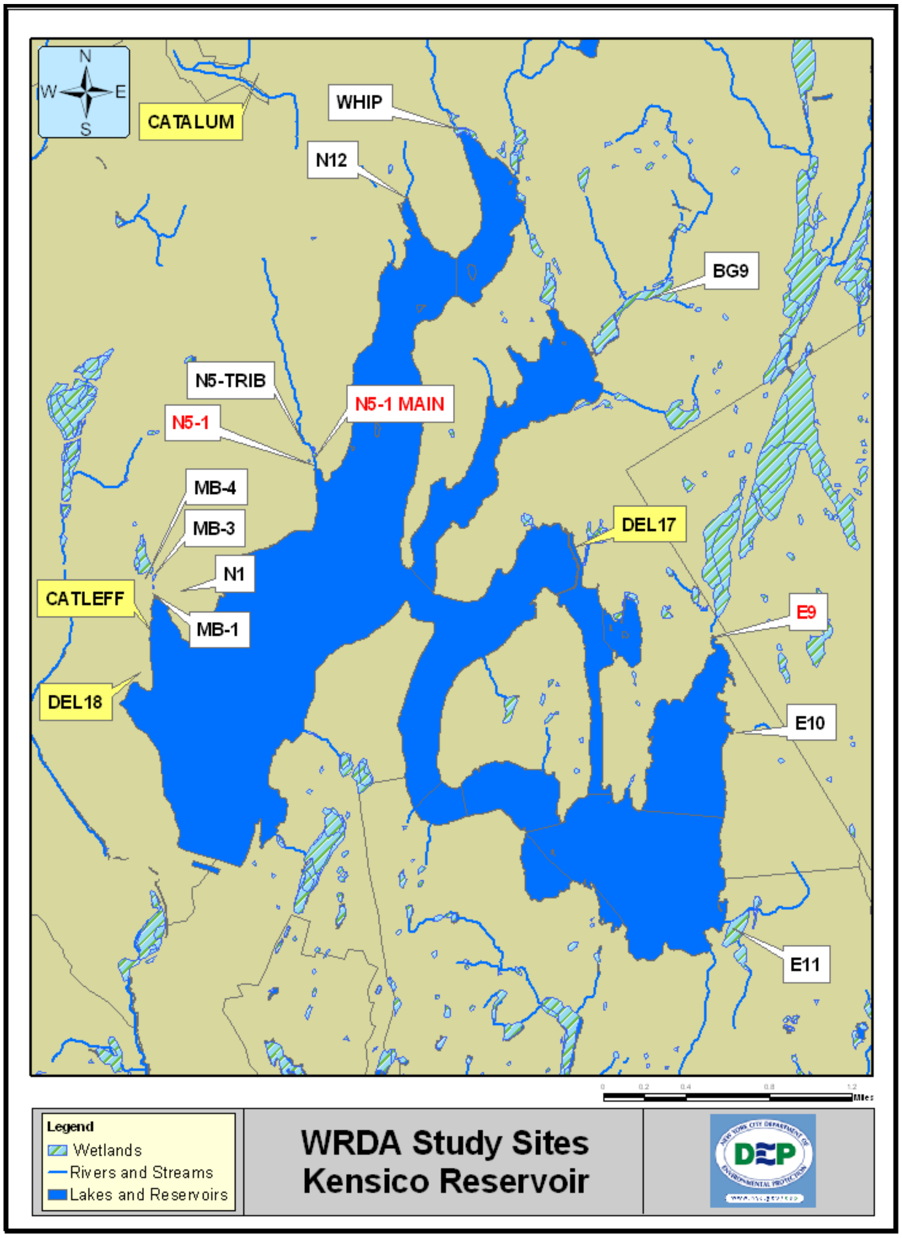


Figure 4.8 WRDA sample sites in the Kensico watershed.

Table 4.9. Estimated relative *Cryptosporidium* oocysts, *Giardia* cysts, and flow into Kensico Reservoir. mgd = million gallons per day.

| Site and Flow | *Giardia* | *Cryptosporidium* |
|---|---|---|
| CATALUM: 500 mgd (35.5%) | 41,790,020 (19.7%) | 5,325,044 (31.3%) |
| DEL 17: 900 mgd (64.0%) | 159,128,367 (75.0%) | 10,157,130 (59.7%) |
| All Streams: 6.5 mgd (0.5%) | 11,168,900 (5.3%) | 1,524,900 (9.0%) |
| Est. Total Daily Loading | 212,087,287 (100.0%) | 17,007,074 (100.0%) |

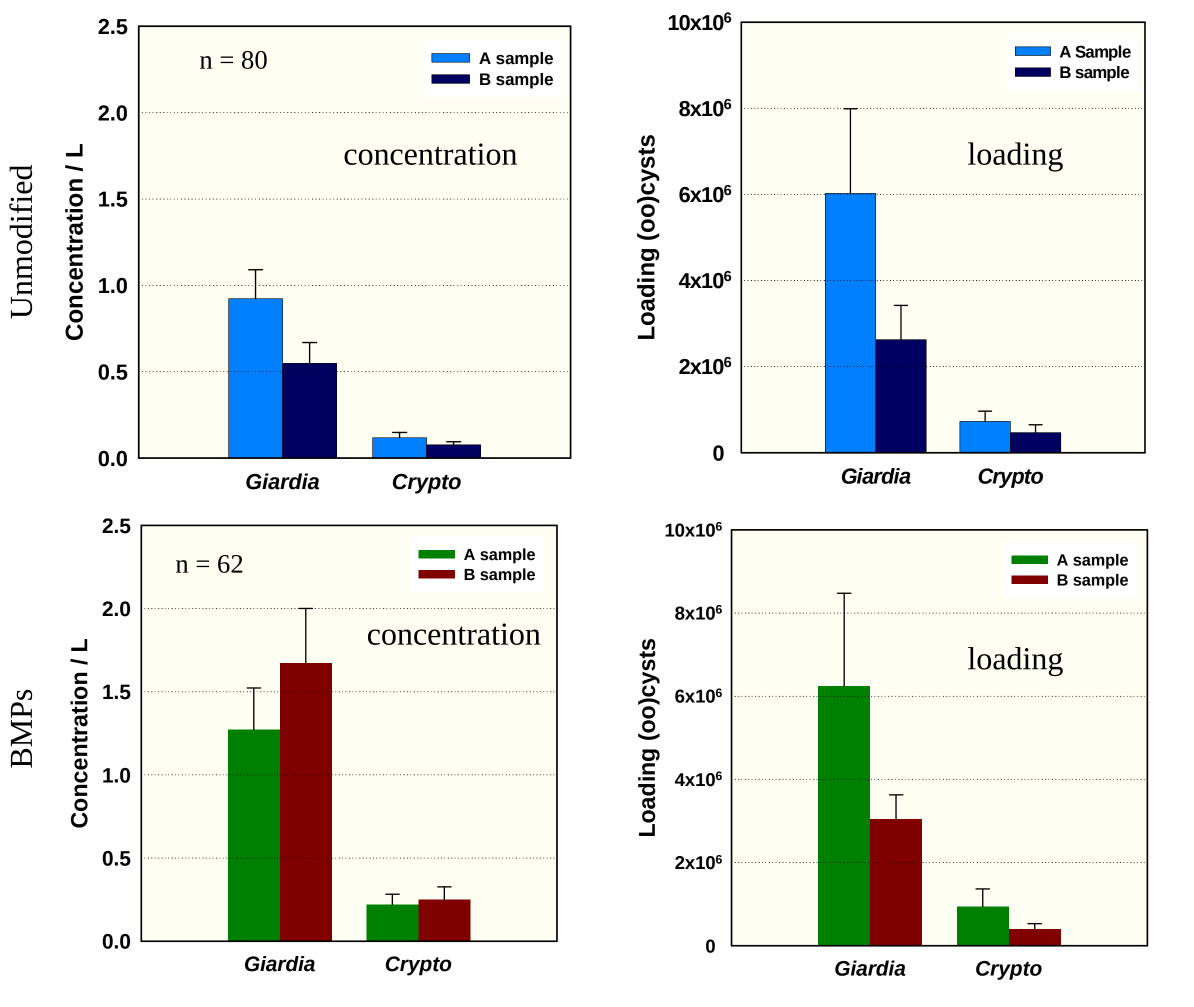


Figure 4.9 Storm hydrograph patterns (A = rising vs. B = descending limb) comparison between unmodified and post-BMP sample sites.

In addition to the relative loading, the average concentration and loading patterns were compared for the first half of a storm event (rising limb) vs. the latter half of a storm (descending limb) [“A” vs. “B” samples (Figure 4.9)]. Furthermore, this comparison was performed for unmodified and post-BMP sample sites. The data revealed a higher loading and concentration for unmodified stream sites in the rising limb of a storm, which is consistent with the “first-flush phenomenon” often cited in storm water investigations for pollutants and pathogens (Krein et al. 2007; Davis et al. 1977; Ahfield and Minihane 2004). Conversely, for BMP sample sites, the data indicate a slightly higher concentration in the latter part of a storm, yet the loading is still higher in the first part of a storm, likely due to the higher stream discharge (Figure 4.9). This indicates a delay or attenuation of the “first flush phenomenon” across the storm duration.

### Preliminary BMP Protozoan Efficiency

Despite the attenuation of the “first flush phenomenon”, preliminary findings for BMP efficiency indicated a higher number of *Cryptosporidium* and *Giardia* (oo)cysts leaving the Kensico BMP systems than coming in (Figure 4.10). This finding was supported by equivalent flow entering and leaving the BMP. Further sampling occurred in 2007 and will continue in 2008. Results from this first year of Phase II were presented at the 2007 Watershed Science and Technical Conference (Pace et al. 2007).

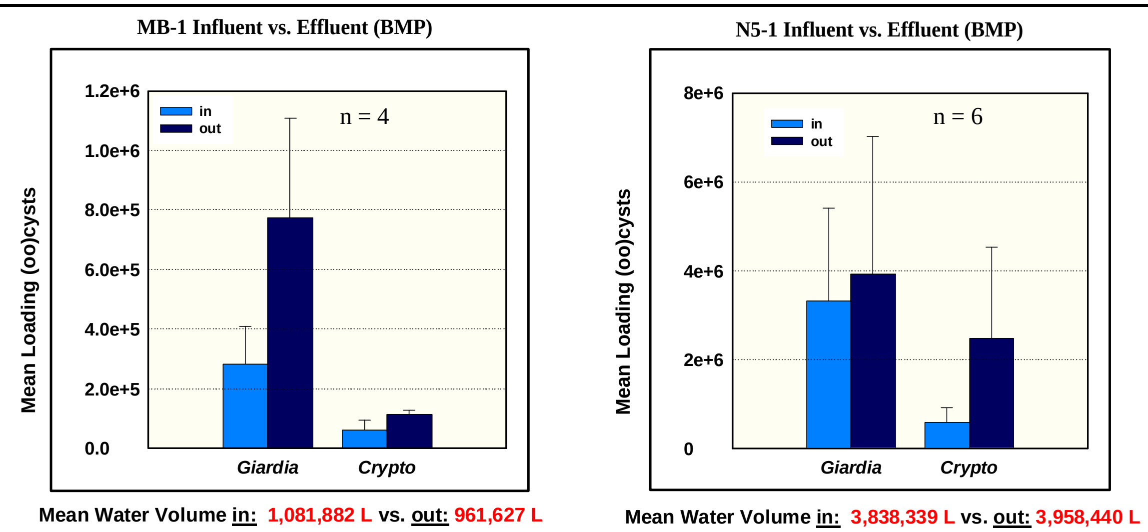


Figure 4.10 Preliminary BMP protozoan efficiency assessment comparing influents and effluents.

**Intrastorm Analysis**

In 2007 (Phase II, Year 2), the project shifted slightly towards a higher resolution sampling effort on the MB1, E10, N5-1, N5-1 TRIB, and N5-1 MAIN tributaries only, with the goal of designing site-specific sample protocols, examining intrastorm patterns, and following up on the findings of BMPs (N5 sample sites). The samples were collected into 1 L aliquots rather than compositing the samples into 24 L cubitainers. In addition to the sample collection, monitoring a given storm event involved using the flow data to graph the storm hydrograph (Figure 4.11). This provided the information necessary to dissect the hydrograph based on the different storm phases (rising limb, peak, and descending limb of a storm) and composite the 1 L samples accordingly to represent these phases.

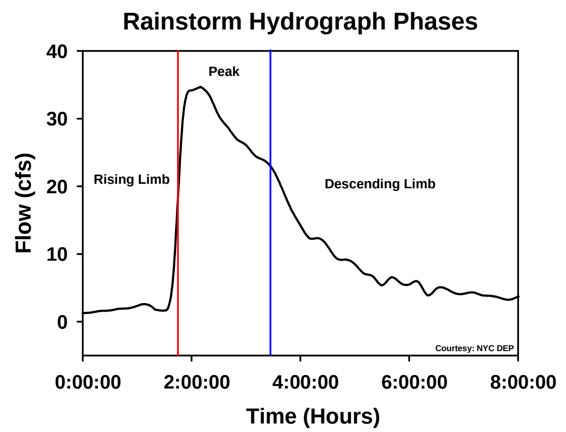


Figure 4.11 Illustration of rainstorm hydrograph phases.

For WRDA Phase II, Year 2, scheduled to end in December 2007, a goal of ten complete storm events was set, with a minimum of six considered acceptable. Sampling was attempted during six storms at the five sample sites, with a total of 64 samples collected. Of these six events, there were five partial sample sets and only one successful complete set of storm samples. Due to the low number of complete storms and samples, DEP requested, and was granted, a five-month extension of the project. This project will now extend into May 2008 in order to collect the minimum amount of data needed for an adequate statistical analysis to answer the questions posed for this last phase of the project.

### 4.5.4 Safe Drinking Water Act: Grant 5 – Project 5.5

Microbial fate and transport are critical concerns for DEP in maintaining filtration avoidance. On August 31, 2006, DEP began work on SDWA Grant 5, Project 5.5, which proceeded through August 31, 2007. The objectives of this project were to (i) characterize the partitioning behavior of two pathogens, *Cryptosporidium* and *Giardia* in five tributaries feeding Kensico Reservoir, (ii) evaluate correlations between the incidence and concentration of *Giardia* and *Cryptosporidium* relative to the indicator organisms (fecal coliform, *E. coli*, somatic coliphage, male specific coliphage, *Enterococci*, and *Clostridium perfringens*), thus providing some measure of the indicator organisms' value as a surrogate for pathogens, which typically occur at low concentrations in DEP's watershed, and (iii) estimate the total loadings of *Giardia* and *Cryptosporidium* (and the indicator organisms) over the course of individual storms, as well as determine how loading might vary during storms. When modeling microbial transport behavior, characterizing the "partitioning" of the organisms (i.e., the fraction of organisms attached to particles in the water column versus the fraction that exists in the “free”, unattached, phase) can be important given its potential impact on microbial settling. Thus, the improved understanding of both microbial partitioning behavior and the effectiveness of coagulation in encouraging greater microbial removal should lead to improved modeling of microbial fate and transport in Kensico Reservoir. DEP’s current pathogen models assume pathogens to be in the “free living” or unattached state. It is known, however, that this is not necessarily the case, since they can attach to particulate matter of various size fractions which may or may not settle, depending on the particle density and residence time. This project allowed DEP to determine what portion of these pathogens are potentially “free living” or “attached”, and in turn refine our models of pathogen transport.

Water samples were collected from five different tributaries entering Kensico Reservoir, labeled as E9, E11, WHIP, MB-1, and N5-1 (Figure 4.12). Three dry weather samples were taken between November 28, 2006 and May 9, 2007. Four storm samples were taken between December 13, 2006 and April 15, 2007. These samples were obtained using an ISCO autosampler, which collected up to 24 L per sample once it had been triggered near the peak of the hydrograph for that storm event. Four intrastorm sampling events, involving multiple samples taken throughout individual storms, were taken between June 4, 2007 and July 12, 2007 at three of the original five tributaries: E9, WHIP, and N5-1. The intrastorm sampling consisted of three samples obtained from each site: one during the rising limb of the hydrograph, one near the peak, and one as the hydrograph receded. Sample temperature and pH were measured in the field, with samples stored in 20 L sterile cubitainers.

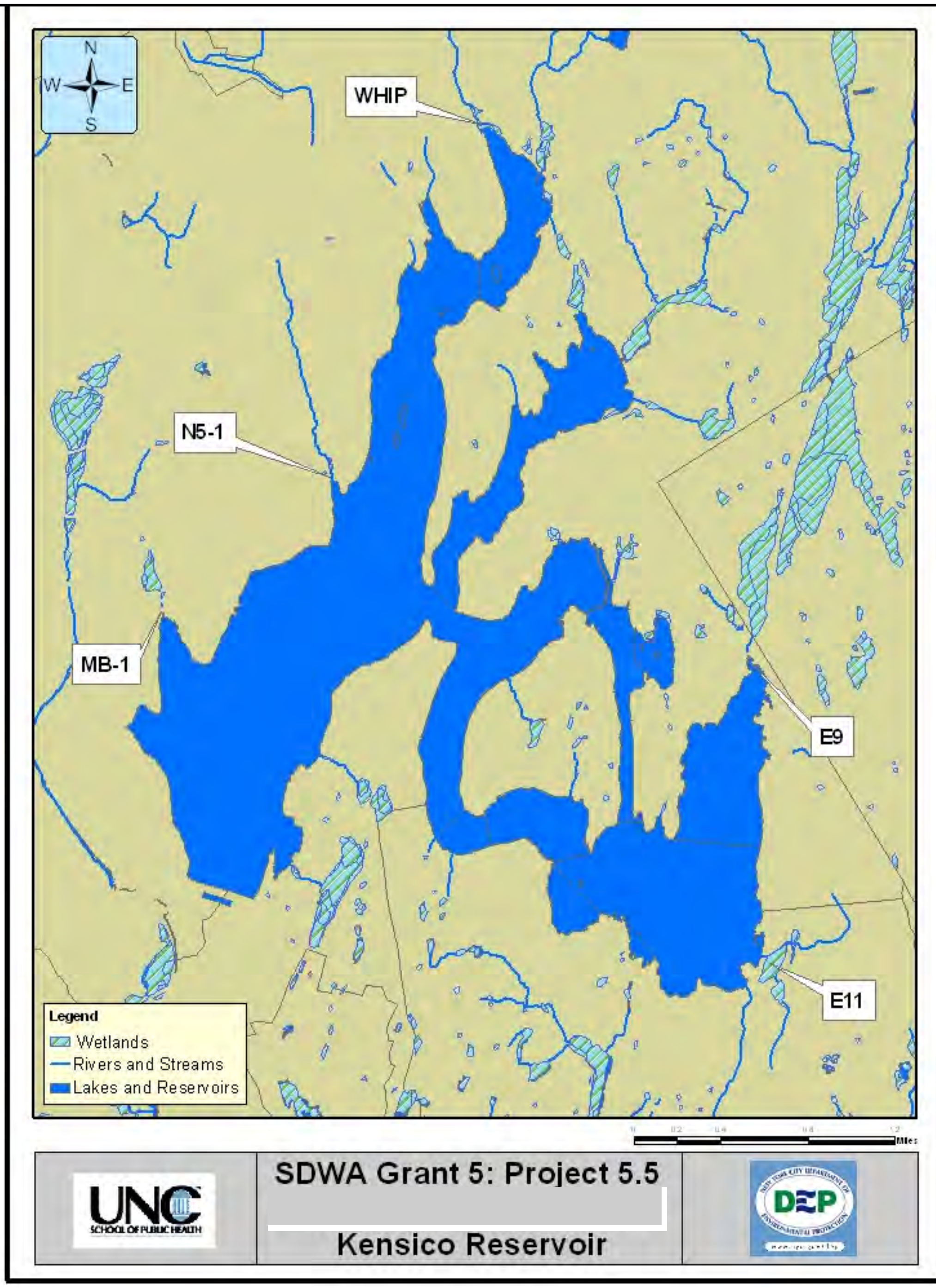


Figure 4.12 SDWA 5 study streams.

Results suggest that a significant fraction of both bacterial indicator organisms and a protozoan indicator organism could potentially be removed by sedimentation due to the evidence that the estimated fraction of the total loadings associated with settleable particles during storm events was 20-30% and up to 80%, respectively. The protozoans examined, *Giardia* and *Cryptosporidium*, experienced smaller fractions associated with settleable particles (0-20%), more consistent with fecal coliform cumulative attachment frequency than its other surrogate, *C. perfringens* spores. While the fraction of microbes associated with particles tends to vary by microbes, partitioning behavior does not appear to change dramatically for indicator organisms. However, *Giardia* and *Cryptosporidium* tend to have initially higher settleable fractions which decrease over the duration of the storm. Estimates of cumulative microbial loading also confirmed that wet-weather periods, although intermittent, significantly contribute to the increase in total microbial load in the tributaries, and therefore Kensico Reservoir. These results should prove useful in the design and development of models and strategies for better predicting and improving water quality, specifically with regard to *Giardia* and *Cryptosporidium* in Kensico Reservoir. The SDWA Grant 5 project results were submitted in final report format in September 2007, and were additionally presented at the 2007 NYWEA Watershed Science and Technical Conference (Di Lonardo et al. 2007).

## 4.6 BMPs

DEP continued to monitor the performance of the Kensico BMPs installed on streams tributary to Kensico Reservoir, as per the schedule previously submitted to EPA. Monitoring of BMP Facility 12 on stream MB-1 was completed during 1999–2001. Monitoring of BMP Facility 37 on stream N5 began in autumn 2002, and continued throughout 2004. During 2005, monitoring was implemented at BMP Facility 57 (a sand filter on Nannyhagen Road) and Facility 13 (an extended detention basin on stream N1). For Facility 13, the monitoring protocols are consistent with those used at the previously monitored extended detention basins. For Facility 57, the sand filter, the protocol was changed to focus on event mean concentrations instead of event loads. This change in protocol has occurred because flow into the sand filter cannot be measured. Instead, the samples are taken at discrete volume intervals from inside the sand filter vault, prior to its passing through the filter material. These data facilitate the calculation of event mean concentrations of the water prior to filtering, but do not facilitate the calculation of loads. Sampling for Facilities 57 and 13 was completed in 2006. Finally, monitoring began at BMP Facility 74, stream basin E11, in autumn 2006, at two inlet sites and one outlet site.

The sampling of the BMPs was continued through 2007 with six events sampled at BMP Facility 74. This was in addition to the three events at this facility that were sampled in 2006. This concludes the FAD sampling requirement of the Kensico BMPs. As per the 2007 FAD, a detailed report of the findings will be presented in the 2009 Kensico Programs Annual Report.

In addition to the ongoing monitoring of the Kensico BMPs in 2007, DEP also contracted with EA Engineering, P.C., and its affiliate EA Science and Technology, Inc., to provide a constructive review of the monitoring program for the Kensico BMPs. The contract was funded through Safe Drinking Water Act funds, and yielded two reports, *Evaluation of BMP Removal Efficiency—Kensico Reservoir Watershed* and *Kensico Stormwater BMP Monitoring Program Assessment Report* (EA Science and Technology 2007a, b). In addition to the reports, the contractor also compiled the data collected to date into a Microsoft Access database and submitted these data to the USEPA/ASCE International BMP Database.

The Kensico Stormwater BMP report stated that "[o]verall no detrimental deficiencies were noted that would affect the integrity/quality of the samples collected to assess the efficiency of the BMPs." There were some suggestions that could be incorporated in future work to further refine the monitoring program. The findings from this work will be discussed in more detail in the 2009 Kensico Programs Annual Report.

# 5. Mathematical Water Quality Modeling

## 5.1 Simulations of Kensico Reservoir Turbidity in Response to April 2007 Storm Event

Unlike the previous years of 2005 and 2006, increases in Catskill System turbidity which could threaten Kensico Reservoir water quality were less frequent and less severe in 2007. There was, however, one large storm event which occurred on April 15-16, 2007, that led to elevated turbidity levels in the Catskill Reservoir system (Figure 5.1). Peak turbidity levels measured in Esopus Creek, just upstream of the confluence with Ashokan Reservoir (Figure 5.1b) exceeded 600 NTU, which when combined with high discharge levels led to an increase in Ashokan Reservoir turbidity levels. By April 19, West Basin turbidity ranged between 20 - 60 NTU and the turbidity entering the Catskill Aqueduct and input to Kensico Reservoir (Figure 5.1c) exceeded 20 NTU. In other cases (NYCDEP 2006a), turbidity of this magnitude would have been sufficient to trigger the use of alum.

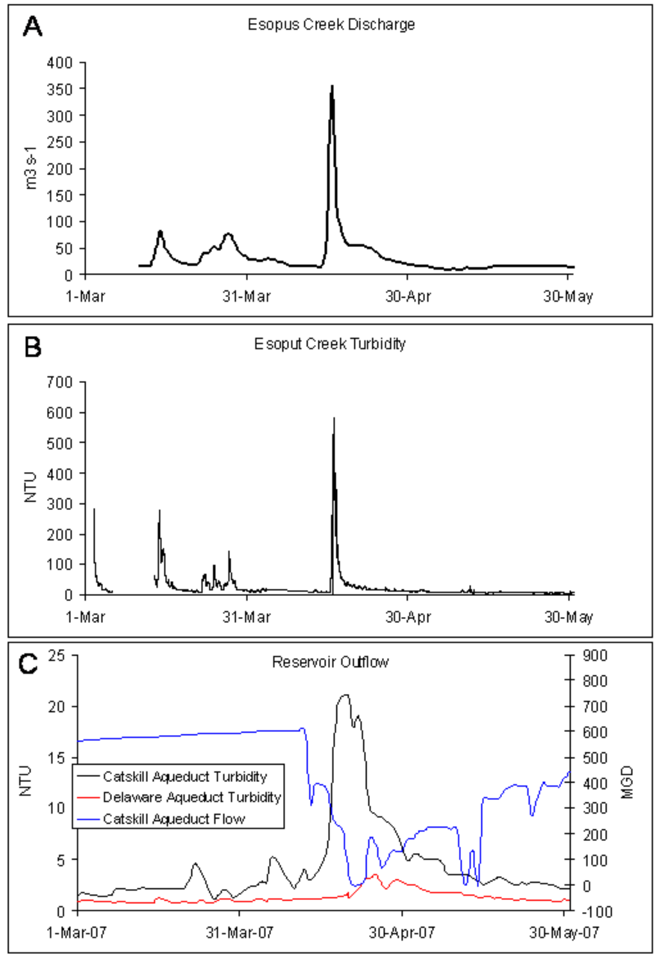


Figure 5.1 Conditions leading up to and following the April 2007 turbidity event. A) Discharge and B) turbidity measured in the Esopus Creek near its confluence with Ashokan Reservoir. C) Turbidity levels measured in the Catskill Aqueduct withdrawal from Ashokan Reservoir and the Catskill Aqueduct flow. Also shown in C) is the turbidity measured in the Delaware Aqueduct leaving Rondout Reservoir.

In the case of this event, however, turbidity levels were not high enough to demand immediate use of alum treatment. Rather, it seemed possible to mitigate the effects of elevated Catskill turbidity by cutting back on the Catskill System flow entering Kensico Reservoir. Model simulations were run to test a reservoir operation strategy that relied on reducing the Catskill Aqueduct flow, while maximizing Delaware System withdrawal. DEP believed that this would be a viable operating strategy under these conditions, given that Ashokan turbidity levels were moderate, and that Kensico Reservoir was well mixed, which would maximize the dilution of turbidity as it traveled between influent and effluent locations. Figure 5.3 shows the areas of the

NYC Water Supply System that were included in the model simulations. A number of factors complicated the implementation of this strategy and defining the optimal Catskill System flow rates. These include: 1) Ashokan effluent turbidity increased for a number of days following the storm event, 2) at the same time, Delaware System turbidity also increased, compromising DEP's ability to dilute the Catskill water to below 5 NTU, and 3) Kensico Reservoir levels began to decrease, requiring that the total input to the reservoir be increased.

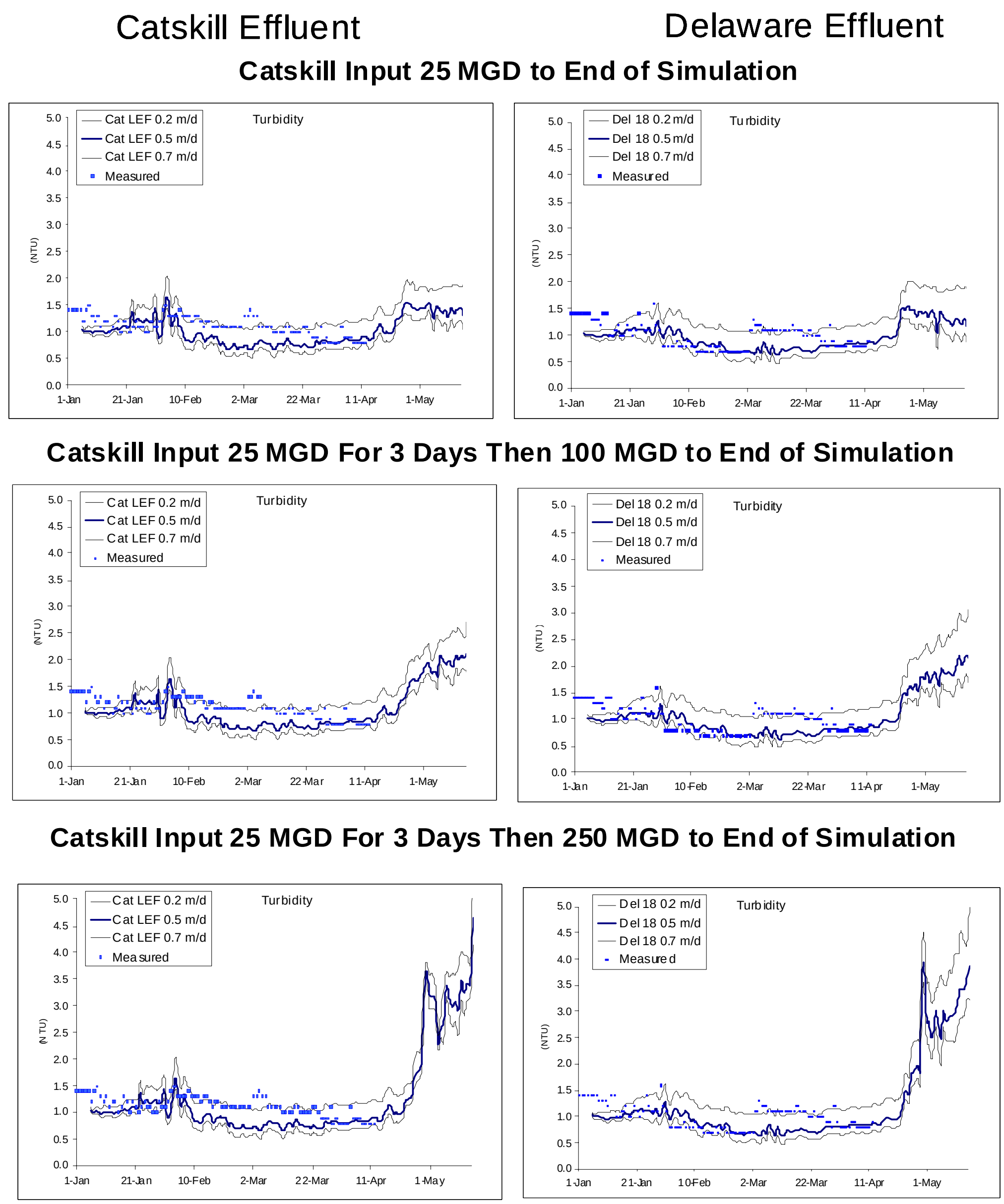


Figure 5.2 Simulated variations in Kensico Catskill effluent (left column) and Delaware effluent (right column) turbidity levels as a function of different Catskill Aqueduct flow rates and assuming a worst case turbidity level of 30 NTU.

Model simulations (Table 5.1) were used to predict the results of reductions in Catskill Aqueduct flow on the turbidity levels measured at the Kensico Reservoir effluent locations. All simulations summarized in Table 5.1 and a description of the model setup and simulation strategy are presented in the October 2007 Multi-tiered Modeling Program Status Report (NYCDEP 2007b).

Table 5.1. Kensico Reservoir model simulations run in response to the April 2007 turbidity event.

| Date | Description | Simulation Support |
|---|---|---|
| 16-April | On April 15-16, 2007, a major storm event occurred which resulted in Esopus Creek flows increasing to over 350 $m^3 s^{-1}$. Stream water turbidity during peak discharge reached 600 NTU. At the time of these simulations East Basin effluent turbidity levels had been increasing, but had not yet peaked. | Simulations were run on the day of the event to examine the influence of increasing Catskill System turbidity inputs on Kensico Reservoir effluent turbidity levels. At the time of the storm event Catskill Aqueduct flows had already been reduced to 250 MGD. These simulations examined the effect of sustained inputs of 10, 15, and 20 NTU Catskill Aqueduct water at this relatively low flow rate. |
| 19-April | By the time of these simulations, following the peak turbidity loading associated with the April 16 storm, it was clear that Catskill Aqueduct turbidity levels would exceed 20 NTU for a sustained period of time. | Simulations were run using a constant worst case Catskill Aqueduct turbidity input to Kensico Reservoir of 30 NTU. Simulations examined the effects of further cutting back Catskill Aqueduct flow rates on Kensico effluent turbidity levels. |
| 24-April | At the time of these simulations Ashokan Reservoir turbidity levels had declined so that Catskill Aqueduct turbidity was at 15 NTU. At the same time turbidity levels in the Delaware System (Rondout Reservoir) had increased from 1 NTU to 3 NTU. | In order to reduce Catskill Aqueduct flow rates, it is necessary to make similar increases in withdrawal from the Delaware System. These simulations were run to examine if Kensico effluent turbidity levels would remain below 5 NTU if the Delaware System water underwent a small, but potentially significant increase in turbidity. |

**Example Simulations**

The model runs made on April 19, 2007, provide a good example of how simulations were used during this period of elevated Ashokan Reservoir turbidity to define acceptable levels of Catskill Aqueduct flow. The goal was to find a flow level that would provide sufficient water to Kensico Reservoir, and which would also allow DEP to maintain safe effluent turbidity levels while avoiding the use of alum treatment. At the time the simulations were run, turbidity was still rising and had reached 21 NTU in the water being withdrawn from the East Basin of Ashokan Reservoir. In response to this turbidity increase Catskill Aqueduct flow had been temporarily cut back to 25 MGD; however, this operating strategy could not be sustained. Even though Delaware System output could be increased, Kensico Reservoir would be drawn down without greater inputs of Catskill System water. An additional concern was that turbidity in Rondout Reservoir had also increased to 1.5 NTU (Figure 5.1), which would decrease the effectiveness of the dilution of Catskill System water.

From the beginning of 2007 and up to the April turbidity event, the Kensico CE Qual W2 turbidity transport model was driven using measured Catskill and Delaware Aqueduct flow and turbidity data. During this period predictions of Kensico effluent turbidity were compared to measured turbidity at these locations. This allowed the model to "spin up" to the conditions prior to the turbidity event, and also demonstrated that the model simulations were reasonably representative of the turbidity measured at the Kensico effluent withdrawal locations. Following this initial period, the goal of the simulations was to forecast future turbidity levels assuming constant conditions for approximately one month into the future. Simulations examined the effects of changing the Catskill System flow rate on the turbidity levels at the Kensico effluent withdrawals. The simulations used constant and near maximum Delaware System flow conditions, and an increased Delaware System turbidity of 2.0 NTU. A worst case Catskill System turbidity of 30 NTU was used at the present Catskill Aqueduct flow of 25 MGD and at two increased flow rates of 100 MGD and 250 MGD (Table 5.2). Simulations were run varying the sinking rate of turbidity-causing material between 0.2 m $d^{-1}$ – 0.7 m $d^{-1}$ in order to examine the sensitivity of the turbidity predictions to plausible variations in particle sinking.

Table 5.2. Constant flow and turbidity conditions used in simulations of Kensico Reservoir during the April 2007 turbidity event. Aqueduct flows were specified for inputs and outputs to the reservoir. Input turbidity levels were based on turbidity levels measured in Ashokan and Rondout Reservoirs at the start of the simulations.

| | Flows | | | | Turbidity | |
|---|---|---|---|---|---|---|
| Simulations | Cat In MGD | Del In MGD | Cat Out MGD | Del Out MGD | Cat In NTU | Del In NTU |
| Series 2-19 April 2007 | | | | | | |
| | 25 | 850 | 350 | 850 | 30 | 2 |
| | 100 | 850 | 350 | 850 | 30 | 2 |
| | 250 | 850 | 350 | 850 | 30 | 2 |

Comparison of the simulated and measured Kensico effluent turbidity levels (Figure 5.2), measured until the onset of the turbidity event, show that the model was capable of predicting the pre-event turbidity levels within the margin of error related to uncertainty in particle sinking. Previous simulations (NYCDEP 2006b) showed that the model is capable of simulating increases in Kensico effluent turbidity in response to increased inputs of turbidity to the reservoir. However, prior to the April 2007 event there was little variation in either simulated or measured effluent turbidity levels. The future forecasts of Kensico effluent turbidity showed that under worst case Catskill System turbidity levels of 30 NTU, bringing Catskill Aqueduct flow rates back up to 250 MGD could bring Kensico effluent turbidity levels uncomfortably close to the 5 NTU regulatory limit. Flows of 100 MGD or somewhat greater would, however, lead to relatively small and acceptable increases in Kensico effluent turbidity.

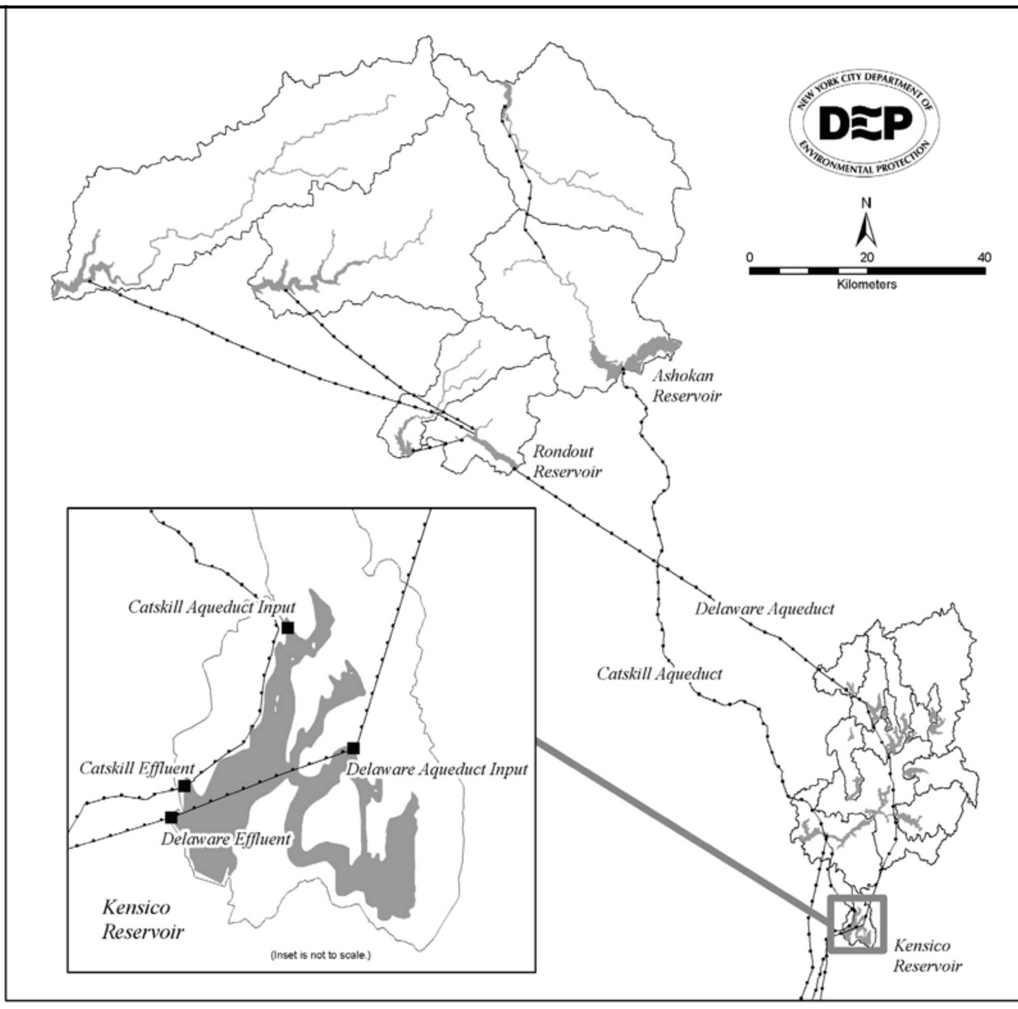


Figure 5.3 The New York City Water Supply reservoir system. Simulations reported here were made on Kensico Reservoir, which receives inputs from the Catskill and Delaware Aqueducts, which in turn serve as the outputs of Ashokan and Rondout Reservoirs. The main river input shown entering Ashokan Reservoir is Esopus Creek.

In the period following these simulations Catskill Aqueduct flow was increased to between 100-150 MGD over a one-week period, and then further increased to 200-225 MGD as Ashokan effluent turbidity declined to approximately 5 NTU (Figure 5.2). These operational decisions were based partially on the guidance provided by model simulations, which were conservative given assumptions of maximum and constant turbidity inputs. From these simulations (Figure 5.2), it was clear that Catskill Aqueduct flows of at least 100 MGD could be tolerated even if the aqueduct turbidity remained constantly high at 30 NTU. As measured Catskill Aqueduct turbidity levels declined to well below 30 NTU, these simulations showed that it was safe to increase the Catskill Aqueduct flow without jeopardizing Kensico effluent turbidity limits. The use of models to examine the potential impacts of changing conditions and constraints on operating conditions in order to help optimize reservoir operations during this event was a powerful tool which helped DEP avoid the use of alum treatment.

# 6. Other Areas of Interest

## 6.1 Kensico Reservoir Alum Dredging

Commencing in April 2005, several heavy rain events were experienced in upstate New York, creating record flooding which in turn led to extensive erosion of stream banks and channels throughout the Catskill System and a significant increase in turbidity in water entering the Catskill Aqueduct. NYSDEC has issued a SPDES permit to allow DEP to add aluminum sulfate (alum) to coagulate the suspended solids in the Catskill water entering Kensico Reservoir during high turbidity events caused by stormwater. The SPDES permit, issued on December 15, 2006, includes a condition that DEP remove the resulting alum floc, including the entrained solids, from Kensico Reservoir. Through competitive bidding, DEP will procure the services of a dredging contractor to remove the floc from the reservoir in the vicinity of the Catskill Influent Chamber (CATIC), where water from the Catskill Aqueduct enters Kensico Reservoir.

Figure 6.1 Catskill Influent Chamber and weir where Catskill Aqueduct water enters Kensico Reservoir.

Hydraulic dredging and mechanical dewatering, with the resultant concentrated cake disposed of at an offsite location, has been determined to be the best method at this time. The scientific investigations of the area of floc deposition were completed in July 2007. DEP and the design consultants at Malcolm Pirnie, Inc., submitted reports of the bathymetric, benthic, core sampling, computer modeling, and flow study findings to NYSDEC in October 2007. Figure 6.1 shows the Catskill Influent Chamber and weir where Catskill Aqueduct water enters Kensico Reservoir. Water quality parameters, total organics, and grain size of sediments were measured at each of the benthic sample locations. The benthic grab samples were obtained in both April 2007 and July 2007. The samples were analyzed for the following parameters:

- Number of Taxa
- Abundance
- Shannon Diversity
- Hilsenhoff Biotic Index (HBI)
- Dominance 3
- Non-Chironomidae and Oligochaeta (NCO) Richness
- Percent Chironomid Individuals
- Number of Diptera Taxa

In addition to the engineering and s cientific reports specified in the SPDES permit, DEP has provided NYSDEC and NYSDOH, since October 2005, with a monthly progress report on the investigations conducted to finalize the construction contract for this project. The Environmental Review for SEQR and the required permitting process is underway. Contract documents were completed in 2007 and are under legal review. It is anticipated that the dredging operations will take approximately two years to complete.

## 6.2 Bird Management

DEP's Waterfowl Management Program (WMP), developed in response to seasonal increases in water bird activity at Kensico Reservoir, continued to show impressive results in the reduction of roosting birds. This program has been instrumental in reducing reservoir fecal coliform bacteria levels, thereby ensuring continued compliance with the Federal Surface Water Treatment Rule (SWTR). The most recent Waterfowl Management Program Contract (WMP-08) commenced on August 1, 2007 and will continue through the end of July 2010. The program was first implemented in 1993. For a more detailed account of DEP's Waterfowl Management Program, see the 2007 Waterfowl Management Program annual report (NYCDEP 2007c).

The basic objectives of the WMP-08 are listed below:

- Record daily water bird survey counts from 0500 to 0800 hours including spatial and temporal distribution of roosting water birds, and document behavioral changes of the birds from August 1 through March 31. Survey frequency is decreased to weekly from April 1 through July 31. All morning surveys are conducted from boat and/or shoreline.
- Conduct daily water bird dispersal methods from 0800 hours until 1.5 hours past sunset from August 1 through March 31. Methods include harassment via motorboat, Husky Airboat, pyrotechnics, and broadcasting bird distress tapes.
- Record daily surveillance of water influent facilities for alewives (*Alosa pseudoharengus*), a baitfish. Alewives that are transported through the NYC aqueducts from reservoir to reservoir attract water bird foraging. Containment booms are used to collect dead or dying alewives to eliminate this feeding attraction to the water birds. A fish deterrent system will be installed at Ashokan Reservoir (source water to Kensico) in 2008 to eliminate the transport of the baitfish.
- Daily modification of bird dispersal techniques based on the previous day's success at eliminating bird activity.

Additional water bird management measures deployed annually in the spring include the following:

- Egg and nest depredation under federal and state permit for three species of water bird including Canada Goose (*Branta canadensis*), Mute Swan (*Cygnus olor*), and Double-crested Cormorant (*Phalacrocorax auritus*) from April through June annually.
- Meadow management, including maintenance of shoreline fencing to keep nesting geese away from water intake facilities.

Similar management measures are being conducted at six additional reservoirs (Rondout, West Branch, Ashokan, Croton Falls, Cross River, and Hillview) on an "as needed" basis as outlined in the 2002 and 2007 Filtration Avoidance Determinations.

Water bird data collected from August 1, 1992 through November 1, 2007 are presented in Figure 6.2. Bird counts for 2007 remained relatively low compared with the data from the early 1990s, prior to implementation of the bird dispersal program.

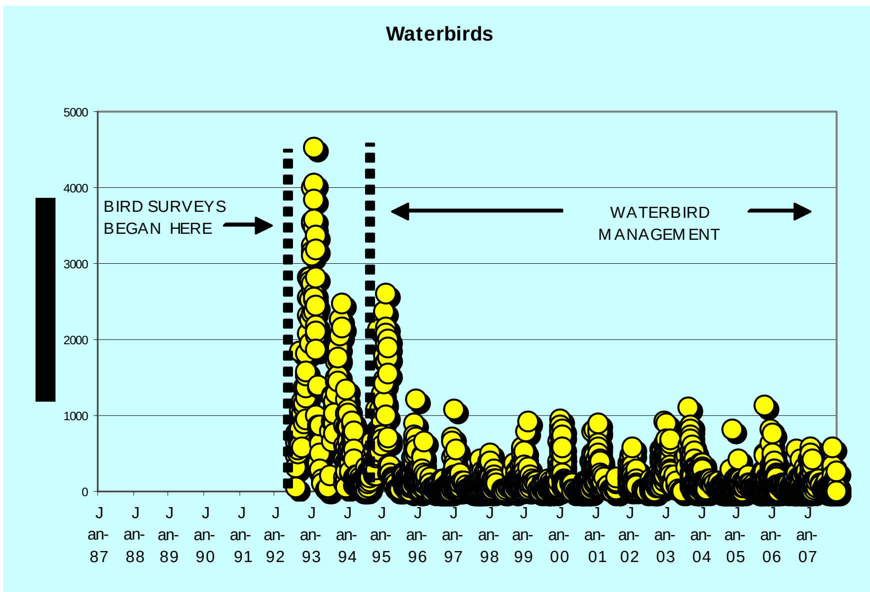


Figure 6.2 Kensico Reservoir water bird counts, 1992-2007

Figure 6.3 shows the regulatory keypoint water samples analyzed for fecal coliform bacteria collected at the two primary water outflow facilities at Kensico Reservoir. The data represent the percentage of samples recorded with a greater than 20 CFU $100mL^{-1}$ result as a continuous average over the previous six months. During 2007 there was only one "hit" or regulatory exceedance, at the CATLEFF facility and there were no "hits" at the DEL18 facility. The fecal coliform increase recorded at the CATLEFF facility on October 13, 2007, may be attributed to approximately 1 inch of rain recorded on October 11 and 12, 2007 (see Section 4.3.3).

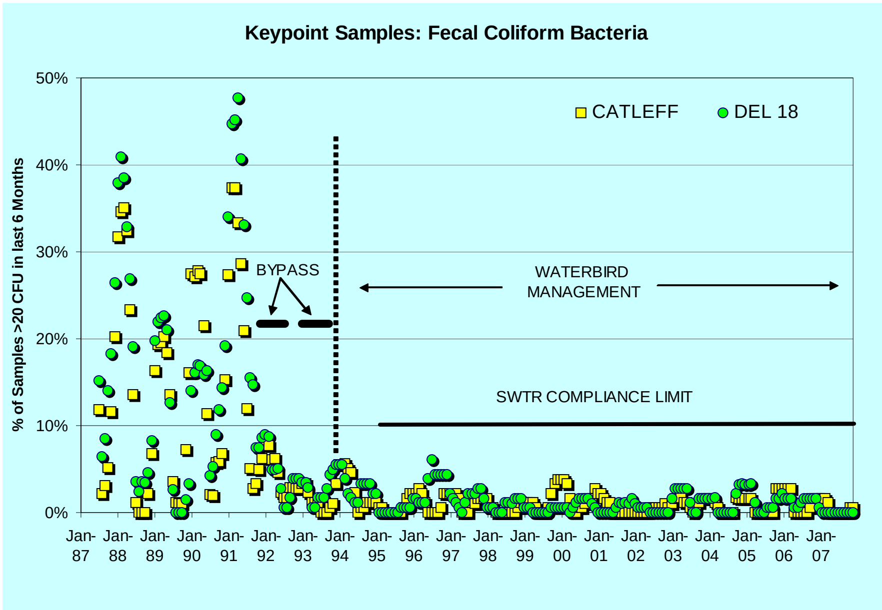


Figure 6.3 Kensico Reservoir keypoint water samples, 1987-2007.

DEP also implemented a reproductive management program for three locally breeding species of water birds including the Canada Goose, Mute Swan, and Double-crested Cormorant at Kensico and 14 additional reservoirs in 2007. Among the 16 reservoirs (including Kensico) that were examined for nesting geese, a total of 694 eggs in 173 nests were treated. There was no nest treatment for cormorants during the 2007 nesting season, although a total of 24 nests were observed among the 16 reservoirs treated other than Kensico. At Kensico, there were 138 eggs from 31 nests treated in 2007. A total of 5 eggs from 1 Mute Swan nest were depredated at Kensico in 2007.

Overall, the management of water birds at Kensico Reservoir during 2007 was deemed highly successful, as migratory and resident bird populations were reduced to numbers low enough to remain in full compliance with the SWTR for fecal coliform bacteria levels. Full compliance with the SWTR for fecal coliform bacteria levels has been accomplished with the Waterfowl Management Program since its inception in 1993. The implementation of the WMP continues to provide the most cost-effective means for fecal coliform bacteria reductions and full compliance with the SWTR.

## 6.3 Forestry

Two forest research projects are currently underway in the Kensico Reservoir watershed. The Deer Exclosure Project and the Forest Ecosystem Health Study were both established in 2000 as part of larger forestry studies being conducted on the watershed. More detailed information on these studies can be found in their respective QAPP documents: *Forest Ecosystem Health Assessment: Phase I Program, Effects of Silvicultural Treatment on Forest Ecosystem Health,* and *Deer Herbivory Impacts on Forest Regeneration: Deer Exclosure Study* (NYCDEP 2001a,b). Due to unforeseen circumstances, study sites at Kensico have been eliminated from both studies for which they were originally established. However, the silvicultural treatment sites will continue to be useful as part of the continuous forest inventory process on water supply lands and the deer exclosure plots serve as a case study.

The Deer Exclosure Project was established at Loudens Cove in order to compare seedling establishment, survival, and growth on a site protected from deer herbivory with one that was not protected. The results and status of this study were reported in the 2004 Kensico Report (NYCDEP 2004). There were no data scheduled to be collected in 2007 for this project.

The first post-treatment measurements of the Forest Ecosystem Health Plots were taken in 2007. The Forest Ecosystem Health Plots were established and measured for baseline conditions on two sites in the Kensico watershed during 2000-2001. The purpose of the study is to gather data on plant ecological communities and their overall health in a variety of conditions. These areas were originally slated for, but eventually eliminated from, silvicultural treatments that were carried out in 2005-2006. In 2007, measurements were completed on one site (the Route 120 site) and on a portion of another site (the Nannyhagen Road site). The remaining Nannyhagen Road plots are scheduled to be measured in Spring 2008. An interim report will be issued following completion of these measurements.

As silvicultural treatments were not applied to these plots, these sites will not be included in the summary and analysis of silvicultural treatment data and measurements will not be made every two years as previously planned. However, plots will be included in continuous forest inventory data for East-of-Hudson forests and used to obtain basic forest growth information for stand modeling purposes. As part of continuous forest inventory, these plots will be re-measured at approximately 10-year intervals. Continuous forest inventory reports will also be issued at approximately 10-year intervals for each basin inventoried.

## 6.4 Routine Inspections

DEP's Water Quality Directorate conducts visual inspections of the turbidity curtain at the Catskill Upper Effluent Chamber cove, as well as at potential erosion sites. Erosion sites have been progressively stabilized by remediation measures such as planting of vegetation and in 2007, as a result of these improved conditions, inspection frequencies were reduced. Table 6.1 lists the dates and results of the turbidity curtain inspections carried out in 2007. If observations indicated that maintenance was required, Systems Operations was notified and conducted appropriate repairs or adjustments. In addition to the inspections carried out by the Water Quality Directorate, Systems Operations performs its own routine inspections and maintenance of the turbidity curtain (see Section 1.1.3).

Figure 6.4 Photograph of turbidity curtain in the Catskill Upper Effluent Chamber cove.

Table 6.1. Visual inspections of the Catskill Upper Effluent Chamber turbidity curtain.

| Inspection Dates | Comment |
|---|---|
| 01/10/07 | No unusual conditions |
| 02/07/07 | No unusual conditions |
| 03/07/07 | No unusual conditions |
| 03/21/07 | No unusual conditions |
| 04/05/07 | No unusual conditions |
| 04/19/07 | No unusual conditions |
| 05/02/07 | Maintenance required |
| 05/16/07 | No unusual conditions |
| 05/30/07 | No unusual conditions |
| 06/13/07 | No unusual conditions |
| 06/27/07 | No unusual conditions |
| 07/11/07 | No unusual conditions |
| 07/25/07 | No unusual conditions |
| 08/08/07 | No unusual conditions |

Table 6.1. (continued) Visual inspections of the Catskill Upper Effluent Chamber turbidity

| Inspection Dates | Comment |
|---|---|
| 08/22/07 | No unusual conditions |
| | |
| 09/05/07 | No unusual conditions |
| 09/19/07 | No unusual conditions |
| 10/03/07 | No unusual conditions |
| 10/17/07 | No unusual conditions |
| 10/31/07 | No unusual conditions |
| | |
| 11/14/07 | No unusual conditions |
| 11/28/07 | No unusual conditions |
| 12/12/07 | No unusual conditions |
| 12/26/07 | Maintenance required |

## 6.5 Special Investigations

There were three special investigations conducted within the Kensico Reservoir watershed during 2007. These were an oil sheen near Shaft 17 in April (NYCDEP 2007d), a sewage spill near the reservoir in July (NYCDEP 2007e), and a surface water sheen near Shaft 17 in October (NYCDEP 2007f). In addition, DEP conducts routine bi-weekly inspections of the turbidity curtain boom between Malcolm Brook and the Catskill Upper Influent Chamber (see Section 1.1.3).

On April 19, 2007, an oil sheen developed in the mixing channel at Shaft 17. A 50-year-old gate operator that was scheduled for replacement was identified as the source of the spill. Booms and absorbent pads were deployed across the channel. Samples were collected on April 19 and April 20 at the Shaft 17 cove and limnology sampling sites 7 BRK and 6.5 BRK (Rye Lake) for TPH, PCBs, mercury, and lead. Detections occurred only for TPH. It was determined that the pollutant of concern was lubricating oil, and a small amount had escaped in a thin surface layer. Although migration of the fugitive oil in detectable concentrations the additional four to five miles to the reservoir effluents was considered unlikely, on April 21, 23, and 24, samples were collected at effluent keypoints CATLEFF and DEL18. All results were non-detect for lubricating oil.

On July 30, 2007, a sewage pump station spill occurred along New King Street in the town of North Castle, spilling into Kensico tributary E10. Tributary E10 has a semi-permanant boom in place across its mouth, as do E9 and E11. Spill volume estimated by the town was 200-300 gallons. However, analysis of data from DEP's continuous monitoring station at E10 indicated that a more realistic assessment of the spill volume was 20,000 gallons. Stream, reservoir, and keypoint samples were collected over the next few days. Samples collected on August 2 and 3 in transects across Rye Lake, and at the Kensico Reservoir effluent keypoints CATLEFF and DEL18, were all within normal range for all analytes.

On October 10, 2007, what appeared to be an oil sheen was observed in the Shaft 17 channel. Sampling was conducted for TPH and VOCs. This analysis was aborted when field observation and microscopic evaluation at Kensico Laboratory revealed that the material was algal, and not petrochemical, in nature.

# 7. Summary

From January to December 2007, daily regulatory samples for fecal coliform concentration exceeded the SWTR limit of 20 CFU $100mL^{-1}$ only once at the Catskill Lower Effluent Chamber (CATLEFF) and did not exceed the limit at the Delaware Effluent Chamber (DEL18). The mean concentrations for this period were 1.7 and 1.9 CFU $100mL^{-1}$ for CATLEFF and DEL18, respectively. These concentrations are similar to the last reporting period.

In 2007, turbidity, measured every four hours, did not exceed the SWTR limit of 5 NTU at CATLEFF or at DEL18. Mean turbidity measured at the reservoir effluent keypoints was only 1.1 NTU at CATLEFF and 1.0 NTU at DEL18. Therefore, both the fecal coliforms and turbidity were well below SWTR limits throughout 2007.

Annual surveillance monitoring of DEL18 and CATLEFF for 67 VOCs and 68 SVOCs resulted in no compounds being detected.

Routine stream monitoring continued in 2007. Data collected this year were not significantly different from data collected during previous years. Sampling of the BMPs installed on streams tributary to Kensico Reservoir was continued through 2007. This concludes the FAD sampling requirement of the Kensico BMPs. As per the 2007 FAD, a more detailed report of DEP’s findings will be presented in the 2009 Kensico Programs Annual Report.

In 2007, over 300 routine bacteria samples were collected from Kensico Reservoir for total and fecal coliform analyses. The medians for total and fecal coliform samples were below their respective DEP guidelines of 100 CFU $100mL^{-1}$ and 20 CFU $100mL^{-1}$, respectively. As in previous years, there were multiple times when total coliform exceeded the guideline, typically in autumn when most reservoirs experience an increase in bacterial counts. There were only seven instances where fecal coliform samples exceeded the DEP guideline. None of the 335 turbidity samples collected during routine surveys exceeded 5 NTU. As in the past, Site 5 near the Catskill Influent had the highest median turbidity among the eight sites. At the sites closest to the effluent chambers (sites 2 and 3) the turbidity was less than 2.5 for all routine samples.

By agreement with EPA, DEP’s routine monitoring of Kensico watershed groundwater has been discontinued. DEP will continue to receive and review results of ongoing sampling of Westchester County Airport groundwater monitoring wells by Westchester County DOT.

In 2007, DEP collected 420 protozoan samples for *Cryptosporidium* and *Giardia* within the Kensico Reservoir watershed between January 1 and December 24. This sample set included 208 routine fixed-frequency samples with seven enhanced monitoring samples from four keypoints (Kensico Reservoir influent and effluent aqueducts), and 91 fixed-frequency samples with two enhanced monitoring samples at the eight perennial streams. In addition, 64 samples were collected for the Water Resources Development Act (WRDA) project and 48 samples were collected to finalize Safe Drinking Water Act (SDWA) project 5.5. In addition, 208 samples were collected and analyzed for human enteric viruses at the two influent and effluent keypoint locations. Once collected, the protozoan samples were analyzed by the DEP Pathogen Laboratory and the human enteric virus samples were analyzed by Environmental Associates Laboratory.

Keypoint sampling is performed at the aqueduct influents (CATALUM, DEL17) and effluents (CATLEFF, DEL18) of Kensico Reservoir. As in most years, sampling during 2007 included fixed-frequency sampling (weekly) as well as some enhanced monitoring (in response to specific water quality results or events). Kensico Reservoir influent and effluent concentrations of protozoa were typical of previous years. *Cryptosporidium* occurred at very low concentrations and detection frequency. The maximum at all the keypoints was 1 oocyst 50 $L^{-1}$. *Giardia* occurred in most of the keypoint samples analyzed, as observed in 2006, with maxima of 5 and 7 for CATALUM and DEL17 influents, compared to 10 and 8 for the CATLEFF and DEL18 effluents. Furthermore, a greater mean concentration of *Giardia* was detected at the effluents compared to the influents (CATALUM: 0.71 cysts 50 $L^{-1}$ vs. CATLEFF: 2.58; DEL17: 1.54 cysts 50 $L^{-1}$ vs. DEL18: 1.92).

The Kensico streams, which represent the local landscape, averaged approximately 1 *Cryptosporidium* oocyst and 15 *Giardia* cysts per sample this year, which was comparable to the results obtained in 2006. The maximum *Cryptosporidium* result (11 oocysts 50 $L^{-1}$) was detected at Malcolm Brook in December and the maximum *Giardia* result (131 cysts 50 $L^{-1}$) was detected at stream E11 in February.

Three enhanced monitoring sample events occurred at the keypoints. The reasons for these included an elevated result at CATLEFF (1 *Cryptosporidium* 50 $L^{-1}$, 7 *Giardia* 50 $L^{-1}$) on February 6, a six-inch rain event on April 15, and a sewage spill in the North Castle Sewage District on August 3. The follow-up results indicated no elevated protozoan levels, hence enhanced sampling was not continued.

The research projects performed at Kensico Reservoir in 2007 included the continuation of the Water Resources Development Act (WRDA) and Safe Drinking Water Act (SDWA) Grant 5 projects. The analysis of the 2006 WRDA results indicate that the streams monitored for the WRDA project contribute to about 0.5% of the Kensico Reservoir annual water budget and about 5-10% of the (oo)cyst loading, which was potentially higher during large storm events. In addition, the relative loading, average concentration, and loading patterns for the first half of a storm event (rising limb) were compared to those for the latter half of the storm (descending limb). This comparison was also performed for unmodified and post-BMP sample sites. The data revealed a higher loading and concentration for unmodified stream sites in the rising limb of a storm. Conversely, for BMP sample sites, the data indicate slightly higher protozoan concentrations occurring in the descending limb of a storm, even though protozoan loading is higher in the rising limb of a storm, likely due to proportionally greater stream discharge in the rising limb.

The goal of WRDA Phase II, Year 2, was to sample 10 storms (with a minimum of six storms being acceptable) at five sample sites around Kensico Reservoir. By increasing the sampling effort on fewer streams, DEP sought to capture the average protozoan concentrations at the different phases of a storm (rising limb, peak, and descending limb) at each site, and to develop an automated monitoring strategy for sample collection during storm events.

In 2007, six storms were attempted, with five partial sample sets and only one successful complete set of storm samples. Due to the low number of complete storms and samples, DEP requested, and was granted, a five-month extension of the project. The project will now extend into May 2008 in order to collect the minimum amount of data needed for an adequate statistical analysis to answer the questions posed for this last phase of the project.

The SDWA Grant 5 project was designed to determine whether protozoa and other indicator microbial organisms attach to particulate matter during storm events or during base flow conditions. This information will help DEP identify the potential transport of these organisms by determining if they would settle to the bottom of Kensico Reservoir, or be transported across the reservoir into the aqueducts leading to distribution.

The results indicate that a significant fraction of both bacterial indicator organisms, and a protozoan indicator organism, could potentially be removed by sedimentation, based on the evidence that the estimated fraction of the total loadings associated with settleable particles during storm events was 20-30% for the bacteria indicators and up to 80% for the protozoan indicator. Moreover, *Giardia* and *Cryptosporidium* tend to have initially higher settleable fractions which decrease over the duration of the storm. Estimates of cumulative microbial loading also confirmed that wet-weather periods, although intermittent, significantly contribute to the increase in total microbial load in the tributaries, and therefore to Kensico Reservoir.

The management of migratory and resident water bird populations at Kensico Reservoir during 2007 was highly successful. Since its inception in 1993, the Waterfowl Management Program continues to provide the most cost-effective means for fecal coliform bacterial reductions and full compliance with the SWTR.

In 2007 water quality models were used to assist in managing turbidity levels in Kensico Reservoir, which were a concern due to elevated Catskill turbidity following a large storm event in April. Model simulations were used to predict the results of various reductions in Catskill Aqueduct flow on the turbidity levels measured at the Kensico Reservoir effluent locations. Operational decisions were based partially on the guidance provided by the model simulations. The models provided information that helped optimize reservoir operations during this event and proved to be a powerful tool in helping DEP avoid the use of alum treatment.

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