



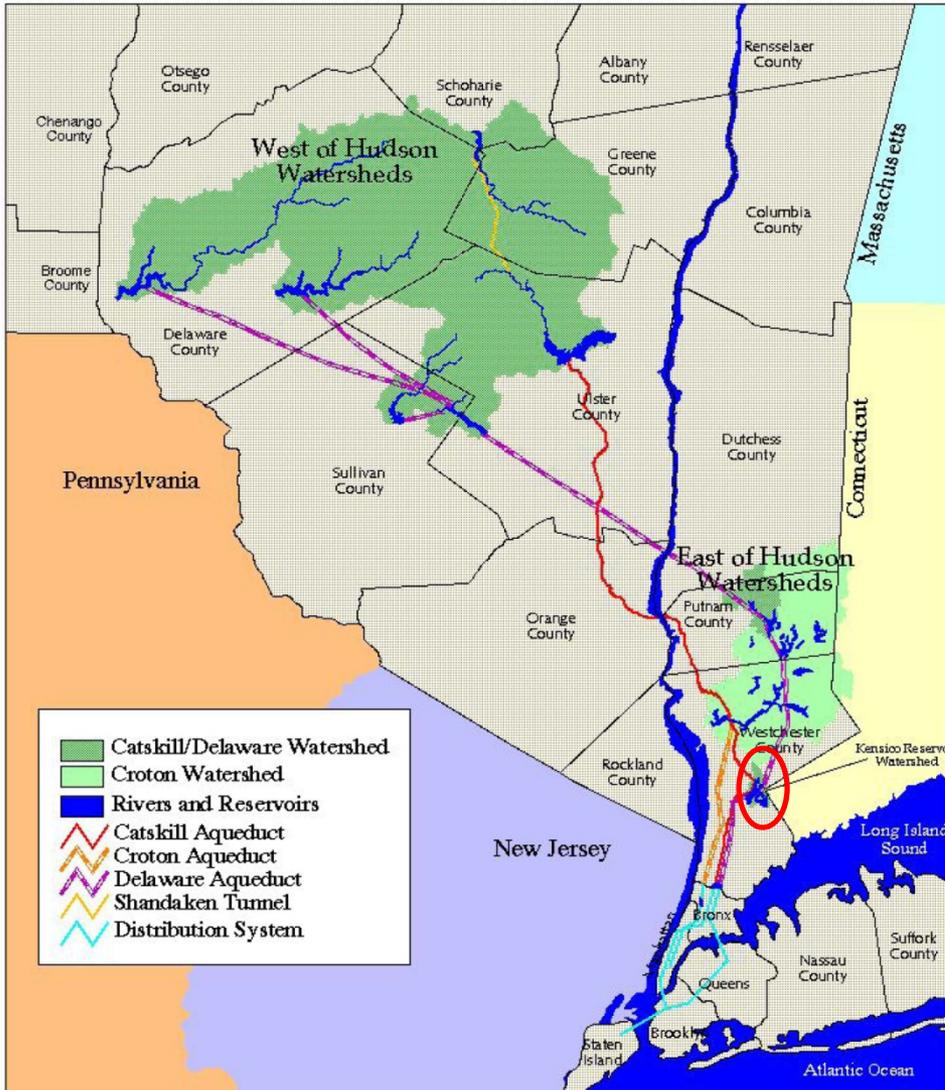
**Environmental
Protection**

Managing Source Water Coliform Bacteria Concentrations After Heavy Storms in 2011

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New York City's Water Supply System



- Over one billion gallons of unfiltered drinking water supplied daily.
- Filtration avoidance requires raw water fecal coliform concentrations be <20 per 100 mL in 90% of the samples collected over a running 6 month period (40 CFR §141.74(a))

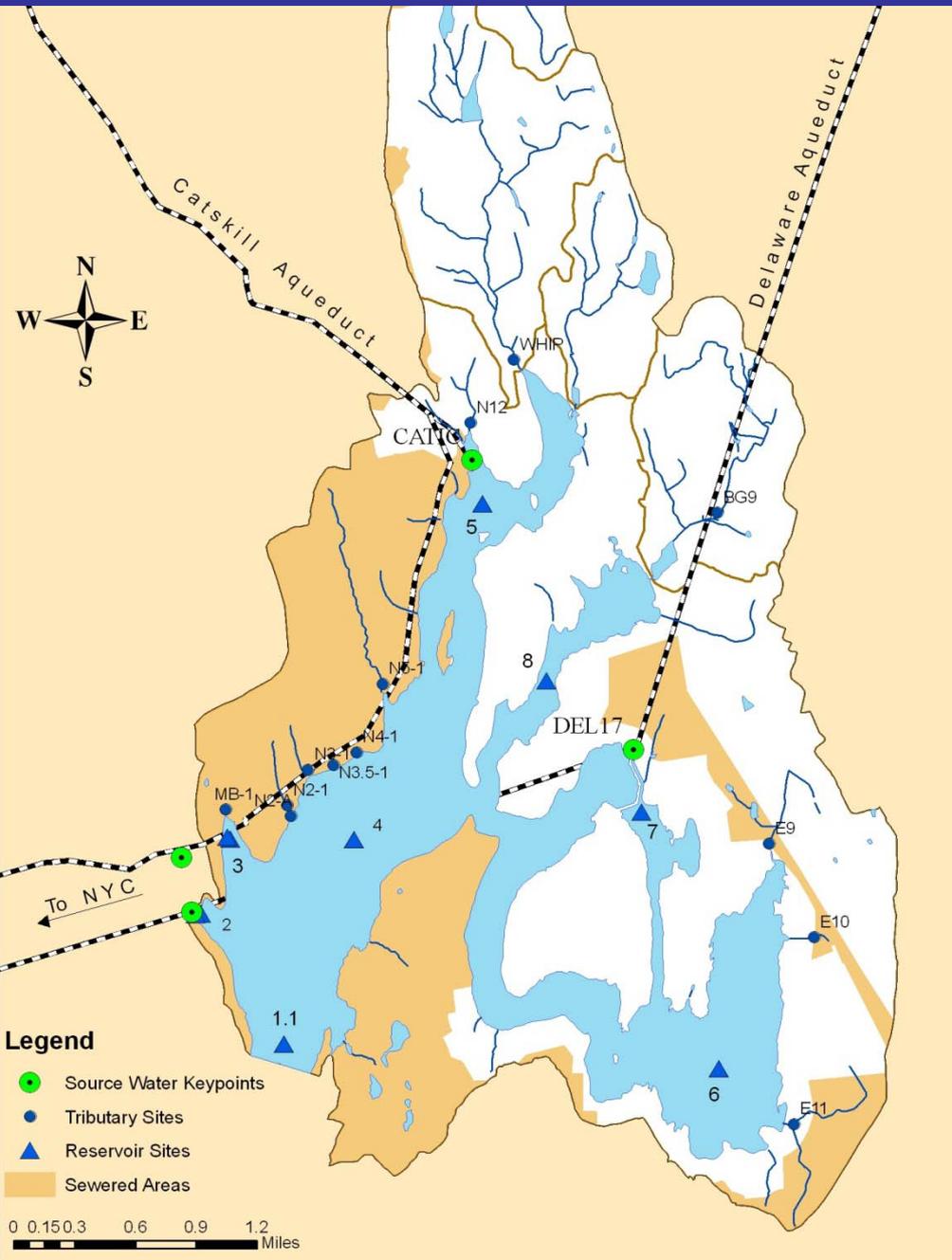


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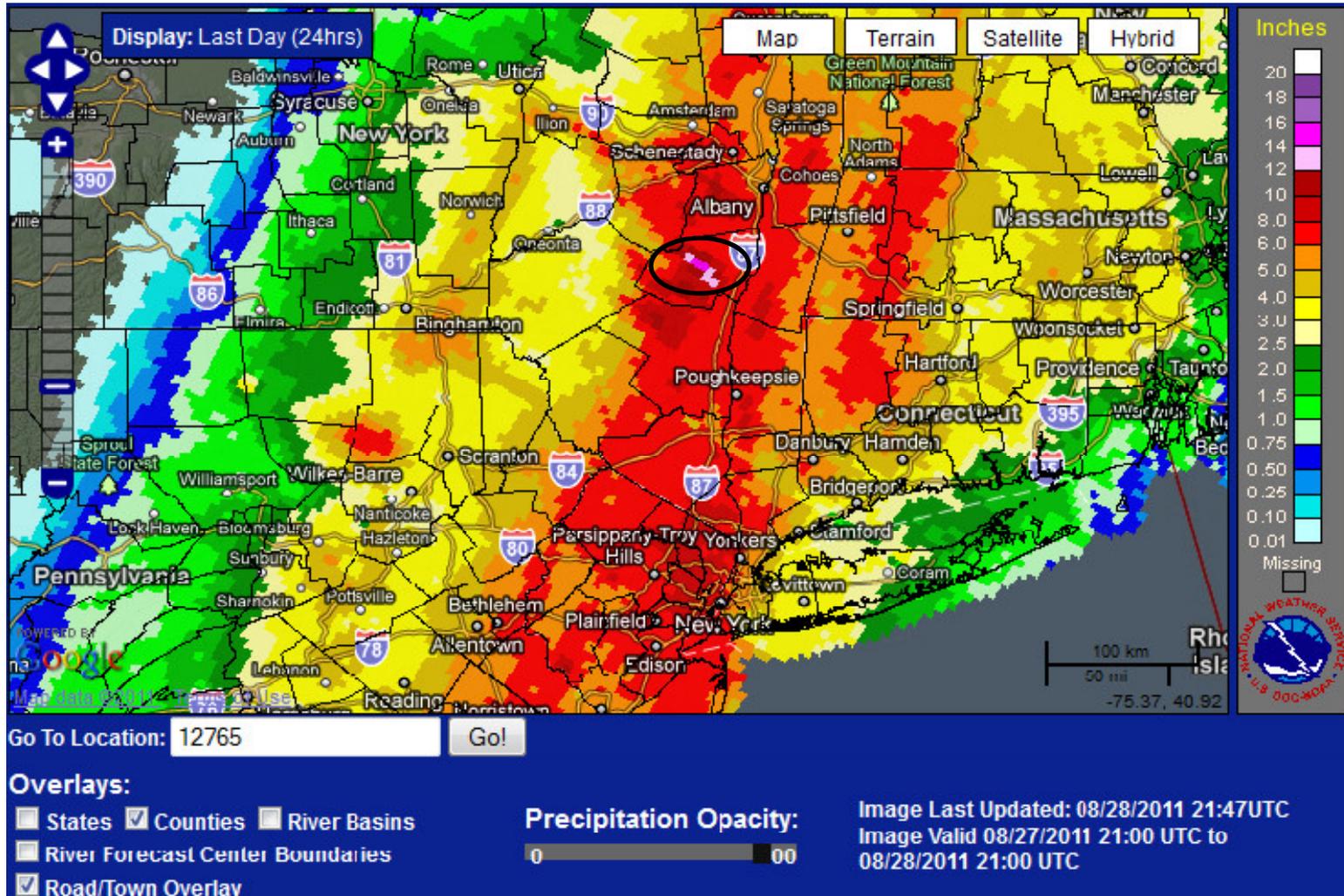
Kensico Reservoir

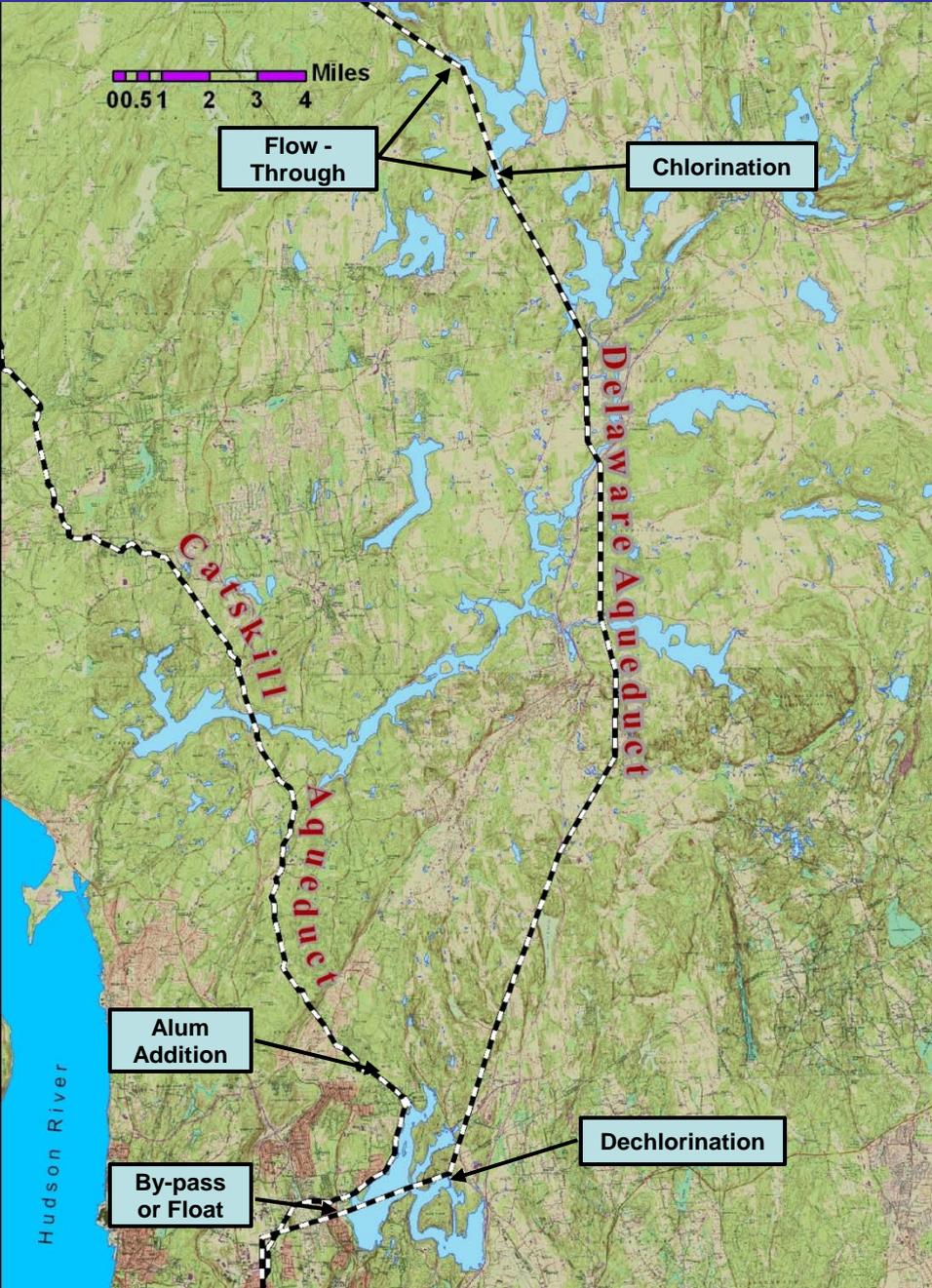
- First placed in service in 1917
- 30.6 BG useable capacity
- NYC's primary Source Water for the Catskill/Delaware System
- Since 1993, Kensico Reservoir has easily complied with the fecal coliform criterion.



- In May 2011 the Kensico Reservoir watershed received over 5 inches of rainfall over five days, and six samples exceeded the 20 FC /100mL threshold over the succeeding five days.
- Human-sourced Bacteroidales were identified from a tributary in the northernmost subbasin of Kensico Reservoir, where private dwellings still use individual septic systems.

Tropical Storm Irene August 28, 2011





Operational Options

- **Flow-through of West Branch Reservoir –** Provides settling time for particulates prior to sending the water to Kensico Reservoir via the Delaware Aqueduct.
- **Alum Addition –**After addition to water in the Catskill Aqueduct, alum floc settles in a cove around the Catskill Influent Chamber in the northern arm of Kensico, and additional monitoring is conducted in accordance with a SPDES permit for the water transfer.
- **Chlorination of Delaware Aqueduct –**Liquid sodium hypochlorite can be injected into the Delaware Aqueduct for control of bacteria in water leaving West Branch Reservoir. Treated water must be dechlorinated before being discharged to Kensico Reservoir in accordance with a SPDES permit for the water transfer.
- **By-pass or Float Mode Operation at DEL18 –** If water quality in Kensico Reservoir is inferior to that of northern reservoirs in the Delaware System, the aqueduct can by-pass the Reservoir completely or be placed in float (partial by-pass) mode, where most water by-passes the Reservoir.

Enhanced Monitoring

Matrix	Typical Frequency	Enhanced Frequency (approx.)
Kensico Keypoints	Daily	Daily
Kensico Limno	Twice monthly	Every 2-3 days
Kensico Tributaries	Monthly	Weekly
West Branch Limno	Twice monthly	Weekly
Pathogen (Keypoints and Tributaries)	Monthly	Every 4-5 days
Rondout Keypoints	Five days a week	Daily
Rondout Limno	Monthly	Every 2-3 days
Ashokan Keypoints	Five days a week	Daily
Ashokan Limno	Monthly	Every 2-5 days



Aug. 28	<ul style="list-style-type: none">• Tropical Storm Irene delivers approximately 6.9 inches of precipitation, 5.6 inches in 24 hours on 8/28.• Catskill and Delaware Systems placed on turbidity alert (>1.5 NTU).• Catskill System leaving Kensico Reservoir shutdown due to high turbidity.	CATLEFF Fecal Coliform 150/100mL	DEL18 Fecal Coliform 53/100mL
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Aug. 29	<ul style="list-style-type: none">• Catskill System leaving Kensico reservoir re-started.• Application of alum to the Catskill Aqueduct north of Kensico Reservoir begins.• Limnology sampling of Kensico Reservoir near CATLEFF finds all sites with fecal coliform concentrations ≥ 100 per 100 mL.• Sampling of Kensico Reservoir tributaries finds fecal coliform from 770 to 32,000 per 100mL at all sites.	CATLEFF Fecal Coliform 150 /100mL	DEL18 Fecal Coliform 70 /100mL
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Aug. 31	<ul style="list-style-type: none">• Kensico Reservoir sampling shows fecal coliform in front of CATLEFF and DEL18 12-72 per 100mL.• Tributary fecal coliform are all 910 or <1000 per 100mL	CATLEFF Fecal Coliform 42 /100mL	DEL18 Fecal Coliform 39 /100mL
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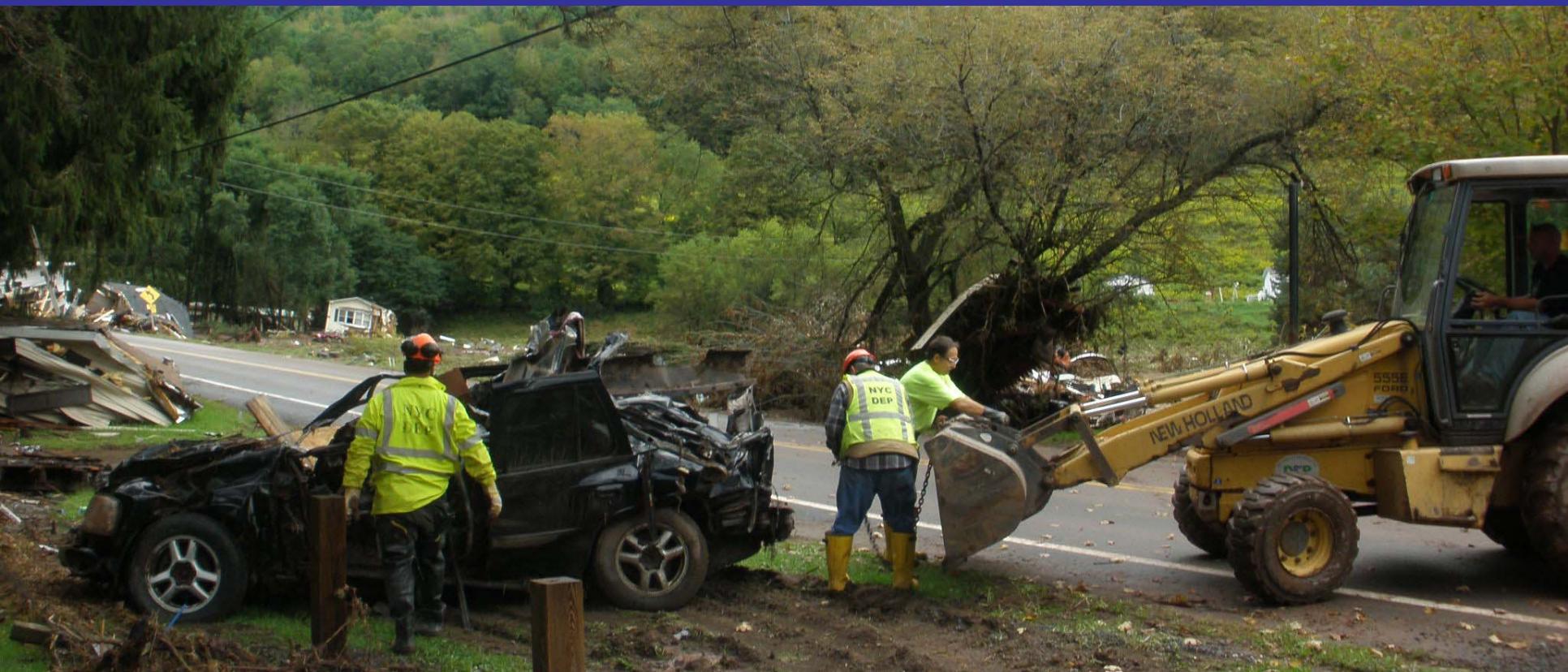




Sept. 1	CATLEFF Fecal Coliform 42 /100mL	DEL18 Fecal Coliform 37 /100mL
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<p>Sept. 3</p>	<ul style="list-style-type: none"> Delaware System placed on by-pass mode at Kensico Reservoir. 	<p>CATLEFF Fecal Coliform 10 /100mL</p>	<p>DEL18 Fecal Coliform 2 /100mL</p>
<p>Sept. 5</p>	<ul style="list-style-type: none"> Delaware System placed back on reservoir mode at Kensico Reservoir. Limnology survey of Kensico Reservoir shows fecal coliform in front of CATLEFF and DEL18 <1-13 per 100mL Kensico Reservoir tributary sampling expanded to BMP influent sites. Fecal coliform 83-1300 per 100mL. 	<p>CATLEFF Fecal Coliform 4 /100mL</p>	<p>DEL18 Fecal Coliform 1 /100mL</p>



Sept. 6	<ul style="list-style-type: none"> Tropical storm Lee begins ultimately delivering 6.2 inches of precipitation over 72 hours. 	CATLEFF Fecal Coliform 7 /100 mL	DEL18 Fecal Coliform 5 /100 mL
Sept. 7	<ul style="list-style-type: none"> Limnology survey of Kensico Reservoir shows fecal coliform in front of CATLEFF and DEL18 3-135. Kensico Reservoir tributary fecal coliform 1000-14,000 per 100mL. 	CATLEFF Fecal Coliform 40 /100 mL	DEL18 Fecal Coliform 39 /100 mL
Sept. 8		CATLEFF Fecal Coliform 760 /100 mL	DEL18 Fecal Coliform 42 /100 mL



<p>Sept. 9</p>	<ul style="list-style-type: none"> • Chlorination of Delaware Aqueduct leaving West Branch Reservoir and dechlorination at aqueduct entering Kensico Reservoir begins. This treatment regime ends on Oct. 19. • Limnology survey of Kensico Reservoir shows fecal coliform in front of CATLEFF and DEL18 9-180 per 100mL. • Reservoir and one tributary sample sent for analysis of F-specific RNA coliphage. 	<p>CATLEFF Fecal Coliform 58 /100mL</p>	<p>DEL18Fecal Coliform 150 /100mL</p>
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Sept. 10	<ul style="list-style-type: none"> Catskill Aqueduct shutdown for 24 hours. 	CATLEFF Fecal Coliform (N.S.)	DEL18 Fecal Coliform 33 /100mL
Sept. 11		CATLEFF Fecal Coliform 36/100mL	DEL18 Fecal Coliform 27/100mL
Sept. 12	<ul style="list-style-type: none"> Limnology survey of Kensico Reservoir shows fecal coliform in front of CATLEFF and DEL18 6-68 per 100mL. Kensico tributary sampling expanded to intermittent swales in the vicinity of the CATELFF and DEL18 intakes. Six samples send for coliphage analysis. Fecal coliform 45-270 per 100mL. 	CATLEFF Fecal Coliform 20/100mL	DEL18 Fecal Coliform 29/100mL



Sept. 29	<ul style="list-style-type: none"> • 2.27" of precipitation over 72 hours. • Limnology survey of Kensico Reservoir shows fecal coliform in front of CATLEFF and DEL18 1-36 per 100mL. • Kensico Reservoir tributary sampling included bacteroides for source tracking. Fecal coliform 150-9700 per 100mL. 	CATLEFF Fecal Coliform 7 /100 mL	DEL18 Fecal Coliform 4 /100mL
Sept. 30	<ul style="list-style-type: none"> • Limnology survey of Kensico Reservoir for turbidity only. Turbidity ~2 NTU near CATLEFF and DEL18. • 6.63% of six month CATLEFF fecal coliform samples >20. • 8.74% of six month DEL18 fecal coliform samples >20. 	CATLEFF Fecal Coliform 6/100mL	DEL18 Fecal Coliform 37/100mL



Oct. 13	<ul style="list-style-type: none"> • 1.45 inches of precipitation over 72 hours. • Automated hourly storm sampling conducted at five tributary sites. Bacteroidales sampled for source tracking at three sites. Positive human marker seen at WHIP. Fecal coliform 16-37,000 per 100mL. 	<p>CATLEFF Fecal Coliform 1 /100mL</p>	<p>DEL18 Fecal Coliform <1 /100mL</p>
Oct. 18	<ul style="list-style-type: none"> • Chlorination/dechlorination of Delaware Aqueduct terminated. 	<p>CATLEFF Fecal Coliform 3/100mL</p>	<p>DEL18 Fecal Coliform 2/100mL</p>

Source Tracking Sampling

Analyte	No. of Samples	Results	Future Monitoring?
F-specific RNA coliphage	22	3 samples with non-human phage, others non-detect	Probably not.
Bacteroidales	12	8 – negative for human 3 – trace human 1 – positive for human	Yes, for human/non-human source tracking
MBAS	8	One detection at MDL inconclusive	Possibly; low-cost analysis

Conclusions from HDR-Gannett Fleming report on Operational Response

- A simple fecal coliform loading analysis “strongly” suggested that Kensico Reservoir sub-basin loads local to CATLEFF and DEL18 are more important to effluent coliform concentrations than distant loads from aqueduct influents or distant sub-basins.
- Very large storms yield higher runoff (on a flow per inch of rainfall basis) than average storms because of disproportionately higher runoff from pervious areas.
- Water quality downstream of extended detention basins analyzed may not be affected solely by the time elapsed since sediment was removed from the basin.

Acknowledgements

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Everyone in the NYC Bureau of Water Supply!