NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATER SUPPLY

DEP Pathogen Mid-Term Surveillance Report on *Giardia* spp., *Cryptosporidium* spp., and Human Enteric Viruses

This report presents the six-month mid-term status of DEP's watershed surveillance results for Giardia spp. and Cryptosporidium spp. for wastewater treatment plants, upstream source water, Kensico perennial streams, pathogen source origin, and method updates. This report provides information primarily for the period of July 1 through December 31, 2012.

January 31, 2013

Prepared in accordance with Section 5.1 of the 2007 United States Environmental Protection Agency Filtration Avoidance Determination

Prepared by: The New York City Department of Environmental Protection
Bureau of Water Supply
Directorate of Water Quality
Watershed WQ Science and Research Division
Watershed Impacts and Pathogen Assessment

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Acknowledgments

This report summarizes results of the protozoan and virus samples collected and analyzed by the New York City Department of Environmental Protection (DEP) Watershed Water Quality Operations (WWQO) staff in the last six months of 2012 that are not already included in the current weekly and monthly DEP reports. This report was produced by the Watershed Water Quality Science and Research (WWQSR) Watershed Impacts and Pathogen Assessment section.

The DEP WWQO field groups, both east and west of the Hudson River, collected all samples during this period and the DEP Kingston Pathogen Laboratory analyzed all protozoan and HEV samples included in this report.

All meteorological data in this report were sourced from the internet via the Weather Underground website (www.weatherunderground.com).

List of Acronyms

CCD	Croton Consent Decree
DEP	New York City Department of Environmental Protection
WQD	Water Quality Directorate
EOH	East of Hudson
FAD	Filtration Avoidance Determination
HEV	Human Enteric Virus
HV	High Volume (50 liters)
ICR	Information Collection Rule
L	Liter
L^{-1}	per liter
MPN	Most Probable Number
NYSDOH	New York State Department of Health
SDWA	Safe Drinking Water Act
USEPA	United States Environmental Protection Agency
WOH	West of Hudson
WWQMP	Watershed Water Quality Monitoring Plan
WWQO	Watershed Water Quality Operations
WWTP	Wastewater Treatment Plant
WWQSR	Watershed Water Quality Science and Research

Executive Summary

The New York City Department of Environmental Protection (DEP) performs compliance and surveillance monitoring for *Cryptosporidium*, *Giardia* and human enteric viruses (HEV) in the New York City Watershed as outlined in the Watershed Water Quality Monitoring Plan (WWQMP) (DEP 2009). Routine samples (n = 134, 133 protozoan and 1 virus) were collected by DEP during this six-month reporting period (July 1 to December 31, 2012). This report includes the sampling results not included in the current weekly and monthly reports that are already written and distributed by DEP. Routine sampling was performed weekly, monthly, bimonthly, or quarterly depending on the WWQMP requirements.

Specifically, this document provides an update on four of the objectives outlined in the WWQMP: Wastewater Treatment Plants (WWTPs), upstream source waters, Kensico Reservoir perennial streams, and watershed pathogen source origin. In addition, an update on laboratory in-house methods is provided.

All WWTPs were sampled at the required sampling frequency during this period and none of the 23 WWTP samples were positive for *Cryptosporidium* or *Giardia*. One HEV sample was collected at the Brewster WWTP in July, and that too was negative. Pathogen monitoring at Brewster WWTP, along with some other Croton Consent Decree previously mandated sampling, was discontinued as of August 1, 2012, after appropriate regulatory permission was granted since NYC has not delivered New Croton water to consumers since 2008.

DEP monitors five reservoir effluents upstream of Kensico monthly for *Cryptosporidium* and *Giardia*. Of the 27 samples, only one was positive for *Cryptosporidium* during this sampling period. Conversely, *Giardia* was detected relatively frequently at the five upstate keypoint sites (55.6% positive) and at concentrations ranging from 0 to 19 cysts $50.8L^{-1}$. The highest detection rate (66.6%) came from the Cannonsville Reservoir, and Schoharie detections decreased to 60.0% from 80.0% positive this time period last year.

The eight Kensico perennial streams were sampled monthly for *Cryptosporidium* and *Giardia* (oo)cysts in 2012. *Cryptosporidium* oocysts were detected in 8.3% of the 48 samples, with results ranging from 0 to 1 oocyst $40.0L^{-1}$ and *Giardia* cysts were detected in 64.6% of the Kensico stream samples, with a range of 0 to 240 cysts $34.8L^{-1}$. This is lower than the detection rate during the same period in 2011 (93.9%), but an increase in the *Giardia* concentration range (0 to 143 cysts $50.1L^{-1}$). Samples taken on November 5 from streams E9 and E11 had the highest *Giardia* results (240 cysts $34.8L^{-1}$ and 67 cysts $50L^{-1}$, respectively).

To satisfy the objective of monitoring for a geographic source origin for protozoa, the 2009 WWQMP includes monthly monitoring at eight stream sites in the Delaware and Catskill districts, where protozoan concentrations have historically been found to be the highest. During the latter six-month period of 2012, *Cryptosporidium* was found in 6 of the 24 samples (25.0%) collected at the six routine source indicator sites, with a maximum concentration of 1 oocyst in a 12.5L sample. *Giardia* was found in all of the 24 samples, demonstrating the ubiquitous nature of *Giardia* in WOH streams. The highest mean cyst concentration was 90.9 cysts $50L^{-1}$ at stream site S4 on Schoharie Creek. Samples targeted for identifying the geographic source of protozoa

found at S7i were rotated among three upstream sites during the last six months of 2012. Results suggest a source of *Giardia* between sites S7iD2 and S7iD3; however, only two rounds of samples have been collected at S7iD3 and sampling will continue into 2013.

As of June 1, 2012 the DEP Kingston Pathogen Laboratory began to analyze DEP HEV samples in-house along with the protozoan samples. It is a great benefit for DEP to have its own in-house virus testing program, as it saves in shipping and analytical costs, as well as allows for more flexibility if unexpected sampling events should arise.

1.0 Introduction

Since July 2002, all *Cryptosporidium* and *Giardia* samples (50L volumes, unless specified) have been collected and analyzed by DEP following EPA Method 1623HV (USEPA 2005). Human enteric virus (HEV) sampling and analyses follow general procedures listed in the Information Collection Rule (ICR) Microbial Laboratory Manual (USEPA 1996) and were processed by DEP's Kingston Lab beginning in June 2012. While references may be made to historical data, previous semi-annual reports or the DEP website should be reviewed to assess historical data. Appendix A, displaying mean concentrations of protozoa per liter, is provided at the end of the document in order to simplify a comparison of data among the non-WWTP sites.

2.0 Surveillance Monitoring

This section addresses four of the objectives outlined in the Watershed Water Quality Monitoring Plan (WWQMP). The purpose of the first subsection is to present results of the long-term monitoring of (oo)cysts at WWTPs in order to monitor treatment upgrades. The second and third subsections present, respectively, a summary of data collected from the upstate keypoint source water monitoring and a summary of surveillance data from the perennial tributaries of Kensico Reservoir. The fourth section is an update on DEP's sampling program at stream indicator sites which attempts to identify any potential geographic point source or nonpoint source origins of protozoa in the watershed.

2.1 Long-term Protozoan Monitoring at WWTPs

In total, there were 12 WWTPs monitored in 2012: nine WOH and three EOH. Sampling was conducted quarterly at 11 plants as required by the WWQMP; therefore, they were monitored at least twice during this six-month reporting period. The Brewster WWTP site, previously required to be monitored under the Croton Consent Decree (CCD), specified monitoring for protozoan pathogens (monthly) and for HEVs (bi-monthly). However, this sampling regime was discontinued August 1, 2012 when DEP was granted relief of WWTP pathogen monitoring under the CCD by the US Attorney's Office, since DEP has not provided New Croton water to consumers since 2008. Therefore, Brewster WWTP was only sampled once (July) during this six month period.

West of Hudson

In February 2012, Ashland WWTP was added to the list of plants sampled West of Hudson, for a total of nine plants. All of the 18 WWTP samples collected West of Hudson during the latter half of 2012 were negative for *Cryptosporidium* and *Giardia* (Figure 1).

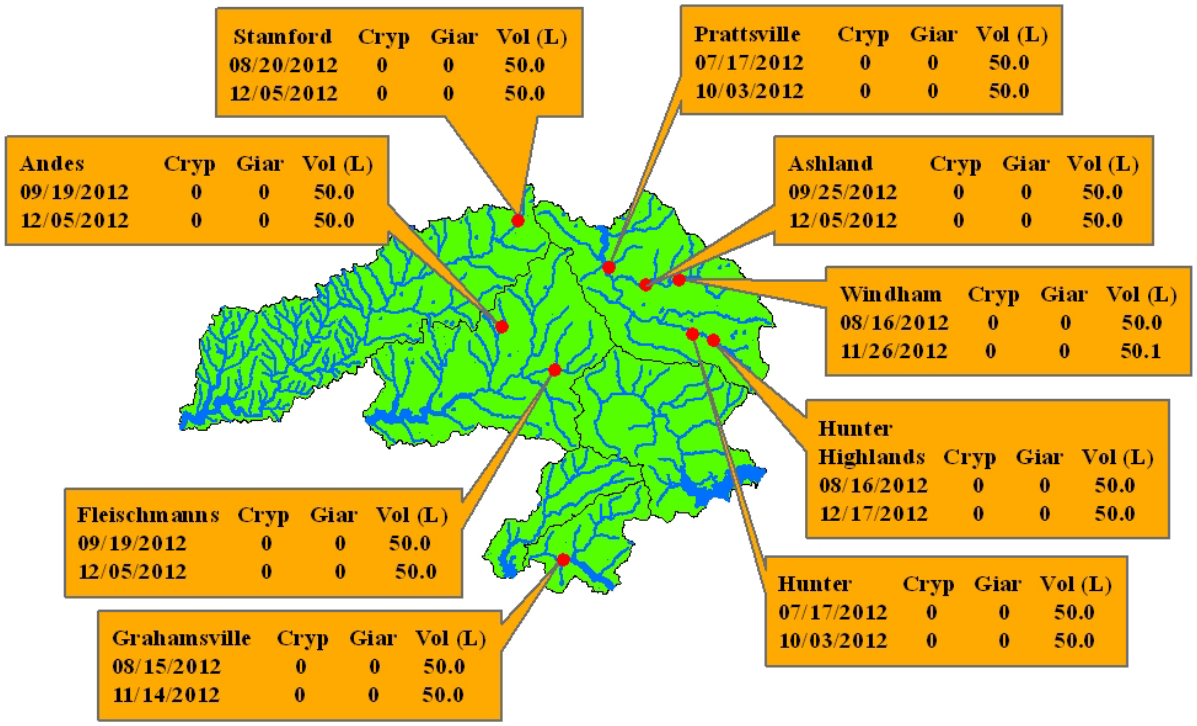

Figure 1. *Cryptosporidium* and *Giardia* monitoring results and sample volumes at WOH WWTPs, July 1 – December 31, 2012.

East of Hudson

EOH WWTP monitoring was scheduled to include monthly protozoan monitoring with bi-monthly HEV monitoring at the Brewster WWTP, and quarterly monitoring for protozoa at the Carmel and Mahopac WWTPs. No *Cryptosporidium* oocysts or *Giardia* cysts were detected in any of the five samples taken at the three EOH treatment plants during this six-month period (Figure 2) and no HEV were detected in the sample taken at the Brewster plant in July.

DEP requested and received permission to discontinue Croton Consent Decree pathogen sampling at WWTPs in 2012. Confirmation of this agreement is presented in a letter from the US Attorney, Loretta Lynch, to Carrie Noteboom of NYC Law Department, dated July 24, 2012, after which no additional Brewster WWTP pathogen samples were collected.

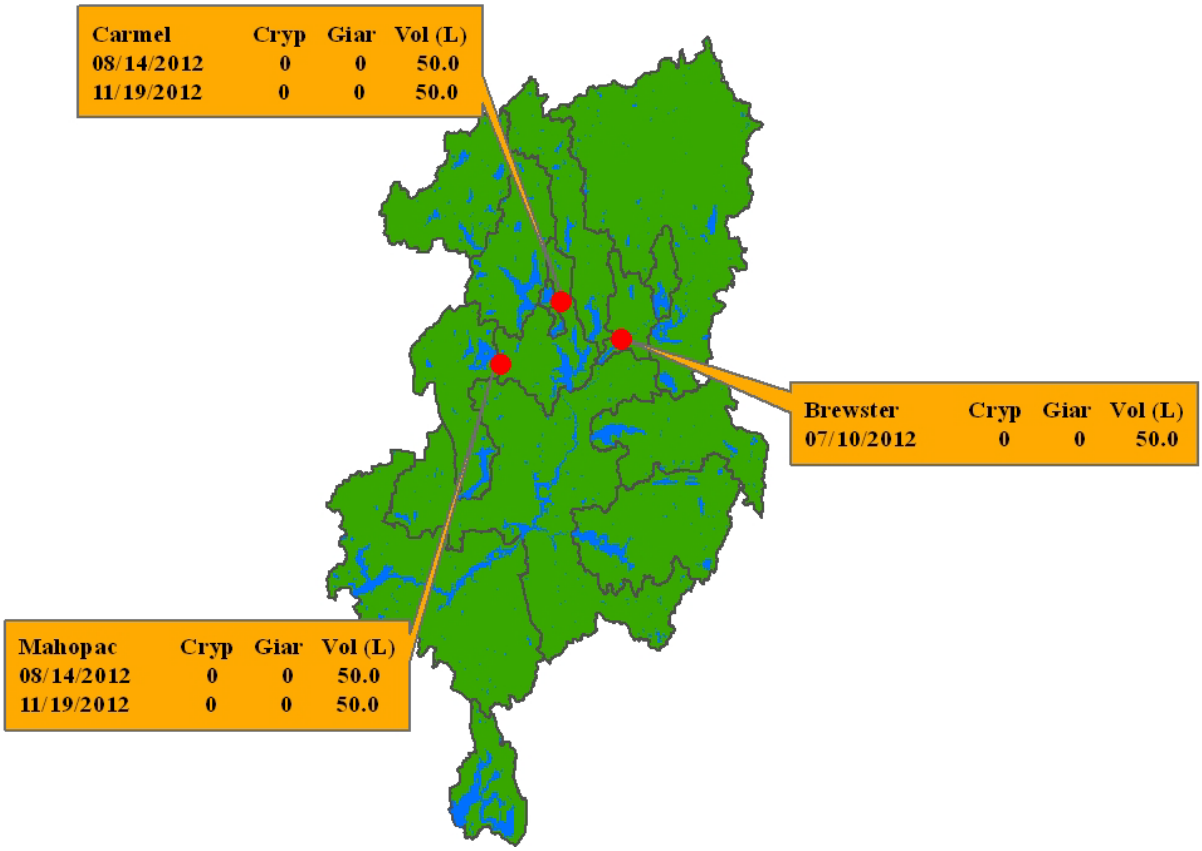

Figure 2. *Cryptosporidium* and *Giardia* monitoring results with sample volumes at EOH WWTPs, July 1 – December 31, 2012.

2.2 Keypoint Monitoring Upstream of Source Water

DEP conducts monthly monitoring at five upstate reservoir effluents; Cannonsville (WDTO), Pepacton (PRR2CM), Neversink (NRR2CM), Rondout (RDRRCM), and Schoharie (SRR2CM). Four of these effluents are in the Delaware district and one reservoir effluent (Schoharie) is in the Catskill district. As part of this objective, DEP is also required to sample the Catskill and Delaware source waters just prior to their entry to Kensico Reservoir. However, the Catskill and Delaware influent sample results (CATALUM and DEL17, respectively) are already reported monthly according to FAD requirements, hence those results have not been repeated in this report. As of September 12, 2011, DEP discontinued sampling at alternate upstream sample taps when the reservoir diversions are not actively in use. For this reason, four monthly samples (three from Neversink and one from Schoharie) were not scheduled because the reservoir diversions were off-line.

Four of the upstream source water sites (WDTO, RDRRCM, PRR2CM and SRR2CM) were negative for *Cryptosporidium* during this period, while the fifth site (NRR2CM) had a single detection in December 2012 (1 oocyst $40.8L^{-1}$) (Figure 3). The mean concentration at this site remained low at 0.008 oocysts L^{-1}.

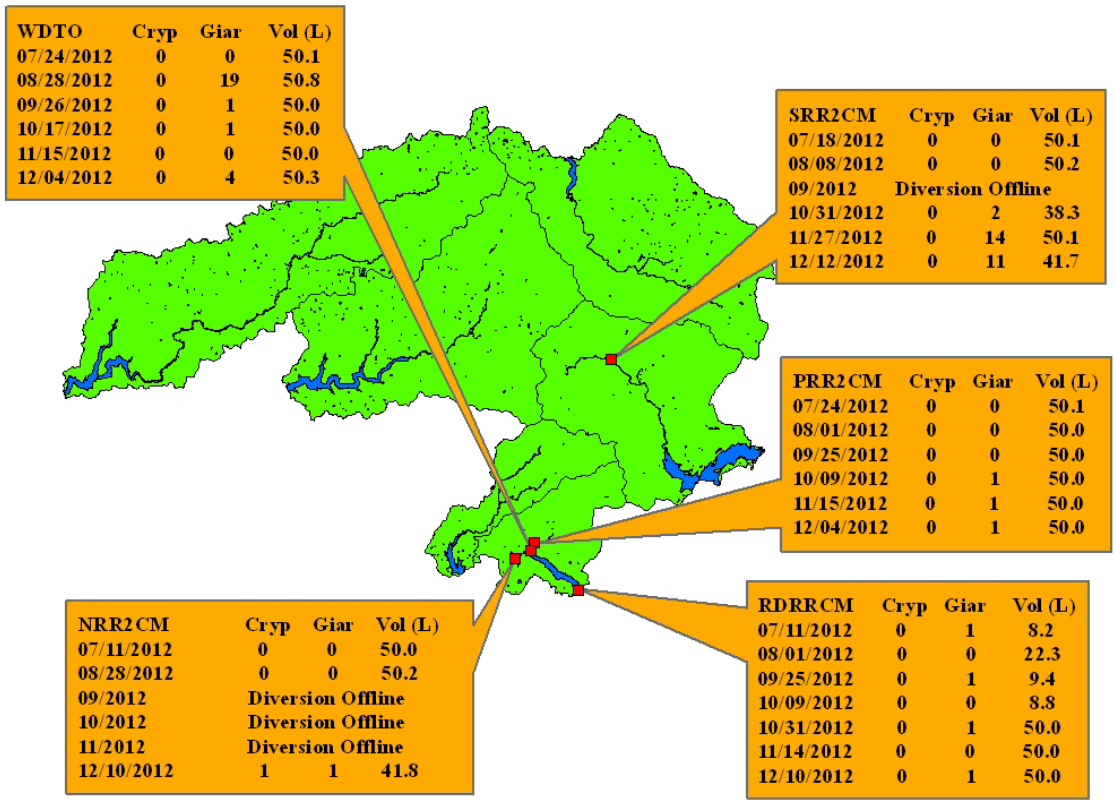

Figure 3. Upstream keypoint *Cryptosporidium* and *Giardia* monitoring results and sample volumes, July 1 – December 31, 2012.

Giardia was detected in just over half of samples (15 of 27, 56%) taken at the upstream keypoint sites, a slight increase from the 48% of samples (12 out of 25) with *Giardia* detections during the same period in 2011. Cannonsville (WDTO) had the highest site detection rate (67%) and the highest concentration of *Giardia* for a single sample (0.37 cysts L^{-1} on August 28) during the period (Table 1). A review of precipitation data from the meteorological station in Walton, NY shows over 2 inches of rain for August 27 and 28, indicating that heavy rainfall may have been the cause of this elevated result at WDTO. Schoharie (SRR2CM) had the highest mean concentration (0.12 cysts L^{-1}) over the six-month period, however this represents a reduction in the mean at this site compared to the same period in 2011 (0.18 cysts L^{-1}).

Table 1. *Giardia* concentrations (L^{-1}) found in individual samples taken at upstream reservoir keypoint sites (July 1 – December 31, 2012).

Sites	July	August	September	October 9	October 31	November	December
NRR2CM	0.00	0.00	NSR	NSR	NSR	NSR	0.02
PRR2CM	0.00	0.00	0.00	0.02	NSR	0.02	0.02
RDRRCM	0.12	0.00	0.11	0.00	0.02	0.00	0.02
SRR2CM	0.00	0.00	NSR	NSR	0.05	0.28	0.26
WDTO	0.00	0.37	0.02	0.02	NSR	0.00	0.08

NSR = no sample required

An additional sample was taken at the Rondout keypoint site (RDRRCM) in October as an attempt to reach the full target volume for DEP sampling. The target volume of 50L had not been reached at this site since August 2011, despite generally low turbidity, because sample line pressure was limited and could not be modified by staff. In response, the collection method for this site was modified to collect the sample from a steadily filled sterile carboy (rather than directly from the tap), in order to collect 50L. The detection rate was slightly higher compared to the same time frame in 2011 (50% to 67%), while the mean concentration decreased from 2.85 to 0.67 cysts L^{-1}. It should be noted that all the detections at this site were 1 cyst per sampled volume collected.

2.3 Evaluation of Kensico Reservoir Stream Inputs

Eight perennial streams representing the major watershed inputs of Kensico Reservoir were monitored monthly during this period. These eight streams represent a very small proportion, approximately 0.5%, of Kensico Reservoir's annual flow budget (Pace et al. 2009) compared to the amount contributed by the Catskill and Delaware influents (over 1 billion gallons per day). However, these streams are monitored for pathogens due to their proximity to the Kensico Reservoir effluents and their potential to have an abrupt, negative impact on those effluents.

During the July through December sampling period, 48 samples were collected and analyzed for *Cryptosporidium* and *Giardia* (Figure 4). The target sample volume was always 50L; however, 17 of the 48 samples (35%) (compared to 19 out of 49 samples during the same period last year) were less than 50L because filters became clogged with suspended particles during collection.

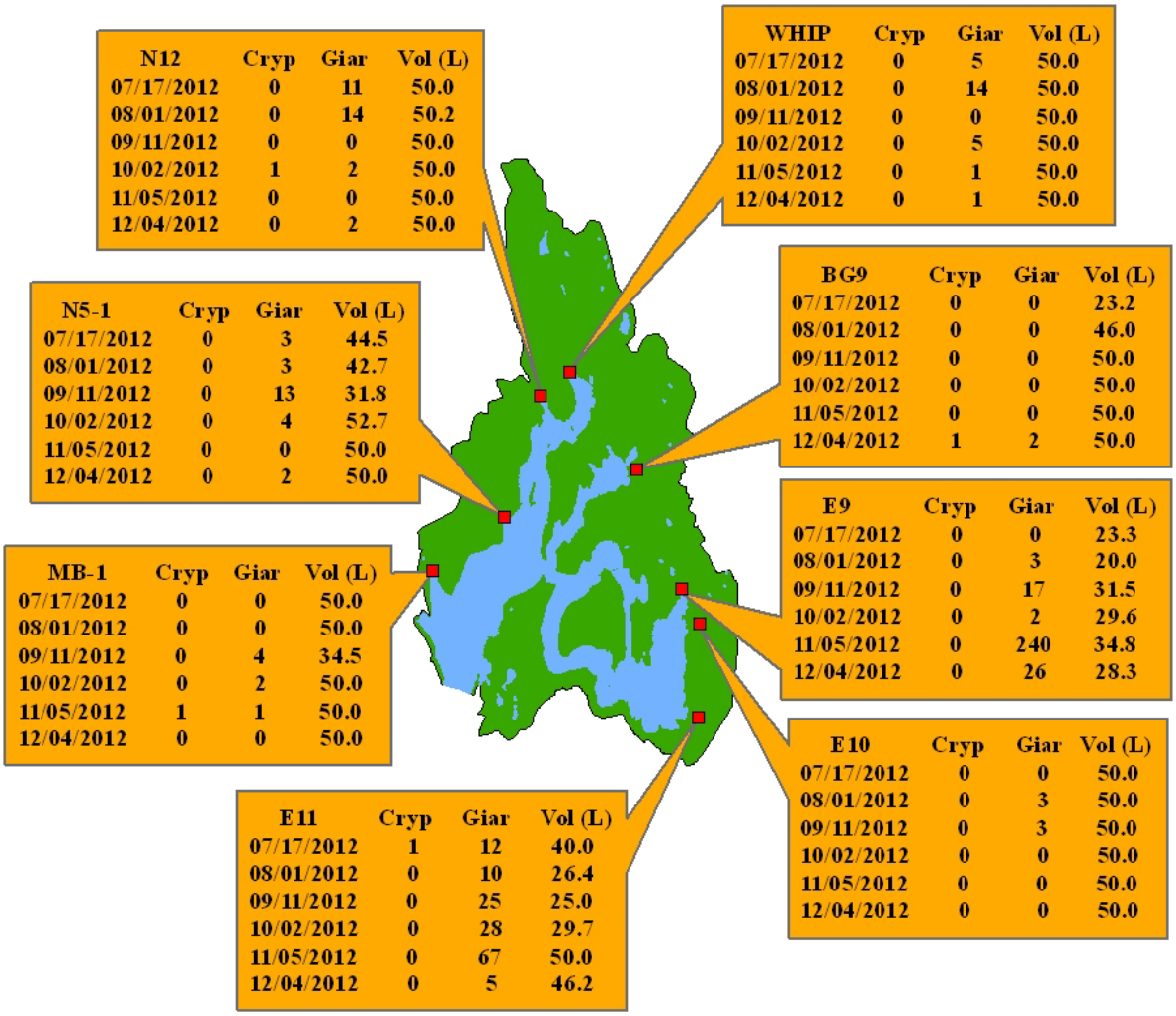

Figure 4. *Cryptosporidium* and *Giardia* monitoring results and sample volumes for Kensico perennial streams, July 1–December 31, 2012.

Analysis of Kensico Reservoir tributary samples demonstrated a low occurrence of *Cryptosporidium*, as 4 of 48 samples (8.3%) were positive for *Cryptosporidium* and the highest individual sample count was 1 oocyst in a 40.0L sample at E11 in July (Figure 4). As in the past, detections of *Cryptosporidium* were not focused at any one stream or area of the reservoir, but were dispersed among four of the eight streams in the watershed.

Giardia was detected in 31 of 48 Kensico tributary samples (64.6%) taken during this period, with results ranging from 0 to 240 cysts per sample, with many sample volumes below 50L. This is lower than the same six month period in 2011 which had an 80% *Giardia* detection rate. Seventeen of the 48 samples had volumes less than 50 L (Figure 4) and these samples had a higher rate of *Giardia* detection (82.4%) than the 31 samples with 50L or higher volumes (54.8% positive for *Giardia*). This may suggest an increase in detection when there are more particles in the sample that in turn clog the filter; however, past years have not indicated this same phenomenon. Stream E9 had the highest *Giardia* result per sample (240 cysts $34.8L^{-1}$) and E11

had the second highest (67 cysts $50L^{-1}$), and both samples were collected on November 5. While there were no rain events in the five days prior to these samples, Hurricane Sandy made landfall in New York approximately seven days before (on October 29), with damaging winds and just short of half an inch of precipitation in the Kensico area. It is possible that this major storm event, especially the high winds, had an effect on protozoan transport in the Kensico streams. For ease of comparison between individual samples, concentrations of *Giardia* per liter are provided below (Table 2).

Table 2. *Giardia* concentrations (L^{-1}) found in individual samples taken at Kensico perennial stream sites (July 1–December 31, 2012).

	Sample Dates					
Sites	7/17/2012	8/1/2012	9/11/2012	10/2/2012	11/5/2012	12/4/2012
BG9	0.000	0.000	0.000	0.000	0.000	0.040
E10	0.000	0.060	0.060	0.000	0.000	0.000
E11	0.300	0.379	1.000	0.943	1.340	0.108
E9	0.000	0.150	0.540	0.068	6.897	0.919
MB-1	0.000	0.000	0.116	0.040	0.020	0.000
N12	0.220	0.279	0.000	0.040	0.000	0.040
N5-1	0.067	0.070	0.409	0.076	0.000	0.040
WHIP	0.100	0.280	0.000	0.100	0.020	0.020

2.4 Watershed Pathogen Source Origin

To satisfy the objective of monitoring WOH stream sites with higher mean protozoan concentrations relative to other previously monitored sites, the WWQMP includes monthly monitoring at a total of eight stream sites located in the Delaware and Catskill districts. Monitoring at four of these sites was reduced to bi-monthly in 2012 to accommodate other field monitoring activities. Monitoring at the other four sites (three in the S7i Manorkill watershed, and one at PROXG) was not reduced but kept to a monthly schedule to facilitate the ongoing investigation into high *Giardia* counts in the Manorkill, and to support future investigation upstream of PROXG.

As reported previously, analysis of historical data up through June 2009 indicated no concerns regarding *Cryptosporidium* concentrations at the eight sites; however, there were some interesting *Giardia* results at stream site S7i. In order to investigate two new sites upstream of S7i, DEP discontinued sampling at the two sites that had the lowest *Giardia* means, which were PMSB in Pepacton and ABCG in Ashokan. As a result, neither PMSB nor ABCG were sampled during 2012, as DEP rotated through four sites upstream of S7i.

Cryptosporidium concentrations were low at the six routine sites monitored during this reporting period, with no more than 1 oocyst detected per volume sampled, and a 25% detection rate (Figure 5). Two sites (S5i and S4) sampled on September 19, each had a single oocyst detected in much lower than normal sample volumes (12.5 and 20.4L, respectively), and while these

concentrations are low, they exceeded the site 95th percentile since historical values have been so low. Albany Airport recorded a precipitation event over 3 inches of rain the previous day (September 18), and this may have been the cause of the elevated results as heavy precipitation is known to move contaminants from the watershed surfaces into streams.

Giardia was detected in 100% of samples at the six routine sites, demonstrating the ubiquitous nature of *Giardia* in WOH streams, and they were recovered at a range of 8 to 202 cysts per volume sampled. A sample taken at site S4 in July had a count of 202 *Giardia* cysts in a 50L sample, which exceeded the 95th percentile for *Giardia* at this site. According to meteorological stations at Albany Airport and Hunter Mountain, only trace amounts of rain were recorded in the week prior to this sample, suggesting that the elevated result was not a direct result of precipitation, but perhaps a direct source upstream (wild or farm animals). Values per liter for each sample along with a mean for each site sampled during this period are provided in Table 3 for comparison purposes. Results from the routine sites generally exhibited a similar range in mean *Giardia* concentrations (0.22 to 1.82 cysts L^{-1}) compared to the same period in 2011 (0.26 to 1.80 cysts L^{-1}). Overall, these results support historical data showing that *Giardia* is generally one to two orders of magnitude higher in concentration than *Cryptosporidium* in the watershed.

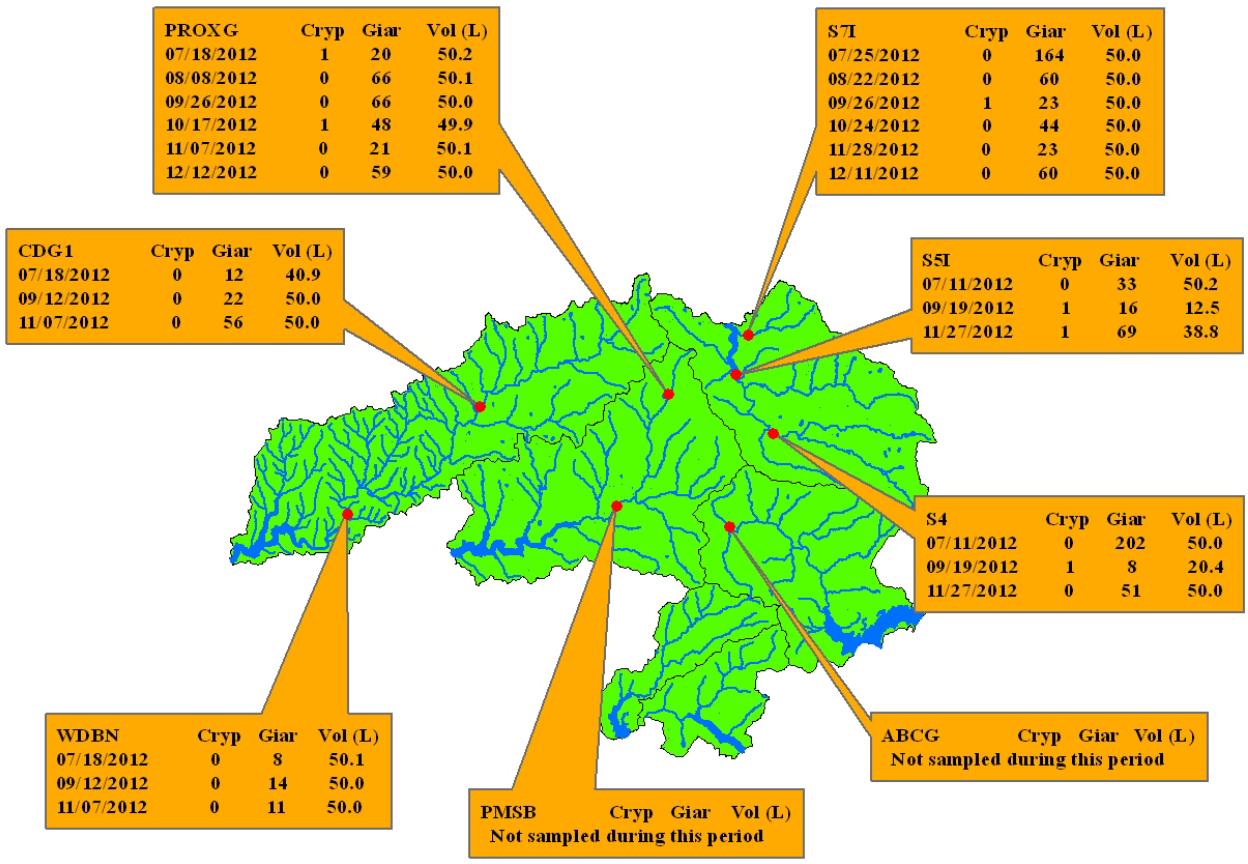

Figure 5. Routine watershed pathogen source indicator site *Cryptosporidium* and *Giardia* monitoring results and sample volumes, July 1 – December 31, 2012.

Table 3. *Giardia* concentrations (L^{-1}) found in individual samples taken at pathogen source origin sites (July 1 – December 31, 2012) and the mean for the reporting period.

Sites	July	August	September	October	November	December	Mean
ABCG	NS	NS	NS	NS	NS	NS	NS
CDG1	0.293	NSR	0.440	NSR	1.120	NSR	0.618
PMSB	NS	NS	NS	NS	NS	NS	NS
PROXG	0.398	1.317	1.320	0.962	0.419	1.180	0.933
S4	4.040	NSR	0.392	NSR	1.020	NSR	1.817
S5i	0.657	NSR	1.280	NSR	1.778	NSR	1.239
S7i	3.280	1.200	0.460	0.880	0.460	1.200	1.247
S7iB	0.020	0.059	0.140	0.380	0.440	0.840	0.313
S7iD2	1.487	2.808	0.540	0.620	NS	NS	1.364
S7iD3	NS	NS	NS	NS	0.020	0.060	0.040
WDBN	0.160	NSR	0.280	NSR	0.220	NSR	0.220

NS = not sampled

NSR = no sample required

Targeted monthly sampling upstream of site S7i began in January 2010 with sites S7iA and S7iB, progressing upstream over the years to S7iE through October 2011 (Figure 6). It was determined that the *Giardia* source was most likely downstream of S7iE due to its low results. Sampling continued from 2011 into early 2012 upstream of S7iD and downstream of S7iE at sites S7iD1 and S7iD2, where high results continued to be found up through October 2012. Samples from both of these "in between" sites indicated an upstream source for high *Giardia* counts, at which point, the sampling location was again moved upstream to S7iD3. Two samples have been taken at this new site concurrent with samples downstream at S7i and S7iB and results suggest that the G*iardia* source is downstream of S7iD3 (highlighted in Table 4). Additional months of sampling at S7iD3 are expected in 2013.

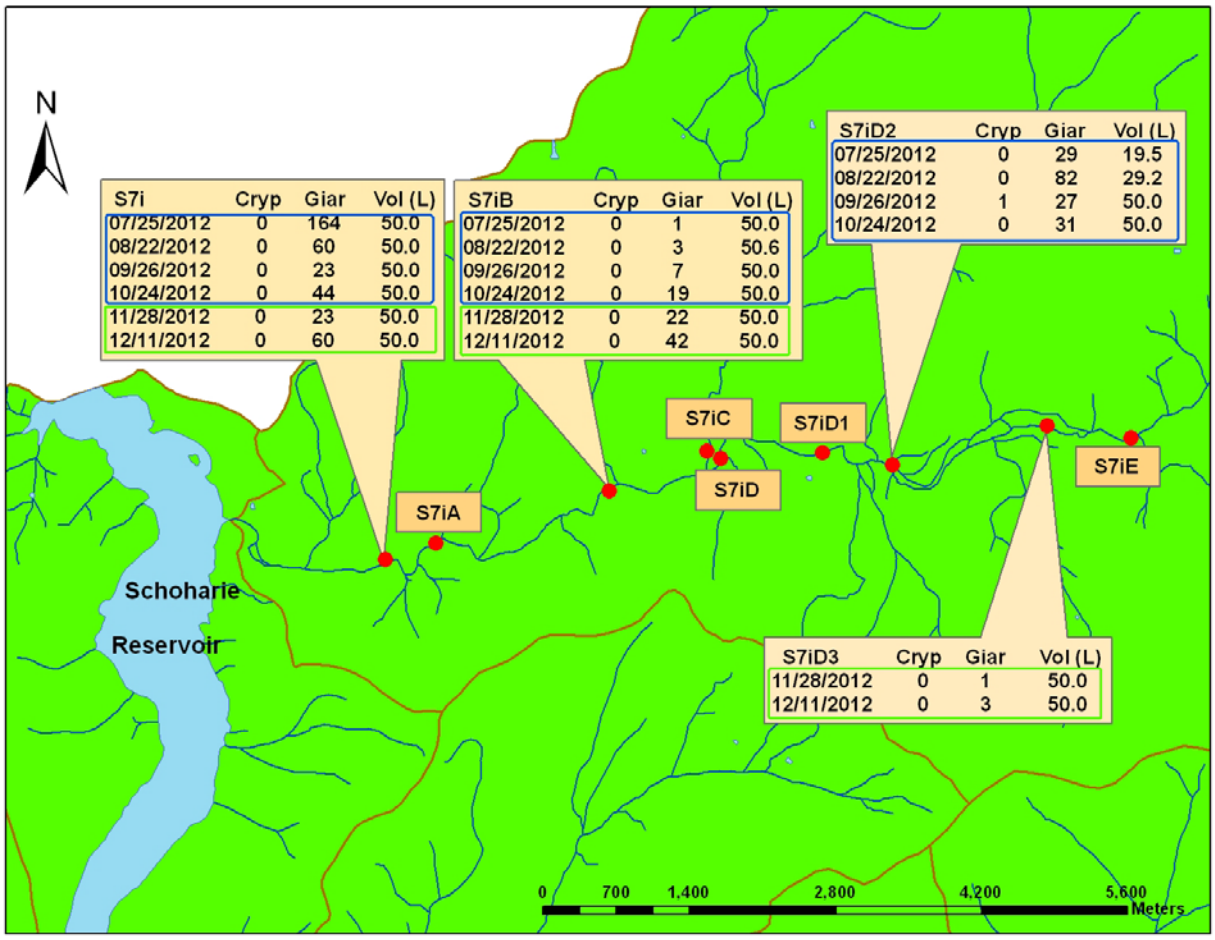

Figure 6. Map of targeted upstream sampling sites in the S7i Manorkill watershed with protozoan sample data from July to December 2012.

3.0 Pathogen Method Updates

This section provides updates on activities and methods in-house at DEP during the course of this reporting period.

3.1 In-House Human Enteric Virus (HEV) Analysis

In 2011, responsibility for sterilizing the HEV filter housings was transferred in-house to the DEP Pathogen Laboratory. This reduced the contract laboratory cost for DEP to HEV testing only. After several months spent examining health and safety concerns, DEP moved forward with learning the various parts of the ICR HEV method that was being used by the contract laboratory, and had a goal to bring all HEV testing in-house during 2012.

Starting a new analytical program is no small task. Various equipment and supplies needed to be purchased to perform the new testing. Additionally, staff made several visits to learn more about the method, which included visiting the current contract laboratory, Environmental Associates

Ltd., and the University of New Hampshire to meet with Dr. Aaron Margolin to observe the HEV method in real time. Conference calls were also held to discuss issues that arose when practicing the method in the DEP laboratory. Ultimately, demonstration of capability testing was completed, and a validation package was approved by DEP's Quality Assurance staff. The DEP began processing HEV samples as of June 1, 2012 and the outside contract for analysis was discontinued.

4.0 References

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Appendix A

Mean concentrations per liter for *Cryptosporidium* and *Giardia* at upstream reservoir keypoints Kensico perennial streams, and pathogen source origin objective sites during the sampling period July 1–December 31, 2012.

Late 2012

Objective	Site	Mean Cryptosporidium / L	Mean Giardia / L
Upstream Reservoir Keypoints	NRR2CM	0.008	0.008
	PRR2CM	0.000	0.010
	RDRRCM	0.000	0.038
	SRr2CM	0.000	0.119
	WDTO	0.000	0.082
Kensico Perennial Streams	BG9	0.003	0.007
	E10	0.000	0.020
	E11	0.004	0.678
	E9	0.000	1.429
	MB-1	0.003	0.029
	N12	0.003	0.096
	N5-1	0.000	0.110
	WHIP	0.000	0.087
Pathogen Source Origin	ABCG	NS	NS
	CDG1	0.000	0.618
	PMSB	NS	NS
	PROXG	0.007	0.933
	S4	0.016	1.817
	S5i	0.035	1.239
	S7i	0.003	1.247
	S7iB	0.000	0.313
	S7iD2	0.005	1.364
	S7iD3	0.000	0.040
	WDBN	0.000	0.220