RUTGERS
New Jersey Agricultural Experiment Station

Water Resources Program

Watershed Restoration and Protection Plan for the Musconetcong River Watershed from Hampton to Bloomsbury Water Quality Monitoring Data Report

Developed by the Rutgers Cooperative Extension Water Resources Program
for North Jersey Resource Conservation & Development Council

Funded by North Jersey Resource Conservation & Development Council
and the New Jersey Department of Environmental Protection
319(h) Program ~ RP06-073

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Acknowledgements

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Table of Contents

List of Figures

List of Tables

Watershed Overview

The Musconetcong River Watershed is one of the five major subwatershed basins of the Upper Delaware Watershed. Located in northwest New Jersey, the Musconetcong River Watershed is 156 square miles in total size. The specific project area for this Watershed Restoration and Protection Plan covers approximately seven (7) river miles of the Musconetcong River and an additional 19 miles of tributaries (i.e., West Portal Brook, Turkey Hill Brook, and five (5) unnamed tributaries). The project area covers 19.6 square miles, portions of five (5) municipalities (Hampton Borough, Lebanon, Bethlehem, Washington, and Franklin Townships) and two (2) counties (Hunterdon and Warren) (Figure 1). Two HUC-14 subwatersheds (HUC 02040105160040 and 50) delineate the project area. The project area is characterized by large expanses of agricultural land in the river valley, woodlands on the ridgelines, and scattered residential and commercial development (Figure 2). Approximately 45% of the watershed is comprised of agricultural land cover. Forest, wetland and water comprise approximately 39%, and urban development is approximately 15% of the watershed (Figure 3). The urban development is comprised mostly (i.e., 65%) of single unit rural residential land use.

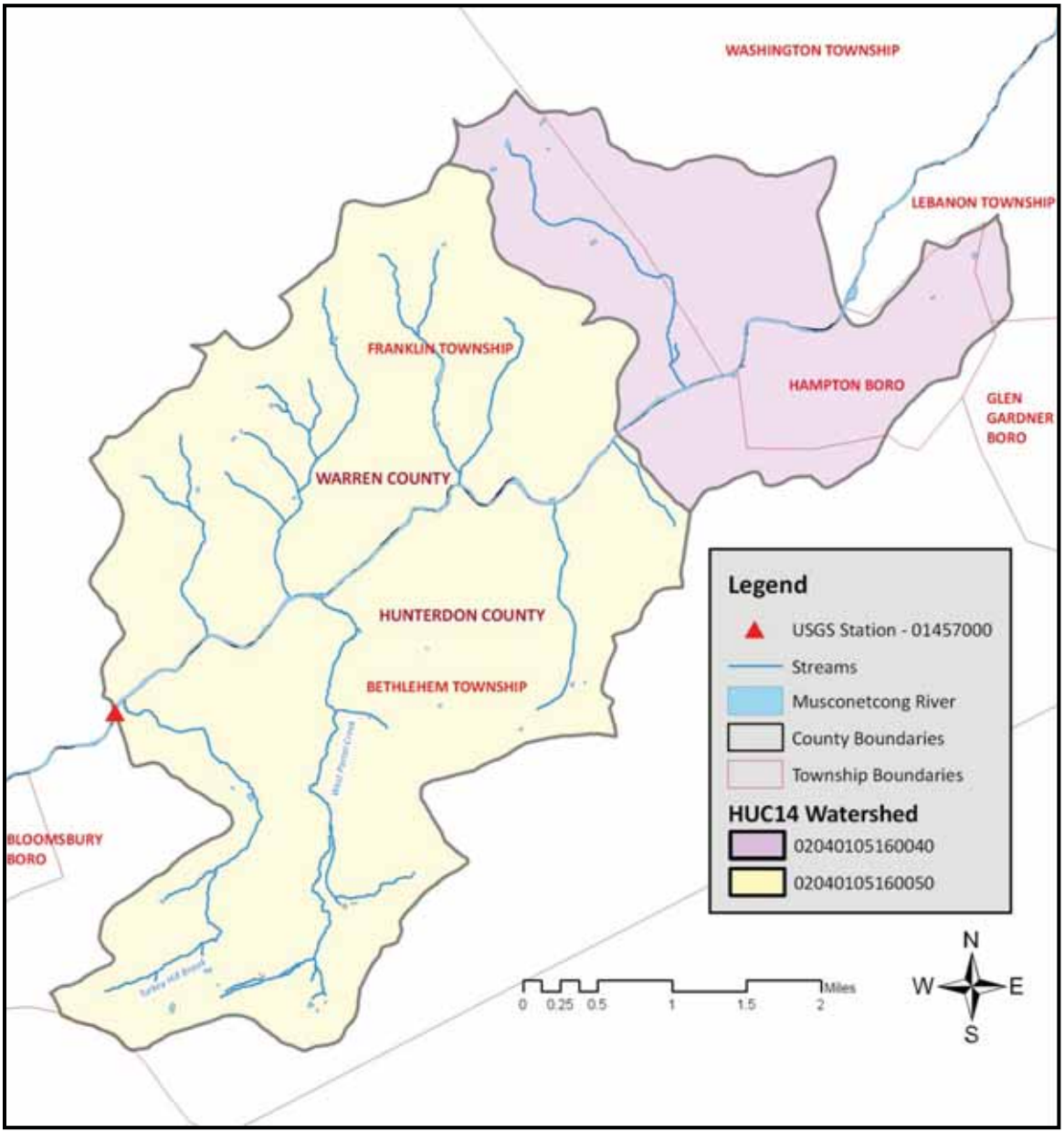

Figure 1. Municipalities, waterbodies, streams and rivers located within the Musconetcong River Watershed (NJDEP, 2002b)

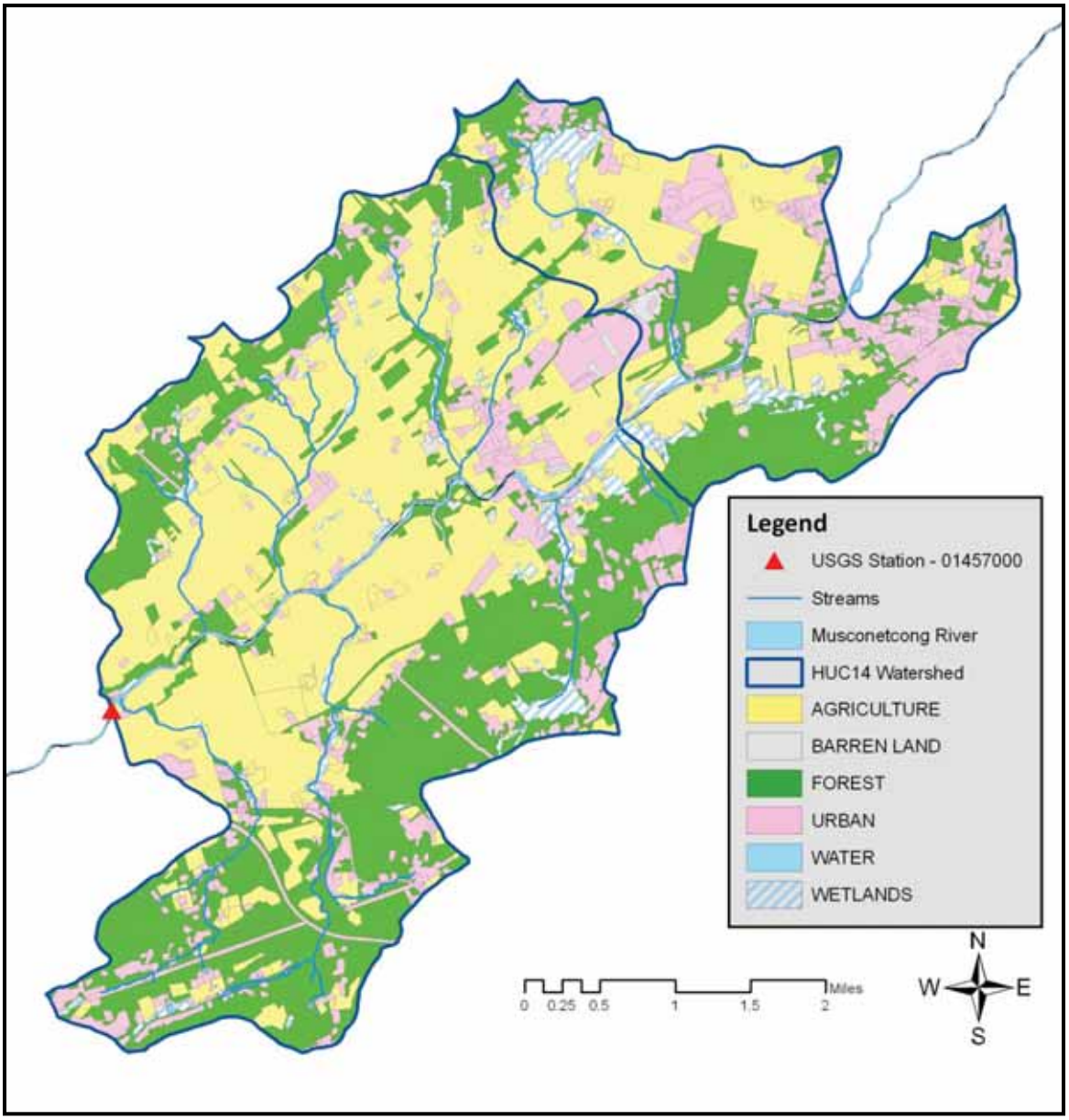

Figure 2. Land use map for the Musconetcong River Watershed (NJDEP, 2002b)

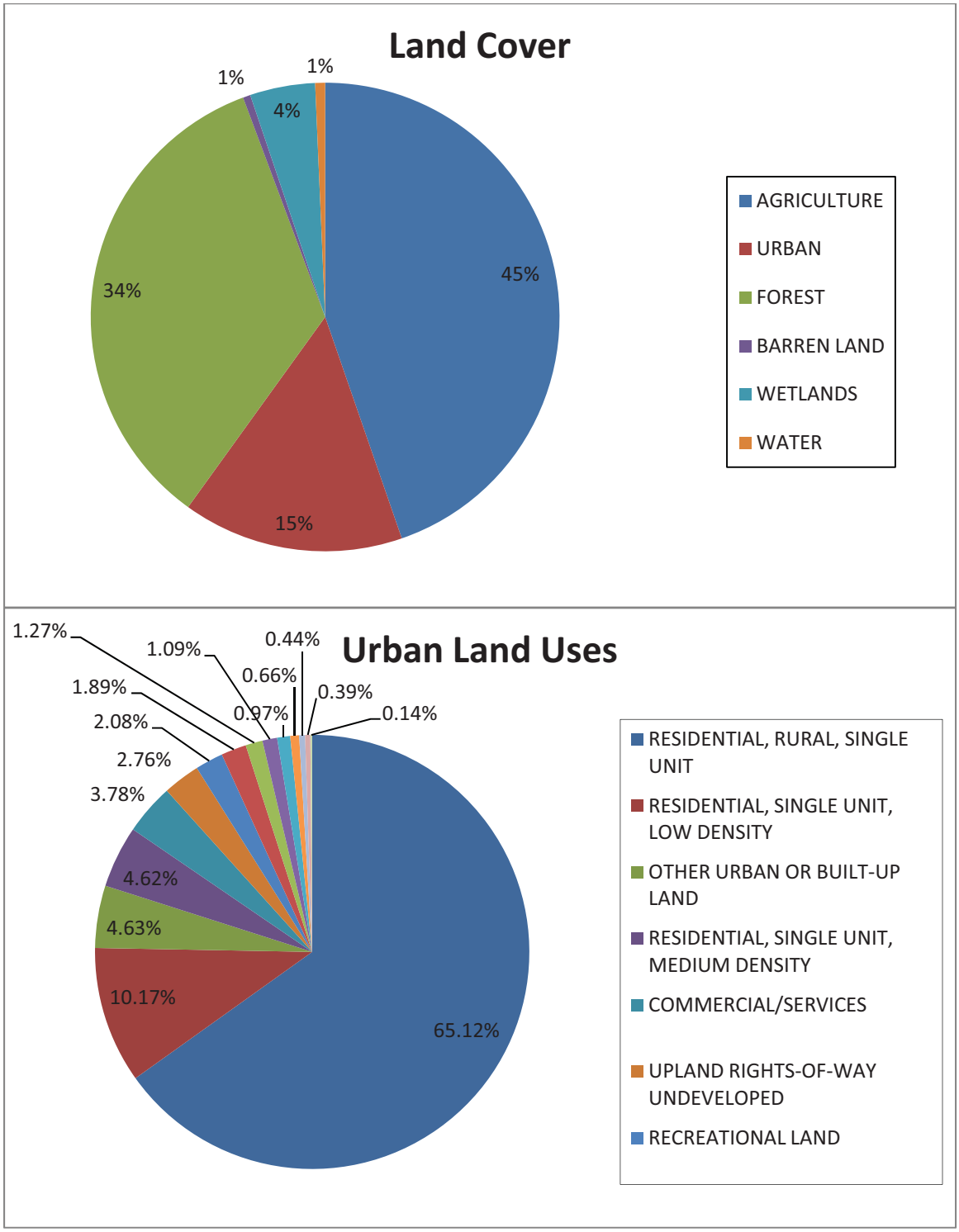

Figure 3. Land cover and urban land distribution for the Musconetcong River Watershed (NJDEP, 2002b)

Project Background

In accordance with Section 305(b) of the Clean Water Act, New Jersey addresses the overall water quality of the State's waters and identifies impaired waterbodies through the development of a document referred to as the *Integrated List of Waterbodies*. Within this document are lists that indicate the presence and level of impairment for each waterbody monitored. It is recommended by the USEPA (United States Environmental Protection Agency) that this list be a guideline for water quality management actions that will address the cause of impairment. The lists are defined as follows (NJDEP, 2009):

- **Sublist 1** suggests that the waterbody is meeting water quality standards.
- **Sublist 2** states that a waterbody is attaining some of the designated uses, and no use is threatened. Furthermore, Sublist 2 suggests that data are insufficient to declare if other uses are being met.
- **Sublist 3** maintains a list of waterbodies where no data or information are available to support an attainment determination.
- **Sublist 4** lists waterbodies where use attainment is threatened and/or a waterbody is impaired; however, a TMDL (total maximum daily load) will not be required to restore the waterbody to meet its use designation.
    - ➢**Sublist 4a** includes waterbodies that have a TMDL developed and approved by the USEPA, that when implemented, will result in the waterbody reaching its designated use.
    - ➢**Sublist 4b** establishes that the impaired reach will require pollutant control measurements taken by local, state, or federal authorities that will result in full attainment of designated use.

➢**Sublist 4c** states that the impairment is not caused by a pollutant, but is due to factors such as instream channel condition and so forth.

- **Sublist 5** clearly states that the water quality standard is not being attained and requires a TMDL.

Based upon numerous monitoring sources, including the New Jersey Department of Environmental Protection (NJDEP) Ambient Biomonitoring Network (AMNET), the NJDEP/United States Geological Survey (USGS) water quality monitoring network, and the Metal Recon Program, the Musconetcong River near Bloomsbury was listed on Sublist 5 of the New Jersey 2002 Integrated Water Quality Monitoring and Assessment Report (NJDEP, 2002a) for fecal coliform and pH. The Musconetcong River at New Hampton Road in Lebanon Township was listed on Sublist 5 for Aquatic Life, as well. The fecal coliform impairment has been addressed through the TMDL process. A TMDL for fecal coliform has been adopted for the Musconetcong River; therefore, this parameter has been moved to Sublist 4a. This TMDL requires 93% reductions in fecal coliform from medium/high density residential, low density/rural residential, commercial, industrial, mixed urban/other urban, forest, and agricultural lands (NJDEP, 2003).

The Musconetcong River near Bloomsbury was listed on Sublist 5 of the New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report (NJDEP, 2004) for pH. The Musconetcong River at New Hampton road in Lebanon was listed on Sublist 5 for benthic macroinvertebrates. According to the 2006 Integrated List, which used a HUC-14 based water quality impairment listing methodology, the Musconetcong River (HUC 02040105160040 and 50) had no listing on Sublist 5 (NJDEP, 2006). In addition, the Musconetcong River at New Hampton Road in Lebanon was delisted for benthic

macroinvertebrates, and the Musconetcong River near Bloomsbury was delisted for pH based on more recent and/or more accurate data that demonstrated that the designated use was being met for the waterbody (NJDEP, 2006). According to the most recent listings (i.e., the 2008 Integrated List and 2010 Integrated List) the Musconetcong River (HUC 02040105160040 ~ 75d 00m to Rt. 31) is on Sublist 5 for aquatic life (general and trout) and the Musconetcong River (HUC 02040105160050 ~ I-78 to 75d 00m) is on Sublist 5 for aquatic life (trout). The specific pollutant identified in this case is temperature (NJDEP, 2009; NJDEP 2011b).

Based on the conditions described above, the Musconetcong River Watershed Restoration and Protection Plan project team, North Jersey Resource Conservation & Development Council, Rutgers Cooperative Extension Water Resources Program, and the Musconetcong Watershed Association, was assembled. A 319(h) grant proposal was submitted by the team to NJDEP in 2006 to develop a plan for the 19.6 square mile Musconetcong River Watershed from Route 31 in Hampton to the USGS gauging station #01457000 near Bloomsbury. The goal of the overall project is to develop a watershed restoration and protection plan that, through its implementation, will improve water quality in the project area. The development of the Musconetcong River Watershed Restoration and Protection Plan was funded in 2006 by the NJDEP (RP06-073) under the 319(h) program.

A total of twelve (12) tasks have been identified to achieve the goals and objectives of the 319(h) grant. The Rutgers Cooperative Extension Water Resources Program has acted as team lead for *Task 5: Implement the Quality Assurance Project Plan (QAPP), analyze the newly collected data, prepare a data report, and submit the*

data report to NJDEP. The purpose of this data report is to provide a summary of the water quality data collected under Task 5 in accordance with an approved QAPP within the Musconetcong River Watershed in support of the development of a watershed restoration and protection plan.

Surface Water Quality Monitoring

Monitoring Program May 2007 - October 2007

To further characterize the impairments identified in the *Integrated List of Waterbodies* from 2002, 2004, 2006, 2008, and 2010 within the Musconetcong River Watershed, the Rutgers Cooperative Extension Water Resources Program began surface water quality monitoring in May 2007 in accordance with an approved QAPP (See Appendix A). Surface water quality samples were collected from ten sampling locations within the Musconetcong River Watershed as described in Table 1 and mapped in Figure 4.

The temporal and spatial aspects of the surface water quality monitoring program for 2007 are summarized in Table 2. The tabulated water quality monitoring results from the biweekly and additional bacteria sampling are presented in Appendix B. Basic summary statistics (i.e., n, minimum, maximum, mean, and standard deviation) are provided with the tables. The results from the biweekly and additional bacteria sampling for suspected parameters of concern (i.e., pH, temperature, total phosphorus, fecal coliform, and *Escherichia coli* (*E. coli*)) are graphed in Appendix C.

Table 1. Description of and basis for water quality monitoring locations within the Musconetcong River Watershed, 2007 monitoring program

Site	Description	Basis for Sampling
1	Musconetcong River at the Route 31 crossing in Hampton, NJ	Site #1 was selected to serve as the upstream control prior to potential effluent from Hampton septic systems and cesspools entering the river. This site delineates the upstream boundary of the study area.
2	Unnamed Tributary/Stormwater Outfall flowing through Hampton, just upstream of confluence with the Musconetcong River	Site #2 was selected to show if fecal impairments in the Musconetcong are coming from potentially failing septic systems in the Borough of Hampton.
4	Musconetcong River at the Valley Road crossing downstream of Hampton	Site #4 was selected to determine the levels of fecal coliform in the river downstream of potential septic effluent from Hampton.
11	Unnamed Tributary at Maple and Shruts Road in Washington Township	Site #11 was selected to determine a baseline fecal coliform level and to determine how this tributary influences the river between Site #4 and Site #6.
5a	Unnamed Tributary flowing from the village of Asbury, just upstream of confluence with the Musconetcong River	Site #5a was selected to determine if the Asbury village septic systems are influencing the tributary.
6	Musconetcong River downstream of Asbury	Site #6 was selected to determine the levels of fecal coliform in the river downstream of potential septic effluent from Asbury.
7	West Portal Brook just upstream of confluence with Musconetcong River	Site #7 was selected to help identify if loadings are coming from the livestock in this subwatershed.
8	Musconetcong River at the Valley Station Road crossing	Site #8 was selected to determine the levels of fecal coliform in the river downstream of the potential agricultural inputs of Site #7.
9	Unnamed Tributary just upstream of confluence with Musconetcong River	Site #9 was selected to help identify if loadings were coming from the livestock in this subwatershed.
10	Musconetcong River at Person Road crossing at the USGS monitoring station near Bloomsbury (#01457000)	Site #10 was selected as it delineates the downstream end of the priority subwatershed.

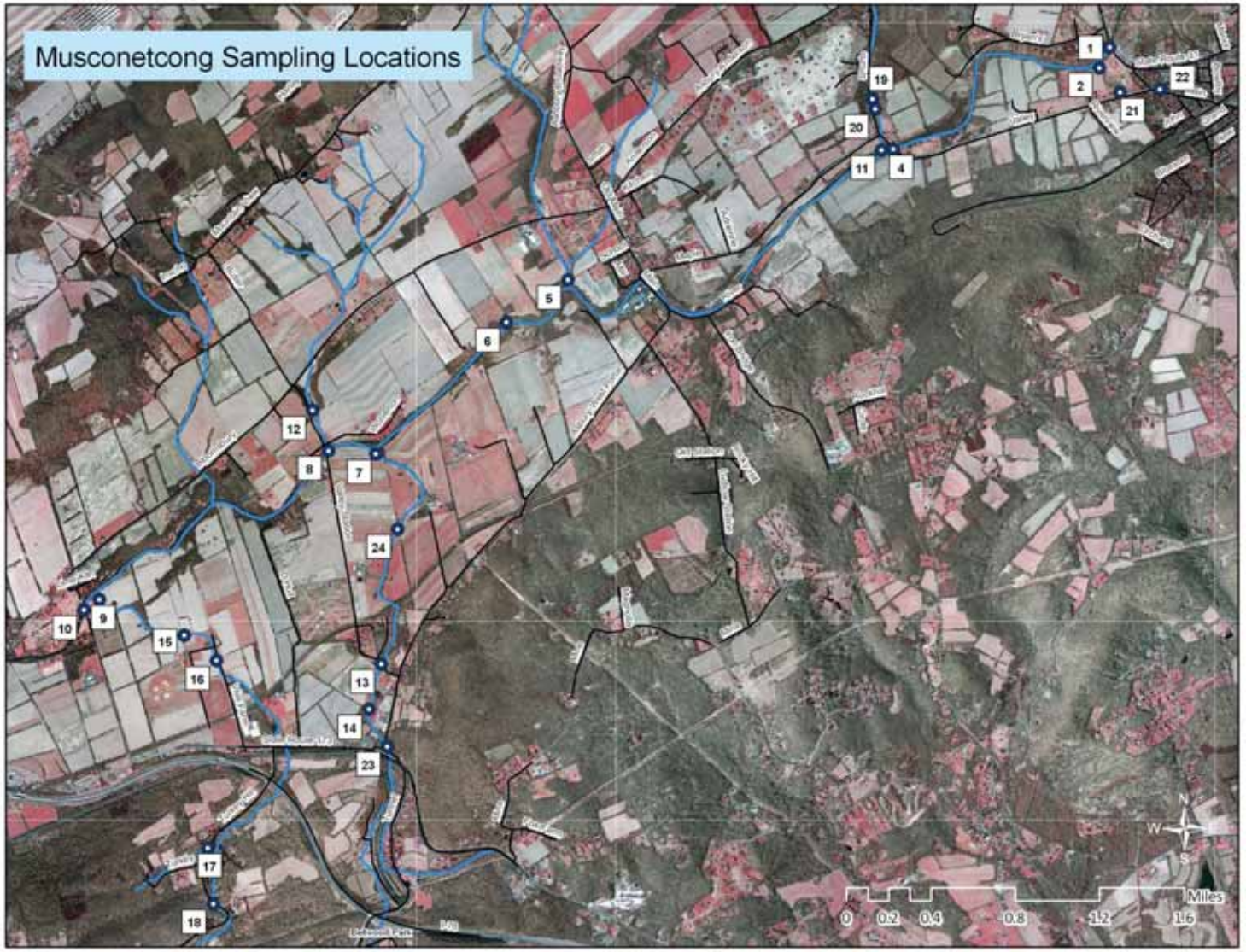

Figure 4. Musconetcong River Watershed monitoring locations, May 2007 - September 2010

Table 2. Summary of temporal and spatial aspects of surface water quality monitoring program for the Musconetcong River Watershed, 2007 monitoring program

Type:	Biweekly Surface Water Sampling	Additional Bacteriology Sampling
Frequency:	Two (2) times a month from May - October 2007 (12 events)	Three (3) times, in addition to biweekly samples, in June, July, & August 2007 (9 events)
Parameters:	pH, temperature, dissolved oxygen (DO), stream width, stream depth, stream velocity, ammonia-N (NH_3-N), nitrate-N (NO_3-N), nitrite-N (NO_2-N), total Kjeldahl nitrogen (TKN), total phosphorus (TP), dissolved orthophosphate phosphorus (DOP), total suspended solids (TSS), fecal coliform, *E. coli*	Stream width, stream depth, stream velocity, fecal coliform, *E. coli*
1	X	X
2	X	X
4	X	X
11	X	X
6	X	X
5a	X	X
8	X	X
7	X	X
9	X	X
10	X	X

To evaluate the health of the Musconetcong River Watershed, the monitoring results were compared to applicable surface water quality criteria. Water quality criteria are developed according to the waterbody's designated uses (NJDEP, 2011c). The Musconetcong River is classified as FW2-TM, or freshwater (FW) trout maintenance (TM). "FW2" refers to waterbodies that are used for maintenance, migration, and propagation of natural and established biota; primary contact recreation; industrial and agricultural water supply; public potable water supply after conventional filtration treatment and disinfection; and any other reasonable uses. "TM" means those freshwaters designated for the support of trout throughout the year (NJDEP, 2011c). The applicable water quality criteria for this project are detailed in Table 3.

Table 3. Applicable Surface Water Quality Criteria – N.J.A.C. 7:9B (*Last Amended: April 4, 2011 43 N.J.R. 833(a)*)

Substance	Surface Water Classification	Criteria
Bacterial quality (Counts/100 ml) *E. coli*	FW2	*E. coli* shall not exceed a geometric mean of 126/100 mL or a single sample maximum of 235/100 mL
Bacterial quality (Counts/100 ml) *Fecal Coliform – former criterion for bacterial quality*	*FW2*	*Fecal coliform shall not exceed geometric average of 200/100 mL, nor should more than 10% of the total samples taken during any 30-day period exceed 400/100 mL*
Dissolved oxygen (mg/L)	FW2-TM	24 hour average not less than 6.0. Not less than 5.0 at any time.
pH (Standard Units)	FW2	6.5 – 8.5
Total Phosphorus (mg/L)	FW2	Streams: Except as necessary to satisfy the more stringent criteria in accordance with "Lakes" (above) or where watershed or site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g)3, phosphorus as total P shall not exceed 0.1 in any stream, unless it can be demonstrated that total P is not a limiting nutrient and will not otherwise render the waters unsuitable for the designated uses.
Solids, Suspended (Non-filterable residue) (mg/L)	FW2-TM	25.0
Temperature (°C)	FW2-TM	Temperatures shall not exceed a daily maximum of 25 degrees Celsius or rolling seven-day average of the daily maximum of 23 degrees Celsius, unless due to natural conditions. *(Current criterion)*
Temperature (°C) – former criterion	*FW2-TM*	*No thermal alterations which would cause temperatures in excess of 20 °C*
Nitrate (mg/L)	FW2	10 mg/L (human health criterion)

The percentage of samples that exceeded the surface water quality criteria is provided in Table 4. A high percentage of the samples collected throughout the Musconetcong River Watershed, as part of the biweekly and additional bacteria sampling

Table 4. Percentage of samples from the biweekly and additional bacteria sampling that exceeded surface water quality criteria (SWQC)

Site	SWQC	Count	Minimum	Maximum	Mean	% not satisfying SWQC
pH (SU)						
10	minimum 6.5 (SU)	14	6.64	8.01	7.40	0
9		8	5.71	7.62	7.11	13% (1/8)
7		12	6.67	8.15	7.44	0
8		12	6.93	8.01	7.58	0
5a		12	6.31	7.82	7.05	8% (1/12)
6		12	6.74	7.89	7.59	0
11		12	6.99	7.80	7.53	0
4		12	6.90	8.33	7.78	0
1		14	6.94	8.26	7.86	0
Temperature (°C)						
10	No thermal alterations which would cause temperatures in excess of 20°C	14	13.1	21.5	17.7	0
9		8	14.4	23.3	17.7	13% (1/8)
7		12	11.0	17.8	15.4	0
8		12	13.3	21.9	18.1	33% (4/12)
5a		12	12.6	22.0	18.0	25% (3/12)
6		12	13.6	22.0	18.2	25% (3/12)
11		12	13.5	16.4	14.6	0
4		12	14.3	22.3	18.7	33% (4/12)
1		14	14.6	22.6	19.2	33% (4/12)
***E. coli* (org./100 ml)**						
10	Single sample maximum of 235 (counts/100 ml)	21	110	4,100	346	81% (17/21)
9		17	320	80,000	6,629	100% (17/17)
7		21	670	92,000	9,221	100% (21/21)
8		21	200	5,100	519	86% (18/21)
5a		20	200	7,300	502	75% (15/20)
6		21	90	2,500	286	57% (12/21)
11		21	20	2,900	129	38% (8/21)
4		21	120	2,500	284	71% (15/21)
1		21	120	3,300	278	52% (11/21)
Fecal Coliform (col/100 ml)						
10	No more than 10% of the total samples taken during any 30-day period can exceed 400 (counts / 100 ml)	21	100	960	307	38% (8/21)
9		17	580	28,000	3,654	100%(17/17)
7		21	180	42,000	6,039	95% (20/21)
8		21	100	1,400	468	52% (11/21)
5a		21	60	10,000	528	48% (10/21)
6		21	100	1,000	315	29% (6/21)
11		21	8	2,300	151	19% (4/21)
4		21	120	1,100	307	29% (6/21)
1		21	44	1,400	222	19% (4/21)
Total Phosphorus (mg/L)						
10	0.1mg/L in any stream	12	0.03	0.09	0.06	0
9		8	0.05	0.19	0.08	13% (1/8)
7		12	0.06	0.11	0.08	8% (1/12)
8		12	0.03	0.11	0.05	8% (1/12)
5a		12	0.03	0.08	0.05	0
6		12	0.03	0.08	0.05	0
11		12	0.01	0.09	0.03	0
4		12	0.03	0.11	0.05	0
1		12	0.03	0.08	0.05	0

exceeded both the current bacteria criteria for *E. coli* and the former criteria for fecal coliform. Elevated temperature levels were observed throughout the watershed. A single violation of the pH minimum criterion at Site #9 and at Site #5a was observed, and a single violation of the total phosphorus criterion was observed at Site #9, at Site #7, and at Site #8.

The NJDEP's Integrated Water Quality Monitoring and Assessment Methods indicates that if the frequency of water quality results exceed the water quality criteria twice within a five-year period, then the waterway's quality may be compromised (NJDEP, 2011a). Clearly the Musconetcong River Watershed's quality is compromised given the continual and persistent violations of the surface water quality criteria for bacteria and the occasional elevated surface water temperatures. Total phosphorus and pH are not parameters of concern for the Musconetcong River Watershed.

To evaluate the relationship of water quality to land use within the Musconetcong River Watershed, the median concentration/level of the parameters of concern (i.e., temperature, *E. coli*, and fecal coliform) were plotted in relation to increasing agricultural land use (Figures 5-8), increasing forested land use (Figures 9-12), and increasing urban land use (Figure 13-16). Agricultural, forested, and urban land uses are the three largest land uses found within the watershed (See Figure 3). With an increase in agricultural land use, a slightly decreasing trend in *E. coli* and fecal coliform concentrations was noted. With an increase in forest land use, an increasing trend in *E. coli* and fecal coliform concentrations was found. No trends were noted for temperature, *E. coli*, or fecal coliform with respect to increasing urban land use. In addition, no trends were noted for temperature with respect to agriculture or forest land uses.

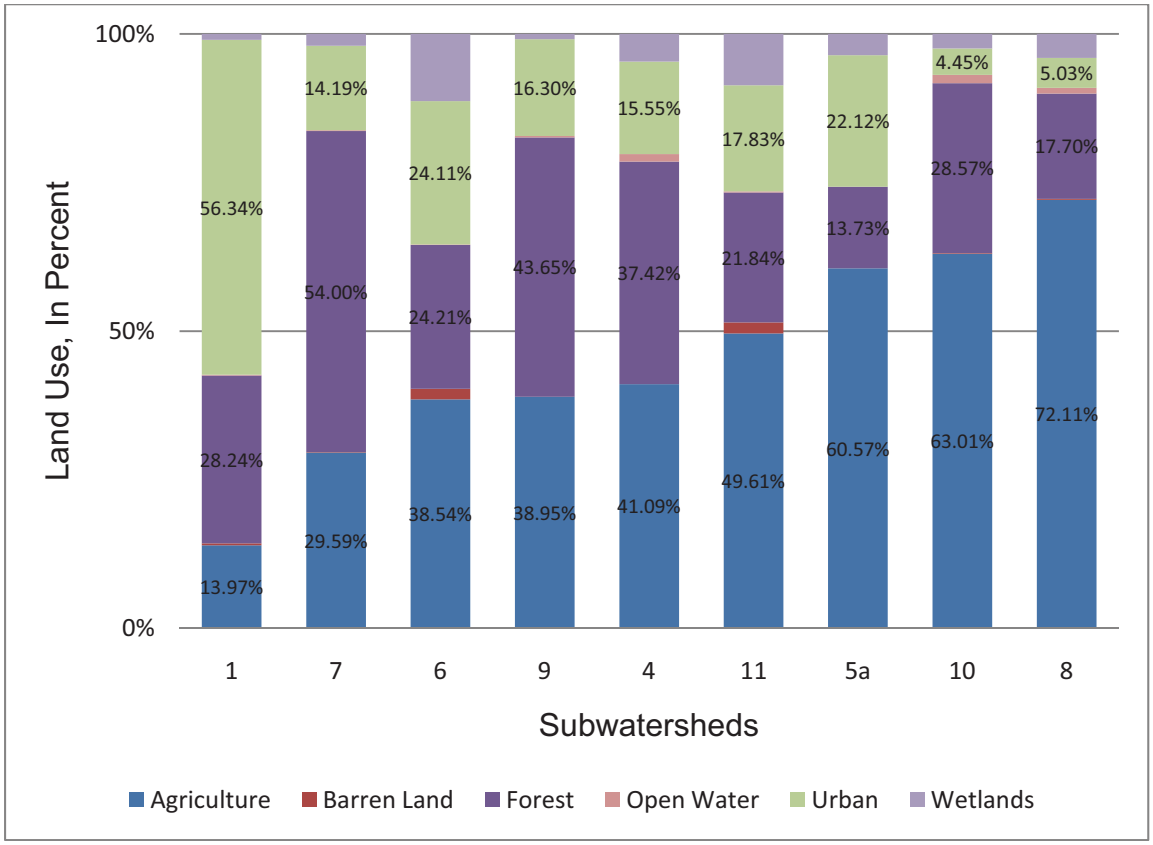

Figure 5. Increasing percent agriculture land use by subwatershed

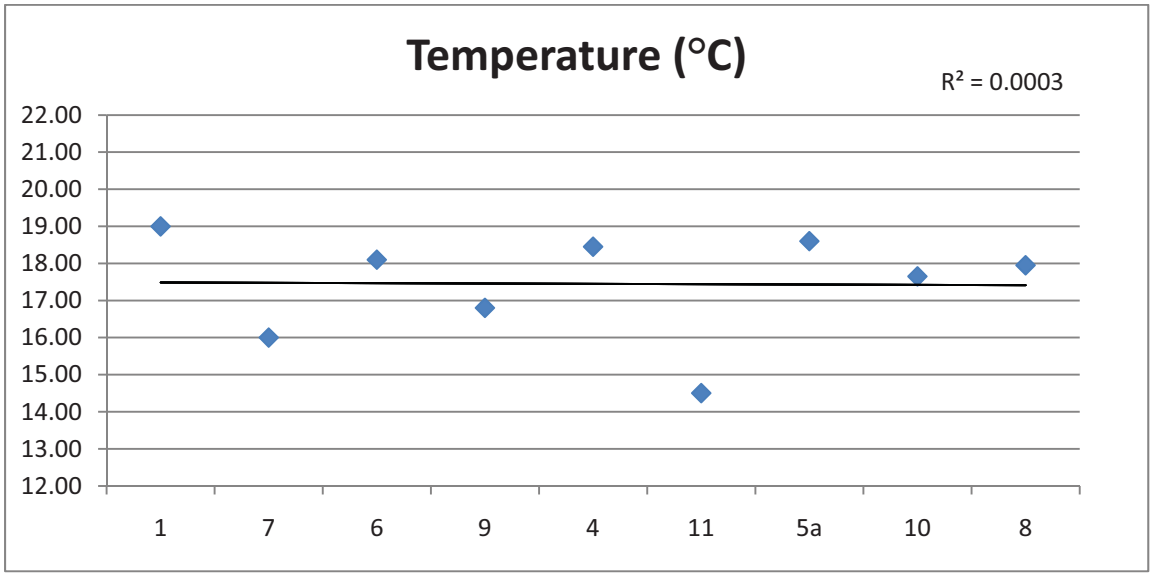

Figure 6. Relation of median value of temperature to percent agriculture land use within the Musconetcong River Watershed

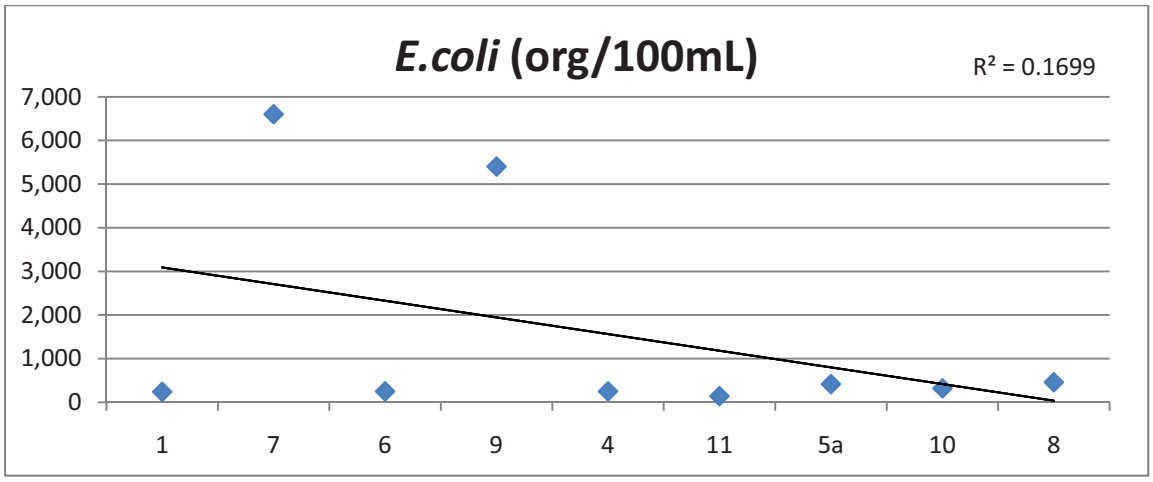

Figure 7. Relation of median value of *E. coli* to percent agriculture land use within the Musconetcong River Watershed

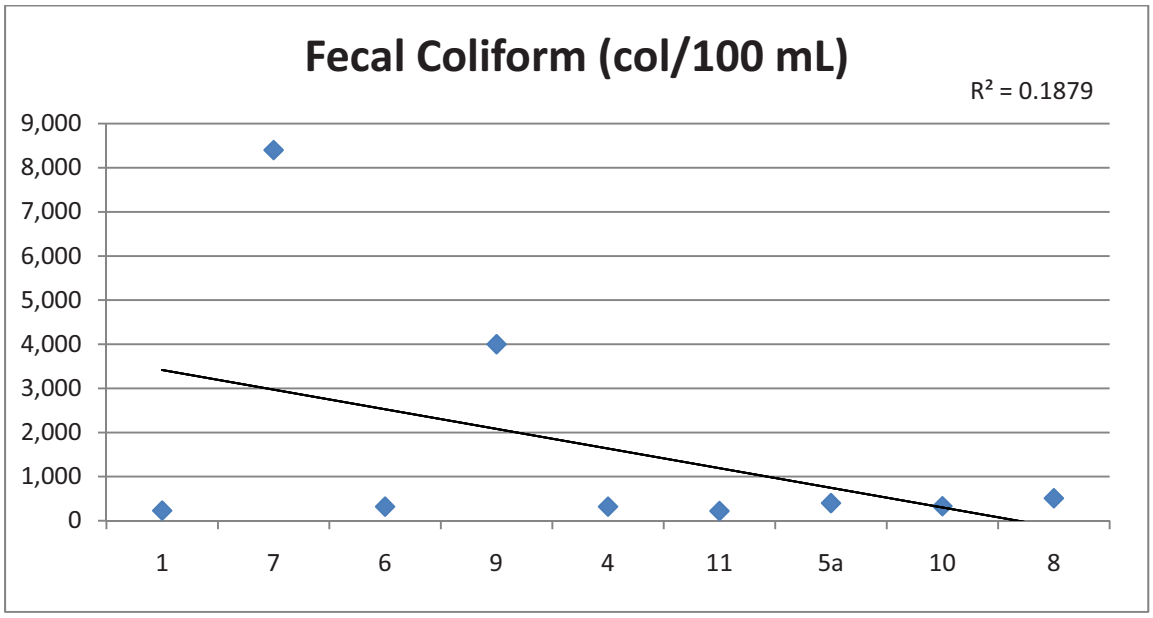

Figure 8. Relation of median value of fecal coliform to percent agriculture land use within the Musconetcong River Watershed

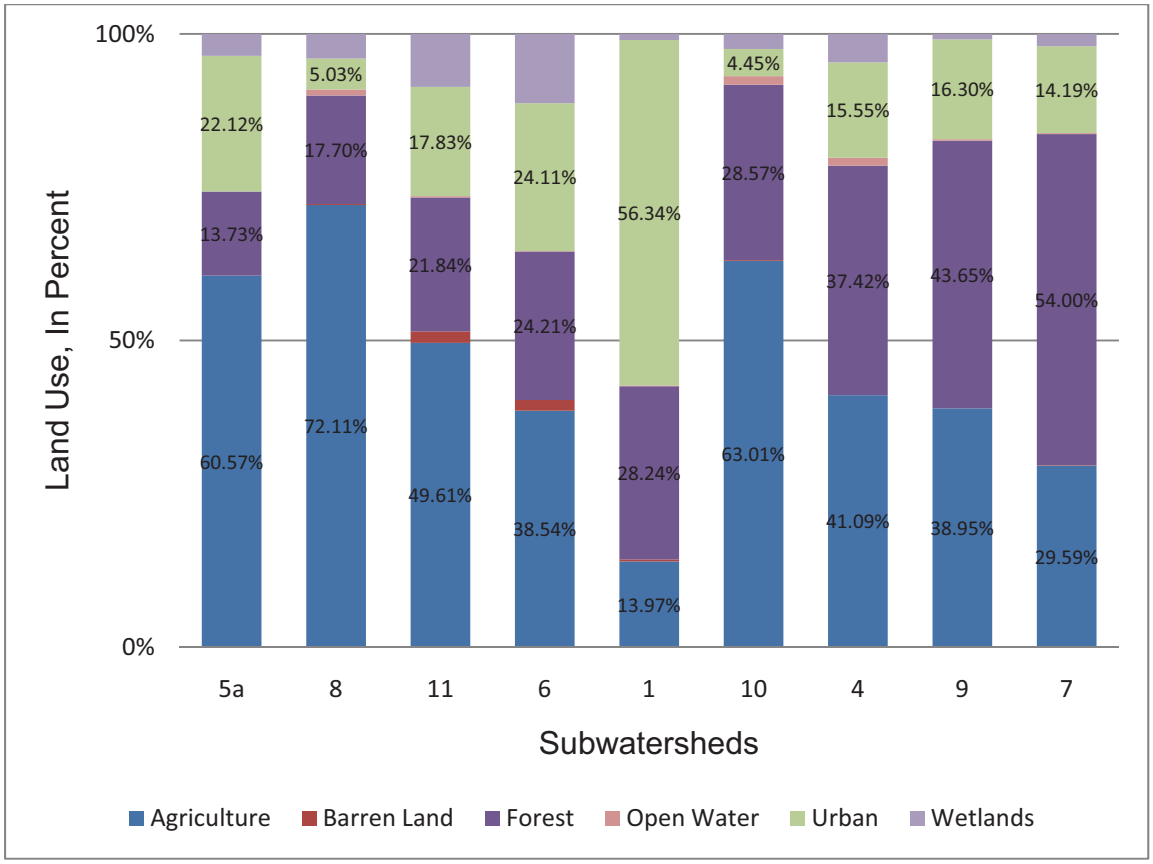

Figure 9. Increasing percent forest land use by subwatershed

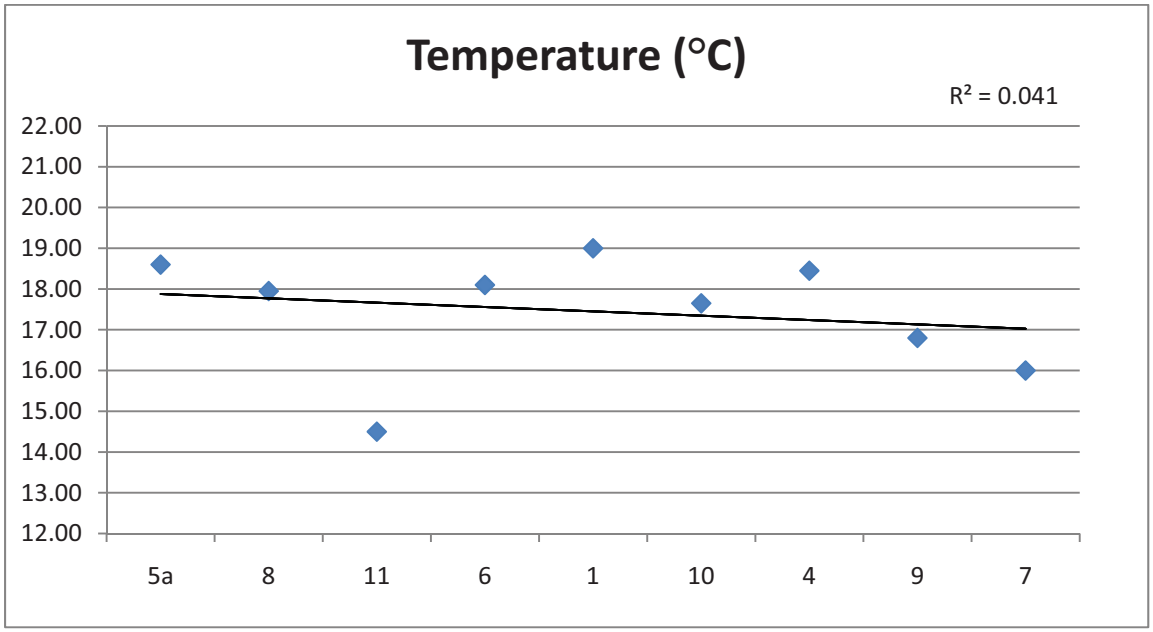

Figure 10. Relation of median value of temperature to percent forest land use within the Musconetcong River Watershed

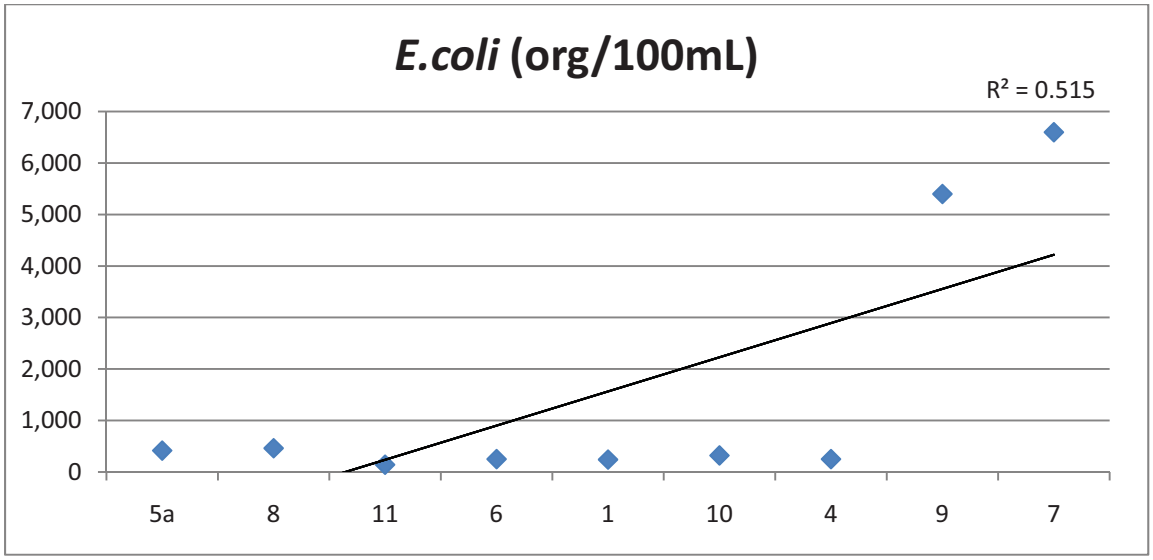

Figure 11. Relation of median value of *E. coli* to percent forest land use within the Musconetcong River Watershed

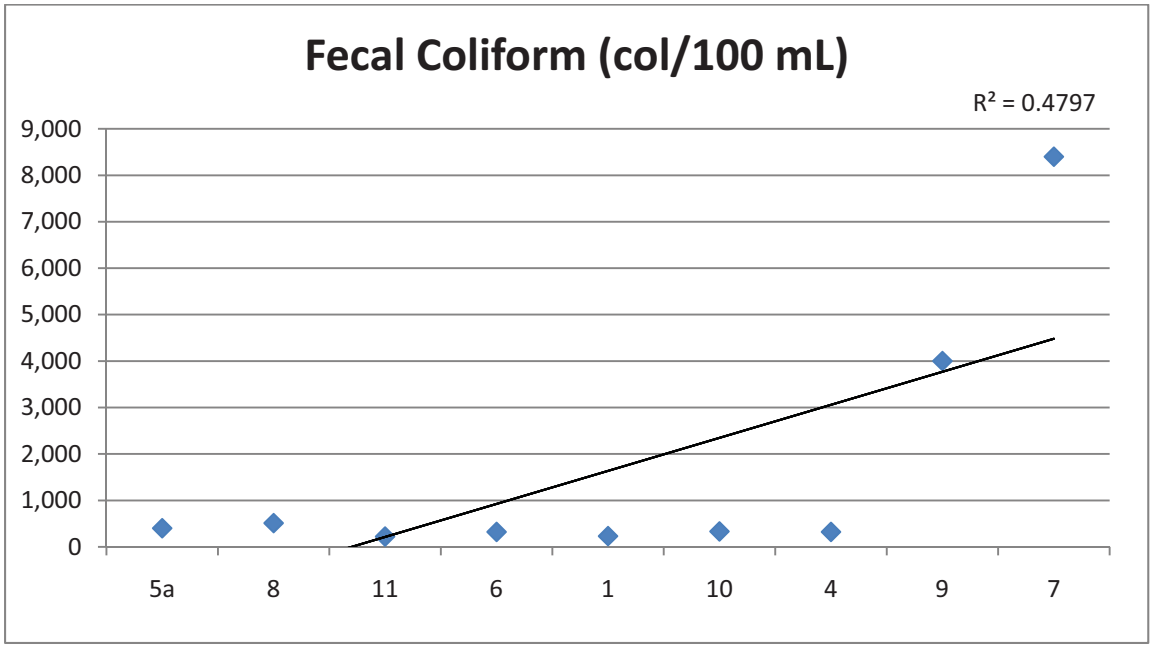

Figure 12. Relation of median value of fecal coliform to forest land use within the Musconetcong River Watershed

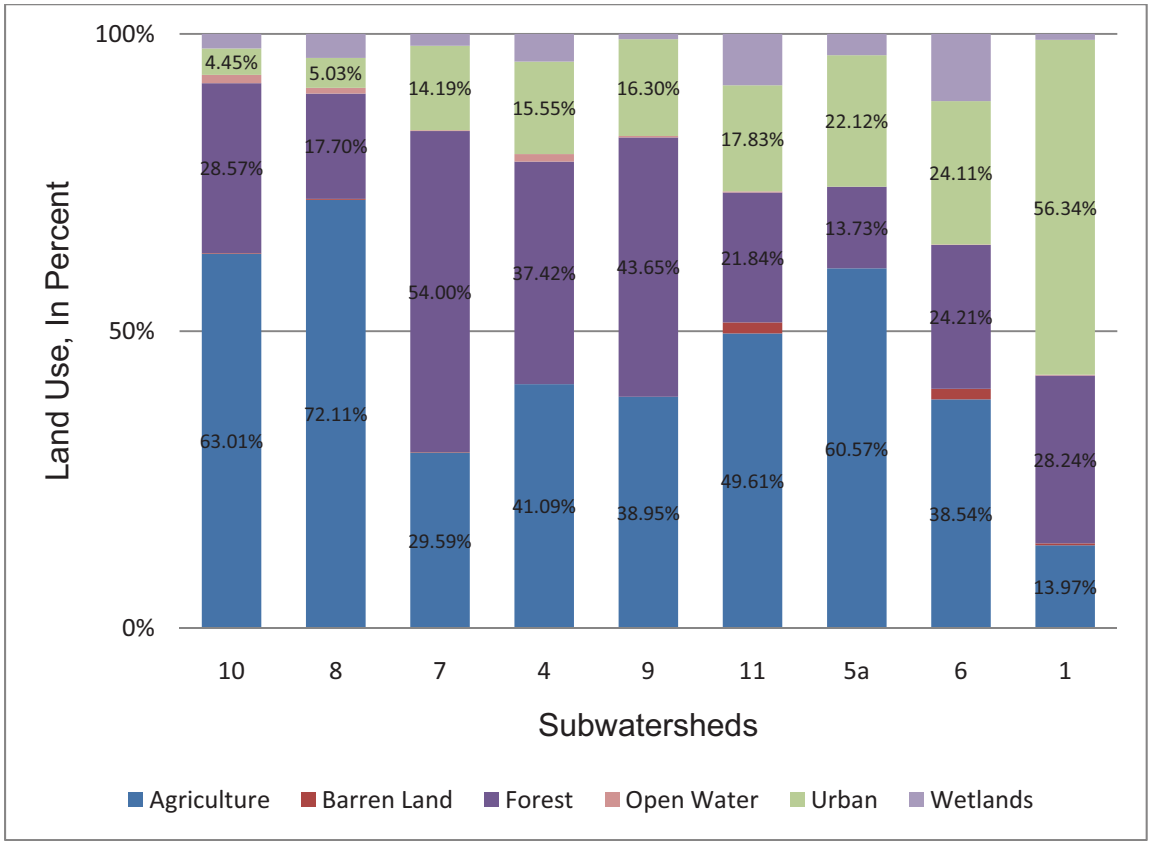

Figure 13. Increasing percent urban land use by subwatershed

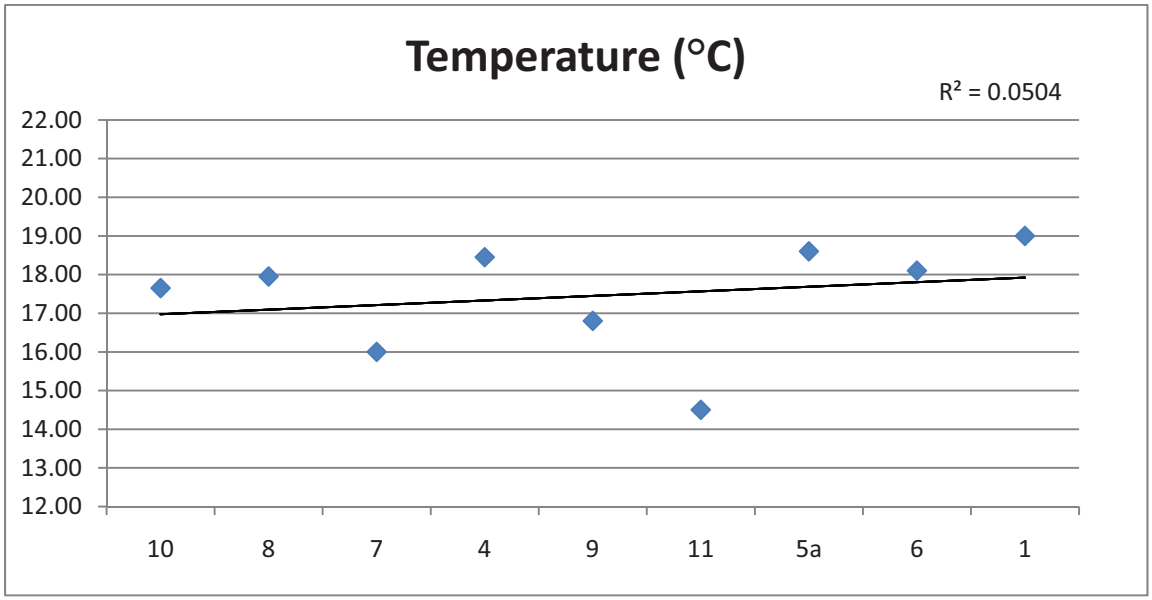

Figure 14. Relation of median value of temperature to percent urban land use within the Musconetcong River Watershed

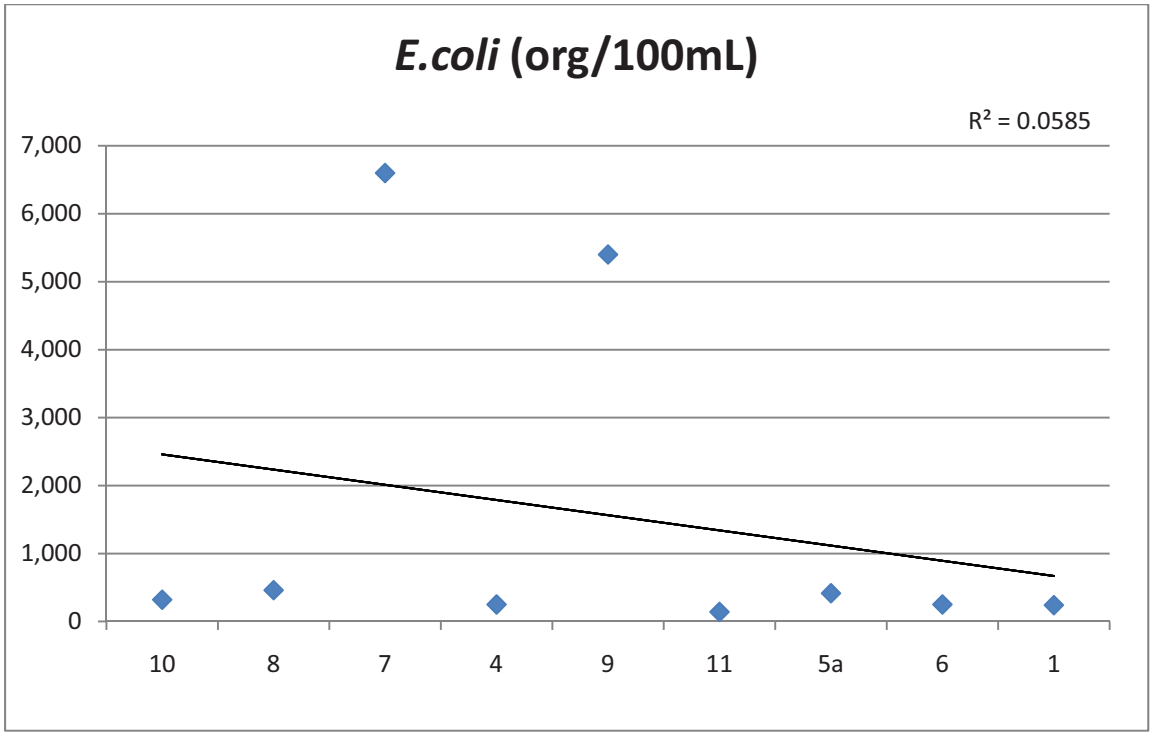

Figure 15. Relation of median value of *E. coli* to percent urban land use within the Musconetcong River Watershed

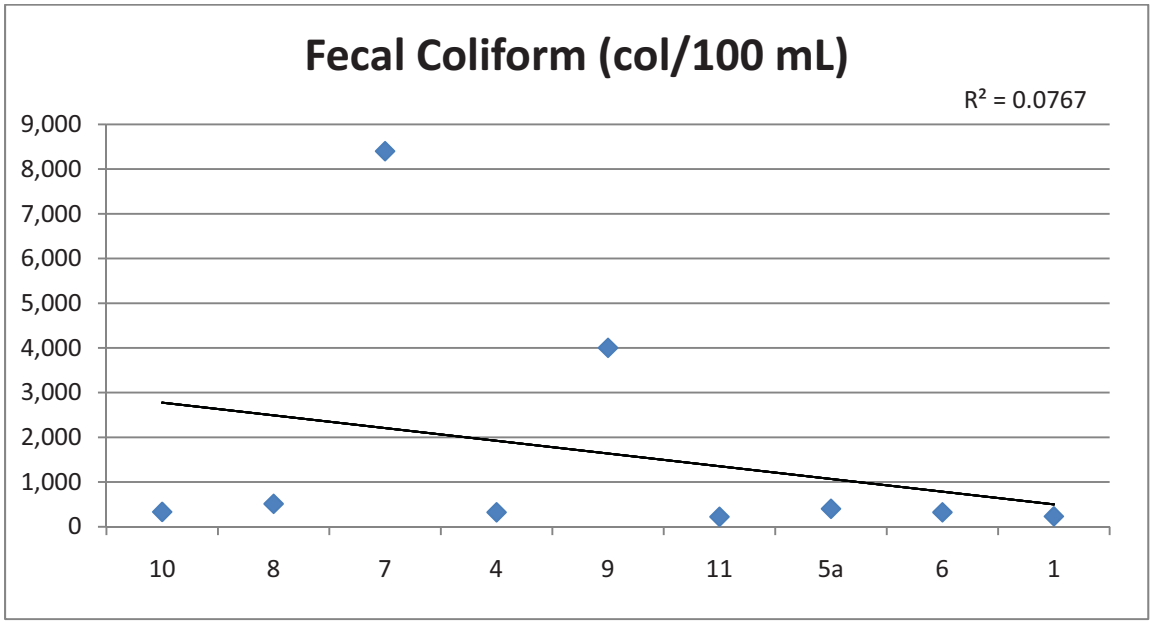

Figure 16. Relation of median value of fecal coliform to urban land use within the Musconetcong River Watershed

Wet Weather Surface Water Sampling

According to the approved May 2007 QAPP, three wet weather sampling events, at a minimum, were to be conducted between May and October 2007 at each sampling location. It was difficult to capture wet weather events as proposed in the approved QAPP. The laboratories will not accept samples after 4 pm and before 7 am, as well as on weekends; many, if not all, of the significant rainfall events that occurred between May and October 2007 were during these time periods. Furthermore, it was difficult to capture runoff from "scattered thundershowers," especially when they only occurred in a portion of the watershed, as was common during the designated sampling period of May through October 2007.

The USGS program "PART" was used to estimate base flow in the Musconetcong River at Site #10 (http://water.usgs.gov/ogw/part/). Based on flows above the calculated base flow and 36 hour rainfall totals from local weather stations, probable storm events that were captured during the biweekly surface water sampling included June 4, July 30, and August 13, 2007. Elevated pathogen counts (i.e., fecal coliform and *E. coli*) were observed on these sampling dates, and it was concluded, based on the PART analysis, that the 2007 monitoring program did include wet weather surface water sampling to some extent.

Additional Monitoring Program for August 2008

In February 2007 the North Jersey Resource Conservation & Development Council, along with the Rutgers Cooperative Extension Water Resources Program and the Musconetcong Watershed Association, met with NJDEP to present findings from the 2007 monitoring program. Two of the most severely impacted subwatersheds, West Portal Brook and Turkey Hill Brook, were identified. Monitoring conducted during May

2007 through October 2007 revealed highly elevated fecal coliform and *E. coli* levels in the West Portal Brook subwatershed at Site #7 and in the Turkey Hill Brook subwatershed at Site #9, just upstream of their confluence with the Musconetcong River.

Rather than continue to try to collect wet weather surface water samples as defined in the approved May 2007 QAPP, the Project Team identified seven additional monitoring locations to obtain a more complete picture of the sources of impairment in the Turkey Hill Brook and West Portal Brook subwatersheds. Additional monitoring was conducted during August 2008 to further characterize the input of bacteria, in particular fecal coliform and *E. coli*, along these two subwatersheds. The seven additional monitoring locations are shown in Figure 4 and in Appendix A (See Addendum: June 30, 2008 – *revised July 18, 2008)* and are described in Table 5. Sampling was conducted in accordance with the approved July 2008 addendum to the QAPP (See Appendix A). Site #12 was dry during August 2008, therefore only six sites were monitored.

Three out of the six sites monitored (i.e., #13, #15, and #17) exceeded the surface water quality criterion for *E. coli* (i.e., *E. coli* shall not exceed a geometric mean of 126 counts/100 mL), and 43% of the samples collected exceeded the single sample criterion for *E. coli* (i.e., single sample maximum of 235 counts/100 ml). The same three sites (i.e., #13, #15, and #17) exceeded the former surface water quality criterion for fecal coliform (i.e., fecal coliform shall not exceed a geometric mean of 200 counts/100 mL), and 47% of the samples collected exceeded the former single sample criterion for fecal coliform (i.e., single sample maximum of 400 counts/100 ml). These monitoring results are summarized in Table 6.

Table 5. Additional monitoring locations for August 2008 bacteria monitoring

Site	Description	Basis for Sampling
#12	Unnamed Tributary, Warren County, Wolverton Road, by pipeline	Site #12 was selected to further characterize any bacteria input from the Warren County tributaries in the watershed.
#13	West Portal Brook, Hunterdon County, Valley Station Road, near bridge by old stone structure	Sites #13 and #14 were selected to characterize bacteria from suspected septic inputs and from livestock along West Portal Brook, upstream of the establish Site #7
#14	West Portal Brook, Hunterdon County, behind school	
#15	Turkey Hill Brook, Hunterdon County, downstream from small animal farm near Heritage Park	Sites #15 and #16 were selected to characterize bacteria inputs from a small animal farm along Turkey Hill Brook, upstream of Site #9.
#16	Turkey Hill Brook, Hunterdon County, upstream from small animal farm near Heritage Park	
#17	Turkey Hill Brook, Hunterdon County, off Turkey Hill Road, approximately 0.6 miles up road	Sites #17 and #18 were selected to characterize bacteria inputs from miscellaneous agricultural operations, as well as suspected septic inputs along Turkey Hill Brook, upstream of established Site #9 and Sites #15 and #16.
#18	Turkey Hill Brook, Hunterdon County, off Turkey Hill Road, approximately one mile up road	

Table 6. Results of August 2008 bacteria monitoring

Site	Date	*E. coli* (col/100 ml)	Fecal Coliform (col/100 ml)
#13	08/06/08	240	520
#13	08/14/08	150	480
#13	08/20/08	230	220
#13	08/26/08	560	280
#13	08/28/08	320	390
mean		***272***	***359***
#14	08/06/08	20	50
#14	08/14/08	230	690
#14	08/20/08	100	50
#14	08/26/08	190	40
#14	08/28/08	20	60
mean		***71***	***84***
#15	08/06/08	4,800	6,900
#15	08/14/08	3,900	7,500
#15	08/20/08	2,900	2,800
#15	08/26/08	6,500	11,000
#15	08/28/08	5,000	5,800
mean		***4,460***	***6,211***
#16	08/06/08	90	540
#16	08/14/08	680	1,300
#16	08/20/08	40	40
#16	08/26/08	70	60
#16	08/28/08	20	60
mean		***81***	***159***
#17	08/06/08	560	1,200
#17	08/14/08	5,800	7,800
#17	08/20/08	210	350
#17	08/26/08	190	100
#17	08/28/08	180	180
mean		***472***	***568***
#18	08/06/08	250	1,200
#18	08/14/08	570	660
#18	08/20/08	30	20
#18	08/26/08	40	20
#18	08/28/08	10	5
mean		***70***	***69***

In addition, *E. coli* was monitored at the seven additional monitoring locations and at the ten established sampling locations from the 2007 monitoring program during three storm events on July 14, 2008, July 24, 2008, and September 26, 2008. In regard to this wet weather sampling, 86% of the samples collected exceeded the surface water quality criterion for *E. coli* (i.e., single sample maximum of 235 counts/100 ml). These data are summarized in Table 7.

Additional Monitoring Program for May 2009

The results of bacteria monitoring conducted during three storm events during the summer of 2008 and during August 2008 revealed elevated fecal coliform and *E. coli* levels in three subwatersheds of the Musconetcong River. Additional monitoring was conducted to further characterize the input of bacteria, in particular fecal coliform and *E. coli*, along the three subwatersheds. Six additional locations were selected to obtain a

Table 7. Results of bacteria monitoring conducted during three storm events during the summer of 2008

Site	Date	*E. coli* (col/100 ml)
#1	7/14/08	360
	7/24/08	1,500
	9/26/08	850
#2	7/14/08	*NO FLOW*
	7/24/08	860
	9/26/08	1,300
#4	7/14/08	1,400
	7/24/08	1,000
	9/26/08	400
#11	7/14/08	80
	7/24/08	80
	9/26/08	100
#6	7/14/08	360
	7/24/08	540
	9/26/08	350
#5a	7/14/08	3,600
	7/24/08	140
	9/26/08	1,600
#8	7/14/08	220
	7/24/08	1,000
	9/26/08	1,200
#7	7/14/08	8,600
	7/24/08	900
	9/26/08	2,900
#9	7/14/08	9,000
	7/24/08	6,600
	9/26/08	3,700
#10	7/14/08	880
	7/24/08	960
	9/26/08	1,300

Site	Date	*E. coli* (col/100 ml)
#12	7/14/08	18,000
	7/24/08	540
	9/26/08	5,100
#13	7/14/08	1,800
	7/24/08	580
	9/26/08	900
#14	7/14/08	560
	7/24/08	420
	9/26/08	500
#15	7/14/08	3,600
	7/24/08	1,100
	9/26/08	3,400
#16	7/14/08	2,700
	7/24/08	1,300
	9/26/08	200
#17	7/14/08	6,800
	7/24/08	4,800
	9/26/08	4,600
#18	7/14/08	200
	7/24/08	280
	9/26/08	600

more complete picture of the sources of impairment in the West Portal Brook, the unnamed tributary along Shurts Road, and the unnamed tributary in Hampton Borough. The additional sampling locations are shown in Figure 4 and in Appendix A (See Addendum: March 9, 2009 – *revised April 24, 2009)* and described in Table 8. Sampling was conducted in accordance with the approved April 2009 addendum to the QAPP (See Appendix A) and included sampling at established sites #2, #11, #7, #13, and #14. Sites #2, #21, and #22 were dry for most of the sampling events.

Table 8. Additional monitoring locations for May 2009 bacteria monitoring

Site	Description	Basis for Sampling
Site #19	Unnamed Tributary, Warren County, Shurts Road	Sites #19 and #20 were selected to characterize bacteria inputs to an unnamed tributary along Shurts Road prior to its confluence with the Musconetcong River just downstream from established Site #4.
Site #20	Unnamed Tributary, Warren County, Shurts Road below pond outlet	
Site #21	Unnamed Tributary, Hunterdon County, Hampton Borough off Valley Road above Borough Park	The Hampton locations, #21 and #22, were selected after discussions with Borough officials while sharing the 2007 and 2008 sampling data information. Potential human sources of bacteria were suspected in this area.
Site #22	Unnamed Tributary, Hunterdon County, Hampton Borough upstream of Site #21 off Main Street	
Site #23	West Portal Brook, Hunterdon County, Asbury-West Portal Road just after stop sign above school	Sites #23 and #24 were selected to further characterize bacteria from suspected septic inputs and from livestock along West Portal Brook, upstream of the established Site #7 to help further justify the implementation and benefit of a project on agricultural property along West Portal Brook.
Site #24	West Portal Brook, Hunterdon County, Asbury-West Portal Road in between agricultural properties	

Three out of the eight sites monitored (i.e., #7, #24, and #13) exceeded the surface water quality criterion for *E. coli* (i.e., *E. coli* shall not exceed a geometric mean of 126 counts/100 mL), and 48% of the samples collected exceeded the single sample criterion for *E. coli* (i.e., single sample maximum of 235 counts/100 ml). Two sites (i.e., #7 and #24) exceeded the former surface water quality criterion for fecal coliform (i.e., fecal coliform shall not exceed a geometric mean of 200 counts/100 mL), and 39% of the samples collected exceeded the former single sample criterion for fecal coliform (i.e., single sample maximum of 400 counts/100 ml). These monitoring results are summarized in Table 9.

Temperature Monitoring Program for Summer 2010

Sites #1, #4, and #10 were selected to monitor temperature conditions in the mainstem of the Musconetcong River. Temperatures were found to be elevated in the summer of 2007, and several exceedances of the surface water quality criteria for temperature were noted at that time. The North Jersey Resource Conservation & Development Council, Rutgers Cooperative Extension Water Resources Program, and the Musconetcong Watershed Association, in consultation with NJDEP, decided that a more extensive database through continuous monitoring would help confirm if temperature impairments do in fact occur along the mainstem. The Rutgers Cooperative Extension Water Resources Program, in accordance with the approved QAPP (See Appendix A: Addendum June 28, 2010 – *revised September 13, 2010*) deployed three (3) HOBO® U22 Water Temp Pro v2 Logger units in the Musconetcong River at Sites #1, #4, and #10. The HOBO units were programmed to continuously monitor temperature at two

Table 9. Results of May 2009 bacteria monitoring

Site	Date	*E. coli* (org/100 ml)	Fecal Coliform (org/100 ml)
#7	05/07/09	2,600	1,300
#7	05/11/09	2,700	1,200
#7	05/14/09	2,000	950
#7	05/18/09	2,400	1,100
#7	05/21/09	1,500	390
mean		***2,191***	***913***
#24	05/07/09	2,200	1,600
#24	05/11/09	780	600
#24	05/14/09	2,400	2,300
#24	05/18/09	1,100	1,000
#24	05/21/09	1,000	530
mean		***1,353***	***1,032***
#13	05/07/09	480	230
#13	05/11/09	210	120
#13	05/14/09	490	210
#13	05/18/09	210	40
#13	05/21/09	130	60
mean		***267***	***107***
#14	05/07/09	380	380
#14	05/11/09	140	90
#14	05/14/09	30	20
#14	05/18/09	50	50
#14	05/21/09	10	20
mean		***60***	***58***
#23	05/07/09	470	510
#23	05/11/09	180	70
#23	05/14/09	20	20
#23	05/18/09	70	20
#23	05/21/09	20	10
mean		***75***	***43***
#11	05/07/09	23,000	20,000
#11	05/11/09	40	20
#11	05/14/09	10	10
#11	05/18/09	30	30
#11	05/21/09	10	40
mean		***77***	***86***
#20	05/07/09	270	300
#20	05/11/09	10	<10
#20	05/14/09	10	<10
#20	05/18/09	40	10
#20	05/21/09	10	10
mean		***26***	***20***
#19	05/07/09	47,000	44,000
#19	05/11/09	40	30
#19	05/14/09	10	<10
#19	05/18/09	<10	<10
#19	05/21/09	10	<10
mean		***72***	***67***
#2	05/07/09	2,600	3,500
#21	05/07/09	1,000	1,400
#21	05/11/09	6,200	26,000
#22	05/07/09	3,100	6,700

minute increments from late June through late September 2010. Unfortunately, the HOBO unit at Site #4 was vandalized and only the data from Sites #1 and #10 were recovered for the monitoring period.

The daily maximum temperatures recorded at Sites #1 and #10 for the monitoring period were plotted (See Figure 17) with respect to the first part of the current surface water quality criterion for temperature (i.e., *Temperatures shall not exceed a daily maximum of 25 °C …* (NJDEP, 2011c)). Only 1% of the daily maximum temperatures at Site #10 exceeded the daily maximum portion of the criterion for the monitoring period, whereas 9% of the daily maximum temperatures at Site #1 exceeded the criterion. The seven-day rolling/moving average of the daily maximum temperatures was calculated for Sites #1 and #10 for the monitoring period and plotted (See Figure 18) with respect to the second part of the current surface water quality criterion for temperature (i.e., *…or rolling seven-day average of the daily maximum of 23 °C* (NJDEP, 2011c). Approximately 23% of the daily maximum temperatures measured at Site #10 and 38% of the daily maximum temperatures measured at Site #1 exceeded the rolling seven-day average of the daily maximum portion of the criterion during the monitoring period.

Microbial Source Tracking

Microbial source tracking (MST) is the concept of applying microbiological, genotypic (molecular), phenotypic (biochemical), and chemical methods to identify the origin of fecal pollution (Scott *et al.*, 2002). MST techniques typically report fecal contamination sources as a percentage of targeted bacteria. One of the most promising

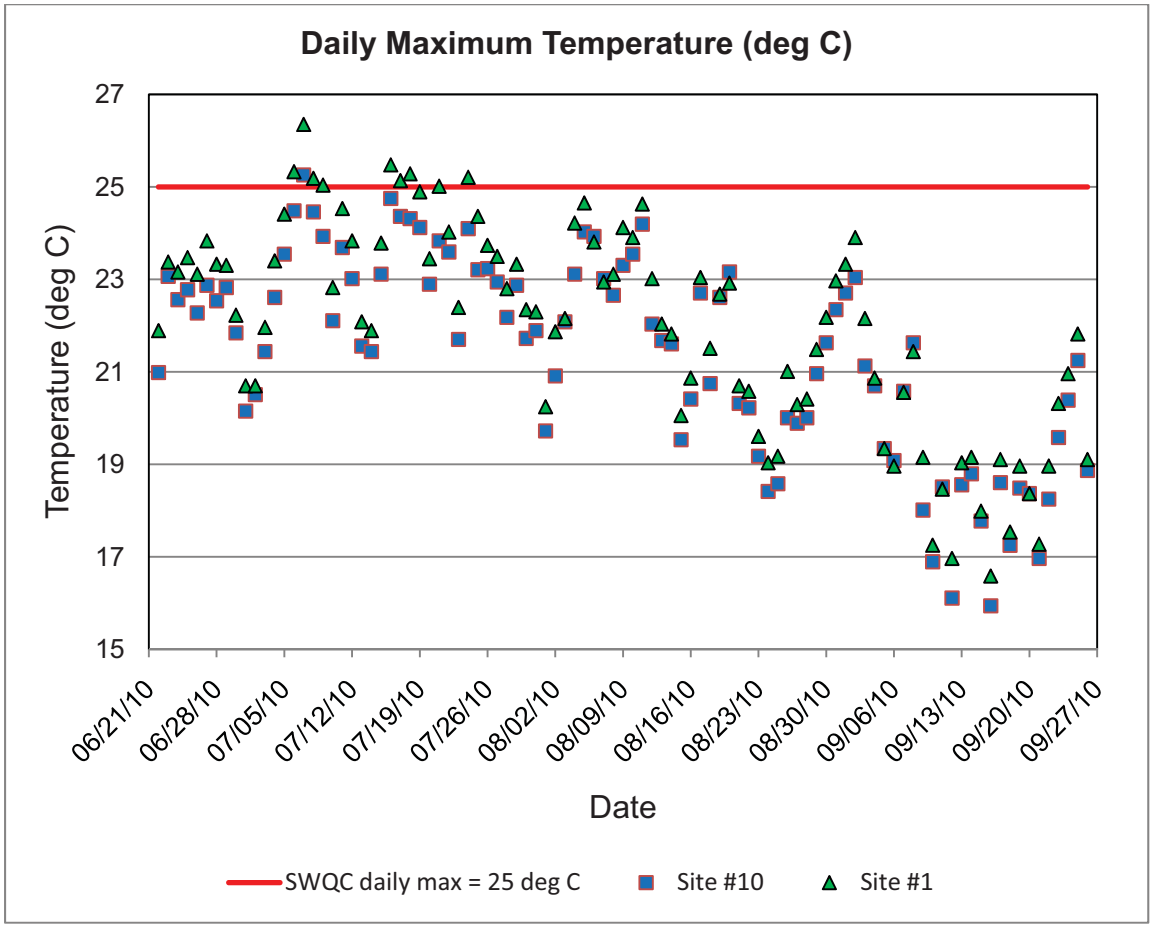

Figure 17. Daily maximum temperatures, June 22, 2010 to September 26, 2010

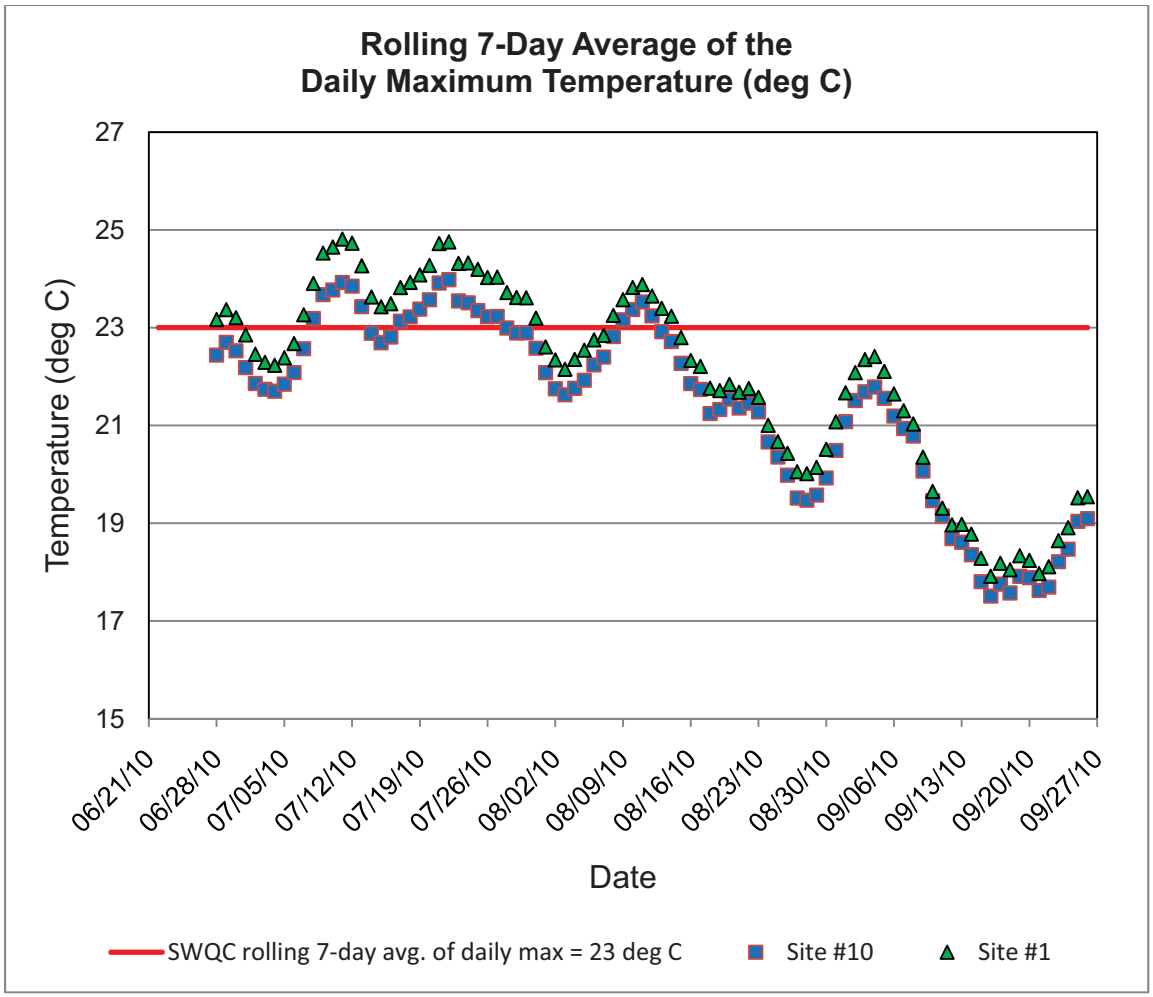

Figure 18. Rolling 7-day average of daily maximum temperatures, June 22, 2010 to September 26, 2010

targets for MST is group *Bacteroides,* a genus of obligately anaerobic, gram-negative bacteria that are found in all mammals and birds. *Bacteroides* comprise up to 40% of the amount of bacteria in feces and 10% of the fecal mass. Due to the large quantity of *Bacteroides* in feces, they are an ideal target organism for identifying fecal contamination (Layton *et al.*, 2006). In addition, *Bacteroides* have been recognized as having broad geographic stability and distribution in target host animals and are a promising microbial species for differentiating fecal sources (USEPA, 2005; Dick *et al.*, 2005; Layton *et al.*, 2006).

Methods

MST techniques applied within the Musconetcong River Watershed were supplemental to the sampling and analyses conducted under the approved QAPP and Addenda provided in Appendix A. The results of the bacteria monitoring conducted during May 2007 through October 2007 revealed highly elevated fecal coliform and *E. coli* levels in the West Portal Brook subwatershed at Site #7 and in the Turkey Hill Brook subwatershed at Site #9, just upstream of their confluence with the Musconetcong River. To further characterize the input of bacteria within the Musconetcong River, MST samples were collected during three wet weather events in 2008 (i.e., July 14, 2008; July 24, 2008, September 26, 2008) from all the established sampling locations from the 2007 monitoring program (i.e., #1, #2, #4, #11, #5a, #6, #7, #8, #9, and #10), as well as additional sites along the West Portal Brook (#13 and #14), Turkey Hill Brook (i.e., #15, #16, #17, and #18), and an unnamed tributary draining from Warren County (i.e., #12). A map showing the approximate location of these sites within the Musconetcong River Watershed is provided in Appendix D and also in Figure 4.

In May 2009, samples for MST analyses were collected at eleven sites total to obtain a more complete picture of the sources of impairment in the West Portal Brook (i.e., #7, #13, #14, #23, and #24), the unnamed tributary along Shurts Road (i.e., #11, #19, #20) , and the unnamed tributary in Hampton Borough (i.e., #2, #21, #22) . A map showing the approximate location of these sites within the Musconetcong River Watershed is provided in Appendix D and also in Figure 4. Samples were collected, independent of weather conditions, on May 7, 11, 14, 18, and 21, 2009.

Samples were collected in sterile bottles and held at 4˚C until processing. A 100 mL aliquot of each sample was filtered aseptically onto a membrane filter, and DNA was extracted from total filtered biomass using a DNeasy® tissue kit. The protocol used for the Musconetcong River Watershed samples is a modification of the procedure found in the DNeasy Tissue Handbook (Qiagen, Inc., 2004). After extraction, all DNA samples were quantified by spectroscopy (Beckman DU 640) at 260 and 280 ηm and then diluted in sterile water to a concentration of 1 µg/mL. This diluted DNA was used as the template for quantitative, real-time PCR reactions to measure the number of *Bacteroides* present. Three sets of PCR primers (targets) were used to quantify *Bacteroides* from 1) human sources ("HuBac"), 2) bovine sources ("BoBac"), and other sources ("OtherBac") (e.g., wildlife). This assay is based on published results from a study sponsored by the Tennessee Department of Environmental Conservation (Layton *et al*., 2006).

Results of qPCR

The results of the qPCR analyses from the samples collected during three wet weather events in 2008 are provided in Appendix D. These data show that some sites (i.e., #2, #7, #8, #11, and #17) have a higher incidence, during wet weather events, of

contamination with human feces. Some sites (i.e., #7, #8, #11, and #17) were found to have a higher incidence, during wet weather events, of contamination with bovine feces. These findings are summarized in Table 10 and indicate that fecal contamination occurs within the West Portal Brook, the unnamed tributary along Shurts Road, and the unnamed tributary in Hampton Borough.

The results of the qPCR analyses from samples collected in May 2009 are provided in Appendix D. These data show that some sites (i.e., #2, #11, #19, #21, and #22) have a higher incidence of contamination with human feces following storm events. The rainfall total within 48 hours of sample collection on May 7, 2009 was 1.16 inches, and human *Bacteroides* were only detected from the samples collected on May 7, 2009. Bovine *Bacteroides* were detected at Sites #7, #11, #13, #19, #21, and #24, and bovine *Bacteroides* were detected in the majority of the samples collected from Sites #7, #13, and #24, which are located downstream from livestock occurring within the West Portal Brook subwatershed (See Table 11).

Other sources of *Bacteroides*, not surprisingly, were detected at all the sampling locations during each sampling event. These other sources of *Bacteroides* may include wildlife, birds, horses, domestic animals, etc. Although these data illustrate the highly variable nature of water quality measures, these data are useful in regard to determining the potential sources and extent of fecal contamination within the watershed.

Table 10. Presence (+) and absence (-) of human and bovine *Bacteroides* within the Musconetcong River Watershed during three wet weather sampling events in 2008

Station	Date		
	7/14/08	7/24/08	9/26/08
Human *Bacteroides*			
#1	-	-	-
#2	NS	+	NS
#4	-	-	-
#5a	-	-	-
#6	-	-	-
#7	-	+	-
#8	-	+	-
#9	-	-	-
#10	-	-	-
#11	+	+	-
#12	-	-	-
#13	-	-	-
#14	-	-	-
#15	-	-	-
#16	-	-	-
#17	+	-	-
#18	-	-	+
Bovine *Bacteroides*			
#1	-	-	-
#2	NS	-	NS
#4	-	-	-
#5a	-	-	-
#6	-	-	-
#7	-	+	-
#8	-	+	-
#9	-	-	-
#10	-	-	-
#11	-	+	-
#12	-	-	-
#13	-	-	-
#14	-	-	-
#15	-	-	-
#16	-	-	-
#17	+	-	-
#18	-	-	-

NS – no sample due to low/no flow

Table 11. Presence (+) and absence (-) of human and bovine *Bacteroides* within the Musconetcong River Watershed in May 2009

Station	Date				
	5/7/09	5/11/09	5/14/09	5/18/09	5/21/09
	Human *Bacteroides*				
#2	+	NS	NS	NS	NS
#7	-	-	-	-	-
#11	+	-	-	-	-
#13	-	-	-	-	-
#14	-	-	-	-	-
#19	+	-	-	-	-
#20	-	-	-	-	-
#21	+	-	NS	NS	NS
#22	+	NS	NS	NS	NS
#23	-	-	-	-	-
#24	-	-	-	-	-
Bovine *Bacteroides*					
#2	-	NS	NS	NS	NS
#7	+	+	+	+	+
#11	+	-	-	-	-
#13	-	+	-	+	+
#14	-	-	-	-	-
#19	+	+	-	-	-
#20	-	-	-	-	-
#21	-	+	NS	NS	NS
#22	-	NS	NS	NS	NS
#23	-	-	-	-	-
#24	-	+	+	+	+

NS – no sample due to low/no flow

Biological Monitoring

Biological monitoring data is available for the Musconetcong River Watershed as part of the Ambient Biomonitoring Monitoring Network (AMNET), which is administered by the NJDEP. The NJDEP has been monitoring the biological communities of the State's waterways since the early 1970's, specifically the benthic macroinvertebrate communities. Benthic macroinvertebrates are primarily bottom-dwelling (benthic) organisms that are generally ubiquitous in freshwater and are macroscopic. Due to their important role in the food web, macroinvertebrate communities reflect current perturbations in the environment. There are several

advantages to using macroinvertebrates to gauge the health of a stream. First, macroinvertebrates have limited mobility, and thus, are good indicators of site-specific water conditions. Also, macroinvertebrates are sensitive to pollution, both point and nonpoint sources; they can be impacted by short-term environmental impacts such as intermittent discharges and contaminated spills. In addition to indicating chemical impacts to stream quality, macroinvertebrates can gauge non-chemical issues of a stream such as turbidity and siltation, eutrophication, and thermal stresses. Finally, macroinvertebrate communities are a holistic overall indicator of water quality health, which is consistent with the goals of the Clean Water Act (NJDEP, 2007). These organisms are normally abundant in New Jersey freshwaters and are relatively inexpensive to sample.

The AMNET program began in 1992 and is currently comprised of more than 800 stream sites with monitoring locations in each of the five major drainage basins of New Jersey (i.e., Upper and Lower Delaware, Northeast, Raritan, and Atlantic). These sites are sampled once every five years using a modified version of the USEPA Rapid Bioassessment Protocol (RBP) II (NJDEP, 2007). To evaluate the biological condition of the sampling locations, several community measures are calculated by the NJDEP from the data collected and include the following:

1. Taxa Richness: Taxa richness is a measure of the total number of benthic macroinvertebrate families identified. A reduction in taxa richness typically indicates the presence of organic enrichment, toxics, sedimentation, or other factors.

2. EPT (Ephemeroptera, Plecoptera, Trichoptera) Index: The EPT Index is a measure of the total number of Ephemeroptera, Plecoptera, and Trichoptera families (i.e., mayflies, stoneflies, and caddisflies) in a sample. These organisms typically require clear moving water habitats.

3. %EPT: Percent EPT measures the numeric abundance of the mayflies, stoneflies, and caddisflies within a sample. A high percentage of EPT taxa is associated with good water quality.

4. %CDF (percent contribution of the dominant family): Percent CDF measures the relative balance within the benthic macroinvertebrate community. A healthy community is characterized by a diverse number of taxa that have abundances somewhat proportional to each other.

5. Family Biotic Index: The Family Biotic Index measures the relative tolerances of benthic macroinvertebrates to organic enrichment based on tolerance scores assigned to families ranging from 0 (intolerant) to 10 (tolerant).

This analysis integrates several community parameters into one easily comprehended evaluation of biological integrity referred to as the New Jersey Impairment Score (NJIS) (NJDEP, 2007). The NJIS has been established for three categories of water quality bioassessment for New Jersey streams: non-impaired, moderately impaired, and severely impaired. A non-impaired site has a benthic community comparable to other high quality "reference" streams within the region. The community is characterized by maximum taxa richness, balanced taxa groups, and a good representation of intolerant individuals. A moderately impaired site is characterized by reduced macroinvertebrate taxa richness, in particular the EPT taxa. Changes in taxa composition result in reduced community balance and intolerant taxa become absent. A severely impaired site is one in which the benthic community is significantly different from that of the reference streams. The macroinvertebrates are dominated by a few taxa which are often very abundant. Tolerant taxa are typically the only taxa present. The scoring criteria used by the NJDEP for the NJIS are as follows:

- non-impaired sites have total scores ranging from 24 to 30,
- moderately impaired sites have total scores ranging from 9 to 21, and
- severely impaired sites have total scores ranging from 0 to 6.

It is important to note that the entire scoring system is based on comparisons with reference streams and a historical database consisting of 200 benthic macroinvertebrate samples collected from New Jersey streams. While a low score indicates "impairment," the score may actually be a consequence of habitat or other natural differences between the subject stream and the reference stream (NJDEP, 2007).

Starting with the second round of sampling under the AMNET program, habitat assessments were conducted in conjunction with the biological assessments. The first round of sampling under the AMNET program did not include habitat assessments. The habitat assessment, which was designed to provide a measure of habitat quality, involves a visually based technique for assessing stream habitat structure, as presented in the USEPA RBP II. The habitat assessment is designed to provide an estimate of habitat quality based upon qualitative estimates of selected habitat attributes. The assessment involves the numerical scoring of ten habitat parameters (i.e., epifaunal substrate/available cover, embeddedness, velocity/depth regime, sediment deposition, channel flow status, channel alteration, channel sinuosity, bank stability, vegetative protection, riparian vegetative zone width) to evaluate instream substrate, channel morphology, bank structural features, and riparian vegetation. Each parameter is scored and summed to produce a total score which is assigned a habitat quality category of optimal, sub-optimal, marginal, or poor. Sites with optimal/excellent habitat conditions have total scores ranging from 160 to 200; sites with suboptimal/good habitat conditions have total scores ranging from 110 to 159; sites with marginal/fair habitat conditions have total scores ranging from 60 to 109, and sites with poor habitat conditions have total scores less than 60. The findings from the habitat assessment are used to interpret survey

results and identify obvious constraints on the attainable biological potential within a study area (NJDEP, 2007).

The NJDEP Bureau of Biological & Freshwater Monitoring maintains two Ambient Biomonitoring Network (AMNET) stations within the Musconetcong River Watershed (i.e., Stations AN00072 and AN0073) in the vicinity of the project area. Station AN0072 is approximately 0.94 miles upstream from Site #1. Station AN0073 is approximately 2.0 miles downstream from Site #10. In 1992 Station AN0072 was assessed as being non-impaired by NJDEP (NJDEP, 1994). However, in 1997 Station AN0072 was assessed as being moderately impaired with optimal habitat conditions (NJDEP, 1999). This particular assessment most likely is the reason for this section of the Musconetcong River being listed in the *New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report* as an impaired waterway for benthic macroinvertebrates (NJDEP, 2004). In 2002, NJDEP assessed Station AN0072 as being non-impaired with optimal habitat conditions (NJDEP, 2008). Also, in the fall of 2007, NJDEP assessed Station AN0072 as having optimal habitat conditions and having a rating of "good" under the High Gradient Macroinvertebrate Index (HGMI) (NJDEP, 2010). Station AN0072 is considered to be at full attainment of the regulatory threshold. In 1993, 1997, and 2002, Station AN0073 was assessed as being non-impaired by NJDEP, and in 1997 and 2002, optimal habitat conditions were noted at Station AN0073 (NJDEP, 1994; NJDEP, 1999; NJDEP, 2008). In the fall of 2007, NJDEP assessed Station AN0073 as having optimal habitat conditions and having a rating of "excellent" under the HGMI (NJDEP, 2010). Station AN0073, like AN0072, is considered to be at full attainment of the regulatory threshold.

A biological assessment was conducted by the Rutgers Cooperative Extension Water Resources Program in the early and late summer of 2007 within the Musconetcong River Watershed at Site #1 and Site #10. The biological assessment is fully described in Appendix E. The assessment demonstrates that the biological condition has remained at a non-impaired status, and the habitat condition has remained as optimal within this section of the Musconetcong River Watershed. The assessments conducted by NJDEP at Stations AN0072 and AN0073 in the early fall of 2007, following the assessment conducted by the Rutgers Cooperative Extension Water Resources Program, confirm these findings. Since no impairments have been noted at this time, there is no reason to conduct the U.S. Environmental Protection Agency (USEPA) Stressor Identification (SI) process, which is used to identify any type of stressor or combination of stressors that might cause biological impairment (USEPA, 2000).

Summary

Clearly the Musconetcong River Watershed's quality is compromised given the seasonal elevated surface water temperatures and the continual and persistent violations of the surface water quality criteria for bacteria throughout most of the project area. Continuous temperature monitoring at Sites #1 and #10 during the summer of 2010 confirmed that temperature impairments do in fact occur along the mainstem. MST analyses suggested that fecal contamination, both from human and bovine sources, occurred within the West Portal Brook and the unnamed tributary along Shurts Road during wet weather events. MST analyses for the unnamed tributary in Hampton Borough suggested human sources of fecal contamination during wet weather events.

Furthermore, MST analyses revealed that fecal contamination from bovine sources most often occurred in samples located immediately downstream from livestock operations occurring within the West Portal Brook subwatershed, regardless of the weather conditions.

Since no impairments were noted for the aquatic community (i.e., benthic macroinvertebrates), there was no reason to conduct the USEPA Stressor Identification process, which is used to identify any type of stressor or combination of stressors that might cause biological impairment. The assessment conducted at Sites #1 and #10 in the early and late summer of 2007 demonstrated that the biological condition remained at a non-impaired status, and the habitat condition remained as optimal within this section of the Musconetcong River Watershed. The assessments conducted by NJDEP at nearby AMNET monitoring sites in the early fall of 2007 confirmed these findings.

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Appendix A: Quality Assurance Project Plan, RP06-073 Musconetcong River Watershed Restoration Plan, North Jersey Resource Conservation & Development Council, Inc. (North Jersey RC&D), Rutgers Cooperative Extension Water Resources Program, May 17, 2007 & Addenda - July 18, 2008, April 24, 2009, and September 13, 2010

QUALITY ASSURANCE PROJECT PLAN

RP06-073 MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

North Jersey Resource, Conservation & Development Council, Inc. (North Jersey RC&D)
Rutgers Cooperative Extension Water Resources Program

January 8, 2007

Revised & Resubmitted April 17, 2007

Revised & Resubmitted May 17, 2007

QUALITY ASSURANCE PROJECT PLAN

***RP06-073* MUSCONETCONG RIVER WATERSHED RESTORATION PLAN**

North Jersey Resource, Conservation & Development Council, Inc. (North Jersey RC&D)
Rutgers Cooperative Extension Water Resources Program

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1. Project Name: Musconetcong River
Watershed Restoration Plan

Requested By: Dana Cartwright
New Jersey Department of Environmental Protection

2. This project has been initiated by the New Jersey Department of Environmental Protection to collect data needed to prepare a comprehensive watershed restoration plan for the Musconetcong River.

3. Date Project Requested: January 2007

4. Date Project Initiated: May 2007

5. Project Officer: Grace Messinger
North Jersey RC&D

6. QA Officers: Christopher C. Obropta
Lisa Galloway Evrard
Rutgers Cooperative Extension Water Resources Program

7. Project Description:

A. Objective and Scope

The Musconetcong River is the main boundary between Hunterdon and Warren Counties; and between Morris and Sussex Counties. It is one of five major subwatershed basins in the Upper Delaware Watershed, and it is a significant tributary to the Delaware River. In total, the Musconetcong River captures a 156 square mile area of drainage over the four counties, and the main stem covers 42 miles on its journey to the Delaware River. The selected project area is on the lower Musconetcong River between two United States Geological Survey (USGS) and New Jersey Department of Environmental Protection (NJDEP) combined monitoring network stations. It is made up of two USGS HUC 14 subwatersheds encompassing 19.6 square miles of drainage, and the main stem is approximately seven river miles in length. This segment runs southwest from Route 31 through Lebanon Township, Hampton Borough, and Bethlehem Township in Hunterdon County and from Washington Township into Franklin Township in Warren County. There are six mapped unnamed tributaries that total approximately 19 water miles that enter the river. The waters of the Musconetcong in this section are mainly FW2-TM; one tributary that enters from Washington Township is classified as FW2-TP (C1). The three large tributaries that enter the main stem through agricultural fields in Franklin Township are classified as FW2-TM, and two large tributaries that enter the main stem through Bethlehem Township are classified as FW2-TP(C1).

NJDEP has included this section of the Musconetcong River on Sublist 5 for non-attainment of fecal coliform, pH and aquatic life in the *New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report.* According to the recently adopted 2006 Integrated List, which uses a HUC-14 based water quality impairment listing methodology, the Musconetcong River

Watershed (HUC 02040105160040 and 50) maintains the following listing: Sublist 4 for fecal coliform (primary recreation impairment).

A Total Maximum Daily Load (TMDL) for fecal coliform has been adopted for this area. This TMDL requires 93% reductions in nonpoint source fecal coliform loads from medium/high density residential, low density/rural residential, commercial, industrial, mixed urban/other urban, and agricultural lands. Within this subwatershed, three primary sources of fecal coliform exist: livestock, septic and wildlife. Through additional sampling, pH impairments will be confirmed and the impairment will be addressed to determine if its origin is due to natural geologic conditions in the watershed or from agricultural or human influences. Through NJDEP's Ambient Biomonitoring Network (AMNET), aquatic non-attainment has been identified. Potential sources for this non-attainment include environmental stressors including: increased water temperature, decreased dissolved oxygen, soil and streambank erosion, stormwater runoff, and decreased water quality from nonpoint source pollution.

The major land use types in the watershed are: agriculture at 49%, forested woodlands at 32% and urban at 13.5%. With the growing population in this watershed, land use from agriculture and forested land has been converted to urban uses. This watershed is suffering from degraded water quality, decreased habitat and increased streambank erosion and sedimentation. The main population in this watershed is centered in the small boroughs of Hampton and Asbury and in Bethlehem Township, which rely solely on individual on-site waste disposal systems. Concerns have been raised recently regarding residents in these small hamlets properly maintaining their septic systems. The TMDL document specifically identifies septic systems as one of the contributors to bacterial contamination in the area.

This subwatershed has been identified as a priority water segment and currently has a stream restoration plan in development to begin to address the fecal impairments. Additional data for this segment has been collected and summarized as part of this 2004 NJDEP Priority Waters initiative. Through this ongoing project, North Jersey RC&D is working to identify the causes and sources of fecal coliform contamination in the project area. In the summer of 2004, an extensive fecal coliform sampling program was undertaken. Sampling was conducted at ten locations within the two HUC 14's along the Musconetcong River main stem and the six tributaries. Under an approved QAPP, this monitoring program followed the NJDEP sampling protocol of collecting five samples within a 30-day period during summer months. Based on the data collected, seven out of the ten samples exceed the 200CFU/100 ml standard. Of these seven sites that exceeded standards, two of them were tributaries with exceedances averaging over 1200 CFU/100 ml and 1500 CFU/100 ml. Also of note is the intermittent drainage from Hampton Borough which was only sampled once due no flow conditions. The one sample obtained for this presented an exceedance of 4500 CFU/100 ml.

The North Jersey RC&D has begun to see small successes as municipalities, farmers and others work to implement best management practices. Through another 319(h) grant, North Jersey RC&D completed the installation of a riparian forest buffers in this watershed at Hampton Borough Park, and work is proposed to begin on implementing a riparian forest buffer on agricultural fields in Bethlehem Township just above a 2004 sampling location. However, to achieve the required load reductions and improve aquatic habitat, more work is need. The North

Jersey RC&D will work with project partners to take the work that began through the NJDEP Priority Waters initiative, and develop a Watershed Restoration and Protection plan that will address all impairments with involvement and support from all major stakeholder groups.

B. Data Usage

The data collected in accordance with this Quality Assurance Project Plan (QAPP) will help describe both dry weather and wet weather water quality conditions. These data will provide the information needed to identify and quantify sources of pollution so that appropriate management practices can be implemented to minimize these sources.

C. Monitoring Network Design and Rationale

Sampling Locations:

For the most part, the sampling locations for this study are established sampling locations from a 2004 NJDEP Priority Waters initiative. An initial visual assessment and data collection provided by the WMA 1 Technical Advisory Committee identified priority sites where sampling for fecal coliform could provide additional data or site-specific information. In addition, an overview of the QAPP and the sampling locations was presented to various stakeholders at the Project Launch Meeting on 1/30/07 for review and comment.

The sampling locations are shown in Attachment A. The ten sampling stations throughout the watershed are as follows:

Site #1: Musconetcong River at the Route 31 crossing in Hampton, NJ
Site #2: Unnamed Tributary/Stormwater Outfall flowing through Hampton, just upstream of confluence with the Musconetcong River
Site #4: Musconetcong River at the Valley Road crossing downstream of Hampton
Site #5a: Unnamed Tributary flowing from the village of Asbury, just upstream of confluence with the Musconetcong River
Site #6: Musconetcong River downstream of Asbury
Site #7: West Portal Brook just upstream of confluence with Musconetcong River
Site #8: Musconetcong River at the Valley Station Road crossing
Site #9: Unnamed Tributary just upstream of confluence with Musconetcong River
Site #10: Musconetcong River at Person Road crossing at the USGS monitoring station near Bloomsbury (#01457000)
Site #11: Unnamed Tributary at Maple and Shruts Road in Washington Township

A WAAS-enable Garmin Rino 120 GPS (global positioning system) unit will be used to locate and identify the sampling locations. Sampling locations will be marked with stakes and surveying tape ***or flags***. Field personnel will take GPS readings in the field to aid in verifying the correct sampling locations during the first sampling event.

Basis for Sampling Locations:

Surface water quality sampling will be conducted to assess the loading inputs of nutrients, total suspended solids and bacteria to the Musconetcong River, as well as the movement of nutrients, total suspended solids and bacteria from basin to basin to identify and quantify the sources of

pollution under dry weather and wet weather conditions. Biological sampling will be conducted so that the benthic macroinvertebrate community can be better characterized, compared, and evaluated for biological integrity within the study area.

- Site #1 – Musconetcong River at the Route 31 crossing in Hampton was selected to serve as the upstream control prior to potential effluent from Hampton septic systems and cesspools entering the river. This site delineates the upstream boundary of the study area.
- Site #2 – Unnamed Tributary/Stormwater Outfall flowing through Hampton, just upstream of confluence with the Musconetcong River, was selected to show if fecal impairments in the Musconetcong are coming from potentially failing septic systems in the Borough of Hampton.
- Site #4 – Musconetcong River at the Valley Road crossing downstream of Hampton was selected to determine the levels of fecal coliform in the river downstream of potential septic effluent from Hampton.
- Site #5a – Unnamed Tributary flowing from the village of Asbury, just upstream of confluence with the Musconetcong River, was selected to determine if the Asbury village septic systems are influencing the tributary.
- Site #6 – Musconetcong River downstream of Asbury was selected to determine the levels of fecal coliform in the river downstream of potential septic effluent from Asbury.
- Site #7 – West Portal Brook just upstream of confluence with Musconetcong River was selected to help identify if loadings are coming from the livestock in this subwatershed.
- Site #8 – Musconetcong River at the Valley Station Road crossing was selected to determine the levels of fecal coliform in the river downstream of the potential agricultural inputs of Site #7.
- Site #9 – Unnamed Tributary (a.k.a. Turkey Hill Brook) just upstream of confluence with Musconetcong River was selected to help identify if loadings were coming from the livestock in this subwatershed.
- Site #10 – Musconetcong River at Person Road crossing at the USGS monitoring station near Bloomsbury (#01457000) was selected as it delineates the downstream end of the priority subwatershed.
- Site #11 – Unnamed Tributary at Maple and Shurts Road in Washington Township was selected to determine a baseline fecal coliform level and to determine how this tributary influences the river between Site #4 and Site #6.

Temporal and Spatial Aspects:

Biweekly Surface Water Sampling

Surface water quality samples will be collected from all sampling locations in a downstream to upstream order to avoid disturbances to downstream water column samples twice a month, independent of weather, from May through October 2007 (12 events). Three additional surface water quality samples will be collected from all sampling locations in June, July, and August 2007 for fecal coliform and Eschericia coli (*E. coli*) analyses (nine additional sampling events). These nine additional sampling events will be independent of precipitation and will allow for a total of five fecal coliform, as well as five *E. coli* analyses at all sampling locations within a 30 day period during the warmer summer months. NJDEP considers the warm weather sampling months to fall between Memorial Day (i.e., May 28, 2007) and Labor Day (i.e., September 3, 2007).

All scheduling is subject to the natural occurrence of appropriate stream flow conditions (i.e., non-flooding conditions). In accordance with the Field Sampling Procedures Manual (See Section 6.8.1.1, Chapter 6D – page 59 of 188), field personnel will not wade into flowing water when the product of depth (in feet) and velocity (in feet per second) equals ten or greater to ensure the health and safety of all field personnel. If the stream flow conditions preclude entry into the stream, samples will be collected from the closest bridge crossing to that location or from the stream bank.

Bacteriology samples will be collected directly into a bacteriological sample container in accordance with the methods outlined in section 6.8.2.2.7 of the Field Sampling Procedures Manual (See Chapter 6D - page 67 of 188). Composite samples will not be collected for bacteriology samples.

For the most part, the Musconetcong River and its tributaries are uniformly mixed and of high velocity which warrants grab sampling (See Section 6.8.2.2.3, Chapter 6D-Page 66 of 188 of the Field Sampling Procedures Manual). A single grab sample will be collected at all locations where the stream width is six feet or less. At stream locations with a width greater than six feet, a minimum of three subsurface grab samples (i.e., quarter points) will be collected at equidistant points across the stream. The number of individual samples in a composite varies with the width of the stream being sampled. Horizontal intervals will be at least one foot wide (See Section 6.8.2.2.2, Chapter 6D – Page 64 of 188 of the Field Sampling Procedures Manual). These grab samples then will be composited in a larger volume container from which the desired volume will be transferred to the sample bottles. A dedicated large volume container will be assigned to each sample location.

Field equipment used for surface water quality sample collection (i.e., bottles and buckets) will be decontaminated/cleaned in the laboratory prior to each sampling event. A dedicated large volume container will be assigned to each sample location. Prior to each sampling event, the large volume containers will be decontaminated in the laboratory using the following procedures in accordance with the Field Sampling Procedures Manual (See Chapter 2A – Page 10 of 61): 1) laboratory grade glassware detergent plus tap water wash, 2) generous tap water rinse, 3) distilled/deionized water rinse, 4) 10% nitric acid rinse, 5) distilled/deionized water rinse. Note that the samples collected will not be analyzed for metals or organics. Also, field equipment decontamination water will be disposed of in accordance with the laboratory's Standard Operating Procedures and Quality Assurance Manual.

Wet Weather Surface Water Sampling

Three wet weather sampling events, at a minimum, will be conducted between May and October 2007 at each station. The wet weather samples for this plan will be in addition to the 12 biweekly surface water sampling events described above. Collection of stormwater samples will begin at the onset of the storm (i.e., a storm predicted to produce a minimum of ½ inch of precipitation), and an attempt will be made to span the course of the event. By using this method of sampling, the samples should accurately reflect loading for the entire event. A priority will be to acquire first flush samples. Flow will be measured along with concentrations to quantify loading for selected parameters. A total of three samples will be obtained between the onset of

the storm and the time when the flow reaches the pre-storm level, unless impractical, at each station during each storm event. At each station, the samples obtained for the entire event will be flow-weight composited to provide one sample from each station, with the exception of fecal coliform and *E. coli*, which will require analysis of each individual grab sample. Rainfall data will be collected from a rain gauge that will be installed in the watershed.

If three samples can not be collected between the onset of the storm and the time when the flow reaches the pre-storm level, then the sampling event will not count as a wet weather surface water sampling event. If three ½ inch storm events are not captured between May - October 2007, the Water Resources Program, after consultation with the Department, may have to defer the Wet Weather Surface Water Sampling portions of the study to May – October 2008. Attempts will be made to conduct this portion of the study as early on in the study period as possible. Regarding time for collection of the first flush samples, the Water Resources Program will attempt to capture the first flush using the expected or anticipated rising limb of the hydrograph. The actual point on the hydrograph will have to be confirmed after sample completion.

Biological Sampling

Samples of the benthic macroinvertebrate community will be collected in accordance with the Rapid Bioassessment Protocol (RBP) procedure used by the NJDEP Bureau of Freshwater and Biological Monitoring, which is based on USEPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers* (EPA 841-B-99-002 Nov. 1999). A multihabitat sampling approach, concentrating on the most productive habitat of the stream plus coarse particulate organic matter (CPOM) or leaf litter, will be used. Benthic macroinvertebrates will be collected from two locations (i.e., #1 and #10) in early summer (i.e, late June/early July) and late summer (i.e., late August/early September) as described in Attachment B. The biological sampling locations were selected to bracket the upstream and downstream boundaries of the study area. In addition, locations with comparable substrate, canopy coverage, and flow conditions were selected for data comparability.

Summary of Monitoring Network Design and Rational –
Temporal and Spatial Aspects

Type:	Biweekly Surface Water Sampling	Additional Bacteriology Sampling	Wet Weather Surface Water Sampling	Biological Sampling
Frequency:	Two (2) times a month from May - October 2007 (12 events)	Three (3) times, in addition to biweekly samples, in June, July, & August 2007 (9 events)	Three (3) times between May - October 2007 (3 events)	Two (2) times – once in early summer and once in late summer (2 events)
Parameters:	pH, temperature, dissolved oxygen, stream width, stream depth, stream velocity, ammonia-N, nitrate-N, nitrite-N, total Kjeldahl nitrogen, total phosphorus, dissolved orthophosphate phosphorus, total suspended solids, fecal coliform, *E. coli*	Stream width, stream depth, stream velocity, fecal coliform, *E. coli*	pH, temperature, dissolved oxygen, stream width, stream depth, stream velocity, ammonia-N, nitrate-N, nitrite-N, total Kjeldahl nitrogen, total phosphorus, dissolved orthophosphate phosphorus, total suspended solids, fecal coliform, *E. coli*	pH, temperature, dissolved oxygen, stream width, stream depth, stream velocity, total dissolved solids, benthic macroinvertebrate survey, habitat assessment
Sampling Locations:				
1	X	X	X	X
2	X	X	X	
4	X	X	X	
5a	X	X	X	
6	X	X	X	
7	X	X	X	
8	X	X	X	
9	X	X	X	
10	X	X	X	X
11	X	X	X	

D. Monitoring Parameters

Surface water quality sample collection will be conducted by the Rutgers Cooperative Extension Water Resources Program (RCE WRP). Stream width, stream depth, and stream velocity will be measured in accordance with the methods outlined in Attachment C by the RCE WRP. *In situ* measurements of pH, temperature, and dissolved oxygen will be conducted by the Rutgers EcoComplex Laboratory (NJDEP Certified Laboratory #03019). Collected samples will be analyzed for fecal coliform, ammonia-nitrogen, nitrate-nitrogen, nitrite-nitrogen, total Kjeldahl nitrogen, total phosphorus, dissolved orthophosphate phosphorus, and total suspended solids by New Jersey Analytical Laboratories (NJDEP Certified Laboratory #11005). In addition, collected samples will be analyzed for *E. coli* by Garden State Laboratories (NJDEP Certified Laboratory #20044).

Biological sampling will include benthic macroinvertebrate grab/jab type sampling, along with the collection of CPOM. Physicochemical measurements will include total dissolved solids and *in situ* pH, temperature, dissolved oxygen, stream width, stream depth, and stream velocity. Benthic macroinvertebrate sampling and identification will be conducted by the RCE WRP in accordance with the Rapid Bioassessment Protocol (RBP) procedure used by the NJDEP Bureau of Freshwater and Biological Monitoring, which is based on USEPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers* (EPA 841-B-99-002 Nov. 1999). The RCE WRP will make stream width, stream depth, and stream velocity determinations in accordance with the procedures specified in Attachment C. *In situ* measurements of pH, temperature, and dissolved oxygen will be conducted by the Rutgers EcoComplex Laboratory (NJDEP Certified Laboratory #03019). Total dissolved solids will be measured by New Jersey Analytical Laboratories (NJDEP Certified Laboratory #11005).

E. Parameter Table

Measurements of the sampled parameters will be performed in accordance with Table 1A – List of Approved Biological Methods and Table 1B – List of Approved Inorganic Test Procedures (40 CFR Part 136.3) of Attachment D. Sample containers, preservation techniques, and holding times will be in accordance with Table II (40 CFR Part 136.3) of Attachment E. New Jersey Analytical Laboratories and Garden State Laboratories will provide appropriate containers for all analyses. The circled methods and test procedures noted in Attachments D and E are the actual tests/methods that will be used as part of this project. These are the methods and procedures that the laboratories referenced in this QAPP are certified for. Any deviations from the test procedures and/or preservation methods and holding times will be reported to the NJDEP Office of Quality Assurance and will be noted in the final report from the laboratory.

8. Schedule:*

Task	Date
Submit QAPP	January 2007
Conduct biweekly surface water sampling	May – October 2007
Conduct additional bacteriology sampling	June, July, August 2007
Conduct wet weather surface water sampling	May - October 2007
Conduct biological sampling	Early Summer and Late Summer 2007
Submit data and summary report to NJDEP	January 2008

* All scheduling is subject to the natural occurrence of appropriate stream flow conditions (i.e., non-flooding conditions).

9. Project Organization and Responsibility:

Laboratory Operations:	(NJ Analytical)	Allen Thomas
	(Garden State L.)	Harvey Klein
	(Rutgers EcoComplex)	Lisa Galloway Evrard
	(NJDEP Representative)	Marc Ferko
Sampling Operations:	(QA Officer)	Lisa Galloway Evrard
	(NJDEP Representative)	Marc Ferko
Data Processing/	(QA Officer)	Lisa Galloway Evrard
Data Quality Review:	(NJDEP Representative)	Beth Torpey
		Dana Cartwright
Overall QA:	(QA Officers)	Christopher C. Obropta
		Lisa Galloway Evrard
Overall Coordination:	(Project Officer)	Grace Messinger

10. Organizational Chart:

Overall Coordination: Grace Messinger (North Jersey RC&D) Overall QA: Christopher C. Obropta (RCE WRP) Lisa Galloway Evrard (RCE WRP)
Data Quality Review/Data Processing: Lisa Galloway Evrard (RCE WRP) Beth Torpey (NJDEP) Dana Cartwright (NJDEP)
Sampling QC/Sampling Operations: Lisa Galloway Evrard (RCE WRP) Marc Ferko (NJDEP)
Laboratory Operations: Allen Thomas (NJ Analytical) Harvey Klein (Garden State Laboratories) Lisa Galloway Evrard (Rutgers EcoComplex) Marc Ferko (NJDEP)

11. Sampling Procedures:

All sampling procedures will be in conformance with the NJDEP 2005 Field Sampling Procedures Manual, any applicable USEPA guidance, or with prior written approval.

- Bacteriology samples will be collected in accordance with the methods outlined in section 6.8.2.2.7 of the Field Sampling Procedures Manual (See Chapter 6D - page 67 of 188).
- Manual composite sampling for wider portions of the streams will be conducted in accordance with the methods outlined in section 6.8.2.2.2 of the Field Sampling Procedures Manual (See Chapter 6D – page 64 of 188).
- Grab sampling where the natural stream conditions make compositing unnecessary will be conducted in accordance with the methods outlined in section 6.8.2.2.3 of the Field Sampling Procedures Manual (See Chapter 6D – page 66 of 188).

In addition, instrumentation used for the collection of field data will be properly calibrated, in conformance with the manufacturer's instructions, laboratory SOPs and QA Manuals, and the NJDEP Field Sampling Procedures Manual.

12. Chain of Custody Procedures:

Chain of Custody procedures will be followed for all samples collected for this monitoring program. A sample chain of custody form is provided in Attachment F. A sample is in someone's "custody" if 1) it is in one's actual physical possession, 2) it is in one's view, after being in one's physical possession, 3) it is in one's physical possession and then locked up so that no one can tamper with it, and 4) it is kept in a secured area, restricted to authorized personnel only.

13. Calibration Procedures and Preventative Maintenance:

Calibration and preventative maintenance of laboratory and field equipment will be in accordance with the manufacturer's instructions, NJDEP Field Sampling Procedures Manual, NJAC 7:18 and 40 CFR Part 136.

14. Documentation, Data Reduction, and Reporting:

The QA Officer, for a minimum of five years, will keep all data on file, and all applicable data will be included in the summary report to NJDEP. An electronic version of all reports and data will be provided on a CD for the Department’s use.

15. Quality Assurance and Quality Control:

NJAC 7:18 and 40 CFR Part 136 will be followed for all quality assurance and quality control (QA/QC) practices, including detection limits, quantitation limits, precision, and accuracy. Tables of parameter detection limits, quantitation limits, accuracy, and precision applicable to this study are provided in Attachment G. New Jersey Analytical Laboratories, Garden State Laboratories, and Rutgers Cooperative Extension will perform data validation.

Marion McClary, Jr., Ph.D. (Associate Professor of Biological Sciences and Associate Director of Biological Sciences at Fairleigh Dickinson University) will verify the reference/voucher collections prepared by Lisa Galloway Evrard of the Rutgers Cooperative Extension Water Resources Program.

16. Performance and Systems Audits:

All NJDEP certified laboratories participate ***annually in a NJDEP mandated Performance Testing program.*** The NJDEP Office of Quality Assurance conducts a performance audit of each laboratory that is certified. The NJDEP Office of Quality Assurance also periodically conducts on-site technical systems audits of each certified laboratory. The findings of these audits, together with the ***NJDEP mandated Performance Testing program***, are used to update each laboratory's certification status.

The NJDEP Office of Quality Assurance periodically conducts field audits of project sampling operations. The Office of Quality Assurance will be contacted during the project to schedule a possible field audit.

17. Corrective Action:

All NJDEP certified laboratories must have a written corrective action procedure which they adhere to in the event that calibration standards, performance evaluation results, blanks, duplicates, spikes, etc. are out of the acceptable range or control limits. If the acceptable results cannot be obtained for the above-mentioned QA/QC samples during any given day, sample analysis must be repeated for that day with the acceptable QA/QC results. NJDEP will be notified if there are any deviations from the approved work plan.

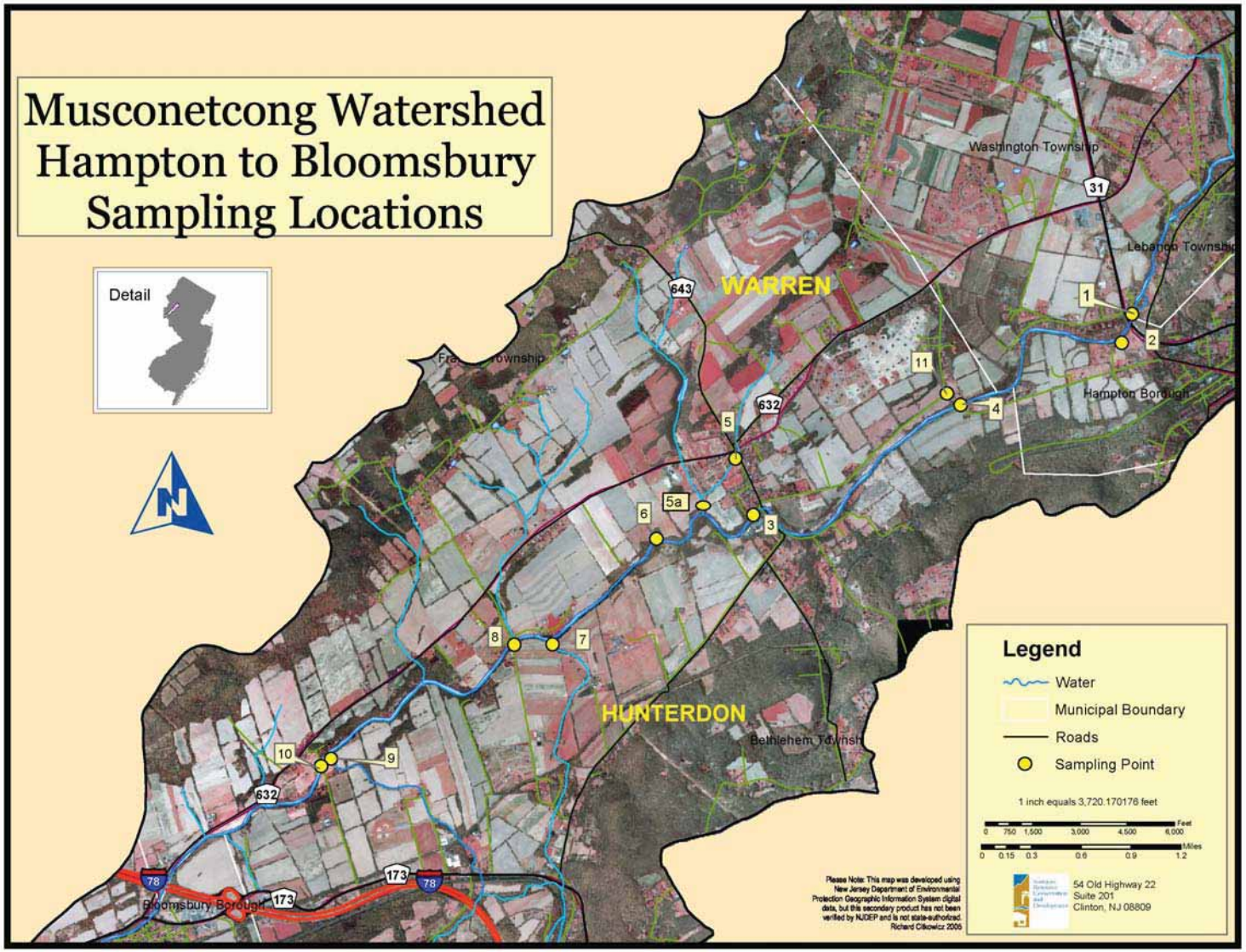
All signatories of this QAPP will be notified when deviations to the QAPP are made prior to their implementation.

18. Reports:

The summary report will include at a minimum an Introduction, Purpose and Scope, Results and Discussion, Conclusions and Recommendations, and an appendix with data tables. An electronic version of all reports and data will be provided on a CD for the Department’s use.

ATTACHMENT A

Sampling Locations
Musconetcong River Watershed



** Note that Site 3 and Site 5 on this map are not included in this study.*

ATTACHMENT B

Biological Sampling Procedures and Analysis

Biological Sampling Procedures and Analysis

These sampling and data analysis procedures are in accordance with the Rapid Bioassessment Protocol procedures used by the NJDEP Bureau of Freshwater and Biological Monitoring, which is based on USEPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers* (EPA 841-B-99-02 Nov. 1999).

Sampling Procedures:

Samples will be collected using a multi-habitat sampling approach, concentrating on the most productive habitat of the stream (i.e., the riffle/run areas), plus coarse particulate organic matter (CPOM) or leaf litter. This sampling method minimizes habitat or substrate variation between sampling sites, and includes all likely functional feeding groups of macroinvertebrates in the stream. Three grab type samples will be collected at each sampling site. These samples will be sorted in the field, composited (i.e., the contents from the three grab samples from each site will be combined into a single container), and preserved in 80% ethanol for later subsampling, identification and enumeration.

A composite collection of a variety of CPOM forms (e.g., leaves, needles, twigs, bark, or fragments of these) will be collected. It is difficult to quantify the amount of CPOM to be collected in terms of weight or volume, given the variability of its composition. Collection of several handfuls of material is usually adequate, and the material is typically found in depositional areas, such as in pools and along snags and undercut banks. The CPOM sample will be processed using a U.S. Standard No. 30 sieve, and added to the composite of the grab samples for each site.

A 100-organism subsample of the benthic macroinvertebrate composite sample from each sampling site will be taken in the laboratory according to the methods outlined in the Rapid Bioassessment Protocol used by the NJDEP Bureau of Freshwater and Biological Monitoring. With the exception of chironomids and oligochaetes, benthic macroinvertebrates will be identified to genus. Chironomids will be identified to subfamily as a minimum, and oligochaetes will be identified to family as a minimum.

A habitat assessment will be conducted concurrent with the benthic macroinvertebrate sampling in accordance with the methods used by the NJDEP Bureau of Freshwater and Biological Monitoring. The measurement of physicochemical parameters will also be conducted concurrent with the benthic macroinvertebrate sampling. Surface water sampling for the measurement of pH, temperature, and dissolved oxygen will be conducted on a representative cross section of the steam. At least four subsurface grab samples will be collected across an established transect. These grab samples will be composited, and an appropriate volume will be transferred to sample bottles for *in situ* measurements of pH, temperature, and dissolved oxygen. Stream width, stream depth, and stream velocity will be measured in accordance with the methods outlined in Attachment C. Total dissolved solids (TDS) will also be measured as part of the biological sampling.

Biological Sampling Procedures and Analysis (continued)

Data Analysis:

The NJDEP Bureau of Freshwater and Biological Monitoring uses several community measures of biometrics adapted from the Rapid Bioassessment Protocols to evaluate the biological condition of sampling sites within the Ambient Biomonitoring Network in New Jersey. These community measures include taxa richness, EPT index, %EPT, %CDF, and Modified Family Biotic Index. This analysis integrates several community parameters into one easily comprehended evaluation of biological integrity referred to as the New Jersey Impairment Score (NJIS). The NJIS has been established for three categories of water quality bioassessment for New Jersey streams: non-impaired, moderately impaired, and severely impaired, and is based on comparisons with reference streams and a historical database consisting of 200 benthic macroinvertebrate samples collected from New Jersey streams.

If the above metrics are not utilized, or if different metrics or indices are used, these changes will be discussed with NJDEP for approval. For example, to determine the similarity among the sampling sites with respect to species composition, the Percentage Similarity Index may be calculated for all pair wise comparisons of the sampling sites. Also, the benthic macroinvertebrates may be separated into the four broad functional feeding groups to evaluate community structure. In addition, the Shannon diversity index may be calculated to evaluate community structure. In addition, the findings from the habitat assessment will be used to interpret survey results and identify obvious constraints on the attainable biological potential of the site.

The final report will include a characterization of the aquatic biota, in particular the benthic macroinvertebrate community.

ATTACHMENT C

Stream Flow Measurement Procedure

Stream Flow Measurement Procedure

Stream width, depth, velocity, and flow determinations will be made in conformance with the following procedures:

1. A measuring tape is extended across the stream, from bank to bank, perpendicular to flow. Meter calibration is checked.

2. Using a Marsh-McBirney, Inc. Model 2000 Flo-Mate Portable Water Flow meter, velocity and depth measurements are made at points along the tape. Normally depth is measured using a rod calibrated in tenths of a foot. In shallow streams, a yardstick may be used to measure depth. Velocities are measured at approximately 0.6 depth (from the surface) where depths are less than 2.5 feet and at 0.2 and 0.8 depth (from the surface) in areas where the depth exceeds 2.5 feet.

3. The stream cross section is divided into segments with depth and velocity measurements made at equal intervals along the cross section. The number of measurements will vary with site conditions and uniformity of stream cross section. Each cross section is divided into equal parts depending upon the total width and uniformity of the section. At a minimum, velocities are taken at quarter points for very narrow sections. In general, velocity and depth measurements are taken every one to five feet. A minimum of ten velocity locations is used whenever possible. The velocity is determined by direct readout from the Marsh-McBirney meter set for 5 second velocity averaging.

4. Using the field data collected, total flow, average velocity, and average depth can be computed. Individual partial cross-sectional areas are computed for each depth and velocity measurement. The mean velocity of flow in each partial area is computed and multiplied by the partial cross-sectional area to produce an incremental flow. Incremental flows are summed to calculate the total flow. The average velocity for the stream can be computed by dividing the total flow by the sum of the partial cross-sectional areas. The average depth for the stream can be computed by dividing the sum of the partial cross-sectional areas by the total width of the stream. The accuracy of this method depends upon a number of factors, which include the uniformity of the steam bottom, total width, and the uniformity of the velocity profile.

- Flow measurements will be collected for all sampling events. However, in accordance with the Field Sampling Procedures Manual (See Section 6.8.1.1, Chapter 6D – page 59 of 188), field personnel will not wade into flowing water when the product of depth (in feet) and velocity (in feet per second) equals ten or greater. All scheduling is subject to the natural occurrence of appropriate stream flow conditions (i.e., non-flooding conditions) to ensure the health and safety of all field personnel. If the stream flow conditions preclude entry into the stream, flow will have to be estimated or calculated based on the recorded flow at the closest USGS gaging station and the drainage area.

ATTACHMENT D

Table 1A – List of Approved Biological Methods
&
Table 1B – List of Approved Inorganic Test Procedures
40 CFR Part 136.3
July 1, 2005

TABLE IA—LIST OF APPROVED BIOLOGICAL METHODS

Parameter and units	Method [1]	EPA	Standard methods 18th, 19th, 20th Ed.	ASTM	AOAC	USGS	Other
Bacteria:							
1. Coliform (fecal), number per 100 mL.	Most Probable Number (MPN), 5 tube, 3 dilution, or	p. 132 [3]	9221C E [4]				
	Membrane filter (MF) [2], single step.	p. 124 [3]	9222D [4]			B–0050–85 [5]	
2. Coliform (fecal) in presence of chlorine, number per 100 mL.	MPN, 5 tube, 3 dilution, or	p. 132 [3]	9221C E [4]				
	MF, single step [6]	p. 124 [3]	9222D [4]				
3. Coliform (total), number per 100 mL.	MPN, 5 tube, 3 dilution, or	p. 114 [3]	9221B [4]				
	MF [2], single step or two step	p. 108 [3]	9222B [4]	....	....	B–0025–85 [5]	
4. Coliform (total), in presence of chlorine, number per 100 mL.	MPN, 5 tube, 3 dilution, or	p. 114 [3]	9221B [4]				
	MF [2] with enrichment	p. 111 [3]	9222(B+B.5c) [4]				
5. E. coli, number per 100 mL [28].	MPN [7,9,15], multiple tube,		9221B.1/9221F [4,12,14]				
	multiple tube/multiple well,		9223B [4,13]	....	991.15 [11]	....	Colilert® [13,17] Colilert-18® [13,16,17]
	MF [2,6,7,8,9] two step, or	1103.1 [20]	9222B/9222G [4,19] 9213D [4]	D5392–93 [10]			
	single step	1603 [21] 1604 [22]					mColiBlue 24 [18]
6. Fecal streptococci, number per 100 mL.	MPN, 5 tube, 3 dilution,	p. 139 [3]	9230B [4], 9230C [4]				
	MF [2], or	p. 136 [3]	....	....	B–0055–85 [5]		
	Plate count	p. 143 [4]					
7. Enterococci, number per 100 mL.	MPN [7,9] multiple tube	....	9230B [4]				
	multiple tube/multiple well	....	....	D6503–99 [10]	....	....	Enterolert® [13,23]
	MF [2,6,7,8,9] two step	1106.1 [24]	9230C [4]	D5259–92 [10]			
	single step, or	1600 [25]					
	Plate count	p. 143 [3]					
Protozoa:							
8. *Cryptosporidium* [26]	Filtration/IMS/FA	1622 [26] 1623 [27]					
9. *Giardia* [28]	Filtration/IMS/FA	1623 [27]					
Aquatic Toxicity:							
10. Toxicity, acute, fresh water organisms, LC50, percent effluent.	*Ceriodaphnia dubia* acute	2002.0 [29]					

	Sea urchin, *Arbacia punctulata*, fertilization.	1008.0[31]					

Notes to Table IA:

[1] The method must be specified when results are reported.

[2] A 0.45 µm membrane filter (MF) or other pore size certified by the manufacturer to fully retain organisms to be cultivated and to be free of extractables which could interfere with their growth.

[3] USEPA. 1978. Microbiological Methods for Monitoring the Environment, Water, and Wastes. Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio. EPA/600/8–78/017.

[4] APHA. 1998, 1995, 1992. Standard Methods for the Examination of Water and Wastewater. American Public Health Association. 20th, 19th, and 18th Editions. Amer. Publ. Hlth. Assoc., Washington, D.C.

[5] USGS. 1989. U.S. Geological Survey Techniques of Water-Resource Investigations, Book 5, Laboratory Analysis, Chapter A4, Methods for Collection and Analysis of Aquatic Biological and Microbiological Samples, U.S. Geological Survey, U.S. Department of Interior, Reston, Virginia.

[6] Because the MF technique usually yields low and variable recovery from chlorinated wastewaters, the Most Probable Number method will be required to resolve any controversies.

[7] Tests must be conducted to provide organism enumeration (density). Select the appropriate configuration of tubes/filtrations and dilutions/volumes to account for the quality, character, consistency, and anticipated organism density of the water sample.

[8] When the MF method has not been used previously to test ambient waters with high turbidity, large number of noncoliform bacteria, or samples that may contain organisms stressed by chlorine, a parallel test should be conducted with a multiple-tube technique to demonstrate applicability and comparability of results.

[9] To assess the comparability of results obtained with individual methods, it is suggested that side-by-side tests be conducted across seasons of the year with the water samples routinely tested in accordance with the most current Standard Methods for the Examination of Water and Wastewater or EPA alternate test procedure (ATP) guidelines.

[10] ASTM. 2000, 1999, 1996. Annual Book of ASTM Standards—Water and Environmental Technology. Section 11.02. American Society for Testing and Materials. 100 Barr Harbor Drive, West Conshohocken, PA 19428.

[11] AOAC. 1995. Official Methods of Analysis of AOAC International, 16th Edition, Volume I, Chapter 17. Association of Official Analytical Chemists International. 481 North Frederick Avenue, Suite 500, Gaithersburg, Maryland 20877–2417.

[12] The multiple-tube fermentation test is used in 9221B.1. Lactose broth may be used in lieu of lauryl tryptose broth (LTB), if at least 25 parallel tests are conducted between this broth and LTB using the water samples normally tested, and this comparison demonstrates that the false-positive rate and false-negative rate for total coliform using lactose broth is less than 10 percent. No requirement exists to run the completed phase on 10 percent of all total coliform-positive tubes on a seasonal basis.

[13] These tests are collectively known as defined enzyme substrate tests, where, for example, a substrate is used to detect the enzyme β-glucuronidase produced by *E. coli*.

[14] After prior enrichment in a presumptive medium for total coliform using 9221B.1, all presumptive tubes or bottles showing any amount of gas, growth or acidity within 48 h ± 3 h of incubation shall be submitted to 9221F. Commercially available EC-MUG media or EC media supplemented in the laboratory with 50 µg/mL of MUG may be used.

[15] Samples shall be enumerated by the multiple-tube or multiple-well procedure. Using multiple-tube procedures, employ an appropriate tube and dilution configuration of the sample as needed and report the Most Probable Number (MPN). Samples tested with Colilert® may be enumerated with the multiple-well procedures, Quanti-Tray® or Quanti-Tray® 2000, and the MPN calculated from the table provided by the manufacturer.

[16] Colilert-18® is an optimized formulation of the Colilert® for the determination of total coliforms and *E. coli* that provides results within 18 h of incubation at 35 °C rather than the 24 h required for the Colilert® test and is recommended for marine water samples.

[17] Descriptions of the Colilert®, Colilert-18®, Quanti-Tray®, and Quanti-Tray®/2000 may be obtained from IDEXX Laboratories, Inc., One IDEXX Drive, Westbrook, Maine 04092.

[18] A description of the mColiBlue24" test, Total Coliforms and *E. coli*, is available from Hach Company, 100 Dayton Ave., Ames, IA 50010.

[19] Subject total coliform positive samples determined by 9222B or other membrane filter procedure to 9222G using NA-MUG media.

[20] USEPA. 2002. Method 1103.1: *Escherichia coli* (*E. coli*) In Water By Membrane Filtration Using membrane-Thermotolerant *Escherichia coli* Agar (mTEC). U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA–821–R–02–020.

[21] USEPA. 2002. Method 1603: *Escherichia coli* (*E. coli*) In Water By Membrane Filtration Using Modified membrane-Thermotolerant *Escherichia coli* Agar (modified mTEC). U.S. Environmental Protection Agency, Office of Water, Washington D.C. EPA–821–R–02–023.

[22] Preparation and use of MI agar with a standard membrane filter procedure is set forth in the article, Brenner *et al.* 1993. "New Medium for the Simultaneous Detection of Total Coliform and *Escherichia coli* in Water." Appl. Environ. Microbiol. 59:3534–3544 and in USEPA. 2002. Method 1604: Total Coliforms and *Escherichia coli* (*E. coli*) in Water by Membrane Filtration by Using a Simultaneous Detection Technique (MI Medium). U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA 821–R–02–024.

[23] A description of the Enterolert® test may be obtained from IDEXX Laboratories, Inc., One IDEXX Drive, Westbrook, Maine 04092.

[24] USEPA. 2002. Method 1106.1: Enterococci In Water By Membrane Filtration Using membrane-Enterococcus-Esculin Iron Agar (mE-EIA). U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA–821–R–02–021.

[25] USEPA. 2002. Method 1600: Enterococci in Water by Membrane Filtration Using membrane-Enterococcus Indoxyl-β-D-Glucoside Agar (mEI). U.S. Environmental Protection Agency, Office of Water, Washington, DC. EPA–821–R–02–022.

[26] Method 1622 uses filtration, concentration, immunomagnetic separation of oocysts from captured material, immunofluorescence assay to determine concentrations, and confirmation through vital dye staining and differential interference contrast microscopy for the detection of *Cryptosporidium*. USEPA. 2001. Method 1622: Cryptosporidium in Water by Filtration/IMS/FA. U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA–821–R–01–026.

[27] Method 1623 uses filtration, concentration, immunomagnetic separation of oocysts and cysts from captured material, immunofluorescence assay to determine concentrations, and confirmation through vital dye staining and differential interference contrast microscopy for the simultaneous detection of *Cryptosporidium* and *Giardia* oocysts and cysts. USEPA. 2001. Method 1623. Cryptosporidium and Giardia in Water by Filtration/IMS/FA. U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA–821–R–01–025.

[28] Recommended for enumeration of target organism in ambient water only.

[29] USEPA. October 2002. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. Fifth Edition. U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA/821/R–02/012.
[30] USEPA. October 2002. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms. Fourth Edition. U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA/821/R–02/013.
[31] USEPA. October 2002. Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Marine and Estuarine Organisms. Third Edition. U.S. Environmental Protection Agency, Office of Water, Washington DC. EPA/821/R–02/014.

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES

Parameter, units and method	Reference (method number or page)				
	EPA[1,35]	*Standard Methods* [Edition(s)]	ASTM	USGS[2]	Other
1. Acidity, as $CaCO_3$, mg/L:					
Electrometric endpoint or phenolphthalein endpoint.	305.1	2310 B(4a) [18th, 19th, 20th].	D1067–92	I–1020–85	
				I–2030–85	
2. Alkalinity, as $CaCO_3$, mg/L:					
Electrometric of Colorimetric titration to pH 4.5, manual or automatic.	310.1	2320 B [18th, 19th, 20th]	D1067–92	I–1030–85	973.43[3]
	310.2.			I–2030–85	
3. Aluminium—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration[36]	202.1	3111 D [18th, 19th]		I–3051–85	
AA furnace	202.2	3113 B [18th, 19th].			
Inductively Coupled Plasma/Atomic Emission Spectrometry (ICP/AES)[36].	200.7[5]	3120 B [18th, 19th, 20th]		I–4471–97[50]	
Direct Current Plasma (DCP)[36].			D4190–94		Note 34.
Colorimetric (Eriochrome cyanine R).		3500–Al B [20th] and 3500–Al D [18th, 19th].			
4. Ammonia (as N), mg/L:					
Manual, distillation (at pH 9.5)[6] followed by.	350.2	4500–NH_3 B [18th, 19th, 20th].			973.49[3]
Nesslerization	350.2	4500–NH_3 C [18th]	D1426–98(A)	I–3520–85	973.49[3]
Titration	350.2	4500–NH_3 C [19th, 20th] and 4500–NH_3 E [18th].			
Electrode	350.3	4500–NH_3 D or E [19th, 20th] and 4500–NH_3 F or G [18th].	D1426–98(B).		
Automated phenate, or	350.1	4500–NH_3 G [19th, 20th] and 4500–NH_3 H [18th].		I–4523–85	
Automated electrode					Note 7.
5. Antimony-Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration[36]	204.1	3111 B [18th, 19th]			
AA furnace	204.2	3113 B [18th, 19th]			
ICP/AES[36]	200.7[5]	3120 B [18th, 19th, 20th]			
6. Arsenic-Total[4] mg/L:					

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	Reference (method number or page)				
	EPA[1,35]	*Standard Methods* [Edition(s)]	ASTM	USGS[2]	Other
Titrimetric (EDTA), or Ca plus Mg as their carbonates, by inductively coupled plasma or AA direct aspiration (See Parameters 13 and 33).	130.2	2340 B or C [18th, 19th, 20th]	D1126–86(92)	I–1338–85	973.52B[3]
28. Hydrogen ion (pH), pH units:					
Electrometric measurement, or	150.1	4500–H+ B [18th, 19th, 20th]	D1293–84 (90)(A or B)	I–1586–85	973.41[3]
Automated electrode				I–2587–85	Note 21.
29. Iridium—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration or	235.1	3111 B [18th, 19th]			
AA furnace	235.2				
30. Iron—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration[36]	236.1	3111 B or C [18th, 19th]	D1068–96(A or B)	I–3381–85	974.27[3]
AA furnace	236.2	3113 B [18th, 19th]	D1068–96(C)		
ICP/AES[36]	200.7[5]	3120 B [18th, 19th, 20th]		I–4471–97[50]	
DCP[36] or			D4190–94		Note 34.
Colorimetric (Phenanthroline)		3500–Fe B [20th] and 3500–Fe D [18th, 19th].	D1068–96(D)		Note 22.
31. Kjeldahl Nitrogen—Total, (as N), mg/L:					
Digestion and distillation followed by:	351.3	4500–N_{org} B or C and 4500–NH_3 B [18th, 19th, 20th]	D3590–89(A)		
Titration	351.3		D3590–89(A)		973.48[3]
Nesslerization	351.3	4500–NH_3 C [18th]	D3590–89(A)		
Electrode	351.3	4500–NH_3 C [19th, 20th] and 4500–NH_3 E [18th].			
Automated phenate colorimetric	351.1			I–4551–78[8]	
Semi-automated block digestor colorimetric.	351.2		D3590–89(B)	I–4515–91[45].	
Manual or block digestor potentiometric.	351.4		D3590–89(A)		
Block digester, followed by Auto distillation and Titration, or.					Note 39.
Nesslerization, or					Note 40.
Flow injection gas diffusion					Note 41.
32. Lead—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration[36]	239.1	3111 B or C [18th, 19th]	D3559–96(A or B)	I–3399–85	974.27[3]

14

AA furnace	239.2	3113 B [18th, 19th]	D3559–96(D)	I–4403–89[51]	
ICP/AES[36]	200.7[5]	3120 B [18th, 19th, 20th]		I–4471–97[50]	
DCP[36]			D4190–94		Note 34.
Voltametry[11] or			D3559–96(C)		
Colorimetric (Dithizone)		3500–Pb B [20th] and 3500–Pb D [18th, 19th].			
33. Magnesium—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration	242.1	3111 B [18th, 19th]	D511–93(B)	I–3447–85	974.27[3]
ICP/AES	200.7[5]	3120 B [18th, 19th, 20th]		I–4471–97[50]	
DCP or					Note 34.
Gravimetric		3500–Mg D [18th, 19th]			
34. Manganese-Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration[36]	243.1	3111 B [18th, 19th]	D858–95(A or B)	I–3454–85	974.27[3]
AA furnace	243.2	3113 B [18th, 19th]	D858–95(C)		
ICP/AES[36]	200.7[5]	3120 B [18th, 19th, 20th]		I–4471–97[50]	
DCP[36], or			D4190–94		Note 34
Colorimetric (Persulfate), or		3500–Mn B [20th] and 3500–Mn D [18th, 19th].			920.203[3]
(Periodate)					Note 23.
35. Mercury—Total,[4] mg/L:					
Cold vapor, manual or	245.1	3112 B [18th, 19th]	D3223–91	I–3462–85	977.22[3]
Automated	245.2				
Oxidation, purge and trap, and cold vapor atomic fluorescence spectrometry (ng/L).	1631E[43]				
36. Molybdenum—Total[4], mg/L; Digestion[4] followed by:					
AA direct aspiration	246.1	3111 D [18th, 19th]		I–3490–85	
AA furnace	246.2	3113 B [18th, 19th]		I–3492–96[47]	
ICP/AES	200.7[5]	3120 B [18th, 19th, 20th]		I–4471–97[50]	
DCP					Note 34.
37. Nickel—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration[36]	249.1	3111 B or C [18th, 19th]	D1886–90(A or B)	I–3499–85.	
AA furnace	249.2	3113 B [18th, 19th]	D1886–90(C)	I–4503–89[51].	
ICP/AES[36]	200.7[5]	3120 B [18th, 19th, 20th]		I–4471–97[50].	
DCP[36], or			D4190–94		Note 34.
Colorimetric (heptoxime)		3500–Ni D [17th].			
38. Nitrate (as N), mg/L:					
Colorimetric (Brucine sulfate), or Nitrate-nitrite N minus Nitrite N (See parameters 39 and 40).	352.1				973.50,[3] 419D,[17] p. 28[9]
39. Nitrate-nitrite (as N), mg/L:					
Cadmium reduction, Manual or.	353.3	4500–NO_3^-E [18th, 19th, 20th].	D3867–99(B).		

Nitrate: EPA 300.0;
Ion Chromatography

TABLE IB—LIST OF APPROVED INORGANIC TEST PROCEDURES—Continued

Parameter, units and method	Reference (method number or page)				
	EPA[1,35]	*Standard Methods* [Edition(s)]	ASTM	USGS[2]	Other
Automated, or	353.2	4500–NO_3^- F [18th, 19th, 20th].	D3867–99(A)	I–4545–85.	
Automated hydrazine	353.1	4500–NO_3^- H [18th, 19th, 20th].			
40. Nitrite (as N), mg/L; Spectrophotometric:					
Manual or	354.1	4500–NO_2^- B [18th, 19th, 20th].			Note 25.
Automated (Diazotization)				I–4540–85.	
41. Oil and grease—Total recoverable, mg/L:					
Gravimetric (extraction)	413.1	5520B [18th, 19th, 20th][38].			
Oil and grease and non-polar material, mg/L: Hexane extractable material (HEM): n-Hexane extraction and gravimetry.	1664A[42]	5520B [18th, 19th, 20th][38].			
Silica gel treated HEM (SGT-HEM): Silica gel treatment and gravimetry.	1664A[42].				
42. Organic carbon—Total (TOC), mg/L:					
Combustion or oxidation	415.1	5310 B, C, or D [18th, 19th, 20th].	D2579–93 (A or B)		973.47,[3] p. 14[24]
43. Organic nitrogen (as N), mg/L: Total Kjeldahl N (Parameter 31) minus ammonia N (Parameter 4).					
44. Orthophosphate (as P), mg/L; Ascorbic acid method:					
Automated, or	365.1	4500–P F [18th, 19th, 20th]		I–4601–85	973.56[3]
Manual single reagent	365.2	4500–P E [18th, 19th, 20th]	D515–88(A)		973.55[3]
Manual two reagent	365.3				
45. Osmium—Total[4], mg/L; Digestion[4] followed by:					
AA direct aspiration, or	252.1	3111 D [18th, 19th].			
AA furnace	252.2.				
46. Oxygen, dissolved, mg/L:					
Winkler (Azide modification), or	360.2	4500–O C [18th, 19th, 20th]	D888–92(A)	I–1575–78[8]	973.45B[3]
Electrode	360.1	4500–O G [18th, 19th, 20th].	D888–92(B)	I–1576–78[8].	

Nitrite: EPA 300.0,
Ion Chromatography

47. Palladium—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration, or	253.1	3111 B [18th, 19th]			p. S27[10]
AA furnace	253.2				p. S28[10]
DCP					Note 34.
48. Phenols, mg/L:					
Manual distillation[26]	420.1				Note 27.
Followed by:					
Colorimetric (4AAP) manual, or	420.1				Note 27.
Automated[19]	420.2.				
49. Phosphorus (elemental), mg/L:					
Gas-liquid chromatography					Note 28.
50. Phosphorus—Total, mg/L:					
Persulfate digestion followed by:	365.2	4500–P B, 5 [18th, 19th, 20th].			973.55[3]
Manual or	365.2 or 365.3	4500–P E [18th, 19th, 20th]	D515–88(A)		
Automated ascorbic acid reduction.	365.1	4500–P F [18th, 19th, 20th]		I–4600–85	973.56[3]
Semi-automated block digestor.	365.4		D515–88(B)	I–4610–91[48].	
51. Platinum—Total,[4] mg/L: Digestion[4] followed by:					
AA direct aspiration	255.1	3111 B [18th, 19th].			
AA furnace	255.2.				
DCP					Note 34
52. Potassium—Total,[4] mg/L: Digestion[4] followed by:					
AA direct aspiration	258.1	3111 B [18th, 19th]		I–3630–85	973.53[3]
ICP/AES	200.7[5]	3120 B [18th, 19th, 20th].			
Flame photometric, or		3500–K B [20th] and 3500–K D [18th, 19th].			
Colorimetric					317 B[17]
53. Residue—Total, mg/L:					
Gravimetric, 103–105°	160.3	2540 B [18th, 19th, 20th]		I–3750–85.	
54. Residue—filterable, mg/L:					
Gravimetric, 180°	160.1	2540 C [18th, 19th, 20th]		I–1750–85.	
55. Residue—nonfilterable (TSS), mg/L:					
Gravimetric, 103–105° post washing of residue.	160.2	2540 D [18th, 19th, 20th]		I–3765–85.	
56. Residue—settleable, mg/L:					
Volumetric, (Imhoff cone), or gravimetric.	160.5	2540 F [18th, 19th, 20th].			
57. Residue—Volatile, mg/L:					
Gravimetric, 550°	160.4			I–3753–85.	
58. Rhodium-Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration, or	265.1	3111 B [18th, 19th].			

Colorimetric (methylene blue).	376.2	4500–S^{-2}D [18th, 19th, 20th].			
67. Sulfite (as SO_3), mg/L:					
Titrimetric (iodine-iodate)	377.1	4500–SO_3^{-2}B [18th, 19th, 20th].			
68. Surfactants, mg/L:					
Colorimetric (methylene blue)	425.1	5540 C [18th, 19th, 20th]	D2330–88.		
69. Temperature, °C:					
Thermometric	170.1	2550 B [18th, 19th, 20th]			Note 32.
70. Thallium—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration	279.1	3111 B [18th, 19th].			
AA furnace	279.2.				
ICP/AES	200.7[5]	3120 B [18th, 19th, 20th].			
71. Tin—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration	282.1	3111 B [18th, 19th]		I–3850–78[8].	
AA furnace, or	282.2	3113 B [18th, 19th].			
ICP/AES	200.7[5].				
72. Titanium—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration	283.1	3111 D [18th, 19th].			
AA furnace	283.2.				
DCP					Note 34.
73. Turbidity, NTU:					
Nephelometric	180.1	2130 B [18th, 19th, 20th]	D1889–94(A)	I–3860–85.	
74. Vanadium—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration	286.1	3111 D [18th, 19th].			
AA furnace	286.2		D3373–93.		
ICP/AES	200.7[5]	3120 B [18th, 19th, 20th]		I–4471–97[50].	
DCP, or			D4190–94		Note 34.
Colorimetric (Gallic Acid)		3500–V B [20th] and 3500–V D [18th, 19th].			
75. Zinc—Total,[4] mg/L; Digestion[4] followed by:					
AA direct aspiration[36]	289.1	3111 B or C [18th, 19th]	D1691–95(A or B)	I–3900–85	974.27,[3] p. 37[9]
AA furnace	289.2.				
ICP/AES[36]	200.7[5]	3120 B [18th, 19th, 20th]		I–4471–97[50].	
DCP,[36] or			D4190–94		Note 34.
Colorimetric (Dithizone) or		3500–Zn E [18th, 19th].			
(Zincon)		3500–Zn B [20th] and 3500–Zn F [18th, 19th].			Note 33.

Table 1B Notes:

[1] "Methods for Chemical Analysis of Water and Wastes," Environmental Protection Agency, Environmental Monitoring Systems Laboratory—Cincinnati (EMSL-CI), EPA-600/4–79–020, Revised March 1983 and 1979 where applicable.

[2] Fishman, M.J., *et al.* "Methods for Analysis of Inorganic Substances in Water and Fluvial Sediments, "U.S. Department of the Interior, Techniques of Water-Resource Investigations of the U.S. Geological Survey, Denver, CO, Revised 1989, unless otherwise stated.

[3] "Official Methods of Analysis of the Association of Official Analytical Chemists," methods manual, 15th ed. (1990).

[4] For the determination of total metals the sample is not filtered before processing. A digestion procedure is required to solubilize suspended material and to destroy possible organic-metal complexes. Two digestion procedures are given in "Methods for Chemical Analysis of Water and Wastes, 1979 and 1983". One (Section 4.1.3), is a vigorous digestion using nitric acid. A less vigorous digestion using nitric and hydrochloric acids (Section 4.1.4) is preferred; however, the analyst should be cautioned that this mild digestion may not suffice for all samples types. Particularly, if a colorimetric procedure is to be employed, it is necessary to ensure that all organo-metallic bonds be broken so that the metal is in a reactive state. In those situations, the vigorous digestion is to be preferred making certain that at no time does the sample go to dryness. Samples containing large amounts of organic materials may also benefit by this vigorous digestion, however, vigorous digestion with concentrated nitric acid will convert antimony and tin to insoluble oxides and render them unavailable for analysis. Use of ICP/AES as well as determinations for certain elements such as antimony, arsenic, the noble metals, mercury, selenium, silver, tin, and titanium require a modified sample digestion procedure and in all cases the method write-up should be consulted for specific instructions and/or cautions.

NOTE TO TABLE 1B NOTE 4: If the digestion procedure for direct aspiration AA included in one of the other approved references is different than the above, the EPA procedure must be used. Dissolved metals are defined as those constituents which will pass through a 0.45 micron membrane filter. Following filtration of the sample, the referenced procedure for total metals must be followed. Sample digestion of the filtrate for dissolved metals (or digestion of the original sample solution for total metals) may be omitted for AA (direct aspiration or graphite furnace) and ICP analyses, provided the sample solution to be analyzed meets the following criteria:

a. has a low COD (<20)

b. is visibly transparent with a turbidity measurement of 1 NTU or less

c. is colorless with no perceptible odor, and

d. is of one liquid phase and free of particulate or suspended matter following acidification.

[5] The full text of Method 200.7, "Inductively Coupled Plasma Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes," is given at Appendix C of this Part 136.

[6] Manual distillation is not required if comparability data on representative effluent samples are on company file to show that this preliminary distillation step is not necessary; however, manual distillation will be required to resolve any controversies.

[7] Ammonia, Automated Electrode Method, Industrial Method Number 379–75 WE, dated February 19, 1976, Bran & Luebbe (Technicon) Auto Analyzer II, Bran & Luebbe Analyzing Technologies, Inc., Elmsford, NY 10523.

[8] The approved method is that cited in "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments", USGS TWRI, Book 5, Chapter A1 (1979).

[9] American National Standard on Photographic Processing Effluents, Apr. 2, 1975. Available from ANSI, 25 West 43rd Street, New York, NY 10036.

[10] "Selected Analytical Methods Approved and Cited by the United States Environmental Protection Agency", Supplement to the Fifteenth Edition of Standard Methods for the Examination of Water and Wastewater (1981).

[11] The use of normal and differential pulse voltage ramps to increase sensitivity and resolution is acceptable.

[12] Carbonaceous biochemical oxygen demand ($CBOD_5$) must not be confused with the traditional BOD_5 test method which measures "total BOD". The addition of the nitrification inhibitor is not a procedural option, but must be included to report the $CBOD_5$ parameter. A discharger whose permit requires reporting the traditional BOD_5 may not use a nitrification inhibitor in the procedure for reporting the results. Only when a discharger's permit specifically states $CBOD_5$ is required can the permittee report data using a nitrification inhibitor.

[13] OIC Chemical Oxygen Demand Method, Oceanography International Corporation, 1978, 512 West Loop, PO Box 2980, College Station, TX 77840.

[14] Chemical Oxygen Demand, Method 8000, Hach Handbook of Water Analysis, 1979, Hach Chemical Company, PO Box 389, Loveland, CO 80537.

[15] The back titration method will be used to resolve controversy.

[16] Orion Research Instruction Manual, Residual Chlorine Electrode Model 97–70, 1977, Orion Research Incorporated, 840 Memorial Drive, Cambridge, MA 02138. The calibration graph for the Orion residual chlorine method must be derived using a reagent blank and three standard solutions, containing 0.2, 1.0, and 5.0 mL 0.00281 N potassium iodate/100 mL solution, respectively.

[17] The approved method is that cited in Standard Methods for the Examination of Water and Wastewater, 14th Edition, 1976.

[18] National Council of the Paper Industry for Air and Stream Improvement, Inc. Technical Bulletin 253, December 1971.

[19] Copper, Biocinchoinate Method, Method 8506, Hach Handbook of Water Analysis, 1979, Hach Chemical Company, PO Box 389, Loveland, CO 80537.

[20] After the manual distillation is completed, the autoanalyzer manifolds in EPA Methods 335.3 (cyanide) or 420.2 (phenols) are simplified by connecting the re-sample line directly to the sampler. When using the manifold setup shown in Method 335.3, the buffer 6.2 should be replaced with the buffer 7.6 found in Method 335.2.

[21] Hydrogen ion (pH) Automated Electrode Method, Industrial Method Number 378–75WA, October 1976, Bran & Luebbe (Technicon) Autoanalyzer II. Bran & Luebbe Analyzing Technologies, Inc., Elmsford, NY 10523.

[22] Iron, 1,10-Phenanthroline Method, Method 8008, 1980, Hach Chemical Company, PO Box 389, Loveland, CO 80537.

[23] Manganese, Periodate Oxidation Method, Method 8034, Hach Handbook of Wastewater Analysis, 1979, pages 2–113 and 2–117, Hach Chemical Company, Loveland, CO 80537.

[24] Wershaw, R.L., *et al*, "Methods for Analysis of Organic Substances in Water," Techniques of Water-Resources Investigation of the U.S. Geological Survey, Book 5, Chapter A3, (1972 Revised 1987) p. 14.

[25] Nitrogen, Nitrite, Method 8507, Hach Chemical Company, PO Box 389, Loveland, CO 80537.

[26] Just prior to distillation, adjust the sulfuric-acid-preserved sample to pH 4 with 1 + 9 NaOH.

[27] The approved method is cited in Standard Methods for the Examination of Water and Wastewater, 14th Edition. The colorimetric reaction is conducted at a pH of 10.0±0.2. The approved methods are given on pp 576–81 of the 14th Edition: Method 510A for distillation, Method 510B for the manual colorimetric procedure, or Method 510C for the manual spectrometric procedure.

[28] R.F. Addison and R.G. Ackman, "Direct Determination of Elemental Phosphorus by Gas-Liquid Chromatography," Journal of Chromatography, Vol. 47, No. 3, pp. 421–426, 1970.

[29] Approved methods for the analysis of silver in industrial wastewaters at concentrations of 1 mg/L and above are inadequate where silver exists as an inorganic halide. Silver halides such as the bromide and chloride are relatively insoluble in reagents such as nitric acid but are readily soluble in an aqueous buffer of sodium thiosulfate and sodium hydroxide to pH of 12. Therefore, for levels of silver above 1 mg/L, 20 mL of sample should be diluted to 100 mL by adding 40 mL each of 2 M $Na_2S_2O_3$ and NaOH. Standards should be prepared in the same manner. For levels of silver below 1 mg/L the approved method is satisfactory.

[30] The approved method is that cited in Standard Methods for the Examination of Water and Wastewater, 15th Edition.

[31] EPA Methods 335.2 and 335.3 require the NaOH absorber solution final concentration to be adjusted to 0.25 N before colorimetric determination of total cyanide.

[32] Stevens, H.H., Ficke, J.F., and Smoot, G.F., "Water Temperature—Influential Factors, Field Measurement and Data Presentation," Techniques of Water-Resources Investigations of the U.S. Geological Survey, Book 1, Chapter D1, 1975.

[33] Zinc, Zincon Method, Method 8009, Hach Handbook of Water Analysis, 1979, pages 2–231 and 2–333, Hach Chemical Company, Loveland, CO 80537.

[34] "Direct Current Plasma (DCP) Optical Emission Spectrometric Method for Trace Elemental Analysis of Water and Wastes, Method AES0029," 1986—Revised 1991, Thermo Jarrell Ash Corporation, 27 Forge Parkway, Franklin, MA 02038.

[35] Precision and recovery statements for the atomic absorption direct aspiration and graphite furnace methods, and for the spectrophotometric SDDC method for arsenic are provided in Appendix D of this part titled, "Precision and Recovery Statements for Methods for Measuring Metals".

[36] "Closed Vessel Microwave Digestion of Wastewater Samples for Determination of Metals", CEM Corporation, PO Box 200, Matthews, NC 28106–0200, April 16, 1992. Available from the CEM Corporation.

[37] When determining boron and silica, only plastic, PTFE, or quartz laboratory ware may be used from start until completion of analysis.

[38] Only use Trichlorotrifluorethane (1,1,2-trichloro-1,2,2-trifluoroethane; CFC–113) extraction solvent when determining Total Recoverable Oil and Grease (analogous to EPA Method 413.1). Only use *n*-hexane extraction solvent when determining Hexane Extractable Material (analogous to EPA Method 1664A). Use of other extraction solvents is strictly prohibited.

[39] Nitrogen, Total Kjeldahl, Method PAI-DK01 (Block Digestion, Steam Distillation, Titrimetric Detection), revised 12/22/94, OI Analytical/ALPKEM, PO Box 9010, College Station, TX 77842.

[40] Nitrogen, Total Kjeldahl, Method PAI-DK02 (Block Digestion, Steam Distillation, Colorimetric Detection), revised 12/22/94, OI Analytical/ALPKEM, PO Box 9010, College Station, TX 77842.

[41] Nitrogen, Total Kjeldahl, Method PAI-DK03 (Block Digestion, Automated FIA Gas Diffusion), revised 12/22/94, OI Analytical/ALPKEM, PO Box 9010, College Station, TX 77842.

[42] Method 1664, Revision A "n-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Treated n-Hexane Extractable Material (SGT-HEM; Non-polar Material) by Extraction and Gravimetry" EPA–821–R–98–002, February 1999. Available at NTIS, PB–121949, U.S. Department of Commerce, 5285 Port Royal, Springfield, Virginia 22161.

[43] USEPA. 2002. Method 1631, Revision E, "Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry," September 2002. Office of Water, U.S. Environmental Protection Agency (EPA–821–R–02–019). The application of clean techniques described in EPA's draft Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels (EPA–821–R–96–011) are recommended to preclude contamination at low-level, trace metal determinations.

[44] Available Cyanide, Method OIA–1677 (Available Cyanide by Flow Injection, Ligand Exchange, and Amperometry), ALPKEM, A Division of OI Analytical, PO Box 9010, College Station, TX 77842–9010.

[45] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Ammonia Plus Organic Nitrogen by a Kjeldahl Digestion Method", Open File Report (OFR) 00–170.

[46] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Chromium in Water by Graphite Furnace Atomic Absorption Spectrophotometry", Open File Report (OFR) 93–449.

[47] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Molybdenum by Graphite Furnace Atomic Absorption Spectrophotometry", Open File Report (OFR) 97–198.

[48] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Total Phosphorus by Kjeldahl Digestion Method and an Automated Colorimetric Finish That Includes Dialysis" Open File Report (OFR) 92–146.

[49] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Arsenic and Selenium in Water and Sediment by Graphite Furnace-Atomic Absorption Spectrometry" Open File Report (OFR) 98–639.

[50] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Elements in Whole-water Digests Using Inductively Coupled Plasma-Optical Emission Spectrometry and Inductively Coupled Plasma-Mass Spectrometry", Open File Report (OFR) 98–165.

[51] "Methods of Analysis by the U.S. Geological Survey National Water Quality Laboratory—Determination of Inorganic and Organic Constituents in Water and Fluvial Sediment", Open File Report (OFR) 93–125.

TABLE IC—LIST OF APPROVED TEST PROCEDURES FOR NON-PESTICIDE ORGANIC COMPOUNDS

Parameter[1]	EPA method number[2,7]			Other approved methods		
	GC	GC/MS	HPLC	*Standard Methods* [Edition(s)]	ASTM	Other
1. Acenaphthene	610	625, 1625B	610	6440 B [18th, 19th, 20th].	D4657–92	Note 9, p.27.
2. Acenaphthylene	610	625, 1625B	610	6440 B, 6410 B [18th, 19th, 20th].	D4657–92	Note 9, p.27.
3. Acrolein	603	624[4], 1624B				
4. Acrylonitrile	603	624[4], 1624B				
5. Anthracene	610	625, 1625B	610	6410 B, 6440 B [18th, 19th, 20th].	D4657–92	Note 9, p. 27.

ATTACHMENT E

Table II - Required Containers, Preservation Techniques, and Holding Times
40 CFR Part 136.3
July 1, 2005

3544. Available from the American Society for Microbiology, 1752 N Street NW., Washington, DC 20036. Table IA, Note 22.

(58) USEPA. 2002. Method 1604: Total Coliforms and *Escherichia coli (E. coli)* in Water by Membrane Filtration using a Simultaneous Detection Technique (MI Medium). U.S. Environmental Protection Agency, Office of Water, Washington D.C. September 2002, EPA 821–R–02–024. Available from NTIS, PB2003–100129. Table IA, Note 22.

(59) USEPA. 2002. Method 1600: Enterococci in Water by Membrane Filtration using membrane-Enterococcus Indoxyl-β-D-Glucoside Agar (mEI). U.S. Environmental Protection Agency, Office of Water, Washington D.C. September 2002, EPA–821–R–02–022. Available from NTIS, PB2003–100127. Table IA, Note 25.

(60) USEPA. 2001. Method 1622: *Cryptosporidium* in Water by Filtration/IMS/FA. U.S. Environmental Protection Agency, Office of Water, Washington, DC April 2001, EPA–821–R–01–026.

Available from NTIS, PB2002–108709. Table IA, Note 26.

(61) USEPA. 2001. Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA. U.S. Environmental Protection Agency, Office of Water, Washington, DC April 2001, EPA–821–R–01–025. Available from NTIS, PB2002–108710. Table IA, Note 27.

(62) AOAC. 1995. Official Methods of Analysis of AOAC International, 16th Edition, Volume I, Chapter 17. AOAC International. 481 North Frederick Avenue, Suite 500, Gaithersburg, Maryland 20877–2417. Table IA, Note 11.

(c) Under certain circumstances the Regional Administrator or the Director in the Region or State where the discharge will occur may determine for a particular discharge that additional parameters or pollutants must be reported. Under such circumstances, additional test procedures for analysis of pollutants may be specified by the Regional Administrator, or the Director upon the recommendation of the Director of the Environmental Monitoring Systems Laboratory—Cincinnati.

(d) Under certain circumstances, the Administrator may approve, upon recommendation by the Director, Environmental Monitoring Systems Laboratory—Cincinnati, additional alternate test procedures for nationwide use.

(e) Sample preservation procedures, container materials, and maximum allowable holding times for parameters cited in Tables IA, IB, IC, ID, and IE are prescribed in Table II. Any person may apply for a variance from the prescribed preservation techniques, container materials, and maximum holding times applicable to samples taken from a specific discharge. Applications for variances may be made by letters to the Regional Administrator in the Region in which the discharge will occur. Sufficient data should be provided to assure such variance does not adversely affect the integrity of the sample. Such data will be forwarded, by the Regional Administrator, to the Director of the Environmental Monitoring Systems Laboratory—Cincinnati, Ohio for technical review and recommendations for action on the variance application. Upon receipt of the recommendations from the Director of the Environmental Monitoring Systems Laboratory, the Regional Administrator may grant a variance applicable to the specific charge to the applicant. A decision to approve or deny a variance will be made within 90 days of receipt of the application by the Regional Administrator.

TABLE II—REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter No./name	Container[1]	Preservation[2,3]	Maximum holding time[4]
Table IA—Bacteria Tests:			
1–5 Coliform, total, fecal, and *E. coli*	PP, G	Cool, <10 °C, 0.0008% $Na_2S_2O_3$[5]	6 hours.
6 Fecal *streptococci*	PP, G	Cool, <10° 0.0008% $Na_2S_2O_3$[5]	6 hours.
7 *Enterococci*	PP, G	Cool, <10° 0.0008% $Na_2S_2O_3$[5]	6 hours.
Table IA—Protozoa Tests:			
8 *Cryptosporidium*	LDPE	0–8 °C	96 hours.[17]
9 *Giardia*	LDPE	0–8 °C	96 hours.[17]
Table IA—Aquatic Toxicity Tests:			
6–10 Toxicity, acute and chronic	P,G	Cool, 4 °C[16]	36 hours.

TABLE II—REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES—Continued

Parameter No./name	Container[1]	Preservation[2,3]	Maximum holding time[4]
Table IB—Inorganic Tests:			
1. Acidity	P, G	Cool, 4°C	14 days.
2. Alkalinity	P, G	do	Do.
3. Ammonia	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days.
5. Biochemical oxygen demand	P, G	Cool, 4°C	48 hours.
10. Boron	P, PFTE, or Quartz	HNO_3 TO pH<2	6 months.
11. Bromide	P, G	None required	28 days.
14. Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours.
15. Chemical oxygen demand	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days.
16. Chloride	P, G	None required	Do.
17. Chlorine, total residual	P, G	do	Analyze immediately.
21. Color	P, G	Cool, 4°C	48 hours.
23–24. Cyanide, total and amenable to chlorination.	P, G	Cool, 4°C, NaOH to pH>12, 0.6g ascorbic acid[5]	14 days[6]
25. Fluoride	P	None required	28 days.
27. Hardness	P, G	HNO_3 to pH<2, H_2SO_4 to pH<2	6 months.
28. Hydrogen ion (pH)	P, G	None required	Analyze immediately.
31, 43. Kjeldahl and organic nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days.
Metals:[7]			
18. Chromium VI[7]	P, G	Cool, 4°C	24 hours.
35. Mercury[12]	P, G	HNO_3 to pH<2	28 days.
3, 5–8, 12, 13, 19, 20, 22, 26, 29, 30, 32–34, 36, 37, 45, 47, 51, 52, 58–60, 62, 63, 70–72, 74, 75. Metals, except boron, chromium VI and mercury[7].	P, G	do	6 months.
39. Nitrate	P, G	Cool, 4°C	48 hours.
40. Nitrate-nitrite	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days.
41. Nitrite	P, G	Cool, 4°C	48 hours.
41. Oil and grease	G	Cool to 4°C, HCl or H_2SO_4 to pH<2.	28 days.
42. Organic Carbon	P, G	Cool to 4 °C HCl or H_2SO_4 or H_3PO_4 to pH<2.	28 days.
44. Orthophosphate	P, G	Filter immediately. Cool, 4°C	48 hours.
46. Oxygen, Dissolved Probe	G Bottle and top	None required	Analyze immediately.
47. Winkler	do	Fix on site and store in dark	8 hours.
48. Phenols	G only	Cool, 4°C, H_2SO_4 to pH<2	28 days.
49. Phosphorus (elemental)	G	Cool, 4°C	48 hours.
50. Phosphorus, total	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days.
53. Residue, total	P, G	Cool, 4°C	7 days.
54. Residue, Filterable	P, G	do	7 days.
55. Residue, Nonfilterable (TSS)	P, G	do	7 days.
56. Residue, Settleable	P, G	do	48 hours.
57. Residue, volatile	P, G	do	7 days.
61. Silica	P, PFTE, or Quartz	Cool, 4 °C	28 days.
64. Specific conductance	P, G	do	Do.
65. Sulfate	P, G	do	Do.
66. Sulfide	P, G	Cool, 4°C add zinc acetate plus sodium hydroxide to pH>9.	7 days.
67. Sulfite	P, G	None required	Analyze immediately.
68. Surfactants	P, G	Cool, 4°C	48 hours.
69. Temperature	P, G	None required	Analyze.
73. Turbidity	P, G	Cool, 4°C	48 hours.
Table IC—Organic Tests[8]			
13, 18–20, 22, 24–26, 34–37, 39–43, 45–47, 56, 76, 104, 105, 108–111, 113. Purgeable Halocarbons.	G, Teflon-lined septum.	Cool, 4 °C, 0.008% $Na_2S_2O_3$[9]	14 days.
6, 57, 106. Purgeable aromatic hydrocarbons	do	Cool, 4 °C, 0.008% $Na_2S_2O_3$,[9] HCl to pH 2[9]	Do.
3, 4. Acrolein and acrylonitrile	do	Cool, 4 °C, 0.008% $Na_2S_2O_3$,[9] adjust pH to 4–5[10]	Do.
23, 30, 44, 48, 53, 77, 80, 81, 98, 100, 112 Phenols[11].	G, Teflon-lined cap.	Cool, 4 °C, 0.008% $Na_2S_2O_3$[9]	7 days until extraction; 40 days after extraction.
7, 38. Benzidines[11]	do	do	7 days until extraction.[13]
14, 17, 48, 50–52. Phthalate esters[11]	do	Cool, 4 °C	7 days until extraction; 40 days after extraction.

TABLE II—REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES—Continued

Parameter No./name	Container[1]	Preservation[2,3]	Maximum holding time[4]
82–84. Nitrosamines[11,14]	....do	Cool, 4 °C, 0.008% $Na_2S_2O_3$,[5] store in dark.	Do.
88–94. PCBs[11]	....do	Cool, 4 °C	Do.
54, 55, 75, 79. Nitroaromatics and isophorone[11]	....do	Cool, 4 °C, 0.008% $Na_2S_2O_3$,[5] store in dark.	Do.
1, 2, 5, 8–12, 32, 33, 58, 59, 74, 78, 99, 101. Polynuclear aromatic hydrocarbons[11]	....do	....do	Do.
15, 16, 21, 31, 87. Haloethers[11]	....do	Cool, 4 °C, 0.008% $Na_2S_2O_3$[5]	Do.
29, 35–37, 63–65, 73, 107. Chlorinated hydrocarbons[11]	....do	Cool, 4 °C	Do.
60–62, 66–72, 85, 86, 95–97, 102, 103. CDDs/CDFs[11]			
aqueous: field and lab preservation	G	Cool, 0–4 °C, pH<9, 0.008% $Na_2S_2O_3$.[5]	1 year.
Solids, mixed phase, and tissue: field preservation	....do	Cool, <4 °C	7 days.
Solids, mixed phase, and tissue: lab preservation	....do	Freeze, < 10 °C	1 year.
Table ID—Pesticides Tests:			
1–70. Pesticides[11]	....do	Cool, 4°C, pH 5–9[15]	Do.
Table IE—Radiological Tests:			
1–5. Alpha, beta and radium	P, G	HNO_3 to pH<2	6 months.

Table II Notes

[1] Polyethylene (P) or glass (G). For microbiology, plastic sample containers must be made of sterilizable materials (polypropylene or other autoclavable plastic).

[2] Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

[3] When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of Table II, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: Hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); Nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.82 or greater); Sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and Sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

[4] Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that for the specific types of samples under study, the analytes are stable for the longer time, and has received a variance from the Regional Administrator under § 136.3(e). Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability. See § 136.3(e) for details. The term "analyze immediately" usually means within 15 minutes or less of sample collection.

[5] Should only be used in the presence of residual chlorine.

[6] Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

[7] Samples should be filtered immediately on-site before adding preservative for dissolved metals.

[8] Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

[9] Sample receiving no pH adjustment must be analyzed within seven days of sampling.

[10] The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

[11] When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6–9; samples preserved in this manner may be held for seven days before extraction and for forty days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re the requirement for thiosulfate reduction of residual chlorine), and footnotes 12, 13 (re the analysis of benzidine).

[12] If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0±0.2 to prevent rearrangement to benzidine.

[13] Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

[14] For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7–10 with NaOH within 24 hours of sampling.

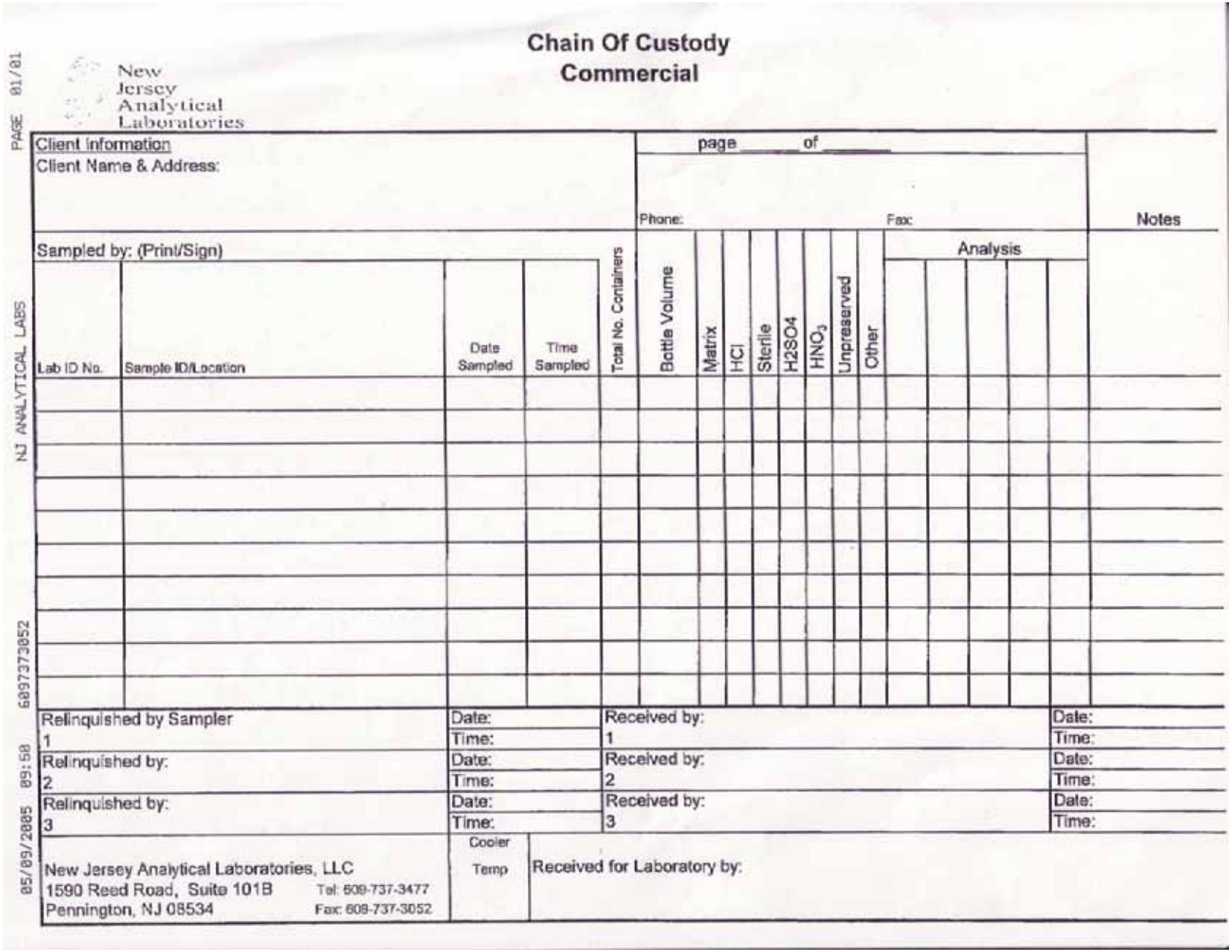
[15] The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

[16] Sufficient ice should be placed with the samples in the shipping container to ensure that ice is still present when the samples arrive at the laboratory. However, even if ice is present when the samples arrive, it is necessary to immediately measure the temperature of the samples and confirm that the 4C temperature maximum has not been exceeded. In the isolated cases where it can be documented that this holding temperature can not be met, the permittee can be given the option of on-site testing or can request a variance. The request for a variance should include supportive data which show that the toxicity of the effluent samples is not reduced because of the increased holding temperature.

[17] Samples collected for the determination of trace level mercury (100 ng/L) using EPA Method 1631 must be collected in tightly-capped fluoropolymer or glass bottles and preserved with BrCl or HCl solution within 48 hours of sample collection. The time to preservation may be extended to 28 days if a sample is oxidized in the sample bottle. Samples collected for dissolved trace level mercury should be filtered in the laboratory. However, if circumstances prevent overnight shipment, samples should be filtered in a designated clean area in the field in accordance with procedures given in Method 1669. Samples that have been collected for determination of total or dissolved trace level mercury must be analyzed within 90 days of sample collection.

ATTACHMENT F

Sample Chain of Custody Form



Chain Of Custody
Commercial

New Jersey Analytical Laboratories

PAGE 01/01

NJ ANALYTICAL LABS 6097373052 09:58 05/03/2005

Client information

Client Name & Address:

page ____ of ____

Phone: Fax:

Notes

Sampled by: (Print/Sign)

Analysis

Lab ID No.	Sample ID/Location	Date Sampled	Time Sampled	Total No. Containers	Bottle Volume	Matrix	HCl	Sterile	H_2SO_4	HNO_3	Unpreserved	Other						

Relinquished by Sampler 1	Date: Time:	Received by: 1	Date: Time:
Relinquished by: 2	Date: Time:	Received by: 2	Date: Time:
Relinquished by: 3	Date: Time:	Received by: 3	Date: Time:

New Jersey Analytical Laboratories, LLC
1590 Reed Road, Suite 101B Tel: 609-737-3477
Pennington, NJ 08534 Fax: 609-737-3052

Cooler Temp

Received for Laboratory by:

ATTACHMENT G

Tables of Parameter Detection Limits, Accuracy, and Precision

Parameter Detection Limits, Accuracy, and Precision

Parameter:	Dissolved Ortho-Phosphate (as P)	Total Phosphorus (as P)	Ammonia-Nitrogen	Nitrate-Nitrogen	Nitrite-Nitrogen	Total Kjeldahl Nitrogen	Total Suspended Solids
Referenced Methodology – (NJDEP Certified Methodology)	EPA 365.3	EPA 365.2	EPA 350.2 +.3	EPA 300.0	EPA 300.0	EPA 351.3	EPA 160.2
Technique Description	Ascorbic Acid, Manual Two Reagents	Persulfate Digestion + Manual	Distillation, Electrode	Ion Chro-mato-graphy	Ion Chro-mato-graphy	Digestion, Distillation, Titration	Gra-vimetric, 103-105˚C
Method Detection Limit (ppm)-Calculated	0.0029	0.0060	0.004	0.034	0.031	0.048	NA
Instrument Detection Limit (ppm)	NA	NA	NA	0.034	0.031	NA	NA
Project Detection Limit (ppm)	***0.01***	***0.02***	***0.05***	***0.04***	***0.04***	***0.05***	***0.5***
Quantitation Limit (ppm)	0.01	0.02	0.05	0.04	0.04	0.05	0.5
Accuracy (mean % recovery)	106.9	108.6	94.9	97.5	98.2	96.9	NA
Precision-% (mean – RPD)	2.18	2.80	4.31	3.01	3.46	5.98	8.61
Accuracy Protocol (% recovery for LCL/UCL)	83.8/ 130.0	91.3/ 126.0	62.6/ 127.2	92.2/ 102.8	80.1/ 116.3	67.1/ 126.7	NA
Precision Protocol-% (maximum RPD)	8.10	10.13	10.63	5.03	6.74	9.28	28.03

RPD – Relative % Difference; NA – Not Applicable

Laboratory: New Jersey Analytical (NJDEP #11005)

Parameter Detection Limits, Accuracy, and Precision

Parameter:	pH (SU)	Temperature (°C)	Dissolved Oxygen (mg/L)	†Total Dissolved Solids (mg/L)	†Fecal Coliform	‡*Eschericia coli* (*E. coli*)
Referenced Methodology – (NJDEP Certified Methodology)	Standard Methods 4500-H^+ B	Standard Methods 2550 B	Standard Methods 4500-O G	EPA 160.1	Standard Methods 9222D	EPA 1603
Technique Description	Electrometric	Thermometric	Electrode	Gravi-metric, 180˚C	Membrane Filter (MF), Single Step	Membrane Filter (modified mTEC)
Method Detection Limit (ppm)	NA	NA	NA	5.35	<10 (col/ 100 ml)	<10 organisms per 100 ml
Instrument Detection Limit (ppm)	0.00-14.00 S.U.	0.0 to 100.0 °C	0 – 20 mg/L	NA	NA	NA
Project Detection Limit (ppm)	0.00-14.00 S.U.	0.0 to 100.0 °C	0 - 20 mg/L	***10.0***	<10 (col/ 100 ml)	<10 organisms per 100 ml
Quantitation Limit (ppm)	NA	NA	NA	10.0	NA	60,000 organisms per 100 ml
Accuracy (mean % recovery)	NA	NA	NA	103.65	NA	NA
Precision (mean – RPD)	± 0.01 S.U.	± 0.3 °C	± 0.3 mg/l	3.50	17.34	NA
Accuracy Protocol (% recovery for LCL/UCL)	NA	NA	NA	72.4/135.0	NA	Detect – 144%
Precision Protocol (maximum RPD)	± 0.01 S.U.	± 0.3 °C	± 0.3 mg/l	6.47	24.82	61%

RPD – Relative % Difference; NA – Not Applicable

Laboratory: Rutgers EcoComplex Laboratory (NJDEP #03019), †Laboratory: New Jersey Analytical (NJDEP #11005), ‡Laboratory: Garden State Laboratories, Inc. (NJDEP #20044)

QUALITY ASSURANCE PROJECT PLAN

RP06-073 MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

North Jersey Resource, Conservation & Development Council, Inc. (North Jersey RC&D)
Rutgers Cooperative Extension Water Resources Program

January 8, 2007

Revised & Resubmitted April 17, 2007
Revised & Resubmitted May 17, 2007
Addendum June 30, 2008 – *revised July 18, 2008*

QUALITY ASSURANCE PROJECT PLAN

***RP06-073* MUSCONETCONG RIVER WATERSHED RESTORATION PLAN**

North Jersey Resource, Conservation & Development Council, Inc. (North Jersey RC&D)
Rutgers Cooperative Extension Water Resources Program

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Grace Messinger

6/30/08

Signature Date

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6/30/08

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_____

Signature Date

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_____

Signature Date

Additional Monitoring Program for August 2008

In February 2007 North Jersey RC&D along with Rutgers Cooperative Extension Water Resources Program and the Musconetcong Watershed Association met with staff from the Division of Watershed Management to present findings from the 2007 Water Quality Sampling Program. Two of the most severely impacted subwatersheds, West Portal Brook and Turkey Hill Brook, were identified.

The results of the bacteria monitoring conducted during May 2007 through October 2007 revealed highly elevated fecal coliform and *Eschericia coli (E. coli)* levels in the West Portal Brook subwatershed at Site #7 and in the Turkey Hill Brook subwatershed at Site #9, just upstream of their confluence with the Musconetcong River.

Additional monitoring is proposed to further characterize the input of bacteria, in particular fecal coliform and *E. coli*, along these two subwatersheds and to supplement microbial source tracking efforts that will be conducted within the study area for three wet weather events during the summer of 2008. The microbial source tracking will be conducted independent of the approved Quality Assurance Project Plan (QAPP).

Wet Weather Surface Water Sampling:

According to the approved May 2007 QAPP, three wet weather sampling events, at a minimum, were to be conducted between May and October 2007 at each sampling location. It has been difficult to capture wet weather events as proposed in the approved QAPP. The laboratories will not accept samples after 4 pm and before 7 am, as well as on weekends; many, if not all, of the significant rainfall events that occurred between May and October 2007 were during these time periods. Furthermore, it is very difficult to capture runoff from "scattered thundershowers," especially when they only occur in a portion of the watershed, as was common during the designated sampling period of May through October 2007.

The USGS program “PART” was used to estimate base flow in the Musconetcong River at Site #10. Based on flows above the calculated base flow and 36 hour rainfall totals from local weather stations, probable storm events that were captured during the biweekly surface water sampling included June 4, July 30, and August 13, 2007. Elevated pathogen counts (i.e., fecal coliform and *E. coli*) were observed on these sampling dates, and it was concluded, based on the PART analysis, that the 2007 Water Quality Sampling Program did include wet weather surface water sampling to some extent.

With the funds remaining in the contractual category for “*Water Quality Analysis and Microbiology Lab*,” rather than continue to try to collect wet weather surface water samples as defined in the approved May 2007 QAPP, the Project Team has identified seven additional locations that will be sampled to obtain a more complete picture of the sources of impairment in the Turkey Hill Brook and West Portal Brook subwatersheds.

Sampling Locations:

The sampling locations are shown in Attachment 1. The seven additional sampling locations are as follows:

Station ID	Waterway	Location	Coordinates:	
			POINT_X	POINT_Y
Site #12	Unnamed Tributary	Warren County, Wolverton Road, by pipeline	496669.10538200000	4503757.24893000000
Site #13	West Portal Brook	Hunterdon County, Valley Station Road, near bridge by old stone structure	497157.07539000000	4501982.02066000000
Site #14	West Portal Brook	Hunterdon County, behind school	497080.00680400000	4501630.28844000000
Site #15	Turkey Hill Brook	Hunterdon County, downstream from small animal farm near Heritage Park	495747.74708600000	4502203.32921000000
Site #16	Turkey Hill Brook	Hunterdon County, upstream from small animal farm near Heritage Park	495908.98073400000	4501996.17753000000
Site #17	Turkey Hill Brook	Hunterdon County, off Turkey Hill Road, approximately 0.6 miles up road	495920.77171200000	4500696.80744000000
Site #18	Turkey Hill Brook	Hunterdon County, off Turkey Hill Road, approximately one mile up road	495910.12127100000	4500167.04437000000

A WAAS-enable Garmin Rino 120 GPS (global positioning system) unit will be used to locate and identify the seven additional sampling locations. Sampling locations will be marked with stakes and surveying tape or flags. Field personnel will take GPS readings in the field to aid in verifying the correct sampling locations during the first sampling event in August 2008.

Basis for Sampling Locations:

The results of the bacteria monitoring conducted during May 2007 through October 2007 revealed highly elevated fecal coliform and *E. coli* levels in West Portal Brook at Site #7 and in Turkey Hill Brook at Site #9 just upstream of their confluence with the Musconetcong River. The geometric mean at Site #7 for *E. coli* was 9,221 org/100ml, and for fecal coliform the geometric mean was 6,039 col/100ml. At location #9, the geometric mean for *E. coli* was 6,629 org/100ml, and for fecal coliform the geometric mean was 3,654 col/100ml. The geometric mean for *E. coli* and fecal coliform was less than 530 org/100 ml or col/100 ml at all the other designated sampling locations for this project.

Site #12 has been selected to further characterize any bacteria input from the Warren County tributaries in the watershed. Sites #13 and #14 have been selected to characterize bacteria from suspected septic inputs and from livestock along West Portal Brook, upstream of the establish Site #7. Sites #15 and #16 have been selected to characterize bacteria inputs from a small animal farm along Turkey Hill Brook, upstream of Site #9. Sites #17 and #18 have been selected to characterize bacteria inputs from miscellaneous agricultural operations, as well as suspected septic inputs along Turkey Hill Brook, upstream of established Site #9 and proposed Sites #15 and #16.

Sampling Frequency and Methodology:

Bacteriology samples for fecal coliform and *E. coli* analyses will be collected by the Rutgers Cooperative Extension Water Resources Program (RCE WRP) from the seven additional sampling locations in a downstream to upstream order to avoid disturbances to downstream water column samples a total of five (5) times, independent of weather conditions, within a 30 day period during the month of August 2008.

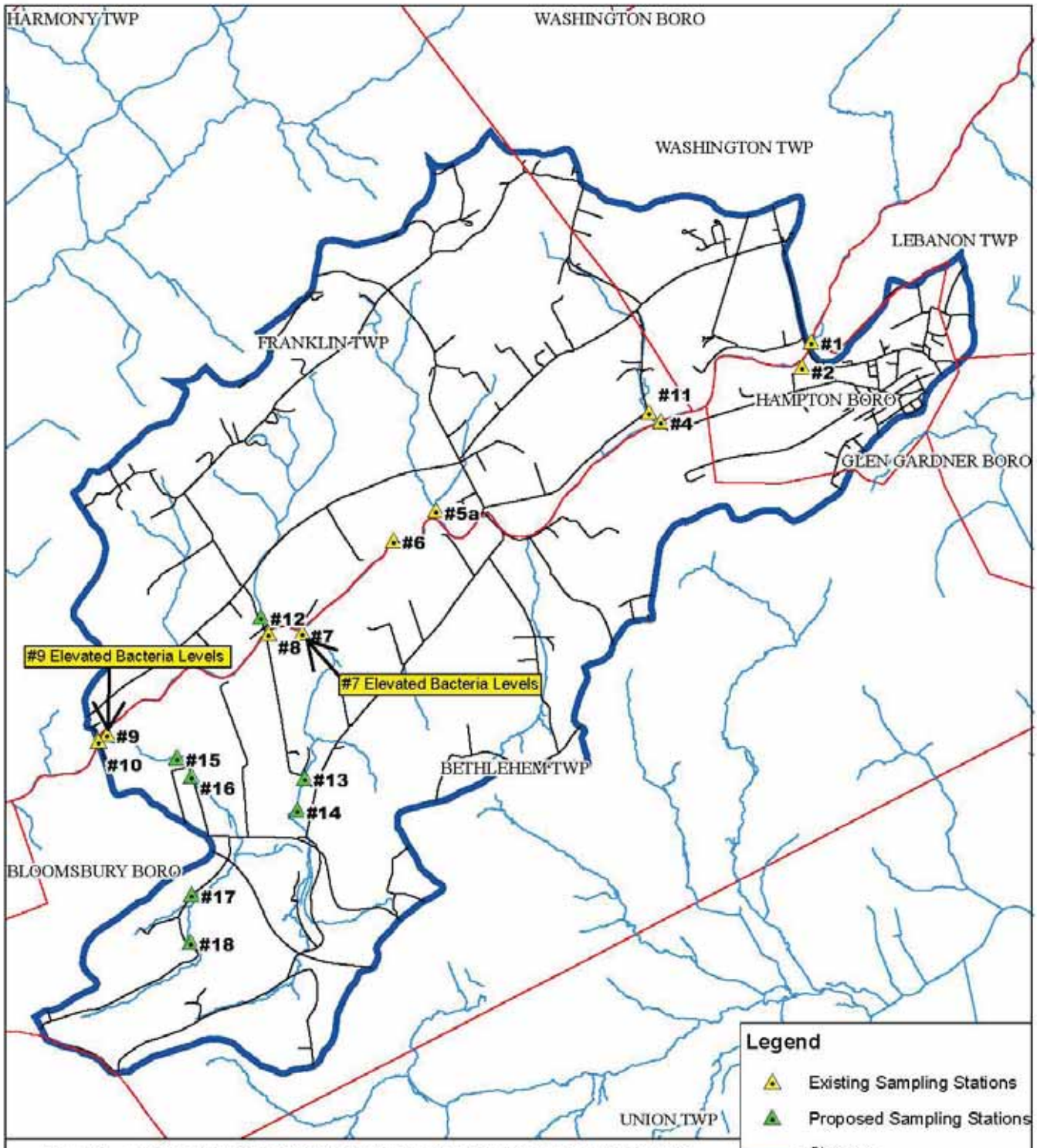
No other parameters will be measured in conjunction with the five (5) sampling events for fecal coliform and *E. coli* within a 30 day period during the month of August 2008 at the seven additional sampling locations.

Bacteriology samples will be collected directly into a bacteriological sample container in accordance with the methods outlined in section 6.8.2.2.7 of the Field Sampling Procedures Manual (See Chapter 6D - page 67 of 188). Composite samples will not be collected for bacteriology samples.

New Jersey Analytical Laboratories (NJDEP Certified Laboratory #11005) will do the analyses for fecal coliform and *E. coli* as outlined in the attached table of parameter detection limits, accuracy, and precision (See Attachment 2).

ATTACHMENT 1

Sampling Locations
Musconetcong River Watershed



MAP #1 - LOCATION OF EXISTING AND PROPOSED SAMPLING SITES

MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

Data Source: NJDEP 2002

RUTGERS
New Jersey Agricultural Experiment Station

Rutgers University
RCE Water Resources Program
14 College Farm Road
New Brunswick, NJ 08901
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ATTACHMENT 2

Table of Parameter Detection Limits, Accuracy, and Precision

Parameter Detection Limits, Accuracy, and Precision

Parameter:	Fecal Coliform	Eschericia coli (E. coli)
Referenced Methodology – (NJDEP Certified Methodology)	Standard Methods 9222D	Other Hach Company
Technique Description	Membrane Filter (MF), Single Step	Membrane Filter – M-Coliblue 24 Test
Method Detection Limit (ppm)	<10 (col/ 100 ml)	<10 (col/ 100 ml)
Instrument Detection Limit (ppm)	NA	NA
Project Detection Limit (ppm)	<10 (col/ 100 ml)	<10 (col/ 100 ml)
Quantitation Limit (ppm)	NA	NA
Accuracy (mean % recovery)	NA	NA
Precision (mean – RPD)	17.34	18.06
Accuracy Protocol (% recovery for LCL/UCL)	NA	NA
Precision Protocol (maximum RPD)	24.82	26.48

RPD – Relative % Difference; NA – Not Applicable
Laboratory: New Jersey Analytical (NJDEP #11005)

QUALITY ASSURANCE PROJECT PLAN

RP06-073 MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

North Jersey Resource, Conservation & Development Council, Inc. (North Jersey RC&D)
Rutgers Cooperative Extension Water Resources Program

January 8, 2007

Revised & Resubmitted April 17, 2007
Revised & Resubmitted May 17, 2007
Addendum June 30, 2008 – *revised July 18, 2008*
Addendum March 9, 2009 – *revised April 24, 2009*

QUALITY ASSURANCE PROJECT PLAN

***RP06-073* MUSCONETCONG RIVER WATERSHED RESTORATION PLAN**

North Jersey Resource, Conservation & Development Council, Inc. (North Jersey RC&D)
Rutgers Cooperative Extension Water Resources Program

Applicant/
Project Officer:

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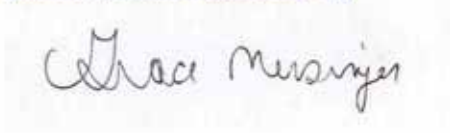

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Signature Date

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Dana.Cartwright@dep.state.nj.us

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Pat.Rector@dep.state.nj.us

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Signature Date

Additional Monitoring Program for May 2009

The results of bacteria monitoring conducted during three storm events during the summer of 2008 and during August 2008 revealed elevated fecal coliform and *Eschericia coli* (*E. coli*) levels in three subwatersheds of the Musconetcong River.

Additional monitoring is proposed to further characterize the input of bacteria, in particular fecal coliform and *E. coli*, along the three subwatersheds and to supplement microbial source tracking efforts that will be conducted within the study area during May 2009.

The Project Team has identified six additional locations that will be sampled to obtain a more complete picture of the sources of impairment in the West Portal Brook, the unnamed tributary along Shurts Road, and the unnamed tributary in Hampton Borough.

Sampling Locations:

The sampling locations are shown in Attachment 1. The six additional sampling locations are as follows:

Station ID	Waterway	Location	Coordinates:	
			POINT_X	POINT_Y
Site #19	Unnamed Tributary	Warren County, Shurts Road	356302.428	682983.216
Site #20	Unnamed Tributary	Warren County, Shurts Road below pond outlet	356428.726	682762.194
Site #21	Unnamed Tributary	Hunterdon County, Hampton Borough off Valley Road above Borough Park	362612.285	683175.347
Site #22	Unnamed Tributary	Hunterdon County, Hampton Borough upstream of Site #21 off Main Street	363625.618	683310.749
Site #23	West Portal Brook	Hunterdon County, Asbury-West Portal Road just after stop sign above school	344239.866	666847.493
Site #24	West Portal Brook	Hunterdon County, Asbury-West Portal Road in between agricultural properties	344555.059	672185.811

A WAAS-enable Garmin Rino 120 GPS (global positioning system) unit will be used to locate and identify the six additional sampling locations. Sampling locations will be marked with stakes and surveying tape or flags. Field personnel will take GPS readings in the field to aid in verifying the correct sampling locations during the first sampling event in May 2009.

Basis for Sampling Locations:

The Hampton locations, #21 and #22, were selected after discussions with Borough officials while sharing the 2007 and 2008 sampling data information. Potential human sources of bacteria are suspected in this area.

Locations #19 and #20 have been selected to characterize bacteria inputs to an unnamed tributary along Shurts Road prior to its confluence with the Musconetcong River just downstream from established Location #4.

Locations #23 and #24 have been selected to further characterize bacteria from suspected septic inputs and from livestock along West Portal Brook, upstream of the establish Location #7 to help further justify the implementation and benefit of a project on agricultural property along West Portal Brook.

Sampling Frequency and Methodology:

Bacteriology samples for fecal coliform and *E. coli* analyses will be collected by the Rutgers Cooperative Extension Water Resources Program (RCE WRP) and/or staff from the North Jersey RC&D office from the six additional sampling locations, as well as the established sampling locations #2, #11, #7, #13, and #14, in a downstream to upstream order to avoid disturbances to downstream water column samples a total of five (5) times, independent of weather conditions, within a 30 day period during the month of May 2009.

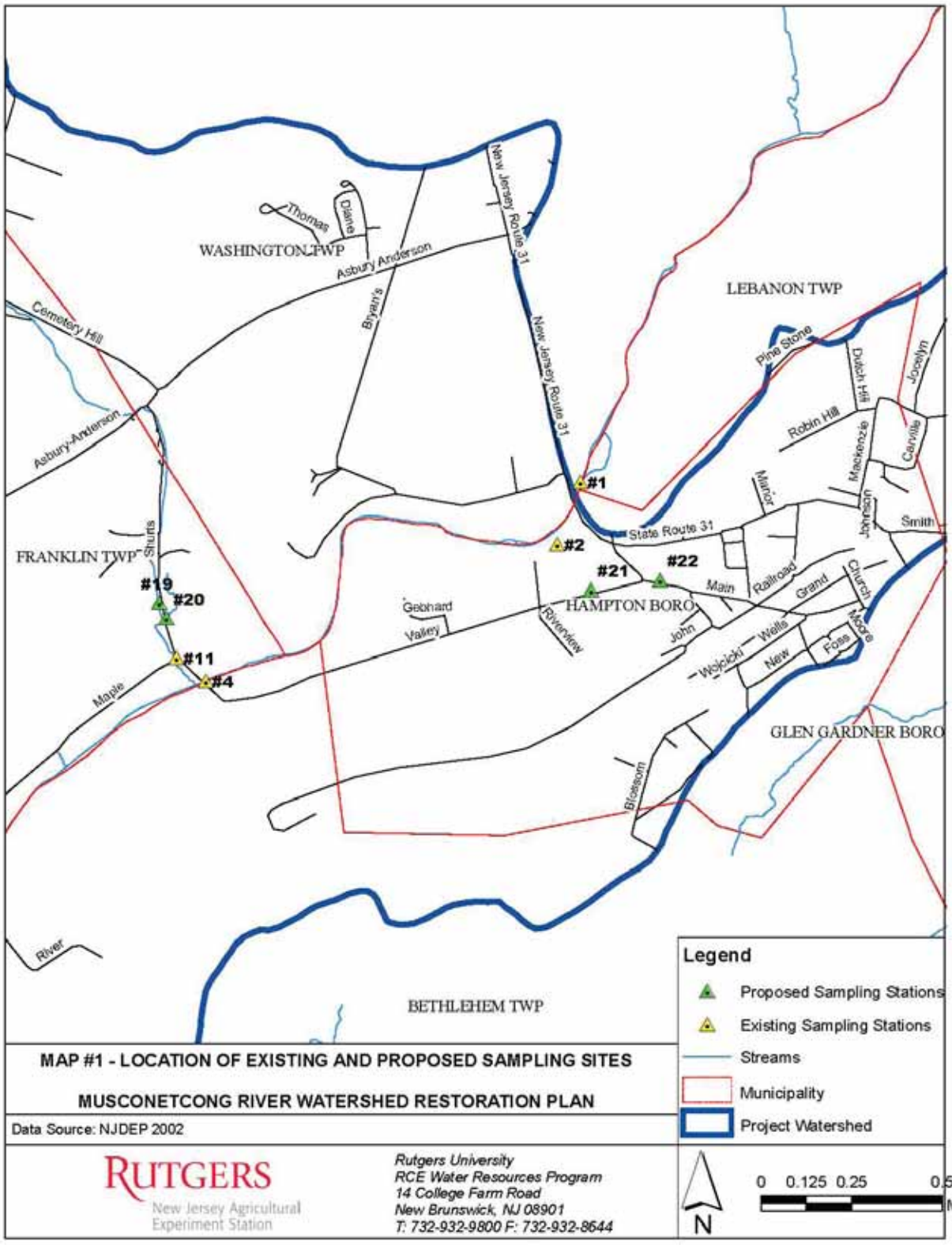
No other parameters will be measured in conjunction with the five (5) sampling events for fecal coliform and *E. coli* within a 30 day period during the month of May 2009 at the six additional sampling locations, plus the established locations #2, #11, #7, #13, and #14.

Bacteriology samples will be collected directly into a bacteriological sample container in accordance with the methods outlined in section 6.8.2.2.7 of the Field Sampling Procedures Manual (See Chapter 6D - page 67 of 188). Composite samples will not be collected for bacteriology samples.

Garden State Laboratories, Inc. (NJDEP Certified Laboratory #20044) will do the analyses for fecal coliform and *E. coli* as outlined in the attached table of parameter detection limits, accuracy, and precision (See Attachment 2).

ATTACHMENT 1

Sampling Locations
Musconetcong River Watershed



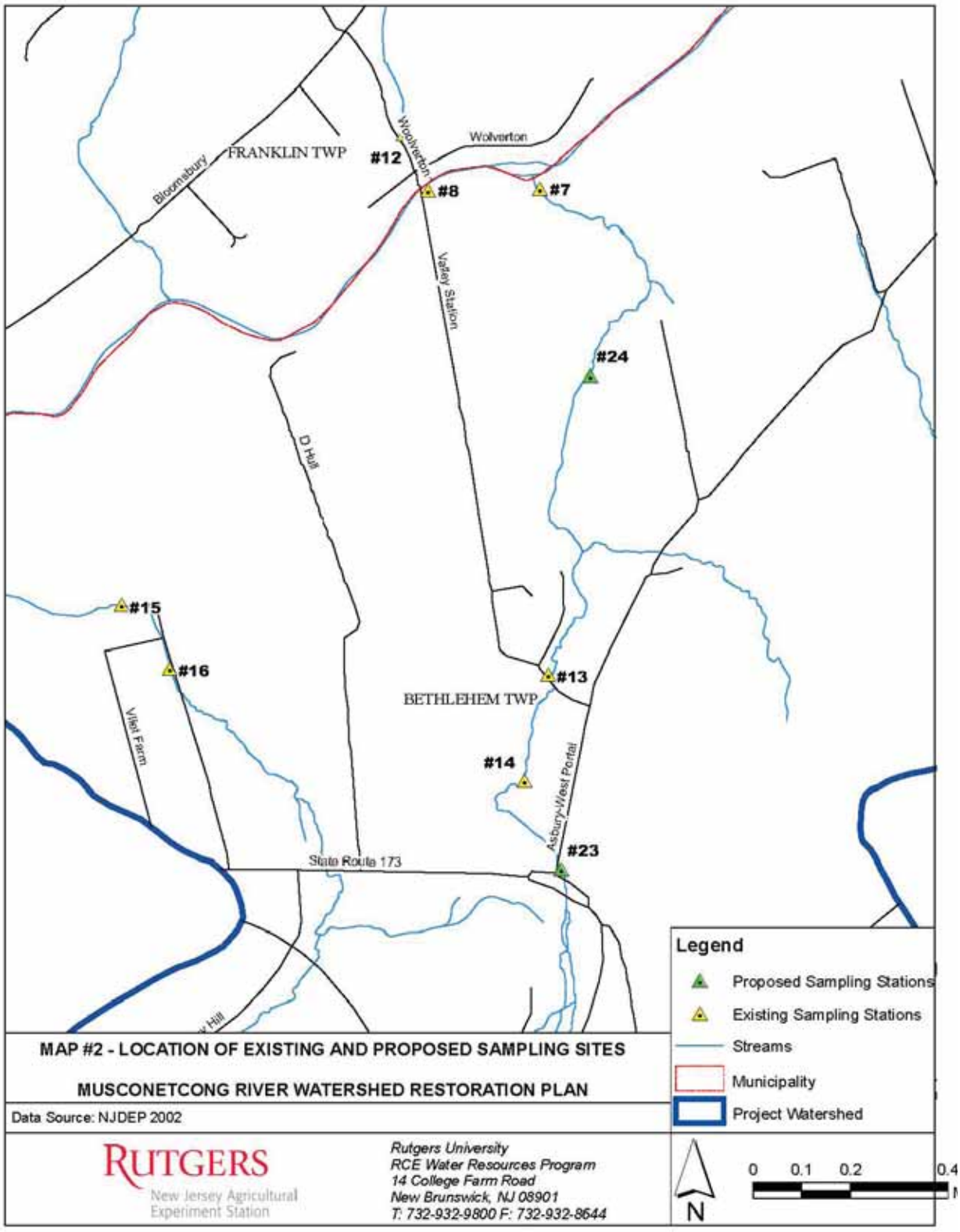
MAP #1 - LOCATION OF EXISTING AND PROPOSED SAMPLING SITES

MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

Data Source: NJDEP 2002

RUTGERS
New Jersey Agricultural Experiment Station

Rutgers University
RCE Water Resources Program
14 College Farm Road
New Brunswick, NJ 08901
T: 732-932-9800 F: 732-932-8644



MAP #2 - LOCATION OF EXISTING AND PROPOSED SAMPLING SITES

MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

Data Source: NJDEP 2002

RUTGERS
New Jersey Agricultural Experiment Station

Rutgers University
RCE Water Resources Program
14 College Farm Road
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ATTACHMENT 2

Table of Parameter Detection Limits, Accuracy, and Precision

Parameter Detection Limits, Accuracy, and Precision

Parameter:	Fecal Coliform	*Eschericia coli* (*E. coli*)
Referenced Methodology – (NJDEP Certified Methodology)	Standard Methods 9222D	EPA 1603
Technique Description	Membrane Filter (MF), Single Step	Membrane Filter (modified mTEC)
Method Detection Limit (ppm)	2 (col/ 100 ml)	<10 organisms per 100 ml
Instrument Detection Limit (ppm)	NA	NA
Project Detection Limit (ppm)	2 (col/ 100 ml)	<10 organisms per 100 ml
Quantitation Limit (ppm)	2 (col/ 100 ml)	60,000 organisms per 100 ml
Accuracy (mean % recovery)	NA	NA
Precision (mean – RPD)	5.7	NA
Accuracy Protocol (% recovery for LCL/UCL)	NA	Detect – 144%
Precision Protocol (maximum RPD)	20.55	61%

LCL/UCL – Lower/Upper Control Limit; RPD – Relative % Difference; NA – Not Applicable

Laboratory: Garden State Laboratories, Inc. (NJDEP #20044)

QUALITY ASSURANCE PROJECT PLAN

RP06-073 MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

North Jersey Resource, Conservation & Development Council, Inc. (North Jersey RC&D)
Rutgers Cooperative Extension Water Resources Program

January 8, 2007

Revised & Resubmitted April 17, 2007
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Addendum June 30, 2008 – *revised July 18, 2008*
Addendum March 9, 2009 – *revised April 24, 2009*
Addendum June 28, 2010 – *revised September 13, 2010*

QUALITY ASSURANCE PROJECT PLAN

***RP06-073* MUSCONETCONG RIVER WATERSHED RESTORATION PLAN**

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Grace Messinger 6/28/2010
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Lisa Galloway Evrard 6/28/2010
Signature Date

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_____

Signature Date

NJDEP Data Quality Review:	Robert Mancini Division of Watershed Management New Jersey Department of Environmental Protection 401 East State Street P.O. Box 418 Trenton, New Jersey 08625-0418 609-633-3812 (phone); 609-777-1282 (fax) Robert.Mancini@dep.state.nj.us

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NJDEP Office of Quality Assurance:	Marc Ferko Research Scientist Office of Quality Assurance New Jersey Department of Environmental Protection 9 Ewing Street P.O. Box 424 Trenton, NJ 08625-0418 609-292-3950 (phone); 609-777-1774 (fax) Marc.Ferko@dep.state.nj.us

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Signature Date

Additional Monitoring Program for July - September 2010

The Project Team has identified three (3) locations that will be monitored for temperature to obtain a more complete picture of suspected temperature impairments within the Musconetcong River Watershed.

Monitoring Locations:
The proposed temperature monitoring locations are as follows:

Station ID	Waterway	Location	Coordinates:	
			Lat	Long
Site #1	Musconetcong	Musconetcong River at the Route 31 crossing in Hampton, NJ	40.7112	74.9684
Site #4	Musconetcong	Musconetcong River at the Valley Road crossing downstream of Hampton	40.7043	74.9878
Site #10	Musconetcong	Musconetcong River at Person Road crossing at the USGS monitoring station near Bloomsbury (#01457000)	40.6723	75.0605

A WAAS-enable Garmin Rino 120 GPS or Garmin CSX 60 GPS (global positioning system) unit will be used to locate and identify the monitoring locations. Sampling locations will be marked with stakes and surveying tape or flags.

Basis for Sampling Locations:

Sites #1, #4, and #10 were selected to monitor temperature conditions in the mainstem of the Musconetcong River. Temperatures were found to be elevated in the summer of 2007, and several exceedances of the surface water quality criteria for temperature were noted at that time. A more extensive database through continuous monitoring will help confirm if there are temperature impairments along the mainstem.

Sampling Frequency and Methodology:

The Rutgers Cooperative Extension Water Resources Program has deployed three (3) HOBO® U22 Water Temp Pro v2 Logger units in the Musconetcong River at Sites #1, #4, and #10. These HOBO units have been calibrated against the Rutgers Cooperative Extension Water Resources Program Laboratory's certified thermometer (NJDEP Certified Laboratory #12039) prior to deployment.

All HOBO units will be programmed to continuously monitor temperature at two minute increments from late June through late September 2010. Data will be retrieved from the units in

late September 2010. The data collected will be summarized and presented to NJDEP by early November 2010.

The Standard Operating Procedure (SOP) for continuous temperature monitoring using HOBO® U22 Water Temp Pro v2 Logger units is provided in Attachment 1.

ATTACHMENT 1

Standard Operating Procedures
Temperature: Continuous Thermometric
Reference: Standard Methods (20th Edition) 2550B

NJDEP I.D. Number: 12039
Rutgers Cooperative Extension
Water Resources Program
New Brunswick, New Jersey

LABORATORY STANDARD OPERATING PROCEDURE

Temperature: Continuous Thermometric

Reference: Standard Methods (20th Edition) 2550B

Effective Date: June 18, 2010 Revision 0

Approved for Implementation:

6/18/10

Rutgers Cooperative Extension **Date**
Water Resources Program

Standard Operating Procedures: Continuous Temperature

Approved Method: SM 2550B – Continuous Thermometric, WPP03.14100

Scope:

Why measure temperature in ambient waters? Human activities should not change water temperatures beyond natural seasonal fluctuations. To do so could disrupt aquatic ecosystems. Temperature affects the solubility of oxygen and therefore affects fish and other aquatic organisms. Lowland streams, known as "warmwater" streams, are different from mountain or spring fed streams that are normally cool. In a warmwater stream, temperatures should not exceed 89 degrees Fahrenheit. Cold water streams should not exceed 68 degrees Fahrenheit.

Application:

ambient waters

Equipment & Reagents:

1. HOBO® U22 Water Temp Pro v2 Logger
   Range: -40 to 70˚C (-40 to 158˚F) in air; max of 50˚C (122˚F) in water
   Resolution: 0.02˚C at 25˚C (0.04˚F at 77˚F)
   Accuracy: ±0.2˚C between 0˚ and 50˚C (±0.36˚F between 32˚ and 122˚F)
   Battery: 2/3 AA, 3.6 Volt Lithium, factory-replaceable only
2. HOBO® Optic USB Base Station – allows communication between host computer and HOBO® optic loggers.
3. U22 Water Temp Pro v2 (COUPLER2-C) – connects Base Station to Logger.

Operation:

Set-up

1. Install the logger software onto computer before proceeding.
2. Plug the USB connector on the base station into an available USB port on computer. Strong sunlight may interfere with communications. If the base station does not seem to be working, try again in a shaded area.
3. Firmly insert the optical end of the base station into the D-shaped end of the coupler.
4. Firmly insert the logger into the coupler with the arrow on the logger label aligned with the arrow on the coupler label.
5. Use HOBOware® Pro to launch the logger, by clicking **Launch Logger**.
6. Edit the description and select the channels that are to be logged.
7. Set how often the logger will record data from the sensors in the *Logging Interval* area.
8. Select when to launch the logger; *Now*, *At Interval*, or *Delayed*.
9. Click **Launch** to launch the device.
10. Unplug the logger. Insert the next logger into the coupler if another is to be set-up.

Deployment

1. Depending on water conditions and desired measurement location, the logger should be appropriately weighted, secured and protected.
2. Ensure that the logger is appropriately secured so that the temperature sensor is in the desired measurement location.

Measurement

1. Remove the logger from the water and wipe off excess moisture.
2. Connect the logger to a computer as described above under Set-up.
3. Use HOBOware® Pro to check the logger's status or read out the logger.
4. To check current temperature readings and other device details, click **Device status**.
5. To read out the logger, click **Readout device**. This will create a plot of the logger's temperature readings.

Battery:

1. The battery life of the logger is approximately six years.
2. Frequent deployments with logging intervals of less than one minute and continuous storage/operation at temperatures above 35˚C will result in significantly shorter battery life.
3. If the logger's datafile contains "bad battery" events or if logged battery voltage repeatedly falls below 3.3 V, the battery is failing and the logger should be returned to Onset for battery replacement.
4. Remove the logger from the coupler when it is not communicating with the computer. Storing the logger in the coupler may cause the logger's battery to run down prematurely.

QC:

A NIST certified thermometer graduated in at least 0.2 degrees Celsius increments will be used to calibrate the HOBO® U22 Water Temp Pro v2 Logger prior to deployment, every three months during deployment (i.e., on a quarterly basis), and when retrieved. The laboratory will maintain a log of the calibration checks for each HOBO® U22 Water Temp Pro v2 Logger.

Appendix B: Tabulated water quality monitoring results from biweekly and additional bacteria sampling, May 2007 – October 2007

Musconetcong River Watershed Restoration and Protection Plan
Biweekly & Additional Bacteria Sampling - May 2007 to October 2007

Location	Date	Discharge (cfs)	Time of Sampling Discharge (cfs)	Daily Avg. Discharge (cfs)	pH (SU)	temperature (˚C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#10	05/29/07	154.85	157	156	8.01	17.2	8.98	***410***	350	0.07	0.02 ND	2.27	0.01	0.05	0.37	2.0
#10	05/30/07	218.26	152	150	7.76	16.5	9.25	***320***	210	0.08	0.02 ND	2.35	0.02	0.06	0.46	1.0
#10	06/04/07	***flow too high***	247	235	8.00	17.9	8.63	***4,100***	***960***	0.025 ND	0.02 ND	2.07	0.04	0.09	0.84	21.0
#10	06/11/07	107.87	136	134				***400***	***590***							
#10	06/13/07	116.69	126	127				***460***	***530***							
#10	06/18/07	87.57	121	120	6.92	18.9	8.83	***470***	***570***	0.025 ND	0.02 ND	2.29	0.04	0.08	0.18	5.0
#10	06/21/07	138.84	149	148	6.64	18.8	8.21									
#10	06/25/07	100.90	112	111				230	120							
#10	07/02/07	101.88	107	106	6.82	16.0	8.82	***400***	340	0.05	0.02 ND	2.25	0.02	0.05	0.16	2.5
#10	07/09/07	89.64	103	102				***240***	280							
#10	07/16/07	94.63	100	100	7.57	19.7	8.07	***270***	240	0.06	0.02 ND	2.25	0.02	0.05	0.15	4.5
#10	07/23/07	85.58	98	212				200	160							
#10	07/30/07	201.92	180	177				***480***	***540***							
#10	08/02/07	120.69	128	128				***260***	***460***							
#10	08/06/07	161.90	144	142	7.78	21.5	8.68	***250***	260	0.025 ND	0.02 ND	1.87	0.03	0.05	0.49	4.0
#10	08/13/07	334.43	268	264				***460***	330							
#10	08/20/07	118.60	157	158	7.18	17.1	9.02	***460***	200	0.07	0.02 ND	1.97	0.04	0.07	0.42	3.5
#10	08/27/07	***flow too high***	247	239				***660***	***440***							
#10	09/06/07	106.45	109	108	7.78	17.5	9.25									
#10	09/10/07	113.71	98	97	7.39	20.4	8.34	110	180	0.025 ND	0.02 ND	2.95	0.005 ND	0.03	0.52	1.0
#10	09/24/07	111.48	114	112	7.36	15.1	9.26	140	100	0.025 ND	0.02 ND	2.61	0.02	0.03	0.70	1.0
#10	10/08/07	81.45	90	89	7.73	17.8	8.73	***240***	150	0.07	0.02 ND	3.24	0.03	0.06	0.64	0.25 ND
#10	10/22/07	179.54	133	131	6.86	13.1	9.85	***240***	***600***	0.18	0.02 ND	2.37	0.02	0.05	0.59	2.5
n		21	23	23	14	14	14	21	21	12	12	12	12	12	12	12
minimum		81	90	89	6.64	13.1	8.07	110	100	0.03	0.02	1.87	0.01	0.03	0.15	0.3
maximum		334	268	264	8.01	21.5	9.85	***4,100***	***960***	0.18	0.02	3.24	0.04	0.09	0.84	21.0
mean		135	142	145	7.40	17.7	8.85	***346***	307	0.06	0.02	2.37	0.02	0.06	0.46	4.0
std. dev.		60	50	49	0.46	2.2	0.47	833	214	0.04	0.00	0.39	0.01	0.02	0.22	5.6

= violation of surface water quality criteria (SWQC)
ND = non-detect; 1/2 the detection limit provided

Musconetcong River Watershed Restoration and Protection Plan
Biweekly & Additional Bacteria Sampling - May 2007 to October 2007

Location	Date	Discharge (cfs)	pH (SU)	temperature (˚C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#9	05/29/07	0.82	7.60	16.5	9.09	***80,000***	***1,200***	0.21	0.02 ND	1.30	0.14	***0.19***	0.46	1.0
#9	05/30/07	0.47	7.40	15.4	9.92	***32,000***	***1,700***	0.08	0.02 ND	1.27	0.03	0.07	0.36	1.0
#9	06/04/07	2.85	7.19	17.1	8.78	***23,000***	***19,000***	0.025 ND	0.02 ND	0.99	0.03	0.10	0.61	7.5
#9	06/11/07	0.85				***29,000***	***2,000***							
#9	06/13/07	0.40				***31,000***	***4,200***							
#9	06/18/07	0.42	***5.71***	18.9	8.23	***5,400***	***8,400***	0.025 ND	0.02 ND	1.20	0.04	0.07	0.13	5.5
#9	06/25/07	0.28				***4,400***	***2,000***							
#9	07/02/07	0.67	6.61	14.4	10.02	***44,000***	***28,000***	0.08	0.02 ND	1.14	0.04	0.07	0.09	5.0
#9	07/09/07	0.41				***2,000***	***8,600***							
#9	07/16/07	0.19	7.62	19.8	8.17	***1,000***	***2,100***	0.06	0.02 ND	1.09	0.02	0.05	0.08	2.5
#9	07/23/07	0.11				***4,000***	***4,400***							
#9	07/30/07	0.26				***2,400***	***4,000***							
#9	08/02/07	0.04				***470***	***580***							
#9	08/06/07	0.02	7.58	***23.3***	7.26	***320***	***800***	0.025 ND	0.02 ND	1.32	0.03	0.05	0.22	5.0
#9	08/13/07	0.13				***21,000***	***7,800***							
#9	08/20/07	0.19	7.41	16.3	9.28	***25,000***	***23,000***	0.06	0.02 ND	1.23	0.04	0.07	0.37	0.25 ND
#9	08/27/07	0.06				***1,100***	***910***							
#9	09/10/07	***NO FLOW***												
#9	09/24/07	***NO FLOW***												
#9	10/08/07	***NO FLOW***												
#9	10/22/07	***NO FLOW***												
n		16	8	8	8	17	17	8	8	8	8	8	8	8
minimum		0.02	***5.71***	14.4	7.26	***320***	***580***	0.03	0.02	0.99	0.02	0.05	0.08	0.3
maximum		2.85	7.62	***23.3***	10.02	***80,000***	***28,000***	0.21	0.02	1.32	0.14	***0.19***	0.61	7.5
mean		0.46	7.11	17.7	8.84	***6,629***	***3,654***	0.07	0.02	1.19	0.05	0.08	0.29	3.5
std. dev.		0.68	0.67	2.9	0.94	21,393	8,375	0.06	0.00	0.11	0.04	0.05	0.19	2.6

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Musconetcong River Watershed Restoration and Protection Plan
Biweekly & Additional Bacteria Sampling - May 2007 to October 2007

Location	Date	Discharge (cfs)	pH (SU)	temperature (˚C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#7	05/29/07	4.74	8.15	16.1	9.21	***1,600***	***780***	0.06	0.02 ND	1.53	0.03	0.06	0.48	1.5
#7	05/30/07	3.81	6.80	14.8	9.93	***6,100***	***730***	0.08	0.02 ND	1.55	0.03	0.07	0.35	3.5
#7	06/04/07	7.23	7.24	15.9	9.15	***6,400***	***3,200***	0.025 ND	0.02 ND	1.16	0.03	0.09	0.57	8.5
#7	06/11/07	3.03				***5,900***	180							
#7	06/13/07	2.54				***7,700***	***5,800***							
#7	06/18/07	2.68	7.25	17.0	7.95	***14,000***	***9,900***	0.025 ND	0.02 ND	1.50	0.04	0.07	0.42	4.5
#7	06/25/07	2.19				***6,600***	***8,400***							
#7	07/02/07	3.12	6.67	14.0	9.52	***670***	***9,000***	0.025 ND	0.02 ND	1.48	0.04	0.07	0.025 ND	6.5
#7	07/09/07	2.68				***4,100***	***6,200***							
#7	07/16/07	2.27	7.64	17.1	8.24	***92,000***	***34,000***	0.025 ND	0.02 ND	1.35	0.04	0.08	0.10	9.0
#7	07/23/07	1.91				***18,000***	***14,000***							
#7	07/30/07	2.43				***18,000***	***15,000***							
#7	08/02/07	2.30				***7,100***	***9,000***							
#7	08/06/07	2.12	7.55	17.6	9.00	***52,000***	***42,000***	0.025 ND	0.02 ND	1.54	0.06	***0.11***	0.26	9.5
#7	08/13/07	2.16				***53,000***	***39,000***							
#7	08/20/07	1.64	7.67	15.0	9.70	***26,000***	***25,000***	0.09	0.02 ND	1.42	0.05	0.09	0.71	6.5
#7	08/27/07	1.81				***15,000***	***13,000***							
#7	09/10/07	1.09	7.58	17.8	9.05	***5,600***	***4,000***	0.025 ND	0.02 ND	1.65	0.04	0.08	0.59	3.0
#7	09/24/07	1.05	7.47	12.6	10.31	***4,700***	***1,100***	0.025 ND	0.02 ND	1.72	0.04	0.06	0.59	8.0
#7	10/08/07	1.49	7.71	16.2	9.29	***6,400***	***4,500***	0.15	0.02 ND	1.67	0.05	0.08	0.53	1.5
#7	10/22/07	1.76	7.58	11.0	10.80	***6,600***	***4,200***	0.15	0.02 ND	1.67	0.05	0.06	0.55	4.5
n		21	12	12	12	21	21	12	12	12	12	12	12	12
minimum		1.05	6.67	11.0	7.95	***670***	180	0.03	0.02	1.16	0.03	0.06	0.03	1.5
maximum		7.23	8.15	17.8	10.80	***92,000***	***42,000***	0.15	0.02	1.72	0.06	***0.11***	0.71	9.5
mean		2.57	7.44	15.4	9.35	***9,221***	***6,039***	0.06	0.02	1.52	0.04	0.08	0.43	5.5
std. dev.		1.37	0.40	2.1	0.80	22,429	12,596	0.05	0.00	0.16	0.01	0.01	0.21	2.9

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Musconetcong River Watershed Restoration and Protection Plan
Biweekly & Additional Bacteria Sampling - May 2007 to October 2007

Location	Date	Discharge (cfs)	pH (SU)	temperature (˚C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#8	05/29/07	155.94	7.70	17.9	8.82	***240***	100	0.06	0.02 ND	2.24	0.02	0.04	0.24	2.5
#8	05/30/07	170.00	7.19	17.1	9.19	***240***	170	0.06	0.02 ND	2.24	0.02	0.05	0.44	2.5
#8	06/04/07	***flow too high***	7.89	18.0	8.35	***3,300***	***1,400***	0.025 ND	0.02 ND	2.06	0.03	***0.11***	0.68	17.0
#8	06/11/07	117.61				***480***	***1,000***							
#8	06/13/07	121.38				***460***	***550***							
#8	06/18/07	117.81	6.94	***20.2***	9.01	***430***	400	0.025 ND	0.02 ND	2.12	0.02	0.04	0.19	3.5
#8	06/25/07	101.56				***1,700***	***580***							
#8	07/02/07	106.35	6.93	16.1	8.00	***5,100***	***750***	0.025 ND	0.02 ND	1.93	0.02	0.05	0.12	3.5
#8	07/09/07	89.83				***480***	***560***							
#8	07/16/07	100.08	7.86	***20.3***	7.13	***1,000***	***1,100***	0.11	0.02 ND	1.81	0.01	0.04	0.19	3.0
#8	07/23/07	88.41				***800***	***1,100***							
#8	07/30/07	204.34				***400***	300							
#8	08/02/07	122.22				***530***	***820***							
#8	08/06/07	142.21	7.55	***21.9***	9.42	200	200	0.025 ND	0.02 ND	1.73	0.02	0.05	0.42	2.5
#8	08/13/07	250.93				***540***	***1,300***							
#8	08/20/07	120.25	7.79	17.2	9.11	***590***	340	0.07	0.02 ND	1.87	0.03	0.06	0.41	2.0
#8	08/27/07	***flow too high***				***450***	***510***							
#8	09/10/07	89.11	8.01	***20.9***	9.63	200	310	0.11	0.02 ND	2.49	0.005 ND	0.04	0.51	1.0
#8	09/24/07	110.67	7.78	15.4	9.91	200	200	0.025 ND	0.02 ND	2.43	0.02	0.03	0.61	1.5
#8	10/08/07	77.90	7.88	18.4	9.03	***260***	320	0.07	0.02 ND	2.92	0.02	0.05	0.65	0.25 ND
#8	10/22/07	128.88	7.56	13.3	10.16	***280***	350	0.09	0.02 ND	2.39	0.02	0.05	0.54	1.0
n		19	12	12	12	21	21	12	12	12	12	12	12	12
minimum		77.90	6.93	13.3	7.13	200	100	0.03	0.02	1.73	0.01	0.03	0.12	0.3
maximum		250.93	8.01	***21.9***	10.16	***5,100***	***1,400***	0.11	0.02	2.92	0.03	***0.11***	0.68	17.0
mean		127.13	7.58	18.1	8.98	***519***	***468***	0.06	0.02	2.19	0.02	0.05	0.42	3.4
std. dev.		43.02	0.37	2.5	0.84	1,199	390	0.03	0.00	0.34	0.01	0.02	0.19	4.4

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Musconetcong River Watershed Restoration and Protection Plan
Biweekly & Additional Bacteria Sampling - May 2007 to October 2007

Location	Date	Discharge (cfs)	pH (SU)	temperature (˚C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#5a	05/29/07	0.74	7.82	18.3	8.74	***320***	***340***	0.025 ND	0.02 ND	4.31	0.02	0.04	0.25	2.5
#5a	05/30/07	0.59	7.73	16.9	9.48	***450***	***590***	0.07	0.02 ND	4.37	0.02	0.04	1.85	1.5
#5a	06/04/07	1.26	7.27	18.9	8.18	***640***	***800***	0.025 ND	0.02 ND	3.43	0.02	0.05	0.54	3.5
#5a	06/11/07	0.46				***660***	***1,200***							
#5a	06/13/07	0.28				230	***270***							
#5a	06/18/07	0.22	6.62	19.3	8.04	***270***	***370***	0.025 ND	0.02 ND	3.91	0.02	0.08	0.33	8.3
#5a	06/25/07	0.37				***440***	***220***							
#5a	07/02/07	0.15	7.00	15.0	8.16	*	***3,100***	0.025 ND	0.02 ND	3.96	0.02	0.05	0.20	4.5
#5a	07/09/07	0.24				***420***	400							
#5a	07/16/07	0.06	7.61	***20.2***	7.45	230	***180***	0.05	0.02 ND	3.35	0.02	0.05	0.12	5.0
#5a	07/23/07	0.20				***7,300***	***10,000***							
#5a	07/30/07	0.17				***2,500***	***160***							
#5a	08/02/07	0.05				***430***	***120***							
#5a	08/06/07	0.02	7.21	***22.0***	8.02	***700***	***1,100***	0.025 ND	0.02 ND	1.46	0.02	0.04	0.61	6.0
#5a	08/13/07	0.15				210	***2,400***							
#5a	08/20/07	0.07	6.94	17.3	8.62	***300***	***60***	0.025 ND	0.02 ND	1.41	0.02	0.04	0.34	2.0
#5a	08/27/07	0.13				200	***280***							
#5a	09/10/07	0.05	6.60	***22.0***	7.39	***410***	***800***	0.025 ND	0.02 ND	1.70	0.03	0.04	0.49	22.0
#5a	09/24/07	0.08	6.60	14.8	9.39	***3,100***	***1,100***	0.025 ND	0.02 ND	1.70	0.02	0.03	0.47	1.0
#5a	10/08/07	0.00	7.09	19.2	7.33	210	***160***	0.025 ND	0.02 ND	1.17	0.04	0.07	0.47	0.25 ND
#5a	10/22/07	0.16	***6.31***	12.6	10.44	***350***	***1,300***	0.07	0.02 ND	1.56	0.01	0.04	0.44	4.0
n		21	12	12	12	20	***21***	12	12	12	12	12	12	12
minimum		0.00	***6.31***	12.6	7.33	200	***60***	0.03	0.02	1.17	0.01	0.03	0.12	0.3
maximum		1.26	7.82	***22.0***	10.44	***7,300***	***10,000***	0.07	0.02	4.37	0.04	0.08	1.85	22.0
mean		0.26	7.05	18.0	8.44	***502***	***528***	0.03	0.02	2.69	0.02	0.05	0.51	5.0
std. dev.		0.30	0.49	2.9	0.95	1,674	2,164	0.02	0.00	1.29	0.01	0.01	0.45	5.8

**** = laboratory lost sample***

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Musconetcong River Watershed Restoration and Protection Plan
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Location	Date	Discharge (cfs)	pH (SU)	temperature (˚C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#6	05/29/07	165.26	7.78	18.2	8.92	90	100	0.06	0.02 ND	2.23	0.02	0.05	0.29	2.5
#6	05/30/07	169.89	7.89	17.5	9.31	150	130	0.06	0.02 ND	2.23	0.02	0.05	0.56	2.5
#6	06/04/07	***flow too high***	7.68	18.0	8.47	***1,600***	***1,000***	0.025 ND	0.02 ND	2.04	0.03	0.08	0.67	14.0
#6	06/11/07	124.03				***2,500***	320							
#6	06/13/07	154.06				***250***	300							
#6	06/18/07	98.56	7.52	20.0		***350***	***550***	0.025 ND	0.02 ND	2.36	0.02	0.05	0.21	5.0
#6	06/25/07	92.98				160	300							
#6	07/02/07	92.60	7.23	16.4	7.32	140	230	0.025 ND	0.02 ND	1.94	0.02	0.04	0.30	3.0
#6	07/09/07	108.23				***290***	320							
#6	07/16/07	82.90	7.82	***20.1***	7.78	180	200	0.025 ND	0.02 ND	1.81	0.01	0.04	0.09	4.5
#6	07/23/07	101.23				***350***	***540***							
#6	07/30/07	183.19				***370***	220							
#6	08/02/07	129.62				230	160							
#6	08/06/07	148.06	7.62	***22.0***	8.32	200	360	0.025 ND	0.02 ND	1.65	0.02	0.05	0.65	3.5
#6	08/13/07	***flow too high***				***270***	***620***							
#6	08/20/07	147.20	7.52	17.1	9.17	***400***	***600***	0.025 ND	0.02 ND	1.83	0.03	0.05	0.39	2.5
#6	08/27/07	***flow too high***				***460***	***490***							
#6	09/10/07	93.04	7.79	***21.1***	9.07	160	320	0.025 ND	0.02 ND	2.48	0.005 ND	0.04	0.48	0.5
#6	09/24/07	120.64	7.71	15.8	9.84	180	220	0.025 ND	0.02 ND	2.64	0.02	0.03	0.61	1.5
#6	10/08/07	63.77	7.85	18.2	9.27	***250***	290	0.08	0.02 ND	2.72	0.02	0.03	0.49	0.25 ND
#6	10/22/07	118.63	6.74	13.6	10.17	***330***	380	0.06	0.02 ND	2.36	0.02	0.04	0.40	0.25 ND
n		18	12	12	11	21	21	12	12	12	12	12	12	12
minimum		63.77	6.74	13.6	7.32	90	100	0.03	0.02	1.65	0.01	0.03	0.09	0.3
maximum		183.19	7.89	***22.0***	10.17	***2,500***	***1,000***	0.08	0.02	2.72	0.03	0.08	0.67	14.0
mean		121.88	7.59	18.2	8.88	***286***	315	0.04	0.02	2.19	0.02	0.05	0.43	3.3
std. dev.		33.40	0.33	2.4	0.85	567	210	0.02	0.00	0.34	0.01	0.01	0.18	3.7

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Location	Date	Discharge (cfs)	pH (SU)	temperature (˚C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#11	05/29/07	3.45	7.65	14.4	8.76	30	48	0.025 ND	0.02 ND	2.84	0.005 ND	0.02	ND	0.5
#11	05/30/07	3.84	7.80	14.2	9.19	30	28	0.025 ND	0.02 ND	2.80	0.005 ND	0.02	0.36	1.0
#11	06/04/07	4.16	7.70	13.5	8.98	***330***	320	0.025 ND	0.02 ND	2.81	0.005 ND	0.04	0.22	0.5
#11	06/11/07	2.53				230	220							
#11	06/13/07	3.48				60	80							
#11	06/18/07	2.42	6.99	15.2	8.52	140	130	0.025 ND	0.02 ND	2.84	0.005 ND	0.09	0.14	13.5
#11	06/25/07	2.43				80	120							
#11	07/02/07	1.98	7.43	14.2	9.75	***270***	300	0.025 ND	0.02 ND	2.81	0.005 ND	0.03	0.22	1.0
#11	07/09/07	3.16				***270***	340							
#11	07/16/07	3.01	7.47	14.8	8.26	110	***440***	0.06	0.02 ND	2.82	0.005 ND	0.03	0.06	1.0
#11	07/23/07	6.86				***2,900***	***2,300***							
#11	07/30/07	2.88				***330***	***440***							
#11	08/02/07	2.75				140	40							
#11	08/06/07	3.07	7.15	15.1	9.84	40	60	0.025 ND	0.02 ND	2.80	0.01	0.05	0.94	1.0
#11	08/13/07	3.04				***250***	370							
#11	08/20/07	2.98	7.47	13.7	9.09	***260***	360	0.025 ND	0.02 ND	2.78	0.005 ND	0.03	0.75	0.25 ND
#11	08/27/07	2.74				230	380							
#11	09/10/07	3.08	7.63	16.4	9.33	40	72	0.025 ND	0.02 ND	3.18	0.005 ND	0.03	0.28	2.0
#11	09/24/07	2.16	7.73	14.6	9.27	20	24	0.025 ND	0.02 ND	3.24	0.005 ND	0.01 ND	1.05	1.5
#11	10/08/07	2.37	7.66	15.2	9.30	20	8	0.025 ND	0.02 ND	3.31	0.005 ND	0.03	0.53	0.25 ND
#11	10/22/07	2.32	7.73	13.9	9.26	***470***	***660***	0.09	0.02 ND	3.31	0.005 ND	0.02	0.47	1.5
n		21	12	12	12	21	21	12	12	12	12	12	11	12
minimum		1.98	6.99	13.5	8.26	20	8	0.03	0.02	2.78	0.01	0.01	0.06	0.3
maximum		6.86	7.80	16.4	9.84	***2,900***	***2,300***	0.09	0.02	3.31	0.01	0.09	1.05	13.5
mean		3.08	7.53	14.6	9.13	129	151	0.03	0.02	2.96	0.01	0.03	0.46	2.0
std. dev.		1.02	0.25	0.8	0.46	610	488	0.02	0.00	0.22	0.00	0.02	0.33	3.7

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Location	Date	Discharge (cfs)	pH (SU)	temperature (˚C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#4	05/29/07	150.26	8.33	18.9	9.07	180	120	0.05	0.02 ND	2.13	0.02	0.06	0.63	1.5
#4	05/30/07	119.65	7.85	18.3	9.35	150	200	0.06	0.02 ND	2.19	0.03	0.06	0.37	4.5
#4	06/04/07	***flow too high***	7.79	18.1	8.45	***2,500***	***1,100***	0.025 ND	0.02 ND	1.90	0.03	***0.11***	0.54	12.0
#4	06/11/07	89.79				200	360							
#4	06/13/07	104.76				180	***420***							
#4	06/18/07	101.01	6.90	***20.8***	9.07	***240***	220	0.025 ND	0.02 ND	2.36	0.02	0.05	0.24	4.5
#4	06/25/07	77.90				***250***	220							
#4	07/02/07	76.67	7.25	16.9	10.34	140	160	0.025 ND	0.02 ND	2.24	0.02	0.05	0.38	2.5
#4	07/09/07	70.16				***250***	300							
#4	07/16/07	68.64	8.02	***20.8***	8.53	***240***	320	0.025 ND	0.02 ND	2.07	0.02	0.04	0.33	2.5
#4	07/23/07	113.82				***520***	***740***							
#4	07/30/07	160.96				***390***	360							
#4	08/02/07	112.84				***290***	140							
#4	08/06/07	127.24	7.82	***22.3***	8.61	***240***	320	0.025 ND	0.02 ND	1.58	0.03	0.05	0.74	1.0
#4	08/13/07	***flow too high***				***300***	290							
#4	08/20/07	123.21	7.71	17.3	9.16	***390***	220	0.025 ND	0.02 ND	1.76	0.03	0.05	0.45	2.0
#4	08/27/07	***flow too high***				***410***	***450***							
#4	09/10/07	79.59	8.26	***21.6***	10.73	***260***	350	0.025 ND	0.02 ND	2.88	0.01	0.04	0.41	1.5
#4	09/24/07	92.99	7.88	16.3	10.31	120	190	0.025 ND	0.02 ND	2.64	0.02	0.03	0.58	1.5
#4	10/08/07	80.97	8.02	18.6	10.06	***380***	***580***	0.025 ND	0.02 ND	2.61	0.02	0.05	0.51	0.25 ND
#4	10/22/07	105.35	7.70	14.3	10.37	***340***	***420***	0.07	0.02 ND	2.19	0.02	0.05	0.41	0.25 ND
n		18	12	12	12	21	21	12	12	12	12	12	12	12
minimum		68.64	6.90	14.3	8.45	120	120	0.03	0.02	1.58	0.01	0.03	0.24	0.3
maximum		160.96	8.33	***22.3***	10.73	***2,500***	***1,100***	0.07	0.02	2.88	0.03	***0.11***	0.74	12.0
mean		103.10	7.78	18.7	9.50	***284***	307	0.03	0.02	2.21	0.02	0.05	0.47	2.8
std. dev.		26.55	0.40	2.4	0.81	496	227	0.02	0.00	0.37	0.01	0.02	0.14	3.2

= violation of surface water quality criteria (SWQC)
ND = non-detect; 1/2 the detection limit provided

Musconetcong River Watershed Restoration and Protection Plan
Biweekly & Additional Bacteria Sampling - May 2007 to October 2007

Location	Date	Discharge (cfs)	pH (SU)	temperature (˚C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#2	05/29/07	***NO FLOW***												
#2	05/30/07	***NO FLOW***												
#2	06/04/07	0.08	7.78	16.8	8.64	***1,400***	***1,100***	0.025 ND	0.02 ND	2.14	0.03	0.09	0.43	4.0
#2	06/11/07	***NO FLOW***												
#2	06/13/07	***NO FLOW***												
#2	06/18/07	***NO FLOW***												
#2	06/25/07	***NO FLOW***												
#2	07/02/07	***NO FLOW***												
#2	07/09/07	***NO FLOW***												
#2	07/16/07	***NO FLOW***												
#2	07/23/07	***NO FLOW***												
#2	07/30/07	***NO FLOW***												
#2	08/02/07	***NO FLOW***												
#2	08/06/07	***NO FLOW***												
#2	08/13/07	***NO FLOW***												
#2	08/20/07	***NO FLOW***												
#2	08/27/07	***NO FLOW***												
#2	09/10/07	***NO FLOW***												
#2	09/24/07	***NO FLOW***												
#2	10/08/07	***NO FLOW***												
#2	10/22/07	***NO FLOW***												

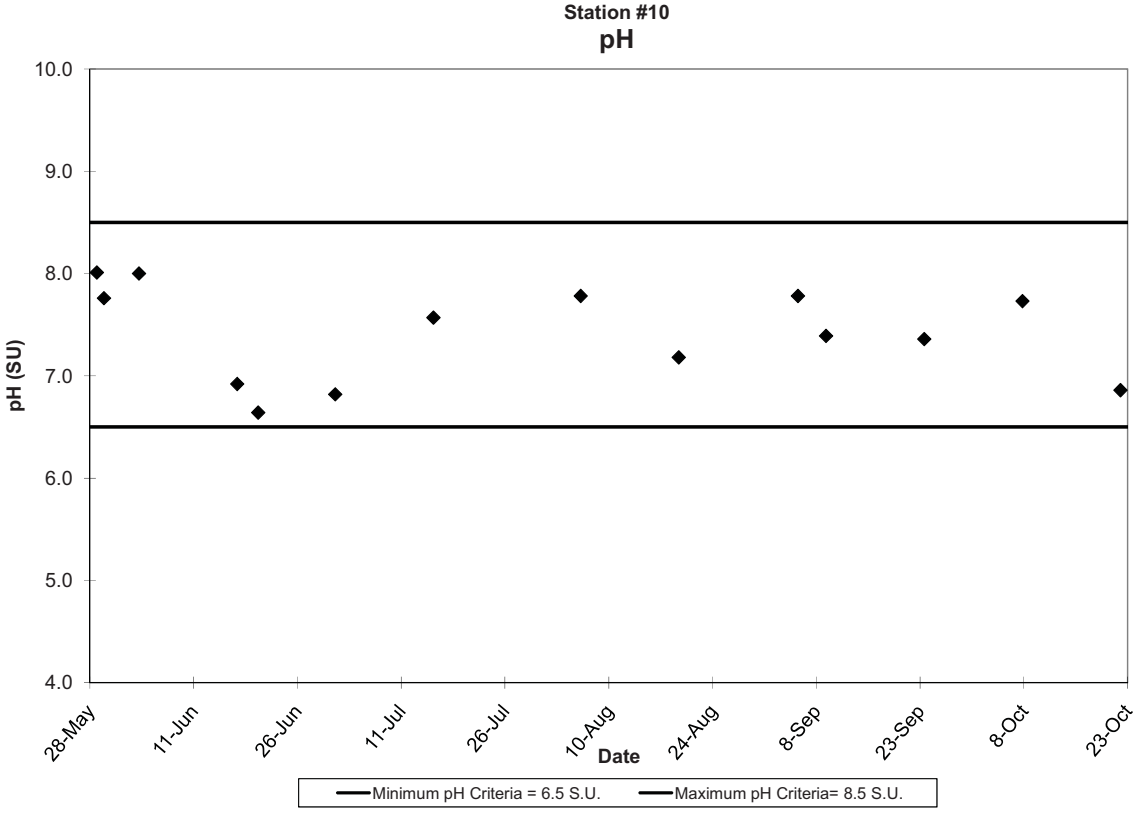
= violation of surface water quality criteria (SWQC)
ND = non-detect; 1/2 the detection limit provided

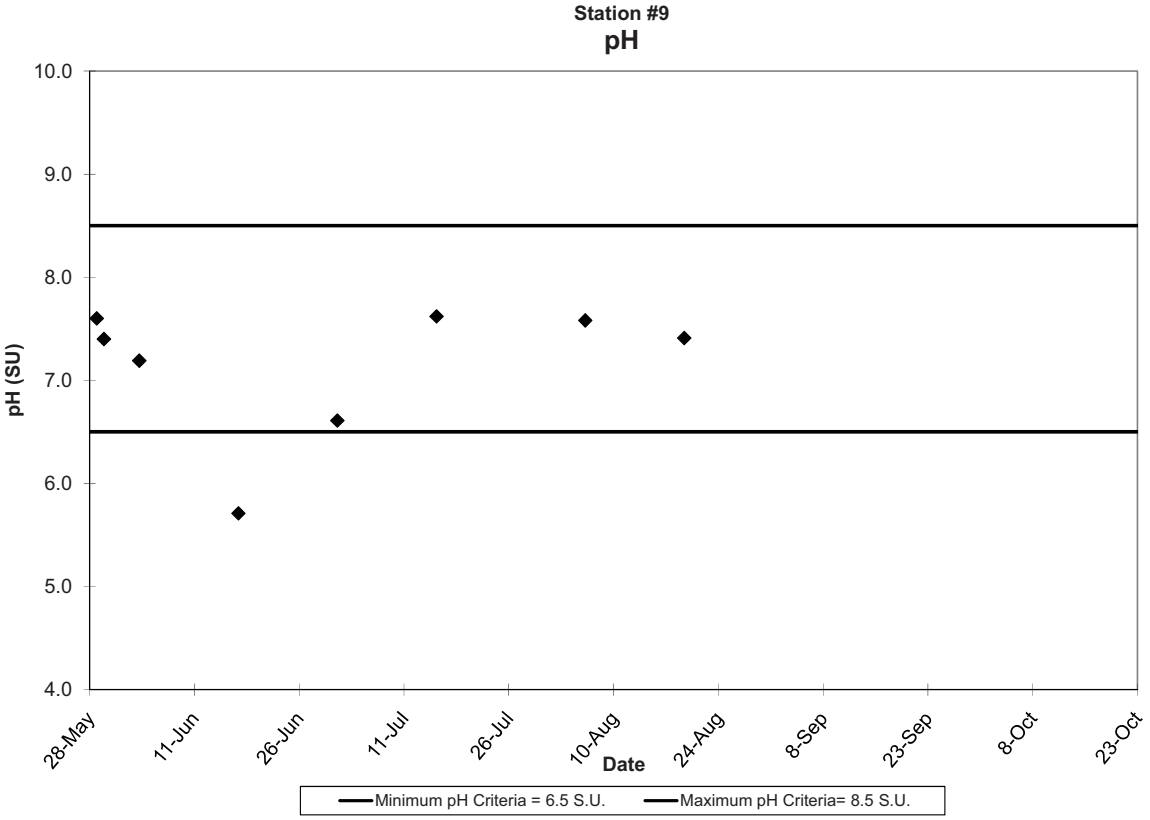
Musconetcong River Watershed Restoration and Protection Plan
Biweekly & Additional Bacteria Sampling - May 2007 to October 2007

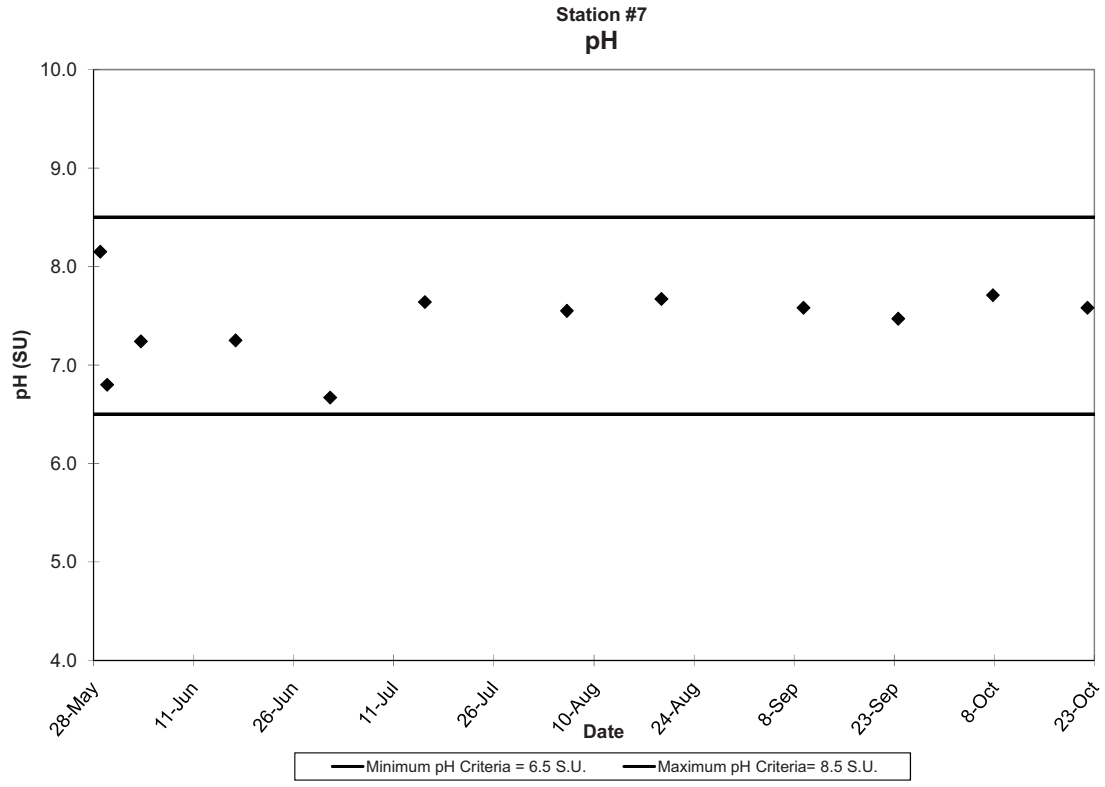
Location	Date	Discharge (cfs)	pH (SU)	temperature (°C)	DO (mg/L)	E. coli (org./100 ml)	Fecal Coliform (col/100 ml)	NH3-N (mg/L)	NO2-N (mg/L)	NO3-N (mg/L)	DOP (mg/L)	TP (mg/L)	TKN (mg/L)	TSS (mg/L)
#1	05/29/07	126.88	8.10	19.5	9.12	190	80	0.06	0.02 ND	2.12	0.02	0.06	0.26	2.0
#1	05/30/07	154.43	8.26	18.8	9.43	150	44	0.05	0.02 ND	2.16	0.03	0.06	0.43	3.0
#1	06/04/07	208.10	7.77	18.4	8.57	***3,300***	***1,400***	0.025 ND	0.02 ND	1.71	0.03	0.08	0.51	8.5
#1	06/11/07	87.30				120	300							
#1	06/13/07	85.58				230	330							
#1	06/18/07	93.70	6.94	***21.5***	9.04	150	280	0.025 ND	0.02 ND	2.26	0.02	0.05	0.35	3.0
#1	06/21/07	115.87	7.52	19.9	8.41									
#1	06/25/07	96.40				190	80							
#1	07/02/07	86.02	7.33	17.9	10.04	170	190	0.025 ND	0.02 ND	2.15	0.02	0.05	0.37	2.5
#1	07/09/07	83.02				***400***	***580***							
#1	07/16/07	87.22	8.21	***21.7***	9.36	170	160	0.12	0.02 ND	2.01	0.02	0.05	0.12	3.0
#1	07/23/07	88.70				***1,700***	***1,000***							
#1	07/30/07	167.16				***360***	260							
#1	08/02/07	118.76				190	80							
#1	08/06/07	132.51	7.89	***22.6***	8.68	***280***	180	0.025 ND	0.02 ND	1.58	0.02	0.07	0.60	2.5
#1	08/13/07	292.64				***240***	260							
#1	08/20/07	111.58	7.80	17.5	9.18	***250***	90	0.025 ND	0.02 ND	1.73	0.03	0.06	0.43	2.0
#1	08/27/07	242.29				***350***	230							
#1	09/06/07	86.11	7.95	18.5	9.87									
#1	09/10/07	68.82	8.24	***22.4***	10.58	***240***	340	0.025 ND	0.02 ND	2.80	0.02	0.04	0.33	0.5
#1	09/24/07	90.46	8.15	16.7	10.53	130	140	0.025 ND	0.02 ND	2.54	0.03	0.03	0.57	0.5
#1	10/08/07	71.15	8.01	19.2	9.73	***470***	200	0.06	0.02 ND	2.91	0.02	0.06	0.39	0.25 ND
#1	10/22/07	127.75	7.98	14.6	10.48	***240***	***510***	0.13	0.02 ND	2.17	0.02	0.04	0.41	0.25 ND
n		21	14	14	14	21	21	12	12	12	12	12	12	12
minimum		68.82	6.94	14.6	8.41	120	44	0.03	0.02	1.58	0.02	0.03	0.12	0.3
maximum		292.64	8.26	***22.6***	10.58	***3,300***	***1,400***	0.13	0.02	2.91	0.03	0.08	0.60	8.5
mean		121.01	7.86	19.2	9.50	***278***	222	0.05	0.02	2.18	0.02	0.05	0.40	2.3
std. dev.		59.22	0.38	2.3	0.73	732	329	0.04	0.00	0.41	0.00	0.01	0.13	2.2

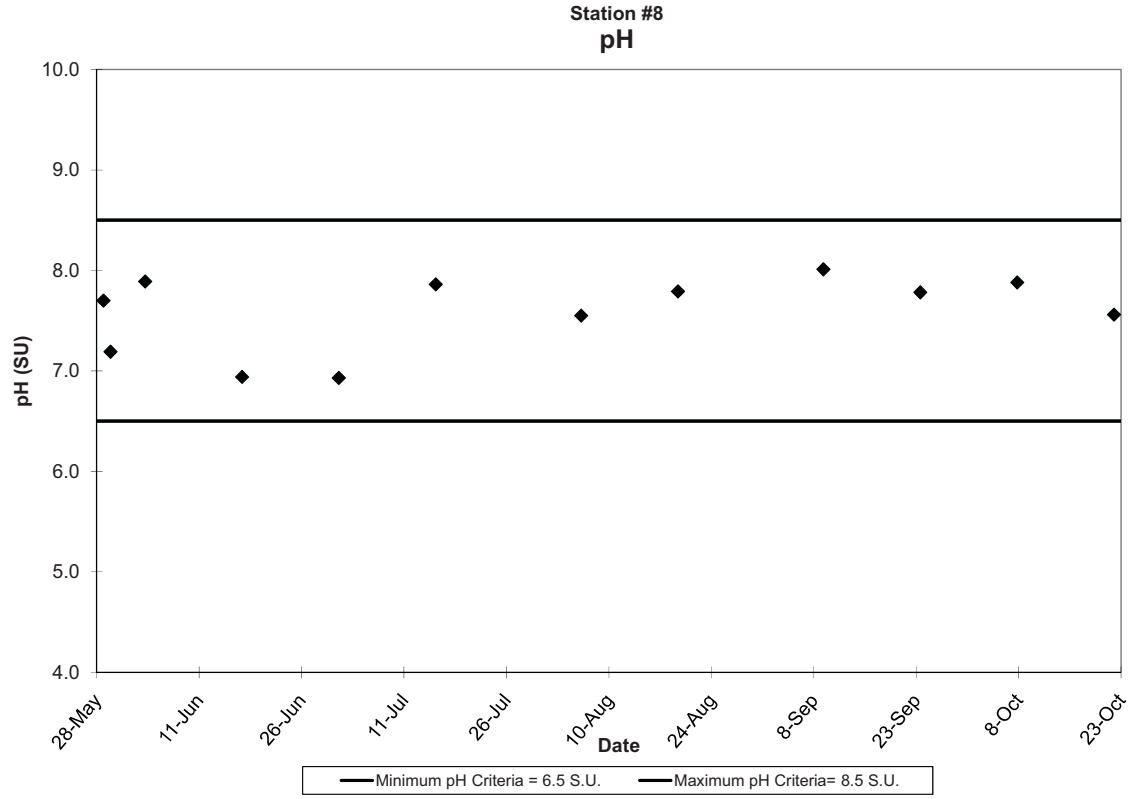
= violation of surface water quality criteria (SWQC)
ND = non-detect; 1/2 the detection limit provided

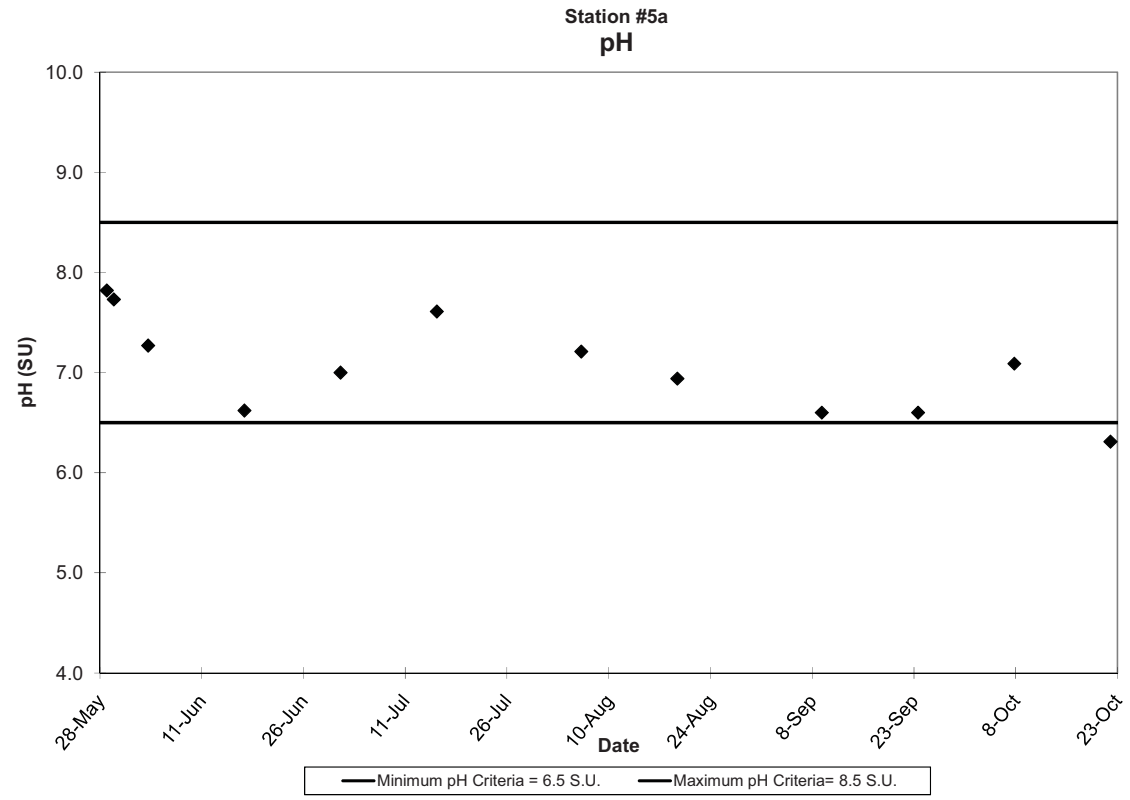
Appendix C: Graphs of water quality monitoring results from biweekly and additional bacteria sampling for pH, temperature, total phosphorus, fecal coliform, and *E. coli*, May 2007 – October 2007

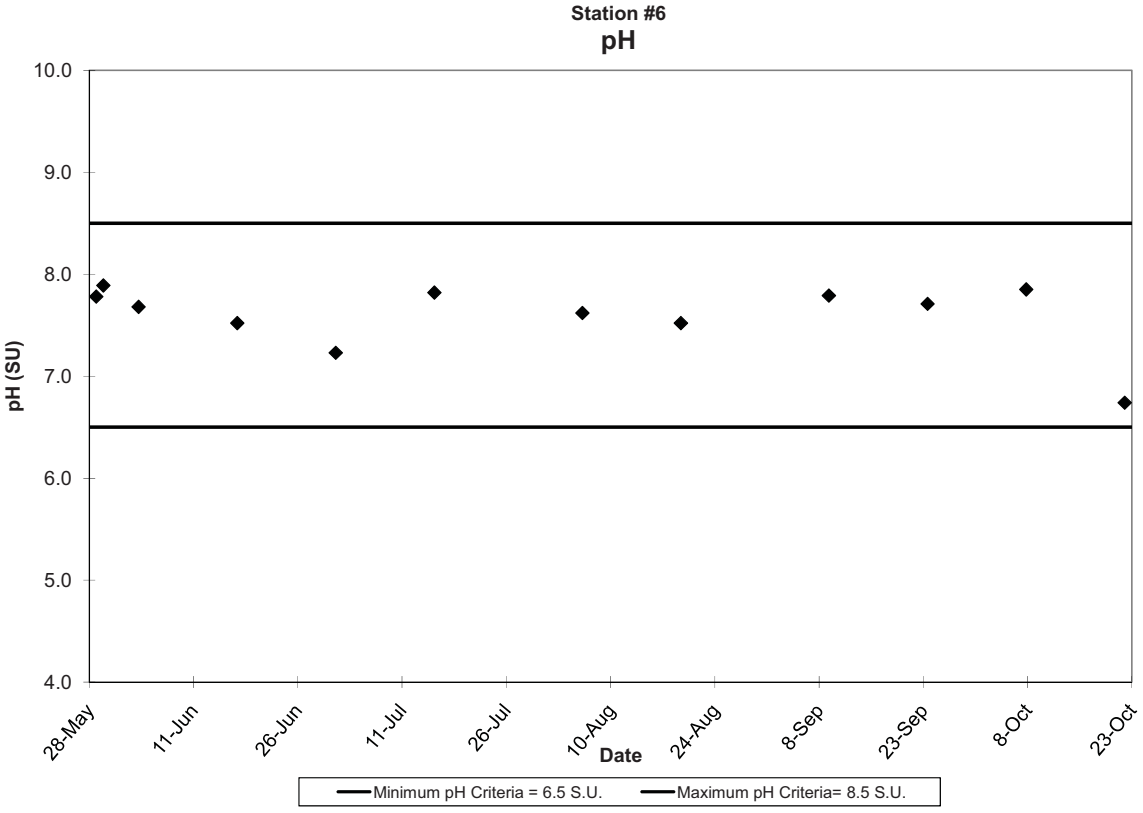

Station #10
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

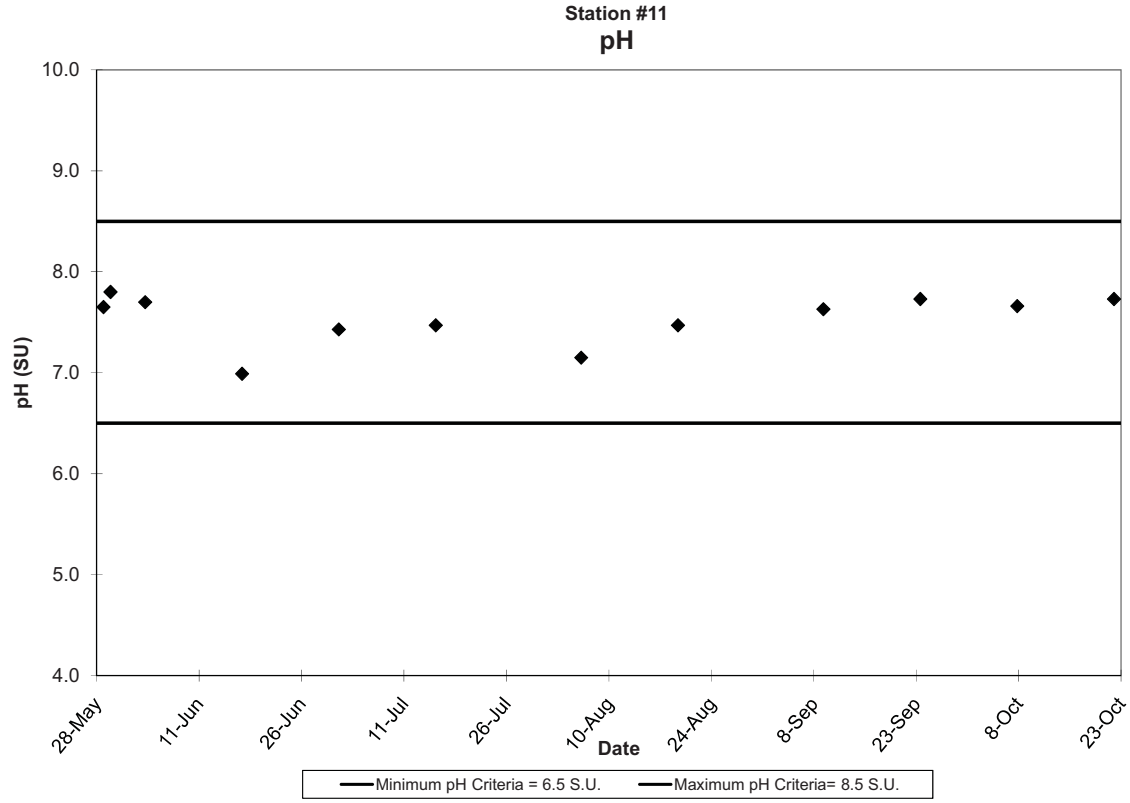

Station #9
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

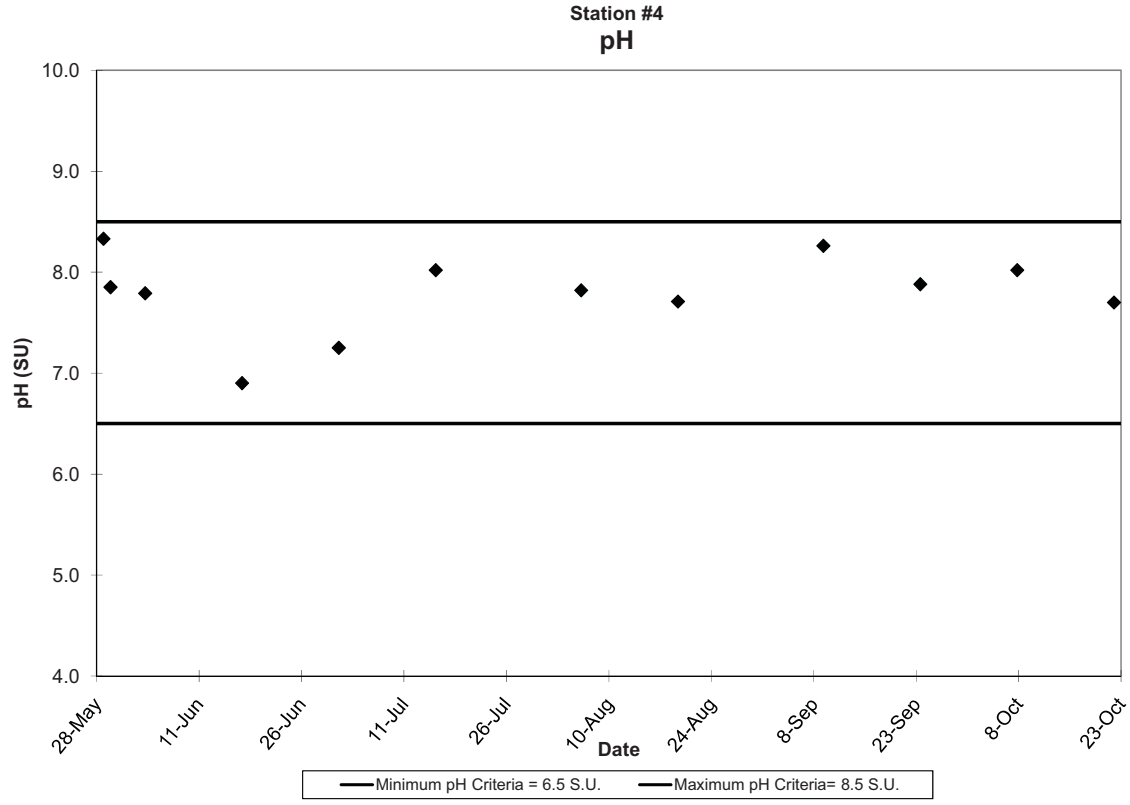

Station #7
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

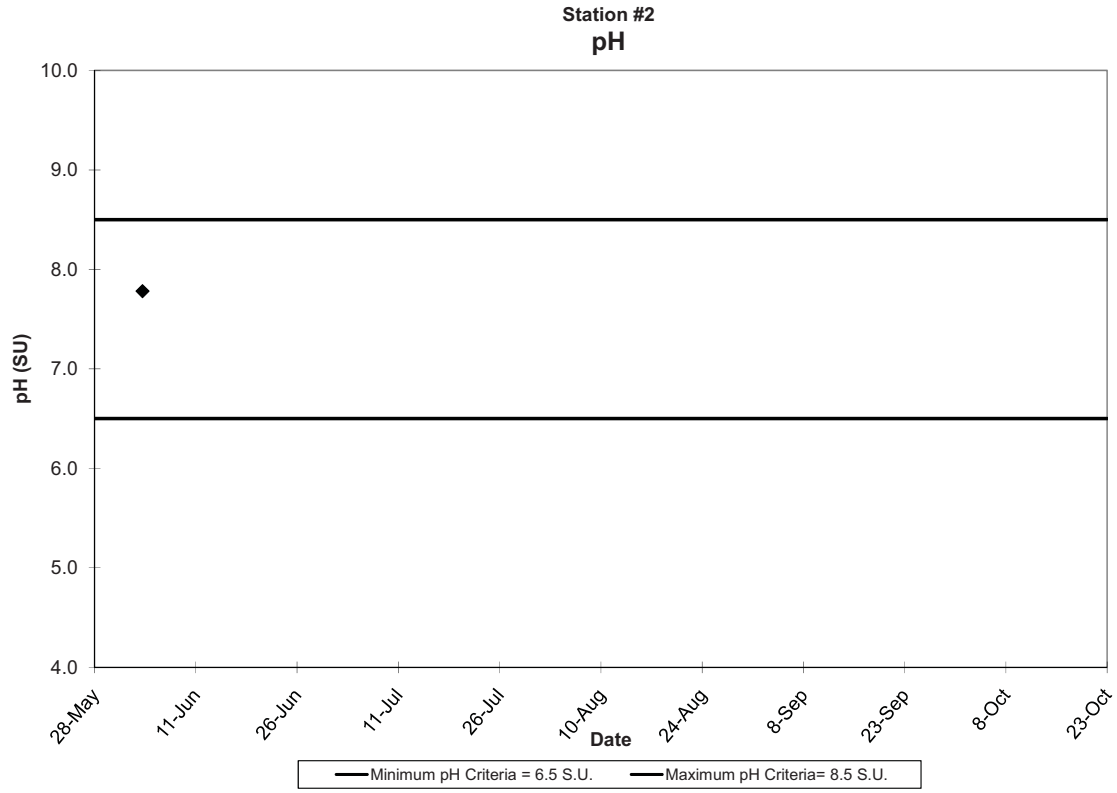

Station #8
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

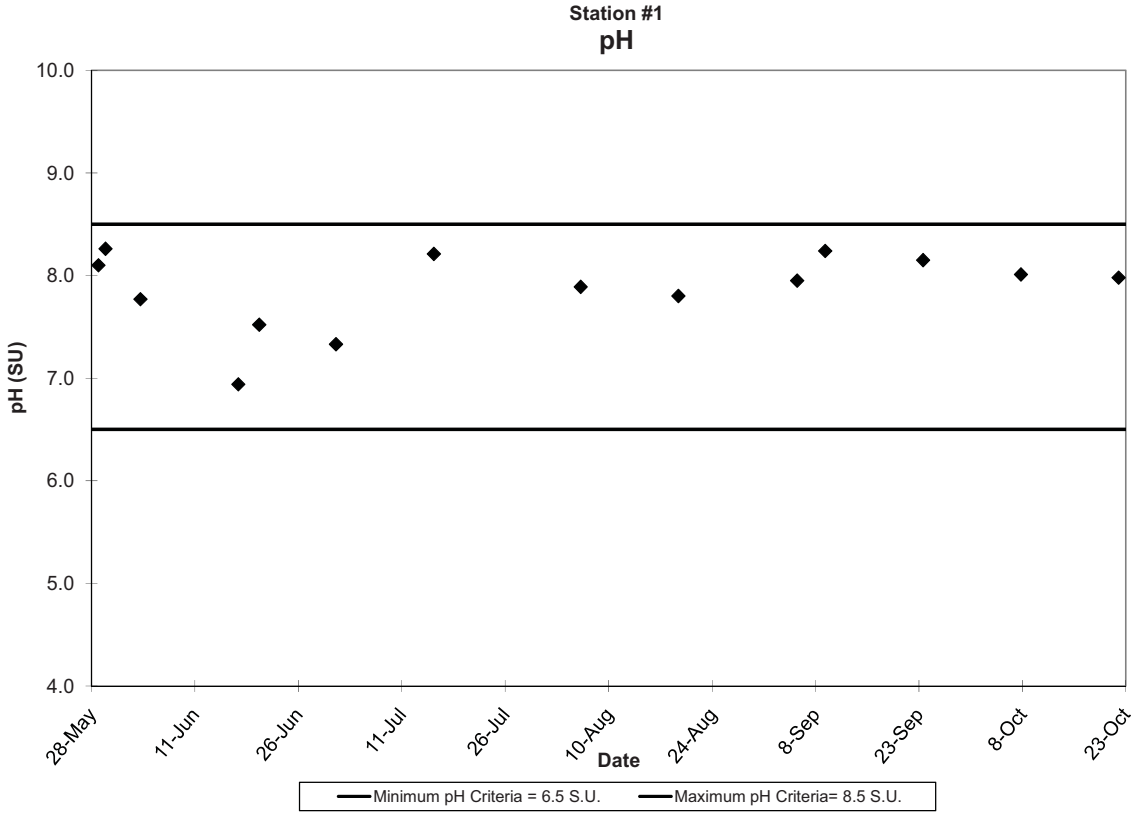

Station #5a
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

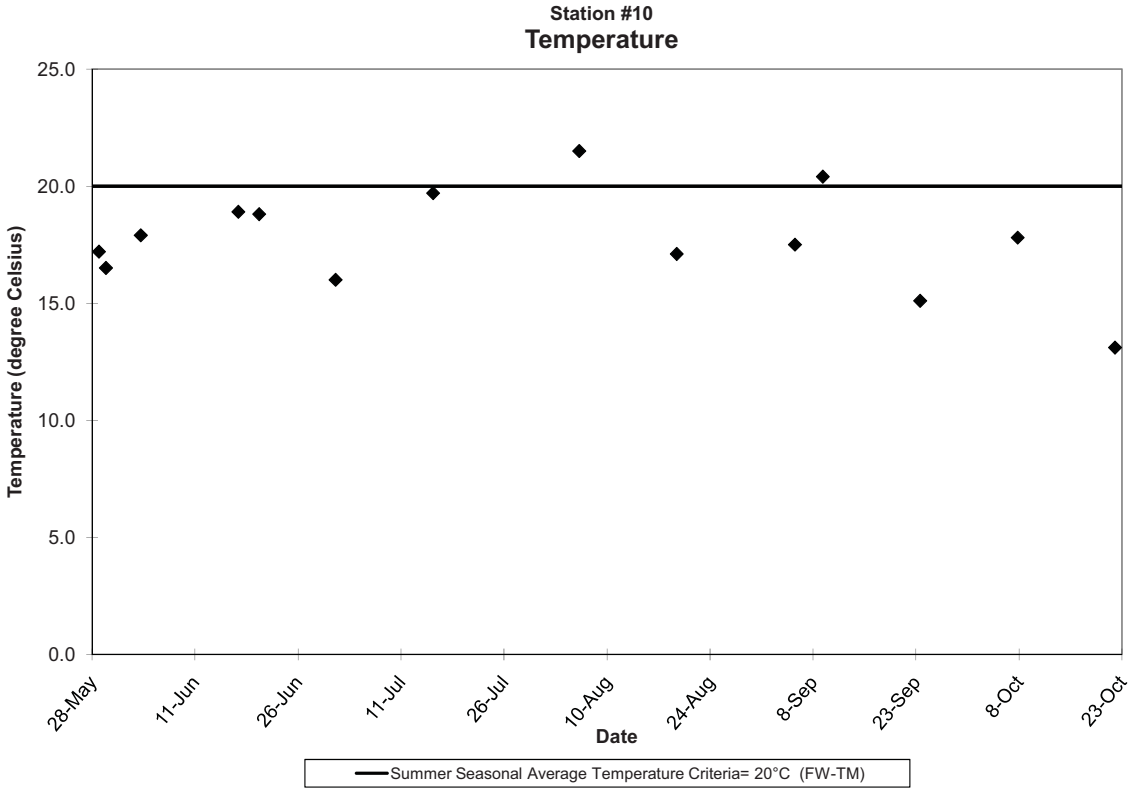

Station #6
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

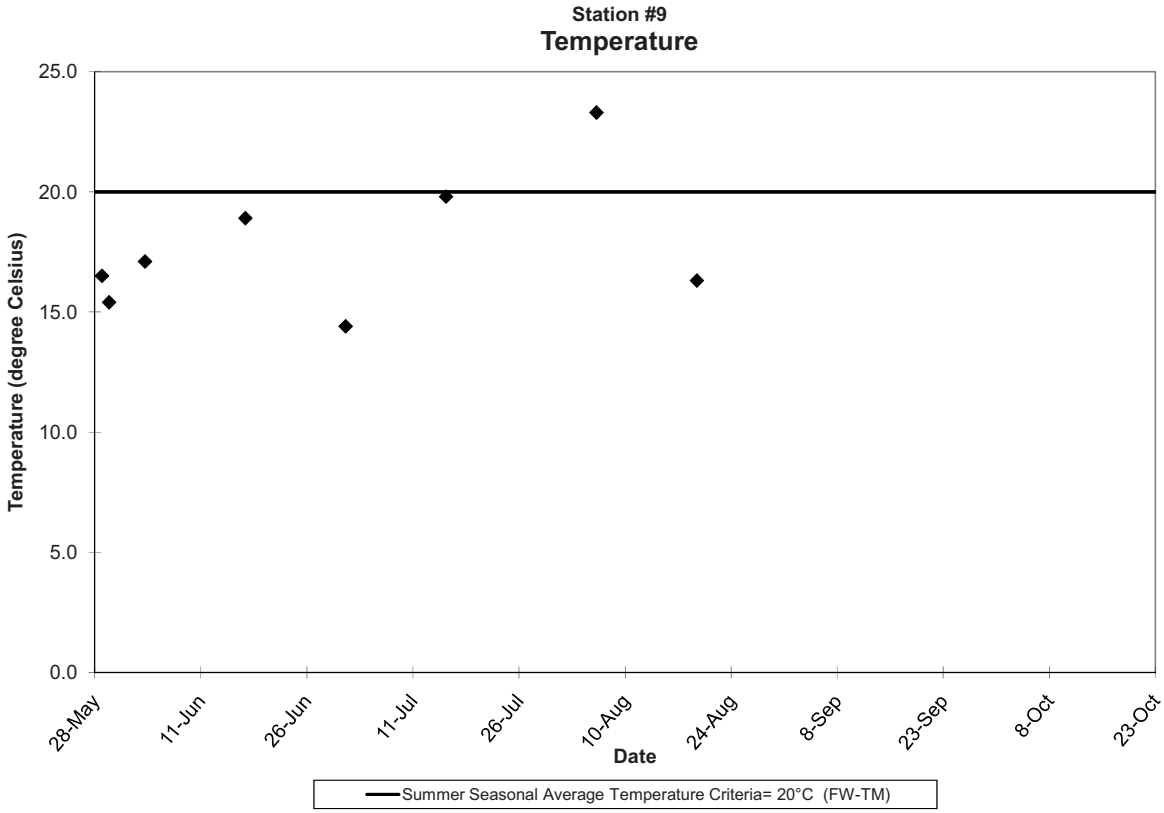

Station #11
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

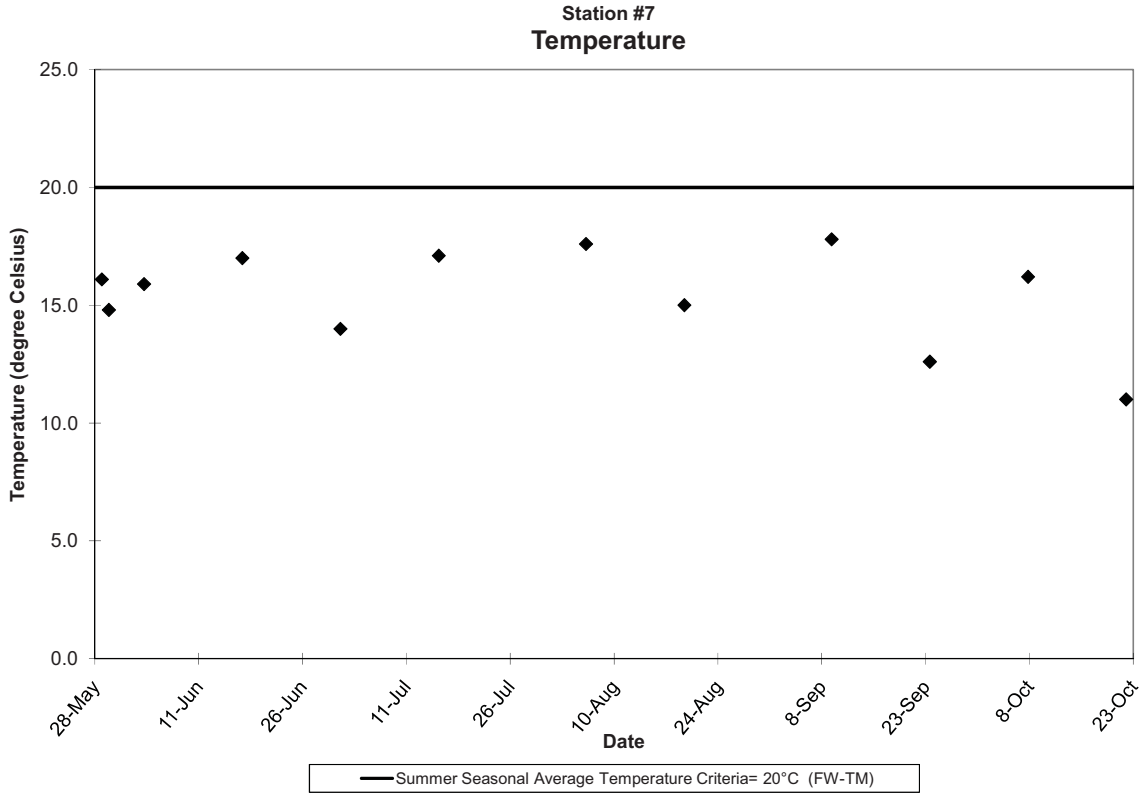

Station #4
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

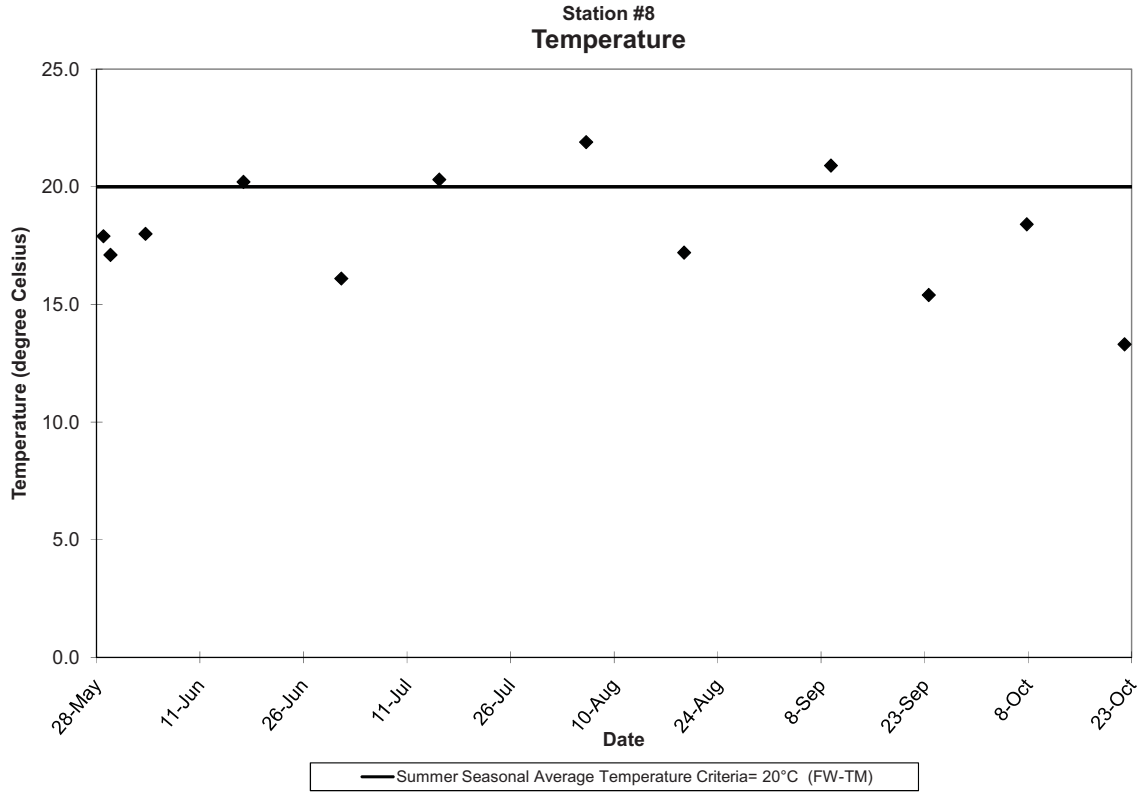

Station #2
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

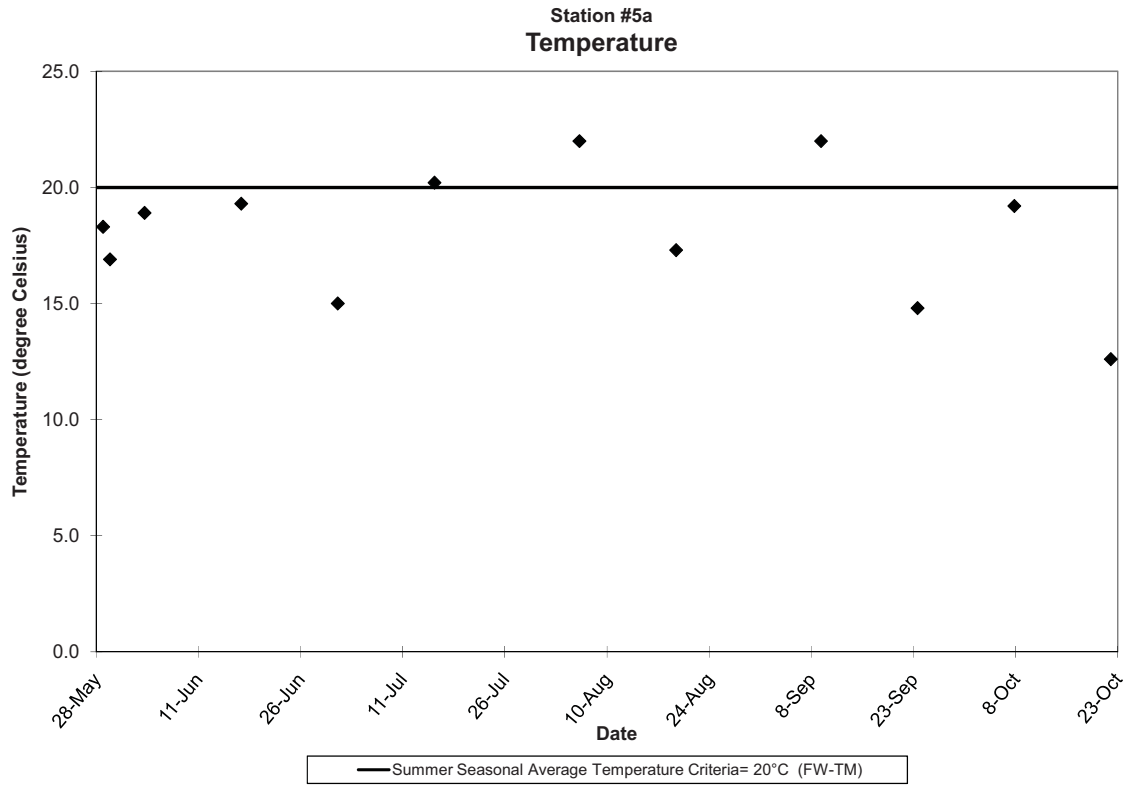

Station #1
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Minimum pH Criteria = 6.5 S.U.
Maximum pH Criteria= 8.5 S.U.

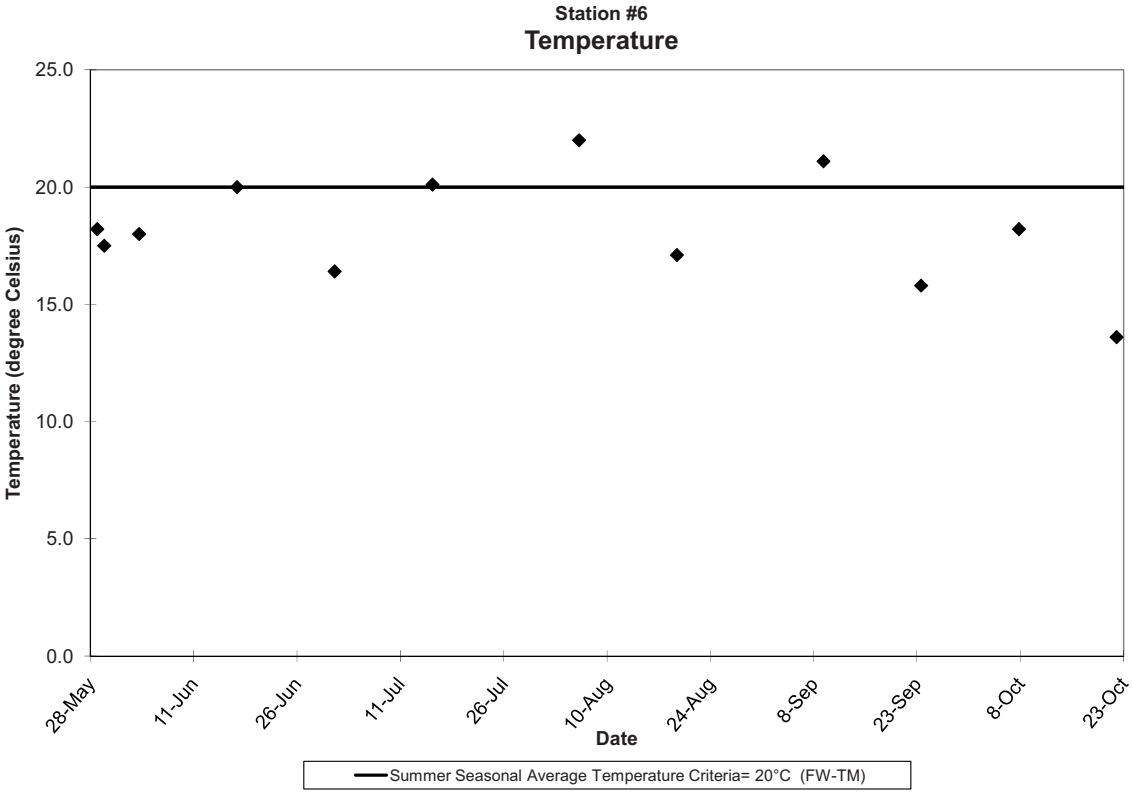

Station #10
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

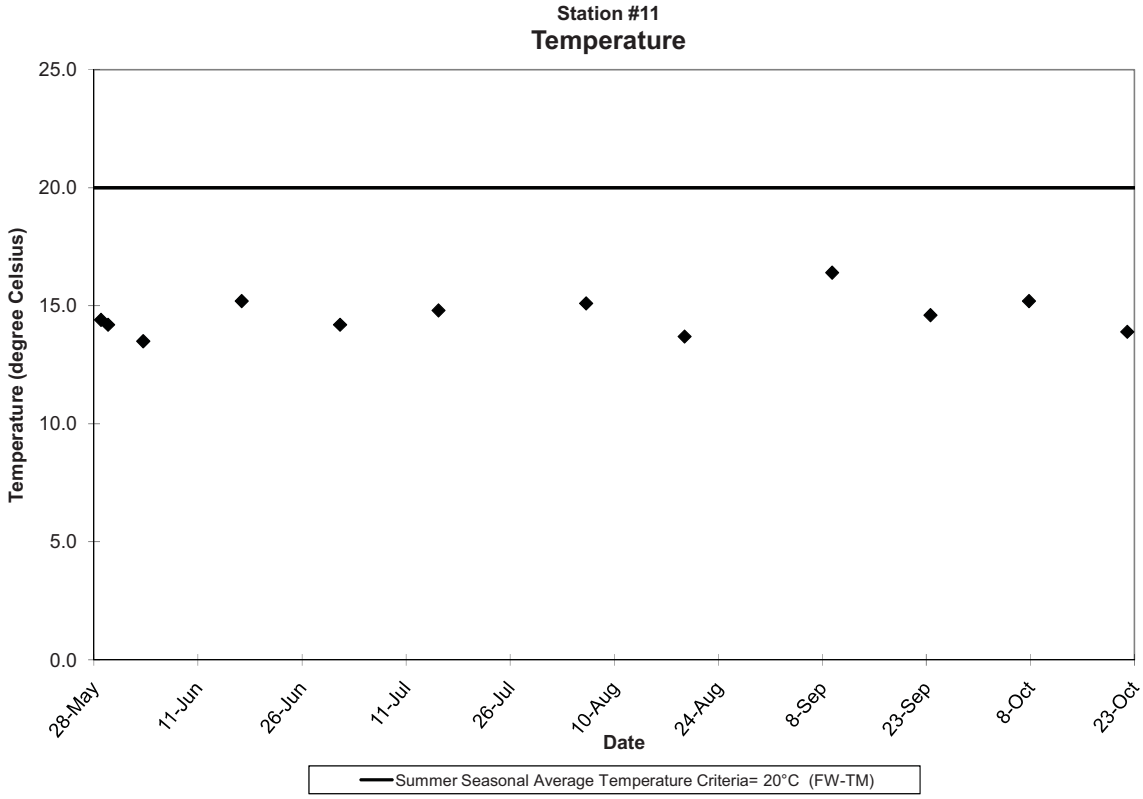

Station #9
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

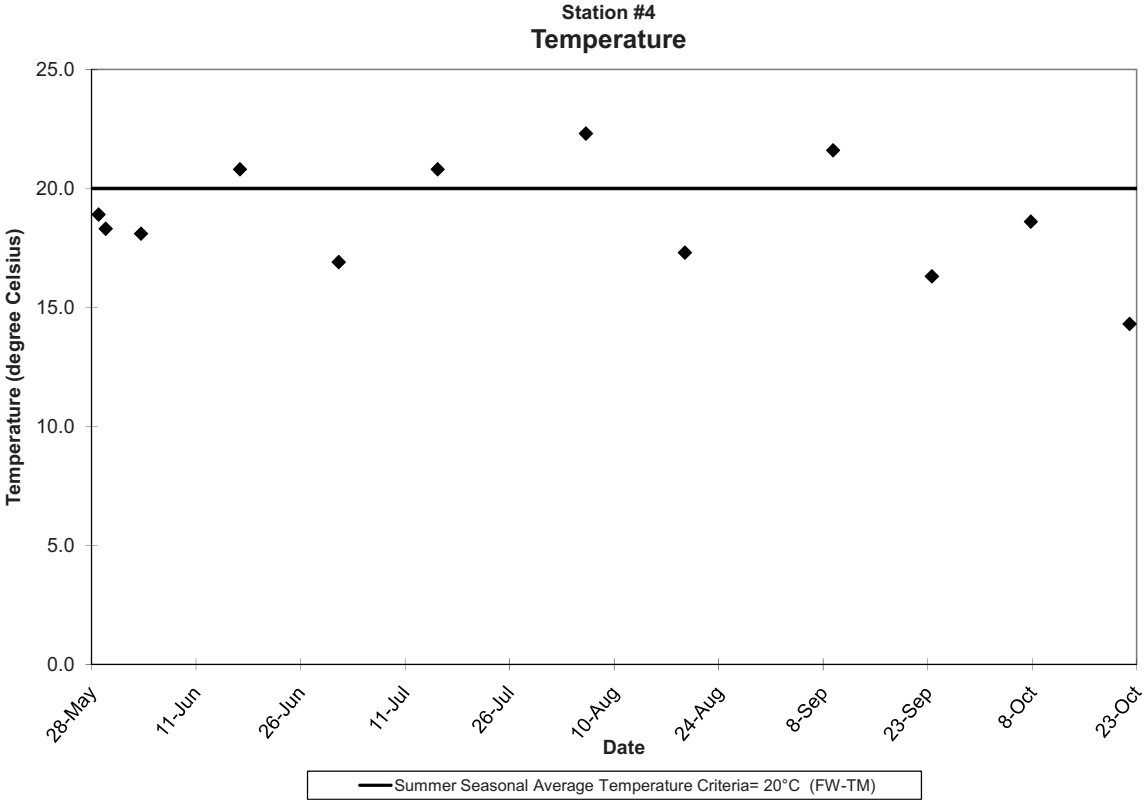

Station #7
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

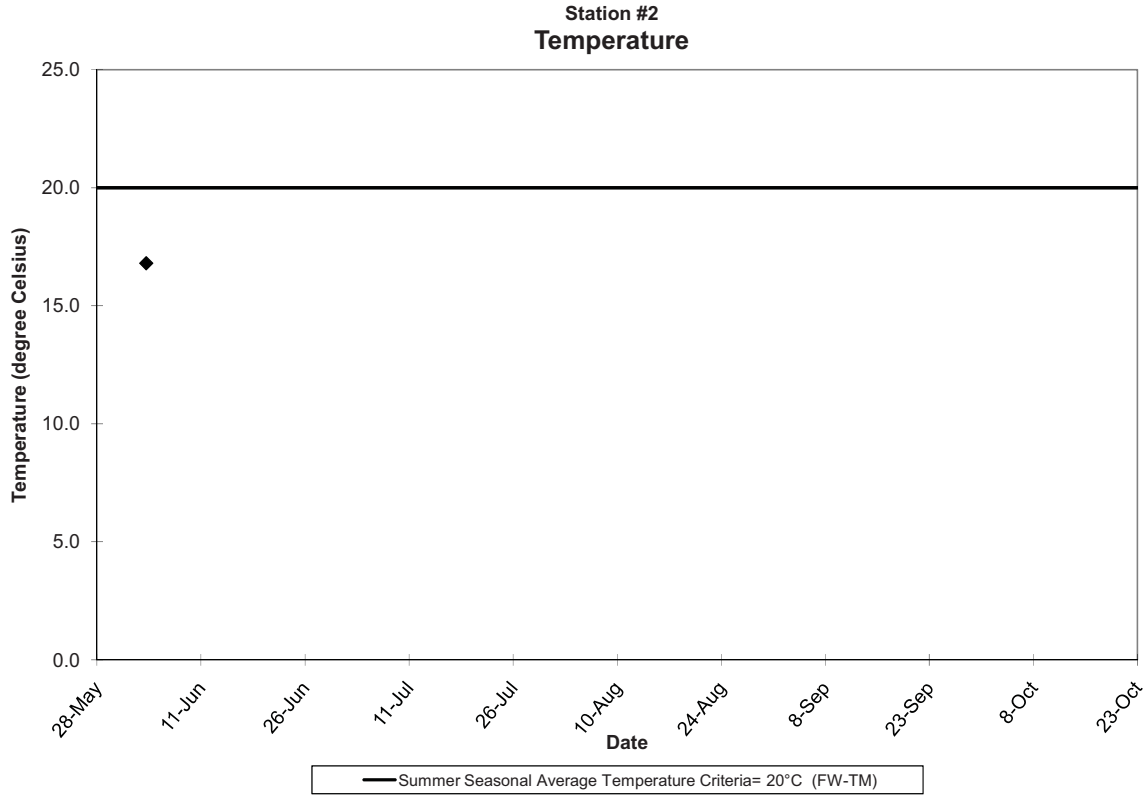

Station #8
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

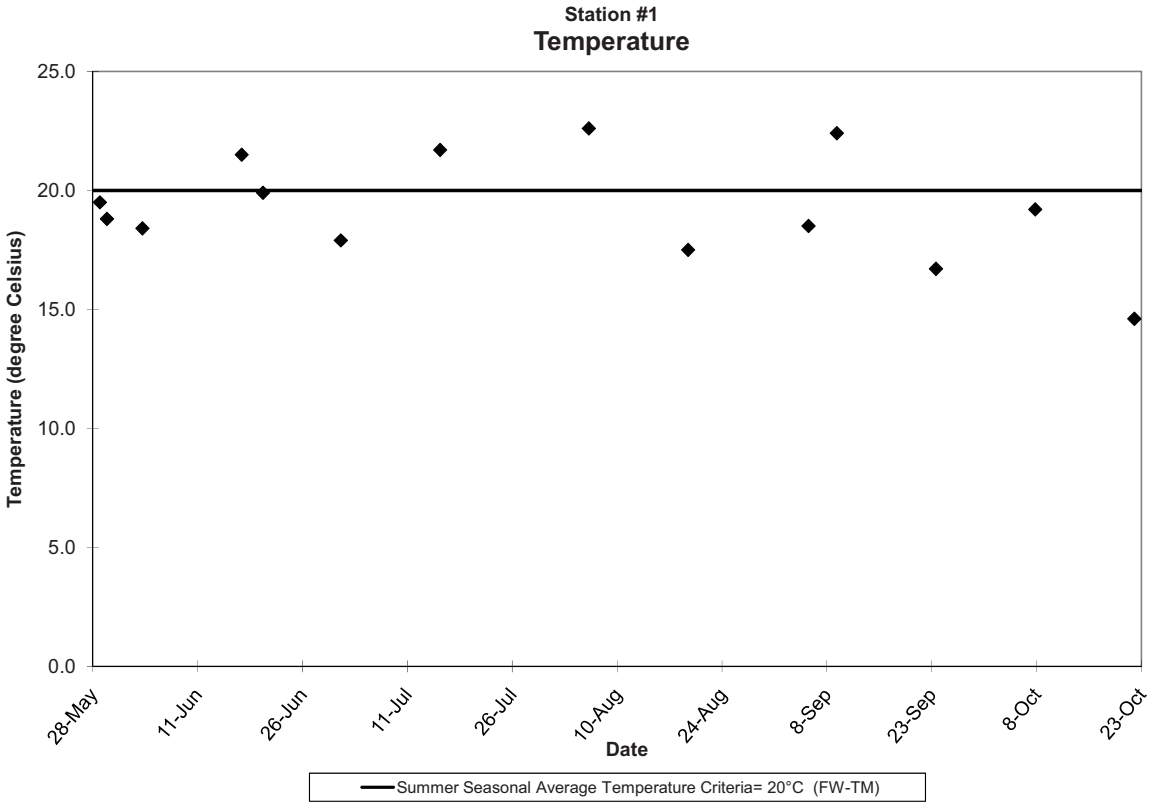

Station #5a
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

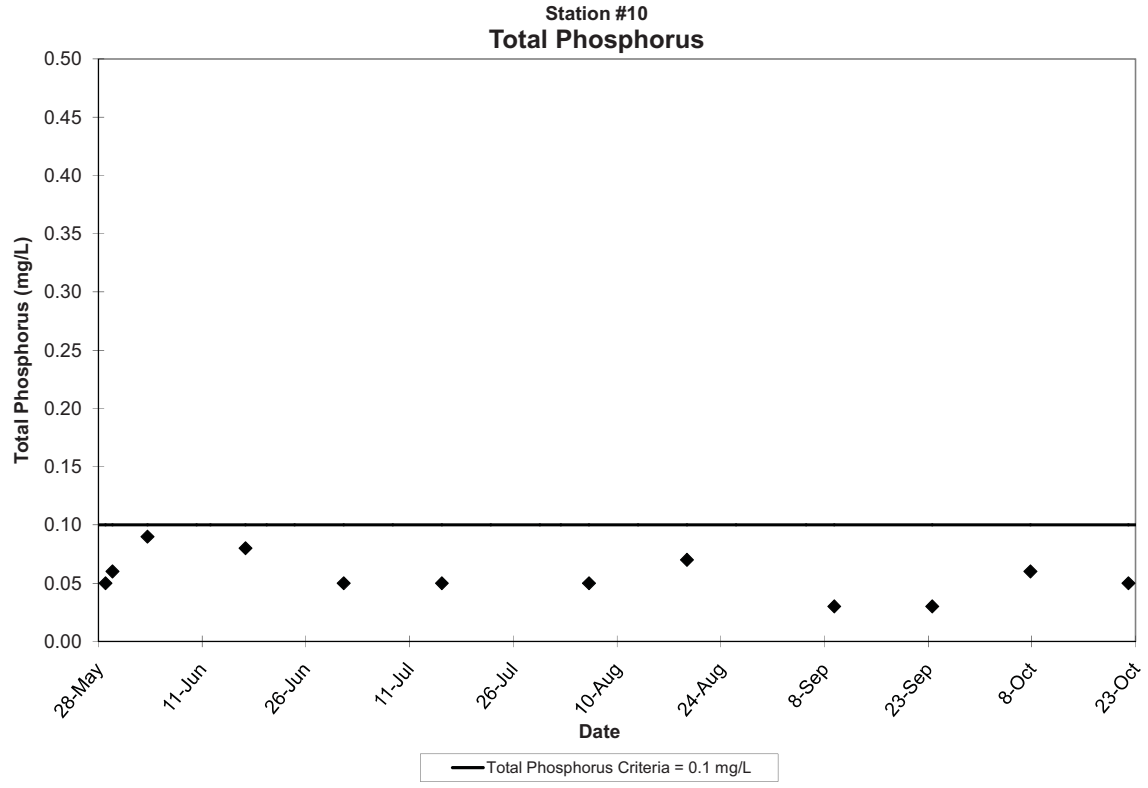

Station #6
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

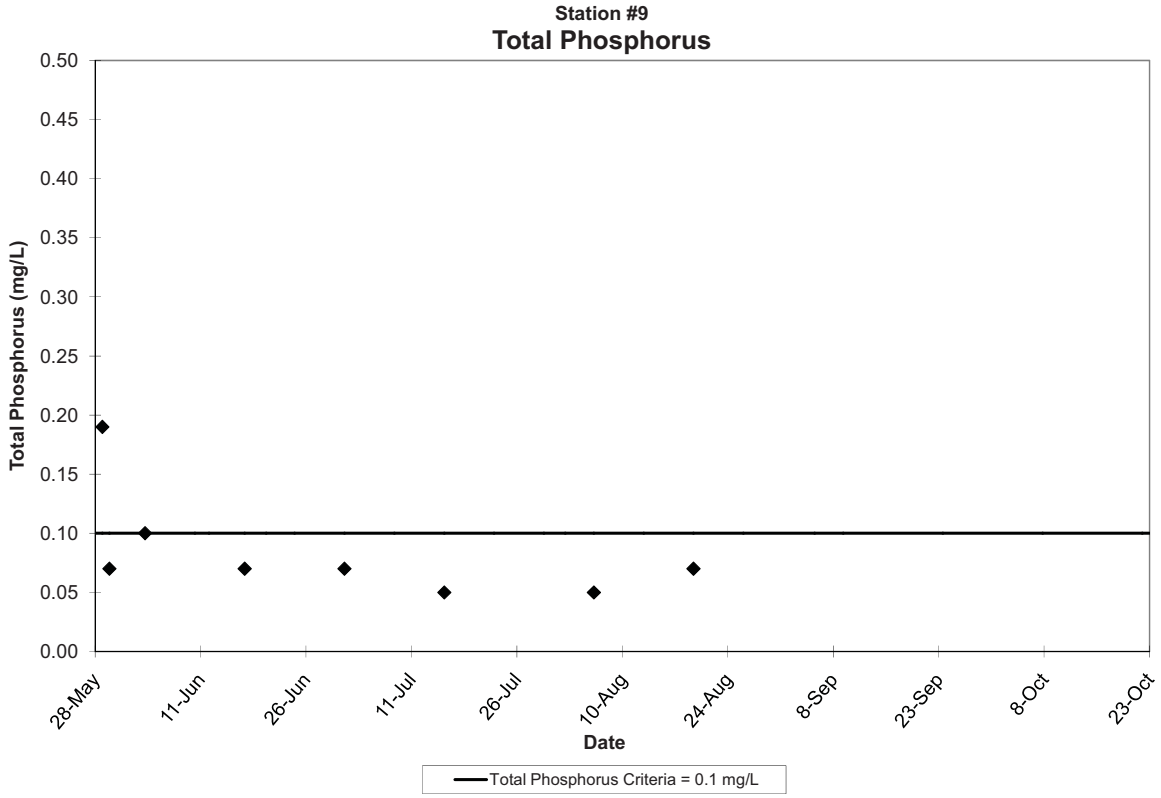

Station #11
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

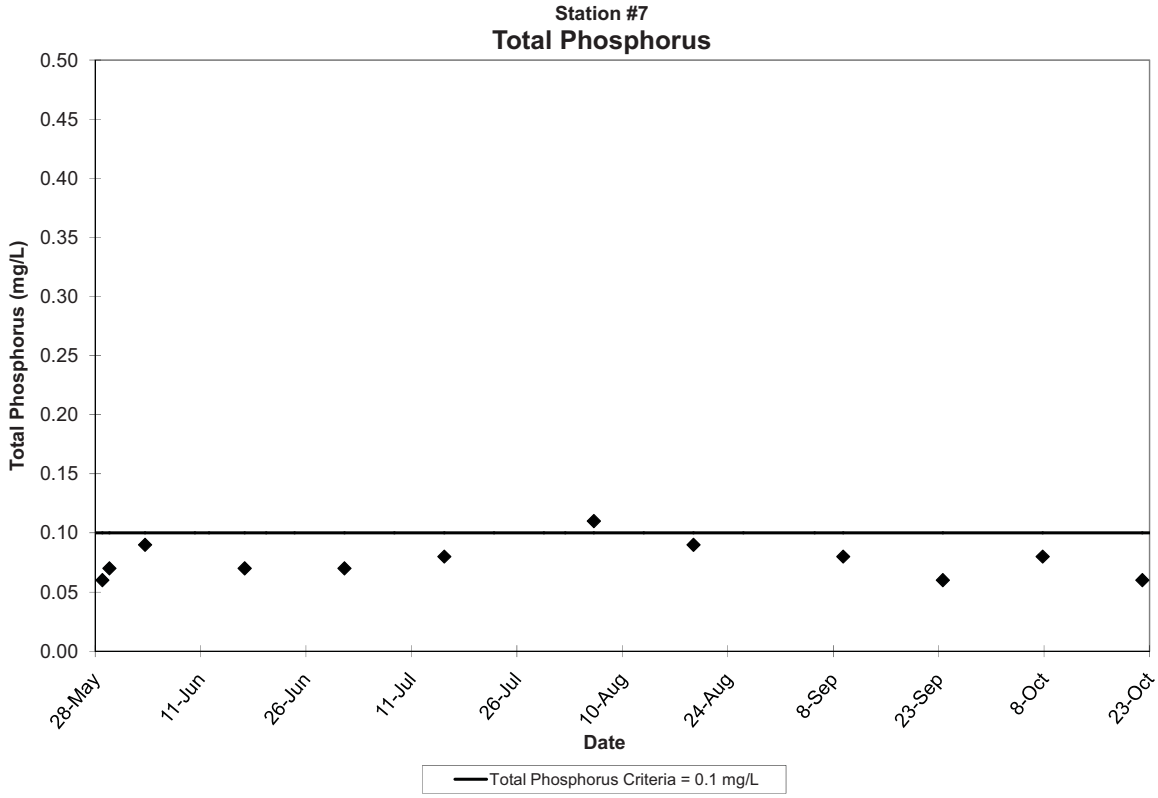

Station #4
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

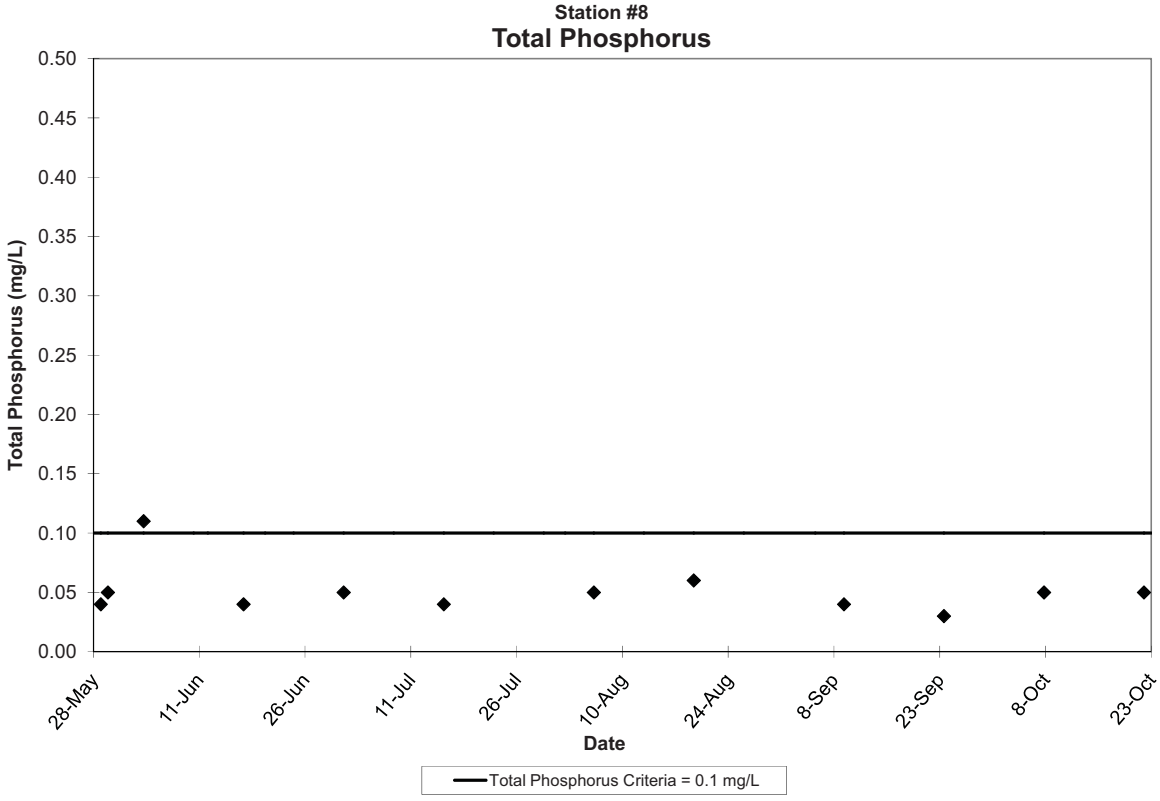

Station #2
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

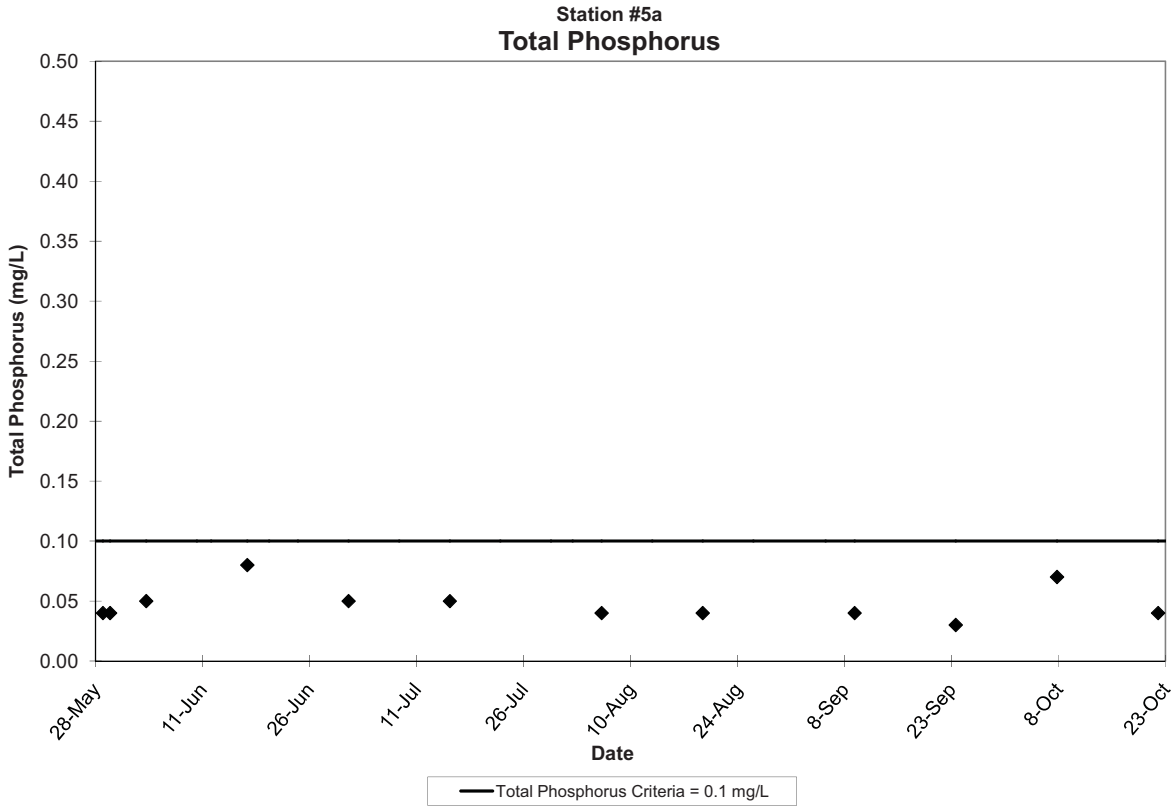

Station #1
Temperature
25.0
20.0
15.0
10.0
5.0
0.0
Temperature (degree Celsius)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Summer Seasonal Average Temperature Criteria= 20°C (FW-TM)

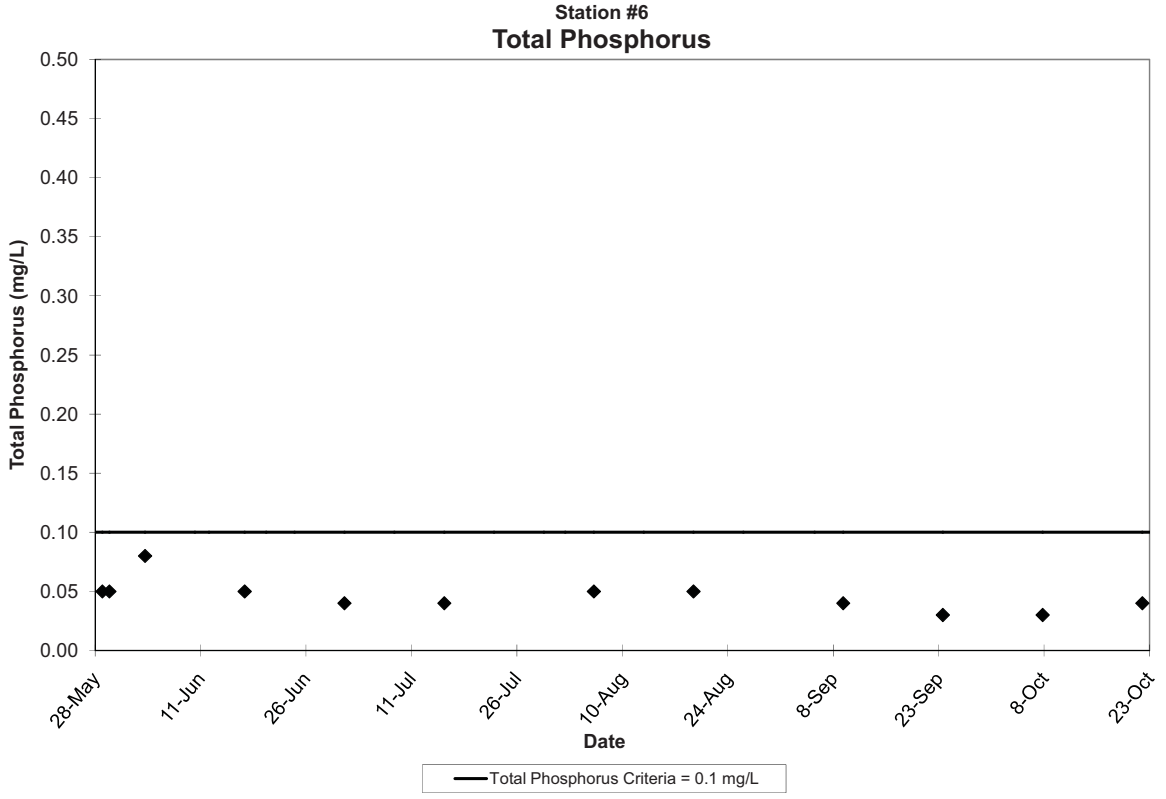

Station #10
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

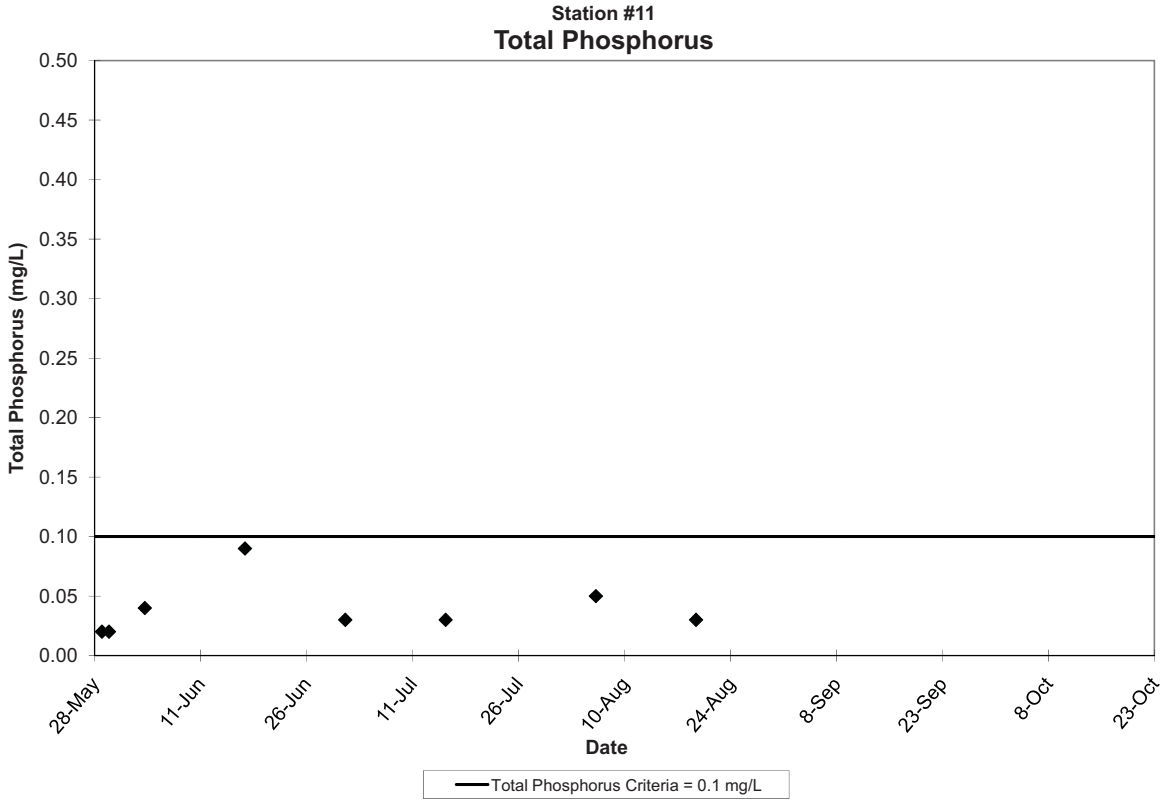

Station #9
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

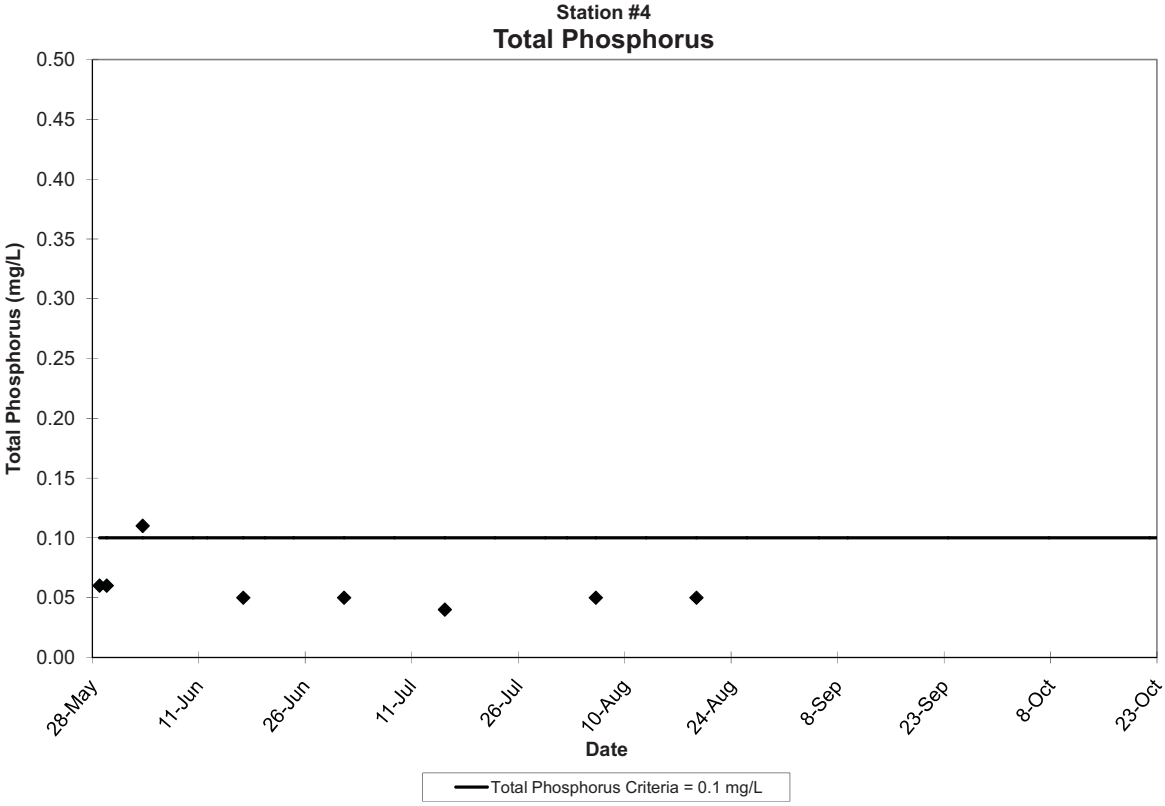

Station #7
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

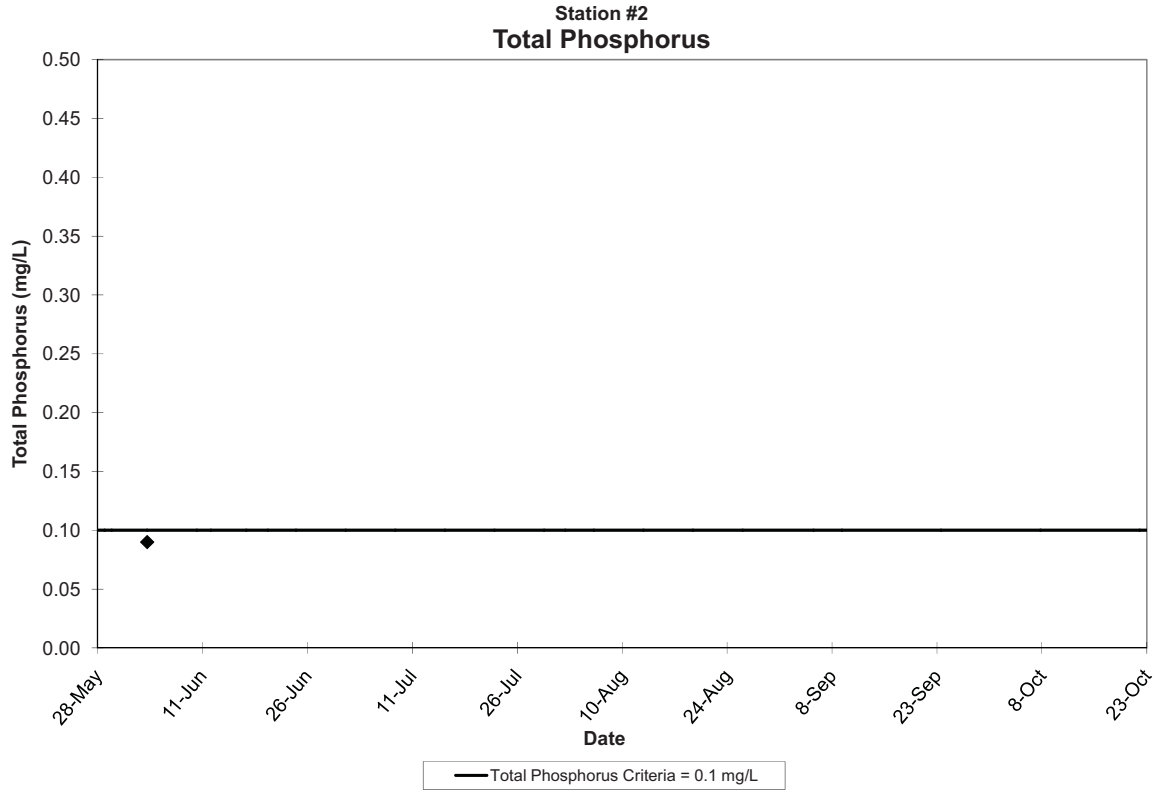

Station #8
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

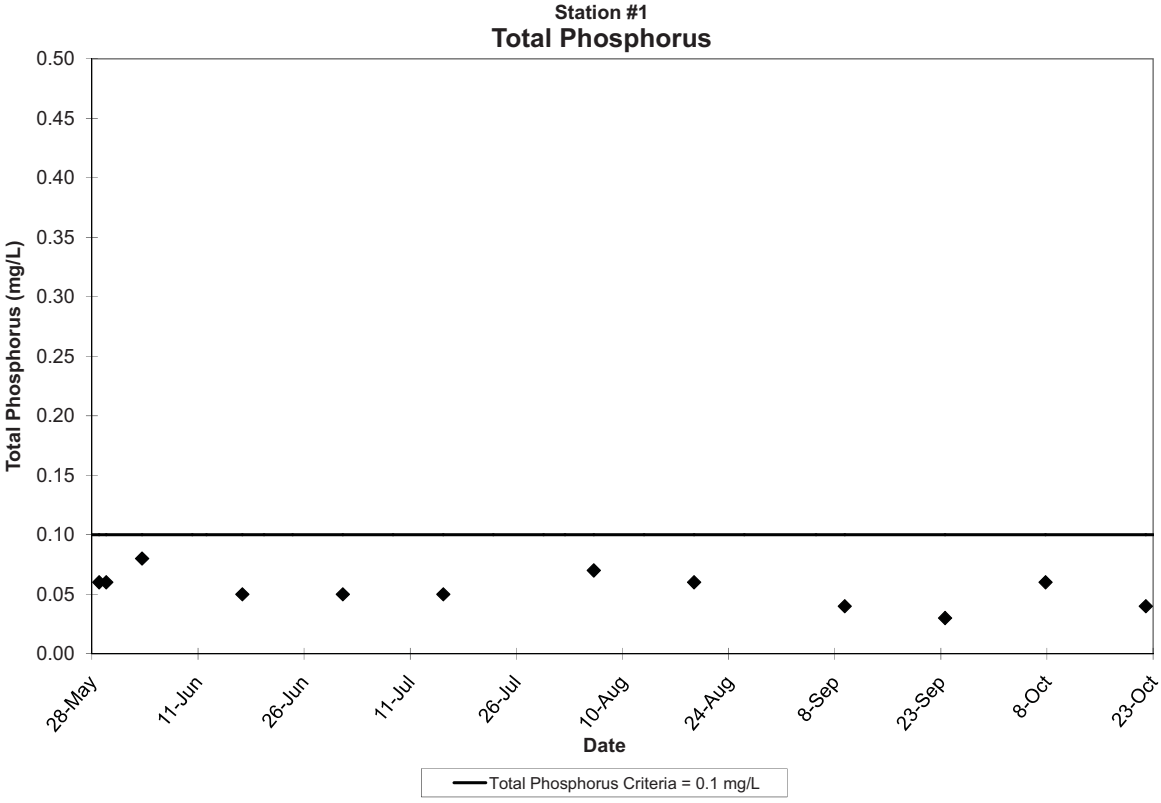

Station #5a
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

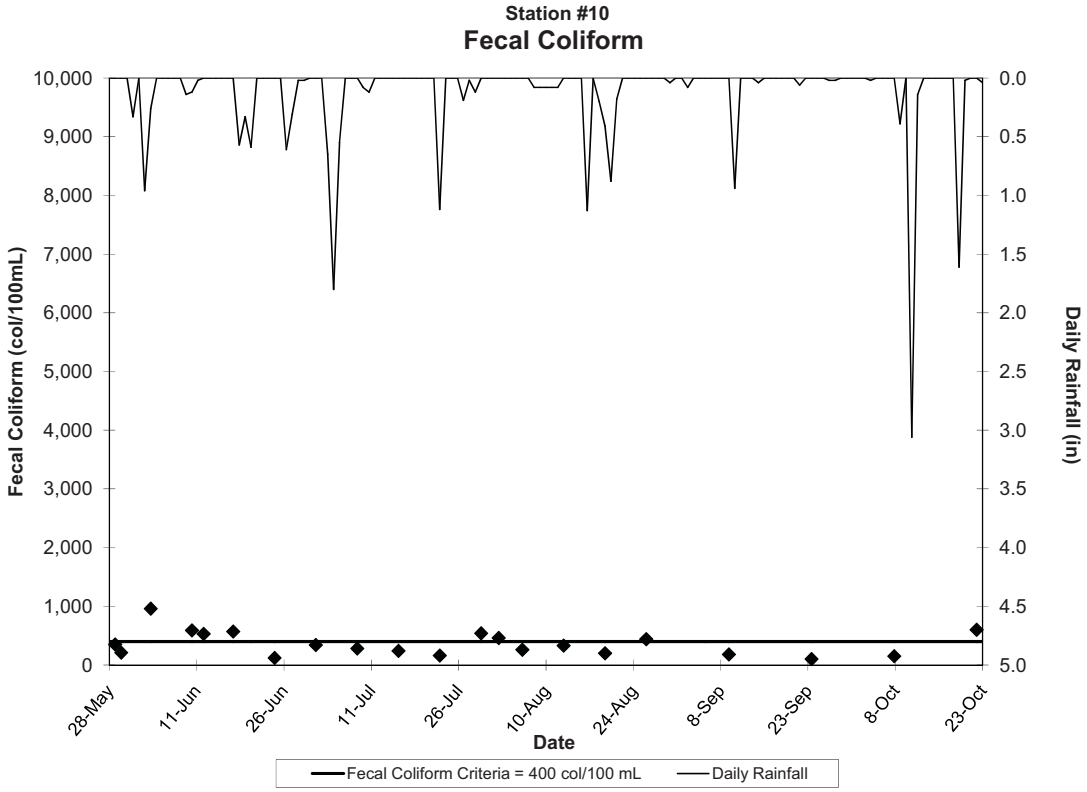

Station #6
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

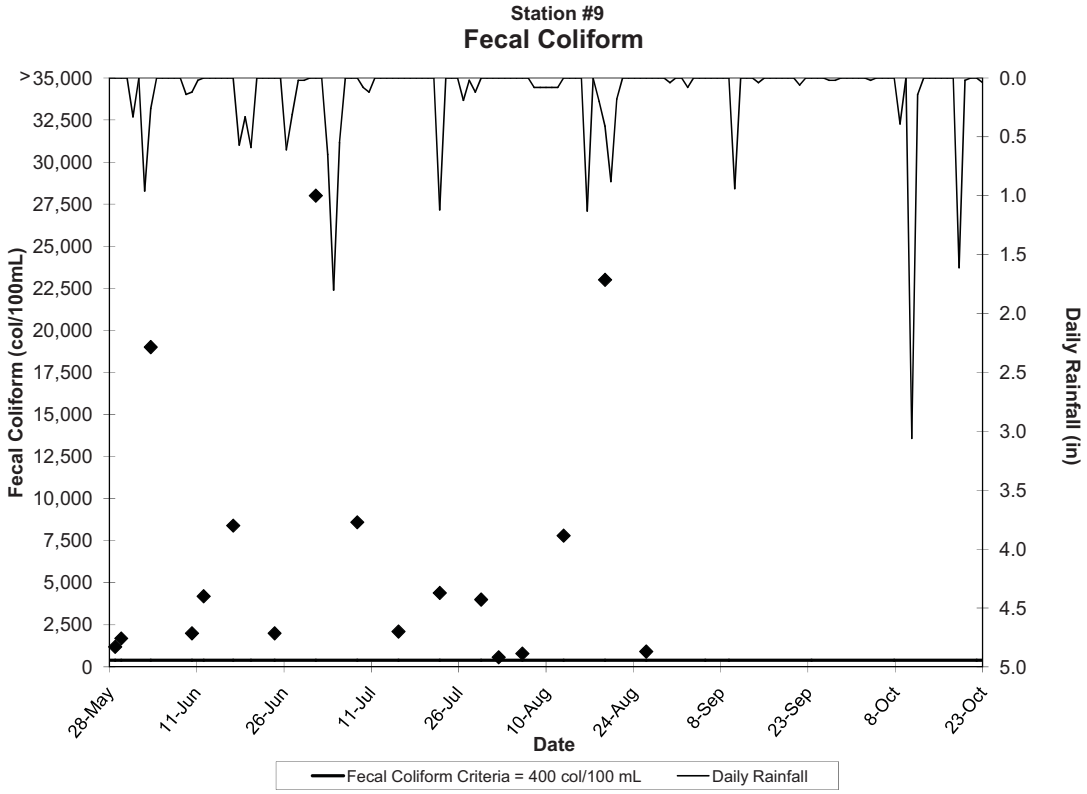

Station #11
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

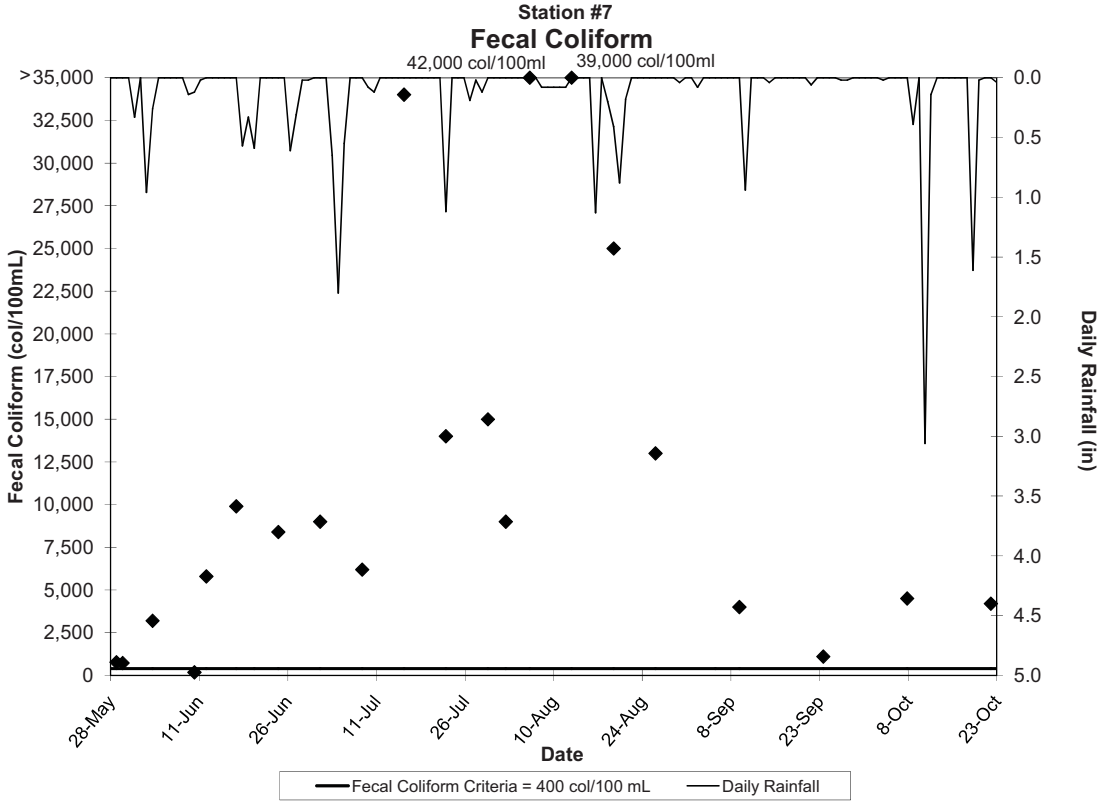

Station #4
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

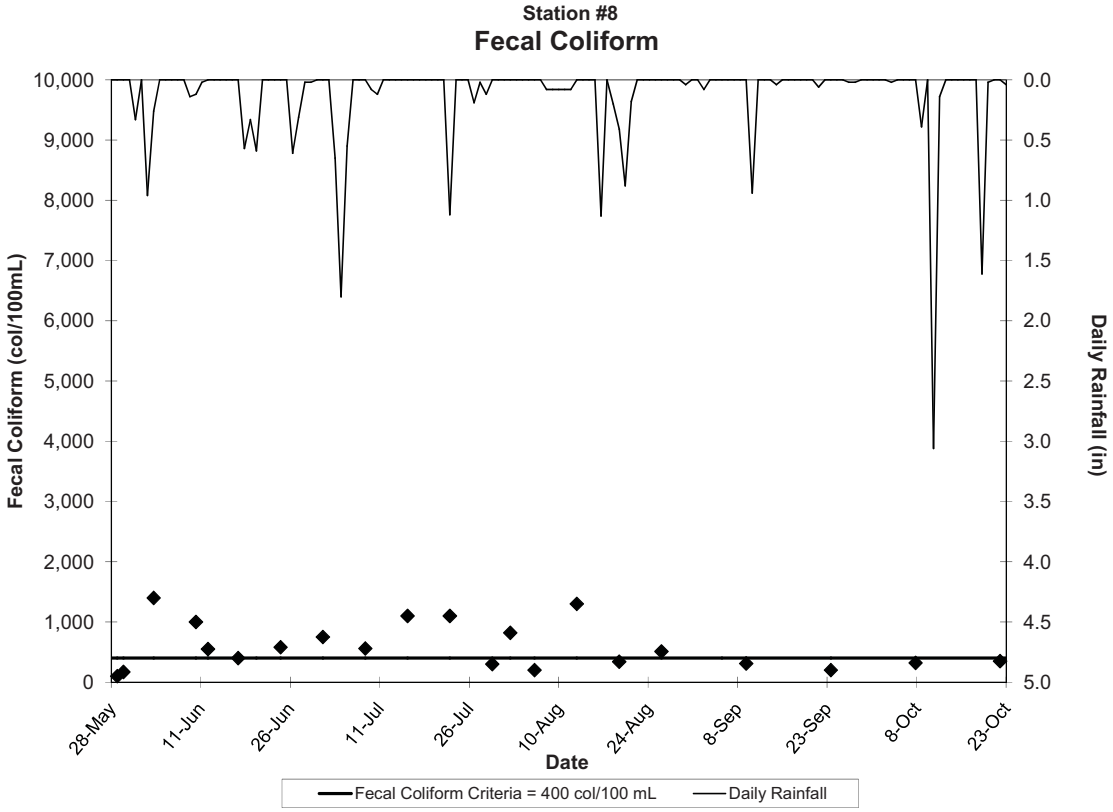

Station #2
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

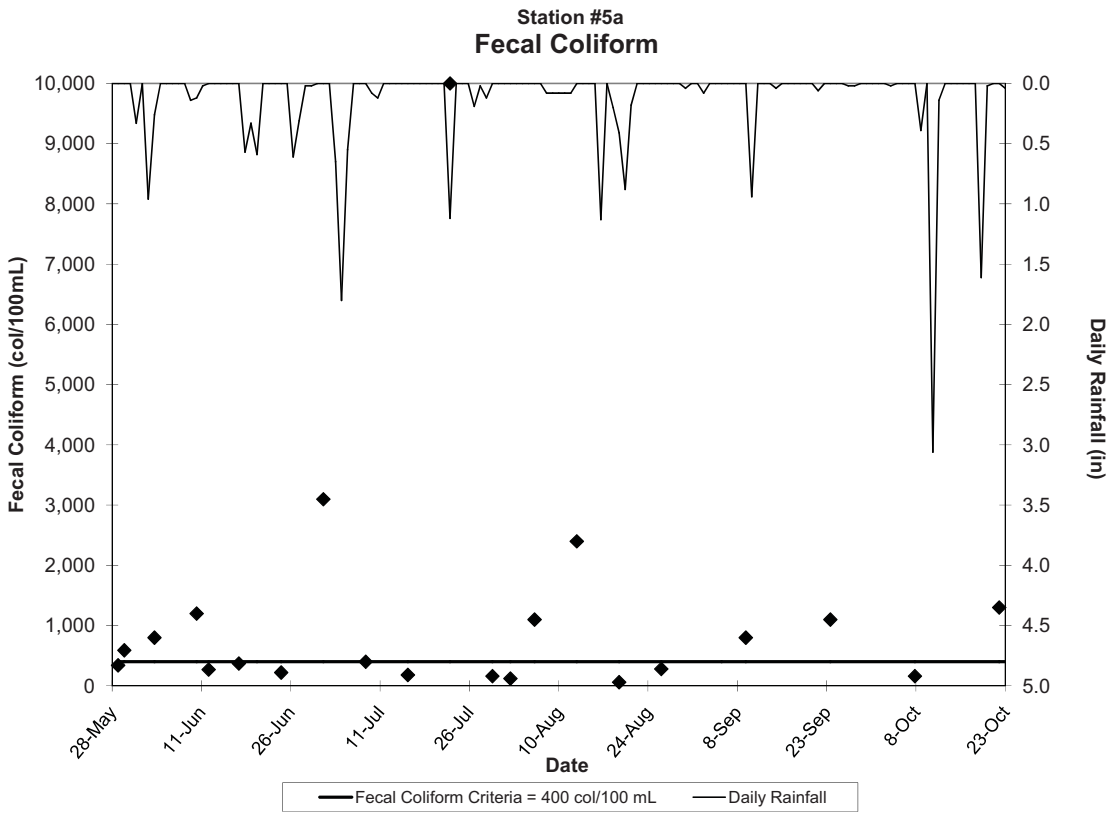

Station #1
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Total Phosphorus Criteria = 0.1 mg/L

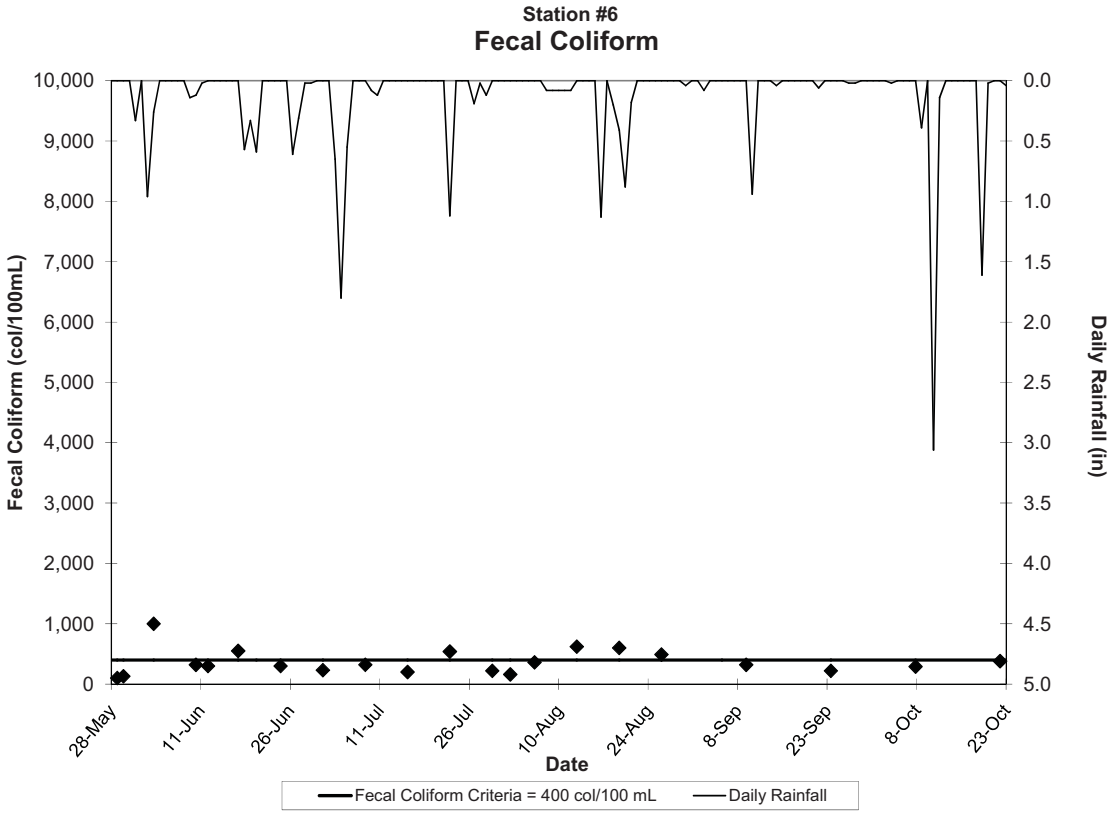

Station #10
Fecal Coliform
Fecal Coliform (col/100mL)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Daily Rainfall (in)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

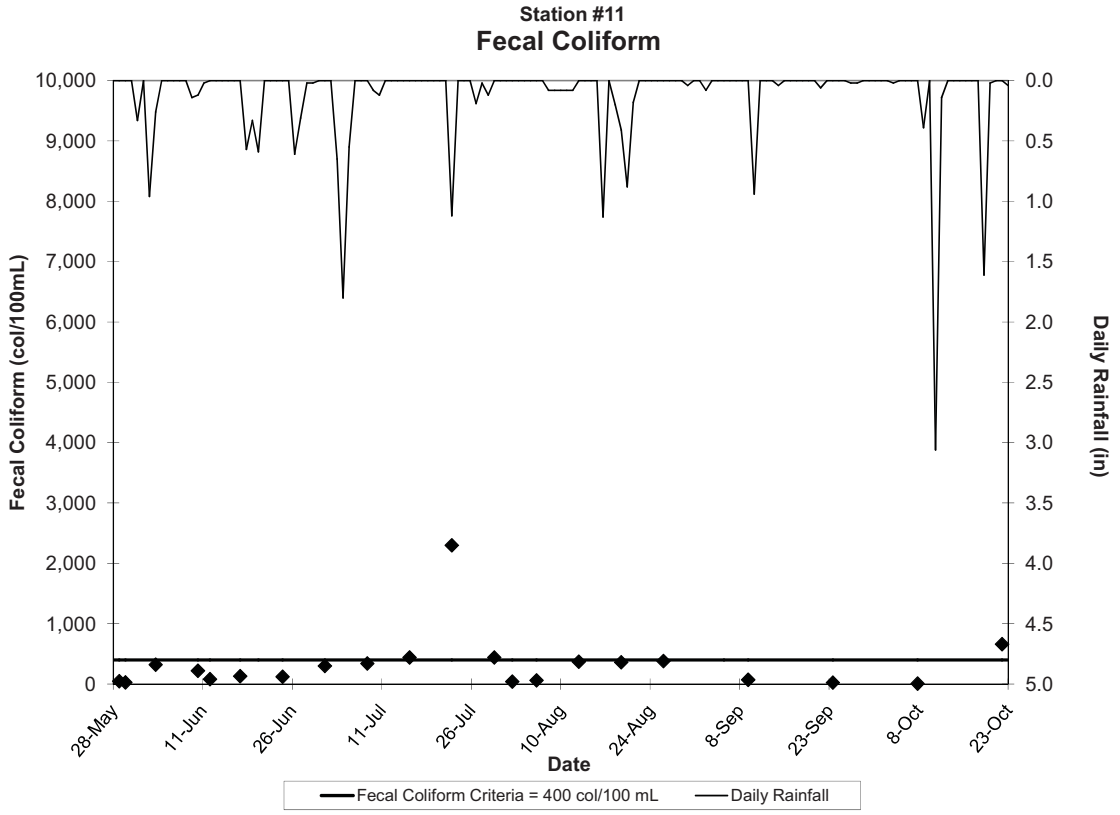

Station #9
Fecal Coliform
Fecal Coliform (col/100mL)
>35,000
32,500
30,000
27,500
25,000
22,500
20,000
17,500
15,000
12,500
10,000
7,500
5,000
2,500
0
Daily Rainfall (in)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

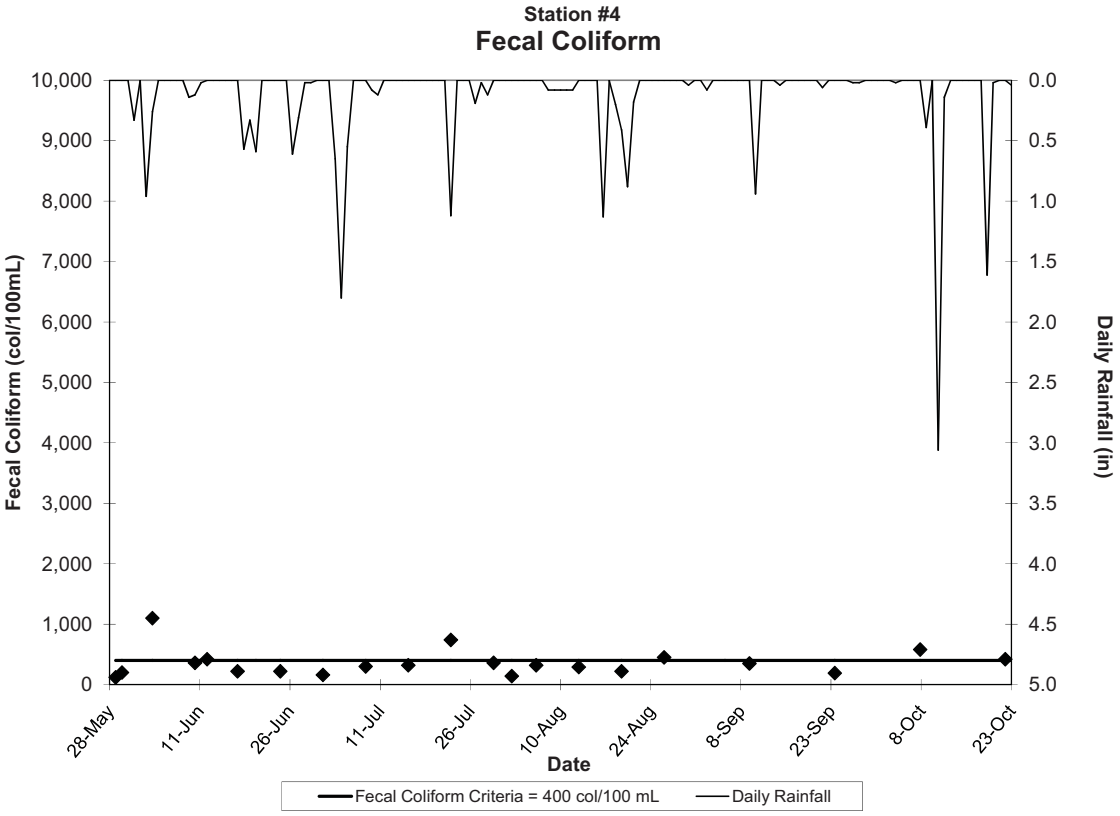

Station #7
Fecal Coliform
42,000 col/100ml
39,000 col/100ml
>35,000
32,500
30,000
27,500
25,000
22,500
20,000
17,500
15,000
12,500
10,000
7,500
5,000
2,500
0
Fecal Coliform (col/100mL)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Daily Rainfall (in)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

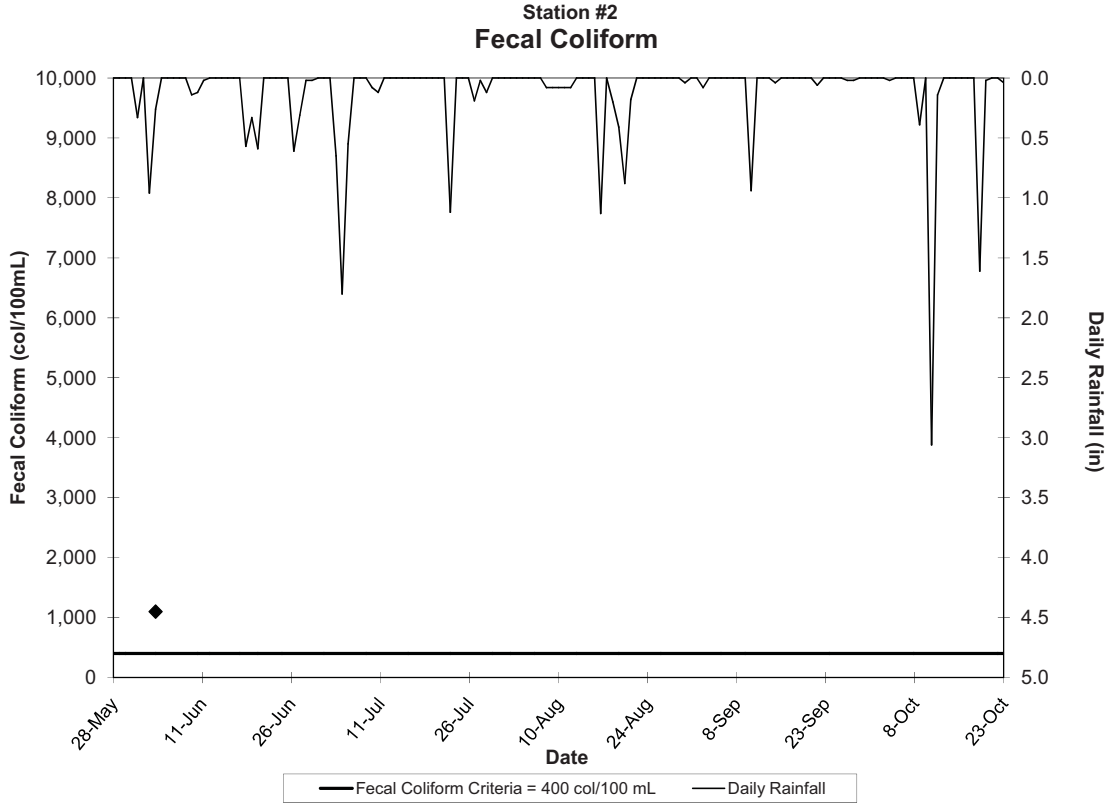

Station #8
Fecal Coliform
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Fecal Coliform (col/100mL)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Daily Rainfall (in)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

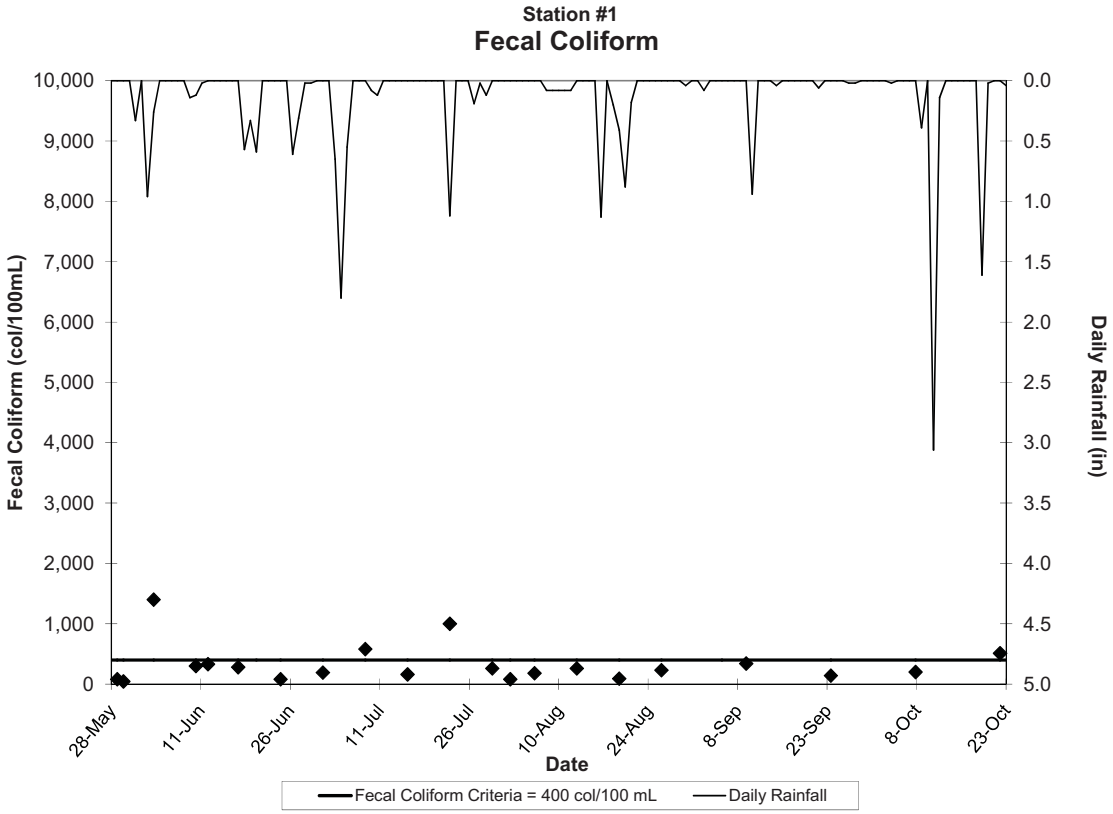

Station #5a
Fecal Coliform
Fecal Coliform (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

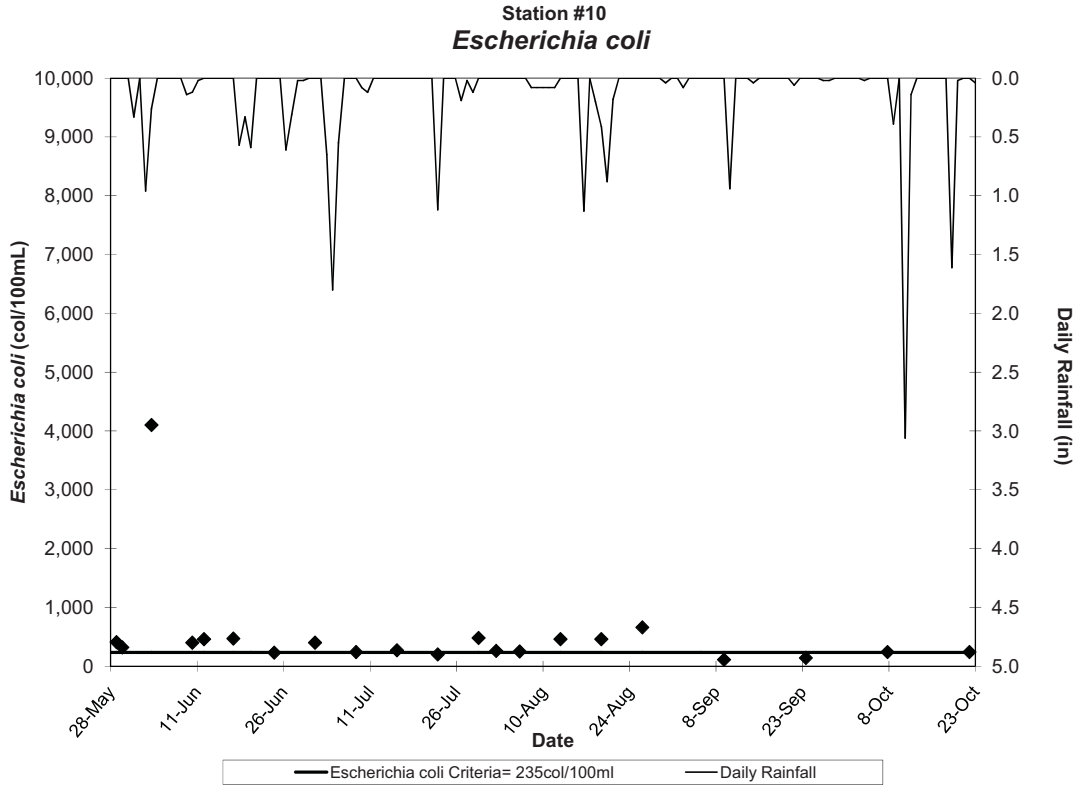

Station #6
Fecal Coliform
Fecal Coliform (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

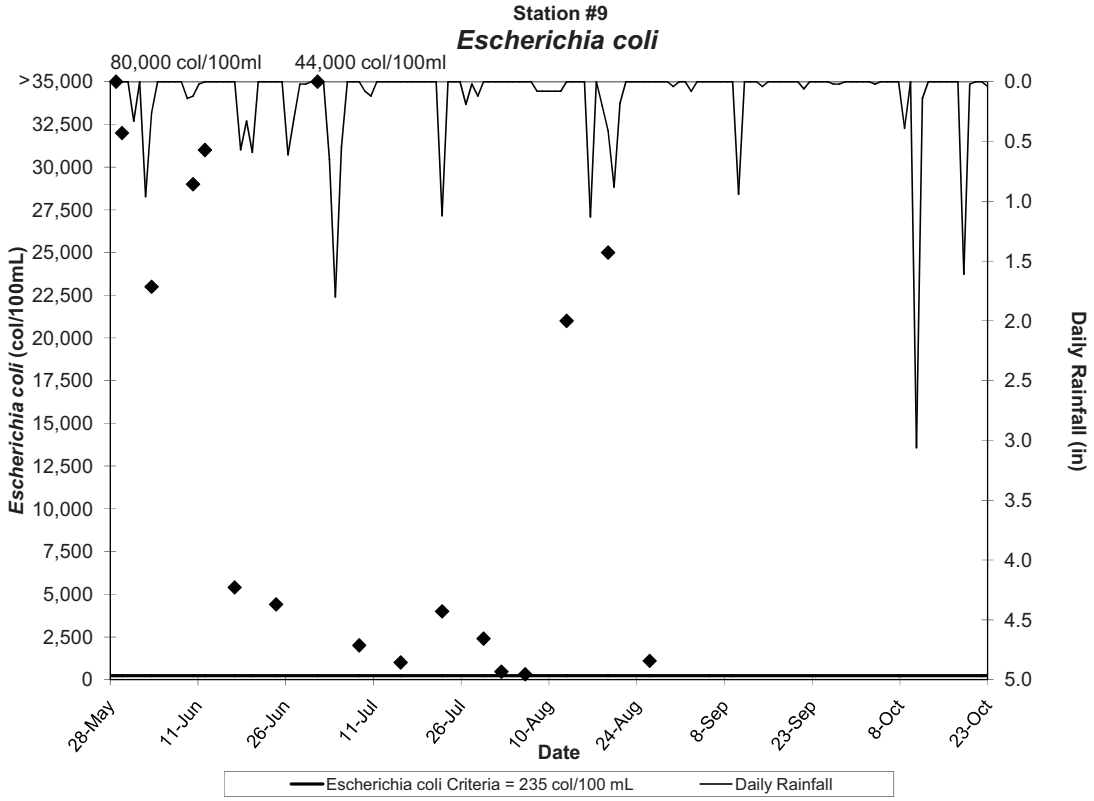

Station #11
Fecal Coliform
Fecal Coliform (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

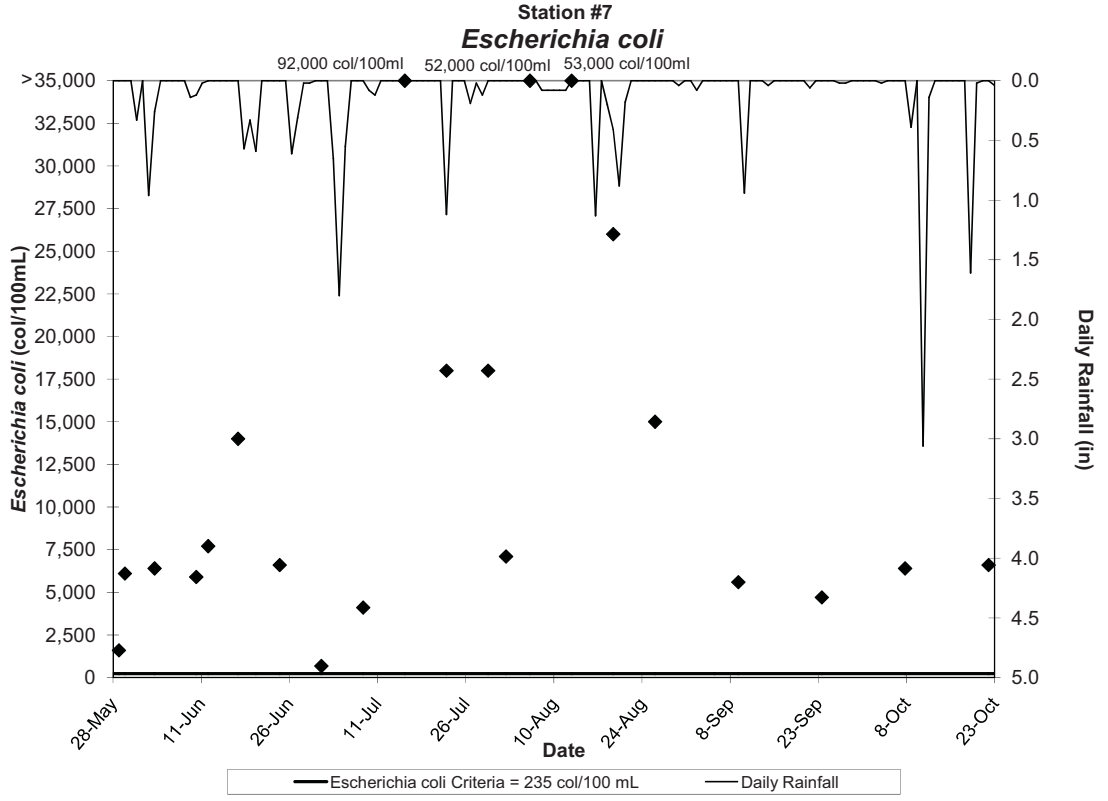

Station #4
Fecal Coliform
Fecal Coliform (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

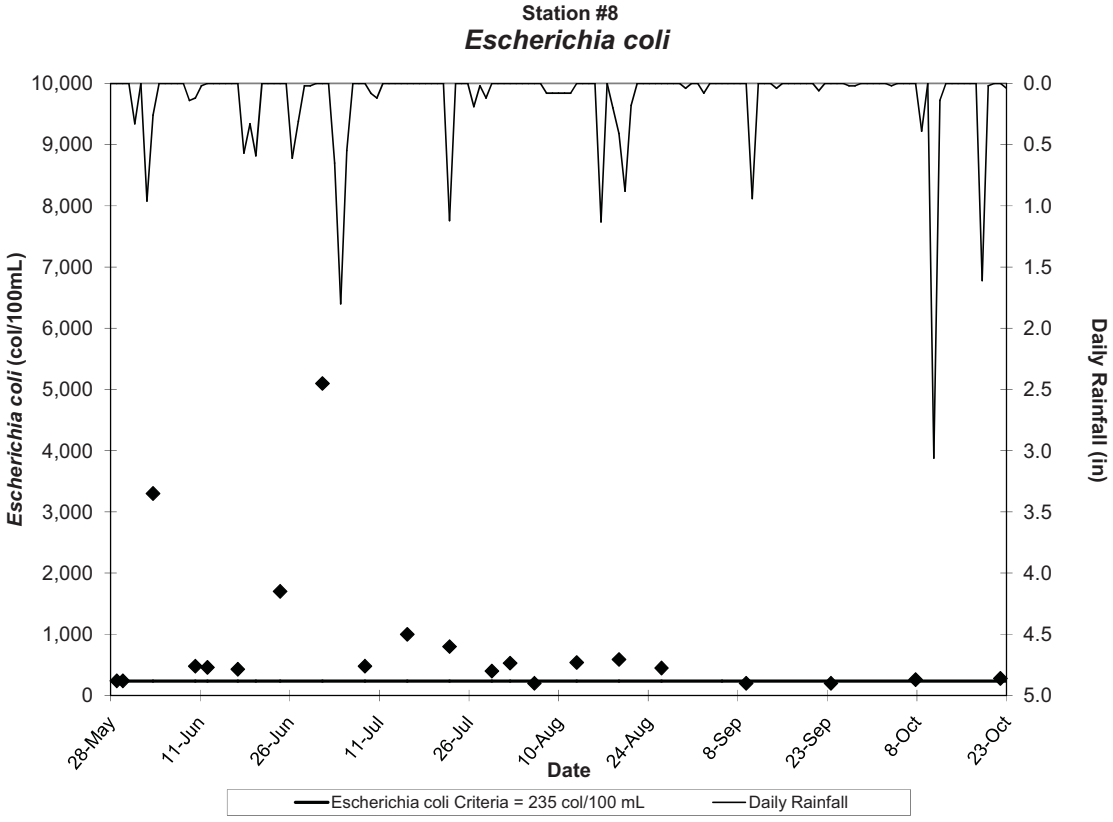

Station #2
Fecal Coliform
Fecal Coliform (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

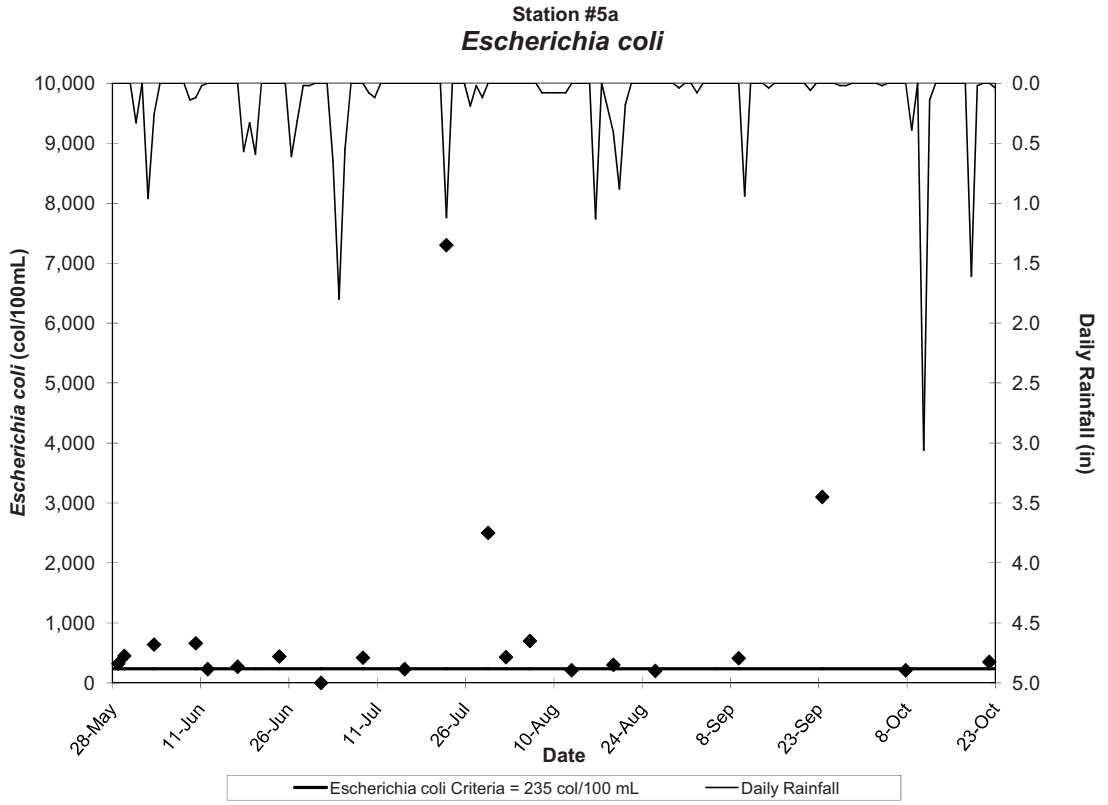

Station #1
Fecal Coliform
Fecal Coliform (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Fecal Coliform Criteria = 400 col/100 mL
Daily Rainfall

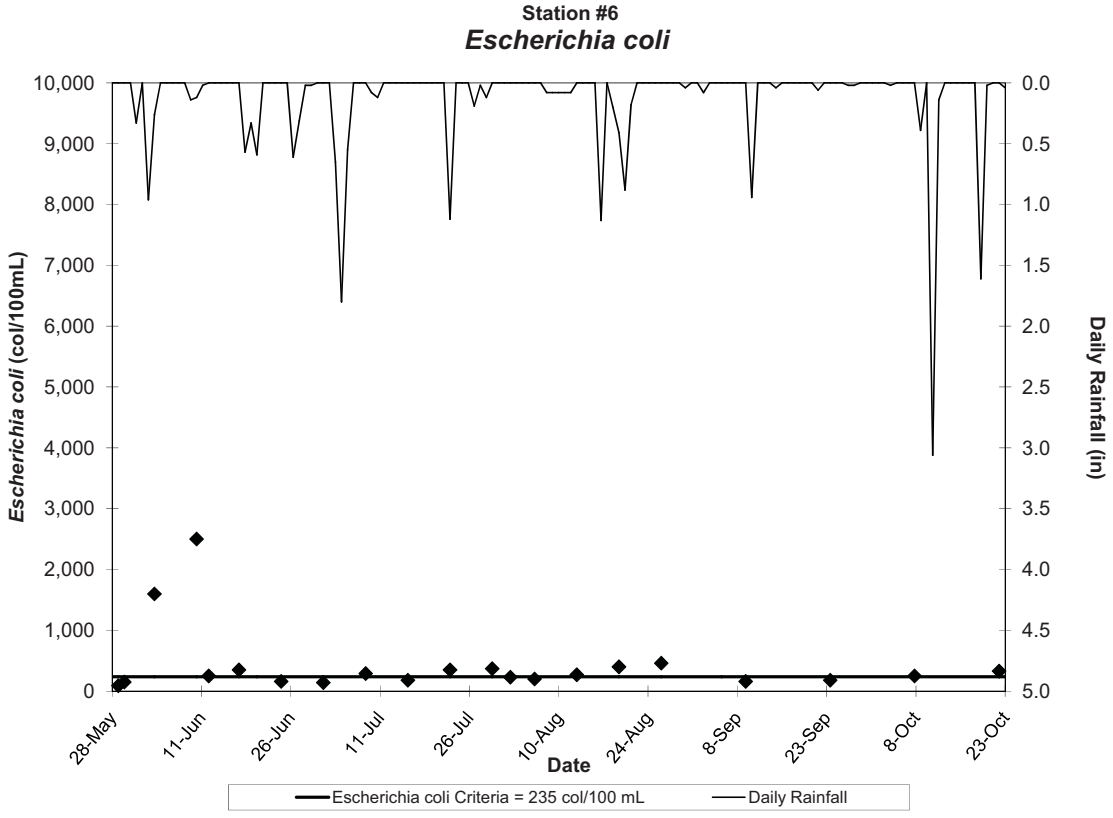

Station #10
Escherichia coli
Escherichia coli (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria= 235col/100ml
Daily Rainfall

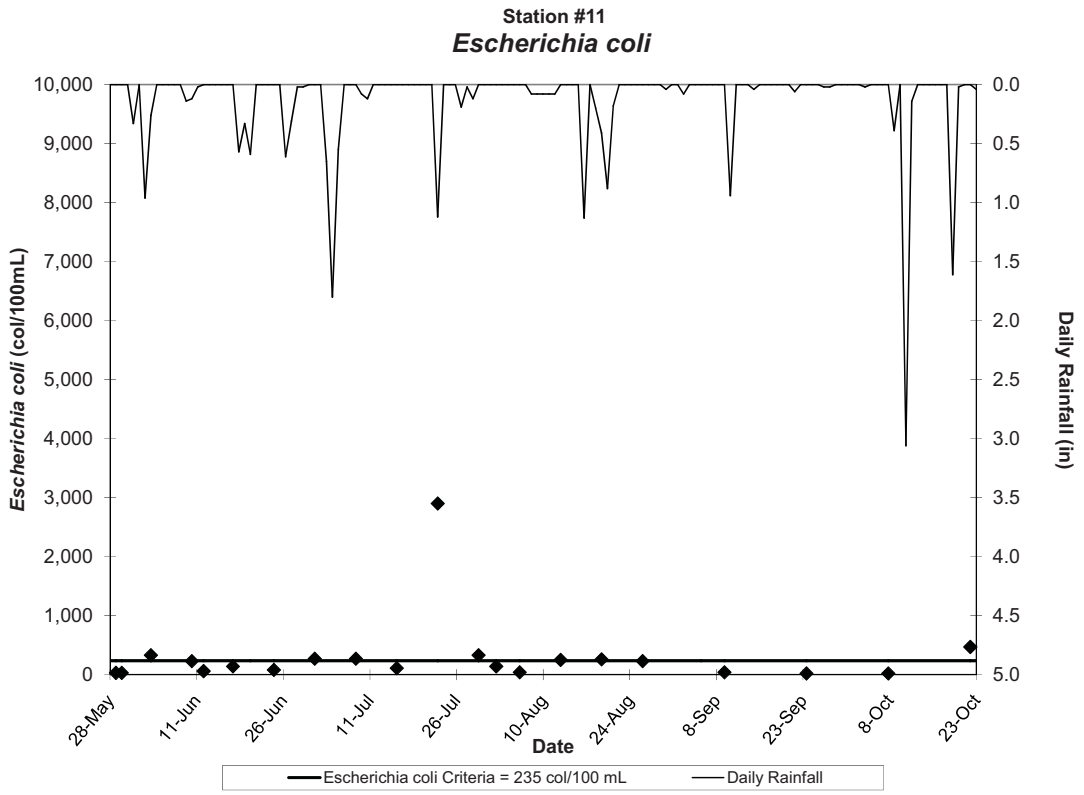

Station #9
Escherichia coli
80,000 col/100ml
44,000 col/100ml
Escherichia coli (col/100mL)
Daily Rainfall (in)
>35,000
32,500
30,000
27,500
25,000
22,500
20,000
17,500
15,000
12,500
10,000
7,500
5,000
2,500
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria = 235 col/100 mL
Daily Rainfall

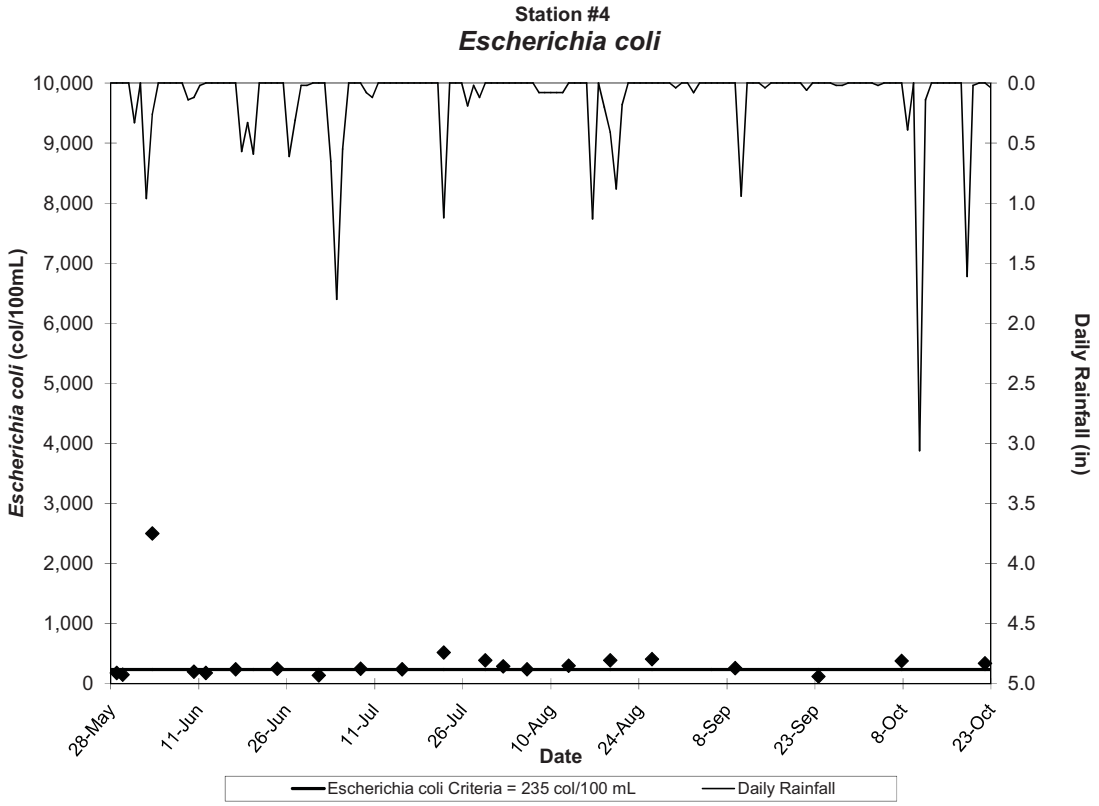

Station #7
Escherichia coli
92,000 col/100ml
52,000 col/100ml
53,000 col/100ml
>35,000
32,500
30,000
27,500
25,000
22,500
20,000
17,500
15,000
12,500
10,000
7,500
5,000
2,500
0
Escherichia coli (col/100mL)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Daily Rainfall (in)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria = 235 col/100 mL
Daily Rainfall

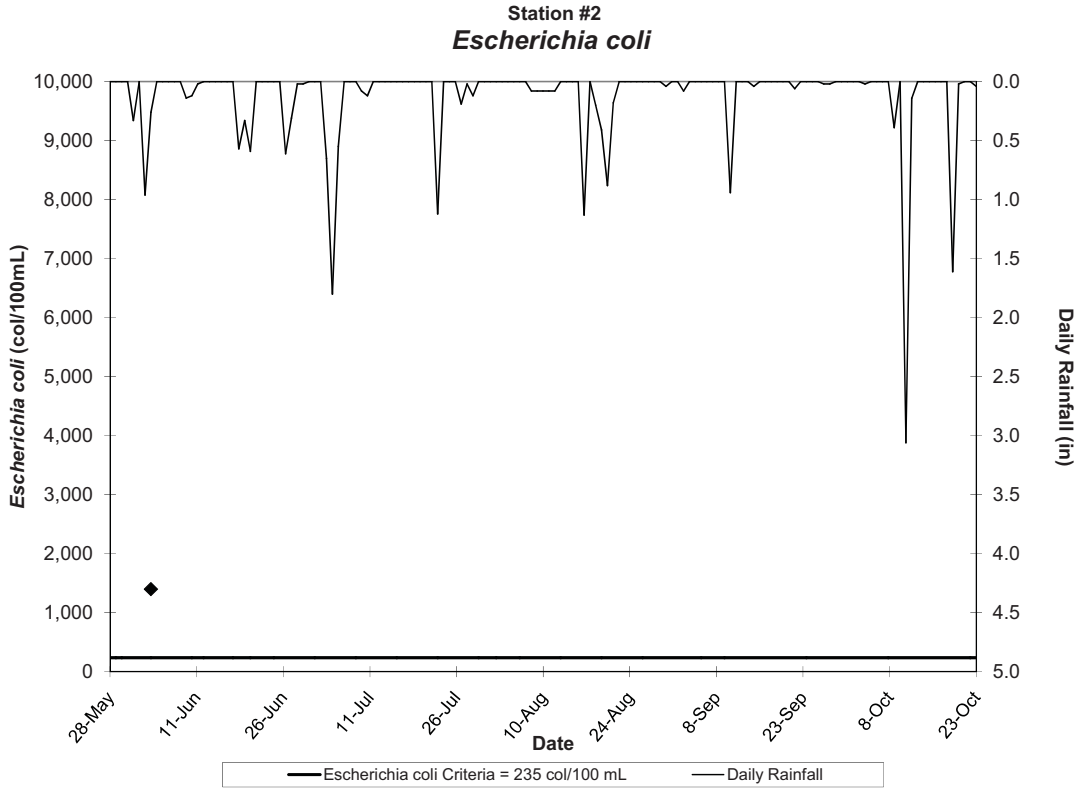

Station #8
Escherichia coli
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Escherichia coli (col/100mL)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Daily Rainfall (in)
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria = 235 col/100 mL
Daily Rainfall

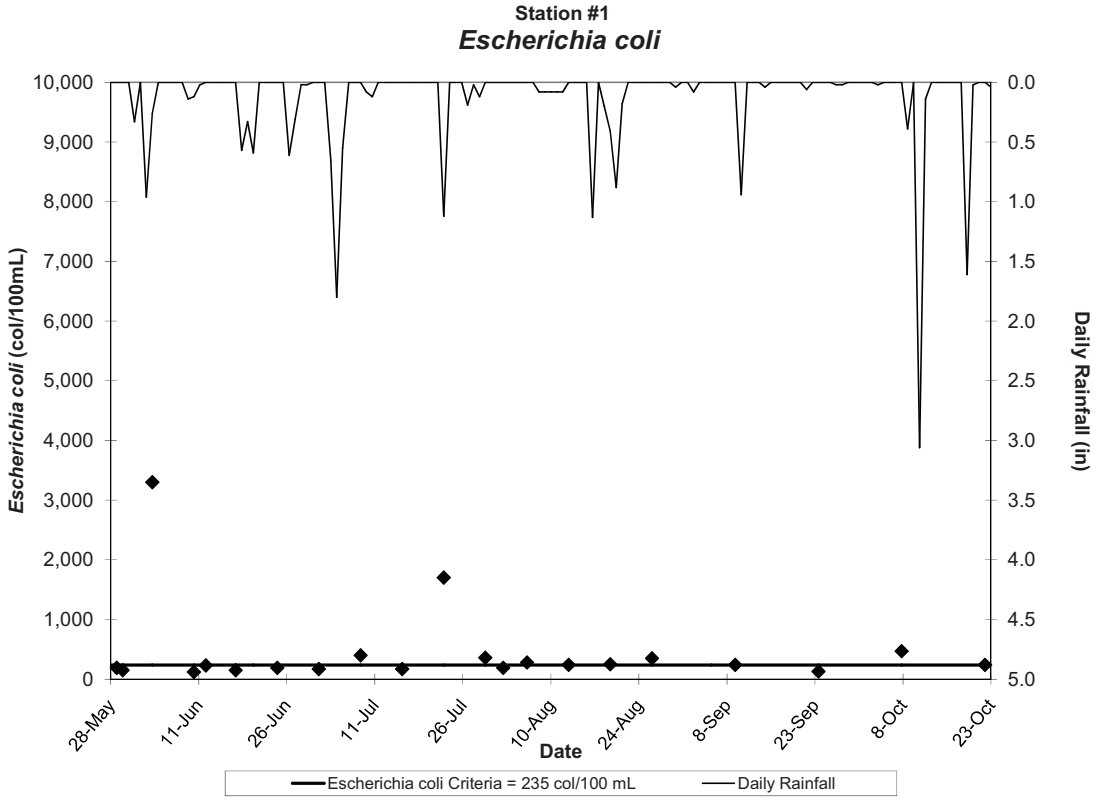

Station #5a
Escherichia coli
Escherichia coli (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria = 235 col/100 mL
Daily Rainfall


Station #6
Escherichia coli
Escherichia coli (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria = 235 col/100 mL
Daily Rainfall


Station #11
Escherichia coli
Escherichia coli (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria = 235 col/100 mL
Daily Rainfall

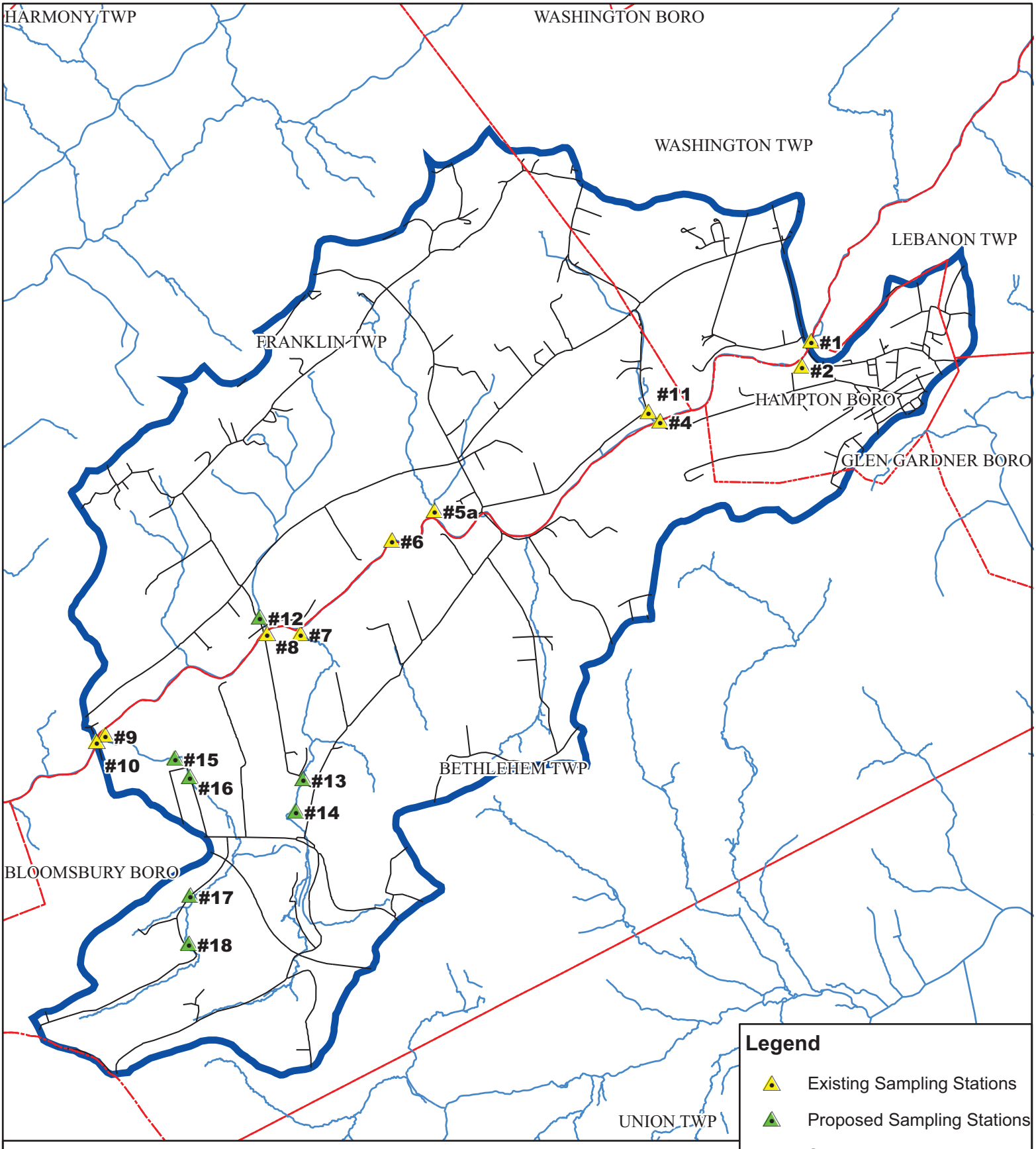

Station #4
Escherichia coli
Escherichia coli (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria = 235 col/100 mL
Daily Rainfall


Station #2
Escherichia coli
Escherichia coli (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria = 235 col/100 mL
Daily Rainfall


Station #1
Escherichia coli
Escherichia coli (col/100mL)
Daily Rainfall (in)
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
28-May
11-Jun
26-Jun
11-Jul
26-Jul
10-Aug
24-Aug
8-Sep
23-Sep
8-Oct
23-Oct
Date
Escherichia coli Criteria = 235 col/100 mL
Daily Rainfall

Appendix D: Microbial Source Tracking (MST) – Musconetcong River Watershed – 2008; Microbial Source Tracking (MST) – Musconetcong River Watershed - 2009

Microbial Source Tracking (MST) – Musconetcong River Watershed – 2008



Legend

- Existing Sampling Stations
- Proposed Sampling Stations
- Streams
- Municipality
- Project Watershed

MAP #1 - LOCATION OF EXISTING AND PROPOSED SAMPLING SITES

MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

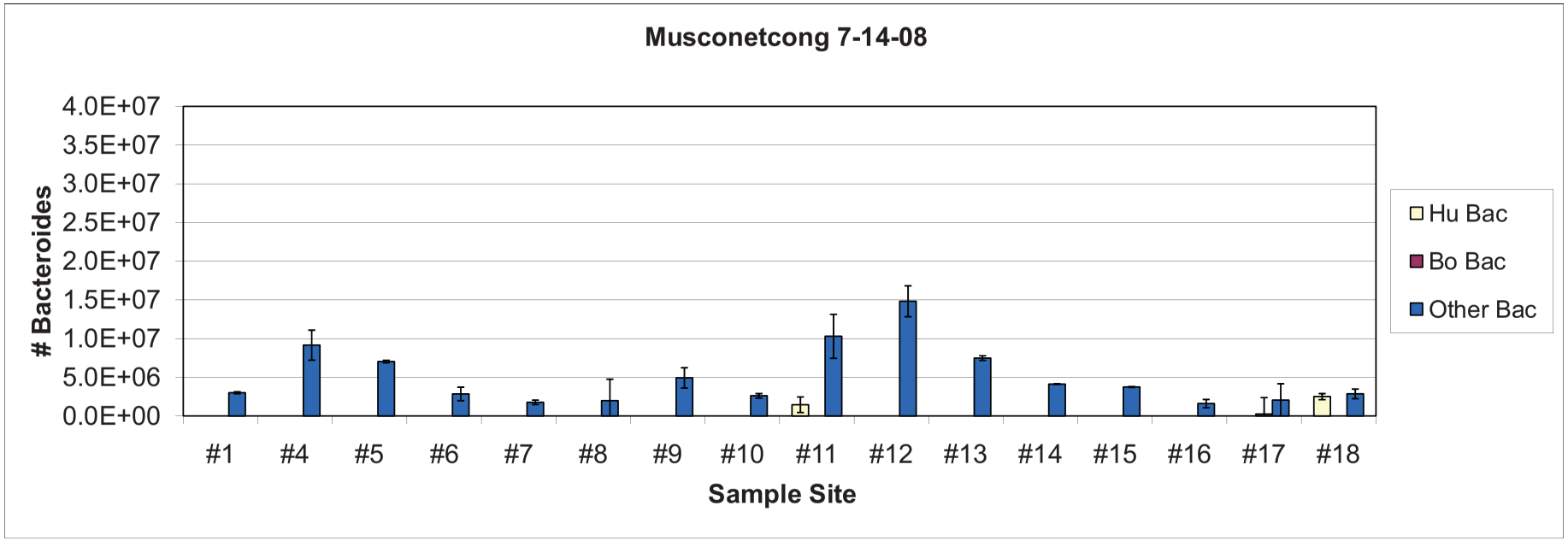
Data Source: NJDEP 2002

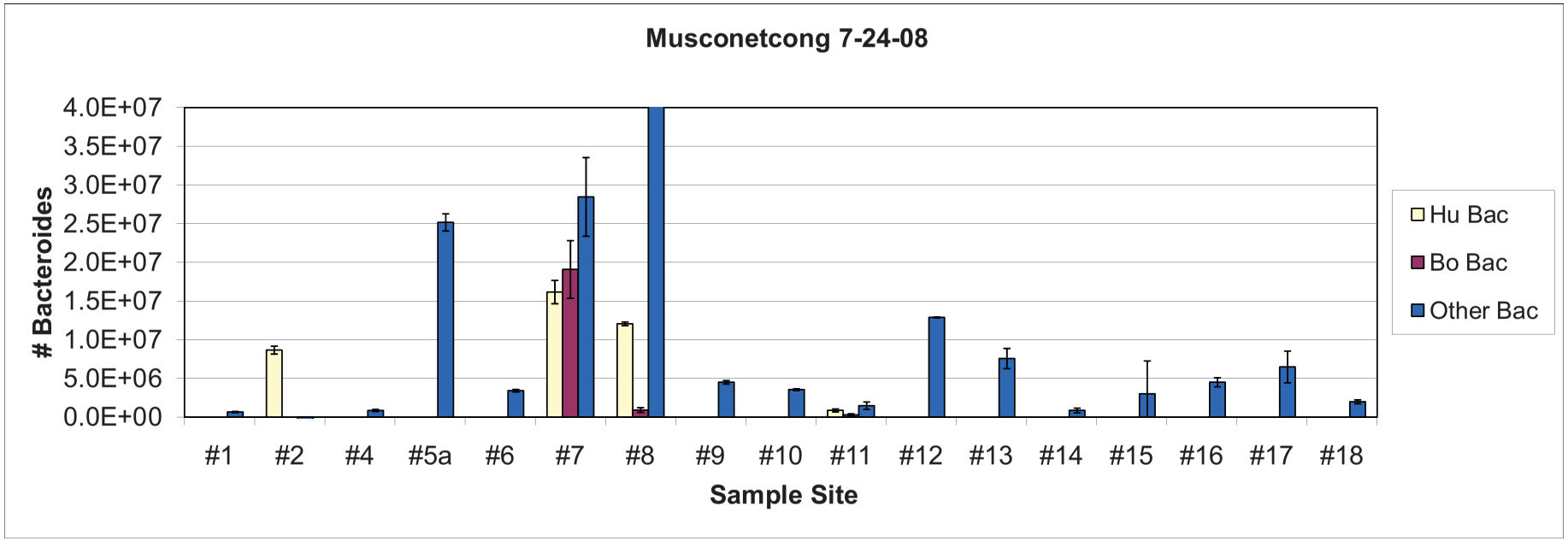
RUTGERS
New Jersey Agricultural Experiment Station

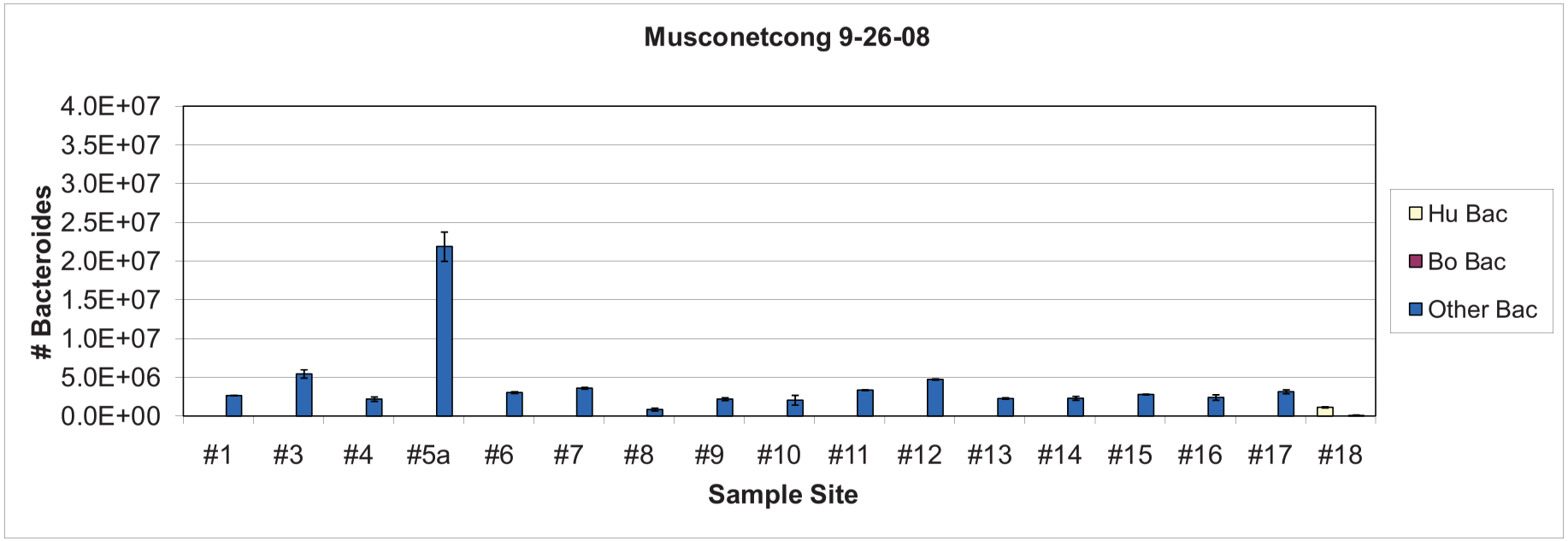
Rutgers University
RCE Water Resources Program
14 College Farm Road
New Brunswick, NJ 08901
T: 732-932-9800 F: 732-932-8644

N

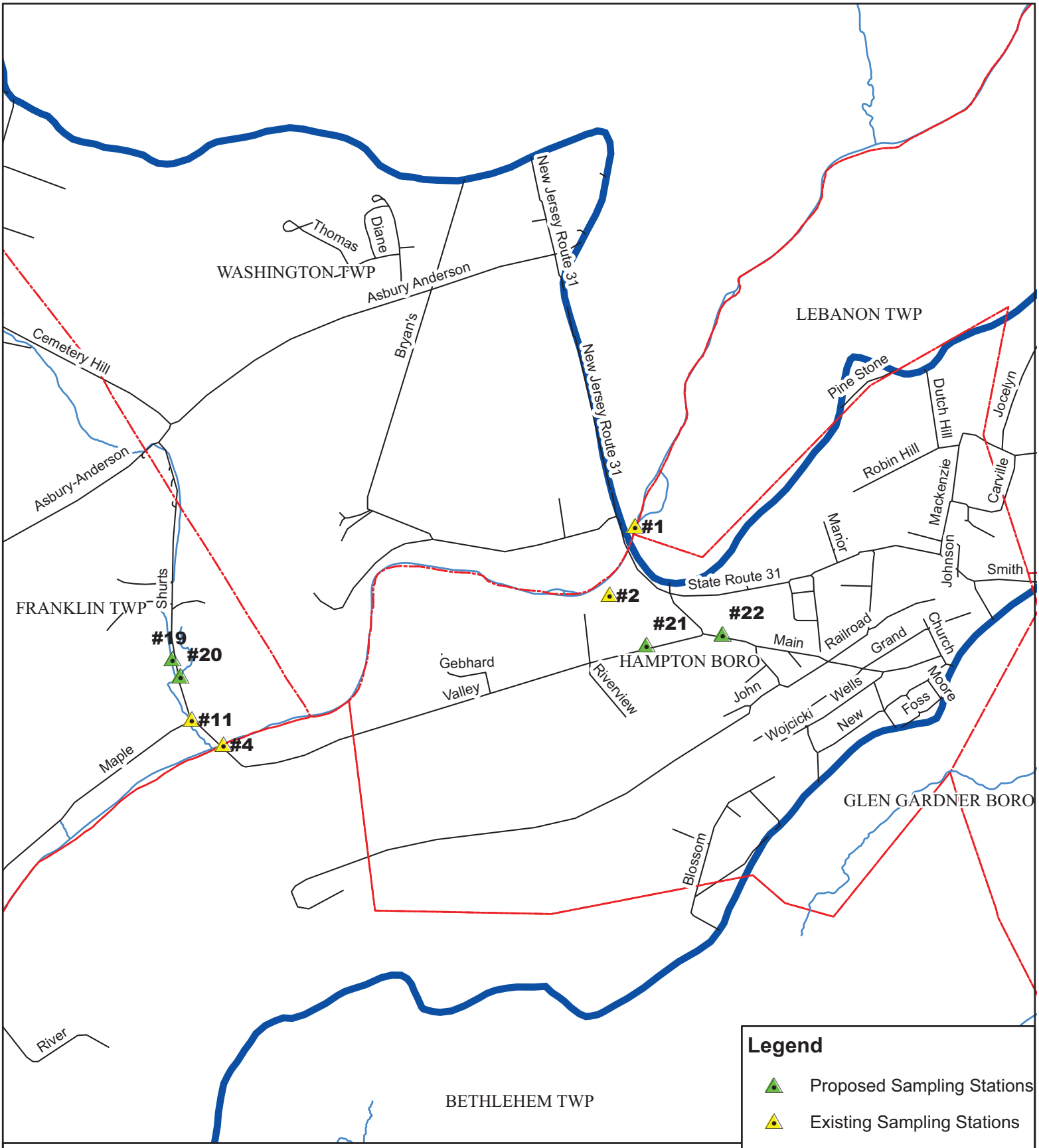
0 0.2 0.4 0.8
Miles


Musconetcong 7-14-08
Bacteroides
4.0E+07
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
#1
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
#16
#17
#18
Sample Site
Hu Bac
Bo Bac
Other Bac


Musconetcong 7-24-08
Bacteroides
4.0E+07
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
#1
#2
#4
#5a
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
#16
#17
#18
Sample Site
Hu Bac
Bo Bac
Other Bac


Musconetcong 9-26-08
Bacteroides
4.0E+07
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
#1
#3
#4
#5a
#6
#7
#8
#9
#10
#11
#12
#13
#14
#15
#16
#17
#18
Sample Site
Hu Bac
Bo Bac
Other Bac

Microbial Source Tracking (MST) – Musconetcong River Watershed – 2009



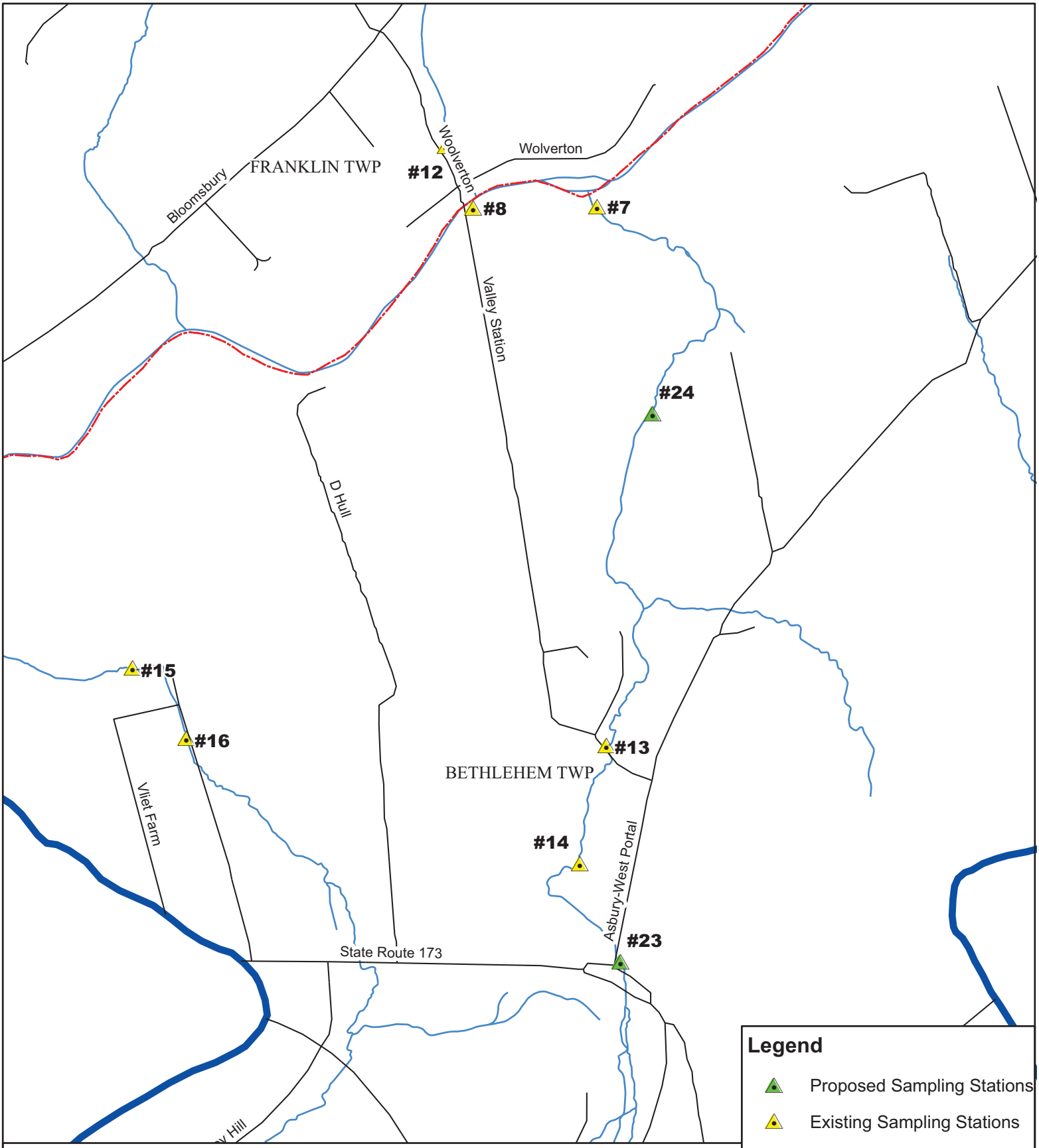
MAP #1 - LOCATION OF EXISTING AND PROPOSED SAMPLING SITES

MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

Data Source: NJDEP 2002

RUTGERS
New Jersey Agricultural Experiment Station

Rutgers University
RCE Water Resources Program
14 College Farm Road
New Brunswick, NJ 08901
T: 732-932-9800 F: 732-932-8644



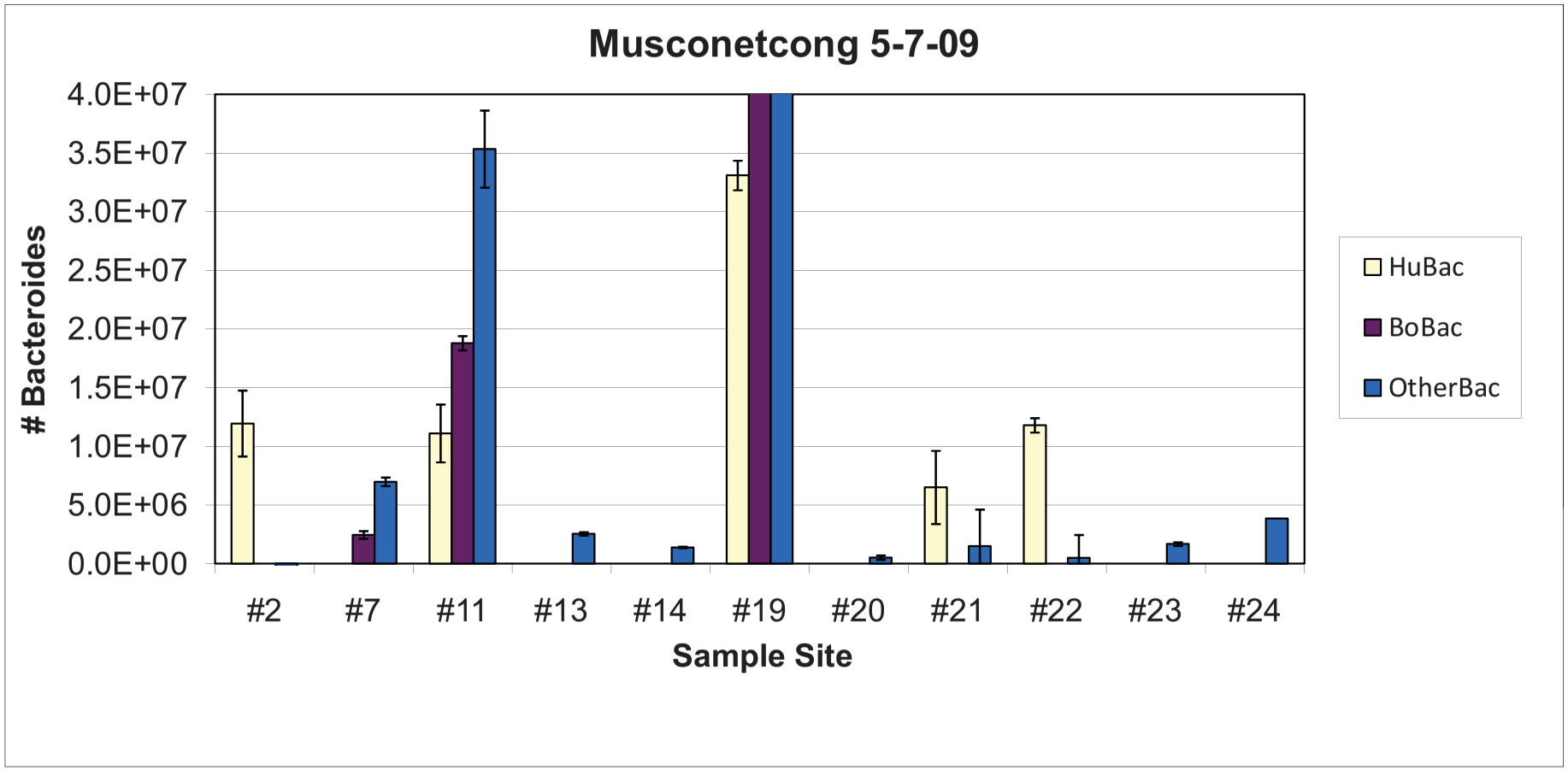
MAP #2 - LOCATION OF EXISTING AND PROPOSED SAMPLING SITES

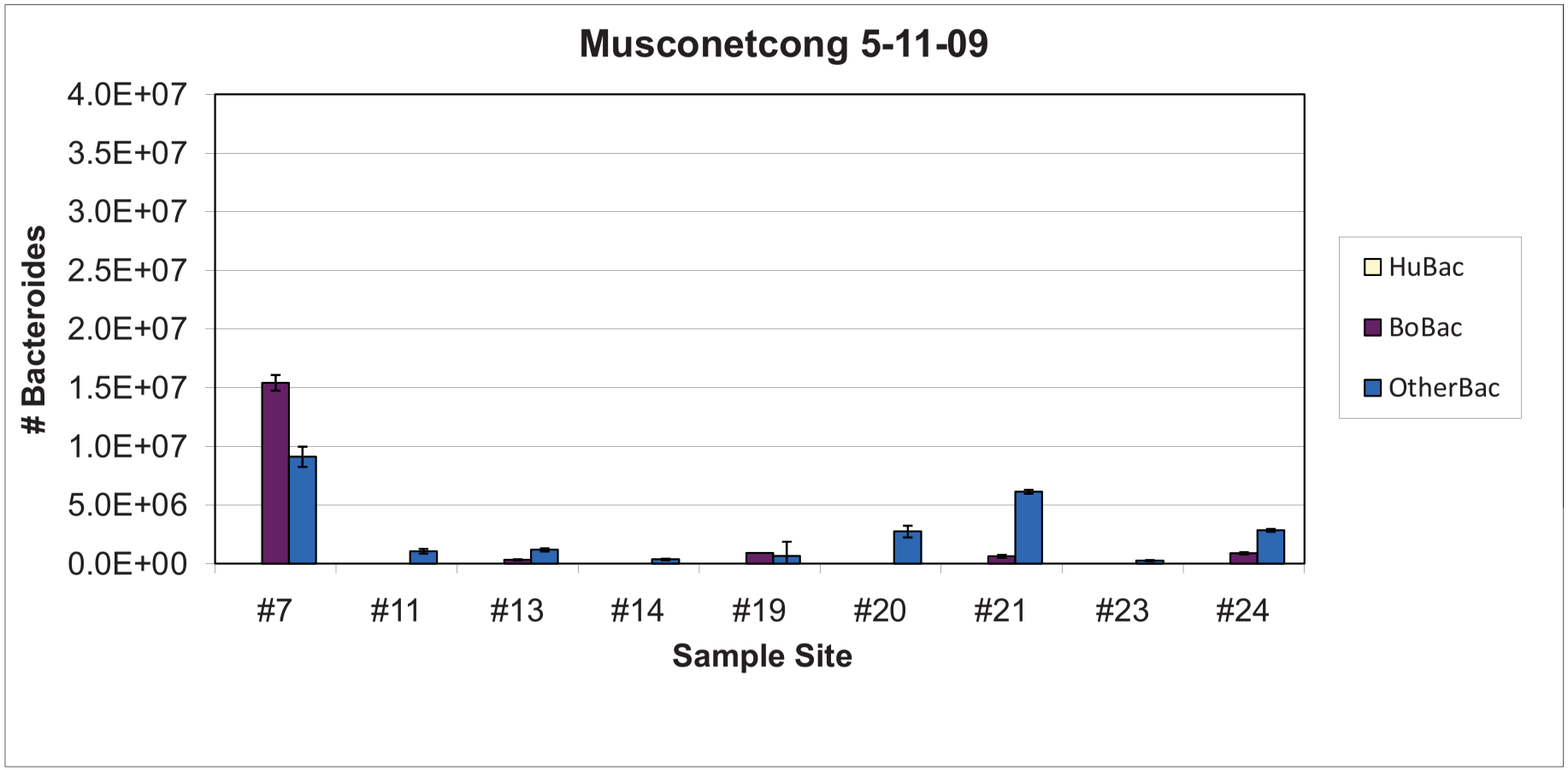
MUSCONETCONG RIVER WATERSHED RESTORATION PLAN

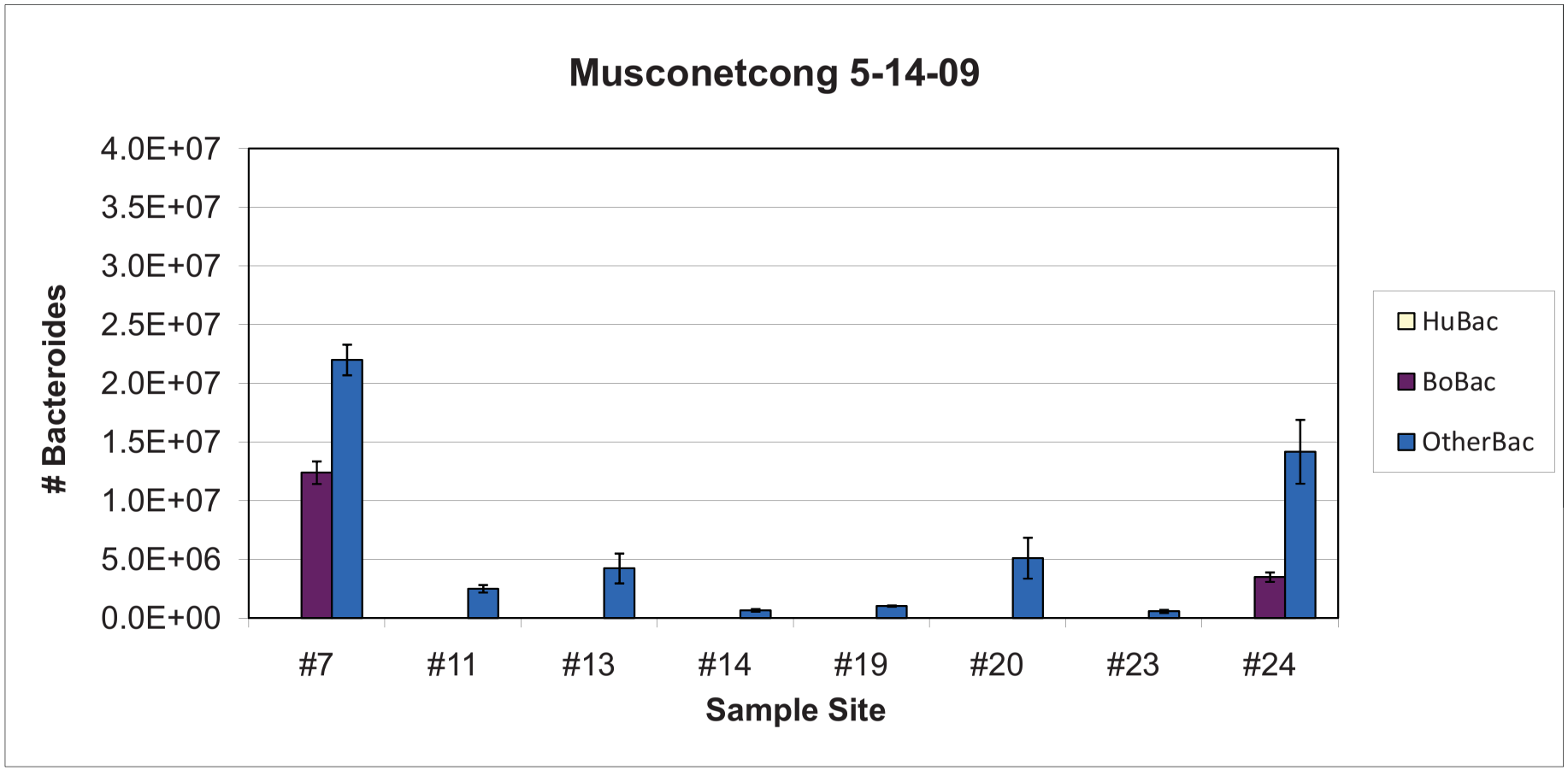
Data Source: NJDEP 2002

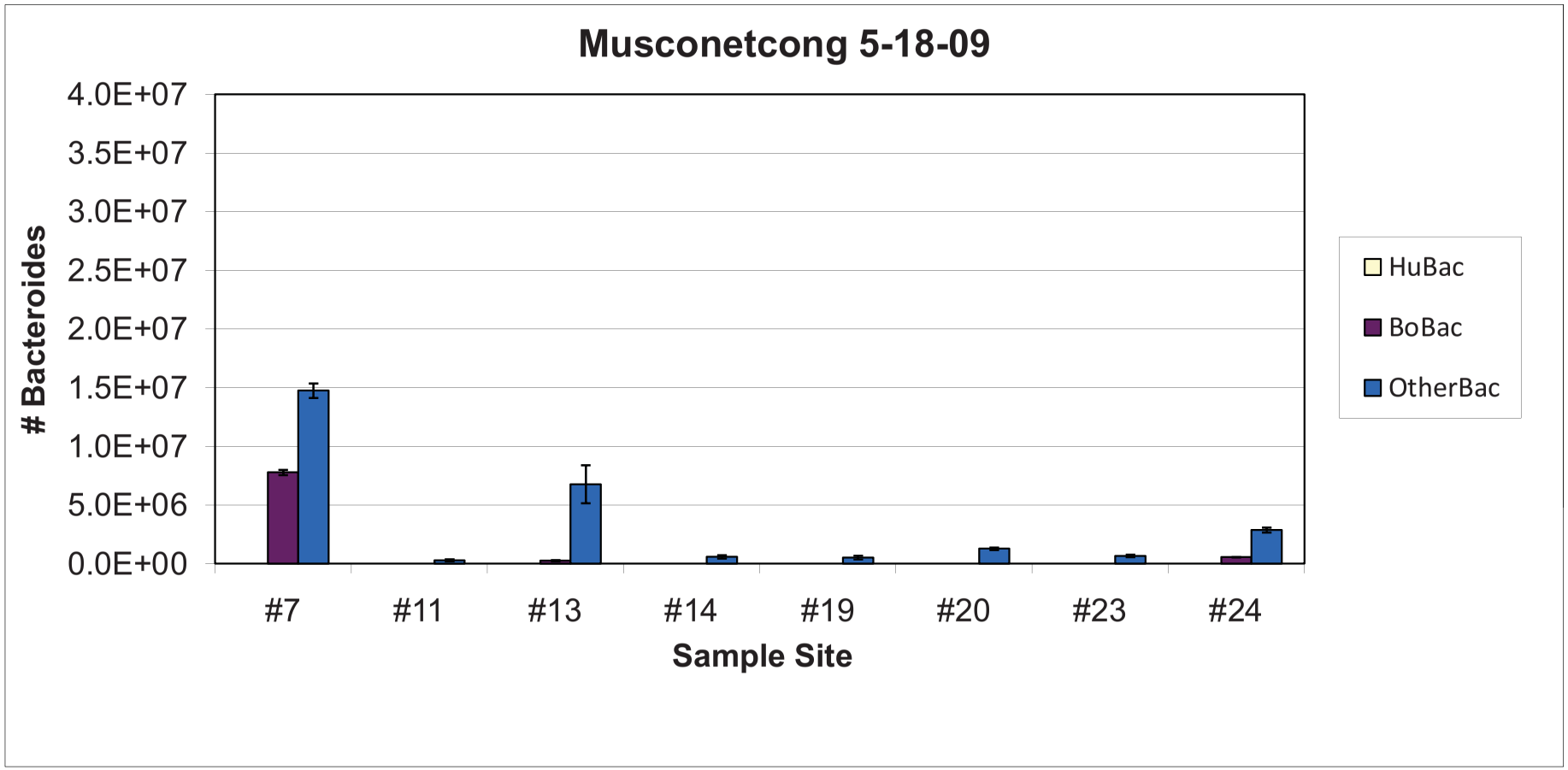
RUTGERS
New Jersey Agricultural Experiment Station

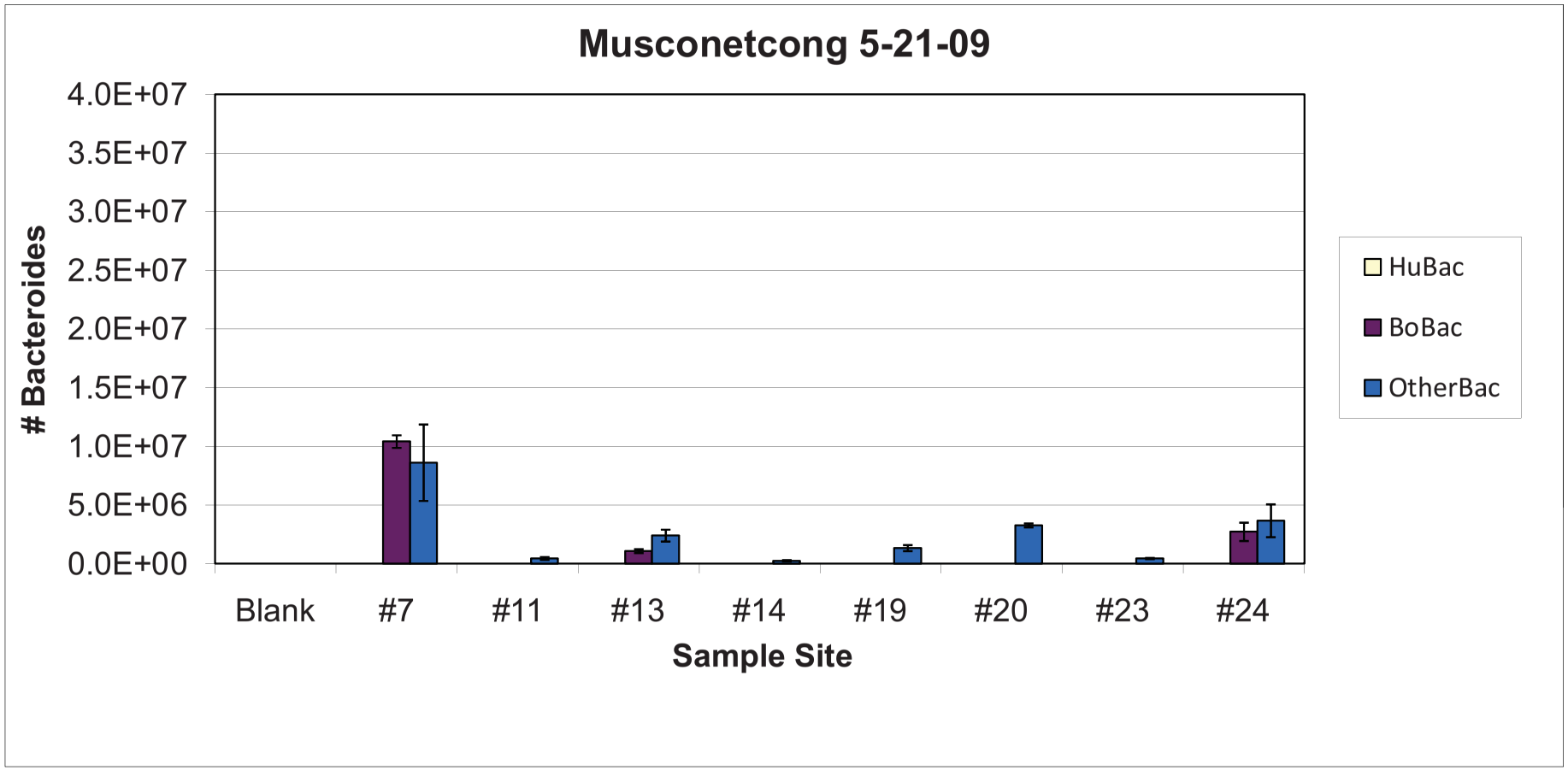
Rutgers University
RCE Water Resources Program
14 College Farm Road
New Brunswick, NJ 08901
T: 732-932-9800 F: 732-932-8644


Musconetcong 5-7-09
Bacteroides
4.0E+07
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
#2
#7
#11
#13
#14
#19
#20
#21
#22
#23
#24
Sample Site
HuBac
BoBac
OtherBac


Musconetcong 5-11-09
Bacteroides
4.0E+07
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
#7
#11
#13
#14
#19
#20
#21
#23
#24
Sample Site
HuBac
BoBac
OtherBac


Musconetcong 5-14-09
Bacteroides
4.0E+07
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
#7
#11
#13
#14
#19
#20
#23
#24
Sample Site
HuBac
BoBac
OtherBac


Musconetcong 5-18-09
Bacteroides
4.0E+07
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
#7
#11
#13
#14
#19
#20
#23
#24
Sample Site
HuBac
BoBac
OtherBac


Musconetcong 5-21-09
Bacteroides
4.0E+07
3.5E+07
3.0E+07
2.5E+07
2.0E+07
1.5E+07
1.0E+07
5.0E+06
0.0E+00
Blank
#7
#11
#13
#14
#19
#20
#23
#24
Sample Site
HuBac
BoBac
OtherBac

Appendix E: Musconetcong River Watershed Restoration and Protection Plan, Data Summary – Summer 2007 Biological Assessment, Rutgers Cooperative Extension Water Resources Program

THE MUSCONETCONG RIVER WATERSHED RESTORATION AND PROTECTION PLAN

DATA SUMMARY – 2007 BIOLOGICAL ASSESSMENT

Rutgers Cooperative Extension Water Resources Program

Introduction

The Musconetcong River Watershed is one of the five major subwatershed basins of the Upper Delaware Watershed. Located in northwest New Jersey, the Musconetcong River Watershed is 156 square miles in total size. The specific project area covers approximately seven (7) river miles of the Musconetcong River and an additional 19 miles of tributaries. The project area covers 19.6 square miles, portions of five (5) municipalities (Hampton Borough, Lebanon, Bethlehem, Washington, and Franklin Townships) and two (2) counties (Hunterdon and Warren). Two HUC-14 subwatersheds (HUC 02040105160040 and 50) delineate the project area. This watershed area is characterized by large expanses of agricultural land in the river valley, woodlands on the ridgelines, and scattered residential and commercial development.

The *New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report* (NJDEP, 2004) identified this section of the Musconetcong River as an impaired waterway for fecal coliform, pH and benthic macroinvertebrates. A TMDL for fecal coliform has been adopted and requires a 93% load reduction in fecal coliform. Additionally, this subwatershed was identified as a priority water segment by the New Jersey Department of Environmental Protection (NJDEP) in 2004.

The following is a data summary of the biological assessment conducted by the Rutgers Cooperative Extension (RCE) Water Resources Program during the summer of 2007 to collect water quality data needed to support the development of a watershed restoration and protection plan for this section of the Musconetcong River.

Biological Data Collection

A survey of the benthic macroinvertebrate community within the Musconetcong River Watershed was conducted by the RCE Water Resources Program on June 21, 2007 (early summer) and September 6, 2007 (late summer) in accordance with a Quality Assurance Project Plan (QAPP) (Submitted January 2007, Approved May 2007). The sampling and data analysis procedures were conducted in accordance with the Rapid Bioassessment Protocol (RBP) procedure used by the NJDEP Bureau of Freshwater and Biological Monitoring, which is based on USEPA's *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers* ((Barbour et al., 1999). Benthic macroinvertebrates were collected at two locations as described below and identified in Figure 1.

Station	Description	Coordinates
#1	*Musconetcong River at the Route 31 crossing in Hampton.* This site was selected to serve as the upstream control prior to potential effluent from Hampton septic systems and cesspools entering the river. This site delineates the upstream boundary of the project area.	N 40.7112° W 74.9684°
#10	*Musconetcong River at Person Road crossing at the USGS monitoring station near Bloomsbury (#01457000).* This site was selected as it delineates the downstream end of the project area.	N 40.6723° W 75.0605°

A multi-habitat sampling approach, concentrating on the most productive habitat of the stream plus coarse particulate organic matter (CPOM) or leaf litter was used. Given the nature of the substrate and the flow conditions at Stations #1 and #10, a Surber Square Foot Bottom Sampler was used to collect three grab type samples from the most productive habitat of the stream (i.e., riffle/run areas). Samples were sorted and processed in the field using a U.S. Standard No. 30 sieve, composited (i.e., the contents from the grab samples from each location were combined into a single container), and preserved in 80% ethanol for later subsampling, identification, and enumeration.

A composite collection of a variety of CPOM forms (e.g., leaves, needles, twigs, bark, or fragments of these) was collected. It is difficult to quantify the amount of CPOM collected in terms of weight or volume given the variability of its composition. Collection of several handfuls of material is usually adequate, and the material is typically found in depositional areas, such as in pools and along snags and undercut banks. The CPOM sample was processed using a U.S. Standard No. 30 sieve and was added to the composite of the grab samples for each location.

A 100-organism subsample of the benthic macroinvertebrate composite sample from each sampling location was taken in the laboratory according to the methods outlined in the Rapid Bioassessment Protocol used by the NJDEP Bureau of Freshwater & Biological Monitoring (Barbour et al., 1999). With the exception of any chironomids and oligochaetes, benthic macroinvertebrates were identified to genus. Chironomids were identified to subfamily as a minimum, and oligochaetes were identified to family as a minimum. Standard taxonomic references were used and included Merritt and Cummins, 1988; Pennak, 1989; Peckarsky, *et al*., 1990; and Thorp and Covich, 1991.

A habitat assessment was conducted in accordance with the methods used by the NJDEP Bureau of Freshwater & Biological Monitoring for high gradient streams (NJDEP, 2007). The habitat assessment, which has been designed to provide a measure of habitat quality, involves a visual based technique for assessing stream habitat structure. The findings from the habitat assessment are used to interpret survey results and identify obvious constraints on the attainable biological potential within the study area.

Results

Physicochemical Characteristics:

The stream width at Station #1 was approximately 65 feet. The stream depth ranged from 0.2 feet to 1.2 feet in the riffle/run areas and was approximately 2 feet in some pool areas. The stream velocity ranged from 0 ft/sec to 3.99 ft/sec. The canopy cover was partly open/partly shaded at this location. The inorganic substrate at Station #1 consisted mostly of cobbles with small boulders, gravel, and some coarse sand. Although minimal, the organic substrate was comprised mainly of detritus in the form of sticks, decomposing leaves, and new fall. Sediment odors and oils were absent. Water odors and surface oils were absent. The water was clear. In June, the water temperature was 19.9˚C; the pH was 7.52 SU; the dissolved oxygen was 8.41 mg/L, and the concentration of total dissolved solids was 320 mg/L. In September, the water temperature was 18.5˚C; the pH was 7.95 SU; the dissolved oxygen was 9.87 mg/L, and the concentration of total dissolved solids was 310 mg/L. The predominant surrounding land uses at Station #1 included recreational fields, rural residential, and local roadways/highway. Local watershed erosion was moderate and obvious sources of local nonpoint sources of pollution were noted from the surrounding land uses (e.g., road runoff and stormwater outfalls).

The stream width at Station #10 was approximately 75 feet. The stream depth ranged from 0.4 feet to 2.0 feet in the riffle/run areas and was greater than 2.5 feet in the pool areas. The stream velocity ranged from 0.25 ft/sec to 2.43 ft/sec. The canopy cover was partly shaded. The inorganic substrate at Station SN1 consisted mostly of cobbles with small boulders, gravel, and some coarse sand. The organic substrate was minimal and was comprised mainly of detritus in the form of sticks, decomposing leaves, and new fall. Sediment odors and oils were absent. Water odors and surface oils were absent. The water was clear. In June, the water temperature was 18.8˚C; the pH was 6.64 SU; the dissolved oxygen was 8.21 mg/L, and the concentration of total dissolved solids was 300 mg/L. In September, the water temperature was 17.5˚C; the pH was 7.78 SU; the dissolved oxygen was 9.25 mg/L, and the concentration of total dissolved solids was 310 mg/L. The predominant surrounding land uses at Station #10 were forest and field/pasture. Local watershed erosion was absent, and potential sources of nonpoint sources included runoff from the nearby roadway.

Habitat Assessment:

The habitat assessment is designed to provide an estimate of habitat quality based upon qualitative estimates of selected habitat attributes. The assessment involves the numerical scoring of ten habitat parameters to evaluate instream substrate, channel morphology, bank structural features, and riparian vegetation. Each parameter is scored and summed to produce a total score which is assigned a habitat quality category of optimal (excellent), sub-optimal (good), marginal (fair), or poor. Table 1 outlines the habitat scoring criteria for high gradient streams by the NJDEP Bureau of Freshwater & Biological Monitoring. Sites with optimal habitat conditions have total scores ranging from 160 to 200; sites with suboptimal habitat conditions have total scores ranging from 110 to 159; sites with marginal habitat conditions have total scores ranging from 60 to 109, and sites with poor habitat conditions have total scores less than 60. The scores for Stations #1 and #10 are summarized in Table 2. Stations #1 and #10 were found to have optimal habitat conditions.

Benthic Macroinvertebrates:

The results of the benthic macroinvertebrate survey are presented in Table 3. These results are organized by the order, the family, and then by the generic taxonomic levels. The

number of taxa and individuals collected from each sampling location is also summarized in Table 3. A total of 27 different taxa of benthic macroinvertebrates was collected within the study area, representing two phyla (i.e., mollusks and arthropods). The arthropods, in particular the insects, were the most strongly represented in terms of the number of different taxa present. In total, 15 insect families were represented.

To evaluate the biological condition of the sampling locations, several community measures were calculated from the data presented in Table 3 and included the following:

1. Taxa Richness: Taxa richness is a measure of the total number of benthic macroinvertebrate families identified. A reduction in taxa richness typically indicates the presence of organic enrichment, toxics, sedimentation, or other factors.

2. EPT (Ephemeroptera, Plecoptera, Trichoptera) Index: The EPT Index is a measure of the total number of Ephemeroptera, Plecoptera, and Trichoptera families (i.e., mayflies, stoneflies, and caddisflies). These organisms typically require clear moving water habitats.

3. %EPT: Percent EPT measures the numeric abundance of the mayflies, stoneflies, and caddisflies within a sample. A high percentage of EPT taxa are associated with good water quality.

4. % CDF (percent contribution of the dominant family): Percent CDF measures the relative balance within the benthic macroinvertebrate community. A healthy community is characterized by a diverse number of taxa that have abundances somewhat proportional to each other.

5. Family Biotic Index: The Family Biotic Index measures the relative tolerances of benthic macroinvertebrates to organic enrichment based on tolerance scores assigned to families ranging from 0 (intolerant) to 10 (tolerant) (Hilsenhoff, 1988).

This analysis integrates several community parameters into one easily comprehended evaluation of biological integrity referred to as the New Jersey Impairment Score (NJIS). The NJIS has been established for three categories of water quality bioassessment for New Jersey streams: non-impaired, moderately impaired, and severely impaired. A non-impaired site has a benthic community comparable to other high quality "reference" streams within the region. The community is characterized by maximum taxa richness, balanced taxa groups, and a good representation of intolerant individuals. A moderately impaired site is characterized by reduced macroinvertebrate taxa richness, in particular the EPT taxa. Changes in taxa composition result in reduced community balance and intolerant taxa become absent. A severely impaired site is

one in which the benthic community is significantly different from that of the reference streams. The macroinvertebrates are dominated by a few taxa which are often very abundant. Tolerant taxa are typically the only taxa present.

The scoring criteria used by the NJDEP Bureau of Freshwater & Biological Monitoring are outlined in Table 4. This scoring system is based on comparisons with reference streams and a historical database consisting of 200 benthic macroinvertebrate samples collected from New Jersey streams. While a low score indicates "impairment," the score may actually be a consequence of habitat or other natural differences between the subject stream and the reference stream. Non-impaired sites have total scores ranging from 24-30, moderately impaired sites have total scores ranging from 9 to 21, and severely impaired sites have total scores ranging from 0 to 6. Impairment scores for Stations #1 and #10 are provided in Tables 5A, 5B, 5C, and 5D. Stations #1 and #10 were assessed as being non-impaired in both the early summer survey and the late summer survey.

Discussion

The NJDEP Bureau of Biological & Freshwater Monitoring maintains two Ambient Biomonitoring Network (AMNET) stations within the Musconetcong River Watershed (i.e., Stations AN00072 and AN0073) in the vicinity of the project area. Station AN0072 is approximately 0.94 miles upstream from Station #1. Station AN0073 is approximately 2.0 miles downstream from Station #10. In 1992 Station AN0072 was assessed as being non-impaired by NJDEP (NJDEP, 1994). However, in 1997 Station AN0072 was assessed as being moderately impaired with optimal habitat conditions (NJDEP, 1999). This particular assessment most likely is the reason for this section of the Musconetcong River being listed in the *New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report* as an impaired waterway for benthic macroinvertebrates (NJDEP, 2004). In 2002, NJDEP assessed Station AN0072 as being non-impaired with optimal habitat conditions (NJDEP, 2008). Also, in the fall of 2007, NJDEP assessed Station AN0072 as having optimal habitat conditions and having a rating of "good" under the High Gradient Macroinvertebrate Index (HGMI) (NJDEP, 2010). Station AN0072 is considered to be at full attainment of the regulatory threshold. In 1993, 1997, and 2002, Station AN0073 was assessed as being non-impaired by NJDEP, and in 1997 and 2002, optimal habitat conditions were noted at Station AN0073 (NJDEP, 1994; NJDEP, 1999; NJDEP, 2008). In the

fall of 2007, NJDEP assessed Station AN0073 as having optimal habitat conditions and having a rating of "excellent" under the HGMI (NJDEP, 2010). Station AN0073, like AN0072, is considered to be at full attainment of the regulatory threshold.

Since no impairments have been noted, there is no reason to conduct the U.S. Environmental Protection Agency (USEPA) Stressor Identification (SI) process, which is used to identify any type of stressor or combination of stressors that might cause biological impairment (USEPA, 2000), at this time. The assessment conducted by the RCE Water Resources Program at Stations #1 and #10 in the early and late summer of 2007 demonstrates that the biological condition has remained at a non-impaired status, and the habitat condition has remained as optimal within this section of the Musconetcong River Watershed. The assessments conducted by NJDEP at Stations AN0072 and AN0073 in the early fall of 2007 confirm these findings.

References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

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Figures & Tables

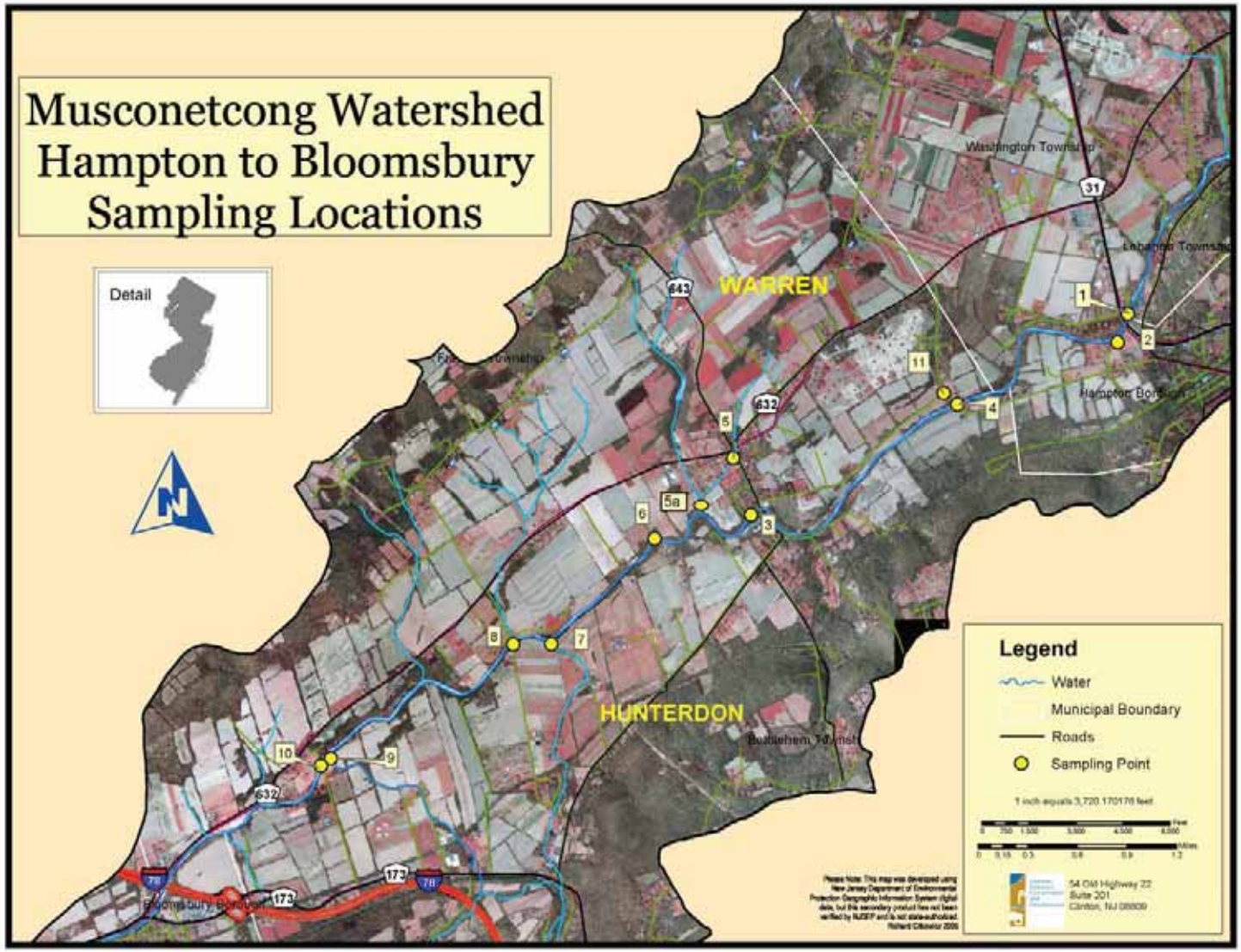

FIGURE 1. Sampling Locations

TABLE 1. Scoring Criteria for Habitat Assessment

Table 4 — **HABITAT ASSESSMENT FOR *HIGH* GRADIENT STREAMS**

Habitat Parameter	Condition Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/Available Cover	Greater than 70% of substrate favorable for epifaunal colonization and fish cover; mix of snags, submerged logs, undercut banks, cobble or other stable habitat and at stage to allow full colonization potential (i. e., logs/snags that are not new fall and not transient).	40-70% mix of stable habitat; well suited for full colonization potential; adequate habitat for maintenance of populations; presence of additional substrate in the form of newfall, but not yet prepared for colonization (may rate at high end of scale).	20-40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
2. Embeddedness	Gravel, cobble, and boulder particles are 0-25% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 25-50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50-75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are more than 75% surrounded by fine sediment.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Velocity/Depth Regimes	All 4 velocity/depth regimes present (slow-deep, slow-shallow, fast-deep, fast-shallow). (slow is < 0.3 m/s, deep is > 0.5 m)	Only 3 of the 4 regimes present (if fast-shallow is missing, score lower than if missing other regimes).	Only 2 of the 4 habitat regimes present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity / depth regime (usually slow-deep).
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
4. Sediment Deposition	Little or no enlargement of islands or point bars and less than 5% (< 20% for low-gradient streams) of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand or fine sediment; 5-30% (20-50% for low-gradient) of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand or fine sediment on old and new bars; 30-50% (50-80% for low-gradient) of the bottom affected; sediment deposits at obstructions, constrictions, and bends; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; more than 50% (80% for low-gradient) of the bottom changing frequently; pools almost absent due to substantial sediment deposition.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
5. Channel Flow Status	Water reaches base of both lower banks, and minimal amount of channel substrate is exposed.	Water fills > 75% of the available channel; or < 25% of channel substrate is exposed.	Water fills 25-75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.) may be present, but recent channelization is not present.	Channelization may be extensive; embankments or shoring structures present on both banks; and 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of the stream reach channelized and disrupted. In stream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
7. Frequency of Riffles (or bends)	Occurrence of riffles relatively frequent; ratio of distance between riffles divided by width of the stream < 7:1 (generally 5 to 7); variety of habitat is key. In streams where riffles are continuous, placement of boulders or other large, natural obstruction is important.	Occurrence of riffles infrequent; distance between riffles divided by the width of the stream is between 7 to 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles divided by the width of the stream is between 15 to 25.	Generally all flat water or shallow riffles; poor habitat; distance between riffles divided by the width of the stream is a ratio of > 25.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
8. Bank Stability (score each bank) Note: determine left or right side by facing downstream.	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. < 5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5-30% of bank in reach has areas of erosion.	Moderately unstable; 30-60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60-100% of bank has erosional scars.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (score each bank)	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, understory shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70-90% of the streambank surfaces covered by native vegetation, but one class of plants is not well-represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of the potential plant stubble height remaining.	50-70% of the streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of the potential plant stubble height remaining.	Less than 50% of the streambank surfaces covered by vegetation; disruption of streambank vegetation is very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (score each bank riparian zone)	Width of riparian zone > 18 meters; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Width of riparian zone 12-18 meters; human activities have impacted zone only minimally.	Width of riparian zone 6-12 meters; human activities have impacted zone a great deal.	Width of riparian zone < 6 meters: little or no riparian vegetation due to human activities.
SCORE ___ (LB)	Left Bank 10 9	8 7 6	5 4 3	2 1 0
SCORE ___ (RB)	Right Bank 10 9	8 7 6	5 4 3	2 1 0

HABITAT SCORES	VALUE
OPTIMAL	160 — 200
SUB-OPTIMAL	110 — 159
MARGINAL	60 — 109
POOR	< 60

TABLE 2. Habitat Assessment Results

Habitat Parameter	Stations	
	#1	#10
1. Epifaunal Substrate/Available Cover	18	18
2. Embeddedness	18	18
3. Velocity/Depth Regime	15	15
4. Sediment Deposition	18	18
5. Channel Flow Status	18	18
6. Channel Alteration	18	18
7. Channel Sinuosity	18	18
8a. Bank Stability (Left Bank)	7	9
8b. Bank Stability (Right Bank)	8	9
9a. Vegetative Protection (Left Bank)	7	9
9b. Vegetative Protection (Right Bank)	7	9
10a. Riparian Vegetative Zone Width (Left Bank)	6	9
10b. Riparian Vegetative Zone Width (Right Bank)	7	10
Total Score	*165*	*178*
Condition Category	*optimal*	*optimal*

TABLE 3. Results of the Benthic Macroinvertebrate Sampling

Taxa:	*Jun'07 Station #1*	*Sep'07 Station #1*	*Jun'07 Station #10*	*Sep'07 Station #10*
Sphaeracea (fingernail clams)				
Corbiculidae				
Corbicula fluminea	1	1		1
Limnophila (snails)				
Limnaeidae				
Fossaria sp.		1		1
Amphipoda (scuds or side swimmers)				
Gammaridae				
Gammarus sp.	1	1	1	5
Ephemeroptera (mayflies)				
Baetidae				
Acentrella sp.		3	3	
Baetis sp.			5	
Centroptilum sp.		16		
Heterocloeon sp.	1			
Ephemerellidae				
Drunella sp.			1	
Serratella sp.			2	2
Heptageniidae				
Stenonema sp.	2			
Siphlonuridae				
Ameletus sp.	2			10
Plecoptera (stoneflies)				
Perlidae				
Acroneuria sp.	4	2	2	2
Eccoptura sp.	2		7	
Trichoptera (caddisflies)				
Brachycentridae				
Brachycentrus sp.	53	51	30	50
Glossosomatidae				
Glossosoma sp.	2	2	4	
Hydropsychidae				
Cheumatopsyche sp.	1		4	4
Hydropsyche sp.	17	8	20	6

TABLE 3. Results of the Benthic Macroinvertebrate Sampling (continued)

Taxa:	***Jun'07 Station #1***	***Sep'07 Station #1***	***Jun'07 Station #10***	***Sep'07 Station #10***
Philopotamidae				
Chimarra sp.	4	2	10	
Rhyacophilidae				
Rhyacophila sp.	1			
Uenoidae				
Neophylax sp.	4	2		1
Coleoptera (beetles)				
Elmidae				
Dubiraphia sp.	1		1	
Optioservus sp.				1
Stenelmis sp.	3	6	9	9
Psephenidae				
Psephenus sp.	4	8	1	5
Diptera (true flies)				
Chironomidae				
Chironominae			3	
Orthocladiinae	1	1		3
Tipulidae				
Antocha sp.		1	1	5
Total # taxa:	***18***	***15***	***17***	***15***
Total # individuals:	***104***	***105***	***104***	***105***

TABLE 4. Scoring Criteria for Rapid Bioassessments in New Jersey Streams

	Non-impaired	***Moderately Impaired***	***Severely Impaired***
Biological Condition Score:	***6***	***3***	***0***
Biometrics:			
1. Taxa Richness	>10	10-5	4-0
2. EPT Index	>5	5-3	2-0
3. %CDF	<40	40-60	>60
4. %EPT	>35	35-10	<10
5. Family Biotic Index	<5	5-7	>7
Biological Condition:	Total Score		
Non-impaired	24-30		
Moderately Impaired	9-21		
Severely Impaired	0-6		

TABLE 5A. Calculation of Biological Condition for Station #1 – June '07

Taxa	*Tolerance Value*	*Station #1 – June '07 Number of Individuals*
Corbiculidae	6	1
Gammaridae	6	1
Baetidae	5	1
Heptageniidae	3	2
Siphlonuridae	4	2
Perlidae	2	6
Brachycentridae	1	53
Glossosomatidae	1	2
Hydropsychidae	4	18
Philopotamidae	3	4
Rhyacophilidae	1	1
Uenoidae	3	4
Elmidae	4	4
Psephenidae	4	4
Chironomidae	6	1
Taxa Richness		15
EPT Index		10
%CDF		51% Brachycentridae
%EPT		89%
Family Biotic Index		2.24 excellent water quality; no apparent organic pollution
NJIS Rating		27
Biological Condition		non-impaired

TABLE 5B. Calculation of Biological Condition for Station #1 – September '07

Taxa	*Tolerance Value*	*Station #1 – September '07 Number of Individuals*
Corbiculidae	6	1
Limnaeidae	6	1
Gammaridae	6	1
Baetidae	5	19
Perlidae	2	2
Brachycentridae	1	51
Glossosomatidae	1	2
Hydropsychidae	4	8
Philopotamidae	3	2
Uenoidae	3	2
Elmidae	4	6
Psephenidae	4	8
Chironomidae	6	1
Tipulidae	3	1
Taxa Richness		14
EPT Index		7
%CDF		49% Brachycentridae
%EPT		82%
Family Biotic Index		2.66 excellent water quality; no apparent organic pollution
NJIS Rating		27
Biological Condition		non-impaired

TABLE 5C. Calculation of Biological Condition for Station #10 – June '07

Taxa	*Tolerance Value*	*Station #10 – June '07 Number of Individuals*
Gammaridae	6	1
Baetidae	5	8
Ephemerellidae	1	3
Perlidae	2	9
Brachycentridae	1	30
Glossosomatidae	1	4
Hydropsychidae	4	24
Philopotamidae	3	10
Elmidae	4	10
Psephenidae	4	1
Tipulidae	3	1
Chironomidae	6	3
Taxa Richness		12
EPT Index		7
%CDF		29% Brachycentridae
%EPT		85%
Family Biotic Index		2.81 excellent water quality; no apparent organic pollution
NJIS Rating		30
Biological Condition		non-impaired

TABLE 5D. Calculation of Biological Condition for Station #10 – September '07

Taxa	*Tolerance Value*	*Station #10 – September '07 Number of Individuals*
Corbiculidae	6	1
Limnaeidae	6	1
Gammaridae	6	5
Ephemerellidae	1	2
Siphlonuridae	4	10
Perlidae	2	2
Brachycentridae	1	50
Hydropsychidae	4	10
Uenoidae	3	1
Elmidae	4	10
Psephenidae	4	5
Chironomidae	6	3
Tipulidae	3	5
Taxa Richness		13
EPT Index		6
%CDF		48% Brachycentridae
%EPT		71%
Family Biotic Index		2.61 excellent water quality; no apparent organic pollution
NJIS Rating		27
Biological Condition		non-impaired