Upper Cohansey River Watershed Restoration and Protection Plan: Data Report

Developed by the Rutgers Cooperative Extension Water Resources Program

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Watershed Overview

The Cohansey River Watershed above U.S. Geological Survey (USGS) streamflow gauge #01412800 (henceforth, the Upper Cohansey River Watershed) is 31 square miles and is dominated by agricultural land uses (Figure 1). Based on a review of aerial photographs, input from Rutgers Cooperative Extension (RCE) of Cumberland County and the Cumberland-Salem Conservation District, and data collection during site visits, the agricultural land uses were further identified as row crops, field nurseries, sod farms, and container nurseries. The New Jersey Department of Environmental Protection (NJDEP, 2007) 2002 land use data identifies agricultural land uses within the Upper Cohansey River Watershed as cropland and pastureland, orchards and vineyards, nurseries and horticultural areas, confined feeding operations, and other agriculture (Figure 2).

The Upper Cohansey River Watershed is comprised of sections of Hopewell, Stow Creek, and Upper Deerfield Townships in Cumberland County and Alloway Township and Upper Pittsgrove Township in Salem County (Figure 3). Approximately 34 miles of river and streams occur within the watershed. The largest surface waterbody in the drainage area is Seeley Lake, which is located near the outlet of this watershed (Figure 3). Previously Bostwick Lake was another large surface waterbody within the watershed until dam failure occurred in 1999. It currently exists as a large wetland area (approximately 28 acres), and approval is being sought to rebuild the dam. The property is owned by three municipalities – Upper Deerfield, Hopewell, and Alloway Townships.

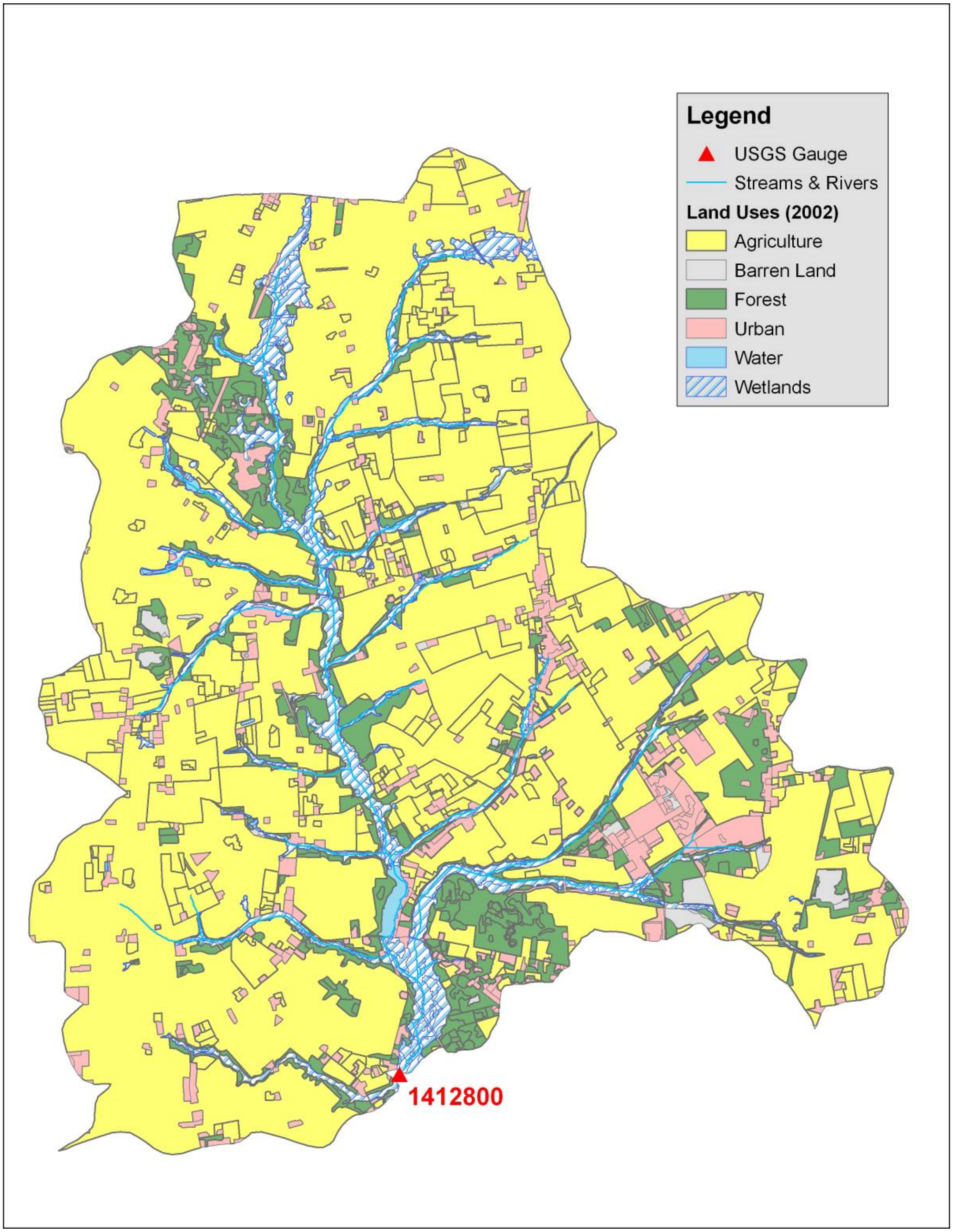
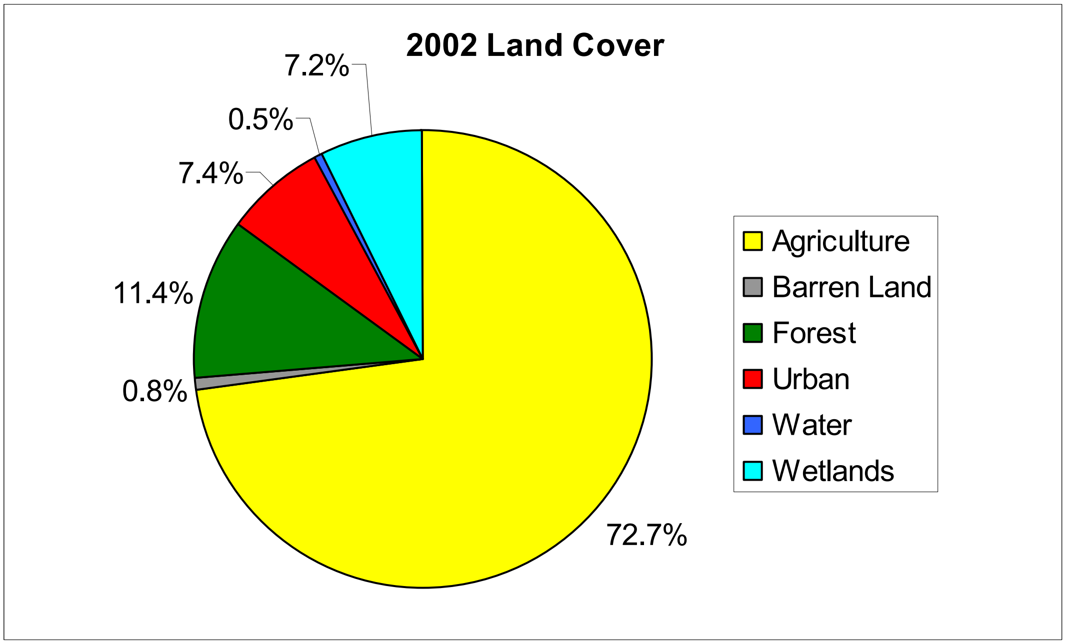


Figure 1: NJDEP 2002 land use/land cover map.



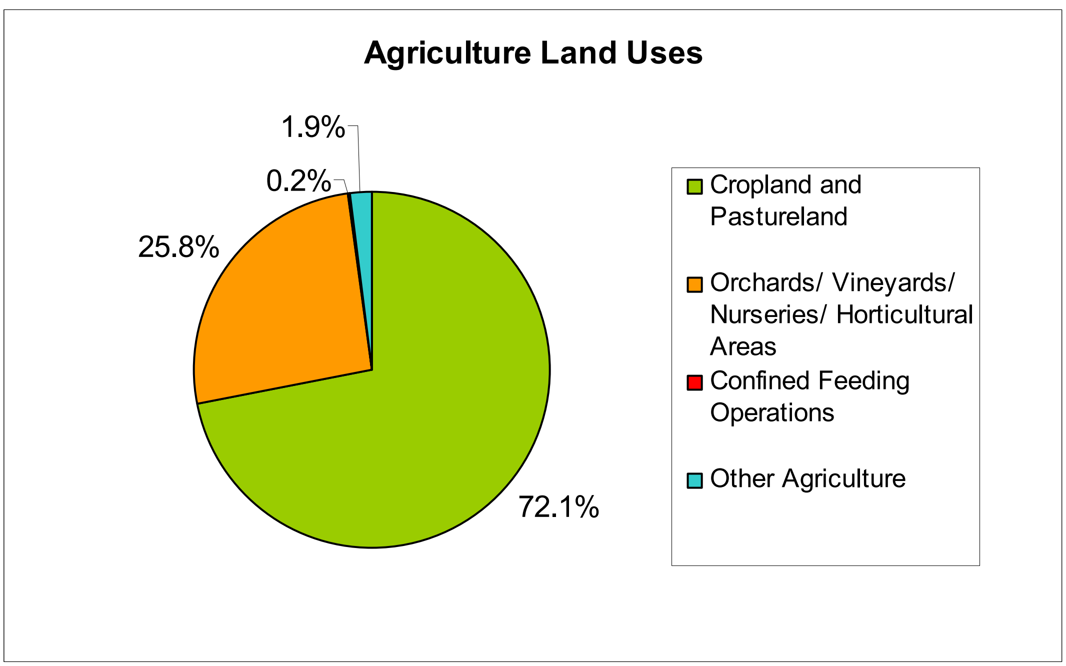


Figure 2: NJDEP 2002 land cover types and agriculture land uses in the Upper Cohansey River Watershed.

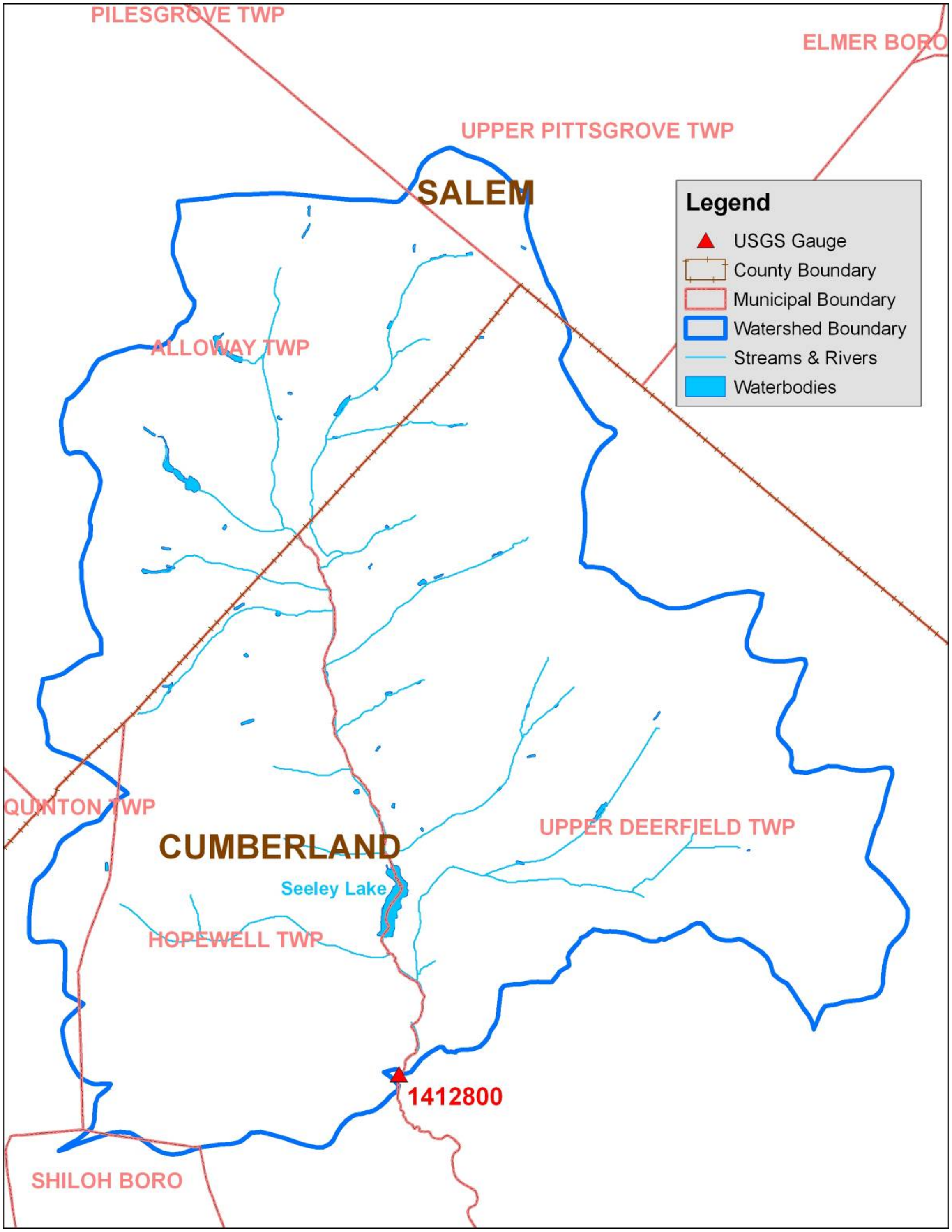


Figure 3: Municipalities and waterbodies located within the Upper Cohansey River Watershed.

Project Background and the TMDL Development Process

The development of the Upper Cohansey River Watershed Restoration and Protection Plan was funded in 2005 by the NJDEP (RP 05-079) and in part by the New Jersey Agricultural Experiment Station through a U.S. Department of Agriculture (USDA) Hatch grant. A Total Maximum Daily Load (TMDL) was developed based on data collected in the Cohansey River at USGS monitoring station 01412800 at Seeley Lake (Figure 3; NJDEP, 2003a) to address fecal coliform impairment.

TMDLs are developed by the NJDEP, and approval is given by the U.S. Environmental Protection Agency (USEPA). 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 every two (2) years through the development of a document referred to as the *New Jersey Integrated Water Quality Monitoring and Assessment Report*, a.k.a. the "Integrated List" (NJDEP, 2006). Within this document are sublists that indicate the presence and level of impairment for each waterbody monitored. The lists are defined as follows:

- **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 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 uses.
    - **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 uses.
    - **Sublist 4c** states that the impairment is not caused by a pollutant, but is due to factors such as instream channel condition, flow alteration, or habitat degradation. It is recommended by the USEPA that this list be a guideline for water quality management actions that will address the cause of impairment.
- **Sublist 5** clearly states that the water quality standard is not being attained and requires a TMDL.

According to the 2002 Integrated List of Impaired Waterbodies (NJDEP, 2002), the Upper Cohansey River at Seeley Lake was listed on Sublist 5 for fecal coliform and total phosphorus, thus, TMDLs were required.

The TMDL for fecal coliform used data collected at USGS streamflow gauge #01412800, Cohansey River at Seeley (Figure 3), to determine that a 66% reduction in fecal coliform loading to the Cohansey River is needed to achieve water quality standards. The TMDL was developed based on summer monitoring results (May through

September) from 1994-2000. The TMDL further states that the load duration curve is consistent with storm-driven values of fecal coliform (NJDEP, 2003a).

Data collected on the Cohansey River at the USGS monitoring station also indicated that the waterway was impaired for total phosphorus (TP), thereby requiring a TMDL for this pollutant. The TMDL developed for TP at this location calls for a relatively high reduction in phosphorus loading. Using the TP standard for freshwater rivers (0.1 mg/L), the phosphorus reduction is mandated at 52%. However, since the Cohansey River drains to Sunset Lake, which also has a TP TMDL (NJDEP, 2003b), the applicable lake criterion of 0.05 mg/L has been used to develop a TP TMDL requiring a load reduction of 92% (NJDEP, 2005a). This higher reduction of **92%** must be met for the entire lakeshed, which includes the portions of the Upper Cohansey River that this study is addressing.

The purpose of this report is to provide a summary of available water quality data for the Upper Cohansey River Watershed, as well as describe the protocols and results of data collected by the RCE Water Resources Program and its partners. A complete analysis of this data to target pollution sources and remediation measures will be presented in the Upper Cohansey River Watershed Restoration and Protection Plan.

Biological Monitoring Data

Biological monitoring data is available for the watershed as part of the Ambient Biological 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, 2004). 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 approximately 200 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. 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). 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 currently used by the NJDEP 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.

Starting with the second round of sampling under the AMNET program held between 2000 and 2001 for the Lower Delaware River region, 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. 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, 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 the study area.

The NJDEP Bureau of Biological & Freshwater Monitoring maintains four AMNET stations within the Upper Cohansey River Watershed (i.e., Stations AN0712, AN0711, AN0710, and AN0709) (Figure 4). All four stations were sampled in AMNET rounds in 1995, 2000, and 2006. In October 1995, AN0712 and AN0710 were assessed by NJDEP under the AMNET program as being moderately impaired, and AN0709 was assessed as being non-impaired (Table 1). AN0711 was assessed as being severely impaired (NJDEP, 1996). In October 2000, AN0712 and AN0710 were again assessed as being moderately impaired (Table 1). Conditions at AN0709 resulted in a change from the 1995 non-impaired status to being moderately impaired (Table 1). Location AN0711 was again assessed as being severely impaired. In October 2006, AN0710, AN0711, and AN0712 were assessed as moderately impaired, while AN0709 was assessed as non-impaired (Table 1).

Habitat assessments were also included in the October 2000 AMNET sampling. Optimal habitat conditions were found at locations AN0712 and AN0709 in October 2000, whereas suboptimal habitat conditions were noted at locations AN0710 and

AN0711 (NJDEP, 2003c; Table 1). In the third round of assessment held in 2006, habitat conditions were scored as suboptimal at all four stations (Table 1).

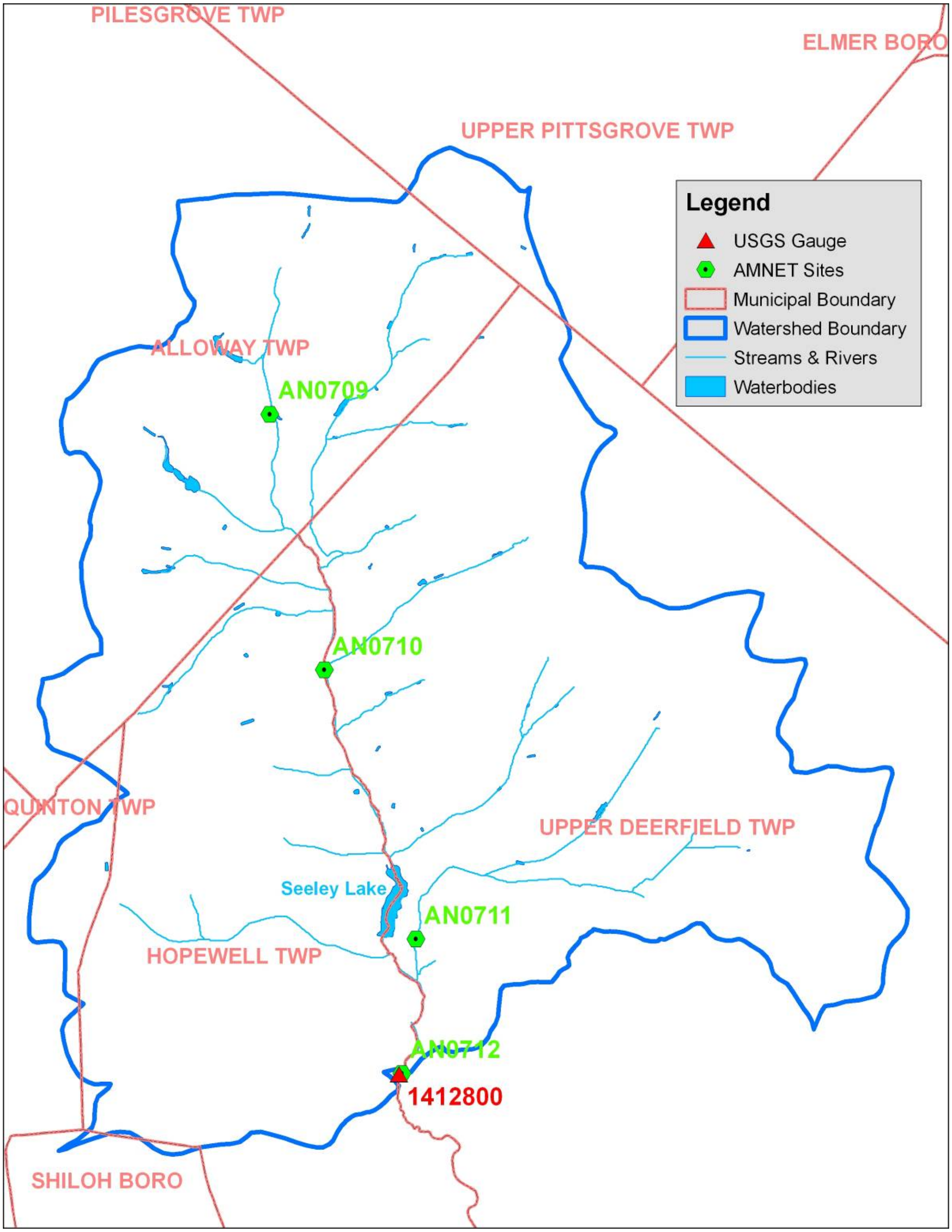


Figure 4: Upper Cohansey River Watershed with State and Federal monitoring stations.

Table 1: Summary of NJDEP Ambient Biological Monitoring Network Results (NJDEP, 1996; NJDEP, 2003c; NJDEP, 2009a)

		1996 Results			2000 Results				2006 Results*		
Station	**Location**	**Date Sampled**	**Impairment Status (Score)**	**Comments**	**Date Sampled**	**Impairment Status (Score)**	**Habitat Analysis Result (Score)**	**Comments**	**Date Sampled**	**Impairment Status**	**Habitat Analysis Result (Score)**
AN0709	Cohansey River, Beal Road, Alloway, NJ	10/19/1995	Non-Impaired (27)	--	10/17/2000	Moderately Impaired (15)	Optimal/ Excellent (166)	Paucity of clean organisms	10/24/2006	Non-Impaired	Suboptimal/ Good (131)
AN0710	Cohansey River, Route 540, Hopewell, NJ	10/19/1995	Moderately Impaired (15)	Paucity of clean organisms	10/17/2000	Moderately Impaired (12)	Suboptimal/ Good (131)	Paucity of clean organisms	10/24/2006	Moderately Impaired	Suboptimal/ Good (147)
AN0711	Parsonage Run, Finley Road, Upper Deerfield, NJ	10/19/1995	Severely Impaired (3)	Paucity of clean organisms; significant organic pollution	10/17/2000	Severely Impaired (3)	Suboptimal/ Good (158)	Paucity of clean organisms; significant organic pollution	10/24/2006	Moderately Impaired	Suboptimal/ Good (151)
AN0712	Cohansey River, Silver Lake Road, Upper Deerfield, NJ	9/26/1995	Moderately Impaired (12)	Paucity of clean organisms	9/19/2000	Moderately Impaired (21)	Optimal/ Excellent (176)	--	11/28/2006	Moderately Impaired	Suboptimal/ Good (136)

**Results from 2006 AMNET sampling are preliminary and may be subject to change when the completed report becomes available.*

Given these aquatic life impairments, an additional biological assessment of the Upper Cohansey River Watershed was proposed as part of the development of the Watershed Restoration and Protection Plan for the Upper Cohansey River. The biological assessment conducted by the RCE Water Resources Program in October 2006 is fully described in Appendix A. The data collected by the RCE Water Resources Program indicate that the Upper Cohansey River Watershed, within the study area, continues to support a moderately to severely impaired benthic macroinvertebrate community. The benthic macroinvertebrate community occurring within the Upper Cohansey River Watershed is apparently under some type of stress as evidenced by low taxa richness, the lack of representation of EPT taxa, and relatively high family biotic index scores. The types of organisms found, or the lack thereof, indicate that possible chemical perturbations are occurring within the system, and/or the benthic community may be subject to physical or habitat constraints. The habitat assessment revealed suboptimal habitat conditions, which may also explain the observed impaired benthic macroinvertebrate community.

Biological assessments have become an important tool for managing water quality to meet the goal of the Clean Water Act (i.e., to maintain the chemical, physical, and biological integrity of the nation's water). Although biological assessments are a critical tool for detecting impairment, they do not identify the cause or causes of the impairment. The USEPA developed a process, known as the Stressor Identification (SI) process, to accurately identify any type of stressor or combination of stressors that might cause biological impairment (USEPA, 2000). The SI process involves the critical review of available information, the formation of possible stressor scenarios that may explain the observed impairment, the analysis of these possible scenarios, and the formation of conclusions about which stressor or combination of stressors are causing the impairment. The SI process is iterative, and in some cases additional data may be needed to identify the stressor(s). In addition, the SI process provides a structure or a method for assembling the scientific evidence needed to support any conclusions made about the stressor(s). When the cause of a biological impairment is identified, stakeholders are then in a better position to locate the source(s) of the stressor(s) and are better prepared to implement the appropriate management actions to improve the biological condition of the impaired waterway. The SI process is recommended as the next step toward improving the biological condition of the Upper Cohansey Watershed.

Stream Visual Assessment Protocol (SVAP) Data Collected in the Upper Cohansey River Watershed

Introduction to SVAP

To characterize watershed health, the USDA Natural Resources Conservation Service (NRCS) developed the Stream Visual Assessment Protocol (SVAP). The SVAP was originally developed for use by landowners (USDA, 1998), but it has also proved to be useful for those familiar with local river systems and flooding occurrences. The protocol provides an outline on how to quantitatively score in-stream and riparian qualities that include water appearance, channel condition, and riparian health. There are ten (10) primary SVAP elements:

- channel condition,
- hydrologic alternation,
- riparian zone,
- bank stability,
- water appearance,
- nutrient enrichment,
- barriers to fish movement,
- instream fish cover,
- presence of pools, and
- invertebrate habitat.

There are five (5) additional elements that should only be scored if applicable. These are canopy cover, manure presence, salinity, riffle embeddedness, and observed macroinvertebrates. Elements are scored from 1 to 10 (poor to excellent) with the exception of observed macroinvertebrates, which uses a scale ranging from 1 to 15 (poor to excellent). Once all the individual elements are scored, their average is calculated and the range of mean scores is used to qualitatively describe overall watershed health as follows:

- < 6.0 is Poor;
- 6.1-7.4 is Fair;

- 7.5-8.9 is Good;
- > 9.0 is Excellent.

The SVAP data sheet was modified by the RCE Water Resources Program to include other reach features to aid in pollution source track down in the Upper Cohansey River Watershed. These reach features include the identification of pipes and ditches, details on erosion or impairment caused by identified pipes or ditches, and access to stream reach for possible restoration. Additionally, all assessed reaches were photo-documented, and a site sketch was made denoting important reach characteristics.

SVAP in the Upper Cohansey River Watershed

SVAP assessments were conducted in the Upper Cohansey River Watershed beginning in June 2005. In May 2005, staff members from all project partners were trained in SVAP procedures. The training workshop consisted of a full day of SVAP introduction and use, and included presentations in a classroom setting and group and paired exercises in the field. This training also included instructions on how to use the RCE online database entry system for SVAP data. The project watershed was divided into a gridded map, and individual maps of each grid were assigned to participating project partners to facilitate completion of the Upper Cohansey River Watershed SVAP assessments.

Access to the river system was the major obstacle in completing visual assessments in the Upper Cohansey River Watershed. Due to the agricultural land use dominating the watershed, it was necessary to alert all landowners of this upcoming effort. Therefore, announcements were made in local newspapers, and letters were hand-delivered to the largest landowners. This was advantageous to the project, as feedback from these landowners improved the assessments and additional information about the stream conditions were gained that might otherwise have been unavailable.

At the onset of the assessment effort, it was decided that macroinvertebrates observed were not to be scored as part of this SVAP process since macroinvertebrate data were collected as part of the NJDEP-approved sampling plan for this project (Appendix A).

SVAP Data

Thirty-five stream reaches were evaluated in the Upper Cohansey River Watershed (Figure 5; Appendix B). Assessed reaches ranged from 24 feet to 840 feet long, approximately. The overall SVAP score for all thirty-five reaches was 7.41, a resulting watershed quality of "good" (Table 2). There were no signs of manure presence, livestock access to the stream, or manure storage facilities within the floodplain (Table 2; Appendix B). Riffles were present at 12 locations and received an average score of poor, which means that riffles were on average 30-40% embedded. Canopy cover was scored at almost every reach and was the highest scoring assessment element with an average score of 8.36 (Table 2). Other than riffle embeddedness, which is an optional assessment element (scored only if present), pools were the lowest scoring assessment element. None of the assessed stream reaches received a score of "excellent" (Table 2).

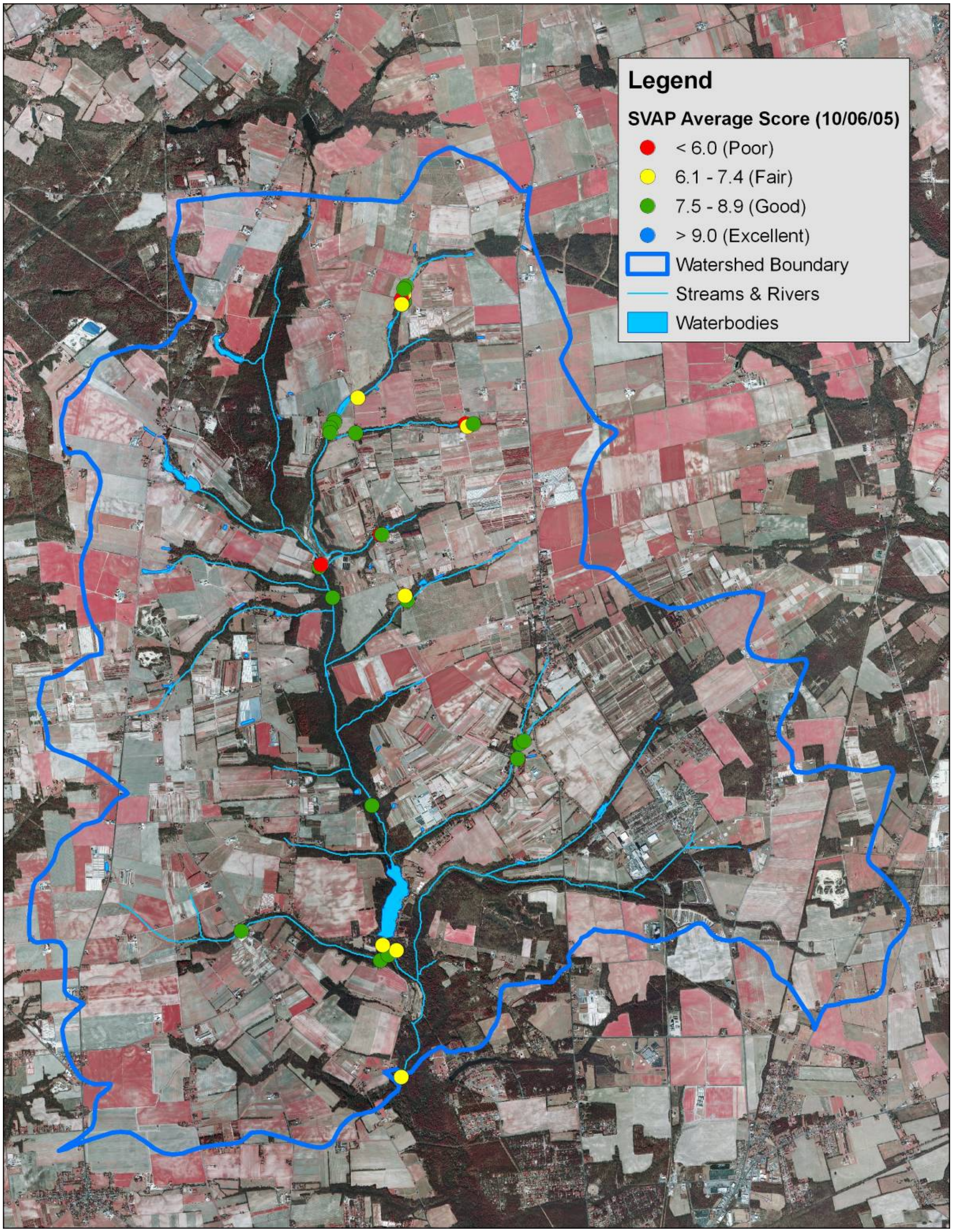


Figure 5: Stream visual assessment reaches with scores in the Cohansey River Watershed.

Table 2: SVAP Assessment Elements and Data

	Channel Condition	**Hydrologic Alteration**	**Riparian Zone - left bank**	**Riparian Zone - right bank**	**Bank Stability - left bank**	**Bank Stability - right bank**	**Water Appearance**	**Nutrient Enrichment**	**Barriers to Fish Movement**
# of scores	35	35	35	35	35	35	35	35	34
minimum value	2.0	2.0	1.0	1.0	3.0	3.0	1.0	1.0	4.0
maximum value	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
average	7.36	8.20	7.63	7.63	7.06	6.51	6.43	7.91	7.91

	Instream Fish Cover	**Pools**	**Invertebrate Habitat**	**Canopy Cover**	**Manure Presence**	**Riffle Embeddedness**	**Water Appearance & Nutrient Enrichment Averages**	**Tiered Assessment Averages***
# of scores	35	34	35	33	NA	12	35	35
minimum value	3.0	1.0	2.0	1.0	NA	1.0	1.0	3.88
maximum value	10.0	10.0	10.0	10.0	NA	8.0	10.0	9.00
average	7.71	6.26	7.89	8.36	NA	5.08	6.87	7.26

	Overall Average - left bank	***Overall Average - right bank***	***Overall Site Average***
# of scores	***35***	***35***	***35***
minimum value	***4.18***	***4.18***	***4.18***
maximum value	***8.82***	***8.80***	***8.80***
average	***7.44***	***7.39***	***7.41***

** "Tiered Assessment Averages" refers collectively to Hydrologic Alteration, Channel Condition, Riparian Zones left and right, Bank Stability left and right, Water Appearance, and Nutrient Enrichment.*

Using the SVAP Data

SVAP scores will be evaluated as individual assessment elements and combined with other data collected as part of this restoration planning effort. The SVAP results will be compared to land use, soil characteristics, slope and stream gradient, and water quality monitoring results to determine the quality of waters within the Upper Cohansey River Watershed. The SVAP scores, information on pipes, ditches, photos, and remediation notes will be used to identify sources of pollution and potential opportunities for improved management.

Water Quality Sampling Overview

To identify the cause(s) of impairment observed through both the SVAP results and biological sampling, project partners, including NJDEP, the RCE of Salem and Cumberland Counties, the RCE Water Resources Program, and the Cumberland-Salem Conservation District, began water quality monitoring on June 14, 2006. As per the NJDEP-approved Quality Assurance Project Plan (QAPP), *in situ* measurements of pH, dissolved oxygen (DO), and temperature were collected (Appendix C). Stream velocity and depth were measured across stream transects at each sampling station. Using this information, flow (Q) was calculated for each event where access to the stream was deemed safe. Water samples were collected and analyzed by QC Laboratories in Vineland, New Jersey (NJDEP Certified Laboratory #PA166) for TP, dissolved orthophosphate phosphorus, ammonia-nitrogen, total Kjeldahl nitrogen (TKN), nitrate-nitrogen, nitrite-nitrogen, total suspended solids (TSS), and fecal coliform.

Water quality monitoring included three different types of sampling events (Table 3). Regular monitoring, which included analysis for all parameters, occurred from June 14, 2006 through November 15, 2006 (Table 3). These events were monitored for all *in situ* parameters, velocity and depth, and TP, dissolved orthophosphate phosphorus, ammonia-nitrogen, TKN, nitrate-nitrogen, nitrite-nitrogen, TSS, and fecal coliform. Bacteria-only monitoring was conducted in the summer months of July through September 2006 (Table 3). This entailed collecting three additional samples in each of those months for fecal coliform analysis, as well as the *in situ* parameters and velocity and depth. In addition, water samples from three storm events were collected in

September through November 2006 (Table 3). Four samples were collected over the course of each storm event for all parameters at all ten (10) monitoring locations.

Table 3: Water Quality Monitoring Events

Date	Regular Monitoring for all Parameters	Bacteria-Only Monitoring	Storm Event Monitoring
6/14/2006	X		
6/28/2006	X		
7/12/2006	X		
7/14/2006		X	
7/19/2006		X	
7/21/2006		X	
7/26/2006	X		
8/2/2006		X	
8/9/2006	X		
8/16/2006		X	
8/23/2006		X	
8/30/2006	X		
9/6/2006		X	
9/11/2006		X	
9/13/2006	X		
9/14/2006	X		X
9/22/2006		X	
9/27/2006	X		
10/4/2006	X		
10/17/2006			X
10/24/2006	X		
11/1/2006	X		
11/15/2006	X		
11/17/2006			X

Surface water samples were regularly collected from ten (10) water quality monitoring stations over the six-month sampling time frame (Figure 6). Five stations were located on the mainstem Cohansey River, and five stations were located on tributaries to the Cohansey River (Figure 6). Station locations are identified in Table 4. All water quality data are presented in Appendices C and D.

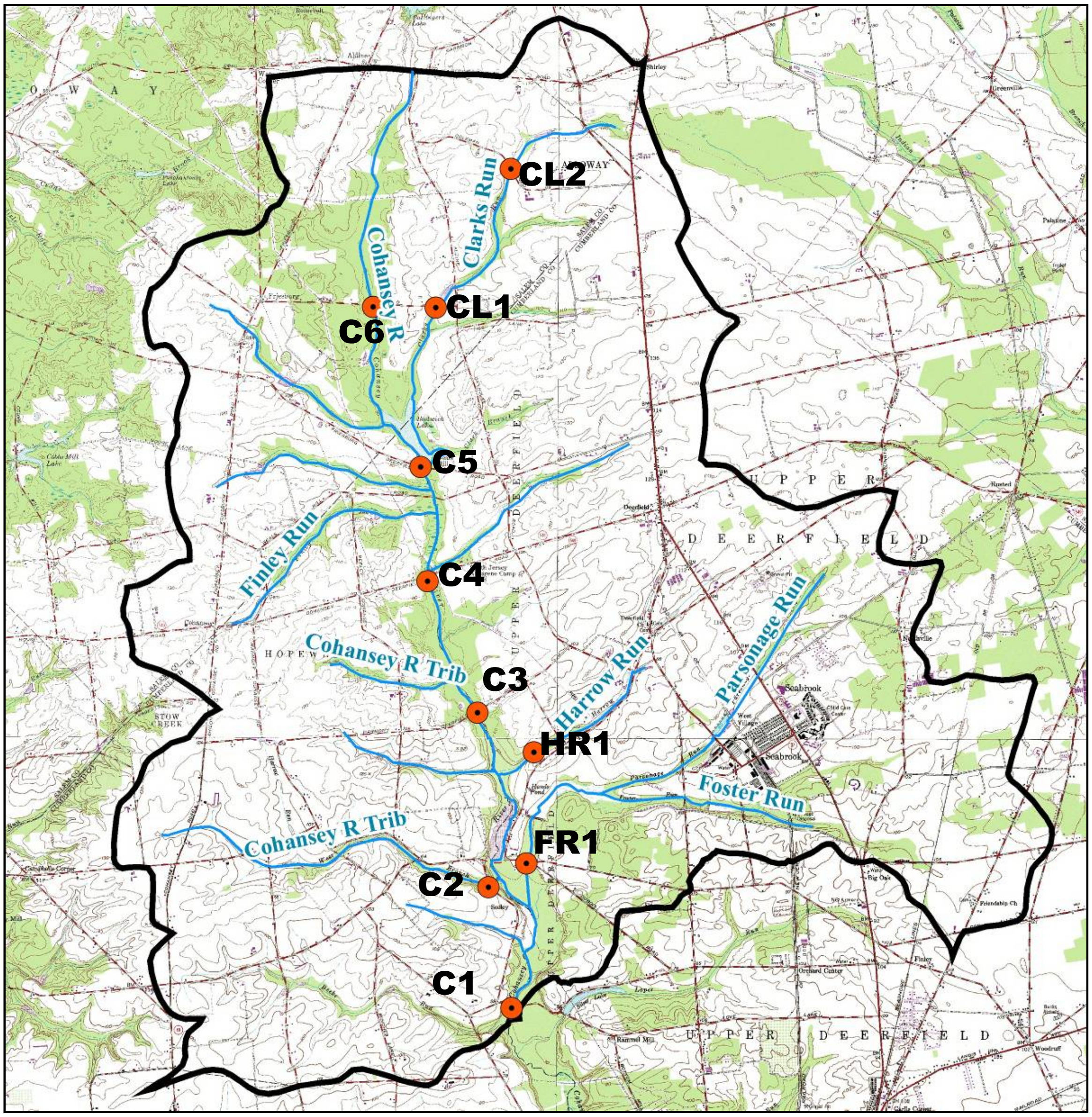


Figure 6: Water Quality Monitoring Stations Map.

Table 4: Water Quality Monitoring Location IDs and Descriptions

Site ID	Site Description
C1	Cohansey River at USGS 01412800 at Seeley Lake (also AN0712)
FR1	Parsonage Run at Finley Road (AN0711)
C2	Tributary to the Cohansey River at Holding Road
HR1	Harrow Run near Cake Road
C3	Cohansey River at Harmony Road
C4	Cohansey River at Cohansey-Deerfield Road (AN0710)
C5	Cohansey River below Bostwick Lake at Friesburg-Deerfield Road
C6	Cohansey River at Beale Road (AN0709)
CL1	Clarks Run at Beale Road below dam
CL2	Clarks Run at Coleman Road

Data Results and Comparison to Water Quality Standards

To evaluate the health of the Upper Cohansey River at all ten (10) stations, the monitoring results were compared to the designated water quality standards. Water quality standards are developed according to the waterbody's designated uses (NJDEP, 2008). The Cohansey River is classified as FW2-NT, or freshwater (FW) non-trout (NT). "FW2" refers to waterbodies that are used for primary and secondary contact recreation; industrial and agricultural water supply; maintenance, migration, and propagation of natural and established biota; public potable water supply after conventional filtration treatment and disinfection; and any other reasonable uses. "NT" means those freshwaters that have not been designated as trout production or trout maintenance. NT waters are not suitable for trout due to physical, chemical, or biological characteristics, but can support other fish species (NJDEP, 2008). The applicable water quality standards for this project are detailed in Table 5. Due to drainage from Seeley Lake (Figure 2), the FW2 Lakes standard was applied to TP results from this study.

Table 5: Water Quality Standards according to N.J.A.C. 7:9B

Substance	Surface Water Classification	Criteria
pH (S.U.)	FW2	6.5 - 8.5
TP (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.
	FW2 Lakes	Phosphorus as total P shall not exceed 0.05 in any lake, pond, or reservoir, or in a tributary at the point where it enters such bodies of water, except where watershed or site-specific criteria are developed pursuant to N.J.A.C. 7:9B-1.5(g)3.
TSS (mg/L)	FW2-NT	Non-filterable residue/suspended solids shall not exceed 40.
Bacterial counts (Col/100 mL): Fecal Coliforms	FW2	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.

The NJDEP's Integrated Water Quality Monitoring and Assessment Methods advises 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, 2009b). NJDEP has further stated that a minimum of eight samples collected quarterly over a two-year period are required to confirm the quality of waters (NJDEP, 2005b; NJDEP, 2009b). Therefore, if a waterbody has a minimum of eight samples collected quarterly over a two-year period and samples exceed the water quality criteria for a certain parameter twice, the waterbody is considered "impaired" for that parameter. By applying this rule to the Upper Cohansey River Watershed water quality data, it is possible to identify which stations are impaired for each parameter that has been identified as a concern for this project (i.e., pH, TP, TSS, aquatic life impairment, and fecal coliform). The number of samples exceeding these standards is given in Table 6.

Table 6: Number of Samples that Exceed Water Quality Criterion

	Selected Monitoring Parameters			
Station	**pH**	**TP**	**TSS**	**Fecal coliform***
C1	12	10	1	5
C2	22	5	2	5
FR1	18	13	0	9
HR1	21	6	2	9
C3	22	7	1	5
C4	21	8	1	3
C5	20	8	1	8
CL1	8	9	1	2
C6	8	6	0	6
CL2	20	7	0	7

**For fecal coliform, the number of samples higher than the 400 col/100ml standard was calculated.*

At the time of this project's initiation and during the time of data collection, fecal coliform was the accepted measure indicating pathogen pollution for New Jersey freshwaters. Since then, the fecal coliform standard has been replaced by the measure of *Escherichia coli* (*E. coli*). For New Jersey freshwaters, *E. coli* shall not exceed a geometric mean of 126 colonies/100mL or a maximum count of 235 col/100mL in a single sample (NJDEP, 2008). However, at the time of this study, only fecal coliform data were collected, which is the measure used in the TMDL for this watershed. Therefore, the water quality standard applied to our results is for fecal coliform.

Tabulated water quality monitoring results are provided in Appendix D. Water quality monitoring data have also been graphed with water quality criteria, and these are available in Appendix E.

MST Data in the Upper Cohansey River Watershed

Microbial source tracking (MST) techniques have recently been developed that have the ability to identify the origin of fecal pollution. 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 source as a percentage of targeted bacteria. One of the most promising 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).

Three sets of PCR primers (targets) were used to quantify *Bacteroides* from 1) all sources of *Bacteroides* ("AllBac"), 2) human sources ("HuBac"), and 3) bovine sources of *Bacteroides* ("BoBac"). This assay is based on published results from a study sponsored by the Tennessee Department of Environmental Conservation (Layton *et al.*, 2006).

Methods

Samples were collected in sterile bottles at all ten (10) monitoring sites as described in the previous section and held at 4˚C until processing. A total of 290 samples were processed over the sampling period. 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 in the Upper Cohansey River Watershed 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. All other procedures that were followed are outlined by Layton *et al.* (2006).

Results of qPCR

Bacteroides from all sources could be readily detected in 100 ml surface water samples by using the qPCR assay. In addition, human and bovine contributions to fecal contamination could be easily distinguished from each other by the relative proportions of the three target sequences. Results from all ten sampling locations on two separate days are shown in Figure 7. There were 1.59 inches of rain on 6/28/05 (Figure 7a) and 0.14 inches on 7/12/05 (Figure 7b). Bovine *Bacteroides* were rarely detected.

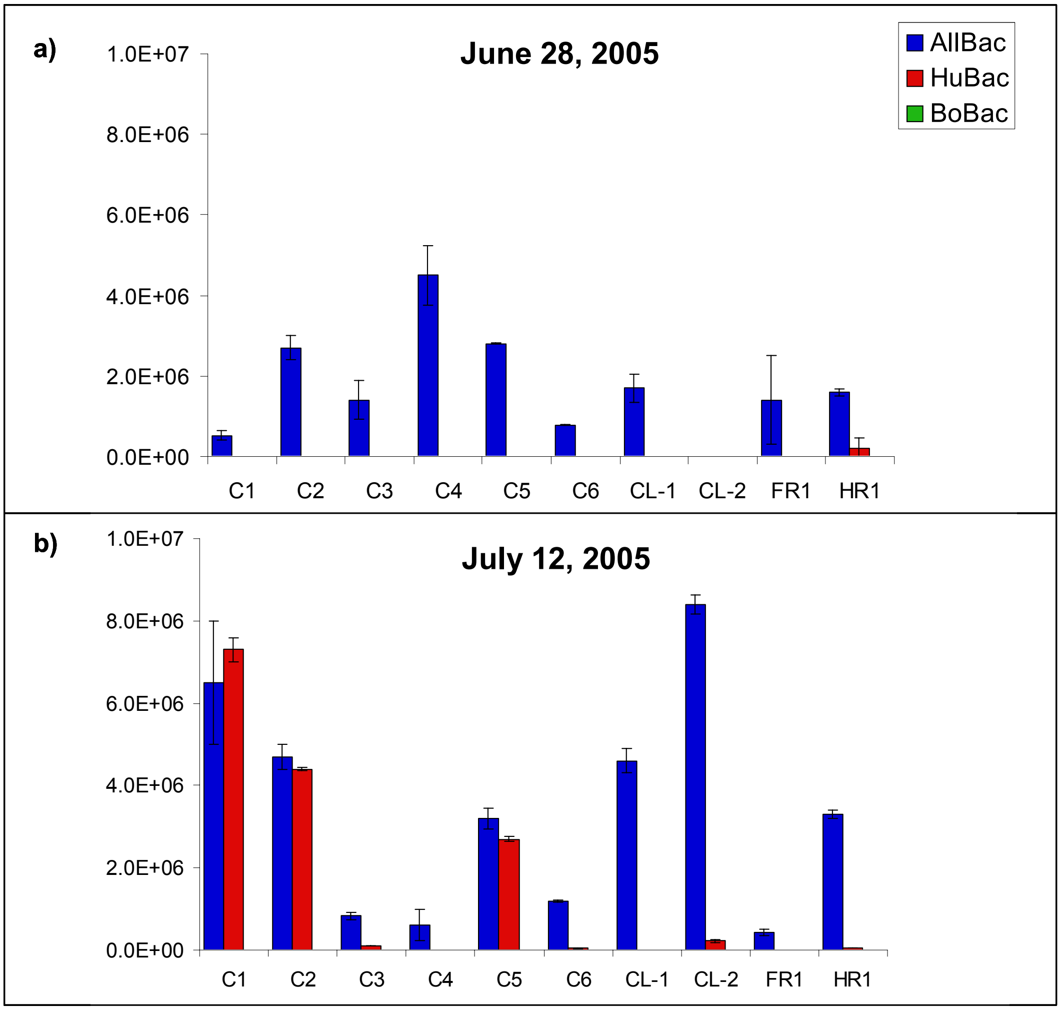


Figure 7: Sample Data Showing the Numbers of *Bacteroides* Detected by the Three Primer Sets on Two Days of Sampling at 10 Stations

The numbers of *Bacteroides* present in individual samples was also compared to the other indicators of water quality including fecal coliform (Table 7). Despite the lack of obvious correlations between total *Bacteroides* and fecal coliform, or any of the other water quality measurements, it is useful data in regard to the sources and extent of fecal contamination in the watershed. These data show the highly variable nature of all of the water quality measures used.

Table 7: Comparison of *Bacteroides* Measurements by qPCR to Other Measures of Water Quality at Three Stations on Five Sampling Dates

Station	Date	Precipitation (in.)	TSS (mg/L)	Total Nitrogen (mg/L)	TP (mg/L)	Fecal Coliform (cfu/100ml)	AllBac (copies/100ml)
C1	6/14	0.00	2.0	5.89	<0.025	10	BD
	6/28	1.59	62.0	3.24	0.439	>600	BD
	7/12	0.14	5.3	5.20	<0.025	20	6.5×10^6
	7/26	0.00	6.7	4.68	0.113	80	8.0×10^5
	8/9	0.44	6.7	6.04	0.034	2000	6.8×10^5
HR1	6/14	0.00	5.3	6.96	<0.025	5	1.8×10^6
	6/28	1.59	73.0	1.85	0.431	>600	1.6×10^6
	7/12	0.14	3.0	7.22	<0.025	190	3.3×10^6
	7/26	0.00	8.0	7.11	0.078	250	1.4×10^6
	8/9	0.44	5.7	8.25	0.034	2000	4.8×10^6
CL2	6/14	0.00	4.7	5.10	<0.025	10	1.6×10^7
	6/28	1.59	39.0	1.65	0.915	>601	BD
	7/12	0.14	10.7	6.13	0.061	100	8.4×10^6
	7/26	0.00	8.7	2.16	<0.025	370	2.1×10^6
	8/9	0.44	5.0	6.30	<0.025	50	1.8×10^6

(BD – below detection)

Source Identification with qPCR

Pollution sources could be determined by the frequency of detection of specific markers at particular stations over ten summer events (Table 8). These data show that certain stations have a higher incidence of contamination with human (C1, C2, C4 and HR1) or bovine (C3) feces.

Table 8: Frequency of Detection of AllBac, HuBac (Human), or BoBac (Bovine) Target Sequences

	% of Samples Containing Target Sequence									
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**CL-1**	**CL-2**	**FR1**	**HR1**
AllBac	70	90	100	70	100	90	100	90	80	100
HuBac	40	30	20	30	10	10	10	10	0	30
BoBac	10	10	20	10	10	10	0	10	0	0

Data Summary

The data show a variety of water quality concerns in the Upper Cohansey River Watershed. The AMNET macroinvertebrate results show moderate impairments to the biological communities within the watershed (Table 1). This is also seen in the RCE collected macroinvertebrate data (Appendix A). The biological community may be impacted by environmental stressors or degraded habitat. Habitat conditions assessed by both NJDEP through AMNET and the RCE assessments show suboptimal conditions in areas within the watershed (Table 1; Appendix A). Habitat quality may be low due to physical alterations as observed during SVAP assessments conducted throughout the watershed. Overall quality of the streams was assessed as "good" but individual element scores ranged from "fair" to "good" (Table 2). Further analysis of this data may help to explain what physical factors (i.e., erosion, habitat structure, and water availability) may be responsible for the composition of the macroinvertebrate communities seen in the watershed.

While the biological monitoring and SVAP assessments shed light on watershed quality, water monitoring provides possible reasons for this quality. Results indicate that TP and fecal coliform concentrations, and pH levels are in violation of water quality criteria established by the NJDEP (Table 6; Appendix D). All ten (10) monitoring locations were in violation of both pH and TP water quality standards in greater than 10% of the samples (Table 6). Nine (9) stations were in violation of fecal coliform (Table 6). Tracking of bacterial sources within the watershed indicate a higher human contribution to bacteria at stations C1, C2, C4 and HR1, and a higher bovine contribution at station C3 (Table 8). Water quality data will be combined with land use data analysis to determine sources of pollutants.

A full analysis of data will be conducted and presented in the Upper Cohansey River Watershed Restoration and Protection Plan.

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Appendix A: Upper Cohansey River Watershed Restoration and Protection Plan, Data Summary – Biological Assessment (Prepared December 2007)

Introduction

The Upper Cohansey River Watershed is comprised of sections of Hopewell, Stow Creek, and Upper Deerfield Townships, Cumberland County and Alloway Township and Upper Pittsgrove Township, Salem County. Approximately 34 miles of river and streams occur within the watershed, which is dominated by agricultural land uses. Based upon the New Jersey Department of Environmental Protection (NJDEP) Ambient Biomonitoring Network (AMNET) data and data collected by the NJDEP/United States geological Survey (USGS) and Metal Recon Program, the Upper Cohansey River is impaired for phosphorous, lead, pH, and aquatic life, and is listed on Sublist 5 of the *New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report*. Additionally, a Total Maximum Daily Load (TMDL) for fecal coliform has been proposed for the Upper Cohansey River. This TMDL requires 66% reductions in nonpoint source bacteria loads from this agriculturally dominated watershed.

Due to the aquatic life impairment listing in the *New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report*, a biological assessment of the Upper Cohansey River Watershed was proposed as part of the development of a Watershed Restoration and Protection Plan for the Upper Cohansey River. The following is a data summary of the biological assessment conducted by the Rutgers Cooperative Extension (RCE) Water Resources Program in the Fall of 2006.

Biological Data Collection

A survey of the benthic macroinvertebrate community within the Upper Cohansey River Watershed was conducted by the Rutgers Cooperative Extension (RCE) Water Resources

Program on October 24, 2006 and October 25, 2006 in accordance with an approved Quality Assurance Project Plan (QAPP). Benthic macroinvertebrates were collected at four locations (i.e., sites C1, FR1, C3, and C6) within the study area (Figure 1). Location C4, Cohansey River at Cohansey-Deerfield Road, was listed as a survey location in the approved QAPP. Due to depth and substrate constraints at location C4 at the time of sampling, location C3 was selected as a safe alternative survey location. Location C1 can be found on the Cohansey River just downstream of the United States Geological Survey (USGS) gauging station #01412800 (39.47237366°N, 75.25555456°W). Location FR1 can be found on Foster Run/Parsonage Run at Finley Road (39.48724525°N, 75.25365388°W). Location C3 is situated on the Cohansey River at Harmony Road (39.50272721°N, 75.26019344°W), and location C6 is situated on the Cohansey River at Beale Road (39.54440681°N, 75.27422290°W).

Samples were collected using a multi-habitat sampling approach, which minimizes habitat or substrate variation between sampling sites and includes all likely functional feeding groups of macroinvertebrates in the stream. Given the nature of the substrate and the flow conditions at locations C1, C3, and C6, 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). At FR1, given the substrate and the flow conditions, samples were collected by jabbing a standard aquatic D-frame dip net in productive and stable habitats (i.e., snags, banks, macrophytes, and the bottom substrate) a total of 20 times (Barbour et al., 1999; NJDEP, 2008). 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 or the contents from the jabs were combined into a single container), and preserved in 80% ethanol for later subsampling, identification and enumeration.

A composite collection of a variety of coarse particulate organic matter (CPOM) forms (e.g., leaves, needles, twigs, bark, or fragments of these) was 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 was processed using a U.S. Standard No. 30 sieve and was added to the composite of the grab/jab 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; NJDEP, 2008). With the exception of 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 (Merritt and Cummins, 1988; Pennak, 1989; Peckarsky, *et al*., 1990; Thorp and Covich, 1991).

A habitat assessment was conducted in accordance with the methods used by the NJDEP Bureau of Freshwater & Biological Monitoring for low gradient streams (NJDEP, 2008). 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 location C1 was approximately 25 feet. The stream depth averaged 1.4 feet in run areas and was greater than 2.5 feet in pool areas. The stream velocity averaged 0.86 ft/sec. The canopy was completely open at this location. The inorganic substrate at location C1 consisted mostly of gravel with fine sands and silt in the depositional areas. The organic substrate was comprised mainly of detritus with some muck-mud. No sediment odors or oils were noted. The water was slightly turbid, and no water odors or surface oils were found. The water temperature was 11.4˚C; the pH was 6.44 SU, and the dissolved oxygen was found to be at 8.49 mg/L.

The stream width at location FR1 was approximately 10 feet. The stream depth averaged 1.1 feet in run areas and was greater than 2.0 feet in pool areas. The stream velocity averaged 0.48 ft/sec. The canopy was completely open at this location. The inorganic substrate at location FR1 consisted mostly of silt and some coarse sand. The organic substrate was dominated by muck-mud. This muck-mud substrate condition prevented safe wading at this location. No sediment odors or oils were noted. The water was turbid, and no water odors were noted. Flecks of water surface oils were observed. The water temperature was 10.5˚C; the pH was 7.27 SU, and the dissolved oxygen was found to be at 8.28 mg/L.

The stream width at location C3 was approximately 15 feet. The stream depth averaged 1.4 feet in run areas and ranged from 2.5 to 3.5 feet in pool areas. The stream velocity averaged 0.48 ft/sec. The canopy was partly open at this location. The inorganic substrate at location C3 consisted mostly of gravel with fine sands and silt in the depositional areas. The organic substrate was comprised mainly of detritus with some muck-mud. No sediment odors or oils were noted. The water was clear, and no water odors were noted. Flecks of water surface oils were observed. The water temperature was 9.8˚C; the pH was 7.42 SU, and the dissolved oxygen was found to be at 10.00 mg/L.

The stream width at location C6 was approximately 6 feet. The stream depth averaged 0.8 feet in run areas and was greater than 1.5 feet in pool areas. The stream velocity averaged 0.18 ft/sec. The stream was completely shaded at this location. The inorganic substrate at location C6 consisted of a mix of coarse sand, gravel, and some silt. The organic substrate was comprised mainly of detritus with some muck-mud. Sulfur sediment odors were noted. Sediment oils were absent. The water was clear, and no water odors were noted. Flecks of water surface oils were found. The water temperature was 9.6˚C; the pH was 7.29 SU, and the dissolved oxygen was found to be at 9.56 mg/L.

The predominant surrounding land use among the sampling locations was forest and shrub/scrub. Local watershed erosion was noted as being moderate at locations C1, C3, and C6 and heavy at FR1. Obvious sources of local watershed nonpoint sources of pollution were found to include runoff from roadways, as well as sedimentation from unstable and eroding stream banks.

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), suboptimal (good), marginal (fair), or poor. Table 1 outlines the habitat scoring criteria for low 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 sampling locations are summarized in Table 2. Locations C1, FR1, C3, and C6 have total scores of 138, 112, 138, and 114, respectively. These scores are indicative of suboptimal 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 21 different taxa of benthic macroinvertebrates were collected within the study area, representing three phyla (i.e., annelids, mollusks, and arthropods). The arthropods, in particular the insects, are the most strongly represented in terms of the number of different taxa present. A total of 13 insect families are 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 currently used by the NJDEP Bureau of Freshwater & Biological Monitoring are outlined in Table 4. 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. 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 (Table 4). Impairment scores for locations C1, FR1, C3 and C6 are provided in Tables 5A, 5B, 5C, and 5D, respectively. Locations C1 and C6 have total scores of 18 and 21, respectively and are assessed as being moderately impaired. Locations FR1 and C3 both have total scores of 6 and are assessed as being severely impaired.

The NJDEP Bureau of Biological & Freshwater Monitoring maintains four Ambient Biomonitoring Network (AMNET) stations within the Upper Cohansey River Watershed and within the study area (i.e., Stations AN0712, AN0711, AN0710, and AN0709). Station AN0712 corresponds to location C1; AN0711 corresponds to location FR1; AN0710 corresponds to location C4, and AN0709 corresponds to location C6. In October 1995, locations C1 and C4 were assessed by NJDEP under the AMNET program as being moderately impaired, and location C6 was assessed as being non-impaired. FR1 was assessed as being severely impaired (NJDEP, 1996). In October 2000, locations C1 and C4 were again assessed as being moderately impaired. Conditions at location C6 resulted in a change from the 1995 non-impaired status to being moderately impaired. location FR1 was again assessed as being severely impaired. Habitat assessments were also part of the October 2000 AMNET sampling. Optimal habitat conditions were found at locations C1 and C6 in October 2000, whereas suboptimal habitat conditions were noted at locations C4 and FR1 (NJDEP, 2003). A third round of sampling by NJDEP was scheduled for late October/early November 2006 (*Personal communication with Vic Poretti of NJDEP on 9/22/06*) for these AMNET stations within the Upper Cohansey River Watershed. The results of the third round of sampling at these locations have not been published by NJDEP to date. However, the data collected under this study in October 2006 by the Rutgers Cooperative Extension (RCE) Water Resources Program indicate that the Upper Cohansey River Watershed, within the study area, continues to support a moderately to severely impaired benthic macroinvertebrate community.

The benthic macroinvertebrate community occurring within the study area is apparently under some type of stress as evidenced by low taxa richness, the lack of representation of EPT taxa, and relatively high family biotic index scores. The types of organisms found, or the lack thereof, indicate that possible chemical perturbations are occurring within the system, and/or the benthic community may be subject to physical or habitat constraints. The habitat assessment revealed suboptimal habitat conditions, which may explain the observed impaired benthic macroinvertebrate community.

Biological assessments have become an important tool for managing water quality to meet the goal of the Clean Water Act (i.e., to maintain the chemical, physical, and biological integrity of the nation's water). However, although biological assessments are a critical tool for detecting impairment, they do not identify the cause or causes of the impairment. The U.S. Environmental Protection Agency (USEPA) developed a process, known as the Stressor Identification (SI) process, to accurately identify any type of stressor or combination of stressors that might cause biological impairment (USEPA, 2000). The SI process involves the critical review of available information, the formation of possible stressor scenarios that may explain the observed impairment, the analysis of these possible scenarios, and the formation of conclusions about which stressor or combination of stressors are causing the impairment. The SI process is iterative, and in some cases additional data may be needed to identify the stressor(s). In addition, the SI process provides a structure or a method for assembling the scientific evidence needed to support any conclusions made about the stressor(s). When the cause of a biological impairment is identified, stakeholders are then in a better position to locate the source(s) of the stressor(s) and are better prepared to implement the appropriate management actions to improve the biological condition of the impaired waterway. The SI process is recommended as the next step toward improving the biological condition of the Upper Cohansey Watershed.

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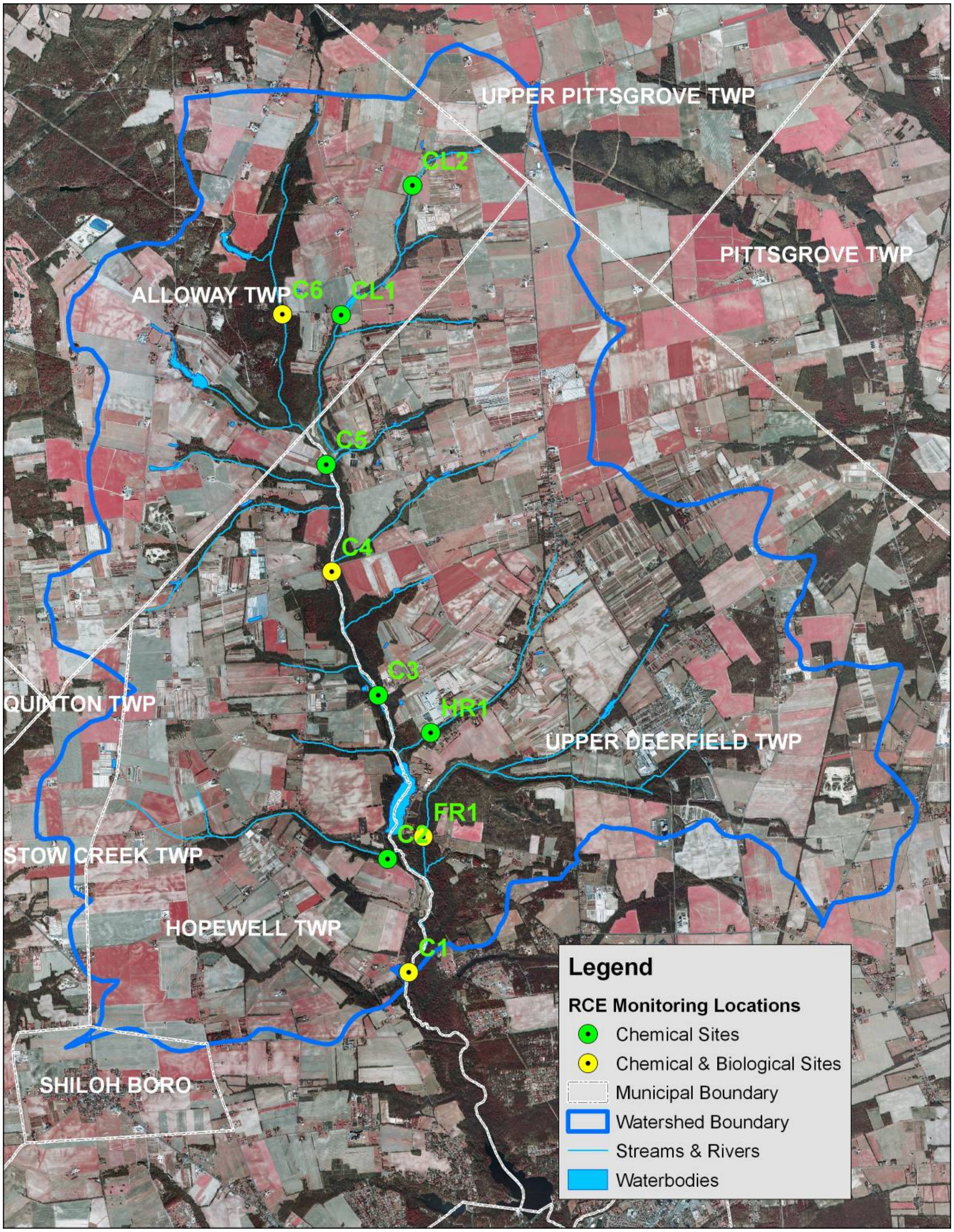


Figure 1: Sampling Locations

Table 1: Scoring Criteria for Habitat Assessment

HABITAT ASSESSMENT FOR *LOW* GRADIENT STREAMS

Habitat Parameter	Condition Category			
	Optimal	Suboptimal	Marginal	Poor
1. Epifaunal Substrate/Available Cover	Greater than 50% 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).	30-50% 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).	10-30% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	Less than 10% 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. Pool Substrate Characterization	Mixture of substrate materials, with gravel and firm sand prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present.	All mud or clay or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
3. Pool Variability	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
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. Channel Sinuosity	The bends in the stream increase the stream length 3 to 4 times longer than if it was in a straight line. (Note - channel braiding is considered normal in coastal plains and other low-lying areas. This parameter is not easily rated in these areas.	The bends in the stream increase the stream length 2 to 3 times longer than if it was in a straight line.	The bends in the stream increase the stream length 2 to 1 times longer than if it was in a straight line.	Channel straight; waterway has been channelized for a long distance.
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)	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) Note: determine left or right side by facing downstream.	More than 90% of the streambank surfaces and immediate riparian zone covered by native vegetation, including trees, under story 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	**Scores**			
	Location C1	**Location FR1**	**Location C3**	**Location C6**
1. Epifaunal Substrate/Available Cover	**13**	**3**	**13**	**11**
2. Pool Substrate Characterization	**13**	**13**	**13**	**8**
3. Pool Variability	**13**	**13**	**13**	**8**
4. Sediment Deposition	**18**	**3**	**13**	**8**
5. Channel Flow Status	**18**	**18**	**18**	**13**
6. Channel Alteration	**13**	**13**	**13**	**20**
7. Channel Sinuosity	**8**	**13**	**13**	**13**
8a. Bank Stability (Left Bank)	**4**	**4**	**4**	**1**
8b. Bank Stability (Right Bank)	**4**	**4**	**4**	**1**
9a. Vegetative Protection (Left Bank)	**7**	**4**	**7**	**7**
9b. Vegetative Protection (Right Bank)	**7**	**4**	**7**	**7**
10a. Riparian Vegetative Zone Width (Left Bank)	**10**	**10**	**10**	**10**
10b. Riparian Vegetative Zone Width (Right Bank)	**10**	**10**	**10**	**7**
Total Score	***138***	***112***	***138***	***114***
Condition Category	***Sub-optimal***	***Sub-optimal***	***Sub-optimal***	***Sub-optimal***

Table 3: Results of the Benthic Macroinvertebrate Sampling

Taxa:	***Location C1***	***Location FR1***	***Location C3***	***Location C6***
Oligochaeta (aquatic worms)				
Naididae	1			
Limnophila (freshwater snails)				
Planorbidae				
Gyraulus sp.	1			
Heterodonta (freshwater clams)				
Corbiculidae				
Corbicula fluminea	14		6	
Amphipoda (scuds or side swimmers)				
Gammaridae				
Gammarus sp.	34	67	78	22
Decapoda (crayfish)				
Cambaridae	1			
Ephemeroptera (mayflies)				
Heptageniidae				
Stenonema sp.	3		2	34
Siphlonuriidae				
Ameletus sp.		2		
Odonata (dragonflies/damselflies)				
Aeshnidae				
Basiaeschna sp.		4		
Boyeria sp.		1		
Calopterygidae				
Calopteryx sp.	3	23	1	2
Cordulegastridae				
Cordulegaster sp.				1
Hemiptera (true bugs)				
Veliidae				
Microvelia sp.		2		
Rhagovelia sp.				1
Megaloptera (fishflies/dobsonflies/alderflies)				
Corydalidae				
Nigronia sp.	3		3	20

Table 3: Results of the Benthic Macroinvertebrate Sampling (continued)

Taxa:	***Location C1***	***Location FR1***	***Location C3***	***Location C6***
Trichoptera (caddisflies)				
Hydropsychidae				
Cheumatopsyche sp.	11		1	13
Hydropsyche sp.	19		2	5
Lepidoptera (butterflies/moths)				
Pyralidae				
Parapoynx sp.	1			
Coleoptera (beetles)				
Elimidae				
Stenelmis sp.	3		1	
Stenelmis sp. (adult)	3		2	
Diptera (true flies)				
Chironomidae				
Chironominae		1	1	1
Simuliidae				
Simulium sp.	7	1	3	3
Tipulidae				
Tipula sp.		1		
Total # taxa:	***13***	***9***	***10***	***10***
Total # individuals:	***104***	***102***	***100***	***102***

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 Location C1

Taxa	***Tolerance Value***	***Location C1 Number of Individuals***
Naididae	8	1
Planorbidae	7	1
Corbiculidae	6	14
Gammaridae	6	34
Cambaridae	6	1
Heptageniidae	3	3
Calopterygidae	6	3
Corydalidae	4	3
Hydropsychidae	4	30
Pyralidae	5	1
Elmidae	4	6
Simulium	6	7
Taxa Richness		12
EPT Index		2
%CDF		33% Gammaridae
%EPT		32%
Family Biotic Index		5.18 fair water quality
NJIS Rating		18
Biological Condition		Moderately Impaired

Table 5b: Calculation of Biological Condition for Location FR1

Taxa	*Tolerance Value*	*Location FR1 Number of Individuals*
Gammaridae	6	67
Siphlonuriidae	4	2
Aeshnidae	3	5
Calopterygidae	6	23
Veliidae	5	2
Chironomidae	6	1
Simuliidae	6	1
Tipulidae	3	1
Taxa Richness		8
EPT Index		1
%CDF		66% Gammaridae
%EPT		2%
Family Biotic Index		5.76 fairly poor water quality
NJIS Rating		6
Biological Condition		Severely Impaired

Table 5c: Calculation of Biological Condition for Location C3

Taxa	*Tolerance Value*	*Location C3 Number of Individuals*
Corbiculidae	6	6
Gammaridae	6	78
Heptageniidae	3	2
Calopterygidae	6	1
Corydalidae	4	3
Hydropsychidae	4	3
Elmidae	4	3
Chironomidae	6	1
Simuliidae	6	3
Taxa Richness		9
EPT Index		2
%CDF		78% Gammaridae
%EPT		5%
Family Biotic Index		5.76 fairly poor water quality
NJIS Rating		6
Biological Condition		Severely Impaired

Table 5d: Calculation of Biological Condition for Location C6

Taxa	*Tolerance Value*	*Location C6 Number of Individuals*
Gammaridae	6	22
Heptageniidae	3	34
Calopterygidae	6	2
Cordulegastridae	3	1
Veliidae	5	1
Corydalidae	4	20
Hydropsychidae	4	18
Chironomidae	6	1
Simuliidae	6	3
Taxa Richness		9
EPT Index		2
%CDF		33% Heptageniidae
%EPT		51%
Family Biotic Index		4.13 very good water quality
NJIS Rating		21
Biological Condition		Moderately Impaired

Appendix B: Tabulated Stream Visual Assessment Protocol (SVAP) Data

Subwatershed	Date	Reference Location	Active Channel Width (feet)	Dominant Substrate	Flow Appearance	Hydrologic Alteration	Channel Condition	Riparian Zone Left Bank	Riparian Zone Right Bank	Bank Stability Left Bank	Bank Stability Right Bank	Water Appearance
C1	7/18/05	Walter's Road	25	silt		9	9	8	7	8	8	7
C1	7/18/05	Walter's Road	30	silt		7	10	9	9	8	8	9
C1	7/18/05	Silverlake Road	50	mud		8	7	10	8	9	9	6
C1	7/19/05	Seeley Road	10	sand		9	9	8	7	7	5	6
C1	7/19/05	Seeley Road	12	gravel		9	9	9	9	6	6	7
C1	7/19/05	Seeley Road/Lake	30	silt		6	7	8	7	6	6	6
C2	6/22/05	Harmony Road near John Dare Road	12	sand	clear	9	8	7	7	10	6	9
C2	7/19/05	n/a	7	silt		8	7	9	9	8	8	9
C4	6/1/05	Biels Mill Road	45	mud		9	9	10	10	10	10	3
C4	6/17/05	Off of Center Road	10	mud		10	10	10	10	3	3	3
C4	6/17/05	Trib to Cohansey south of Clarks Run, North of Har	50	mud		10	10	10	10	9	9	1
C5	6/1/05	Deerfeild Road	30	mud		8	7	10	10	8	4	2
C5	6/1/05	n/a	40	mud	foamy	5	3	3	3	5	5	5
C5	6/7/05	Beals Road	12	gravel		9	7	9	6	7	6	9
C5	6/7/05	Beals Road	11	mud		9	10	8	9	8	7	7
C5	6/7/05	Beal Road	12.15	mud		9	10	10	10	9	9	8
C5	6/21/05	Tice's Lane off of Rt 77	70	mud	clear	5	4	5	7	4	4	3
C5	6/21/05	Off of Tices Road (off of Rt 77)	3	mud		9	7	7	8	10	10	8
C5	6/21/05	Tice's Road (off of Rt 77)	2	mud	clear	9	8	9	9	8	8	7
C5	6/21/05	Center Road off of Tices Lanr across from Feaster's	25	mud	clear	6	4	1	1	3	3	4
C5	6/21/05	Directly across Center Road from r\each 6/21 R005	10	mud	clear	9	8	9	9	9	9	3
C5	7/3/05	Center 663, on bridge, below intersect w/Tices Lane	30	mud		10	7	10	10	8	8	5
CL1	6/3/05	Coleman Road	6	mud		9	5	3	6	8	6	10
CL1	6/3/05	n/a	7	sand		2	2	2	6	3	4	7
CL1	6/3/05	n/a	40	silt		9	6	1	4	7	5	7
CL1	6/5/05	Beals Road	20	mud		9	8	9	7	8	6	7
CL1	6/15/05	Downstream of Coleman Road	5	mud		9	8	8	9	6	6	8
CL1	6/15/05	Downstream of Coleman Road (deep into woods)	3	mud		9	8	9	6	8	7	3
CL1	6/15/05	Downstream of Coleman Road	12	mud		10	9	7	6	6	7	3
CL1	7/21/05	Willow Drive bridge near park	30	sand		7	6	7	6	7	7	9
CL2	6/3/05	Coleman Road	20	gravel	clear	6	6	6	8	5	5	8
CL2	6/15/05	Coleman Road	4	mud	turbid	9	5	6	6	8	8	7
HR1	6/17/05	Harrow's Run & Center Road	6	mud		7	8	10	8	7	7	10
HR1	6/17/05	Directly downstream in Harrow's Run & Center Road	10	mud		10	10	10	10	5	5	9
HR1	6/17/05	Haven Hill Farm (157 Seeley Road)	15	silt	clear	9	7	10	10	6	4	10

Subwatershed	Date	Reference Location	Nutrient Enrichment	Riffle Embeddedness	Barriers to Fish Movement	Instream Fish Cover	Pools	Invertebrate Habitat	Canopy Cover	Manure Presence
C1	7/18/05	Walter's Road	9	7	10	9	8	8	10	n/a
C1	7/18/05	Walter's Road	7	7	8	9	7	8	1	n/a
C1	7/18/05	Silverlake Road	8	n/a	10	6	2	3	2	n/a
C1	7/19/05	Seeley Road	7	6	9	8	7	9	9	n/a
C1	7/19/05	Seeley Road	8	3	6	8	7	7	9	n/a
C1	7/19/05	Seeley Road/Lake	7	7	4	6	5	6	9	n/a
C2	6/22/05	Harmony Road near John Dare Road	5	n/a	n/a	5	n/a	7	10	n/a
C2	7/19/05	n/a	9	n/a	5	8	7	7	9	n/a
C4	6/1/05	Biels Mill Road	8	2	10	10	10	10	10	n/a
C4	6/17/05	Off of Center Road	7	n/a	8	7	8	10	8	n/a
C4	6/17/05	Trib to Cohansey south of Clarks Run, North of Har	1	n/a	10	7	1	10	10	n/a
C5	6/1/05	Deerfeild Road	9	n/a	10	9	7	8	10	n/a
C5	6/1/05	n/a	8	1	7	8	10	7	1	n/a
C5	6/7/05	Beals Road	9	5	7	8	7	7	10	n/a
C5	6/7/05	Beals Road	8	n/a	6	9	7	6	10	n/a
C5	6/7/05	Beal Road	7	n/a	9	7	9	10	10	n/a
C5	6/21/05	Tice's Lane off of Rt 77	2	n/a	10	6	1	2	10	n/a
C5	6/21/05	Off of Tices Road (off of Rt 77)	9	n/a	5	3	4	7	10	n/a
C5	6/21/05	Tice's Road (off of Rt 77)	8	n/a	8	6	6	7	9	n/a
C5	6/21/05	Center Road off of Tices Lane across from Feaster's	9	n/a	10	3	1	4	1	n/a
C5	6/21/05	Directly across Center Road from r\each 6/21 R005	9	n/a	8	6	7	6	10	n/a
C5	7/3/05	Center 663, on bridge, below intersect w/Tices Lane	10	n/a	8	3	10	8	n/a	n/a
CL1	6/3/05	Coleman Road	10	5	7	10	3	10	7	n/a
CL1	6/3/05	n/a	10	n/a	4	9	7	10	n/a	n/a
CL1	6/3/05	n/a	7	n/a	10	10	7	10	3	n/a
CL1	6/5/05	Beals Road	8	n/a	8	6	8	7	9	n/a
CL1	6/15/05	Downstream of Coleman Road	9	7	7	8	7	8	10	n/a
CL1	6/15/05	Downstream of Coleman Road (deep into woods)	7	n/a	9	9	7	9	10	n/a
CL1	6/15/05	Downstream of Coleman Road	8	n/a	7	10	9	10	10	n/a
CL1	7/21/05	Willow Drive bridge near park	7	3	6	8	9	9	10	n/a
CL2	6/3/05	Coleman Road	10	8	10	10	9	8	10	n/a
CL2	6/15/05	Coleman Road	7	n/a	8	9	6	8	9	n/a
HR1	6/17/05	Harrow's Run & Center Road	10	n/a	9	10	1	10	10	n/a
HR1	6/17/05	Directly downstream in Harrow's Run & Center Road	10	n/a	8	10	2	10	10	n/a
HR1	6/17/05	Haven Hill Farm (157 Seeley Road)	10	n/a	8	10	7	10	10	Na

Summary statistics are provided in Table 2.

Appendix C: Quality Assurance Project Plan for the Upper Cohansey River Watershed Surface Water Quality Monitoring Program (June 1, 2005)

QUALITY ASSURANCE PROJECT PLAN

UPPER COHANSEY RIVER WATERSHED
SURFACE WATER QUALITY MONITORING PROGRAM

RUTGERS COOPERATIVE RESEARCH & EXTENSION
WATER RESOURCES PROGRAM

June 1, 2005

QUALITY ASSURANCE WORK PLAN

UPPER COHANSEY RIVER WATERSHED
SURFACE WATER QUALITY MONITORING PROGRAM

RUTGERS COOPERATIVE RESEARCH & EXTENSION
WATER RESOURCES PROGRAM

Applicant/ Project Manager:	Christopher C. Obropta, Ph.D., P.E. Rutgers Cooperative Research & Extension
	______________________________ Signature Date
QA Officer:	Christopher C. Obropta, Ph.D., P.E. Rutgers Cooperative Research & Extension
	______________________________ Signature Date
QA Water Quality Officer:	Katie Buckley Rutgers Cooperative Research & Extension
	______________________________ Signature Date

1. Project Name: Upper Cohansey River Watershed
Evaluation of pollution sources, necessary load reductions, and appropriate management measures needed to improve water quality and restore the watershed.

Requested By: Rutgers Cooperative Research & Extension

2. This project has been initiated by Rutgers Cooperative Research & Extension (RCRE) Water Resources Program, Rutgers Cooperative Extension of Cumberland County and Salem County, Cumberland and Salem County Soil Conservation Districts, Alloway, Hopewell, Upper Deerfield and Upper Pittsgrove Township, and the New Jersey Department of Environmental Protection. This watershed assessment will evaluate the hydrology and water quality of the Upper Cohansey River Watershed. Additionally, the gathered data will be used to develop a restoration plan designed to improve water quality. The water quality data will provide agencies such as the New Jersey Department of Environmental Protection (NJDEP) with data essential for future operation, planning, and management of watersheds in need of restoration.

3. Date Project Requested: June 2004

4. Date Project Initiated: June 2005

5. Project Officer: Christopher C. Obropta, Ph.D., P.E.
Rutgers Cooperative Research & Extension

6. QA Officer: Christopher C. Obropta, Ph.D., P.E.
Rutgers Cooperative Research & Extension

7. Project Description:

A. <u>Objective and Scope</u>

Based upon the New Jersey Department of Environmental Protection (NJDEP) Ambient Biomonitoring Network (AMNET) data and data collected by the NJDEP/United States geological Survey (USGS) and Metal Recon Program, the Upper Cohansey River is impaired for phosphorous, lead, pH, and aquatic life, and is listed on sublist 5 of the *New Jersey 2004 Integrated Water Quality Monitoring and Assessment Report*. Additionally, a Total Maximum daily Load (TMDL) for fecal coliform has been proposed for 33.8 miles of the Upper Cohansey River. This TMDL requires 66% reductions in nonpoint source bacteria loads from this agriculturally dominated watershed. The goal of this project is to improve the water quality of the Upper Cohansey River by developing a watershed restoration plan that achieves the required TMDL reductions and reduces the nonpoint source pollutant loading that is contributing to the additional aquatic life, phosphorous, pH, and lead surface water quality impairments.

This watershed-based plan will:

1. Identify the causes and sources that will need to be controlled to achieve the load reductions that are estimated as part of this watershed-based plan.
2. Estimate the load reductions expected for the management measures that are identified as part of this watershed-based plan.
3. Identify nonpoint pollution sources (NPS) management measures that will need to be implemented to achieve the load reductions estimated as part of this watershed-based plan.
4. Identify critical areas for the implementation of these NPS management measures.
5. Estimate the amounts of technical and financial assistance needed to implement the plan.
6. Identify potential sources of funding to implement each management measure that is identified in the plan.
7. Outline an informational/education plan to enhance public understanding of the project and encourage early and continued participation in implementing the plan.
8. Provide a schedule for implementing the NPS management measures that are identified in the plan.
9. Outline a set of criteria that can be used to determine whether loading reductions are being achieved over time and if substantial progress is being made toward attaining water quality standards.
10. Detail a monitoring component to evaluate the effectiveness of the implementation efforts over time.

B. <u>Data Usage</u>

The data collected will be used to evaluate the hydrology and water quality of the Upper Cohansey River. This data will be used to determine the sources and causes of water quality impairments and identify management measures to address each of the causes. Data collected after management measure implementation will be used to evaluate the effectiveness of the implementation measures over time.

C. <u>Monitoring Network Design and Rationale</u>

Sampling Locations: Attachment A provides a detailed aerial map showing the Upper Cohansey River and surrounding land. There are eleven surface-water sampling locations, which are included in Attachment A.

Temporal and Spatial Aspects:

Water quality samples will be collected in ten events over an 18 month period, including at least three wet weather events. All ten events will analyze nutrient levels and fecal coliforms. The first four events will include a priority pollutant metals analysis. If metals are found to be at a level below concern, no further sampling of metals will be done. If metals are of concern sampling will continue for all ten events. Three subsurface grab samples will be collected at equidistant points across the stream. 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. Prior to each sampling event, the large volume containers will be decontaminated using the following procedures: 1) distilled/deionized water rinse, 2) non-phosphate detergent wash, 3) distilled/deionized water rinse, 4) air dry, and 5) distilled/deionized water rinse.

Basis for Sampling Locations: Surface water quality sampling will be conducted to assess the water quality in representative locations throughout the Upper Cohansey River Watershed. These locations are strategically located to identify pollution sources from individual tributaries and the effects of lakes on water quality in the watershed.

D. Monitoring Parameters

Surface water quality sample collection, as well as *in situ* measurements of pH, temperature, dissolved oxygen, stream width, stream depth, and stream velocity, will be conducted by the Rutgers Cooperative Research & Extension Water Resources Program.

Stream width, stream depth, and stream velocity will be measured in accordance with the methods outlined in Attachment B.

Samples will be analyzed for ammonia-nitrogen, nitrate-nitrite as nitrogen, total Kjeldahl nitrogen, total phosphorus, dissolved orthophosphate phosphorus, total suspended solids, priority pollutant metals, and Fecal coliforms by QC Laboratories (NJDEP Certified Laboratory #PA166).

E. Parameter Table

Measurements of the sampled parameters will be performed in accordance with Table 1B – List of Approved Inorganic Test Procedures (40 CFR Part 136.3) of Attachment C. Sample containers, preservation techniques, and holding times will be in accordance with Table II (40 CFR Part 136.3) of Attachment D. QC Laboratories will provide polyethylene containers for all analyses except for dissolved orthophosphate phosphorus. Samples collected for dissolved orthophosphate phosphorus will be filtered immediately in the field using Corning polystyrene disposable sterile filter systems with pore size 0.45 micron filters. Any deviations from the test procedures and/or preservation methods and holding times will be reported to the NJDEP and will be noted in the final report from the laboratory.

8. Schedule

Task 1: Conduct assessments to identify causes and sources of pollution within the watershed. Volunteers and students will be trained to use an enhanced version of the United States Department of Agriculture's (USDA) Stream Visual Assessment Protocol to assess the health of the stream, identify pollutant sources, and identify potential Best Management Practices (BMPs) to control these pollutant sources. A web-based data entry system will be developed to allow volunteers to quickly and efficiently enter their assessment data into a watershed-wide database. These data will be incorporated into a GIS for the watershed. Rutgers will lead this effort with assistance from the Soil Conservation District offices.

Task 2: Assess available biological and chemical data to determine gaps in the data and to evaluate existing pollutant loadings from various sources. Rutgers will generate a report that outlines the results of this task, with the aid of the Rutgers Cooperative Extension of Salem County and Cumberland County offices.

Task 3: Prepare a QAPP to collect biological and chemical data to fill the data gaps. Rutgers will complete this task.

Task 4: Implement the QAPP, analyze the newly collected data, prepare a data report, and submit the data report to NJDEP. The project partners will assist Rutgers in data collection; Rutgers will prepare the data report.

Task 5: Perform water quality modeling to determine the necessary load reductions to achieve water quality criteria. This modeling effort will also be used to identify critical areas for implementing NPS management measures and the expected reductions that would result from these implemented management measures. A modeling report will be generated as a deliverable for this task. Rutgers will complete the water quality modeling effort and identify expected reductions from the implementation of various management strategies.

Task 6: Prepare a Watershed Restoration Plan that would 1) identify specific sources of pollution, 2) detail management measures to control these sources, 3) identify the costs associated with these management strategies and possible sources of funding for these strategies, 4) describe expected reductions that would result from implementing these management strategies, and 5) provide a schedule for implementing these management strategies. The Watershed Restoration Plan would also include a detailed informational/educational component.

Task	Responsible Party	Timeframe	Anticipated Start Data	Project Deliverable	Anticipated Completion Data
1	Rutgers, Soil Conservation Districts	12 months	7/1/05	GIS Updates and Data Entry	6/30/06
2	Rutgers	Three months	7/1/05	Report	9/31/05
3	Rutgers	one month	10/1/05	QAPP	10/31/05
4	Rutgers, Cooperative Extension County Offices	18 months	11/1/05	Data Report	4/30/07
5	Rutgers	18 months	1/1/06	Modeling Report	6/30/07
6	Rutgers, Soil Conservation Districts, Cooperative Extension	12 months	1/1/07	Final Watershed Restoration	12/31/07

	County Offices, Municipalities			Plan	

9. Project Organization and Responsibility:

Laboratory Operations:		QC Laboratories
Sampling Operations:	(QA Water Quality Sampling Officer)	Katie Buckley
Data Processing/	(QA Water Quality Sampling Officer)	Katie Buckley
Data Quality Review:	(QA Officer)	Christopher C. Obropta, Ph.D., P.E.
Overall QA	(QA Water Quality Sampling Officer)	Katie Buckley
Overall Coordination:	(Project Officer)	Christopher C. Obropta, Ph.D., P.E.

10. Organizational Chart:

Overall Coordination: Christopher C. Obropta, Ph.D., P.E. (Rutgers Cooperative Research & Extension Water Resources Program) Overall QA: Christopher C. Obropta, Ph.D., P.E. (Rutgers Cooperative Research & Extension Water Resources Program) QA Water Quality Sampling Officer: Katie Buckley (Rutgers University)
Data Quality Review/Data Processing: Christopher C. Obropta, Ph.D., P.E. Katie Buckley
Sampling QC/Sampling Operations: Christopher C. Obropta, Ph.D., P.E. Katie Buckley
Laboratory Operations: QC Laboratories

11. Sampling Procedures:

All sampling procedures will be in conformance with the NJDEP 1992 Field Sampling

Procedures Manual, any applicable USEPA guidance, or with prior written approval. In addition, instrumentation used for the collection of field data will be properly calibrated, in conformance with the manufacturer's instructions 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 E. 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 and NFWF.

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 F. QC Laboratories and Rutgers Cooperative Research & Extension will perform data validation.

16. Performance and Systems Audits:

    All NJDEP certified laboratories participate biannually in USEPA's Performance Evaluation (PE) Studies for each category of certification. Laboratories are required to pass each of these PE studies in order to maintain certification. 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 USEPA PE results, are used to update each laboratory's certification status.

    The 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.

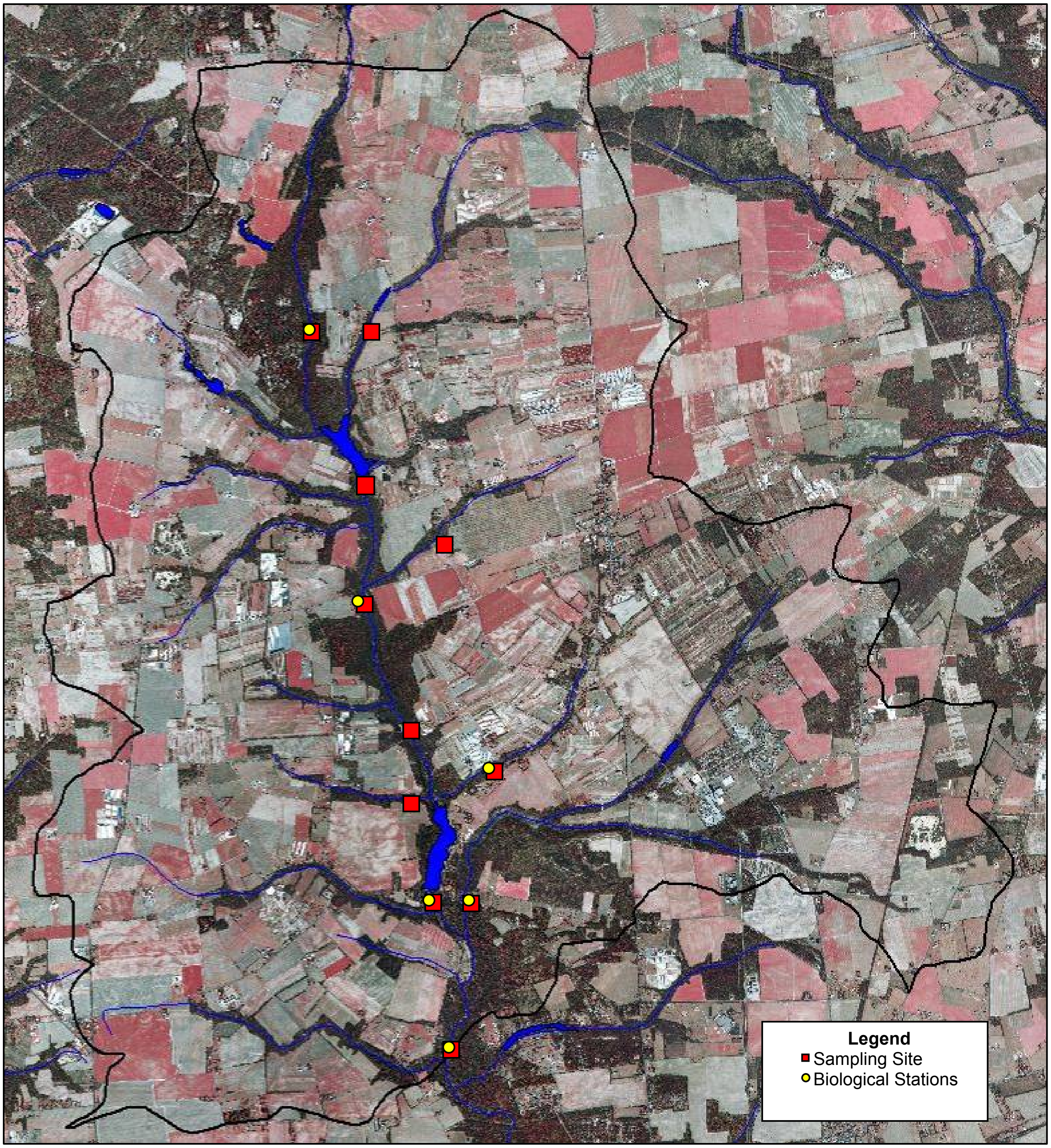
18. Reports:

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.

ATTACHMENT A

Upper Cohansey River Watershed Overview

Upper Cohansey River Watershed Overview



Data Source: NJDEP 1995/97 Digital Orthophotography

ATTACHMENT B

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 section. 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 form the Marsh-McBirney meter set for 45 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 stream bottom, total width, and the uniformity of the velocity profile.

ATTACHMENT C

Table IB – List of Approved Inorganic Test Procedures
40 CFR Part 136.3
July 1, 2003

Available at http://www.gpoaccess.gov/cfr/

ATTACHMENT D

Table II - Required Containers, Preservation Techniques, and Holding Times
40 CFR Part 136.3
July 1, 2003

Available at http://www.gpoaccess.gov/cfr/

ATTACHMENT E

Sample Chain of Custody Form

QC Laboratories

1305 Industrial Blvd.
Southampton, PA 18966-0514

Phone: 215-355-3900
Fax: 215-355-7231

CHAIN OF CUSTODY

Page ____ of ____

Lab LIMS No:

Bill to/Report to: (if different)

Client/Acct. No.
Address
Sampling Site Address: (if different)
City/State/Zip
Phone/Fax
P.O. No.
Client Contact
QC Contact

LAB USE ONLY:

- # ___ Ascorbic/HCl vials # ___ HCl vials
- # ___ $Na_2S_2O_3$
- # ___ NaOH/Zn acetate pH ______
- # ___ HNO_3 pH ______
- # ___ H_2SO_4 pH ______
- # ___ NaOH pH ______
- # ___ Unpreserved
- # ___ Hcl pH ______
- # ___ Temp control ______ C# ______

MATRIX CODES

- DW: DRINKING WATER
- GW: GROUND WATER
- WW: WASTEWATER
- SO: SOIL
- SL: SLUDGE
- OIL: OIL
- SOL: NON SOIL SOLID
- MI: MISCELLANEOUS
- X: OTHER

PROJECT

FIELD ID	Collection Date	Collection Military Time	GRAB	COMP	Matrix Code	Number of Containers Total								ANALYSIS REQUESTED	Field pH, Temp (C or F), DO, Cl_2, S. Cond. etc.

SAMPLED BY: (Name/company)

Verbal/fax data due: ____/____/____
Hardcopy due: ____/____/____

Please call for pricing and availability on rush (<14-21 day) turnaround and on all but standard forms.

Report Format: ☐ Standard ☐ Forms ☐ Standard + QC ☐ NJ Reduced ☐ Disk

Field Parameters Analyzed By:
By:
Date/Time:

SAMPLE CUSTODY EXCHANGES MUST BE DOCUMENTED BELOW. USE FULL LEGAL SIGNATURE, DATE AND MILITARY TIME (24 HOUR CLOCK, I.E. 8AM IS 0800, 4 PM IS 1600)

	DATE	TIME		DATE	TIME
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
RELINQUISHED BY 4	DATE	TIME	RECEIVED BY 4	DATE	TIME
RELINQUISHED BY 5	DATE	TIME	RECEIVED BY 5	DATE	TIME

DELIVERY METHOD ☐ QC COURIER ☐ CLIENT ☐ UPS ☐ FEDEX ☐ OTHER ______

Custody Seal Number

COMMENTS:

Hazardous: yes / no

For example to aid completion, see reverse side.

FINAL REPORT

ATTACHMENT F

Tables of Parameter Detection Limits, Accuracy, and Precision

Parameter Detection Limits, Quantitation Limits, Accuracy, and Precision

Parameter:	Dissolved Ortho-Phosphate (as P)	Total Phosphorus (as P)	Ammonia-Nitrogen	Nitrate-Nitrite as Nitrogen	Total Kjeldahl Nitrogen	Fecal Coliforms	Total Metals	Total Suspended Solids
Referenced Methodology – (NJDEP Certified Methodology)	Standard Methods 4500 P-E	EPA 365.2	Standard Methods 4500 NH_3 D	EPA 300.0	EPA 351.2			Standard Methods 2540D
Method Detection Limit (ppm)	0.01	0.02	0.03	0.06	0.08			1.5
Instrument Detection Limit (ppm)	0.01	0.02	0.03	0.06	0.08			1.5
Project Detection Limit (ppm)	0.01	0.02	0.03	0.06	0.08			1.5
Quantitation Limit (ppm)	0.05	0.05	0.1	0.5	0.3			0.2
Accuracy (mean % recovery)	70.5	76.3	45.7	80.3	49.4			+/- 5
Precision (mean – RPD)	1.3	2.4	4.0	0.1	2.6			NA
Accuracy Protocol (% recovery for LCL/UCL)	86.7	56.6	81.8	79.3	64.6			81.8
Precision Protocol (maximum RPD)	4.1	8.8	14.9	0.96	11.5			5.0

RPD – Relative % Difference; NA – not applicable

Laboratory: QC Laboratories, (NJDEP #PA166)

Parameter Detection Limits, Quantitation Limits, Accuracy, and Precision

Parameter:	**pH (SU)**	**Temperature (°C)**	**Dissolved Oxygen (mg/L)**
Referenced Methodology – (NJDEP Certified Methodology)	Standard Methods 4500-H^+ B	Standard Methods 2550 B	Standard Methods 4500-O G
Method Detection Limit (ppm)	NA	NA	NA
Instrument Detection Limit (ppm)	0.00-14.00 S.U.	0.0 to 100.0 °C	0.00 – 19.99 mg/L
Project Detection Limit (ppm)	0.00-14.00 S.U.	0.0 to 100.0 °C	0.00 – 19.99 mg/L
Quantitation Limit (ppm)	NA	NA	NA
Accuracy (mean % recovery)	NA	NA	NA
Precision (mean – RPD)	±0.01 S.U.	±0.5 °C	±1.5% of full scale
Accuracy Protocol (% recovery for LCL/UCL)	NA	NA	NA
Precision Protocol (maximum RPD)	±0.01 S.U.	±0.5 °C	±1.5% of full scale

RPD – Relative % Difference; NA – not applicable

Laboratory: Rutgers Cooperative Research & Extension Water Resources Program

Appendix D: Tabulated Water Quality Monitoring Results

		Flow Rate	pH	Dissolved Oxygen	Temperature	Fecal Coliform	Total Kjeldahl Nitrogen	Ammonia Nitrogen as N	Nitrite-N	Nitrate-N	TN	Ortho Phosphate Dissolved	Total Phosphorus	TSS
Date	*Station ID*	*cfs*	*S.U.*	*mg/L*	*deg C*	*col/100 ml*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*
6/14/2006	C1	24.08	5.97	7.77	19.4	10	0.50	0.05	0.01	5.33	5.89	0.01	0.03	2.00
6/28/2006	C1	na	5.77	5.62	24.6	601	1.41	0.11	0.10	1.62	3.24	0.07	0.44	62.00
7/12/2006	C1	22.40	5.74	7.81	21.8	20	0.50	0.15	0.22	4.33	5.20	0.24	0.03	5.30
7/14/2006	C1	23.39	5.79	5.71	26.3	40	Bacteria Only							
7/19/2006	C1	20.59	5.74	6.12	25.4	80								
7/21/2006	C1	18.79	5.77	5.86	26.5	10								
7/26/2006	C1	23.24	5.83	6.16	23.6	80	0.50	0.10	0.39	3.69	4.68	0.05	0.11	6.70
8/2/2006	C1	17.96	7.21	5.75	26.8	70	Bacteria Only							
8/9/2006	C1	15.55	6.98	7.04	22.0	2,000	0.50	0.10	0.02	5.42	6.04	0.02	0.03	6.70
8/16/2006	C1	17.54	5.97	6.47	21.9	50	Bacteria Only							
8/23/2006	C1	16.31	7.47	6.34	22.1	50								
8/30/2006	C1	71.42	5.93	5.62	22.1	400	0.50	0.05	0.01	3.11	3.67	0.03	0.18	25.60
9/6/2006	C1	52.38	5.94	7.24	20.3	100	Bacteria Only							
9/11/2006	C1	22.64	5.93	7.74	19.8	100								
9/13/2006	C1	20.01	5.92	7.48	17.4	50	0.50	0.13	0.10	5.21	5.94	0.03	0.11	4.30
9/14/2006	C1	28.30	6.50	7.42	18.1	996	Storm Event				4.37	0.02	0.07	8.88
9/22/2006	C1	19.41	7.65	8.38	15.8	50	Bacteria Only							
9/27/2006	C1	19.36	7.40	7.35	17.9	50	0.50	0.28	0.10	5.57	6.45	0.02	0.03	2.30
10/4/2006	C1	20.05	7.09	6.94	18.6	50	0.50	0.05	0.02	4.96	5.53	0.01	0.03	2.00
10/18/2006	C1	27.70	6.52	9.87	13.8	615	Storm Event				5.27		0.29	7.69
10/24/2006	C1	23.46	7.66	9.47	10.5	50	1.05	0.14	0.10	4.80	6.09	0.03	0.07	2.70
11/1/2006	C1	22.74	7.50	8.21	15.3	100	1.08	0.11	0.04	4.80	6.03	0.03	0.07	3.30
11/15/2006	C1	40.91	6.97	7.32	16.1	50	0.50	0.11	0.03	2.68	3.32	0.06	0.16	14.00
11/17/2006	C1	46.60	6.69	8.23	16.3	52	Storm Event				3.52		0.15	14.63
n		23	24	24	24	24	12	12	12	12	15	13	15	15
min		15.55	5.74	5.62	10.5	10	0.50	0.05	0.01	1.62	3.24	0.01	0.03	2.00
mean*		26.73	6.50	7.16	20.1	85	0.67	0.12	0.10	4.29	5.02	0.05	0.12	11.21
max		71.42	7.66	9.87	26.8	2,000	1.41	0.28	0.39	5.57	6.45	0.24	0.44	62.00
std. dev.		13.55	0.72	1.17	4.3	448	0.32	0.06	0.11	1.25	1.13	0.06	0.12	15.43

		Flow Rate	pH	Dissolved Oxygen	Temperature	Fecal Coliform	Total Kjeldahl Nitrogen	Ammonia Nitrogen as N	Nitrite-N	Nitrate-N	TN	Ortho Phosphate Dissolved	Total Phosphorus	TSS
Date	*Station ID*	*cfs*	*S.U.*	*mg/L*	*deg C*	*col/100 ml*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*
6/14/2006	C2	1.23	5.68	7.95	20.4	30	0.50	0.05	0.21	10.90	11.66	0.01	0.03	2.30
6/28/2006	C2	na	5.98	6.02	23.3	601	1.29	0.20	0.10	1.26	2.85	0.24	1.21	173.00
7/12/2006	C2	1.59	5.85	7.81	21.8	10	0.50	0.05	0.01	10.60	11.16	0.01	0.03	2.30
7/14/2006	C2	1.64	5.66	7.04	22.2	160	Bacteria Only							
7/19/2006	C2	1.43	5.58	7.07	23.0	120								
7/21/2006	C2	1.27	5.58	7.23	22.2	70								
7/26/2006	C2	4.02	5.54	6.85	21.7	90	0.50	0.05	0.01	10.60	11.16	0.01	0.03	3.30
8/2/2006	C2	1.51	6.01	7.05	23.4	70	Bacteria Only							
8/9/2006	C2	1.45	6.61	7.28	19.4	50	0.50	0.05	0.01	11.00	11.56	0.01	0.03	2.30
8/16/2006	C2	1.14	5.62	7.97	19.3	50	Bacteria Only							
8/23/2006	C2	1.12	6.23	7.93	19.5	50								
8/30/2006	C2	3.45	6.01	7.79	19.8	2,600	1.48	1.41	0.01	7.70	10.60	0.03	0.12	15.60
9/6/2006	C2	2.60	5.94	8.13	18.3	200	Bacteria Only							
9/11/2006	C2	1.46	5.97	8.82	17.4	100								
9/13/2006	C2	1.31	5.83	9.74	15.7	50	0.50	0.12	0.10	10.90	11.62	0.03	0.04	1.00
9/14/2006	C2	1.56	6.24	8.83	16.1	3,258	Storm Event				9.60	0.01	0.04	4.98
9/22/2006	C2	1.51	6.30	9.44	13.9	300	Bacteria Only							
9/27/2006	C2	1.11	6.53	8.61	16.6	50	0.50	0.21	0.10	11.80	12.61	0.01	0.01	2.00
10/4/2006	C2	1.32	6.31	8.32	17.3	50	0.50	0.05	0.01	11.99	12.55	0.01	0.01	1.00
10/18/2006	C2	1.81	6.43	10.90	13.8	696	Storm Event				10.49		0.07	6.40
10/24/2006	C2	1.64	6.60	10.67	10.5	100	0.50	0.10	0.10	12.00	12.70	0.01	0.02	1.00
11/1/2006	C2	1.55	6.33	8.88	13.9	50	0.50	0.05	0.03	11.00	11.58	0.01	0.02	1.00
11/15/2006	C2	1.98	6.36	8.95	15.6	50	0.50	0.05	0.03	8.05	8.63	0.01	0.06	3.67
11/17/2006	C2	2.53	6.19	9.03	16.4	644	Storm Event				7.54		0.77	52.21
n		23	24	24	24	24	12	12	12	12	15	13	15	15
min		1.11	5.54	6.02	10.5	10	0.50	0.05	0.01	1.26	2.85	0.01	0.01	1.00
mean*		1.75	6.06	8.26	18.4	123	0.65	0.20	0.06	9.82	10.42	0.03	0.16	18.14
max		4.02	6.61	10.90	23.4	3,258	1.48	1.41	0.21	12.00	12.70	0.24	1.21	173.00
std. dev.		0.74	0.34	1.19	3.5	811	0.35	0.39	0.06	3.02	2.55	0.06	0.35	44.78

		Flow Rate	pH	Dissolved Oxygen	Temperature	Fecal Coliform	Total Kjeldahl Nitrogen	Ammonia Nitrogen as N	Nitrite-N	Nitrate-N	TN	Ortho Phosphate Dissolved	Total Phosphorus	TSS
Date	*Station ID*	*cfs*	*S.U.*	*mg/L*	*deg C*	*col/100 ml*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*
6/14/2006	C3	10.25	6.23	7.80	20.2	5	0.50	0.05	0.01	6.66	7.22	0.01	0.03	2.30
6/28/2006	C3	na	5.91	5.24	23.6	601	0.50	0.10	0.10	1.32	2.02	0.14	0.45	47.00
7/12/2006	C3	1.60	6.33	6.34	24.1	320	0.50	0.05	0.01	5.68	6.24	0.25	0.03	3.70
7/14/2006	C3	10.65	6.18	6.92	23.7	120								
7/19/2006	C3	12.93	6.30	6.68	25.5	230	Bacteria Only							
7/21/2006	C3	8.91	6.22	6.86	25.0	90								
7/26/2006	C3	7.98	5.73	6.38	23.7	190	0.50	0.05	0.01	5.37	5.93	0.03	0.07	4.00
8/2/2006	C3	10.58	6.12	6.51	26.2	60	Bacteria Only							
8/9/2006	C3	9.93	6.25	7.19	22.2	50	0.50	0.05	0.01	6.78	7.34	0.02	0.03	2.00
8/16/2006	C3	9.25	6.32	7.44	21.2	100	Bacteria Only							
8/23/2006	C3	6.72	6.06	7.04	20.9	50								
8/30/2006	C3	7.16	6.11	6.30	20.4	50	0.50	0.30	0.01	2.42	3.23	0.07	0.21	54.70
9/6/2006	C3	39.58	6.27	7.68	19.5	100	Bacteria Only							
9/11/2006	C3	23.20	6.46	8.69	18.1	300								
9/13/2006	C3	9.51	6.50	9.02	16.8	50	0.50	0.05	0.10	6.56	7.21	0.03	0.06	5.30
9/14/2006	C3	12.50	5.34	8.51	17.5	3,158	Storm Event				5.18		0.06	6.13
9/22/2006	C3	9.00	6.38	8.72	15.4	50	Bacteria Only							
9/27/2006	C3	8.53	6.32	7.86	17.8	100	0.50	0.17	0.10	6.53	7.30	0.01	0.02	1.00
10/4/2006	C3	9.74	6.44	7.91	19.8	100	0.50	0.05	0.01	6.54	7.10	0.01	0.02	2.00
10/18/2006	C3	23.20	6.16	8.15	17.1	736	Storm Event				4.37		0.16	16.05
10/24/2006	C3	10.22	6.51	8.72	8.9	200	0.50	0.05	0.10	5.76	6.41	0.01	0.03	2.00
11/1/2006	C3	11.40	6.18	7.66	16.2	50	0.50	0.05	0.02	5.42	5.99	0.01	0.02	1.00
11/15/2006	C3	21.20	6.24	7.46	17.5	400	0.50	0.05	0.01	2.93	3.49	0.02	0.06	4.00
11/17/2006	C3	25.10	6.06	8.55	15.7	923	Storm Event				2.84		0.11	10.47
n		23	24	24	24	24	12	12	12	12	15	12	15	15
min		1.60	5.34	5.24	8.9	5	0.50	0.05	0.01	1.32	2.02	0.01	0.02	1.00
mean*		13.01	6.19	7.48	19.9	138	0.50	0.09	0.04	5.16	5.46	0.05	0.09	10.78
max		39.58	6.51	9.02	26.2	3,158	0.50	0.30	0.10	6.78	7.34	0.25	0.45	54.70
std. dev.		8.22	0.26	0.97	4.0	646	0.00	0.08	0.04	1.87	1.82	0.07	0.11	16.81

Date	Station ID	Flow Rate	pH	Dissolved Oxygen	Temperature	Fecal Coliform	Total Kjeldahl Nitrogen	Ammonia Nitrogen as N	Nitrite-N	Nitrate-N	TN	Ortho Phosphate Dissolved	Total Phosphorus	TSS
Date	*Station ID*	*cfs*	*S.U.*	*mg/L*	*deg C*	*col/100 ml*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*
6/14/2006	C4	3.61	6.27	7.70	18.7	20	0.50	0.10	0.02	6.05	6.67	0.01	0.03	3.70
6/28/2006	C4	na	6.20	4.84	24.7	601	1.69	0.18	0.10	1.17	3.14	0.50	0.82	39.50
7/12/2006	C4	7.39	6.31	6.72	25.2	190	0.50	0.05	0.01	4.57	5.13	0.03	0.03	3.30
7/14/2006	C4	6.74	6.26	6.34	24.1	170	Bacteria Only							
7/19/2006	C4	6.31	6.40	6.28	24.9	240								
7/21/2006	C4	6.31	6.27	5.67	25.5	80								
7/26/2006	C4	6.59	5.78	7.78	24.5	170	0.50	0.05	0.01	4.12	4.68	0.03	0.03	4.30
8/2/2006	C4	4.91	6.23	5.90	27.9	20	Bacteria Only							
8/9/2006	C4	4.38	6.40	6.97	25.6	50	0.50	0.05	0.01	6.78	7.34	0.02	0.03	2.00
8/16/2006	C4	2.85	6.49	7.09	23.2	50	Bacteria Only							
8/23/2006	C4	2.34	6.38	7.14	22.6	200								
8/30/2006	C4	na	6.07	5.50	20.7	800	0.50	0.30	0.01	2.42	3.23	0.07	0.21	54.70
9/6/2006	C4	na	6.36	7.02	19.5	100	Bacteria Only							
9/11/2006	C4	3.57	6.43	7.12	19.4	200								
9/13/2006	C4	3.25	6.30	8.74	17.0	50	0.50	0.10	0.10	5.35	6.05	0.03	0.07	3.70
9/14/2006	C4	6.04	6.75	7.82	17.5	623	Storm Event				4.16		0.09	12.27
9/22/2006	C4	3.53	6.62	8.82	15.5	100	Bacteria Only							
9/27/2006	C4	3.69	6.46	7.70	17.3	100	1.19	0.92	0.10	5.54	7.75	0.01	0.21	2.00
10/4/2006	C4	4.04	6.44	7.82	19.1	50	1.14	0.05	0.01	5.33	6.53	0.01	0.03	1.00
10/18/2006	C4	5.40	6.16	7.68	17.4	69	Storm Event				3.67		0.22	17.92
10/24/2006	C4	4.06	7.05	9.14	8.7	200	0.50	0.05	0.10	4.79	5.44	0.12	0.04	1.00
11/1/2006	C4	4.23	6.40	7.66	15.5	200	1.01	0.16	0.05	4.68	5.90	0.02	0.04	2.30
11/15/2006	C4	5.51	6.26	7.57	17.1	300	0.50	0.10	0.01	2.99	3.60	0.03	0.08	3.30
11/17/2006	C4	5.12	5.97	8.43	15.4	377	Storm Event				2.57		0.12	9.96
n		21	24	24	24	24	12	12	12	12	15	12	15	15
min		2.34	5.78	4.84	8.7	20	0.50	0.05	0.01	1.17	2.57	0.01	0.03	1.00
mean*		4.75	6.34	7.23	20.3	133	0.75	0.18	0.04	4.48	5.06	0.07	0.14	10.73
max		7.39	7.05	9.14	27.9	800	1.69	0.92	0.10	6.78	7.75	0.50	0.82	54.70
std. dev.		1.42	0.25	1.08	4.6	204	0.40	0.25	0.04	1.60	1.63	0.14	0.20	15.76

		Flow Rate	pH	Dissolved Oxygen	Temperature	Fecal Coliform	Total Kjeldahl Nitrogen	Ammonia Nitrogen as N	Nitrite-N	Nitrate-N	TN	Ortho Phosphate Dissolved	Total Phosphorus	TSS
Date	*Station ID*	*cfs*	*S.U.*	*mg/L*	*deg C*	*col/100 ml*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*
6/14/2006	C5	3.91	6.46	7.99	21.2	10	1.04	0.05	0.26	5.78	7.13	0.02	0.03	10.70
6/28/2006	C5	na	5.85	5.28	25.2	601	1.81	0.11	0.10	1.85	3.87	0.08	0.20	51.50
7/12/2006	C5	4.04	6.27	5.47	30.0	310	0.50	0.05	0.02	4.09	4.66	0.02	0.03	6.70
7/14/2006	C5	4.15	6.35	5.50	29.4	160								
7/19/2006	C5	3.86	6.34	5.71	29.1	601	Bacteria Only							
7/21/2006	C5	3.17	6.30	5.54	29.0	601								
7/26/2006	C5	4.46	6.23	5.36	28.0	360	0.50	0.05	0.01	3.72	4.28	0.02	0.03	7.70
8/2/2006	C5	2.78	6.22	5.01	29.7	150	Bacteria Only							
8/9/2006	C5	3.24	6.27	6.00	30.8	2,000	1.14	0.05	0.01	5.47	6.67	0.04	0.08	6.70
8/16/2006	C5	2.12	6.64	5.53	29.4	100	Bacteria Only							
8/23/2006	C5	2.15	6.44	5.74	23.0	100								
8/30/2006	C5	15.14	6.03	4.26	21.1	1,400	0.50	0.05	0.01	2.11	2.67	0.05	0.12	10.00
9/6/2006	C5	10.39	6.33	6.24	21.4	1,100	Bacteria Only							
9/11/2006	C5	3.71	6.39	6.06	21.6	50								
9/13/2006	C5	3.82	6.43	6.87	20.0	50	0.50	0.05	0.10	5.10	5.75	0.03	0.13	4.30
9/14/2006	C5	5.59	6.69	7.26	18.4	3,612	Storm Event				3.42		0.27	6.34
9/22/2006	C5	4.53	6.59	7.58	16.8	100	Bacteria Only							
9/27/2006	C5	3.39	6.43	6.12	21.6	50	0.50	0.14	0.10	5.10	5.84	0.02	0.04	6.00
10/4/2006	C5	4.46	6.36	6.67	22.2	50	0.50	0.05	0.01	5.03	5.59	0.01	0.03	6.00
10/18/2006	C5	11.96	5.76	7.96	15.4	2,310	Storm Event				3.37		0.33	3.47
10/24/2006	C5	5.72	7.04	8.67	9.0	200	0.50	0.05	0.10	3.80	4.45	0.01	0.04	6.00
11/1/2006	C5	5.25	6.31	6.87	17.5	100	0.50	0.05	0.01	3.45	4.01	0.01	0.04	5.30
11/15/2006	C5	9.95	6.14	6.84	17.3	50	0.50	0.05	0.01	1.90	2.46	0.02	0.06	5.00
11/17/2006	C5	13.92	5.84	7.32	14.9	333	Storm Event				2.29		0.09	6.67
n		23	24	24	24	24	12	12	12	12	15	12	15	15
min		2.12	5.76	4.26	9.0	10	0.50	0.05	0.01	1.85	2.29	0.01	0.03	3.47
mean*		5.73	6.32	6.33	22.6	226	0.71	0.06	0.06	3.95	4.43	0.03	0.10	9.49
max		15.14	7.04	8.67	30.8	3,612	1.81	0.14	0.26	5.78	7.13	0.08	0.33	51.50
std. dev.		3.76	0.28	1.08	5.9	896	0.42	0.03	0.08	1.41	1.50	0.02	0.10	11.77

Date	Station ID	Flow Rate cfs	pH S.U.	Dissolved Oxygen mg/L	Temperature deg C	Fecal Coliform col/100 ml	Total Kjeldahl Nitrogen (mg/L)	Ammonia Nitrogen as N (mg/L)	Nitrite-N (mg/L)	Nitrate-N (mg/L)	TN (mg/L)	Ortho Phosphate Dissolved (mg/L)	Total Phosphorus (mg/L)	TSS (mg/L)
6/14/2006	C6	0.35	6.97	7.09	20.1	20	0.50	0.05	0.03	2.75	3.33	0.01	0.06	3.70
6/28/2006	C6	21.88	5.51	5.07	25.2	601	1.04	0.05	0.10	0.25	1.44	0.03	0.27	23.50
7/12/2006	C6	0.53	6.84	5.91	28.5	100	1.27	0.15	0.04	4.67	6.13	0.02	0.06	10.70
7/14/2006	C6	0.73	6.71	5.87	26.7	130								
7/19/2006	C6	0.40	6.75	5.75	27.9	160	Bacteria Only							
7/21/2006	C6	0.34	6.72	5.92	27.4	190								
7/26/2006	C6	0.52	6.68	5.35	27.3	250	0.50	0.14	0.03	1.71	2.38	0.02	0.03	5.30
8/2/2006	C6	0.36	6.72	5.68	29.5	100	Bacteria Only							
8/9/2006	C6	0.22	6.68	6.00	25.8	5,000	0.50	0.05	0.10	2.44	3.09	0.01	0.03	4.00
8/16/2006	C6	0.15	6.89	6.43	25.0	600	Bacteria Only							
8/23/2006	C6	0.15	6.90	6.10	25.6	600								
8/30/2006	C6	2.20	6.30	6.56	20.7	2,000	0.50	0.05	0.01	0.69	1.25	0.03	0.81	10.00
9/6/2006	C6	1.80	6.26	6.55	21.5	1,100	Bacteria Only							
9/11/2006	C6	0.44	6.68	8.01	18.5	100								
9/13/2006	C6	0.32	6.70	7.20	17.9	100	0.50	0.05	0.10	2.57	3.22	0.03	0.07	4.70
9/14/2006	C6	1.18	6.36	7.71	18.3	4,291	Storm Event				1.57		0.06	9.45
9/22/2006	C6	0.39	6.98	6.76	19.8	300	Bacteria Only							
9/27/2006	C6	0.41	6.71	7.21	21.9	300	0.50	0.11	0.10	2.59	3.30	0.01	0.02	3.30
10/4/2006	C6	0.43	6.98	6.76	19.8	100	0.50	0.05	0.00	2.02	2.57	0.01	0.02	4.00
10/18/2006	C6	1.83	5.89	7.56	16.0	441	Storm Event				1.45		0.07	10.78
10/24/2006	C6	0.60	6.95	8.71	9.8	50	0.50	0.05	0.10	1.57	2.22	0.01	0.05	3.70
11/1/2006	C6	0.95	6.38	7.22	17.7	100	1.12	0.05	0.01	1.47	2.65	0.01	0.03	4.70
11/15/2006	C6	1.85	6.19	7.48	17.0	50	0.50	0.05	0.01	0.59	1.15	0.01	0.06	8.67
11/17/2006	C6	3.48	5.89	6.54	17.8	386	Storm Event				0.73		0.12	12.62
n		24	24	24	24	24	12	12	12	12	15	12	15	15
min		0.15	5.51	5.07	9.8	20	0.50	0.05	0.00	0.25	0.73	0.01	0.02	3.30
mean*		1.73	6.57	6.64	21.9	258	0.66	0.07	0.05	1.94	2.43	0.01	0.12	7.94
max		21.88	6.98	8.71	29.5	5,000	1.27	0.15	0.10	4.67	6.13	0.03	0.81	23.50
std. dev.		4.37	0.39	0.89	4.9	1,290	0.30	0.04	0.04	1.20	1.34	0.01	0.20	5.37

		Flow Rate	pH	Dissolved Oxygen	Temperature	Fecal Coliform	Total Kjeldahl Nitrogen	Ammonia Nitrogen as N	Nitrite-N	Nitrate-N	TN	Ortho Phosphate Dissolved	Total Phosphorus	TSS
Date	*Station ID*	*cfs*	*S.U.*	*mg/L*	*deg C*	*col/100 ml*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*
6/14/2006	CL1	0.91	6.59	9.50	21.3	5	0.50	0.05	0.05	6.42	7.02	0.01	0.03	8.70
6/28/2006	CL1	15.30	6.08	5.49	25.2	601	1.60	0.22	0.10	1.60	3.52	0.11	0.44	65.00
7/12/2006	CL1	0.99	6.60	7.30	29.7	40	1.34	0.11	0.03	4.02	5.50	0.02	0.06	5.30
7/14/2006	CL1	1.17	6.74	7.62	31.0	90	Bacteria Only							
7/19/2006	CL1	0.92	6.67	8.34	30.2	90								
7/21/2006	CL1	0.40	6.32	7.16	29.7	50								
7/26/2006	CL1	0.98	6.56	7.26	29.3	90	0.50	0.05	0.32	3.20	4.07	0.01	0.06	8.30
8/2/2006	CL1	0.94	6.33	8.09	31.6	10	Bacteria Only							
8/9/2006	CL1	0.80	6.53	7.37	27.7	50	1.00	0.05	0.32	5.66	7.03	0.01	0.02	3.30
8/16/2006	CL1	0.70	6.85	6.94	28.4	50	Bacteria Only							
8/23/2006	CL1	0.65	6.64	7.11	27.4	50								
8/30/2006	CL1	1.81	6.65	8.41	22.2	400	0.50	0.11	0.04	5.04	5.69	0.03	0.21	8.00
9/6/2006	CL1	1.85	6.37	8.09	22.3	50	Bacteria Only							
9/11/2006	CL1	0.95	6.73	8.52	22.2	50								
9/13/2006	CL1	0.89	6.56	8.77	21.2	100	0.50	0.05	0.10	4.81	5.46	0.03	0.06	5.30
9/14/2006	CL1	1.45	6.74	9.76	19.7	50	Storm Event				4.55		0.22	7.36
9/22/2006	CL1	0.83	6.74	9.50	18.7	50	Bacteria Only							
9/27/2006	CL1	0.98	6.68	6.99	22.9	50	0.50	0.13	0.10	5.53	6.26	0.01	0.02	4.70
10/4/2006	CL1	0.95	6.62	7.38	23.1	50	0.50	0.10	0.03	6.09	6.72	0.01	0.02	3.00
10/18/2006	CL1	2.11	6.18	9.22	15.0	315	Storm Event				5.55		0.09	11.69
10/24/2006	CL1	0.98	6.73	8.93	10.6	50	1.13	0.05	0.10	4.29	5.57	0.01	0.08	4.70
11/1/2006	CL1	1.15	6.37	7.37	17.4	100	1.01	0.05	0.02	4.45	5.53	0.04	0.11	6.30
11/15/2006	CL1	2.34	6.36	7.14	16.8	100	0.50	0.10	0.01	2.49	3.10	0.09	0.19	12.00
11/17/2006	CL1	3.16	6.16	7.68	15.5	77	Storm Event				3.49		0.15	9.08
n		24	24	24	24	24	12	12	12	12	15	12	15	15
min		0.40	6.08	5.49	10.6	5	0.50	0.05	0.01	1.60	3.10	0.01	0.02	3.00
mean*		1.80	6.53	7.91	23.3	66	0.80	0.09	0.10	4.47	5.27	0.03	0.12	10.85
max		15.30	6.85	9.76	31.6	601	1.60	0.22	0.32	6.42	7.03	0.11	0.44	65.00
std. dev.		2.94	0.21	1.02	5.8	138	0.40	0.05	0.11	1.46	1.27	0.04	0.11	15.23

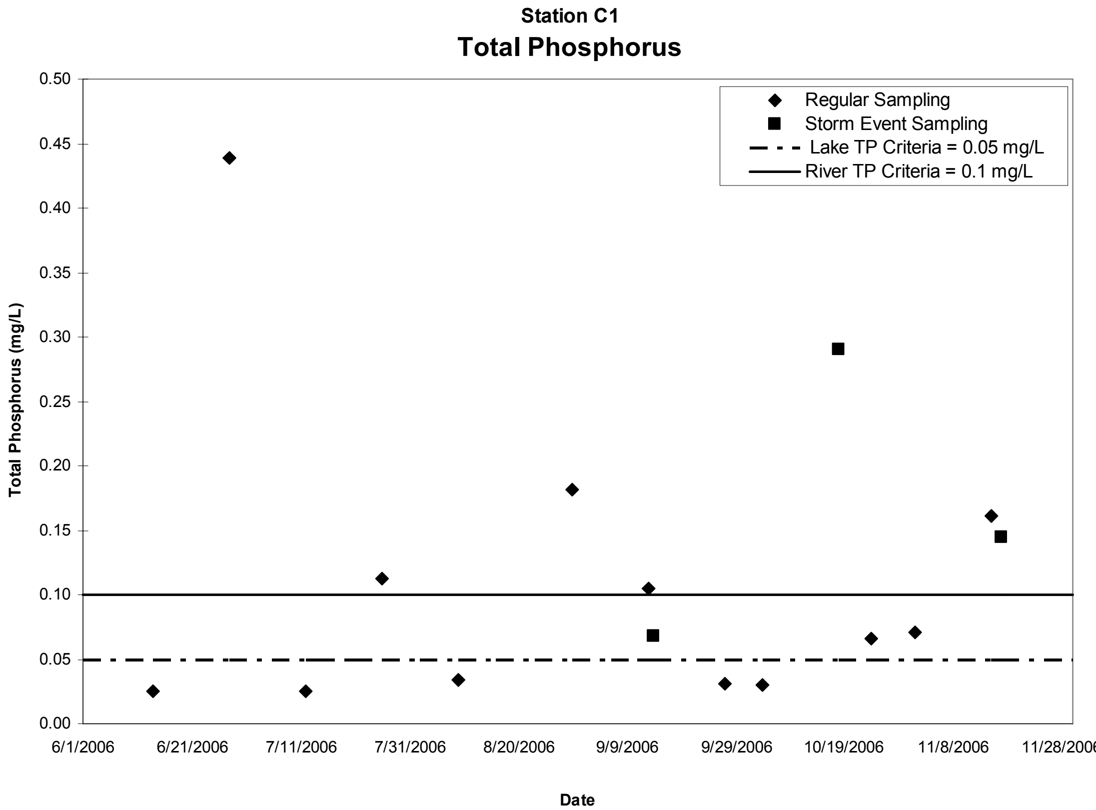
		Flow Rate	pH	Dissolved Oxygen	Temperature	Fecal Coliform	Total Kjeldahl Nitrogen	Ammonia Nitrogen as N	Nitrite-N	Nitrate-N	TN	Ortho Phosphate Dissolved	Total Phosphorus	TSS
Date	*Station ID*	*cfs*	*S.U.*	*mg/L*	*deg C*	*col/100 ml*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*
6/14/2006	CL2	1.23	6.82	8.13	21.4	100	0.50	0.05	0.06	4.49	5.10	0.01	0.03	4.70
6/28/2006	CL2	1.23	6.22	7.90	26.5	601	0.50	0.11	0.10	0.94	1.65	0.17	0.92	39.00
7/12/2006	CL2	0.30	6.11	5.90	27.8	100	1.27	0.15	0.04	4.67	6.13	0.02	0.06	10.70
7/14/2006	CL2	0.27	6.07	5.62	27.8	180								
7/19/2006	CL2	0.30	6.08	5.33	28.0	520	Bacteria Only							
7/21/2006	CL2	0.29	5.92	5.03	27.7	601								
7/26/2006	CL2	0.13	6.09	4.59	26.9	370	0.50	0.11	0.06	1.49	2.16	0.01	0.03	8.70
8/2/2006	CL2	0.31	5.96	4.62	29.6	150	Bacteria Only							
8/9/2006	CL2	0.19	6.41	6.35	25.0	50	1.37	0.05	0.05	4.83	6.30	0.01	0.03	5.00
8/16/2006	CL2	0.15	6.49	6.23	25.9	100	Bacteria Only							
8/23/2006	CL2	0.14	6.44	5.50	24.0	100								
8/30/2006	CL2	0.25	6.23	5.33	20.4	1,600	0.50	0.05	0.03	3.70	4.28	0.03	0.03	3.30
9/6/2006	CL2	0.35	6.34	6.36	22.5	100	Bacteria Only							
9/11/2006	CL2	0.13	6.49	6.74	19.4	100								
9/13/2006	CL2	0.15	6.61	7.27	18.3	100	0.50	0.05	0.10	5.90	6.55	0.03	0.52	2.00
9/14/2006	CL2	0.24	6.01	6.88	19.0	2,327	Storm Event				3.90		0.06	2.81
9/22/2006	CL2	0.15	6.37	6.28	17.7	200	Bacteria Only							
9/27/2006	CL2	0.14	6.61	5.72	20.6	700	0.50	0.11	0.10	5.18	5.89	0.01	0.02	1.00
10/4/2006	CL2	0.15	6.46	6.04	21.7	100	0.50	0.05	0.01	5.37	5.93	0.01	0.02	1.00
10/18/2006	CL2	0.49	5.65	7.50	16.0	1,303	Storm Event				4.63		0.10	3.01
10/24/2006	CL2	0.20	6.60	8.40	9.5	100	0.50	0.05	0.10	5.98	6.63	0.01	0.02	2.30
11/1/2006	CL2	0.21	6.32	7.87	17.7	100	1.06	0.05	0.01	5.12	6.24	0.01	0.02	1.00
11/15/2006	CL2	0.76	5.94	5.91	17.1	300	0.50	0.05	0.01	2.29	2.85	0.05	0.12	6.00
11/17/2006	CL2	0.84	6.01	6.47	16.0	195	Storm Event				3.07		0.13	4.91
n		24	24	24	24	24	12	12	12	12	15	12	15	15
min		0.13	5.65	4.59	9.5	50	0.50	0.05	0.01	0.94	1.65	0.01	0.02	1.00
mean*		0.36	6.26	6.33	21.9	228	0.68	0.07	0.06	4.16	4.75	0.03	0.14	6.36
max		1.23	6.82	8.40	29.6	2,327	1.37	0.15	0.10	5.98	6.63	0.17	0.92	39.00
std. dev.		0.33	0.28	1.08	5.1	566	0.34	0.04	0.04	1.70	1.69	0.05	0.25	9.45

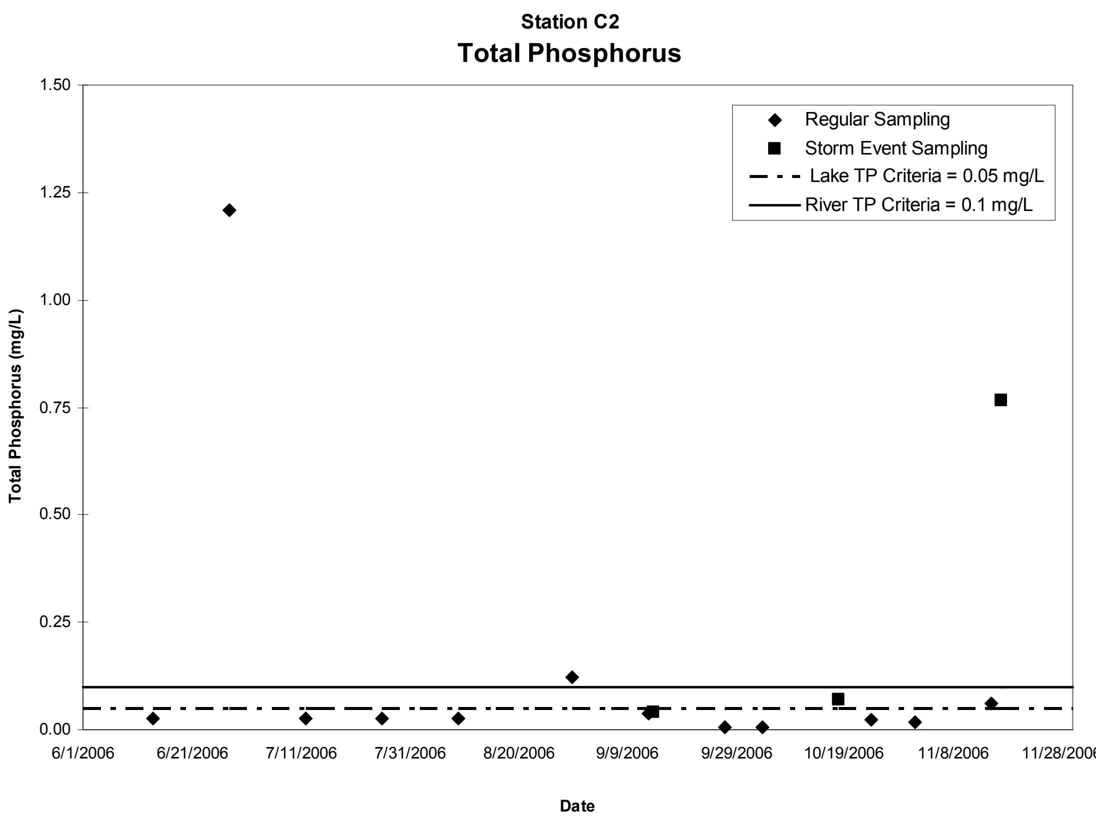
		Flow Rate	pH	Dissolved Oxygen	Temperature	Fecal Coliform	Total Kjeldahl Nitrogen	Ammonia Nitrogen as N	Nitrite-N	Nitrate-N	TN	Ortho Phosphate Dissolved	Total Phosphorus	TSS
Date	*Station ID*	*cfs*	*S.U.*	*mg/L*	*deg C*	*col/100 ml*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*
6/14/2006	FR1	5.31	5.95	7.51	19.9	90	0.50	0.05	0.01	5.14	5.70	0.01	0.03	2.70
6/28/2006	FR1	na	5.86	5.22	23.1	601	0.50	0.05	0.10	0.95	1.60	0.11	0.41	26.00
7/12/2006	FR1	7.02	6.20	7.59	23.5	40	1.05	0.05	0.25	4.89	6.24	0.02	0.08	12.00
7/14/2006	FR1	5.98	6.04	5.37	23.8	30	Bacteria Only							
7/19/2006	FR1	6.38	6.10	6.60	23.8	170								
7/21/2006	FR1	5.96	5.96	6.33	23.2	580								
7/26/2006	FR1	7.01	6.04	6.00	23.1	440	0.50	0.26	0.09	4.43	5.28	0.05	0.15	12.00
8/2/2006	FR1	5.69	6.10	6.08	24.1	110	Bacteria Only							
8/9/2006	FR1	6.66	6.52	7.50	20.3	8,000	1.65	0.05	0.21	5.72	7.63	0.01	0.18	12.70
8/16/2006	FR1	7.29	6.20	7.28	20.6	50	Bacteria Only							
8/23/2006	FR1	7.03	6.20	6.83	20.3	50								
8/30/2006	FR1	7.16	6.15	5.25	20.5	900	0.50	0.13	0.05	1.97	2.65	0.12	0.32	26.50
9/6/2006	FR1	10.57	6.26	7.28	19.3	1,600	Bacteria Only							
9/11/2006	FR1	7.25	6.65	8.00	18.2	200								
9/13/2006	FR1	7.15	6.16	8.78	16.4	400	0.50	0.11	0.10	5.93	6.64	0.03	0.10	8.00
9/14/2006	FR1	10.51	6.41	7.23	17.3	4,248	Storm Event				4.33		0.16	18.84
9/22/2006	FR1	6.61	6.60	8.43	14.8	200	Bacteria Only							
9/27/2006	FR1	7.67	6.36	6.43	19.2	500	0.50	0.21	0.10	5.42	6.23	0.01	0.04	6.00
10/4/2006	FR1	5.23	6.32	5.50	19.7	300	0.50	0.05	0.06	2.83	3.44	0.01	0.09	12.30
10/18/2006	FR1	10.90	6.55	9.19	13.9	676	Storm Event				5.17		0.23	32.85
10/24/2006	FR1	7.69	6.69	7.83	9.4	50	2.04	1.59	0.10	5.30	9.03	0.06	0.19	11.00
11/1/2006	FR1	6.91	6.50	7.69	16.0	50	0.50	0.12	0.07	5.70	6.39	0.02	0.08	7.30
11/15/2006	FR1	9.98	6.36	7.13	17.0	50	0.50	0.22	0.08	4.73	5.53	0.05	0.15	12.00
11/17/2006	FR1	10.35	6.30	8.03	16.6	129	Storm Event				4.85		0.15	11.78
n		23	24	24	24	24	12	12	12	12	15	12	15	15
min		5.23	5.86	5.22	9.4	30	0.50	0.05	0.01	0.95	1.60	0.01	0.03	2.70
mean*		7.49	6.27	7.04	19.3	237	0.77	0.24	0.10	4.42	5.38	0.04	0.16	14.13
max		10.90	6.69	9.19	24.1	8,000	2.04	1.59	0.25	5.93	9.03	0.12	0.41	32.85
std. dev.		1.74	0.23	1.11	3.7	1,765	0.53	0.43	0.07	1.62	1.88	0.04	0.10	8.37

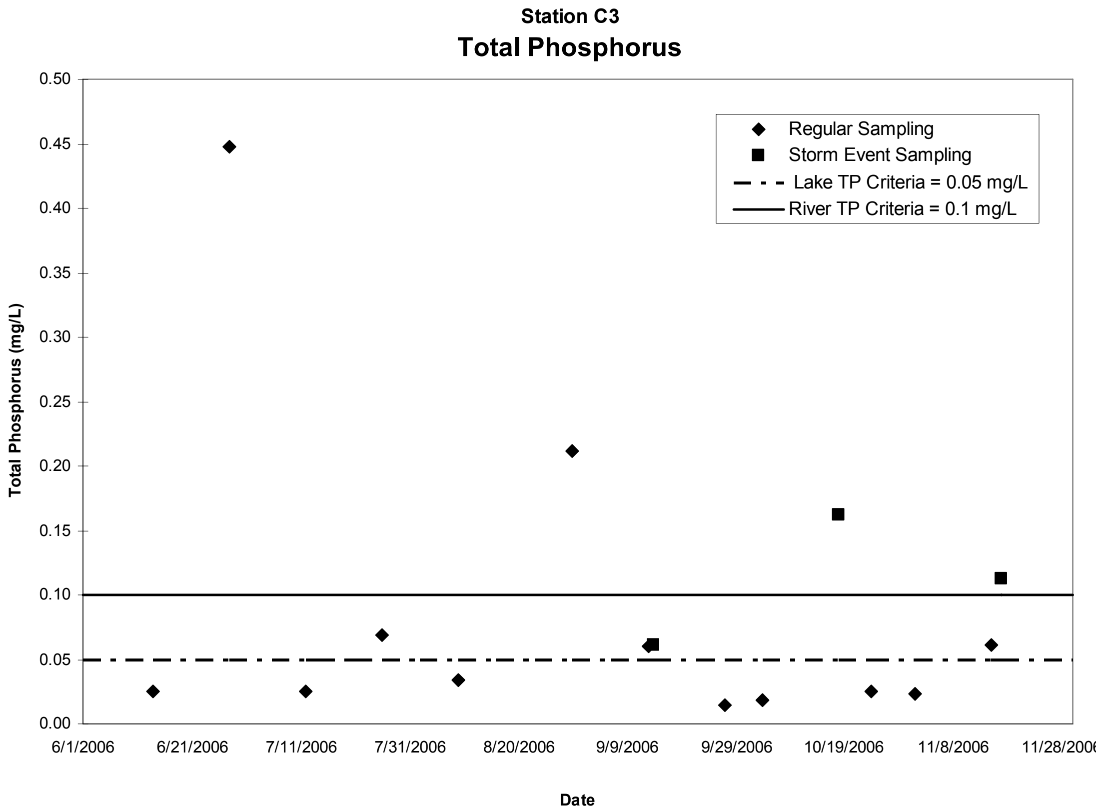
		Flow Rate	pH	Dissolved Oxygen	Temperature	Fecal Coliform	Total Kjeldahl Nitrogen	Ammonia Nitrogen as N	Nitrite-N	Nitrate-N	TN	Ortho Phosphate Dissolved	Total Phosphorus	TSS
Date	*Station ID*	*cfs*	*S.U.*	*mg/L*	*deg C*	*col/100 ml*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*	*(mg/L)*
6/14/2006	HR1	1.27	6.31	7.63	20.0	5	0.05	0.01	6.40	6.96	0.01	0.03	0.03	5.00
6/28/2006	HR1	14.33	6.01	5.53	24.7	601	0.12	0.10	1.22	1.94	0.13	0.43	0.43	601.00
7/12/2006	HR1	1.60	6.10	7.14	23.1	190	0.05	0.01	6.66	7.22	0.02	0.03	0.03	190.00
7/14/2006	HR1	1.16	6.12	7.60	22.2	260	Bacteria Only							
7/19/2006	HR1	1.33	6.06	7.17	23.9	601								
7/21/2006	HR1	1.49	6.12	7.00	24.8	601								
7/26/2006	HR1	1.73	5.58	6.76	23.1	250	0.50	0.05	0.01	6.55	7.11	0.02	0.08	8.00
8/2/2006	HR1	1.65	6.06	6.76	24.6	170	Bacteria Only							
8/9/2006	HR1	1.23	6.02	7.97	19.7	2,000	1.05	0.05	0.01	7.14	8.25	0.01	0.03	5.70
8/16/2006	HR1	1.30	6.06	7.73	20.5	500	Bacteria Only							
8/23/2006	HR1	1.14	6.26	7.84	20.3	300								
8/30/2006	HR1	1.97	6.25	7.18	19.4	3,400	1.35	0.27	0.03	5.27	6.92	0.17	0.26	16.40
9/6/2006	HR1	1.84	6.24	8.30	18.8	1,900	Bacteria Only							
9/11/2006	HR1	1.36	6.49	8.88	17.8	200								
9/13/2006	HR1	1.44	6.25	9.19	16.3	300	0.50	0.05	0.10	7.59	8.24	0.03	0.05	2.30
9/14/2006	HR1	1.95	6.57	8.54	18.0	2,396	Storm Event				5.76		0.11	10.84
9/22/2006	HR1	1.32	6.59	8.50	16.1	100	Bacteria Only							
9/27/2006	HR1	1.65	6.33	7.70	18.3	100	0.50	0.18	0.10	7.38	8.16	0.01	0.02	2.30
10/4/2006	HR1	1.21	6.25	7.95	19.5	50	0.50	0.05	0.01	7.51	8.07	0.01	0.02	2.70
10/18/2006	HR1	1.92	6.05	8.77	16.7	430	Storm Event				6.62		0.17	33.66
10/24/2006	HR1	1.60	6.78	9.62	9.2	300	0.50	0.05	0.10	7.59	8.24	0.02	0.05	3.70
11/1/2006	HR1	1.64	5.88	7.84	14.3	100	0.50	0.05	0.01	7.20	7.76	0.03	0.04	2.00
11/15/2006	HR1	2.60	6.29	7.54	20.6	50	0.50	0.05	0.01	6.35	6.91	0.02	0.05	3.67
11/17/2006	HR1	2.15	5.99	8.34	17.0	589	Storm Event				6.28		0.07	5.68
n		24	24	24	24	24	12	12	12	12	15	12	15	15
min		1.14	5.58	5.53	9.2	5	0.05	0.01	0.01	1.94	0.01	0.01	0.02	2.00
mean*		2.12	6.19	7.81	19.5	290	0.51	0.08	1.22	6.56	5.90	0.07	0.10	59.53
max		14.33	6.78	9.62	24.8	3,400	1.35	0.27	6.66	7.59	8.25	0.43	0.43	601.00
std. dev.		2.63	0.25	0.89	3.7	871	0.38	0.08	2.50	1.60	3.12	0.12	0.11	157.18

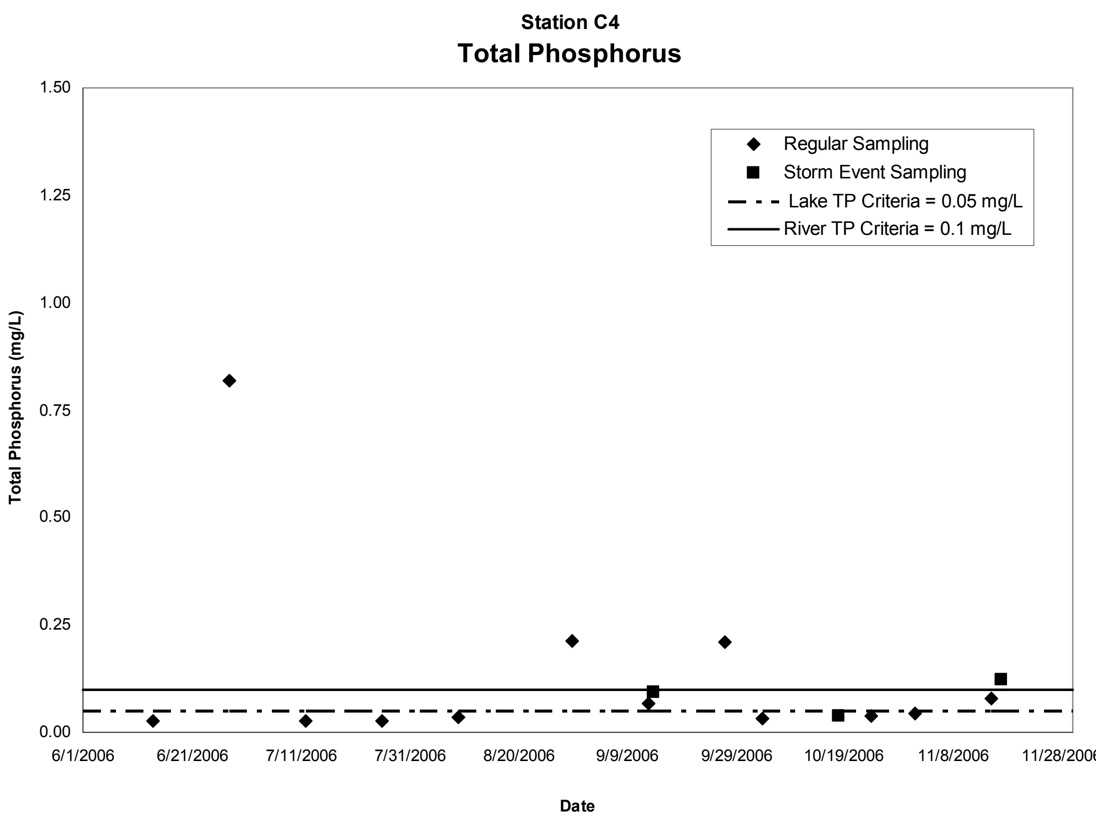
** Mean values for fecal coliform are the calculated geometric mean.*

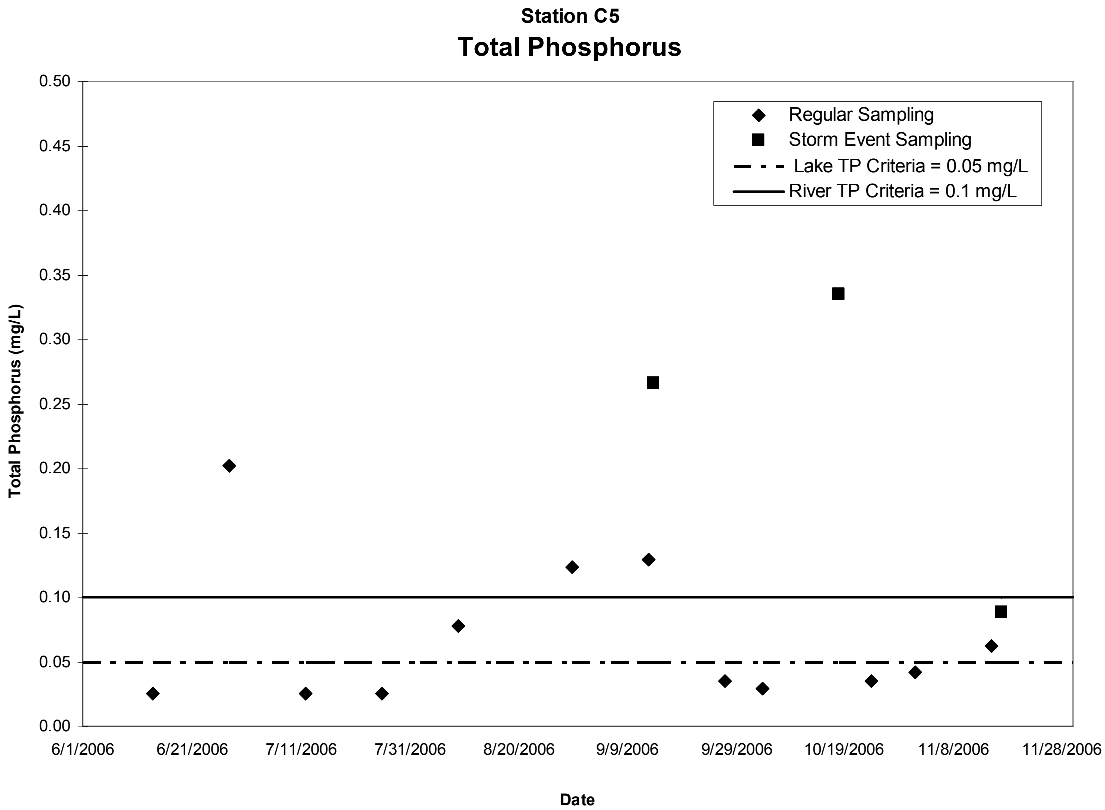
Appendix E: Presentation of Total Phosphorus, pH, and Fecal Coliform Instream Concentrations in Graphs

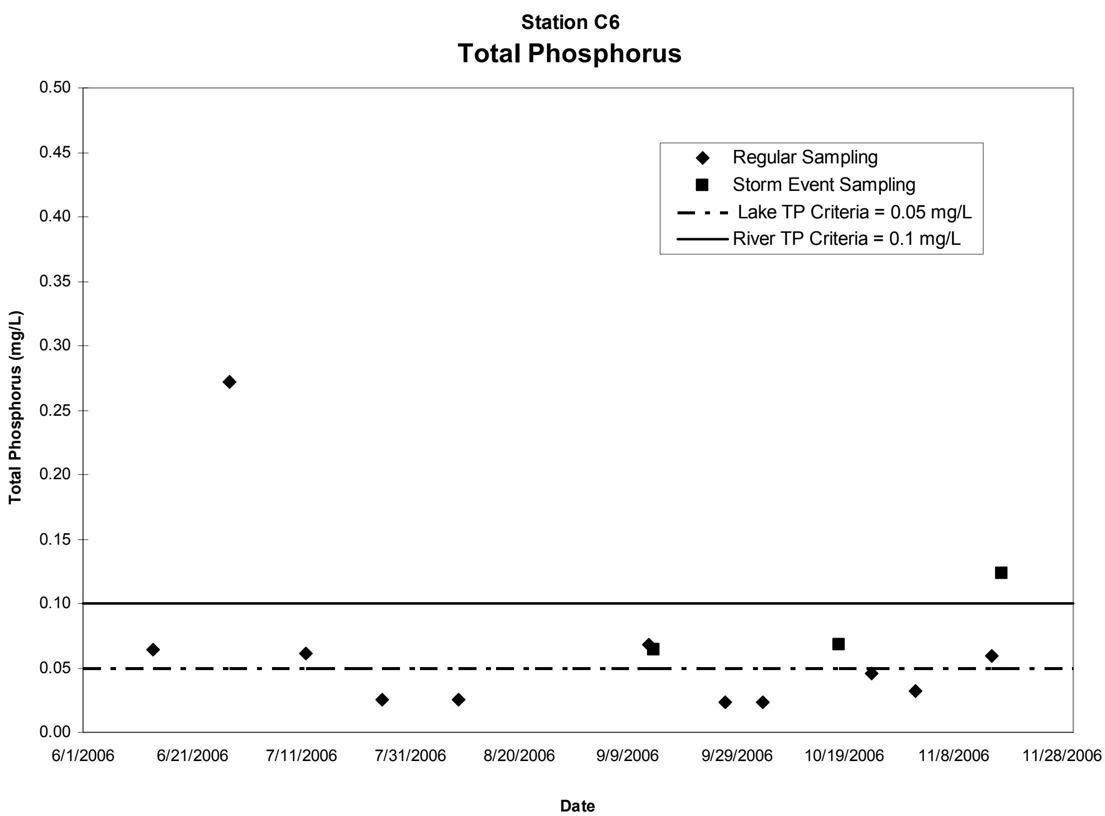

Station C1
Total Phosphorus
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

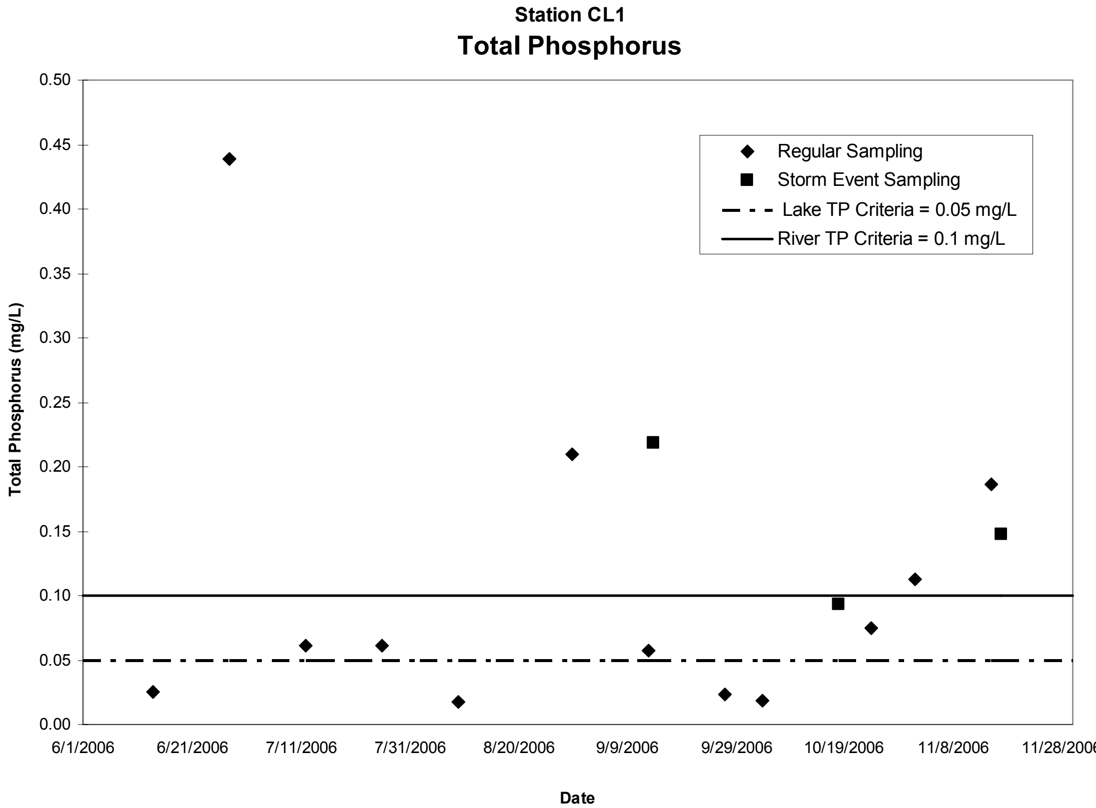

Station C2
Total Phosphorus
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L
Total Phosphorus (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

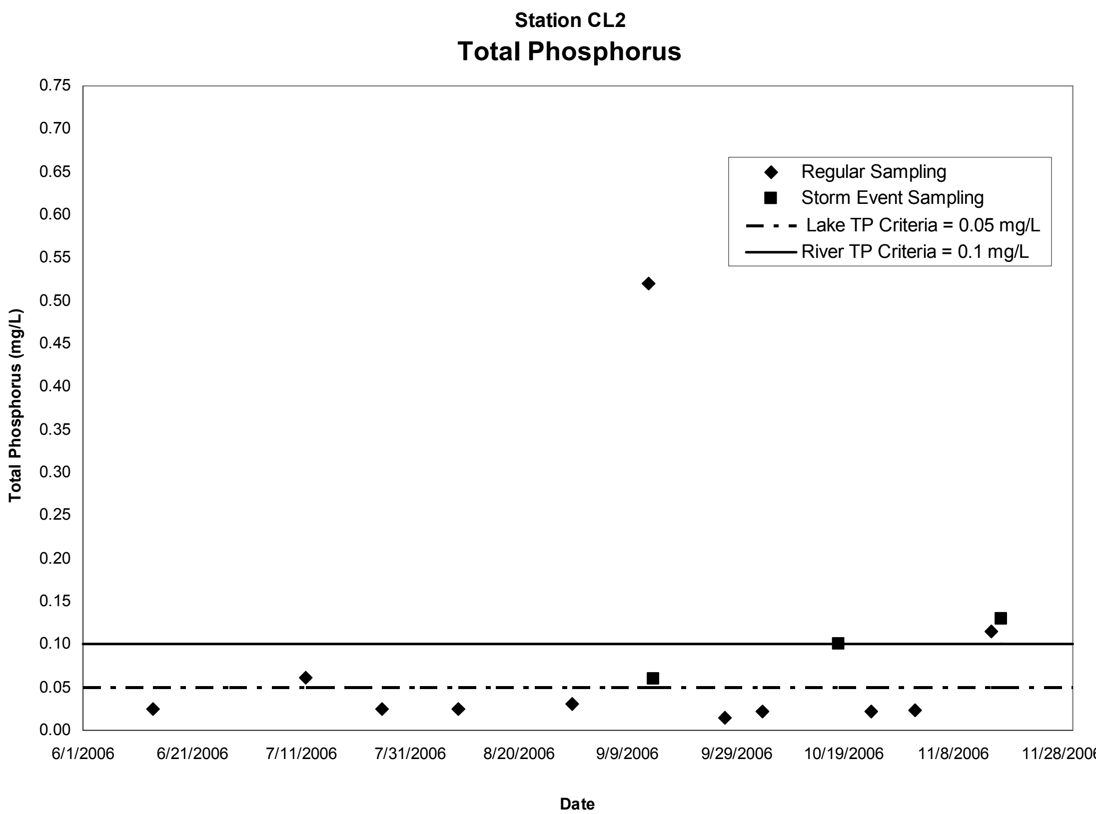

Station C3
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L

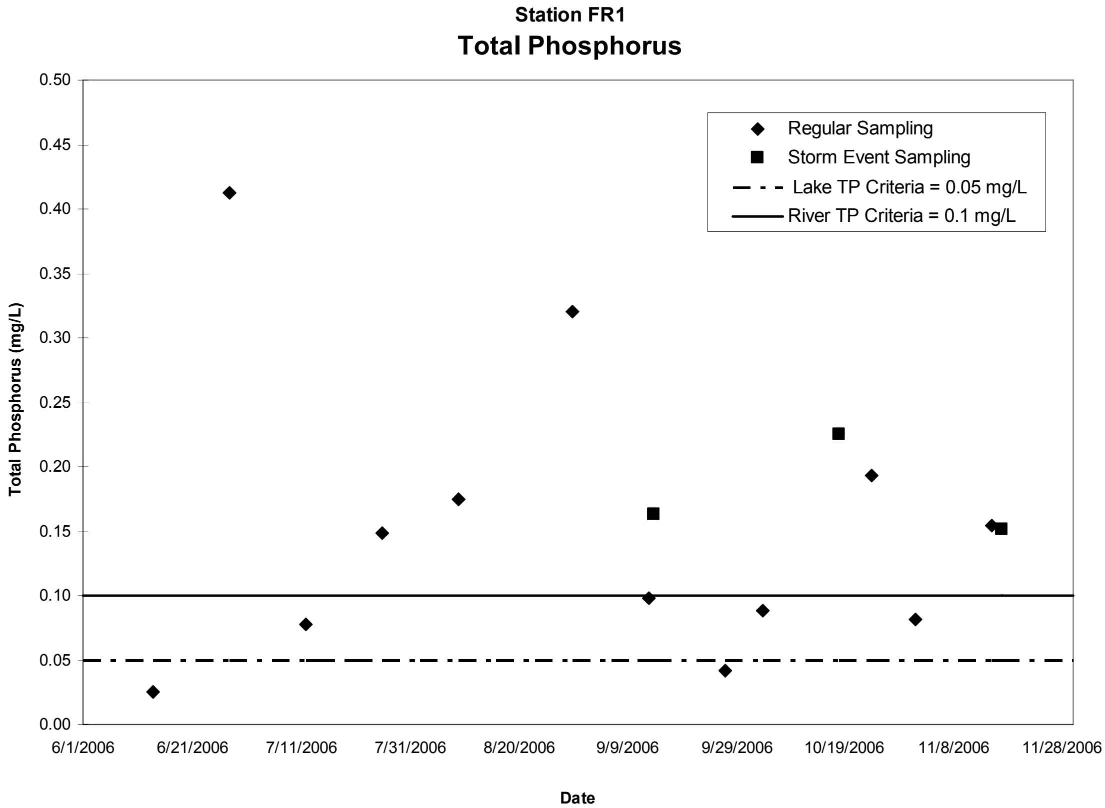

Station C4
Total Phosphorus
Total Phosphorus (mg/L)
1.50
1.25
1.00
0.75
0.50
0.25
0.00
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L

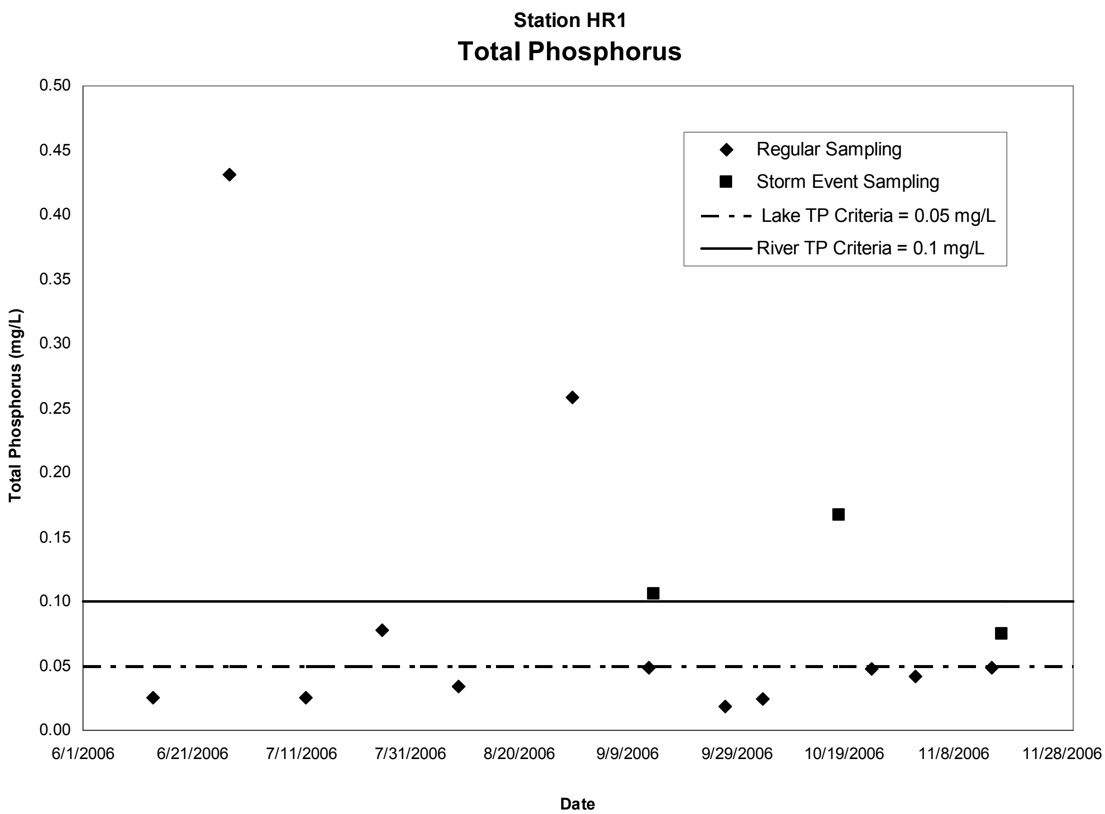

Station C5
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

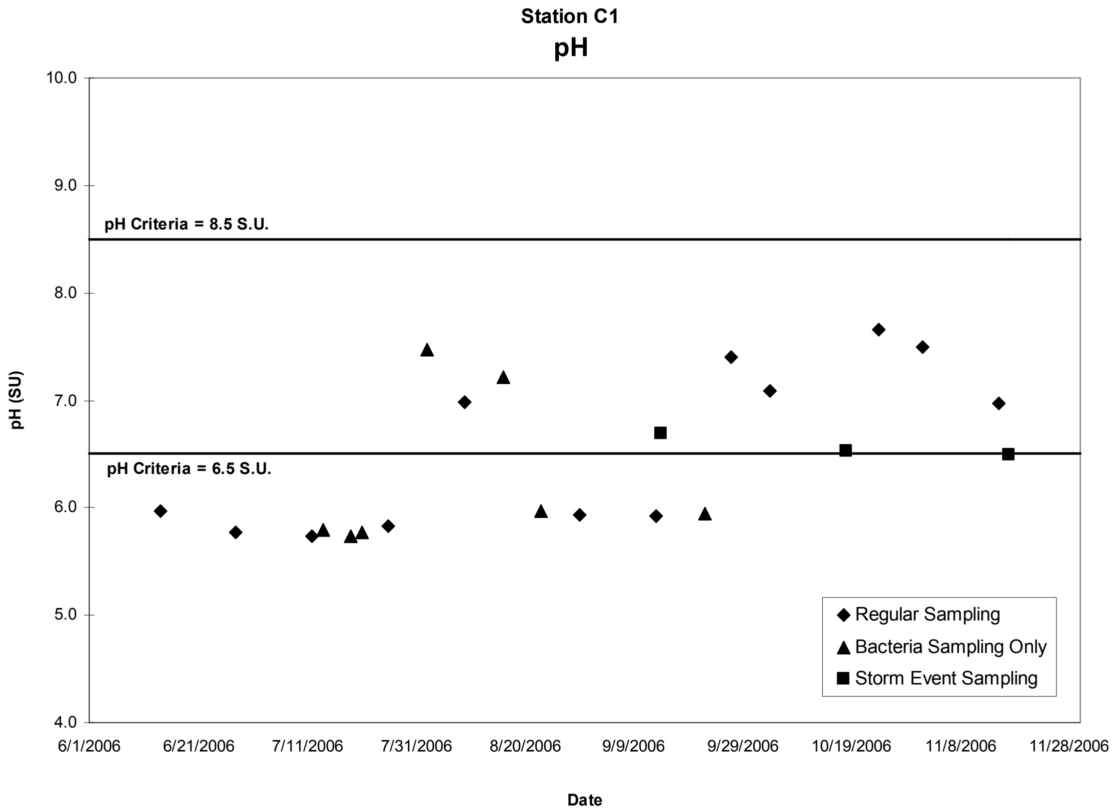

Station C6
Total Phosphorus
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

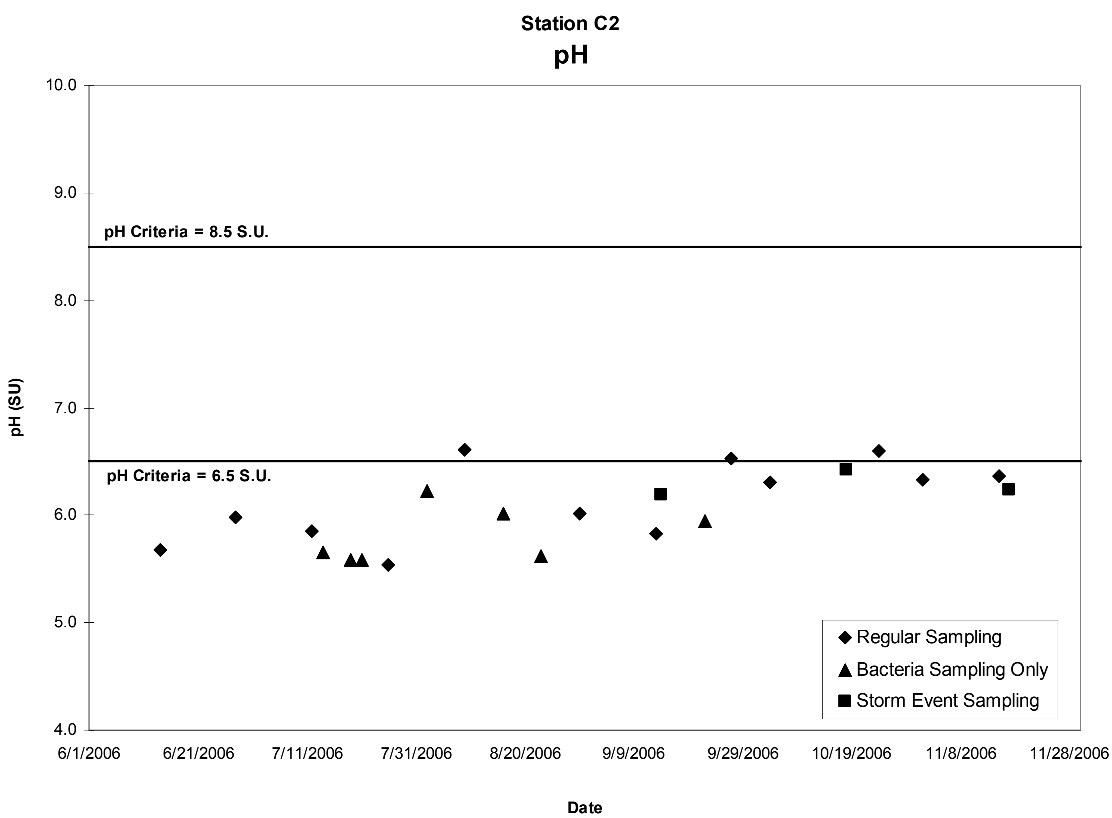

Station CL1
Total Phosphorus
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

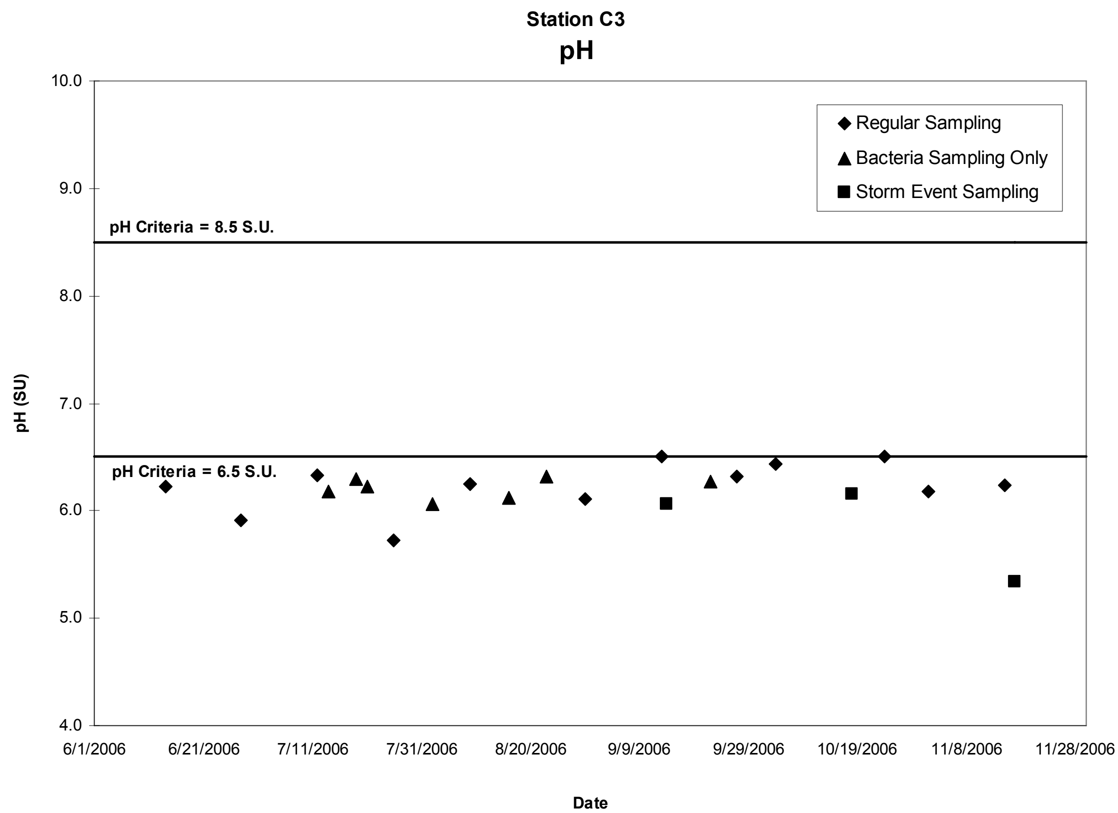

Station CL2
Total Phosphorus
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L
Total Phosphorus (mg/L)
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

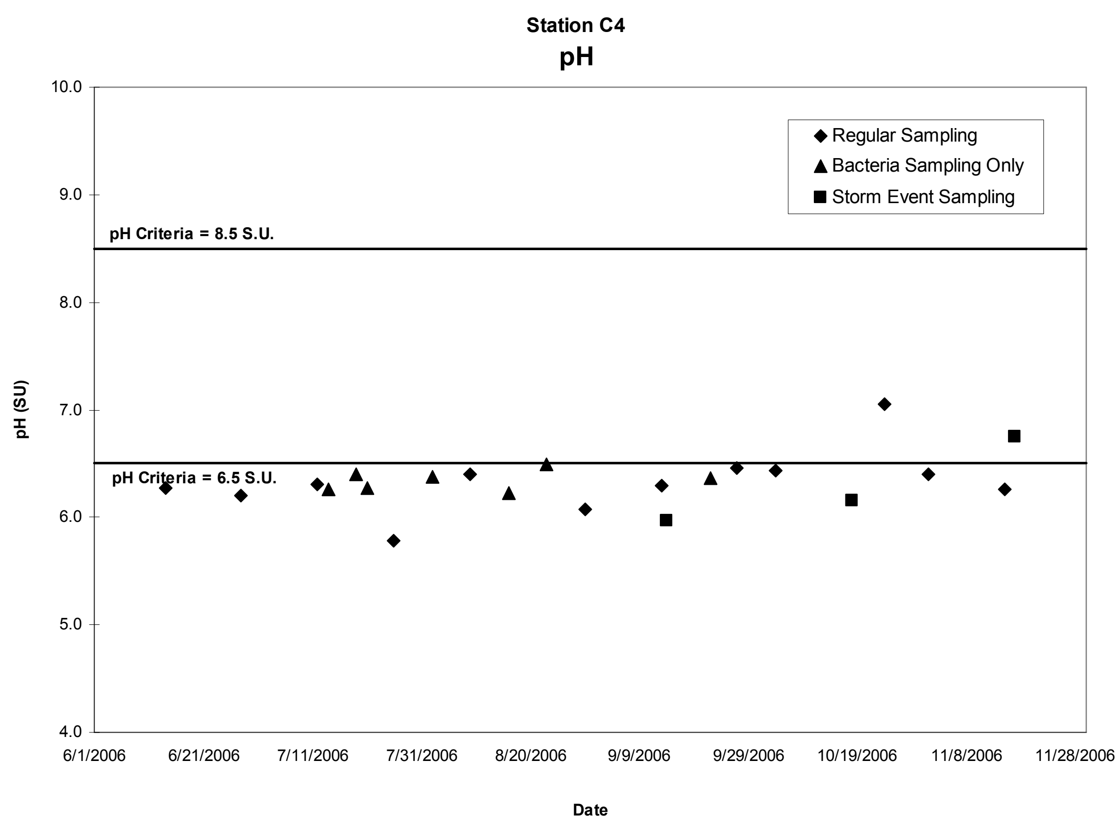

Station FR1
Total Phosphorus
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

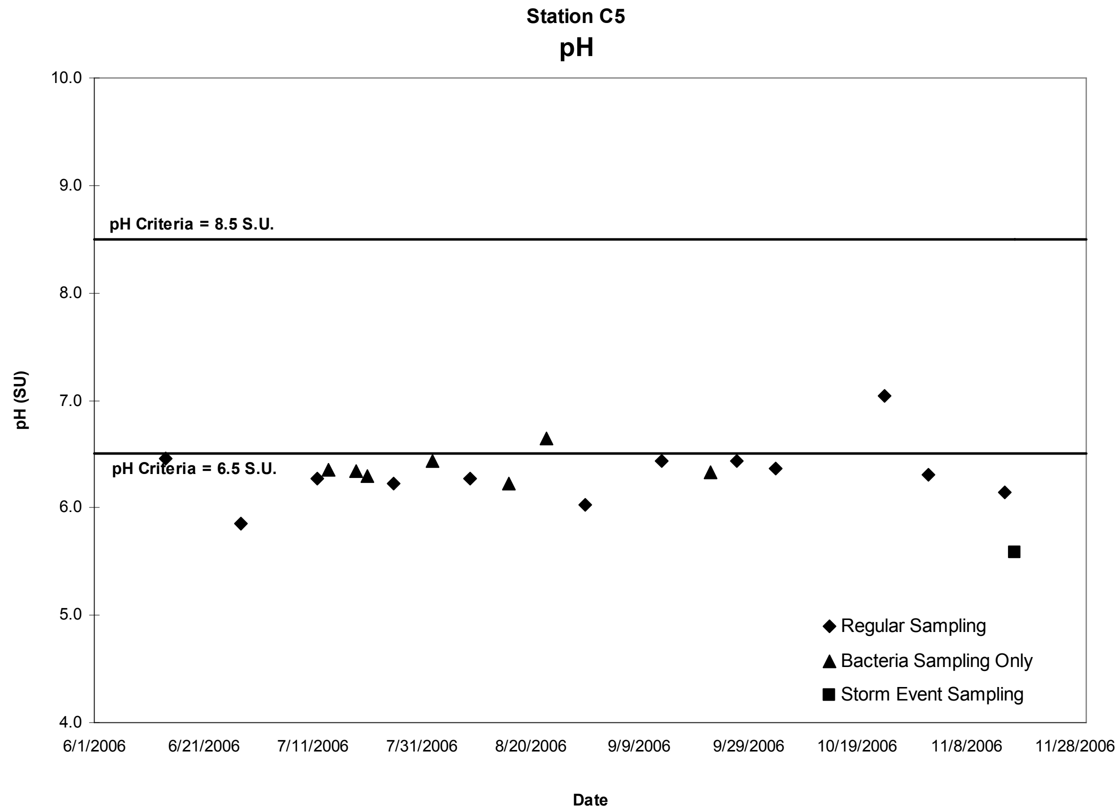

Station HR1
Total Phosphorus
Regular Sampling
Storm Event Sampling
Lake TP Criteria = 0.05 mg/L
River TP Criteria = 0.1 mg/L
Total Phosphorus (mg/L)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

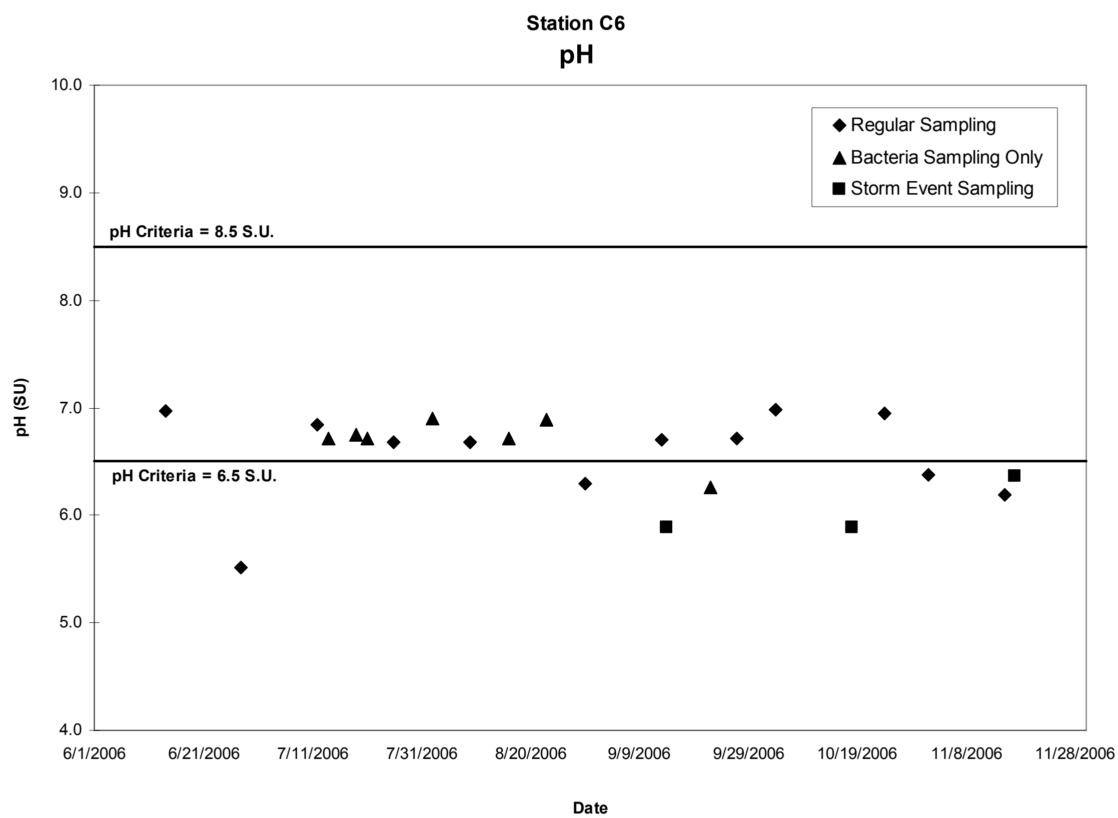

Station C1
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

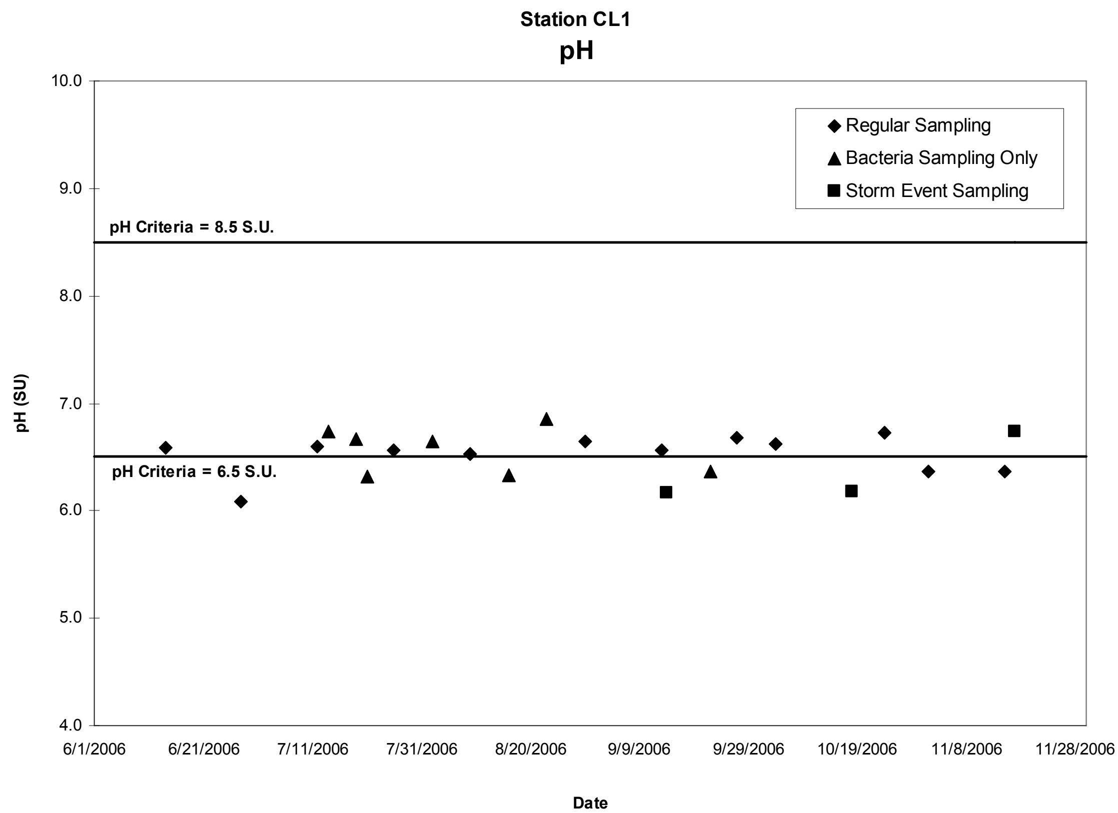

Station C2
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

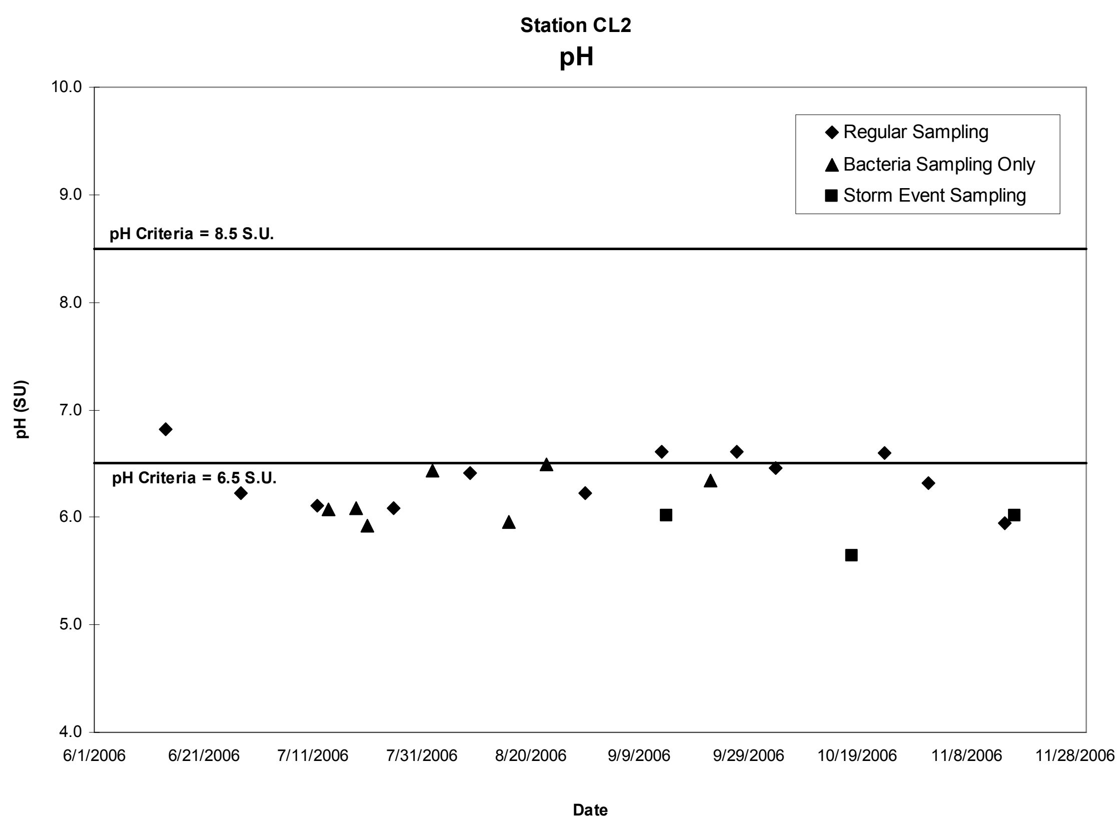

Station C3
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

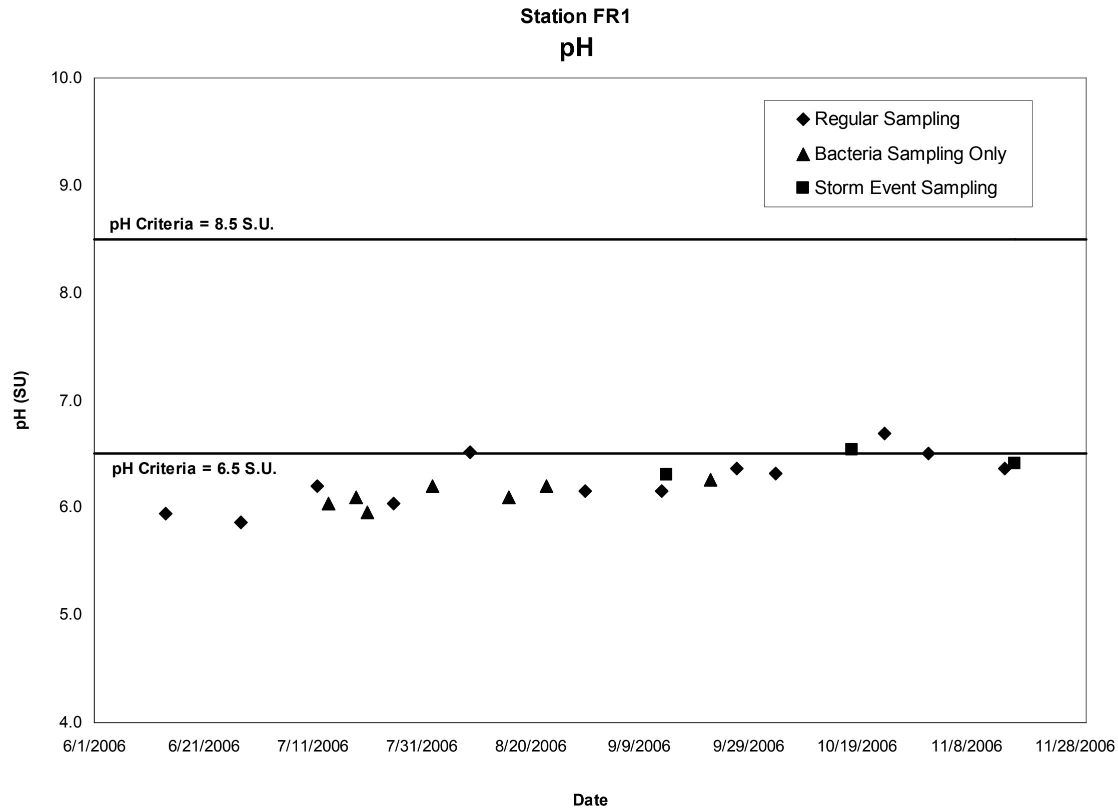

Station C4
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

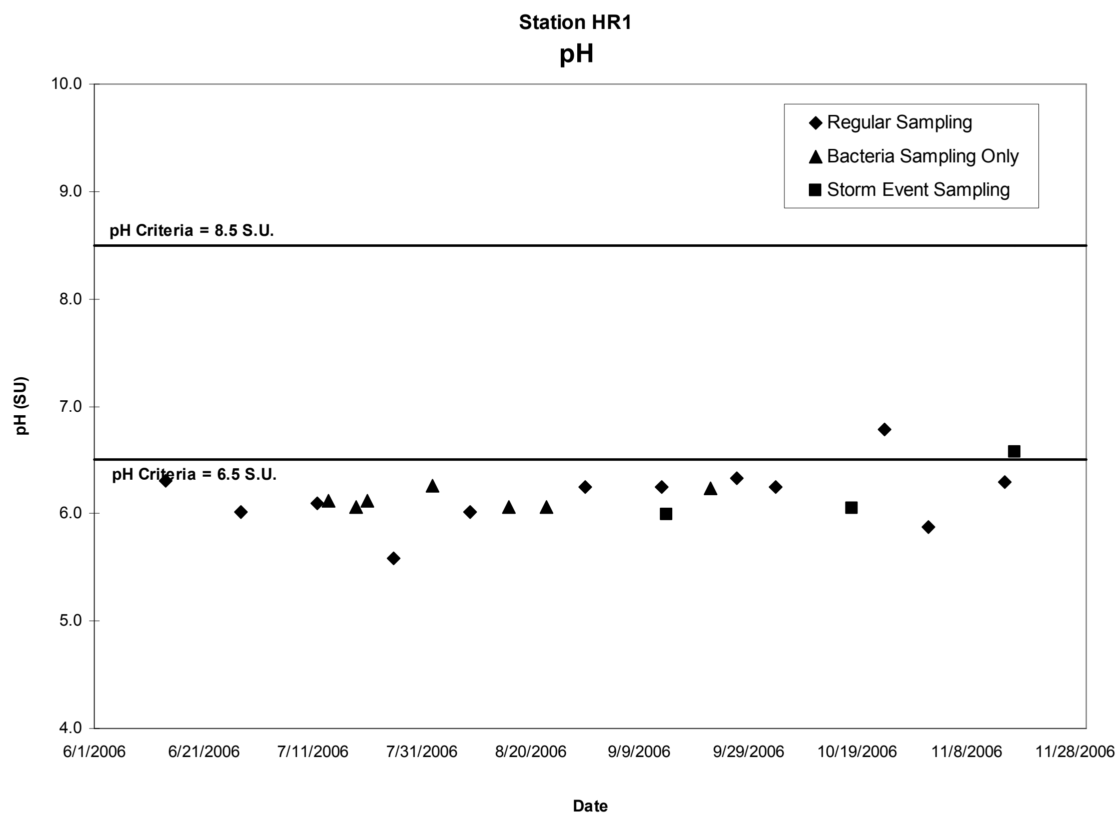

Station C5
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
pH (SU)
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

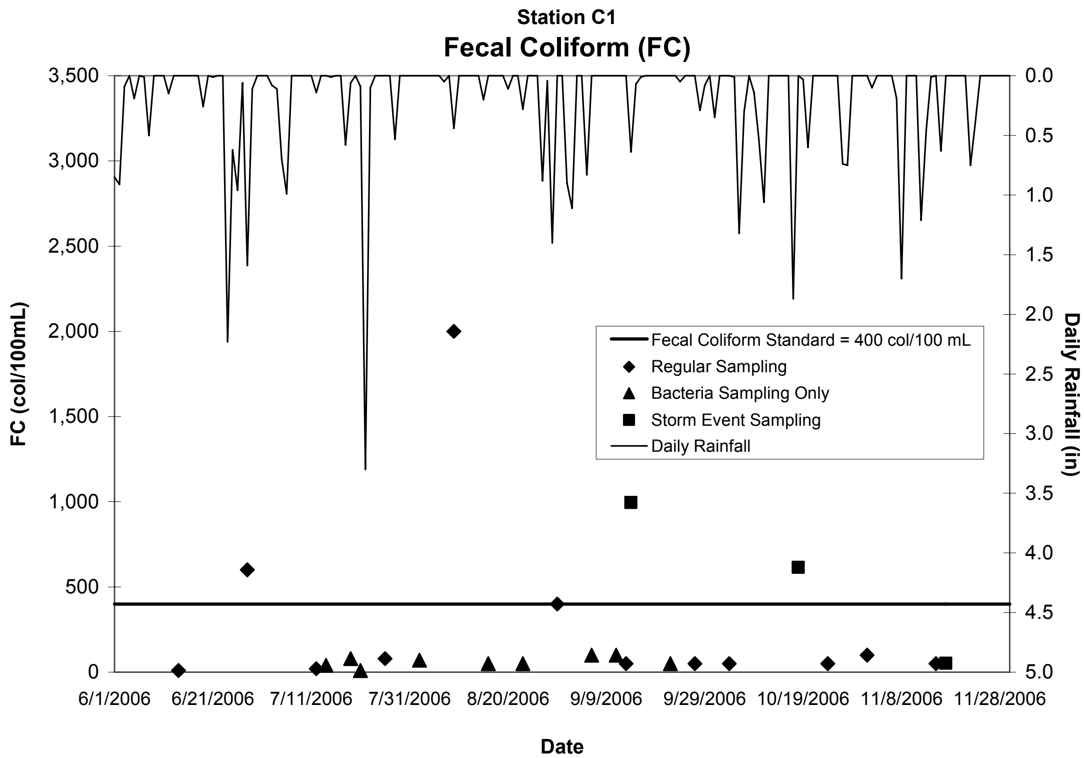

Station C6
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
pH (SU)
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

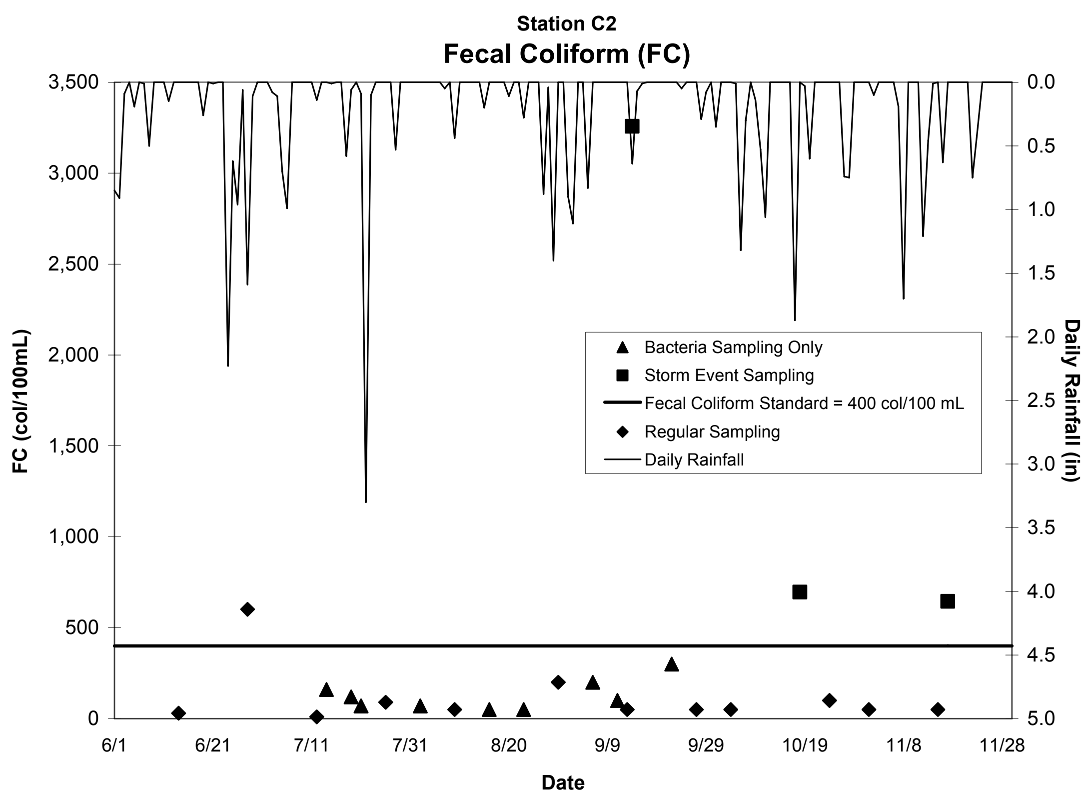

Station CL1
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

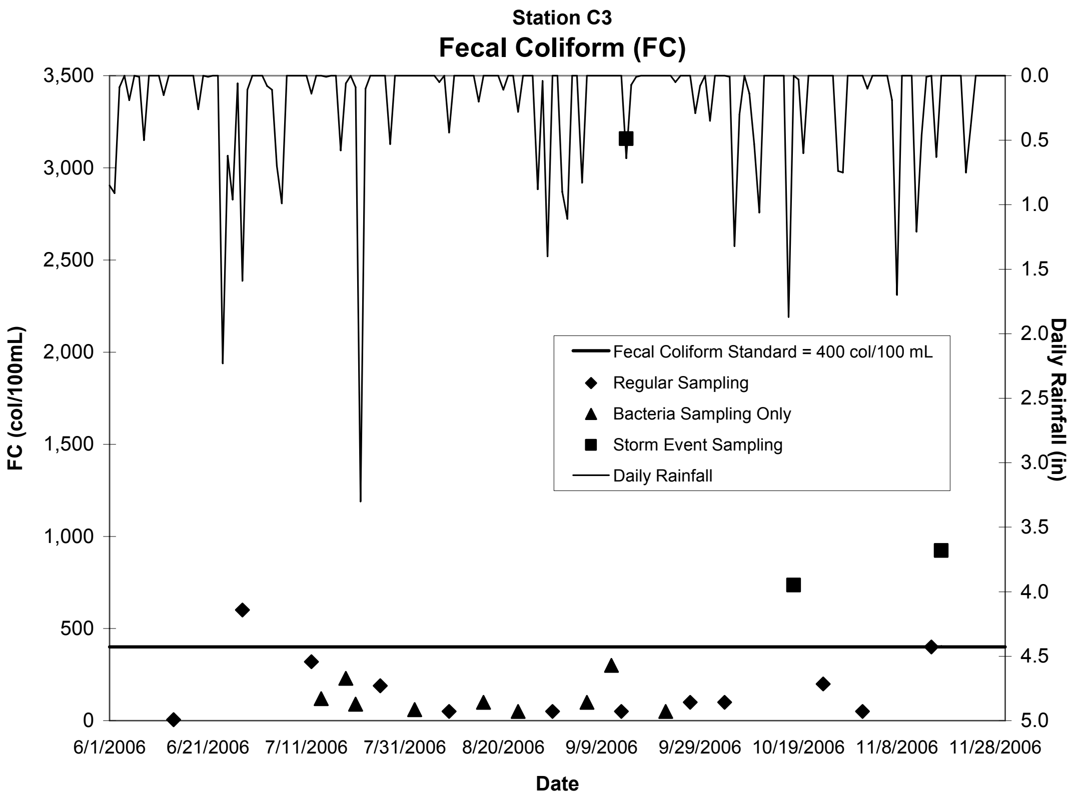

Station CL2
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

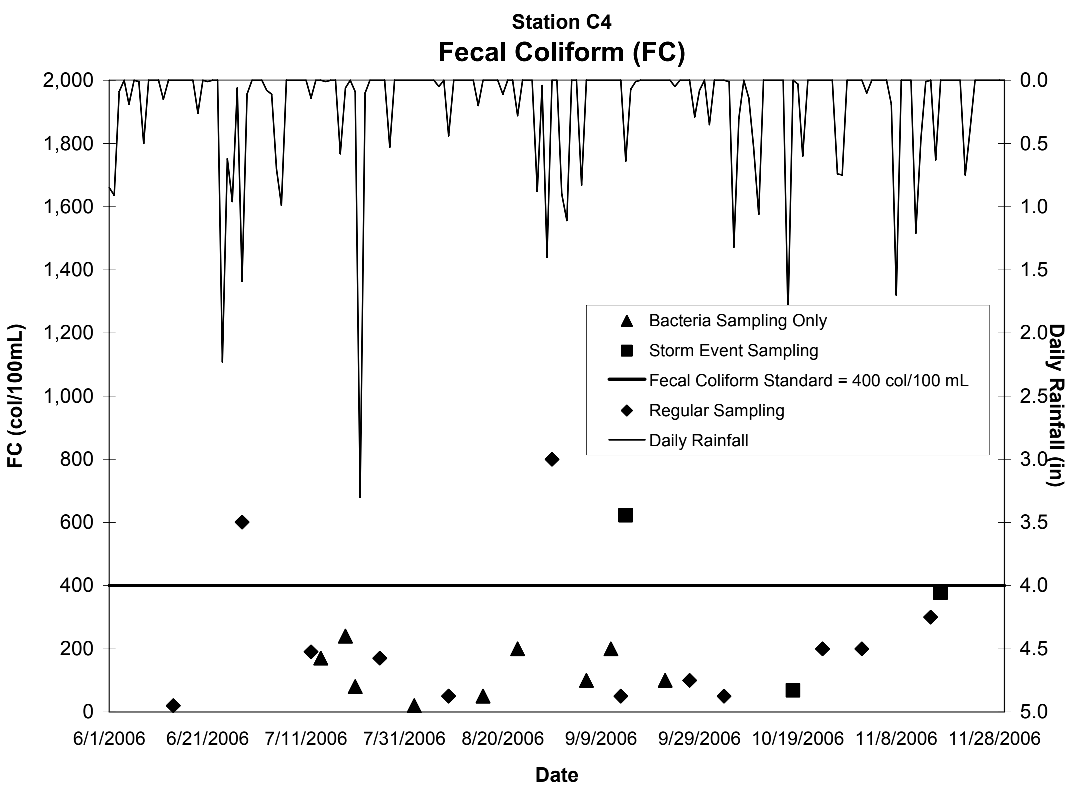

Station FR1
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

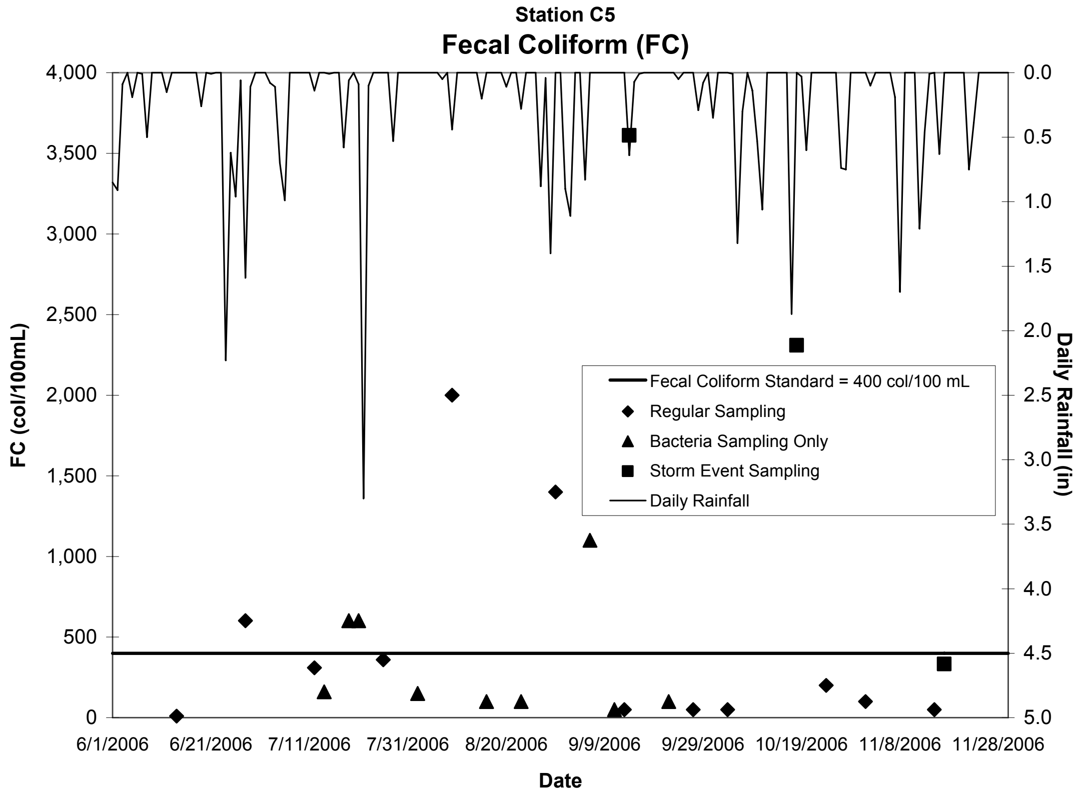

Station HR1
pH
10.0
9.0
8.0
7.0
6.0
5.0
4.0
pH (SU)
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
pH Criteria = 8.5 S.U.
pH Criteria = 6.5 S.U.
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

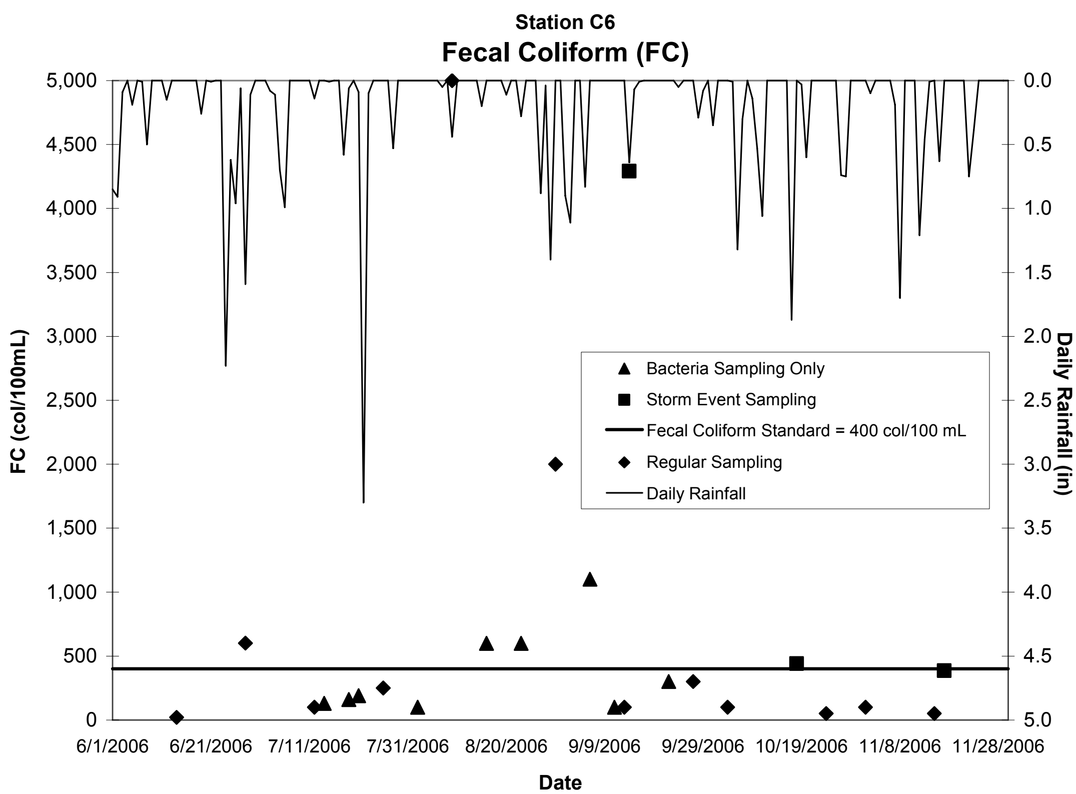

Station C1
Fecal Coliform (FC)
FC (col/100mL)
Daily Rainfall (in)
Date
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
Daily Rainfall
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006

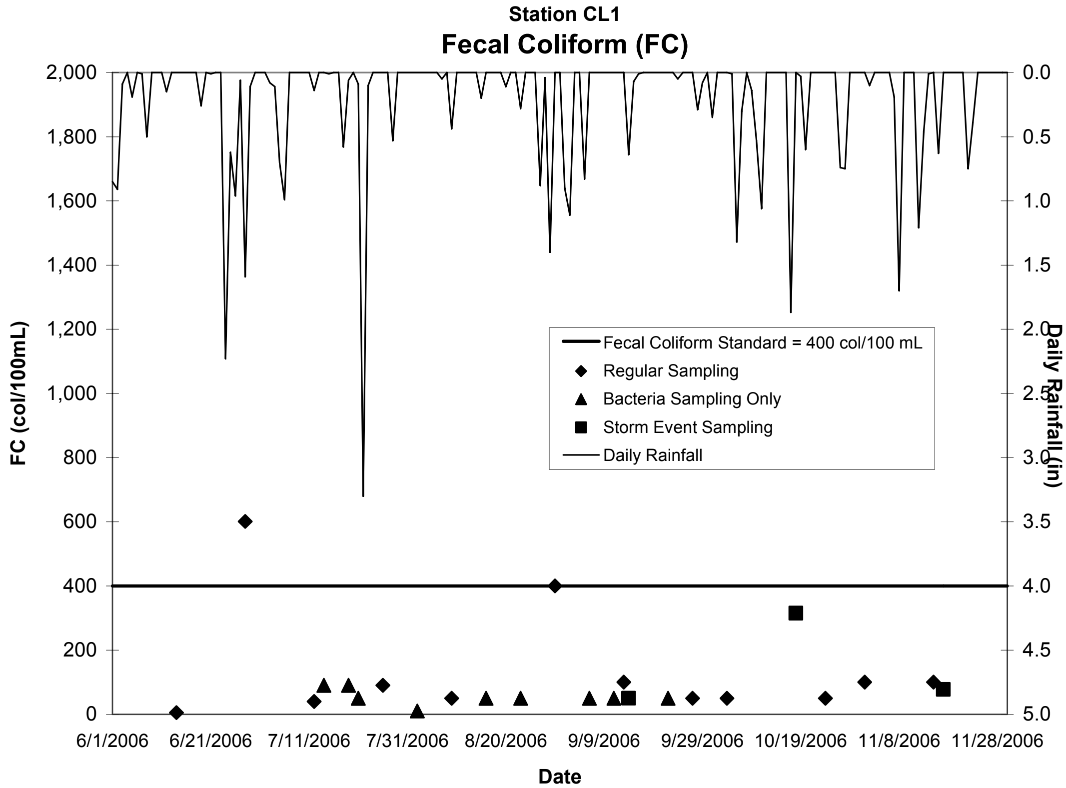

Station C2
Fecal Coliform (FC)
FC (col/100mL)
Daily Rainfall (in)
Date
Bacteria Sampling Only
Storm Event Sampling
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Daily Rainfall
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
6/1
6/21
7/11
7/31
8/20
9/9
9/29
10/19
11/8
11/28

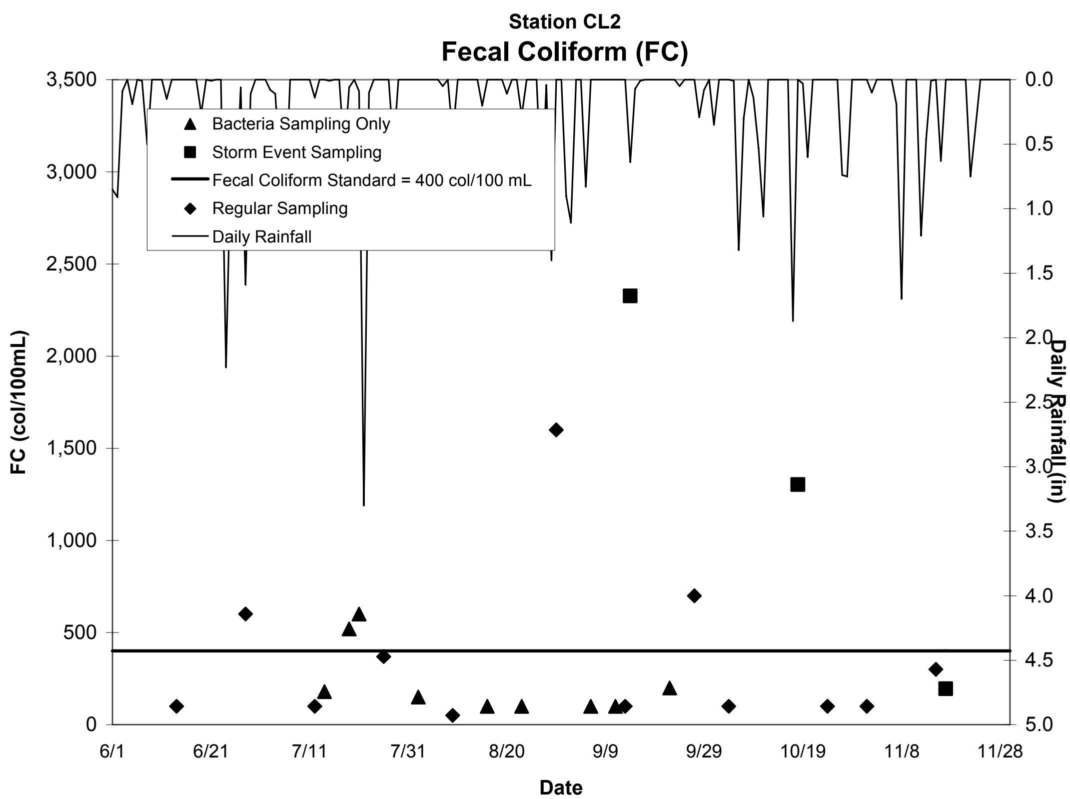

Station C3
Fecal Coliform (FC)
FC (col/100mL)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Daily Rainfall (in)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
Daily Rainfall
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

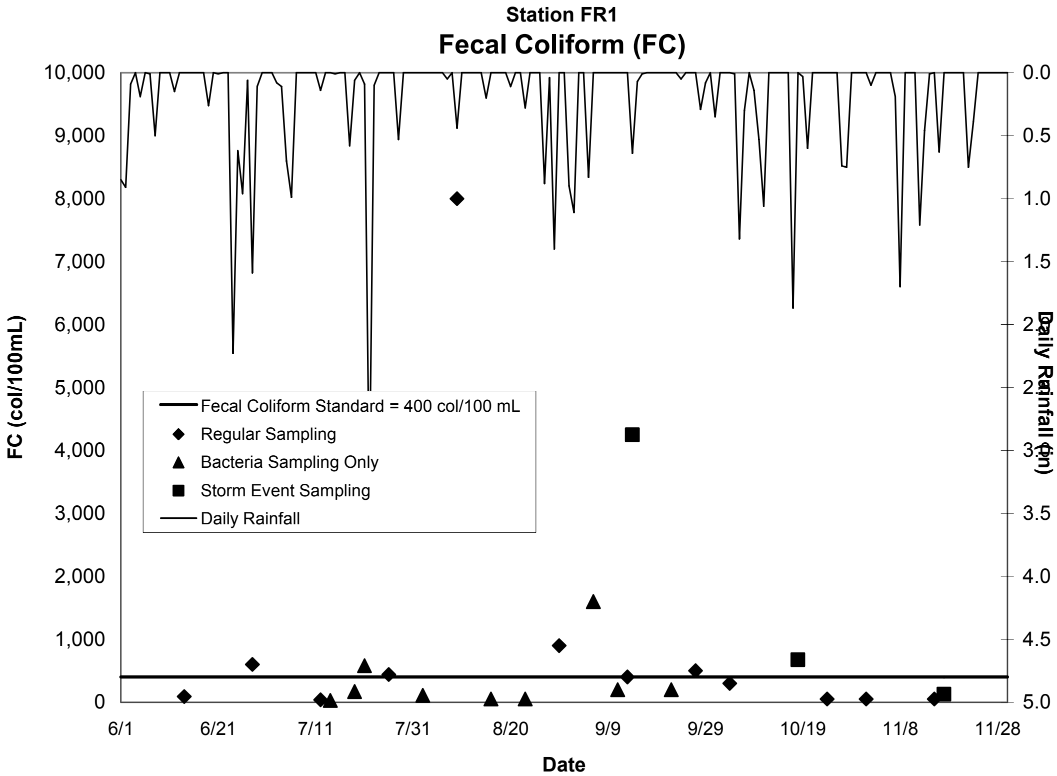

Station C4
Fecal Coliform (FC)
FC (col/100mL)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
Daily Rainfall (in)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Bacteria Sampling Only
Storm Event Sampling
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Daily Rainfall
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date

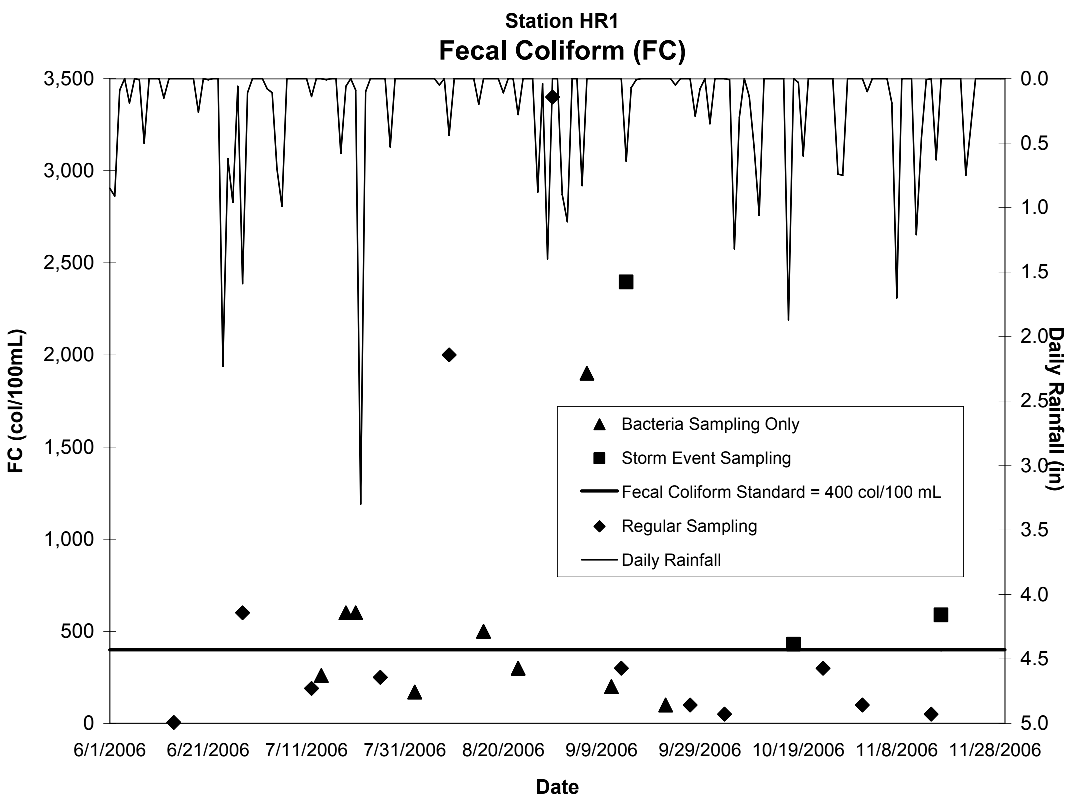

Station C5
Fecal Coliform (FC)
FC (col/100mL)
Daily Rainfall (in)
Date
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
Daily Rainfall


Station C6
Fecal Coliform (FC)
FC (col/100mL)
Daily Rainfall (in)
Date
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Bacteria Sampling Only
Storm Event Sampling
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Daily Rainfall


Station CL1
Fecal Coliform (FC)
FC (col/100mL)
Daily Rainfall (in)
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
Daily Rainfall
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006
Date


Station CL2
Fecal Coliform (FC)
FC (col/100mL)
Daily Rainfall (in)
Bacteria Sampling Only
Storm Event Sampling
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Daily Rainfall
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
6/1
6/21
7/11
7/31
8/20
9/9
9/29
10/19
11/8
11/28
Date


Station FR1
Fecal Coliform (FC)
FC (col/100mL)
Daily Rainfall (in)
Date
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Bacteria Sampling Only
Storm Event Sampling
Daily Rainfall
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
3.5
4.0
4.5
5.0
6/1
6/21
7/11
7/31
8/20
9/9
9/29
10/19
11/8
11/28


Station HR1
Fecal Coliform (FC)
FC (col/100mL)
Daily Rainfall (in)
Date
Bacteria Sampling Only
Storm Event Sampling
Fecal Coliform Standard = 400 col/100 mL
Regular Sampling
Daily Rainfall
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
6/1/2006
6/21/2006
7/11/2006
7/31/2006
8/20/2006
9/9/2006
9/29/2006
10/19/2006
11/8/2006
11/28/2006