Division of Water Quality
Biological Assessment Unit
16 July 2010

MEMORANDUM

To: Michele Drostin

Through: Eric Fleek
Jay Sauber

From: Michael Walters

Subject: Macroinvertebrate assessment in the upper Great Coharie Creek watershed (Cape Fear Basin HUCs 030300060401 and 030300060402)

At the request of staff from the Ecosystem Enhancement Program, nine sites within the upper portion of Great Coharie Creek catchment in the Cape Fear River basin were sampled for benthic invertebrates during the months of February and March 2010. The study is in support of the Great Coharie Creek Local Watershed Plan.

The most downstream site in the watershed (GCC1636b) was the only one in the study to receive a classification of Natural; that site also showed the lowest NCBI value, markedly lower than the other sites in the study. A site on an unnamed tributary to Kill Swamp was designated Not Rated; if it is later determined that swamp criteria can be properly applied to the site it will receive a Moderate. The remaining seven sites received a classification of Moderate. The low NCBI value at GCC1636b relative to the remaining sites suggests that the effects from any potential stressors to the benthic community upstream in the study area are not carried downstream. Overall, a lack of correlation between NCBI values and water chemistry values suggests that local conditions, such as habitat or channel morphology, may be affecting the benthic community more than water-borne stressors. Given the existing data for the study area, there are no indications of specific water-borne stressors that may be impacting the benthic community at the nine sites. Habitat and channel morphology may be a larger influence than water quality in the structure of the communities at each site.

The report for this study is attached.

cc: Stratford Kay—Watershed Assessment Team
Steve Kroeger—Watershed Assessment Team
Belinda Henson—Fayetteville Regional Office
Nora Deamer, Dianne Reid—Basinwide Planning Unit

Division of Water Quality
Biological Assessment Unit
16 July 2010

Results of Macroinvertebrate Assessment in the Upper Great Coharie Creek Watershed (Cape Fear HUCs 030300060401 and 030300060402) Conducted in February and March 2010

INTRODUCTION

Benthic sampling in the upper portion of Great Coharie Creek catchment in the Cape Fear River basin was requested by the Ecosystem Enhancement Program (EEP) to support the development of a Local Watershed Plan (LWP). Prior to the biological sampling conducted for this study, there were no existing benthic data within the study area. Two specific needs for benthic sampling were to: 1) provide baseline data to help assess the biological response to future management plans; 2) potentially identify impaired stream segments that may require immediate attention. This study is in conjunction with activities by the Division of Water Quality Watershed Assessment Team (WAT; details in *Draft Scope of Work: Water Quality Assessments for Great Coharie Creek LWP—Phase II Activities* dated 29 April 2010). Results of the biological study are in the attached report.

WATERSHED DESCRIPTION

The study area (Figure 1) is in the upper portion of the Great Coharie Creek drainage, in the Cape Fear River basin, and within 8-digit HUC 03030006. The area is within the Rolling Coastal Plain Level IV ecoregion, which is characterized by agricultural land use (corn, soybeans, tobacco, cotton, sweet potatoes, peanuts, and wheat), hog and chicken production, and streams of low to moderate gradient with sandy substrata.[1] The town of Newton Grove is encompassed by the study area. Relief for the study area is from 38 to 67 meters altitude.

Land use in the study area includes agriculture, animal production, and a small amount of development concentrated around Newton Grove. Additional land cover includes shrubs, forest, and wetlands.

Four named streams and numerous tributaries are present in the study area. Great Coharie Creek is the major stream in the watershed; its three named tributaries are Sevenmile Swamp, Kill Swamp, and Beaverdam Swamp. Most of the area of Newton Grove is drained by Beaverdam Swamp, with a small western portion of the town drained by the upper portion of Great Coharie Creek. All named streams are classified as “C;Sw”. The entire stretch of Great Coharie Creek has been on the 303(d) list since the year 2000 for mercury.

There are two permitted dischargers in the LWP area: Hog Slat Incorporated—Newton Grove Site, permit NCG030310, permit type Metal Fabrication Stormwater Discharge COC; and Newton Grove Wastewater Treatment Plant, permit NC0072877, permitted discharge of 0.2 million gallons per day. Both discharge to Beaverdam Swamp.

PREVIOUS MONITORING WITHIN THE STUDY AREA

There are no prior DWQ fish or benthic data for the study area. Additionally, there are no Ambient Monitoring System stations nor Monitoring Coalition Program stations located within the area.

[1] Griffith, G.E., Omernik, J.M., Comstock, J.A. Schafale, M.P., McNab, W.H., Lenat, D.R., MacPherson, T.F., Glover, J.B. and Shelburne, V.B. 2002. Ecoregions of North Carolina and South Carolina. (color poster with map, descriptive text, summary tables and photographs): Reston, VA, U.S. Geological Survey (map scale 1:1,500,000).

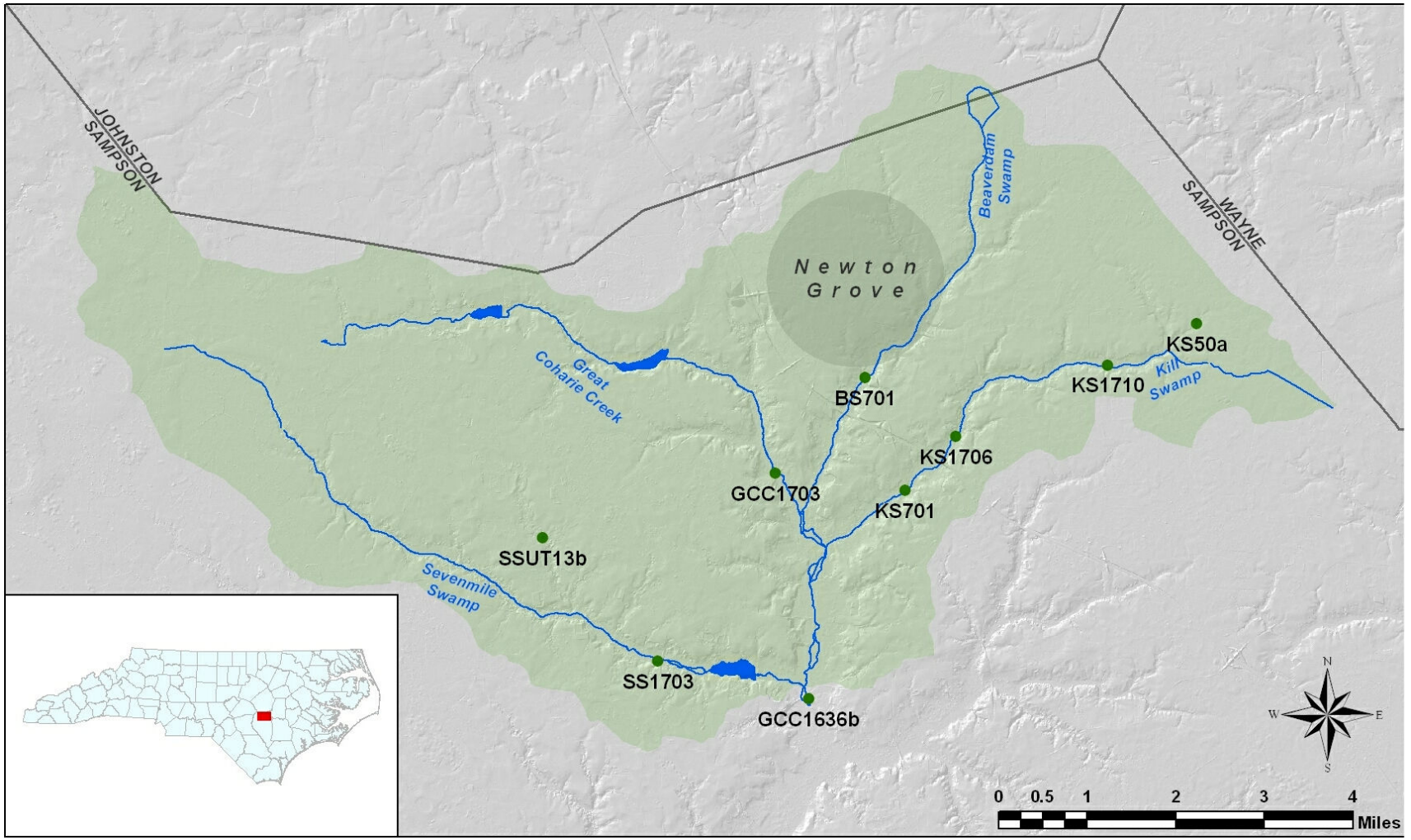


Figure 1. Location of benthic sites within the Great Coharie Creek Local Watershed Plan study area.

METHODS

Macroinvertebrate Collections

Benthic samples were collected from nine sites in the study area on 23 February, 24 February, and 9 March 2010. All samples were collected using swamp methods.[2]

Each swamp sample is a composite of the following qualitative collection methods: nine sweep collections targeting macrophytes, root mats, undercut banks, and detritus deposits; three log and debris washes; and visual collections for taxa potentially missed by the other two collection methods. Representative specimens of all invertebrate taxa collected were removed from the matrix and preserved in 95% ethanol by biologists while in the field.

The purpose of benthic sampling is to produce an inventory of the aquatic macroinvertebrate fauna at the stream site along with the relative abundance of organisms for each taxon, ultimately leading to an assessment of water quality based upon the composition of the benthic community. Organisms are classified as Rare (1-2 specimens, denoted by "R" on taxa tables), Common (3-9 specimens, "C"), or Abundant (≥10 specimens, "A"). Data from the inventory are entered to a relational database.

Habitat Evaluations

Habitat was evaluated at all sites using a qualitative scoring system designed for coastal streams. A score was given to each of the following habitat components: degree of channel modification; amount and variety of in-stream habitat; substrate composition; pool frequency and variety; stream-bank stability and vegetation; light penetration; and riparian vegetative zone width. The scores for each habitat component were summed to give an overall habitat score for each of the sites. Values for the overall score range from 1 to 100.

Physicochemical Measurements

Several physicochemical properties of the stream at each site were measured. Data for temperature, dissolved oxygen, and specific conductance were collected using a YSI-85 multi-meter. Measurements for pH were collected using an Accumet AP61 meter. Meters were calibrated each morning before use and checked for accurate readings each evening.[3]

Derivation of Biological Classifications

Several data summaries (metrics) were calculated from the benthic data to facilitate the detection of physical habitat and/or water quality problems. The metrics are based on a long history of studies that show unstressed streams and rivers have higher invertebrate diversity and a relatively high proportion of species intolerant to pollution. Conversely, polluted streams have lower invertebrate diversity and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness (i.e. the total number of distinct taxa present); the tolerance of the stream community is evaluated using a biotic index (derived from the general response of each taxon to the presence of stressors).

Three biological metrics are included in the derivation of bioclassifications: Total Taxa Richness, EPT Richness, and the North Carolina Biotic Index (NCBI). Total Taxa Richness is a count of all taxa collected and identified from the sample. Higher taxa richness is an indicator of better water quality and habitat. EPT Richness is the count of taxa within the three insect orders Ephemeroptera, Plecoptera, and

[2] NC DWQ. 2006. Standard Operating Procedures for Benthic Macroinvertebrates. North Carolina Department of Environment and Natural Resources, Division of Water Quality, Biological Assessment Unit. July 2006. Unpublished. http://www.esb.enr.state.nc.us/BAUwww/benthossop.pdf

[3] NC DWQ. 2006. Intensive Survey Unit Standard Operating Procedures. North Carolina Department of Environment and Natural Resources, Division of Water Quality, Intensive Survey Unit. December 2006. Unpublished. http://www.esb.enr.state.nc.us/documents/PHYSICAL-CHEMICAL%20SOP.pdf

Trichoptera. Species within the EPT are generally intolerant of pollutants. Therefore, EPT Richness is particularly sensitive to the presence of pollutants. The relative tolerance of the macroinvertebrate community to stressors, as summarized by the NCBI, was also used to evaluate water quality. Both tolerance values for individual taxa and the final biotic index values have a range of 0-10 with higher numbers indicating more tolerant taxa and more polluted conditions respectively.

Criteria for swamp region A sites (i.e. swamp sites within either the Atlantic Southern Loam Plains or Rolling Coastal Plain level IV ecoregions) were used to assign bioclassifications. In addition to the three biological metrics discussed above, habitat score, pH, and channel form (braided versus a well defined main channel), were used to determine a classification for sites within swamp region A. Stream braiding and low pH, both of which can occur naturally in swamp systems, have been observed to reduce taxa richness in streams in this region.[4] A score of one, three, or five was given to the NCBI value, habitat assessment results, EPT Richness (adjusted if the stream was braided and for pH if less than 5.5) and Total Taxa Richness (with similar adjustments as for EPT Richness). A swamp score, which ranges from one to 10, was determined for each site using the following formula:

$$S = \frac{(2n+h+e+t)-5}{2}$$

where:

S is the final swamp score
n is the NCBI score
h is the habitat score
e is the EPT Richness score (adjusted if low pH and/or braided channel)
t is the Total Taxa Richness score (adjusted if low pH and/or braided channel)

Sites were then classified as either Natural (swamp score of nine or 10), Moderate (i.e. moderately stressed; score of four through eight), or Severe (i.e. severely stressed; score of one through three).

[4] Lenat, D. 2003. Macroinvertebrate criteria for North Carolina swamp streams. Internal, unpublished BAU memorandum dated 7 March 2003.

MONITORING SITES

A survey of streams within the study area during the last week of May in 2009 by Michele Drostin and three members of the Biological Assessment Unit (BAU) showed that the named streams and many of the unnamed tributaries in the study area ceased flowing to a detectable level during that part of the year, and thus were suited to potential sampling and assessment using swamp criteria.

Nine sites were sampled for macroinvertebrates for this study (Table 1).[5] These sites were selected during reconnaissance performed by Michael Walters (BAU) and Michele Drostin (EEP) on 18 February 2010. Ten sites were originally selected within the study area. The criteria for selection were visible flow through much of the reach to be sampled and the ability to be waded. One of the ten sites was subsequently dropped due to the loss of detectable flow through most of the reach on the day it was to be sampled.

Table 1. Site data for the nine benthic sites sampled in February and March 2010 within the Great Coharie Creek LWP study area. All sites are in Sampson County.

WAT ID	GCC1703	BS701	KS50a	KS1710	KS1706	KS701	SSUT13b	SS1703	GCC1636b
BAU site ID	BB511	BB512	BB516	BB515	BB514	BB513	BB510	BB509	BB508
BAU sample	10909	10914	10910	10911	10912	10913	10908	10907	10906
Waterbody	Great Coharie Creek	Beaverdam Swamp	UT Kill Swamp	Kill Swamp	Kill Swamp	Kill Swamp	UT Sevenmile Swamp	Sevenmile Swamp	Great Coharie Creek
Location	SR 1703	off Bizzell St, Newton Grove	NC 50/55	SR 1710	SR 1706	US 701	US 13	SR 1703	SR 1636
Latitude	35.2199700	35.2356000	35.2439180	35.2373500	35.2258800	35.2170100	35.2096900	35.1893200	35.1830700
Longitude	-78.3715100	-78.3535900	-78.2872020	-78.3051500	-78.3355700	-78.3457500	-78.4180400	-78.3952000	-78.3652400
AU designation	18-68-1	18-68-1-1		18-68-1-2	18-68-1-2	18-68-1-2		18-68-1-3	18-68-1
Drainage area (sq mi)	10.9	7.7	0.3	3.9	7.1	7.9	2.0	15.2	50.9
Collection date	23-Feb-2010	24-Feb-2010	9-Mar-2010	9-Mar-2010	24-Feb-2010	24-Feb-2010	23-Feb-2010	23-Feb-2010	23-Feb-2010
Primary land use in drainage	cropland, development, forest/wetland	cropland, development, forest/wetland	cropland, forest/wetland	shrub/scrub, cropland, development, forest/wetland	shrub/scrub, cropland, development, forest/wetland	shrub/scrub, cropland, development, forest/wetland	shrub/scrub, cropland, forest/wetland	shrub/scrub, cropland, development, forest/wetland	shrub/scrub, cropland, development, forest/wetland

RESULTS AND DISCUSSION

Habitat scores, other habitat measures, physicochemical measurements, and local land use visible from the sampling location are provided for each site in Table 2. Benthic community metrics are given in Table 3; EPT Richness, Total Taxa Richness, and NCBI values are presented graphically in Figure 2. Taxa collected at each site are given in the appendix. Photos for each site are shown in Figures 3 though 20.

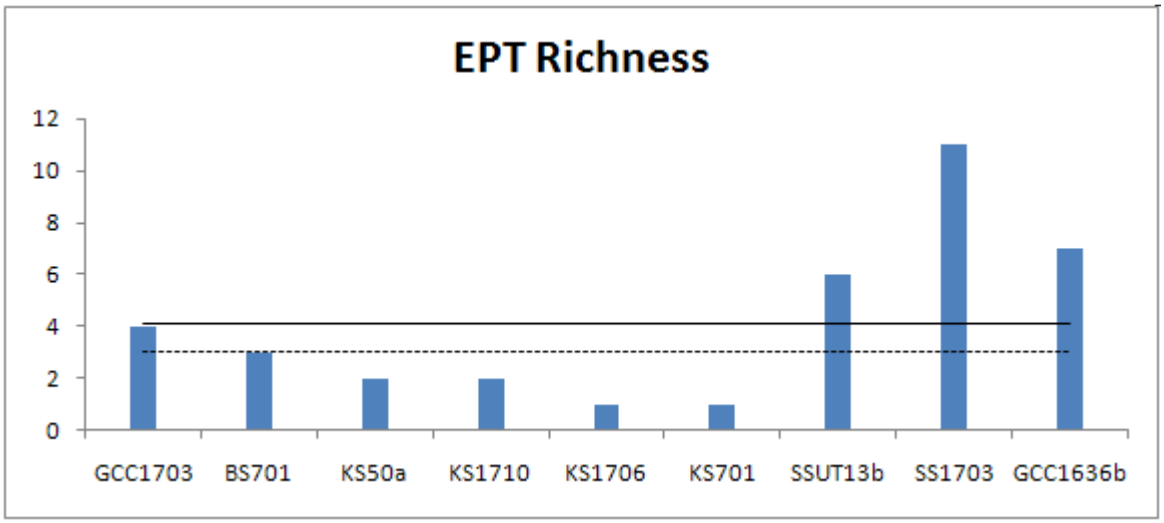
[5] Drainage areas determined with ArcGIS Spatial Analyst Tools using the 30 by 30 meter USGS National Elevation Dataset digital elevation model.

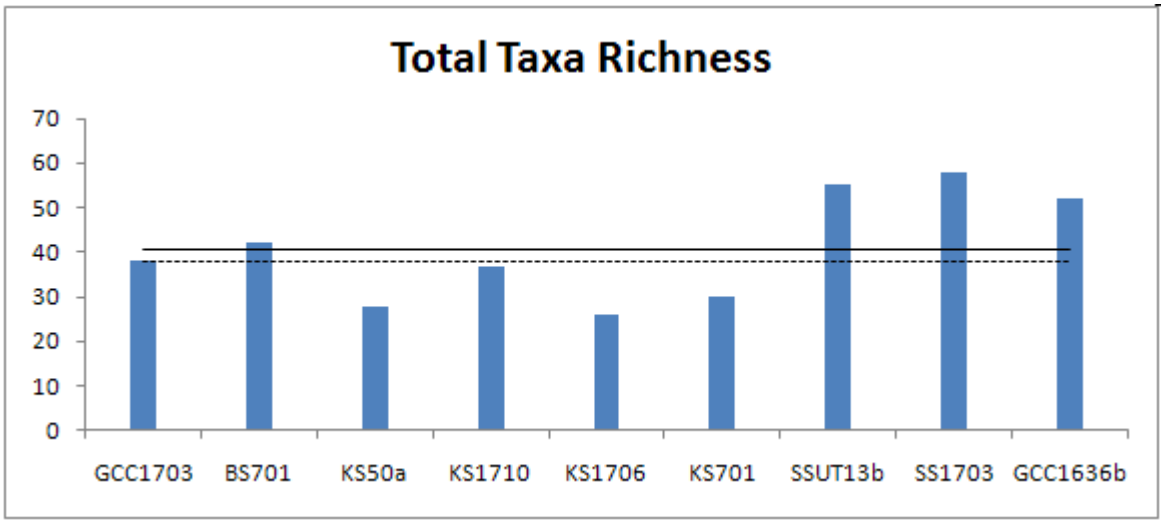
Table 2. Habitat, physicochemical, and local land use for the nine benthic sites sampled in February and March 2010 within the Great Coharie Creek LWP study area.

WAT ID	GCC1703	BS701	KS50a	KS1710	KS1706	KS701	SSUT13b	SS1703	GCC1636b
BAU site ID	BB511	BB512	BB516	BB515	BB514	BB513	BB510	BB509	BB508
BAU sample	10909	10914	10910	10911	10912	10913	10908	10907	10906
Waterbody	Great Coharie Creek	Beaverdam Swamp	UT Kill Swamp	Kill Swamp	Kill Swamp	Kill Swamp	UT Sevenmile Swamp	Sevenmile Swamp	Great Coharie Creek
Location	SR 1703	off Bizzell St, Newton Grove	NC 50/55	SR 1710	SR 1706	US 701	US 13	SR 1703	SR 1636
Collection date	23-Feb-10	24-Feb-10	9-Mar-10	9-Mar-10	24-Feb-10	24-Feb-10	23-Feb-10	23-Feb-10	23-Feb-10
Habitat Scores									
Channel modification (15)	15	15	6	15	15	15	15	15	15
In-stream habitat (20)	12	6	7	12	12	9	8	11	13
Bottom substrate (15)	9	8	7	5	9	9	4	7	14
Pool variety (10)	10	10	4	10	10	10	10	10	10
Bank stability/vegetation (20)	18	20	9	18	20	20	17	19	16
Light penetration (10)	9	7	8	10	7	7	9	10	10
Riparian zone width (10)	10	10	9	4	10	10	10	10	10
Total Habitat (100)	83	76	50	74	83	80	73	82	88
Other Habitat									
Average stream width (m)	---	---	1.5	---	---	---	---	---	11
Average stream depth (m)	0.9	0.4	0.3	0.3	0.7	1.1	0.4	1.0	1.1
Canopy (%)	60	50	100	90	60	50	70	70	80
Substrate (%)									
Gravel	0	0	0	0	0	0	0	0	30
Sand	40	20	85	0	20	20	0	80	60
Silt	0	20	10	65	30	20	0	20	10
Organic/detritus	60	60	5	35	50	60	100	0	0
Physicochemical									
Temperature (ºC)	11.8	9.9	11.0	10.5	9.5	9.0	7.3	9.2	8.9
Dissolved oxygen (mg/L)	9.5	9.1	9.9	8.5	12.6	8.4	8.5	10.2	9.0
Specific conductance (µmhos/cm)	96	111	120	94	107	106	94	104	98
pH	5.8	6.1	4.7	5.1	6.1	5.9	5.7	6.0	6.0
Local land use (%)									
Forest	80	80	10		30	60	40	70	100
Wetland	20	20		20	70	40	60	30	
Cropland			90						
Pasture				80					

Table 3. Benthic community metrics for the nine benthic sites sampled in February and March 2010 within the Great Coharie Creek LWP study area.

WAT ID	GCC1703	BS701	KS50a	KS1710	KS1706	KS701	SSUT13b	SS1703	GCC1636b
BAU site ID	BB511	BB512	BB516	BB515	BB514	BB513	BB510	BB509	BB508
BAU sample	10909	10914	10910	10911	10912	10913	10908	10907	10906
Waterbody	Great Coharie Creek	Beaverdam Swamp	UT Kill Swamp	Kill Swamp	Kill Swamp	Kill Swamp	UT Sevenmile Swamp	Sevenmile Swamp	Great Coharie Creek
Location	SR 1703	off Bizzell St, Newton Grove	NC 50/55	SR 1710	SR 1706	US 701	US 13	SR 1703	SR 1636
Collection date	23-Feb-10	24-Feb-10	9-Mar-10	9-Mar-10	24-Feb-10	24-Feb-10	23-Feb-10	23-Feb-10	23-Feb-10
Sample method	Swamp	Swamp	Swamp	Swamp	Swamp	Swamp	Swamp	Swamp	Swamp
Criteria	Swamp A	Swamp A	---	Swamp A	Swamp A	Swamp A	Swamp A	Swamp A	Swamp A
Richness									
Ephemeroptera	1	0	0	0	0	0	3	5	4
Plecoptera	1	0	0	0	0	0	0	2	1
Trichoptera	2	3	2	2	1	1	3	4	2
Total EPT	4	3	2	2	1	1	6	11	7
Odonata	3	3	3	4	1	1	4	4	3
Megaloptera	0	1	0	0	0	0	0	1	0
Coleoptera	3	6	1	3	0	4	8	4	6
Chironomidae	14	10	9	14	8	7	19	20	20
non-Chironomidae Diptera	6	5	5	3	5	2	5	3	5
Oligochaeta	1	5	3	3	2	5	5	3	1
Mollusca	4	4	0	2	5	5	5	4	6
Other taxa	3	5	5	6	4	5	3	8	4
Total taxa richness	38	42	28	37	26	30	55	58	52
Other biological metrics									
EPT abundance	26	7	4	2	3	3	10	48	49
EPT Biotic Index	6.38	5.84	3.55	6.30	5.90	6.70	6.05	5.94	5.71
NCBI	6.90	7.48	7.27	7.88	7.28	7.32	7.65	7.05	6.16
Swamp Score	5	4	4	4	4	4	4	7	9
Bioclassification	Moderate	Moderate	Not Rated	Moderate	Moderate	Moderate	Moderate	Moderate	Natural





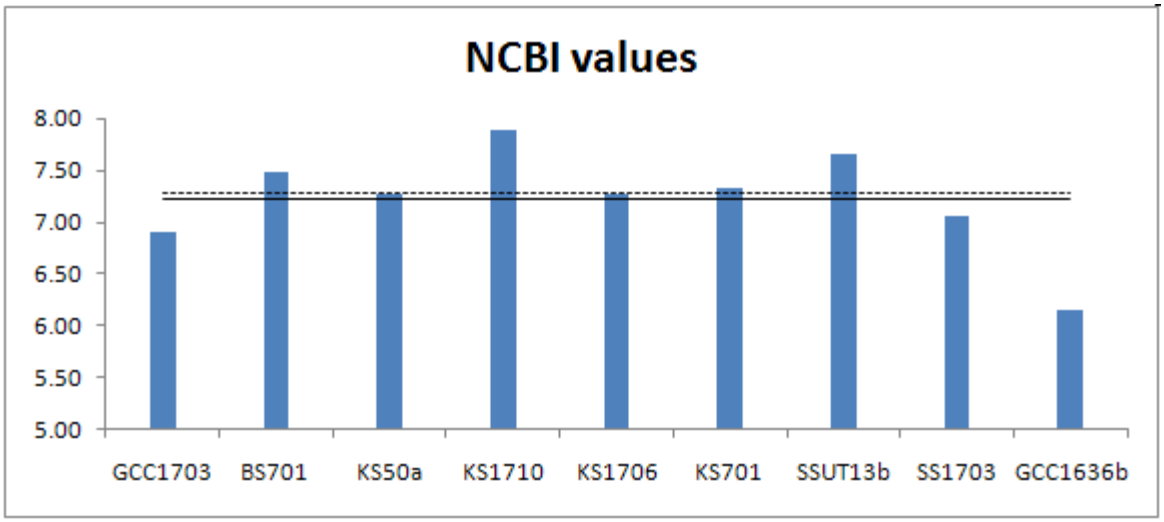


Figure 2. Graphical representations of EPT Richness, Total Taxa Richness, and NCBI values for the nine benthic sites sampled in February and March 2010 within the Great Coharie Creek LWP study area. The solid line in each graph is the mean value; the dashed line is the median.

Figure 3. Great Coharie Creek at SR 1703 (GCC1703) looking upstream.

Figure 4. Great Coharie Creek at SR 1703 (GCC1703) looking downstream.

Figure 5. Beaverdam Swamp off Bizzell St, Newton Grove (BS701) looking upstream.

Figure 6. Beaverdam Swamp off Bizzell St, Newton Grove (BS701) looking downstream.

Figure 7. UT Kill Swamp at NC 50/55 (KS50a) looking upstream.

Figure 8. UT Kill Swamp at NC 50/55 (KS50a) looking downstream.

Figure 9. Kill Swamp at SR 1710 (KS1710) looking upstream.

Figure 10. Kill Swamp at SR 1710 (KS1710) looking downstream.

Figure 11. Kill Swamp at SR 1706 (KS1706) looking upstream.

Figure 12. Kill Swamp at SR 1706 (KS1706) looking downstream.

Figure 13. Kill Swamp at US 701 (KS701) looking upstream.

Figure 14. Kill Swamp at US 701 (KS701) looking downstream.

Figure 15. UT Sevenmile Swamp at US 13 (SSUT13b) looking upstream.

Figure 16. UT Sevenmile Swamp at US 13 (SSUT13b) looking downstream.

Figure 17. Sevenmile Swamp at SR 1703 (SS1703) looking upstream.

Figure 18. Sevenmile Swamp at SR 1703 (SS1703) looking downstream.

Figure 19. Great Coharie Creek at SR 1636 (GCC1636b) looking upstream.

Figure 20. Great Coharie Creek at SR 1636 (GCC1636b) looking downstream.

Great Coharie Creek at SR 1703—GCC1703

Swamp Score: 5
Bioclassification: Moderate Stress

This is the uppermost of the two benthic sites located on Great Coharie Creek, and is upstream of Beaverdam Swamp, Kill Swamp, and Sevenmile Swamp. Forest and wetlands were the visible landcover from the reach. The stream was braided. There was a large amount of organic material present in the form of lightly decomposed grasses, but with open mid-current areas of sand substrate exposed.

EPT Richness at the site was near the mean for all sites in the study; Total Taxa Richness at the site was slightly lower than the mean. The BI value was the second lowest for the area. The site received a swamp score of five. Moderate stress is indicated by habitat evaluation and the benthic community.

Beaverdam Swamp off Bizzell St, Newton Grove—BS701

Swamp Score: 4
Bioclassification: Moderate Stress

This is the only site on Beaverdam Swamp; it is about 280 meters downstream of US 701, and below an unnamed tributary that drains southern and western portions of Newton Grove (thereby capturing most of the area of the town within the drainage). Forest and wetlands were the visible landcover. The reach had a well-defined main channel and a wide, swampy floodplain. The substrate was mostly detritus, with silt and sand also present.

The number of EPT taxa collected at the site was just below the mean for all sites; Total Taxa Richness was slightly higher than the mean. The NCBI value at this site was slightly higher than the mean for sites in the study area. The site received a swamp score of four, the lowest score for a site to receive a classification of Moderate. Low EPT Richness was the cause for the low score within the Moderate range.

Unnamed tributary to Kill Swamp at NC 50/55—KS50a

Swamp Score: 4
Bioclassification: Moderate Stress

The site is on a small tributary in the upper part of the Kill Swamp drainage. A small amount of riparian forest and extensive cropland were visible from the reach. The stream was channelized and had no link to its floodplain. Habitat diversity was low due to channelization, though good root mats were present.

The site received a swamp score of four. It has been provisionally assigned a Not Rated until the BAU can determine whether the site lacks visible flow during the summer; if flow is lacking later in the year then the site qualifies for swamp assessment and will receive a classification of Moderate. A discussion of results will need to wait until it can be determined what type of system the site represents (swamp with discontinuous flow or perennial stream).

Kill Swamp at SR 1710—KS1710

Swamp Score: 4
Bioclassification: Moderate Stress

This is the uppermost site on the mainstem of Kill Swamp. Pasture (with livestock present) and a small amount of wetland were visible. The stream was braided. Benthic sampling was conducted on the reach upstream of the outflow from an adjacent settling pond. A beaver dam with pool was present within the reach sampled, but streamflow was good downstream of it. The substrate was almost entirely silt and detritus. A significant amount of filamentous algae was present.

This is one of four sites in the study for which the number of EPT taxa collected was either one or two (two taxa in this case). Total Taxa Richness was slightly lower than the mean and a single taxon lower than the median for the nine sites in the study. The NCBI here was the highest value for all of the sites. The site received a swamp score of four, the lowest score for a site to receive a classification of

Moderate. The low NCBI score resulting from the high NCBI value would have put the site into the Severe classification, except that it was offset by the high Taxa Richness Score (with adjustments for the pH of 5.1 and stream braiding—see Methods). This was the only site with an active pasture visible and adjacent to the reach sampled. Also unusual for the sites sampled in this study was a nearby settling pond, though the outflow was downstream of the reach sampled.

Kill Swamp at SR 1706—KS1706

Swamp Score: 4
Bioclassification: Moderate Stress

This site is approximately 3.6 stream-kilometers downstream of KS1710. Forest and wetland were the landcover types visible from the stream. The stream at the reach sampled had a well-defined main channel. Some lightly decomposed grasses were present in the stream channel. The exposed substrate was mostly silt with a lesser amount of sand.

This is one of two sites that had the lowest number of EPT taxa collected (one), and also had the lowest Total Taxa Richness for all sites in the study. The NCBI value was the median for all benthic sites in the area. Low EPT and Taxa Richness scores at the site were offset by the high habitat score, resulting in a swamp score of four and a classification of Moderate.

Kill Swamp at US 701—KS701

Swamp Score: 4
Bioclassification: Moderate Stress

This is the most downstream site on Kill Swamp. It is about 1.5 stream-kilometers downstream of KS1706, and about 1.8 stream-kilometers from the confluence with Great Coharie Creek. Landcover visible from the reach was forest and wetland. The main channel was well-defined. Substrate was mostly detritus.

This is the other site for which only a single EPT taxon was collected. Total Taxa Richness was well below the mean and median for all sites collected for this study. The NCBI value was close to the mean. The site received a score of four, indicating Moderate stress.

Unnamed tributary to Sevenmile Swamp at US 13—SSUT13b

Swamp Score: 4
Bioclassification: Moderate Stress

The mouth of the unnamed tributary is about 1.8 stream-kilometers upstream of the benthic site on Sevenmile Swamp proper. Visible landcover was wetland and forest. The stream was braided. Nearly the entire reach was covered with lightly decomposed grassy vegetation, with algae and silt also present.

The site had the third highest number of EPT taxa, and the second highest number of Total Taxa, for all sites in the LWP area. However, the NCBI value was high; only the value at KS1710 was higher. The low NCBI score resulting from the high NCBI value was offset by the high Taxa Richness score, resulting in a swamp score of four and a resulting bioclassification of Moderate.

Sevenmile Swamp at SR 1703—SS1703

Swamp Score: 7
Bioclassification: Moderate Stress

The site is about 2.9 stream-kilometers from the confluence with Great Coharie Creek. Forest and wetland were the visible landcover types. The stream was braided.

Both EPT and Total Taxa Richness were higher at this site than for any other site in the study area. The NCBI value was slightly lower than the mean. The site score was seven, indicating Moderate stress.

Great Coharie Creek at SR 1636—GCC1636b

Swamp Score: 9
Bioclassification: Natural

This is the lowermost site in the Great Coharie LWP area, and is within the northernmost section of an EEP-owned 4850-acre tract of land that borders a section of Great Coharie Creek. The areas adjacent to the stream were entirely forested. The channel here was well-defined with no braiding.

The site has the second highest EPT Richness and third highest Total Taxa Richness values in the study. The NCBI value of 6.16 was lower than for any of the other eight sites, markedly lower than the next lowest value of 6.90. This was the only site in the study to receive a classification of Natural. However, had one fewer EPT taxon been collected at the site, it would have received a classification of Moderate.

Overall Assessment

For comparison of water quality at swamp sites, of those metrics used to derive a swamp classification, the NCBI is the most appropriate. The swamp score that is used to determine the bioclassification is not useful for water quality comparisons since habitat is a component of the score (see Methods). In addition, both Total Taxa Richness and EPT Richness are affected by stream morphology. Though stream channels were described as either braided or well-defined for the purpose of determining a bioclassification, sites within the study area exhibited a continuum of conditions. During the development of criteria for North Carolina swamps, the NCBI was recognized as being "the most reliable way to compare swamp streams."[6]

Figure 21 maps the NCBI values for the nine benthic sites. The lowermost site within the LWP area (GCC1636b) showed the lowest value and therefore indicates the least tolerant macroinvertebrate community. In fact, the value at GCC1636b is markedly lower than for all other sites: 6.16 versus a range

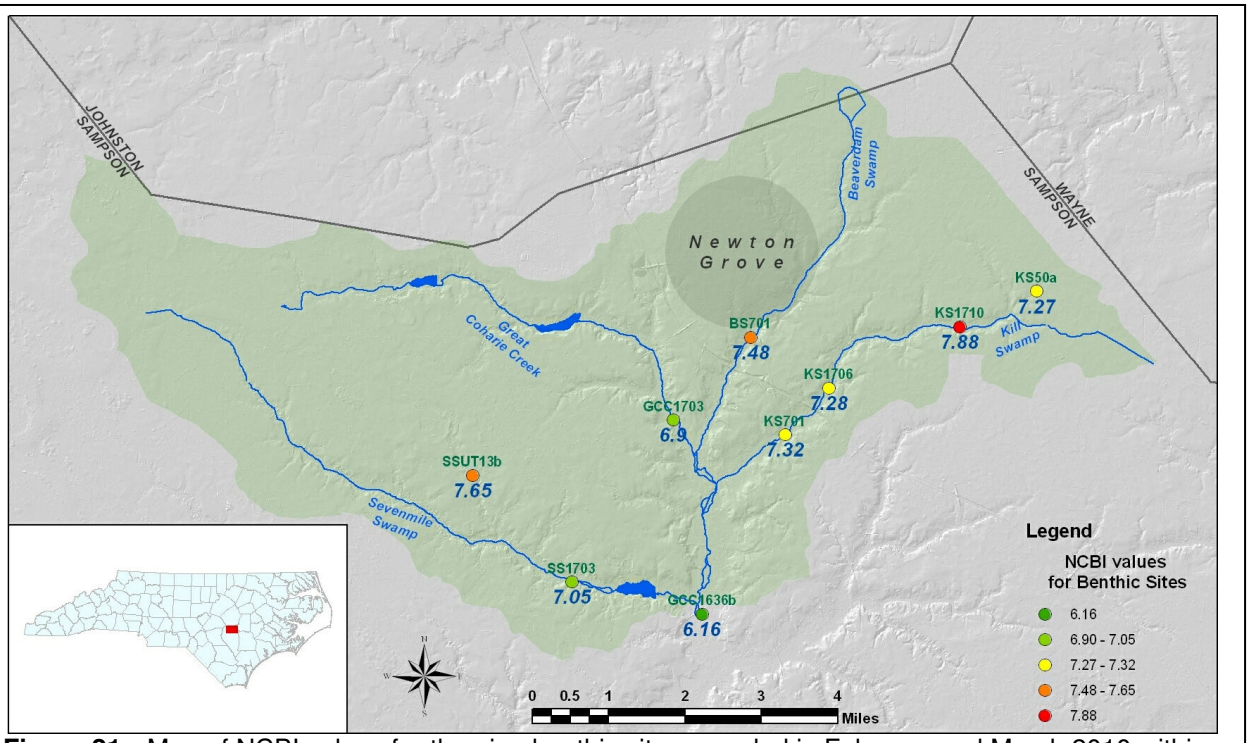


Figure 21. Map of NCBI values for the nine benthic sites sampled in February and March 2010 within the Great Coharie Creek LWP study area.

[6] Lenat, D. 2003. Macroinvertebrate criteria for North Carolina swamp streams. Unpublished, internal BAU memorandum dated 7 March 2003.

of 6.90 through 7.88 for the other sites. The marked difference between the lowermost site and the other sites suggests that the most influential potential stressors are localized and not carried downstream. Physical habitat differences could potentially account for this, and possibly differences in dissolved oxygen levels. Though dissolved oxygen levels measured at the time of benthic sampling showed GCC1636b with a DO value (9.0 mg/L) slightly below the median and mean values (9.1 and 9.5 mg/L respectively) for the nine sites, there should be no expectation that these snapshot values taken during the high-flow period are representative of relative values throughout the year. Dissolved oxygen levels show annual cycles, which are generally more pronounced in swamps than in streams due to loss of flow during the summer and a greater rate of decomposition of organic material. Differences in annual flow regime and amount of organic material between swamp sites will play a far more important role in determining levels of dissolved oxygen during the summer than will the dissolved oxygen level in February or March. Summer dissolved oxygen levels will affect the benthic community as many taxa have univoltine life cycles and may not be adapted to low-level conditions.

Habitat differences are almost certainly playing a role in the composition of the benthic community at GCC1636b with respect to the remaining sites. The site at GCC1636b was more stream-like than all the other sites in the study with the exception of the channelized site at KS50a; the other seven sites were more swamp-like, with several having braided channels. GCC1636b was the only site to have visible amounts of inorganic substrate larger than sand; a visual estimate of 30% of the substrate was gravel. Larger substrates are more useful to macroinvertebrates for colonization than smaller.

The next two lowest NCBI values were determined for GCC1703 on Great Coharie Creek upstream of the three named tributaries in the LWP, and for SS1703 on Sevenmile Swamp. The drainages above the two sites comprise roughly the western half of the LWP area. The high NCBI value at SSUT13b is in contrast to the other two sites in the western section. Again, macroinvertebrate habitat is likely an issue here. SSUT13b is the only benthic site in the study for which there was no exposed inorganic substrate; the channel was filled with lightly decomposed grasses which covered the bottom of the channel as well as any snags that would be available for macroinvertebrate colonization. Generalists can inhabit the stream under such conditions, but more sensitive species would be less likely to be found.

Site BS701 on Beaverdam Swamp includes most of the town of Newton Grove in its drainage. The resultant NCBI value at the site was the third highest for the nine benthic sites in the study. There was little that is remarkable about the site in terms of habitat compared to most of the other sites, except for the wide swamp adjacent to the main channel. It is likely that the elevated NCBI value is due some component of the development in Newton Grove.

Three of the sites in the Kill Swamp drainage had NCBI scores that were very similar to each other and very slightly higher than the mean for all sites in this study: the unnamed tributary (KS50a), and the two lowermost sites on Kill Swamp (KS1706 and KS701). However, the uppermost site on Kill Swamp proper (KS1710, downstream of the KS50a unnamed tributary) showed the highest NCBI value in the study. There is no clear reason for the high value at KS1710 with respect to the other sites in the Kill Swamp drainage, though as noted above this site was unusual for the sites in this study for the presence of an active pasture visible from and adjacent to the reach sampled and for the nearby settling pond (though the outfall was downstream of the reach sampled).

There is a low, statistically insignificant correlation between specific conductance measured at the time of the benthic collection and NCBI for the nine sites (Figure 22). The low correlation holds when KS50a is removed from the analysis. There is also no strong positive correlation between NCBI values and several water chemistry parameters measured by WAT in August and September 2009 at the five locations where the benthic site overlaps or is near to a chemistry site (Figure 23). However, there is a small correlation between NCBI and the combined visual estimate of the amount of silt and organic/detritus present at each benthic site (Figure 24). Biologically, the relationship between substrate and NCBI makes sense. In swamps the primary habitats for invertebrates are logs and sticks, macrophytes, root mats, and undercut banks. Large amounts of silts or the decomposing grass present at most of the sites will smother those habitats. Generalists are able to utilize the silts and grasses to some extent, but most taxa will not.

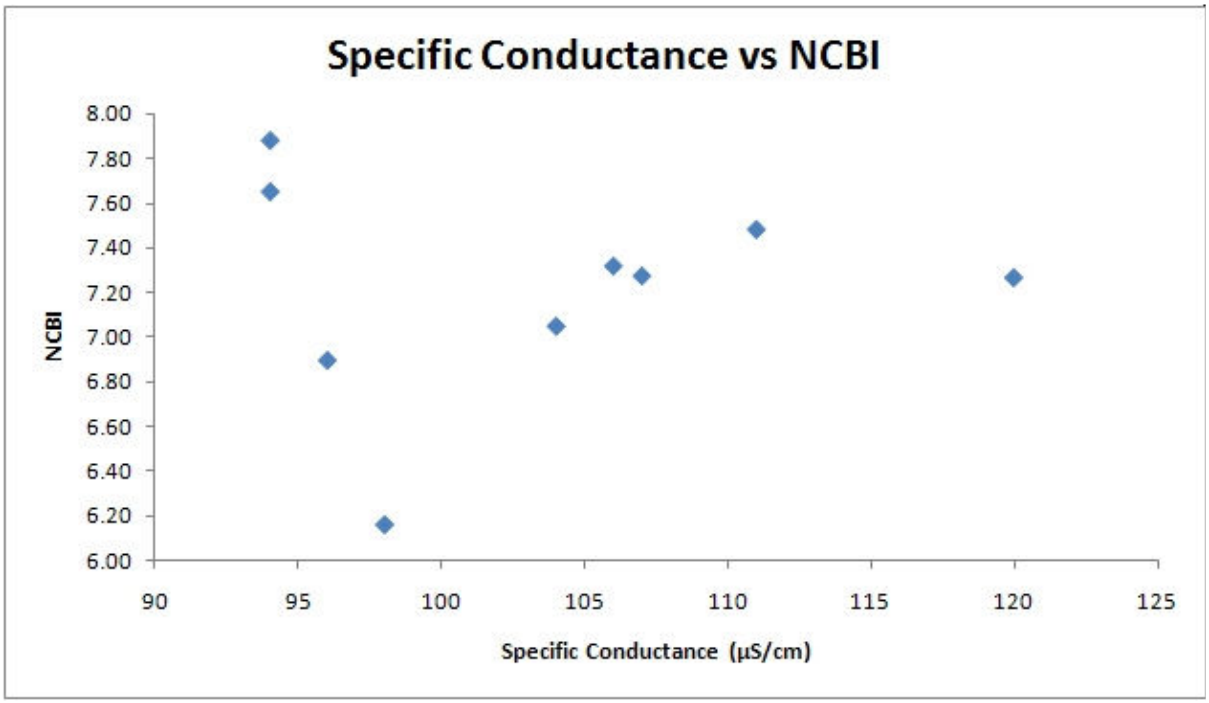


Figure 22. Specific conductance as measured during benthic collections versus NCBI values for the nine benthic sites sampled in February and March 2010 within the Great Coharie Creek LWP study area.

Given the existing data for the study area, there are no indications of specific water-borne stressors that may be impacting the benthic community at the nine sites. Habitat and channel morphology may be a larger influence than water quality in the structure of the communities at each site.

CONCLUSIONS

None of the benthic sites in this study received a classification of Severe, though six of the nine received swamp scores of four and were therefore near the threshold between Moderate and Severe. The most downstream site in the study area received both the lowest NCBI value and the best bioclassification of Natural, an indication that the effects from any potential stressors in the remainder of the area are not carried downstream. Habitat differences may be playing a larger role than water quality in the composition of the benthic communities at the nine sites sampled for this study.

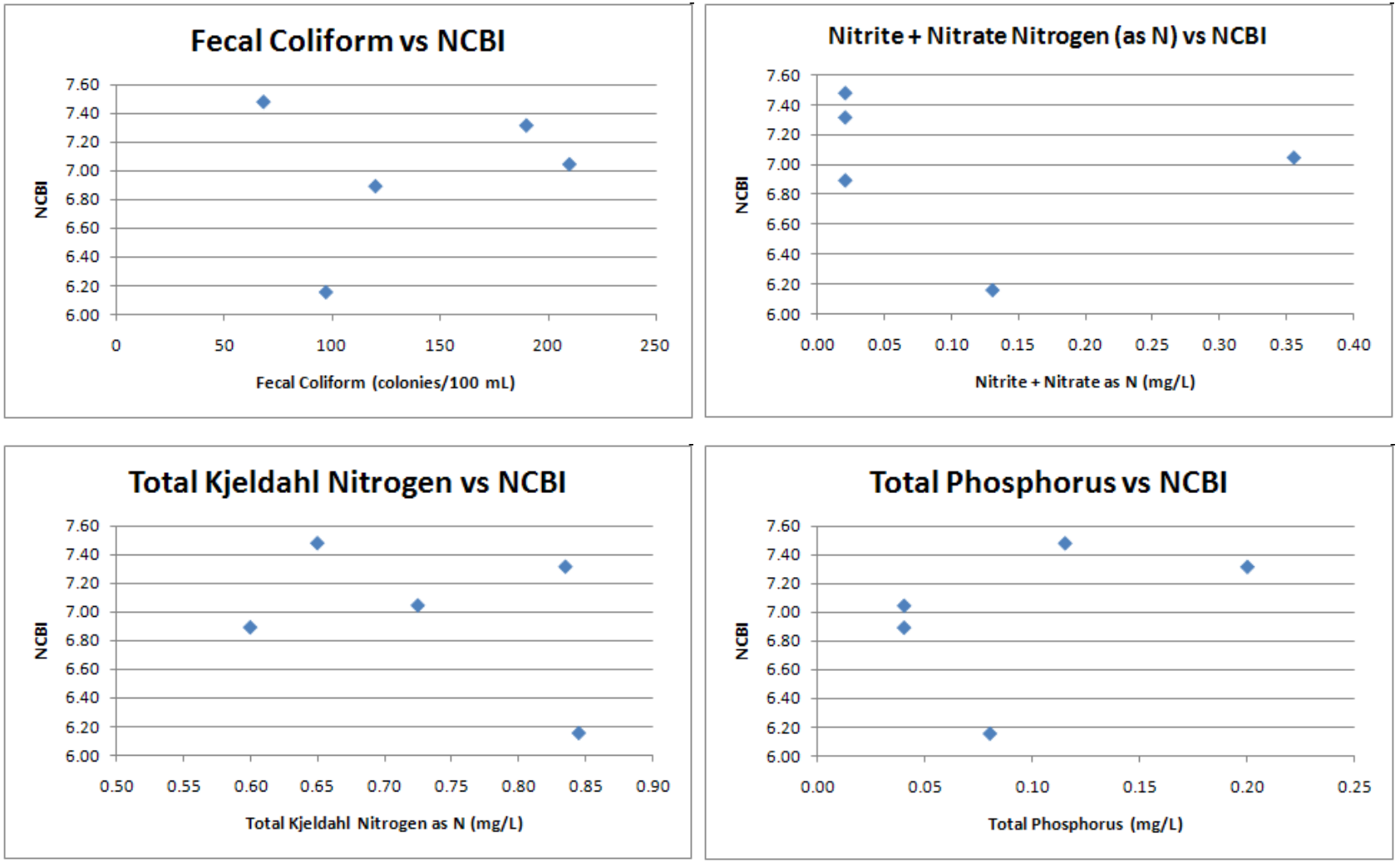


Figure 23. Water chemistry versus NCBI value for five benthic sites: GCC1703; BS701 (WAT chemistry collection downstream 1.1 stream-kilometers at SR 1800); KS701; SS1703; and GCC1636b. Water chemistry was collected by WAT in August and September 2009. Only September data used for fecal coliform due to exceeded holding times for August collections. Mean of the two measurements collected in August and September used for total Kjeldahl nitrogen, nitrite/nitrate, and total phosphorus. Data for ammonia nitrogen are not presented as all but two measurements were at or below the detection limit.

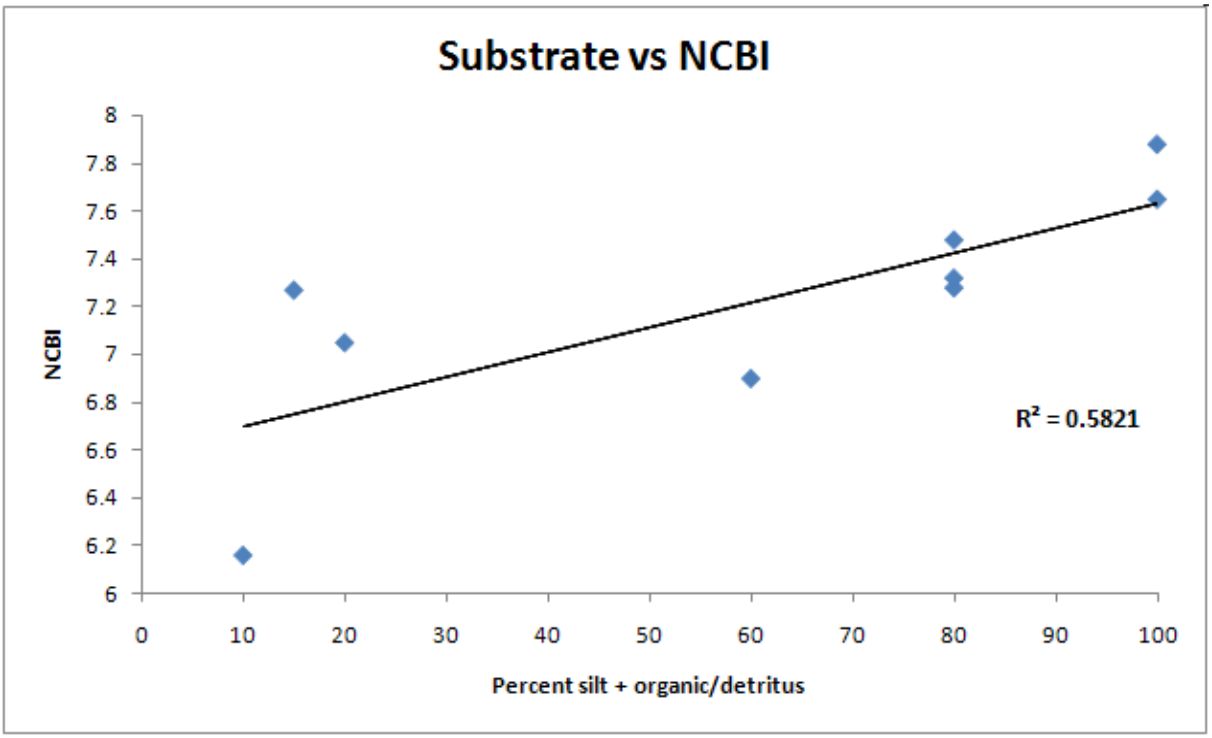


Figure 24. The sum of visual estimates of silt and organic/detritus expressed as percentages of total bottom substrate versus NCBI values for the nine benthic sites sampled in February and March 2010 within the Great Coharie Creek LWP study area.

APPENDIX

Table 4. Taxa collected and abundance classes for the nine benthic sites sampled in February and March 2010 within the Great Coharie Creek LWP study area.

			GCC1703	BS701	KS50a	KS1710	KS1706	KS701	SSUT13b	SS1703	GCC1636b
Ephemeroptera											
	Baetidae	ACERPENNA PYGMAEA								A	A
		CALLIBAETIS SPP								C	
		CENTROPTILUM SPP							R		
		PSEUDOCLOEON PROPINQUUM								R	
	Caenidae	CAENIS SPP	A						C	A	C
	Heptageniidae	MACCAFFERTIUM MODESTUM							C		A
		STENACRON INTERPUNCTATUM									C
	Leptophlebiidae	LEPTOPHLEBIA SPP								C	
Plecoptera											
	Perlodidae	ISOPERLA TRANSMARINA								R	
	Taeniopterygidae	TAENIOPTERYX SPP	A							A	A
Trichoptera											
	Hydropsychidae	CHEUMATOPSYCHE SPP							R	C	A
	Hydroptilidae	HYDROPTILA SPP								R	
	Limnephilidae	IRONOQUIA PUNCTATISSIMA	C	C	R	R		C	R	C	C
		PYCNOPSYCHE SPP			C						
	Phryganeidae	PTILOSTOMIS SPP	C	C		R	C		R	C	
	Polycentropodidae	POLYCENTROPUS SPP		R							
Odonata											
	Aeshnidae	NASIAESCHNA PENTACANTHA						R	R		R
	Calopterygidae	CALOPTERYX SPP			A						R
	Coenagrionidae	ENALLAGMA SPP				R					
		ISCHNURA SPP	C	C		A			A	A	R
	Cordulegasteridae	CORDULEGASTER SPP			R						
	Corduliidae	TETRAGONEURIA SPP								R	
	Libellulidae	ERYTHEMIS SPP		R						R	
		LIBELLULA SPP	R		R	C	C		A	C	
		PACHYDIPLAX LONGIPENNIS	R	C		C			C		
Hemiptera											
	Belostomatidae	BELOSTOMA SPP		R		R			R		
	Corixidae	CORIXIDAE								R	
	Naucoridae	PELOCORIS SPP		R							R
Megaloptera											
	Corydalidae	CHAULIODES PECTINICORNIS		R						R	
Coleoptera											
	Dytiscidae	AGABUS SPP	R						C		
		BIDESSONOTUS SPP									R
		NEOPORUS SPP	C	A		A		R	C	C	A
		THERMONECTUS BASILLARIS							R		
	Elmidae	STENELMIS SPP							R		
	Haliplidae	HALIPLUS FASCIATUS		C							
		PELTODYTES SPP	R	C		R		R	R	R	R
	Hydrophilidae	BEROSUS SPP							R		
		ENOCHRUS OCHRACEUS		R							R
		HYDROBIUS MELAENUS						R		R	
		SPERCHOPSIS TESSELLATUS			R						R
		TROPISTERNUS BLATCHLEYI						R		R	
		TROPISTERNUS NATATOR							R		
	Noteridae	HYDROCANTHUS SPP		R		R			R		
		SUPHISELLUS PUNCTICOLLIS		R							R

Table 4. Continued.

			GCC1703	BS701	KS50a	KS1710	KS1706	KS701	SSUT13b	SS1703	GCC1636b
Chironomidae											
	Chironomidae	ABLABESMYIA MALLOCHI							R	C	
		ABLABESMYIA PELEENSIS				C					R
		CHIRONOMUS SPP		R	R						
		CORYNONEURA SPP								R	
		CRICOTOPUS BICINCTUS	C				C		C	A	R
		CRYPTOCHIRONOMUS SPP			R						
		DICROTENDIPES MODESTUS				R			C	C	
		DICROTENDIPES SIMPSONI							C	C	R
		DICROTENDIPES SPP						R			
		DIPLOCLADIUS CULTRIGER			C	C					
		ENDOCHIRONOMUS NIGRICANS				R					
		EUKIEFFERIELLA CLARIPENNIS GR	C				R				
		GLYPTOTENDIPES SPP								R	
		HETEROTRISSOCLADIUS MARCIDUS	C	R					R		
		KIEFFERULUS SPP							C	C	
		NATARSIA SP A				R					R
		ORTHOCLADIUS LIGNICOLA			R						
		ORTHOCLADIUS OBUMBRATUS GR	A	A		C	A	A		A	R
		ORTHOCLADIUS OLIVERI	A	A		A	A	A	A	C	A
		ORTHOCLADIUS ROBACKI	A	A		R	A	A	C	A	
		PARAMETRIOCNEMUS SPP								R	R
		PARATANYTARSUS DISSIMILIS	C			R					
		PARATANYTARSUS SPP				R	R		C		R
		PHAENOPSECTRA PUNCTIPES GR			R				C		
		POLYPEDILUM AVICEPS									C
		POLYPEDILUM ILLINOENSE GR	R							R	R
		POLYPEDILUM SCALAENUM GR			C						
		POLYPEDILUM TRIGONUS				R					
		POLYPEDILUM TRITUM		R		R	R	R	C	C	C
		PROCLADIUS SPP	R			R			C		
		PSEUDORTHOCLADIUS SPP								R	
		RHEOTANYTARSUS SPP		R					R	C	A
		TANYTARSUS SP C								R	R
		TANYTARSUS SP G	C	C					C		
		TANYTARSUS SP L							A	A	C
		TANYTARSUS SP V						R			
		THIENEMANIELLA SPP							R		C
		THIENEMANNIMYIA GR	R	C	A				A	A	A
		TRIBELOS FUSCICORNE									R
		TRIBELOS JUCUNDUM	R		A					C	R
		TVETENIA SP GA									C
		ZALUTSCHIA BRIANI	C	A	R	A	R	C	C	R	R
		ZALUTSCHIA SP A	C						C		

Table 4. Continued.

			GCC1703	BS701	KS50a	KS1710	KS1706	KS701	SSUT13b	SS1703	GCC1636b
non-Chironomidae Diptera											
	Ceratopogonidae	PALPOMYIA COMPLEX	R	R		R	R		C		R
	Ptychopteridae	BITTACOMORPHA SPP	C	A				C	C		
	Simuliidae	CNEPHIA ORNITHOPHILIA	C	C			C		R		A
		SIMULIUM SPP	A		R	C	A	R	C	A	A
		STEGOPTERNA MUTATA/DIPLOMUTATA	C	C	A		A		C	R	R
	Tabanidae	CHRYSOPS SPP				R					
		TABANUS SPP			R						
	Tipulidae	PILARIA SPP			C						R
		PSEUDOLIMNOPHILA SPP		R							
		TIPULA SPP	R		C		C			R	
Oligochaeta											
	Enchytraeidae	ENCHYTRAEIDAE		R				R			
	Lumbriculidae	LUMBRICULIDAE		C		A	C	C	A	C	A
	Megadrile	MEGADRILE OLIGOCHAETE		C	A						
	Naididae	DERO SPP							C		
		NAIS SPP		C		C				R	
		SLAVINA APPENDICULATA	R				C	R	A	C	
		STYLARIA LACUSTRIS				C		C	C		
	Tubificidae	ILYODRILUS TEMPLETONI		A							
		ISOCHAETIDES CURVISETOSUS			C						
		LIMNODRILUS HOFFMEISTERI			C						
		TUBIFICIDAE						R	R		
Crustacea											
	Asellidae	CAECIDOTEA COMMUNIS			A						
		CAECIDOTEA SPP		R						R	
	Cambaridae	CAMBARUS SPP			A						
		PROCAMBARUS SPP			C	R	R			R	
	Gammaridae	CRANGONYX SERRATUS	A					R			
		CRANGONYX SPP	A	A	C		C	A			A
		SYNURELLA SPP			A	A	C		A	C	
	Talitridae	HYALELLA SPP							R	C	
Gastropoda											
	Hydrobiidae	SOMATOGYRUS SPP									R
	Lymnaeidae	PSEUDOSUCCINEA COLUMELLA	C	C			C	C	A	R	C
	Physidae	PHYSA SPP	R	C		A	A	C	R	A	R
	Planorbidae	MICROMENETUS DILATATUS	C				R	R	C	R	R
	Pleuroceridae	LEPTOXIS SPP									R
	Viviparidae	CAMPELOMA DECISUM									R
Bivalvia											
	Sphaeriidae	MUSCULIUM SPP	C	A		A	R	C	C		
		PISIDIUM SPP		R			C	R	A		
		SPHAERIIDAE								R	
Other											
	Cnidaria	HYDRA SPP				R					
	Erpobdellidae	MOOREOBDELLA SPP	R	R			R	C		R	
	Glossiphoniidae	GLOSSIPHONIIDAE				R					
	Hirudinidae	HAEMOPIS SPP				R					
	Hydracarina	HYDRACARINA						R		C	R
	Planariidae	DUGESIA TIGRINA						R		R	C