

**Division of Water Quality
Biological Assessment Unit
23 July, 1998**

MEMORANDUM

To: Jimmie Overton
Through: Trish MacPherson
From: David Penrose
Subject: Chapel Hill Water Quality Investigation ape Fear River basin 030306), Orange County

BACKGROUND

Benthic macroinvertebrate samples were collected in 1993 from 5 locations as part of a water quality investigation with the Town of Chapel Hill. These sites were selected to determine water quality conditions associated with several major land-use types within the study area. Five other locations were sampled within this same study area as part of the 1993 basinwide monitoring program of the Cape Fear River basin. Data from all ten locations were summarized in report #B-930930. Data from these investigations noted water quality degradation in several stream reaches within the study area. Fair or Poor water quality conditions were noted at all streams which drain the central business district of Chapel Hill. These degraded water quality conditions are associated with the effects of urban and/or stormwater runoff. These include lower reaches of Morgan, Little, Bolin, and Meeting of the Waters Creeks. Good or Good/Fair water quality conditions were found at Morgan Creek above the OWASA WWTP, upper reaches of Bolin Creek, and Pritchards Mill Creek above University Lake. An Excellent bioclassification was given to Morgan Creek at NC 54.

Since the 1993 investigation, the Town of Chapel Hill has initiated a chemical, physical, and biological monitoring program of streams within the study area. These investigations are conducted in cooperation with the Town of Carrboro and the University of North Carolina. Monthly water quality samples are collected from 9 monitoring locations. In addition, the Town of Chapel Hill initiated a public education program that includes citizen monitoring projects, stream clean-ups, and storm drain stenciling.

STATION LOCATIONS (Table 1, Figure 1)

Benthic macroinvertebrate samples were collected from 10 locations in the Chapel Hill study area during February and March, 1998. At some stations, benthic macroinvertebrates were collected twice during February in 1998. Data were collected as part of winter surveys in low flow streams of the Cape Fear River Basin and during this special investigation. These data were collected from many of the sites sampled during the 1993 investigation to determine long term trends in water quality conditions and to assess water quality in a variety of land cover conditions.

Cane Creek at SR 1114. The Cane Creek catchment is primarily agricultural with pasture and row crops. Cane Creek, at this location, and Morgan Creek at NC 54 are parallel watersheds within the Carolina Slate Belt. Also, both catchments have drainage areas of approximately 8 square miles. Both locations were selected as control catchments for this investigation.

Morgan Creek at NC 54. This site was used as a reference watershed for the 1993 investigation. Benthic macroinvertebrate data have been collected from this location as part of the basinwide planning process, and to determine effects of low flow on Slate Belt streams. Good or Excellent bioclassifications have been assigned to this site during these investigations. This site also is monitored by the Town of Chapel Hill.

Morgan Creek at the Botanical Gardens Trail. This site is below University Lake and Carrboro, and receives nonpoint source runoff from a low-density residential area of Chapel Hill. Most of the homes along this section of the Morgan Creek corridor were built in the 1950's or 60's and very little new construction is taking place. However, some new construction and high-density residential areas are located in upstream tributary catchments of Morgan Creek, which may affect water quality at this location. Chapel Hill collects water quality data from a site immediately upstream of this location.

Morgan Creek below OWASA. Fair bioclassifications have been given to this section of Morgan Creek during the two most recent investigations. This site is below the WWTP and the Finley golf course, however, the land use is primarily stable, low-density residential areas.

Meeting of the Waters Creek at Laurel Hill Road. This is a small tributary of Morgan Creek that drains an urban section of Chapel Hill, including the Kenan Stadium area. The land use contains high-density residential areas, but no new construction is occurring in the catchment. Since 1993, all runoff from the athletic complex has been rerouted from Meeting of the Waters Creek to the Chapel Hill sewerage collection system.

Bolin Creek at SR 1777. This is the most upstream monitoring location in the Bolin Creek catchment. Much of the catchment at this location is forest with some limited residential land use. A Good bioclassification was assigned to this location during the 1993 investigation.

Bolin Creek near Umstead City Park. A Good bioclassification also was given to this location during the 1993 investigation. The land use in this catchment is primarily low to moderate-density residential, but no new construction is occurring. Chapel Hill collects water quality data from this location.

Bolin Creek at E. Franklin Street. Much of this reach of Bolin Creek is high-density residential and urban. Several small tributaries drain the central business district of Chapel Hill and flow into Bolin Creek between the Umstead Park location and this site. The Town of Chapel Hill collects water quality data from this site.

Booker Creek at Piney Mountain Road. Benthic macroinvertebrate samples have not been collected from this stream before 1998. This site is located below Lake Ellen but above Eastman lake.

Little Creek above Pinehurst Drive. Little Creek originates at the confluence of Bolin and Booker Creeks. Our monitoring location is approximately 3/4 of a mile below the confluence. Much of the land use between the confluence and our monitoring site is high-density residential and commercial (University Mall).

METHODS

Benthic macroinvertebrates were collected at six locations using the Division of Water Quality's standard qualitative sampling procedure. This method includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs. The purpose of these collections is to inventory the aquatic fauna and produce an indication of relative abundance for each taxon. Organisms were classified as Rare (1-2 specimens), Common (3-9 specimens), or Abundant (10 or more specimens).

Several data-analysis summaries (metrics) can be produced from standard qualitative samples to detect water quality problems. These metrics are based on the idea that unstressed streams and rivers have many invertebrate taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index.

EPT taxa richness (EPT S) is used with DWQ criteria to assign water quality ratings (bioclassifications). "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution. Higher EPT taxa richness values usually indicate better water quality. Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI). Both tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions. Water quality ratings assigned with the biotic index numbers were combined with EPT taxa richness ratings to produce a final bioclassification, using criteria for piedmont streams.

EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. When the EPT taxa richness rating and the biotic index differ by one bioclassification, the EPT abundance value can be used to produce the final site rating.

Benthic macroinvertebrates also were collected at four locations using DWQ's EPT sampling procedure. This type of collection is intended to quickly assess between-station differences in water quality. Four composite samples were taken at these sites: 1 kick, 1 sweep, 1 leafpack and visual collections. Only intolerant "EPT" groups (Ephemeroptera, Plecoptera, Trichoptera) were collected and identified. EPT samples were collected from Meeting of the Waters Creek, Bolin Creek at SR 1777, Booker Creek, and Little Creek.

RESULTS AND DISCUSSION (Table 2 and 3, Appendices 1 and 2)

Results of this investigation are summarized in Tables 2 and 3 and all benthic macroinvertebrate taxa collected during these surveys are listed in Appendices 1 and 2. Data collected from previous investigations also are summarized. The Town of Chapel Hill has collected monthly water quality samples from many of these locations since November, 1993. These data are briefly summarized in the following discussions. However, a more detailed analyses of the water

quality data will be completed by the Town of Chapel Hill.

Cane Creek at SR 1114. This site was selected as a companion reference location to Morgan Creek. Both streams have approximately the same catchment size and land use. However, flow permanence records indicate that this Cane Creek location has no flow more often than Morgan Creek at NC 54, which may affect the benthic community. Data were collected from this location during winter surveys in 1998 and 1993 as part of the Cape Fear Basinwide monitoring program and as a reference location for this investigation. Good and Good-Fair water quality conditions have been historically recorded from this location. Good instream and riparian habitat characteristics were noted during the 1998 investigation. However, prolific Aufwuchs growths were observed suggesting some enrichment. Despite some variability in the data, Excellent and Good bioclassifications have been recorded from this location during the 1998 investigations. Much higher EPT taxa richness values were collected from this location during a full scale collection in February, 1998 relative to EPT collections in 1998 and 1993. In addition, a new species of Barbaetis was collected during this survey. The species identification of these organisms are being verified.

Morgan Creek at NC 54. Data have been collected from this location on numerous occasions. However, most recently, samples have been collected during Basinwide surveys in 1998 and 1993 and as a reference location for this investigation. Much of the Morgan Creek catchment above NC 54 has agricultural land uses, including pasture for dairy cattle. Residential land uses also are common in the catchment. Good instream and riparian habitat characteristics were noted from this location. There appeared to be some overbank deposition of sand and floodplain areas had recently been scoured by high flows. In addition, there appeared to be excessive tree falls due to the effects of Hurricane Fran. Excellent bioclassifications have been recorded from this location during full scale surveys in 1998 and 1993, suggesting that water quality conditions have not changed significantly between investigations.

The Town of Chapel Hill has collected monthly water quality samples from this location since November, 1993. Other than fecal coliform numbers, most of the water quality results appear to be within normal ranges for piedmont stream systems, with few exceedances of NC water quality criteria. Occasional high concentrations of nitrate-nitrite nitrogen were noted. A detailed analyses of these data will be conducted by the Town of Chapel Hill.

Morgan Creek at the Botanical Trail. Data have been collected from this site three times since 1993. Good instream and riparian habitat characteristics were noted at this location. However, excessive amounts of sand had been deposited in flood prone areas along the stream. Good-Fair bioclassifications were given to this site during surveys in 3/98 and 2/93, although some variability in the data exists. Lower total and EPT taxa richness values were recorded from this site during the 1998 survey following a high flow event. Many invertebrate groups had few taxa during the 1998 survey (Ephemeroptera, Coleoptera, Chironomidae, and Mollusca). These lower numbers may be a response to high flow and scour. A Fair bioclassification was given to this site during an EPT survey conducted there in 4/93 following high flows. These data again suggest that this reach of Morgan Creek is susceptible to the effects of scour during high flow periods.

The Town of Chapel Hill has collected monthly water quality samples since November, 1993 from a site slightly upstream from our monitoring location. Elevated concentrations of some water quality parameters were noted: suspended and total solids, nitrate-nitrite nitrogen, and fecal coliforms. These data are stage related and therefore can be converted into total daily loads for each of the parameters.

Morgan Creek below the WWTP. Habitat characteristics at this location change significantly from those at upstream Morgan Creek locations. Much lower gradient has allowed for the deposition of massive quantities of sand at this site resulting in lower instream habitat characteristics. Overbank deposition of sand into flood prone areas is substantial at this location. Benthic macroinvertebrate samples have been collected from this location in 3/98 and 2/93 resulting in Fair bioclassifications during each survey. EPT taxa richness and abundance values were higher during the 1998 investigation following high flow events than they were during the 1993 investigation conducted during low to normal flows. Compliance records indicate that the OWASA facility has consistently met its effluent limits. *Isonychia* and *Centroptilum* were abundant during the 1998 survey, and not collected during the 1993 survey. These observations suggest that dilution of the effluent during high flow periods may improve biological integrity.

The Town of Chapel Hill recorded extremely high values for several water quality parameters from this location: ammonia and nitrate-nitrite nitrogen, total phosphorus, and fecal coliform.

Meeting of the Waters Creek. Poor bioclassifications were given to this stream during both investigations. Instream and riparian habitats appeared to be healthy, although the substrate was primarily coarse, shifting sand. The benthic fauna is still dominated by a tolerant hydropsyche caddisfly (*Hydropsyche betteni*), although one mayfly taxa was collected during the 1998 survey (*Eurylophella verisimilis*). Water quality may improve once pollution sources are identified and corrected.

The Town of Chapel Hill has collected monthly water quality samples from this location since November, 1993. Elevated numbers of fecal coliforms were noted from most samples collected at this site and occasional values for ammonia nitrogen and total phosphorus also were high. Physical and chemical water quality parameters also were collected from this catchment during dry weather and spate event conditions to determine the impacts of point versus nonpoint sources (Marquis 1996). Degraded water quality conditions were noted during this investigation, including extremely high total phosphorus and chlorine values. Results of this investigation estimated that total yearly pollutant loads were primarily contributed during baseflow, suggesting that water quality problems are dominated by point sources. As part of this investigation, many pollutant sources have been identified and management practices have been implemented to protect water quality.

Bolin Creek at SR 1777. Much of the land cover in this catchment remains in forest and low density residential, although there is a significant amount of construction in neighboring catchments, and within this catchment downstream of SR 1777. Much of the riparian zone along the stream has been removed and is in fallow pasture. Good bioclassifications were given to this location during surveys conducted in 3/98 and 4/93. Many of the abundant or common benthic macroinvertebrate taxa remained similar between surveys, suggesting that water quality has not

changed. Some differences in presence or absence of intolerant taxa were noted between investigations: *Acentrella ampla*, *Caenis*, *Stenacron pallidum* and *Chimarra* were only collected during the 1998 investigation, while several stonefly taxa (*Amphinemura*, *Eccoptura xanthenes*, and *Isoperla transmarina*) were only collected during the 1993 survey.

Bolin Creek near Umstead Park. This site was selected to assess water quality conditions of Bolin Creek above the central business district of Chapel Hill. The Town of Chapel Hill has recorded high numbers of the fecal coliforms and elevated concentrations of total solids, and nitrate-nitrogen from this location. Much of the land use within this section of Bolin Creek is low to moderate density residential. Good instream and riparian habitat characteristics were noted from this location, although riparian zone width was reduced along the north bank. Very little overbank deposition of sand was observed, suggesting that this reach of Bolin Creek is transporting sediment effectively. Good and Good-Fair bioclassifications have been documented from this location, although the difference in EPT taxa richness between surveys is minimal. More intensive collection methods were used during the 1998 survey, which accounts for some of the difference in taxa richness between collections. More mayflies (especially Baetidae), but fewer caddisflies were collected during the 1998 survey. One interesting exception to this observation is the presence of *Chimarra* collected during the 1998 survey. This taxa, which is an intolerant caddisfly, was not collected during the 1993 survey. However, *Chimarra* was collected in 1979 during a 208 survey of urban streams and again during this investigation.

Bolin Creek near East Franklin Street. This is the most downstream monitoring location on Bolin Creek. This site was chosen to assess the runoff from the central business district of Chapel Hill. Instream and riparian zone characteristics are altered at this location compared to upstream locations. The substrate is primarily shifting sand with little stable habitat present. Although the riparian zone is wide at this point, the field team noted numerous breaks in the riparian zone. Water quality data collected by the Town of Chapel Hill at this location has resulted in high numbers of fecal coliforms and occasional elevated concentrations of ammonia nitrogen, total phosphorus, and lead. Benthic macroinvertebrate collections during the 1998 surveys were made slightly upstream of previous surveys due to construction of a greenway at the East Franklin Street location. Samples have been collected from this location four times: 1986, 1993, and twice in 1998. Results have illustrated a decline in water quality since the 1986 study. A Good-Fair bioclassification was given to this site in 1986, while Fair or Poor ratings were recorded in 1993 and 1998. Six Plecoptera were collected during the 1986 survey and three were common or abundant. However, only one Plecoptera was collected during the 1993 and 1998 surveys and both taxa were rare. Some variability exists in the data collected during the two 1998 surveys. Very low EPT taxa richness and abundance values were found during an EPT survey in February. The EPT sample was collected under low flow conditions and resulted in a Poor bioclassification. A full scale survey was conducted in March following high flows and data resulted in a Fair bioclassification. More EPT taxa were collected during the full scale investigation which resulted in a Fair bioclassification. An increase in the number of EPT taxa also may be related to dilution of urban runoff or drift from upstream locations during high flow events.

Booker Creek. Booker Creek is a tributary of Bolin Creek. The Town of Chapel Hill is collecting water quality data from this location, although only high values for fecal coliforms

have been reported. Much of the land use within the Booker Creek catchment is moderate-density residential, however construction is widespread and active. The monitoring location on Booker Creek is located between Lake Ellen and Eastman Lake on Piney Mountain Road. Residents along Lake Ellen have complained that the lake is filling in with sediment. In response to these complaints, DOT has constructed sediment detention basins near construction activities (personal communication with Mike Neal). The regulated nature of this section of Booker Creek may account for the altered physical and biological characteristics of this reach compared to other sections of Booker Creek. Lake Ellen, which is located above our monitoring location, is acting as a sediment trap, therefore the substrate at our location was primarily boulder and rubble with coarse sand deposits only in pools. This site was given a Fair bioclassification. Only two mayflies were abundant: *Caenis* and *Stenonema modestum*.

Little Creek. During recent discussions with personnel with the Town of Chapel Hill, it was noted that flow at Pinehurst Drive may backup and stop during high flow events due to wildlife ponds constructed downstream. Water quality data collected by the Town of Chapel Hill has noted violations in the NC dissolved oxygen standard (5.0 mg/L) and elevated fecal coliform numbers during summer months. This section of Little Creek is characterized by severe bank erosion, poor soil binding and massive amounts of sedimentation. Benthic macroinvertebrates have been collected at Pinehurst drive twice: 1993 and 1998. Fair and Poor bioclassifications have resulted from these investigations. EPT abundance values also were very low during both surveys, suggesting that scour of substrate material and/or low flow because of the wildlife ponds is severely detrimental to the benthic fauna at this location. Sampling in February, 1998 followed a high flow event.

SUMMARY

Benthic macroinvertebrate samples were collected from 10 locations in the Chapel Hill area of complement water quality monitoring conducted by the Town of Chapel Hill. Nine of these locations also were sampled in 1993. Excellent water quality conditions and very high taxa richness values were recorded from two reference streams: Cane Creek at SR 1114 and Morgan Creek at NC 54. Good and Good/Fair bioclassifications have been historically recorded from the Cane Creek location. Thirty-seven EPT taxa from this location represents the highest number of EPT taxa collected from any stream in Orange County. Good/Fair and Fair water quality conditions were recorded from Morgan Creek at the Botanical Trail and from a site below the WWTP, respectively. Similar bioclassifications were recorded from these locations in 1993, suggesting that water quality conditions have not changed substantially between investigations.

Similar water quality conditions were noted at a site on Meeting of the Waters Creek. Very little change was noted in taxa richness or EPT abundance values between investigations.

Three sites were again sampled on Bolin Creek. Data from the 1998 investigation illustrated a decline in water quality ratings from upstream to downstream locations: Good at SR 1777, Good-Good/Fair near Umstead Park, and Fair or Poor near East Franklin Street. Similar bioclassifications were noted in 1993, suggesting that water quality has not changed substantially between investigations. However, these data suggest a decline in water quality at the East Franklin Street location relative to data collected in 1986, when it was Good-Fair. The Bolin

Creek locations near Umstead Park and near East Franklin Street bracket runoff from the central business district of Chapel Hill. A Fair rating was assigned to Booker Creek in 1998. This site is located below the outfall from Lake Ellen and represents data from a regulated reach of the catchment. A Poor (borderline Fair) bioclassification was given to Little Creek below the confluence of Booker and Bolin. The effects of flow alteration, habitat reduction from excessive amounts of sedimentation, and stormwater runoff have resulted in very low taxa richness and EPT abundance values at this location.

cc: Mike Neal, Town of Chapel Hill

REFERENCES

Marquis, Kraig D. An Investigation into the Sources of Water Quality Impairment in a Small Developed Watershed. Master of Science Thesis. University of North Carolina. Department of Environmental Sciences and Engineering, School of Public Health. 1996.

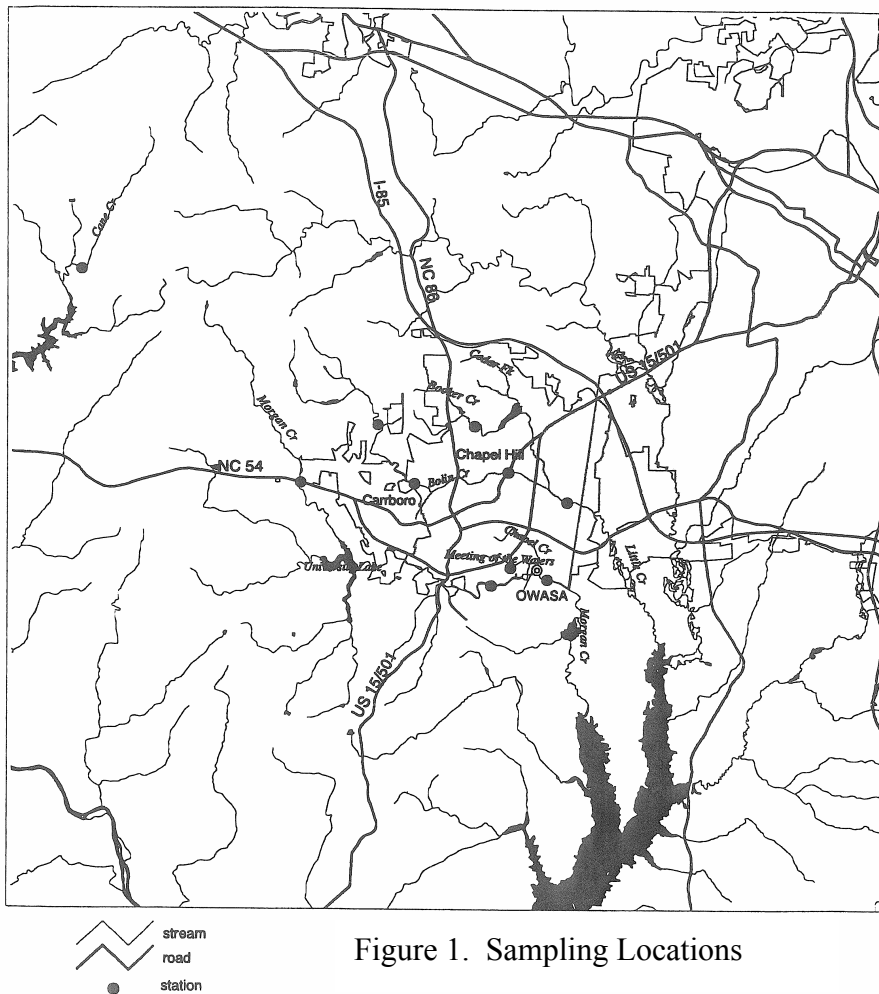


Figure 1. Sampling Locations

Table 1. Summary of Physical and Chemical Parameters from Chapel Hill Streams, Orange County, February and March, 1998.

Stream:	Cane Cr.		Morgan Creek		Meeting of Waters	Bolin Creek			Booker Cr	Little Cr
Location:	SR 1114	NC 54	Bot Trail	be WWTP	Laurel Hill Rd.	SR 1777	Umstead	E Franklin	Piney Mtn	Pinehurst Dr.
Date:	2/26/1998	2/26/1998	3/17/1998	3/17/1998	3/11/1998	3/11/1998	2/26/1998	3/11/1998	3/11/1998	2/2/1998
Width (meters)	7	7	14	15	4	4	9	6	4	5
Depth (meters)										
Average	0.3	0.3	0.4	0.4	0.2	0.3	0.3	0.3	0.2	0.7
Maximum	0.8	1	1	1	1	1	0.7	0.7	0.5	0.9
Canopy(%)	90	90	50	80	80	60	65	60	70	80
Aufwuchs	Abun	Mod	Abun	Abun	Mod	Abun	Mod	Mod	Abun	None
Bank Erosion	Mod	Mod	Mod	Mod	Severe	Mod	Mod	Severe	Mod	Mod
Substrate (%)										
Boulder	25	25	10	-	5	20	35	-	35	-
Rubble	35	35	30	-	15	20	35	20	25	-
Gravel	15	20	20	10	25	15	15	25	20	5
Sand	25	20	35	80	65	40	20	55	20	90
Silt/FPOM	-	-	5	10	-	5	-	-	-	5
Water Temperature(°C)	8.0	10.0	-	11.0	6.0	-	11.0	-	-	7.0
Dissolved Oxygen (mg/L)	12.0	12.4	-	10.0	-	-	11.7	-	-	12.3
Conductivity (µS/cm)	65.0	71.0	-	237.0	-	-	84.0	-	-	122.0
pH (Units)	7.1	7.2	-	6.8	7.1	6.8	7.4	-	7.0	7.2

Table 2. Summary of benthic macroinvertebrate data from Cane, Morgan and Meeting of the Waters Creeks. Orange County, North Carolina. 1998 and 1993.

Stream Location Date	Cane Creek SR 1114			Morgan Creek NC 54			Morgan Creek Botanical Garden Trail			Meeting of the Wate Laurel Hill Rd		Morgan Creek below WWTP	
	Feb-98	Feb-98	Feb-93	Feb-98	Feb-98	Feb-93	Mar-98	Feb-93	Apr-93	Mar-98	Apr-93	Mar-98	Feb-93
Ephemeroptera	17	12	11	14	12	14	7	11	5	1	0	8	4
Plecoptera	8	7	5	7	6	6	7	8	6	0	0	1	1
Trichoptera	12	6	12	12	13	16	6	7	5	2	2	2	2
Coleoptera	4	-	-	4	-	5	1	5	-	-	-	1	2
Odonata	3	-	-	7	-	7	9	6	-	-	-	8	5
Megaloptera	3	-	-	3	-	2	2	2	-	-	-	2	1
Diptera: Chironomidae	11	-	-	18	-	20	6	12	-	-	-	11	15
Misc. Diptera	8	-	-	6	-	6	2	3	-	-	-	3	3
Oligochaeta	2	-	-	3	-	2	2	3	-	-	-	2	4
Crustacea	3	-	-	2	-	4	2	5	-	-	-	2	2
Mollusca	5	-	-	4	-	6	1	6	-	-	-	2	2
Other	1	-	-	0	-	2	1	3	-	-	-	2	1
Total Taxa Richness	77	-	-	80	-	90	46	71	-	-	-	44	42
EPT Richness	37	25	28	33	31	36	20	26	16	3	2	11	7
Seasonally corr EPT	33	21	24	30	27	33	16	22	13	3	2	11	6
EPT Abundance	163	101	111	165	148	176	85	74	64	12	11	64	22
Biotic Index	4.8	-	-	4.2	-	4.4	6.1	6	-	-	-	6.7	7.1
Seasonally corr BI	4.9	-	-	4.3	-	4.5	6.2	6.1	-	-	-	6.8	7.2
Bioclassification	Excell	Good	Good	Excell	Good	Excell	G/F	G/F	Fair	Poor	Poor	Fair	Fair

Table 3. Benthic macroinvertebrate data summaries from Bolin, Booker, and Little Creeks. Orange County, North Carolina. 1998 and 1993.

Stream Location Date	Bolin Creek SR 1777		Bolin Creek ab Umstead Park		Bolin Creek near East Franklin Street				Booker Cr Piney Mt. Rd	Little Creek Pinehurst Dr	
	Mar-98	Apr-93	Feb-98	Apr-93	Mar-98	Feb-98	Feb-93	Apr-86	Mar-98	2/98	2/93
Ephemeroptera	9	7	12	10	8	1	5	15	3	3	5
Plecoptera	3	6	6	3	1	1	0	6	3	0	0
Trichoptera	11	11	8	11	4	2	3	7	4	2	2
Coleoptera	-	-	3	-	0	-	1	8	-	-	1
Odonata	-	-	4	-	8	-	4	9	-	-	4
Megaloptera	-	-	1	-	0	-	2	1	-	-	0
Diptera: Chironomidae	-	-	9	-	7	-	9	24	-	-	15
Misc. Diptera	-	-	4	-	4	-	3	7	-	-	1
Oligochaeta	-	-	4	-	1	-	3	5	-	-	4
Crustacea	-	-	4	-	2	-	1	2	-	-	3
Mollusca	-	-	3	-	1	-	1	4	-	-	2
Other	-	-	1	-	1	-	0	1	-	-	0
Total Taxa Richness	-	-	59	-	37	-	32	89	-	-	37
EPT Richness	23	24	26	24	13	4	8	28	10	5	7
Seasonally corr EPT	22	21	23	22	12	4	8	24	8	5	7
EPT Abundance	90	76	91	88	42	22	32	145	36	7	16
Biotic Index	-	-	5	-	6	-	6.5	6.1	-	-	7.1
Seasonally corr BI	-	-	5.1	-	6.1	-	6.6	6.2	-	-	7.2
Bioclassification	Good	Good	Good	G/F	Fair	Poor	Fair	G/F	Fair	Poor	Fair

	Cane Creek SR 1114			Morgan Creek NC 54			Morgan Creek Botanical Garden Trail			Meeting of Waters Cr Laurel Hill Rd		Morgan Creek below WWTP	
	Feb-98	Feb-98	Feb-93	Feb-98	Feb-98	Feb-93	Mar-98	Feb-93	Apr-93	Mar-98	Feb-93	Mar-98	Feb-93
PLECOPTERA (CON'T)													
ISOPERLA NAMATA (GR)	C	R		C	C	A	R		C				
ISOPERLA TRANSMARINA (GR)							R	R	R				
NEOPERLA SPP				C									
PERLESTA SPP	R	R		R			C	R	C			C	
STROPHOPTERYX SPP	A	A	A	A	A	C	R	A					R
TAENIOPTERYX SPP		C			R	C		C					
TRICHOPTERA													
ANISOCENTROPUS PYRALOIDES					R	C							
CERACLEA SPP							R						
CERACLEA ANCYLUS	A		A	A	C	C							
CERACLEA RESURGENS				C	R								
CERACLEA TRANS VERSA	A		C			C							
CHEUMATOPSYCHE SPP	R	A	R	A	A	A	A	A	A	R		A	C
CHIMARRA SPP	C	R	A	A	A	A			R				
DIPLECTRONA MODESTA								R			R		
HYDROPSYCHE BETTENI			C	R	C	R	A	C	A	A	A	C	R
HYDATOPHYLAX SPP			R										
HYDROPTILA SPP								R					
IRONOQUIA PUNCTATISSIMA							R	R					
LEPIDOSTOMA SPP					R	R						R	
LYPE DIVERSA	C					R							
MICRASEMA RUSTICUM	R			R		C							
NEOPHYLAX OLIGIUS	R	R	R	A	A	A		R					
NYCTIOPHYLAX MOESTUS	C	R	C										
POLYCENTROPUS SPP	C	C	A	R	R	C	R						
PSILOTRETA SPP				C		C							
PTILOSTOMIS SPP			R		R								
PYCNOPSYCHE SPP	C		C	C	C	A	R	R	R				
RHYACOPHILA CAROLINA	R			R	R	R							
RHYACOPHILA LEDRA	A	C	A	A	C	C							
RHYACOPHILA NIGRITA						R							
COLEOPTERA													
ANCYRONYX VARIEGATUS												R	R
DINEUTES SPP								A					
DUBIRAPHIA SPP						C	C	R					

	Cane Creek SR 1114			Morgan Creek NC 54			Morgan Creek Botanical Garden Trail			Meeting of Waters Cr Laurel Hill Rd		Morgan Creek below WWTP	
	Feb-98	Feb-98	Feb-93	Feb-98	Feb-98	Feb-93	Mar-98	Feb-93	Apr-93	Mar-98	Feb-93	Mar-98	Feb-93
PELECYPODA													
CORBICULA FLUMINEA							C	C				A	R
ELLIPTIO COMPLANATA	R												
PISIDIUM SPP				R		C							
SPHAERIUM SPP	R			R		R		R				R	
GASTROPODA													
CAMPELOMA DECISUM	R												
ELIMIA SP	R			A		A		R					
FERRISSIA SPP	C					C		R					
HELISOMA ANCEPS				C				R					
MENETUS DILATUS						R							
PHYSELLA SPP						R		C					C
OTHER													
DUGESIA TIGRINA						R		R				R	C
HYDRACARINA	C						A	R				R	
PROSTOMA GRAECENS						R		R					

Stream Station Date	Bolin Creek SR 1777		Bolin Creek ab Umstead Park		Mar-98	Bolin Creek near E. Franklin Street			Booker Cr Piney Mt. Rd.	Little Creek Pinehurst Dr	
	Mar-98	Apr-93	Feb-98	Apr-93		Feb-98	Feb-93	Apr-86	Mar-98	Feb-98	Feb-93
TRICHOPTERA											
AGAPETUS SPP				R							
CERACLEA ANCYLUS	A	C	C	C							
CERACLEA NEFFI		C									
CERACLEA RESURGENS	R		R				R				
CERACLEA TRANS VERSA				R							
CHEUMATOPSYCHE SPP	C	R	A	R	A	A		C	C	C	R
CHIMARRA SPP	C		C								
DLPLECTRONA MODESTA	R	R					R	R	C		
DOLOPHILODES SPP								C			
HYDROPSYCHE BETTENI	R	C			A	A	A	C	C		R
HYDROPTILA SPP								R			
IRONOQUIA PUNCTATISSIMA				R	R				R		
MICRASEMA CHARONIS				R							
MYSTACIDES SEPULCHRALUS		R									
NEOPHYLAX OLIGIUS	C	C	C	C							
NEOPHYLAX ORNATUS	R										
OCHROTRICHIA SPP		R									
POLYCENTROPUS SPP	R	R	R								
PYCNOPSYCHE SPP	C	C	R	R	R						
PYCNOPSYCHE GUTTIFER								R			
RHYACOPHILA CAROLINA				R							
RHYACOPHILA LEDRA	C	C	C	R							
RIIYACOPHILA NIGRITA										R	
STACTOBIELLA SPP				R							
TRIAENODES TARDUS								C			
COLEOPTERA											
ANCHYTARSUS BICOLOR								R			
ANCYRONYX VARIEGATUS								C			
DERONECTES SP								R			
DUBIRAPHIA SPP			R					A			
GYRINUS SPP											R
HELICHUS SP								C			
HYDROPORUS SPP			C					R			
MACRONYCHUS GLABRATUS								A			
PSEPHENUS HERRICKI			A					A			
STENELMIS SPP							R				

Stream Station Date	Bolin Creek SR 1777		Bolin Creek ab Umstead Park		Bolin Creek near E. Franklin Street			Booker Cr Piney Mt. Rd.	Little Creek Pinehurst Dr		
	Mar-98	Apr-93	Feb-98	Apr-93	Mar-98	Feb-98	Feb-93	Apr-86	Mar-98	Feb-98	Feb-93
ODONATA											
ARGIA SPP			C		R			C	A		R
BOYERIA VINOSA					C			R	R		R
CALOPTERYX SPP					C			R	C		R
CORDULEGASTER SPP					R				R		
ENALLAGMA SPP			C		R				A		
GOMPHUS SPP					R				C		
MACROMIA SPP					R				R		
NEUROCORDULIA OBSOLETA									R		
PROGOMPHUS OBSCURUS			R								C
STYLOGOMPHUS ALBISTYLUS			R		C			R	R		
MEGALOPTERA											
CORYDALUS CORNUTUS									R		
NIGRONIA SERRICORNIS									R	R	
SIALIS SPP			R								
DIPTERA: CHIRONOMIDAE											
ABLABESMYIA MALLOCHI									A		R
ABLABESMYIA PARAJANTA/JANTA									R		R
BRILLIA SPP									A		C
CRICOTOPUS BICINCTUS			C						A		C
ORTHOCLADIUS OBUMBRATUS GR									A		
ORTHOCLADIUS ROBACKI			A		R				C		
O. (EUORTHOCLADIUS) TYPE III			R								
ORTHOCLADIUS (EUORTHOCLADIUS)										A	
CRICOTOPUS INFUSCATUS GR									A		
CRICOTOPUS VARIPES GR									C		C
CHIRONOMUS SPP									A		C
CONCHAPELOPIA GROUP			R						C	A	A
CRYPTOCHIRONOMUS BLARINA GR											R
DIAMESA SPP									R		
DICROTENDIPES NEOMODESTUS			C		R						
DICROTENDIPES SIMPSONI											R
DIPLOCLADIUS CULTRIGER			C								A
TVETENIA BAVARICA GR			A		R						
EUKIEFFERIELLA CLARIPENNIS GR									A		
TVETENIA DISCOLORIPES GR									A		

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	Mar-98	Apr-93	Feb-98	Apr-93	Mar-98	Feb-98	Feb-93	Apr-86	Mar-98	Feb-98	Feb-93

CHIRONOMIDAE (CON'T)

LARSIA SPP											R
NANOCLADIUS SPP							R				
OLIVERIDIA SPP					C						
POLYPEDILUM CONVICTUM					R						
POLYPEDILUM FALLAX								C			R
POLYPEDILUM HALTERALE							R	A			A
POLYPEDILUM ILLINOENSE					R						
POLYPEDILUM SCALAENUM							R				
PARACLADOPELMA SPP					R						
PARACLADOPELMA UNDINE								R			
PARAMETRIOCNEMUS LUNDBECKI							R	C			
PARATENDIPES SPP								A			
PHAENOPSECTRA FLAVIPES								A			
PHAENOPSECTRA SP2								C			
POTTHASTIA SPP								C			
POTTHASTIA LONGIMANUS								C			
PROCLADIUS SPP								A			
RHEOCRICOTOPUS ROBACKI								A			
STENOCHIRONOMUS SPP								R			
STICTOCHIRONOMUS SPP			R								
TANYTARSUS SPP								C			
THIENEMANIELLA SPP								R			
TRIBELOS SPP			R								A
ZAVRELIMYIA SPP											R

MISC. DIPTERA

AEDES SP								R			
ANOPHELES SPP								R			
ANTOCHA SPP							C	R			
PALPOMYIA (COMPLEX)			R		R			C			
PROSIMULIUM SPP			A		A						
SIMULIUM SPP			R		C		R				
SIMULIUM VITTATUM								A			
TIPULA SPP			C		R		C	C			C

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	Mar-98	Apr-93	Feb-98	Apr-93	Mar-98	Feb-98	Feb-93	Apr-86	Mar-98	Feb-98	Feb-93
OLIGOCHAETA											
ILYODRILUS TEMPLETONI							R	C			R
LIMNODRILUS SPP			R								
LIMNODRILUS HOFFMEISTERI			R								R
LUMBRICULIDAE			R		A		C				C
NAIS SPP							R	C			
OPISTHOPORA			R					C			R
SPIROSPERMA NIKOLSKYI								C			
STYLARIA LACUSTRIS								C			
CRUSTACEA											
CAECIDOTEA SP			C								R
CAMBARIDAE			R				C				C
CAMBARUS SPP					A			C			
CRANGONYX SPP			A								R
HYALLELA AZTECA			C					C			
PROCAMBARUS SPP					R						
PELECYPODA											
CORBICULA FLUMINEA					R						R
SPHAERIUM SPP			R								
ELIMIA SP			A					C			
FERRISSIA SPP								C			
MENETUS DILATUS								C			
PHYSELLA SPP			R				R	C			R
OTHER											
DUGESIA TIGRINA								R			
HYDRACARINA			R		R						