BIOLOGICAL MONITORING OF CHAPEL HILL STREAMS, NORTH CAROLINA

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HOW TO READ THIS REPORT

This is the 2nd report by Lenat Consulting on water quality and habitat quality of streams in Chapel Hill, North Carolina. It includes data on Bolin Creek, Booker Creek, Morgan Creek, Little Creek and their tributaries. A companion report also has been prepared for the Town of Carrboro, with information on Bolin Creek and selected tributaries. Data from four sites have been included in both reports: Morgan Creek at NC 54, Bolin Creek at Village Drive, Jolly Branch and an Unnamed Tributary to Tanyard Branch. There is some duplication between these reports, especially in the introduction, summary of flow data, methods, and summary of prior biological monitoring. Long lists of species are primarily confined to the appendices, but the reader will often find some species names used in the discussion, especially in regard to *tolerant* or *intolerant* species. **In order to comprehend many of the summary tables, the reader should understand the terms "EPT taxa richness" and "biotic index", and should understand how bioclassifications are assigned to streams** (see Methods section). Given some familiarity with these terms, Tables 2 and 3 provide the quickest summary this study. The Introduction, Methods and Review of Other Biological Data are largely repeated from the 2011 report; flow information has been updated to include 2011 and 2012 data. **Individuals who have read the 2011 report may wish to skip to the Results and Discussion sections**.

INTRODUCTION (Most of this section is taken from the 2011 report)

Water quality in Chapel Hill was evaluated in April and June of 2012 by sampling benthic macroinvertebrates at 22 sites: 2 Bolin Creek sites, Morgan Creek, Little Creek and 18 smaller tributaries. The tributaries were sampled in April, while the larger streams were sampled in June.

There are several reasons for using biological surveys in monitoring water quality. Conventional water quality surveys do not integrate fluctuations in water quality between sampling periods. Therefore, short-term critical events may often be missed. The biota, especially benthic macroinvertebrates, reflect both long and short-term conditions. Since many species in a macroinvertebrate community have life cycles of a year or more, the effects of a short-term pollutant will generally not be overcome until the following generation appears.

Macroinvertebrates are useful biological monitors because they are found in all aquatic environments, they are less mobile than many other groups of organisms, and they are small enough to be easily collectable. Moreover, chemical and physical analysis for a complex mixture of pollutants is generally not feasible. The aquatic biota, however, show responses to a wide array of potential pollutants, including those with synergistic or antagonistic effects. Additionally, the use of benthic macroinvertebrates has been shown to be a cost-effective monitoring tool (Lenat 1988). The sedentary nature of the benthos ensures that exposure to a pollutant or stress reliably denotes local conditions, and allows for comparison of sites that are in close proximity (Engel and Voshell 2002).

Analysis of stream life is one way to detect water quality problems (Rosenberg et al 1986). Different kinds of stress will often produce different benthic macroinvertebrate communities. For example, the species associated with organic loading (and low dissolved oxygen) are well known. More recent studies have begun to identify the biological impacts of sedimentation and toxic stress. Identification at, or near, the species level is desirable for many groups of organisms (Resh and Unzicker 1975), and recent work by Lenat and Resh (2001) has shown the benefits of precise taxonomy for both pollution monitoring and conservation biology.

Organisms cannot always be identified at the species level, thus counts of the number of kinds of stream organisms often include identifications at higher levels (genus, family, etc.). Each different type of organism in these situations is called a "taxon" and the plural form of this word is "taxa". Thus "taxa richness" is a count of the number of different types of organisms.

LITTLE CREEK CATCHMENT

The following overview of this catchment is modified from a report by North Carolina Department of Environment and Natural Resources (2003): Assessment Report - Biological Impairment in the Little Creek Watershed Cape Fear River Basin.

Located in Orange and Durham Counties, Little Creek flows into the New Hope arm of B. Everett Jordan Lake, draining a 24.6-square mile area in subbasin 03-06-06 of the Cape Fear River basin. Two major tributaries, Booker Creek and Bolin Creek, drain the majority of the Little Creek catchment. The watershed includes extensive areas of residential and commercial development, as well as a portion of the campus of the University of North Carolina at Chapel Hill (UNC). As of 1999, impervious areas such as roads and buildings covered approximately 15 percent of the study area. The upper three quarters of this area lies in the Carolina Slate Belt, and streams here exhibit the narrow valleys and rocky substrates associated with this geologic zone. Little Creek and the downstream reaches of Booker and Bolin Creek are located in a Triassic basin and exhibit its characteristic broad floodplains and sandy substrates. Visual assessment suggests that most streams downstream of East Franklin Street were channelized (straightened and dredged) in the past. An OWASA (Orange Water and Sewer Authority) sewer easement follows Booker, Bolin and Little Creeks for much of their length.

Bolin Creek

The headwaters of Bolin Creek are located northwest of the intersection of Homestead Road (SR 1777) and Old NC 86 (SR 1109), north of Carrboro. Bolin Creek is joined by the following named tributaries, in order from upstream to downstream: Jones Creek, Jolly Branch, Tanyard Branch, and Battle Branch. This report also includes information from some of the smaller tributaries, including an unnamed tributary at Severin Street, an unnamed tributary of Tanyard Branch at Baldwin Park, Mill Race Branch, Cole Springs Branch, and Library Branch. Bolin Creek is dammed several times in its headwaters, most notably to form Lake Hogan, a 12-acre impoundment located just downstream of Old NC 86. Bolin Creek begins in a fairly undeveloped area and drains progressively more urban and developed areas in Carrboro and Chapel Hill as it flows towards its confluence with Booker Creek. Bolin Creek is approximately eleven miles long, mostly located within the planning jurisdiction of Carrboro. The 12-square mile watershed includes about half of Carrboro's downtown commercial district, the majority of Chapel Hill's central business district and approximately 146 acres of the University of North Carolina at Chapel Hill (UNC) campus (primarily draining to Battle Branch). The stream also drains a variety of residential areas in Chapel Hill and Carrboro, and the dense commercial district along Estes Drive near University Mall.

Booker Creek

The headwaters of Booker Creek rise southwest of the intersection of Martin Luther King Jr Blvd. (old Airport Road, NC 86) and Weaver Dairy Road in Chapel Hill. Booker Creek is joined by two named tributaries: Cedar Fork and Crow Branch. The mainstem of Booker Creek has been dammed to create Lake Ellen (surface area of seven acres, built in 1961) and, further downstream, Eastwood Lake. Unlike Bolin Creek, which drains progressively more developed areas as it flows downstream, most of the Booker Creek watershed is heavily developed.

MORGAN CREEK CATCHMENT

Morgan Creek originates in a rural and residential area west of Chapel Hill, although much of this area is undergoing further residential development. It is the major tributary of University Lake. Downstream of University Lake, the stream flows through residential areas in the southern part of Chapel Hill. Major tributaries downstream of University Lake include Fan Branch and Wilson Creek. Most of the Morgan Creek catchment is located in the Slate Belt ecoregion, producing rocky streams. The Southern tributaries, however, had stream beds largely comprised of sand and gravel. These streams are similar to headwater tributaries of Pokeberry Creek in Chatham County (Lenat, unpublished data).

OTHER STREAMS
This report also includes data from Old Field Creek and Dry Creek, which flow north into New Hope Creek.

METHODS [Note: this section largely repeated from prior report.]

All collection methods are derived from techniques used by the NC Division of Water Quality (Lenat 1988). These methods have been in use by North Carolina since 1982, and have been thoroughly tested for accuracy and repeatability. In addition to collection of organisms, field work includes habitat evaluations, water quality field parameters (pH, dissolved oxygen, temperature, and specific conductivity), and photos. More details can be found at DWQ's Biological Assessment Unit web site: http://portal.ncdenr.org/web/wq/ess/bau. Three of DWQ's collection methods have been used for studies in Carrboro and Chapel Hill: intensive "Standard Qualitative" collections and more rapid" EPT" and Qual-4 collections. These three methods are briefly described below. A Quality Assurance Program Plan (QAPP) was developed based on the plan used by DWQ to document data collection and quality assurance procedures in order that data collected in this study are directly comparable to those collected by DWQ.

Drainage basins for all sites were delineated in a Geographic Information System (GIS), drainage areas calculated, and percentages of particular land uses were determined based on the US Geological Survey 2006 National Land Cover Dataset. Percentages of impervious surface (pavement, driving surfaces, rooftops, and other parts of the built environment) in each drainage area were calculated based on locally-collected data, current to 2003 in Carrboro and 2011 in Chapel Hill. This land use data was supplied by the Town of Chapel Hill (Patricia D'Arconte, Stormwater Management Division).

Standard Qualitative Method – Overview [Bolin Creeks sites 4-5 and Morgan Creek site 2]
The standard qualitative technique includes 10 separate samples and is designed to sample all habitats and all sizes of invertebrates. This collection technique consists of two kicknet samples (kicks), three sweep-net samples (sweeps), one leaf-pack sample, two fine-mesh rock and/or log wash samples, one sand sample, and visual collections. Invertebrates are separated from the rest of the sample in the field ("picked") using forceps and white plastic trays, and preserved in glass vials containing 95% ethanol. Data were collected from these sites in June 2012 to match standard procedures for larger streams.

Organisms are picked roughly in proportion to their abundance, but no attempt is made to remove all organisms. If an organism can be reliably identified as a single taxon in the field, then no more than 10 individuals need to be collected. Some organisms are not picked, even if found in the samples, because abundance is difficult to quantify or because they are most often found on the water surface or on the banks and are not truly benthic.

Organisms are classified as Abundant if 10 or more specimens are collected, Common if 3-9 specimens are collected, and Rare if 1-2 specimens are collected.

EPT Method – Overview [Morgan Creek at NC 54]
The EPT method is a more rapid collection technique, limited to 4 samples: 1 kick, 1 bank sweep, 1 leaf pack and visuals. Furthermore, collections are limited to the most intolerant "EPT" groups: Ephemeroptera, Plecoptera and Trichoptera. Note that the EPT method is a subset of the standard qualitative method described above.

Qual-4 Method – Overview [Smaller tributary sites and Little Creek]
The Qual-4 method uses the same 4 samples as the EPT method, but all benthic macroinvertebrates are collected. DWQ uses this method to evaluate small streams (drainage area < 3 square miles) and assigns ratings based solely on the biotic index values. This

method is intended for use, however, only in perennial streams. For this reason, the majority of bioclassifications assigned to the Chapel Hill tributaries are tentative ratings supplemented by best professional judgment. Data were collected from these sites in April 2012 to match standard procedures for small streams.

Assigning Bioclassifications - Overview

The ultimate result of a benthos sample is a bioclassification. Bioclassifications used by NC DWQ are Excellent, Good, Good/Fair, Fair or Poor for standard qualitative samples; they are based on both EPT taxa richness and the biotic index values. A score (1-5) is assigned for both EPT taxa richness and the NC biotic index. The final site classification is based on the average of these two scores. In some situations, adjustments must be made for stream size or the season, but such adjustments were not required for this study.

EPT Criteria

The simplest method of data analysis is the tabulation of species richness (number of species), and species richness is the most direct measure of biological diversity. The association of good water quality with high species (or taxa) richness has been thoroughly documented. Increasing levels of pollution gradually eliminate the more sensitive species, leading to lower and lower species richness. A score from 1 to 5 is assigned to each site, with 1 for Poor EPT taxa richness and a 5 for Excellent EPT taxa richness (see below).

The relationship of total taxa richness to water quality is nonlinear, as this metric may increase with mild enrichment of nitrogen and/or phosphorus. Taxa richness for the most intolerant groups (Ephemeroptera + Plecoptera + Trichoptera) is more reliable, but must be adjusted for ecoregion. Piedmont criteria were used for the Bolin Creek study.

Biotic Index Criteria

To supplement EPT taxa richness criteria, the North Carolina Biotic Index (NCBI) was derived as another (independent) method of bioclassification to support water quality assessments (Lenat 1993). This index is similar to the Hilsenhoff Biotic Index (Hilsenhoff, 1987) with tolerance values derived from the NC database. Biotic indices are based on a 0-10 scale, where 0 represents the best water quality and 10 represents the worst. Abundance values used in the biotic index calculation are 10 for Abundant taxa, 3 for Common taxa, and 1 for Rare taxa. The highest values (>5.1) indicate the worst water quality and receive a score of 5; the lowest values indicate Excellent water quality and receive a score of 1 (see below)

NC Division of Water Quality: Scoring for Biotic Index and EPT taxa richness values for Piedmont streams

Score	BI Values	EPT Values
5	<5.14	>33
4.6	5.14-5.18	32-33
4.4	5.19-5.23	30-31
4	5.24-5.73	26-29
3.6	5.74-5.78	24-25
3.4	5.79-5.83	22-23
3	5.84-6.43	18-21
2.6	6.44-6.48	16-17
2.4	6.49-6.53	14-15
2	6.54-7.43	10-13
1.6	7.44-7.48	8-9
1.4	7.49-7.53	6-7
1	>7.53	0-5

Derivation of Final Bioclassification for Standard Qualitative Samples

For most mountain, piedmont and coastal plain (Coastal A) streams, equal weight should be given to both the NC Biotic Index value and EPT taxa richness value in assigning

bioclassifications. For these metrics, bioclassifications are assigned from the following site scores:

Excellent: 5 Good: 4 Good-Fair: 3 Fair: 2 Poor: 1

"Borderline" values are assigned near half-step values (1.4. 2.6, etc.) and are defined as boundary EPT values ±1 (except coastal plain), and boundary biotic index values ±0.05. The two ratings are then averaged together, and rounded up or down to produce the final classification. When the EPT and BI score differ by exactly one unit, the EPT abundance value is used to decide on rounding up or rounding down.

Small Stream Criteria

Small streams (<4 meters wide) are expected to have lower EPT taxa richness relative to larger streams. NC DWQ has developed criteria for small piedmont stream based solely on biotic index values:

Excellent	<4.4
Good	4.4-5.4
Good-Fair	5.5-6.0
Fair	6.1-7.0
Poor	>7.0

These criteria were developed only for permanent criteria; *most of the Chapel Hill small streams are intermittent.*

SAMPLING SITES (See Figure 1 for a map of sampling locations.)
More detailed site descriptions (with photos) are presented in Appendices 3 and 4.

Table 6 gives data on habitat ratings and substrate composition at all sites sampled in March 2011. The habitat rating is based on standard Division of Water Quality procedures, and produces a value between 0 and 100. A higher value indicates better habitat quality. Abundant growths of filamentous algae were observed at many sites in March 2011; such growths were not seen in June 2012. With the exception of the Triassic Basin sites, most Chapel Hill streams had adequate habitat to support a diverse benthic macroinvertebrate community.

FLOW DATA

The fauna of Chapel Hill streams have been frequently affected by droughts, with some streams becoming entirely dry during severe droughts. Changes due to water quality problems cannot be discerned without taking into consideration this natural stress. The data in Table 1 below is taken from the USGS web site, using data from 1999 to 2012. The USGS measures daily flow at Morgan Creek at NC 54 and Cane Creek; both streams are in Orange County and both are similar in geology to the Bolin Creek catchment. The Cane Creek site, however, may be affected by the upstream Cane Creek Reservoir, so this year's report only shows the Morgan Creek flow information.

Table 1: Mean Monthly flow (cfs) in streams most similar to Bolin Creek, 1999-2009.

Morgan Creek nr White Cross (Drainage area 8.3 square miles)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999	13	4	5	10	0.9	0.5	*0.4*	***0.09***	40	8	7	4
2000	11	15	7	11	3	4	12	4	3	1.3	1.7	2.2
2001	2.4	6	17	12	3	5	1.1	0.6	*0.2*	*0.1*	*0.1*	*0.3*
2002	7	4	4	2	0.7	***0.03***	***0.04***	***0.01***	***0.04***	6	4	15
2003	6	20	32	39	11	7	6	3	2	2	2	5
2004	2	8	5	4	3	*0.4*	0.7	5	7	2	4	3
2005	7	7	15	6	2	0.7	*0.3*	*0.2*	***0.01***	*0.2*	0.6	7
2006	3	2	2	2	0.7	1.7	5	***0.08***	0.5	1.9	16	6
2007	13	7	9	12	1.8	0.6	*0.2*	***0.002***	***0***	***0.008***	***0.003***	*0.2*
2008	0.4	1.3	9	6	2	*0.4*	1.6	4	15	*0.3*	1.4	9
2009	5	3	19	6	3	4	*0.4*	*0.2*	***0.05***	***0.05***	7.7	18.7
2010	13	21	7	3	4	0.6	*0.1*	***0.02***	0.6	0.3	0.6	0.8
2011	0.7	1.4	3	4	1.1	*0.1*	0.6	***0.004***	***0.01***	*0.05*	*0.2*	3
2012	2	2	20	3								

Flow data from further downstream on Morgan Creek at Chapel Hill (41 square miles) did not indicate any months with average flows less than 7 cfs (1999-2012).

Low flows (less than 0.5 cfs) are in *underlined italics*; severe low flows (less than 0.1 cfs) are in ***bold italics***. Values past September 2011 are median monthly values (not means).

Water Quality Field Parameters

Table 2 shows results of water quality field parameter measurements taken at the time of sample collection.

Table 2: 2012 Water Quality Field Parameter Measurements				
Sample Site	**Dissolved Oxygen (mg/L)**	**Specific Conductivity (µS/cm)**	**pH**	**Temperature (°C)**
Wilson above Wave Rd	9.38	115.4	7.16	14.1
Wilson above Arlen Park Dr	10.33	120.8	7.35	15
Dry Creek above Erwin Rd	9.88	320	7.63	14
Booker Creek at Willow Dr	4.68	196.6	7.02	14.2
Booker Creek at MLK Blvd	8.36	165.6	7.17	11.4
Cedar Fork at Brookview Dr	10.44	165.5	7.48	11.7
Old Field at Town Operations Center	9.28	289	7.22	12
UT to Bolin at Severin St	7.57	188.3	7.33	15.1
UT to Morgan at Bayberry Dr	9.64	186.4	7.77	14.7
Fan Branch below Parkview Crescent	9.32	134.4	7.25	13.7
Pritchard Branch at Chase Park Apts	10.37	259	7.64	12.6
Battle Branch near Weaver Rd	9.36	244	7.53	12
Library Creek below Library Dr	7.51	156.8	7.09	12.5
Jolly Branch below CHHS	10.97	204.7	7.47	17.1
Cole Springs Branch nr Cedar St	9.68	256	7.65	14.8
Mill Race Branch at Bolinwood Dr	9.47	245	7.45	14
Tanyard Branch nr Carver St	9.7	352	7.41	11.9
UT to Tanyard at Baldwin Park	9.79	510	7.66	13
Morgan Creek at Ashe Place			7.58	19.7
Bolin Creek above Village Drive	9.02	116.6	7.72	19.5
Bolin Creek above Franklin St	8.1	172.7	7.43	20.4
Little Creek near Rashkis Greenway	5.94	173.1	7.3	21.2

Table 3 shows average values and ranges of water quality field parameters for a subset of the above sites that were monitored monthly at low flow (baseflow) between the years 1994 and 2008.

Table 3: Water Quality Field Parameter Values For Selected Sites, Averages and Ranges, 1994 Through 2004				
Sample Site	**Average Dissolved Oxygen (mg/L)**	**Average Specific Conductivity (µS/cm)**	**Average pH**	**Average Temperature (°C)**
Booker Creek at Willow Dr	6.2	183	7.3	14.5
Booker Creek at MLK Blvd	6.4	161	7.1	13.5
Morgan Creek at Ashe Place	8.5	135	7.5	15.2
Bolin Creek above Franklin St	8.0	159	7.3	14.2
	Range Dissolved Oxygen	**Range Specific Conductivity**	**Range pH**	**Range Temperature**
Booker Creek at Willow Dr	1.61 to 14.65	46 to 504	6.1 to 7.99	1.05 to 26.13
Booker Creek at MLK Blvd	0.01 to 14.44	108.2 to 305.1	5.97 to 8.06	0.31 to 26.94
Morgan Creek at Ashe Place	0.83 to 18.69	64 to 361	5.97 to 8.14	0.37 to 26.14
Bolin Creek above Franklin St	0.94 to 17.26	92 to 334.1	6.1 to 8.07	0.16 to 25.77

Drainage Area Characteristics

Table 4: Watershed Size and Percent Covered By Impervious Surface		
Sample Site	**Drainage Area (acres)**	**% Impervious Surface**
Battle Br near Weaver Rd	304	22
Bolin Cr above Franklin St	6820	15
Bolin Cr above Village Dr	5052	10
Booker Cr at MLK Blvd	497	20
Booker Cr at Willow Dr	3917	22
Cedar Fork at Brookview Dr	861	21
Cole Springs Br near Cedar St	271	20
Dry Cr above Erwin Rd	716	12
Fan Br below Parkview Crescent	815	15
Jolly Br below CHHS	187	18
Library Cr below Library Dr	78	18
Little Cr near Rashkis Greenway	13200	19
Mill Race Br at Bolinwood Dr	235	42
Morgan Cr at Ashe Pl	24500	6.5
Old Field Creek at Town Operations Center	1070	7.3
Pritchard Br at Chase Park Apts	178	28
Tanyard Br near Carver St	351	46
UT to Bolin Cr at Severin Dr	116	18
UT to Morgan Cr at Bayberry Dr	187	11.5
UT to Tanyard Branch at Baldwin Park	76	44
Wilson Cr above Arlen Park Dr	1260	6.3
Wilson Cr above Wave Rd	745	3.5

Table 5: Percentage Land Uses in Watersheds in 2006

Sample Site	Open water	Devel. open space	Devel. low intensity	Devel. medium intensity	Devel. high intensity	Barren land	Decid. forest	Everg. forest	Mixed forest	Shrub	Grassland	Pasture	Crops	Woody swamp	Marsh
UT at Severin	0	38	12	5.5	23	0	9.3	21	3.4	0	1.9	6.5	0	0	0
Tanyard	0	28	40	21	9.4	0	1.0	0	0	0	0.5	0	0	0	0
Pritchard	0	43	20	4.2	2.1	0	21	7.2	2.5	0	0	0	0	0	0
Old Field	0	8.8	4.1	2.1	0.4	0.3	38	20	2.7	1.1	14	8.2	0	0	0
Morgan 2	0.9	10.6	3.8	1.8	0.3	0.1	43	18	5.1	0.5	3.5	12	0.5	0.1	0.04
Mill Race	0	49	31	14	2.9	0	2.9	0	0	0	0.3	0	0	0	0
Little	0.3	39	13	4.2	0.9	0.01	22	13	2.1	0.3	1.6	2.6	0	0.9	0
Library	0	57	8.3	1.7	0	0	17	14	2.2	0	0	0	0	0	0
Jolly	0	19	13	13	2.5	0	17	29	0.1	0	2.1	3.3	0	0	0
Fan	0.1	15	7	8.8	1.0	0	31	21	5.6	0.8	2.7	7.2	0	0	0
Dry	0.3	24	19	0.8	0.7	0	9	20	3.9	0.61	4	6.3	0	0.8	0
Cole Springs	0	26	12	9.6	3.8	0	25	12	3.4	0	0.7	8	0	0	0
Cedar	0.3	46	11	4.4	0.7	0	22	12	1.5	0.16	0.9	1.4	0	0	0
Booker 2	0.2	48	15	5.9	1	0.05	15	11	1.5	0.07	1.1	0.9	0	0	0
Booker 1	0	37	30	5.5	0	0	12	11	0.9	0.09	2.8	1.5	0	0	0
Bolin 4	0.6	21	8.9	1.4	0.2	0	34	22	2.8	0.7	2.9	5.6	0	0.5	0
Wilson 1	0	6.8	2.4	0.2	0	0	42	21	11	0	2.8	14	0	0	0
Wilson 2	0	7.4	3.6	2	0.3	0	46	18.9	9.5	0.3	2.8	9.3	0	0	0
UT Tanyard	0	26	43	18	14	0	0	0	0	0	0	0	0	0	0
UT at Bayberry	0	27	6.0	0	0	0	56	3.9	4.9	0.9	0	0.9	0	0	0
Bolin 5	0.4	27	12.1	3.2	0.9	0	29	17.3	2.6	0.5	2.2	4.5	0	0.4	0
Battle	0	45	8.2	3.9	0.4	0	38	04	4.1	0	0	0	0	0	0

Table 6. Site characteristics, Chapel Hill Streams, April and June 2012, Orange County.

	Habitat Components									Substrate						
Stream	**CM**	**IH**	**BS**	**PV**	**RH**	**BSV**	**LP**	**RVZW**	**Total**	**Width**	**B**	**R**	**Gr**	**Sa**	**Si**	**Comments**
Slate Belt (Rocky)																
Bolin 4	4	15	12	6	14	4/4	7	4/4	74	7	30	30	15	25	Tr	Rocky, less algae compared to 2011.
Bolin 5*	4	16	12	6	16	7/7	7	3/3	81	6	5	10	25	60	Tr	Rocky near Franklin St, but sandy upstream. Poor bank habitat. 2012 Habitat Scoring focuses on near-bridge riffles.
Morgan 2	4	20	14	6	14	6/7	10	5/4	90	10	20	20	20	30	10	Sand deposited in pools, less algal growth than in 2011.
Pritchard	4	12	8	8	14	1/8	10	1/8	72	1.5	15	25	20	40	Tr	Embedded, recent sand addition. "Clean" rocks.
Mill Race	5	11	6	6	14	5/3	7	5/5	67	2	5	20	40	35	Tr	Sandy, embedded substrate. Fauna sparse.
Tanyard Br*	5	16	8	8	12	6/6	7	3/5	76	2	20	40	20	20	-	Fauna very sparse, heavily developed catchment.
UT Tanyard	4	15	11	10	14	5/6	7	4/4	79	1	15	50	25	15	Tr	Mitigation site, highly urban
Old Field	4	16	3	4	7	6/6	10	5/5	66	2.5	20	30	20	15	15	Lots of bedrock, silt deposition over most substrate.
Cedar Fk*	5	12	12	6	16	7/7	10	3/4	82	3	40	35	15	10	Tr	Old neighborhood, but houses close to stream, excessive filamentous algae.
Booker 1	5	16	6	4	7	6/6	10	3/5	68	2	10	15	20	55	Tr	Moss/algae abundant, but less than 2011. Crayfish abundant.
Library	4	11	3	6	3	5/5	10	4/4	55	1	Tr	10	30	50	10	Largely residential area, fauna sparse. Small sandy stream.
Cole Springs	5	16	8	10	10	6/7	10	5/5	82	2	30	25	20	25	-	Old residential area, forested riparian, good habitat. Evidence of recent sediment input.
Jolly	5	10	14	10	10	5/5	7	5/5	76	1	15	40	25	15	10	Severe bank erosion, but largely forested. Good habitat.
UT at Severin*	4	11	12	10	16	5/6	10	4/4	82	<1	25	40	25	10	-	Very small, just barely flowing.
UT at Bayberry	4	14	14	6	10	7/7	10	5/5	82	1	15	60	20	5	-	Small and rocky. Good buffer zone.
Sandy Transition Streams																
Battle	5	16	8	6	12	3/4	7	3/4	68	2	Tr	35	30	55	Tr	Very sandy with eroding banks. No bank habitat.
Fan	5	11	3	6	14	6/6	10	5/5	71	2	Tr	Tr	25	70	5	High-density development at site, but good buffer zone.
Wilson 1	5	16	8	10	7	6/6	10	5/5	78	2	Tr	15	40	35	10	Less developed catchment, but sandy.
Wilson 2	5	12	3	8	12	2/2	7	4/2	57	3	Tr	5	25	70	10	High density development at site, but older development upstream with large lots, mostly forested, sandy.
Triassic (Clay/Sand)																
Little	5	14	3	4	3	6/6	10	5/5	61	7	-	-	-	80	20	Sandy stream, but with good snag and leafpack habitat. Many seeps in area, swamp habitat.
Dry	3	15	1	6	10	3/3	10	5/5	63	<1	-	-	-	5	95	Poor habitat (mostly clay), but good riparian buffer. Many seeps in this area, swamp habitat upstream.
Booker 2*	4	11	3	8	3	6/6	10	4/4	59	4.5	-	-	5	70	25	Poor habitat (sand/clay),entrenched and widened.

Habitat Components: CM = Channel Modification (0-5), IH = Instream Habitat (0-20), BS = Bottom Substrate (1-15), PV = Pool Variety (0-10), RH = Riffle Habitats (0-16), BSV = Bank Stability and Vegetation (0-7 for both left and right banks), LP = Light Penetration (0-10), RVZM = Riparian Vegetative Zone Width (0-5 for both left and right banks). Total habitat scores range from 0 (worst) to 100 (best).
Substrate (in percent): Boulder (B), Rubble (R), Gravel (Gr), Sand (Sa), Silt (Si), Tr = Trace (<10%). Stream width is in meters.
*Significant between-year change in evaluation of habitat quality. ***Low scores (indicating habitat problems) are shown in bold italics.***

PRIOR BIOLOGICAL DATA

Benthic macroinvertebrates have been collected in Orange County for over 30 years. One of the first publications was a list of species found in Cane Creek, prior to the existence of the Cane Creek Reservoir (Lenat 1983). The NC Division of Water Quality has multiple collections from Morgan Creek and Bolin Creek, including both standard qualitative and EPT samples. EPT samples use a shorter 4-sample method (vs. 10 samples for the standard qualitative), and are limited to the Ephemeroptera, Plecoptera, and Trichoptera (see Methods).

The following data are taken from the Cape Fear River basin report (NC DWQ 2003):

NC DWQ data, 1985-2003. Standard Qualitative and EPT samples.

	Date	Total S	EPT S	BI	Bioclass*
Bolin Cr at SR 1777	7/01	87	24	5.96	Good-Fair
	2/01	82	17	6.40	Not Rated
	4/00	-	26	-	Good
	3/98	-	23	-	Good
	4/93	-	24	-	Good
Bolin Cr at Village Rd	3/02	40	7	7.00	Fair (follows Drought)
	7/01	52	9	6.6	Fair
	2/01	54	6	7.00	Poor
	2/98	59	26	5.1	Good
	4/93	-	24	-	Good-Fair
Bolin Cr, E Franklin St	7/01	41	4	6.9	Poor
	3/01	53	4	7.1	Poor
	3/98	37	13	6.3	Fair
	2/98	-	4	-	Poor
	2/93	32	8	6.5	Fair
	4/86	89	28	6.1	Good-Fair
Booker Cr, Piney Mtn Rd	7/01	35	4	6.1	Not Rated
	2/01	39	8	6.3	Not Rated
	3/98	-	10	-	Fair
Booker Cr, Barbara Ct	7/01	45	3	6.6	Not Rated
	2/01	31	4	7.3	Not Rated
Booker Ct, Walnut St	7/01	31	4	7.3	Not Rated
	2/01	51	7	6.9	Not Rated
Morgan Cr, NC 54	03/09	-	26	-	Good
	03/08	-	12	-	Not Rated (Drought)
	06/04	-	18	-	Good-Fair
	10/03	-	22	-	Good
	7/03	-	20	-	Good-Fair
	5/03	-	16	-	Good-Fair
	3/03	-	12	-	Not Rated (Drought)
	1/03	-	8	-	Not Rated (Drought)
	9/02	-	2	-	Not Rated (Drought)
	4/00	-	36	-	Excellent
	2/98	80	33	4.4	Excellent
	10/96	64	22	5.0	Good
	7/93	61	22	4.9	Good
	2/93	90	36	4.5	Excellent
	4/85	109	32	5.7	Good

Morgan Creek near the Botanical gardens	3/98	46	20	6.1	Good-Fair
	4/93	-	16	-	Fair
	2/93	71	26	6.0	Good-Fair
Little Cr at Pinehurst Dr	7/01	27	5	6.8	Not Rated
	3/01	45	3	7.3	Poor
	2/93	37	7	7.1	Fair

*DWQ did not assign ratings to streams in the Triassic basin, pending development of criteria for this ecoregion.

NC Department of Environment and Natural Resources (2003 "WARP study") provided the following summary of the Bolin Creek data:

> "When Bolin Creek was first sampled at East Franklin Street in 1986, the benthic community was reasonably diverse, and the stream, though showing indications of impact, was not considered impaired. Impairment was evident when the stream was next sampled in 1993 and has persisted at this downstream site. Upstream sites supported a reasonably intact benthic fauna until 2000, when impairment became evident as far upstream as Waterside Drive in Carrboro, located between Homestead Road and Estes Drive Extension. It is probably too soon to evaluate whether this decline in the benthic community is persistent, or was due to a specific perturbation from which this portion of the stream will yet recover. Currently, only the upper portion of Bolin Creek (Homestead Road) appears to support an adequate benthic fauna.
>
> The causes of impairment in the portion of Bolin Creek between Airport Road and Waterside Drive are less clear than in the downstream section of Bolin Creek. In-stream habitat is adequate. Some effects of toxicity and scour are likely, although these impacts appear less pronounced than in lower Bolin Creek, and likely decline significantly at the upstream end of this section."

DWQ collections from Morgan Creek in 2002 and 2003 were intended to show recovery from the 4- month drought. These data indicated that the stream took about one year to recover from extreme low flow. It had shown a decline over time, never attaining the very high EPT taxa richness values seen in 1985, 1993, 1998, and 2000.

RESULTS AND DISCUSSION (Tables 2-4, Appendices 1-2)

Early samples from Bolin Creek (prior to 2000) indicated Good water quality in the upper section, declining slightly to Good-Fair further downstream. Surveys in 2000, however, produced a Fair rating for sites at Waterside Drive (#3) and Estes Drive (#4). It appears that nonpoint source runoff had a significant negative effect on water quality in Bolin Creek between 1998 and 2000. Note that changes in habitat were not responsible for any these changes.

After August 2001, Bolin Creek was potentially affected by a series of severe droughts, with very low flows (see USGS flow data for Morgan Creek) in:

-Sept-Dec 2001 (4 months, with lowest flow in Oct-Nov)
-June-Sept 2002 (4 months with streams drying up much of this time)
-June 2004
Note that 2003-2004 would be expected to be a period of recovery.
-July-Oct 2005 (4 months with streams going dry in September)
-Aug 2006
-July-Dec 2007 (6 months, with streams going dry for 4-6 months)
-June and September 2008 – no streams went completely dry. Another period of possible recovery.
-July-Oct 2009 (4 months with severe drought for 2-3 months)
-June-August 2010 (severe drought in August)
-August-November 2011

These repeated shocks to the stream biota would be expected to severely affect the diversity of the stream fauna, and bioclassifications based on taxa richness counts might underestimate water quality conditions. The repeated Fair and Poor rating assigned to much of Bolin Creek in Carrboro and Chapel Hill during this period have been used to show that Bolin Creek does not support designated uses, but note that some intolerant species were still abundant at most Bolin sites through 2012. The exception to this pattern was Bolin Creek at Village Drive in 2012, where no intolerant species were found to be abundant. Morgan Creek at NC 54 (intended as a control site) has lost some components of a normal stream fauna (*Elimia*, most Baetidae, *Chimarra*), but still supported a community that included some highly intolerant aquatic species through 2012. DWQ studies have documented the affects of severe drought in Morgan Creek; there is no good information on other activities in the upper Morgan Creek catchment.

Routine sampling in Carrboro and Chapel Hill had been switched from summer months to winter/spring months (esp. March), to avoid these periods of extreme low flow. In 2012, tributaries were sampled in April and the larger streams were sampled in June, following DWQ standard procedures. Note that June collections may miss some of the spring species, which may have emerged in April and May. "Emergence" is the natural process of going from the aquatic nymph to the aerial adult. In comparing data from March 2011 with June 2012, some species may disappear due to emergence, rather than being lost due to a change in water quality. Many of the data tables and appendices (especially Appendices 1-2 and Table 4A) identify such spring species.

Much of Bolin Creek is functioning as an intermittent stream and may be difficult to evaluate using DWQ criteria for perennial streams. Taxa typical of temporary stream or smaller streams are increasing at Bolin Creek in Carrboro, especially the caddisflies *Rhyacophila fenestra* and *Ironoquia punctatissima*. Conversely some components of a normal stream fauna (esp. hydropsychid and philopotamid caddisflies) are declining in abundance at both Morgan Creek and upper Bolin Creek. The latter species are filter-feeders and they are highly dependent on the presence of flowing water. This pattern suggests that the continuing droughts are having an impact on the composition of the invertebrate fauna in Carrboro and Chapel Hill streams. The 2003 DWQ study of Little Creek found low base flow to be a likely stressor of the biotic community. The cause of these low base flows has not been determined.

Tables 2 and 3 present a summary of the biological monitoring for Chapel Hill streams during April and June 2012. These tables also make comparisons with March 2011 data. A list of selected intolerant species is presented in Tables 4A and 4B, producing a score (the "Sum" line) that is useful in comparing sites. Species are only included in Tables 4A and 4B that were Common or Abundant at one or more sites. Although scientific names are used in the latter tables, you can simply consider these as "intolerant species #1" through "intolerant species #22".

None of the Chapel Hill sites had a community that would indicate organic loading, especially sewage leaks or unpermitted dischargers. Some sites, however, had fauna (especially the snail *Physa*) that suggested low dissolved oxygen concentrations. *Physa* was abundant at Bolin Creek #4, Cedar Fork, Tanyard Branch. UT Tanyard Branch, Old Field Creek, Lower Booker Creek and Dry Creek.

Site Evaluations

It is important to realize that stream-flow conditions over the last few years make it difficult to accurately rate water quality in Chapel Hill streams. *Repeated drought conditions have resulted in very low flow rates, with some streams going completely dry. This would be expected*

to reduce the diversity of the fauna, but would have less effect on the tolerance of the aquatic fauna. For this reason, more emphasis is placed on biotic index ratings than taxa richness ratings.

Large Streams

Bolin Creek Site 4 (Village Drive). This site is intended to be equivalent to the Estes Drive site that has been monitored by the Town of Carrboro since 2000. The Estes Drive site had usually received a Fair rating during drought years, but recovered to Good-Fair in 2008 in a period of higher summer flows. The return of severe summer-drought conditions in 2010 and 2011, however, brought the bioclassification for this segment of Bolin Creek back down to Fair. The biotic index for this segment of Bolin Creek was significantly higher (6.7-6.8) in 2011 and 2012 relative to prior collections (5.8-6.4), suggesting a long-term decline in water quality. The abundance of the snail *Physa* in both 2011 and 2012 indicated that this segment of Bolin Creek had experienced low dissolved oxygen concentrations. Collections in a year with of better flow regime might produce a more intolerant benthic macroinvertebrate community.

Bolin Creek Site 5 (Franklin Street). This site received a Poor bioclassification in 2011, similar to DWQ collections in 1998 and 2008. In 2012, however, the Franklin Street site was assigned a Fair bioclassification, indicating a modest improvement in water quality. The abundance of one intolerant caddisfly (*Chimarra*) in both 2011 and 2012 supports the higher rating. This site is quite sandy upstream of the bridge area, but DWQ collections in 1986 demonstrated that habitat for this site is capable of supporting a Good or Good-Fair aquatic fauna. Urban runoff (toxics) is the most likely cause of problems in lower Bolin Creek. This is a common pattern for streams draining major cities throughout North Carolina.

Morgan Creek Site 1, NC 54. This site has been used as a reference site for studies in Carrboro, and there also have been many collections by the Division of Water Quality. Sampling at Morgan Creek site was limited to the intolerant "EPT" taxa, so it was not possible to calculate a biotic index value. EPT taxa richness was much lower in 2012 (13) than in 2011 (21), but much of this decline was due to the change in sampling period from April to June. The upper part of Morgan Creek also has been drastically affected by extreme low flows in summer months. One highly intolerant mayfly (*Leucrocuta*) was very abundant at this site, and another five intolerant species were rare or common (Table 4A). Because of this pattern, upper Morgan Creek was tentatively assigned a Good-Fair rating. It would be useful to conduct a more comprehensive collection (DWQ Full scale 10-sample) in future surveys.

Morgan Creek at Ashe Place (near Botanical Garden). Prior DWQ sampling (1993, 1998) produced a Good-Fair rating for this site. Collections from March 2011 produced only a Fair bioclass, but the fauna had some common or abundant intolerant species, including *Isonychia*, *Chimarra*, and *Psephenus herricki*. The June 2012 collection also resulted in a Fair bioclassification, but no intolerant species were abundant. The overall pattern suggests a long-tem decline in water quality for this segment of Morgan Creek. A paved greenway was constructed fairly close to Morgan Creek's banks (along the OWASA sewer easement) upstream of this site between the 2011 and 2012 samples.

Morgan Creek had a bloom of bright green filamentous algae during the March 2011 collections, but this problem was not observed in June 2012.

Little Creek near Meadowmont Lane. The geology of the Little Creek area is very different from the Morgan Creek and Bolin Creek catchments. The Triassic Basin geology here produces a sandy stream running through a swampy floodplain. Recent DWQ samples from Little Creek have been "Not Rated", as adequate criteria have not been established for the Triassic ecoregion. The most recent DWQ collections (2 collections in 2001) had 27-45 species, with 3-5 EPT taxa and a biotic index of 6.8-7.3. Our 2011-2012 sample had a total taxa richness of 24-31, EPT taxa richness of 3-4, and a biotic index of 6.7. These values are similar to those obtained by DWQ,

indicating no recent change in water quality. Rating this stream with normal Piedmont criteria would produce a Fair or Poor rating. Although Little Creek is very sandy, there is adequate habitat (banks, snags, leafpacks) to support a much more diverse benthic community. While the stream had a poor invertebrate community, the wide floodplain area supports diverse wlldlife.

Small Streams

Slate Belt (Rocky Streams)

New sites

-Pritchard Branch. Pritchard Branch is a rocky tributary to Morgan Creek in southwestern Chapel Hill. There is residential development in this catchment (esp. in the headwaters), but a good buffer zone was seen around the stream. Pritchard Branch appeared to have recent sediment inputs, with deposition of new sand, scoured substrate and bank erosion. The only abundant intolerant species in this stream was the snail *Elimia*. Although no tolerant species have become dominant in Pritchard Branch (hence the relatively low Biotic index value), note that *there were no common or abundant species in the EPT groups.* This clearly indicates major water quality problems, and Pritchard Branch has been tentatively assigned a Fair-Poor rating.

-UT Morgan Creek at Bayberry Drive. Assigned an Excellent rating; see further discussion below under "Higher Quality Slate Belt Streams".

Sites with improvement from 2011-2012. These sites likely benefited from slightly higher flows in spring 2012 relative to spring 2011. The slightly later sampling date also "added" some species, especially baetid mayflies. This resulted in slightly higher EPT taxa richness in 2012.

-Cedar Fork. Cedar Fork is located in an older residential area with large lots, but the houses are often placed very close to the stream. Cedar Fork had abundant growth of filamentous algae in both 2011 and 2012, and the macroinvertebrate fauna (*Physa* abundant) indicated problems in both years associated with low dissolved oxygen. This site received a Fair-Poor rating in 2011, based on the high biotic index (7.3) and very low EPT taxa richness (2). A higher rating (Fair) was assigned in 2012 due to higher EPT taxa richness (7) and a lower biotic index (6.5). Although flow-dependent species were found here in both years, the abundance of the caddisfly *Ironoquia* indicated that flow is sometimes intermittent. NC DOT has been conducting extensive road widening in the Cedar Fork watershed. A significant release of sediment-laden storm runoff from malfunctioning erosion control occurred earlier in 2012.

-Old Field Creek. Old Field Creek runs north into New Hope Creek. A landfill is located within the Old Field catchment, but there is no current evidence that it is causing problems. Like Cedar Fork, the macroinverterbrate fauna produced a higher rating here in 2012 (Fair) than in 2011 (Poor). The lack of flow-dependent caddisflies suggested that this this stream has intermittent flow.

-Booker Creek 1 (MLK). Booker Creek had a very sparse fauna with intolerant mayflies and stoneflies absent in both 2011 and 2012. The headwaters of Booker Creek improved from Poor in 2011 to Fair in 2012, but there were no large changes in the stream fauna. The Fair rating is similar to that produced by DWQ sampling in 2001. Booker Creek had some flow-dependent species in 2012, but these were already in the pupal stage, indicating this stream become intermittent during summer months. Crustacea were the dominant taxa, including crayfish, amphipods and isopods.

Sites with a Poor rating in both 2011 and 2012. These sites were located in areas of dense residential and/or commercial development.

-Mill Race Branch. All metrics indicated Poor water Quality in Mill Race Branch in both 2011 and 2012, likely due to urban runoff. This catchment has poor riparian buffer zones with severe bank erosion. The stream substrate is largely sand and gravel (75%), with only 20% rubble. The abundance of hydropsychid caddisflies (especially in 2011) suggested the Mill Race Branch is usually a perennial stream. Abundant macroinvertebrate species indicated problems associated with both low dissolved oxygen (*Physa*) and toxics (*Cricotopus annulator group*, *Conchapelopia group*). Mill Race continues to experience significant instream erosion and sediment from damaged infrastructure and uncontrolled stormwater throughout the watershed. Illicit discharges of soapy washwater have been identified multiple times.

-Tanyard Branch. Like Mill Race Branch, Tanyard Branch had a very sparse fauna and appeared to have perennial flow. The majority of downtown Chapel Hill drains to this stream. The fauna at Tanyard Branch in 2012 suggested problems with both low dissolved oxygen concentrations (*Physa*) and toxics (2 species of *Cricotopus*). Total taxa richness was unusually low (11), in spite of suitable habitat. This site had a Poor rating in both 2011 and 2012.

-UT Tanyard Branch below Baldwin Park. This stream drains both residential and commercial areas, with most of the catchment in Carrboro. This site was not sampled during the regular tributary collections in the spring of 2011, but a special collection had been made in March 2009. The latter collection was to establish baseline conditions, prior to mitigation efforts near the park. Although both collections produced a Poor rating, total taxa richness increased from only 12 in 2009 to 21 in 2012; EPT taxa richness increased from 2 to 4 over the same period. The mayfly *Baetis flavistriga* was especially abundant in this stream segment. Although this small stream has good habitat after the mitigation project, conductivity remains very high (500+ µmohs/cm in 2012).

Higher Quality Slate Belt Streams

-Jolly Branch. Jolly Branch is located near the Carrboro/Chapel Hill boundary; it has been included in the reports to both towns. The lack of some expected species (for example all heptagenid mayflies and hydropsychid caddisflies) clearly indicated stream flow has been intermittent in recent years. The abundance of *Ironoquia* in 2011 also suggested intermittent flow. Abundant EPT species in both years included two stoneflies *(Perlesta, Amphinemura*) and one caddisfly (*Rhyacophila fenestra*), indicating no significant water quality problems. This site was tentatively given a Good-Fair rating in both 2011 and 2012.

-Library Branch. This very small stream had evidence of sediment inputs, having a substrate largely composed of sand and gravel. The fauna was sparse, but contained a few intolerant species. Although about 7 intolerants were recorded in Library Branch in 2012, the only common or abundant intolerant taxa were *Neophylax ornatus* (Common) and the snail *Elimia* (Abundant). It is possible that a few high quality seeps are still present further upstream in this developed catchment. This site also was tentatively given a Good-Fair rating in both 2011 and 2012, although water quality and habitat quality were significantly worse than at Jolly Branch.

-Cole Springs Branch. Cole Springs Branch was located in a largely forested area; this older residential area had large lot sizes and a wide forested buffer zone adjacent to the stream. Some upstream activity had added sand to the streambed in 2012, but this did not seem to affect the aquatic fauna. In spite of the change in substrate composition, total taxa richness (38) and EPT taxa richness (11) was actually higher in 2012 than in 2011. The biotic index was extremely low in both years (4.6-4.7) indicating dominance by highly intolerant species. In 2012, these taxa included *Haploperla brevis, Diplectrona modesta, Chimarra sp, Neophylax oligius, N. ornatus, Psephenus herricki*, and *Elimia sp.* This site was given a Good rating in both years.

-Unnamed Tributary to Bolin Creek at Severin St. This minute stream had barely visible flow; much of the flow may have been subsurface. However, it contained a good number of very intolerant species and was given an Excellent rating using small-stream criteria. EPT taxa richness was high (8) for such a tiny stream and the very low Biotic Index value (4.2) clearly indicated high water quality in 2012. The slightly high biotic index value from 2011 (5.1) had produced a Good rating for UT Bolin Creek, but this did not reflect a significant change in water quality. Like Cole Springs Branch, this site has a forested buffer zone and was located in an older residential area. Abundant intolerant species included *Paraleptophlebia, Amphinemura* and *Neophylax ornatus*. The lack of flow-dependent caddisflies suggested that this small stream is intermittent.

-Unnamed Tributary to Morgan Creek at Bayberry Drive. This is another very small rocky stream, only one meter wide. The fauna was very similar to that recorded for UT Bolin Creek, but with a greater diversity of intolerant stoneflies and caddisflies. This stream was assigned an Excellent rating.

Transitional Area Streams (Sandy)

-Wilson Creek and Fan Branch. These two streams appear to be affected by sedimentation, but the sand/gravel substrate may actually reflect local geology. Similar streams have been observed a little further south in the headwaters of Pokeberry Creek in Chatham County (Lenat, unpublished). The lower ends of both streams are located in a high-density residential area, but most of the catchment is comprised of heavily-forested older residential areas with large lot sizes. Wilson Creek and Fan Branch had the most diverse fauna in our survey of small Chapel Hill streams, reflecting land use, land management, larger stream size and the different geology. Single downstream sites were sampled on these two streams in 2011; an additional upstream site on Wilson Creek was added in 2012.

-Fan Branch, Parkview Drive. The stream channel for Fan Branch was entrenched and substrate composition was 95% sand and gravel. However, there was good bank and leaf pack habitat. The sampling site is within the "Southern Village" development, but there is a good buffer zone adjacent to the stream. Fan Branch was rated as Good in both 2011 and 2012 based on high EPT taxa richness (11-14) and a low biotic index (5.4-5.7). The abundance of the caddisfly *Ironoquia* and the scarcity of flow-dependent caddisflies in both years indicate that this stream has intermittent flow.

-Wilson Creek #1 (upstream at Wave Drive). This is a new site, upstream of the Southern Village development. Although it is intended as a control site, upper Wilson Creek is still a very sandy stream with gravel riffles. At the sampling site, there are many open areas adjacent to the stream. This site had the lowest Biotic Index value in the 2012 collections (4.0) and the highest EPT taxa richness (23), producing an Excellent rating. Many intolerant species had their maximum abundance at Wilson Cr #1, including *Baetis pluto, Ephemerella dorothea, Isonychia sp, Eccoptura xanthenes*, and *Pycnopsyche sp*. The community structure of this site suggests that upper Wilson Creek may be intermittent in some years.

-Wilson Creek #2 (downstream at Arlen Park Drive). Lower Wilson Creek was similar to Fan Branch, but the larger catchment may result in more permanent flow. Filamentous algae were very abundant, suggesting some enrichment. The rating was upgraded from Good-Fair in 2011 to Good in 2012, but this reflects only a very small change in the stream community. In comparison with upper Wilson Creek:

-There was a decline in the abundance of intolerant species,
-There was a decline in some small-stream species, and
-There was an increase in large-stream species.

A slight decline in water quality can be observed between the 2 sites on Wilson Creek, reflected by a decline in the most intolerant species and the addition of some very tolerant midges (*Cricotopus bicinctus, C. annulator group*).

-Battle Branch. Battle Branch had instream habitat similar to Wilson Creek and Fan Branch, but the fauna indicated much worse water quality. Conductivity was higher at this site (244 µmohs/cm) than at the Fan Br and Wilson Creek sites (<140 µmhos/cm).

Salamanders were vey abundant in the 2012 collections. Battle Branch showed a significant improvement from 2011 (Fair) to 2012 (Good-Fair). Higher flow rates are likely the cause of this change. The presence of some intolerant taxa (*Chimarra, Psephenus herricki*) supports a Good-Fair classification. Installation of a new greenway bridge close to the monitoring site, and a streambank stabilization project was completed between the 2011 and 2012 visits.*Triassic Basin Streams*

Triassic basin geology (clays) tends to produce very flashy streams that go dry during summer droughts. This undoubtedly contributes to low diversity at these two sites.

-Booker Creek 2 (Willow Drive). Booker Creek is a channelized stream in a heavily developed catchment. Abundant filamentous algae and silt covered most of the stream bottom. DWQ collected twice at a site near Willow Drive in 2001 (Walnut St) and obtained total taxa richness of 31-51, EPT taxa richness of 4-7, and a biotic index of 6.9-7.3. The 2011 and 2012 collections indicate a substantial long-term decline in water quality, with only 1-2 EPT species and an extremely high biotic index (8.1-8.2). A Poor rating is assigned to this portion of Booker Creek. The abundance of the midge *Chironomus* indicated some organic loading to lower Booker Creek. This site is downstream of an area of dense commercial development.

-Dry Creek. Upper Dry Creek is too small to receive a rating, and likely goes dry during drought periods. The stream bottom is clay with roots and leafpacks. Conductivity was very high at 320 µmhos/cm. Dry Creek was dominated by tolerant species (biotic index = 7.9) and had a fauna typical of swamp streams. The abundance of the caddisfly *Ironquia punctatissima* in 2011 suggested that this stream is frequently dry; the abundance of the snail *Physa* suggested that this stream has low dissolved oxygen concentrations.

SUMMARY

Although this is only the second survey of Chapel Hill streams by the town of Chapel Hill, it is possible to evaluate some long-term trends using data from both the North Carolina Division of Water Quality (DWQ) and the Town of Carrboro. Long-term (20-year) DWQ data indicated a major decline in water quality for lower Bolin Creek (Good-Fair → Poor), during a time when Chapel Hill was rapidly developing (1986-1993). The 2012 collections, however, assigned a Fair rating to the most downstream Bolin Creek site at East Franklin Street.

DWQ data also showed a long-term decline at a site further upstream (near the Carrboro/Chapel Hill boundary at Village Drive), especially between 1998 and 2001. This site is currently assigned a Fair rating following periods of extreme summer droughts (2011 and 2012), but might show some recovery in a year with a better flow regime.

Declining water quality has also been seen in lower Booker Creek (Fair → Poor) and Morgan Creek near the Botanical Gardens (Good-Fair → Fair). It is not clear how much summer low-flow conditions may have contributed to these changes.

Only lower Booker Creek had indications of organic-loading problems, but several tributary sites showed symptoms of low dissolved oxygen: Cedar Fork, Tanyard Branch, UT Tanyard Branch, Old Field Creek, Lower Booker Creek and Dry Creek.

Macroinvertebrate collections at Chapel Hill streams in 2012 produced a very wide range of bioclassifications, from Poor to Excellent:

Not Rated

-*Dry Creek*. This small stream is frequently dry, also in the Triassic Basin ecoregion

-*Little Creek.* This site is within the "Triassic" ecoregion, and DWQ has not yet derived criteria for stream in this area. The benthic macroinvertebrate community, however, suggests Fair-Poor water quality.

Poor and Fair-Poor

-*Pritchard Branch*. This small stream showed evidence of recent a recent pollution event, including sand deposition. Intolerant aquatic insect species were rare or absent.

-*Mill Race Branch.* Urban area with poor buffer zones and considerable instability upstream.

-*Tanyard Branch and UT Tanyard Branch.* Urban areas. Mitigation efforts on UT Tanyard Branch suggested some improvement in 2012, but not enough to change the rating to Fair. The macroinvertebrate community suggests some toxic problems and conductivity was very elevated at UT Tanyard Branch.

-*Booker Creek 2* (downstream). This stream drains a highly developed catchment. The fauna suggested organic loading and low dissolved oxygen.

Fair

-*Cedar Fork*. Residential area with poor buffer zones. This stream, however, improved from Poor in 2011 to Fair in 2012.

-*Old Field Creek.* Unknown problems; land fill is upstream. May go dry frequently? The bioclassification for this site was upgraded from Poor in 2011 to Fair in 2012.

-*Booker Creek 1* (upstream). Residential area. The bioclassification for this site was upgraded from Poor in 2011 to Fair in 2012. The fauna indicated intermittent flow for this portion of Booker Creek.

Good-Fair

-*Jolly Branch*. Intermittent, but with some intolerant species. Good buffer zone.

-*Library Branch*. Fauna sparse, but some intolerant species still present

-*Battle Branch*. Residential, but with good buffer zone.

Good

-*Cole Springs Branch*. Residential area with large lots and good buffer zone.

-*Fan Branch*. In highly developed area, but with good buffer zone and good upstream water quality.

-*Wilson Creek 2* (downstream). Also in heavily developed area, but with good buffer zone and good upstream water quality. One of the few permanent tributaries.

Excellent

-*UT Bolin Creek* at Severin Dr and *UT Morgan Creek* at Bayberry Dr. Minute streams, but with good habitat and a good buffer zone. Similar to UT Bolin Creek at Seawell Rd in Carrboro.

-*Wilson Creek 1* (upstream). The least developed stream.

Streams with Good-Fair, Good or Excellent ratings often were associated with older developments and forested buffer zones. It is encouraging to see that such areas of higher water quality can still be maintained within the city limits. Some of the smaller streams showed signs of intermittent flow, i.e. going dry in the summer months. Even in areas where the larger streams have poor water quality, it is useful to look for these pockets of higher ecological value. Urban planners must "think small" and conduct surveys in winter or spring months.

Urban runoff caused Fair conditions in Bolin Creek at Village Drive and Battle Branch. A Poor (or Fair-Poor) was given to Bolin Creek at Franklin Street, Old Field Creek, Booker Creek (2 sites), Mill Race Branch, and Tanyard Branch. The NC Division of water Quality uses Fair ratings to indicate streams that are partially supporting designated uses, while a Poor rating is used to indicate streams that do not support designated uses.

Table 2. Taxa richness and summary parameters, Bolin Creek, Morgan Creek and Little Creek, Chapel Hill, North Carolina, 2011-2012.

	March 2011					June 2012				
Site:	B4	B5	MM1*	MM2	Little	B4	B5	MM1*	MM2	Little
Ephemeroptera	4	1	9	7	-	3	3	7	6	2
Plecoptera	1	-	6	-	-	1	-	2	-	-
Trichoptera	3	3	3	5	3	4	2	2	3	2
Coleoptera	2	-		6	1	5	3		3	1
Odonata	2	6		3	1	3	5		2	-
Megaloptera	-	-		1	-	1	-		-	-
Diptera; Misc.	8	6		5	3	2	2		4	3
Diptera: Chironomidae	22	20		23	14	19	12		13	11
Oligochaeta	8	6		3	2	2	2		1	1
Crustacea	4	2		3	3	3	1		3	1
Mollusca	4	4		5	4	5	-		3	1
Other	1	2		2	-	3	-		1	2
Total Taxa Richness	59	50		63	31	51	30		39	24
EPT Taxa Richness	8	4	21*	12	3	8	5	13*	9	4
EPT Abundance	21	26	67	74	5	48	34	44	67	24
EPT Score	1.6	1	3	2	1	1.6	1	2	1.6	1
NC Biotic Index	6.7	7.0	-	6.7	7.3	6.8	6.5		6.3	6.7
BI Score	2	2	-	2	2	2	2.4		3	2
Site Score	1.8	1.5	3-4?	2	1.5	1.8	1.7		2.3	1.5
Rating	Fair	Poor	Good?	Fair	Not Rated (Poor or Fair?)	Fair	Fair	G-F?	Fair	Not Rated (Poor or Fair?)

*EPT sample only, EPT taxa richness count corrected to predicted 10-sample value

Table 3A. Taxa richness and summary parameters, Slate Belt streams, Chapel Hill, North Carolina, April 2012.

Site:	PF	MR	Tan	UTTan	OF	Cedar	Bk1	Libr	Cole	Jolly	UTSev	UTBay
Width (m):	1.5	2	2	1	2.5	3	2	1	2	1	<1	1
Ephemeroptera	1	1	1	1	1	2	-	1	3	1	2	2
Plecoptera	-	-	-	-	2	2	-	1	2	2	2	4
Trichoptera	2	2	2	3	1	3	3	5	6	3	4	8
Coleoptera	1	1	-	1	1	-	1	4	2	2	1	1
Odonata	1	2	-	1	1	2	-	2	1	2	-	-
Diptera; Misc.	1	-	-	1	1	2	1	1	2	2	1	2
Diptera: Chironomidae	9	10	5	9	11	8	11	8	14	7	4	9
Oligochaeta	1	1	2	4	3	3	4	3	5	1	4	1
Crustacea	1	2	-	-	3	3	3	2	2	3	3	2
Mollusca	2	1	1	1	3	2	1	1	1	1	-	-
Other	-	-	-	-	-	-	1	-	-	-	-	-
Abundance of indicators												
Low DO (Physa)			+	+	+	+						
Toxics (Certain midges)			+	+								
Total Taxa Richness	19	20	11	21	27	27	25	28	38	24	21	29
EPT Taxa Richness	3	3	3	4	4	7	3	7	11	6	8	14
EPT Score	1	1	1	1	1	1.6	1	1.6	2	1.4	2	2.6
NC Biotic index	6.0	7.9	7.7	7.8	6.5	6.5	6.4	4.7	4.7	6.1	4.2	4.6
BI Score (Normal Streams)	3	1	1	1	2.4	2.4	3	5	5	3	5	5
Bi Rating (Small Streams)	G-F	Poor	Poor	Poor	Fair	Fair	Fair	Good	Good	Fair	Ex	Good
Flow												
(Perennial or Intermittent)	?	Per	Per	Per	Int	Int	Int	P/I	Per	Int	Int	P/I
Combined Site Score	2	1	1	1	1.7	2	2	3.3	3.5	2.2	3.5	3.8
Overall Rating	**F-P**	**Poor**	**Poor**	**Poor**	**Fair**	**Fair**	**Fair**	**G-F**	**Good**	**G-F**	**Ex**	**Ex**
2011 Data												
Total Taxa Richness	-	18	7	12	22	20	20	24	29	33	21	-
EPT Taxa Richness	-	3	2	2	1	2	2	6	8	8	9	-
Biotic index	-	7.7	7.2	7.5	7.6	7.3	7.5	5.6	4.6	6.2	5.1	-
Overall Rating	**-**	**Poor**	**Poor**	**Poor**	**Poor**	**F-P**	**Poor**	**G-F**	**Good**	**G-F**	**Good**	**-**
Change	-	0	0	+?	+	+	+	0	0	0	0	-

*Flow: Per = Perennial, Int = intermittent (Based on faunal composition)
**Rating: Ex = Excellent, G-F = Good-Fair, F = Fair, P = Poor. Small stream criteria may not work for Intermittent streams. Fair and Poor ratings are used to designate streams that do not support designated uses.

Site abbreviations: PF = Prichard Branch, Cedar = Cedar Fork, OF = Old Field Creek, Bk1 = Booker Cr #1, MR = Mill Race Branch, Tan = Tanyard Branch, UTTan = UT Tanyard Branch, Cole = Cole's Spring Branch, Jolly = Jolly Branch, Libr = Library Branch, UTSev = UT Bolin Creek at Severin St, UTBay = UT Morgan Cr at Baybery Dr.

Table 3B. Taxa richness and summary parameters, Triassic and "Transition" streams, Chapel Hill, North Carolina, April 2012.

Site:	Batt	Fan	Wil1	Wil2	Dry	Bk2
Width (m):	2	2	2	3	1	4.5
Ephemeroptera	1	3	8	11	1	1
Plecoptera	1	3	7	4	1	-
Trichoptera	4	5	8	4	1	1
Coleoptera	3	1	2	3	1	-
Odonata	-	2	1	-	-	1
Diptera; Misc.	2	1	3	3	-	1
Diptera: Chironomidae	15	14	9	15	8	11
Oligochaeta	4	3	3	4	3	5
Crustacea	2	3	3	2	2	2
Mollusca	1	2	1	1	1	6
Abundance of indicators						
Low DO (Physa)						
Toxics (Certain midges)						
Total Taxa Richness	33	37	45	47	18	28
EPT Taxa Richness	6	11	23	19	3	2
EPT Score	1.4	2	3.4	3	1	1
NC Biotic index	6.0	5.7	4.0	5.3	6.5	8.1
BI Score (Normal Streams)	3	4	5	4	2.4	1
Bi Rating (Small Streams)	G-F	G-F	Ex	Good	Fair	Poor
Flow						
(Perennial or Intermittent)	P/I	Int	P/I	Per	I	I
Combined Site Score	2.2	3	4.2	3.5	1.7	1
Overall Rating	**G-F**	**Good**	**Ex**	**Good**	**NR**	**Poor**
2011 Data						
Total Taxa Richness	17	35	-	45	18	31
EPT Taxa Richness	4	14	-	17	2	1
Biotic index	6.7	5.4	-	6.0	7.9	8.2
Overall Rating	**Fair**	**Good**	**-**	**G-F**	**NR**	**Poor**
Change	+	0	-	+?	+	0

*Flow: Per = Perennial, Int = intermittent (Based on faunal composition)
**Rating: Ex = Excellent, G-F = Good-Fair, Small stream criteria may not work for Intermittent streams. Fair and Poor ratings are used to designate streams that do not support designated uses.

Site abbreviations: Batt = Battle Branch, Wil = Wilson Creek (#1 and #2), Fan = Fan Branch, Bk2 = Booker Creek #2, Dry = Dry Creek

Table 4A. Selected intolerant species at larger Chapel Hill streams: Bolin Creek (B4, B5), Morgan Mill Creek (MM1, MM2) and Little Creek, March 2011 and June 2012. Taxa must be Common or Abundant at one or more sites. Note that "Spring" species (see below) have emerged prior to June collections.

	March 2011					June 2012				
Site:	B4	B5	MMI	MM2	Little	B4	B5	MMI	MM2	Little
Leucrocuta aphrodite	-	-	C	-	-	-	-	A	-	-
Isonychia spp	-	-	-	A	-	-	-	R	C	-
Aconeuria abnormis	-	-	-	-	-	R	-	C	-	-
Perlesta sp	-	-	-	-	-	-	-	C	-	-
Chimarra sp	R	A	-	A	-	C	A	-	C	-
Paraleptophlebia sp	-	-	C	-	-	-	-	R	-	-
Psephenus herricki	A	-		C	-	C	-	C	C	-
Elimia sp	C	-		-	-	-	-	-	-	-
Spring only										
Ameletus lineatus	-	-	C	-	-					
Isoperla namata gr	-	-	A	-	-					
Clioperla clio	-	-	A	-	-					
Rhyacophila fenestra	-	-	C	-	-					
Sum*	14	10	29	23	0	7	10	21	9	0

*Using Rare = 1, Common = 3, and Abundant = 10.

Table 4B. Selected intolerant species at smaller Chapel Hill streams, March 2011 and April 2012. Taxa must be Common or Abundant at one or more sites. Site abbreviations: PF = Prichard Branch, Cedar = Cedar Fork, OF = Old Field Creek, Bk1 = Booker Cr #1, MR = Mill Race Branch, Tan = Tanyard Branch, UTTan = UT Tanyard Branch, Cole = Cole's Spring Branch, Jolly = Jolly Branch, Libr = Library Branch, UTSev = UT Bolin Creek at Severin St, UTBay = UT Morgan Cr at Bayberry Dr.

March 2011

Site[1]:	CFk	OF	Bk1	MR	Tan	Cole	Jolly	Libr	UTSev	Batt	Wils2	Fan	Bk2	Dry
Ameletus lineatus	-	-	-	-	-	-	C	R	C	-	C	-	-	-
Paraleptophlebia sp -	-	-	-	-	-	-	-	C	-	R	-	-	-	
Haploperla brevis	-	-	-	-	-	A	-	R	-	-	R	C	-	-
Isoperla namata gr	-	-	-	-	-	-	-	-	-	-	C	C	-	-
Amphinemura sp	-	-	-	-	-	-	A	R	A	-	A	A	R	-
Chimarra sp	-	-	C	-	-	-	-	-	-	C	R	R	-	-
Diplectrona modesta -	-	-	R	-	R	-	R	R	-	C	R	-	-	
Rhyacophila fenestra-	-	-		-	-	A	-	R	-	-	A	-	-	
Neophylax oligius	-	-	-	-	-	A	-	-	-	-	-	-	-	-
Neophylax ornatus	-	-	-	-	-	-	R	-	A	-	-	-	-	-
Psephenus herricki	-	-	-	-	R	C	-	-	R	R	C	-	-	-
Elimia sp	-	-	-	-	-	A	-	A	-	-	-	A	-	-
Sum*	**0**	**0**	**3**	**1**	**1**	**34**	**24**	**14**	**28**	**4**	**22**	**38**	**1**	**0**

April 2012

	Repeat sites														New sites			
Site[1]:	CFk	OF	Bk1	MR	Tan	Cole	Jolly	Libr	UTSev	Batt	Wils2	Fan	Bk2	Dry	Prit	UTTan	Wils1	UTBA
Ameletus lineatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-
Baetis pluto	-	-	-	-	-	-	-	-	-	-	A	-	-	-	-	-	A	-
Paraleptophlebia sp-	-	-	-	-	-	-	-	A	-	R	-	-	-	-	-	R	A	
Ephemerella dorothea	-	-	-	-	-	-	-	-	-	-	R	C	-	-	-	-	A	-
Isonychia sp	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	A	-
Haploperla brevis	-	-	-	-	-	A	-	-	-	R	C	C	-	-	-	-	A	C
Eccoptura xanthenes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	R
Perlesta sp	-	-	-	-	-	-	A	-	C	-	A	A	-	-	-	-	A	A
Amphinemura sp	-	R	-	-	-	R	A	R	A	-	R	A	-	R	-	R	C	C
Chimarra sp	-	-	R	-	-	A	-	R	-	C	-	-	-	-	-	R	-	R
Rhyacophila fenestra	-	-	-	-	-	-	A	-	R	-	R	-	-	-	-	-	-	C
Rhyacophila glaberrima	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-
Neophylax oligius	-	-	-	-	-	A	-	-	-	-	A	-	-	-	-	-	A	-
Neophylax ornatus	-	-	-	-	-	C	R	C	A	-	-	-	-	-	R	-	R	R
Pycnopsyche sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-
Lepidostoma sp	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-	-	R	R
Psephenus herricki -	-	-	-	-	A	-	-	-	A	R	-	-	-	-	-	C	R	
Elimia sp	-	-	-	-	-	A	-	A	-	-	-	C	-	-	A	-	-	-
Sum*	**0**	**1**	**1**	**0**	**0**	**54**	**31**	**15**	**37**	**14**	**41**	**32**	**0**	**1**	**11**	**2**	**83**	**34**

*Using Rare = 1, Common = 3, and Abundant = 10.

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Appendix 1. Benthic macroinvertebrates collected from Bolin Creek (B4, B5), Morgan Creek (MM1, MM2) and Little Creek, Chapel Hill, March 2011 and June 2012. R=Rare, C=Common, A=Abundant. Upstream Morgan Creek collections (M1: NC 54) limited to most intolerant (EPT) groups. Blue highlights indicate most intolerant species; red highlights indicate most tolerant species. Yellow highlights show selected between-year changes. Species found only in the spring (and therefore missing from the 2012 samples) are grouped together at the end of each section.

	March 2011					June 2012				
	B4	B5	MM1	MM2	Little	B4	B5	MM1	MM2	Little
EPHEMEROPTERA										
Baetis flavistriga (summer)	-	-	-	-	-	A	A	-	A	A
Baetis intercalaris (summer)	-	-	-	-	-	-	R	R	A	C
Maccaffertium modestum	-	C	R	A	-	A	C	A	A	-
Stenonema femoratum	-	-	C	-	-	-	-	C	-	-
Stenacron interpunctatum	C	-	-	A	-	C	-	-	A	-
Leucrocuta aphrodite	-	-	C	-	-	-	-	A	-	-
Acentrella nadineae	-	-	-	-	-	-	-	-	R	-
Centroptilum triangulifer	A	-	-	R	-	-	-	R	-	-
Caenis spp	-	-	C	A	-	-	-	-	-	-
Isonychia spp	-	-	-	A	-	-	-	R	C	-
Paraleptophlebia sp	-	-	C	-	-	-	-	R	-	-
Plauditus dubius gr*	-	-	A	R	-	-	-	-	-	-
Acentrella ampla*	-	-	A	-	-	-	-	-	-	-
Siphlonurus sp*	R	-	R	-	-	-	-	-	-	-
Eurylophella spp*	R	-	R	-	-	-	-	-	-	-
Ameletus lineatus*	-	-	C	-	-	-	-	-	-	-
PLECOPTERA										
Acroneuria abnormis	-	-	-	-	-	R	-	C	-	-
Perlesta sp	-	-	-	-	-	-	-	C	-	-
Isoperla namata gr*	-	-	A	-	-	-	-	-	-	-
I. burkesi*	-	-	R	-	-	-	-	-	-	-
Clioperla clio*	-	-	A	-	-	-	-	-	-	-
Amphinemura sp*	R	-	-	-	-	-	-	-	-	-
Leuctra sp*	-	-	R	-	-	-	-	-	-	-
TRICHOPTERA										
Cheumatopsyche spp	C	A	-	A	R	A	A	A	A	A
Hydropsyche betteni	R	C	-	A	C	A	-	-	A	R
Chimarra sp	R	A	-	A	-	C	A	-	C	-
Polycentropus sp	-	-	-	R	-	-	-	R	-	-
Neophylax oligius	-	-	R	-	-	-	-	-	-	-
Oecetis sp A	-	-	-	-	-	R	-	-	-	-
Triaenodes ignitus	-	-	-	R	-	-	-	-	-	-
Ironoquia punctatissima*	-	-	C	-	R	-	-	-	-	-
Rhyacophila fenestra*	-	-	C	-	-	-	-	-	-	-

	March 2011				June 2012			
	B4	B5	MM2	Little	B4	B5	MM2	Little
COLEOPTERA								
Ancyronyx variegata	-	-	R	-	-	-	-	-
Macronychus glabratus	-	-	-	R	-	R	-	-
Dubiraphia sp	-	-	R	-	R	-	-	-
Stenelmis crenata	R	-	C	-	A	C	C	-
Psephenus herricki	A	-	C	-	C	-	C	-
Helichus spp	-	-	R	-	R	R	-	R
Neoporus mellitus gr	-	-	R	-	-	-	R	-
Peltodytes sp	-	-	-	-	R	-	-	-
ODONATA								
Argia spp	-	R	-	-	-	C	A	-
Calopteryx sp	-	C	R	R	-	-	-	-
Enallagma spp	R	C	A	-	-	R	-	-
Gomphus sp	-	R	R	-	-	-	-	-
Progomphus obscurus	-	A	-	-	-	R	R	-
Stylogomphus albistylus	-	-	-	-	-	R	-	-
Libellula sp	-	-	-	-	R	-	-	-
Pachydiplax longipennis	R	-	-	-	R	-	-	-
Somatochlora sp	-	R	-	-	R	R	-	-
MEGALOPTERA								
Sialis sp	-	-	R	-	R	-	-	-
DIPTERA: MISC.								
Antocha spp	R	-	R	-	-	-	R	-
Pseudolimnophila sp	-	-	-	-	-	-	-	R
Tipula spp	R	C	C	C	C	C	C	C
Palpomyia complex	R	-	R	-	-	-	-	-
Anopheles sp	-	-	-	-	-	-	R	-
Simulium spp	A	C	A	R	A	A	A	A
Cnephia mutate*	C	-	-	-				
Prosimulium spp*	C	-	A	-	-	-	-	
DIPTERA: CHIRONOMIDA								
Ablabesmyia janta/parajanta	-	-	C	-	R	-	-	-
Ablabesmyia mallochi	A	A	A	A	C	R	R	C
Clinotanypus pinguis	-	-	R	-	-	-	-	-
Conchapelopia group	C	R	R	R	R	R	C	A
Natarsia spp	-	-	-	-	R	C	-	C
Nilotanypus sp	-	-	-	-	-	R	-	-
Procladius sp	R	-	C	R	C	-	-	-
Cardiocladius sp	-	C	-	-	-	-	-	-
Corynoneura spp	R	R	R	-	-	-	-	-
Thienemaniella spp	-	-	C	R	R	-	R	-
Cricotopus bicinctus	A	-	A	A	C	-	R	-
Cricotopus triannulatus gr	-	-	-	-	R	-	-	-
Diplocladius cultriger*	R	R	R	-	-	-	-	-
Eukiefferiella claripennis gr	R	R	R	-	R	-	-	-
Hydrobaenus sp*	-	C	C	-	-	-	-	-
Nanocladius spp	C	R	-	-	-	-	-	-
Orthocladius spp								
O. obumbratus	A	A	A	-	-	-	-	-
O. dorenus	A	A	A	-	-	-	-	-
O. oliveri*	-	-	A	-	-	-	-	-
O. (Eud.) dubitatus	-	R	R	-	-	R	-	-
Parametriocnemus lundbecki	R	-	-	-	-	R	-	-
Paraphaenocladius sp	-	R	-	-	-	-	-	-
Rheocricotopus robacki	-	-	R	-	-	-	-	R

	March 2011				June 2012			
	B4	B5	MM2	Little	B4	B5	MM2	Little
Synorthocladius sp	-	-	-	-	R	-	-	-
Tvetenia bavarica gr	C	-	-	-	-	-	-	-
Diamesa sp*	C	-	-	-	-	-	-	-
Potthastia longimanus	R	R	C	C	-	-	-	-
Chironomus sp	C	-	-	-	-	-	-	-
Cryptochironomus spp	-	C	C	-	-	R	R	R
Cryptotendipes sp	-	-	-	-	-	-	R	-
Dicrotendipes spp	R	-	-	R	R	-	C	-
Microtendipes spp	C	R	-	-	-	-	-	-
Paratendipes sp	R	-	R	-	-	R	-	-
Phaenopsectra spp	-	R	R	-	R	C	-	R
Phaenopsectra flavipes gr	C	-	-	C	R	-	-	-
Polypedilum flavum (= convictum)	C	R	A	A	A	A	A	A
Polypedilum illinoense gr	-	A	A	A	-	-	R	-
Polypedilum scalaenum gr	-	-	-	R	C	-	R	R
Polypedilum halterale gr	-	-	-	-	-	C	-	-
Stenochironomus sp	-	-	-	R	R	-	-	R
Tribelos sp	-	R	-	-	C	-	R	-
Rheotanytarsus spp	-	-	R	-	-	-	R	A
Paratanytarsus sp	-	-	-	-	R	-	-	-
Tanytarsus spp	A	R	-	R	C	R	C	C
OLIGOCHAETA								
Limnodrilus spp	C	C	-	R	C	A	-	-
Ilyodrilus templetoni	R	-	-	-	-	-	-	-
Spirosperma nikolsyii	R	-	-	-	-	-	-	-
Nais spp	-	R	R	-	-	-	-	-
Dero sp	C	-	-	-	-	-	-	-
Stylaria lacustris	R	R	C	-	-	-	-	-
Slavinia appendiculata	-	R	-	-	-	-	-	-
Haplotaxis gordioides	-	-	-	R	-	-	-	-
Ecclipidrilus spp	R	-	-	-	-	-	-	-
Lumbriculus variegatus	C	R	-	-	-	-	-	-
Megadriles	C	R	-	-	C	C	R	C
CRUSTACEA								
Crangonyx spp	C	-	C	R	R	-	R	-
Hyallela azteca	A	-	-	-	A	-	R	-
Caecidotea sp	R	R	C	-	C	-	R	-
Cambarus spp	C	C	A	C	-	A	-	C
Procambarus acutus	-	-	-	R	-	-	-	-
MOLLUSCA								
Elimia sp	C	-	-	-	-	-	-	-
Campeloma decisum	R	-	-	R	R	-	-	-
Physella sp	A	C	C	R	A	-	C	-
Stagnicola sp?	-	-	-	-	R	-	-	-
Helisoma anceps	C	R	R	-	C	-	C	-
Menetus dilatatus	-	-	C	-	-	-	-	-
Laevapex fuscus	-	-	R	-	-	-	-	-
Pisidium spp	-	R	R	R	R	-	-	-
Sphaerium sp	-	-	-	-	-	-	-	R
Corbicula fluminea	-	R	-	-	A	-	A	-

	March 2011				June 2012			
	B4	B5	MM2	Little	B4	B5	MM2	Little
OTHER								
Turbellaria								
Dugesia tigrina	R	-	C	-	R	-	R	-
Hemiptera: Corixidae	-	-	-	-	R	-	-	-
Hirudinea								
Helobdella triserialis	-	-	-	-	R	-	-	-
Helobdella papillefera	-	-	-	-	-	-	-	R
Neuroptera: Climacia	-	-	-	-	-	-	-	R

Appendix 2. Benthic macroinvertebrates collected at small streams in Chapel Hill, April 2012.
R = Rare, C = Commonn, A = Abundant. Site abbreviations: Prit = Prichard Branch, Cedar = Cedar Fork, OF = Old Field Creek, Bk1 = Booker Cr #1, MR = Mill Race Branch, Tan = Tanyard Branch, UTTan = UT Tanyard Branch, CSpr = Cole's Spring Branch, Libr = Library Branch.

Site[1]:	Prit	MR	Tan	UTTan	OF	Cedar	Bk1	Libr	CSpr
Width (m):	1.5	2	2	1	4.5	3.5	2	1	2
EPHEMEROPTERA									
Plauditus dubius gr	-	-	-	-	C	R	-	-	R
Baetis flavistriga	R	C	A	A	-	A	-	-	C
Eurylophella verisimilis	-	-	-	-	-	-	-	R	-
Maccaffertium modestum	-	-	-	-	-	-	-	-	R
PLECOPTERA									
Perlesta sp	-	-	-	-	C	R	-	-	-
Haploperla brevis	-	-	-	-	-	-	-	-	A
Leuctra sp	-	-	-	-	-	R	-	-	-
Amphinemura sp	-	-	-	-	R	-	-	R	R
TRICHOPTERA									
Cheumatopsyche spp	-	R	A	A	-	C	A	R	C
Hydropsyche betteni	-	R	C	R	-	-	-	-	R
Diplectrona modesta	R	-	-	-	-	-	-	R	C
Chimarra sp	-	-	-	R	-	-	R	R	A
Rhyacophila fenestra	-	-	-	-	-	C	-	-	-
Neophylax oligius	-	-	-	-	-	-	-	-	A
Neophylax ornatus	R	-	-	-	-	-	-	C	C
Ironoquia punctatissima	-	-	-	-	C	A	C	R	-
COLEOPTERA									
Stenelmis crenata	R	-	-	-	-	-	-	R	-
Psephenus herricki	-	-	-	-	-	-	-	-	A
Anchytarsus bicolor	-	-	-	-	-	-	-	C	-
Helichus spp	-	R	-	-	C	-	C	C	-
Neoporus spp	-	-	-	-	-	-	-	C	R
Hydroporus sp	-	-	-	R	-	-	-	-	-
ODONATA									
Argia spp	-	A	-	C	-	R	-	-	-
Calopteryx sp	R	R	-	-	-	-	-	-	-
Cordulegaster sp	-	-	-	-	-	-	-	R	-
Stylogomphus albistylus	-	-	-	-	-	-	-	R	R
Somatochlora sp	-	-	-	-	R	R	-	-	-
DIPTERA: MISC.									
Tipula sp	-	-	-	R	-	R	-	C	C
Simulium spp	A	-	-	-	A	A	C	-	A
DIPTERA: CHIRONOMIDAE									
Conchapelopia group	A	A	-	R	-	-	A	-	A
Zavrelimyia sp	C	-	-	R	-	-	-	-	R
Tanypus sp	-	-	-	-	R	-	-	-	-
Corynoneura spp	-	-	R	R	-	R	R	R	-
Thienemaniella sp	-	-	-	-	-	-	-	-	R
Cricotopus bicinctus	R	C	C	-	C	R	C	R	R
Cricotopus fugax	-	-	-	R	-	-	-	-	-
Cricotopus triannulatus gr	-	-	A	A	-	-	-	-	-
Cricotopus annulator gr	R	A	A	A	-	-	-	C	R
Eukiefferiella claripennis gr	A	A	A	C	R	A	R	C	A
Tvetenia bavarica gr	-	-	-	-	-	-	R	C	C
Nanocladius sp	-	-	-	-	-	-	-	-	R

Site[1]:	Prit	MR	Tan	UTTan	OF	Cedar	Bk1	Libr	CSpr
Width (m):									
Orthocladius spp									
O. obumbratus	-	-	-	-	C	-	C	R	-
O. dorenus	C	-	-	-	-	-	-	-	-
O. robacki	-	-	-	-	C	-	-	-	-
O. (Euorthocladius) sp	-	-	-	-	-	R	-	-	-
Parametriocnemus lundbecki	C	-	-	-	C	C	A	A	A
Psectrocladius sp	-	-	-	R	-	-	-	-	-
Potthastia longimanus	-	R	-	-	R	-	-	-	R
Chironomus spp	-	R	-	-	R	R	-	-	R
Microtendipes spp	-	-	-	-	-	-	R	-	-
Paracladopelma sp	-	-	-	-	R	-	-	-	-
Paratendipes sp	-	-	-	-	-	-	-	R	R
Phaenopsectra spp	-	R	-	-	-	-	-	-	-
Phaenopsectra flavipes gr									
Polypedilum flavum	-	-	-	-	-	R	-	-	C
Polypedilum aviceps	R	-	-	-	-	-	A	-	R
Polypedilum halterale	-	R	-	-	-	-	-	-	-
Polypedilum illinoense	C	-	-	R	-	-	-	-	-
Polypedilum scalaenum	-	-	-	-	R	-	R	-	-
Tribelos sp	-	R	-	-	-	-	-	-	-
Paratanytarsus spp	-	C	-	-	-	-	C	-	-
Tanytarsus spp	-	-	-	-	R	R	-	-	-
OLIGOCHAETA									
Limnodrilus spp	-	C	-	C	R	-	-	-	-
Ilyodrilus templetoni	-	-	-	-	R	-	R	-	-
Nais spp	C	A	-	C	-	-	C	-	C
Slavina appendiculata	-	C	-	C	-	-	-	-	-
Ecclipidrilus spp	-	-	-	-	-	R	-	-	-
Lumbriculus variegata	-	-	-	-	-	C	A	C	C
Enchytraeidae	-	C	R	R	-	-	-	-	-
CRUSTACEA									
Crangonyx spp	-	R	-	-	R	A	C	R	R
Caecidotea forbesi	-	-	-	-	C	C	A	-	-
Cambarus sp	R	C	-	-	A	C	A	C	A
MOLLUSCA									
Elimia sp	A	-	-	-	-	-	-	A	A
Physella sp	R	R	A	A	A	A	C	-	-
Heliso anceps	-	-	-	-	-	C	-	-	-
Fossaria sp	-	-	-	-	R	-	-	-	-
Pisidium spp	-	-	-	-	C	-	-	-	-
OTHER									
Cura foremanii	-	-	-	-	-	-	R	-	-

[1]Site abbreviations: Prit = Prtchard Branch, Cedar = Cedar Fork, OF = Old Field Creek, Bk1 = Booker Cr #1, MR = Mill Race Branch, Tan = Tanyard Branch, UTTan = Unnamed Tanyard Branch, CSpr = Cole's Spring Branch, Libr = Library Branch.

Appendix 2B. Benthic macroinvertebrates collected at small stream in Chapel Hill, March 2012. Streams are grouped by geologic region, then by size within each region. R = Rare, C = Commonn, A = Abundant. Site abbreviations: Jolly = Jolly Branch, UTSev = UT Bolin Creek at Severin St, UTBa = UT Morgan Cr at Baybery Dr, Batt = Battle Branch, Wil = Wilson Creek (#1 and #2), Fan = Fan Branch, Bk2 = Booker Creek #2, Dry = Dry Creek

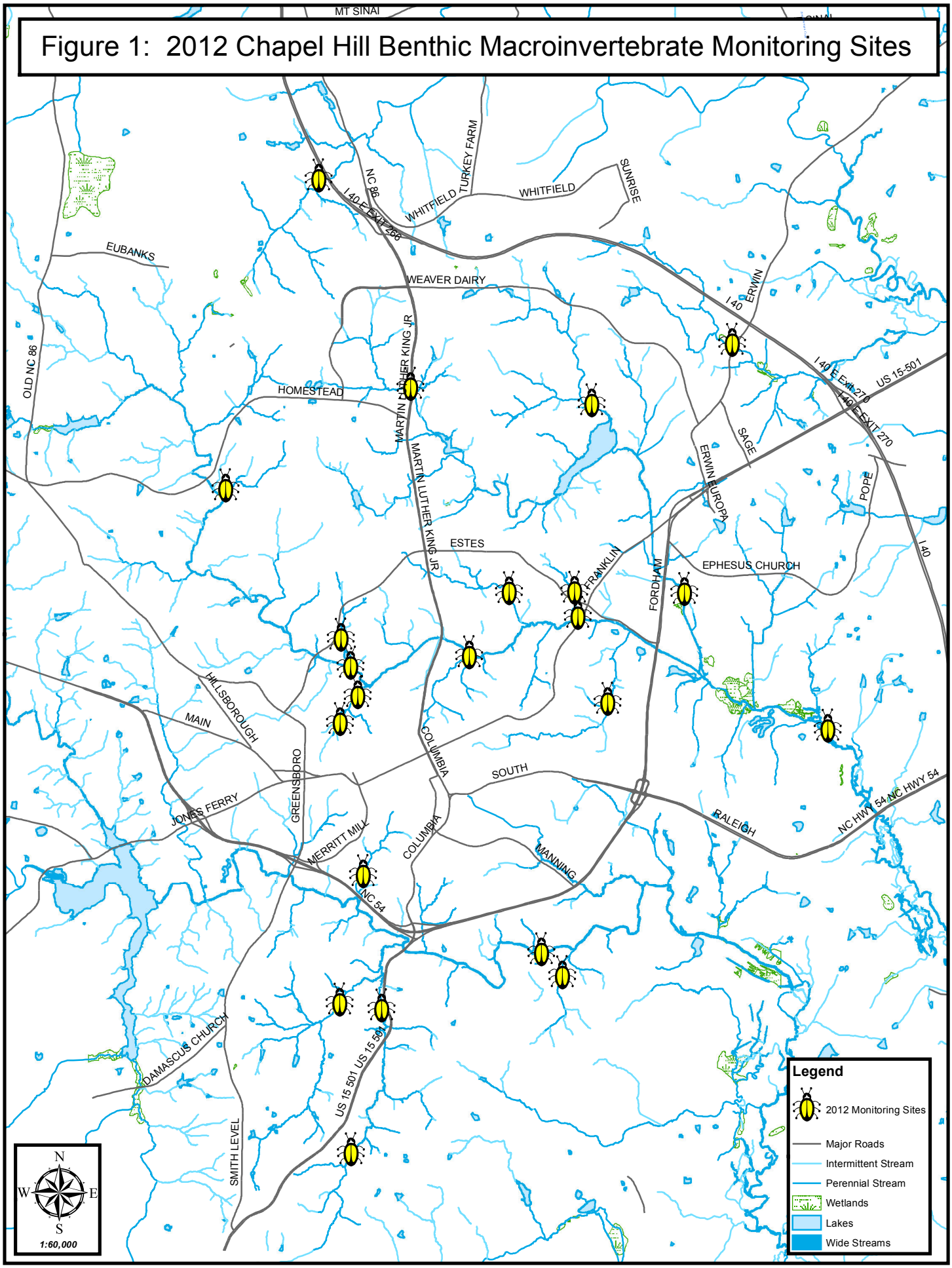
Site[1]:	Jolly	UTSev	UTBa	Batt	Fan	Wils1	Wils2	Dry	Bk2
Width (m):	1	0.5	1	2	2	2	3	1	4.5
EPHEMEROPTERA									
Plauditus dubius gr	C	R	-	-	-	A	A	A	-
Plauditus puntiventris gr	-	-	-	-	-	-	R	-	-
Plauditus cestus	-	-	-	-	-	-	R	-	-
Baetis flavistriga	-	-	-	A	-	-	-	-	-
Baetis pluto	-	-	-	-	-	A	C	-	-
Heterocloeon amplum	-	-	-	-	-	-	R	-	-
Procloeon sp	-	-	-	-	-	R	R	-	-
Caenis spp	-	-	-	-	-	-	R	-	R
Ephemerella dorothea	-	-	-	-	C	A	R	-	-
Eurylophella verisimilis	-	-	R	-	R	-	-	-	-
Danella simplex	-	-	-	-	-	R	-	-	-
Ameletus lineatus	-	-	-	-	-	R	-	-	-
Isonychia sp	-	-	-	-	-	A	C	-	-
Paraleptophlebia sp	-	A	A	-	-	R	R	-	-
Maccaffertium modestum	-	-	-	-	C	-	R	-	-
PLECOPTERA									
Perlesta sp	A	C	A	-	A	A	A	-	-
Haploperla brevis	-	-	C	R	C	A	C	-	-
Eccoptura xanthenes	-	-	R	-	-	C	-	-	-
Isoperla namata gr	-	-	-	-	-	R	-	-	-
Diploperla duplicate	-	-	-	-	-	R	-	-	-
Amphinemura sp	A	A	C	-	A	C	R	R	-
Leuctra sp	-	-	-	-	-	R	R	-	-
TRICHOPTERA									
Cheumatopsyche spp	-	-	R	R	R	C	C	-	C
Hydropsyche betteni	-	-	R	R	R	R	R	-	-
Diplectrona modesta	-	-	R	-	R	R	-	-	-
Chimarra sp	-	-	R	C	-	-	-	-	-
Rhyacophila fenestra	A	R	C	-	-	-	R	-	-
Rhyacophila glaberrima	-	C	-	-	-	-	-	-	-
Neophylax oligius	-	-	-	-	-	A	A	-	-
Neophylax ornatus	R	A	R	-	-	R	-	-	-
Ironoquia punctatissima	R	C	R	R	A	C	-	R	-
Pycnopsyche sp	-	-	-	-	-	A	-	-	-
Lepidostoma sp	-	-	R	-	C	R	-	-	-
COLEOPTERA									
Stenelmis crenata	C	-	-	C	R	-	C	-	-
Psephenus herricki	-	-	R	A	-	C	R	-	-
Helichus spp	-	R	-	-	-	C	R	C	-
Neoporus spp	R	-	-	C	-	-	-	-	-
ODONATA									
Calopteryx sp	-	-	-	-	R	-	-	-	-
Cordulegaster sp	-	-	-	-	-	R	-	-	-
Progomphus obscurus	-	-	-	-	R	-	-	-	-
Stylogomphus albistylus	R	-	-	-	-	-	-	-	-
Somatochlora sp	C	-	-	-	-	-	-	-	C

Site[1]:	Jolly	UTSev	UTBa	Batt	Fan	Wils1	Wils2	Dry	Bk2
DIPTERA: MISC.									
Antocha spp	C	-	-	-	-	-	-	-	-
Tipula sp	C	C	R	C	-	C	R	-	R
Pseudolimnophila sp	-	-	R	-	-	-	-	-	-
Palpomyia complex	-	-	-	-	-	R	R	-	-
Simulium spp	-	-	-	A	C	A	A	-	-
DIPTERA: CHIRONOMIDAE									
Ablabesmyia mallochi	-	-	-	-	-	C	-	-	C
Conchapelopia group	A	-	R	A	A	R	R	-	A
Procladius sp	-	-	-	-	-	-	R	-	R
Zavrelimyia sp	C	-	R	-	-	C	-	-	-
Corynoneura spp	R	R	-	R	-	R	-	-	R
Thienemaniella spp	-	R	-	R	R	-	R	-	-
Brillia sp	-	-	-	-	R	-	-	-	-
Cricotopus bicinctus	-	R	C	C	C	-	A	-	-
Cricotopus triannulatus gr	-	-	-	-	R	-	-	-	-
Cricotopus annulator gr	-	C	-	R	R	R	A	-	-
Diplocladius cultriger	-	-	-	C	-	-	-	-	-
Eukiefferiella claripennis gr	R	-	-	A	-	-	C	C	-
Tvetenia bavarica gr	-	-	C	C	-	C	-	-	-
Hydrobaenus sp	-	-	-	-	-	-	-	R	-
Limnophyes sp	-	-	-	R	R	-	-	-	-
Orthocladius spp									
O. obumbratus	-	-	-	-	-	-	R	R	-
O. robacki	-	-	R	-	-	-	C	-	-
Parakiefferiella sp	-	-	-	-	-	-	R	R	-
Parametriocnemus lundbecki	-	-	-	-	-	-	-	-	R
Rheocricotopus robacki	-	-	-	R	R	-	R	-	-
Potthastia longimana	R	-	R	C	C	R	-	-	-
Cryptochironomus spp	-	-	-	-	-	-	R	R	R
Chironomus spp	C	-	-	-	R	-	R	-	A
Microtendipes spp	-	-	C	-	R	-	-	-	-
Paracladopelma sp	-	-	-	-	R	-	-	-	-
Paratendipes sp	-	-	R	-	-	-	-	-	-
Phaenopsectra spp	-	-	-	-	-	-	-	-	R
Phaenopsectra flavipes gr	-	-	-	-	-	-	R	-	-
Polypedilum aviceps	-	-	R	A	R	-	-	-	-
Polypedilum illinoense	-	-	-	R	-	-	C	R	A
Polypedilum scalaenum	-	-	-	-	-	-	-	-	C
Paratanytarsus sp	-	-	-	-	-	-	-	R	-
Rheotanytarsus spp	-	-	-	R	-	R	C	-	R
Tanytarsus spp	C	-	-	R	R	R	-	C	-
OLIGOCHAETA									
Limnodrilus spp	-	-	-	R	R	-	R	-	C
Ilyodrilus templetoni	-	R	-	-	-	-	-	-	-
Spirosperma nikolsyii	-	-	-	-	-	-	-	R	-
Nais spp	C	-	R	R	-	C	R	A	R
Dero sp	-	-	-	-	-	-	-	-	C
Slavina appendiculata	-	-	-	R	R	-	-	-	-
Stylaria lacustris	-	-	-	-	-	-	-	-	A
Ecclipidrilus spp	-	-	-	R	-	A	C	-	-
Lumbriculus variegata	-	-	R	-	C	C	C	R	R

Site[1]:	Jolly	UTSev	UTBa	Batt	Fan	Wils1	Wils2	Dry	Bk2
CRUSTACEA									
Crangonyx spp	A	A	A	-	C	C	-	C	-
Caecidotea forbesi	C	A	-	R	C	C	R	C	R
Cambarus sp	C	R	C	C	C	R	C	-	-
Procambarus acutus	-	-	-	-	-	-	-	-	R
MOLLUSCA									
Elimia sp	-	-	-	-	C	-	-	-	-
Physella sp	C	-	-	R	C	C	-	A	A
Pseudosuccinea columella	-	-	-	-	-	-	-	-	R
Menetus dilatatus	-	-	-	-	-	-	R	-	C
Ferrissia sp	-	-	-	-	-	-	-	-	R
Sphaerium spp	-	-	-	-	-	-	-	-	A
Corbicula fluminea	-	-	-	-	-	-	-	-	A

[1]Site abbreviations: Jolly = Jolly Branch, UTSev = Unnamed tributary Bolin Creek at Severin, UTBat = UT Morgan Cr at Bayberry, Batt = Battle Branch, Wils = Wilson Creek (2 sites), Fan = Fan Branch, Bk2 = Booker Creek #2, Dry = Dry Creek.

Figure 1: 2012 Chapel Hill Benthic Macroinvertebrate Monitoring Sites



Appendix 3. Chapel Hill Large Stream Sites, June 2012

Bolin Creek sites are numbered from most upstream (Site 1) to most downstream (Site 5). Sites 1-3 are in Carrboro and are not included in this report. Site 4 was moved from Estes Drive (at the town boundary) to Village Drive in Chapel Hill. Bolin Creek sites are largely in the Slate Belt geologic region and are expected to have a very rocky stream bottom. Little Creek, however, is in the Triassic Basin and would be expected to have a sand/clay stream bottom. The lower Bolin Creek site may have characteristics of both ecoregions.

Bolin Creek 4. Site 4 was moved slightly downstream into Chapel Hill (Village Dr) in 2011, so that data from this site could be used by both towns.

Bolin Creek Site 4, June 2012.

This portion of Bolin Creek is similar to the site on Estes Drive, having good rocky substrate. Attached filamentous algae was very abundant at the Village Drive site in March 2011, but was not a problem in 2012

Bolin Creek 5 (Franklin St). Bolin Creek has good rocky substrate near the bridge, but the stream bottom is mostly sand further upstream. A greenway path parallels Bolin Creek in this area.

Bolin Creek Site 5 (Franklin) , June 2012.

This site drains a heavily developed catchment, including the downtown areas of both Carrboro and Chapel Hill.

Morgan Creek 1 (NC 54). Morgan Creek has been used as a reference site for Carrboro surveys, although this stream is frequently affected by droughts. Prior surveys by the NC Division of Water Quality generally produced a Good or Excellent bioclassification for this site.

Morgan Cr Site 1 (NC 54), June 2012.

This catchment has a largely rural character. Habitat quality, stream width and substrate composition are similar to Bolin Creek.

Morgan Creek 2 (Ashe St). This site is located near the Arboretum and it is downstream of University Lake. Although this part of Morgan Creek is located in a residential area, there is a forested buffer zone along most of the stream.

There was good rocky substrate in the riffles, but pools areas were being filled-in by sand deposition.

Morgan Creek Site 2 (Ashe), June 2012

Little Creek. Samples were taken near Meadowmont lane, following the greenway trail 200 meters upstream. Little Creek is located in the Triassic geological region, and runs through an area of sand and clay. The surrounding area is very swampy, with many small seeps running through the floodplain. This floodplain appeared to be excellent habitat for birds and other wildlife.

Little Creek, June 2012.

There were no rocky riffles, but snags and leaf-packs offered good habitat for macroinvertebrates.

Appendix 4. Chapel Hill Small Stream Sites, April 2012

These streams are grouped into 3 categories, according to local geology. Slate Belt streams are expected to have a very rocky substrate and are located in the western part of Chapel Hill. Triassic Basin streams naturally have a stream bottom of sand and clay and are located in the eastern part of Chapel Hill. Some "Transition" stream share characters of both geologic zones, although the substrate is largely sand and gravel. Within each of these three groups, streams have been sorted by size (as measured by stream width). Slate Belt streams usually have a boulder-rubble substrate, although the more developed areas have sandy pools and/or embedded riffles. Triassic sites are largely sand and clay, with a very swampy floodplain. The Transitional sites are very sandy, with gravel/rubble riffles.

These sites generally had less filamentous algal growths, relative to 2011 collections. This change may be related to higher or more constant flow in the winter and spring of 2012.

SLATE BELT STREAMS

Pritchard Branch. Pritchard Branch is a tributary of Morgan Creek in the southwest portion of Chapel Hill. There is no prior data from this stream. Although this is a naturally rocky stream, there have been recent inputs of sand. The substrate is embedded and rocks are embedded. Most rocks are very "clean" looking, although there was abundant filamentous algae in some areas.

Pritchard Branch, April 2012.

The stream appears both entrenched and widened by erosion. The extremely sparse invertebrate fauna indicated a very severe water quality problem in this catchment. Conductivity values were moderately elevated (259 µmhos/cm) at the time of the invertebrate collections.

Mill Race Branch. Mill Race Branch is located in a largely residential area; it was sampled off Bolinwood Drive just above its confluence with Bolin Creek. The substrate was largely gravel and sand, but with small rocky riffles areas.

Mill Race Branch, April 2012.

There was little periphyton growth on rocks, and the fauna was very sparse. Conductivity values were moderately elevated (240 µmhos/cm) at the time of the invertebrate collections.

Tanyard Branch. Tanyard Branch is a small stream (2 meters wide) that was sampled near the end of Carver Street.

Tanyard Branch, April 2012.

There is a forested riparian zone, but the stream runs through a heavily developed residential area. The stream substrate was rocky, but 40-80% embedded with sand. Conductivity values were highly elevated (352 µmhos/cm) at the time of the invertebrate collections.

Unnamed Tributary to Tanyard Branch below Baldwin Park. This unnamed tributary of Tanyard Branch is near the Carrboro/Chapel Hill border. It drains an urban section of Carrboro and a highly developed residential area. The headwater area (above our sample site) had been recently restored to improve habitat, reduce erosion and limit direct inputs of urban runoff.


Tanyard Branch, April 2012.

Conductivity values were highly elevated (510 µmhos/cm) at the time of the invertebrate collections.

Old Field Creek. Old Field Creek was sampled north of town, near the Chapel Hill Operations Center. The surrounding area is largely forested, but there is some development (including a landfill) further upstream. Conductivity values were moderately elevated (289 µmhos/cm) at the time of the invertebrate collections.

The stream is very rocky (often having extensive areas of bedrock), but there was a layer of silt and algae over most of the stream bottom. The composition of the fauna suggested that this stream is intermittent.


Old Field Creek, April 2012.

Cedar Fork. Cedar Fork is located in the northern section of Chapel Hill; it is one of the largest tributaries of Booker Creek (3 meters wide). The stream was sampled off Brookview Street, just above Eastwood Lake.


Cedar Fork, April 2012.

The surrounding land is an older residential area with large lots. Many of the houses, however, are placed very close to the stream. The substrate was rocky, but had abundant growths of filamentous algae.

Booker Creek 1 (Above MLK Blvd). This segment of Booker Creek is in the Slate Belt. The surrounding area provided a forested buffer next to the stream, but it drains a largely residential area. Booker Creek had higher flows in 2012, relative to collections in 2011. This resulted in less filamentous algae.

Crayfish were the dominant invertebrate in this portion of Booker Creek. The overall

community composition indicated that this stream has intermittent flow.

Booker Creek Site 1 (MLK) April 2012.

Library Branch. Library Branch was sampled downstream of Library Road. This very small stream (1 meter wide) had poor habitat due to the largely sand substrate. The abundance of the snail (*Elimia*), however, suggests that this stream does not dry up during drought periods.

Library Branch, April 2012.

Library Branch appears to be intermediate between the Slate Belt and Triassic classifications, with more clay than a normal Slate Belt stream. Construction of an expansion to the Library, just upstream from the sample site, has been underway since the previous visit in 2011.

Cole Springs Branch. Cole Springs Branch was sampled near the end of Cedar Drive. This stream drains an older residential area with large lots and has a good buffer zone; the area sampled was largely forest. This rocky stream had excellent habitat for aquatic fauna. In 2011, the stream was mostly boulder and rubble with little sand and gravel. In 2012, however, there had been inputs of sand with sand deposition in areas of lower gradient.

Cole Springs Branch, April 2012. Note sediment deposition at upper part of photo.

Jolly Branch near SR 1777 (just downstream of Bolin Creek 3). This site was accessed by walking about 100 meters downstream of SR 1777 (Homestead), crossing Bolin Creek, and going about 30 meters upstream on Jolly Branch. This small stream (1 meter wide) had good rocky habitat, but showed severe bank erosion in many places.

The surrounding area was largely forested, although there are residential areas further upstream. The aquatic life at Jolly Branch indicates that it may stop flowing (or go dry) during drought periods.

Jolly Branch, April 2012.

Unnamed Tributary to Bolin Creek at Severin St. This very small stream (<1 meter wide) was sampled at the end of Severin Street. It is located in an older residential area with a forested buffer zone adjacent to the stream. The substrate was primarily boulder/rubble, with barely perceptible flow that may be largely subsurface. The fauna was limited, but dominated by intolerant species.

UT Bolin Creek at Severin, April 2012.

UT Morgan Creek at Bayberry Drive. This very small stream was similar in size and habitat to the Severin UT, but in a less developed catchment, draining to Morgan Creek

UT Morgan Creek at Bayberry, April 2012.

TRANSITION STREAMS

Battle Branch. Battle Branch was sampled near Glendale Road where the stream transitions from Slate Belt to Triassic Basin. This stream is located in an older residential area, with forest and hiking paths next to the stream. The substrate is largely sand and gravel, with occasional rubble riffles. Battle Branch was entrenched with severely eroding banks.

Battle Branch, April 2012.

Fan Branch. Fan Branch was sampled in a newer high-density residential development (at Parkview Crescent), but the upstream area is comprised of an older residential development with large lot sizes. There was a good buffer zone around the stream.

The stream channel is entrenched, but it has good bank habitat. This is a very sandy stream (90% sand and gravel), although it supports a surprisingly diverse invertebrate community. Fan Branch appears to be a perennial stream based on the presence of filter-feeding caddsiflies.

Fan Branch, April 2012.

Wilson Creek 1 (Upstream at Wave Rd)). This site was added to help evaluate the effects of development between the two

Wilson Creek sites. This is a sandy stream (gravel riffles), but it has a less developed catchment relative to other Chapel Hill streams in this area. The compostion of the fauna suggests that this stream may have intermittent flow in some years.

Wilson Creek 1 (upstream), April 2012.

Wilson Creek 2 (Downstream). Wilson Creek was sampled at Arlen Park Drive, in a new residential area. The upstream area, however, is an older residential area (mostly forest) with large lot sizes.

Wilson Creek 2 (downstream), April 2012.

Although this small stream was very sandy (95 % gravel, sand and silt), it supported a surprisingly diverse invertebrate community. Filamentous algae were very abundant at Wilson Creek. This part of Wilson Creek may have more permanent flow than Wilson Creek #1.

TRIASSIC STREAMS

Dry Creek. This very small stream (1 meter wide) was sampled upstream of Erwin Road. The substrate was mostly clay/silt, likely due to the Triassic Basin geology. Roots and logs were the most important habitat for the aquatic fauna.

Dry Creek, April 2012.

The stream was entrenched near the road, but was more swamp-like further upstream. This stream probably goes dry during summer months. Debris piles along the banks suggested that this stream goes over its banks after heavy rain events.

Booker Creek 2 (Willow Drive). This segment of Booker Creek flows through a largely residential catchment, but is directly downstream of a dense commercial zone. The stream appears to have been channelized at some time, with a very entrenched channel. The substrate is entirely sand and clay, but was mostly covered by a layer of filamentous algae.

This site had the lowest dissolved oxygen of the 2102 samples: 4.7 mg/l.

Booker Creek 2, April 2012.