BIOLOGICAL MONITORING OF CHAPEL HILL STREAMS, NORTH CAROLINA

April – July 2018

Bolin Creek at Village Drive, July 2018

Prepared for the Town of Chapel Hill by:

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ATTENTION: PLEASE READ THIS SECTION FIRST

This report provides information on the present status of water quality in Chapel Hill's streams and evaluates any temporal changes in water quality.

This is the third annual report by Eaton Scientific (2016-2018), following five annual reports by Lenat Consulting (2011-2015), on water quality and habitat quality of streams in Chapel Hill, North Carolina. This report includes biological monitoring data on Bolin Creek, Booker Creek, Morgan Creek, Old Field Creek, and their tributaries. This report, as well as reports from previous years, can be obtained from the Town of Chapel Hill's Biological Monitoring webpage. A companion report has also been prepared for the Town of Carrboro that provides additional information on Bolin Creek and Morgan Creek; see the Town of Carrboro's Benthic Monitoring webpage for more information.

This study uses information about freshwater macroinvertebrates – "bugs" to the non-biologist. Invertebrates are animals without a backbone; "macro" means they are large enough to see with the naked eye. They constitute a large proportion of the aquatic life in streams and serve as indicators of the health of the entire stream community. Furthermore, they are indicators of how well the stream supports fishing, swimming and other uses by Chapel Hill's citizens. The use of the macroinvertebrate community to assess stream water quality is supported by decades of scientific research. With increasing levels of pollution, we expect to see both fewer species and a shift in community structure to more tolerant groups.

The information provided in the Introduction, Methods and review of Prior Biological Data sections is largely repeated from earlier reports. Additional biological data from sites collected in previous years are found in earlier reports, but are also summarized in this report. Flow Data has been updated to include data into 2018.

Sites are described (with photos) in Appendices 4-5. An evaluation of each site is provided in the Results and Discussion section, and a summary of site ratings is provided in the Summary and Conclusions section.

Tables 35-37 (pages 42-47) provide the quickest summary of this study. To understand the summary tables, the reader must understand the terms "Taxa Richness" (especially "EPT Taxa Richness"), "NC Biotic Index" and "Bioclassifications" (see Introduction and Methods). Streams are rated as Excellent, Good, Good-Fair, Fair, or Poor using information on the macroinvertebrate community.

The long lists of scientific names (in the appendices) are intended for specialists; they provide support for the scientific validity of conclusions about water quality. The reader will often find some species names used in the discussion, especially concerning *tolerant* or *intolerant* species.

Individuals who have read prior reports may wish to skip to the Results and Discussion and Summary and Conclusions sections.

NOTE: In 2017, the NC Division of Water Resources (NCDWR) clarified that the incorrect Biotic Index criteria had been used in previous Town monitoring reports for the Fair/Good-Fair cut off for Qual 4 samples; as a result, some previous ratings have been updated in this report, and the ratings reported here are considered the most current for all past years. Previous reports also included ratings for some sites that were not strictly based on NCDWR (2016), and past ratings for those sites have been corrected as well. Sites affected by these changes are Old Field Creek, Battle Branch, Wilson 1, Wilson 2, and Pritchard Branch.

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INTRODUCTION

Water quality in Chapel Hill was evaluated in April and July of 2018 by sampling benthic macroinvertebrates at 28 sites, including the three long-term sites on Bolin and Morgan Creeks in July. Twenty-two tributary sites were sampled in April, most of which had been sampled in previous years. Three additional large stream sites were collected in July on the Bolin Creek and Morgan Creek mainstems. A long-term site collected on Morgan Creek (at NC54) in Carrboro is also included in this report for comparison.

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 for many months, 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. **"EPT Taxa Richness" is a count of the taxa in the most intolerant groups. Higher EPT taxa richness is associated with good water quality; low EPT taxa richness is associated with poor water quality.**

Little Creek Catchment

The following overview of the Little Creek catchment is modified from a report by the 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. Based on 2011 land cover data, approximately 52 percent of the Little Creek catchment is developed (urban), and this percentage has likely increased since that time. 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 (SR1777) and Old NC 86 (SR1109), 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. Previous reports include information from some of the smaller tributaries not sampled in 2018.

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 relatively undeveloped area and drains progressively more urban and developed areas in Carrboro and Chapel Hill as it flows toward 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 Place (formerly University Mall).

In 2018, ten samples were collected in the Bolin Creek watershed. These sites include three sites on the mainstem: above Village Drive, above Bolinwood Drive, and above Franklin Street; plus seven more sites on tributaries: Jolly Branch, an unnamed tributary (UT) at Severin Drive, Tanyard Branch (near Carver Street), Mill Race Branch, Library Branch, Cole Springs Branch, and Battle Branch.

Booker Creek

The headwaters of Booker Creek rise southwest of the intersection of 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 (surface area of 47 acres, built in 1937). Unlike Bolin Creek, which drains progressively more developed areas as it flows downstream, most of the Booker Creek watershed is heavily developed.

In 2018, Booker Creek and its tributaries were sampled at eight locations. The mainstem of Booker Creek was sampled in five locations: above MLK Jr. Boulevard (below Aquatics Center Drive), above Piney Mountain Road, above Tadley Greenway, below Tadley Greenway, and below Willow Drive. Cedar Fork, a major tributary of Booker Creek, was sampled at three sites: below Kenmore Drive, at Brookview Drive, and a UT to Cedar Fork was sampled south of Brookview Drive. Crow Branch could not be sampled in 2017 due to low flow conditions, so was also not sampled in 2018.

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, a drinking water supply owned by OWASA, with a surface area of about 200 acres. 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, have streambeds largely comprised of sand and gravel. These

streams are similar to headwater tributaries of Pokeberry Creek in Chatham County (Lenat, unpublished data). Wilson Creek originates in Chatham County and flows north to Morgan Creek.

In 2018, ten sites were sampled in the Morgan Creek catchment, including nine sites in Chapel Hill and one in Carrboro. The largest tributary to Morgan Creek, Wilson Creek, was sampled in four locations: above Wave Road, behind Solar Strata (within the approved Obey Creek Development), above Arlen Park Drive in Southern Village, and a UT with a mostly undeveloped watershed (within the Obey Creek Development). Pritchard Branch was sampled at Chase Park Apartments, and Fan Branch was sampled above Parkview Crescent Drive in Southern Village. The mainstem of Morgan Creek was sampled at a long-term site located at Ashe Place, and also two new mainstem sites, one located below Smith Level Road and the other near the Morgan Creek Greenway Trail off NC 54. Additionally, a sample was collected from Morgan Creek much further upstream, at NC 54 in Carrboro, in April 2018, and data are included in this report for comparison.

Upper New Hope Creek Catchment

Many small streams on the eastern side of Chapel Hill flow to New Hope Creek, which flows into the Upper New Hope Arm of Jordan Lake. Those include Old Field Creek in the Eubanks Road vicinity, Dry Creek, partially located behind East Chapel Hill High School, and the stream leading from Clark Lake off Pope Road on the Durham County border. A portion of New Hope Creek's watershed is in Durham.

Old Field Creek, a tributary to New Hope Creek, was sampled near its headwaters in 2018. It has been sampled annually since 2011 (except in 2016). Access was via the Chapel Hill Transit property.

METHODS

All collection methods are derived from techniques used by the NC Division of Water Resources (Lenat 1988; NCDWR 2016). These methods have been in use by North Carolina since 1982, and have been thoroughly tested for accuracy and repeatability. More details can be found on the NCDWR Biological Assessment Branch website at: https://deq.nc.gov/about/divisions/water-resources/water-resources-data/water-sciences-home-page/biological-assessment-branch.

Three of NCDWR's collection methods have been used for monitoring water quality in the Chapel Hill/Carrboro watersheds. These methods are intensive "Standard Qualitative" collections, and more rapid "EPT" and "Qual-4" collections. These three methods are briefly described below.

Overview of Sample Methods

Standard Qualitative Method

(Large stream sites)

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 70-95% ethanol.

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

(Morgan Creek NC 54)

The EPT method is a more rapid collection technique, limited to four samples: one kick, one bank sweep, one 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 and, like the standard qualitative method, only used in larger streams.

Qual-4 Method

(Smaller stream sites)

The Qual-4 method uses the same four samples as the EPT method, but all benthic macroinvertebrates are collected. NCDWR 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.

Assigning Bioclassifications

The ultimate result of a benthos sample is a bioclassification. Bioclassifications used by NCDWR 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), as species richness is the most direct measure of biological diversity. The term EPTS means the number of EPT taxa collected at a site. 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 fewer EPT taxa. **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.

Biotic Index Criteria

To supplement EPT taxa richness criteria, the North Carolina Biotic Index (NCBI, or BI) 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 NCDWR 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 BI values 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 Table 1 below).

Table 1. Thresholds for determining NC Biotic Index (BI) and EPT Taxa Richness scores using Full Scale (Standard Qualitative) Method Criteria for Piedmont Streams (NC Division of Water Resources 2016).

Score	NC Biotic Index (BI) Values	EPT Taxa Richness 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 (BI) value and EPT taxa richness value in assigning bioclassifications, so the bioclassification score is calculated by adding the BI value and the EPT value and dividing by two. 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 $\pm$1 (except coastal plain), and boundary biotic index values $\pm$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, and a drainage area less than or equal to 3.0 square miles) are expected to have lower EPT taxa richness relative to larger streams. NCDWR has developed criteria for small piedmont stream based solely on biotic index values:

Table 2. NC Biotic Index (BI) thresholds for determining bioclassifications using Small Stream Criteria (NCDWR 2016).

Bioclass Rating	BI Values
Excellent	<4.31
Good	4.31-5.18
Good-Fair	5.19-5.85

Bioclass Rating	BI Values
Fair	5.86-6.91
Poor	>6.91

Small Stream Criteria were developed only for perennial streams – streams that typically have water all year. Many small streams in Chapel Hill are intermittent and thus they cannot be rated.

NOTE: In 2017, NCDWR clarified that the incorrect Biotic Index criteria had been used in previous Town monitoring reports for the Fair/Good-Fair cut off for Qual 4 samples; as a result, some previous ratings have been updated in this report, and the ratings reported here are considered the most current for all past years. Previous reports also included ratings for some sites that were not based strictly on NCDWR 2016, and past ratings for those sites have been corrected as well. Sites affected by these changes are Old Field Creek, Battle Branch, Wilson 1, Wilson 2, and Pritchard Branch.

Toxicity Assessment Using Chironomidae Deformities

When there are large numbers of the chironomid, *Chironomus*, the degree of in-stream toxicity can be evaluated by tabulating deformities of its mouthparts. This situation has been documented only in lower Booker Creek. The technique was developed (Lenat 1993) to help separate out the effects of low dissolved oxygen from any toxic effects when both types of stress might be occurring at the same site. The presence of *Chironomus* is associated with organic loading and low dissolved oxygen, but high numbers of mentum deformities are observed only when there is also some degree of toxicity. A "toxic score" is calculated using both the percentage and severity of the deformities. The following Toxic Score criteria are derived from Lenat (1993):

Non-Toxic: <20 Toxic Fair: 20-70 Toxic Poor: >70

FLOW DATA

The fauna of Chapel Hill streams have been frequently affected by droughts, with some perennial 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 below is taken from the USGS website for the gage Morgan Creek at NC54 near White Cross using daily flow data from 1999 to 2017.

Table 3 shows mean monthly flow data in cubic feet per second (cfs). Low flows (less than 0.5 cfs) are highlighted in yellow; severe low flows (less than 0.1 cfs) are highlighted in red. Summer flows for 2014 were much higher than for 2004-2013; 2013-2015 fall/winter/spring flows were relatively high. Low flows have not been an issue in 2016 and 2017. Monthly mean data is not available past November 2017, but the following graph shows daily flows for December 1, 2017 to September 1, 2018 (Figure 1). This combined data suggests adequate winter and spring flows in 2017-2018 in the Carrboro/Chapel Hill area.

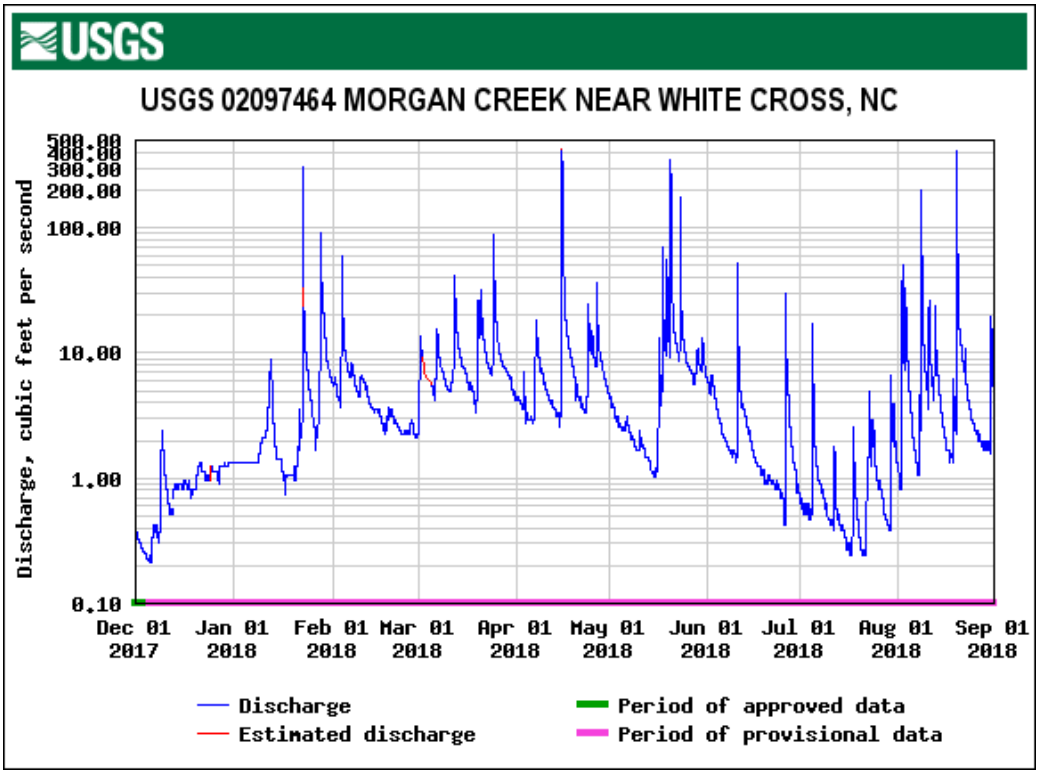
Table 3. Mean Monthly Flow (cfs) in Upper Morgan Creek (similar to Bolin Creek), 1999-2017. Yellow highlighting indicates low flows (<0.5cfs), and red highlighting indicates severely low flows (<0.1cfs).

Mean Monthly Flow (cfs) at USGS Streamgage at Morgan Creek near White Cross (drainage area 8.3 square miles)												
	MONTH											
YEAR	1	2	3	4	5	6	7	8	9	10	11	12
1999	13	4	5	10	0.9	0.5	0.4	0.09	40	8	7	4
2002	7	4	4	2	0.7	0.03	0.04	0.01	0.04	6	4	15

Mean Monthly Flow (cfs) at USGS Streamgage at Morgan Creek near White Cross (drainage area 8.3 square miles)												
	MONTH											
YEAR	1	2	3	4	5	6	7	8	9	10	11	12
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	0.0002	0.000	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	0.03	1.5	3
2012	2	3	7	3	2	0.5	0.2	0.3	8	0.8	0.5	0.8
2013	7	9	4	6	9	8	13	4	0.7	2*	1*	8*
2014	15	13	21	15	12	0.8	0.3	1.1	0.3	0.6	1.6	4.8
2015	6.7	7.1	14.5	13.5	2.7	1.2	1	0.09	1.2	10	12	44
2016	10	18	14	6.9	6.9	6.3	9	17	2.8	16	1.8	1.5
2017	6.9	3.8	4.4	22	8.3	7.1	1.5	0.6	1.2	0.2	0.7	**

**Data may not be complete for these months so the average is not as comparable to other months*
***Data not yet available for Dec 2017*

Figure 1. Daily discharge (cfs) at USGS streamgage on Morgan Creek near White Cross, December 1, 2017 to September 1, 2018.



SAMPLING SITES

Water quality in Chapel Hill was evaluated in April and July of 2018 by sampling benthic macroinvertebrates at six large stream sites, including the three long-term sites on Bolin and Morgan Creeks, and 22 small stream sites. Most of these sites had been sampled in previous years. Three additional large stream sites were collected for the first time in 2018 on the Bolin Creek and Morgan Creek mainstems, and one new small stream site was added to compare with a similar site upstream (see new sites in bold, in Tables 4 & 5 below). Small stream sites were collected in April, and large stream sites were collected in July.

Data collected from a long-term site on Morgan Creek (at NC54) in Carrboro is also included in this report for comparison.

Table 4. Chapel Hill Monitoring Sites on Large Streams, July 2018.

Large Stream Sites (Standard Qualitative Method)	
SITE ID	**SITE NAME**
2	Morgan Creek at Ashe Place ("Morgan Creek 2")
3	Bolin Creek above Franklin Street ("Bolin Creek 5")
10	Bolin Creek above Village Drive ("Bolin Creek 4")
37	**Bolin Creek above Bolinwood Drive ("Bolin Creek 4A")**
38	**Morgan Creek below Smith Level Road ("Morgan Creek 1a")**
39	**Morgan Creek below US15-501 ("Morgan Creek 1b")**

Table 5. Chapel Hill Monitoring Sites on Small Streams, April 2018.

Small Stream Sites (Qual 4 Method)	
SITE ID	**SITE NAME**
1	Wilson Creek above Arlen Park Drive ("Wilson 2")
4	Booker Creek at Willow Drive ("Booker Creek 2")
5	Booker Creek at Martin Luther King, Jr. Blvd. ("Booker Creek 1")
6	Cedar Fork at Brookview Drive ("Cedar Fork 1")
7	Old Field Creek at Town Operations Center
9	Fan Branch below Parkview Drive
11	Jolly Branch below Chapel Hill HS ("Jolly Branch near SR 1777")
12	UT to Bolin Creek near Severin Street
13	Tanyard Branch near Carver Street
14	Mill Race Branch at Bolinwood Drive
15	Cole Springs Branch near Cedar Street
16	Library Creek at Library Drive (School House Branch)
17	Battle Branch near Weaver Road Greenway
19	Pritchard Branch at Chase Park Apts on Fordham Blvd.
22	Wilson Creek above Wave Road ("Wilson 1")
24	UT to Cedar Fork S of Brookview ("UT Cedar Fork 1")
25	Cedar Fork at Kenmore Road ("Cedar Fork 2")
29	Booker Creek above Piney Mountain Road
30	Booker Creek above Tadley Greenway Bridge

Small Stream Sites (Qual 4 Method)	
SITE ID	**SITE NAME**
35	Wilson Creek at Obey Creek Development ("Wilson 1a")
36	UT to Wilson Creek at Obey Creek Development
40	**Booker Creek below Tadley Greenway Bridge**

Evaluations of each sampling site are summarized below (see Site Evaluations), and more detailed site descriptions (with photos) are presented in Appendix 4 and Appendix 5. See Appendix 3 for a map that shows the locations of the sites sampled in 2018.

Table 6 (below) provides data on habitat ratings and substrate composition at all sites sampled in 2017. The habitat rating is based on standard NC Division of Water Resources 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, but such growths were not widespread in later collections. With the exception of the Triassic sites, most Chapel Hill streams had adequate habitat to support a diverse benthic macroinvertebrate community.

Table 6. Site characteristics of Chapel Hill, North Carolina streams, April and July 2018.

STREAM/SITE	HABITAT COMPONENT SCORING (Total 0-100)*									Width (m)	SUBSTRATE (%)					COMMENTS
	CM	IH	BS	PV	RH	BSV	LP	RVZW	Total		B	R	Gr	Sa	Si	
Small Streams																
Booker Creek Sites																
Booker Cr 1, above MLK Jr. Blvd	5	12	12	6	12	3/5	10	4/5	**74**	3	30	10	20	30	10	Downstream from Homestead Park and suburban residential. Good habitat.
Booker Cr, above Piney Mtn Rd	5	11	10	10	14	3/7	10	4/5	**79**	4	30	30	10	20	10	Good habitat. Below Lake Ellen.
Booker Cr, above Tadley Grnwy	4	7	3	6	0	0/5	10	5/5	**45**	5	0	0	10	70	20	Triassic Basin. Sand/gravel. Below Eastwood Lake.
Booker Cr, below Tadley Grnwy	5	13	15	8	12	3/6	10	1/5	**78**	8	50	20	0	20	10	Downstream from the usual Booker Cr site (above Tadley Grnwy), but with rip rap riffle and good flow.
Booker Cr 2, below Willow Dr	3	7	3	10	0	0/7	10	5/3	**48**	5	0	0	0	80	20	Triassic Basin. Sand/gravel, entrenched and widened. Overbank sand deposition starting to restore a more natural channel. Dense commercial development just upstream.
Cedar Fk 1, below Brookview	5	11	12	6	10	3/7	10	4/4	**72**	4	70	20	10	0	0	Houses close to stream in older neighborhood. Lots of bedrock.
UT Cedar Fk 1, S of Brookview Dr	4	15	12	6	12	3/5	7	5/2	**71**	1	40	40	10	10	0	Small stream, but good fauna – four stonefly taxa and crayfish and salamanders Common in 2018.
Cedar Fk 2, below Kenmore Rd	4	11	12	4	14	3/7	10	5/5	**75**	2	50	30	10	10	0	Good habitat, but poor fauna.
Bolin Creek Sites																
Jolly Branch	5	11	12	8	14	0/5	10	5/5	**75**	1	30	10	30	30	0	Some bank erosion, but largely forested. Good habitat but low flow.
UT Bolin at Severin Dr	3	7	12	8	14	6/5	10	2/5	**72**	1	70	10	10	10	0	Small stream. Boulder/rubble.
Tanyard Branch, near Carver St	4	7	8	6	7	6/5	7	2/4	**56**	4	30	30	20	20	0	Urban. Receiving stream for much of W. Franklin St. stormwater. Heavy filamentous algae in 2018.
Mill Race Branch, Bolinwood Dr	4	7	6	8	10	0/5	10	5/2	**57**	2	10	20	20	50	0	Urban. Sandy, embedded substrate. Fauna sparse. Receiving stream for downtown Chapel Hill stormwater.
Cole Springs Br, near Cedar St	5	11	10	8	16	3/6	10	4/4	**77**	2	30	20	10	30	10	Old residential area, forested riparian zone, good habitat.
Library Br, above Library Dr	5	11	6	4	14	6/7	10	5/5	**73**	1	0	10	10	80	0	Largely residential area, fauna sparse. Small sandy stream.

STREAM/SITE	HABITAT COMPONENT SCORING (Total 0-100)*									Width (m)	SUBSTRATE (%)					COMMENTS
	CM	IH	BS	PV	RH	BSV	LP	RVZW	Total		B	R	Gr	Sa	Si	
Battle Br, near Weaver Rd Grnwy	4	6	4	8	7	3/6	7	5/2	**52**	2	0	0	10	90	0	Sandy transition stream, with severe bank erosion. Receiving stream for UNC campus stormwater.
New Hope Creek Site																
Old Field Creek	5	11	12	8	14	3/5	10	5/4	**77**	4	40	30	20	10	0	Lots of bedrock but with layer of silt. Low flow. New development upstream in 2018 (Carraway Village).
Morgan Creek Sites																
Morgan Creek 1, NC 54	4	16	3	4	16	6/7	7	5/5	**73**	9	60	10	20		10	Within Carrboro's jurisdiction. Largely rural.
Wilson Cr 1, above Wave Rd	5	12	8	6	7	3/5	10	5/5	**66**	2	0	10	30	50	10	Sandy transition stream, with less developed catchment.
UT Wilson, Obey Creek Dev	5	16	11	4	14	6/5	10	5/5	**81**	1	0	20	40	40	0	Small, relatively undeveloped watershed.
Wilson Cr 1a, Obey Creek Dev	5	11	11	4	14	0/5	7	5/5	**67**	2	0	10	30	50	10	Behind Strata Solar and below potential Obey Creek Development outfalls.
Wilson Cr 2, above Arlen Park Dr	5	12	4	10	7	0/7	7	5/2	**59**	4	0	0	20	70	10	Big oxbow, lots of sand. High-density development at site, but older development upstream with large lots, mostly forested.
Fan Branch, above Parkview Dr	5	10	4	4	7	3/7	10	5/5	**60**	2	0	0	5	90	5	Urban/suburban (Southern Village), but good buffer zone.
Pritchard Branch, at Chase Apts	5	12	8	8	16	6/5	10	4/1	**75**	1	20	50	10	20	0	Urban. Receiving stream for downtown Chapel Hill stormwater. Rocky substrate, embedded with incised channel.
Large Streams																
Bolin Cr 4, above Village Dr	3	7	15	4	14	6/5	10	4/2	**70**	8	60	20	10	10	Tr	Rocky. Downstream from Carrboro.
Bolin Cr 4a, Bolinwood Dr	3	11	12	4	7	6/7	10	3/1	**64**	7	40	40	Tr	20	Tr	Rocky. Channelization old.
Bolin Cr 5, above Franklin St	2	11	12	10	7	3/5	7	1/4	**62**	8	20	10	10	30	10	Rocky near Franklin St, but sandy upstream. Heavily developed catchment.
Morgan Cr 1a, below Smith Level Rd	4	7	12	8	3	6/7	7	4/5	**63**	12	10	30	20	30	10	Behind Frank Porter Graham school, downstream from Carrboro.
Morgan Cr 1b, Morgan Cr Trail	4	11	11	8	7	6/5	10	4/4	**70**	9	10	30	10	50	Tr	Below confluence w/ UT, and downstream from Pritchard Br.
Morgan Cr 2, at Ashe Pl	5	15	12	6	14	6/7	10	4/4	**83**	12	20	30	10	40	Tr	Older residential neighborhood with good buffer zone. Rocky substrate in riffles, with sand deposition in pools. .

**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). Substrate: Boulder (B), Rubble (R), Gravel (Gr), Sand (Sa), Silt (Si), Tr = Trace (<10%). Stream width is in meters.*

Table 7. Water chemistry data for monitoring sites sampled in April & July 2018.

SITE	Dissolved Oxygen (mg/L)	Conductivity* (µS/cm)	pH	Temperature (degrees C)
SMALL STREAMS (April 2018)				
Booker Creek Sites				
Booker Cr 1, above MLK Jr. Blvd	9.6	157	6.7	11.7
Booker Cr, above Piney Mtn Rd	9.9	184	7.1	13.5
Booker Cr, above Tadley Grnwy**	8.9	114	7.1	18.9
Booker Cr, below Tadley Greenway	8.6	114	6.8	18.2
Booker Cr 2, below Willow Dr	8.6	125	6.7	19.1
Cedar Fk 1, below Brookview	10.2	134	7.	15.3
UT Cedar Fk 1, S of Brookview Dr	9.8	131	6.8	13.7
Cedar Fk 2, below Kenmore Rd	9.8	143	6.7	15.5
Bolin Creek Sites				
Jolly Branch	9.6	206	6.7	13.4
UT Bolin at Severin Dr	10.2	133	7.4	13.7
Tanyard Branch, near Carver St	10.6	336	7.6	14.0
Mill Race Branch, Bolinwood Dr	10.4	278	7.2	14.7
Cole Springs Branch, near Cedar St	9.3	151	7.1	16.3
Library Br, above Library Dr	9.4	148	7.2	14.3
Battle Branch, near Weaver Rd Grnwy	8.7	164	6.8	11.8
New Hope Creek Site				
Old Field Creek	9.4	244	7	18.7
Morgan Creek Sites				
Wilson Cr 1, above Wave Rd	9.0	120	6.7	12.5
UT Wilson, Obey Creek Dev	9.6	113	6.7	13.7
Wilson Cr 1a, Obey Creek Dev	11.2	116	6.7	17.2
Wilson Cr 2, above Arlen Park Dr	11.0	118	7.0	18.7
Fan Branch, below Parkview Dr	12.34	131	6.8	19.4
Pritchard Branch, at Chase Apts	9.0	255	6.7	19.9
LARGE STREAMS (July 2018)				
Bolin Cr 4, above Village Dr	8.2	136	7.3	24.6
Bolin Cr 4a, above Bolinwood Dr	7.3	204	7.3	23.4

SITE	Dissolved Oxygen (mg/L)	Conductivity* (µS/cm)	pH	Temperature (degrees C)
Bolin Cr 5, above Franklin St	5.9	229	6.6	23.2
Morgan Cr 1a, below Smith Level Rd	6.4	184	6.9	25.7
Morgan Cr 1b, at Morgan Trail	6.8	182	6.7	24.2
Morgan Cr 2, at Ashe Pl	7.0	183	7.1	22.7

**High conductivity values were often associated with streams that receive urban runoff and drain a high percentage of impervious surfaces.*
***Meter calibration issues*

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 Resources (formerly 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 (Table 8) are taken from the Cape Fear River basin report (NCDENR 2003), with more recent NCDWR data from Morgan Creek at NC 54 included as well.

Table 8. NC Division of Water Resources data for Chapel Hill benthic monitoring sites, 1985-2018, including both Standard Qualitative and EPT samples.

SITE NAME	DATE (Month/Year)	TOTAL SPECIES	EPT SPECIES	BI VALUE	BIOCLASS*
Bolin Creek, SR 1777 (Homestead Rd)	7/2001	87	24	6.0	Good-Fair
	2/2001	82	17	6.4	Not Rated
	4/2000	-	26	-	Good
	3/1998	-	23	-	Good
	4/1993	-	24	-	Good
Bolin Creek, Village Rd	3/2002	40	7	7.0	Fair (follows Drought)
	7/2001	52	9	6.6	Fair
	2/2001	54	6	7.0	Poor
	2/1998	59	26	5.1	Good
	4/1993	-	24	-	Good-Fair
Bolin Creek, E Franklin St	7/2001	41	4	6.9	Poor
	3/2001	53	4	7.1	Poor
	3/1998	37	13	6.3	Fair
	2/1998	-	4	-	Poor
	2/1993	32	8	6.5	Fair
	4/1986	89	28	6.1	Good-Fair
Booker Creek, Piney Mtn Rd	7/2001	35	4	6.1	Not Rated
	2/2001	39	8	6.3	Not Rated
	3/1998	-	10	-	Fair
Booker Creek, Barbara Ct	7/2001	45	3	6.6	Not Rated
	2/2001	31	4	7.3	Not Rated
Booker Creek, Walnut St	7/2001	31	4	7.3	Not Rated
	2/2001	51	7	6.9	Not Rated
Morgan Creek, NC 54	4/2018	-	28	-	Good
	6/2013	-	19	-	Good-Fair
	3/2009	-	26	-	Good
	3/2008	-	12	-	Not Rated (Drought)
	6/2004	-	18	-	Good-Fair
	10/2003	-	22	-	Good
	7/2003	-	20	-	Good-Fair

SITE NAME	DATE (Month/Year)	TOTAL SPECIES	EPT SPECIES	BI VALUE	BIOCLASS*
	5/2003	-	16	-	Good-Fair
	3/2003	-	12	-	Not Rated (Drought)
	1/2003	-	8	-	Not Rated (Drought)
	9/2002	-	2	-	Not Rated (Drought)
	4/2000	-	36	-	Excellent
	2/1998	80	33	4.4	Excellent
	10/1996	64	22	5.0	Good
	7/1993	61	22	4.9	Good
	2/1993	90	36	4.5	Excellent
	4/1985	109	32	5.7	Good
Morgan Creek near Botanical Garden	3/1998	46	20	6.1	Good-Fair
	4/1993	-	16	-	Fair
	2/1993	26	26	6.0	Good-Fair
Little Creek at Pinehurst Dr	7/2001	27	5	6.8	Not Rated
	3/2001	45	3	7.3	Poor
	2/1993	37	7	7.1	Fair

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

The NC Department of Environment and Natural Resources (2003) 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 [now MLK Jr. Boulevard] and Waterside Drive [Carrboro] 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."

NCDWR collections from Morgan Creek at NC54 in 2002 and 2003 were intended to show recovery from the 4-month drought. These data indicate 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

(See also Tables 35-37, Appendices 1 and 2A-2C)

Long-term Trends in Bolin Creek

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) in Carrboro, and at Estes Drive (#4) in Chapel Hill. 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 water quality 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:

MONTH(S)	YEAR	NOTES
September - December	2001	4 months, with lowest flow in Oct-Nov
June - September	2002	4 months, with streams drying up much of this time
June	2004	2003-2004 would be expected to be a period of recovery
July - October	2005	4 months, with streams going dry in September
August	2006	
July - December	2007	7 months, with streams going dry for 4-6 months
June - September	2008	No streams went completely dry; another period of recovery
July - October	2009	4 months, with severe drought for 2-3 months
June - August	2010	Severe drought in August
August - November	2011	
August	2015	Severe drought in August

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 ratings 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 2018.

Routine sampling in Carrboro and Chapel Hill had been switched from summer months to winter/spring months to avoid these periods of extreme low flow. Beginning in 2012, tributaries (small streams) are sampled in Spring (April) and the larger streams are sampled in Summer (June/July). Note that Summer 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 samples, some species may disappear due to emergence, rather than being lost due to a change in water quality.

Tables 35, 36 and 37 present a summary of the biological monitoring for Chapel Hill streams for 2018. A list of selected intolerant species is presented in Tables 38 and 39, producing a score (the "Sum" line) that is useful in comparing sites. Species are only included in Tables 38 and 39 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 #16".

Site Evaluations

It is important to realize that drought conditions during some 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. Flow conditions have improved in the last 5 years (2013-2018). The NCDWR system for rating small piedmont and mountain streams relies entirely on biotic index values, but note that it is not intended to apply to intermittent streams.

Large Streams

(Note: Bolin Creek sites 1-3 and Morgan Creek site 1 are in Carrboro; they are discussed in a separate report.)

A total of six (6) large stream sites were sampled in Chapel Hill in 2018, including three (3) long-term sites and an additional three sites on the main stem of Bolin Creek and Morgan Creek.

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 and was also sampled by the NC Division of Water Quality from 1993-2002. When all sources of data are combined, the pattern clearly shows a large decline in water quality for the period between 1998 and 2001.

The Estes Drive/Village Drive site had usually received a Fair rating during drought years, but recovered to Good-Fair in July of 2009. 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 for all collections through 2014. 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), but the 2013-2015 collections again produced a lower biotic index (5.8-6.3). This suggests some recovery, largely due to the appearance of the intolerant caddisfly, *Chimarra*. Recovery was also evident by the increased abundance of the intolerant snail, *Elimia*, in 2015. The 2014 collection produced a rating right on the borderline between a Fair and a Good-Fair rating, but the Good-Fair rating was not achieved until 2015. In 2016, the results showed a return to 2014 borderline conditions – if one more EPT had been collected, the site would have rated Good-Fair. In 2017 and 2018, EPT taxa richness and abundance declined to levels not seen since 2013 and was rated Fair. The biotic index stayed stable so this may not be a new trend of declining 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, but this problem was not evident in 2013-2018.

An additional, more subtle, metric is EPTN – the number of individual EPT (intolerant taxa) collected at a site. This metric can give more information than just the EPTS – the number of EPT taxa. For example, if one site had 5 EPT taxa that were all Rare, the EPTN would be 5. If another site had an EPTS of 5, but they were all Abundant, that would give an EPTN of 50. This could be interpreted that the site with EPTN=50 had slightly better water quality than the site with EPTN=5 since more intolerant animals are able to live there. *The EPTN in 2018 tied 2009 for the highest numbers recorded at this site.*

Table 9. Bolin Creek at Village Drive ("Bolin 4") data from Town of Carrboro, Town of Chapel Hill, and NCDWR, 1993-2018.

DATE	TOTAL SPECIES	EPTS (# OF EPT SPECIES)	BI	EPTN (# OF EPT INDIVIDUALS)	BIOCLASS
7/2018	60	8	6.1	73	Fair
7/2017	59	8	6.1	46	Fair

DATE	TOTAL SPECIES	EPTS (# OF EPT SPECIES)	BI	EPTN (# OF EPT INDIVIDUALS)	BIOCLASS
7/2016	63	11	6.1	71	Fair
6/2015	53	12	5.8	69	Good-Fair
6/2014	57	10	6.3	64	Fair
6/2013	33	6	5.9	53	Fair
6/2012	52	8	6.8	48	Fair
3/2011	58	8	6.7	21	Fair
3/2010	42	9	5.8	35	Fair
7/2009	58	10	6.2	73	Good-Fair
12/2008	44	12	5.9	63	Fair
8/2006**	21	6	-	19	Poor?
9/2004**	25	8	-	46	Fair
9/2003**	25	8	-	48	Fair
3/2002*	40	7	7	-	Fair (follows Drought)
7/2001*	52	9	6.6	-	Fair
2/2001*	54	6	7	-	Poor?
9/2000**	45	4	-	26	Poor
2/1998*	59	26	5.1	-	Good
4/1993*	-	24	-	-	Good-Fair

**NCDWR data, 1993 collections were limited to EPT taxa*
***Early Carrboro data, Ecological Consultants/Pennington. Bioclass based only on EPT Taxa richness.*

Bolin Creek Site 4a (Bolinwood Drive). This site was collected for the first time in 2018 to see if there were any impacts to the stream from Mill Race Branch, which drains eastern downtown Chapel Hill. There were small declines in the Total Taxa Richness and EPT Taxa Richness, plus a slight increase in the Biotic Index compared to Village Drive (Bolin Cr 4), which suggests that Mill Race Branch may, in fact, be having a small impact on Bolin Creek.

Table 10. Bolin Creek above Bolinwood Drive ("Bolin 4a") data Town of Chapel Hill, 2018.

DATE	TOTAL SPECIES	EPTS	BI	BIOCLASS
7/2018	52	6	6.3	Fair

Bolin Creek Site 5 (Franklin Street). This site received a Poor bioclassification in 2011, similar to NCDWR collections in 1998 and 2008. In 2012-2018, however, the Franklin Street site was assigned a Fair bioclassification, indicating a modest improvement in water quality. The abundance of one intolerant caddisfly (*Chimarra*), from 2012-2018, supported the higher rating. This site is quite sandy upstream of the bridge area, but NCDWR 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. Total Taxa Richness peaked in 2016, possibly due to higher flows providing additional habitat, and nearly returned to those levels in 2108. *EPT taxa richness in 2018 was the highest since 1998, continuing a generally upward trend since 2012.*

Table 11. Bolin Creek above Franklin Street ("Bolin 5") data from NCDWR and Town of Chapel Hill, 1986 to 2018.

DATE	TOTAL SPECIES	EPTS	BI	BIOCLASS
7/2018	60	11	6.4	Fair

DATE	TOTAL SPECIES	EPTS	BI	BIOCLASS
7/2017	37	8	6	Fair
7/2016	62	7	6.4	Fair
6/2015	46	9	5.9	Fair
6/2014	48	8	6.8	Fair
6/2013	34	4	6.2	Fair
6/2012	30	5	6.5	Fair
3/2011	50	4	7.2	Poor
7/2001*	41	4	6.9	Poor
3/2001*	53	4	7.1	Poor
3/1998*	37	13	6.3	Fair
2/1998*	-	4	-	Poor
2/1993*	32	8	6.5	Fair
4/1986*	89	28	6.1	Good-Fair

**NCDWR data*

Morgan Creek Site 1a (Smith Level Road). This site was collected for the first time in 2018 and was intended to measure the water quality of Morgan Creek coming into Chapel Hill from Carrboro. While more EPT taxa were collected here than downstream, the Biotic Index was substantially higher, indicating a more stressed community. This stress is probably related to low flow events since the low oxygen tolerant snail, *Physa* sp. was Abundant here, as well as the still water loving flatworm, *Dugesia tigrina*. Also of note, the limpet found at this site was *Laevapex fusculus*, a pond dweller, instead of the usual stream dweller, *Ferrissia* sp. The distance between this site and the Morgan Creek Trail site is small enough that probably only one of these sites should be sampled going forward. This site should probably be dropped because of its elevated indicators of low flow problems compared to Morgan Creek Trail, as well as its higher proportion of glass in the sediment, which can be a safety hazard.

Table 12. Morgan Creek below Smith Level Rd ("Morgan 1a") data Town of Chapel Hill, 2018.

DATE	TOTAL SPECIES	EPTS	BI	BIOCLASS
7/2018	72	13	6.8	Fair

Morgan Creek Site 1b (Morgan Creek Trail). This site was collected for the first time in 2018 to see if the Wilson Creek watershed contributes to the improved water quality in Morgan Creek downstream at Ashe Place. There was limited habitat above Prichard Branch, so this site includes the effects of southern downtown. Even in a year without flow problems, this stretch of stream only had a small flowing section. The low dissolved oxygen tolerant snail, *Physa* sp. was abundant here, so it is likely this site will have little to no flow in dry years. Water quality here was solidly Fair and comparable to Bolin Creek this year. Since the Wilson Creek watershed is the only major tributary entering Morgan Creek between this site and Ashe Place, it does appear the generally higher water quality in that watershed is helping improve the water quality in Morgan Creek.

Table 13. Morgan Creek near Morgan Creek Trail ("Morgan 1b") data Town of Chapel Hill, 2018.

DATE	TOTAL SPECIES	EPTS	BI	BIOCLASS
7/2018	79	11	6.1	Fair

Morgan Creek Site 2 at Ashe Place (near the NC Botanical Garden). Prior NCDWR 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 2012-2013 collections also resulted in a Fair bioclassification, but the only abundant intolerant species was *Chimarra*. This site improved to Good-Fair in 2014 – 2018. Although some intolerant taxa have not returned, in 2017 the mayfly *Isonychia* was Abundant here for the first time since 2011 and was Abundant again in 2018.

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

Table 14. Morgan Creek at Ashe Place ("Morgan Creek 2") data from NCDWR and Town of Chapel Hill, 1993 to 2018.

DATE	TOTAL SPECIES	EPTS	BI	BIOCLASS*
7/2018	75	14	5.7	Good-Fair
7/2017	66	16	5.9	Good-Fair
7/2016	75	17	6.3	Good-Fair
6/2015	-	15 (17*)	-	Good-Fair
6/2014	58	17	6.1	Good-Fair
6/2013	50	9	6.6	Fair
6/2012	39	9	6.3	Fair
3/2011	63	12	6.7	Fair
3/1998**	46	20	6.1	Good-Fair
4/1993**	-	16 (18*)	-	Good-Fair
2/1993**	71	26	6	Good-Fair

**Converted to equivalent full-scale sample*
***NCDWR data*

Small Streams

Many small stream sites have been regularly sampled from 2011 – 2015. Limited sampling in 2016 preceded a busy 2017 (20 small stream sites) and 2018 (22 small sites).

Many sites now have 5-6 years of data, allowing a better long-term assessment of water quality. Some differences between years, however, can result from small changes in stream temperature, causing a change in either the time of emergence or the hatching of eggs.

Slate Belt Streams (Rocky)

Pritchard Branch. Pritchard Branch is a rocky tributary to Morgan Creek in southwestern Chapel Hill. There is residential development in this catchment (especially in the headwaters), but there is a good buffer zone around the stream, with the exception of the OWASA sewer easement. This stream also drains the southern portion of downtown Chapel Hill. Pritchard Branch showed signs of sediment inputs in 2012-2013, with deposition of new sand and bank erosion. The substrate was also heavily scoured in 2012-2013, having a very "clean" appearance. A more normal periphyton community was observed in 2014-18.

The only Common or Abundant intolerant species in this stream in 2012 and 2013 was the snail *Elimia*, but in 2014-2015, the caddisfly *Diplectrona modesta* was Abundant and the caddisfly *Chimarra* was present. Some further improvement was seen in 2015, mainly through the loss of some highly tolerant species. The pattern over 4 years (2012-2015) clearly indicated improving water quality, although the amount of improvement is limited by the amount of urban area in the headwaters of this catchment. The community in 2017 declined slightly from 2015, but not enough to drop a bioclassification. However, the decline continued in 2018; the Biotic Index increased a full unit higher than in 2015, and the bioclassification dropped back to Fair.

NOTE: In 2017, NCDWR clarified that the incorrect Biotic Index criteria had been used in previous Town monitoring reports for the Fair/Good-Fair cut off for Qual 4 samples; as a result, the bioclass rating of Fair for this site reported in 2015 should have been Good-Fair (G-F) instead. See page 12 above for the correct Small Stream BI criteria thresholds.

Table 15. Pritchard Branch data, 2012-2015 & 2017-2018.

	2012	2013	2014	2015	2017	2018
Total Taxa Richness	19	28	26	22	18	25
EPT Taxa Richness	3	3	5	5	4	5
EPT Abundance	3	27	32	26	24	29
NC Biotic Index	6	6	6.6	5.3	5.85	6.38
Overall Rating*	Fair	Fair	Fair	G-F	G-F	Fair

**Orange highlighting indicates a change in overall rating from previous reports due to an error in the criteria used to determine the overall rating. Previous reports showed a Fair-Poor rating in 2012-2014 and Fair in 2015, when the rating should have been Fair in 2012-2014 and Good-Fair (G-F) in 2015.*

Fan Branch. Despite having a decidedly suburban watershed, in the past this stream supported many intolerant taxa (Telaganopsis deficiens, Plauditus dubiatus, Diplectrona modesta, Lepidostoma and Elimia), though Haploperla brevis was the only Abundant taxon. All but T. deficiens were collected in 2018. The presence of several very tolerant taxa here that were Common or Abundant (Chironomus, Cricotopus bicintus, and Limnodrilus hoffmeisteri) suggest this watershed may be prone to degradation from its consistently Good-Fair rating with additional development in the watershed. The 2015 Good rating is probably related to favorable flow conditions that year, since an improvement in water quality was noted in several sites that year, including Fan Branch and Old Field Creek.

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Table 16. Fan Branch data, 2011-2013, 2015 & 2017-2018.

	2011	2012	2013	2015	2017	2018
Total Taxa Richness	35	37	41	43	47	35
EPT Taxa Richness	14	11	14	14	13	9
EPT Abundance	65	46	65	76	37	26
NC Biotic Index	5.4	5.7	5.2	4.6	5.6	5.76
Overall Rating	G-F	G-F	G-F	Good	G-F	G-F

**G-F = Good-Fair*

Mill Race Branch. All metrics indicated Poor water quality in Mill Race Branch from 2011 through 2015, likely due to urban runoff. This catchment has poor riparian buffer zones with severe bank erosion. The stream substrate is largely sand and gravel (70%), with only 20% Cobble. The abundance of hydropsychid caddisflies in 2011 suggested the Mill Race Branch can be a perennial stream, but it may sometimes experience periods of low flow. Common and abundant macroinvertebrate species sometimes indicated problems associated with both low dissolved oxygen (*Physa*) and toxics (*Cricotopus annulator group*, *Conchapelopia group*). Although these taxa were not abundant in 2013-2017, two of the three were abundant in 2018 and taxa richness and Biotic Index returned to 2013 levels. The fauna was very depauperate in 2014, due to scour after heavy rainfall and was further complicated by stream restoration work prior to the 2014 collection, which caused a short-term increase in sedimentation and turbidity.

It is unclear why water quality dropped precipitously between 2017 and 2018, though, based on the decline of hydropsychid caddisflies to Common and the presence of the pond snail *Pseudosuccinea columella*, it may have something to do with low/no flow.

Table 17. Mill Race Branch data, 2011-2015 & 2017-2018.

	2011	2012	2013	2014	2015	2017	2018
Total Taxa Richness	18	20	18	11	19	25	29
EPT Taxa Richness	3	3	2	1	3	5	2
NC Biotic Index	7.7	7.9	7.5	6.8	6.9	6.6	7.5
Overall Rating	Poor	Poor	Poor	Poor	Poor	Fair	Poor

**Yellow highlighting indicates a notable decline in EPT Taxa Richness and the Biotic Index in 2018.*

UT Bolin Creek at Severin Street. In the early part of this decade, this small headwater stream received Good and Excellent ratings. In 2017, the rating dropped to Fair. This is likely due to sampling at the end of Severin Street, which is several dozen meters below the usual sampling reach that had better flow. Moving back to the original location has returned its rating to Good.

Table 18. UT of Bolin Creek at Severin Street data, 2011-2013 & 2017-2018.

	2011	2012	2013	2017*	2018
Total Taxa Richness	21	21	24	35	22
EPT Taxa Richness	9	8	9	9	7
EPT Abundance	33	41	49	19	40
NC Biotic Index	5.1	4.2	4.1	6.6	4.7
Overall Rating	Good	Excellent	Excellent	Fair	Good

**Sample in 2017 was not collected at the same location as previous samples.*

Tanyard Branch. Tanyard Branch receives stormwater from downtown Chapel Hill through two 48" pipes upstream from this site. This site has consistently been rated Poor from 2011-2018, though this year additional intolerant taxa brought down the Biotic Index slightly. Heavy filamentous algae growth suggests nutrients are causing low DO problems here.

Table 19. Tanyard Branch data, 2011-2014 & 2017-2018.

	2011	2012	2013	2014	2017	2018
Total Taxa Richness	7	11	13	13	17	25
EPT Taxa Richness	2	3	2	1	3	3
EPT Abundance	11	23	13	1	14	23
NC Biotic index	7.2	7.7	7.4	7.4	7.5	7.1
Overall Rating	Poor	Poor	Poor	Poor	Poor	Poor

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. The problems in Old Field Creek seem to be more associated with low flow. The macroinvertebrate fauna has produced successively higher ratings over the years: Poor in 2011, Fair in 2012-2014 and Good-Fair in 2015 as several years of normal flows were experienced. The trend ended in 2017 following an extremely low flow August 2016, when the rating returned to Fair.

More constant flow (and better water quality) was indicated by the abundance of *Maccaffertium modestum, Cheumatopsyche, Amphinemura*, and *Perlesta* in 2014-2015, and suggested that this stream supports its designated uses when flowing. In 2017 and 2018, these taxa were rare or absent, being replaced by low flow indicator *Caenis* sp. and intermittent stream indicator *Ironoquia punctatissima*, suggesting a lack of flow, rather than a decline in water quality is affecting the stream. New development just upstream of the site may lead to additional stresses due to runoff.

NOTE: In 2017, NCDWR clarified that the incorrect Biotic Index criteria had been used in previous Town monitoring reports for the Fair/Good-Fair cut off for Qual 4 samples; as a result, the bioclass rating of Good-Fair for this site reported in 2014 should have been Fair instead. See page 12 above for the correct Small Stream BI criteria thresholds.

Table 20. Old Field Creek data, 2011-2015 & 2017-2018.

	2011	2012	2013	2014	2015	2017	2018
Total Taxa Richness	22	27	33	37	40	46	34
EPT Taxa Richness	1	4	5	12	11	7	4
EPT Abundance	1	10	23	54	60	10	33
NC Biotic Index	7.6	6.5	6.3	6.2	5.7	6.4	6.2
Overall Rating*	Poor	Fair	Fair	Fair	G-F	Fair	Fair

**Orange highlighting indicates a change in overall rating from previous reports due to an error in the BI criteria threshold that was used to determine the overall rating. Previous reports showed a Good-Fair (G-F) rating in 2014, when the rating should have been Fair.*

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 at Brookview Drive (Site 1) was first sampled in 2011 and had abundant growth of filamentous algae in most years, although the abundance of attached algae was reduced by scour in 2014. The macroinvertebrate fauna (*Physa* common-abundant) indicated problems associated with low dissolved oxygen. In 2014, a special study was conducted of Cedar Fork that sampled four (4) sites on mainstem Cedar Fork (Sites 1-4), as well as three (3) unnamed tributaries (UT Sites 1-2/2A). In 2015, an additional mainstem site (Site 3A near Steeplechase Road) was sampled, but that site as well as the most upstream Cedar Fork site (Site 3 near Silo Road) were ultimately determined to be too small to receive a bioclassification, and were dropped from further sampling. Site 4 (Cedar Fork near Scott Lane) was determined to be too small in 2014. The southern (unnamed) tributaries (UT Sites 1-2/2A) support many intolerant species and have had good water quality, and do not contribute to the problems previously observed at the most downstream site (Cedar Fork Site 1). The northern section of Cedar Fork, however, shows problems along the entire length of the stream; a lack of buffer area around most of the stream may contribute to these problems. UT Site 2A (UT Cedar Fork, N of Brookview Drive) could not be sampled in 2017 and 2018 due to low flow.

In 2018, three Cedar Fork sites were sampled. They are listed below in upstream-downstream order. The wetter winter and cooler spring of 2018 added enough water to these streams that the bioclassifications increased one level.

UT Cedar Fork, S of Brookview Drive (Site UT 1). This tiny site was previously sampled in 2014 and 2017. Though there was very little flow in 2014, there were five stonefly taxa, the intolerant mayfly *Paraleptophlebia* and the rare caddisfly *Neophylax atlanta*. While the site was given a Good-Fair rating in 2017, the biotic index was only 0.04 - too high to assign a Good rating at that time. In 2018, the rating improved to Good, with four stoneflies and *Paraleptophlebia*.

Cedar Fork at Brookview Dr (Site 1). This portion of Cedar Fork, just upstream from Eastwood Lake, had rocky riffles and good riparian zone, with the only break being a sewer easement. The site was given a Good-Fair rating in 2017, up from the Fair rating in 2014. In 2018, it received the highest rating yet (Good).

Cedar Fork at Kenmore Road (Site 2). This portion of Cedar Fork has good habitat, with a good buffer zone around the site. This site was first sampled in 2014, and was assigned a Poor rating based on EPT taxa richness of 4 and a biotic index of 7.2. It also received a Fair rating in 2015, but there were minimal between-year

changes in the invertebrate community. In 2017, this site again received a Poor rating. However, in 2018 the rating returned to Fair.

Table 21. Cedar Fork data for three sites sampled in 2014, 2015, 2017 and 2018.

	UT Cedar Fork Site 1 (S of Brookview Dr)			Cedar Fork Site 1 (Brookview Dr)			Cedar Fork Site 2 (Kenmore Rd)			
	2014	2017	2018	2014	2017	2018	2014	2015	2017	2018
Total Taxa Richness	37	33	26	32	32	33	19	28	31	20
EPT Taxa Richness	12	11	8	8	7	9	4	4	4	2
EPT Abundance	62	45	41	32	45	45	19	31	15	2
NC Biotic Index	5.5	5.2	4.7	6.5	5.7	4.8	7.2	6.9	7.1	6.6
Overall Rating*	G-F	G-F	Good	Fair	G-F	Good	Poor	Fair	Poor	Fair

**G-F = Good-Fair*

Upper Booker Creek. Two headwater sites on Booker Creek are in the Slate Belt ecoregion, producing rocky streams. The two downstream sites (Tadley Greenway and Willow Drive) are discussed in the section on Triassic streams under Lower Booker Creek.

Booker Creek 1 (above MLK Jr. Blvd). This Booker Creek site had a very sparse fauna through 2014, with intolerant mayflies and stoneflies absent. This headwater site on Booker Creek improved from Poor in 2011 to Fair in 2012-2014. However, there were no large changes in the stream fauna over this time period. The Fair rating from this period was similar to that produced by NCDWR sampling in 2001.

In 2017, the site was moved several hundred yards upstream to an area of easier access and improved habitat. Though it appears that low flow could be a problem in drought years, the intolerant caddisfly, *Chimarra*, was common, and the intolerant snail, *Elimia,* was abundant. The biotic index was over a point lower than has been recorded here previously and the site was rated Good-Fair.

In 2018, the Biotic Index rose slightly (0.3), but just enough to drop the bioclassification back to Fair even though more taxa were collected in 2018 than ever before and intolerant taxa such as *Chimarra*, *Elimia* and *Parametriocnemus* were all Abundant.

Table 22. Booker Creek above MLK Jr. Boulevard data, 2011-2015 & 2017-2018.

	2011	2012	2013	2014	2015	2017	2018
Total Taxa Richness	20	25	27	28	32	40	43
EPT Taxa Richness	2	3	3	3	6	4	5
NC Biotic Index	7.5	6.4	6.3	6.2	6.7	5.6	5.9
Overall Rating*	Poor	Fair	Fair	Fair	Fair	G-F	Fair

**G-F = Good-Fair*

Booker Creek, above Piney Mountain Road. The NC Division of Water Resources sampled this site in 1998 and 2001. The spring samples (February 2001, March 1998) had produced EPT taxa richness of 8-10. Samples from April 2015 and 2017

produced an EPT taxa richness of 8 and 6, respectively. This was the only Booker Creek site with intolerant stoneflies (*Perlesta*), but several of the EPT found at the upstream MLK site were reduced or absent (*Maccafertium modestum,* and *Chimarra*). The bioclassification dropped from Good-Fair at the MLK site to Fair at the Piney Mountain site in 2017, but not in 2015 or 2018, when both sites were rated Fair. In December 2016, an abandoned outlet pipe from Lake Ellen collapsed, releasing large amounts of sediment and dead fish downstream into this reach. The presence of the freshwater sponge here in 2017 suggests that some of the problems here are related to low dissolved oxygen. While Taxa Richness was lower in 2018, it did not affect the Biotic Index, which was unchanged from 2017 and the stream was again rated Fair.

Table 23. Booker Creek above Piney Mountain Road data, 1998, 2001, 2015, & 2017-2018.

	1998*	2001*	2015	2017	2018
Total Taxa Richness	-	39	38	49	36
EPT Taxa Richness	10	8	8	6	7
NC Biotic Index	-	6.3	6.7	6.4	6.4
Overall Rating	Fair	Not rated	Fair	Fair	Fair

**Data reported by NCDWR for Spring 1998 and 2001.*

Cole Springs Branch. Cole Springs Branch is located in a largely forested area; this older residential area has large lot sizes and a wide forested buffer zone adjacent to the stream. Some upstream activity has added sand to the streambed in in recent years, but this did not initially affect the aquatic fauna. Total taxa richness has remained fairly stable, but EPT taxa richness declined slightly in 2014. More distinct changes, however, were seen in 2014 for EPT abundance and the biotic index. Two intolerant species virtually disappeared from this segment of Cole Springs Branch in 2014: *Neophylax ornatus/atlanta* and *Psephenus herricki*. These changes were sufficient to drop the rating from Good in 2011-2013 to Good-Fair in 2014. EPT taxa richness showed some recovery in 2015, but the abundance of key species (*Haploperla brevis, Neophylax oligius, Psephenus herricki*) remained low (see below). In fact, there were no abundant EPT species in either 2014 or 2015 and the bioclassification remained at Good-Fair in 2015.

The bioclassification returned to a Good rating in 2017, largely because the majority of Abundant taxa were intolerant (tolerance value <4), thus bringing down the biotic index below 5 for the first time since 2013. While there were slightly fewer taxa in 2018, the Biotic Index was unchanged from 2017 and the rating remained Good.

Table 24. Cole Springs Branch data, 2011-2015 & 2017-2018.

	2011	2012	2013	2014	2015	2017	2018
Total Taxa Richness	29	38	35	35	26	35	31
EPT Taxa Richness	8	11	10	7	10	9	8
EPT Abundance	40	43	47	26	25	35	30
NC Biotic Index	4.6	4.7	4.9	5.8	5.6	4.8	4.8
Overall Rating*	Good	Good	Good	G-F	G-F	Good	Good

**G-F = Good-Fair*

Table 25. Cole Springs Branch selected intolerant taxa data, 2011-2015 & 2017-2018.

Selected Intolerant taxa	2011	2012	2013	2014	2015	2017	2018
Haploperla brevis	A	A	A	C	C	A	A
Neophylax sp.	A	A	A	-	R	C	A

Selected Intolerant taxa	2011	2012	2013	2014	2015	2017	2018
Psephenus herricki	C	A	A	R	C	A	C

**R=Rare, C=Common, A=Abundant*

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 some intolerant species were recorded in Library Branch in 2012 and 2013, the only common or abundant intolerant taxa were *Neophylax ornatus/atlanta* (Common in 2012) and the snail *Elimia* (Abundant). It is possible that a few high quality seeps are still present further upstream in this developed catchment. In 2018, the stream maintained its Good rating, despite the Biotic Index rising compared to 2013. Abundant small stream intolerant taxa collected in 2018 were the caddisflies *Neophylax atlanta* and *Lepidostoma*.

Table 26. Library Branch data, 2011- 2013 & 2018.

	2011	2012	2013	2018
Total Taxa Richness	24	28	26	32
EPT Taxa Richness	6	7	5	8
EPT Abundance	-	-	7	39
Biotic index	5.6	4.7	4.4	5.1
Overall Rating*	G-F	Good	Good	Good

**G-F = Good-Fair*

Jolly Branch. This site has been consistently rated as Good-Fair, though the stream fauna includes many intolerant species. With EPT taxa richness increasing and the biotic index decreasing, water quality appeared to be improving from 2011-2017; however, 2018 had a decline in EPT taxa and a rise in the Biotic Index, which disrupted that trend.

Table 27. Jolly Branch data, 2011-2014 & 2017-2018.

	2011	2012	2013	2014	2017	2018
Total Taxa Richness	33	24	39	37	48	27
EPT Taxa Richness	8	6	11	10	13	6
EPT Abundance	46	35	49	39	36	28
Biotic index	6.2	6.1	5.5	5.4	5.4	5.8
Overall Rating*	G-F	G-F	G-F	G-F	G-F	G-F

**G-F = Good-Fair*

Transitional Area Streams (Sandy)

Wilson Creek. Since 2011, Wilson Creek has been monitored in most years at two locations: above Wave Road (Site 1), near the Chatham County line, and above Arlen Park Drive (Site 2) in Southern Village. In 2016, two sites within the proposed Obey Creek Development were established and sampled in July: Wilson 1a and UT Wilson. In 2017, these sites were sampled in April.

Wilson 1a (within the Obey Creek development) is located almost midway between sites Wilson 1 and 2, and near the downstream end of the proposed development. The catchment here is approximately 1.7 mi^2 with a watershed that was 74% forested and 10% developed, based on 2011 land use data. UT Wilson Creek (also within the Obey Creek development) was a sample on the largest tributary in this segment of stream and has a watershed of 0.2 mi^2 (130 acres). UT Wilson Creek is perennial, which is uncommon for streams this small in either the Slate Belt or the Triassic

Basin. Since the stream temperature was nearly 3°C cooler than nearby Wilson Creek, it is possible that the stream is spring fed. The current plan for the Obey Creek development is to preserve this tributary stream and its watershed; land use data from 2011 showed the watershed was 95% forested and <3% developed.

Wilson Creek appears 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). As indicated above, the lower end of Wilson Creek is located in a high-density residential area, but most of the catchment is comprised of heavily forested older residential areas with large lot sizes.

The upstream site (Wilson 1) showed a steady decline in Total and EPT Taxa Richness until 2018, when the site returned to 2012-13 levels. In 2015, the site was officially rated Good, when it should have been Excellent. Since that time, however, the Biotic Index has continued to climb and the site rated Good in 2017 and 2018.

Lower Wilson Creek (Wilson 2) also showed a decline in taxa richness from its peak in 2015 (see Table 37) to levels closer to 2012. While Total and EPT Taxa Richness varied only slightly from 2015 to 2017, the EPT Abundance dropped by nearly 50%, leading to a more tolerant community and increase in the Biotic Index. This trend has increased in 2018, with EPT Taxa Richness declining 30% and EPT Abundance declining 60% from the already depressed 2017 levels. Use of incorrect biocriteria prior to 2015 led to consistently incorrect bioclassifications, which have been corrected in Table 28 & 29 below.

Sampling of Wilson Creek 1a and UT Wilson Creek in summer 2016 and then in the spring of 2017 and 2018 confirmed that water quality was high (both Excellent in 2018) in this section of the creek.

NOTE: In 2017, NCDWR clarified that incorrect Biotic Index criteria had been used in previous Town monitoring reports for the Fair/ Good-Fair cut off for Qual 4 samples. As a result, the bioclass rating of Wilson 1 in 2015 and has been corrected in Table 28 below. See page 12 above for the correct Small Stream Criteria for BI thresholds. Ratings for Wilson 2 (Table 29) have also been corrected to reflect criteria in NCDWR 2016.

Table 28. Wilson Creek above Wave Road ("Wilson 1)" data, 2012-2013, 2015, 2017 & 2018.

	Wilson 1 (Wave Road)				
	2012	**2013**	**2015***	**2017**	**2018**
Total Taxa Richness	45	50	43	35	52
EPT Taxa Richness	23	20	17	16	22
EPT Abundance	103	104	68	63	97
NC Biotic Index	4.0	4.1	3.8	4.3	4.46
Overall Rating**	Excellent	Excellent	Excellent	Good	Good

**Yellow highlighting indicates a notable decline in EPT Taxa Richness and Abundance in Wilson 1 in 2015.*
***Orange highlighting indicates a change in overall rating from previous reports due to an error in applying criteria that were used to determine the overall rating. Previous reports showed a Good rating for Wilson 1 in 2015, when the rating should have been Excellent.*

Table 29. Wilson Creek above Arlen Park Drive ("Wilson 2) data, 2011-2015, 2017 & 2018.

Wilson 2 (Arlen Park Drive)						
2011	**2012**	**2013**	**2014**	**2015***	**2017**	**2018**

	Wilson 2 (Arlen Park Drive)						
	2011	**2012**	**2013**	**2014**	**2015***	**2017**	**2018**
Total Taxa Richness	45	47	38	41	47	49	44
EPT Taxa Richness	17	19	11	16	22	20	13
EPT Abundance	54	54	17	54	122	63	25
NC Biotic Index	6.0	5.3	6.0	5.0	4.3	5.6	5.9
Overall Rating**	Fair	G-F	Fair	G-F	Excellent	G-F	Fair

**Blue highlighting indicates a notable increase in EPT Taxa Richness and Abundance in Wilson 2 in 2015 (downstream from Wilson 1, above).*

***Orange highlighting indicates a change in overall rating from previous reports due to an error in applying criteria that were used to determine the overall rating. Previous reports showed a G-F for Wilson 2 in 2011, Good in 2012, G-F in 2013, and Good in 2014; the ratings above reflect corrections to those ratings based on NCDWR 2016. G-F = Good-Fair.*

Table 30. Wilson Creek at Obey Creek Development ("Wilson 1a") and UT to Wilson Creek at Obey Creek Development ("UT Wilson") data, 2016-2018.

	Wilson 1a			UT to Wilson		
	Summer 2016*	**Spring 2017**	**Spring 2018**	**Summer 2016***	**Spring 2017**	**Spring 2018**
Total Taxa Richness	38	50	41	35	35	44
EPT Taxa Richness	12	23	18	10	18	21
EPT Abundance	47	109	67	79	72	110
NC Biotic Index	5.5	4.5	4.2	4.2	3.6	4.1
Overall Rating	Good-Fair	Good	Excellent	Excellent	Excellent	Excellent

**Small Stream ratings are for collections made in the spring. In 2016, these samples were collected in the summer, under more stressful conditions. Spring sampling in 2017 & 2018 yielded increased EPT taxa richness and decreased biotic indices compared with summer collections, reflecting these less stressful conditions.*

Battle Branch. Battle Branch has instream habitat similar to Wilson Creek, but the fauna indicates much worse water quality. In 2014, conductivity was higher at this site (212-244 µS/cm) than at the Fan Branch and Wilson Creek sites (<140 µS/cm). Salamanders have been abundant in past collections, but were only common in 2018. Battle Branch showed improvement from 2011 to 2012-2013, suggesting higher flows may be the cause of this change. The steady decline in EPT Abundance and increase in Biotic Index from 2013-2018 is worrisome even though the rating hasn't changed.

NOTE: In 2017, NCDWR clarified that incorrect Biotic Index criteria had been used in previous Town monitoring reports for the Fair/ Good-Fair cut off for Qual 4 samples. As a result, the bioclass rating of Good-Fair for this site reported from 2011 to 2014 should have been Fair instead and has been corrected in Table 31 below. See page 13 above for the correct Small Stream Criteria for BI thresholds.

Using the correct NCDWR (2016) BI criteria, this stream has consistently earned a Fair rating. Other instances where this error led to an incorrect bioclassification are Old Field Creek, Wilson Creek 1 and

2, and Pritchard Branch.

Table 31. Battle Branch data, 2011-2014 & 2017-2018.

	2011	2012	2013	2014	2017	2018
Total Taxa Richness	17	33	34	20	39	23
EPT Taxa Richness	4	6	4	4	5	1
EPT Abundance	12	17	19	10	9	1
NC Biotic index	6.7	6.0	6.1	6.4	6.4	6.8
Overall Rating*	Fair	Fair	Fair	Fair	Fair	Fair

**Orange highlighting indicates a change in overall rating from previous reports due to an error in the BI criteria threshold that was used to determine the overall rating. Previous reports consistently showed a Good-Fair rating in 2011-2014, when the rating should have been Fair. This change does not indicate any change in actual water quality from 2011 to 2017.*

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 sites in lower Booker Creek.

Lower Booker Creek

These sites are quite different from the rocky sites seen further upstream in Booker Creek. They have clay banks, with a sand and gravel substrate. Both Booker Creek above Tadley Greenway and at Willow Drive had abundant *Chironomus* larvae (a midge), permitting an evaluation of instream toxicity in 2015 (see Toxicity Assessment above).

Booker Creek above Tadley Greenway. This site was sampled for the first time in April 2015. Highly tolerant snails, midges and worms, mostly those genera that indicate low dissolved oxygen and organic loading, dominated: *Physa, Conchapelopia group, Chironomus, Dicrotendipes* and *Limnodrilus.* In 2017, the dominant taxa were similar, except the tolerant midge *Dicrotendipes* was replaced by the tolerant midge *Cricotopus bicinctus*. Town staff identified an unpermitted outdoor swimming pool discharge in 2016 upstream from this site and has since eliminated it. It is hoped that the removal of periodic inputs of toxic chlorine will reduce the dominance of very tolerant taxa at this site. The dominance of such tolerant species produced a very high biotic index value (7.9 in 2015, 7.7 in 2017 and 7.4 in 2018) and a Poor rating each year.

About 30% of the *Chionomus* larvae in 2015 had deformities, producing a "Toxic Score" (Lenat 1993) of 65 (see Toxicity Assessment above). This clearly indicates some in-stream toxicity, in addition to low dissolved oxygen concentrations. While *Chironomus* were abundant in 2017, there were not enough collected (20-30) to do a deformity assessment. Only four *Chironomus* were collected in 2018; however, one of those four had a deformity.

Table 32. Booker Creek above Tadley Greenway data, 2015 2017 & 2018.

	2015	2017	2018
Total Taxa Richness	35	36	31
EPT Taxa Richness	4	3	4
NC Biotic Index	7.9	7.7	7.4
Overall Rating	Poor	Poor	Poor

Booker Creek below Tadley Greenway. This site is located about 200 meters

downstream of the usual site (above Tadley Greenway) in an area of good flow and rip rap to provide habitat. If the Poor rating upstream was due to sparse habitat or poor flow, this site should have rated better. In fact it did, with more EPT Taxa and a lower Biotic Index, giving the site a Fair rating. It is suggested that future sampling at this location be moved downstream to this site.

Table 33. Booker Creek below Tadley Greenway data, 2018.

	2018
Total Taxa Richness	36
EPT Taxa Richness	7
NC Biotic Index	6.7
Overall Rating	Fair

Booker Creek below Willow Drive. Booker Creek is a channelized stream in a heavily developed catchment. Abundant filamentous algae and silt covered most of the stream bottom during years with low flow at this site. This algal growth was much less abundant after 2013. In 2017, a petroleum sheen was observed at this site.

NCDWR made collections twice at a site near Willow Drive in 2001 (Walnut Street) and obtained total taxa richness of 31-51, EPT taxa richness of 4-7, and a biotic index of 6.9-7.3. The 2011-2015 collections indicate a substantial long-term decline in water quality, with only 1-3 EPT species and an extremely high biotic index (7.3-8.2). A Poor rating is consistently assigned to this portion of Booker Creek, although the biotic index values suggest some moderate improvement from 2011-2015, followed by a decline to 2011 levels in 2018.

The abundance of the midge *Chironomus* had indicated some organic loading to lower Booker Creek during low-flow years, although this taxon was not found in 2013 or 2014. It became abundant again, however, in 2015, and about 30% of the larvae had deformed mouthparts. A "Toxic Score" of 70 (Lenat 1993) indicated substantial in-stream toxicity (see Toxicity Assessment above). Other low-dissolved oxygen indicators (*Physa, Limnodrilus),* however, were rare or absent, suggesting that low dissolved oxygen is less of a problem here than at the Tadley Greenway site. While there were not enough *Chironomus* collected in 2017 and 2018 to perform a deformity analysis, it does not appear that water quality has improved at this site.

Table 34. Booker Creek at Willow Drive data, 2011-2015 & 2017-2018.

	2011	2012	2013	2014	2015	2017	2018
Total Taxa Richness	31	28	32	30	27	35	28
EPT Taxa Richness	1	2	2	3	1	3	2
NC Biotic Index	8.2	8.1	7.6	7.6	7.3	7.7	8.2
Overall Rating	Poor	Poor	Poor	Poor	Poor	Poor	Poor

SUMMARY AND CONCLUSIONS

Large Streams

Current Status and Short-term Changes. Until recently, Bolin Creek has shown a decline in water quality between Village Drive and Franklin Street, going from Good-Fair to Fair or from Fair to

Poor. In other words, there is usually a decline of one bioclassification between the upstream and downstream sites on Bolin Creek. Since 2016, however, all main stem Bolin Creek sites have rated Fair. In 2018, Morgan Creek was rated Excellent upstream (at NC54 in Carrboro), Fair at Smith Level Road and Morgan Trail, and back up to Good-Fair downstream (in Chapel Hill at Ashe Place). This suggests that the impairment to Morgan Creek was greater than originally thought in the upper section, but that the better quality water coming in from Wilson Creek helps the lower section of Morgan Creek recover.

Long-term Changes. Some of the larger sites (Bolin Creek and Morgan Creek) have information on the benthic macroinvertebrate fauna going back to the mid-1980s, allowing an examination of long-term changes in water quality. This analysis combines data from the NC Division of Water Resources (formerly the Division of Water Quality), the Town of Carrboro, and the Town of Chapel Hill. The two long-term sites on Bolin Creek (above Village Drive and above Franklin Street) have showed a long-term decline in water quality, likely reflecting greater urban land use in Carrboro and Chapel Hill. Morgan Creek also shows a slight, consistent decline in water quality from above the Chapel Hill/Carrboro area (Excellent, Good to Good-Fair) to the site in southern Chapel Hill at Ashe Place (Good-Fair to Fair).

Small Streams

Current Status. Much better water quality can be found in many of the small streams in Chapel Hill, usually those in older neighborhoods with adequate buffer zones around the stream. Local geology also affects stream bioclassification, with the streams in the Slate Belt ecoregion usually having the most diverse aquatic communities. Many of these streams go dry during summer droughts, but spring sampling (April) has allowed an evaluation of water quality in these small streams.

Below are brief summaries of small streams grouped by their bioclassification ratings for 2018.

Poor

- *Tanyard Branch.* This stream drains a highly developed urban area, and receives stormwater from much of W. Franklin Street (downtown Chapel Hill). The consistently high conductivity here (336 µS/cm in 2018), even during low flows, suggests an undetected discharge or groundwater contamination in addition to the effects of the stormwater runoff.

- *Mill Race Branch.* This site is within an urban area with poor buffer zones, and this stream receives stormwater from downtown Chapel Hill. Previous years, except 2017, have rated this stream Poor and 2018 was no exception. Conductivity at this site is consistently high (278 µS/cm in 2018).

- *Booker Creek, above Tadley Greenway.* Slow flows and reduced habitat, plus its location below Eastwood Lake, combine to create water quality problems at this site. This site is also downstream from dense residential development with little to no stream buffers.

- *Booker Creek, Willow Drive.* This stream drains a highly developed catchment. The fauna suggests organic loading and low dissolved oxygen are problems.

Fair

- *Pritchard Branch.* Pritchard Branch drains parts of downtown Chapel Hill. Water quality appears to have improved since 2012, and now rates in the Fair/Good-Fair range. In 2018, taxa richness was low with only a few intolerant aquatic insect species, and conductivity was high (255 µS/cm).

- *Wilson Creek 2, Arlen Park Drive.* This site, one of the few perennial tributaries of Morgan Creek, is within a heavily developed area, but with good buffer zones and good upstream water quality. This stream alternated between a Fair and a Good-Fair rating

from 2011 to 2014, and in 2017-2018. It was rated Excellent in 2015, though it appears to be sampling error that led to the 40% increase in EPT Taxa Richness and over 100% increase in EPT Abundance in that year. (See above for more information on changes in this site's rating from previous reports.)

- *Booker Creek, below Tadley Greenway.* This site is a short distance downstream of the usual site above Tadley Greenway, in an area where habitat includes rip-rap with good flow. It appears that the slow flow and habitat issues just upstream caused one bioclass decline; however, the stream here still has its share of problems such as its location below a small lake, and its dense residential development upstream with little to no stream buffers.

- *Booker Creek, above Piney Mountain Road.* Increased urbanization between this site and MLK Jr. Boulevard upstream is likely the cause of the decline in water quality. This site also experienced increased sediment loading in December 2016 due to the failure of an abandoned outlet pipe in the Lake Ellen dam, causing the lake level to partially drop and drain into this reach of Booker Creek.

- *Booker Creek 1, above MLK Jr. Blvd*. This stream drains a developed residential area. The bioclassification for this site was upgraded from Poor in 2011 to Fair in 2012 and 2013, then to Good-Fair in 2015 and continued that rating in 2017; however, it declined again in 2018. The fauna indicates there may be intermittent flow for this portion of Booker Creek.

- *Cedar Fork 2, Kenmore Road.* This site, the most upstream site sampled in Cedar Fork, has very sparse fauna, possibly due to low flows. With a second year of decent flow, this site, like the other two sites in this watershed, improved a bioclassification.

- *Old Field Creek.* It is unknown what problems there may be at this site. The Orange County landfill is upstream. This stream may also go dry frequently. The bioclassification for this site was upgraded from Poor in 2011 to Fair in 2012, where it has remained since. Conductivity recorded at this site the past two years has been relatively high (244 µS/cm in 2018, 271 µS/cm in 2017). (See above for more information on changes in this site's rating from previous reports.)

- *Battle Branch.* This stream drains a residential area and part of the UNC campus, but has a good buffer zone. This site has rated consistently Fair. (See above for more information on changes in this site's rating from previous reports.)

Good-Fair

- *Fan Branch.* This stream is in a highly developed area, but with a good buffer zone and many intolerant taxa. With the exception of 2015, this site has consistently rated Good-Fair since it was first sampled in 2011.

- *Jolly Branch.* This stream may be intermittent, but with some highly intolerant species and a good buffer zone. This site has been consistently rated as Good-Fair since 2011.

Good and Excellent

- *Wilson Creek 1, above Wave Road.* Upper Wilson Creek has been rated as either Excellent (2012-2015) or Good (2017-2018). It has a heavy sediment load, although the source of nonpoint runoff in this catchment is not clear. (See above for more information on changes in this site's rating from previous reports.)

- *UT Wilson Creek, Obey Creek Development.* This appears to be another small stream with good habitat and a good buffer zone; this seems to be where to find high quality streams in this part of the State. It has been consistently rated Excellent since July 2016.

- *Wilson Creek 1a, Obey Creek Development.* This site is located between Wilson 1 and 2, within the currently undeveloped but approved Obey Creek mixed-use development. While sandy, this site still rated Good-Fair when sampled in July 2016, Good in April 2017 and Excellent in 2018.

- *Cole Springs Branch*. This stream drains a residential area with large lots and a good buffer zone. Some upstream activity added sand to the streambed in recent years, but this did not initially affect the aquatic fauna. This site retained its Good rating in 2018 with two intolerant species, which had virtually disappeared from this stream segment in 2014 and 2015 (*Neophylax ornatus/atlanta* and *Psephenus herricki*), that were Abundant and Common, respectively. Return of these intolerant taxa may be related to the YMCA removing their pool backwash discharge from an upstream tributary in 2018.

- *Library Branch*. This very small stream drains an old residential area with large lots and has a good buffer zone. Even though it was last sampled in 2013, this site has retained its Good rating.

- *Cedar Fork 1, Brookview Drive.* This site is within a residential area. This stream improved from Fair in 2014, to Good-Fair in 2017, to Good in 2018. This may be due to several years without very low flows.

- *UT Cedar Fork 1, South of Brookview Drive.* This is a very small stream, probably with flow problems in dry years, but supported many different stoneflies despite its size. With a couple of years since a prolonged drought, the community has improved from a Good-Fair rating in 2016 to a Good rating in 2018.

- *UT Bolin Creek, Severin Street.* This small stream, with minimal development in the watershed, has been rated Good or Excellent, and was again rated Good in 2018.

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 Town limits. In previous years, 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.

Table 35. Taxa richness and summary parameters for larger stream sites in Bolin Creek (sites B4 and B5) and Morgan Creek (site M2), Chapel Hill, North Carolina, 2011-2018.

	March 2011			June 2012			June 2013			June 2014			June 2015			July 2016			July 2017			July 2018		
TAXA SITE:	**B4**	**B5**	**M2**	**B4**	**B5**	**M2**	**B4**	**B5**	**M2**	**B4**	**B5**	**M2**	**B4**	**B5**	**M2**	**B4**	**B5**	**M2**	**B4**	**B5**	**M2**	**B4**	**B5**	**M2**
Ephemeroptera	4	1	7	3	3	6	3	1	3	4	4	9	4	5	8	5	4	8	3	5	7	3	5	6
Plecoptera	1	-	-	1	-	-	-	-	-	1	-	-	1	-	1	1	-	-	1	-	1	1	-	-
Trichoptera	3	3	5	4	2	3	3	3	6	5	4	8	7	4	6	5	3	9	4	3	8	4	5	8
Coleoptera	2	-	6	5	3	3	6	3	4	6	2	4	2	3	-	5	7	7	4	6	6	5	5	10
Odonata	2	6	3	3	5	2	1	4	2	6	5	4	5	6	-	4	5	9	5	5	7	4	7	6
Megaloptera	-	-	1	1	-	-	-	-	1	-	-	-	2	1	-	1	-	-	-	1	-	-	1	2
Diptera; Misc.	8	6	5	2	2	4	4	2	3	4	3	3	4	4	-	3	4	-	3	3	3	4	3	3
Diptera: Chironomidae	22	20	23	19	12	13	9	12	21	19	20	16	15	19	-	25	28	21	10	29	22	27	21	26
Oligochaeta	8	6	3	2	2	1	1	4	2	4	6	3	3	2	-	4	3	4	2	1	2	2	3	4
Crustacea	4	2	3	3	1	3	2	1	3	3	1	3	2	1	-	3	1	1	1	1	1	1	2	2
Mollusca	4	4	5	5	-	3	3	2	4	3	1	3	6	2	-	5	4	6	2	1	4	7	4	6
Other	1	2	2	3	-	1	1	2	1	2	2	3	3	1	-	2	3	3	2	4	4	2	3	2
Total Taxa Richness	59	50	63	51	30	39	33	34	50	57	48	58	53	46	-	63	62	75	37	59	66	60	60	75
EPT Taxa Richness	8	4	12	8	5	9	6	4	9	10	8	17	12	9	17*	11	7	17	8	8	16	8	11	14
EPT Abundance	21	26	74	48	34	67	53	40	42	64	48	97	69	47	75	71	54	80	57	46	85	73	51	106
EPT Score	1.6	1	2	1.6	1	1.6	1.4	1	1.6	2	1.6	2.6	2	1.6	2.6	2	1.4	2.6	1.6	1.6	2.6	2.6	2.0	2.4
NC Biotic Index	6.7	7.0	6.7	6.8	6.5	6.3	5.9	6.2	6.6	6.3	6.8	6.1	5.8	5.9	-	6.1	6.4	6.3	6	6.1	5.9	6.1	6.4	5.7
BI Score	2	2	2	2	2.4	3	3	3	2	3	2	3	3.4	3	-	3	3	3	3	3	3	3.0	3.0	3.6
Site Score	1.8	1.5	2	1.8	1.7	2.3	2.2	2	1.8	2.5	1.8	2.8	2.7	2.3	-	2.5	2.2	2.8	2.3	2.3	2.8	2.3	2.5	3.0
Overall Rating**	Fair	Poor	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair/ G-F	Fair	G-F	G-F	Fair	G-F	Fair/ G-F	Fair	G-F	Fair	Fair	G-F	Fair	Fair	G-F

**4-sample EPT collection; EPT taxa richness count has been corrected to the predicted 10-sample value for easy comparison with the other sites.*
***G-F=Good-Fair*

*Table 36. Taxa richness and summary parameters for small Slate Belt streams, Chapel Hill, NC.**

SITE:	Pritchard Br	Mill Race Br	Tanyard Br	Old Field Cr	Cedar Fk 1, Brookview	UT Cedar Fk 1, S of Brookview	Cedar Fk 2, Kenmore	Booker Cr 1, MLK Blvd	Booker Cr, Piney Mtn	Cole Sprgs Br	Library Br	Jolly Br	UT Bolin Cr, Severin St
TAXA Width (m):	1	2	4	4	4	1	2	3	4	2	1	1	1
Ephemeroptera	1	1	1	1	4	1	-	2	2	2	1	1	4
Plecoptera	-	-	-	2	4	4	1	-	-	1	1	2	2
Trichoptera	4	1	2	1	1	3	1	3	5	5	6	3	1
Coleoptera	2	2	1	3	2	2	2	3	1	2	3	4	1
Odonata	1	2	-	4	1	1	-	4	2	2	2	1	-
Diptera; Misc.	2	2	2	3	2	2	2	3	4	3	2	3	1
Diptera: Chironomidae	10	11	13	12	12	7	7	17	12	12	6	7	5
Oligochaeta	2	4	2	2	3	2	2	2	2	2	5	2	2
Crustacea	1	2	1	3	3	3	3	3	3	1	2	3	3
Mollusca	1	2	1	2	2	1	2	5	4	1	3	1	1
Other	1	2	2	1	-	-	-	1	1	-	1	-	2
2018 Data													
Total Taxa Richness	25	29	25	34	33	26	20	43	36	15	32	27	22
EPT Taxa Richness	5	2	3	4	9	8	2	5	7	8	8	6	7
EPT Abundance	29	6	23	33	45	41	2	34	36	30	39	28	36
NC Biotic Index	6.4	7.4	7.1	6.2	4.8	4.7	6.6	5.9	6.4	4.8	5.1	5.9	4.7
Overall Rating	**Fair**	**Poor**	**Poor**	**Fair**	**Good**	**Good**	**Fair**	**Fair**	**Fair**	**Good**	**Good**	**G-F**	**Good**
2017 Data													
Total Taxa Richness	18	25	17	46	32	33	31	40	49	35	NS	48	35
EPT Taxa Richness	4	5	3	7	7	11	4	4	6	9	NS	13	9
EPT Abundance	24	16	14	10	45	45	15	26	22	35	NS	36	19
NC Biotic Index	5.85	6.6	7.5	6.4	5.7	5.2	7.1	5.6	6.4	4.8	NS	5.4	6.6
Overall Rating	**G-F**	**Fair**	**Poor**	**Fair**	**G-F**	**G-F**	**Poor**	**G-F**	**Fair**	**Good**	**NS**	**G-F**	**Fair**

SITE:	Pritchard Br	Mill Race Br	Tanyard Br	Old Field Cr	Cedar Fk 1, Brookview	UT Cedar Fk 1, S of Brookview	Cedar Fk 2, Kenmore	Booker Cr 1, MLK Blvd	Booker Cr, Piney Mtn	Cole Sprgs Br	Library Br	Jolly Br	UT Bolin Cr, Severin St
2015 data													
Total Taxa Richness	22	19	NS	40	NS	NS	28	32	38	26	NS	NS	NS
EPT Taxa Richness	5	3	NS	11	NS	NS	4	6	8	10	NS	NS	NS
EPT Abundance	26	17	NS	60	NS	NS	31	46	32	25	NS	NS	NS
NC Biotic Index	5.3	6.9	NS	5.7	NS	NS	6.9	6.7	6.7	5.6	NS	NS	NS
Overall Rating	**G-F**	**Poor**	**NS**	**G-F**	**NS**	**NS**	**Fair**	**G-F**	**Fair**	**G-F**	**NS**	**NS**	**NS**
2014 Data													
Total Taxa Richness	26	11	13	37	32	37	19	28	NS	35	NS	37	NS
EPT Taxa Richness	5	1	1	12	8	12	4	3	NS	7	NS	10	NS
EPT Abundance	27	1	1	54	32	62	19	16	NS	26	NS	39	NS
NC Biotic Index	6.6	6.8	7.4	6.2	6.5	5.5	7.2	6.2	NS	5.8	NS	5.4	NS
Overall Rating	**Fair**	**Poor**	**Poor**	**Fair**	**Fair**	**G-F**	**Poor**	**Fair**	**NS**	**G-F**	**NS**	**G-F**	**NS**
2013 Data													
Total Taxa Richness	28	18	13	33	29	NS	NS	27	NS	35	26	39	24
EPT Taxa Richness	3	2	2	5	5	NS	NS	3	NS	10	4	11	9
EPT Abundance	3	4	13	23	27	NS	NS	21	NS	47	6	49	49
NC Biotic Index	6	7.5	7.4	6.3	6.9	NS	NS	6.3	NS	4.9	5.2	5.5	4.1
Overall Rating	**Fair**	**Poor**	**Poor**	**Fair**	**Fair**	**NS**	**NS**	**Fair**	**NS**	**Good**	**Good**	**G-F**	**Excellent**
2012 Data													
Total Taxa Richness	19	20	11	27	27	NS	NS	25	NS	38	28	24	21
EPT Taxa Richness	3	3	3	4	7	NS	NS	3	NS	11	7	6	8
EPT Abundance	3	6	23	10	29	NS	NS	14	NS	43	9	35	41
NC Biotic Index	6	7.9	7.7	6.5	6.5	NS	NS	6.4	NS	4.7	4.7	6.1	4.2
Overall Rating	**Fair**	**Poor**	**Poor**	**Fair**	**Fair**	**NS**	**NS**	**Fair**	**NS**	**Good**	**G-F**	**G-F**	**Excellent**
2011 Data													
Total Taxa Richness	NS	18	7	22	20	NS	NS	20	NS	29	24	33	21
EPT Taxa Richness	NS	3	2	1	2	NS	NS	2	NS	8	6	8	9

SITE:	Pritchard Br	Mill Race Br	Tanyard Br	Old Field Cr	Cedar Fk 1, Brookview	UT Cedar Fk 1, S of Brookview	Cedar Fk 2, Kenmore	Booker Cr 1, MLK Blvd	Booker Cr, Piney Mtn	Cole Sprgs Br	Library Br	Jolly Br	UT Bolin Cr, Severin St
EPT Abundance	NS	14	11	1	13	NS	NS	4	NS	40	6	46	33
NC Biotic Index	NS	7.7	7.2	7.6	7.3	NS	NS	7.5	NS	4.6	5.6	6.2	5.1
Overall Rating	**NS**	**Poor**	**Poor**	**Poor**	**F-P**	**NS**	**NS**	**Poor**	**NS**	**Good**	**G-F**	**G-F**	**Good**

**Orange highlighting indicates a change in rating from previous reports. See Results and Discussion section above for each individual site. NS = Not Sampled, G-F = Good-Fair, F-P = Fair-Poor*

*Table 37. Taxa richness and summary parameters for small Triassic and "Transition" streams, Chapel Hill, NC.**

SITE:	Battle Br	Fan Br	Wilson Cr 1, Wave Rd	UT Wilson, Obey Cr Dev	Wilson Cr 1a, Obey Cr Dev	Wilson Cr 2, Arlen Pk Dr	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr 2, Willow Dr
TAXA Width (m):	**2**	**2**	**2**	**1**	**2**	**4**	**5**	**5**	**5**
Ephemeroptera	-	3	8	6	8	6	3	2	1
Plecoptera	-	2	7	5	4	3	-	-	-
Trichoptera	-	4	7	11	6	4	1	5	1
Coleoptera	2	4	3	5	2	2	1	4	-
Odonata	3	2	2	2	2	4	4	-	5
Diptera; Misc.	1	2	4	4	3	5	1	2	2
Diptera: Chironomidae	10	12	17	5	8	14	11	11	10
Oligochaeta	4	3	1	2	4	2	4	5	4
Crustacea	2	-	1	2	1	-	3	2	2
Mollusca	1	2	2	2	3	5	3	3	3
Other	1	-	-	1	-	1	-	2	-
2018 Data									
Total Taxa Richness	23	35	52	44	41	44	31	36	28
EPT Taxa Richness	1	9	22	21	18	13	4	7	2
EPT Abundance	1	26	97	110	67	25	6	20	2
NC Biotic Index	6.7	5.8	4.5	4.1	4.2	5.9	7.4	6.6	8.2

SITE:	Battle Br	Fan Br	Wilson Cr 1, Wave Rd	UT Wilson, Obey Cr Dev	Wilson Cr 1a, Obey Cr Dev	Wilson Cr 2, Arlen Pk Dr	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr 2, Willow Dr
Overall Rating	**Fair**	**G-F**	**Good**	**Excellent**	**Excellent**	**Fair**	**Poor**	**Fair**	**Poor**
2017 Data									
Total Taxa Richness	39	47	35	35	50	49	36	NS	35
EPT Taxa Richness	5	13	16	18	23	20	3	NS	3
EPT Abundance	9	37	63	72	109	63	3	NS	5
NC Biotic Index	6.4	5.6	4.33	3.6	4.5	5.6	7.9	NS	7.7
Overall Rating	**Fair**	**G-F**	**Good**	**Excellent**	**Good**	**G-F**	**Poor**	**NS**	**Poor**
2015 Data									
Total Taxa Richness	NS	43	43	NS	NS	47	35	NS	27
EPT Taxa Richness	NS	14	17	NS	NS	22	4	NS	1
EPT Abundance	NS	76	68	NS	NS	122	6	NS	3
NC Biotic Index	NS	4.6	3.8	NS	NS	4.3	7.9	NS	7.3
Overall Rating	**NS**	**Good**	**Excellent**	**NS**	**NS**	**Excellent**	**Poor**	**NS**	**Poor**
2014 Data									
Total Taxa Richness	20	NS	NS	NS	NS	41	NS	NS	30
EPT Taxa Richness	4	NS	NS	NS	NS	16	NS	NS	3
EPT Abundance	10	NS	NS	NS	NS	54	NS	NS	5
NC Biotic Index	6.4	NS	NS	NS	NS	5.0	NS	NS	7.6
Overall Rating	**Fair**	**NS**	**NS**	**NS**	**NS**	**G-F**	**NS**	**NS**	**Poor**
2013 Data									
Total Taxa Richness	34	41	50	NS	NS	38	NS	NS	32
EPT Taxa Richness	4	14	20	NS	NS	11	NS	NS	2
EPT Abundance	19	65	104	NS	NS	17	NS	NS	11
NC Biotic Index	6.1	5.2	4.1	NS	NS	6.0	NS	NS	7.6
Overall Rating	**Fair**	**Good**	**Excellent**	**NS**	**NS**	**Fair**	**NS**	**NS**	**Poor**
2012 Data									
Total Taxa Richness	33	37	45	NS	NS	47	NS	NS	28
EPT Taxa Richness	6	11	23	NS	NS	19	NS	NS	2

SITE:	Battle Br	Fan Br	Wilson Cr 1, Wave Rd	UT Wilson, Obey Cr Dev	Wilson Cr 1a, Obey Cr Dev	Wilson Cr 2, Arlen Pk Dr	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr 2, Willow Dr
EPT Abundance	17	46	103	NS	NS	54	NS	NS	4
NC Biotic Index	6.0	5.7	4.0	NS	NS	5.3	NS	NS	8.1
Overall Rating	**Fair**	**Good**	**Excellent**	**NS**	**NS**	**G-F**	**NS**	**NS**	**Poor**
2011 Data									
Total Taxa Richness	17	35	NS	NS	NS	45	NS	NS	31
EPT Taxa Richness	4	14	NS	NS	NS	17	NS	NS	1
EPT Abundance	12	65	NS	NS	NS	54	NS	NS	1
NC Biotic Index	6.7	5.4	NS	NS	NS	6.0	NS	NS	8.2
Overall Rating	**Fair**	**Good**	**NS**	**NS**	**NS**	**Fair**	**NS**	**NS**	**Poor**

**Orange highlighting indicates a change in rating from previous reports. See Results and Discussion section above for each individual site. NS = Not Sampled, G-F = Good-Fair.*

Table 38. Selected intolerant species at larger Chapel Hill streams: Bolin Creek (B4, B5) and Morgan Creek (M1, M2), June 2012-July 2018.

	June 2012				June 2013				June 2014				June 2015				July 2016			July 2017				July 2018			
Taxon	**B4**	**B5**	**MI**	**M2**	**B4**	**B5**	**MI**	**M2**	**B4**	**B5**	**MI**	**M2**	**B4**	**B5**	**MI**	**M2**	**B4**	**B5**	**M2**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**
Leucrocuta aphrodite	-	-	A	-	-	-	A	-	-	-	A	-	-	-	A	-	-	-	-	-	-	A	-	-	-	A	-
Isonychia spp	-	-	R	C	-	-	-	-	-	-	A	-	-	-	A	-	-	-	C	-	-	C	A	-	-	-	A
Aconeuria abnormis	R	-	C	-	-	-	-	-	R	-	C	-	C	-	A	-	C	-	-	R	-	A	R	A	R	A	-
Perlesta sp	-	-	C	-	-	-	A	-	-	-	C	-	-	-	A	R	-	-	-	-	-	A	-	-	-	A	-
Chimarra sp	C	A	-	C	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	R	A
Neophylax oligius	-	-	-	-	-	-	-	-	-	-	A	R	-	-	A	-	-	-	-	-	-	R	-	-	-	R	-
Paraleptophlebia sp	-	-	R	-	-	-	C	-	-	-	-	-	-	-	R	-	-	-	-	-	-	R	-	-	-	-	-
Habrophlebia vibrans	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus herricki	C	-	C	C	A	-	A	R	A	R	A	-	A	R	A	R	A	R	-	A	R	A	-	-	-	A	R
Elimia sp	-	-	-	-	R	R	-	-	R	-	-	-	A	-	C	-	C	R	-	C	-	C	-	C	-	-	-
Sum*	7	10	21	9	22	11	46	11	22	11	56	11	33	11	74	12	26	12	13	24	11	58	21	23	11	42	21

**Rare = 1, Common = 3, and Abundant = 10. Taxa must be Common or Abundant at one or more sites.*

Table 39. Selected intolerant species (Tolerance Value < 3.4) at smaller Chapel Hill streams, April 2018.

Taxon	Booker Cr abv MLK Blvd	Booker Cr Piney Mtn	Booker Cr abv Tadley Grnwy	Booker Cr bel Tadley Grnwy	Booker Cr Willow Dr	Cedar Fk 2 Kenmore Dr	UT Cedar Fk S Brookview	Cedar Fk 1 Brookview	Jolly Br	UT Bolin at Severin St	Tanyard Br	Mill Race Br	Cole Spgs Br Cedar St	Library Br	Battle Br	Old Field Cr	Morgan Cr NC 54	Pritchard Br	Fan Br	Wilson Cr 1 Wave Rd	UT Wilson At Obey Cr Dev	Wilson Cr 1a at Obey Cr Dev	Wilson Cr 2 Arlen Pk Dr
Acroneuria abnormis	-	-	-		-	-	-	-	-	-	-	-	-		-	-	A	-	-	R	-	-	-
Chimarra spp	A	C	-	C	-	-	-	-	-	-	-	-	R	C	-	-	R	C	-	R	C	R	R
Diplectrona modesta	-	-	-		-	-	-	-	R	-	-	3	R	R	-	-	-	C	C	R	C	-	-
Lepidostoma	-	-	-		-	-	-	-	-	-	-	-		A	-	-	R	-	C	A	A	R	-
Neophylax sp	-	-	-		-	-	C	-	-	A	-	-	A	A	-	-	R	-	-	C	C	A	-
Dixa sp	-	-	-		-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
Anchytarsus bicolor	-	-	-		-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	C	-	-
Helichus sp	R	-	-	R	-	-	-	-	C	-	-	R	-	R	R-	R	R	R	R	C	C	-	C
Optioservus ovalis	-	-	-		-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-
Psephenus herricki	-	-	-		-	C	-	A	R	-	-	-	C		-	-	A	-	-	C	C	A	R
Elimia sp	A	-	-		-	-	-	-	-	-	-	-	A	R	-	-	-	A	-	A	A	C	C
Sum*	**21**	**3**	**0**	**4**	**0**	**3**	**3**	**10**	**5**	**10**	**0**	**4**	**25**	**26**	**1**	**1**	**24**	**17**	**7**	**32**	**38**	**25**	**7**

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

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Appendix 1. Benthic macroinvertebrates collected from Bolin Creek (B4, B4a, B5) and Morgan Creek (M1, M1a, M1b, M2), Chapel Hill, June 2015-July 2018.

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
EPHEMEROPTERA																	
Baetis flavistriga (summer)	A	A	C	A	A	A	C	A	A	C	A	-	C	A	C	C	A
Baetis intercalaris (summer)	-	-	-	C	R	-	A	-	R	A	-	-	-	-	C	C	A
Baetis pluto	-	-	A	A	R	R	A	-	-	C	-	-	R	A			R
Acentrella spp	-	-	-	R	-	-	R	-	-	-	-	-	-	-	-	-	A
Acerpenna pygmea	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diphetor hageni	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Heterocloeon amplum	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-
Centroptilum triangulifer	R	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Paracloeodes minutus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-
Plauditus dubiatus	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-
Procloeon sp	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Labiobaetis propinquus	-	R	-	-	-	-	-	-	R	R	-	-	R	-	R	-	-
Maccaffertium modestum	A	C	A	A	A	A	A	A	A	A	A	C	A	R	A	A	A
Stenonema femoratum	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenacron interpunctatum	A	R	A	C	A	C	-	C	R	R	A	-	R	R	-	-	-
Stenacron pallidum	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-
Leucrocuta aphrodite	-	-	A	-	-	-	-	-	-	-	-	-	-	A	-	-	-
Caenis spp	-	-	-	R	-	-	R	-	-	-	-	-	-	A	R	-	-
Tricorythodes sp	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
Danella simplex	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Ephemerella dorothea	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Eurylophella enoensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eurylophella verisimilis	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-
Isonychia spp	-	-	A	-	-	-	C	-	-	A	-	-	-	-	-	-	A
Paraleptophlebia sp	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Habrophlebia vibrans	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hexagenia sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLECOPTERA																	
Acroneuria abnormis	C	-	A	-	C	-	-	R	-	R	A	C	R	A	-	-	-
Eccoptura xanthines	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Perlesta sp	-	-	A	R	-	-	-	-	-	-	-	-	-	A	-	-	-
Neoperla sp	-	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clioperla clio	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Amphinemoura sp	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-
Isoperla kerchneri	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-
Leuctra sp	-	-	R	-	-	-	-	-	-	-	-	-	-	R	-	-	-
TRICHOPTERA																	
Cheumatopsyche spp	A	A	A	A	A	A	A	A	C	A	A	A	A	R	A	A	A
Hydropsyche betteni	A	A	A	A	A	A	A	A	A	A	A	A	A	R	A	A	A
Chimarra sp	A	A	A	A	A	A	A	A	A	A	A	R	A	R	C	A	A
Polycentropus sp	-	-	C	R	-	-	C	-	-	C	-	-	-	-	C	C	A
Phylocentropus sp	R	-	-	R	C	-	-	-	-	-	-	-	-	-	-	-	-
Nyctiophylax sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroptila sp	R	-	R	-	-	-	R	-	-	R	-	-	-	R	R	R	R
Lepidostoma sp	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
Neophylax atlanta	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Neophylax oligius	-	-	A	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Pycnopsyche sp	-	-	R	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Rhyacophila fenestra/ledra	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-
Rhyacophila glaberrima	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Ceraclea ancylus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceraclea spongillovorax	-	-	-	-	-	-	-	-	-	R	-	-	-	C	-	-	-
Ceraclea transversa	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Oecetis sp A	-		-	-	-	-	C	-	-	-	-	-	-	-	R	-	-
Oecetis sp F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oecetis cinerascens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oecetis persimilis	-	-	-	-	-	-	-	-	-	R	-	-	R	-	R	R	C
Triaenodes ignitus	R	R	-	A	C	-	C	C	-	A	C	R	R	-	C	C	A
Triaenodes injustus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R
Triaenodes perna/helo	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mystacides supulchralis	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Nectopsyche exquisita	R	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
COLEOPTERA																	
Anyronyx variegatus	-	-	-	-	-	R	R	-	R	-	-	-	-	-	-	-	R
Microcyllopus pusillis	-	-	-	-	-	R	-	-	-	R	-	-	C	-	-	C	C
Macronychus glabratus	-	R	-	-	C	R	C	-	C	C	R	R	A	-	-	R	A
Dubiraphia sp	-	-	-	-	C	R	C	R	R	R	R	-	A	-	R	R	C
Stenelmis spp	C	C	-	-	C	A	A	C	C	C	R	C	A	C	A	A	A
Ectopria nervosa	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Psephenus herricki	A	R	-	-	A	R	-	A	R	-	-	C	-	A	-	-	R

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
Helichus spp	-	-	-	-	R	-	R	-	-	R	R	R	A	R	-	R	R
Copelatus sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R
Coptotomus sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neoporus sp	-	-	-	-	-	R	R	R	-	R	-	R	-	-	-	A	C
Neoporus mellitus gr	-	-	-	-	-	-	C	-	-	-	R	-	-	-	R	C	C
Enochrus sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-
Peltodytes sp	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
ODONATA																	
Argia spp	C	A	-	-	R	R	A	C	R	C	-	C	A	R	A	A	A
Calopteryx sp	-	R	-	-	R	R	C	C	C	C	-	C	A	R	-	R	R
Enallagma spp	-	C	-	-	-	-	R	-	R	C	R	R	C	-	A	A	-
Ischnura sp	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gomphus sp	-	-	-	-	-	-	A	-	-	R	-	R	-	-	-	C	C
Hagenius brevistylus	R	-	-	-	-	-	-	R	R	C	R	-	R	-	-	-	R
Progomphus obscurus	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	R	-
Stylogomphus albistylus	R	R	-	-	R	C	-	-	R	R	-	-	R	-	-	-	-
Macromia sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R
Libellula sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pachydiplax longipennis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Perithemis	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	C	-
Neurocordulia sp	-	-		-	-	-	-	-	-	-	-	-	-	-	R	R	-
Somatochlora sp	R	R	-	-	R	C	R	R	-	-	C	C	R	-	C	-	-
Boyeria vinosa	C	C	-	-	-	-	C	C	-	C	C	R	A	-	R	C	A
Basiaeshna janata	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
MEGALOPTERA																	
Sialis sp	R	-	-	-	R	-	A	-	-	-	-	-	-	-	C	A	A

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
Corydalus cornutus	-	-	-	-	-	-	A	-	R	A	-	-	C	R	C	A	A
DIPTERA: MISC.																	
Antocha spp	-	R	-	-	C	R	C	R	C	C	R	-	C	R	R	C	C
Hexatoma sp	-	-	-	-				-	-	-	-	-	-	-	-	R	-
Tipula spp	C	R	-	-	A	C	C	C	R	-	C	C	C	C	A	C	C
Palpomyia complex	-	-	-	-	-	R	R	-	-	-	-	-	-	C	R	C	-
Polymeda/Ormosa	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-
Simulium spp	A	A	-	-	A	A	-	C	C	C	A	A	A	A	R	R	A
Dixella sp	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-
Anopheles sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Forcipiomyia	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
Odontomyia	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
DIPTERA: CHIRONOMIDAE																	
Ablabesmyia janta/parajanta	C	R	-	-	-	-	R	-	-	-	-	-	-	R	-	-	-
Ablabesmyia ramphe gp	-	-	-	-	-	-	-	-	-	-	C	R	-	-	R	C	C
Ablabesmyia mallochi	C	A	-	-	-	-	C	-	C	C	C	C	C	R	R	C	C
Clinotanypus sp	-	-	-	-				-	-	-	-	-	-	-	R	R	R
Conchapelopia group	C	A	-	-	-	R	A	C	C	A	C	C	A	C	A	A	A
Labrundinia pilosella	-	R	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Natarsia spp	-	R	-	-	-	A	R	-	-	-	-	-	-	R	-	R	-
Nilotanypus sp	-	-	-	-	-	R	R	-	R	R	-	-	R	-	R	C	C
Procladius sp	-	R	-	-	-	-	R	-	-	C	-	-	-	-	-	-	-
Cardiocladius sp	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Corynoneura spp	-	-	-	-	-	A	-	-	-	R		R	C	R	R	C	C
Thienemaniella spp	-	-	-	-	-	A	-	-	-	-	C	R	C	-	C	-	R

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
Zavrelimyia spp	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-
Potthastia longimana	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
Brillia sp	-	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cardiocladius obscurus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus annulator	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-
Cricotopus bicinctus	R	-	-	-	-	C	-	R	R	-	-	-	R	R	-	-	-
Cricotopus cylindraceus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-
Cricotopus fugax	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-
Cricotopus infuscatus	-	-	-	-	-	R	-	R	R	-	R	-	-	-	R	R	A
Cricotopus patens	-	-	-	-	-	-	-	-	R	C	-	-	-	-	-	-	-
Cricotopus sp	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-
Cricotopus triannulatus gr	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-
Cricotopus vierriens gp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	C	C
Eukiefferiella claripennis gr	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-
Nanocladius spp	-	-	-	-	-	-	R	-	-	R	R	-	-	-	R	R	R
Orthocladiius carlatus	-	-	-	-	-	-	-	R	R	R	R	R	-	-	-	-	-
Orthocladius dorenus	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-
O. (Eud.) dubitatus	-	-	-	-	-	-	-	-	R	R	R	-	-	-	-	-	-
Orthocladius robacki	-	-	-	-	-	-	-	-	R	-	-	R	-	C	-	-	-
Orthocladius rubicundus	-	-	-	-	-	-	-	-	-	-	-	-	-	A	-	-	-
Pagastiella sp	-	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-
Parametriocnemus lundbecki	R	R	-	-	-	-	-	-	-	-	R	R	C	A	-	-	-
Rheocricotopus robacki	-	-	-	-	-	-	-	-	R	-	-	R	R	-	R	-	-
Synorthocladius sp	-	-	-	-	-	R	-	-	-	R	C	-	R	-	-	-	-

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
Tvetenia bavarica gr	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-	-
Tvetenia vitraces	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-
Xylotopus par	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-
Chironomus sp	R	C	-	-	-	R	-	-	R	-	-	R		R	-	-	-
Cryptochironomus fulvus	-	R	-	-	R	-	C	-	-	C	-	-	R	-	C	C	R
Cryptotendipes sp	-	-	-	-	-	-	-	-	-	-	-	-	-	R	R	-	R
Dicrotendipes neomodestus	R	-	-	-	C	C	C	-	C	C	A	-	C	-	R	C	C
Microtendipes pedellus	C	C	-	-	A	C	A	-	R	R	A	C	A	-	R	A	C
Nilothauma sp	-	-	-	-				-	-	-	-	-	-	-	R	R	R
Parachironomus carinatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Paracladopelma sp	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-
Paratendipes sp	R	C	-	-	R	A	-	-	-	-	-	A	-	R	-	-	-
Phaenopsectra spp	R	C	-	-	C	-	-	-	R	R	R	C	R	-	-	R	R
Phaenopsectra flavipes gr	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum flavum	R	-	-	-	C	C	A	C	A	A	C	C	A	A	A	A	A
Polypedilum illinoense gr	-	R	-	-	R	R	-	C	-	R	-	C	A	A	R	C	C
Polypedilum fallax	-	R	-	-	-	-	-	-	-	-	-	-	-	R	R	-	-
Polypedilum halterale gr	-	-	-	-	-	-	-	R	R	R	C	-	-	R	-	R	-
Polypedilum scalaenum gr	C	C	-	-	R	R	R	-	-	-	-	-	R	-	C	C	C
Polypedilum ontario	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	R	-
Pseudochironomus sp	R	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	C
Stenochironomus sp	-	-	-	-	-	C	-	-	R	-	C	-	-	-	-	C	R
Stictochironomus devinctus	-	-	-	-	C	-	-	-	-	-	C	-	-	-	-	-	-

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
Tribelos sp	A	C	-	-	A	A	-	R	C	R	C	A	-	-	C	C	R
Xenochironomus xenolabis	-	R	-	-	-	R	A	-	-	-	R	-	R	-	-	-	-
Cladotanytarsus sp	-	-	-	-	-	-	C	-	-	-	-	-	-	-	-	-	R
Rheotanytarsus spp	-	-	-	-	R	R	C	C	R	C	-	R	C	-	A	C	C
Paratanytarsus sp	-	-	-	-	R	-	-	-	R	-	-	R	C	-	-	-	-
Tanytarsus spp	R	C	-	-	-	C	A	R	C	R	A	C	C	C	A	A	R
OLIGOCHAETA																	
Limnodrilus spp	R	R	-	-	C	-	R	-	-	-	R	R	-	-	A	-	-
Ilyodrilus templetoni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	C	R
Allonais	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-
Nais spp	-	-	-	-	-	-	R	-	-	-	-	-	R	C	R	-	R
Stylaria lacustris	R	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Slavinia appendiculata	-	-	-	-	-	-	-	R	-	R	-	-	-	R	-	-	R
Ecclipidrilus spp	-	C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lumbriculus variegatus	C	-	-	-	A	A	C	A	C	C	A	A	A	R	A	A	A
Cambarinicolidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CRUSTACEA																	
Crangonyx spp	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-
Hyallela azteca	R	-	-	-	R	-	-	-	-	-	-	-	-	R	-	-	-
Caecidotea sp	-	-	-	-	R	C	-	-	-	-	-	R	R	-	R	-	C
Cambarus spp	C	C	-	-	C	-	A	C	R	R	C	R	R	C	R	R	C
Procambarus acutus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOLLUSCA																	
Elimia sp	A	-	-	-	C	R	-	C	-	-	C	C	-	-	-	-	-
Campeloma decisum	-	-	-	-	C	-	-	-	-	-	-	-	-	-	-	-	-

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
Physa sp	R	R	-	-	R	-	R	-	R	-	C	R	A	C	A	A	R
Stagnicola sp?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helisoma anceps	C	-	-	-	-	-	R	-	-	-	C	A		C	-	C	-
Menetus dilatus	-	-	-	-	C	-	R	-	-	R	R	R	A	-	-	R	R
Ferrissia sp	R	-	-	-	-	R	R	C	-	C	R	C	R	C	-	R	R
Pseudosuccinea columella	-	-	-	-	-	-	-	-	-	-	-	-	C	-	R	R	R
Laevapex fuscus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	C	-	-
Musculium sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-
Pisidium spp	-	-	-	-	-	R	-	-	-	-	R	-	-	-	-	C	-
Sphaerium	-	-	-	-	-	-	A	-	-	C	-	-	-	-	A	A	R
Corbicula fluminea	-	-	-	-	R	R	A	-	-	A	R	C	-	-	C	C	A
OTHER - TURBELLARIA																	
Dugesia tigrina	-	-	-	-	C	R	R	C	R	R	-	-	A	R	A	C	C
Cura foremanii	A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrolimax grisea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHER - HEMIPTERA								-	-	-							
Aquarius sp	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-	-
Corixidae	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rhagovelia sp	-	-	-	-	-	-	-	-	-	R	-	R	-	-	-	-	-
Ranatra sp	R	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHER - HIRUDINEA																	
Actinobdella pediculata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-
Desserobdella picta	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-	-	-
Gloiobdella elongata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-
Desserobdella phalerata	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-	-	-

YEAR	Jun-15				Jul-16			Jul-17			Jul-18						
TAXA / SITE	B4	B5	M1	M2	B4	B5	M2	B4	B5	M2	B4	B4A	B5	M1	M 1A	M 1B	M2
Helobdella triserialis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-
Placobdella papillIfera	-	-	-	-	-	R	-	-	-	-	-	-	-	-	-	-	-
Placobdella parasitica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-
Erpobdella/Mooreobdella	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHER																	
Neuroptera: Climacia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gordius sp	-	-	-	-	-	-	-	-	-	-	-	-	-	-	R	-	-
Prostoma graecens	-	R	-	-	-	-	-	-	-	R	-	R	-	-	-	-	-
Hydracarina	-	-	-	-	R	R	-	R	A	C	C	C	C	R	A	A	-
Porifera	-	-	-	-	-	-	-	-	-	C	-	-	-	-	-	-	C

**R=Rare, C=Common, A=Abundant*

NOTE: Morgan Creek 1 and 2 collections in 2015 were limited to the most intolerant (EPT) groups.

Appendix 1A. Benthic macroinvertebrates collected from Bolin Creek (B4, B5) and Morgan Creek (M1, M2), Chapel Hill, June 2012-June 2014.

YEAR	Jun-12				Jun-13				Jun-14			
TAXA / SITE	B4	B5	M1	M2	B4	B5	M1	M2	B4	B5	M1	M2
EPHEMEROPTERA												
Baetis flavistriga (summer)	A	A	-	A	A	A	C	C	A	A	R	A
Baetis intercalaris (summer)	-	R	R	A	-	-	-	-	-	R	-	A
Baetis pluto	-	-	-	-	-	-	-	-	R	-	A	A
Acentrella spp	-	-	-	R	-	-	-	-	-	-	-	C
Acerpenna pygmea	-	-	-	-	-	-	-	-	-	-	-	-
Diphetor hageni	-	-	-	-	-	-	-	-	-	-	-	-
Heterocloeon amplum	-	-	-	-	-	-	-	-	-	-	-	-
Centroptilum triangulifer	-	-	R	-	-	-	-	-	-	-	R	-
Paracloeodes minutus	-	-	-	-	-	-	-	-	-	-	-	-
Plauditus dubiatus	-	-	-	-	-	-	-	-	-	-	-	-
Procloeon sp	-	-	-	-	-	-	-	-	-	-	R	R
Labiobaetis propinquus	-	-	-	-	-	-	-	-	-	-	C	C
Maccaffertium modestum	A	C	A	A	C	-	A	A	A	A	A	A
Stenonema femoratum	-	-	C	-	-	-	A	-	-	-	R	-
Stenacron interpunctatum	C	-	-	A	A	-	A	C	A	C	A	C
Stenacron pallidum	-	-	-	-	-	-	R	-	-	-	-	-
Leucrocuta aphrodite	-	-	A	-	-	-	A	-	-	-	A	-
Caenis spp	-	-	-	-	-	-	C	-	-	-	-	A
Tricorythodes sp	-	-	-	-	-	-	-	-	-	-	-	-
Danella simplex	-	-	-	-	-	-	-	-	-	-	-	-
Ephemerella dorothea	-	-	-	-	-	-	-	-	-	-	-	-
Eurylophella enoensis	-	-	-	-	-	-	-	-	-	-	-	-

YEAR	Jun-12				Jun-13				Jun-14			
TAXA **SITE**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**
Eurylophella verisimilis	-	-	-	-	-	-	-	-	-	-	-	-
Isonychia spp	-	-	R	C	-	-	-	-	-	-	A	-
Paraleptophlebia sp	-	-	R	-	-	-	C	-	-	-	-	-
Habrophlebia vibrans	-	-	-	-	-	-	C	-	-	-	-	-
Hexagenia sp	-	-	-	-	-	-	R	-	-	-	-	-
PLECOPTERA												
Acroneuria abnormis	R	-	C	-	-	-	-	-	R	-	C	-
Eccoptura xanthines	-	-	-	-	-	-	-	-	-	-	-	-
Perlesta sp	-	-	C	-	-	-	A	-	-	-	C	-
Neoperla sp	-	-	-	-	-	-	-	-	-	-	-	-
Clioperla clio	-	-	-	-	-	-	-	-	-	-	-	-
Amphinemoura sp	-	-	-	-	-	-	-	-	-	-	-	-
Isoperla kerchneri	-	-	-	-	-	-	-	-	-	-	-	-
Leuctra sp	-	-	-	-	-	-	-	-	-	-	-	-
TRICHOPTERA												
Cheumatopsyche spp	A	A	A	A	A	A	A	A	A	C	A	A
Hydropsyche betteni	A	-	-	A	A	A	R	A	A	A	A	A
Chimarra sp	C	A	-	C	A	A	A	C	A	A	A	A
Polycentropus sp	-	-	R	-	-	-	-	R	-	-	C	R
Phylocentropus sp	-	-	-	-	-	-	-	-	-	-	-	-
Nyctiophylax sp	-	-	-	-	-	-	-	-	-	-	-	-
Hydroptila sp	-	-	-	-	-	-	-	-	R	R	-	R
Lepidostoma sp	-	-	-	-	-	-	-	-	-	-	-	-
Neophylax atlanta	-	-	-	-	-	-	-	-	-	-	-	-
Neophylax oligius	-	-	-	-	-	-	-	-	-	-	A	R
Pycnopsyche sp	-	-	-	-	-	-	-	-	-	-	-	-

YEAR	Jun-12				Jun-13				Jun-14			
TAXA **SITE**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**
Rhyacophila fenestra/ledra	-	-	-	-	-	-	-	-	-	-	-	-
Rhyacophila glaberrima	-	-	-	-	-	-	-	-	-	-	-	-
Ceraclea ancylus	-	-	-	-	-	-	-	-	-	-	-	-
Ceraclea spongillovorax	-	-	-	-	-	-	-	-	-	-	-	-
Ceraclea transversa	-	-	-	-	-	-	-	-	-	-	-	-
Oecetis sp A	R	-	-	-	-	-	-	-	-	-	-	-
Oecetis sp F	-	-	-	-	-	-	-	-	-	-	-	-
Oecetis cinerascens	-	-	-	-	-	-	-	-	-	-	-	-
Oecetis persimilis	-	-	-	-	-	-	-	-	-	-	-	R
Triaenodes ignitus	-	-	-	-	-	-	-	R	R	-	-	C
Triaenodes injustus	-	-	-	-	-	-	-	-	-	-	-	-
Triaenodes perna/helo	-	-	-	-	-	-	-	-	-	-	-	-
Mystacides supulchralis	-	-	-	-	-	-	-	-	-	-	-	-
Nectopsyche exquisita	-	-	-	-	-	-	-	-	-	-	-	-
COLEOPTERA												
Anyronyx variegatus	-	-		-	-	-		-	-	-		-
Microcyllopus pusillis	-	-		-	-	-		-	-	-		-
Macronychus glabratus	-	R		-	-	-		-	-	-		-
Dubiraphia sp	R	-		-	R	R		-	R	-		-
Stenelmis spp	A	C		C	C	A		A	A	A		C
Ectopria nervosa	-	-		-	-	-		-	-	-		-
Psephenus herricki	C	-		C	A	-		R	A	R		-
Helichus spp	R	R		-	R	R		-	R	-		R
Copelatus sp		-		-	-	-		-	-	-		-
Coptotomus sp	-	-		-	-	-		-	R	-		-
Neoporus sp	-	-		-	R	-		R	A	-		R

YEAR	Jun-12				Jun-13				Jun-14			
TAXA **SITE**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**
Neoporus mellitus gr	-	-		R	R	-		R	-	-		R
Enochrus sp		-		-	-	-		-	-	-		-
Peltodytes sp	R	-		-	-	-		-	-	-		-
ODONATA												
Argia spp	-	C		A	-	A		A	C	A		A
Calopteryx sp	-	-		-	-	-		-	-	-		-
Enallagma spp	-	R		-	R	R		-	C	R		-
Ischnura sp	-	-		-	-	-		-	-	-		-
Gomphus sp	-	-		-	-	-		-	R	-		-
Hagenius brevistylus	-	-		-	-	-		-	R	-		-
Progomphus obscurus	-	R		R	-	-		-	-	-		-
Stylogomphus albistylus	-	R		-	-	R		-	R	R		-
Macromia sp	-	-		-	-	-		-	-	-		R
Libellula sp	R	-		-	-	-		-	-	-		-
Pachydiplax longipennis	R	-		-	-	-		R	-	-		-
Perithemis	-	-		-	-	-		-	-	-		-
Neurocordulia sp	-	-		-	-	-		-	-	-		-
Somatochlora sp	R	R		-	-	-		-	C	A		-
Boyeria vinosa	-	-		-	-	R		-	-	-		C
Basiaeshna janata	-	-		-	-	-		-	-	C		R
MEGALOPTERA												
Sialis sp	R	-		-	-	-		-	-	-		C
Corydalus cornutus	-	-		-	-	-		C	-	-		C
DIPTERA: MISC.												
Antocha spp	-	-		R	R	-		C	-	-		C
Hexatoma sp	-	-		-	-	-		-	-	-		-

YEAR	Jun-12				Jun-13				Jun-14			
TAXA **SITE**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**
Tipula spp	C	C		C	C	C		A	C	C		-
Palpomyia complex	-	-		-	-	-		-	-	-		R
Polymeda/Ormosa	-	-		-	-	-		-	-	-		-
Simulium spp	A	A		A	A	A		A	A	A		A
Dixella sp	-	-		-	-	-		-	-	-		-
Anopheles sp	-	-		-	-	-		-	-	-		-
Forcipiomyia	-	-		-	-	-		-	-	-		-
Odontomyia	-	-		-	-	-		-	-	-		-
DIPTERA: CHIRONOMIDAE												
Ablabesmyia janta/parajanta	R	-		-	-	-		R	-	-		-
Ablabesmyia ramphe gp	-	-		-	-	-		-	-	-		-
Ablabesmyia mallochi	C	R		R	-	-		R	R	C		C
Clinotanypus sp	-	-		-	-	-		-	-	-		-
Conchapelopia group	R	R		C	C	C		A	R	R		C
Labrundinia pilosella	-	-		-	-	-		R	-	-		-
Natarsia spp	R	C		-	-	-		R	-	-		R
Nilotanypus sp	-	R		-	-	R		-	R	-		R
Procladius sp	C	-		-	-	-		-	-	-		-
Cardiocladius sp	-	-		-	-	-		R	-	R		C
Corynoneura spp	-	-		-	-	R		-	R	R		-
Thienemaniella spp	R	-		R	-	-		R	-	-		R
Zavrelimyia spp	-	-		-	-	-		-	-	-		-
Potthastia longimana	-	-		-	-	-		-	-	-		-
Brillia sp	-	-		-	R	-		R	-	-		-
Cardiocladius obscurus	-	-		-	-	-		-	-	-		-
Cricotopus annulator	-	-		-	R	-		-	-	-		-

YEAR	Jun-12				Jun-13				Jun-14			
TAXA / SITE	B4	B5	M1	M2	B4	B5	M1	M2	B4	B5	M1	M2
Cricotopus bicinctus	C	-		R	-	-		-	C	-		-
Cricotopus cylindraceus	-	-		-	-	-		-	-	-		-
Cricotopus fugax	-	-		-	-	-		-	-	-		-
Cricotopus infuscatus	-	-		-	-	-		-	-	-		-
Cricotopus patens	-	-		-	-	-		-	-	-		-
Cricotopus sp		-		-	-	-		-	-	-		-
Cricotopus triannulatus gr	R	-		-	-	R		-	R	-		R
Cricotopus vierriens gp	-	-		-	-	-		-	-	-		-
Eukiefferiella claripennis gr	R	-		-	-	C		-	-	R		-
Nanocladius spp	-	-		-	-	-		C	-	R		R
Orthocladiius carlatus	-	-		-	-	-		-	-	-		-
Orthocladius dorenus	-	-		-	-	-		-	-	-		-
O. (Eud.) dubitatus	-	R		-	-	-		-	R	-		-
Orthocladius robacki	-	-		-	-	-		-	-	-		-
Orthocladius rubicundus		-		-	-	-		-	-	-		-
Pagastiella sp	-	-		-	-	-		-	-	-		-
Parametriocnemus lundbecki	-	R		-	A	A		C	-	C		-
Rheocricotopus robacki	-	-		-	-	-		R	-	-		-
Synorthocladius sp	R	-		-	-	-		-	R	R		R
Tvetenia bavarica gr	-	-		-	-	C		-	-	-		-
Tvetenia vitraces		-		-	-	-		-	-	-		-
Xylotopus par	-	-		-	-	-		-	-	-		-
Chironomus sp	-	-		-	-	-		-	-			R
Cryptochironomus fulvus	-	R		R	-	-		R	-	C		R
Cryptotendipes sp	-	-		R	-	-		-	-	R		-
Dicrotendipes neomodestus	R	-		C	-	-		R	R	C		-

YEAR	Jun-12				Jun-13				Jun-14			
TAXA **SITE**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**
Microtendipes pedellus	-	-		-	C	C		R	C	C		R
Nilothauma sp		-		-	-	-		-	-	-		-
Parachironomus carinatus	-	-		-	-	-		-	-	-		-
Paracladopelma sp	-	-		-	-	-		-	-	-		-
Paratendipes sp	-	R		-	-	R		R	A	C		-
Phaenopsectra spp	R	C		-	-	-		R	R	A		-
Phaenopsectra flavipes gr	R	-		-	-	R		-	R	-		-
Polypedilum flavum	A	A		A	A	C		A	C	-		A
Polypedilum illinoense gr	-	-		R	-	C		A	-	A		R
Polypedilum fallax	-	-		-	-	R		-	-	-		-
Polypedilum halterale gr	-	C		-	-	-		-	-	-		-
Polypedilum scalaenum gr	C	-		R	R	-		-	C	A		-
Polypedilum ontario	-	-		-	-	-		-	-	-		-
Pseudochironomus sp	-	-		-	-	-		-	-	-		-
Stenochironomus sp	R	-		-	-	-		R	-	-		-
Stictochironomus devinctus	-	-		-	-	-		-	-	-		-
Tribelos sp	C	-		R	R	R		-	C	-		-
Xenochironomus xenolabis	-	-		-	-	R		-	-	-		R
Cladotanytarsus sp	-	-		-	-	-		-	-	R		-
Rheotanytarsus spp	-	-		R	R	-		C	C	C		C
Paratanytarsus sp	R	-		-	R	-		-	-	C		-
Tanytarsus spp	C	R		C	-	C		C	-	A		-
OLIGOCHAETA												
Limnodrilus spp	C	A		-	-	-		R	-	R		-
Ilyodrilus templetoni	-	-		-	-	-		-	-	R		-
Allonais	-	-		-	-	-		-	-	-		-

YEAR	Jun-12				Jun-13				Jun-14			
TAXA **SITE**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**	**B4**	**B5**	**M1**	**M2**
Nais spp	-	-		-	-	R		-	R	C		R
Stylaria lacustris	-	-		-	-	R		-	-	-		R
Slavinia appendiculata	-	-		-	-	-		-	R	R		-
Ecclipidrilus spp	-	-		-	-	-		-	-	-		R
Lumbriculus variegatus	-	-		-	C	R		-	R	C		-
Cambarinicolidae	-	-		-	-	-		-	R	R		-
CRUSTACEA												
Crangonyx spp	R	-		R	-	-		-	-	-		-
Hyallela azteca	A	-		R	R	-		A	C	-		C
Caecidotea sp	C	-		R	R	-		R	R	-		-
Cambarus spp	-	A		-	-	C		C	C	C		C
Procambarus acutus	-	-		-	-	-		-	-	-		R
MOLLUSCA												
Elimia sp	-	-		-	R	R		-	R	-		-
Campeloma decisum	R	-		-	-	-		-	-	-		-
Physa sp	A	-		C	C	-		R	R	C		R
Stagnicola sp?	R	-		-	-	-		-	-	-		-
Helisoma anceps	C	-		C	-	-		R	R	-		-
Menetus dilatus	-	-		-	-	-		-	-	-		-
Ferrissia sp	-	-		-	R	C		-	-	-		-
Pseudosuccinea columella	-	-			-	-		-	-	-	-	-
Laevapex fuscus	-	-		-	-	-		R	-	-		C
Musculium sp	-	-			-	-		-	-	-		-
Pisidium spp	R	-		-	-	-		-	-	-		-
Sphaerium	-	-		-	-	-		-	-	-		-
Corbicula fluminea	A	-		A	-	-		A	-	-		R

YEAR	Jun-12				Jun-13				Jun-14			
TAXA / SITE	B4	B5	M1	M2	B4	B5	M1	M2	B4	B5	M1	M2
OTHER - TURBELLARIA												
Dugesia tigrina	R	-		R	-	-		-	-	R		C
Cura foremanii	-	-		-	A	R		-	C	R		-
Hydrolimax grisea	-	-		-	-	-		-	-	-		R
OTHER - HEMIPTERA												
Aquarius sp	-	-		-	-	-		-	-	-		-
Corixidae	R	-		-	-	-		-	-	-		-
Rhagovelia sp	-	-		-	-	-		-	-	-		-
Ranatra sp	-	-		-	-	-		-	-	-		-
OTHER - HIRUDINEA												
Actinobdella pediculata	-	-		-	-	-		-	-	-		-
Desserobdella picta	-	-		-	-	-		-	-	-		-
Gloiobdella elongata	-	-		-	-	-		-	-	-		-
Desserobdella phalerata	-	-		-	-	-		-	-	-		-
Helobdella triserialis	R	-		-	-	-		-	-	-		-
Placobdella papillIfera	-	-		-	-	R		-	-	-		-
Placobdella parasitica	-	-		-	-	-		-	R	-		-
Erpobdella/Mooreobdella	-	-		-	-	-		-	-	-		-
OTHER												
Neuroptera: Climacia	-	-		-	-	-		-	-	-		C
Gordius sp	-	-		-	-	-		-	-	-		-
Prostoma graecens	-	-		-	-	-		-	-	-		-
Hydracarina	-	-		-	-	-		-	-	-		-
Porifera	-	-		-	-	-		-	-	-		-

**R=Rare, C=Common, A=Abundant*

NOTE: Morgan Creek 1 collections in 2012-2014 are limited to the most intolerant (EPT) groups; grey cells indicate other taxa that were not sampled in those years.

Appendix 2A. Benthic macroinvertebrates collected at small streams in Chapel Hill, April 2018: Booker Creek and Cedar Fork sites.*

Site: / Taxa / Biotic Index Value	Booker Cr, abv MLK Jr	Booker Cr, Piney Mtn	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr, Willow	Cedar Fk, Kenmore	UT Cedar Fk, S Brookview	Cedar Fk, Brookview
EPHEMEROPTERA								
Family Baetidae								
Baetis flavistriga (6.8)	-	A	R	C	-	-	-	A
Plauditus dubius (2.2)	-	-	-	-	-	-	-	R
Family Caenidae								
Caenis spp (6.8)	-	-	R	-	-	-	-	-
Family Heptageniidae								
Maccaffertium modestum (5.7)	A	A	C	R	R	-	-	R
Stenacron pallidum (2.8)	R	-	-		-	-	-	-
Family Leptophlebiidae								
Paraleptophlebia spp (1.2)	-	-	-		-	-	R	R
PLECOPTERA								
Family Chloroperlidae								
Haploperla brevis	-	-	-		-	-	C	R
Family Leuctridae								
Leuctra spp	-	-	-		-	-	A	A
Family Nemouridae								
Amphinemoura (3.8)	-	-	-		-	R	A	A
Family Perlidae								
Perlesta spp (2.9)	-	-	-		-	-	A	A
TRICHOPTERA								

Site: / Taxa / Biotic Index Value	Booker Cr, abv MLK Jr	Booker Cr, Piney Mtn	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr, Willow	Cedar Fk, Kenmore	UT Cedar Fk, S Brookview	Cedar Fk, Brookview
Family Hydropsychidae								
Cheumatopsyche spp (6.6)	A	A	R	A	-	-	-	-
Hydropsyche betteni (7.9)	-	R	-	R	-	-	-	-
Family Leptoceridae								
Oecetis persimilis (4.6)	-	R	-	R	R	-	-	-
Triaenodes ignitus (4.6)	-	-	-	R	-	-	-	-
Family Limnephilidae								
Ironoquia punctatissima (6.7)	C	R	-	-	-	R	R	-
Family Philopotamidae								
Chimarra spp (3.3)	A	C	-	C	-	-	-	-
Family Rhyacophilidae								
Rhyacophila carolina (0.4)	-	-	-		-	-	C	R
Family Ueonidae								
Neophylax atlanta	-	-	-		-	-	C	-
MISC DIPTERA								
Family Ceratopogonidae								
Palpomyia complex (5.7)	R	R	-	-	-	-	C	-
Family Limoniidae								
Epiphragma spp	-	-	-	-	R	-	-	-
Hexatoma spp (3.5)	-	R	-	-	-	-	-	-
Family Simuliidae								
Simulium spp (4.9)	C	R	-	A	R	R	-	-
Family Tipulidae								
Tipula spp (7.5)	C	C	R	R	-	C	R	R
DIPTERA; CHIRONOMIDAE								

Site: / Taxa / Biotic Index Value	Booker Cr, abv MLK Jr	Booker Cr, Piney Mtn	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr, Willow	Cedar Fk, Kenmore	UT Cedar Fk, S Brookview	Cedar Fk, Brookview
Ablabesmyia mallochi (7.4)	-	R	R	-	C	-	-	-
Brillia flavifrons (5.7)	R	-	-	-	-	-	-	-
Chironomus spp (9.3)	-	-	C	C	A	-	-	-
Corynoneura spp (5.7)	-	R	R	R	-	-	R	R
Cricotopus bicintus (C/O sp 1) (8.7)	-	-	-	-	C	-	-	-
Cricotopus luciae (C\O sp 20)	-	-	-	-	-	-	R	-
Cryptochironomus fulvus (6.7)	C	-	-	-	-	-	-	-
Diamesa spp (6.6)	-	-	-	-	-	-	-	R
Diplocladius cultriger (8.0)	-	-	-	-	-	-	R	-
Eukiefferiella claripenis (6.2)	-	R	R	C	-	C	-	C
Microspectra polita (2.4)	-	-	R	-	-	-	-	-
Microtendipes pedellus (4.6)	R	-	-	-	-	-	-	-
Orthocladius carlatus (C/O sp 54 (4.4)	-	-	R	C	-	-	-	-
Orthocladius omumbratus (8.1)	C	-	-	-	-	C	-	C
Orthocladius robacki (6.4)	C	A	-	-	-	C	R	C
Orthocladius rubicundus	-	C	-	-	-	-	-	C
Parametriocnemus lundbecki (3.9)	A	R	-	R	-	R	C	A
Paratanytarsus spp (8.0)	C	-	-	-	R	-	-	-
Paratendipes albimanus (5.6)	-	R	-	-	-	-	-	-
Phaenopsectra obediens gp (6.5)	-	-	-	R	-	-	-	-
Phaenopsectra punctipes gr (7.1)	R	-	R	R	-	-	-	-
Polypedilum aviceps (3.6)	C	-	-	-	-	-	-	-
Polypedilum fallax (6.5)	R	-	-	-	-	-	-	-
Polypedilum flavum (5.7)	R	A	A	A	R	-	-	-
Polypedilum illinoense (8.7)	-	-	R	-	-	-	-	-

Site: / Taxa / Biotic Index Value	Booker Cr, abv MLK Jr	Booker Cr, Piney Mtn	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr, Willow	Cedar Fk, Kenmore	UT Cedar Fk, S Brookview	Cedar Fk, Brookview
Potthastia longimana (8.4)	R	R	-	-	C	C	-	C
Rheocricotopus glabricolis (4.7)	C	R	-	-	-	-	R	-
Rheocricotopus robacki (4.7)	-	-	-	-	R	-	-	-
Rheotanytarsus spp (6.5)	C	-	-	C	R	-	-	-
Stictochironomus devinctus (5.4)	R	-	-	-	-	-	-	-
Tanytarsus buckleyi	-	-	R	-	-	-	-	-
Tanytarsus sp G (6.6)	-	R	-	-	-	-	-	-
Thienemannimyia group (8.4)	R	C	A	A	A	R	R	R
Tribelos jacundum (5.7)	-	-	-	-	R	-	-	-
Tvetenia bavarica (3.6)	R	-	-	C	-	-	-	R
Zavrelimyia spp (6.1)	-	-	-	-	-	R	C	R
COLEOPTERA								
Family Dryopidae								
Helichus fastigiatus (4.1)	R	-	-	R	-	-	-	-
Family Dytiscidae								
Neoporus spp (7.0)	-	-	-	-	-	-	R	-
Family Elmidae								
Stenelmis spp (5.6)	A	C	-	A	-	A	C	A
Family Psephenidae								
Ectopria nervosa (4.3)	R	-	-	-	-	-	-	-
Psephenus herricki (2.3)	-	-	-	-	-	C	-	A
Family Scirtidae								
Scirtes spp	-	-	R	R	-	-	-	-
ODONATA								
Family Calopterygidae								

Site: / Taxa / Biotic Index Value	Booker Cr, abv MLK Jr	Booker Cr, Piney Mtn	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr, Willow	Cedar Fk, Kenmore	UT Cedar Fk, S Brookview	Cedar Fk, Brookview
Calopteryx spp (7.5)	R	C	-	-	R	-	-	-
Family Coenagrionidae								
Argia spp (8.3)	A	R	C	-	C	-	-	-
Enallagma sp (8.5)	C	-	R	-	R	-	-	-
Ischnura spp (9.5)	-	-	-	-	R	-	-	-
Family Corduliidae								
Somatochlora spp (8.9)	-	-	R	-	-	-	-	-
Tetragoneuria spp	-	-	-	-				
Family Gomphidae								
Progomphus obscurus (8.2)	-	-	R	-	-	-	-	-
Stylogomphus albistylus (5.0)	C	-	-	-	-	-	-	-
Family Libelluliidae							C	
OLIGOCHAETA								
Family Enchytraeidae	-	C	R	R	R	R	C	R
Family Lumbriculidae (7.0)	A	C	C	A	-	R	R	C
Family Naididae								
Nais sp (8.7)	C	-	-	R	-	-	-	-
Slavina appendiculata (8.4)	-	-	R	-	-	-	-	R
Specaria josinae	-	-	-	-	R	-	-	-
Stylaria lacustris (8.4)	-	-	R	R	C	-	-	-
Family Tubificidae								
Limnodrilus hoffmeisteri (9.4)	-	-	-	-	R	-	-	-
Tubiflex tubiflex	-	-	-	R	-	-	-	-
CRUSTACEA								
Family Asellidae								

Site: / Taxa / Biotic Index Value	Booker Cr, abv MLK Jr	Booker Cr, Piney Mtn	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr, Willow	Cedar Fk, Kenmore	UT Cedar Fk, S Brookview	Cedar Fk, Brookview
Caecidotea spp (8.4)	R	R	R	-	R	C	C	C
Family Cambaridae								
immature crayfish (7.5)	C	C	C	R	R	C	C	R
Family Crangonicidae								
Crangonyx (7.2)	C	C	-	-	-	C	A	C
Family Hyalidae								
Hyallela azteca (7.2)	-	-	R	-	-	-	-	-
MOLLUSCA								
Family Ancylidae								
Ferrissia spp	C	-	-	-	-	-	-	-
Family Lymnaeidae								
Pseudosuccinea columella (7.7)	-	-	-	R	-	-	-	-
Family Pleuroceridae								
Elimia spp (2.7)	A	-	-	-	-	-	-	-
Family Physidae								
Physa sp (8.7)	C	C	A	A	A	C	-	C
Family Planorbidae								
Helisoma anceps (6.6)	-	R	-	-	-	-	-	-
Mentus dilatus (7.6)	-	R	R		A	-	-	R
Family Corbiculidae								
Corbicula fluminea (6.6)	-	A	R	-	R	-	-	-
Family Sphaeriidae								
Pisidium sp (6.6)	C	-	-	-	-	-	-	-
Sphaerium spp (7.2)	-	R	-	-	-	-	R	-
OTHER TAXA								

Site: / Taxa / Biotic Index Value	Booker Cr, abv MLK Jr	Booker Cr, Piney Mtn	Booker Cr, above Tadley Grnwy	Booker Cr, below Tadley Grnwy	Booker Cr, Willow	Cedar Fk, Kenmore	UT Cedar Fk, S Brookview	Cedar Fk, Brookview
Family Dugesiidae								
Dugesia tigrina (7.1)	-	R	-	C	-	-	-	-
Family Spongilla								
Spongilla spp	R	-	-	R	-	-	-	-

**R = Rare, C = Common, A = Abundant*

Appendix 2B. Benthic macroinvertebrates collected at small streams in Chapel Hill, April 2018: Jolly Branch, UT Bolin near Severin, Tanyard Branch, Mill Race Branch, Cole Springs Branch, Library Branch, Battle Branch, and Old Field Creek sites.*

Site: / Taxa / Biotic Index Value	Jolly Br	UT Bolin near Severin	Tanyard Br	Library Br	Mill Race Br	Cole Springs Br	Battle Br	Old Field Cr
EPHEMEROPTERA								
Family Baetidae								
Baetis flavistriga (6.8)	-	C	A	-	C	C	-	-
Baetis pluto (3.4)	-	R	-	-	-	-	-	-
Family Caenidae								
Caenis spp (6.8)	-	-	-		-	-	-	A
Family Heptageniidae								
Maccaffertium modestum (5.7)	-	R	-	A	-	C	-	-
Family Leptophlebiidae								
Paraleptophlebia spp (1.2)	R	A	-		-	-	-	-
PLECOPTERA								
Family Chloroperlidae								
Haploperla brevis (1.4)	-	-	-	R	-	A	-	-
Family Nemouridae								
Amphinemoura (3.8)	A	A	-	-	-	-	-	A
Family Perlidae								
Perlesta spp (2.9)	A	R	-	-	-	-	-	A
TRICHOPTERA								
Family Hydropsychidae								
Cheumatopsyche spp (6.6)	-	-	C	C	-	R	-	-
Diplectrona modesta (2.3)	R	-	-	R	C	R	-	-
Hydropsyche betteni (7.9)	-	-	A	R	-	R	R	-

Site: / Taxa / Biotic Index Value	Jolly Br	UT Bolin near Severin	Tanyard Br	Library Br	Mill Race Br	Cole Springs Br	Battle Br	Old Field Cr
Family Lepidostomatidae								
Lepidostoma sp (1.0)	-	-	-	A	-	-	-	-
Family Limnephilidae								
Ironoquia punctatissima (6.7)	C	-	-	-	-	-	-	C
Family Philopotamidae								
Chimarra spp (3.3)	-	-	-	C	-	R	-	-
Family Rhyacophilidae								
Rhyacophila fenestra/ledra (4.6)	C	-	-	-	-	-	-	-
Family Ueonidae								
Neophylax atlanta	-	A	-	A	-	A	-	-
MISC DIPTERA								
Family Ceratopogonidae								
Palpomyia complex (5.7)	R	-	-	-	-	R	-	R
Family Simuliidae								
Simulium spp (4.9)	R	R	C	R	-	R	-	C
Family Stratiomyidae								
Stratiomys spp	-	-	-	-	R	-	-	-
Family Tipulidae								
Pseudolimnophila spp (6.2)	-	-	-	-	-	-	-	R
Tipula spp (7.5)	R	-	R	C	R	A	R	R
DIPTERA; CHIRONOMIDAE								
Chironomus spp (9.3)	R	-	-	-	-	-	-	C
Corynoneura spp (5.7)	-	C	R	R	R	-	-	-
Cladopelma spp	-	-	-	-	-	-	-	R
Cricotopus bicintus (C/O sp 1) (8.7)	-	-	C	-	R	R	R	-
Cricotopus cf patens (C/O sp 31)	-	-	R	-	-	-	-	-

Site: / Taxa / Biotic Index Value	Jolly Br	UT Bolin near Severin	Tanyard Br	Library Br	Mill Race Br	Cole Springs Br	Battle Br	Old Field Cr
Cricotopus intersectus (C/O sp 44)	-	-	C	-	-	-	-	-
Dicrotendipes neomodestus (7.9)	-	-	-	-	R	-	-	-
Eukiefferiella claripenis (6.2)	-	-	A	-	C	R	-	R
Limnophyes spp	-	-	-	-	-	R	-	-
Microtendipes pedellus (4.6)	-	-	-	-	-	-	-	C
Orthocladius dentifer (C/O sp 11) (4.4)	-	-	C	-	C	-	-	-
Orthocladius dorenus (C/O sp 7) (5.8)	-	-	-	-	-	R	-	-
Orthocladius omumbratus (8.1)	-	R	A	R	A	R	-	-
Orthocladius robacki (6.4)	-	-	C	R	-	R	-	A
Orthocladius rubicundus	-	-	-	-	-	R	-	-
Orthocladius thienemanni (C/O sp 13) (8.1)	C	-	A	-	-	-	-	-
Parametriocnemus lundbecki (3.7)	A	A	-	R	R	C	C	C
Paratendipes albimanus (5.6)	-	-	-	-	-	-	-	R
Polypedilum aviceps (3.6)	-	-	-	-	-	-	R	-
Polypedilum flavum (5.7)	-	-	-	-	R	-	C	-
Polypedilum halterale (7.4)	-	-	-	-	-	-	R	-
Polypedilum illinoense (8.7)	-	-	-	-	-	-	-	R
Potthastia longimana (8.4)	-	-	R	-	R	C	R	-
Rheocricotopus glabricolis (4.7)	-	C	R	-	-	-	C	-
Rheotanytarsus spp (6.5)	-	-	-	-	-	-	R	-
Stenochironomus spp (6.3)	-	-	-	-	-	-	-	R
Stictochironomus devinctus	-	-	-	-	-	R	R	-
Thienemaniella spp (6.4)	-	-	-	-	-	-	R	-
Thienemannimyia group (8.4)	C	-	R	C	A	C	-	R
Tvetenia bavarica (3.6)	R	R	R	-	-	R	-	R
Zavrelimyia spp (6.1)	R	-	-	C	C	-	-	R

Site: / Taxa / Biotic Index Value	Jolly Br	UT Bolin near Severin	Tanyard Br	Library Br	Mill Race Br	Cole Springs Br	Battle Br	Old Field Cr
COLEOPTERA								
Family Dryopidae								
Helichus fastigiatus (4.1)	C	-	-	R	R	-	R	R
Family Dytiscidae								
Copelatus spp	-	-	R	-	-	-	-	-
Neoporus spp (7.0)	C	R	-	C	-	-	-	R
Family Elmidae								
Stenelmis spp (5.6)	A	-	-	R	R	R	R	R
Family Psephenidae								
Psephenus herricki (2.3)	R	-	-	-	-	C	-	-
ODONATA								
Family Aeshnidae								
Boyeria vinosa (5.6)	-	-	-	-	-	-	-	R
Family Calopterygidae								
Calopteryx spp (7.5)	-	-	-	C	-	R	A	R
Family Coenagrionidae								
Argia spp (8.3)	-	-	-	-	A	-	-	-
Enallagma sp (8.5)	-	-	-	-	R	-	-	-
Family Cordullidae								
Somatochlora spp (8.9)	-	-	-	R	-	-	-	R
Family Gomphidae								
Stylogomphus albistylus (5.0)	-	-	-	R	-	-	-	R
Family Libellulidae								
Pachydiplax longipennis (9.6)	-	-	-	-	-	-	R	-
OLIGOCHAETA								
Family Enchytraeidae	-	-	C	-	C	-	-	-

Site: / Taxa / Biotic Index Value	Jolly Br	UT Bolin near Severin	Tanyard Br	Library Br	Mill Race Br	Cole Springs Br	Battle Br	Old Field Cr
Family Lumbriculidae (7.0)	C	-	-	R	C	C	C	R
Family Naididae								
Nais sp (8.7)	C	R	C	C	R	C	-	-
Pristinella (7.7)	-	R	-	R	-	-	-	-
Slavina appendiculata (8.4)	-	-	-	-	R	-	-	-
Family Tubificidae								
Ilyodrilus templetoni (9.3)	-	-	-	R	-	-	-	-
Limnodrilus hoffmeisteris (9.4)	-	-	-	R	-	-	R	R
CRUSTACEA								
Family Asellidae								
Caecidotea spp (8.4)	A	C	-	-	-	-	-	A
Family Cambaridae								
Cambarus bartoni (7.5)	-	A	-	-	-	-	-	-
Immature crayfish (7.5)	C	-	R	C	R	-	C	C
Family Crangonyctidae								
Crangonyx spp (7.2)	A	A	-	R	C	R	R	C
MOLLUSCA								
Family Ancylidae								
Ferrissia spp	-	-	-	C	-	-	-	R
Family Lymnaeidae								
Pseudosuccinea columella (7.7)	-	-	-	-	C	-	-	-
Family Pleuroceridae								
Elimia spp (2.7)	-	-	-	R	-	A	-	-
Family Physidae								
Physa sp (8.7)	C	-	A	-	A	-	C	A
Family Sphaeriidae								

Site: / Taxa / Biotic Index Value	Jolly Br	UT Bolin near Severin	Tanyard Br	Library Br	Mill Race Br	Cole Springs Br	Battle Br	Old Field Cr
Pisidium sp (6.6)	-	-	-	R	-	-	-	-
OTHER TAXA								
Family Dugesiidae								
Cura foremani (5.5)	-	-	-	-	R	-	-	-
Dugesia tigrina (7.1)	-	-	C	-	-	-	-	-
Family Hydrachnidae								
Hydracarina spp (5.5)	-	R	-		-	R	-	R
Family Irpobdellidae								
Erpobdella/Mooreobdella spp (8.6)	-	-	R	-	-	-	-	-
Family Veliidae								
Microvelia spp	-	R	-	R	R	-	R	R

**R = Rare, C = Common, A = Abundant*

Appendix 2C. Benthic macroinvertebrates collected at small streams in Chapel Hill, April 2018: Morgan Creek at NC54, Pritchard Branch, Fan Branch, and Wilson Creek sites.*

Site: / Taxa / Biotic Index Value	Morgan at NC54**	Pritchard Br	Fan Br, Parkview Dr	Wilson Cr, Wave Rd	UT Wilson Cr	Wilson Cr, Obey Cr Dev	Wilson Cr, Arlen Pk Dr
EPHEMEROPTERA							
Family Baetidae							
Acentrella alachua (3.0)	-	-	-	-	-	R	-
Baetis flavistriga (6.8)	A	A	-	C	-	R	-
Baetis pluto (3.4)	A	-	-	A	R	R	-
Diphetor hageni (1.1)	R	-	-	-	-	-	-
Heterocloeon amplum (3.6)	A	-	-	-	-	-	-
Plauditus dubius (2.2)	A	-	R	A	R	A	C
Procloeon spp (1.9)	R	-	-	-	-	-	-
Family Caenidae							
Caenis spp (6.8)	A	-	-	-	-	-	-
Family Ephemerellidae							
Danella simplex (3.4)	R	-	-	R	-	R	R
Ephemerella dorothea (3.3)	R	-	R	A	A	A	R
Eurylophella funeralis (2.5)	A	-	-	-	R	-	-
Eurylophella verisimilis (3.9)	-	-	-	A	C	-	C
Telagonopsis deficiens (2.6)	-	-	-	C	-	C	R
Family Heptageniidae							
Leucrocuta aphrodite (2.9)	A	-	-	-	-	-	-
Maccaffertium modestum (5.7)	R	-	C	A	A	A	R
Stenacron interpunctatum (6.4)	R	-	-	-	-	-	-
Stenacron pallidum (2.8)	C	-	-	-	-	-	-
PLECOPTERA							

Site: / Taxa / Biotic Index Value	Morgan at NC54**	Pritchard Br	Fan Br, Parkview Dr	Wilson Cr, Wave Rd	UT Wilson Cr	Wilson Cr, Obey Cr Dev	Wilson Cr, Arlen Pk Dr
Family Capniidae							
Allocapnia sp (3.3)	R	-	-	R	R	-	-
Family Chloroperlidae							
Haploperla brevis	-	-	A	R	A	-	-
Family Nemouridae							
Amphinemoura (3.8)	A	-	-	A	A	A	C
Family Perlidae							
Acroneuria abnormis (2.1)	A	-	-	R	-	-	-
Eccoptura xanthines (4.7)	R	-	C	C	A	R	C
Perlesta spp (2.9)	A	-	-	C	R	C	C
Family Perlodidae							
Isoperla kerchneri (3.2)	C	-	-	R	-	R	-
TRICHOPTERA							
Family Hydropsychidae							
Cheumatopsyche spp (6.6)	R	C	R	R	A	R	R
Diplectrona modesta (2.3)	-	R	C	R	C	-	-
Hydropsyche betteni (7.9)	R	A	-	-	R	-	-
Family Hydroptilidae							
Hydroptila spp (6.5)	R	-	-	-	-	-	-
Family Lepidostomatidae							
Lepidostoma spp (1.0)	R	-	C	A	A	R	-
Family Leptoceridae							
Ceraclea ancylus	C	-	-	-	-	-	-
Mystacides sepulchralis (2.6)	R	-	-	-	-	-	-
Triaenodes ignitus (4.6)	-	-	-	R	-	R	C
Family Limnephilidae							
Ironoquia punctatissima (6.7)	-	-	R	C	C	-	-

Site: / Taxa / Biotic Index Value	Morgan at NC54**	Pritchard Br	Fan Br, Parkview Dr	Wilson Cr, Wave Rd	UT Wilson Cr	Wilson Cr, Obey Cr Dev	Wilson Cr, Arlen Pk Dr
Pycnopsyche spp (2.5)	R	-	-	-	-	-	-
Family Philopotamidae							
Chimarra spp (3.3)	R	C	-	R	C	R	R
Family Rhyacophilidae							
Rhyacophila carolina (0.4)	-	-	-	-	R	-	-
Rhyacophila fenestra/ledra (4.6)	C	-	-	-	-	-	-
Rhyacophila glaberrima	R	-	-	-	-	-	-
Family Ueonidae							
Neophylax atlanta	R	-	-	C	C	-	-
Neophylax oligius (2.4)	R	-	-	-	A	A	-
MISC DIPTERA							
Family Ceratopogonidae							
Palpomyia complex (5.7)	-	-	-	-	C	-	R
Family Dixidae							
Dixa spp (2.5)	-	-	-	R	A	-	-
Dixella spp (4.7)	-	-	-	R	-	-	-
Family Simuliidae							
Simulium spp (4.9)	-	A	A	A	R	A	A
Family Tipulidae							
Polymeda/Ormosa (5.7)	-	-	-	-	-	R	-
Tipula spp (7.5)	-	C	R	A	A	R	R
DIPTERA; CHIRONOMIDAE							
Ablabesmyia spp	-	-	-	-	C	-	-
Ablabesmyia mallochi (7.4)	-	-	-	-	-	-	C
Brillia flavifrons (5.7)	-	-	-	R	-	-	-
Chironomus spp (9.3)	-	-	R	-	-	-	A
Corynoneura spp (5.7)	-	R	R	C	-	-	-

Site: / Taxa / Biotic Index Value	Morgan at NC54**	Pritchard Br	Fan Br, Parkview Dr	Wilson Cr, Wave Rd	UT Wilson Cr	Wilson Cr, Obey Cr Dev	Wilson Cr, Arlen Pk Dr
Cricotopus bicintus (C/O sp 1) (8.7)	-	-	A	C	-	-	-
Cryptotendipes spp (6.2)	-	-	-	-	-	-	R
Diamesa spp (6.6)	-	R	-	-	-	-	-
Eukieferiella claripennis (6.2)	-	R	-	-	-	-	-
Labrundinia spp (6.2)	-	-	-	R	-	-	-
Limnophyes spp	-	R	-	-	-	-	-
Orthocladius obumbratus gr (C/O sp 10) (8.1)	-	A	C	C	-	-	C
Orthocladius robacki (C/O sp 12) (6.4)	-	C	A	C	-	-	C
Orthocladius rubicundus (C/O sp 54)	-	-	-	-	-	-	A
Paracladopelma spp (6.3)	-	-	C	-	-	R	-
Parametriocnemus lundbecki (3.9)	-	R	R	A	C	A	C
Paratanytarsus spp (8.0)	-	-	-	C	-	-	R
Paratendipes albimanus (5.6)	-	R	C	-	-	-	-
Polypedilum aviceps (3.6)	-	-	-	A	C	C	-
Polypedilum fallax (6.5)	-	-	-	C	-	-	-
Polypedilum flavum (5.7)	-	-	C	C	-	R	A
Polypedilum illinoense (8.7)	-	-	R	-	-	R	R
Potthastia longimana (8.4)	-	-	-	-	-	-	R
Rheocricotopus glabricolis (4.7)	-	-	-	R	-	C	R
Rheotanytarsus spp (6.5)	-	-	-	-	-	R	-
Tanytarsus acifer	-	-	-	R	-	-	R
Tanytarsus buckleyi (6.6)	-	-	-	R	-	-	-
Thienemaniella spp (6.4)	-	-	-	R	-	-	-
Thienemannimyia group (8.4)	-	R	R	C	C	-	C
Tribelos jacundum (5.7)	-	R	-	A	R	C	R
Tvetenia bavarica (3.6)	-	R	-	A	R	C	R
COLEOPTERA							

Site: / Taxa / Biotic Index Value	Morgan at NC54**	Pritchard Br	Fan Br, Parkview Dr	Wilson Cr, Wave Rd	UT Wilson Cr	Wilson Cr, Obey Cr Dev	Wilson Cr, Arlen Pk Dr
Family Dryopidae							
Helichus spp (4.1)	-	R	R	C	C	-	C
Family Dytiscidae							
Neoporus spp (5.0)	-	-	R	R	-	R	-
Family Elmidae							
Macronychus glabratus (4.7)	-	-	R	-	R	-	-
Stenelmis spp (5.6)	-	A	R	-	R	-	-
Family Psephenidae							
Psephenus herricki (2.3)	-	-	-	C	C	A	R
Family Ptilodactylidae							
Anchytarsus bicolor (2.4)	-	-	-	-	C	-	-
ODONATA							
Family Aeshnidae							
Boyeria vinosa (5.6)	-	-	-	-	-	-	R
Family Calopterygidae							
Calopteryx spp (7.5)	-	A	C	R	R	C	R
Family Coenagrionidae							
Argia spp (8.3)	-	-	-	-	-	-	C
Family Corduligastridae							
Cordulegaster spp (5.7)	-	-	-	R	R	-	-
Family Gomphidae							
Gomphus spp (5.9)	-	-	R	-	-	-	R
Progomphus obscurus (8.2)	-	-	-	-	-	R	-
OLIGOCHAETA							
Family Enchytraeidae	-	-	-	-	-	R	-
Family Lumbriculidae (7.0)	-	C	R	C	R	R	R
Family Naididae							

Site: / Taxa / Biotic Index Value	Morgan at NC54**	Pritchard Br	Fan Br, Parkview Dr	Wilson Cr, Wave Rd	UT Wilson Cr	Wilson Cr, Obey Cr Dev	Wilson Cr, Arlen Pk Dr
Nais spp (8.7)	-	A	R	-	R	-	-
Slavina appendiculata (8.4)	-	-	-	-	-	R	-
Family Tubificidae							
Limnodrilus hoffmeisteris (9.4)	-	-	R	-	-	R	-
Tubifex tubifex	-	-	-	-	-	-	R
CRUSTACEA							
Family Cambaridae							
Cambarus bartoni (7.5)	-	-	-	C	-	-	-
Immature crayfish (7.5)	-	A	R	-	A	C	-
Family Crangonycidae							
Crangonyx (7.2)	-	-	-	-	R	-	-
MOLLUSCA							
Family Ancylidae							
Ferrissia spp (6.6)	-	-	-	-	R	-	C
Family Lymnaeidae							
Pseudosuccinea columella (7.7)	-	-	R	-	-	R	-
Family Pleuroceridae							
Elimia spp (2.7)	-	A	-	A	A	C	C
Family Physidae							
Physa sp (8.7)	-	-	A	C	-	R	A
Family Planorbidae							
Mentus dilatus (7.6)	-	-	-	-	-	-	R
Family Sphaeriidae							
Pisidium sp (6.6)	-	-	-	-	-	-	C
OTHER TAXA							
Family Dugesiidae							
Cura foremanii (5.5)	-	R	-	-	R	-	-

Site: / Taxa / Biotic Index Value	Morgan at NC54**	Pritchard Br	Fan Br, Parkview Dr	Wilson Cr, Wave Rd	UT Wilson Cr	Wilson Cr, Obey Cr Dev	Wilson Cr, Arlen Pk Dr
Family Hydrachnidae							
Hydracarina spp (5.5)	-	-	-	-	-	-	R

**R = Rare, C = Common, A = Abundant*
***Morgan Creek at NC54 only sampled for EPT tax*

Appendix 3. Map of benthic macroinvertebrate monitoring sites in Chapel Hill, April and July 2018.

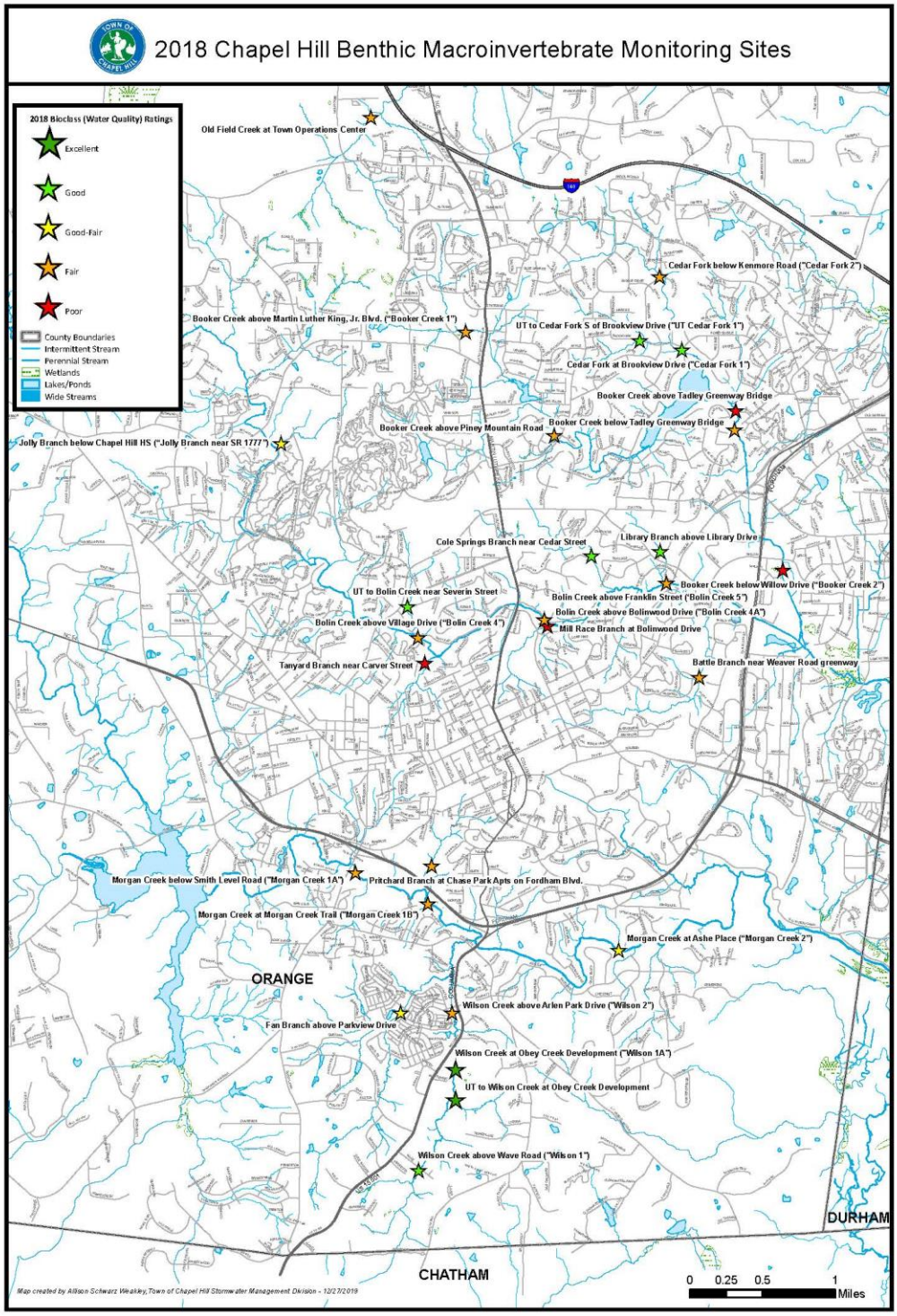

Figure 2. Map of benthic monitoring sites, 2018.

Appendix 4. Chapel Hill Large Stream Sites, July 2018.

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 with Carrboro) to Village Drive in Chapel Hill, and Site 4A (Bolinwood Drive) was sampled for the first time in 2018. Bolin Creek sites are largely in the Slate Belt geologic region and are expected to have a very rocky stream bottom. The lower Bolin Creek sites may have characteristics of both Slate Belt and Triassic Basin ecoregions.

Morgan Creek has a similar numbering system. Site 1 is upstream of Chapel Hill, Carrboro and University Lake at NC-54. Site 2 is on the south side of Chapel Hill, near the botanical gardens. In 2018, two additional sites were added: 1a at Smith Level Rd near the town border with Carrboro, and 1b off Morgan Creek Trail near Prichards Branch.

In 2018, Chapel Hill sampled three additional sites, Bolin Creek at Bolinwood Drive, Morgan Creek at Smith Level Road and Morgan Creek at Morgan Greenway Trail.

Bolin Creek 4 (Village Drive). This site was moved slightly downstream into Chapel Hill (Village Drive) in 2011 so data from this site could be used by both Towns of Carrboro and Chapel Hill.

Figure 3. Bolin Creek Site 4, July 2018.

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 2012-2018. Specific conductance for this site in July 2018 (136 µS/cm) was similar to 2017 (129 µS/cm).

Bolin Creek 4a (Bolinwood Drive). This site was sampled for the first time in 2018, and was located about midway between sites 4 and 5 and near the confluence with Mill Race Branch. A greenway runs along the right bank so the wooded buffer is narrow on that side.

Figure 4. Bolin Creek Site 4a, July 2018.

Judging by the slow flow in 2018, flow could be a problem in dry years. This portion of Bolin Creek is similar to the site on Estes Drive, having good rocky substrate. Specific conductance for this site in July 2018 (204 µS/cm) was an increase from upstream at Village Drive (136 µS/cm), so there does appear to be some effects from Mill Race Branch.

Bolin Creek 5 (Franklin St). Bolin Creek has good rocky substrate near the Franklin Street bridge, but the stream bottom is mostly sand further upstream.

A concrete greenway path parallels Bolin Creek in this area. This site drains a heavily developed catchment, including the downtown areas of both Carrboro and Chapel Hill. Specific conductance was much higher at Site 5 than at Site 4 (Village Drive) in July 2018: 136 vs. 229 µS/cm, possibly due to the entry of Tanyard Branch between the two sites.

Figure 5. Bolin Creek Site 5, July 2018.

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

Figure 6. Morgan Creek Site 1 (NC 54), April 2018.

With an 8 square mile watershed, this site is technically not a small stream in the sense of small stream criteria. It is, however relatively small compared to the Bolin Creek and lower Morgan Creek (large stream) sites. In past years, this site has been sampled using the EPT method, which would be proper for large streams.

Prior surveys by the NCDWR generally produced a Good or Excellent bioclassification for this site. Recent collections have produced only Good-Fair ratings until the higher flow years of 2017 and 2018 when the bioclass was Good and Excellent, respectively.

Morgan Creek 1a (Smith Level Road). This site was first sampled in 2018, and is located near the upstream end of Morgan Creek, just inside the Chapel Hill town limits. It is located only 1-2 miles above the Morgan Trail site, and there are no major tributaries between the two sites so probably only one of these sites needs to be sampled in the future.

There was good rocky substrate interspersed with glass in the riffles, with large sandy pools on either side, with a possibly defunct stormwater outfall on the left bank. Flows were adequate in 2018, however they could become problematic in low flow years.

Figure 7. Morgan Creek Site 1a (Smith Level Rd), July 2018.

Morgan Creek 1b (Morgan Trail). This site was first sampled in 2018, and is located above the confluence of Wilson Creek to see if the input of the generally higher quality water in that watershed is improving Morgan Creek. The stream was sampled just below Prichard Branch, which drains the south side of downtown Chapel Hill.

Habitat here was a long rocky riffle sandwiched between sandy, barely flowing pools. Flows could be a problem in drier years. While specific conductance was the same here as downstream (182 µS/cm), there was a bioclass improvement between the two sites indicating that Wilson Creek is assisting the recovery of downstream Morgan Creek.

Figure 8. Morgan Creek Site 1b (Morgan Trail), July 2018.

Morgan Creek 2 (Ashe Place). This site is located near the NC Botanical Garden. 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. Flows were very low in 2016, only being visible in the riffles, but were better in 2017 and 2018.

Figure 9. Morgan Creek Site 2 (Ashe Place), July 2018.

Appendix 5. Chapel Hill Small Stream Sites, April 2018.

Small streams are grouped into three 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 streams naturally have a stream bottom of sand and clay and are located in the eastern part of Chapel Hill. Some "Transition" streams 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 Transition sites are very sandy, with gravel/rubble riffles.

SLATE BELT STREAMS

Pritchard Branch. Pritchard Branch is a tributary of Morgan Creek, in the southwest portion of Chapel Hill. Although this is a naturally rocky stream, there have been large inputs of sand. Pritchard Branch drains the southern part of downtown Chapel Hill.

Figure 10. Pritchard Branch, April 2018.

The stream appears both entrenched and widened by erosion. The invertebrate fauna was sparse in 2018. Conductivity values were moderately elevated in 2018 (255 µS/cm) at the time of the invertebrate collections.

Mill Race Branch. Mill Race Branch is located in a dense residential area, and receives stormwater from downtown Chapel Hill. A portion of this stream is also piped through a parking lot upstream. Mill Race Branch was sampled off Bolinwood Drive, just above its confluence with Bolin Creek. The substrate is largely gravel and sand, but with small rocky riffles areas.

Figure 11. Mill Race Branch, April 2018.

Conductivity values were moderately elevated (278 µS/cm) in 2018.

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

Figure 12. Tanyard Branch, April 2018.

There is a forested riparian zone, but the stream runs through a heavily developed residential area and receives substantial stormwater from W. Franklin Street (downtown Chapel Hill). The stream substrate was rocky, but was highly embedded with sand and covered by a thick mat of filamentous algae. Conductivity values were highly elevated (336 µS/cm) at the time of the invertebrate collections.

Old Field Creek. Old Field Creek was sampled north of town, near the Chapel Hill Town Operations and Transit Center. The surrounding area is largely forested, but there is some development (including a landfill) further upstream, and new construction just upstream of the site.

.

Figure 13. Old Field Creek, April 2018.

The stream is very rocky (often having extensive areas of bedrock), with good root and leafpack habitat. The composition of the fauna suggested that this stream is sometimes intermittent, although there was still a small amount of flow when it was sampled in 2018. Conductivity was moderately elevated (244 µS/cm) at the time of the invertebrate collections in 2018.

Cedar Fork 1, Brookview Drive. Cedar Fork is located in the northern section of Chapel Hill; it is one of the largest tributaries of Booker Creek (4 meters wide). The stream was sampled off Brookview Drive, just above a small lake (Eastwood Lake). It appears much of the Cedar Fork catchment is prone to drying so a couple of years of good flow have improved the macroinvertebrate community.

Figure 14. Cedar Fork at Brookview Drive, April 2018.

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 and there was severe bank erosion at bends. Conductivity was measured at 134 µS/cm in 2018.

UT to Cedar Fork 1, South of Brookview Drive. This small (1 meter wide), shallow stream parallels Brookview Drive and is one of two tributaries that enter Cedar Fork between sites 1 and 2. The other tributary (north of Brookview Drive) was not sampled because it was smaller and had even less flow.

Figure 15. UT Cedar Fork, South of Brookview Drive, April 2018.

The substrate was rocky and supported a large number of crayfish and larval salamanders. The conductivity (131 µS/cm) was less than the mainstem of Cedar Fork.

Cedar Fork 2, below Kenmore Drive. This segment of Cedar Fork had good habitat, with 80% boulder rubble substrate. There was a good buffer zone downstream of Kenmore Drive, but there was more development in the upstream area. The conductivity (143 µS/cm) and the fauna did not indicate good water quality.

Figure 16. Cedar Fork 2, below Kenmore Drive, April 2018.

Booker Creek 1, above MLK Jr. Blvd.

This site is located above MLK Jr. Boulevard, downstream from Homestead Park, and is accessed via Northern Park Drive (Aquatics Drive). Booker Creek has a forested buffer next to the stream, but it drains a largely residential area. The substrate is rocky, but flows are low enough that this stream may have intermittent flow in some years.

Figure 17. Booker Creek Site 1 (above MLK), April 2018.

Booker Creek, above Piney Mountain Rd.

This site is located above Piney Mountain Road. This is a rocky site with good habitat, very similar to Bolin Creek upstream in Carrboro. Historic data from NCDWR collections have been evaluated as either Fair or Not Rated, with EPT taxa richness of 8-10 in spring collections. Conductivity here was moderate (184 µS/cm).

Figure 18. Booker Creek, above Piney Mountain Road, April 2018.

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 a good buffer zone; the area sampled was largely forested. This rocky stream had excellent habitat for aquatic fauna. The stream was mostly boulder and rubble with sand and gravel embedding some riffles. Conductivity was much lower this year (152 µS/cm) than last (271 µS/cm), but the water was very cloudy at the time of sampling.

Figure 19. Cole Springs Branch, April 2018.

Library Branch.

Library Branch was sampled upstream 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* in some years suggests that this stream does not dry up completely during drought periods, hinting at the possibility of some springs in the watershed. Library Branch appears to be intermediate between the Slate Belt and Triassic classifications, with more clay than a normal Slate Belt stream.

Figure 20. Library Branch, April 2018.

Jolly Branch near Homestead Road (SR 1777). This site was accessed by walking about 100 meters downstream of SR 1777 (Homestead Road), 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, as well as Chapel Hill High School and Smith Middle School. The aquatic life at Jolly Branch indicates that it may stop flowing (or go dry) during drought periods.

Figure 21. Jolly Branch, April 2018.

UT Bolin Creek near Severin Street. This very small stream (1-2 meters wide) was sampled near 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 contained several intolerant species.

Figure 22. UT Bolin Creek near Severin Street, April 2018.

TRANSITION STREAMS

Battle Branch. Battle Branch was sampled near Glendale Drive and the Weaver Road Greenway section of the Battle Branch Trail. This stream is located in an older residential area, with forest, hiking paths and a sewer easement next to the stream. The substrate is largely sand and gravel, with occasional rubble riffles. Battle Branch was entrenched with severely eroding banks.

Figure 23. Battle Branch, April 2018.

Fan Branch below Parkview Drive. This site is located downstream from Parkview Crescent 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.

Figure 24. Fan Branch, April 2018.

Wilson Creek 1, above Wave Road. This site is located upstream from Wave Road. 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. Despite the sand, the conductivity was low (120 µS/cm) and the invertebrate community was intolerant.

Figure 25. Wilson Creek 1 (above Wave Road), April 2018.

UT Wilson Creek (Obey Creek Development). UT Wilson Creek was sampled for the first time in July 2016. The sample was collected at the mouth of a small (130 acres), undeveloped, catchment upstream from Wilson Creek 1a, which will be preserved as part of the Obey Creek development.

Figure 26. UT Wilson Creek within the Obey Creek development, April 2018.

Although this stream was very small and very sandy (80% gravel, sand and silt), it supported a surprisingly diverse invertebrate community and had the lowest conductivity of all sites sampled (113 µS/cm).

Wilson Creek 1a (Obey Creek Development). This site is located behind Strata Solar, within the Obey Creek Development site. This stream was sampled for the first time in 2016. It is a sandy stream with bank erosion, but prior samples upstream and downstream have indicated good water quality. This section of stream appears to carry a heavy sediment load.

Figure 27. Wilson Creek within the Obey Creek Development, April 2018.

Wilson Creek 2, above Arlen Park Drive. Wilson Creek was sampled above Arlen Park Drive, in a residential area of the Southern Village development. The upstream area is an older residential area (mostly forest) with large lot sizes. The stream continues its sandy character; however, there is also adequate habitat for invertebrates. This part of Wilson Creek probably has more permanent flow than Wilson Creek 1.

Figure 28. Wilson Creek 2 above Arlen Park Drive, April 2018.

TRIASSIC STREAMS

Booker Creek, above Tadley Greenway. This site is located just below the confluence of Booker Creek and Cedar Fork and Eastwood Lake. The substrate was primarily sand, silt and clay. While there was very little flow when the stream was sampled, the banks were severely eroded.

Figure 29. Booker Creek above Tadley Greenway, April 2018.

Booker Creek, below Tadley Greenway. This site is located about 100 m below the above Tadley Greenway site.in an aberrant area where there is flow over riprap. This site was sampled to get an idea of how much of the reduced water quality here was due to slow flow and poor habitat that has been documented upstream, and how much was due to water quality.

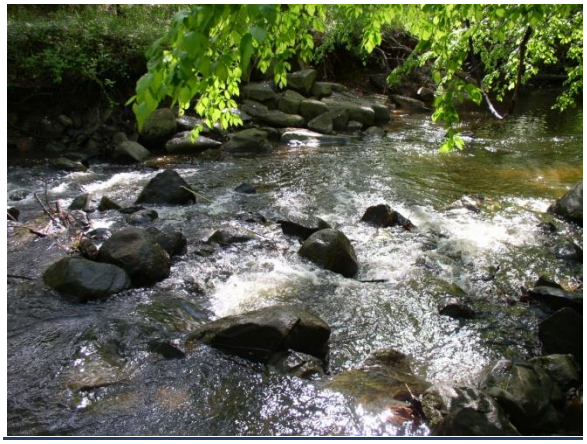

Figure 30. Booker Creek below Tadley Greenway, April 2018.

Booker Creek 2, below Willow Drive.

This segment of Booker Creek drains a largely residential catchment. The stream appears to have been channelized at some time, with a very entrenched channel. The substrate is entirely sand and clay which made finding good habitat difficult

Figure 31. Booker Creek below Willow Drive, April 2018.