Final Report
Aquatic Life in Ephemeral, Intermittent and Perennial Streams in the Coastal Plain of North Carolina

WL 96435005-1

Version 2.1, 1/6/2010

Background

Any discussion of small, headwater streams must begin with a definition of flow regimes. Currently, there is no universally accepted set of definitions of stream types, so comparisons between studies must be made with care. North Carolina DWQ defines a perennial channel as one that contains water all year around and an intermittent channel as one that contains water for a significant part of the year, but is dry for some part, during a year of normal rainfall (15A NCAC 2B.0233).

This grant continued the investigation of headwater streams started by a previous EPA grant (Development of Policy for Protection of Intermittent Streams through the 401 Water Quality Certification Program grant # CD 974043-00-0) which investigated the aquatic life in headwater (intermittent and perennial) streams in the mountains and piedmont of North Carolina. Some of the results of this study are summarized in the following four paragraphs.

Streams start in different ways and require different sized drainage areas. In the mountains, most streams start as perennial springs with small watersheds (usually <10 acres), though there are a few documented cases of streams starting as overland flow or with wet weather springs. In both of these cases, the intermittent reaches were very short (< 7 m). In the piedmont, most streams started via overland flow, however it was not uncommon to find a spring-fed stream. Watersheds supporting intermittent streams ranged from 10-20 acres and intermittent streams were usually 10 m or less, except in the Triassic Basins and Slate Belt ecoregions, which were much longer. Stream mapping efforts in these ecoregions found similar results (Periann Russell. Personal Communication)

While there were a few species that were found only in intermittent streams (the dipterans *Dasyhelea* and family Dolichopodidae and beetle larvae *Helichus*), most species found in intermittent streams were found in perennial streams as well. This agreed with the findings of Delucchi and Pecarsky 1989, Feminella 1996, and Del Rosario and Resh 2000. Some species live only in headwater perennial streams: the caddisflies *Homoplectra* and *Pseudostenophylax* in the mountains, and the phantom crane flies (*Ptychoptera* and *Bittacomorpha*) in the piedmont. While shredders, particularly winter stone flies like *Allocapnia*, could be dominant in headwater reaches in winter, as found by Haggety et al. 2002, the much more omnivorous amphipod *Crangonyx*, was at least as likely to dominate intermittent reaches when they were wet.

On average, intermittent stream segments supported approximately 60-70% of the aquatic life in a perennial segment. There is a large variance around these numbers because of faunal changes between wet and dry seasons, wet and dry years, ecoregion and whether the discussion involved number of aquatic species or number of individuals. On average, ephemeral reaches supported about 20-30% of the aquatic life in a perennial segment with the same large variance for the same reasons. This is not far from the results of Fritz and Dodds (2002), who found intermittent streams in the tallgrass prairie had 45-50% of the aquatic life of downstream perennial segments.

In wet years, when intermittent segments did not dry out, it took about 18 months for the fauna at an intermittent site to evolve to the point that it resembled the fauna at perennial sites downstream. In dry years, it took only a few weeks of a dry stream bed to extirpate most of the aquatic species.

While these observations gave us significantly more insight to the behavior of intermittent streams in the piedmont and mountains of North Carolina, before the Division of Water Quality could move forward with policy changes based on this improved understanding, we had to evaluate headwater streams in the coastal plain as well.

Sites

Initially, eight small, minimally impacted watersheds were identified in southern and eastern North Carolina (Figure 1). The three western most sites were located in the Sandhills level 4 ecoregion (Griffith et. al. 2002), the southernmost and eastern most sites were in the outer coastal plain (Carolina Flatwoods to Griffith) and the three sites in the middle were located in the inner coastal plain (Griffith's Rolling Coastal Plain). Each stream was divided into five to thirteen segments. These divisions were usually based upon a change in one of the features of the stream, however in some cases (especially Brices Creek) the changes were so subtle that segments were made at 100m intervals. The location of each stream segment is detailed in Appendix 1. Significant time was spent looking for a natural stream that flowed in the Tidewater area (Griffith's Chesapeake-Pamlico Lowlands and Tidal marshes and Nonriverine Swamps and Peatlands), however there did not appear to be enough gradient east of the Suffolk scarp and on the barrier islands to cause water to flow unidirectionally without human intervention such as ditching.

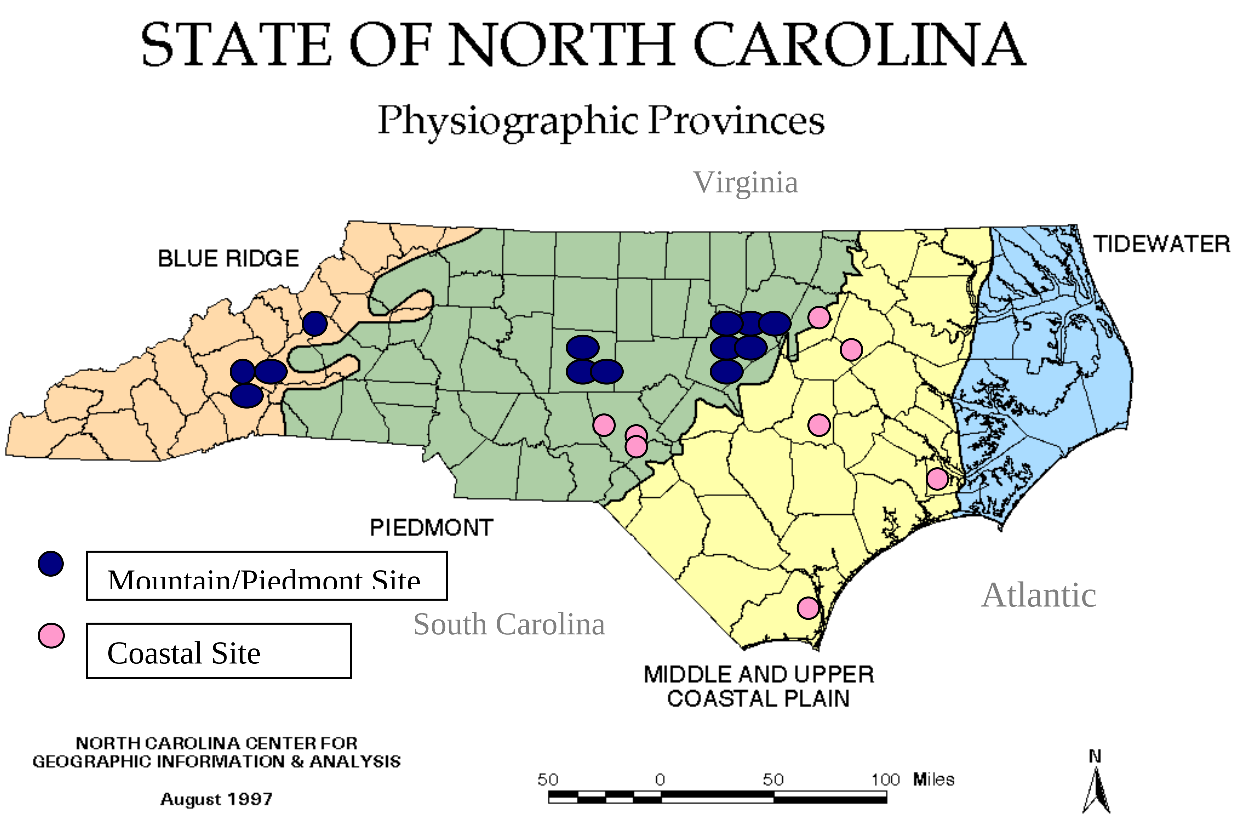

Figure 1. Map of Study Streams

Each stream segment was scored by two people using the DWQ stream determination form (NCDENR 2005) and the site was assigned the average of the two scores. The transition from an ephemeral channel to an intermittent stream was indicated by a rating score of 19; while the transition from intermittent to perennial was assigned with a rating score of 29. Permission to access one of the Inner Coastal Plain streams (Bynum Mill) was rescinded in December 2007, so the stream ceased to be monitored from that date.

Methods

Biological sampling of benthic macroinvertebrates occurred three times per year in the ephemeral, intermittent and perennial stream reaches in each study catchment. Sampling times were selected to sample seasonal differences as well as varying flow conditions: (1) May - when base flow is decreasing due to increased evapotranspiration, (2) September – when base flow is at the seasonal low in perennial streams and has stopped in intermittent streams, and (3) late February – when base flow is near the seasonal high in both intermittent and perennial streams. Photos were taken of stream segments at the time of sampling.

A stratified random sampling design was used to select four stream segments for sampling within each stream. For each stream, one sample was collected in the ephemeral, one in the intermittent, and two in the perennial reaches.

Different macroinvertebrate sampling methods were employed depending on the presence or absence of water in the stream reach being sampled (Figure 2). Irrespective of water level, an area of 200 cm^2 of the stream bed, to a depth of 10 cm, was collected. The invertebrate community was separated from the sediment by elutriation through a 300 micron mesh screen in the field and the sediment was returned to the streambed. Macroinvertebrates were returned to the laboratory for sorting enumeration and identification.

Wet sampling (i.e. when there was water in the channel) consisted of an additional sample, which was kept separately from the quantitative sample. Two sweeps were taken with a dip net - one in a pool, one in a riffle, if the features existed. Both sediment and sweep samples were returned to the laboratory in 70% ethanol, where sorting and identification took place.

Monthly, each stream segment was visited and assessed for the presence of water and flow. This allowed for a rough estimation of how long individual stream segments had been dry before sampling. During 2008, sites containing water were sampled for pH to see if there was any pattern from upstream to downstream or between sites.

Results

Most streams in the coastal plain that haven't been "improved" by humans, start as wetlands or seeps. At some point, the water in these features pass between two trees close enough together to channel the water and cause it to start flowing with enough velocity to begin forming erosive channel features (Figure 3). Even then, channel forming features are more subtle in the coastal plain (compared to the mountains or piedmont) because of the lower gradient and slower stream flows.

Figure 2. Sampling equipment

pH was variable at all sites and usually ranged between 4.0 - 5.0 or 5.5 - 6.5. It usually changed by approximately 0.2 (maximum range was 1.1 units) between the top and the bottom of the wetted watershed, but pH increased downstream as often as it decreased. These trends did not appear to be associated with ecoregion or season, however the sites with the higher pH (Bynum Mill, Cuzack and Stoney) appear to be the watersheds that have, or had, agricultural disturbances in the watersheds.

Figure 3. Mill Br 1 above and below constriction

Monthly flow observations showed an interesting trend of drying and rewetting of individual sites over the course of this study. This study began at the end of a wetter-than-average year, where stream segments that should have been intermittent had held water for so long that their aquatic communities looked more like perennial communities. Streams began feeling the effects of the drought in Spring (March-May) 2007 and stream segments that had not been dry for many months, dried out. Water levels came back up in late winter (February – March) 2008, but not back to winter 2007 levels. May – September 2008 recorded lower water levels than the worst of the 2007 drought. Water levels recovered at about half the sites (Nicks, Mill 2, Stoney and Brice) by November 2008, but still remained near summer lows at the remaining sites.

Where a stream starts moves up and down slope depending on the rainfall for the year, as evidenced by Figure 4. This graph looks at the percent of stream segments with water during the winter and spring for 2007 (a wet year) and 2008 (a year of record drought). During a wet year, reaches defined as ephemeral (0-20 points) had water in them 40-70% of the time during the wet part of the year. This would suggest that at least some of these stream segments are intermittent during wet years, since they would no longer fit the definition of an ephemeral channel – only having water in it during and immediately following rainfall.

Drought years are a different story, however, when even during the wettest part of the year, ephemeral reaches only had water in them 5-30% of the time. In fact, intermittent reaches (20-30 points) only had water in them about 50% of the time during the wettest part of the year, suggesting that some intermittent reaches behave more like ephemeral reaches during a drought. In all cases, by the time a stream scored more than 30 points, it always had water in it during the wet part of the year no matter what the rainfall pattern.

Also interesting is the observation that as the stream gets closer to perennial, there appears to be a resistance to drying. While there was no decline between wet and dry years in stream segments scoring more than 30 points, stream segments scoring less than that showed a fairly consistent decline of 30-40 percentage points between years. This fairly constant decline makes for larger between-year differences in wetted segments as the stream scores decline (35% for 20-30 points, 56% for 10-20 points and 86% for 0-10 point stream segments).

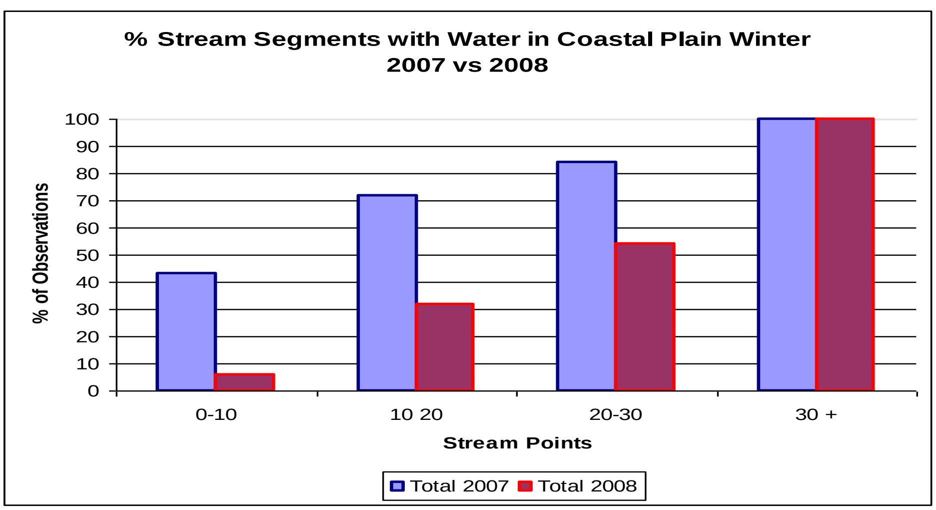

Figure 4. % Coastal Plain stream segments with water in Winter 2007 and 2008.

Some ecoregions are more susceptible to rain induced water level fluctuations than others. Figure 5 is a breakdown by ecoregion of the data in Figure 4. In nearly every case, Sandhills (SH) segments were wetter than Inner Coastal Plain (ICP) segments which were wetter than similarly scored Outer Coastal Plan (OCP) segments.

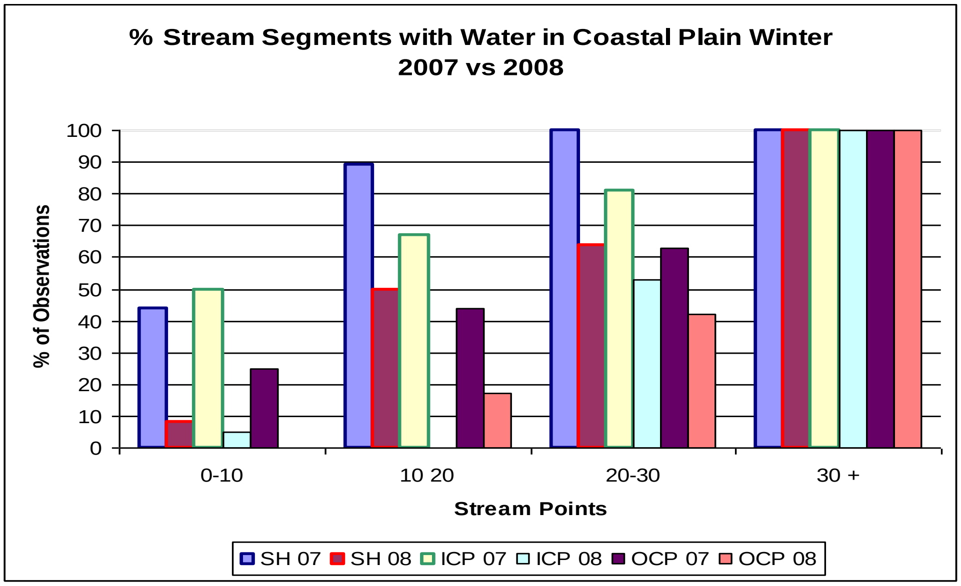

Figure 5. % Coastal Plain stream segments with water, Winter and Spring 2007 and 2008 by ecoregion.

During the wet year (2007), Sandhills intermittent segments (20-30 pts) behaved like perennial segments (100% water for all five months), as did many of the lower ephemeral Sandhills reaches (10-20 points), which averaged 90% of the sites with water. Even in the dry year (2008), water occurred in the Sandhills stream segments (10-30 points) at about the same frequency as similarly rated Outer Coastal Plain sites in the wet year. It is possible that Sandhills streams, like Mountain streams, may often begin as springs, which lack the channel forming velocities to form the geomorphology present in surface fed streams of similar permanence. In these cases it would be appropriate to use biological indicators instead of a stream score based on geomorphology to determine stream origins in the Sandhills.

Data for Summer 2007 and 2008 samples (Figures 6 and 7) show, with three exceptions, the classic pattern of no (or one) perennial indicator taxa until about 30 points, then two or more at all sites thereafter. What needs to be kept in mind, however, is that Summer 2007 was during a drought worse than the drought of 2002. In that previous drought, perennial stream segments scoring 30-34 points also went dry, suggesting that the I/P point in the coastal plain may be somewhere in the 25-30 point range in a year of normal rainfall. 2008 was a more normal flow year, however groundwater tables had not recharged so the point where more than one perennial indicator was collected was even further downstream than 2007. A case in point was Cliffs 7 (21.5 points). In 2007, the segment had been wet for the previous year and contained a diverse aquatic community (356 individuals of 28 aquatic taxa), including three long lived taxa. The segment then dried out from March to June 2008, then rewetted in July. As a result, Cliffs 6, which experienced the same wet/dry timing as Cliffs 7, only had 46 individuals from 18 aquatic taxa, including only a single long lived species. While annual rainfall is the metric used to predict the location of water located along the gradient of the stream, this metric is really just a surrogate for groundwater level which often lags behind rainfall by months or even a year or more.

This pattern is probably caused by the much flatter topography of the coastal plain leading to wetlands in many of the “ephemeral” segments and longer intermittent segments than documented in the Piedmont and extend down into areas with channel forming features normally associated with perennial streams. It is unknown whether groundwater fluctuations in the coastal plain are greater than the piedmont, or if longer segments of streams are affected by similar or smaller fluctuations.

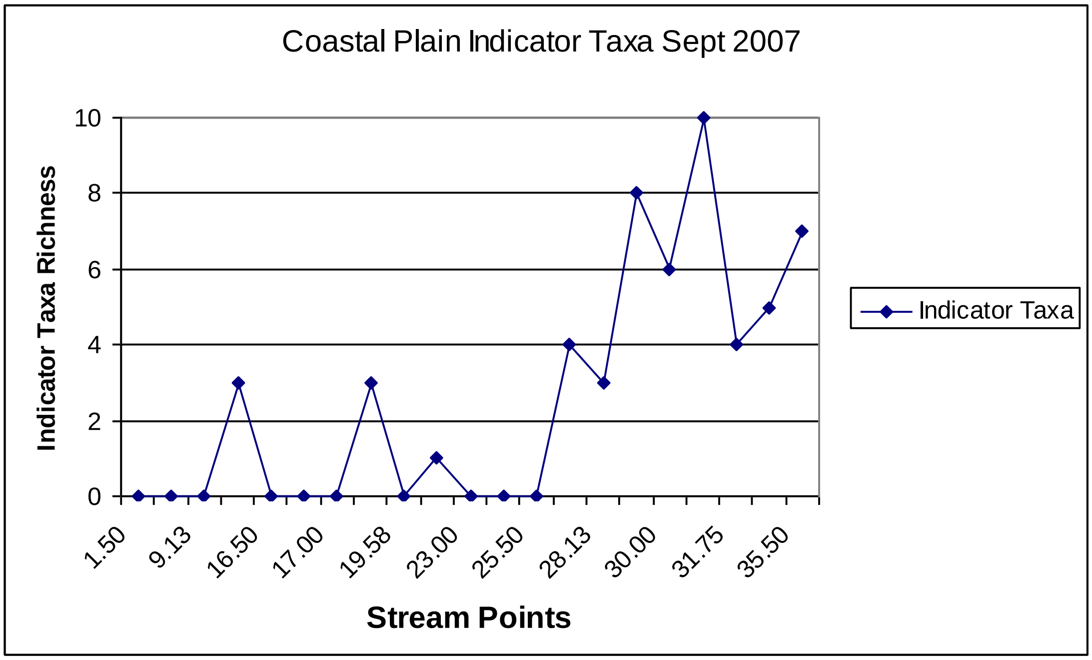

Figure 6. Perennial Indicator Taxa Summer 2007

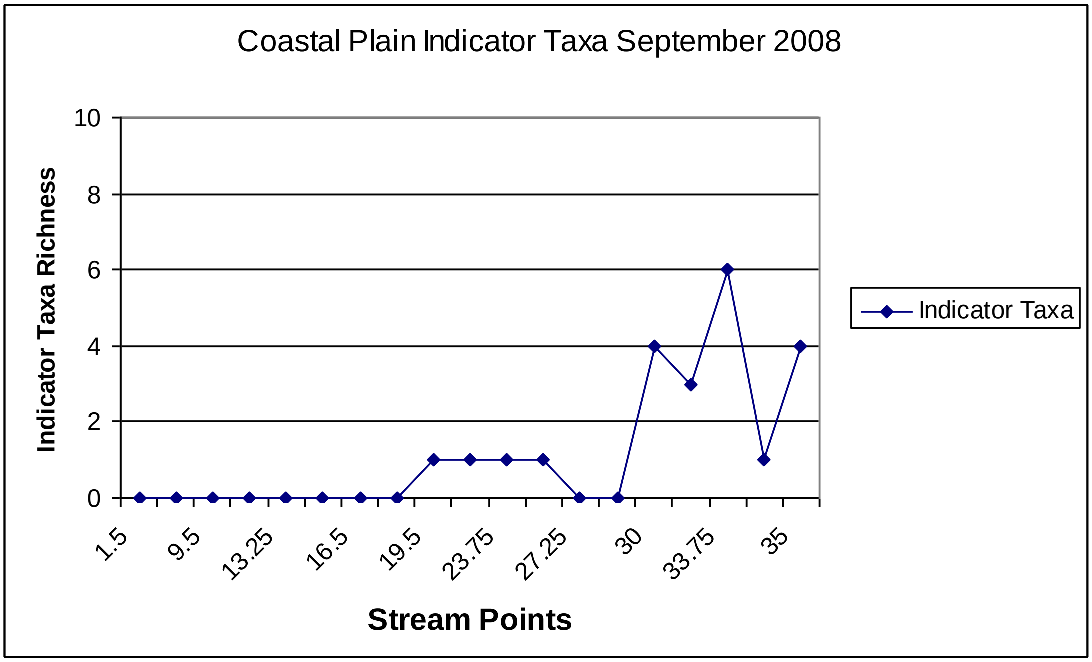

Figure 7. Perennial Indicator Taxa Summer 2008

Additional information can be gleaned from the stream flow data, when looked at in a different way. Figure 8 is a graph of the frequency of water presence and flow as a function of stream permanence.

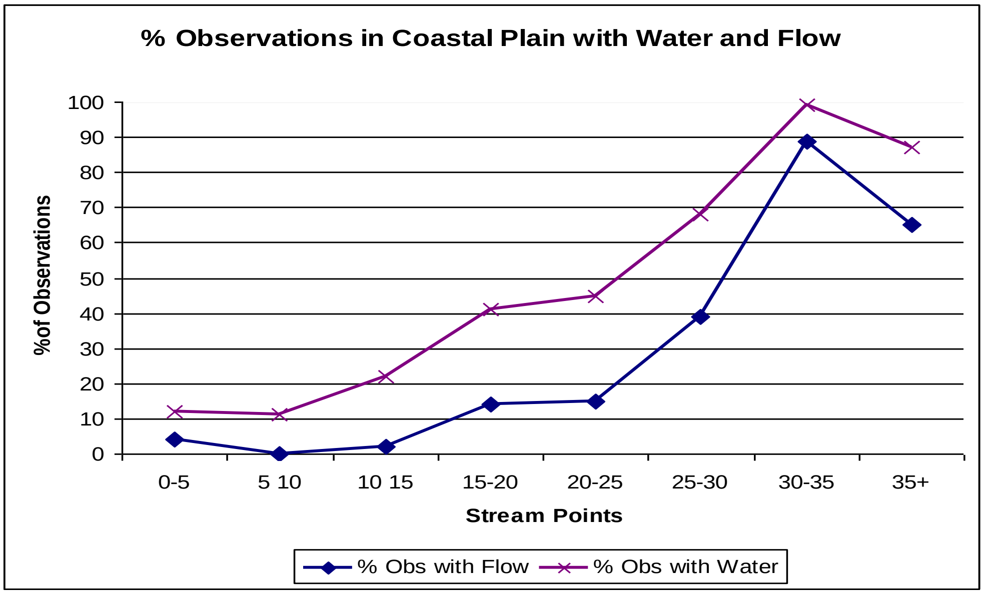

Figure 8. Percent of Observations in NC Coastal Plain of Stream Segments with Water and Flow

Streams scoring 30-35 points had water in them almost 100% of the time and flowing water almost 90% of the time. This confirms DWQ's regulatory definition of perennial with the numerical cutoff of 30 points. The two lines showing the percentage of observations with water and flow are relatively parallel, widening some in the intermittent range indicating that water tends to pool more in these areas. The drop off in both flow and water in the final 35+ point category is entirely due to the streams in the outer coastal plain (Figure 9) which were suffering from a severe drought for most of this study. Streams from the inner coastal plain and sandhills both showed water peaking at 100% in this category as one would expect. However perennial outer coastal plain streams were dry for long periods because of the extended drought in 2008 extending into mid 2009.

Two categories with minimal observations were the 5-10 points range (four segments – none in the sandhills) and the 35 points plus category (six segments) make these two categories most susceptible to outliers. The 25-30 point range of inner coastal plain is based on two segments in a single stream on private property. We lost permission to sample this stream after fall 2008, so the truncated data set here does not represent the natural winter rewetting that was represented in the sandhills and outer coastal plain.

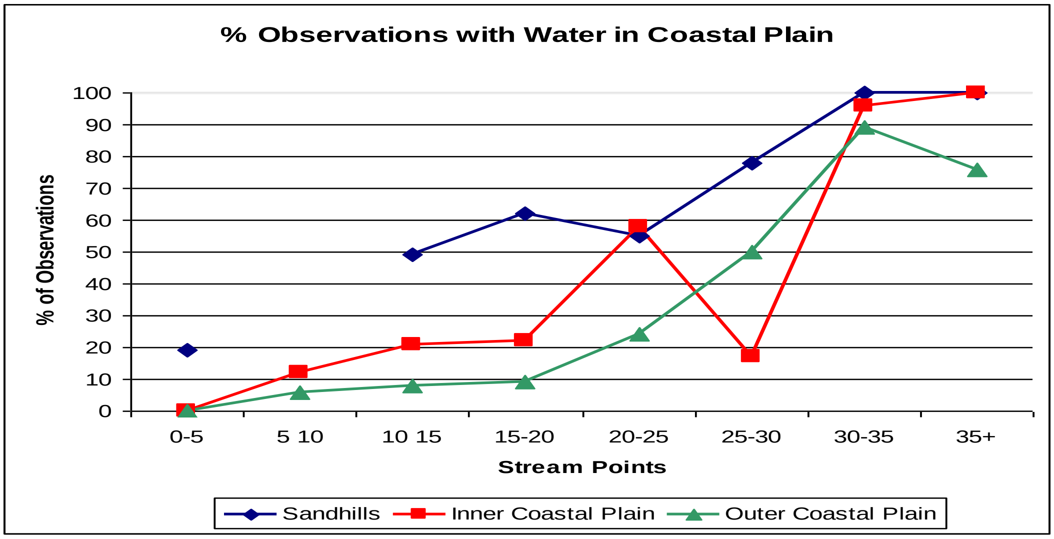

Figure 9. Percent of Observations in NC Coastal Plain with Water by Ecoregion

The definition of a perennial stream, water in channel all year round in a year of normal rainfall, is met by stream reaches of 30 points and up in all coastal ecoregions, and possibly fewer in the sandhills, since this study period was dominated by below normal rainfall. However it is more difficult to infer where the intermittent should start based on the NC regulatory definition of water in channel for several months out of the year, but dry for some part. If one accepts the Corps definition of seasonally wet (3 months or 25% of year), this could correspond to approximately 24 points in the outer coastal plain, 20 points in the inner coastal plain and about 10 points in the sand hills, though this last estimate falls in the middle of a data gap. Since it has been a policy decision to make 19 points the beginning of intermittent reaches and 30 the beginning of perennial across ecoregions, it would appear that further training would be in order for those people making stream calls in the coastal plain, particularly the sandhills, to be more aware of between-ecoregion differences in the strength of channel forming features to bring these scores up back where they should be.

Figure 10 shows all aquatic abundance data for the coastal plain and Figure 11 shows the same for the Piedmont. Aquatic taxa richness data show the same trends. The first three sets of columns of the two graphs are comparable, while the last set of columns on the Coastal Abundance graph is equivalent to the last two sets of columns in the Piedmont graph. Once again, the story is “more water, more aquatic life”. The large spikes in aquatic life in Coastal Plain lower “ephemeral” and “intermittent” stream segments in February and May 2007 were because these areas had stayed wet for months previously and were populated by short-lived taxa. Primarily these taxa were midges from the subfamily Chironomini (*Tanytarsus, Polypedilum, Tribelos*), other Diptera (*Pseudolimnephila* and *Palpomyia/ Bezzia* gp), isopods *(Asellus*), amphipods (*Crangonyx*) and dytiscid beetles (*Neoporus*).

The second observation is that, on average, more aquatic life was present in ephemeral coastal segments than in piedmont segments with similar scores, roughly the same amount of aquatic life in piedmont and coastal intermittent reaches and less life in perennial coastal streams, compared to perennial piedmont streams. In areas scoring fewer than 10 points, in the coastal plain there were two seasons in 2007 when an average of >50 aquatic animals were found, when not even the wettest season reached this level in the Piedmont. In the lower ephemeral segments, both coastal plain and piedmont sites had four seasons with an average of

100 or more aquatic animals, however two of these seasons averaged 300 animals or more. Both Piedmont and Coastal Plain had four seasons with an average of nearly 200 animals, two of which exceeded 400 individuals. Finally, six of the seven Coastal Plain perennial sites had between 200-300 aquatic individuals, whereas in the Piedmont, seven of the eight seasons averaged > 200 individuals/site, however four of these seven sites averaged > 400 individuals/site.

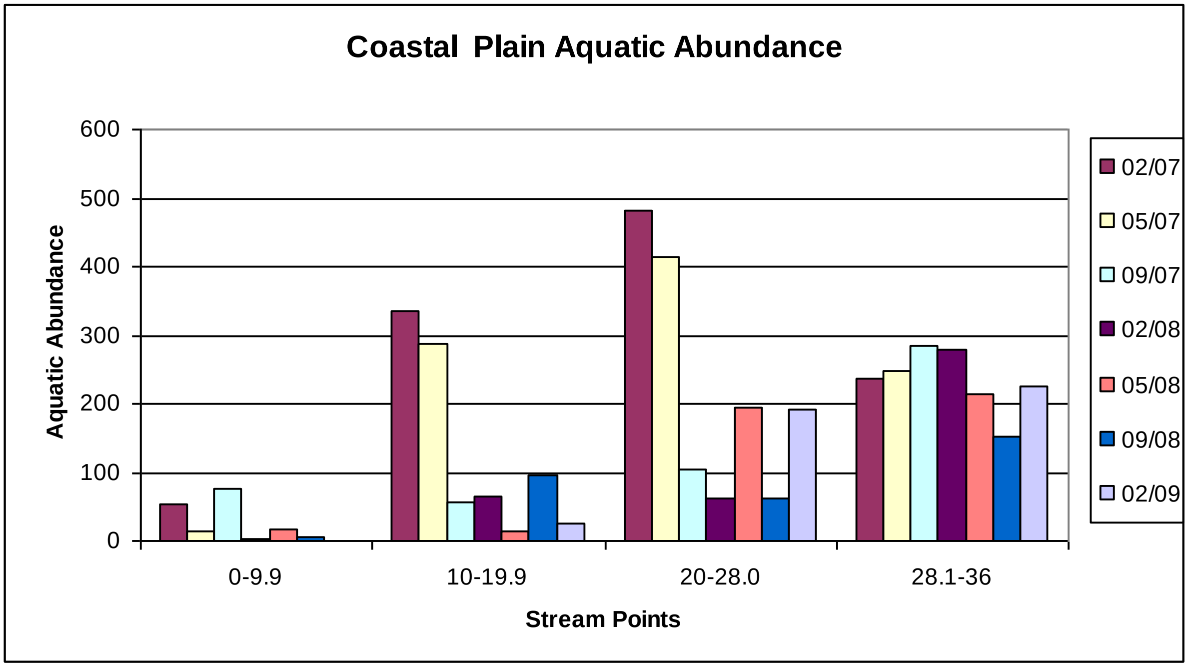

Figure 10. Total Aquatic Abundance at Coastal Plain Headwater Sites

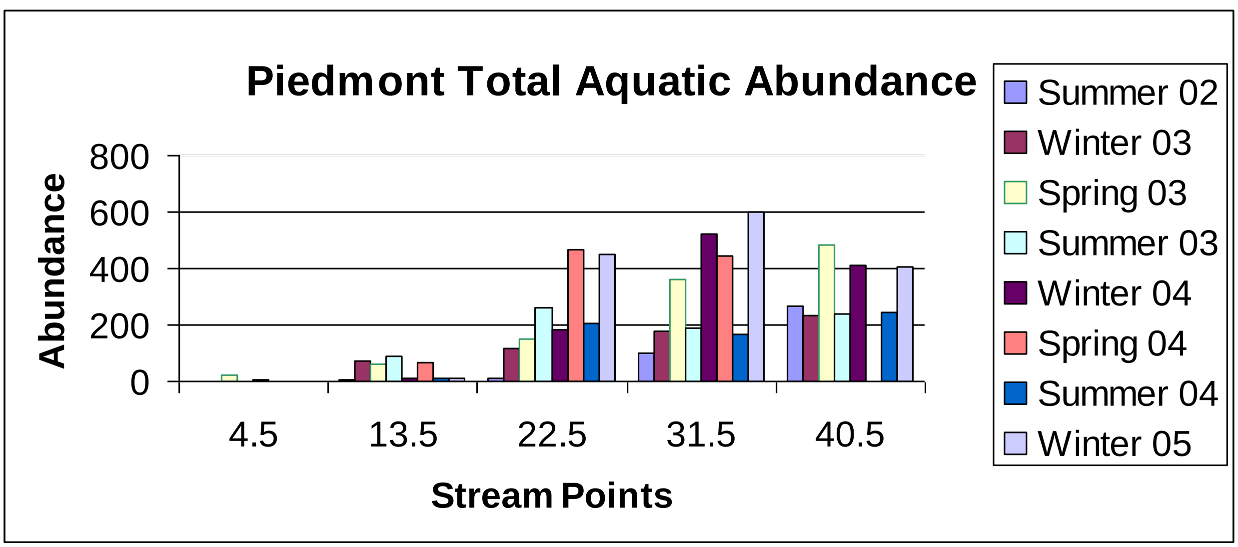

Figure 11. Total Aquatic Abundance at Piedmont Headwater Sites

Table 2 presents a summary of the taxa collected at each site in this study. Most sites reflect two years of collecting in three seasons over a wet year and a dry year. The exception is

Bynum Mill, which was only monitored for one year before landowner permission was revoked. During this year, however, 102 different taxa were collected, nearly half (47%) of them diptera. All sites at Bynum Mill were rated intermittent (19-27 points on NC stream determination form), which was borne out by the lack of taxa from many groups considered to be perennial indicators: caddisflies, stoneflies, megalopterans, vertebrates and snails and only a single mayfly (*Centroptilum*). Interestingly, the percent of terrestrial taxa from an intermittent stream (12%) like Bynum Mill does not appear to be different from streams that have ephemeral, intermittent and perennial components (9-19%).

Even though the Brice Creek site had perennial segments, which had contained water for years previously, the entire reach dried out in 2008, as did the Bynum Mill site. This may explain why there were several community characteristics in common with the two otherwise dissimilar sites: lowest taxa richness and EPT taxa richness numbers, low % of community as Terrestrial Taxa and no stoneflies.

Mollusc presence seemed to be associated with pH, ranging from 0-2 taxa in the streams with lower pHs (4.0-5.0) and 3-10 in streams (Bynum, Stoney and Cusack) with higher pH (5.5-6.5). Interestingly, two of the four sites where more than one mayfly was collected were in the lower pH group, even though mayflies are generally considered to be sensitive to low pH (Hubbard and Peters 1978). There did not appear to be any between-ecoregion trends that were greater than interecoregion variability.

Table 2. Total number of taxa collected at each site over the course of the study.

Parameter/Site	**Bynum***	**Stoney**	**Cliffs**	**Nicks**	**Mill 1**	**Mill 2**	**Brice**	**Cusack**
Ephemeroptera	1	3	0	4	1	3	0	5
Trichoptera	0	7	8	9	7	7	4	8
Plecoptera	0	5	1	2	1	1	0	1
Misc Diptera	21	22	23	18	27	26	16	31
Chironomidae	26	54	36	57	56	51	27	42
Coleoptera	12	12	8	6	13	11	13	18
Odonata	4	3	5	3	4	10	8	5
Oligochaeta	10	12	7	8	8	7	5	14
Megaloptera	0	1	3	3	2	2	3	1
Crustacea	11	13	11	9	9	11	10	13
Mollusca	3	5	2	0	2	2	2	10
Other	13	15	12	18	24	18	13	22
Total Taxa	102	152	116	137	154	149	101	170
EPT Taxa	1	15	8	15	9	11	4	13
Terrestrial Taxa (%)	12 (12)	16 (11)	22 (19)	16 (12)	27 (18)	18 (12)	9 (9)	29 (17)

*Bynum Mill was only sampled for one yr, so taxa list is shorter than other sites sampled for two years.

Appendix 2 contains a list of the 358 taxa collected during this study. As usual, the single largest group was the Diptera, which made up 48% of the total taxa richness in this study. Of these, 116 taxa were in the family Chrionomidae (midges) and 56 taxa were in all the other families combined). Beetles (Coleoptera) were the second most abundant group, with 46 taxa. The family Dytiscidae accounted for nearly 1/3 of their taxa richness. The major groups of macroinvertebrates that were the least well represented in these headwater systems were the mayflies (Ephemeroptera), stoneflies (Plecopetera) and caddisflies (Trichoptera), with 30 taxa between them. While this diversity would be considered good for a single collection from a mid-order coastal plain stream (DENR 2006), this taxa richness was the sum of multiple sites collected from multiple streams over multiple seasons over two years. One reason for the low taxa richness of these groups was their general intolerance to drying and the drought in the second year of this study, which dried up many of the perennial stream segments.

Interestingly, the nematodes, a group frequently overlooked in macroinvertebrate assessments due to their low abundance, had more taxa in this study (11) than the mayflies (9 taxa) or the molluscs (10 taxa). This is probably due to the smaller mesh size (250 microns) used in the sand sample catching a larger number of small taxa that normally pass through the more customary 600 micron mesh net. Water mites (Hydracarina), another group not usually included in macroinvertebrate collections in North Carolina, also turned out to have a surprising diversity (eight taxa) and should be considered as important to collect and identify as a component of a water quality assessment as isopods (nine taxa), and amphipods (two taxa).

Conclusions

With the completion of this study, the State of North Carolina has concluded that there is now enough information documenting the presence and abundance of aquatic life in intermittent streams such that the State will begin to require mitigation for impacts to intermittent streams beginning October 13, 2009. Mitigation for intermittent streams will be at the same rate as impacts to perennial streams; 1:1 for impacts greater than 150 feet (NCDENR 2009). It is estimated that this will require avoidance of, or mitigation for impacts to, over two miles of intermittent streams every year whose aquatic functions have not been replaced through compensatory mitigation up until now.

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Appendix 1. Study locations.

Station	Latitude	Longitude	Ave Pts
Mill 1 A1	35 09 12.913	79 21 17.567	3.00
Mill 1 A2	35 09 12.559	79 21 16.974	16.25
Mill 1 A3	35 09 13.045	79 21 17.339	25.50
Mill 1 A4	35 09 13.340	79 21 16.825	26.75
Mill 1 A5	35 09 14.772	79 21 16.152	20.00
Mill 1 A6	35 09 15.156	79 21 16.042	3.75
Mill 1 A7	35 09 15.176	79 21 15.912	22.75
Mill 1 B5	35 09 14.315	79 21 15.943	16.50
Mill 1 B6	35 09 14.477	79 21 15.975	2.75
Mill 1 B7	35 09 14.701	79 21 15.679	16.00
Mill 1 B8	35 09 15.101	79 21 15.504	23.50
Mill 1 B9	35 09 15.445	79 21 14.970	29.00
Mill 1 B10	35 09 15.735	79 21 14.788	30.00
Mill 1 B11	35 09 16.369	79 21 14.763	32.00
Mill 1 B12	35 09 16.871	79 21 14.961	30.25
Mill 1 B13	35 09 17.417	79 21 15.733	26.50
Mill 2 1	35 09 15.933	79 21 18.786	1.50
Mill 2 2	35 09 16.024	79 21 18.530	13.00
Mill 2 3	35 09 16.345	79 21 18.170	16.50
Mill 2 4	35 09 16.591	79 21 17.766	19.50
Mill 2 5	35 09 17.034	79 21 17.361	28.75
Mill 2 6	35 09 16.993	79 21 16.933	29.25
Mill 2 7	35 09 17.138	79 21 16.452	33.25
Mill 2 8	35 09 17.960	79 21 16.119	33.75

Station	Latitude	Longitude	Ave Pts
Nicks Cr 1	35 13 38.274	79 32 02.020	4.00
Nicks Cr 2	35 13 38.523	79 32 02.019	16.50
Nicks Cr 3	35 13 38.969	79 32 02.361	25.25
Nicks Cr 4	35 13 39.717	79 32 02.135	31.75
Nicks Cr 5	35 13 40.077	79 32 01.631	31.50
Nicks Cr 6	35 13 41.060	79 32 00.444	36.50
Brice Cr 1	35 02 14.408	77 03 49.272	17.00
Brice Cr 2	35 02 13.794	77 03 46.915	22.25
Brice Cr 3	35 02 12.562	77 03 42.854	23.38
Brice Cr 4	35 02 11.741	77 03 39.545	22.25
Brice Cr 5	35 02 10.990	77 03 36.050	28.63
Brice Cr 6	35 02 09.546	77 03 32.987	29.00
Brice Cr 7	35 02 10.706	77 03 29.883	28.13
Brice Cr 8	35 02 11.025	77 03 26.119	29.50
Brice Cr 9	35 02 10.163	77 03 22.294	26.75
Brice Cr 10	35 02 10.081	77 03 18.548	28.13
Brice Cr 11	35 02 10.594	77 03 15.028	33.50
Brice Cr 12	35 02 11.038	77 03 11.582	35.50
Brice Cr 13	35 02 11.277	77 03 08.320	37.00
Cusak Cr 1	34 09 57.203	78 07 00.213	3.25
Cusak Cr 2	34 09 56.931	78 07 00.183	10.63
Cusak Cr 3	34 09 55.606	78 07 00.169	11.63
Cusak Cr 4	34 09 54.379	78 07 00.663	9.13

Cusak Cr 5	34 09 54.492	78 07 02.608	13.25
Cusak Cr 6	34 09 54.131	78 07 03.351	23.00
Cusak Cr 7	34 09 53.466	78 07 04.144	15.88
Cusak Cr 8	34 09 53.164	78 07 04.483	11.50
Cusak Cr 9	34 09 53.012	78 07 04.889	16.50
Cusak Cr 10	34 09 52.768	78 07 05.363	19.00
Cusak Cr 11	34 09 52.796	78 07 06.800	25.50
Cusak Cr 12	34 09 52.814	78 07 07.404	27.25
Turkey Cr Conf.	34 09 52.267	78 07 08.852	40.5
Stoney Cr 1	35 57 58.797	77 56 03.745	9.50
Stoney Cr 2	35 57 59.280	77 56 03.985	15.00
Stoney Cr 3	35 58 00.940	77 56 04.136	21.00
Stoney Cr 4	35 58 01.753	77 56 05.366	23.75
Stoney Cr 5	35 58 04.482	77 56 06.858	31.25
Stoney Cr 6	35 58 06.154	77 56 06.809	31.50
Stoney Cr 7	35 58 06.885	77 56 05.833	33.75
Stoney Cr 8	35 58 07.049	77 56 05.458	37.50
Cliffs 1	35 13 50.8	77 53 27.1	3.50
Cliffs 2	35 13 52.2	77 53 26.7	8.50
Cliffs 3	35 13 53.58	77 53 26.22	11.75
Cliffs 4	35 13 54.9	77 53 25.74	22.00
Cliffs 5	35 13 55.44	77 53 25.32	4.75
Cliffs 6	35 13 55.92	77 53 25.14	23.75
Cliffs 7	35 13 56.7	77 53 24.42	21.50
Cliffs 8	35 13 56.64	77 53 23.4	30.00
Cliffs 9	35 13 56.76	77 53 22.98	32.25
Cliffs 10	35 13 56.4	77 53 22.26	34.25
Cliffs 11	35 13 57.24	77 53 20.94	33.75
Cliffs 12	35 13 57.36	77 53 20.04	37.75
Cliffs 13	35 13 57.72	77 53 19.02	35.00
Bynum Mill 1	35 45 45.348	77 42 54.778	19.58
Bynum Mill 2	35 45 46.052	77 42 55.226	21.00
Bynum Mill 3	35 45 47.109	77 42 55.218	27.08
Bynum Mill 4	35 45 47.879	77 42 55.089	27.17
Bynum Mill 5	35 45 48.659	77 42 54.778	18.83

Appendix 2. Taxa collected during coastal headwater study.

Ephemeroptera

Baetis frondalis
Caenis
Centroptilum
Eurylophella doris
Eurylophella funeralis
Leptophlebia spp
Leptophlebia intermedia
Paraleptophlebia
Stenonoma modestum

Trichoptera

Chevmatopsyche
Diptetrona modesta
Heterplectron americanum
Hydatophylax
Ironoquia punctatissima
Lepidostoma
Lype diversa
Molanna blenda
Oxyethira
Platycentropus
Polycentropus
Ptilostomis
Pycnopsyche
Triaenodes abus
Wormaldia

Plecoptera

Allocapnia
Amphinemura
Leuctra
Perlesta placida
Prostoia
Shipsa rotunda

Misc Diptera

Aedes
Anepholes
Bezzia
Bezzia (long & narrow)
Bittacomorpha
cf Dolichopodidae
Chaoborus
Chrysops
Circulonidae (terrestrial)
Culex
Culicidae
Dasyhela
Dixa
Dolichopodidae
cf Dolichopodidae
Dorniphora cornuta
Empididae
Ephydra
Erioptera
Eristalsis
Hexatoma
Hexatoma sm white
Limnephila
Nemotelus
cf Nemotelus
Neoascia
Nippotipula
Ormosa
Orthopodomyia signifera
Palpomyia
Palpomyia (wide & short)
Pedicia
Pericoma
Pilaria
Platytipula
Pseudolimnephila
Psorophora
Psychoda
Ptychoptera
Simulium
Tabanus
Telmatoscopus
Terr muscid 6 hairs
Terr 8 anal hairs
Terr cf Psychoda
Terr Hairy Muscid 4 dorsal hairs
Terr White Muscidae
Yamatotipula

Chironomidae

Ablabesmyia mallochi
Allotanypus
Antillocladius
Apedilum elastichus
Apsectrotanypus
Bethbilbeckia
Brundiniella
Camptocladius
Chaetocladius
Chironomus
Cladotanytarsus dautesi

Clinotanypus
Conchapelopia
Constempellina
Corynoneura
Cryptochironomus fulvus
Cryptotendipes
Diamesa?
Dicrotendipes leucoselis
Diplocladius cultriger
Doithrix villosa
Endochironomous nigricans
Endotribelos hesperium
Eukiefferiella sp1
Eukiefferiella sp4
Eukiefferiella sp6
Georthocladius
Georthocladius fimbratus
Glyptotendipes
Gymnometriocnemus
Heterotrissocladius
Heterotrissocladius marcidus
Hydrobaenus
Hydrobaenus sp O
Labrundinia
Labrundinia pilosella
Larsia
Larsia sp B (epler)
Limnophyes
Macropelopia
Micropsectra spA (sp1)
Micropsectra spD (sp4?)
Micropsectra sp5
Microspectra sp 9
Microtendipes
Microtendipes pedellus
Nanocladius
Natarsia
Nilothauma
Orthocladius annectens C/O 52
Orthocladius lignicola
Orthocladius robacki C/O 12
Parachaetocladius
Parachaetocladius abnobaeus
Parakieferiella
Parakieferiella sp A
Parametreonemus lundbecki
Paraphaenocladius
Paraphaenocladius exigitans
Paratanytarsus
Paratendipes (subaequalis)
Paralauterborniella nigrohalteralis
Phaenopsectra
Phaenopsectra obediens sp
Phaenopsectra punctipis
Polypedilum aviceps
Polypedilum flavum
Polypedilum halterale
Polypedilum illinoense
Polypedilum scalenum
Polypedilum tritum
Procladius
Psectrocladius
Psectrotanypus elatus
Psectrocladius pilosus
Pseudorthocladius
Pseudosmittia
Psilometriocnemus
Psilometriocnemus elatus
Rheocricotopus
Rheocricotopus tuberculatus
Rheotanytarsus
Smittia
Smittia sp B
Stempellinella
Stempellinella sp A
Stempelllina sp C
Stenochironomus
Sublettea coffmani
Tanypus
Tanytarsus sp1
Tanytarsus sp10
Tanytarsus sp14
Tanytarsus sp15
Tanytarsus sp2
Tanytarsus sp3
Tanytarsus sp4
Tanytarsus sp5
Tanytarsus sp6
Tanytarsus sp7
Thienemaniella
Tribelos
Tribelos fuscicorne
Tribelos jacundis
Uniella
Uniella multivirgata
Virgatanytarsus?
Zavrelia
Zavrelimyia
Zavrelimyia sp A

Coleoptera

Acilius mediatus
Agabetes (larvae)
Agabus (adult & larvae)
Agabus punctatus (adult)
Anchytarsus bicolor (adult & larvae)
Celina (adult & larvae)
Circulonidae (terr)
Copelatus (adult & larvae)
Copelatus chevrolati
Dubiraphia (adult)
Dubiraphia (larvae)
Enochrus
Helichus (adult & larvae)
Helocombus (adult & larvae)
Hydaticus bimarginatus (adult)
Hydaticus cinctipeniis (adult)
Hydraenidae (larvae)
Hydrobius (adult & larvae)
Hydrophilidae (adult & larvae)
Hydroporus (adult & larvae)
Hydroporus deflatus
Hydroporus politus
Hygrotus (adult)
Ilybius (larvae)
Laccophilus fasciatus rufus
Laccornis (larvae)
Laccornis difformis
Neoporus (adult & larvae)
Neoporus mellitus
Rhantus
Rhantus calidus
Peltodytes (larvae)
Psephenus herricki
Pseudo hydrophilidae (terr)
Scirtes
Scirtes like (long antennae)
Scirtes like (short antennae)
Sperchopsis tessalatus
Stenelmis (larvae)
Terr beetle (Cantharidae)
Terr Beetle larvae
Terr Beetle larvae elimidae
Terr Hairy Elmid like
Terr Beetle larvae nr circulonidae
Thermonectes basillaris (adult)
Tropisternus

Odonata

Aeshna umbrosa
Aeshnidae
Argia
Boyeria grafiana
Boyeria vinosa
Calopteryx
Cordulegaster
Cordulegaster maculata
Enallagma
Gomphaeshna antilope
Ischnura
Ladona
Libellula
Pachydiplax longipenis
Perithemis
Plathemis lydia
Somatochlora
Sympetrum

Oligochaeta

Earthworm
Enchytreidae
Haplotaxis gordioides
Ilyodrilus frantzi
Isochaetides curvistetosus
Isochaetides freyi
Limnodrilus hoffmeisteri
Limnodrilus udekemaianus
Lumbriculidae
Lumbriculidae (short probiscus)
Nais
Opisthoporus
Potamothryx vejdovski
Pristinella
Pristinella jenkinsae
Spirosperma ferox
Spirosperma nikolski
Tubifex
Tubificidae no hair
Tubificidae w/ hair

Megaloptera

Chauliodes pectinicomis
Nigronia fasciatus
Nigronia serratocornis
Sialis

Crustacea

Asellus
Asellus attenuatus

Asellus forbesi
Asellus laticaudatus
Asellus montanus
Asellus obtusus
Asellus occidentalis
Asellus racovitzai
Asellus rodulus
Astacidae
Collembola
Cambarus
Cambarus bartoni
Crangonyx
Crangonyx serratus
Copepod (calenoid)
Copepod (harpacticoid)
Copepod (cyclopoid)
Ostracod
Procambarus
Procambarus acutus
Terrestrial isopod

Mollusca

Amnicola limosa
Campeloma decisom
Ferrissia
Micromenetus dilatus
Musculium
Physella
Pisidium
Pseudosuccinea collumella
Sphaerium
Terrestrial Snail

Other

Alaimus
Albia
Anatonchus
Ant
Centipede sm, long antennae
Chain pickerel
Cura foremani
Dugesia tigrina
Earwig
Ethmolaimus
Flea
Gerris
Heteroptera
Hydracarina (white & hairy)
Hydrodroma
Hydroma
Hygrobates
Ironus
Laimydorus
Limnesia
Lepidoptera larvae
Leptolaimus
Mesodorylaimus w tail
Mesovelia
Metrobates
Millipede
Mite (terrestrial)
Mosquito fish (Gambusia)
Mud Minnow? (Umbra pygmaea?)
Nematoda
Nemertea
Notonecta
Oxydirus
Pirate perch
Pleidae
Prostoma graecens
Pseudoscorpion
Pyralidae
Rhagovelia
Salamander (undescribed sp)
Salamander (4 toes)
Salamander (2lined?)
Sigara
Spider
Sperchon
Springtail (collembola)
Tadpole
Termite
Thrips (Thysanopetera)
Thornia