Appendix II

Biological Water Quality Data Collected by DWQ

Benthic Macroinvertebrate Sampling Methods and Criteria

Freshwater Wadeable and Flowing Waters

Benthic macroinvertebrates can be collected from wadeable, freshwater, flowing waters using two sampling procedures. The Division of Water Quality's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (NCDEHNR, 1997). The purpose of these collections is to inventory the aquatic fauna and produce an indication of relative abundance for each taxon. Organisms are classified as Rare (1-2 specimens), Common (3-9 specimens), or Abundant (≥10 specimens).

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

EPT taxa richness (EPT S) is used with DWQ criteria to assign water quality ratings (bioclassifications). "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution. Higher EPT taxa richness values usually indicate better water quality. Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI).

Both tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions. Water quality ratings assigned with the biotic index numbers are combined with EPT taxa richness ratings to produce a final bioclassification, using criteria for coastal plain streams. EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. If the EPT taxa richness rating and the biotic index differ by one bioclassification, the EPT abundance value is used to determine the final site rating.

Benthic macroinvertebrates can also be collected using an EPT sampling procedure. Four rather than 10 composite qualitative samples are taken at each site: 1 kick, 1 sweep, 1 leafpack and visual collections. Only EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification.

Both EPT taxa richness and biotic index values also can be affected by seasonal changes. DWQ criteria for assigning bioclassification are based on summer sampling: June - September. For samples collected outside summer, EPT taxa richness can be adjusted by subtracting out winter/spring Plecoptera or other adjustment based on resampling of summer site. The biotic index values also are seasonally adjusted for samples outside the summer season.

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis.

Boat Sampling and Coastal B Criteria

Coastal B rivers are defined as waters in the coastal plain that are deep (nonwadeable) with little or no visible current under normal or low flow conditions and that have freshwater. Other characteristics may include open canopy, low pH and low dissolved oxygen. These waters require a boat for sampling. These are usually large coastal plain rivers, including the lower sections of the Alligator, Chowan, Meherrin, Neuse, Pasquotank, Perquimans, Roanoke, Tar, South, Black, Waccamaw, Wiccacon, Northeast Cape Fear and Cape Fear Rivers. In such habitats, petite Ponar dredge sampling replaces kick-net samples, but all other standard qualitative collections techniques are still useable.

The standard boat method still aims at a total of 10 composite samples per site:

- Dredges - 3 composite samples using a petite Ponar.
- Sweeps - 3 samples collected from bank habitats, sampling as much of the edge habitat as possible, including aquatic macrophytes, roots and areas of debris.
- Leaf packs/Debris wash -1 composite sample of leaves and other large particulate organic matter are to be rinsed in a wash bucket.
- Epifaunal collections - 2 composite samples of macrophytes and well-colonized logs both in the current and along the shore.
- Visuals - should cover macrophytes, logs along the shore, and especially logs in the current.

The Biological Assessment Unit has limited data on Coastal B rivers and has had a difficult time gathering more data. Criteria have been developed based only on EPT taxa richness (Table A-II-1), although using biotic index values and total taxa richness values were also evaluated. The criteria that are presented here will continue to be evaluated, and any bioclassifications derived from them should be considered tentative and not used for use support decisions.

Swamp streams

Swamp streams are located in the coastal plain area and cease flowing during summer low flow periods. This seasonal interruption in flow limits the diversity of the fauna, requiring special criteria to properly rate such streams. The swamp stream sampling method utilizes a variety of collection techniques to inventory the macroinvertebrate fauna at a site. Nine sweep samples (one series of three by each field team member) are collected from each of the habitat types: macrophytes, root mats/undercut banks, and detritus deposits. If one of these habitat types is not present, a sweep from one of the other habitats should be substituted. A sweep for the swamp method is defined as the area that can be reached from a given standing location. Three log/debris washes also are collected. Visual collections are the final technique used at each site.

Samples are picked on site. The primary output for this sampling method is a taxa list with an indication of relative abundance (Rare, Common or Abundant) for each taxon. Sampling during

winter flow periods provides the best opportunity for detecting impacts, and only winter benthos (February and March) data can be used to evaluate swamp streams.

A draft multi-metric system is being developed to evaluate swamp streams, using the NC Biotic Index (BI), habitat score, total taxa richness (S), and EPT abundance (EPT N). The system uses data from the Lumber, White Oak, Cape Fear, Neuse and Tar River basins. Other basins will need different criteria. Swamp streams are divided into two broad types: streams with a distinct channel and streams with a braided channel. EPT abundance and total taxa richness are expected to be lower in braided swamp streams. Stream pH also affects these metrics, and scoring criteria will likely be adjusted for all sites with pH <5.5.

References

Chutter, F. M. 1972. *An Empirical Biotic Index of the Quality of Water in South African Streams and Rivers*. Water Research. 6:19-30.

Hilsenhoff, W. L. 1977. *Use of Arthropods to Evaluate Water Quality in Streams*. Wisconsin Department of Natural Resources. Technical Bulletin No. 100.

Lenat, D. L. 1993. *A Biotic Index for the Southeastern United States: Derivation and List of Tolerance Values, with Criteria for Assigning Water Quality Ratings*. J. North American Benthological Society. 12:279-290.

Flow Measurement

Changes in the benthic macroinvertebrate community are often used to help assess between-year changes in water quality. Some between-year changes in the macroinvertebrates, however, may be due largely to changes in flow. High flow years magnify the potential effects of nonpoint source runoff, leading to scour, substrate instability and reduced periphyton. Low flow years may accentuate the effect of point source dischargers by providing less dilution of wastes. For these reasons, all between-year changes in the biological communities are considered in light of flow conditions (high, low or normal) for one month prior to the sampling date. Daily flow information is obtained from the closest available USGS monitoring site and compared to the long-term mean flows. High flow is defined as a mean flow >140 percent of the long-term mean for that time period, usually July or August. Low flow is defined as a mean flow <60 percent of the long-term mean, while normal flow is 60-140 percent of the mean. While broad scale regional patterns are often observed, there may be large geographical variation within the state, and large variation within a single summer period.

Habitat Evaluation

The Division has developed a habitat assessment form to better evaluate the physical habitat of a stream. The habitat score has a potential range of 1-100, based on evaluation of channel modification, amount of instream habitat, type of bottom substrate, pool variety, bank stability, light penetration and riparian zone width. Higher numbers suggest better habitat quality, but no criteria have been developed to assign impairment ratings.

Table A-II-1 Benthic Macroinvertebrate Data, Lumber River Basin, 1983 – 2001
(Basin sites are in **bold**.)

Waterbody	Location	County	Index No.	Date	ST	EPT	BI	EPTBI	BioClass
03-07-50									
Drowning Cr	SR 1124	Moore	14-2-(1)	02/16/89	35	35	3.45	3.45	Good
White Cedar Br	USGS site	Richmond	14-2-(1)	03/05/86	47	10	5.01	2.97	Good
				02/09/84	35	10	4.59	2.78	Good
Jackson Cr	SR 1122	Moore	14-2-5	07/09/01	---	23	---	3.16	Good
				07/08/96	---	25	---	2.88	Excellent
				02/16/89	---	26	---	3.39	Good-Fair
Naked Cr	SR 1490	Richmond	14-2-6	01/17/90	94	46	4.45	3.30	Excellent
Naked Cr	SR 1003	Richmond	14-2-6	07/13/01	98	41	4.55	3.61	Excellent
				07/08/96	81	33	4.75	3.61	Excellent
				09/09/91	94	35	4.61	2.91	Excellent
				11/07/90	83	31	5.12	3.89	Excellent
				07/17/90	80	34	4.58	3.15	Excellent
				05/09/90	---	39	---	3.45	Excellent
				04/06/90	92	42	4.82	3.12	Excellent
				01/17/90	---	37	---	3.13	Excellent
				02/16/89	---	46	---	3.20	Excellent
				10/23/86	98	33	4.66	2.95	Excellent
				03/01/85	101	35	4.28	2.74	Excellent
				12/12/84	93	37	4.55	2.88	Excellent
				02/09/84	85	35	4.26	2.67	Excellent
				05/18/83	86	32	4.66	3.18	Excellent
Joe's Br	near SR 1003	Richmond	14-2-6	05/09/90	---	16	---	3.10	Excellent
				03/05/85	40	14	4.59	3.60	Good
				02/09/84	45	13	4.74	3.35	Good
Rocky Ford Br	SR 1424	Richmond	14-2-6-1	05/09/90	---	27	---	3.93	Excellent
Drowning Cr	SR 1004	Richmond	14-2-(6.5)	07/13/01	81	31	4.51	2.81	Excellent
				07/08/96	74	34	4.57	3.26	Excellent
				09/09/91	90	39	4.50	2.81	Excellent
				02/16/89	---	40	---	2.65	Excellent
				07/14/88	87	30	4.67	2.69	Excellent
				09/11/85	74	28	4.36	2.76	Excellent
Horse Cr	SR 1102	Moore	14-2-10	07/09/01	---	20	---	2.80	Good
				07/08/96	---	28	---	2.78	Excellent
				09/09/91	---	26	---	2.39	Excellent
UT Deep Cr	USGS site	Moore	14-2-10-1-(1)	03/06/86	48	13	5.07	2.90	Excellent
				02/14/84	49	12	4.64	2.72	Excellent
Aberdeen Cr	SR 1102	Moore	14-2-11-(6)	10/08/87	---	23	---	3.17	Good
Aberdeen Cr	below WWTP	Moore	14-2-11-(6)	10/08/87	---	21	---	3.92	Good
Quewhiffle Cr	SR 1214	Hoke	14-2-14	03/05/98	---	7	---	3.56	Not Rated
				04/24/89	40	12	4.94	3.40	Not Rated
				01/30/84	27	4	6.42	3.75	Not Rated
Quewhiffle Cr	SR 1225	Hoke	14-2-14	04/24/89	73	26	4.69	2.99	Good
				01/30/84	79	22	4.74	3.03	Good
Mountain Cr	SR 1219	Hoke	14-2-16-(2)	07/13/01	---	9	---	4.96	Not Rated
Buffalo Cr	SR 1203	Hoke	14-2.5	01/30/84	69	22	5.30	3.99	Good
03-07-51									
Lumber R	SR 1404	Scotland	14-(3)	07/17/01	90	36	4.57	3.45	Excellent
				07/09/96	75	33	4.06	2.98	Excellent
				05/03/94	104	46	4.49	3.18	Excellent
				09/10/91	83	30	5.17	2.99	Excellent
				10/22/86	85	36	5.02	3.62	Excellent
				07/14/86	88	30	5.06	3.69	Excellent
				10/22/85	89	34	5.05	2.84	Excellent

Waterbody	Location	County	Index No.	Date	ST	EPT	BI	EPTBI	BioClass
Lumber R	SR 1433	Scotland	14-(3)	07/14/86	89	30	5.02	3.59	Excellent
				10/22/85	90	29	5.33	3.25	Good
Lumber R	NC 71	Robeson	14-(4.5)	07/17/01	92	34	5.27	4.06	Excellent
				07/09/96	69	27	4.77	3.49	Excellent
				05/03/94	85	29	4.97	3.51	Good
				09/10/91	78	23	5.54	3.84	Good
				08/07/90	92	26	5.88	4.46	Good
				07/13/88	88	29	5.25	3.59	Excellent
				10/22/86	69	27	5.11	3.50	Excellent
				07/17/85	74	22	5.23	4.01	Excellent
				04/03/85	97	36	5.77	3.85	Excellent
Lumber R	SR 1303	Robeson	14-(4.5)	04/03/85	79	32	5.42	3.48	Excellent
Lumber R	SR 1153	Robeson	14-(4.5)	04/03/85	88	38	5.44	3.76	Excellent
Lumber R	SR 1354	Robeson	14-(4.5)	10/22/86	73	26	5.20	3.63	Excellent
				07/14/86	71	25	4.97	3.99	Excellent
Gum Swp	SR 1312	Robeson	14-5	07/17/01	---	15	---	5.73	Not Impaired
				02/08/01	75	21	6.10	4.64	Not Rated
Lumber R	SR 1003	Robeson	14-(7)	07/18/01	92	32	5.10	4.03	Excellent
				07/09/96	71	31	4.79	3.79	Excellent
				09/11/91	86	30	5.79	3.89	Excellent
				08/07/90	87	28	5.37	4.18	Excellent
				07/13/88	88	28	5.20	4.25	Excellent
				10/23/86	82	31	5.21	3.56	Excellent
				07/15/86	84	32	5.27	4.06	Excellent
				07/17/85	84	30	5.31	4.25	Excellent
				07/27/83	95	30	5.43	3.90	Excellent
				07/27/83	79	24	5.29	4.41	Excellent
Lumber R	NC 72/711	Robeson	14-(7)	09/11/91	67	27	5.98	4.48	Good
Back Swp	SR 1003	Robeson	14-8-(2.5)	07/17/01	61	11	6.16	4.81	Not Rated
				02/08/01	80	25	5.90	4.84	Not Rated
Back Swp	US 301	Robeson	14-8-(2.5)	09/11/91	---	15	---	4.85	Good-Fair
Bear Swp	SR 1339	Robeson	14-9-(1.5)	07/18/01	---	11	---	6.31	Not Rated
				02/08/01	79	17	6.22	4.89	Not Rated
				03/14/96	58	20	6.13	5.31	Not Rated
Lumber R	NC 41/72	Robeson	14-(13)	07/18/01	91	30	5.77	4.58	Excellent
				07/10/96	73	30	5.40	4.30	Excellent
Lumber R	SR 2289	Robeson	14-(13)	09/11/91	84	29	5.73	3.86	Good
				07/15/86	73	28	5.79	4.21	Good
				10/23/85	91	29	5.62	3.99	Good
				07/16/85	78	28	6.03	4.56	Good
Lumber R	SR 2202	Robeson	14-(13)	07/16/85	62	15	6.53	3.71	Good-Fair
Lumber R	above WWTP	Robeson	14-(13)	07/16/86	77	22	6.75	4.28	Good-Fair
				10/23/85	75	19	6.63	3.59	Good-Fair
Lumber R	NC 72, below WWTP	Robeson	14-(13)	08/21/01	53	12	6.46	4.61	Good-Fair
				07/11/96	57	15	6.33	4.38	Good-Fair
				07/16/86	43	5	8.08	6.53	Poor
				07/16/85	65	15	7.35	4.18	Good-Fair
Lumber R	US 74	Robeson	14-(21)	09/10/01	92	32	5.64	4.55	Excellent
				07/11/96	82	26	5.58	4.31	Good
				09/10/91	53	20	5.00	4.07	Good
				07/13/88	92	27	5.46	4.32	Excellent
				06/24/86	73	27	5.71	4.45	Good
Lumber R	NC 904	Robeson	14-(21)	07/10/96	81	30	5.06	3.65	Excellent
				09/10/91	69	23	4.96	4.11	Excellent
Porter Swp	SR 1503	Columbus	14-27	02/06/01	49	6	7.51	5.17	Not Rated
				03/15/96	41	6	7.32	3.20	Not Rated
				03/05/92	60	6	7.66	6.94	Not Rated
				09/11/91	---	3	---	6.59	Not Rated

Waterbody	Location	County	Index No.	Date	ST	EPT	BI	EPTBI	BioClass
Gapway Swp	SR 1356	Columbus	14-31	01/06/01	71	11	7.62	6.40	Not Rated
				03/15/96	57	16	7.10	5.98	Not Rated
03-07-52									
Raft Swp	SR 1505	Robeson	14-10-(1)	02/07/01	82	20	5.99	4.33	Not Rated
Big Raft Swp	NC 211	Robeson	14-10-(1)	09/11/91	---	16	---	4.64	Good-Fair
				12/29/88	75	24	6.28	4.82	Good-Fair
L Raft Swp	SR 1776	Robeson	14-10-5	02/21/01	48	8	7.47	7.11	Not Rated
L Raft Swp	SR 1505	Robeson	14-10-5	02/07/01	64	9	7.56	5.78	Not Rated
Big Raft Swp	SR 1526	Robeson	14-10-(5.5)	12/29/88	87	30	6.24	4.98	Good-Fair
Burnt Swp	above RR	Robeson	14-10-8-4-(0.5)	06/04/91	41	4	7.09	5.88	Not Rated
Burnt Swp	SR 1515	Robeson	14-10-8-4-(0.5	06/04/91	44	5	7.39	5.59	Not Rated
03-07-53									
Big Swp	NC 211	Robeson	14-22	07/10/96	---	15	---	4.24	Good-Fair
				09/23/91	59	14	6.30	3.93	Good-Fair
Big Swp	SR 1002	Robeson	14-22	09/23/91	61	15	6.11	3.70	Good-Fair
Gallberry Swp	NC 20	Robeson	14-22-1	09/12/91	---	19	---	4.40	Good
L Marsh Swp	SR 1907	Robeson	14-22-1-3	02/07/01	67	17	6.03	4.52	Not Rated
Big Marsh Swp	above Croft Metals	Robeson	14-22-2	08/11/92	45	10	6.76	6.11	Not Rated
Big Marsh Swp	below Croft Metals	Robeson	14-22-2	08/11/92	49	10	6.85	5.87	Not Rated
Big Marsh Swp	SR 1924	Robeson	14-22-2	02/07/01	77	20	6.25	4.73	Not Rated
				09/12/91		16		4.67	Not Rated
Jackson Br	SR 2100	Robeson	14-22-3-7	03/04/92	69	10	7.62	5.65	Not Rated
03-07-54									
Ashpole Swp	NC 41	Robeson	14-30	01/30/01	53	11	6.68	5.55	Not Rated
				03/15/96	53	10	6.67	5.84	Not Rated
				09/11/91	---	8	---	5.64	Not Rated
Ashpole Swp	SR 2258	Robeson	14-30	06/24/86	45	3	8.08	7.79	Not Rated
Hog Swp	SR 2262	Robeson	14-30-7	01/31/01	52	11	6.72	6.40	Not Rated
				03/13/96	51	13	6.69	6.10	Not Rated
				09/22/91	---	8	---	6.62	Not Rated
Indian Swp	SR 2255	Robeson	14-30-8	03/04/92	57	4	8.27	5.75	Not Rated
03-07-55									
Gum Swamp Cr	SR 1323	Scotland	14-32-(7)	07/09/01	---	22	---	3.01	Good
				07/10/96	---	15	---	2.71	Good-Fair
				09/09/91	---	17	---	2.86	Good-Fair
Gum Swamp Cr	SR 1319	Scotland	14-32-(10)	02/06/90	51	16	5.33	4.53	Good-Fair
Gum Swamp Cr	below Fieldcrest Mills	Scotland	14-32-(10)	02/06/90	39	17	6.26	4.63	Good-Fair
Gum Swamp Cr	US 15/401	Scotland	14-32-(12)	07/09/01	---	20	---	2.86	Good
				07/09/96	---	21	---	3.45	Good
				09/09/91	---	24	---	3.85	Excellent
Leiths Cr	SR 1610	Scotland	14-33	09/10/91	---	12	---	5.95	Good-Fair
Shoe Heel Cr	SR 1369	Scotland	14-34	09/06/90	82	27	5.70	3.74	Good
Shoe Heel Cr	SR 1612	Scotland	14-34	09/05/90	76	19	6.38	5.06	Good-Fair
Shoe Heel Cr	SR 1101	Robeson	14-34	07/10/01	53	18	4.87	3.44	Good
				07/10/96	68	25	4.53	3.54	Excellent
				09/10/91	75	26	5.47	3.67	Good
				08/07/90	80	28	5.37	3.78	Excellent
				07/07/87	73	24	4.89	5.58	Excellent
				09/17/85	70	21	5.04	3.94	Good

Waterbody	Location	County	Index No.	Date	ST	EPT	BI	EPTBI	BioClass
Jordan Cr	USGS site	Scotland	14-34-4-(1)	03/05/86	43	13	4.83	2.96	Good
				02/23/84	39	11	4.75	3.24	Good
Jordan Cr	US 401	Scotland	14-34-4-(2)	07/09/01	---	12	---	3.54	Good-Fair
				07/10/96	---	15	---	3.17	Good-Fair
03-07-56									
Waccamaw R	below dam	Columbus	15-(1)	06/19/91	55	13	6.36	4.92	Good-Fair
Waccamaw R	Crusoe Island	Columbus	15-(1)	06/19/91	84	28	5.86	4.47	Good
Waccamaw R	SR 1928	Columbus	15-(1)	07/17/01	23	18	5.03	5.14	Good
				06/17/91	78	27	5.27	4.03	Excellent
Big Cr	SR 1947	Columbus	15-2-6	06/18/91	42	2	7.70	7.28	Not Rated
Friar Swp	SR 1740	Columbus	15-2-6-3	02/01/01	49	11	6.72	6.21	Not Rated
				02/18/99	45	10	6.47	5.19	Not Rated
				03/03/98	44	9	6.27	5.78	Not Rated
				02/25/97	48	13	6.51	5.98	Not Rated
				03/13/96	48	12	6.30	6.11	Not Rated
Slap Swp	SR 1740	Columbus	15-2-6-4	03/15/96	45	6	7.29	6.20	Not Rated
03-07-57									
Waccamaw R	NC 130	Columbus	15-(1)	07/17/01	62	22	5.79	4.58	Good
				09/02/97	54	19	6.38	4.55	Good-Fair
				06/17/91	94	27	6.08	4.22	Good
				08/08/90	78	19	6.43	3.34	Good-Fair
				06/07/87	72	19	6.08	4.73	Good-Fair
				07/09/84	90	22	6.21	4.26	Good-Fair
Waccamaw R	NC 904	Columbus	15-(1)	05/09/01	84	21	6.51	5.04	Good-Fair
				07/17/01	---	23	---	4.63	Good
				09/10/91	57	19	6.07	4.50	Good-Fair
				07/26/83	56	7	7.51	5.11	Fair
Juniper Cr	NC 211	Brunswick	15-7	06/18/91	30	3	6.53	5.62	Not Rated
Juniper Cr	SR 1928	Columbus	15-7	06/17/91	50	10	6.50	4.29	Not Rated
Grissett Swp	SR 1173	Columbus	15-17-1-(5)	09/11/91	---	5	---	6.92	Not Rated
Grissett Swp	SR 1141	Columbus	15-17-1-(5)	02/05/01	36	6	7.40	5.53	Not Rated
Monie Swp	SR 1006	Columbus	15-17-1-12	03/27/96	33	6	7.34	6.75	Not Rated
				09/11/91	---	5	---	7.04	Not Rated
Caw Caw Swp	SR 1305	Brunswick	15-23	03/03/98	---	5	---	3.97	Not Rated
				07/09/96	---	5	---	5.72	Not Rated
03-07-58									
White Marsh	above US 74 Bus	Columbus	15-4	09/29/94	49	3	7.32	3.93	Not Rated
White Marsh	old RR grade	Columbus	15-4	09/29/94	38	2	8.06	7.42	Not Rated
White Marsh	SR 1001	Columbus	15-4	02/01/01	33	2	7.05	6.61	Not Rated
Brown Marsh Swp	SR 1700	Bladen	15-4-1-1-1	03/13/96	41	2	7.93	4.92	Not Rated
Elkton Marsh	SR 1710	Bladen	15-4-1-1-2	02/05/01	29	4	6.19	4.19	Not Rated
				03/13/96	37	5	7.15	6.44	Not Rated
Soules Swp	SR 1420	Columbus	15-4-8	03/05/92	63	6	8.25	6.97	Not Rated
03-07-59									
Freshwater sites									
Lockwoods Folly R	SR 1501	Brunswick	15-25-1-(1)	07/08/96	66	14	6.33	5.41	Good-Fair
				07/10/84	67	6	7.79	7.33	Good-Fair
Royal Oak Swp	NC 211	Brunswick	15-25-1-12	07/11/01	---	13	---	5.49	Not Rated
				02/05/01	58	18	6.01	4.56	Not Rated
				02/18/99	75	21	6.41	5.19	Not Rated
				03/03/98	55	18	6.24	4.96	Not Rated
				07/08/96	---	15	---	3.45	Not Rated

Waterbody	Location	County	Index No.	Date	ST	EPT	BI	EPTBI	BioClass
Shallotte R	US 17	Brunswick	15-25-2-(5)	07/11/01	31	6	6.84	6.11	Fair
				07/08/96	50	9	6.29	5.59	Good-Fair
				09/09/91	58	11	6.92	5.79	Good-Fair
				07/13/83	48	7	6.87	5.59	Good-Fair
Estuarine sites									
ICWW	CM 105 #1	Brunswick	15-25	06/25/96	79				Not Rated
ICWW	CM 105 #2	Brunswick	15-25	06/25/96	62				Not Rated
ICWW	CM 105 #3	Brunswick	15-25	06/25/96	92				Not Rated
ICWW	Ocean Isle Canal	Brunswick	15-25	06/25/96	105				Not Rated
Lockwoods Folly R	NC 211	Brunswick	15-25-1-(11)	09/09/91	38				Not Rated
Lockwoods Folly R	CM 14	Brunswick	15-25-1-(16)	06/26/96	51				Not Rated
Shallotte R	Shallotte Cr	Brunswick	15-25-2-(10)	06/26/96	106				Not Rated
Calabash R	CM 7	Brunswick	15-25-5	06/25/96	48				Not Rated

Fish Community Sampling Methods and Criteria

Wadeable Stream Sampling Methods

At each sample site, a 600-foot section of stream was selected and measured. The fish in the delineated stretch of stream were then collected using two backpack electrofishing units and two persons netting the stunned fish. After collection, all readily identifiable fish were examined for sores, lesions, fin damage or skeletal anomalies, measured (total length to the nearest 1 mm), and then released. Those fish that were not readily identifiable were preserved and returned to the laboratory for identification, examination and total length measurement. Detailed descriptions of the sampling methods may be found in NCDENR (2001) or electronically at http://www.esb.enr.state.nc.us/BAUwww/IBI%20Methods%202001.pdf.

Nonwadeable Small Boat Sampling Methods

At each site, a 400 m section of stream is measured off into 100 m segments. There are four segments along each shoreline and two segments down the center of the stream, for a total of 10 segments. For each of the 100 m segments, fish are collected and processed the same as those collected using the wadeable stream method. The last collection technique used at each location is a timed catfish collection effort outside the measured stream reach. Data from each of the 100-meter segments and the catfish sampling are currently treated as a separate subsample.

NCIBI Analysis

The scoring criteria, metric performance and fish community ratings are currently being revised for wadeable streams in the Sandhills and coastal plain. Evaluation protocols for nonwadeable streams sampled with the small electrofishing boat are also currently under development.

References

Fels, J. 1997. *North Carolina Watersheds Map*. North Carolina State University Cooperative Extension Service. Raleigh, NC.

Karr, J. R. 1981. *Assessment of Biotic Integrity Using Fish Communities*. Fisheries. 6:21-27.

NCDENR. 2001. *Stream Fish Community Assessment and Fish Tissue. Standard Operating Procedure Biological Monitoring*. Biological Assessment Unit. Environmental Sciences Branch. Water Quality Section. Division of Water Quality. North Carolina Department of Environment and Natural Resources. Raleigh, NC.

Table A-II-2 Fish Community Structure Data Collected in the Lumber River Basin, 1990 – 2001 (Current basinwide sites are **bolded**.)

Subbasin	Waterbody	Station	County	Index No.	Date	Rating
03-07-50						
	Drowning Cr	NC 73	Moore	14-2-(1)	03/25/96	Not Rated
					05/31/96	Not Rated
					06/06/01	Not Rated
	Jackson Cr	SR 1122	Moore	14-2-5	06/06/01	Not Rated
	Naked Cr	SR 1003	Richmond	14-2-6	03/25/96	Not Rated
					05/31/96	Not Rated
					06/06/01	Not Rated
	Rocky Ford Br	SR 1424	Richmond	14-2-6-1	08/20/90	Not Rated
	Deep Cr	SR 1113	Moore	14-2-10-1-(1)	06/07/01	Not Rated
	Aberdeen Cr	SR 1105	Moore	14-2-11-(6)	06/07/01	Not Rated
	Quewhiffle Cr	SR 1225	Hoke	14-2-14	06/05/01	Not Rated
	Mountain Cr	SR 1215	Hoke	14-2-16-(2)	06/05/01	Not Rated
	Buffalo Cr	SR 1203	Hoke	14-2.5	06/05/01	Not Rated
03-07-51						
	Gum Swp	NC 71	Robeson	14-5	09/30/91	Not Rated
					03/26/96	Not Rated
	Back Swp	SR 1003	Robeson	14-8-(2.5)	07/24/91	Not Rated
					03/26/96	Not Rated
					05/22/01	Not Rated
	Porter Swp	SR 1503	Columbus	14-27	04/29/92	Not Rated
					03/27/96	Not Rated
	Gapway Swp	SR 1356	Columbus	14-31	05/22/01	Not Rated
03-07-54						
	Ashpole Swp	NC 41	Robeson	14-30	03/26/96	Not Rated
					07/25/91	Not Rated
					10/22/92	Not Rated
03-07-55						
	Gum Swp Cr	SR 1344	Scotland	14-32-(1)	05/24/01	Not Rated
	Joes Cr	NC 79	Scotland	14-32-14	05/24/01	Not Rated
	Shoe Heel Cr	SR 1433	Scotland	14-34	05/23/01	Not Rated
	L Shoe Heel Cr	SR 1405	Scotland	14-34-3	09/30/91	Not Rated
					03/25/96	Not Rated
	Jordan Cr	SR 1324	Scotland	14-34-4-(2)	05/23/01	Not Rated
	Juniper Cr	SR 1405	Scotland	14-34-4-3	05/23/01	Not Rated
03-07-56						
	Friar Swp	SR 1740	Columbus	15-2-6-3	03/27/96	Not Rated
03-07-57						
	Juniper Cr	SR 1928	Columbus	15-7	12/11/91	Not Rated
	Grissett Swp	SR 1141	Columbus	15-17-1-(5)	04/29/92	Not Rated
	Monie Swp	SR 1006	Columbus	15-17-1-12	04/29/92	Not Rated
	Toms Fork Cr	SR 1118	Columbus	15-17-1-10	04/29/92	Not Rated
03-07-58						
	Brown Marsh Swp	SR 1700	Bladen	15-4-1-1	03/27/96	Not Rated
					08/11/92	Not Rated
03-07-59						
	Lockwoods Folly R	US 17	Brunswick	15-25-1-(1)	04/28/92	Not Rated
					04/02/96	Not Rated
	Royal Oak Swp	NC 211	Brunswick	15-25-1-12	04/25/92	Not Rated
					05/21/01	Not Rated
	Cool Run	US 17	Brunswick	15-25-2-3	04/28/92	Not Rated
					04/02/96	Not Rated

Fish Tissue Criteria

In evaluating fish tissue analysis results, several different types of criteria are used. Human health concerns related to fish consumption are screened by comparing results with Federal Food and Drug Administration (FDA) action levels (USFDA, 1980), Environmental Protection Agency (USEPA) recommended screening values, and criteria adopted by the North Carolina State Health Director (Table A-II-3). Individual parameter results which appear to be of potential human health concern are evaluated by the NC Division of Occupational and Environmental Epidemiology by request from DWQ.

The FDA levels were developed to protect humans from the chronic effects of toxic substances consumed in foodstuffs, and thus, employ a "safe level" approach to fish tissue consumption. Presently, the FDA has only developed metals criteria for mercury.

The USEPA has recommended screening values for target analytes which are formulated from a risk assessment procedure (USEPA, 1995). These are the concentrations of analytes in edible fish tissue that are of potential public health concern. The DWQ compares fish tissue results with USEPA screening values to evaluate the need for further intensive site-specific monitoring.

The North Carolina State Health Director has adopted a selenium limit of 5 μg/g for issuing an advisory. Although the USEPA has suggested a screening value of 0.7 ppt (pg/g) for dioxins, the State of North Carolina currently uses a value of 3.0 ppt in issuing an advisory.

Table A-II-3 Fish Tissue Criteria (All wet weight concentrations are reported in parts per million (ppm, μg/g), except for dioxin which is in parts per trillion (ppt, pg/g)).

Contaminant	FDA Action Levels	US EPA Screening Values	NC Health Director
Metals			
Cadmium		10.0	
Mercury	1.0	0.6	0.4
Selenium		50.0	5.0
Organics			
Aldrin	0.3		
Chlorpyrifos		30.0	
Total chlordane		0.08	
Cis-chlordane	0.3		
Trans-chlordane	0.3		
Total DDT[1]		0.3	
o,p DDD	5.0		
p, p DDD	5.0		
o,p DDE	5.0		
p,p DDE	5.0		
o,p DDT	5.0		
p,p DDT	5.0		
Dieldrin		0.007	
Dioxins (total)		0.7	3.0
Endosulfan (I and II)		60.0	
Endrin	0.3	3.0	
Heptachlorepoxide		0.01	
Hexachlorobenzene		0.07	
Lindane		0.08	
Mirex		2.0	
Total PCBs		0.01	
PCB-1254	2.0		
Toxaphene		0.1	

[1] Total DDT includes the sum of all its isomers and metabolites (i.e., p,p DDT, o,p DDT, DDE and DDD).
[2] Total chlordane includes the sum of cis-and trans- isomers as well as nonachlor and oxychlordane.

Table A-II-4 Wet Weight Concentrations of Mercury (Hg), Arsenic (As), Chromium (Crt), Copper (Cu), Nickel (Ni) and Zinc (Zn) in Fish Tissue from the Lumber River at US 74 (Subbasin 51), near Boardman, Columbus County, July 2000

Species	Length (mm)	Weight (g)	Hg (µg/kg)	As (µg/kg)	Crt (µg/kg)	Cu (µg/kg)	Ni (µg/kg)	Zn (µg/kg)
Amia calva	410	663	0.50	0.18	0.19	0.18	ND	ND
	530	1532	1.2	0.28	0.23	ND	ND	0.86
	550	1853	1.2	0.43	0.29	0.12	ND	1.5
	522	1490	1.4	0.30	0.29	0.13	ND	0.57
	590	2256	1.5	0.34	0.26	0.14	ND	1.8
Esox niger	340	365	0.62	ND	0.30	0.17	ND	4.1
	306	190.5	0.64	ND	0.24	0.17	ND	6.1
	435	554	0.67	ND	0.25	0.10	ND	3.0
	294	185.5	0.70	ND	0.27	0.16	0.15	5.4
	307	212	0.89	ND	0.18	0.19	ND	5.9
	375	388	0.92	ND	0.27	0.14	ND	4.2
Ictalurus punctatus	495	1291	0.58	ND	0.26	0.19	ND	2.6
Lepomis microlophus	208	207.5	0.30	ND	0.21	0.15	ND	6.4
	250	357	0.30	ND	0.25	0.52	ND	4.0
	230	290.5	0.43	ND	0.28	0.18	ND	3.5
	250	388	0.66	ND	0.25	0.36	ND	2.5
Micropterus salmoides	275	327	0.72	ND	0.24	0.19	ND	4.2
	302	453	0.86	ND	0.22	0.31	0.51	2.7
	440	1303	1.8	ND	0.23	0.19	ND	1.4
Minytrema melanops	475	1617	0.50	ND	0.31	0.14	ND	2.0
	450	1187	0.51	ND	0.25	0.14	ND	3.0
Pomoxis nigromaculatus	270	328	0.79	ND	0.23	0.22	ND	5.5

Cadmium and lead were non-detectable in all samples.

ND = non-detect; detection level for arsenic and nickel = 0.1µg/kg, and detection level for zinc = 0.4 µg/kg.

Lake Sampling Methodology

Lake monitoring stations are sited to provide representative samples of lake water quality based on morphology, size and site-specific considerations. Physical field measurements (dissolved oxygen, pH, water temperature and conductivity) are made with a calibrated Hydrolab™. Readings are taken at the surface of the lake (0.15 meters) and at one-meter increments to the bottom of the lake. Secchi depths are measured at each sampling station with a weighted Secchi disk attached to a rope marked off in centimeters. Surface water samples (0.15 meters) are collected for chloride, hardness, fecal coliform bacteria and metals.

A Labline™ sampler is used to composite water samples within the photic zone (a depth equal to twice the Secchi depth). Nutrients, chlorophyll *a*, solids, turbidity and phytoplankton are collected at this depth. Nutrients and chlorophyll *a* from the photic zone are used to calculate the North Carolina Trophic State Index score. The Labline™ sampler is also used to collect a grab water samples near the bottom of the lake for nutrients. Water samples are collected and preserved in accordance with protocols specified in the Standard Operating Procedures Manual, Physical and Chemical Monitoring (NCDEHNR, February 1996 and subsequent updates).