APPENDIX III

DWQ Water Quality Monitoring Programs
in the Hiwassee River Basin

- Benthic Macroinvertebrate Sampling
- Fisheries Studies
- Lakes Assessment Program
- Aquatic Toxicity Monitoring

A - III.I BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates, or benthos, are organisms that live in and on the bottom substrates of rivers and streams. These organisms are primarily aquatic insect larvae. The use of benthos data has proven to be a reliable monitoring tool, as benthic macroinvertebrates are sensitive to subtle changes in water quality. Since many taxa in a community have life cycles of six months to one year, the effects of short term pollution (such as a spill) will generally not be overcome until the following generation appears. The benthic community also integrates the effects of a wide array of potential pollutant mixtures. Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups Ephemeroptera, Plecoptera and Trichoptera (EPT S). Likewise, ratings can be assigned with a Biotic Index. This index summarizes tolerance data for all taxa in each collection. The two rankings are given equal weight in final site classification. Higher taxa richness values are associated with better water quality. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis. Different criteria have been developed for the major ecoregions (mountains, piedmont and coastal) within North Carolina.

Classification Criteria by Ecoregion*

A. EPT taxa richness values

	10-sample Qualitative Samples			4-sample EPT Samples		
	Mountains	Piedmont	Coastal	Mountains	Piedmont	Coastal
Excellent	>41	>31	>27	>35	>27	>23
Good	32-41	24-31	21-27	28-35	21-27	18-23
Good-Fair	22-31	16-23	14-20	19-27	14-20	12-17
Fair	12-21	8-15	7-13	11-18	7-13	6-11
Poor	0-11	0-7	0-6	0-10	0-6	0-5

B. Biotic Index Values (Range = 0-10)

	Mountains	Piedmont	Coastal A
Excellent	<4.05	<5.19	<5.47
Good	4.06-4.88	5.19-5.78	5.47-6.05
Good-Fair	4.89-5.74	5.79-6.48	6.06-6.72
Fair	5.75-7.00	6.49-7.48	6.73-7.73
Poor	>7.00	>7.48	>7.73

*These criteria apply to flowing water systems only. Biotic index criteria are only used for full-scale (10-sample) qualitative samples.

Appendix A - III.1 lists all the benthic macroinvertebrate collections in the Hiwassee River basin between 1983 and 1994, giving site location, DEM classification schedule index number, collection date, taxa richness and biotic index values, and bioclassifications. Final bioclassifications assigned may take into account seasonal correction of both EPT taxa richness and Biotic Index value if the sample was collected outside of summer. Bioclassifications listed in this report may differ from older reports because evaluation criteria have changed since 1983. Originally, total taxa richness and EPT taxa richness criteria were used to assign rating, then just EPT taxa richness. Currently BI as well as EPT taxa richness criteria are used to assign bioclassification. Refinements of the criteria continue to occur as more data is gathered.

Benthos data were collected at 15 basin assessment sites during 1994, and a total of 37 sites (73 samples) have been rated using benthic macroinvertebrate data since 1983. Overall water quality

Table A - III.1 Benthic Macroinvertebrate Data Collected from 1983 through 1994 in the Hiwassee River Basin

HIW 01

Site	Old/New DEM #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Shooting Cr, SR 1349, ab poultry farm, Clay	/B-1	1-5	08/94	68/37	2.68/2.03	Excellent
Shooting Cr, SR 1168, be poultry UT, Clay	/B-2	1-5	08/94	59/28	2.99/2.60	Good
Shooting Cr, SR 1347, Clay	/B-3	1-5	07/94	-/32	-/2.36	Good
Tusquitee Cr, off SR 1307 ab trout farm, Clay	16/B-4	1-21-(0.5)	03/89	-/35	-/2.13	Good
Tusquitee Cr, SR 1307, ab Big Tuni Cr, Clay	15/B-5	1-21-(0.5)	03/89	-/49	-/2.49	Excellent
Tusquitee Cr, SR 1330, Clay	4/B-6	1-21-(4.5)	07/94	69/34	3.60/2.67	Excellent
			03/89	-/45	-/2.25	Excellent
			04/87	95/53	3.57/2.32	Excellent
			05/87	101/51	3.59/2.23	Excellent
Big Tuni Cr, FS Rd 440 (headwaters) Clay	3,20/B-7	1-21-5	03/89	-/46	-/1.46	Excellent*
			06/88	-/41	-/1.24	Excellent
			04/88	-/39	-/1.37	Excellent
			05/87	90/46	2.58/1.24	Excellent
			04/87	77/38	2.48/1.35	Excellent
Big Tuni Cr, SR 1311, Clay	19/B-8	1-21-5	07/94	63/38	2.03/1.53	Excellent
			03/89	83/45	3.26/2.10	Excellent
Johnson (Mill) Cr, SR 1307, Clay	18/B-9	1-21-13	03/89	-/42	-/1.71	Excellent
Tusquitee Cr, SR 1300, Clay	/B-10	1-21-(16.5)	03/89	90/47	3.43/2.22	Excellent
Greasy Cr, SR 1318, Clay	17/B-11	1-21-20-(1)	03/89	-/38	-/2.38	Good
Albone Cr, SR 1300, Clay	5/B-12	1-21-24	05/87	79/37	3.32/1.70	Excellent*
			04/87	77/38	3.54/2.08	Excellent*
Fires Cr, FS Rd"C" (headwaters), Clay	10/B-13	1-27-(0.5)	06/88	-/35	-/1.15	Excellent*
			04/88	-/39	-/1.19	Excellent*
Coldspring Br, FS Rd, Clay	/B14	1-27-4-3	06/88	-/39	-/1.90	Excellent
			04/88	-/37	-/1.33	Excellent
Fires Cr, Bristol Camp, Clay	6/B-15	1-27-(5.5)	07/94	80/43	2.50/1.54	Excellent
			06/88	102/47	3.01/1.67	Excellent
			04/88	103/54	3.17/1.68	Excellent
			05/87	95/52	3.29/1.86	Excellent
Fires Cr, at Picnic Area, Clay	A,8/B-16	1-27-(5.5)	08/94	81/38	3.39/2.19	Excellent
			07/94	-/35	-/1.78	Excellent
			08/88	107/54	3.40/2.43	Excellent
			04/88	-/48	-/1.47	Excellent
			05/87	113/58	3.23/1.89	Excellent
			04/87	101/54	2.98/1.85	Excellent
			08/85	111/50	3.95/2.25	Excellent
Fires Cr, SR 1300, Clay	B-17	1-27-(5.5)	05/87	-/40	-/2.16	Excellent
			04/87	-/43	-/2.27	Excellent
Little Fires Cr, FS Rd nr mouth, Clay	12/B-18	1-27-7	12/91	-/34	-/1.75	Excellent
			06/88	-/38	-/1.46	Excellent
			04/88	-/37	-/1.43	Excellent
Leatherwood Br, FS Rd, Clay	7/B-19	1-27-12	06/88	-/30	-/2.25	Excellent*
			04/88	-/34	-/1.78	Excellent*
			05/87	60/30	3.20/1.66	Excellent*
			04/87	58/34	2.56/1.44	Excellent*
Brasstown Cr, SR 1104, Clay	/B-20	1-42	07/94	-/18	-/4.41	Fair

HIW 02

Site	Old/New DEM #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Hiwassee R, US 64, nr Murphy, Cherokee	B-1	1-(42.7)	08/90	78/38	4.29/3.25	Good
			08/87	78/35	4.61/3.29	Good
			07/86	65/32	4.94/3.92	Good-Fair
			08/85	56/26	4.37/3.57	Good
			08/84	67/29	4.50/3.35	Good
			08/83	62/23	4.67/3.43	Good-Fair
Peachtree Cr, SR 1537, Cherokee	B-2	1-44	07/94	-/37	-/2.42	Excellent
Valley R, off US 19, nr Rhodo, Cherokee	B-3	1-52	8/94	-/23	-/2.84	Good-Fair
Valley R, Stewart Rd, ab Andrews, Cherokee	B-4	1-52	8/94	-/15	-/3.30	Fair

Site	Old/New DEM #	Index #	Date	S/EPT S	BI/BIEPT	Bioclass
Valley R, Main St, Andrews, ab WWTP, Cherokee	B-5	1-52	8/94	40/6	5.84/2.47	Fair
Valley R, ab landfill, off US 19, Cherokee	B-6	1-52	8/94	57/13	5.30/3.56	Fair
Valley R, ab Andrews WWTP, Cherokee	1/B-7	1-52	08/85	76/33	5.19/3.70	Good-Fair
Valley R, be Andrews WWTP, Cherokee	2/B-8	1-52	08/85	75/30	5.52/3.52	Good-Fair
Valley R , SR 1554 nr Tomatla, Cherokee	C/B-9	1-52	07/94	77/29	4.84/4.11	Good-Fair
			08/90	87/33	4.58/3.63	Good
			08/88	91/33	4.99/4.20	Good-Fair
			07/86	71/28	5.51/3.83	Good-Fair
			08/84	70/26	4.93/3.88	Good-Fair
Junaluska Cr, SR 1505, Cherokee	B-10	1-52-25	07/94	-/25	-/2.11	Good-Fair
			08/94	-/22	-/2.50	Good-Fair
Britton Cr, off FS Rd nr SR 1339, Cherokee	B-11	1-52-29-(1)	12/91	-/35	-/1.54	Excellent
Hanging Dog Cr, SR 1331, Cherokee	B-12	1-57	7/94	-/46	-/2.49	Excellent
Nottely R, SR 1596,Cherokee	B-13	1-58	7/94	-/36	-/2.83	Excellent
Persimmon Cr, SR 1127, Cherokee	B-14	1-63	7/94	-/42	-/2.97	Excellent
Beaverdam Cr, SR 1326, Cherokee	B-15	1-72	8/94	-/39	-/2.45	Excellent
South Shoal Cr, SR 1314,Cherokee	B-16	1-77	8/94	-/30	-/2.40	Good
Shuler Cr, SR 1323, Cherokee	B-17	1-86	8/94	-/35	-/2.42	Good

*Small stream criteria

Benthos data were collected at 15 basin assessment sites during 1994, and a total of 37 sites (73 samples) have been rated using benthic macroinvertebrate data since 1983. Overall water quality is Excellent in the Hiwassee basin. The fifteen 1994 sites resulted in a bioclassification of Excellent at 9 sites, Good at 3 sites, Good-Fair at 2 sites, and Fair at one site, Brasstown Creek. Of the 73 samples collected since 1983, 66% were given an Excellent bioclassification.

A - III.II FISHERIES

Fish Tissue

Since fish spend their entire lives in the aquatic environment, they incorporate chemicals from this environment into their body tissues. Contamination of aquatic resources, including freshwater, estuarine, and marine fish and shellfish species, have been documented for heavy metals, pesticides, and other complex organic compounds. Once these contaminants reach surface waters, they may be available for bioaccumulation either directly or through aquatic food webs and may accumulate in fish and shellfish tissues. Results from fish tissue monitoring can serve as an important indicator of further contamination of sediments and surface water. Fish tissue analysis results are used as indicators for human health concerns, fish and wildlife health concerns, and the presence and concentrations of various chemicals in the ecosystem.

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, U. S. Environmental Protection Agency (EPA) recommended screening values, and criteria adopted by the North Carolina Health Department. Only metals were evaluated in the Hiwassee samples, and the metals screening values are listed below. 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. At present, the FDA has only developed metals criteria for mercury. The North Carolina Health Department has adopted a selenium limit of 5 ppm for issuing fish consumption advisories.

Food and Drug Administration (FDA) Action Levels

Metals	
Mercury	1.0 ppm

Environmental Protection Agency (EPA) Screening Values

Metals		
Cadmium	10.0	ppm
Mercury	0.6	ppm
Selenium	50.0	ppm

Hiwassee Fish Tissue Overview

Fish samples collected within the Hiwassee drainage were analyzed for metals contaminants only. Fish tissue samples were collected at 2 sites (Hiwassee River and Hiwassee Lake) from 1981 to 1986, consisting of 13 observations. Samples were collected as part of the DEM's ambient fish tissue monitoring program. Fish species collected for analyses included catfish, walleye and bass. Results of fish tissue analyses indicated that mean levels of metals

contaminants in Hiwassee samples were non-detectable or present at levels below FDA and EPA criteria.

A - III.III LAKES ASSESSMENT PROGRAM

Lakes are valued for the multiple benefits they provide to the public, including recreational boating, fishing, drinking water, and aesthetic enjoyment. The North Carolina Lake Assessment Program seeks to protect these waters through monitoring, pollution prevention and control, and restoration activities. Assessments have been made at publicly accessible lakes, at lakes which supply domestic drinking water, and lakes (public or private) where water quality problems have been observed. Data are used to determine the trophic state of each lake, a relative measure of nutrient enrichment and productivity, and whether the designated uses of the lake have been threatened or impaired by pollution.

Tables presented in each subbasin summarize data used to determine the trophic state and use support status of each lake. These determinations are based on information from the most recent summertime sampling (date listed). The most recent North Carolina Trophic State Index (NCTSI) value is shown, followed by the descriptive trophic state classification (O=oligotrophic, M=mesotrophic, E=eutrophic, H=hypereutrophic, D=dystrophic).

Numerical indices are often used to evaluate the trophic state of lakes. An index was developed specifically for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NCDNRCD 1982). The North Carolina Trophic State Index (NCTSI) is based on total phosphorus (TP in mg/l), total organic nitrogen (TON in mg/l), Secchi depth (SD in inches), and chlorophyll-a (CHL in µg/l). Lakewide means for these parameters are manipulated to produce a NCTSI score for each lake, using the following equations:

$$TON_{Score} = \frac{Log(TON) + 0.45}{0.24} \times 0.90$$

$$TP_{Score} = \frac{Log(TP) + 1.55}{0.35} \times 0.92$$

$$SD_{Score} = \frac{Log(SD) - 1.73}{0.35} \times -0.82$$

$$CHL_{Score} = \frac{Log(CHL) - 1.00}{0.48} \times 0.83$$

$$NCTSI = TON_{Score} + TP_{Score} + SD_{Score} + CHL_{Score}$$

In general, NCTSI scores relate to trophic classifications as follows: less than -2.0 is oligotrophic, -2.0 to 0.0 is mesotrophic, 0.0 to 5.0 is eutrophic, and greater than 5.0 is hypereutrophic. When scores border between classes, best professional judgment is used to assign an appropriate classification. NCTSI scores may be skewed by highly colored water typical of dystrophic lakes.

Some variation in the trophic state of a lake between years is not unusual due to the potential variability of data collections which usually involve sampling on a single day during the growing season. This survey methodology does not adequately evaluate changes which might occur throughout the year between lake samplings. More intensive (monthly) monitoring is required to identify lake specific variability. However, monitoring a lake once per growing season does provide a relatively valuable assessment of water quality conditions on a large number of lakes. Lakes are classified for their "best usage" and are subject to the state's water quality standards. Primary classifications are C (suited for aquatic life propagation/protection and secondary recreation such as wading), B (primary recreation, such as swimming, and all class C uses), and WS-I through WS-V(water supply source ranging from highest watershed protection level I to lowest watershed protection V, and all class C uses). Lakes with a CA designation represent water supplies with watersheds that are considered to be Critical Areas (i.e., an area within 1/2 mile and draining to water supplies from the normal pool elevation of reservoirs, or within 1/2 mile and draining to a river intake). Supplemental classifications in the Cape Fear River basin may include SW (slow moving Swamp Waters where certain water quality standards may not be applicable), NSW (Nutrient Sensitive Waters subject to excessive algal or other plant growth where nutrient controls are required), HQW (High Quality Waters which are rated excellent based on biological and physical/chemical characteristics), and ORW (Outstanding Resource Waters which are unique and special waters of exceptional state or national recreational or ecological value). A complete listing of these water classifications and standards can be found in Title 15 North Carolina Administrative Code, Chapter 2B, Section .0100 and .0200.

Phytoplankton are microscopic algae found in the water column of lakes, rivers, streams, and estuaries. Phytoplankton populations respond to nutrient availability and other environmental factors such as light, temperature, pH, salinity, water velocity, and grazing by organisms in higher trophic levels. Phytoplankton may be useful as indicators of eutrophication and are often collected with ambient water quality samples from lakes. Prolific growths of phytoplankton, often due to high concentrations of nutrients, sometimes result in "blooms" in which one or more species of algae may discolor the water or form visible mats on top of the water. Blooms may be unsightly and deleterious to water quality, causing fish kills, anoxia, or taste and odor problems. The Algal Bloom Program was initiated in 1984 to document suspected algal blooms with species identification, quantitative biovolume, and density estimates. Usually, an algal sample with a biovolume larger than 5000 mm^3/m^3, density greater than 10,000 units/ml, or chlorophyll *a* concentration approaching or exceeding 40 µg/l (the North Carolina state standard) constitutes a bloom. Bloom samples may be collected as a result of complaint investigations, fish kills, or during routine monitoring if a bloom is suspected.

The summary tables presented within the body of this document list lakewide averages of total phosphorus (TP in mg/l), total organic nitrogen (TON in mg/l), chlorophyll *a* (CHLA in µg/l), and Secchi depth, followed by surface water classification. Causes of use impairment are explained below each table.

There were three lakes in the Hiwassee River Basin sampled as part of the Lakes Assessment Program. These lakes, by river subbasin, are presented below.

SUBBASIN 040501	SUBBASIN 040502
Chatuge Lake (NC portion)	Apalachia Lake
	Hiwassee Lake

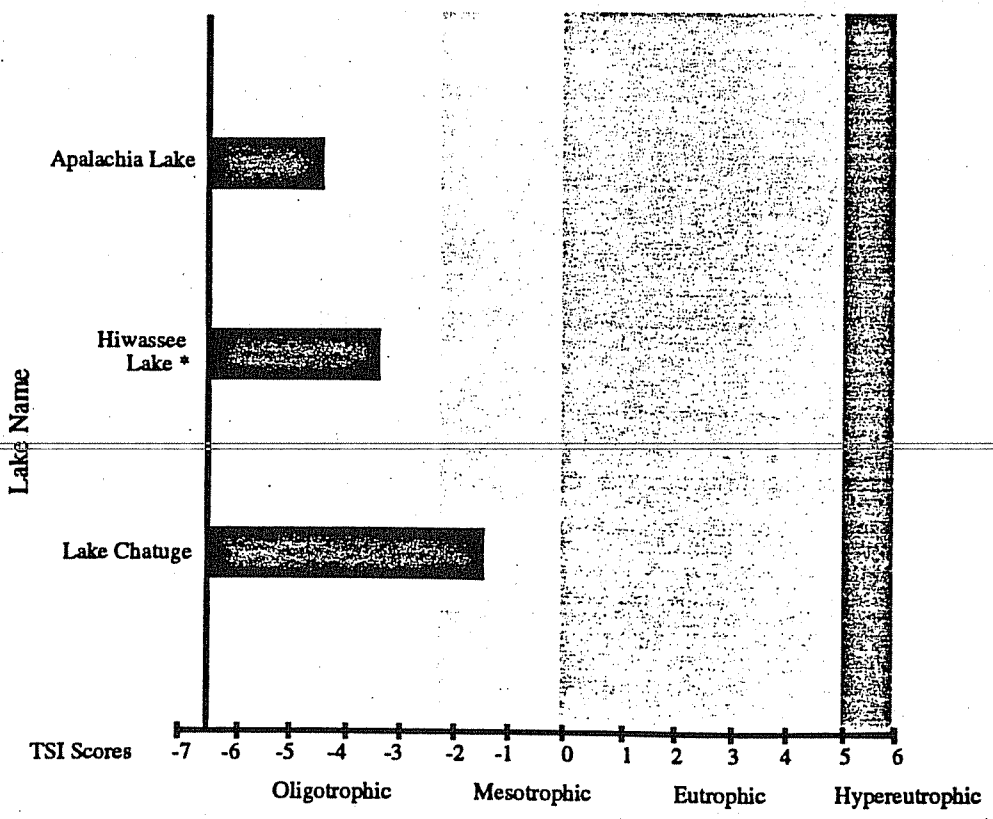
Only Hiwassee Lake has been sampled for the potential of supporting algal growth with the Algal Growth Potential Test (AGPT). The results of the Algal Growth Potential Test are mentioned in the appropriate subbasin discussion. The objective of the Algal Growth Potential Test is to assess a waterbody's potential for supporting algal biomass and to determine whether algal growth is limited by nitrogen, by phosphorus, or co-limited by both nutrients. When a

waterbody supports excessive algal growth without additional increases in nitrogen or phosphorus, the system may be subject to frequent nuisance algal blooms. The test exposes a standard alga, Selenastrum capricornutum, to the test water (this constitutes the control). Additional test samples are enriched with nitrogen or phosphorus. When one of these nutrients is added to a water sample which is growth limiting to that nutrient, the resulting mean standing crop (MSC) will generally reflect the level of the added nutrient. In some cases, the bioavailable nitrogen and phosphorus in a sample may approach their optimum ratio for growth of the test alga and the addition of nutrients may not clearly identify the limiting nutrient. A waterbody may be considered protected from nuisance algal blooms if an AGPT value is consistently less than or equal to 5 mg/l.

Hiwassee Lake was the only lake intensively monitored during the growing seasons of 1991 through 1993 as part of the reference lake program. The purpose of this program was to identify lakes in each of the four regions of the state (Mountain, Piedmont, Sandhills and Coastal Plains) which were representative of minimally impacted lakes by which similar lakes in the same region could be compared.

Each lake is individually discussed in the appropriate subbasin section with a focus on the most recent available data. Figure A - III.1 shows the most recent NCTSI scores for the three lakes of the Hiwassee River basin. All of the lakes were sampled most recently in 1994 and all of these lakes are fully supporting their designated uses.

Figure A - III.1 Hiwassee Basin - TSI Scores (Last Assessment Date)



All lakes sampled in 1994.
* Reference Lake

A - III.IV AQUATIC TOXICITY MONITORING

Acute and/or chronic toxicity tests are used to determine toxicity of discharges to sensitive aquatic species (usually fathead minnows or the water flea, Ceriodaphnia dubia). Results of these tests have been shown by several researchers to be predictive of discharge effects on receiving stream populations. Many facilities are required to monitor whole effluent toxicity by their NPDES permit or by administrative letter. Other facilities may be tested by DEM's Aquatic Toxicology Laboratory. The Aquatic Toxicology Unit maintains a compliance summary for all facilities required to perform tests and provides a monthly update of this information to regional offices and DEM administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.