APPENDIX II

DEM Water Quality Monitoring Programs:

- Benthic Macroinvertebrate Sampling
- Fisheries Studies
- Lakes Assessment
- Effluent Toxicity Testing

A - II.1 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 North Carolina Biotic Index (BI). This index summarizes tolerance data for all taxa in each collection. The two rankings are given equal weight in final site classification for the qualitative (10 sample) method. An abbreviated (4 sample) EPT method uses just the EPT criteria. 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 different ecoregions (mountains, piedmont and coastal) within North Carolina for freshwater flowing waterbodies. Details of benthos sampling, criteria, and data analysis can be found in the Biological Monitoring SOP Manual (NCDENR 1997).

Table 1. 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
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.

A - II.2 FISHERIES

Fish Communtiy Structure Assessment

The fish communities of the Broad River basin were sampled in 1995 using methods developed for the application of the North Carolina Index of Biotic Integrity (NCIBI). Details of sampling, metrics, and data analysis can be found in the Biological Monitoring SOP Manual (NCDENR 1997). At each sample site, a 200 meter section of stream was selected and measured. The fish in the delineated stretch of stream were then collected using two backpack electrofishing units. A seine also was used at the Green River site where riffles were abundant, to increase collecting efficiency. After collection, all readily identifiable fish (usually sport fishes, catfishes, and suckers) were examined for sores, lesions, fin damage, and skeletal anomalies, measured (total length to the nearest 1 mm), and then released. Fish that could not be identified were preserved in 10% formalin and returned to the laboratory for identification, examination, and total length measurement. The resulting data were then analyzed with the NCIBI.

The NCIBI is a modification of the Index of Biotic Integrity initially proposed by Karr (1981) and Karr et al. (1986). The Index has been subsequently modified for applicability to wadeable streams in North Carolina. The IBI method was developed for assessing a stream's biological integrity by examining the structure and health of its fish community. The scores derived from this index are a measure of the ecological health of the waterbody and may not directly correlate to water quality. For example, a stream with excellent water quality, but with poor or fair fish habitat, would not be rated excellent with this index. However, a stream which rated excellent on the NCIBI should be expected to have excellent water quality. Currently, the NCIBI is not applicable to high elevation or small, coldwater trout streams, lakes, or estuaries.

The Index of Biological Integrity incorporates information about species richness and composition, trophic composition, fish abundance, and fish condition. The NCIBI summarizes the effects of all classes of factors influencing aquatic faunal communities (water quality, energy source, habitat quality, flow regime, and biotic interactions). While any change in a fish community can be caused by many factors, certain aspects of the community are generally more responsive to specific influences. Species composition measurements reflect habitat quality effects. Information on trophic composition reflects the effect of biotic interactions and energy supply. Fish abundance and condition information indicates additional water quality effects. It should be noted, however, that these responses may overlap. For example, a change in fish abundance may be due to decreased energy supply or a decline in habitat quality, not necessarily a change in water quality.

The assessment of biological integrity using the NCIBI is provided by the cumulative assessment of 12 parameters or metrics. The values provided by the metrics are converted into scores on a 1, 3, or 5 scale. A score of 5 represents conditions which would be expected for undisturbed streams in the specific river basin or ecoregion, while a score of 1 indicates that the conditions vary greatly from those expected in undisturbed streams of the region. Each metric is designed to contribute unique information to the overall assessment. The scores for all metrics are then summed to obtain the overall IBI score. Finally, the NCIBI score (an even number between 12 and 60) is then used to determine the ecological integrity class of the stream from which the sample was collected.

Table 2. Definitions of NCIBI Scores

NCIBI Scores	Integrity Class	Class Attributes[1]
58 or 60	Excellent	Comparable to the best situations without human disturbance. All regionally expected species for the habitat and stream size, including the most intolerant forms, are present along with a full array of size classes and a balanced trophic structure.
54 or 56	Good-Excellent	
48, 50, or 52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant species; some species are present with less than optimal abundances or size distributions; and the trophic structure shows some signs of stress.
46	Fair-Good	
40, 42, or 44	Fair	Signs of additional deterioration include the loss of intolerant species, fewer species, and a highly skewed trophic structure.
36 or 38	Poor-Fair	
28, 30, 32, or 34	Poor	Dominated by omnivores, tolerant species, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; and diseased fish often present.
24 or 26	Very Poor-Poor	
12, 14, 16, 18, 20, or 22	Very Poor	Few fish present, mostly introduced or tolerant species; and disease fin damage and other anomalies are regular.
----	No fish	Repeated sampling finds no fish.

[1] Over-lapping classes share attributes with classes greater than and less than the respective NCIBI score.

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 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 State Health Director.

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. A list of fish tissue analytes accompanied by their FDA criteria are presented below (USFDA, 1980). At present, the FDA has only developed metals criteria for mercury. Individual parameters which appear to be of potential human health concern are evaluated by the N.C. Division of Epidemiology by request of the Water Quality Section.

Table 3. Food and Drug Administration (FDA) Action Levels

	Metals		
Mercury	1.0 ppm		
	Organics		
Aldrin	0.3 ppm	p,p DDE	5.0 ppm
Dieldrin	0.3 ppm	o,p DDT	5.0 ppm
Endrin	0.3 ppm	p,p DDT	5.0 ppm
o,p DDD	5.0 ppm	PCB-1254	2.0 ppm
p,p DDD	5.0 ppm	cis-chlordane	0.3 ppm
o,p DDE	5.0 ppm	trans-chlordane	0.3 ppm

In the guidance document, Fish Sampling and Analysis: Volume 1 (USEPA, 1993), EPA has recommended screening values for target analytes which are formulated from a risk assessment procedure. These are the concentrations of analytes in edible fish tissue that are of potential public health concern. The DWQ compares fish tissue results with EPA screening values to evaluate the need for further intensive site specific monitoring. A list of target analytes and EPA recommended screening values for the general adult population is presented below.

The North Carolina State Health Director has adopted a selenium limit of 5 ppm for issuing fish consumption advisories. Total DDT includes the sum of all its isomers and metabolites (i.e. p,p DDT, o,p DDT, DDE, and DDD). Total chlordane includes the sum of cis-and trans- isomers as well as nonachlor and oxychlordane. Although the EPA has suggested a screening value of 7.0×10^{-7} ppm for dioxins, the State of North Carolina currently uses a value of 3.0 ppt (3×10^{-3}) in issuing fish consumption advisories.

Table 4. Environmental Protection Agency (EPA) Screening Values

	Metals		
Cadmium	10.0 ppm		
Mercury	0.6 ppm		
Selenium	50.0 ppm		
	Organics		
Chlorpyrifos	30.00 ppm	Heptachlor epoxide	0.01 ppm
Total chlordane	0.08 ppm	Hexachlorobenzene	0.07 ppm
Total DDT	0.30 ppm	Lindane	0.08 ppm
Dieldrin	0.007 ppm	Mirex	2.00 ppm
Dioxins	7.0×10^{-7} ppm	Total PCB's	0.01 ppm
Endosulfan (I and II)	20.00 ppm	Toxaphene	0.10 ppm
Endrin	3.00 ppm		

A - II.3 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 Lakes Assessment Program seeks to protect these waters through monitoring and pollution prevention and control. 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.

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. 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 used 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.

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 Broad River basin may include Trout Waters (Tr) for waters that support the survival and propogation of trout and HQW (High Quality Waters which are rated excellent based on biological and physical/chemical characteristics). 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.

Three lakes have been sampled for the potential of supporting algal growth with the Algal Growth Potential Test (AGPT) in the Broad River Basin. These are Lake Lure, Kings Mountain Reservoir and Lake Montonia. The results of the Algal Growth Potential Test are mentioned in each of the appropriate subbasin discussions in Chapter 4 of the main document. The objective of the Algal Growth Potential Test is assessment of 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 algal growth at bloom levels without additional increases in nitrogen and/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 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 protected from nuisance algal blooms if an AGPT value is consistently less than or equal to 5 mg/l.

Five lakes in the Broad River basin have been sampled as part of the Lakes Assessment Program. These lakes are presented below.

SUBBASIN 030801	SUBBASIN 030803	SUBBASIN 030805
Lake Lure	Lake Summit	Lake Montonia
	Lake Adger	Kings Mountain Reservoir

Each lake is individually discussed in the appropriate subbasin section with a focus on the most recent available data. The figure below shows the most recent NCTSI scores for the five lakes of the Broad River basin. Kings Mountain Reservoir was monitored intensively during the growing seasons of 1991 through 1993 as part of the reference lake program to determine if this lake was representative of a minimally impacted lake in the region of the state in which it is located. It was not found to represent a reference lake. All of the lakes in this basin were sampled most recently by DWQ in 1995 except for Lake Montonia, which was most recently sampled in 1996.

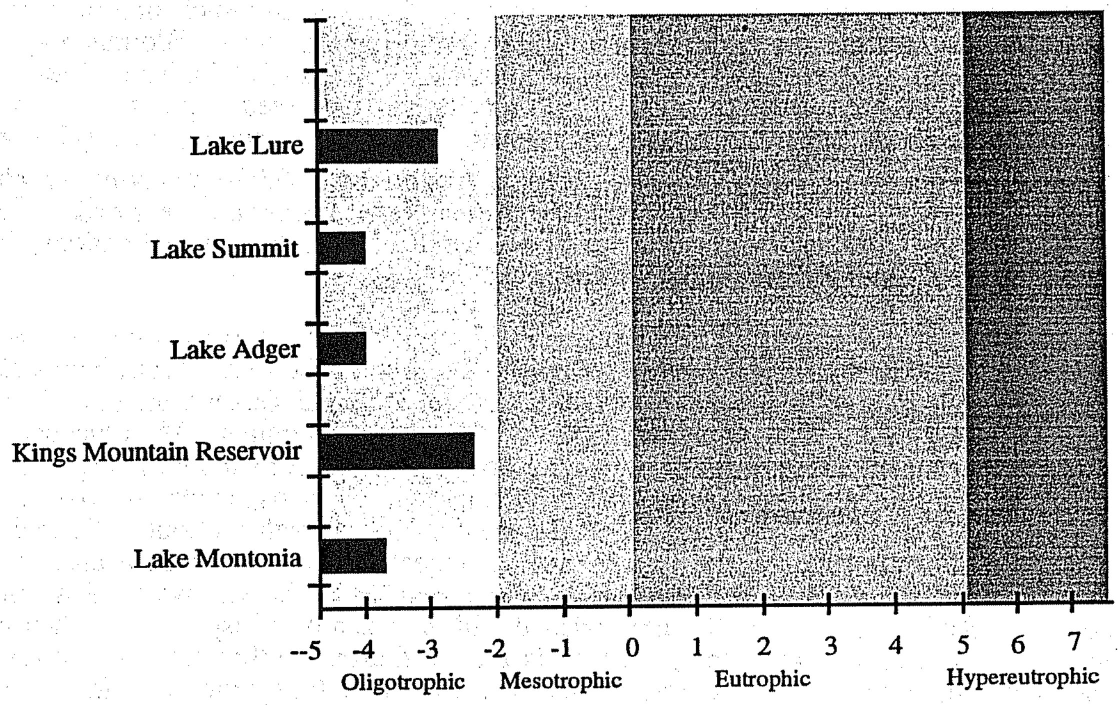

Figure 1. Broad Basin - TSI Scores (Last Assessment Date)

A-II.4 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 Survey andToxicology 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. Facilities in the Broad River Basin required to monitor effluent toxicity are presented in the table below.

Table 5. Facilities in the Broad River Basin Monitoring Aquatic Toxicity

Subbasin 02					
Facility	NPDES#	Receiving Stream	County	Flow(MGD)	IWC(%)
Alexander Mills WWTP	NC0020320/001	Brackett's Cr	Rutherford	0.200	11.0
Burlington Ind.-Cowan 001	NC0006025/001	Second Broad R	Rutherford	2.000	5.5
Columbus WWTP	NC0021369/001	UT White Oak Cr	Polk	0.800	37.1
Cone Mills- Cliffside	NC0004405/001	Second Broad R	Rutherford	1.750	4.2
Duke Power-Cliffside	NC0005088/002	Broad R	Rutherford	8.800	4.5
Forest City WWTP	NC0025984/001	Second Broad R	Rutherford	4.950	18.0
J. H. Mont. Mill/Spartan Mills	NC0080993/001	Broad R	Rutherford	0.175	0.1
New Cherokee/Harris Fin. Plant	NC0083275/001	Broad R	Rutherford	0.910	0.7
Rutherfordton WWTP	NC0025909/001	Cleghorn Cr	Rutherford	1.000	48.0
Spindale WWTP	NC0020664/001	Holland's Cr	Rutherford	6.000	73.0
Subbasin 04					
Facility	NPDES#	Receiving Stream	County	Flow(MGD)	IWC(%)
Cleveland Co.- Burns HS	NC0066486/001	UT Maple Cr	Cleveland	0.017	100.0
Cleveland Mills/001	NC0004120/001	First Broad R	Cleveland	0.780	2.4
Jefferson Smurfit Corp.	NC0005061/001	EF Beaverdam Cr	Cleveland	0.010	11.0
PPG-Shelby -001	NC0004685/001	Overflow Br	Cleveland	1.300	33.0
Shelby WWTP	NC0024538/001	First Broad R	Cleveland	6.000	11.6
Subbasin 05					
Facility	NPDES#	Receiving Stream	County	Flow(MGD)	IWC(%)
Cyprus Foote Mineral Co./001	NC0033570/001	Kings Cr	Cleveland	0.123	17.0
Grover Industries, Inc.	NC0083984/001	Buffaloe Cr	Cleveland	0.380	1.8
Hoechst-Celanese Corp.	NC0004952/001	Buffalo Cr	Cleveland	0.550	4.5
King's Mtn.-Pilot Cr. WWTP	NC0020737/001	Buffalo Cr	Cleveland	6.000	33.0
New Minette Textiles	NC0004235/001	Lick Br	Cleveland	0.450	77.7
Subbasin 06					
Facility	NPDES#	Receiving Stream	County	Flow(MGD)	IWC(%)
Grover Industries, Inc.	NC0004391/001	N Pacolet R	Polk	0.450	6.1
Tryon WWTP	NC0021601/001	Vaughn Cr	Polk	1.500	37.0

NOTE: IWC = Instream Waste Concentration

REFERENCES

Karr, J. R 1981. Assessment of biotic integrity using fish communities. Fisheries. 6:21-27.

Karr, J. R, Fausch, K. D., Angermeier, P. L., Yant, P. R, and I. J. Schlosser. 1986. Assessing Biological Integrity in Running Water: A Method and Its Rationale. Ill. Nat. Hist. Surv. Spec. Publ. 5. 28 pp.

NCDENR, Division of Water Quality. 1997. Biological Monitoring SOP Manual.

USFDA. 1980 Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed, Shellfish Sanitation Branch, Washington, D.C.