FINAL REPORT
BENTHIC MACROINVERTEBRATE SURVEY
OLD HICKORY PROJECT
OCTOBER 1999

FOR
US ARMY CORPS OF ENGINEERS
NASHVILLE DISTRICT

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EXECUTIVE SUMMARY

On October 28, 1999, personnel from the Nashville District, Corps of Engineers Water Management Section (Hydrology and Hydraulics Branch, Engineering-Planning Division) collected water quality and benthic macroinvertebrate samples from three locations (Drakes Creek Mile 1.9 and Cumberland River Miles 216.9 and 245.0) in the Old Hickory Project area.

Benthic macroinvertebrate community structure at each location and comparison of the sites were assessed using: taxa richness, Shannon's Index of Diversity, evenness, percent contribution of dominant taxa, EPT taxa, scraper and filtering collectors ratio, EPT to Chironomidae abundance ratio, Hilsenhoff's Biotic Index, Jaccard's Coefficient and percent similarity. Cluster analyses were accomplished using 1-Jaccard's Coefficient and percent dissimilarity. The clusters were interpreted graphically to relate similar communities.

A minimum of 28 species of benthic macroinvertebrates was taken from the three sites within the Old Hickory Project area. Cumberland River Mile 245.0 had 27 species, Cumberland River Mile 216.9 had 17, and Drake's Creek Mile 1.9 had 15. In terms of density Drake's Creek Mile 1.9 had 6171/m^2, CRM 216.9 had 3603/m^2 and CRM 245.0 had 2363/m^2.

The three sites supported few species and not very diverse benthic communities, dominated by tubificid worms and midges. Species found were generally those tolerant to degraded conditions or typical of organic rich, silty habitats. The benthic communities at the three main stem/embayment locations are indicative of "Fairly Poor" to "Very Poor" water quality conditions.

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INTRODUCTION

On October 28, 1999, personnel from the Nashville District, Corps of Engineers Water Management Section (Hydrology and Hydraulics Branch, Engineering-Planning Division) collected water quality and benthic macroinvertebrate samples from three locations in the Old Hickory Reservoir Project area. The Water Management Section maintains a baseline, water quality data collection and monitoring program. A wide range of physical, chemical and biological data is collected, analyzed and reported from various locations representing tailwaters, impounded sites and reservoir inflows for the ten Nashville District reservoirs in the Cumberland River Basin. During 1999, biological data collections included extensive quantitative sampling for benthic macroinvertebrates at four of the ten Cumberland River Basin projects.

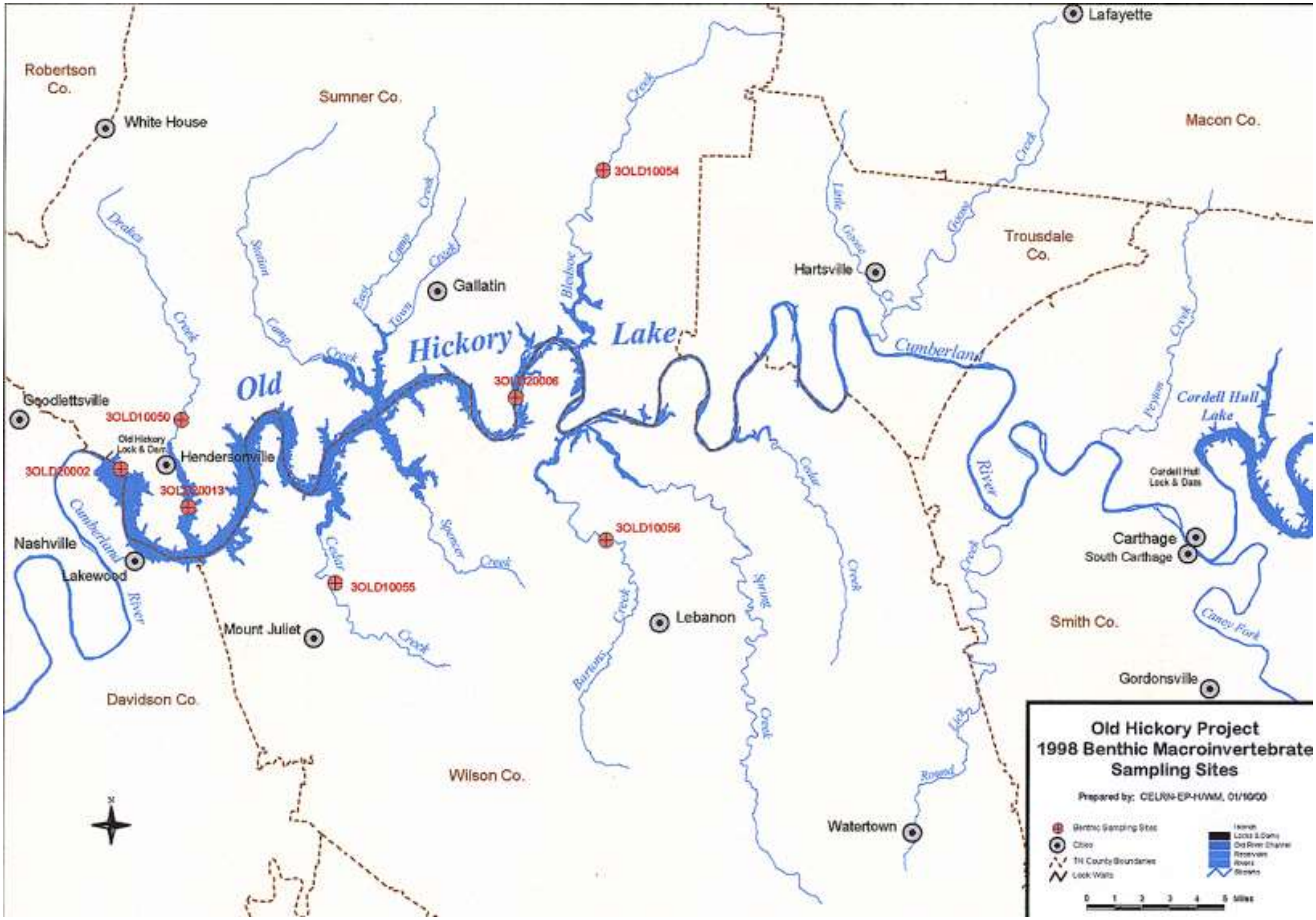
SAMPLING LOCATIONS

Sampling locations in the Old Hickory Project area in the Cumberland River Basin are shown in Figure 1. The following is a brief description of the three benthic macroinvertebrate sampling sites.

3OLD20002-Cumberland River Mile 216.9, Latitude $36^0$17’26”, Longitude $86^0$39’48”, main channel location.

3OLD20006-Cumberland River Mile 245.0, Latitude $36^0$19’46”, longitude $86^0$23’52”, main channel location

3OLD20013-Drake’s Creek Mile 1.9, Latitude $36^0$16’16”, Longitude $86^0$36’04”, embayment location.



Old Hickory Project
1998 Benthic Macroinvertebrate
Sampling Sites
Prepared by: CELRN-EP-H/WM, 01/10/00
Lafayette
Robertson Co.
Sumner Co.
White House
Macon Co.
Trousdale Co.
Hartsville
Gallatin
Old Hickory Lake
Cumberland
Cordell Hull Lake
Goodlettsville
Hendersonville
Nashville
Lakewood
Mount Juliet
Lebanon
Carthage
South Carthage
Smith Co.
Gordonsville
Davidson Co.
Wilson Co.
Watertown
3OLD10054
3OLD20006
3OLD10050
3OLD20002
3OLD20013
3OLD10056
3OLD10055
Old Hickory Lock & Dam
Cordell Hull Lock & Dam

BACKGROUND

As found in other similar studies, the alteration of the physical or chemical norms of an aquatic environment has the potential to influence nearly all organisms residing in that environment (Goodnight 1973). A community represented by numerous species with no particular numerical domination evident in the population is usually indicative of an unstressed environment (Weber 1973, Klemm etal. 1990). Conversely, a benthic community composed of a few species with large numbers of individuals typifies a stressed community from which intolerant species have been reduced or eliminated by a pollutant or substrate change. The populations of tolerant species expand due to reduced competition or increased resources, or both. The often dramatic benthic community shifts, which can occur in stressed ecosystems, are due to the varying sensitivities of the different macroinvertebrate species. Mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) or EPT species, which spend most of their lives in an aquatic environment, are generally less tolerant of most types of pollution, whereas many flies (Diptera) and worms (Oligochaeta) are more tolerant of stressful environmental conditions (Brinkhurst 1962, Beck 1977, Mason 1971, and Merritt and Cummins 1996). Stream reaches may be divided into several ecological categories depending upon whether or not they are subject to stressful agents and, if they are, to what extent or type. They can also be divided into these categories on the basis of the benthic fauna that is supported in that reach.

Attention is usually focused on the macroinvertebrate species because they are more indicative of the relative health of a stream. In addition, macroinvertebrates are found in all habitats, less mobile than other groups of aquatic organisms, easily collected, and most have relatively long periods of development in the aquatic environment. Thus, macroinvertebrate species can be used to indicate deleterious events that have occurred in an aquatic system during any stage of their development.

Clean water streams with variable habitat features often have a high diversity of species with each species represented by a few individuals. Streams receiving organic pollution generally show a decrease in diversity and an increase in density (Gaufin and Tarzwell 1956), while streams receiving toxic products frequently show a decrease in both diversity and density (Cairns et al., 1971).

Increased sedimentation in streams is a problem most often the result of poor agriculture practices and construction activity in the vicinity streams (Waters, 1995). The effects of increased sedimentation vary, but the primary effect is habitat loss caused by the filling of cracks and crevices with sand and silt and general decrease in habitat diversity.

MATERIALS AND METHODS

At stations Cumberland River Miles 216.9 and 245.0 and Drake's Creek Mile 1.9, samples were collected by use of a 6" x 6" Petite Ponar Grab ($0.023m^2$) lowered from a boat. Reservoir sites were sampled on a transect at multiple locations. Sampling sites on the transect represented the old main channel (thalweg), right overbank, and left overbank. Typically the sampling process involved anchoring and then lowering the Ponar Grab to the bottom, taking care to allow the Ponar Grab to gently contact the bottom. This was done to minimize "blow out" of the topmost sediments and associated organisms. The Ponar Grab was then retrieved and the contents brought to the surface, dumped into a plastic tub, and processed through a sieve bucket with a 583-micron stainless steel mesh screen. Retained debris and organisms were then placed in a container. The normal procedure used was to collect six grab samples (total sample area $0.14m^2$) at each site, which were then composited into one sample for laboratory analysis. The samples were preserved with formalin, labeled with a unique number, and recorded on a chain of custody form. Brief field notes were made. All samples were returned to the Nashville District's Water Management Support Center for storage prior to delivery to the analytical laboratory. Storage times for samples taken at reservoir sites were approximately four months.

In the laboratory, all benthic samples were washed in a 120-micron mesh screen. After washing, the macroinvertebrates were removed from the detritus under 5x magnification and preserved in 85% ethanol. The organisms were identified to the lowest practical taxonomic level using available keys (Pennington and Associates, Inc. 1994) and counted. Identifications were made with a stereomicroscope (7X to 60X). Slide mounts were made of the chironomids, simuliids, oligochaetes and small crustaceans, and identifications were made with a compound microscope. The chironomids, simuliids, and oligochaetes were cleared for 24 hours in cold 10% KOH. Temporary mounts were made in glycerine and the animals returned to 80% ethanol after identification. When permanent mounts were desired, the organisms were transferred to 95% ethanol for 30 minutes and mounted in euperol.

SUBSTRATE DETERMINATION

A classification of substrate based on the size scale proposed by Wentworth (Compton 1962) was used to make field observations of the substrate present at each station. This classification of detrital sediments is by grain diameter and is as follows:

Diameters	Approximate Inch Equivalents	Name of Loose Aggregate
>256 mm	>10 inch	Boulder
64 to 256 mm	2.5 to 10 inch	Cobble
2 to 64 mm	0.08 to 2.5 inch	Gravel
1/16 to 2 mm	0.002 to 0.08 inch	Sand
1/256 to 1/16 mm	0.00015 to 0.002 inch	Silt
<1/256 mm	<0.00015 inch	Clay

Substrate types encountered at the three sites varied somewhat. In general, reservoir sites consisted of sand, silt, and clay with varying amounts of plant detritus.

COMMUNITY STRUCTURE MEASURES

Brower and Zar (1984) provide a detailed discussion of a variety of techniques for measuring community structure. The use of diversity indices is based upon the observation that normally undisturbed environments support communities with large numbers of species having no individuals present in overwhelming abundance. If the species of a disturbed community are ranked by numerical abundance, there may be relatively few species with large numbers of individuals. Mean diversity is affected by both "richness" of species (or abundance of different species) and by the distribution of individuals among the species. High species diversity indicates a highly complex community.

Species diversity was estimated using Shannon's Index of Diversity (H):

$$H = -\sum p_i \log p_i$$

where p_i is the proportion of the total number of individuals occurring in species i ($p_i=n_i/N$), N is the total number of individuals in all species.

Diversity indices take into account both the species richness and the evenness of the individuals' distribution among the species. Separate measures of these two components of diversity are often desirable. Species richness can be expressed simply as the number of species in the community. Evenness may be expressed by considering how close a set of observed species abundance are to those from an aggregation of species having maximum possible diversity for a given N and s (Brower and Zar 1984).

Evenness is calculated as follows:

$$\text{Pielou } J' = H/H_{max}$$

where H is calculated diversity and H_{max} is maximum possible diversity.

Community similarity between sites is measured by Jaccards Coefficient, Community Loss Index, and Percent Similarity.

$$\text{Jaccards Coefficient} = \frac{C}{S_1 + S_2 - C}$$

$$\text{Community Loss Index} = \frac{S_1 - C}{S_2}$$

where S = Species in each community (S_1 is reference Community in Community loss Index)

C = Species common to both communities

The Community Loss Index is an index of dissimilarity with values increasing as the degree of dissimilarity from the reference station (S_1) increases (Plafkin et al. 1989). Values range from 0 to infinity. Community Loss was not calculated because no station was designated as a reference site.

Percent Similarity, for a two-community comparison, is calculated as follows: The number of individuals in each species is calculated as a fractional portion of the total community. The value for species i in community 1 is compared to the value for species i in community 2. The lower of the two is tabulated. This procedure is followed for each species. The tabulated list (of the lower of each pair of values) is summed. The sum is defined as the Percent Similarity of the two communities.

The software package Number Cruncher Statistical Systems version 5.03 was used to evaluate community similarity (Hintze 1992). Cluster analysis sorts sampling units into groups based on the overall resemblance to each other (Lundwig and Reynolds 1988). By using 1-Jaccards Coefficient and Percent Dissimilarity, sampling units are sorted to permit grouping. The cluster analysis combines the distances between sampling units into a matrix table, and two strategies of clustering are used to calculate a distance for N-1 cycles (N=number of sampling units). The cluster analysis is interpreted graphically on a dendrogram to relate the similar communities (Hintze 1992, Ludwig and Reynolds 1988).

The percent contribution of the numerically dominant taxon to the total number of organisms in the community is a rough measure of community balance at the lowest possible taxonomic level (Plafkin et al. 1989). A community, which is dominated by a few species, may be under environmental stress.

The total number of species within the pollution sensitive groups Ephemeroptera, Plecoptera, and Trichoptera is generally considered a measure of water quality and is listed as the EPT Index (Plafkin et al. 1989). The EPT Index generally increases with increasing water quality.

According to Plafkin et al. (1989) the scraper and filtering collector ratio (Sc/FC) reflects the riffle/run community food base and may provide insights into the nature of potential disturbance factors. The ratio of scraper abundance to the combined totals of scrapers and filtering collectors (scrapers / scrapers and filtering collectors) is an adjustment of the scrapers / filtering collectors from a ratio to a measure of percent contribution (Barbour et al. 1992).

The ratio of shredder functional feeding group and total number of individuals (Sh/Total) in the CPOM sample, allows evaluation of potential impairment as indicated by the shredder community. Shredders are considered sensitive to riparian zone impacts and are believed to be good indicators of toxic effects when toxicants are absorbed by or associated with the course particulate organic matter (CPOM) (Plafkin et al 1989). This metric was not included in this study because no CPOM samples were obtained at each station.

The EPT and Chironomidae abundance ratio (EPT/Chironomidae) is the relative abundance of the pollution sensitive groups Ephemeroptera, Plecoptera, and Trichoptera to the more tolerant Chironomidae as a measure of community balance (Plafkin et al. 1989). It is believed that good biotic condition is reflected in benthic communities with an even distribution of species among all four major groups and with substantial representation of Ephemeroptera, Plecoptera, and Trichoptera. Populations with a disproportional number of Chironomidae relative to the sensitive groups is most likely an indication of environmental stress (Plafkin et al. 1989).

A scoring approach developed by Plafkin et al. (1989) to estimate community health utilizes many of the community measures previously discussed. This rapid bioassessment is presented in flow chart format in Figure 2.

Metric	Biological Condition Scoring Criteria			
	6	4	2	0
1. Taxa Richness[a]	>80%	60-80%	40-60%	<40%
2. Hilsenhoff Biotic Index (modified)[b]	>85%	70-85%	50-70%	<50%
3. Ratio of Scrapers/Filt. Collectors[a,c]	>50%	35-50%	20-35%	<20%
4. Ratio of EPT and Chironomid Abundance[a]	>75%	50-75%	25-50%	<25%
5. % Contribution of Dominant Taxon[d]	<20%	20-30%	30-40%	>40%
6. EPT Index[a]	>90%	80-90%	70-80%	<70%
7. Community Loss Index[e]	<0.5	0.5-1.5	1.5-4.0	>4.0
8. Ratio of Shredders/Total[a,c]	>50%	35-50%	20-35%	<20%

(a) Score is a ratio of study site to reference site X 100.
(b) Score is a ratio of reference site to study site X 100.
(c) Determination of Functional Feeding Group is independent of taxonomic grouping.
(d) Scoring criteria evaluate actual percent contribution, not percent comparability to the reference station.
(e) Range of values obtained. A comparison to the reference station is incorporated in these indices.

BIOASSESSMENT		
% Comp. to Ref. Score[a]	**Biological Condition Category**	**Attributes**
>83%	**Nonimpaired**	Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure. Optimum community structure (composition and dominance) for stream size and habitat quality.
54-79%	Slightly impaired	Community structure less than expected. Composition (species richness) lower than expected due to loss of some intolerant forms. Percent contribution of tolerant forms increases.
21-50%	Moderately impaired	Fewer species due to loss of most intolerant forms. Reduction in EPT index.
<17%	Severely impaired	Few species present. If high densities of organisms, then dominated by one or two taxa.

(a) Percentage values obtained that are intermediate to the above ranges will require subjective judgement as to the correct placement. Use of the habitat assessment and physiochemical data may be necessary to aid in the decision process.

Figure 2. Biological Condition Scoring Criteria (Plafkin et al. 1989)

BIOTIC INDEX

Both the evenness and diversity indices are based on information of community structure and do not reflect any knowledge of the physiological attributes or ecological affinities of the organisms comprising the community (Howmiller and Scott 1977). Howmiller and Scott (1977) suggest the use of a trophic index for assessing ecological stress using Oligochaete species. After a two-year study of 53 Wisconsin streams, Hilsenhoff (1982) proposed using a biotic index of arthropod populations as a rapid method for evaluating water quality. Hilsenhoff (1987) expanded and improved his biotic index and this index, which is a measure of organic and nutrient pollution, was used in this study.

To calculate the biotic index, species are assigned pollution tolerance values of 0 to 10. A value of 0 is assigned to species found only in unaltered streams of very high water quality, and a value of 10 is assigned to species known to occur in severely polluted or disturbed streams. Intermediate values are assigned to species that occur in streams with intermediate degrees of pollution or disturbance. Where species cannot be identified, genera are assigned values instead. The biotic index is calculated from the formula:

$$\mathrm{BI} = \sum \frac{n_i a_i}{N}$$

where n_i is the number of individuals of each species, a_i is the tolerance value assigned to that species and N is the total number of individuals in the sample (Hilsenhoff 1982). The index is an average of tolerance values, and measures saprobity (pertaining to tolerance of organic enrichment) and to some extent trophism.

According to Hilsenhoff (1987) the calculated Biotic Index values reflect the following:

Biotic Index	Water Quality	Degree of Organic Pollution
0.00 - 3.50	Excellent	No apparent organic pollution
3.51 - 4.50	Very Good	Possibly slight organic pollution
4.51 - 5.50	Good	Some organic pollution
5.51 - 6.50	Fair	Fairly significant organic pollution
6.51 - 7.50	Fairly Poor	Significant organic pollution
7.51 - 8.50	Poor	Very significant organic pollution
8.51 - 10.00	Very Poor	Severe organic pollution

In response to previous requests of the Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Biotic Index values are calculated using tolerance values provided in North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management Water Quality Section, Standard Operating Procedures Biological Monitoring, Environmental Sciences Branch Ecosystems Analysis Unit, Biological Assessment Group, January, 1997 (North Carolina, Department of Environment, Health and Natural Resources 1997).

Since North Carolina provides water quality classifications for Biotic Index values based on three geographic regions (mountains, piedmont and coastal) it is probably more appropriate to use scoring criteria for the piedmont region. North Carolina's scoring criteria for water quality assessment for the piedmont region are as follows:

NC Biotic Index (Piedmont)	Water Quality
< 5.19	Excellent
5.19 - 5.78	Good
5.79 - 6.48	Good - Fair
6.49 - 7.48	Fair
> 7.48	Poor

RESULTS AND DISCUSSION

A list of all aquatic benthic macroinvertebrate species, assigned tolerance values, functional feeding groups and numbers of individuals of each species collected from each location are presented in Table 1. A summary of benthic community metrics is presented in Table 2. A comparison of the stations using Percent Dissimilarity is found in Figure 3 while similar comparisons using 1-Jaccard's Coefficient is clustered in Figure 4.

A minimum of 28 species of benthic macroinvertebrates was taken from the three locations in the Old Hickory Project area (Table 1). The fauna represented four phyla, 13 orders and 18 families with eight families being aquatic insects. Cumberland River Mile (CRM) 245.0 had the highest number of species with 27 followed by 17 from CRM 216.9, and 15 from Drake's Creek Mile 1.9. In terms of density, the embayment location, Drake's Creek Mile 1.9, had the highest population densities of 6171/m^2 followed by Cumberland River Mile 216.9 with 3603/m^2 and the least at CRM 245.0 with 2363/m^2.

The main stem location, Cumberland River Mile 245.0 (3OLD2006), the most upstream main channel location, had a minimum of 27 benthic species present and overall population densities of 2363 individuals/m^2 (Table 1). Tubificid worms were dominant at all locations with chironomids also very abundant. There were 2 EPT species taken and the fauna is considered to exist under "Fairly Poor" water quality conditions with significant organic pollution.

Cumberland River Mile 216.9 (3OLD20002), just upstream of Old Hickory Lock and Dam, had 17 species of benthic macroinvertebrates present in the Petite Ponar Grab samples (Table 1). Tubificid worms were dominant throughout the site with the midge *Coelotanypus tricolor* also very common. There were no EPT species found in the Petite Ponar Grab samples. The Biotic Index values (7.32-7.61) for CRM 216.9 are indicative of "Fairly Poor" to "Poor" water quality conditions with significant to very significant organic pollution.

The embayment location, Drake's Creek at Mile 1.9 (3OLD20013), had a low number of species present with 15. Population densities ranged from 3127 individuals/m^2 at the right overbank location to 11,174/m^2 in the mid-channel (Table 1). Tubificid worms were abundant at the left overbank and mid-channel locations. The phantom midge *Chaoborus punctipennis* and the midge *Chironomus sp*. were dominant at the right overbank location and abundant at the left overbank and mid-channel. There were no EPT species found at this site and the Biotic Index values indicated “Poor” to “Very Poor” water quality conditions with very significant to severe organic pollution.

A comparison of the three locations, using Percent Dissimilarity (Figure 3) and Jaccard’s Coefficient (Figure 4) groups the locations primarily by site. The secondary clusters between locations of the main channel/embayment sites are a reflection of similarity of species and habitat type between the various locations

TABLE 1. SUMMARY OF BENTHIC MACROINVERTEBRATES COLLECTED FROM OLD HICKORY RESERVOIR, OCTOBER 1999.										
SPECIES	**T.V.****	**F.F.G.*****	**Cumberland River Mile 216.9**							
			3OLD20002							
			Right Overbank		**Left Overbank**		**Mid-Channel**		**Total**	
			Count	**Density**	**Count**	**Density**	**Count**	**Density**	**Count**	**Density**
NEMATODA	**6**	**P**	1	7.14					1	2.38
MOLLUSCA										
Bivalvia										
Veneroida										
Corbiculidae										
Corbicula fluminea	**6.1**	**FC**			2	14.28	2	14.28	4	9.52
Sphaeriidae										
Musculium transversum	***8**	**FC**					51	364.1	51	121.4
Pisidium sp.	***5**	**SC**					6	42.84	6	14.28
ANNELIDA										
Oligochaeta										
Haplotaxida										
Tubificidae w.h.c.	**7.1**	**CG**	21	149.9			96	685.4	117	278.5
Tubificidae w.o.h.c.	**7.1**	**CG**	116	828.2	135	963.9	818	5841	1069	2544
Limnodrilus hoffmeisteri	**9.5**	**CG**					48	342.7	48	114.2
Lumbriculida										
Lumbriculidae	**7**	**CG**								
Hirudinea	***8**	**P**			1	7.14			1	2.38
ARTHROPODA										
Crustacea										
Ostracoda										
Copepoda										
Cyclopoida										
Amphipoda										
Asellidae	***6**									
Caecidotea sp.	**9.1**	**CG**								
Ephemeroptera										
Caenidae										
Caenis sp.	**7.4**	**CG**								

TABLE 1. SUMMARY OF BENTHIC MACROINVERTEBRATES COLLECTED FROM OLD HICKORY RESERVOIR, OCTOBER 1999.										
SPECIES	**T.V.****	**F.F.G.*****	**Cumberland River Mile 216.9**							
			3OLD20002							
			Right Overbank		**Left Overbank**		**Mid-Channel**		**Total**	
			Count	**Density**	**Count**	**Density**	**Count**	**Density**	**Count**	**Density**
Ephemeridae										
Hexagenia limbata	***5**	**CG**								
Odonata										
Gomphidae										
Gomphus sp.	**5.8**	**P**								
Megaloptera										
Sialidae										
Sialis sp.	**7.1**	**P**	1	7.14					1	2.38
Coleoptera										
Elmidae										
Dubiraphia sp.	**5.9**	**SC**								
Diptera										
Chaoboridae										
Chaoborus punctipennis	**8.5**	**P**	2	14.28	1	7.14	6	42.84	9	21.42
Ceratopogonidae										
Bezzia/Palpomyia	**6.9**	**P**	1	7.14			1	7.14	2	4.76
Chironomidae							1	7.14	1	2.38
Ablabesmyia annulata	**7.2**	**P**			1	7.14	3	21.42	4	9.52
Axarus sp.		**CG**	2	14.28	5	35.7			7	16.66
Chironomus sp.	**9.6**	**CG**	16	114.2	26	185.6	25	178.5	67	159.5
Coelotanypus tricolor	**8**	**P**	60	428.4	44	314.2	20	142.8	124	295.1
Cryptochironomus fulvus	**6.4**	**P**					2	14.28	2	4.76
Dicrotendipes sp.	**8.1**	**CG**								
Epoicocladius	**0**									
Harnischia sp.	**9.1**	**CG**								
Polypedilum halterale	**7.3**	**SH**								
Procladius sp.	**9.1**	**P**								
Tanypus stellatus	**9.2**	**P**								
Tanytarsus sp.	**7.8**	**FC**								

TABLE 1. SUMMARY OF BENTHIC MACROINVERTEBRATES COLLECTED FROM OLD HICKORY RESERVOIR, OCTOBER 1999.										
SPECIES	T.V.**	F.F.G.***	Cumberland River Mile 216.9							
			3OLD20002							
			Right Overbank		Left Overbank		Mid-Channel		Total	
			Count	Density	Count	Density	Count	Density	Count	Density
TOTAL NO. OF ORGANISMS			220	1571	215	1535	1079	7704	1514	3603
TOTAL NO. OF SPECIES			9		8		13		17	

TABLE 1. SUMMARY OF BENTHIC MACROINVERTEBRATES COLLECTED FROM OLD HICKORY RESERVOIR, OCTOBER 1999.										
SPECIES	**T.V.****	**F.F.G.* ****	**Drakes Creek Mile 1.9**							
			3OLD20013							
			Right Overbank		**Left Overbank**		**Mid-Channel**		**Total**	
			Count	**Density**	**Count**	**Density**	**Count**	**Density**	**Count**	**Density**
NEMATODA	**6**	**P**	1	7.14					1	2.38
MOLLUSCA										
Bivalvia										
Veneroida										
Corbiculidae										
Corbicula fluminea	**6.1**	**FC**								
Sphaeriidae										
Musculium transversum	***8**	**FC**	10	71.4			3	21.42	13	30.94
Pisidium sp.	***5**	**SC**								
ANNELIDA										
Oligochaeta										
Haplotaxida										
Tubificidae w.h.c.	**7.1**	**CG**	13	92.82	894	6383.2	12	85.68	919	2187
Tubificidae w.o.h.c.	**7.1**	**CG**	7	49.98	99	706.86	207	1478	313	744.9
Limnodrilus hoffmeisteri	**9.5**	**CG**					24	171.4	24	57.12
Lumbriculida										
Lumbriculidae	**7**	**CG**								
Hirudinea	***8**	**P**								
ARTHROPODA										
Crustacea										
Ostracoda			6	42.84	2	14.28			8	19.04
Copepoda										
Cyclopoida			3	21.42	1	7.14			4	9.52
Amphipoda										
Asellidae	***6**									
Caecidotea sp.	**9.1**	**CG**								

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SPECIES	**T.V.****	**F.F.G.*** **	**Drakes Creek Mile 1.9**							
			3OLD20013							
			Right Overbank		**Left Overbank**		**Mid-Channel**		**Total**	
			Count	**Density**	**Count**	**Density**	**Count**	**Density**	**Count**	**Density**
Ephemeroptera										
Caenidae										
Caenis sp.	**7.4**	**CG**								
Ephemeridae										
Hexagenia limbata	***5**	**CG**								
Odonata										
Gomphidae										
Gomphus sp.	**5.8**	**P**								
Megaloptera										
Sialidae										
Sialis sp.	**7.1**	**P**								
Coleoptera										
Elmidae										
Dubiraphia sp.	**5.9**	**SC**								
Diptera										
Chaoboridae										
Chaoborus punctipennis	**8.5**	**P**	187	1335	349	2491.9	189	1349	725	1726
Ceratopogonidae										
Bezzia/Palpomyia	**6.9**	**P**								
Chironomidae			1	7.14	4	28.56			5	11.9
Ablabesmyia annulata	**7.2**	**P**	2	14.28			2	14.28	4	9.52
Axarus sp.		**CG**			2	14.28			2	4.76
Chironomus sp.	**9.6**	**CG**	193	1378	204	1456.6	147	1050	544	1295
Coelotanypus tricolor	**8**	**P**	15	107.1	2	14.28	3	21.42	20	47.6
Cryptochironomus fulvus	**6.4**	**P**			4	28.56	3	21.42	7	16.66
Dicrotendipes sp.	**8.1**	**CG**								
Epoicocladius	**0**									
Harnischia sp.	**9.1**	**CG**								

TABLE 1. SUMMARY OF BENTHIC MACROINVERTEBRATES COLLECTED FROM OLD HICKORY RESERVOIR, OCTOBER 1999.										
SPECIES	**T.V.****	**F.F.G.* ****	**Drakes Creek Mile 1.9**							
			3OLD20013							
			Right Overbank		**Left Overbank**		**Mid-Channel**		**Total**	
			Count	**Density**	**Count**	**Density**	**Count**	**Density**	**Count**	**Density**
Polypedilum halterale	**7.3**	**SH**								
Procladius sp.	**9.1**	**P**			4	28.56			4	9.52
Tanypus stellatus	**9.2**	**P**								
Tanytarsus sp.	**7.8**	**FC**								
TOTAL NO. OF ORGANISMS			**438**	**3127**	**1565**	**11174**	**590**	**4213**	**2593**	**6171**
TOTAL NO. OF SPECIES			**11**		**11**		**9**		**15**	

TABLE 1. SUMMARY OF BENTHIC MACROINVERTEBRATES COLLECTED FROM OLD HICKORY RESERVOIR, OCTOBER 1999.										
SPECIES	**T.V.****	**F.F.G.*****	**Cumberland River Mile 245.0**							
			3OLD20006							
			Right Overbank		**Left Overbank**		**Mid-Channel**		**Total**	
			Count	**Density**	**Count**	**Density**	**Count**	**Density**	**Count**	**Density**
NEMATODA	**6**	**P**								
MOLLUSCA										
Bivalvia										
Veneroida										
Corbiculidae										
Corbicula fluminea	**6.1**	**FC**	1	7.14					1	2.38
Sphaeriidae										
Musculium transversum	***8**	**FC**	4	28.56	2	14.28	3	21.42	9	21.42
Pisidium sp.	***5**	**SC**					1	7.14	1	2.38
ANNELIDA										
Oligochaeta										
Haplotaxida										
Tubificidae w.h.c.	**7.1**	**CG**	73	521.2	20	142.8	84	599.8	177	421.3
Tubificidae w.o.h.c.	**7.1**	**CG**	171	1221	121	863.9	252	1799	544	1295
Limnodrilus hoffmeisteri	**9.5**	**CG**			30	214.2			30	71.4
Lumbriculida										
Lumbriculidae	**7**	**CG**			30	214.2			30	71.4
Hirudinea	***8**	**P**								
ARTHROPODA										
Crustacea										
Ostracoda										
Copepoda										
Cyclopoida										
Amphipoda										
Asellidae	***6**									
Caecidotea sp.	**9.1**	**CG**	1	7.14					1	2.38
Ephemeroptera										

TABLE 1. SUMMARY OF BENTHIC MACROINVERTEBRATES COLLECTED FROM OLD HICKORY RESERVOIR, OCTOBER 1999.										
SPECIES	**T.V.****	**F.F.G.*****	**Cumberland River Mile 245.0**							
			3OLD20006							
			Right Overbank		**Left Overbank**		**Mid-Channel**		**Total**	
			Count	**Density**	**Count**	**Density**	**Count**	**Density**	**Count**	**Density**
Caenidae										
Caenis sp.	**7.4**	**CG**	1	7.14					1	2.38
Ephemeridae										
Hexagenia limbata	***5**	**CG**	13	92.82	11	78.54	2	14.28	26	61.88
Odonata										
Gomphidae										
Gomphus sp.	**5.8**	**P**	1	7.14					1	2.38
Megaloptera										
Sialidae										
Sialis sp.	**7.1**	**P**								
Coleoptera										
Elmidae										
Dubiraphia sp.	**5.9**	**SC**	1	7.14					1	2.38
Diptera										
Chaoboridae										
Chaoborus punctipennis	**8.5**	**P**			2	14.28			2	4.76
Ceratopogonidae										
Bezzia/Palpomyia	**6.9**	**P**	1	7.14	3	21.42			4	9.52
Chironomidae							2	14.28	2	4.76
Ablabesmyia annulata	**7.2**	**P**	2	14.28	6	42.84	1	7.14	9	21.42
Axarus sp.		**CG**	1	7.14					1	2.38
Chironomus sp.	**9.6**	**CG**	9	64.26	6	42.84	36	257	51	121.4
Coelotanypus tricolor	**8**	**P**	2	14.28	7	49.98			9	21.42
Cryptochironomus fulvus	**6.4**	**P**	11	78.54	12	85.68	12	85.68	35	83.3
Dicrotendipes sp.	**8.1**	**CG**			2	14.28			2	4.76
Epoicocladius	**0**				1	7.14			1	2.38
Harnischia sp.	**9.1**	**CG**	2	14.28			1	7.14	3	7.14
Polypedilum halterale	**7.3**	**SH**	1	7.14			1	7.14	2	4.76
Procladius sp.	**9.1**	**P**	10	71.4	14	99.96	11	78.54	35	83.3

TABLE 1. SUMMARY OF BENTHIC MACROINVERTEBRATES COLLECTED FROM OLD HICKORY RESERVOIR, OCTOBER 1999.										
SPECIES	**T.V.****	**F.F.G.*****	**Cumberland River Mile 245.0**							
			3OLD20006							
			Right Overbank		**Left Overbank**		**Mid-Channel**		**Total**	
			Count	**Density**	**Count**	**Density**	**Count**	**Density**	**Count**	**Density**
Tanypus stellatus	**9.2**	**P**			1	7.14	1	7.14	2	4.76
Tanytarsus sp.	**7.8**	**FC**	12	85.68	1	7.14			13	30.94
TOTAL NO. OF ORGANISMS			**317**	**2263**	**269**	**1921**	**407**	**2906**	**993**	**2363**
TOTAL NO. OF SPECIES			**19**		**17**		**13**		**27**	

TABLE 2. SUMMARY OF RBPIII METRICS, OLD HICKORY RESERVOIR DRAINAGE, OCTOBER 1999												
	Cumberland River Mile 216.9				Drakes Creek Mile 1.9				Cumberland River Mile 245.0			
METRIC	3OLD20002				3OLD20013				3OLD20006			
	LOB	ROB	MC	TOTAL	LOB	ROB	MC	TOTAL	LOB	ROB	MC	TOTAL
Taxa Richness	8	9	13	17	11	11	9	13	17	19	13	27
Biotic Index	7.610	7.546	7.325	7.397	7.757	8.903	8.285	8.545	7.435	7.183	7.368	7.327
Ratio of Scrapers/Filtering Collectors	0.000	0.000	0.113	0.109	0.000	0.000	0.000	0.000	0.000	0.059	0.333	0.087
Ratio of Ept/Chironomidae abuncance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.220	0.280	0.031	0.164
Percent Contribution of Dominant Taxon	62.79%	52.73%	75.81%	70.61%	57.12%	44.06%	35.08%	36.58%	44.98%	53.94%	61.92%	54.78%
EPT Index	0	0	0	0	0	0	0	0	1	2	1	2
Shannon Diversity (H')	1.078	1.266	0.979	1.156	1.171	1.242	1.388	1.464	1.952	1.549	1.201	1.675
Pielou Evenness (J')	0.519	0.576	0.382	0.408	0.488	0.518	0.632	0.571	0.689	0.526	0.468	0.508

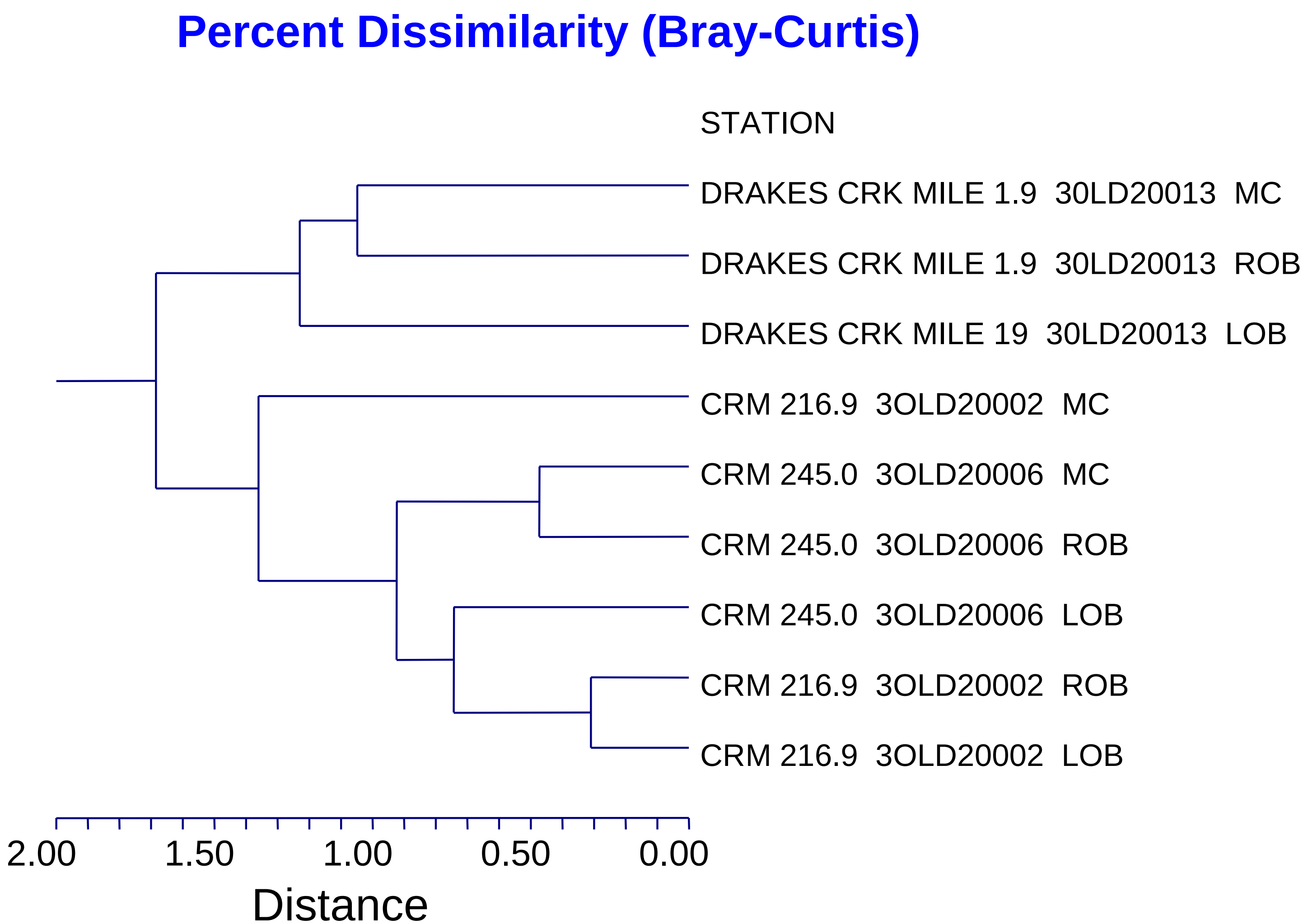

Figure 3. Percent Dissimilarity (Bray-Curtis) Cluster Analysis, Old Hickory Reservoir Drainage, Fall 1999 (CRM = Cumberland River Mile).

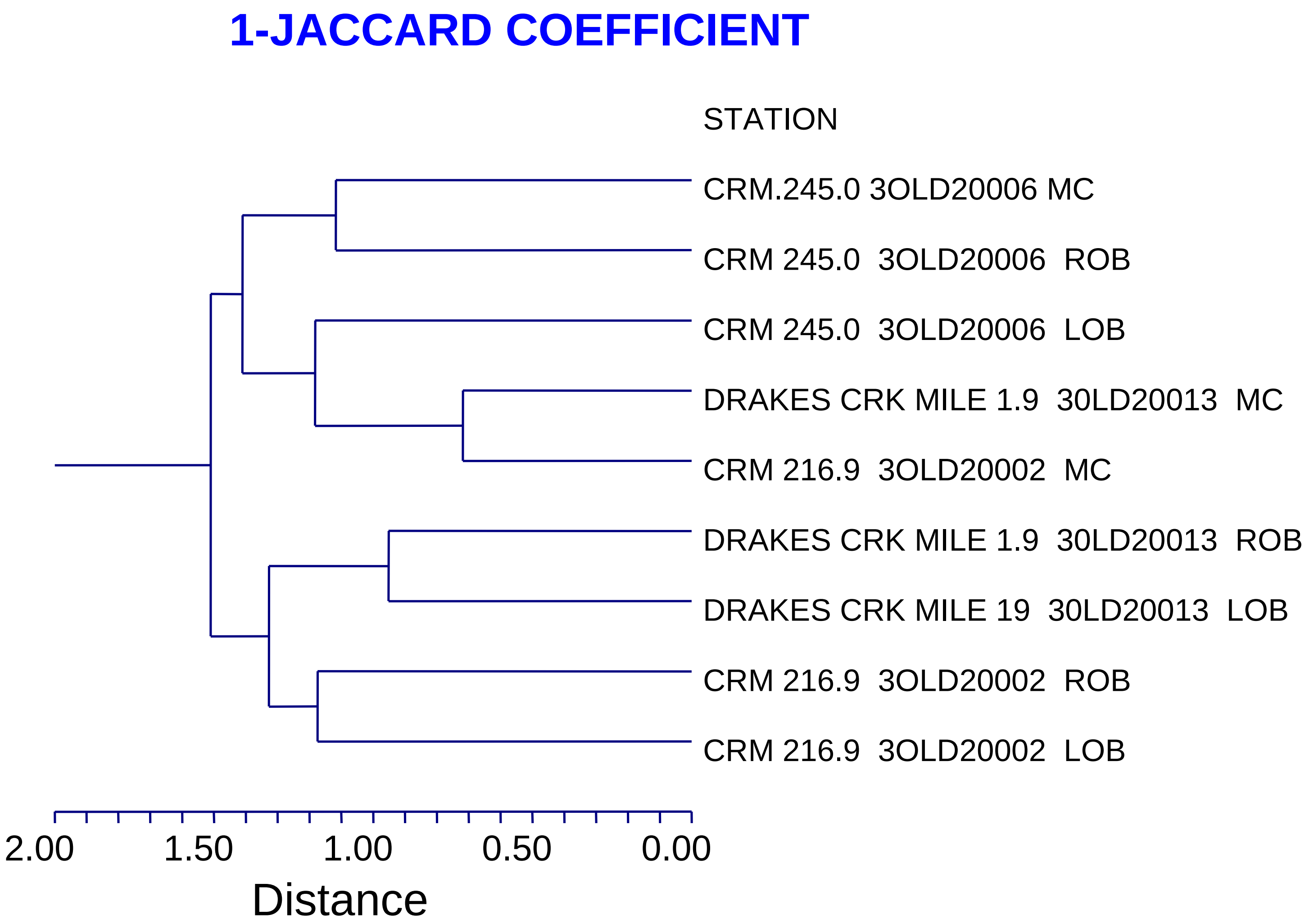

Figure 4. 1-Jaccard's Coefficient Cluster Analysis, Old Hickory Reservoir Drainage, Fall 1999 (CRM = Cumberland River Mile).

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