CHARACTERIZATION OF ENDANGERED DWARF WEDGEMUSSEL (*ALASMIDONTA HETERODON*) HABITATS IN MARYLAND

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Prepared by:
Alfred E. Pinkney
Daniel R. Murphy
Peter C. McGowan

Under supervision of:
Robert E. Foley, Section Chief
Robert J. Pennington, Branch Chief
John P. Wolflin, Supervisor

U.S. Fish and Wildlife Service
Branch of Water Quality and
Environmental Contaminants
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401

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Title: Characterization of Endangered Dwarf Wedgemussel (*Alasmidonta heterodon*) Habitats in Maryland

Abstract: The dwarf wedgemussel (*Alasmidonta heterodon*) has been listed by the U.S. Fish and Wildlife Service as an endangered species since 1990. This species, once found in at least 70 locations along the Atlantic coast, now inhabits only 20 locations in eight drainages, four of which are in Maryland. The FWS recovery plan states that the two eastern shore streams -- Long Marsh Ditch and Norwich Creek -- may be impacted by agricultural practices; populations are sparse and may not be reproducing. One of the two western shore locations, McIntosh Run, appears to support an apparently reproducing population of hundreds of dwarf wedgemussels. The other western shore location, Nanjemoy Creek, may be intermediate in health between the eastern shore locations and McIntosh Run. The objectives of this study were to generate and compile chemical, physical, ecological, and toxicological data on the four Maryland mussel sites to identify possible stressors. Sediment and water column chemistry did not indicate the presence of organic or inorganic contamination; nor did sediment toxicity tests with *Hyalella azteca* indicate acute toxicity. Acetylcholinesterase assays with the common mussel, *Elliptio complanata* (used as a surrogate), revealed significant differences in activity between the streams but no evidence of pesticide-induced inhibition. Dwarf wedgemussels require an intermediate fish host for larval development and metamorphosis. Tesselated darters (*Etheostoma olmstedi*), a known host fish, were obtained during electroshocking surveys at all four streams. The data base is inadequate to determine whether sufficient numbers of host fish are present at critical times to support mussel reproduction. Physical habitat characteristics at Long Marsh Ditch were particularly poor, indicating the effects of channelization. Further investigations should quantify sediment loading, identify stressful levels of nutrients and suspended sediments, and repeat the cholinesterase assays during a period of heavy agricultural runoff. Research on the identification of fish hosts is underway. Regular quantitative (yet non-destructive) monitoring of mussel and fish host populations is needed to guide remediation efforts. Recommended management actions are to increase the extent of forested buffers on the two eastern shore streams, prevent dumping at Nanjemoy Creek, and strictly control erosion in the McIntosh Run watershed.

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1.0 INTRODUCTION

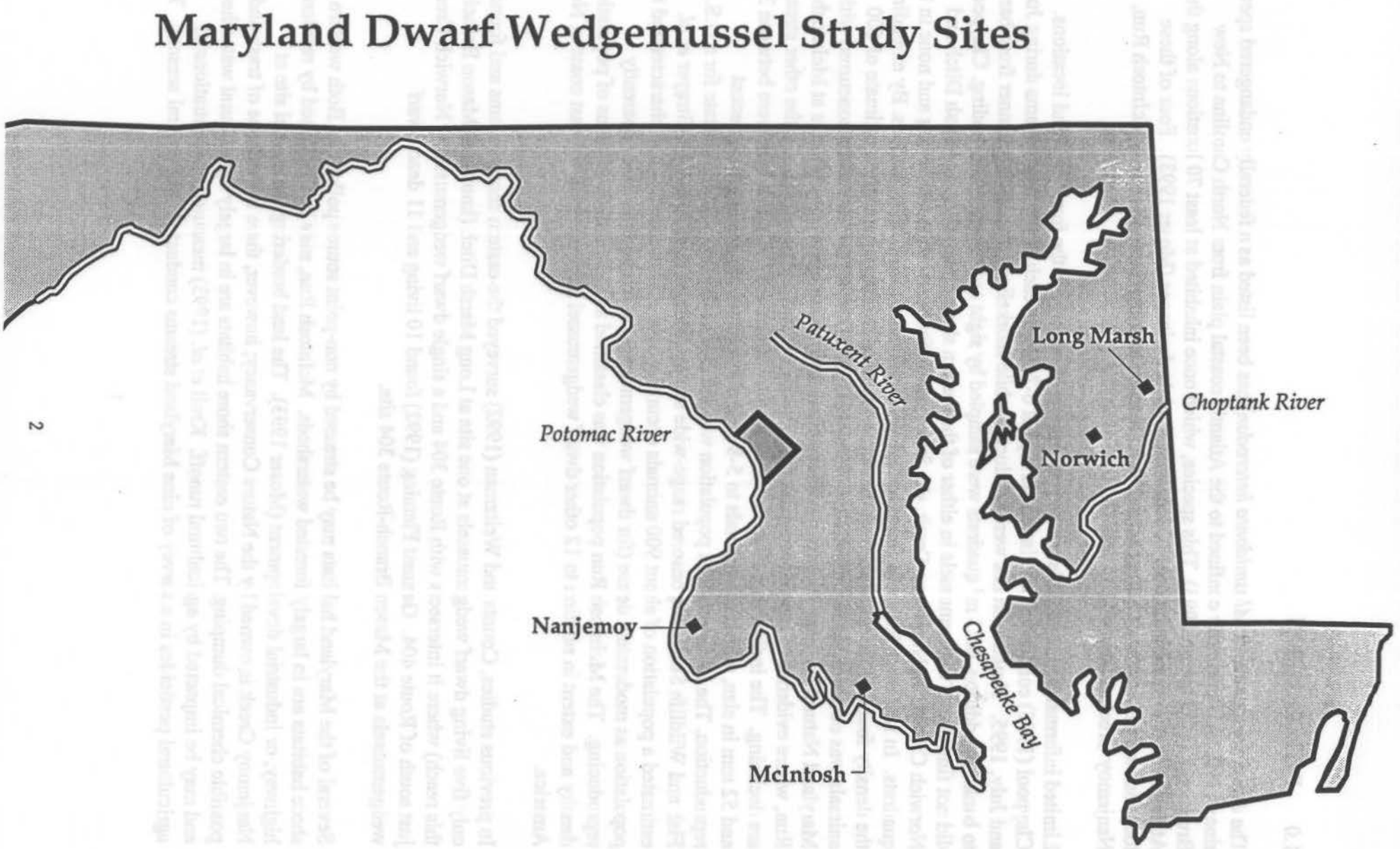
The dwarf wedgemussel (*Alasmidonta heterodon*) has been listed as a federally endangered species since 1990. It is primarily confined to the Atlantic coastal plain from North Carolina to New Brunswick (Michaelson 1993). This species, which once inhabited at least 70 locations along the Atlantic coast, now inhabits only 20 locations in eight drainages (Moser 1993). Four of these locations are in Maryland: Long Marsh Ditch (Mason Branch), Norwich Creek, McIntosh Run, and Nanjemoy Creek (Figure 1).

Limited information is available on the populations of mussels in the four Maryland locations. Claypool (1995) conducted population surveys at 6-7 sites in each of the four streams during June and July, 1995. Timed searches were conducted while snorkeling in a zig-zag manner from bank to bank. In addition, 0.25 m^2 quadrats were sampled by sight and touch, while wading. Claypool did not find dwarf wedgemussels in either of the eastern shore streams (Long Marsh Ditch and Norwich Creek). In Nanjemoy Creek, she found two individuals while snorkeling and none in the quadrats. In McIntosh Run, she found a total of 13 individuals from both methods. By extending the density found in the quadrats over the entire occupied habitat, a population estimate of 600 animals was obtained for McIntosh Run. Claypool (1995) stated that her results concurred with Maryland Natural Heritage Program's observations that the strongest population is at McIntosh Run, where evidence of reproduction has been found, and that the populations in the other streams are declining. The individuals observed in Nanjemoy Creek and McIntosh Run were between 36 and 52 mm in size, which corresponds to 5-8 year old animals, suggesting fairly recent reproduction. The McIntosh Run population was selected as the strongest in the state for a U.S. Fish and Wildlife Service-sponsored range-wide survey (Strayer *et al.* in press). Strayer *et al.* estimated a population of about 900 animals occurring over a 5-km reach. They characterized the population as moderately dense (for dwarf wedgemussels) and stated that it is apparently reproducing. The McIntosh Run population was classified as intermediate in terms of population density and extent in relation to 12 other dwarf wedgemussel habitats along the east coast of North America.

In previous studies, Counts and Weitzman (1992) surveyed the eastern shore streams and found only five living dwarf wedgemussels at one site at Long Marsh Ditch (known as Mason Branch in this reach) where it intersects with Route 304 and a single dwarf wedgemussel at Norwich Creek just south of Route 404. Gannett Fleming (1992) found 10 living and 11 dead dwarf wedgemussels at the Mason Branch-Route 304 site.

Several of the Maryland habitats may be stressed by non-point source pollution. Both western shore habitats are in largely forested watersheds. McIntosh Run, may be threatened by residential, highway, or industrial development (Moser 1993). The land bordering the mussel site at Nanjemoy Creek is owned by the Nature Conservancy; however, there is evidence of trash and possible chemical dumping. The two eastern shore habitats are in largely agricultural watersheds and may be impacted by agricultural runoff. Kroll *et al.* (1993) measured concentrations of agricultural pesticides in a survey of nine Maryland streams conducted over several seasons. The

Figure 1. Locations of the dwarf wedgemussel study sites.



highest levels of several agricultural pesticides measured in a single sample were found in the German Branch which is in the same Tuckahoe River watershed as the eastern shore mussel sites. FWS observed that pulses of cadmium and zinc at concentrations toxic to larval striped bass (*Morone saxatilis*) occurred in the water column of several Tuckahoe watershed streams following heavy rains (R. Everett, FWS, Chesapeake Bay Field Office (CBFO), personal communication).

Sediments entering mussel habitats may serve as physical stressors or as a vehicle for chemical stressors. Freshwater mussels often require habitats that are relatively free of silt (White 1982). Sediments can adversely affect mussels by irritating their gills and forcing them to close their valves and suspend feeding. Nutrients in these sediments can contribute to poor water quality resulting in eutrophication. Toxicants in sediments can cause acute or chronic poisoning to aquatic organisms and can be bioaccumulated. If physical and chemical stressors are acting on dwarf wedgemussel habitats, populations at individual sites could be deteriorating. The complex life cycle of these mussels, which requires a fish host, may preclude rapid recovery.

The overall goal of this study was to establish a data base on the dwarf wedgemussel habitats in Maryland and identify factors that may be stressful to the populations. Its primary objectives were to (1) characterize the water quality, sediment chemistry, and physical habitat of the mussel sites, (2) evaluate the toxicity of in-place and newly-deposited sediments, (3) establish if mussels are responding biochemically to pulse loadings of pesticides, and (4) determine whether the streams are supporting healthy fish populations (including those species that may serve as intermediate hosts).

2.0 MATERIALS AND METHODS

2.1 Locations

Studies were conducted in 1994 and 1995 in the reaches of four Maryland streams -- Long Marsh Ditch, Norwich Creek, McIntosh Run, and Nanjemoy Creek -- that have been reported to support dwarf wedgemussels over the past twenty years (Moser 1993). In each stream, a 100 meter long reach (study site) was surveyed. Each reach's origin was at least 50 meters downstream of the nearest road crossing.

2.2 Approach

There were three general approaches. First, a chemical/toxicological approach was used to (1) measure the concentrations of contaminants in sediments and water, (2) determine whether sediments were toxic to a standard test organism, and (3) observe whether there were biochemical indicators of pesticide exposure. The second approach was to characterize the physical habitat through (1) measurements of flow and particle size and the Rapid Bioassessment Protocol and (2) *in situ* monitoring of stream temperature. Land use data were analyzed for each of the watersheds to aid in the habitat characterization. The third approach was to evaluate the status of the fish community through an electroshocking survey, Index of Biological Integrity, and an enumeration of the number of individuals of known host species. In addition, state and federal resource agencies were contacted, and relevant data on these sites were obtained and interpreted.

2.3 Chemical/Toxicological Studies

2.3.1 Water Quality Data

Standard water quality parameters (temperature, conductivity, pH, and dissolved oxygen) were monitored during the spring, summer, and fall using a Hydrolab Surveyor II (Hydrolab Corp., Austin, TX) unit. Stream velocity was also recorded during the spring using a Pygmy current meter at 60% of the depth (Teledyne Gurley, Inc., Troy, NY). Flows were measured at a single cross section near the mid-point of each study site on five (western shore) and seven (eastern shore) occasions during the spring of 1994 to provide preliminary data on velocity and discharge.

A grab sample was obtained for measurement of alkalinity and hardness according to American Public Health Association (APHA 1989) Standard Methods. On several occasions, nitrate and phosphate were analyzed from a single grab sample from each stream using CHEMets colorimetric kits (Chemetrics, Inc., Calverton, VA). *In situ* monitoring of stream temperature was conducted by installing HOBO temperature monitors (Onset Instruments, Pocasset, MA) at mid-depth in each stream near the mid-point of each study site. The instruments provided temperature data at 1.2 hour intervals for a 90-day period from mid-June through mid-September, 1994.

2.3.2 Collection of Water and Sediment Samples

Water samples were collected from all four sites on May 27, 1994 by filling chemically-cleaned one liter glass jars at a depth of about one-half meter under the surface. Water samples were collected in separate jars for metals; organochlorine pesticides and polychlorinated biphenyls (PCBs); and organophosphate and carbamate pesticides. Samples were not filtered. The organophosphate/carbamate samples were preserved by adding 50 mL methylene chloride at the time of collection. Water samples were kept refrigerated at 4 °C before shipping to the laboratory.

Sediment samples were collected, using a stainless steel Wildco corer (Wildlife Supply Co., Saginaw, MI), at Long Marsh on June 14, 1994, Norwich on June 15, 1994, and McIntosh and Nanjemoy on June 20, 1994. A reference sediment sample was collected from Bear Swamp Pond, Bombay Hook National Wildlife Refuge (Smyrna, DE) on July 5, 1994. The location within the stream reach with the finest available grain size was determined by inspecting cores from various areas before sampling. Samples of the top two centimeters taken from 10-15 cores were composited and mixed in a Teflon bowl with a stainless steel spoon. Sediments were divided into four separate jars for chemical analyses (three as described for the water samples, one for grain size and total organic carbon (TOC)). The grain size/TOC sample jars were kept at 4 °C whereas the metals and organic sediment jars were kept frozen at -20 °C. Two additional one liter glass jars of sediments were used for toxicity testing and kept at 4 °C.

Newly loaded sediments were obtained by embedding 5-7 one quart (0.95 L) mason jars into the streambed near the 0, 50, and 100 m points along each study site. A four-inch (10.2 cm) diameter, eight-inch (20.4 cm) long perforated polyvinyl chloride (PVC) pipe section was first installed in the stream bed. The sediment within the pipe section was removed, and after allowing the newly released sediment to disperse, the mason jar was placed inside of the PVC pipe. The top of the jar extended about one cm above the top of the pipe and about three cm above the stream bottom. For 21-30 days at each stream, the jars were allowed to collect incoming sediment, which would settle out of the water column into the bottom of the jar. Jars were deployed at Nanjemoy and McIntosh on May 20, 1994 and collected on June 20, 1994. Jars were deployed at Long Marsh and Norwich on May 24, 1994 and collected from Long Marsh on June 14, 1994 and from Norwich on June 15, 1994. After removing twigs and rocks, and allowing the sample to settle, water was decanted and sediments trapped in the jars deployed at each stream were composited and mixed in a Teflon bowl with a stainless steel spoon. Sediment trap samples were handled in the same manner as the sediment samples.

2.3.3 Chemical Analysis

The metals and sediment parameters were analyzed by Research Triangle Institute, Research Triangle Park, NC. The following carbamate and organophosphate pesticides were analyzed by the Patuxent Analytical Control Facility (PACF; Laurel, MD) of FWS: EPN, acephate, aldicarb, azinphos-methyl, carbaryl, carbofuran, chlorpyrifos, coumaphos, demeton, diazinon, dichlorvos, dimethoate, disulfoton, ethoprop, famphur, fensulfothion, fenthion, malathion, methamidophos,

methiocarb, methomyl, methyl parathion, mevinphos, monocrotophos, oxamyl, parathion, phorate, terbufos, and trichlorfon. The following organochlorine compounds were analyzed by Mississippi State Chemical Laboratory, Mississippi State, MS: DDE, DDD, and DDT isomers; total polychlorinated biphenyls (PCBs); hexachlorobenzene; alpha-, beta-, delta-, and gamma-benzene hydrochloride (BHC); alpha- and gamma-chlordane; cis- and trans-nonachlor; dieldrin; endrin; heptachlor epoxide; mirex; oxychlordane; and toxaphene. All analyses were performed according to protocols approved by PACF, which also validated the data. Methods and quality assurance procedures are included in Appendix A.

2.3.4 Sediment Toxicity Tests

Sediment toxicity tests were performed to determine whether any of the habitats contained acutely toxic sediments. Ten-day static solid phase toxicity tests were conducted with the amphipod crustacean, *Hyalella azteca,* on sediment and sediment trap samples, according to American Society for Testing and Materials (ASTM 1992) procedures. Four replicate one quart (0.95 L) mason jars were filled with 180 mL test sediment and 720 mL moderately hard reconstituted water (EPA 1989). The sediment and water were allowed to settle overnight. On the following day, ten 2-3 mm amphipods, obtained from CBFO's laboratory culture, were placed in each test jar. The trap sample from Norwich Creek only contained enough sediment for one test jar; in this case 20 amphipods were used. The amount of sediment obtained from the Nanjemoy Creek traps was insufficient for testing.

Water quality parameters were monitored daily during the ten-day test. Each jar received one mL of a suspension of a 1:1 mixture of TetraMin flake fish food and Purina rabbit chow on days 2, 4, 6, and 8. On the tenth day, the jars were sieved and the number of surviving amphipods was counted. One way analysis of variance (ANOVA) was used to test for differences ($p = 0.05$) between samples after using the arcsine transformation on the percent survival data (Sokal and Rohlf 1981).

2.3.5 Biochemical Analyses

Due to pulse-like exposures of aquatic biota to pesticides and the rapid degradation of organophosphate and carbamate compounds, biochemical methods are often more sensitive than residue analyses at detecting exposure (Hill and Fleming 1982). Fleming *et al.* (1995) reported that exposure of freshwater mussels to these pesticides can be detected by measuring the levels of acetylcholinesterase (AChE) activity. Inhibition of this enzyme is the mode of action for these classes of pesticides. Following the methods of Fleming *et al.* (1995), ten common mussels (*Elliptio complanata*) were collected from each of the four streams on four occasions (mid-May, the end of May, mid-June, and early November). The May-June periods were intended to obtain samples shortly after the period of pesticide application, based on information from the local agricultural extension agent. The November period was intended to determine if there were differences between streams that were not related to pesticide exposure. AChE activity was determined (in units of µmol substrate hydrolyzed per gram tissue per minute) for each site and

each date. A two way ANOVA ($p = 0.05$) was used to evaluate the differences between the streams.

2.4 Physical Habitat Studies

2.4.1 Rapid Bioassessment Protocol - Physical Habitat Assessment

Rapid Bioassessment Protocols (RBP) were developed by the U.S. Environmental Protection Agency (EPA) as cost-effective methods of obtaining physical and biological data on stream systems (Plafkin *et al.* 1989). The physical habitat characterization method used in this study was developed by the Mid-Atlantic Coastal Streams Workgroup (MACS 1993), as a modification to the Plafkin *et al.* protocol. The MACS Physical Habitat protocol utilizes methods developed for low gradient nontidal streams common throughout the middle Atlantic coastal plain region from New Jersey to Georgia. The methods are appropriate for second- to sixth-order wadable, perennial streams. Seven habitat metrics are scored as excellent, good, fair, or poor. Each metric has a total of 20 possible points; a total of 140 points is the optimum for a given site. The metrics are described briefly as follows:

General Characteristics - the overall physical configuration of the stream, with regard to the degree of channelization and frequency of bends.

Instream Measures - habitat conditions within the water column.

Stream Bank Measures - habitat conditions along the stream bank where the water surface meets the land.

Riparian Zone Measurements - habitat conditions next to the stream within a distance of 18 meters.

Each site was evaluated in March 1995. Scoring of each metric was conducted by first selecting one of the four categories (excellent, fair, good, poor) using the criteria provided on the MACS data sheet (Appendix B). Numerical values were selected, based on best professional judgment. Total scores were divided by the total number of possible points (140), resulting in a percent of optimum score.

2.4.2 Particle Size Determination

The particle size-distribution of channel bed and bank materials was determined for each study site, using the Rosgen (1994) modification of the Wolman (1954) pebble count methodology. The linear proportion of each study reach comprising pool, riffle, or run bed features was determined. Ten cross-sections were then apportioned among these channel features. Along each cross section, ten randomly selected pebbles were sized by measuring the intermediate axis diameter. Pebble measurements were tallied in standard size categories (Wolman 1954) to calculate cumulative

percent particle size distributions. The dominant particle size was identified as the median size, or the size that 50% of the measured particles is of the same size or finer (D_{50}).

2.4.3 Land Use Data Analysis

A polygon, representing the watershed upstream of each sampling site, was digitized from United States Geological Service (USGS) 7.5 minute maps. Land use within the polygon was determined using 1990 data provided by the Maryland Office of Planning (Baltimore, MD). The ArcInfo and ArcView programs (Environmental Systems Research Institute, Inc., Redlands, CA) were used to calculate the land uses within the watershed and within a 100 meter band along each side of the streams in the watershed.

2.5 Biological Characterization

2.5.1 Index of Biological Integrity (IBI)

Fish species were collected from each stream in September, 1994. Single pass electrofishing was conducted with a Smith Root Model 12-volt battery operated, backpack instrument (Smith-Root, Inc., Vancouver, WA). The electrofisher voltage was set between 400 and 800 volts pulsed direct current, which was found to provide optimum results. A single electrofishing pass was conducted through a 100-meter stream segment, which contained each of the various instream habitats (riffles, runs, and pools) observed at the site. After sampling, fish were sorted and identified in the field; unknown species were preserved for later identification. Total numbers of fish per species were recorded, along with total length, standard length, and body depth for the largest and smallest individual of each species.

The IBI (Karr 1981) as modified by Hall *et al.* (1994) was used to evaluate fish community structure and populations to estimate the overall ecological health of a particular stream. The modified IBI method uses twelve metrics (listed below) to assess species richness and composition, trophic composition, and the abundance and condition of the fish community. For a discussion of the derivation and rationale for each metric, see Hall et al. (1994).

A. <u>Species Richness and Composition</u>

1. Total number of native fish species
2. Number of darter and sculpin species
3. Number and identity of sunfish species
4. Number of shiner species
5. Number and identity of intolerant species
6. Proportion of tolerant individuals

B. Trophic Composition

7. Proportion of individuals as omnivores
8. Proportion of individuals as insectivores
9. Proportion of individuals as pioneering species

C. Fish Abundance and Condition

10. Number of fish per 100 meter by electrofishing (excluding tolerant forms)
11. Proportion of individuals as simple lithophilic species
12. Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies.

Total IBI scores for each stream were compared to each other. In addition, percent of optimum score was also calculated in the same manner as the Physical Habitat protocol.

2.5.2 Presence of Host Species

In laboratory experiments, Michaelson (1993) identified three fish species as possible hosts for dwarf wedgemussels: tesselated darter (*Etheostoma olmstedi*), the Johnny darter (*E. nigrum*), and the mottled sculpin (*Cottus bairdi*). Because of the critical role played by host fish in the dwarf wedgemussel life cycle, the numbers (and percentages of total catch) of these three species collected during the electroshocking survey were evaluated.

3.0 RESULTS AND DISCUSSION

3.1 Site Descriptions

3.1.1 Nanjemoy Creek

Nanjemoy Creek is part of the Potomac River drainage system. The dwarf wedgemussel site lies within a 113 hectare tract of land in Charles County owned by the Nature Conservancy. An additional 567 hectares is being purchased, which will make the Nanjemoy site the Conservancy's second largest tract of land in Maryland (D. Samson, The Nature Conservancy, personal communication). The original acreage was purchased because it was the site of a large great blue heron (*Ardea herodias*) rookery.

The stream reach is a third order section of Nanjemoy Creek flowing through a densely forested wetland, whose canopy provides extensive shading of the stream. Tree species of note include American beech (*Fagus grandifolia*), swamp white oak (*Quercus bicolor*), and sweet gum (*Liquidambar styraciflua*). The stream does not appear to be channelized, but there is some evidence of human disturbance *e.g.*, trash, empty drums, shotgun shells. The banks of the stream appear to be quite stable, with little evidence of erosion. Instream vegetation was limited. Water was clear but with a distinct mahogany color, probably due to a high tannin content resulting from terrestrial drainage through the forested areas, and instream degradation of leaf litter. Bottom substrate consisted of fine grained sediments along the edges of the stream, with sand and gravel in the channel.

According to 1990 land use data provided by the Maryland Office of Planning, 78.5% of the watershed is forested (Table 1, Figure 2). The major other land uses in the watershed are residential uses (12.0%), and cropland (6.4%). Only 0.9% of the watershed is used for pasture. Of the land within 100 meters of the streams in the watershed, 89.2% is forested and only 1.4% is cropland.

3.1.2 McIntosh Run

McIntosh Run is part of the Potomac River drainage system. The section of McIntosh Run examined in this study is a fifth order stream, located approximately 0.6 km north of MDSR 5 (Leonardtown Road) in St. Mary's County. It is bordered to the west by forested areas, while agricultural land use dominates the eastern portion of the watershed. There is a moderately forested riparian zone on both sides of the study site. The stream appears to have had some channel modifications, but these may have been implemented some time ago. Bank vegetation was dominated by mature- and sapling-aged trees; very little herbaceous vegetation occurred along the stream banks. A dense forest canopy shaded the stream for most of the growing season, allowing only filtered light to reach the stream surface. Instream vegetation was generally sparse. In the downstream portion of the study area, a few scattered patches of pondweed (*Potomogeton* sp.) were observed. Water clarity was quite good, with the bottom visible during most of the site

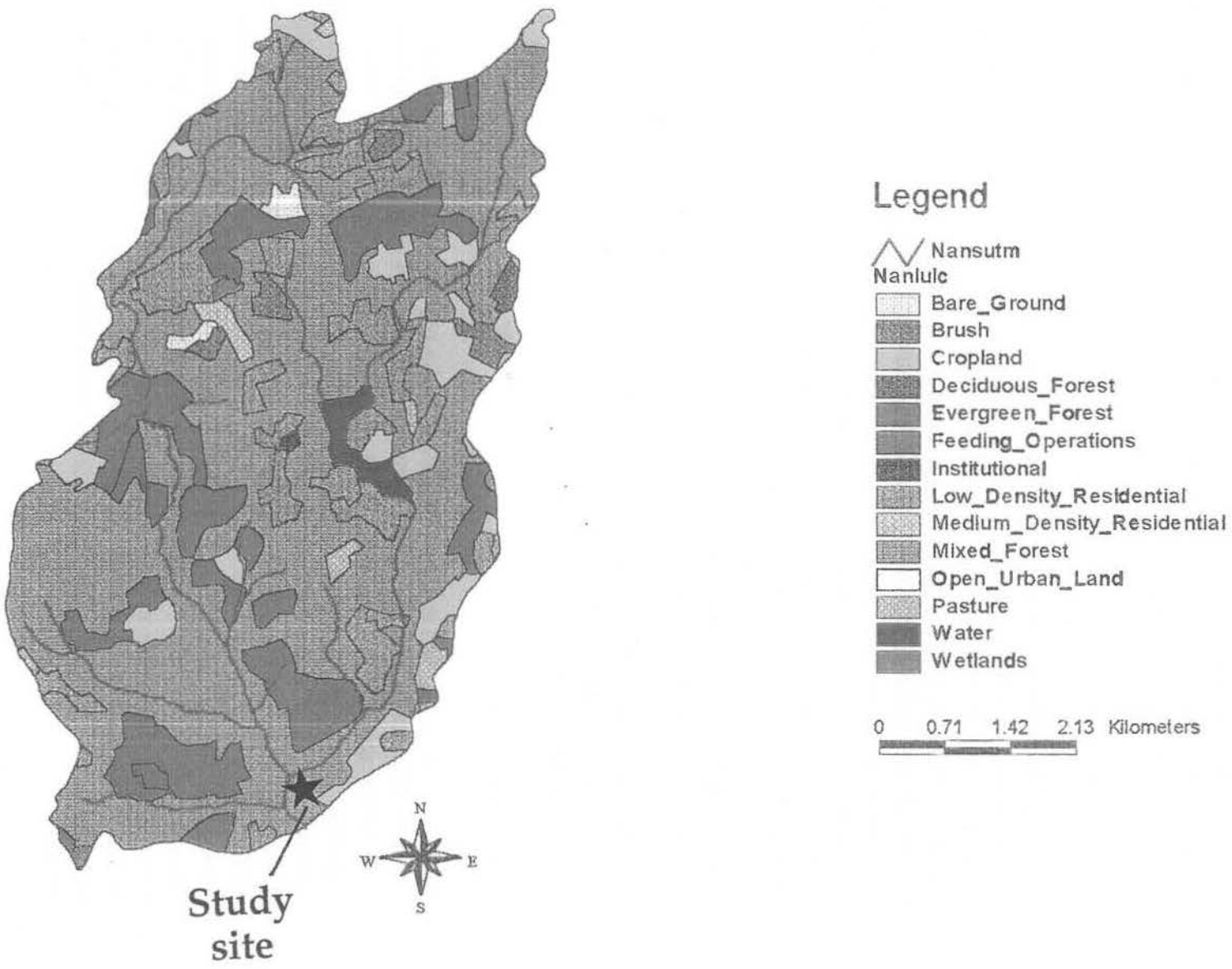
Table 1. Land use data for the mussel site watersheds.

Land use grouping	Land use classification	Nanjemoy Creek		McIntosh Run		Long Marsh Ditch		Norwich Creek	
		Total land area	Area within 100 m of streams	Total land area	Area within 100 m of streams	Total land area	Area within 100 m of streams	Total land area	Area within 100 m of streams
		hectares (%)	hectares (%)	hectares (%)	hectares (%)	hectares (%)	hectares (%)	hectares (%)	hectares (%)
Urban built-up	Low density residential	404 (11.3)	40.4 (5.4)	484 (6.2)	82.9 (3.0)	49.2 (1.0)	13.1 (0.7)	31.7 (1.2)	1.3 (0.2)
	Medium density residential	20.5 (0.6)							
	Commercial			56.7 (0.7)	0.4 (0.02)				
	Institutional	3.5 (0.1)		9.0 (0.1)	0.5 (0.02)				
	Extractive			3.2 (0.0)					
	Open urban land	0.1 (0.0)		30.5 (0.4)					
	Large lot subdivision (agric)					17.7 (0.4)	9.8 (0.5)		
	Large lot subdivision (forest)			41.1 (0.5)	25.4 (0.9)				
Agric.	Cropland	227 (6.4)	10.1 (1.4)	1554 (20.0)	252 (9.0)	2717 (56.7)	1299 (68.6)	1875 (72.5)	410 (65.7)
	Pasture	31.7 (0.9)	0.1 (0.01)	128 (1.6)	46.4 (1.7)	6.3 (0.1)	4.2 (0.2)	41.8 (1.6)	16.8 (2.7)
	Orchards					11.7 (0.2)	2.7 (0.1)		

Table 1. (Cont.)

Land use grouping	Land use classification	Nanjemoy Creek		McIntosh Run		Long Marsh Ditch		Norwich Creek	
		Total land area	Area within 100 m of streams	Total land area	Area within 100 m of streams	Total land area	Area within 100 m of streams	Total land area	Area within 100 m of streams
		Hectares (%)	Hectares (%)	Hectares (%)	Hectares (%)	Hectares (%)	Hectares (%)	Hectares (%)	Hectares (%)
Agric. (cont.)	Feeding Operations	14.9 (0.4)		3.7 (0.1)		6.0 (0.1)	6.0 (0.3)		
	Agricultural facilities					13.2 (0.3)	10.7 (0.6)	16.6 (0.6)	6.8 (1.1)
	Row and garden crops			9.1 (0.1)	0.3 (0.01)			102 (4.0)	26.3 (4.2)
Forest	Deciduous forest	10.2 (0.3)		3207 (41.3)	1518 (54.4)	1814 (37.8)	507 (26.8)	418 (16.2)	135 (21.6)
	Evergreen forest	559 (15.7)	69.3 (9.3)	496 (6.4)	158 (5.7)	13.9 (0.3)	8.5 (0.5)	13.4 (0.5)	2.3 (0.4)
	Mixed forest	2173 (61.0)	594 (79.5)	1415 (18.2)	617 (22.1)	82.1 (1.7)	23.1 (1.2)	84.2 (3.3)	24.2 (3.9)
	Brush	51.7 (1.5)	3.0 (0.4)	293 (3.8)	79.8 (2.9)	63.7 (1.3)	8.9 (0.5)		
Water	Water	38.5 (1.1)	29.7 (4.0)					1.6 (0.1)	1.6 (0.3)
Wetlands	Wetlands	5.1 (0.1)							
Barren land	Bare ground	20.8 (0.6)	0.4 (0.1)	28.9 (0.4)	9.8 (0.4)				
Totals		**3560 (100)**	**746 (100)**	**7766 (100)**	**2790 (100)**	**4794 (100)**	**1893 (100)**	**2584 (100)**	**624 (100)**

Figure 2. Land use map of the Nanjemoy Creek watershed.



visits. Stream bottom substrate varied from fine-grained sand and silt in low-flow areas to coarse sand and gravel in higher-flow areas.

The dominant land use in the watershed is forest (69.7%; Table 1; Figure 3). Cropland accounts for 20.0% of the land use and pasture for 1.6%. Residential uses account for 7.5% of the land use. Analysis of the land use within 100 meters of the streams in the watershed indicated that 85.0% is forested and 9.0% is cropland.

3.1.3 Long Marsh Ditch

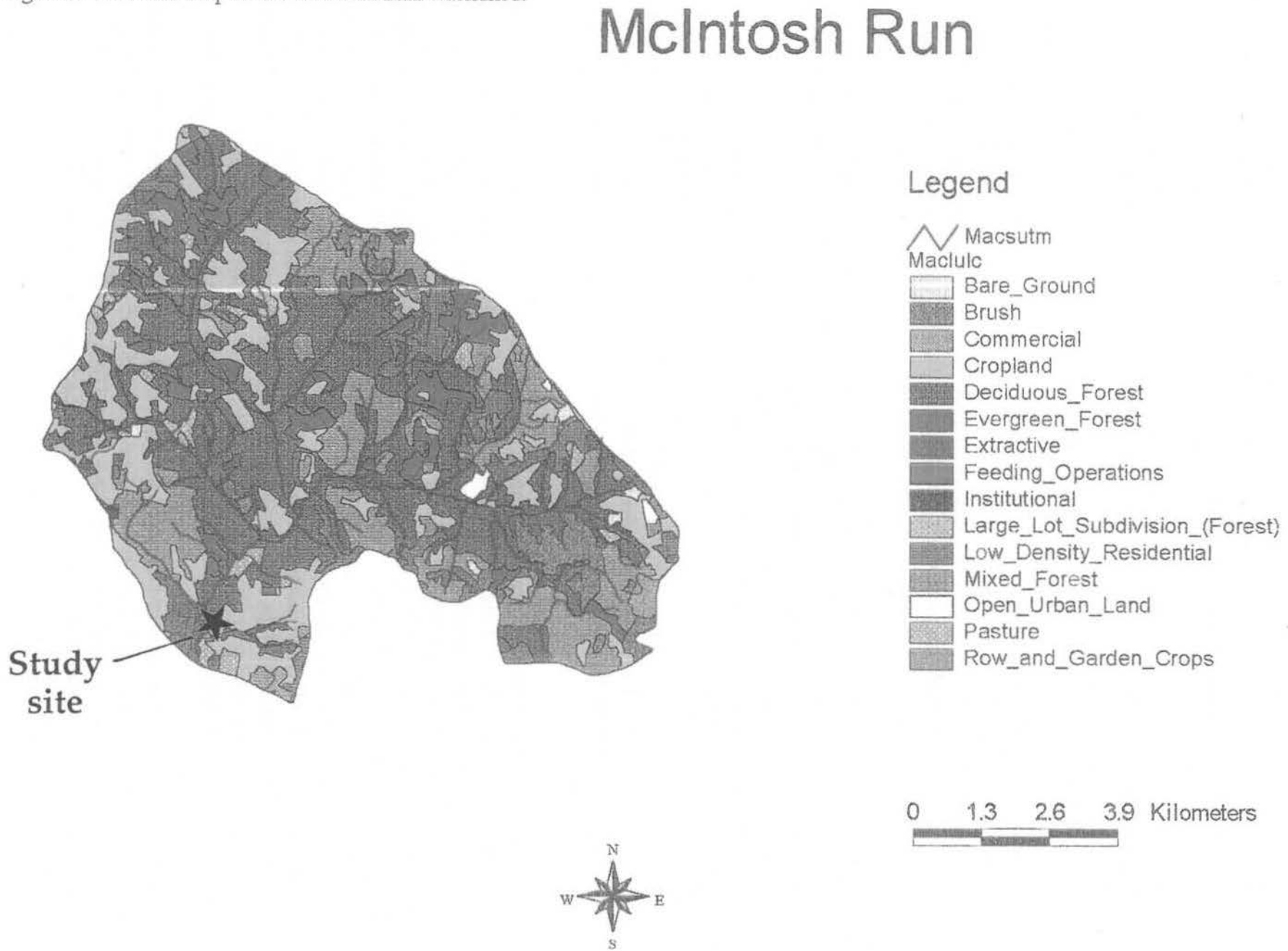
The Long Marsh Ditch system is part of the Tuckahoe Creek-Choptank River drainage. The section examined in this study is a fourth order portion of the stream, located approximately 0.2 km south of MDSR 313, serving as the border between Caroline and Queen Anne's Counties. The stream in this location drains extensive agricultural croplands on both sides. It has been extensively channelized, with steep, heavily vegetated embankments. Dominant bank vegetation was composed of common reed (*Phragmites communis*), hibiscus (*Hibiscus* sp.), and blackberry (*Rubus* sp). A riparian zone is nonexistent with farming occurring up to about three meters from the top of the steeply sloped stream bank. Instream vegetation is dominated by grass species (Poaceae). Both bank vegetation and instream vegetation were dense during the sampling period. Water within the stream was clear at all times with a strong flow during most of the study period. Stream bottom substrate was generally composed of fine- to coarse-grained sand in the midchannel areas, while fine-grained organic silt tended to accumulate in the shallower areas close to shore.

The major land use in the watershed is agricultural crops (56.7%). Forest and brush account for 41.1% of the land (Table 1, Figure 4). Analysis of the land use within 100 meters of the streams in the watershed indicated that 68.6% is cropland and 28.9% is forested.

3.1.4 Norwich Creek

Norwich Creek is part of the Tuckahoe-Choptank drainage system. The study site is a third order stream section, located 0.3 km downstream of the MDSR 404 Bridge, in Talbot County. Although it lies within agricultural lands, this portion of the stream is bordered on both sides by an approximately 50 meter-wide forested riparian zone, which shades most parts of the stream. The eastern banks of the stream are densely covered in the growing season; stinging nettle (*Urtica dioica*) and jewel weed (*Impatiens capensis*) were the dominant herbaceous species. The western bank of the stream is dominated by a mixture of tree species, including American beech (*Fagus grandifolia*) and oak (*Quercus* sp). Instream vegetation was nonexistent at this site. The stream was never observed to have vigorous water flows during the monitoring period. The water tended to be turbid, probably due to the disturbance and resuspension of the fine grained silt-clay sediments that formed the substrate of the stream bottom. However, at the downstream portion of the study segment, a small riffle area occurred, where sediment consisted of coarse-grained sand and gravel.

Figure 3. Land use map of the McIntosh Run watershed.



Land use in the watershed is primarily as cropland (72.5%; Table 1, Figure 5). Row and garden crops account for 4.0% of the land use and pasture accounts for 1.6%. Forest and brush account for 20.0% of the land use. Analysis of the land use within 100 meters of the streams in the watershed indicated that 65.7% is cropland, 25.9% is forested, and 2.7% is pasture.

3.2 Water Quality, Flow, and Particle Size Data

Water quality parameters are provided in Table 2, with the complete data base included as Appendix C. At present, there are inadequate data to determine the effects of levels of nutrients, pH, dissolved oxygen, turbidity, or temperature on dwarf wedgemussel populations. Data are summarized on the relationships between particle size and stream velocity with respect to the distribution of dwarf wedgemussels in surveys conducted along the species' range.

In general, the four streams were well-oxygenated and had similar pH values in the 6-7 range. Except for one reading (3.8 mg/L at Nanjemoy Creek), dissolved oxygen concentrations were above the EPA (1986) 7-day mean warmwater criterion of 4.0 mg/L. Based on hardness and alkalinity data, the streams can be characterized as soft to moderately hard water systems with moderate buffering capacity. The lowest hardness and alkalinity occurred at Nanjemoy Creek which had a hardness of 24 mg/L $CaCO_3$ and an acid neutralizing capacity (alkalinity) of 332 μequivalents/L. Streams having alkalinities of 200 μequivalents/L or less are considered to be sensitive to acidification (Maryland Power Plant Research Program 1988). The MBSS pilot study reported ANC values of 297.4 and 294.1 μequivalents/L for two sites at Nanjemoy Creek within 0.5 km of the study site (Volstad *et al.* 1995). Thus, none of the four streams can be considered to be acid-sensitive.

The two eastern shore streams were rather high in nitrate concentration (> 8 mg/L) compared with the western shore streams (< 1 mg/L), based on single grab samples collected in the fall of 1994 and the summer of 1995. The nitrate values can be placed in context by comparing them with monitoring data obtained by FWS in 1985 and 1986, as part of a year-long program to identify Choptank River subwatersheds that contribute disproportionate amounts of nutrients and sediments to the overall watershed (FWS 1988). At the same Norwich Creek site, FWS reported a mean (± standard deviation) nitrate concentration of 12.89 ± 0.79 mg/L, based on 47 measurements. At the same Long Marsh Ditch site, the mean ± SD nitrate concentration was 5.36 ± 0.43 mg/L, based on 52 measurements. FWS (1988) compared these concentrations with the mean concentration of 4.52 mg/L nitrate measured at the U.S. Geological Survey (USGS) gaging station on the Choptank River at Red Bridges Road near Greensboro, MD. FWS concluded that both of these subwatersheds contributed a disproportionately large share of nitrate to the Choptank watershed.

In the present study, phosphate levels were in the 0-0.4 mg/L range at all four sites, based on single grab samples collected in the fall of 1994 and the summer of 1995. FWS (1988) reported that the mean total phosphorus concentration at the Long Marsh Ditch and Norwich Creek sites in 1985-86 were 0.043 mg/L (n = 52) and 0.098 mg/L (n = 47), respectively. These concentrations correspond

Figure 4. Land use map of the Long Marsh Ditch watershed.

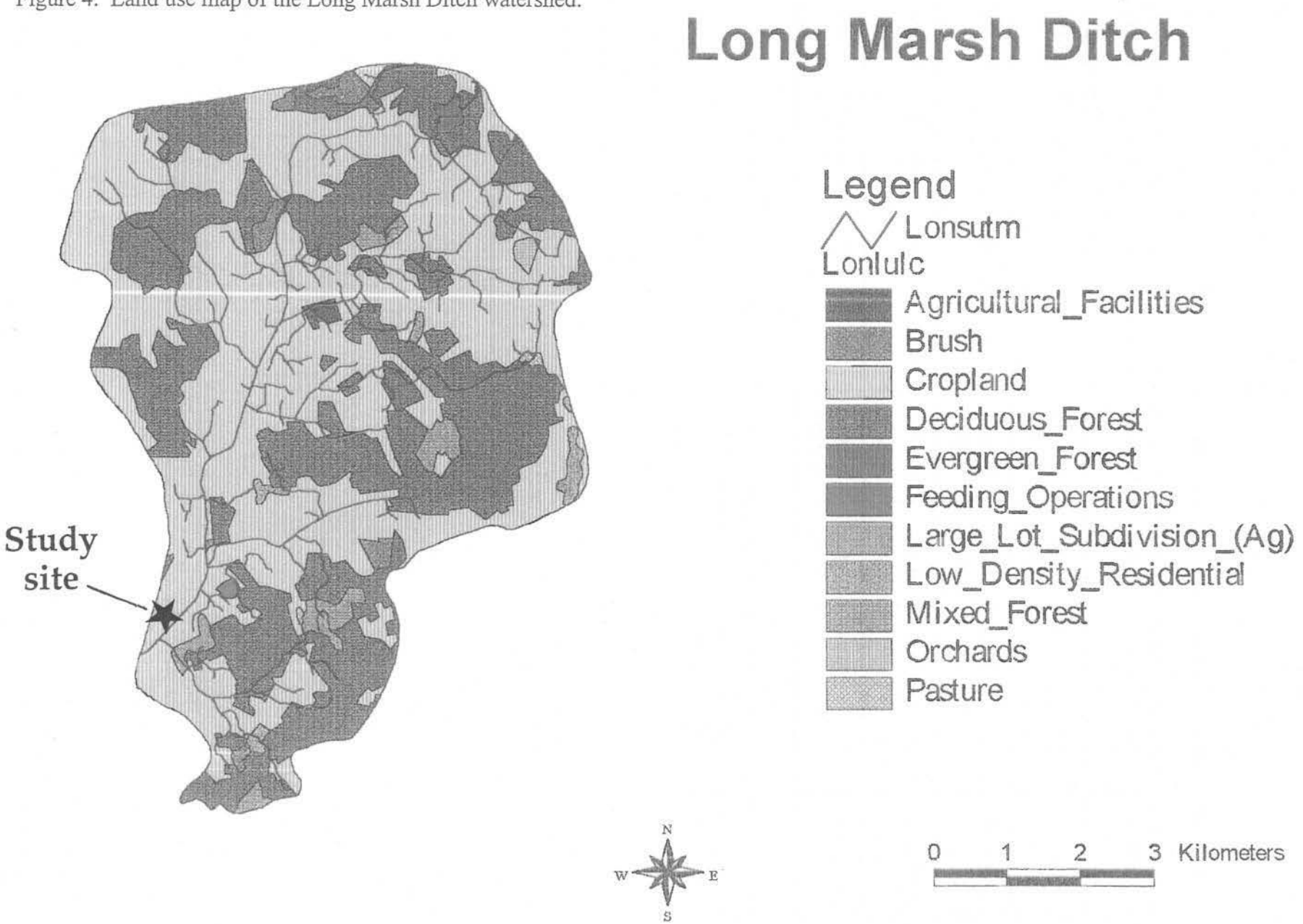
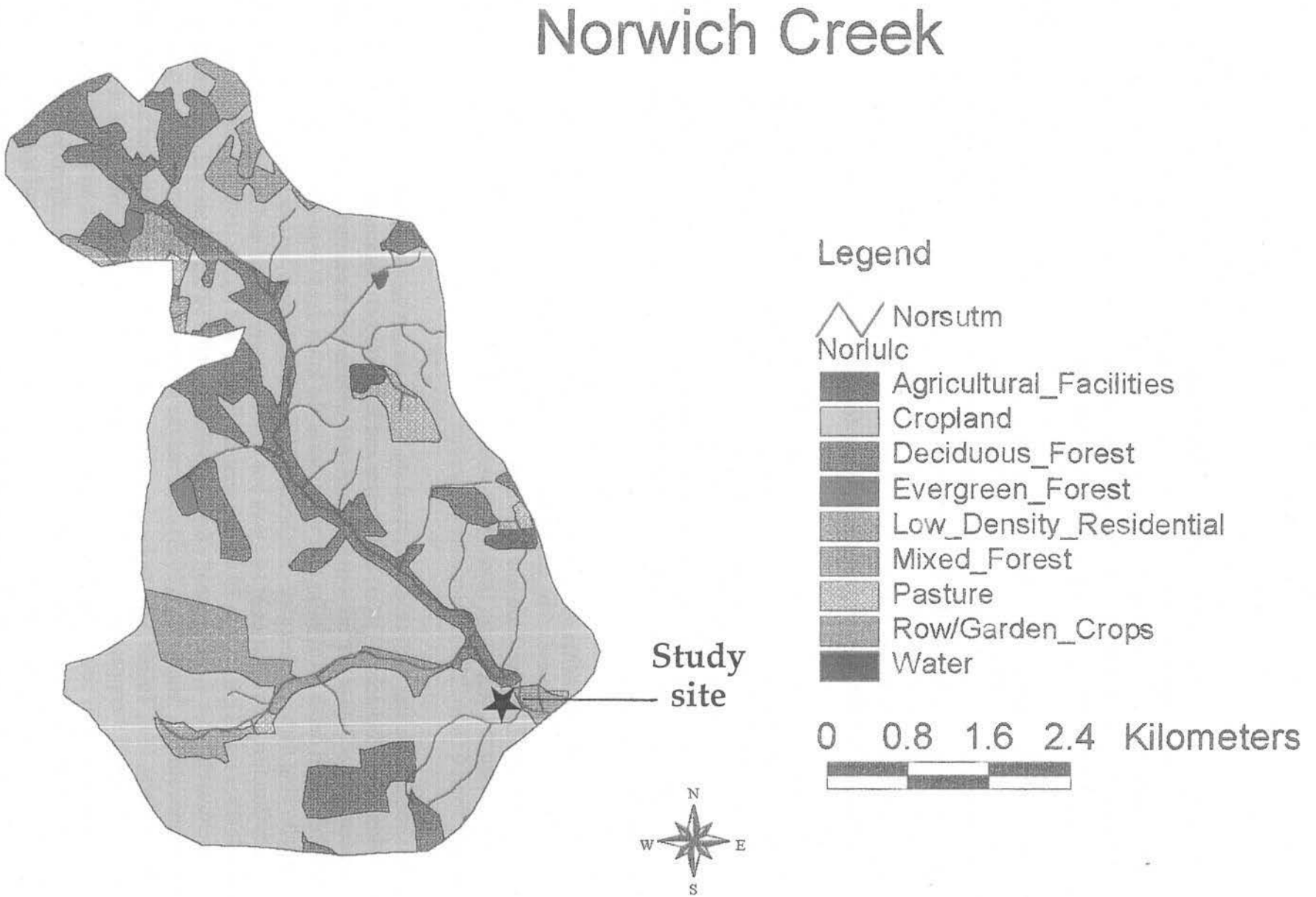


Table 2. Water quality data collected at the four streams.

Stream	Temp.	D.O.	pH	Cond.	Hard.	Alk.	Nitrate	Phos.
Long Marsh	11.7-24.8	5.8-9.9	6.18-6.93	0.057-0.181	64	744	8.0-11.0	0.0-0.4
Norwich	11.9-24.3	5.2-9.3	6.38-7.32	0.205-0.301	92	1051	8.8-19.8	0.0-0.4
McIntosh	11.3-22.1	6.4-10.1	6.21-7.50	0.077-0.127	40	574	0.44-0.88	0.0-0.4
Nanjemoy	9.7-25.3	3.8-9.6	5.84-6.82	0.050-0.092	24	332	0.0-0.4	0.0-0.2

Units: Temperature - °C; D.O., nitrate, phosphate - mg/L; Conductivity - millimhos/cm; hardness - mg/L $CaCO_3$; alkalinity - μequivalents/L

Figure 5. Land use map of the Norwich Creek watershed.



to 0.132 and 0.288 mg/L phosphate (assuming all phosphorus is in phosphate form (APHA 1989)). FWS (1988) reported that the Norwich Creek site mean total phosphorus concentration of 0:098 mg/L exceeded the USGS gaging station mean of 0.055 mg/L total phosphorus. Thus, the Long Marsh Ditch subwatershed was considered to have contributed a disproportionately large amount of the phosphorus loading in the Choptank watershed.

Strayer (1993) suggested that eutrophication may have a deleterious effect on two congeneric species -- *Alasmidonta varicosa* and *A. undulata* -- and on the pearl mussel (*Margaritifera margaritifera*). He observed a negative correlation between calcium content and distribution of these four species and hypothesized that a factor correlated with calcium content (rather than calcium content itself) may be responsible. He hypothesized that this factor may be plant nutrients and suggested that nitrate content may be particularly important. He concluded that an investigation of the effects of eutrophication on *Alasmidonta* species was warranted.

Turbidity was not measured in the present study. Maryland criteria for classified waters are 50 Nephelometric Turbidity Units (NTU) monthly average and 150 NTU maximum (FWS 1988). In 1985 and 1986, FWS (1988) reported mean and maximum turbidities of 37 and 324 NTU for the Norwich Creek site (n = 56) and 20 and 181 for the Long Marsh site (n = 54). FWS identified both subwatersheds as having contributed a disproportionately large share of the sediment loading (as measured by turbidity) to the Choptank watershed. No turbidity data have been identified for the western shore streams.

Stream flow and discharge data (Table 3) indicate that flows ranged from 3.7 to 30.6 cm per second at the four streams. The lowest flows occurred at Norwich Creek, where on six of the seven dates the flows were too low to be measured with the Pygmy meter. The two highest flows were recorded at Long Marsh Ditch (30.6 cm/sec) and at McIntosh (27.8 cm/sec). Discharges ranged from 0.04 to 2.15 cubic meters per second.

The stream velocities in the four Maryland study sites cannot be compared directly with data developed by Michaelson (1993) and Strayer and Ralley (1993) because these researchers measured velocities at 2.5 cm above the substrate whereas we measured current at the traditional 60% of stream depth. Assuming that velocities at the lower depth would be less than at mid-depth, the following data are presented. Michaelson (1993) found dwarf wedgemussels in the Tar River (North Carolina) at velocities of less than one centimeter per second and in Aquia Creek (Virginia) at velocities ranging from 0 to 29 cm per second. Strayer and Ralley (1993) reported that dwarf wedgemussels were most frequently found at velocities of 3-10 cm per second. In laboratory preference studies, Michaelson (1993) observed the movements of mussels in Living Stream (Frigid Units, Inc., Toledo, OH) tanks. In one experiment, mussels were allowed to either remain in a moderate (8.9 cm per second) current or move to a refuge with no flow. In the second experiment, mussels could choose between low (3.7 cm per second) flow and a no flow refuge. regimes. In the moderate flow test, after six days of exposure, significantly more mussels were found in the refuge area than in the flow area. No preference for flow vs. refuge area occurred in the low flow test. Despite the differences in methodology, it appears that the velocities measured

Table 3. Stream velocity and discharge data.

Stream	Date	Mean Velocity (cm per second)	Discharge (cubic m per second)
Long Marsh Ditch	4-19-94	30.6±18.0	2.15
	4-21-94	14.2±17.6	0.63
	5-24-94	14.8±20.8	0.29
	5-27-91	13.1±19.4	0.28
	5-31-94	10.2±16.2	0.21
	6-7-94	16.7±16.5	0.19
	6-14-94	5.6±8.7	0.11
Norwich	4-19-94	6.0±39.5	0.34
Macintosh	4-12-94	21.8±9.7	0.61
	5-20-94	11.7±6.8	0.35
	5-27-94	18.0±7.6	0.57
	6-3-94	3.9±5.5	0.11
	6-17-94	27.8±13.0	1.88
Nanjemoy	4-12-94	10.7±6.2	0.24
	5-20-94	4.2±5.8	0.05
	5-27-94	3.7±5.9	0.04

Flows were too low to measure at Norwich on 4-21-94, 5-24-94, 5-27-94, 5-31-94, 6-7-94, and 6-14-94 and at Nanjemoy on 6-3-94 and 6-10-94.

in the present study would frequently be within the same range as those reported in the Tar River and Aquia Creek.

Particle-size distributions indicate a clear difference between the western shore and eastern shore streams. Nanjemoy Creek and McIntosh Run have median particle sizes (D_{50}) in the gravel range, while Long Marsh Run and Norwich Creek have sand channels. The relative percent of fine channel material (particles < 2 mm diameter, including sands and silt-clay fractions) was less than 50% in Nanjemoy and McIntosh, and greater than 60% in Long Marsh and Norwich. Cumulative frequency graphs of particle size distributions are provided as Appendix D. The D_{50}s were: Long Marsh Ditch -- 0.15 mm, Norwich Creek -- 0.20 mm, Nanjemoy Creek -- 8 mm, and McIntosh Run -- 4 mm. Michaelson (1993) reported D_{50}s ranging from 0.10 to 0.33 mm in microhabitats where dwarf wedgemussels were found in the Tar River. He reported D_{50}s of 0.21 to 0.50 mm in dwarf wedgemussel microhabitats in Aquia Creek. In laboratory preference experiments, dwarf wedgemussels preferred fine-grained sediment (0.063-0.850 mm diameter) to coarse-grained (3.37-8.00 mm diameter) sediment (Michaelson 1993). Strayer and Ralley (1993) reported that dwarf wedgemussels were most frequently found in areas that contained patches of fine sands and silts (0.25 mm and below).

All of the Maryland sites had substantial amounts of fine-grained sized sediments, which seem to be preferred by dwarf wedgemussels. Even Nanjemoy Creek with a D_{50} of 8 mm, had 20% of the sediments with a diameter of 0.3 mm or less.

In situ temperature data indicated that mean stream temperatures were similar at the four streams, ranging from 22.5 ± 2.4 °C at McIntosh to 23.2 ± 2.5 °C at Nanjemoy Creek. Temperatures at Long Marsh Ditch, where there was no shading averaged 22.8 ± 2.9 °C. The slightly higher standard deviation at Long Marsh may be indicative of more rapid heating and cooling which would occur in the unbufferred stream section. On seven occasions, Long Marsh Ditch temperature exceeded 30 °C. This temperature was exceeded only once at Nanjemoy and at no times at any of other streams. A statistical summary of the temperature data is provided as Appendix E.

The effects of temperature on the survival and reproductive success of dwarf wedgemussels or their fish hosts are unknown. The data indicate that although Long Marsh Ditch had a slightly greater variability, the stream was not markedly elevated in temperature.

3.3 Chemistry

No organic contaminants were detected in the water samples collected at the four sites (see Appendix A for detection limits for all samples). Aluminum, iron, nickel, and zinc were the only metals detected. Concentrations of nickel and zinc were lower than EPA ambient water quality criteria (Table 4; see Appendix A for a listing of all metals data). Aluminum concentrations were higher than the 4-day average AWQC at all four sites; however the aluminum levels are likely the result of traces of particulates in the samples (which were not filtered). (AWQC are based on

Table 4. Metal concentrations (mg/L) compared to Ambient Water Quality Criteria.

Analyte	Long Marsh Ditch	Long Marsh Duplicate	Norwich Creek	McIntosh Run	Nanjemoy Creek	Acute AWQC	Chronic AWQC
Aluminum	0.254	0.220	0.299	0.632	0.338	0.75	0.087
Arsenic	ND	ND	ND	ND	ND	-	-
Beryllium	ND	ND	ND	ND	ND	-	-
Cadmium	ND	ND	ND	ND	ND	-	-
Chromium	ND	ND	ND	ND	ND	-	-
Copper	ND	ND	ND	ND	ND	-	-
Iron	3.01	2.89	1.03	1.82	3.28	-	1.0
Lead	ND	ND	ND	ND	ND	-	-
Mercury	ND	ND	ND	ND	ND	-	-
Nickel*	0.007	0.006	0.003	0.003	0.003	0.790	0.088
Selenium	ND	ND	ND	ND	ND	-	-
Zinc*	0.021	0.019	0.010	0.016	0.005	0.065	0.059

* Nickel and zinc ambient water quality criteria are given at 50 mg/L $CaCO_3$ hardness, which is appropriate for the four streams.

filtered samples.) Iron, also higher than the AWQC at all sites, may be the result of particulates in the unfiltered samples. Both of these metals are major components of soils.

No organic contaminants were detected in either the sediment or sediment trap samples collected at the four sites (see Appendix A for detection limits). No metals were detected at concentrations exceeding effects range - median (ER-L) values (Table 5; see Appendix A for a complete listing of all metals data). The ER-L values are the 10th percentile of a data base containing sediment chemical concentrations that were associated with adverse biological effects. An ER-L is interpreted as a concentration below which toxic effects rarely occurred (Long et al. 1995).

3.4 Sediment Toxicity Tests

Mean percent survival ranged from 67.5% for the trap samples from McIntosh Run to 92.5% for the Long Marsh sediment samples (Table 6). The single sediment trap sample from Norwich Creek had 95% survival. The 85% survival from the Bombay Hook reference location exceeds the ASTM (1992) 80% criterion for test acceptability. The differences in mean survival between the various samples were not statistically significant ($p = 0.27$).

3.5 Acetylcholinesterase Assays

AChE activity was calculated as both µmoles per gram tissue per minute and as µmoles per gram protein per minute. Since expressing the values on a protein basis did not decrease the relative standard deviation of the data, activity was expressed on a per gram tissue basis. AChE varied significantly among the four sites (2-way ANOVA, $p<0.000001$; Figure 6; Appendix F). The least significant difference (LSD) post-hoc test indicated that all four sites were significantly different from each other. The highest activity occurred at Nanjemoy Creek which ranged from 5.35 to 7.32 µmoles per gram tissue per minute. AChE activity was lowest at Norwich Creek, ranging from 0.79 to 1.39 µmoles per gram tissue per minute.

For each site, however, there were similar levels of activity in spring and fall. If mussel AChE activity was being inhibited by a pulsed pesticide exposure, there would be a marked decrease in activity during one of the spring samplings. The differences between sites, therefore, appear to be unrelated to pesticide exposure.

National Weather Service precipitation data were obtained for the six week period beginning 14 days before the mid-May mussel collection through the day of the mid-June mussel collection. The Mechanicsville, MD weather station was used as a source of data for the two western shore tributaries. It is located approximately 65 kilometers east of the Nanjemoy site and approximately 15 kilometers northwest of the McIntosh site. The Chestertown, MD station, used for the eastern shore streams, is approximately 25 km northwest of the Long Marsh Ditch site and 35 km north-northwest of the Norwich Creek site. Total precipitation at the Mechanicsville station during this period was 2.36 inches (6.07 cm) or 39% of the 6.03 inch (15.32 cm) normal amount. The only substantial storm was a 1.25 inch (3.18 cm) event which occurred on June 16, 1994. Total

Table 5. Metal concentrations (mg/kg dry weight) in stream sediments compared to ER-L and ER-M levels.

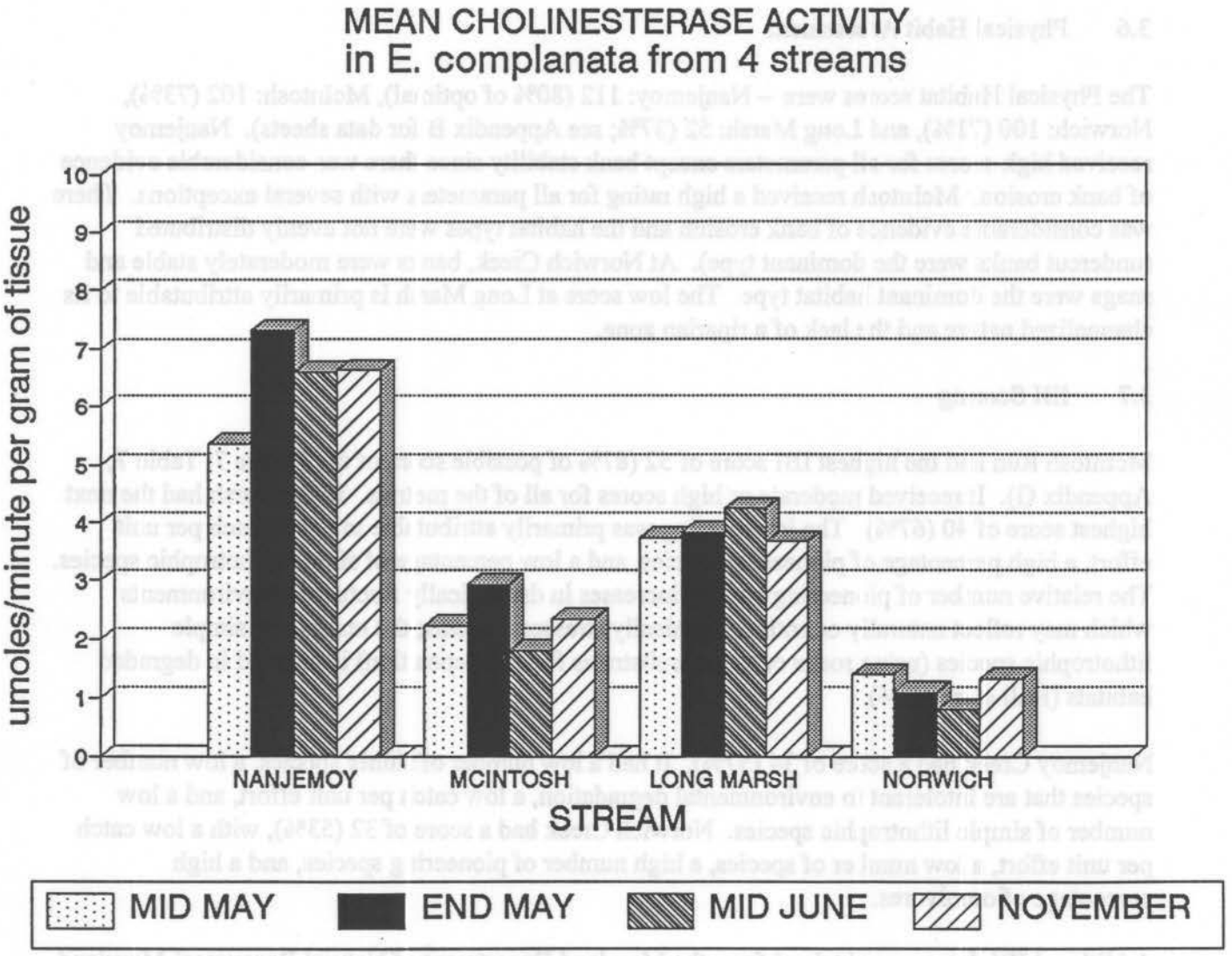
Analyte	Sample Type	Bombay Hook	Long Marsh Ditch	Norwich Creek	Norwich Duplicate	McIntosh Run	Nanjemoy Creek	ER-L	ER-M
Arsenic	Sediment	1.72	1.28	0.253	0.252	0.730	0.810	33	85
	Sed Trap	-	4.99	4.75	-	1.57	-		
Cadmium	Sediment	0.101	0.100	0.101	0.377	0.100	0.100	5	9
	Sed Trap	-	1.21	0.100	-	1.34	-		
Chromium	Sediment	32.0	108	6.56	37.6	52.2	12.1	80	145
	Sed Trap	-	111	14.2	-	22.2	-		
Copper	Sediment	8.51	2.51	2.53	2.52	2.50	2.51	70	390
	Sed Trap	-	7.05	7.28	-	2.51	-		
Lead	Sediment	22.5	8.05	8.94	8.99	8.79	13.7	35	110
	Sed Trap	-	14.2	27.5	-	6.79	-		
Mercury	Sediment	0.102	0.050	0.050	0.050	0.050	0.050	0.15	1.3
	Sed Trap	-	0.050	0.050	-	0.050	-		
Nickel	Sediment	9.99	12.4	2.53	7.09	8.17	5.46	30	50
	Sed Trap	-	29.8	12.6	-	7.14	-		
Zinc	Sediment	41.0	26.3	22.2	27.0	23.7	22.3	120	270
	Sed Trap	-	114	71.1	-	37.3	-		

Table 6. Sediment toxicity test data.

Sample	% Survival (Mean±SD)
Long Marsh Sediment	92.5 ± 9.6
Long Marsh Sediment Trap	87.5 ± 5.0
Norwich Sediment	85.0 ± 19.2
Norwich Sediment Duplicate	90.0 ± 14.1
Norwich Sediment Trap	95.0*
McIntosh Sediment	75.0 ± 12.9
McIntosh Sediment Trap	67.5 ± 9.6
Nanjemoy Sediment	85.0 ± 10.0
Bombay Hook Sediment	85.0 ± 17.3

* All samples had four replicates with 10 amphipods per replicate except Norwich Sediment Trap which had one replicate with 20 amphipods

Figure 6. Mean cholinesterase activity in *E. complanata* from the dwarf wedgemussel study sites.



precipitation at Chestertown during the six week period in May-June 1994 was 3.77 inches (9.58 cm) or 68% of the 5.52 inch (14.02 cm) normal amount. The only substantial storm was a 1.48 inch (3.76 cm) event which occurred on May 26, 1994.

Analysis of the weather data provides further evidence that it is unlikely that the differences in enzyme activity in the mussels resulted from exposure to pesticide runoff. The sampling period appears to have been a drier than normal period with only a single identified storm at each weather station. Thus, pesticide inputs may have been minimal.

3.6 Physical Habit Assessment

The Physical Habitat scores were -- Nanjemoy: 112 (80% of optimal), McIntosh: 102 (73%), Norwich: 100 (71%), and Long Marsh: 52 (37%; see Appendix B for data sheets). Nanjemoy received high scores for all parameters except bank stability since there was considerable evidence of bank erosion. McIntosh received a high rating for all parameters with several exceptions. There was considerable evidence of bank erosion and the habitat types were not evenly distributed (undercut banks were the dominant type). At Norwich Creek, banks were moderately stable and snags were the dominant habitat type. The low score at Long Marsh is primarily attributable to its channelized nature and the lack of a riparian zone.

3.7 IBI Scoring

McIntosh Run had the highest IBI score of 52 (87% of possible score of 60; Figure 7; Table 7; Appendix G). It received moderate or high scores for all of the metrics. Long Marsh had the next highest score of 40 (67%). The lower rating was primarily attributable to a low catch per unit effort, a high percentage of pioneering species, and a low percentage of simple lithotrophic species. The relative number of pioneering species increases in dramatically fluctuating environments which may reflect naturally or anthropogenically stressed systems; the number of simple lithotrophic species (using rocks or gravel substrates for egg deposition) is reduced in degraded habitats (Hall *et al.* 1994).

Nanjemoy Creek had a score of 34 (57%). It had a low number of shiner species, a low number of species that are intolerant to environmental degradation, a low catch per unit effort, and a low number of simple lithotrophic species. Norwich Creek had a score of 32 (53%), with a low catch per unit effort, a low number of species, a high number of pioneering species, and a high percentage of omnivores.

Additional IBI data were obtained from the Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS; P. Kazyak, personal communication). The fish collection method for the MBSS consisted of two 75 meter passes with backpack electroshockers, using block nets to enhance the capture. Thus, data from our sampling and the MBSS cannot be compared without discussing methodological differences.

Figure 7. IBI scores for the four dwarf wedgemussel streams. (Fish were collected in 1993 and 1994 by the Department of Natural Resources, Maryland Biological Stream Survey (MBSS) and the U.S. Fish and Wildlife Service, Chesapeake Bay Field Office (CBFO)).

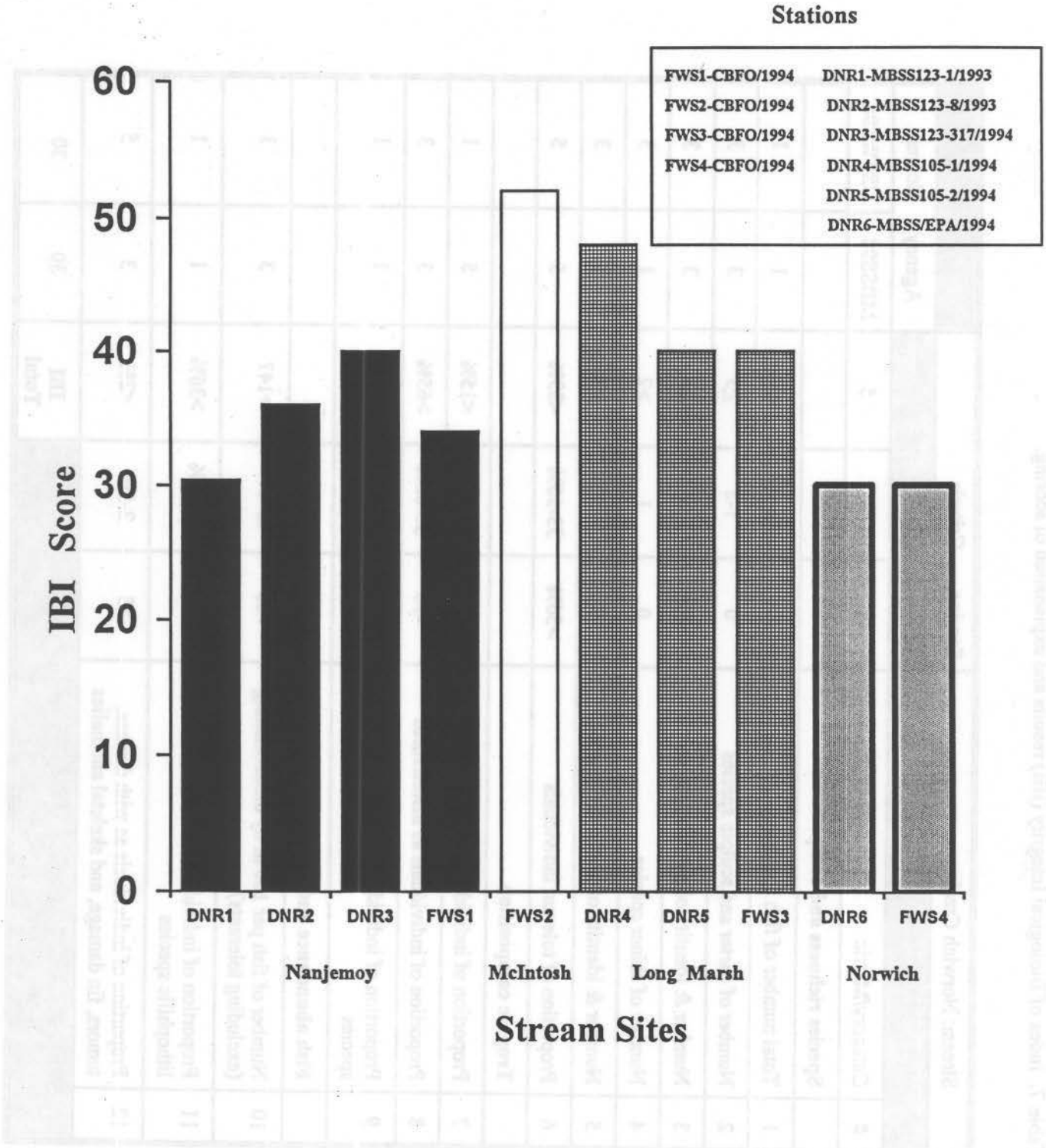


Table 7. Index of Biological Integrity (IBI) results and explanation of scoring.

	Stream: Norwich Creek	Scoring Criteria				
					Agency	Scores
#	Category/Metric	1	3	5	MBSS94	USFWS94
	Species richness and composition					
1	Total number of fish species	≤9	10-12	≥13	1	1
2	Number of darter and sculpin species	0	1-2	≥3	3	3
3	Number & identity of sunfish species	0-1	2	≥3	3	3
4	Number of shiner species	0	1	≥2	1	3
5	Number & identity of intolerant species	0	1	≥2	1	3
6	Proportion of tolerant individuals	>56%	33-56%	<33%	5	5
	Trophic composition					
7	Proportion of individuals as omnivores	>30	15-30%	<15%	5	1
8	Proportion of individuals as insectivores	<30	30-65%	>65%	3	3
9	Proportion of individuals as pioneering species	>30	15-30%	<15%	1	1
	Fish abundance and condition					
10	Number of fish per 100 m by electrofishing (excluding tolerants)	<83	83-147	>147	3	1
11	Proportion of individuals as simple lithophilic species	<18	18-36%	>36%	1	1
12	Proportion of individuals as with disease, tumors, fin damage, and skeletal anomalies	>5	2-5%	<2%	3	5
				IBI Total	30	30

Table 7. (Cont.)

	Stream: Long Marsh Ditch	Scoring Criteria					
					Agency Scores		
#	Category/Metric	1	3	5	MBSS94 105-1	MBSS94 105-2	USFWS94
	Species richness and composition						
1	Total number of fish species	≤9	10-12	≥13	5	5	5
2	Number of darter and sculpin species	0	1-2	≥3	3	3	3
3	Number & identity of sunfish species	0-1	2	≥3	5	5	3
4	Number of shiner species	0	1	≥2	5	3	5
5	Number & identity of intolerant species	0	1	≥2	5	3	5
6	Proportion of tolerant individuals	>56%	33-56%	<33%	3	3	3
	Trophic composition						
7	Proportion of individuals as omnivores	>30	15-30%	<15%	5	5	5
8	Proportion of individuals as insectivores	<30	30-65%	>65%	3	3	3
9	Proportion of individuals as pioneering species	>30	15-30%	<15%	5	5	1
	Fish abundance and condition						
10	Number of fish per 100 m by electrofishing (excluding tolerants)	<83	83-147	>147	5	3	1
11	Proportion of individuals as simple lithophilic species	<18	18-36%	>36%	1	1	1
12	Proportion of individuals as with disease, tumors, fin damage, and skeletal anomalies	>5	2-5%	<2%	3	1	5
				IBI Total	48	40	40

Table 7. (Cont.)

	Stream: McIntosh Run	Scoring Criteria			
					Agency Scores
#	Category/Metric	1	3	5	USFWS94
	Species richness and composition				
1	Total number of fish species	≤9	10-12	≥13	5
2	Number of darter and sculpin species	0	1-2	≥3	3
3	Number & identity of sunfish species	0-1	2	≥3	5
4	Number of shiner species	0	1	≥2	5
5	Number & identity of intolerant species	0	1	≥2	5
6	Proportion of tolerant individuals	>56%	33-56%	<33%	5
	Trophic composition				
7	Proportion of individuals as omnivores	>30	15-30%	<15%	5
8	Proportion of individuals as insectivores	<30	30-65%	>65%	5
9	Proportion of individuals as pioneering species	>30	15-30%	<15%	3
	Fish abundance and condition				
10	Number of fish per 100 m by electrofishing (excluding tolerants)	<83	83-147	>147	3
11	Proportion of individuals as simple lithophilic species	<18	18-36%	>36%	3
12	Proportion of individuals as with disease, tumors, fin damage, and skeletal anomalies	>5	2-5%	<2%	5
				IBI Total	52

Table 7. (Cont.)

	Stream: Nanjemoy Creek	Scoring Criteria						
					Agency Scores			
#	Category/Metric	1	3	5	MBSS93 123-1	MBSS93 123-8	MBSS94 123-317	USFWS94
	Species richness and abundance							
1	Total number of fish species	≤9	10-12	≥13	3	3	5	3
2	Number of darter and sculpin species	0	1-2	≥13	3	3	3	3
3	Number & identity of sunfish species	0-1	2	≥3	3	5	5	5
4	Number of shiner species	0	1	≥2	3	1	1	1
5	Number & identity of intolerant species	0	1	≥2	5	3	3	1
6	Proportion of tolerant individuals	>56%	33-56%	<33%	3	5	5	3
	Trophic composition							
7	Proportion of individuals as omnivores	>30	15-30%	<15%	1	5	5	5
8	Proportion of individuals as insectivores	<30	30-65%	>65%	3	5	5	5
9	Proportion of individuals as pioneering species	>30	15-30%	<15%	3	3	3	3
	Fish abundance and condition							
10	Number of fish per 100 m by electrofishing (excluding tolerants)	<83	83-147	>147	1	1	3	1
11	Proportion of individuals as simple lithophilic species	<18	18-36%	>36%	1	1	1	1
12	Proportion of individuals as with disease, tumors, fin damage, and skeletal anomalies	>5	2-5%	<2%	1	1	1	3
				IBI Total	30	36	40	34

Explanation of IBI scores, integrity classes and attributes (Karr 1981).

Total IBI score[1]	Integrity class of site	Attributes
58-60	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 with a full array of age (size) classes; balanced trophic structure.
48-52	Good	Species richness somewhat below expectation, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; trophic structure shows some signs of stress.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores and green sunfish or other tolerant species); older age classes of top predators may be rare.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.
12-22	Very poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular.
2	No fish	Repeated sampling finds no fish.

[1]Sum of all 12 metrics; sites with values between classes assigned to appropriate integrity class following careful consideration of individual criteria/metrics by informed biologists.
[2]No score can be calculated where no fish were found.

MBSS IBI data were available for the Nanjemoy Creek site, a site approximately two kilometers upstream and to the west on an unnamed tributary (a first order stream) of Norwich Creek near MD Route 404, and a site on Long Marsh Ditch approximately four kilometers upstream of our site (P. Kazyak, Maryland DNR and W. Killen, University of Maryland, Wye Research and Education Center, personal communications).

IBI scores based on the MBSS and the FWS samplings were similar, despite the differences in sampling methods. For example, IBI scores at Nanjemoy Creek were 30, 36, and 40 (based on MBSS data) and 34 based on FWS data (Table 7). MBSS-based scores at Long Marsh Ditch were 48 and 40 vs. 40 for FWS. For Norwich, both the MBSS-based scores and the FWS-based scores were 30. Based on total IBI scores, the integrity classes of the four streams are: McIntosh (FWS: 52) -- good; Long Marsh -- (FWS: 40; MBSS: 48, 40) -- fair; Nanjemoy (FWS: 34; MBSS: 30, 36, 40) -- poor; Norwich (FWS: 30; MBSS: 30) -- poor. A good classification indicates that species richness is somewhat below expectation with the loss of the most intolerant forms. A fair classification indicates that there are signs of deterioration such as the presence of fewer species, a skewed trophic structure, loss of intolerant forms, or loss of top predators. A poor classification indicates that the assemblage is dominated by omnivores, tolerant forms, or generalists (Table 7).

3.8 Host Fish Comparison

The tesselated darter was the only tentatively identified (Michaelson 1993) host fish species found in the electroshocking surveys. It was found at all four sites surveyed by FWS and at all three sites surveyed by the MBSS.

In the FWS surveys, the highest number of tesselated darters was collected from McIntosh Run (22), representing 16.3% of the total catch of 135 individuals. A slightly higher percentage of tesselated darters (16.7%) was collected from Nanjemoy Creek, however this only represented 5 fish from a total catch of 30 individuals, the lowest number of fish shocked from the four sites. The lowest percentage catch occurred at Long Marsh Ditch, where 4 tesselated darters were captured out of a total catch of 88 fish (Appendix G).

The MBSS survey of Norwich Creek reported the highest number (51) and percentage (34.4%) of tesselated darters. At Nanjemoy Creek, the three MBSS surveys identified a total of 34 tesselated darters out of 323 fish (10.5%). The two MBSS surveys of Long Marsh Ditch collected a total of 40 tesselated darters out of 488 fish (8.2%).

The large difference in catch per unit effort and the number of tesselated darters collected between the FWS and MBSS may reflect differences in sampling procedures (see section 3.7). Because of the small number of sampling events at the sites, it is not possible to make inferences on the relative populations of tesselated darters. The survey data provide evidence that at least one host species is present at all four sites. A more thorough investigation of tesselated darter populations would be needed to determine whether they are present in adequate numbers at the proper times of the year to support mussel reproduction.

3.9 Benthic Invertebrate Data

RBP benthic macroinvertebrate data, from kick seine and dip net sampling conducted by the Maryland Department of the Environment (D. Boward, Maryland Department of Natural Resources, personal communication), were obtained for each of the four streams. Following taxonomic identification, MDE calculated the percentage of pollution-sensitive and pollution-tolerant organisms and the feeding guilds. These included the relative abundance of Ephemeroptera, Plecoptera, and Trichoptera (EPT) to Chironomidae and the ratio of abundances of scrapers and filterers. The Hilsenhoff Biotic Index (HBI) was calculated as a measure of habitat quality. The HBI is based on a categorization of taxa according to their tolerance to organic and nutrient pollution. The following scale of HBI scores was used: 0 to 1.76 -- excellent water quality; 1.76 to 2.50 -- good water quality; 2.51 to 3.75 -- fair water quality; 3.76 to 4.00 -- poor water quality; and greater than 4.00 -- serious water quality problems. The HBI was slightly modified for Maryland streams by changing some of the tolerance classifications of the species (W. Butler, MDE, pers. comm.).

HBI scores were similar at all four streams, ranging from 2.79 to 3.41, indicative of fair water quality (Table 8). In contrast, the ratio of pollution-sensitive (EPT) to pollution-tolerant (Chironomidae) ranged from 0.06 to 97. In general, ratios much less than one indicate the dominance of chironomids, which is often indicative of organic enrichment or heavy metal contamination (Plafkin et al. 1989). EPT/Chironomidae ratios were compared among the three streams sampled with the same technique. For dip net sampling, the ratio was greatest at Nanjemoy Creek (97), followed by Long Marsh Ditch (1.45 and 3.71), and lowest at McIntosh Run (0.06). In the three streams sampled with kick seines, the ratio was greatest at Nanjemoy Creek (7.2), with ratios of 0.91 at McIntosh Run, and 0.11-1.96 at Norwich Creek.

The ecological health of the four streams as measured by the HBI contrasts with the IBI measurement. Whereas the IBI indicated a "good" fish community at McIntosh Run, the HBI and EPT/Chironomidae ratios rank this stream as only fair for benthic macroinvertebrates. Based on the HBI, there was little discrimination between the health of the habitats for benthic macroinvertebrates, while the health of the habitats for fish appeared to show a gradient -- McIntosh Run ranked above Long Marsh Ditch with Nanjemoy Creek and Norwich Creek both ranked lower.

Table 8. Rapid Bioassessment Protocol: benthic macroinvertebrate data (provided by D. Boward, Maryland Department of Natural Resources).

	Nanjemoy Creek	Nanjemoy Creek	McIntosh Run	McIntosh Run	Long Marsh Ditch	Long Marsh Ditch	Norwich Creek	Norwich Creek	Norwich Creek
Date/Method	7-23-91 kick seine	8-25-93 dip net	7-22-91 kick seine	8-27-93 dip net	5-11-92 dip net	5-9-94 dip net	5-2-90 kick seine	5-13-92 kick seine	5-10-94 kick seine
EPT divided by Chironomidae[a]	7.2	.97	0.91	0.06	3.71	1.45	1.96	0.34	0.11
Scrapers divided by filterers[b]	0.18	--	5	--	--	--	1.37	--	--
Taxa richness[c]	9	14	12	11	11	19	8	13	12
Hilsenhoff Biotic Index[d]	2.98	2.85	2.79	3.29	2.97	3.24	3.25	3.12	3.41

Station locations: Nanjemoy Creek, equivalent to USFWS study site,; McIntosh Run, approximately 0.6 km downstream of USFWS site; Long Marsh Ditch, approximately 2.1 km upstream of USFWS site; Norwich Creek, approximately 0.3 km downstream of USFWS site
EPT: Ephemeroptera, Plecoptera, Trichoptera
[a] Ratio of EPT/Chironomidae abundances
[b] Ratio of abundances of individuals in scraper and filterer feeding groups
[c] Taxa richness = number of species
[d] Hilsenhoff Biotic Index as modified by W. Butler, Maryland Department of the Environment; metric scores are: <1.76 -- excellent water quality; 1.76-2.50 -- good water quality; 2.51-3.75 -- fair water quality, 3.76-4.00 -- poor water quality, >4.00 -- serious water quality problems.

4.0 CONCLUSIONS

No individual factor has been identified that may account for the relative strength of the McIntosh Run population compared with the eastern shore populations. Few quantitative information is available to rank the Nanjemoy Creek population, although it is believed to be intermediate in strength between McIntosh Run and the two eastern shore streams (Claypool 1995). McIntosh Run, however, had the healthiest ecological status, as indicated by the IBI score which is based on analysis of the fish assemblage. A healthy fish assemblage is likely to favor the survival of the host darters and sculpins, which are generally pollutant-sensitive taxa.

Analysis of the chemical and toxicological data indicate that sediments from the streams were not acutely toxic to amphipods and no chemical contaminants were found in the water column or sediments at concentrations warranting concern. The study was unable to determine whether pulse loads of pesticides may be stressing the systems because of the paucity of rainfall during the spring of 1994. The statistically significant differences in acetylcholinesterase activities between the streams appear to be unrelated to pesticide exposure.

Water quality data indicate that the two eastern shore streams may be experiencing nutrient loading. The observation of high nitrate and low phosphate levels during low flow periods suggests that ground water is the primary source of the loading. Since samples were not collected during high flow periods, no information is available on the loading due to surface runoff. It is not known whether the nutrient loading acts as a stressor to the mussels or their fish hosts.

Sediment loading may be a stressor on the eastern shore streams. No data are available on the amounts of sediment loading taking place in these habitats. Silt/clay substrate at Norwich Creek appears to be cycling into the water column as evidenced by the turbid appearance of the stream. At Long Marsh Ditch, depositional areas of fine-grained sediments were observed in the shallower zones near the banks. In contrast, there was little sediment loading at Nanjemoy Creek, where sediment traps remained empty over the sampling period.

A key factor affecting mussel populations is the availability of host fish. At present, only Michaelson (1993) has attempted to identify hosts for dwarf wedgemussels. It is likely that other host species may be identified through further studies. Of the identified host species, only the tesselated darter is found in the study sites. Quantitative sampling during periods that glochidia are present would be needed to assess the relative abundance of tesselated darters at the sites at the relevant time for mussel reproduction. This sampling carries the risk of interfering with mussel reproduction and should follow a protocol that would avoid such an impact.

5.0 RECOMMENDATIONS

5.1 General Recommendations

The seven recovery tasks described by Moser (1993) in the FWS Region 5 Recovery Plan provide a framework for action. We support these tasks and highlight the following tasks specific for the recovery of the four Maryland sites.

On a regular basis, quantitative surveys of all four mussel sites should be undertaken, using the methods and classifications of Strayer *et al.* (in press). These data are needed to determine if all four sites contain reproducing populations. Data on the range and density of the populations are needed to determine the vulnerability of the populations and to prioritize populations for remediation.

Further research on identifying host species is currently underway (R. Raesley, University of Maryland, Frostburg, MD, pers. comm.). A quantitative sampling of fish hosts should be undertaken in the streams containing reproducing mussel populations. These data could be used to determine if the availability of host fish is a limiting factor (and whether stocking with hosts would enhance the mussel populations). Sampling should be performed with adequate care to avoid injury to the fish or mussel populations.

Three possible stressors -- sediments, nutrients, and pesticides --identified in this study merit further research. Studies are needed to quantify the response of mussels and their hosts to sediment and nutrient levels, so that critical levels can be identified. A repeated sampling of common mussel acetylcholinesterase activity in response to spring runoff is needed.

5.2 Site-Specific Recommendations

McIntosh Run: This stream supports the state's healthiest population of dwarf wedgemussels. To enhance the population's survival, local governments need to enforce erosion control regulations to ensure that development of the watershed does not lead to siltation.

Nanjemoy Creek: Despite the largely forested watershed, the stream receives only moderate rankings in terms of fish assemblages. The most obvious disturbance at the site is the steady introduction of garbage. The observation of empty drums in the streams may indicate that chemical dumping has occurred. Local enforcement of anti-dumping regulations is essential.

Long Marsh Ditch: This population is believed to be very low. FWS and U.S. Department of Agriculture should encourage landowners to establish a forested buffer along the mussel site and in the watershed, in general, to reduce inputs of nutrients and to decrease temperature fluctuations. Monitoring of suspended sediment levels and loading is needed. Common mussel acetylcholinesterase monitoring is needed during a wet spring to determine if there is a response to pesticide use.

Norwich Creek: This population is believed to be very low. Siltation appears to be a problem based on the observation of turbidity. FWS and U.S. Department of Agriculture should encourage landowners to establish forested buffers along the streams in the watershed to reduce nutrient loading. Monitoring of suspended sediment levels and loading is needed. Common mussel acetylcholinesterase monitoring is needed during a wet spring to determine if there is a response to pesticide use.

6.0 REFERENCES

American Public Health Association. 1989. *Standard Methods for the Examination of Water and Wastewater*. 17th edition. APHA, Washington, DC.

American Society for Testing and Materials. 1992. Standard guide for conducting sediment toxicity tests with freshwater invertebrates. E 1383-92. ASTM. Philadelphia, PA.

Claypool, S. 1995. A survey of four populations of the dwarf wedge mussel (Alasmidonta heterodon). Report to Maryland Natural Heritage Program, Department of Natural Resources, Annapolis, MD.

Counts, C.L. III and C.K. Weitzman. 1992. The dwarf wedge mussel (*Alasmidonta heterodon*) in Long Marsh Ditch, Mason Branch, and Norwich Creek, Maryland. Report to Maryland Natural Heritage Program, Maryland Department of Natural Resources, Annapolis, MD.

Environmental Protection Agency. 1986. Quality criteria for water - 1986. EPA 440/5-86-001. Washington, DC.

Environmental Protection Agency. 1989. Short-term methods for estimating the chronic toxicity of effluents and receiving waters to freshwater organisms. EPA/600/4-89/001. Cincinnati, OH.

Fish and Wildlife Service. 1988. Nutrient dynamics in the Choptank River watershed. A comparative analysis of subwatershed exports. U.S. Fish and Wildlife Service, Annapolis, MD.

Fleming, W.J., T.P. Augsburger, and J.A. Alderman. 1995. Freshwater mussel die-off attributed to anticholinesterase poisoning. *Environmental Toxicology and Chemistry* **14**:877-879.

Gannett Fleming, Inc. 1992. Biological investigation of the dwarf wedge mussel in the Mason Branch at MD Route 304 Bridge No. 518. Gannett Fleming, Inc., Harrisburg, PA.

Hall, L.W., Jr., S.A. Fischer, W.D. Killen, Jr., M.C. Scott, M.C. Ziegenfuss, and R.D. Anderson. 1994. Status assessment in acid-sensitive and non-acid-sensitive Maryland coastal plain streams using an integrated biological, chemical, physical, and land-use approach. *Journal of Aquatic Ecosystem Health* **3**:145-167.

Hill, E.F. and W.J. Fleming. 1982. Acetylcholinesterase poisoning of birds: field monitoring and diagnosis of acute poisoning. *Environmental Toxicology and Chemistry* **1**:27-38.

Karr, J.R. 1981. Assessing biological integrity using fish communities. *Fisheries* **6**:21-27.

Kroll, R.B., D.L. Murphy, and M.J. Garreis. 1993. Results of a pilot pesticide monitoring project. Maryland Department of the Environment, Baltimore, MD. Presentation at the Spring 1993

Meeting of the Chesapeake and Potomac Chapter of the Society of Environmental Toxicology and Chemistry, Laurel, MD.

Long, E.R. and L.G. Morgan. 1990. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program. NOAA Technical Memorandum NOS OMA 52. Office of Oceanography and Marine Assessment, Seattle, WA.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management* **19**:81-97.

Maryland Power Plant Research Program. 1988. Acid deposition in Maryland: The status of knowledge in 1987. Maryland Department of Natural Resources, Annapolis, MD.

Michaelson, D.L. 1993. Life history of the endangered dwarf wedgemussel, *Alasmidonta heterodon* (Lea 1829) (Pelecypoda: Unionidae), in the Tar River, North Carolina and Aquia Creek, Virginia. M.S. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, VA.

Mid-Atlantic Coastal Streams Workgroup. 1993. Standard operating procedures and technical basis. Macroinvertebrate collection and habitat assessment for low gradient, nontidal streams. U.S. Environmental Protection Agency, Region III, Wheeling, WV.

Moser, G.A. 1993. Dwarf wedge mussel (*Alasmidonta heterodon*) recovery plan. U.S. Fish and Wildlife Service, Northeast Region. Hadley, MA.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. EPA/440/4-89/001. Washington, DC.

Rosgen, D.L. 1994. A classification of natural rivers. *Catena* **22**:169-199.

Sokal, R.R. and F.J. Rohlf. 1981. *Biometry*. Second Edition. W.H. Freeman and Co., New York.

Strayer, D.L. 1993. Macrohabitats of freshwater mussels (Bivalvia: Unionidae) in streams of the northern Atlantic Slope. *Journal of the North American Benthological Society* **12**:236-246.

Strayer, D.L. and J. Ralley. 1993. Microhabitat use by an assemblage of stream-dwelling unionaceans (Bivalvia), including two rare species of *Alasmidonta*. *Journal of the North American Benthological Society* **12**:236-246.

Strayer, D.L., S.J. Sprague, and S. Claypool. in press. A range-wide assessment of populations of *Alasmidonta heterodon*, an endangered freshwater mussel (Bivalvia:Unionidae). *Journal of the North American Benthological Society* .

Volstad, J.H., M.T. Southerland, J.A. Chaillou, H.T. Wilson, D.H. Heimbuch, P.T. Jacobson, and S.B. Weisberg. 1995. Maryland Biological Stream Survey: the 1993 pilot study. Prepared by Versar, Inc. and Coastal Environmental Services, Inc. for Maryland Department of Natural Resources, Annapolis, MD. CBRM-AD-95-3.

White, C.P. 1982. *Endangered and Threatened Wildlife of the Chesapeake Bay Region: Delaware, Maryland, and Virginia.* Tidewater Publishers, Centreville, MD.

Wolman, M.G. 1954. A method of sampling coarse river bed material. *Transactions of the American Geophysical Union* **35**:951-956.

APPENDIX A

ANALYTICAL METHODS, RESULTS, AND QUALITY CONTROL PROCEDURES

Sample identification information

Sample ID	Description
ALFS01	Bombay Hook sediment sample (control for toxicity test)
LONS01	Long Marsh sediment
LONS02	Long Marsh sediment trap
MACS01	McIntosh sediment
MACS02	McIntosh sediment trap
NANS01	Nanjemoy sediment
NORS01	Norwich sediment
NORS02	Norwich sediment trap
NORS03	Norwich sediment field duplicate
LONW01	Long Marsh water
LONW02	Long Marsh water duplicate
MACW01	McIntosh water
NANW01	Nanjemoy water
NORW01	Norwich water

WEIGHT, % MOISTURE, % LIPID, TOTAL SUSPENDED SOLIDS

Sample Number	Sample Matrix	Sample Weight (g)	Percent Moisture	Percent Lipid	Total Suspended Solids (%)
ALFS01C	Sediments	482	69		
LONS01C	Sediments	278	30.5		
LONS02C	Sediments	222	34		
MACS01C	Sediments	404	20		
MACS02C	Sediments	560	36		
NANS01C	Sediments	356	25.5		
NORS01C	Sediments	297	27		
NORS02C	Sediments	178	60		
NORS03C	Sediments	330	28.5		

ECDMS ANALYTICAL REPORT (6)

27-Mar-95

Catalog: 5020038 Regional Study Id: 5F17 Purchase Order: 84055-4-2119

User Id: R5AFO Submitter: Robert Foley - Annapolis, MD

Lab Name: Mississippi State Chemical Laboratory (MSCL)

Report Includes the Following Sections:

- Weight, % Moisture, % Lipid, Total Suspended Solids
- Soil / Sediment Parameters
- Contaminant Concentrations
- Procedural Blanks
- Duplicates
- Reference Materials
- Spike Recoveries
- Comments (Result Modifers and QA/QC Comments)
- Analytical Methods

SOIL / SEDIMENT PARAMETERS

Sample Number	Percent TVS	Percent TOC	%Sand	%Silt	Particle Size %Clay

- NO DATA EXIST FOR THIS SECTION.

CONTAMINANT CONCENTRATIONS

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
HCB	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
PCB-TOTAL	ALFS01C	Sediments	< .1612903	.1612903	< .05	.05
	LONS01C	Sediments	< .0719424	.0719424	< .05	.05
	LONS02C	Sediments	< .0757576	.0757576	< .05	.05
	MACS01C	Sediments	< .0625	.0625	< .05	.05
	MACS02C	Sediments	< .078125	.078125	< .05	.05
	NANS01C	Sediments	< .0671141	.0671141	< .05	.05
	NORS01C	Sediments	< .0684932	.0684932	< .05	.05
	NORS02C	Sediments	< .125	.125	< .05	.05
	NORS03C	Sediments	< .0699301	.0699301	< .05	.05
	LONW01C	Water			< .0005	.0005
	LONW02C	Water			< .0005	.0005
	MACW01C	Water			< .0005	.0005
	NANW01C	Water			< .0005	.0005
	NORW01C	Water			< .0005	.0005
alpha BHC	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
lpha BHC	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
.lpha chlordane	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
)eta BHC	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
beta BHC	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
cis-nonachlor	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
delta BHC	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
ieldrin	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
ndrin	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
gamma BHC	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
;amma BHC	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
;amma chlordane	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
heptachlor epoxide	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
eptachlor epoxide	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
irex	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
',p'-DDD	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
o,p'-DDE	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
o,p'-DDT	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
oxychlordane	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
ıychlordane	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
,p'-DDD	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
,p'-DDE	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
p,p'-DDE	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
p,p'-DDT	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001
toxaphene	ALFS01C	Sediments	< .1612903	.1612903	< .05	.05
	LONS01C	Sediments	< .0719424	.0719424	< .05	.05
	LONS02C	Sediments	< .0757576	.0757576	< .05	.05
	MACS01C	Sediments	< .0625	.0625	< .05	.05
	MACS02C	Sediments	< .078125	.078125	< .05	.05
	NANS01C	Sediments	< .0671141	.0671141	< .05	.05
	NORS01C	Sediments	< .0684932	.0684932	< .05	.05
	NORS02C	Sediments	< .125	.125	< .05	.05
	NORS03C	Sediments	< .0699301	.0699301	< .05	.05
	LONW01C	Water			< .0005	.0005
	LONW02C	Water			< .0005	.0005
	MACW01C	Water			< .0005	.0005
	NANW01C	Water			< .0005	.0005
	NORW01C	Water			< .0005	.0005

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
ns-nonachlor	ALFS01C	Sediments	< .0322581	.0322581	< .01	.01
	LONS01C	Sediments	< .0143885	.0143885	< .01	.01
	LONS02C	Sediments	< .0151515	.0151515	< .01	.01
	MACS01C	Sediments	< .0125	.0125	< .01	.01
	MACS02C	Sediments	< .015625	.015625	< .01	.01
	NANS01C	Sediments	< .0134228	.0134228	< .01	.01
	NORS01C	Sediments	< .0136986	.0136986	< .01	.01
	NORS02C	Sediments	< .025	.025	< .01	.01
	NORS03C	Sediments	< .013986	.013986	< .01	.01
	LONW01C	Water			< .0001	.0001
	LONW02C	Water			< .0001	.0001
	MACW01C	Water			< .0001	.0001
	NANW01C	Water			< .0001	.0001
	NORW01C	Water			< .0001	.0001

ANALYTICAL METHODS

Method Code	Method Description
004	LABORATORY: Mississippi State Chemical Laboratory

Analysis For Organochlorine Pesticides and PCBs, Aliphatic and Polynuclear Aromatic Hydrocarbons In Soil and Sediment

IV. Twenty gram soil or sediment samples are extracted with acetone, followed by petroleum ether, by allowing to soak one hour in each with intermittent shaking. A final acetone/petroleum ether extraction is done, and the extracts are combined, centrifuged, and transferred to a separatory funnel containing sufficient water to facilitate partitioning of residues into petroleum ether portion. The petroleum ether is washed twice with water and concentrated by Kuderna-Danish to appropriate volume. An aliquot of the concentrated extract for pesticide determination is transfered to a 1.6 gram Florisil mini-column topped with 1.6 grams sodium sulfate. Residues are eluted from the column in two elution fractions. Fraction I consists of 12 milliliters hexane followed by 12 milliliters of 1% methanol in hexane, and Fraction II consists of an additional 24 milliliters of 1% methanol in hexane. If additional cleanup is required to separate PCBs from other organochlorines in Fraction I, further chromatography on a Silicic acid column is performed. Quantification of residues in the two Florisil fractions and three Silicic acid fractions is by packed or megabore column, electron capture gas chromatography.

A second aliquot of the concentrated extract for hydrocarbon determination is transfered to a 20 gram 1% deactivated silica gel column, topped with five grams neutral alumina. Aliphatic and polynuclear aromatic hydrocarbon residues are fractionated by eluting aliphatics from the column with 100 ml petroleum ether (Fraction I) followed by elution of aromatics using first, 100 ml 40% methylene chloride/60%petroleum ether, then 50 ml methylene chloride (Combined eluates, Fraction II). If needed, Fraction I containing aliphatics is subjected to additional cleanup by concentration and transfer to a

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
004	deactivated (2% water) Florisil column. Aliphatic residues are eluted from the Florisil column using 200 ml 6% diethyl ether/94% petroleum ether. The eluate is concentrated to appropriate volume for quantification by capillary column, flame ionization gas chromatography. The silica gel Fraction II containing aromatic hydrocarbons is concentrated, reconstituted in methylene chloride, and subjected to gel permeation chromatographic (GPC) cleanup prior to quantification by capillary, flame ionization gas chromatography and fluorescence HPLC.
005	LABORATORY: Mississippi State Chemical Laboratory Analysis For Organochlorine Pesticides and PCBs, Polynuclear Nuclear Aliphatic and Hydrocarbons In Water V. A 500 milliliter water sample is extracted four times by shaking with 50 milliliter portions of methylene chloride. The four extracts are combined and concentrated by Kuderna- Danish to near dryness, then reconstituted in 5 milliliters petroleum ether. An appropriate aliquot is removed for organochlorine and PCB analysis and transfered to a 20 gram Florisil column. The column is eluted with 200 ml 6% diethyl ether/94% petroleum ether (Fraction I) followed by 200 ml 15% diethyl ether/85% petroleum ether (Fraction II). Fraction II is concentrated to appropriate volume for quantification of residues by packed or capillary column electron capture gas chromotography. Fraction I is concentrated and transferred to a silicic acid chromatographic column for additional cleanup required for separation of PCBs from other organochlorines. Three fractions are eluted from the silicic acid column. Each is concentrated to appropriate volume for quantification of residues by packed or megabore column, electron capture gas chromotography. PCBs are found in Fraction II. The remainder of the petroleum ether from the above methylene chloride extraction is transferred to a 20 gram 1% deactivated silica gel column, topped with 5 grams neutral alumina. Aliphatic and polynuclear aromatic hydrocarbon residues are separated by eluting aliphatics from the column with 100 ml petroleum ether (Fraction

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
005	I) folllowed by elution of aromatics using first, 100 ml 40% methylene chloride/60% petroleum ether then 50 ml methylene chloride (combined eluates, Fraction II). If needed, Fraction I containing aliphatics is subjected to additional cleanup by concentration and transfer to a deactivated (2% water) Florisil column. Aliphatic residues are eluted from the Florisil column using 200 ml 6% diethyl ether/94% petroleum ether. The eluate is concentrated to appropriate volume for quantification by capillary column, flame ionization gas chromotography. The silica gel Fraction II containing aromatic hydrocarbons is concentrated, reconstituted in methylene chloride, and subjected to gel permeation chromatographic (GPC) cleanup prior to quantification by capillary, flame ionization gas chromatography and fluorescence HPLC.

ECDMS ANALYTICAL REPORT (6)

07-Sep-94

Catalog: 5020038 Regional Study Id: 5F17 Purchase Order: PACF-4-0035

User Id: R5AFO Submitter: Robert Foley - Annapolis, MD

Lab Name: Patuxent Analytical Control Facility (PACF)

Report Includes the Following Sections:

- Weight, % Moisture, % Lipid, Total Suspended Solids
- Soil / Sediment Parameters
- Contaminant Concentrations
- Procedural Blanks
- Duplicates
- Reference Materials
- Spike Recoveries
- Comments (Result Modifers and QA/QC Comments)
- Analytical Methods

WEIGHT, % MOISTURE, % LIPID, TOTAL SUSPENDED SOLIDS

Sample Number	Sample Matrix	Sample Weight (g)	Percent Moisture	Percent Lipid	Total Suspended Solids (%)
ALFS01P	Sediments	100	69.8564		
LONS01P	Sediments	100	35.2657		
LONS02P	Sediments	100	55.1219		
MACS01P	Sediments	100	23.9024		
MACS02P	Sediments	100	44.2786		
NANS01P	Sediments	100	30.8823		
NANS02P	Sediments	100	64.3902		
NORS01P	Sediments	100	28.9215		
NORS02P	Sediments	100	66.1764		
NORS03P	Sediments	100	29.1262		

SOIL / SEDIMENT PARAMETERS

Sample Number	Percent TVS	Percent TOC	Particle Size %Sand	%Silt	%Clay

- NO DATA EXIST FOR THIS SECTION.

CONTAMINANT CONCENTRATIONS

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
EPN	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
acephate	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
aldicarb	ALFS01P	Sediments	< 3.317461	3.317461	< 1	1
	LONS01P	Sediments	< 1.544776	1.544776	< 1	1

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
ıldicarb	LONS02P	Sediments	< 2.228261	2.228261	< 1	1
	MACS01P	Sediments	< 1.314103	1.314103	< 1	1
	MACS02P	Sediments	< 1.794643	1.794643	< 1	1
	NANS01P	Sediments	< 1.446809	1.446809	< 1	1
	NANS02P	Sediments	< 2.80822	2.80822	< 1	1
	NORS01P	Sediments	< 1.406897	1.406897	< 1	1
	NORS02P	Sediments	< 2.956522	2.956522	< 1	1
	NORS03P	Sediments	< 1.410959	1.410959	< 1	1
	LONW01P	Water			< .005	.005
	LONW02P	Water			< .005	.005
	MACW01P	Water			< .005	.005
	NANW01P	Water			< .005	.005
	NORW01P	Water			< .005	.005
ızinphos-methyl	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
carbaryl	ALFS01P	Sediments	< 3.317461	3.317461	< 1	1
	LONS01P	Sediments	< 1.544776	1.544776	< 1	1
	LONS02P	Sediments	< 2.228261	2.228261	< 1	1
	MACS01P	Sediments	< 1.314103	1.314103	< 1	1
	MACS02P	Sediments	< 1.794643	1.794643	< 1	1

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
carbaryl	NANS01P	Sediments	< 1.446809	1.446809	< 1	1
	NANS02P	Sediments	< 2.80822	2.80822	< 1	1
	NORS01P	Sediments	< 1.406897	1.406897	< 1	1
	NORS02P	Sediments	< 2.956522	2.956522	< 1	1
	NORS03P	Sediments	< 1.410959	1.410959	< 1	1
	LONW01P	Water			< .005	.005
	LONW02P	Water			< .005	.005
	MACW01P	Water			< .005	.005
	NANW01P	Water			< .005	.005
	NORW01P	Water			< .005	.005
carbofuran	ALFS01P	Sediments	< 3.317461	3.317461	< 1	1
	LONS01P	Sediments	< 1.544776	1.544776	< 1	1
	LONS02P	Sediments	< 2.228261	2.228261	< 1	1
	MACS01P	Sediments	< 1.314103	1.314103	< 1	1
	MACS02P	Sediments	< 1.794643	1.794643	< 1	1
	NANS01P	Sediments	< 1.446809	1.446809	< 1	1
	NANS02P	Sediments	< 2.80822	2.80822	< 1	1
	NORS01P	Sediments	< 1.406897	1.406897	< 1	1
	NORS02P	Sediments	< 2.956522	2.956522	< 1	1
	NORS03P	Sediments	< 1.410959	1.410959	< 1	1
	LONW01P	Water			< .005	.005
	LONW02P	Water			< .005	.005
	MACW01P	Water			< .005	.005
	NANW01P	Water			< .005	.005
	NORW01P	Water			< .005	.005
chlorpyrifos	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
hlorpyrifos	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
oumaphos	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
demeton	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
demeton	LONW02P	Water			< .5	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
diazinon	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
dichlorvos	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
chlorvos	NORW01P	Water			< .0025	.0025
chrotophos	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
imethoate	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
isulfoton	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
disulfoton	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
ethoprop	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
famphur	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
amphur	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
ensulfothion	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
fenthion	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
fenthion	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
malathion	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
methamidophos	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
ıethamidophos	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
ıethiocarb	ALFS01P	Sediments	< 3.317461	3.317461	< 1	1
	LONS01P	Sediments	< 1.544776	1.544776	< 1	1
	LONS02P	Sediments	< 2.228261	2.228261	< 1	1
	MACS01P	Sediments	< 1.314103	1.314103	< 1	1
	MACS02P	Sediments	< 1.794643	1.794643	< 1	1
	NANS01P	Sediments	< 1.446809	1.446809	< 1	1
	NANS02P	Sediments	< 2.80822	2.80822	< 1	1
	NORS01P	Sediments	< 1.406897	1.406897	< 1	1
	NORS02P	Sediments	< 2.956522	2.956522	< 1	1
	NORS03P	Sediments	< 1.410959	1.410959	< 1	1
	LONW01P	Water			< .005	.005
	LONW02P	Water			< .005	.005
	MACW01P	Water			< .005	.005
	NANW01P	Water			< .005	.005
	NORW01P	Water			< .005	.005
ıethomyl	ALFS01P	Sediments	< 3.317461	3.317461	< 1	1
	LONS01P	Sediments	< 1.544776	1.544776	< 1	1
	LONS02P	Sediments	< 2.228261	2.228261	< 1	1
	MACS01P	Sediments	< 1.314103	1.314103	< 1	1
	MACS02P	Sediments	< 1.794643	1.794643	< 1	1
	NANS01P	Sediments	< 1.446809	1.446809	< 1	1
	NANS02P	Sediments	< 2.80822	2.80822	< 1	1
	NORS01P	Sediments	< 1.406897	1.406897	< 1	1
	NORS02P	Sediments	< 2.956522	2.956522	< 1	1
	NORS03P	Sediments	< 1.410959	1.410959	< 1	1
	LONW01P	Water			< .005	.005
	LONW02P	Water			< .005	.005
	MACW01P	Water			< .005	.005

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
methomyl	NANW01P	Water			< .005	.005
	NORW01P	Water			< .005	.005
methyl parathion	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
mevinphos	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
onocrotophos	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
xamyl	ALFS01P	Sediments	< 3.317461	3.317461	< 1	1
	LONS01P	Sediments	< 1.544776	1.544776	< 1	1
	LONS02P	Sediments	< 2.228261	2.228261	< 1	1
	MACS01P	Sediments	< 1.314103	1.314103	< 1	1
	MACS02P	Sediments	< 1.794643	1.794643	< 1	1
	NANS01P	Sediments	< 1.446809	1.446809	< 1	1
	NANS02P	Sediments	< 2.80822	2.80822	< 1	1
	NORS01P	Sediments	< 1.406897	1.406897	< 1	1
	NORS02P	Sediments	< 2.956522	2.956522	< 1	1
	NORS03P	Sediments	< 1.410959	1.410959	< 1	1
	LONW01P	Water			< .005	.005
	LONW02P	Water			< .005	.005
	MACW01P	Water			< .005	.005
	NANW01P	Water			< .005	.005
	NORW01P	Water			< .005	.005
arathion	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
parathion	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
phorate	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
terbufos	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
rbufos	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025
ichlorfon	ALFS01P	Sediments	< 1.65873	1.65873	< .5	.5
	LONS01P	Sediments	< .7723881	.7723881	< .5	.5
	LONS02P	Sediments	< 1.11413	1.11413	< .5	.5
	MACS01P	Sediments	< .6570513	.6570513	< .5	.5
	MACS02P	Sediments	< .8973214	.8973214	< .5	.5
	NANS01P	Sediments	< .7234043	.7234043	< .5	.5
	NANS02P	Sediments	< 1.40411	1.40411	< .5	.5
	NORS01P	Sediments	< .7034483	.7034483	< .5	.5
	NORS02P	Sediments	< 1.478261	1.478261	< .5	.5
	NORS03P	Sediments	< .7054794	.7054794	< .5	.5
	LONW01P	Water			< .0025	.0025
	LONW02P	Water			< .0025	.0025
	MACW01P	Water			< .0025	.0025
	NANW01P	Water			< .0025	.0025
	NORW01P	Water			< .0025	.0025

ANALYTICAL METHODS

Method Code	Method Description
001	LABORATORY: Patuxent Analytical Control Facility

Analytical Methodology for Organophosphate/Carbamate Scanning for Tissue and Sediment

I. This method involves homogenization of the sample followed by mixing with acetone and methylene chloride to separate the pesticides from the tissue. The organic extract is filtered and adjusted to volume prior to gas chromatography using a flame photometric detector for organophosphate determinations and a nitrogen phosphorus detector for carbamate determinations. Magabore capillary columns are used for the GC separations.

Reference

Patuxent Wildlife Research Center, Analytical Chemistry Group SOP Organophosphate/Carbamate Scanning Method (0-25.00). April 28, 1989.

020	LABORATORY: Patuxent Analytical Control Facility

Analytical Methodology for Percent Moisture

XX. Preweigh pan. Add aliquot to tared pan. Allow sample to dry 24 hours in an oven at 200 degrees Fahrenheit. Samples are then placed in a desiccator to cool. Record pan + dry weight.

Percent Moisture = 1 - (pan + dry - pan weight / original aliquot) * 100.

ECDMS ANALYTICAL REPORT (6)

23-Nov-94

Catalog: 5020039 Regional Study Id: 5F17 Purchase Order: 84055-4-2120

User Id: R5AFO Submitter: Robert Foley - Annapolis, MD

Lab Name: Research Triangle Institute (RTI)

Report Includes the Following Sections:

- Weight, % Moisture, % Lipid, Total Suspended Solids
- Soil / Sediment Parameters
- Contaminant Concentrations
- Procedural Blanks
- Duplicates
- Reference Materials
- Spike Recoveries
- Comments (Result Modifers and QA/QC Comments)
- Analytical Methods

WEIGHT, % MOISTURE, % LIPID, TOTAL SUSPENDED SOLIDS

Sample Number	Sample Matrix	Sample Weight (g)	Percent Moisture	Percent Lipid	Total Suspended Solids (%)
ALFS01M	Sediments	567	70.4		
LONS01M	Sediments	351	29.6		
LONS02M	Sediments	274	70.6		
MACS01M	Sediments	546	22		
MACS02M	Sediments	456	43.5		
NANS01M	Sediments	458	27.1		
NORS01M	Sediments	309	28		
NORS02M	Sediments	223	67.6		
NORS03M	Sediments	345	29.9		

SOIL / SEDIMENT PARAMETERS

Sample Number	Percent TVS	Percent TOC	Particle Size %Sand	%Silt	%Clay
ALFS01T		2.08	90.8	4.13	.33
LONS01T		.69	78.4	5.84	.16
LONS02T		1.46	92.4	5.93	.32
MACS01T		.38	84.7	10.5	.1
MACS02T		.69	90.1	5.44	.33
NANS01T		.75	75.3	8.59	.2
NORS01T		1.14	83.6	8.95	.24
NORS02T		1.08	77.5	16.2	.31
NORS03T		.52	83.7	9.01	.22

CONTAMINANT CONCENTRATIONS

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
Al	ALFS01M	Sediments	7064	100.8064	2090.944	29.8386944
	LONS01M	Sediments	2534	100.2004	1783.936	70.5410816
	LONS02M	Sediments	7848	100.4016	2307.312	29.5180704
	MACS01M	Sediments	6759	100	5272.02	78
	MACS02M	Sediments	3174	100.4016	1793.31	56.726904
	NANS01M	Sediments	8327	100.2004	6070.383	73.0460916
	NORS01M	Sediments	5920	101.0101	4262.4	72.727272
	NORS02M	Sediments	14300	99.8004	4633.2	32.3353296
	NORS03M	Sediments	6209	100.8064	4352.509	70.6652864
	LONW01M	Water			.2539	.0201
	LONW02M	Water			.2198	.0201
	MACW01M	Water			.6319	.02
	NANW01M	Water			.3379	.02
	NORW01M	Water			.2988	.02
As	ALFS01M	Sediments	1.72	.504	.50912	.149184
	LONS01M	Sediments	1.28	.501	.90112	.352704
	LONS02M	Sediments	4.99	.502	1.46706	.147588
	MACS01M	Sediments	.73	.5	.5694	.39
	MACS02M	Sediments	1.57	.502	.88705	.28363
	NANS01M	Sediments	.81	.501	.59049	.365229
	NORS01M	Sediments	< .5051	.5051	< .363672	.363672
	NORS02M	Sediments	4.75	.499	1.539	.161676
	NORS03M	Sediments	< .504	.504	< .353304	.353304
	LONW01M	Water			< .0056	.0056
	LONW02M	Water			< .0056	.0056
	MACW01M	Water			< .0056	.0056
	NANW01M	Water			< .0056	.0056
	NORW01M	Water			< .0056	.0056

B	ALFS01M	Sediments	9.755	5.0403	2.88748	1.4919288
	LONS01M	Sediments	< 5.01	5.01	< 3.52704	3.52704
	LONS02M	Sediments	< 5.0201	5.0201	< 1.4759094	1.4759094
	MACS01M	Sediments	< 5	5	< 3.9	3.9

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
B	MACS02M	Sediments	< 5.0201	5.0201	< 2.8363565	2.8363565
	NANS01M	Sediments	< 5.01	5.01	< 3.65229	3.65229
	NORS01M	Sediments	< 5.0505	5.0505	< 3.63636	3.63636
	NORS02M	Sediments	< 4.99	4.99	< 1.61676	1.61676
	NORS03M	Sediments	< 5.0403	5.0403	< 3.5332503	3.5332503
	LONW01M	Water			.0038	.003
	LONW02M	Water			.0034	.003
	MACW01M	Water			.0063	.003
	NANW01M	Water			.003	.003
	NORW01M	Water			.0082	.003
Ba	ALFS01M	Sediments	23.88	3.0242	7.06848	.8951632
	LONS01M	Sediments	24.31	3.006	17.11424	2.116224
	LONS02M	Sediments	100.5	3.012	29.547	.885528
	MACS01M	Sediments	59.32	3	46.2696	2.34
	MACS02M	Sediments	63.47	3.012	35.86055	1.70178
	NANS01M	Sediments	82.33	3.006	60.01857	2.191374
	NORS01M	Sediments	67.66	3.0303	48.7152	2.181816
	NORS02M	Sediments	203.9	2.994	66.0636	.970056
	NORS03M	Sediments	62.24	3.0242	43.63024	2.1199642
	LONW01M	Water			.0747	.001
	LONW02M	Water			.0723	.001
	MACW01M	Water			.0344	.001
	NANW01M	Water			.0392	.001
	NORW01M	Water			.0721	.001
Be	ALFS01M	Sediments	.264	.2016	.078144	.0596736
	LONS01M	Sediments	.6246	.2004	.4397184	.1410816
	LONS02M	Sediments	1.946	.2008	.572124	.0590352
	MACS01M	Sediments	.3207	.2	.250146	.156

MACS02M	Sediments	.3836	.2008	.216734	.113452
NANS01M	Sediments	.5664	.2004	.4129056	.1460916
NORS01M	Sediments	.6925	.202	.4986	.14544
NORS02M	Sediments	1.035	.1996	.33534	.0646704
NORS03M	Sediments	.912	.2016	.639312	.1413216

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
Be	LONW01M	Water			< .0005	.0005
	LONW02M	Water			< .0005	.0005
	MACW01M	Water			< .0005	.0005
	NANW01M	Water			< .0005	.0005
	NORW01M	Water			< .0005	.0005
Cd	ALFS01M	Sediments	< .2016	.2016	< .0596736	.0596736
	LONS01M	Sediments	< .2004	.2004	< .1410816	.1410816
	LONS02M	Sediments	1.209	.2008	.355446	.0590352
	MACS01M	Sediments	< .2	.2	< .156	.156
	MACS02M	Sediments	1.341	.2008	.757665	.113452
	NANS01M	Sediments	< .2004	.2004	< .1460916	.1460916
	NORS01M	Sediments	< .202	.202	< .14544	.14544
	NORS02M	Sediments	< .1996	.1996	< .0646704	.0646704
	NORS03M	Sediments	.3769	.2016	.2642069	.1413216
	LONW01M	Water			< .0005	.0005
	LONW02M	Water			< .0005	.0005
	MACW01M	Water			< .0005	.0005
	NANW01M	Water			< .0005	.0005
	NORW01M	Water			< .0005	.0005
Cr	ALFS01M	Sediments	31.97	5.0403	9.46312	1.4919288
	LONS01M	Sediments	107.9	5.01	75.9616	3.52704
	LONS02M	Sediments	110.7	5.0201	32.5458	1.4759094
	MACS01M	Sediments	52.18	5	40.7004	3.9
	MACS02M	Sediments	22.21	5.0201	12.54865	2.8363565
	NANS01M	Sediments	12.13	5.01	8.84277	3.65229
	NORS01M	Sediments	6.556	5.0505	4.72032	3.63636
	NORS02M	Sediments	14.2	4.99	4.6008	1.61676
	NORS03M	Sediments	37.56	5.0403	26.32956	3.5332503

LONW01M	Water	< .005	.005
LONW02M	Water	< .005	.005
MACW01M	Water	< .005	.005
NANW01M	Water	< .005	.005
NORW01M	Water	< .005	.005

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
Cu	ALFS01M	Sediments	8.511	5.0403	2.519256	1.4919288
	LONS01M	Sediments	< 5.01	5.01	< 3.52704	3.52704
	LONS02M	Sediments	7.05	5.0201	2.0727	1.4759094
	MACS01M	Sediments	< 5	5	< 3.9	3.9
	MACS02M	Sediments	< 5.0201	5.0201	< 2.8363565	2.8363565
	NANS01M	Sediments	< 5.01	5.01	< 3.65229	3.65229
	NORS01M	Sediments	< 5.0505	5.0505	< 3.63636	3.63636
	NORS02M	Sediments	7.281	4.99	2.359044	1.61676
	NORS03M	Sediments	< 5.0403	5.0403	< 3.5332503	3.5332503
	LONW01M	Water			< .005	.005
	LONW02M	Water			< .005	.005
	MACW01M	Water			< .005	.005
	NANW01M	Water			< .005	.005
	NORW01M	Water			< .005	.005
Fe	ALFS01M	Sediments	7250	100.8064	2146	29.8386944
	LONS01M	Sediments	3568	100.2004	2511.872	70.5410816
	LONS02M	Sediments	21580	100.4016	6344.52	29.5180704
	MACS01M	Sediments	5284	100	4121.52	78
	MACS02M	Sediments	5508	100.4016	3112.02	56.726904
	NANS01M	Sediments	5655	100.2004	4122.495	73.0460916
	NORS01M	Sediments	7903	101.0101	5690.16	72.727272
	NORS02M	Sediments	23950	99.8004	7759.8	32.3353296
	NORS03M	Sediments	7843	100.8064	5497.943	70.6652864
	LONW01M	Water			3.005	.0201
	LONW02M	Water			2.886	.0201
	MACW01M	Water			1.82	.02
	NANW01M	Water			3.277	.02
	NORW01M	Water			1.029	.02

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	ALFS01M	Sediments	.1019	.1008	.0301624	.0298368	
	LONS01M	Sediments	< .1002	.1002	< .0705408	.0705408	
	LONS02M	Sediments	< .1004	.1004	< .0295176	.0295176	
	MACS01M	Sediments	< .1	.1	< .078	.078	

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
Hg	MACS02M	Sediments	< .1004	.1004	< .056726	.056726
	NANS01M	Sediments	< .1002	.1002	< .0730458	.0730458
	NORS01M	Sediments	< .101	.101	< .07272	.07272
	NORS02M	Sediments	< .0998	.0998	< .0323352	.0323352
	NORS03M	Sediments	< .1008	.1008	< .0706608	.0706608
	LONW01M	Water			< .0011	.0011
	LONW02M	Water			< .0011	.0011
	MACW01M	Water			< .0011	.0011
	NANW01M	Water			< .0011	.0011
	NORW01M	Water			< .0011	.0011
Mg	ALFS01M	Sediments	1982	100.8064	586.672	29.8386944
	LONS01M	Sediments	140.1	100.2004	98.6304	70.5410816
	LONS02M	Sediments	444.1	100.4016	130.5654	29.5180704
	MACS01M	Sediments	459.2	100	358.176	78
	MACS02M	Sediments	344.3	100.4016	194.5295	56.726904
	NANS01M	Sediments	562.9	100.2004	410.3541	73.0460916
	NORS01M	Sediments	441.3	101.0101	317.736	72.727272
	NORS02M	Sediments	1587	99.8004	514.188	32.3353296
	NORS03M	Sediments	462.2	100.8064	324.0022	70.6652864
	LONW01M	Water			3.517	.0201
	LONW02M	Water			3.399	.0201
	MACW01M	Water			2.147	.02
	NANW01M	Water			1.83	.02
	NORW01M	Water			7.35	.02
Mn	ALFS01M	Sediments	95.4	4.0323	28.2384	1.1935608
	LONS01M	Sediments	33.77	4.008	23.77408	2.821632
	LONS02M	Sediments	333.8	4.0161	98.1372	1.1807334
	MACS01M	Sediments	102	4	79.56	3.12

MACS02M	Sediments	1073	4.0161	606.245	2.2690965
NANS01M	Sediments	184.8	4.008	134.7192	2.921832
NORS01M	Sediments	136.9	4.0404	98.568	2.909088
NORS02M	Sediments	3137	3.992	1016.388	1.293408
NORS03M	Sediments	101.8	4.0323	71.3618	2.8266423

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
Mn	LONW01M	Water			.1522	.002
	LONW02M	Water			.1483	.002
	MACW01M	Water			.0978	.002
	NANW01M	Water			.6866	.002
	NORW01M	Water			.1815	.002
Mo	ALFS01M	Sediments	< 5.0403	5.0403	< 1.4919288	1.4919288
	LONS01M	Sediments	< 5.01	5.01	< 3.52704	3.52704
	LONS02M	Sediments	< 5.0201	5.0201	< 1.4759094	1.4759094
	MACS01M	Sediments	< 5	5	< 3.9	3.9
	MACS02M	Sediments	< 5.0201	5.0201	< 2.8363565	2.8363565
	NANS01M	Sediments	< 5.01	5.01	< 3.65229	3.65229
	NORS01M	Sediments	< 5.0505	5.0505	< 3.63636	3.63636
	NORS02M	Sediments	< 4.99	4.99	< 1.61676	1.61676
	NORS03M	Sediments	< 5.0403	5.0403	< 3.5332503	3.5332503
	LONW01M	Water			< .004	.004
	LONW02M	Water			< .004	.004
	MACW01M	Water			< .004	.004
	NANW01M	Water			< .004	.004
	NORW01M	Water			< .004	.004
Ni	ALFS01M	Sediments	9.987	5.0403	2.956152	1.4919288
	LONS01M	Sediments	12.42	5.01	8.74368	3.52704
	LONS02M	Sediments	29.81	5.0201	8.76414	1.4759094
	MACS01M	Sediments	8.165	5	6.3687	3.9
	MACS02M	Sediments	7.138	5.0201	4.03297	2.8363565
	NANS01M	Sediments	5.463	5.01	3.982527	3.65229
	NORS01M	Sediments	< 5.0505	5.0505	< 3.63636	3.63636
	NORS02M	Sediments	12.61	4.99	4.08564	1.61676
	NORS03M	Sediments	7.092	5.0403	4.971492	3.5332503

LONW01M	Water	.0072	.005
LONW02M	Water	.0062	.005
MACW01M	Water	< .005	.005
NANW01M	Water	< .005	.005
NORW01M	Water	< .005	.005

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
Pb	ALFS01M	Sediments	22.51	5.0403	6.66296	1.4919288
	LONS01M	Sediments	8.052	5.01	5.668608	3.52704
	LONS02M	Sediments	14.23	5.0201	4.18362	1.4759094
	MACS01M	Sediments	8.788	5	6.85464	3.9
	MACS02M	Sediments	6.789	5.0201	3.835785	2.8363565
	NANS01M	Sediments	13.68	5.01	9.97272	3.65229
	NORS01M	Sediments	8.944	5.0505	6.43968	3.63636
	NORS02M	Sediments	27.51	4.99	8.91324	1.61676
	NORS03M	Sediments	8.991	5.0403	6.302691	3.5332503
	LONW01M	Water			< .005	.005
	LONW02M	Water			< .005	.005
	MACW01M	Water			< .005	.005
	NANW01M	Water			< .005	.005
	NORW01M	Water			< .005	.005
Se	ALFS01M	Sediments	< .504	.504	< .149184	.149184
	LONS01M	Sediments	< .501	.501	< .352704	.352704
	LONS02M	Sediments	.87	.502	.25578	.147588
	MACS01M	Sediments	< .5	.5	< .39	.39
	MACS02M	Sediments	< .502	.502	< .28363	.28363
	NANS01M	Sediments	< .501	.501	< .365229	.365229
	NORS01M	Sediments	< .5051	.5051	< .363672	.363672
	NORS02M	Sediments	.93	.499	.30132	.161676
	NORS03M	Sediments	< .504	.504	< .353304	.353304
	LONW01M	Water			< .0056	.0056
	LONW02M	Water			< .0056	.0056
	MACW01M	Water			< .0056	.0056
	NANW01M	Water			< .0056	.0056
	NORW01M	Water			< .0056	.0056

;r	ALFS01M	Sediments	24.49	2.0161	7.24904	.5967656
	LONS01M	Sediments	4.034	2.004	2.839936	1.410816
	LONS02M	Sediments	20.8	2.008	6.1152	.590352
	MACS01M	Sediments	4.359	2	3.40002	1.56

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
Sr	MACS02M	Sediments	12.18	2.008	6.8817	1.13452
	NANS01M	Sediments	7.95	2.004	5.79555	1.460916
	NORS01M	Sediments	14.63	2.0202	10.5336	1.454544
	NORS02M	Sediments	30.4	1.996	9.8496	.646704
	NORS03M	Sediments	15.66	2.0161	10.97766	1.4132861
	LONW01M	Water			.1522	.002
	LONW02M	Water			.147	.002
	MACW01M	Water			.045	.002
	NANW01M	Water			.042	.002
	NORW01M	Water			.1936	.002
V	ALFS01M	Sediments	11.28	5.0403	3.33888	1.4919288
	LONS01M	Sediments	< 5.01	5.01	< 3.52704	3.52704
	LONS02M	Sediments	11.74	5.0201	3.45156	1.4759094
	MACS01M	Sediments	9.304	5	7.25712	3.9
	MACS02M	Sediments	6.309	5.0201	3.564585	2.8363565
	NANS01M	Sediments	15.28	5.01	11.13912	3.65229
	NORS01M	Sediments	7.187	5.0505	5.17464	3.63636
	NORS02M	Sediments	24	4.99	7.776	1.61676
	NORS03M	Sediments	7.319	5.0403	5.130619	3.5332503
	LONW01M	Water			< .004	.004
	LONW02M	Water			< .004	.004
	MACW01M	Water			< .004	.004
	NANW01M	Water			< .004	.004
	NORW01M	Water			< .004	.004
Zn	ALFS01M	Sediments	40.95	5.0403	12.1212	1.4919288
	LONS01M	Sediments	26.32	5.01	18.52928	3.52704
	LONS02M	Sediments	113.9	5.0201	33.4866	1.4759094
	MACS01M	Sediments	23.74	5	18.5172	3.9

MACS02M	Sediments	37.33	5.0201	21.09145	2.8363565
NANS01M	Sediments	22.25	5.01	16.22025	3.65229
NORS01M	Sediments	22.23	5.0505	16.0056	3.63636
NORS02M	Sediments	71.08	4.99	23.02992	1.61676
NORS03M	Sediments	26.99	5.0403	18.91999	3.5332503

CONTAMINANT CONCENTRATIONS (Cont.)

Analyte	Sample Number	Sample Matrix	Result (ppm Dry Wt.)	Detection Limit (ppm Dry Wt.)	Result (ppm Wet Wt.)	Detection Limit (ppm Wet Wt.)
Zn	LONW01M	Water			.0206	.01
	LONW02M	Water			.0185	.01
	MACW01M	Water			.0156	.01
	NANW01M	Water			< .01	.01
	NORW01M	Water			.0101	.01

ANALYTICAL METHODS

Method Code	Method Description
001	LABORATORY: Research Triangle Institute I. Homogenization. Tissue samples are prehomogenized using a food processor. A portion of the tissue sample (or sediment) is then freeze dried for determination of moisture content and ground to 100 mesh with a mill.
003	LABORATORY: Research Triangle Institute III. Digest for ICP Measurement. Using a CEM microwave oven, 0.25 to 0.5 g. of freeze dried sample is heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and fifteen minutes at 450 watts. The residue is then diluted to 50 ml with D.I. water.
004	LABORATORY: Research Triangle Institute IV. Digestion for Graphite Furnace and Cold Vapor Atomic Absorption (GFAA) Measurement. Using a CEM microwave oven, 0.25 to 0.5 g of freeze dried sample is heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and fifteen minutes at 450 watts. The residue is then diluted to 50 ml with laboratory pure water.
006	LABORATORY: Research Triangle Institute VI. ICP. ICP measurements are made using a Leeman Labs Plasma Spec I sequential or ES2000 simultaneous spectrometer.

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
007	LABORATORY: Research Triangle Institute
	VII. Graphite Furnace Atomic Absorption (GFAA). GFAA measurements are made using a Perkin-Elmer Zeeman 3030 or 4100ZL atomic absorption spectrometer.
008	LABORATORY: Research Triangle Institute
	VIII. Cold Vapor Atomic Absorption (CVAA). Hg measurements are conducted using SnC14 as the reducing agent. A Leeman PS200 Hg Analyzer is employed.
011	LABORATORY: Research Triangle Institute
	XI. Preconcentration Digestion for Inductively Coupled Plasma Emission (ICP) Measurement. Using a CEM microwave oven, 50 ml of water sample are heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for three minutes at 120 watts, three minutes at 300 watts, and 35 minutes at 450 watts. The vessel contents are then allowed to cool and the cap is removed and rinsed carefully with 3 ml of HNO3 adding the rinse to the vessel contents. The uncapped vessel is then returned to the microwave oven and heated until the vessel contents are less than 1 ml in volume. The contents are carefully rinsed with laboratory pure water into a 5 ml glass volumetric vessel and made to volume with additional laboratory pure water. The sample is now ready for ICP measurement.
012	LABORATORY: Research Triangle Institute

XII. **Digestion for Graphite Furnace Atomic Absorption (GFAA) Measurement. Using a CEM microwave oven, 50 ml of water sample are heated in a capped 120 ml Teflon vessel in the presence of 5 ml of Baker Instra-Analyzed nitric acid for fifteen minutes at 300 watts. The sample is then diluted to 50 ml with laboratory pure water.**

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
020	LABORATORY: Research Triangle Institute
	XX. Total organic carbon (TOC) analyses are performed according to EPA Method 9060 "Text Methods for Evaluating Solid Waste: Physical/Chemical Methods; SW-846 3rd Ed. 1986. Measurement of the TOC as CO2 is performed by IR using a Dohrman DC-80 TOC analyzer. Analyses will be performed either in-house or though purchase order agreement with Chemical and Environmental Technology, Inc. (Gary, NC).
030	LABORATORY: Research Triangle Institute
	Methods for Determination of Grain Size
	XXX. Grain size analysis will be performed to determine the relative proportion of the different grain sizes of unconsolidated soils or sediments. The general classification of grain sizes includes gravel (grain size > 2mm), sand (grain size between 0.0625 mm and 22 mm), silt (grain size between 0.0039 mm and 0.0625 mm) and clay (grain size fractions will be dependent on the nature of the sample. If the sample contains very little silt and clay, it will be dried, weighed, and sieved through a stacked column of sieves of the desired mesh sizes with the bottom sieve having a mesh size of 0.0625 mm (U.S. Standard Sieve Mesh No. 230). The material caught in the collection pan will represent the size fraction <0.0625 mm or the silt-clay fraction. If the sample contains a significant silt-clay fraction, it will be moistened with a dispersing agent and wet-sieved. Again, the material caught in the collection pan represents the silt-clay fraction. Pipette analysis will

be used to determine the relative proportion of silt to clay; the silt-clay fraction is dispersed in 1000 mL of distilled water containing dispersant. After the water and sample are vigorously agitated, measured volumes will be pipetted from the container at specified time intervals at a measured withdrawal depth. Since settling velocity is proportional to the square of the particle diameter, the particle size

ANALYTICAL METHODS (Cont.)

Method Code	Method Description
030	diameter can be computed given the parameters of time and depth. The pipetted samples are then dried and weighed to determine the weight percent fraction of the total sample.

QUALITY ASSURANCE

The Patuxent Analytical Control Facility is responsible for assuring the quality of the chemical analyses it provides through the in-house laboratory and through the contract laboratories. We hope this section of the Reference Manual will answer most of the questions that have been raised regarding the operation and meaning of the Quality Assurance Program. If any questions remain, or if any develop in the future, every user of the PACF should feel free to contact and ask the Project Officer.

PACF can assure the quality of the chemical analyses, only from the point in time after the sample arrives at the laboratory. It can not be overstated that assuring a meaningful analysis must begin with the sample collection. It is the responsibility of the sample submitter to properly collect, contain, label, preserve, document, and ship his/her samples to the laboratory designated to perform the analysis. Unless a gross problem is evident, the laboratory and PACF assumes the samples were properly handled and labeled prior to receipt.

Quality assurance is achieved through a system of quality control and quality assessment procedures. John K. Taylor[1] defines quality control as:

> "A system of inspections, testing, and remedial actions applied to a process or operation so that, by inspecting a small portion (a sample) of the product currently produced, an estimate can be made of its quality and whether or not, or what if any, changes need to be made to achieve or maintain a predetermined or required level of quality."

He defines quality assessment as:

> A system of activities whose purpose is to provide assurance that the overall quality control job is in fact being done effectively. The system involves a continuing evaluation of the adequacy and effectiveness of the overall quality control program with a view to having corrective measures initiated where necessary. For a specific product or service, this involves verifications, audits, and the evaluation of the quality factors that affect the specification, production, inspection and use of the product or service.

Quality assurance is the end product of applying the quality control and quality assessment techniques. The differences between quality control, quality assessment, and quality assurance are often very subtle. It is often difficult to determine whether a specific technique is quality control or quality assessment. This has lead to the common, and confusing, practice of combining quality assurance and quality control into a single term "QA/QC". Some have even converted it to the verb, "to QA/QC", as in: "How long does it take to QA/QC a catalog?"

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1. Taylor, John K. "Quality Assurance of Chemical Measurements". American Chemical Society Short Course. 1984.

The quality of a chemical analysis is considered assured when the analysis is performed in a technically competent manner, by qualified personnel using appropriate methods and equipment, and the precision and accuracy of the measurement are within the expected ranges for the technique. Acceptable quality can vary by analyte, matrix, or analysis technique.

The following is a description of the quality control techniques that are applied to each and every catalog submitted for analyses under the PACF contracts:

Procedural blanks are analyzed to assure that no analyte is added during the processing of the sample. The blank is an empty vessel to which all of the reagents, acids, or solvents used in an analyses are added. The blank is processed just like the samples. Blank data are usually less than the limit of detection, but, are routinely acceptable up to three times the limit of detection. It is recognized that, on occasion, blank results can be unacceptable but also unimportant. For example the limit of detection for iron in sediment is 5 ppm. If a laboratory reported a blank concentration of 50 ppm, but all of the sample concentrations were greater than 20,000 ppm, the data would be accepted. Blank results are reported with each catalog.

Duplicate samples are analyzed to provide a measure of the precision of the methods used for analysis. After the sample is homogenized, two separate subsamples are taken and analyzed. Duplicate analyses are evaluated in accordance with the criteria listed in Table 1. When sufficient data have been collected and processed, the average relative percent difference can be used to provide a rough estimate of the 95 % confidence interval for the method. Duplicate analysis results are reported with each catalog. Confidence interval data are reported when available.

Spiked samples are analyzed to provide a measure of the accuracy of the methods used for analysis. After the sample is homogenized, two separate subsamples are taken; one is processed as a sample; a known quantity of analyte is added to the other and it is analyzed. The difference, after accounting for any differences in sample weight, is the spike recovery and is usually reported as a percentage of the amount added. Spike recoveries are evaluated in accordance with the criteria listed in Table 2. The average recovery of analyte is a good measure of the accuracy or bias of the method used. Spike recovery results are reported with each catalog. Average recovery data are reported when available.

Reference materials are analyzed to provide evidence that the method works with naturally incorporated analyte and that the method produces results that are comparable to those obtained by an independent organization. Reference materials are pre-homogenized samples which are certified to contain a stated amount of analyte. They are readily available for metals, but not for our organic work. Reference materials are evaluated in accordance with the precision and accuracy that would be expected for the amount of analyte present and with the known error in the certification. Results of all reference materials analyzed in conjunction with the samples from a given catalog are reported with that catalog.

In addition to reviewing of the quality control analyses, each report receives a general review. This review includes consistency of the report with the purchase order and catalog, and a scan of the analytical data for obvious errors, such as negative results, or a percent moisture that is greater than 100%. The results are also scanned, in a highly subjective manner, for reasonableness.

In well over 95% of the cases, the entire quality assurance review is completed within 48 hours of receipt of the catalog by PACF. If no major problems are found the report is immediately sent to the submitter. In those cases where corrections are needed, delays of from 3 days to 3 months can occur, depending on the severity and cause of the problem. In most cases, problems are resolved in about two weeks.

The final quality review on an individual catalog basis must be performed by the sample submitter. No one knows what to expect from an analysis better that the sample submitter. If after reviewing results from any catalog, any submitter has any doubts about an analysis, he/she should immediately contact the PACF Project Officer. The sooner contact is made, the more likely a satisfactory resolution can occur.

The PACF conducts a number of quality assessment procedures. These are non catalog specific tests of laboratory performance. The most frequently employed procedure is the crosscheck analysis. In the crosscheck, samples that have been analyzed by the contractor are recalled to the PACF laboratory, where they are reanalyzed. The results of the analyses are compared, and if significant differences occur corrective action is initiated. Each contract laboratory is aware that any catalog can be called back for crosscheck. Approximately 5% of the catalogs submitted to PACF are crosschecked.

On at least an annual basis a round robin is conducted. In the round robin each laboratory analyzes a portion of the same sample. The results are compared, and if any significant differences occur, corrective action is initiated. The round robin yields the same type of information as the crosscheck, but involves all laboratories. PACF would like to conduct more than one each year, but have found the round robins to be very expensive and labor intensive.

Data audits occur on an as needed basis. Usually in trying to resolve a problem with the analyses in a problem catalog or in conjunction with a round robin or crosscheck. In the data audit the laboratory is required to submit copies of all raw data collected

APPENDIX B

PHYSICAL HABITAT ASSESSMENT DATA

Habitat Assessment Field Data Sheet - Coastal Plain Region

Station Location: NANJEMOY Date: 3-15-95 Storet:

Habitat Parameter	Excellent	Good	Fair	Poor
GENERAL CHARACTERISTICS				
1. Channel Modification	Natural channel, bends frequent, good diversity of bends and runs.	Natural channel, long runs, bends infrequent.	Modified channel with bends; OR stream meancers within a straight channel.	Modified channel without bends.
	18 20-16	15-11	10-6	5-0
INSTREAM MEASURES				
2. Instream Habitat circle those present: Snags; Riffles; Macrophytes; Veget.\undercut banks;	3-4 types present & greater than 50% available habitat.	3-4 types present & less than 50% available habitat.	1-2 types present & greater than 50% available habitat.	1-2 types present & less than 50% available habitat.
	16 20-16	15-11	10-6	5-0
3. Pools	Deep and shallow pools present and pools are abundant.	Deep and shallow pools present and pools are rare or stream is uniformly deep.	All pools shallow and pools are abundant.	All pools shallow and pools are rare or pools are absent.
	18 20-16	15-11	10-6	5-0
STREAMBANK MEASURES				
4. Bank Stability	Very stable. No evidence of erosion or bank failure.	Moderately stable, areas of erosion mostly healed over.	Moderately unstable. Moderate frequency & size of erosional areas. < 10% of streambank shows signs of erosion.	Unstable. Many eroded areas. "Raw" areas common along straight sections and bends. > 10% of streambank shows signs of erosion.
	20-16	15-11	10-6	5 5-0
5. Bank Vegetative Type (Left = left side while facing downstream)	Dominant vegetation is shrub.	Dominant vegetation is of tree form.	Dominant vegetation is grass or herbaceous plants.	< 50% of the streambank vegetated; dominant material is rock, soil, bridge material etc.
Left	10 10-9	8-6	5-3	2-0
Right	10 10-9	8-6	5-3	2-0
RIPARIAN ZONE MEASURES				
6. Shading (Percentages based on sun directly overhead)	25-90% of water surface shaded. A mixture of conditions. Some areas fully shaded, some fully exposed to sunlight, others receiving various degrees of filtered light.	> 90% of water surface shaded. Covered by full canopy; entire water surface receiving filtered or no light.	No scoring in this category.	< 25% of water surface shaded. Lack of canopy; full sunlight reaching water surface.
17	20-16	15-11		5-0
7. Riparian Zone Width (Left = left side while facing downstream)	No evidence of human activity within 18 meters of stream.	No evidence of human activity within 12 meters of stream.	No evidence of human activity within 6 meters of stream.	Evidence of human activity within 6 meters of stream.
Left	9 10-9	8-6	5-3	2-0
Right	9 10-9	8-6	5-3	2-0
umn totals:				

Total Score: 112

habsht08.93

Location of assessment (circle one): above road (below road)
other (specify) Downstream of culvert Hancock Road

Photos taken? (yes) no High water mark: _____

Flow: _____ cfs Mean velocity: _____ ft/sec Maximum velocity _____ ft/sec

Average channel width: 31'10" (0) 19'6" (50) 25'5" (100) Average water surface width: 31.10" (0) 19'6" (50) 19'5' (100)

Average depth: _____ Bottom type: mixture of gravel & sand, some rock

Surrounding land use: Forested

Upstream habitat: Forest

Recent Weather Conditions: clear mild 70's last precip >5 days

Macroinvertebrate sample collected: yes (no) If yes describe how (circle one):
wading throughout stream wading along stream edge walking on stream bank from a boat

Habitats sampled for macroinvertebrates: (estimate proportion sampled and condition of each)

	Sampled	Condition
Snags:	_____ %	_____
Riffles:	_____ %	_____
Macrophyte:	_____ %	_____
Banks:	_____ %	_____

Other Observations: high flow at this time, numerous mussels seen at 0' mark. More so than last year.

Vegetation not evident.

Habitat Assessment Field Data Sheet - Coastal Plain Region

...ion Location: Macintosh Date: 3/14/95 Storet: _____

Habitat Parameter	Excellent	Good	Fair	Poor
GENERAL CHARACTERISTICS				
1. Channel Modification	Natural channel, bends frequent, good diversity of bends and runs.	Natural channel, long runs, bends infrequent.	Modified channel with bends; OR stream meancers within a straight channel.	Modified channel without bends.
	17 20-16	15-11	10-6	5-0
INSTREAM MEASURES				
2. Instream Habitat circle those present: (Snags) (Riffles) Macrophytes; (Veget.\undercut banks);	3-4 types present & greater than 50% available habitat.	3-4 types present & less than 50% available habitat.	1-2 types present & greater than 50% available habitat.	1-2 types present & less than 50% available habitat.
	11 20-16	15-11	10-6	5-0
3. Pools	Deep and shallow pools present and pools are abundant.	Deep and shallow pools present and pools are rare or stream is uniformly deep.	All pools shallow and pools are abundant.	All pools shallow and pools are rare or pools are absent.
	19 20-16	15-11	10-6	5-0
STREAMBANK MEASURES				
4. Bank Stability	Very stable. No evidence of erosion or bank failure.	Moderately stable, areas of erosion mostly healed over.	Moderately unstable. Moderate frequency & size of erosional areas. < 10% of streambank shows signs of erosion.	Unstable. Many eroded areas. "Raw" areas common along straight sections and bends. > 10% of streambank shows signs of erosion.
	20-16	15-11	10-6	4 5-0
5. Bank Vegetative Type (Left = left side while facing downstream)	Dominant vegetation is shrub.	Dominant vegetation is of tree form.	Dominant vegetation is grass or herbaceous plants.	< 50% of the streambank vegetated; dominant material is rock, soil, bridge material etc.
Left	10-9	8 8-6	5-3	2-0
Right	10-9	8 8-6	5-3	2-0
RIPARIAN ZONE MEASURES				
6. Shading (Percentages based on sun directly overhead)	25-90% of water surface shaded. A mixture of conditions. Some areas fully shaded, some fully exposed to sunlight, others receiving various degrees of filtered light.	> 90% of water surface shaded. Covered by full canopy; entire water surface receiving filtered or no light.	No scoring in this category.	< 25% of water surface shaded. Lack of canopy; full sunlight reaching water surface.
	17 20-16	15-11		5-0
7. Riparian Zone Width (Left = left side while facing downstream)	No evidence of human activity within 18 meters of stream.	No evidence of human activity within 12 meters of stream.	No evidence of human activity within 6 meters of stream.	Evidence of human activity within 6 meters of stream.
Left	9 10-9	8-6	5-3	2-0
Right	9 10-9	8-6	5-3	2-0
...mn totals:	_____	_____	_____	_____

Total Score: 102

habsht08.93

Location of assessment (circle one): (above road) below road
other (specify) _____

Photos taken? (yes) no High water mark: _____

Flow: _____ cfs Mean velocity: _____ ft/sec Maximum velocity _____ ft/sec

Average channel width: 25'1" / 27'2" / 26'0" (0 / 50 / 100) Average water surface width: 25'2" / 22'.0" / 14'.1" (0 / 50 / 100)

Average depth: _____ / _____ / _____ Bottom type: _____

Surrounding land use: Forest, Residential

Upstream habitat: Forest, Agriculture

Recent Weather Conditions: Clear, mild Last precip > 5 days

Macroinvertebrate sample collected: yes (no) If yes describe how (circle one):
wading throughout stream wading along stream edge walking on stream bank from a boat

Habitats sampled for macroinvertebrates: (estimate proportion sampled and condition of each)

	Sampled	Condition
Snags:	_____ %	_____
Riffles:	_____ %	_____
Macrophyte:	_____ %	_____
Banks:	_____ %	_____

Other Observations:

- Flow - higher than Summer (normal summer).
- lg Quantities of Sand on some banks
- Overhanging Bank at Zero (0) reason for long water surface Width

Habitat Assessment Field Data Sheet - Coastal Plain Region

Station Location: LONG MARSH DITCH Date: 5-16-95 Storet: _____

Habitat Parameter	Excellent	Good	Fair	Poor
GENERAL CHARACTERISTICS				
1. Channel Modification	Natural channel, bends frequent, good diversity of bends and runs.	Natural channel, long runs, bends infrequent.	Modified channel with bends; OR stream meancers within a straight channel.	Modified channel without bends.
	20-16	15-11	10-6	0 5-0
INSTREAM MEASURES				
2. Instream Habitat circle those present: Snags; Riffles; Macrophytes; Veget.\undercut banks;	3-4 types present & greater than 50% available habitat.	3-4 types present & less than 50% available habitat.	1-2 types present & greater than 50% available habitat.	1-2 types present & less than 50% available habitat.
	20-16	11 15-11	10-6	5-0
3. Pools	Deep and shallow pools present and pools are abundant.	Deep and shallow pools present and pools are rare or stream is uniformly deep.	All pools shallow and pools are abundant.	All pools shallow and pools are rare or pools are absent.
	20-16	13 15-11	10-6	5-0
STREAMBANK MEASURES				
4. Bank Stability	Very stable. No evidence of erosion or bank failure.	Moderately stable, areas of erosion mostly healed over.	Moderately unstable. Moderate frequency & size of erosional areas. < 10% of streambank shows signs of erosion.	Unstable. Many eroded areas. "Raw" areas common along straight sections and bends. > 10% of streambank shows signs of erosion.
	18 20-16	15-11	10-6	5-0
5. Bank Vegetative Type (Left = left side while facing downstream)	Dominant vegetation is shrub.	Dominant vegetation is of tree form.	Dominant vegetation is grass or herbaceous plants.	< 50% of the streambank vegetated; dominant material is rock, soil, bridge material etc.
Left	10-9	8-6	5 5-3	2-0
Right	10-9	8-6	5 5-3	2-0
RIPARIAN ZONE MEASURES				
6. Shading (Percentages based on sun directly overhead)	25-90% of water surface shaded. A mixture of conditions. Some areas fully shaded, some fully exposed to sunlight, others receiving various degrees of filtered light.	> 90% of water surface shaded. Covered by full canopy; entire water surface receiving filtered or no light.	No scoring in this category.	< 25% of water surface shaded. Lack of canopy; full sunlight reaching water surface.
	20-16	15-11		0 5-0
7. Riparian Zone Width (Left = left side while facing downstream)	No evidence of human activity within 18 meters of stream.	No evidence of human activity within 12 meters of stream.	No evidence of human activity within 6 meters of stream.	Evidence of human activity within 6 meters of stream.
Left	10-9	8-6	5-3	0 2-0
Right	10-9	8-6	5-3	0 2-0
Column totals:				

Total Score: 52

habsht08.93

Location of assessment (circle one): above road (below road)
other (specify) _____

Photos taken? (yes) no High water mark: _____

Flow: _____ cfs Mean velocity: _____ ft/sec Maximum velocity _____ ft/sec

Average channel width: 36' (0) 31'4" (50) 32' (100) Average water surface width: 36' (0) 31'4" (50) 32' (100)

Average depth: _____ Bottom type: Sand, Gravel, silt on edges

Surrounding land use: Agriculture

Upstream habitat: Agriculture

Recent Weather Conditions: >6 days w/o Rec.P temps 60's / 70's clear

Macroinvertebrate sample collected: yes (no) If yes describe how (circle one):
wading throughout stream wading along stream edge walking on stream bank from a boat

Habitats sampled for macroinvertebrates: (estimate proportion sampled and condition of each)

	Sampled	Condition
Snags:	_____ %	_____
Riffles:	_____ %	_____
Macrophyte:	_____ %	_____
Banks:	_____ %	_____

Other Observations:

Mowed down to water line

Habitat Assessment Field Data Sheet - Coastal Plain Region

Station Location: Norwich Creek Date: 3/16/95 Storet: _____

Habitat Parameter	Excellent	Good	Fair	Poor
GENERAL CHARACTERISTICS				
1. Channel Modification	Natural channel, bends frequent, good diversity of bends and runs.	Natural channel, long runs, bends infrequent.	Modified channel with bends; OR stream meancers within a straight channel.	Modified channel without bends.
	20-16	14 15-11	10-6	5-0
INSTREAM MEASURES				
2. Instream Habitat circle those present: Snags; Riffles; Macrophytes; Veget.\undercut banks;	3-4 types present & greater than 50% available habitat.	3-4 types present & less than 50% available habitat.	1-2 types present & greater than 50% available habitat.	1-2 types present & less than 50% available habitat.
	20-16	15-11	8 10-6	5-0
3. Pools	Deep and shallow pools present and pools are abundant.	Deep and shallow pools present and pools are rare or stream is uniformly deep.	All pools shallow and pools are abundant.	All pools shallow and pools are rare or pools are absent.
	18 20-16	15-11	10-6	5-0
STREAMBANK MEASURES				
4. Bank Stability	Very stable. No evidence of erosion or bank failure.	Moderately stable, areas of erosion mostly healed over.	Moderately unstable. Moderate frequency & size of erosional areas. < 10% of streambank shows signs of erosion.	Unstable. Many eroded areas. "Raw" areas common along straight sections and bends. > 10% of streambank shows signs of erosion.
	20-16	15-11	10 10-6	5-0
5. Bank Vegetative Type (Left = left side while facing downstream)	Dominant vegetation is shrub.	Dominant vegetation is of tree form.	Dominant vegetation is grass or herbaceous plants.	< 50% of the streambank vegetated; dominant material is rock, soil, bridge material etc.
Left	10-9	6 8-6	5-3	2-0
Right	10-9	7 8-6	5-3	2-0
RIPARIAN ZONE MEASURES				
6. Shading (Percentages based on sun directly overhead)	25-90% of water surface shaded. A mixture of conditions. Some areas fully shaded, some fully exposed to sunlight, others receiving various degrees of filtered light.	> 90% of water surface shaded. Covered by full canopy; entire water surface receiving filtered or no light.	No scoring in this category.	< 25% of water surface shaded. Lack of canopy; full sunlight reaching water surface.
	17 20-16	15-11		5-0
7. Riparian Zone Width (Left = left side while facing downstream)	No evidence of human activity within 18 meters of stream.	No evidence of human activity within 12 meters of stream.	No evidence of human activity within 6 meters of stream.	Evidence of human activity within 6 meters of stream.
Left	10 10-9	8-6	5-3	2-0
Right	10 10-9	8-6	5-3	2-0
Column totals:				

Total Score: 100

habsht08.93

Location of assessment (circle one): above road (below road)
other (specify) _____

Photos taken? (yes) no High water mark: _____

Flow: _____ cfs Mean velocity: _____ ft/sec Maximum velocity _____ ft/sec

Average channel width: 24'9" (0) 19'8" (50) 24'4" (100) Average water surface width: 22' (0) 18'5" (50) 20'7" (NO)

Average depth: _____ Bottom type: Clay, Silt, Sand

Surrounding land use: Agriculture

Upstream habitat: Forest, Agriculture

Recent Weather Conditions: Clear Mild ~70° Last Rain 6 days

Macroinvertebrate sample collected: yes (no) If yes describe how (circle one):
wading throughout stream wading along stream edge walking on stream bank from a boat

Habitats sampled for macroinvertebrates: (estimate proportion sampled and condition of each).

	Sampled	Condition
Snags:	_____ %	_____
Riffles:	_____ %	_____
Macrophyte:	_____ %	_____
Banks:	_____ %	_____

Other Observations:

APPENDIX C

WATER QUALITY DATA

Longmarsh								
Date	Temp	D.O.	pH	Cond	Hardness	Alkalinity	Nitrate	Phosphate
	(C)	(mg/L)		(millimhos/cm)	(mg CaCO3/L)	uequiv/L	(mg/L)	(mg/L)
4/21/94	17.4	9.6	6.31	0.128				
5/17/94	15.2	9.9	6.64	0.143				
5/24/94	19.8	8.6	6.62	0.140				
5/27/94	15.8	7.4	6.18	0.134				
5/31/94	22.5	9.6	6.49	0.156				
6/7/94	21.1	6.4	6.93	0.165				
6/14/94	24.2	7.4	6.38	0.057				
8/1/94	24.8	5.8	6.69	0.170				
9/12/94	14.5	6.7	6.68	0.174				
9/15/94							8.8 - 11.0	0.0 - 0.4
11/2/94	11.7	8.1	6.71	0.181				
7/26/95					64.0	744.0	8.0	0.3
Range:	**11.7 - 24.8**	**5.8 - 9.9**	**6.18 - 6.93**	**0.057 - 0.181**	**64**	**744**	**8.0 - 11.0**	**0.0 - 0.4**
Norwich								
Date	Temp	D.O.	pH	Cond	Hardness	Alkalinity	Nitrate	Phosphate
	(C)	(mg/L)		(millimhos/cm)	(mg CaCO3/L)	(uequiv/L)	(mg/L)	(mg/L)
4/21/94	17.5	9.3	6.68	0.205				
5/17/94	15.2	8.6	6.77	0.246				
5/24/94	19.1	7.6	6.69	0.253				
5/27/94	17.0	6.3	6.38	0.221				
5/31/94	20.5	7.4	6.64	0.249				
6/7/94	21.3	6.0	7.26	0.253				
6/14/94	24.3	6.2	6.70	0.245				
8/1/94	24.1	5.2	7.07	0.229				
9/12/94	16.6	7.8	7.32	0.276				
9/15/94							17.6 - 19.8	0.0 - 0.4
11/2/94	11.9	5.6	7.08	0.301				
7/26/95					92	1051	14.0	0.3
Range:	**11.9 - 24.3**	**5.2 - 9.3**	**6.38 - 7.32**	**0.205 - 0.301**	**92**	**1051**	**8.8 - 19.8**	**0.0 - 0.4**

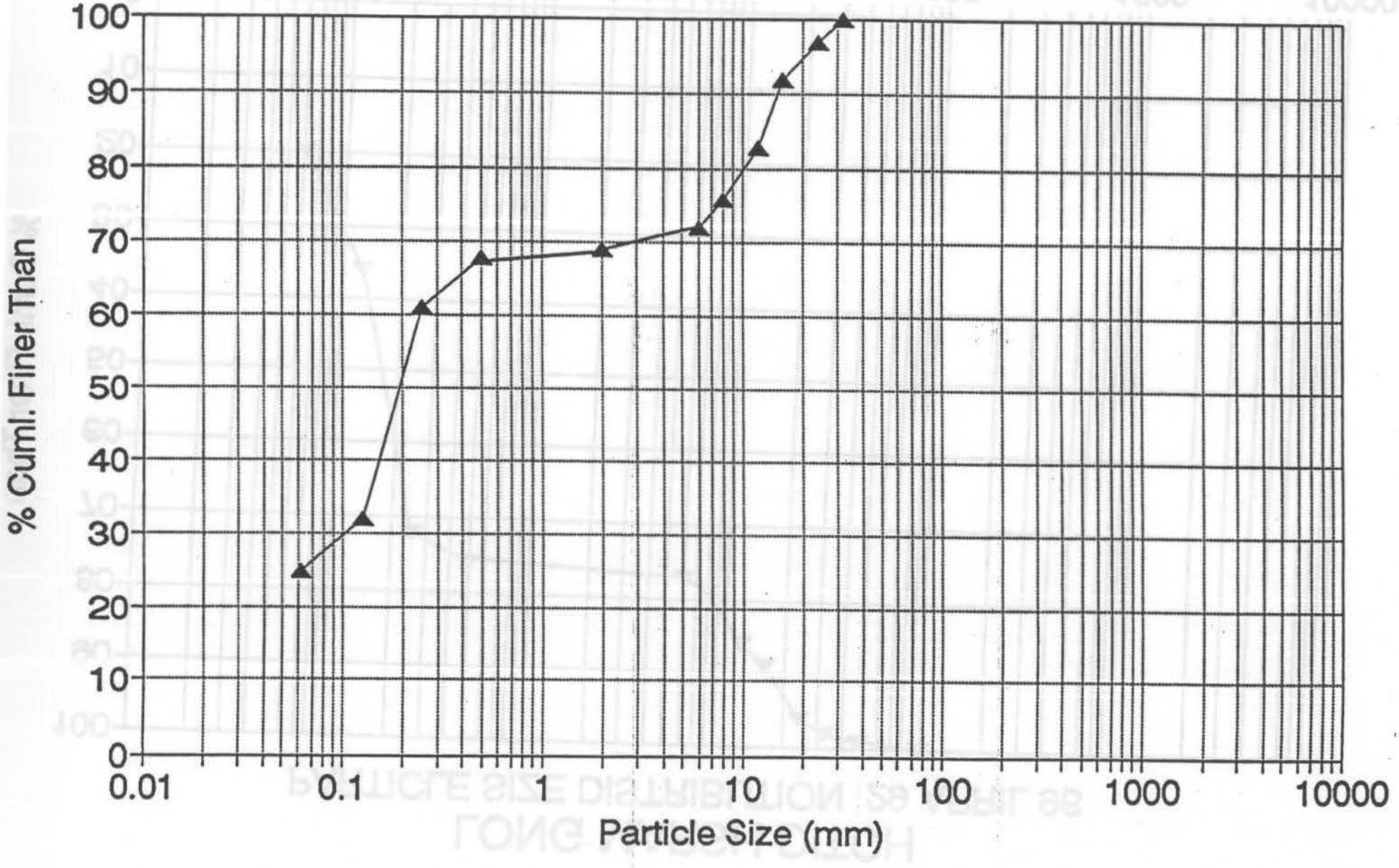
Macintosh								
Date	Temp	D.O.	pH	Cond	Hardness	Alkalinity	Nitrate	Phosphate
	(C)	(mg/L)		(millimhos/cm)	(mg CaCO3/L)	(uequiv/L)	(mg/L)	(mg/L)
4/22/94	12.8	10.1	6.91	0.086				
5/20/94	12.9	9.5	7.16	0.092				
5/27/94	17.3	8.5	6.64	0.080				
6/3/94	16.5	8.6	*	0.096				
6/10/94	17.9	8.3	6.98	0.102				
6/17/94	22.1	6.4	6.21	0.077				
9/14/94	15.7	7.7	7.50	0.127			0.44 - 0.88	0.0 - 0.4
11/4/94	11.3	9.6	7.11	0.124				
7/26/95					40	574	0.8	0.3
Range:	**11.3 - 22.1**	**6.4 - 10.1**	**6.21 - 7.50**	**0.077 - 0.127**	**40**	**574**	**0.44 - 0.88**	**0.0 - 0.4**
Nanjemoy								
Date	Temp	D.O.	pH	Cond	Hardness	Alkalinity	Nitrate	Phosphate
	(C)	(mg/L)		(millimhos/cm)	(mg CaCO3/L)	(uequiv/L)	(mg/L)	(mg/L)
4/22/94	14.4	8.6	6.60	0.060				
5/20/94	14.0	7.7	6.82	0.062				
5/27/94	17.8	6.2	6.36	0.064				
6/3/94	18.9	4.8	*	0.076				
6/10/94	20.0	4.0	6.68	0.086				
6/20/94	25.3	3.8	6.60	0.092				
8/18/94	22.2	6.2	5.84	0.050				
10/5/94	12.9	7.8	6.71	0.065				
11/4/94	9.7	9.6	6.31	0.075				
7/26/95					24.0	332.0	0.4	0.0 - 0.2
Range	**9.7 - 25.3**	**3.8 - 9.6**	**5.84 - 6.82**	**0.050 - 0.092**	**20.0 - 24.0**	**332**	**0.0 - 0.4**	**0.0 - 0.4**
* Equipment Malfunction/No Data Recorded								

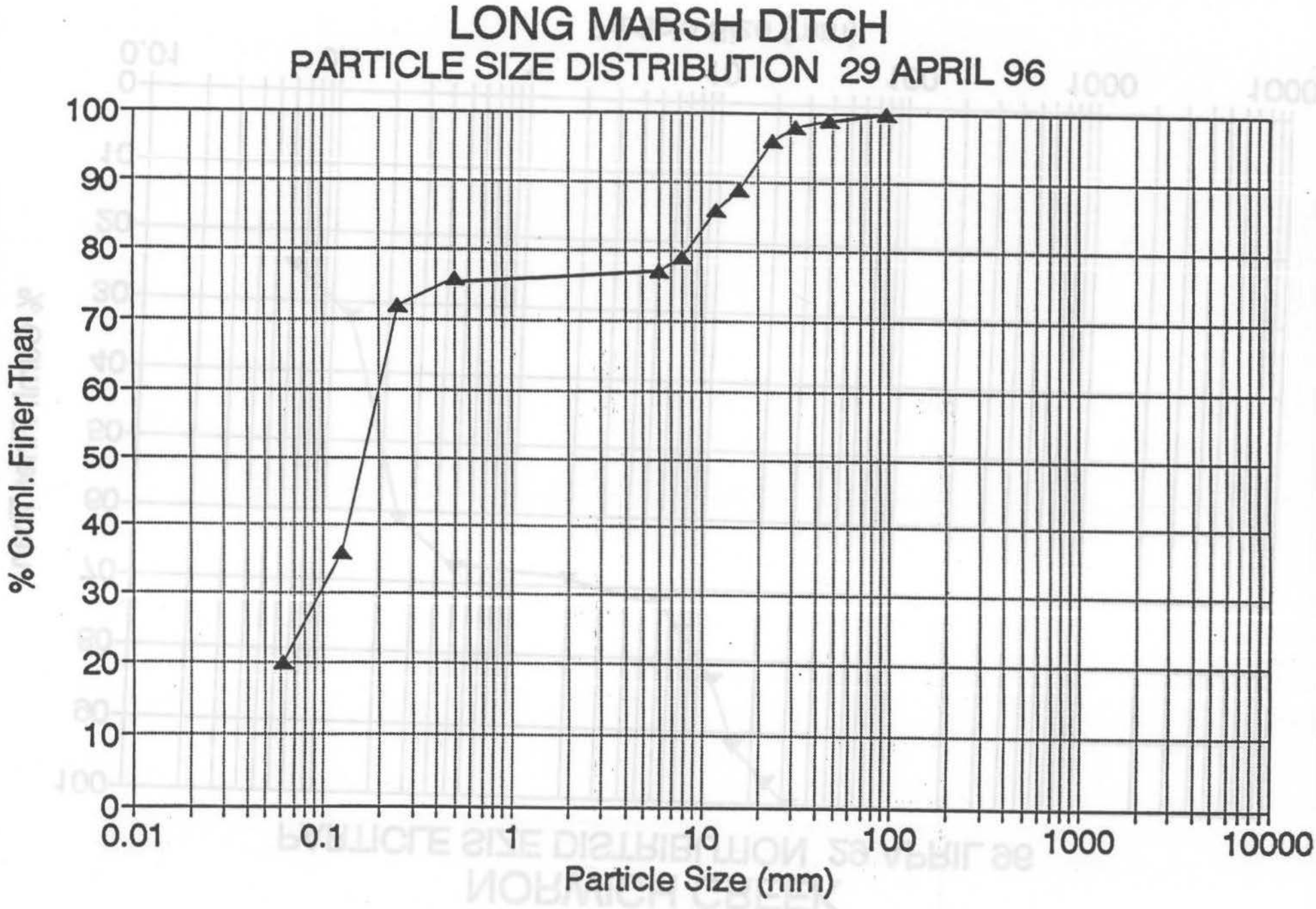
APPENDIX D

PARTICLE SIZE DISTRIBUTION GRAPHS

NORWICH CREEK

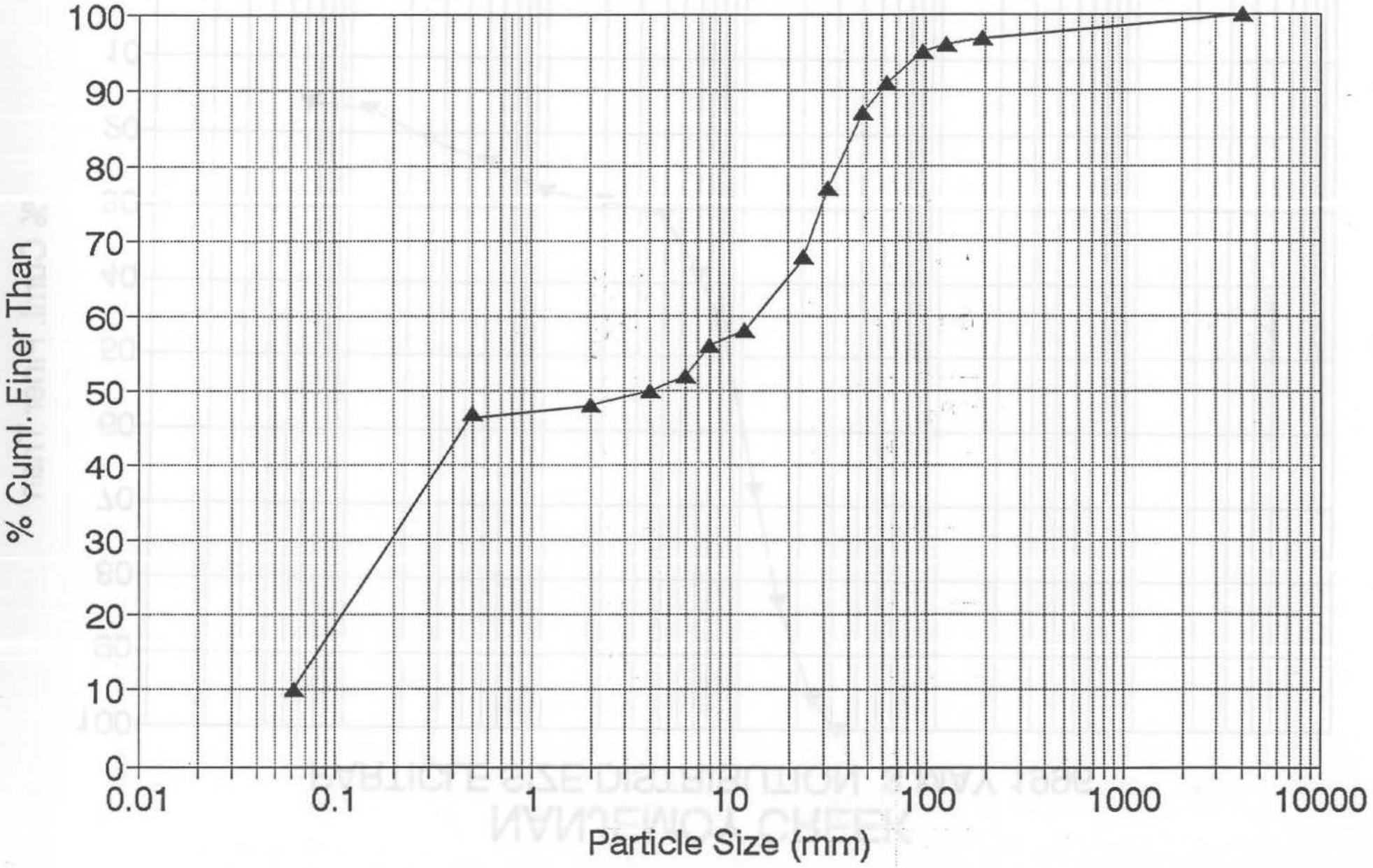
PARTICLE SIZE DISTRIBUTION 29 APRIL 96




LONG MARSH DITCH
PARTICLE SIZE DISTRIBUTION 29 APRIL 96
% Cuml. Finer Than
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
10000
Particle Size (mm)

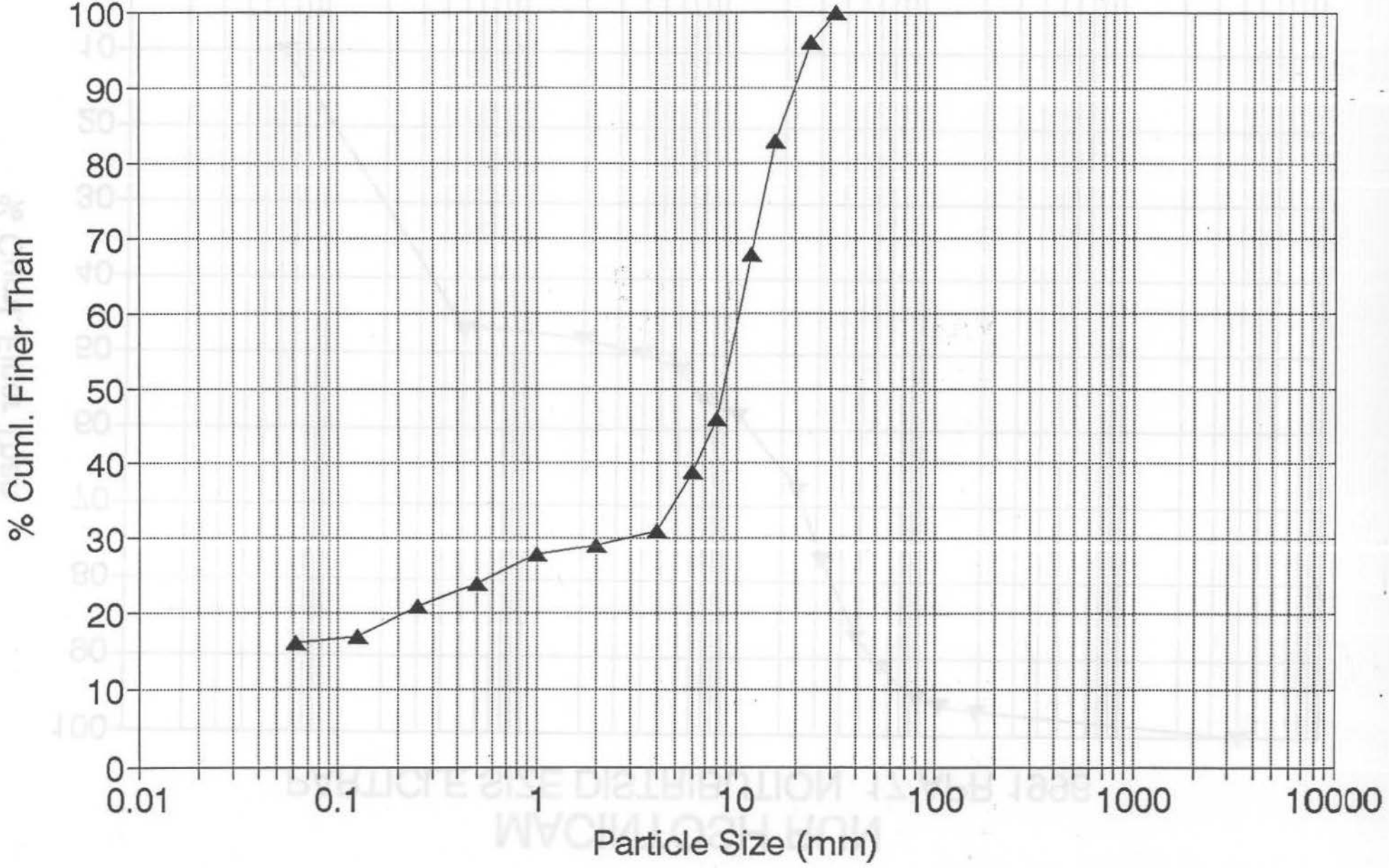
MACINTOSH RUN

PARTICLE SIZE DISTRIBUTION 17 APR 1996



NANJEMOY CREEK

PARTICLE SIZE DISTRIBUTION 3 MAY 1996



APPENDIX E

IN SITU TEMPERATURE MONITORING DATA

Mussel Study Temperature Data

	Nanjemoy	Macintosh	Long Marsh	Norwich
6/18/94-9/12/94				
Minimum (C)	16.2	14.9	14.6	16.2
Maximum (C)	31.1	27.6	31.1	28
Mean (C)	23.19	22.47	22.78	22.72
Std Dev (C)	2.46	2.44	2.90	2.42
No. Days	86	86	86	86
No. Observations	1727	1727	1727	1727
No. Obs. Above 30 C	1	0	7	0
Interval between obs. = 72 min				

Summary of in situ data

APPENDIX F

ACETYLCHOLINESTERASE DATA SUMMARY

Summary statistics for E. complanata Acetylcholinesterase data

E. complanata cholinesterase data 1994					
Stream	**date**	**mean per date**	**sd per date**		
		(micromoles per minute per gram tissue)			rel sd (%)
Macintosh	midmay	2.227	1.016		45.6
	endmay	2.935	0.794		27.1
	midjun	1.802	0.619		34.3
	november	2.341	1.121		47.9
Nanjemoy	midmay	5.352	3.562		66.5
	endmay	7.321	3.014		41.2
	midjun	6.613	2.478		37.5
	november	6.635	3.959		59.7
Norwich	midmay	1.389	0.765		55.1
	endmay	1.091	0.534		48.9
	midjun	0.792	0.498		62.9
	november	1.322	0.482		36.5
Long Marsh	midmay	3.752	2.097		55.9
	endmay	3.838	2.562		66.7
	midjun	4.257	1.486		34.9
	november	3.675	1.990		54.2
				avg rel sd	48.4
				min rel sd	27.1
				max rel sd	66.7

APPENDIX G

INDEX OF BIOLOGICAL INTEGRITY DATA

USFWS-10/5/94

NANJEMOY CREEK			
FAMILY	NAME	* GUILDS	#
Centrarchidae	redbreasted sunfish *Lepomis auritus*	Is,M,_,_	7
	pumpkinseed *Lepomis gibbosus*	Is,M,_,_	1
	bluegill *Lepomis macrochirus*	Is,M,_,_	1
Esocidae	chain pickerel *Esox niger*	Ps,M,_,_	1
Anguillidae	American eel *Anguilla rostrata*	Ps,T,_,_	3
Ictaluridae	margined madtom *Noturus insignis*	Is,M,_,_	7
	brown bullhead *Ameiurus nebulosus*	Om,T,_,_	1
Catastomidae	white sucker *Catostomus commersoni*	Om,T,L,_	2
	creek chubsucker *Erimyzon oblongus*	Om,T,_,P	1
Petromyzontidae	least brook lamprey *Lampetra aepytera*	Fi,I,_,_	1
Percidae	tesselated darter *Etheostoma olmstedi*	Is,M,_,P	5
%of catch consisting of host species	16.7	**Total fish**	**30**
IBI (% optimal score)	57		

*Guilds column incorporates 4 guild levels used in IBI evaluations.
1. Food: Pisciverous (Ps),Insectivorous (Is), Omnivorous(Om), Herbivorous(Hb), Filter(Fi),Parasitic(Pa).
2. Pollution tolerance: Intolerant(I), Moderate(M), Tolerant(T).
3. Breeding habit:Simple lithophilic(L).
4. Species group:Pioneering(P), Shiner species(S).

USFWS-9/14/94

McINTOSH	RUN		
FAMILY	NAME	* GUILDS	#
Centrarchidae	redbreasted sunfish *Lepomis auritus*	Is,M,_ ,_	15
	pumpkinseed *Lepomis gibbosus*	Is,M,_ ,_	34
	bluegill *Lepomis macrochirus*	Is,M,_ ,_	7
Umbridae	eastern mudminnow *Umbra pygmaea*	Ge,T,_ ,_	3
Anguillidae	American eel *Anguilla rostrata*	Ps,T,_,_	9
Aphredoderidae	pirate perch *Aphredoderus sayanus*	Is,M,_ ,_	3
Ictaluridae	brown bullhead *Ameiurus nebulosus*	Om,T,_,_	1
Catastomidae	creek chubsucker *Erimyzon oblongus*	Om,T,_,P	3
Petromyzontidae	least brook lamprey *Lampetera aaepytera*	Fi,I,_,_	5
Percidae	tesselated darter *Etheostoma olmstedi*	Is,M,_,P	22
Cyprinidae	swallowtail shiner *Notropis procne*	Is,I,L,S	20
	comely shiner *Notropis amoenus*	Is,I,L,S	2
	spottail shiner *Notropis hudsonius*	Is,I,L,S	11
% of catch consisting of host species	16.3	**Total fish**	**135**
IBI (% optimal score)	86		

*Guilds column incorporates 4 guild levels used in IBI evaluation.

1. Food: Pisciverous (Ps),Insectivorous (Is), Omnivorous(Om), Herbivorous(Hb), Filter(Fi),Parasitic(Pa).
2. Pollution tolerance: Intolerant(I), Moderate(M), Tolerant(T).
3. Breeding habit:Simple lithophilic(L).
4. Species group:Pioneering(P), Shiner species(S).

USFWS-9/12/94

LONG MARSH DITCH			
FAMILY	NAME	* GUILD	#
Centrarchidae	redbreasted sunfish *Lepomis auritus*	Is,M,_,_	32
	bluegill *Lepomis macrochirus*	Is,M,_,_	7
Esocidae	chain pickerel *Esox niger*	Ps,M,_,_	2
Umbridae	eastern mudminnow *Umbra pygmaea*	Ge,T,_,_	4
Cyprinidae	golden shiner *Notemigonus chrysoleucas*	Om,T,_,S	1
	spottail shiner *Notropis hudsonius*	Om,I,L,S	2
	swallowtail shiner *Notropis procne*	Is,I,L,S	6
	creek chub *Semotilus atromaculatus*	Om,T,_,P	19
	fallfish *Semotilus corporalis*	Ge,M,_,_	3
Catastomidae	creek chubsucker *Erimyzon oblongus*	Om,T,_,P	4
Percidae	shield darter *Percina peltata*	Is,I,L,_	1
	tesselated darter *Etheostoma olmstedi*	Is,M,_,P	4
Ictaluridae	brown bullhead *Ameiurus nebulosus*	Om,T,_,_	3
% of catch consisting of host species	4.5	**Total fish**	88
IBI (% optimal score)	67		

*Guilds column incorporates 4 guild levels used in IBI evaluations.
1. Food: Pisciverous (Ps),Insectivorous (Is), Omnivorous(Om), Herbivorous(Hb), Filter(Fi),Parasitic(Pa).
2. Pollution tolerance: Intolerant(I), Moderate(M), Tolerant(T).
3. Breeding habit:Simple lithophilic(L).
4. Species group:Pioneering(P), Shiner species(S)

USFWS-9/12/94

NORWICH CREEK			
FAMILY	NAME	* GUILDS	#
Centrarchidae	redbreasted sunfish *Lepomis auritus*	Is,M,_,_	10
	bluegill *Lepomis macrochirus*	Is,M,_ ,_	2
Anguillidae	American eel *Anguilla rostrata*	Ps,T,_,_	3
Cyprinidae	spottail shiner *Notropis hudsonius*	Om,I,L,S	12
	creek chub *Semotilus atromaculatus*	Om,T,_,P	5
Catastomidae	white sucker *Catostomus commersoni*	Om,T,L,_	1
	creek chubsucker *Erimyzon oblongus*	Om,T,_,P	3
Percidae	tesselated darter *Etheostoma olmstedi*	Is,M,_,P	6
Aphredoderidae	pirate perch *Aphredoderus sayanus*	Is,M,_,_	1
% of catch consisting of host species	13.9	**Total fish**	43
IBI (% optimal score)	50		

***Guilds column incorporates 4 guild levels used in IBI evaluations.**

1. **Food: Pisciverous (Ps),Insectivorous (Is), Omnivorous(Om), Herbivorous(Hb), Filter(Fi),Parasitic(Pa).**
2. **Pollution tolerance: Intolerant(I), Moderate(M), Tolerant(T).**
3. **Breeding habit:Simple lithophilic(L).**
4. **Species group:Pioneering(P), Shiner species(S).**

MD94SS123-317

NANJEMOY CREEK			
FAMILY	NAME	*GUILDS	#
Centrarchidae	redbreasted sunfish *Lepomis auritus*	Is,M,_,_	59
	pumpkinseed *Lepomis gibbosus*	Is,M,_,_	6
	bluegill *Lepomis macrochirus*	Is,M,_,_	11
	warmouth *Lepomis gulosus*	Ps,M,_,_	2
	Lepomis hybrid	Is,M,_,_	1
Anguillidae	American eel *Anguilla rostrata*	Ps,T,_,_	12
Ictaluridae	margined madtom *Noturus insignis*	Is,M,_,_	9
	brown bullhead *Ameiurus nebulosus*	Om,T,_,_	2
Catastomidae	creek chubsucker *Erimyzon oblongus*	Om,T,_,P	13
Petromyzontidae	least brook lamprey *Lampetra aepytera*	Fi,I,_,_	1
Percidae	tesselated darter *Etheostoma olmstedi*	Is,M,_,P	8
Umbridae	Eastern mudminnow *umbra pygmaea*	Ge,T,_,_	1
Aphredoderidae	pirate perch *Aphredoderus sayanus*	Is,M,_,_	3
% of catch consisting of host species	6.2	**Total fish**	**128**
IBI (% optimal score)	67		

*Guilds column incorporates 4 guild levels used in IBI evaluations.
1. Food: Pisciverous (Ps),Insectivorous (Is), Omnivorous(Om), Herbivorous(Hb), Filter(Fi),Parasitic(Pa).
2. Pollution tolerance: Intolerant(I), Moderate(M), Tolerant(T).
3. Breeding habit:Simple lithophilic(L).
4. Species group:Pioneering(P), Shiner species(S).

MD93SS 123-1

NANJEMOY CREEK			
FAMILY	NAME	* GUILDS	#
Centrarchidae	redbreasted sunfish *Lepomis auritus*	Is,M,_,_	1
	pumpkinseed *Lepomis gibbosus*	Is,M,_,_	6
	bluegill *Lepomis macrochirus*	Is,M,_,_	11
Anguillidae	American eel *Anguilla rostrata*	Ps,T,_,_	6
Ictaluridae	margined madtom *Noturus insignis*	Is,M,_,_	12
	brown bullhead *Ameiurus nebulosus*	Om,T,_,_	14
Cyprinidae	golden shiner *Notemigonus crysoleucas*	Om,T,_,_	10
	spottail shiner *Notropus hudsonius*	Is,I,L,S	10
Catastomidae	creek chubsucker *Erimyzon oblongus*	Om,T,_,P	6
Petromyzontidae	least brook lamprey *Lampetra aepytera*	Fi,I,_,_	8
	sea lamprey *Petromyzon marinus*	Pa,M,_,_	1
Percidae	tesselated darter *Etheostoma olmstedi*	Is,M,_,P	8
Umbridae	Eastern mudminnow *Umbra pygmaea*	Ge,T,_,_	5
% of catch consisting of host species	8.2	**Total fish**	98
IBI (% optimal score)	50		

*Guilds column incorporates 4 guild levels used in IBI evaluations.
1. Food: Pisciverous (Ps),Insectivorous (Is), Omnivorous(Om), Herbivorous(Hb), Filter(Fi),Parasitic(Pa).
2. Pollution tolerance: Intolerant(I), Moderate(M), Tolerant(T).
3. Breeding habit:Simple lithophilic(L).
4. Species group:Pioneering(P), Shiner species(S).

MD93SS 123-8

NANJEMOY CREEK			
FAMILY	NAME	* GUILDS	#
Centrarchidae	redbreasted sunfish *Lepomis auritus*	Is,M,_,_	16
	pumpkinseed *Lepomis gibbosus*	Is,M,_,_	9
	bluegill *Lepomis macrochirus*	Is,M,_,_	4
	blue spotted sunfish *Enneacanthus gloriosus*	Is,M,_,_	3
Anguillidae	American eel *Anguilla rostrata*	Ps,T,_,_	14
Ictaluridae	margined madtom *Noturus insignis*	Is,M,_,_	12
	brown bullhead *Ameiurus nebulosus*	Om,T,_,_	10
Petromyzontidae	least brook lamprey *Lampetra aepytera*	Fi,I,_,_	6
Percidae	tesselated darter *Etheostoma olmstedi*	Is,M,_,P	18
Umbridae	Eastern mudminnow *Umbra pygmaea*	Ge,T,_,_	5
% of catch consisting of host species	18.6	Total fish	97
IBI (% optimal score)	60		

*Guilds column incorporates 4 guild levels used in IBI evaluation.
1. Food: Pisciverous (Ps),Insectivorous (Is), Omnivorous(Om), Herbivorous(Hb), Filter(Fi),Parasitic(Pa).
2. Pollution tolerance: Intolerant(I), Moderate(M), Tolerant(T).
3. Breeding habit:Simple lithophilic(L).
4. Species group:Pioneering(P), Shiner species(S).

MD94SSEPA

NORWICH CREEK			
FAMILY	NAME	* GUILDS	#
Centrarchidae	redbreasted sunfish *Lepomis auritus*	Is,M,_,_	10
	pumpkinseed *Lepomis gibbosus*	Is,M,_ ,_	1
Anguillidae	american eel *Anguilla rostrata*	Ps,T,_,_	8
Cyprinidae	fallfish *Semotilus corporalis*	Ge,M,_,_	19
Catastomidae	white sucker *Catostomus commersoni*	Om,T,L,_	10
	creek chubsucker *Erimyzon oblongus*	Om,T,_,P	5
Umbridae	Eastern mudminnow *Umbra pygmae*	Ge,T,_,_	24
Percidae	tesselated darter *Etheostoma olmstedi*	Is,M,_,P	51
Aphredoderidae	pirate perch *Aphredoderus sayanus*	Is,M,_,_	20
% of catch consisting of host species	34.4	**Total fish**	**148**
IBI (% optimal score)	50		

***Guilds column incorporates 4 guild levels used in IBI evaluations.**

1. **Food: Pisciverous (Ps),Insectivorous (Is), Omnivorous(Om), Herbivorous(Hb), Filter(Fi),Parasitic(Pa).**
2. **Pollution tolerance: Intolerant(I), Moderate(M), Tolerant(T).**
3. **Breeding habit:Simple lithophilic(L).**
4. **Species group:Pioneering(P), Shiner species(S).**