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A Pilot Study for Ambient Toxicity Testing in Chesapeake Bay

Year 3 Report

Chesapeake Bay Program

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FOREWORD

This pilot study was designed to evaluate ambient toxicity in the Chesapeake Bay watershed by using a battery of water column and sediment toxicity tests. A team of scientists from two Chesapeake Bay research laboratories worked jointly to complete this goal. Water column toxicity studies were directed by Lenwood W. Hall, Jr. of the University of Maryland System's Agricultural Experiment Station; sediment toxicity tests were managed by Raymond W. Alden, III of Old Dominion University Applied Marine Research Laboratory. This report summarizes data from the third year of a three-year pilot study. The following government agencies were responsible for supporting and/or managing this research: U.S. Environmental Protection Agency, Maryland Department of Natural Resources and Maryland Department of Environment.

ABSTRACT

Data presented in this report were collected during the third year of a research program designed to develop a method to assess ambient toxicity of living resource habitats in Chesapeake Bay for the purpose of identifying defined regions where ambient toxicity levels warrant further investigation. The goals of this study were to identify toxic ambient areas in the Chesapeake Bay watershed by using a battery of standardized, directly modified, or recently developed water column and sediment toxicity tests. The toxicity of ambient estuarine water and sediment was evaluated during the fall (1992) and spring (1993) at two stations each in the Wye River (Manor House and Quarter Creek), Nanticoke River (Sandy Hill Beach and Bivalve Harbor) and Middle River (Frog Mortar and Wilson Point) to address temporal and spatial variability. The toxicity of ambient estuarine water was assessed at all stations by using the following estuarine tests: 8 day sheepshead minnow, *Cyprinodon variegatus*, survival and growth test; 8 day larval grass shrimp, *Palaemonetes pugio*, survival and growth test; 8 day *Eurytemora affinis* life cycle test and 48 hour coot clam, *Mulinia lateralis* embryo/larval test. Toxicity of ambient estuarine sediment was determined by using the following tests: 10 d sheepshead minnow embryo-larval test; 10 day survival, growth and reburial test with the amphipods *Leptacheirus plumulosus* and *Lepidactylus dytiscus* and 10 day polychaete worm, *Streblospio benedicti* survival and growth test. Both inorganic and organic contaminants were assessed in ambient water and sediment concurrently with toxicity testing to determine "possible" causes of toxicity.

Results from water column testing with the coot clam showed consistent toxicity at both Middle River stations during the fall and spring tests. Concentrations of copper, lead, nickel and zinc were reported to exceed the EPA recommended chronic marine water quality criterion at one of the stations (Wilson Point). Criterion recommended by EPA for both copper and nickel were exceeded at the other Middle River station (Frog Mortar Creek). The only other water column test showing significant effects was the *E. affinis* test (reduced survival) conducted at the Wye River (Quarter Creek) site during the spring test. Potentially toxic concentrations of contaminants were not reported concurrently with toxicity. Significant biological effects likely related to either adverse water quality conditions or elevated contaminants were not reported at any of the other sites with the water column tests.

Results from sediment toxicity tests showed a significant reduction in growth for *L. plumulosus* at the Nanticoke River - Sandy Hill Beach site during the fall of 1992. Three times the ER-L for mercury was found at this site. Although below sediment ER-Ls, several organics and pesticides were also confirmed at the site. Elevated levels of unionized ammonia was present at both Bivalve and Sandy Hill Beach sites. Wye River Manor House produced significantly reduced survival of *L. dytiscus*, and Wye River Quarter Creek sediment significantly reduced growth of *L. plumulosus* during the fall 1992 tests. Concentrations of metals were low at both sites, however 4,4-DDT was detected at Manor House during the fall sampling. Spring toxicity data revealed significant reduction in survival in *L. dytiscus* at day 10 at the Manor House site when mortality was adjusted for particle size effects. Organic data indicated the presence of 4-methylphenol. Neither survival or growth effects were observed at the Middle River sites for either sampling period. Frog Mortar and Wilson Point showed elevated levels (above ER-Ls) of some metals including lead, zinc, mercury, and copper during the spring sampling. AVS/SEM data indicated the lack of bioavailability of these metals. The contaminant 4,4-DDE was also detected at the Frog Mortar site in the fall sampling.

ACKNOWLEDGEMENTS

We would like to acknowledge the following individuals or organizations for assisting in this study: Ted Turner and Mark Scott for technical assistance; Joe Stansberry and Gerald Dawson for the use of their boats, and Versar, Inc. for contaminant analysis. Ian Hartwell, Ron Klauda, Rich Batiuk, Mary Jo Garreis and Deirdre Murphy are acknowledged for their comments on the study design. Special consideration is extended to Mary Hancock and Kellye Richardson for typing the report.

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SECTION 1

INTRODUCTION

The Chesapeake Bay is the nation's largest and most productive estuary. The unique physical, chemical and biological characteristics of the Bay watershed provides habitat for numerous aquatic species. In recent years, there has been concern for this estuary due to the decline of various living resources such as submerged aquatic vegetation, anadromous fish and the American oyster (Majumdar et al., 1987). Factors such as fishing pressure, nutrient enrichment, disease and pollution are often postulated as possible causes of these declining resources. The link between contaminants (including adverse water quality such as reduced dissolved oxygen) and biological effects has been of concern in critical Chesapeake Bay habitat areas in recent years. Information derived from the loading of toxic chemicals and/or chemical monitoring studies are not adequate for assessing the biological effects resulting from numerous sources such as multiple point source effluents, nonpoint source runoff from agriculture, silviculture and urban sites, atmospheric deposition, groundwater contamination, and release of toxic chemicals from sediments. The most realistic approach for evaluating the adverse effects of toxic conditions on living resources is by direct measurement of biological responses in the ambient environment. The ambient environment is defined as aquatic areas located outside of mixing zones of point source discharges.

Research efforts designed to address the link between contaminants and adverse effects on living aquatic resources have been supported by various state and federal agencies in the Chesapeake Bay watershed. For example, the Chesapeake Bay Basinwide Toxics Reduction Strategy has a commitment to develop and implement a plan for Baywide assessment and monitoring of the effects of toxic substances, within natural habitats, on selected commercially, recreationally and ecologically important species of living resources (CEC, 1989). This commitment is consistent with the recommendations of the Chesapeake Bay Living Resource Monitoring Plan (CEC, 1988).

The idea for an Ambient Toxicity Testing Program was discussed at an Ambient Toxicity Assessment Workshop held in Annapolis, Maryland in July of 1989 (Chesapeake Bay Program, 1990). The goals of this workshop were to provide a forum on how to use biological indicators to monitor the effects of toxic contaminants on living resources in Chesapeake Bay. Recommendations from this workshop were used to develop a three year pilot study (1990-1993). Objectives from the first two years of this effort have been completed and reports have been published (Hall et al., 1991; Hall et al., 1992).

Results from our first year of this study demonstrated that ambient toxic conditions were present in the Elizabeth River and Patapsco River based on water column, sediment and suborganismal tests (Hall et al., 1991). Data from sediment and suborganismal tests also suggested that toxic conditions were present at the proposed reference site in the Wye River; water column tests did not demonstrate the presence of toxic conditions at this reference site. Several ambient stations in the Potomac River also had toxic conditions based on water column and sediment tests. The need for multispecies testing was supported by the water column tests as no significant ranking of sensitivity among species was reported. Results from the sediment tests showed that the amphipod test was most sensitive, followed by the polychaete worm test and the grass shrimp test. The need for integrated water column, sediment and suborganismal testing was confirmed during our first year of testing. A spectrum of tests was needed to maximize our ability to identify toxic conditions in the ambient environment of the Chesapeake Bay watershed.

Ambient toxicity tests were conducted twice in the following locations during the second year of this study: Potomac River-Morgantown, Potomac River-Dahlgren, Patapsco River and Wye River (Hall et al., 1992). Significant biological effects (statistically different from controls) were demonstrated from water column tests during at least one sampling period for all stations except the Patapsco River. The most persistent biological effects in the water column were reported from the Wye River station as significant mortality from two different test species was reported from both the first and second test. Sediment tests demonstrated significant biological effects for both tests at the Dahlgren, Morgantown, and Patapsco River stations. Significant biological effects were reported in sediment during the first Wye River test but not the second.

The purpose of this report is to present data from the third year of testing and summarize all information collected over the three year period using a composite index approach based upon that of the sediment quality triad (Alden, 1992). Many of the test procedures described in the first year report were used for the third year of testing; therefore, the first year report by Hall et al. (1991) should be used to provide details on specific procedures. One new water column test (coot clam, *Mulinia lateralis*) and two new sediment tests (*Cyprinodon variegatus*, sheepshead minnow embryo-larval and amphipod, *Leptocheirus plumulosus*) were used in the third year; descriptions of the testing procedures are provided in this report. The goals of this study were to conduct four water column and four sediment toxicity tests on a broader spatial and temporal scale than the previous efforts. Water column and sediment toxicity tests were conducted at two stations in the Wye River, Nanticoke River and Middle River. Seasonal variability was assessed by conducting tests during the fall (low flow) and spring (high flow). Inorganic and organic contaminants were evaluated in both water and sediment during these experiments.

SECTION 2

OBJECTIVES

This pilot ambient toxicity study was a continuation of a research effort previously conducted for two years in the Chesapeake Bay watershed. The major goal of this program was to assess and determine the toxicity of ambient water and sediment in selected areas of the Chesapeake Bay watershed by using a battery of standardized, directly modified, or recently developed water column and sediment toxicity tests.

The specific objectives of the third year of this study were to:

- assess the toxicity of ambient estuarine water and sediment during the fall and spring at two stations each in the Wye, Nanticoke and Middle Rivers of the Chesapeake Bay to address temporal and spatial variability issues in these three rivers;

- determine the toxicity of ambient estuarine water described in the first objective by using the following estuarine tests: 8 day sheepshead minnow, *Cyprinodon variegatus* survival and growth test; 8 day larval grass shrimp, *Palaemonetes pugio* survival and growth test, 8 day *Eurytemora affinis* life cycle test and 48 hour coot clam, *Mulinia lateralis* embryo-larval test;

- evaluate the toxicity of ambient sediment described in the first objective by using the following estuarine tests: 10 day sheepshead minnow embryo-larval test; 10 day amphipod, *Lepidactylus dytiscus* and *Leptocheirus plumulosus* survival, growth and reburial test and 10 day polychaete worm, *Streblospio benedicti* survival and growth test;

- measure inorganic and organic contaminants in ambient water and sediment concurrently with toxicity testing to determine "possible" causes of toxicity;

- determine the relative sensitivity of test species for each type of test and compare between test methods to identify regions where ambient toxicity exists;

- identify longer term test methods development or follow up survey design needs (if any) to support baywide assessment of ambient toxicity; and

- summarize water column and sediment toxicity data from ambient toxicity tests conducted during the 1990-1993 pilot study in the Chesapeake Bay.

SECTION 3

METHODS

3.1 Study Areas

Study areas were selected to represent ecologically important but not overtly contaminated (e.g. Elizabeth River) environments of the Chesapeake Bay. Selecting these type areas provided a true measure of the ambient toxicity testing approach and the sensitivity of this approach for identifing potentially toxic ambient areas in the Bay watershed. Information provided by Maryland Department of The Environment (MDE), Maryland Department of Natural Resources (MDNR) and Maryland Department of Agriculture (MDA) was used in the station selection process. Stations selected for study were located outside of point source discharge mixing zones.

The rivers selected for the 1992 and 1993 study were the Nanticoke, Wye and Middle Rivers (Figure 3.1). A description of these three rivers, along with appropriate rationale for station selection in each river, is presented below. Two estuarine sites in each river were selected for ambient toxicity testing to provide data on spatial variability.

3.1.1 Nanticoke River

The Nanticoke River is a major tributary of Chesapeake Bay that provides valuable habitat for commercially important species such as softshell clams, blue crabs and anadromous fish. This river was historically one of the four major spawning areas for striped bass in the Maryland waters of Chesapeake Bay (Kohlenstein, 1980). The Nanticoke represents a typical eastern shore river bordered by wetland habitats, agricultural activity (non-point source inputs), few point source discharges, and low population density.

Proposed testing sites downriver from Chapter Point were selected to insure that salinity would be present during the spring test period (Figure 3.2). Water quality data from previous studies on the Nanticoke River indicate that saline conditions were detected year-round below Long Point (Stroup et al., 1991).

The two sites selected in the Nanticoke River were Sandy Hill Beach and Bivalve Harbor. Sandy Hill Beach was downriver from the mouth of Quantico Creek in Wicomico County (38° 21' 24" N, 75° 51' 21" W). The Quantico Creek drainage includes a waste treatment facility at the Poplar Hill Pre-release Unit as well as agricultural run-off. Elevated coliform counts (39-75 MPN/100 ml) have been frequently detected at this site (Deirdre Murphy, personal communication). Bivalve harbor in Wicomico County was located at 38° 19' 17" N, 75° 53' 22" W. The Taylor Oil Company discharge is located near this site (upstream). Elevated coliform counts (23-93 MPN/100 ml) have also been observed at this site (Deirdre Murphy, personal communication).

Figure 3.1 Nanticoke River, Wye River and Middle River locations used for ambient testing.

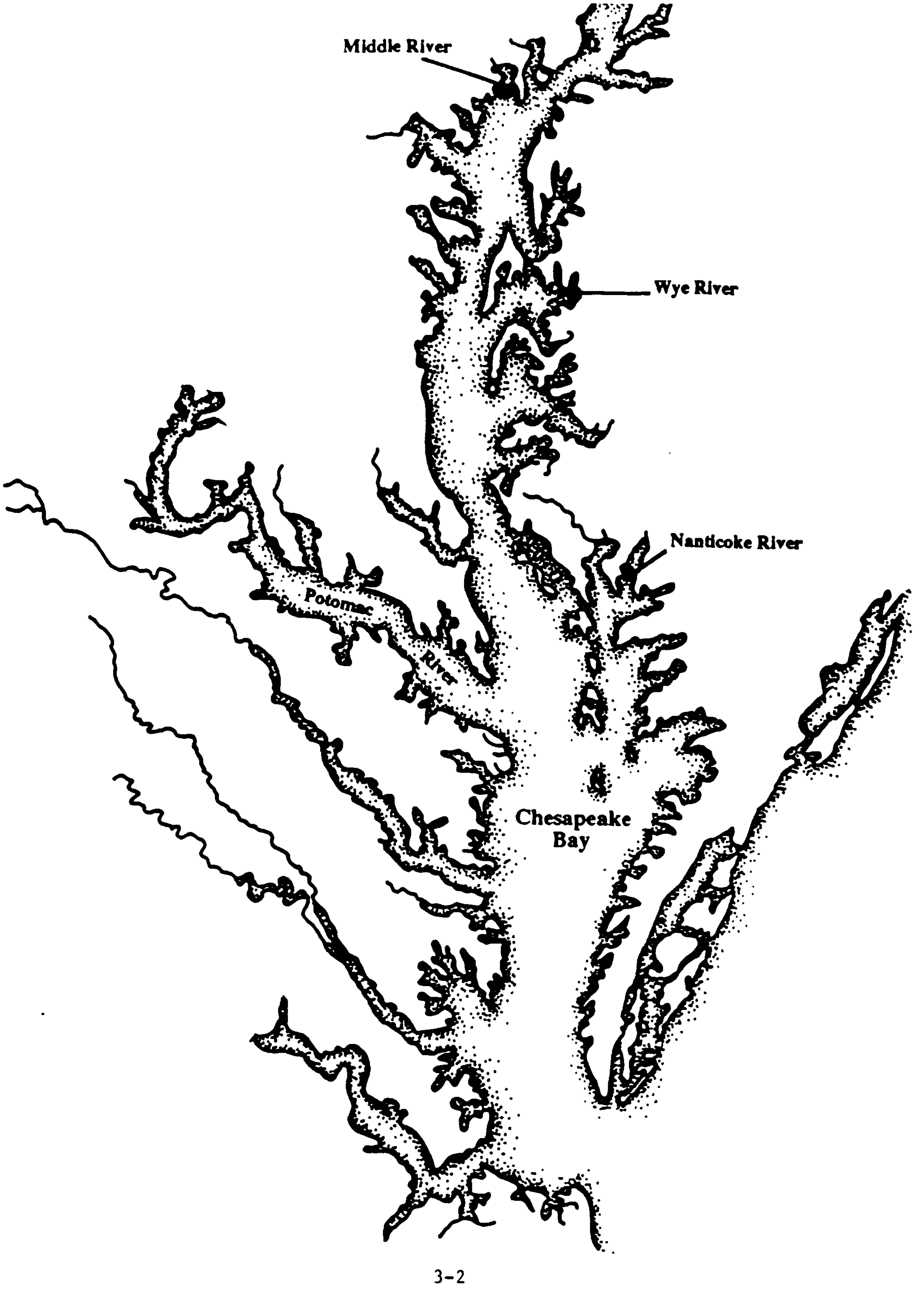
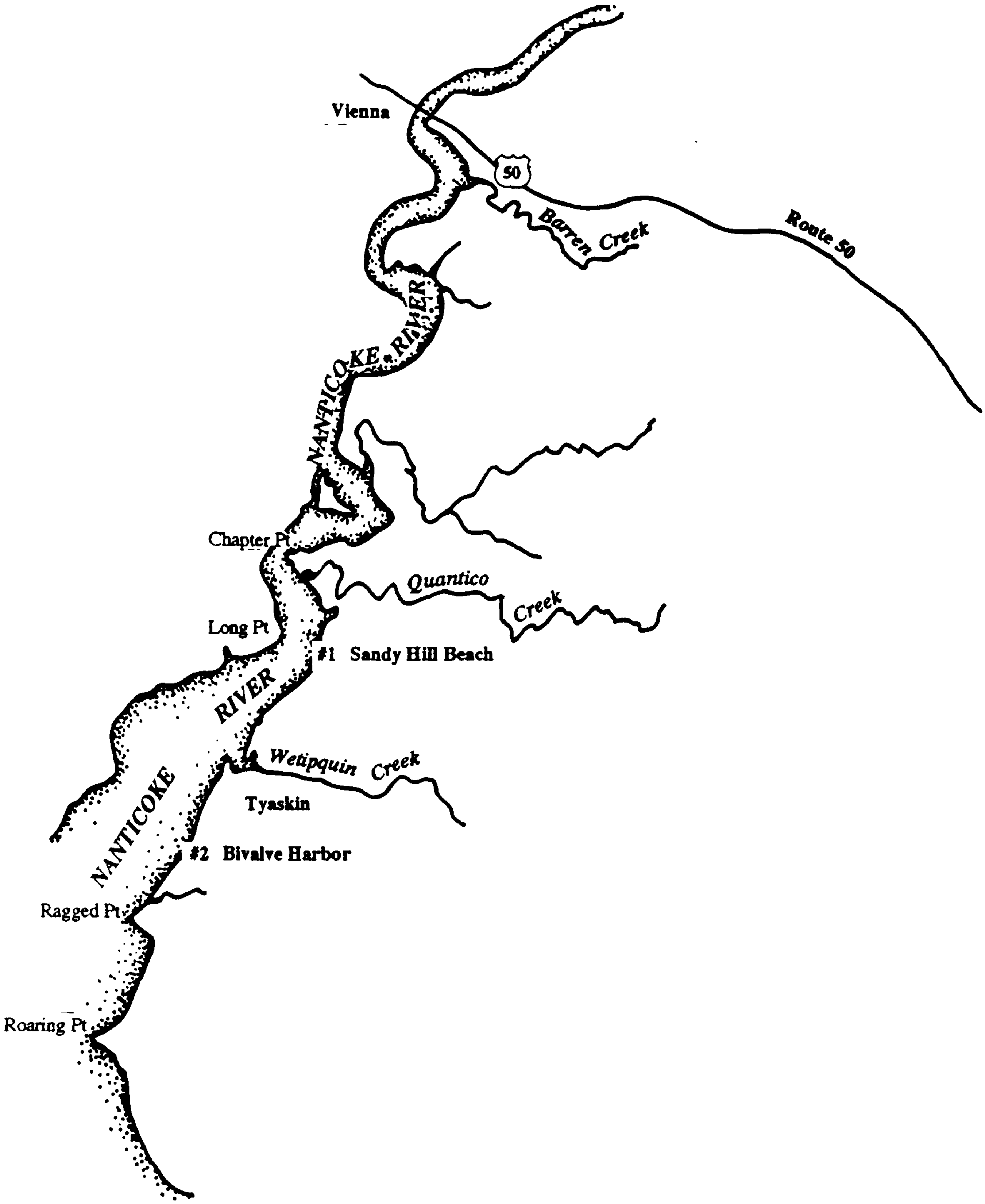


Figure 3.2 Nanticoke River sampling sites located at Sandy Hill Beach and Bivalve Harbor.



3.1.2 Wye River

The Wye River was selected for testing during the previous two year pilot study to represent a reference or relatively "clean" background area (minimal point source input). The site previously selected was located at Wye Narrows above the Manor House (38° 53' 12" N, 76° 1' 54" W) (Figure 3.3). Results from sediment toxicity testing in year 1 and both sediment and water column tests from year 2 suggested this area may have toxic conditions (Hall et al., 1991; Hall et al., 1992). The rationale for retaining this site in year 3 was to provide data from at least one site for three consecutive years for temporal comparisons within each test type (water column or sediment) and among the two different test types. For example, in year 1 toxic conditions were not identified with water column tests but biological effects were reported in year 2. Sediment tests demonstrated effects during both years. Retaining the Wye River site for three years, therefore, provided insight on annual variability with both types of tests.

The other site selected for testing on the Wye River was upriver from DeCoursey Cove near the mouth of Quarter Creek (38° 55' 00" N, 76° 10' 00" W) (Figure 3.3). This site was near MDE shellfish program station 08-02-013A where elevated coliform counts (23-93 MPN/100 ml) have been detected following rain events (Deirdre Murphy, personal communication). Inorganic and organic contaminants have been detected in soft shell clam tissue at two sampling sites in close proximity to this proposed sampling site. Concentrations of the following contaminants were reported in softshell clams in 1985: arsenic (0.74 ug/g), cadmium (0.15 ug/g), copper (7.03 ug/g), mercury (0.001 ug/g), and chlordane (0.019 ug/g). In 1986, arsenic (0.1 ug/g), cadmium (0.13 ug/g), copper (8.41 ug/g), and mercury (0.007 ug/g) were detected (Deirdre Murphy, personal communication).

3.1.3 Middle River

Middle River is a western shore tributary of Chesapeake Bay located north of Baltimore. Two stations were selected in this river to represent possible effects from densely populated urban areas with numerous point source discharges. Both sites were selected in close proximity to Wilson Point to insure that saline conditions would be present during the spring testing period. MDE has monitored this region from 1984 through 1989 and characterized it as a salinity transition zone where seasonal salinity ranged from about 2 to 7 ppt.

Site #1 was located east of Wilson Point near Galloway Point at the mouth of Frog Mortar Creek (39° 18' 30" N, 76° 24' 10" W) (Figure 3.4). This site was likely influenced by the water quality of Frog Mortar Creek. A "fish kill" was reported by MDE in Frog Mortar Creek in June of 1989 (Poukish and Allison, 1989). Approximately 100 fish (perch, carp, sunfish and catfish) were reported dead with no known probable cause. Sediment contaminants data collected by MDE indicated detectable levels of arsenic (25 ug/g), mercury (0.3 ug/g), nickel (50 ug/g), lead (100 ug/g) and

Figure 3.3 Wye River sampling sites located at the Manor House and Quarter Creek.

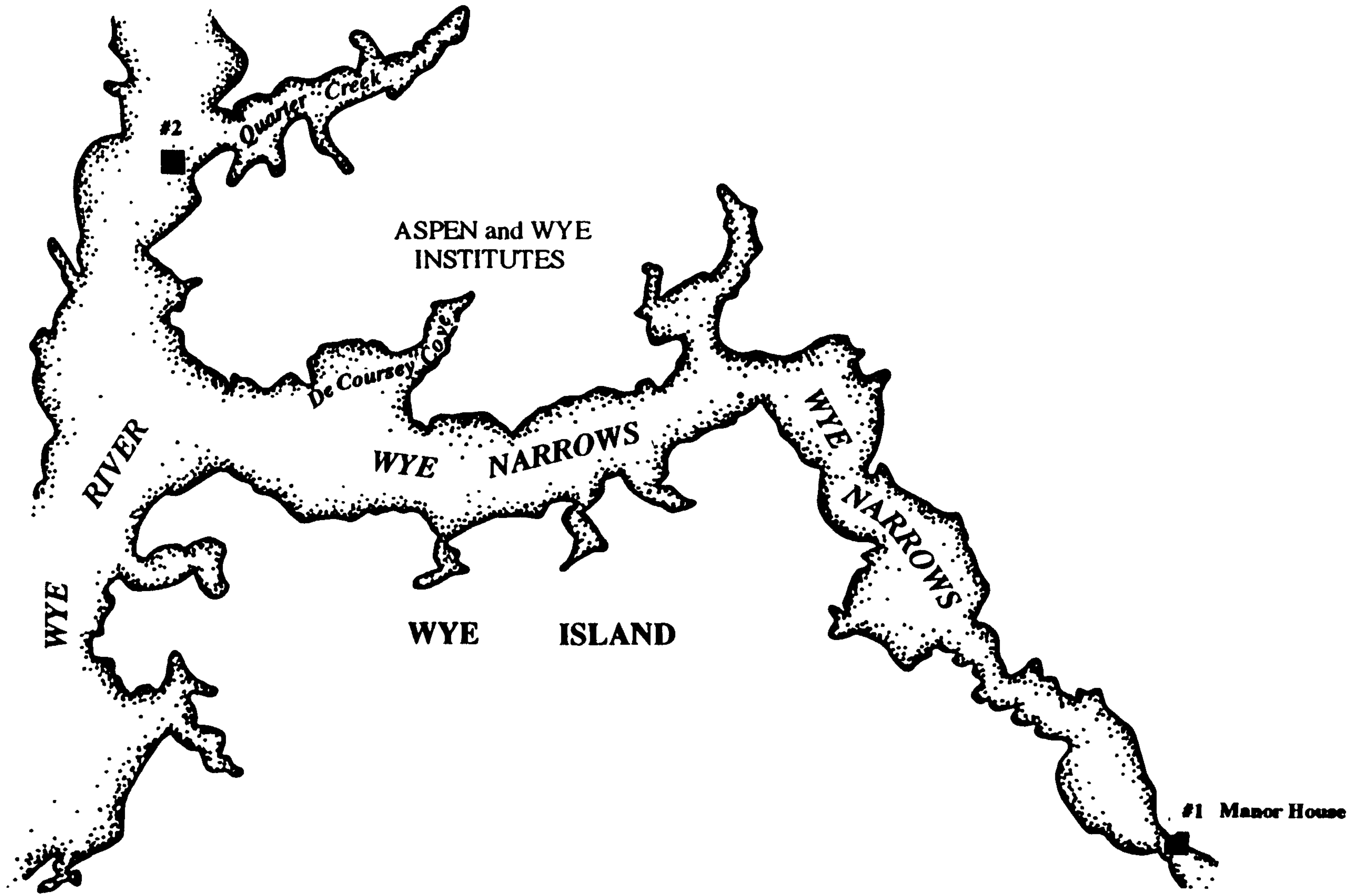
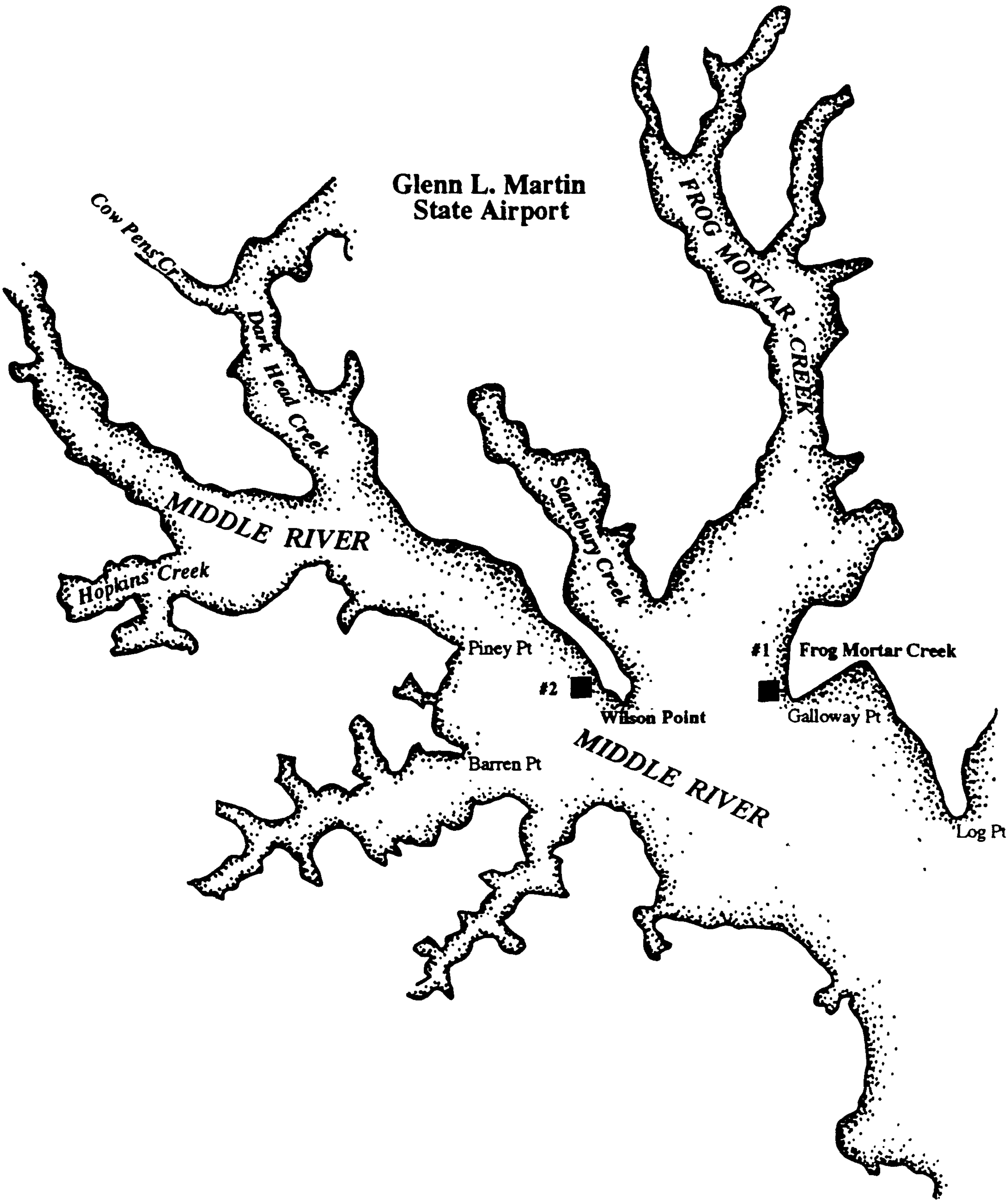


Figure 3.4 Middle River sampling sites located at Wilson Point and Frog Mortar Creek.



zinc (250 ug/g) in sediments found east of Wilson Point (Deirdre Murphy, personal communication). The site was also located downriver (approximately one mile) from the Glen L. Martin State Airport permitted discharge. Numerous marinas were also present in this area.

Site #2 was located west of Wilson Point (39° 18' 30" N, 76° 24' 45" W) (Figure 3.4). This site was likely influenced by numerous marinas from Cow Pens Creek, Dark Head Creek and Hopkins Creek. The sampling site was located downriver from the Chesapeake Industrial Park permitted discharge on Dark Head Creek (approximately 1.25 miles). A chemical spill containing chromium, occurred in Cow Pens Creek in January 1988. In April 1989, MDE found detectable concentrations of inorganic contaminants in water samples taken from Cow Pens Creek in the vicinity of Glen L. Martin Airport. Arsenic (2.2 ug/L), cadmium (10 ug/L), copper (48 ug/L), chromium (50 ug/L), lead (126 ug/L), mercury (0.2 ug/L), nickel (40 ug/L) and zinc (276 ug/L) were detected (Deirdre Murphy, personal communication). In March of 1990, a "fish kill" was reported by MDE in which approximately 100 yellow perch, pumpkinseed sunfish and gizzard shad were found in Dark Head Creek (Charles Poukish, personal communication). No probable cause for the "fish kill" was determined.

3.2 Water Column Toxicity Tests

The objectives of the water column toxicity tests were to determine the toxicity of ambient water at two stations each in the Nanticoke, Wye and Middle Rivers. The following tests were conducted at these six stations during the fall of 1992 and the spring 1993: 8 day sheepshead minnow survival and growth test; 8 day larval grass shrimp survival and growth test; 8 day *E. affinis* life cycle test and two 48 hour coot clam embryo/larval tests. A suite of metals and organics was also measured in ambient water used for these tests.

3.2.1 Test species

Larval sheepshead minnows, larval grass shrimp and the copepod *E. affinis* have been used in the previous two year pilot ambient toxicity testing study. These tests species were selected because they meet most of the following criteria: (1) resident Chesapeake Bay species, (2) sensitive to contaminants in short time period (less than 10 d) and (3) standard test organism that does not require additional research. Both larval sheepshead minnows and larval grass shrimp are highly abundant, resident Chesapeake Bay organisms used extensively in standard tests. Sheepshead minnows have demonstrated moderate sensitivity in subchronic tests. Juvenile and adult grass shrimp are generally considered resistant species, however, larvae have been used to report biological effects in previous ambient tests (Table 3.1). *E. affinis* is an extremely abundant, resident Chesapeake Bay zooplankton species that is sensitive to contaminants. This copepod is not a standard test organism. However, we have conducted successful life cycle

Table 3.1 Summary of water column test species responses from 1990 and 1991 ambient toxicity testing.

Test Species	Number of Tests	Number of Tests with Significant Effects	Percent of Tests with Significant Effects
E. affinis	16	2	12.5
Sheepshead Minnow	16	5	31
Grass Shrimp	16	2	12.5
Mysid Shrimp	8	0	0
Ceriodaphnia *sp* (freshwater)	4	1	25
P. promelas (freshwater)	3	0	0

toxicity tests with this species during the past two years of ambient testing and a detailed method for conducting life cycle toxicity tests with *E. affinis* has been published in the primary literature (Hall et al., 1988).

A summary of significant adverse effects (mortality, reduced growth, etc.) reported from ambient toxicity testing with these species in 1990 and 1991 is presented in Table 3.1. Results from these previous ambient toxicity studies demonstrates that the top three species can detect toxic conditions in ambient salt water. Mysid shrimp were not used in year 3 because they were not sensitive to ambient water during the second year of testing and they are not resident to the Chesapeake Bay. *Ceriodaphnia* and fathead minnows were not used because they are freshwater species and we did not test any freshwater stations during this study.

The coot clam, *M. lateralis*, was a new species tested during year 3. This clam is a small (< 2 cm length) euryhaline bivalve. It is a numerically dominant species in the mesohaline areas of the Chesapeake Bay as well as numerous tributaries (Shaughnessy et al., 1990). Embryo/larval development occurs in the water column in approximately 6-8 days. It is, therefore, suitable for water column testing because the sensitive life stage occurs in the water column. The coot clam adds another dimension to the suite of test organisms because it represents a class of organisms (bivalves) not presently represented. This clam is not a standard test organism, however, the U.S. EPA has written a draft test method for estimating toxicity of effluents using *Mulinia* (Morrison and Petrocelli, 1990a).

3.2.2 Test Procedures

Test procedures and culture methods previously described in the year 1 report for the 8 day sheepshead minnow survival and growth test, 8 day larval grass shrimp survival and growth test and 8 day *E. affinis* life cycle test were used for this study (Hall et al., 1991). The sources for these species were as follows: sheepshead minnows, Aquatic Biosystems, Denver, Colorardo; grass shrimp, S.P. Engineering and Technology, Salem, Massachusetts, and *E. affinis*, in-house cultures (orginally from University of Maryland - Chesapeake Biological Laboratory).

3.2.2.1 Coot Clam

Methods proposed for culturing and testing the coot clam were modified from Morrison and Petrocelli (1990a). Adult brood stock were obtained from U.S. EPA laboratory in Narragansett, Rhode Island and Virginia Institute of Marine Science in Wachapreaque, Virginia. Cultures were maintained in our laboratory at test salinities of 15 ppt and temperatures of 25°C with a photoperiod of 16:8 (L:D.). Adult clams were held in 18L glass aquaria containing 2.5 cm of sandy substrate. The clams were fed four times weekly with a 2L phytoplankton mixture (50/50 v/v) of *Tetraselmus suecica* and *Isochrysis galbana*. Phytoplankton were cultured in F/2 media following the procedures described by Guillard (1975).

Embryos used for testing were obtained by spawning approximately 20 fertile adult clams. The animals were placed in a crystallization dish and covered with clean culture water. The dish was chilled to 4°C in a refrigerator, then rapidly warmed to 28°C in a hot water bath. After several animals had released gametes, the eggs and sperm were suspended and mixed. Fertilization was confirmed by examining the eggs microscopically at 100 x magnification. Fertilized eggs were readily observed by shape, uniform color and presence of polar body. Eggs were collected and concentrated in a beaker by passing them through a 72um mesh screen.

Ambient toxicity tests were conducted in 20 ml glass scintillation vials with 3 replicates per condition (ambient water and control). Each vial contained 10 ml of test solution and approximately 750 embryos that were 2 hours old or less. To determine the amount of embryo stock to add to each vial, 750 was divided by the number of embryos/ml in stock solution. Between 0.1 and 0.2 ml embryo stock were added to each vial.

Embryos were counted by diluting the stock solution of embryos 1:20. One ml was sampled from the diluted stock and dispensed into a Sedgwick-Rafter counting chamber. The number of embryos in the chamber was usually between 188 and 375. This number was multiplied by 20 to determine the number of embryos in stock solution. There were between 3,750 and 7,500 embryos per ml. Vials were then capped and placed in a biological incubator to control temperature (25°C) for 48 hours. The test was terminated by adding 0.5 ml of formalin to each vial following 48 hours of exposure. One hundred larvae per replicate were examined under a microscope (100 x) for shell development by transferring larvae and solution from the bottom of a test vial to a counting chamber. Test results were evaluated by determining the reduction of the proportion of clams with normal shell development. Test organisms from the ambient water were compared with the controls. Two 48 hour tests were conducted per site during each 8 day testing period. Each test was conducted with a different batch of water.

3.2.3 Statistical Analysis

Statistical tests described in Fisher et al. (1988) and Hall et al. (1988) were used for each test species when appropriate. The goal of this study was not to generate typical LC50 data with various dilutions of ambient water. For each test species response, a control was compared with one test condition (100 percent ambient water). A simple T-test was used for this comparison. A statistical difference between the response of a species exposed to a control condition and an ambient condition was used to determine toxicity. Analysis of Variance or Dunnetts Procedures was used in cases where comparisons of a species response on a spatial or temporal scale was necessary.

3.2.4 Sample Collection, Handling and Storage

Sample collection, handling and storage procedures used in the previous pilot study were implemented (Hall et al., 1991). Ambient water was collected from all study areas and taken to our toxicity testing facility at the Wye Research and Education Center, Queenstown, Maryland for testing.

Grab samples were used because they are easier to collect, require minimum equipment (no composite samplers), instantaneous toxicity is evaluated, and toxicity spikes are not masked by dilution. Grab samples collected from each station represented a composite of the water column (top, mid-depth and bottom). A metering pump with teflon line was used to collect samples in 11.25 L glass containers.

The time lapsed from the collection of a grab sample and the initiation of the test or renewal did not exceed 72 hours. Samples were collected on days 0, 3 and 6 during the 8 day tests. All samples were chilled after collection and maintained at 4°C until used. The temperature of the ambient water used for testing was 25°C. Salinity adjustments (increase) were performed on samples collected from saline sites to obtain a standard test salinity of 15 ppt.

3.2.5 Quality Assurance

A copy of our Standard Operating Procedures (SOP) Manual was submitted and approved by the sponsor prior to the study (Fisher et al., 1988). Standard Quality Assurance (QA) procedures used in our laboratory for The State of Maryland's Effluent Toxicity Testing Program were followed (Fisher et al., 1988). These QA procedures were used during the previous two years of ambient toxicity testing study.

Two control water conditions were used during the October testing period. Grass shrimp and *Mulinia* control water consisted of reconstituted water (reverse osmosis) with Hawaiian Marine synthetic sea salts. *Eurytemora* control water was prepared by adding Hawaiian (HW) Marine sea salts to autoclaved estuarine water (DeCoursey Cove). Two control conditions designated EST-Control for the DeCoursey Cove water and H W-Control for the reconstituted (RO) water with sea salts were used in the larval sheepshead test. The EST-Control was the true control used for statistical analyis. The synthetic control condition was used as an experimental condition to compare with the growth data from the EST-Control. One control water condition consisting of Indian River Water (Indian River Inlet, Delaware) diluted to 15 ppt with RO water was used for all species during the April testing period.

Acute reference toxicant tests with cadmium chloride were conducted with the same stocks of species used for ambient toxicity tests. Cadmium chloride was selected as the reference toxicant because there was an established data base with this chemical for all of the proposed tests species except the coot clam. Reference toxicity tests were used to establish the validity of ambient toxicity data generated from toxicity tests by ensuring that the test species showed the expected toxic response to cadmium chloride (Fisher et al., 1988). The reference toxicant tests were conducted on each test species and source (of species) once during this study using procedures described in Hall et al., 1991.

3.2.6 Contaminant Analysis and Water Quality Evaluations

The contaminant analyses proposed for these studies provided limited information on selected contaminants that may be present in the study areas. It was not our intention to suggest that the proposed analysis for inorganic and organic contaminants would provide an absolute "cause and effect relationship" between contaminants and biological effects if effects were reported. Information on suspected contaminants in the study areas may, however, provide valuable insights if high potentially toxic concentrations of contaminants were reported in conjunction with biological effects.

Aqueous samples for analysis of organic and inorganic contaminants listed in Table 3.2 were collected during the ambient toxicity tests. These contaminants and methods for their measurement have been evaluated in our previous ambient toxicity testing study (Hall et al., 1991). Analytical procedures and references for analysis of these samples are presented in Table 3.3. Total inorganic contaminant analysis were conducted on filtered samples using 0.40 um polycarbonate membranes.

Four liter whole water samples were collected for organic contaminants analysis (Table 3.2). Organic contaminants other than those identified in Table 3.2 (non-target organics) were measured if GC/MS peaks were identified. Detailed procedures for preparing samples for inorganic and organic analysis are described in detail in Hall et al. (1988b). Contaminant analysis was conducted at least one time on aqueous samples collected from each station per experiment. Versar, Inc. was responsible for all organic and inorganic analyses.

Standard water quality conditions of temperature, salinity, dissolved oxygen, pH and conductivity was evaluated at each site after sample collection. These conditions were evaluated every 24 hours at all test conditions during the tests.

3.3 Sediment Toxicity Tests

All tests and analyses were conducted according to the SOPs and QA plans previously submitted to the sponsor. The methods described in this report are general summaries of those protocols.

3.3.1 Test Species

Sediment samples (100 percent ambient sediment samples) from six stations were tested using four organisms: eggs of the sheepshead minnow *Cyprinodon variegatus*, the amphipods *Lepidactylus dytiscus* and *Leptocheirus plumulosus*, and the polychaete worm *Streblospio benedicti*.

3.3.2 Test Procedures

All tests were conducted for 10 days at 25°C and monitored daily. Daily monitoring in the sheepshead test included the assessment of egg and larval mortality, hatching success and water

Table 3.2 Concentrations of the following organic and inorganic contaminants were evaluated in water.

Contaminant	Detection Limit (ug/L)
Aroclor 1248	0.050
Aroclor 1254	0.050
Aroclor 1260	0.050
DDE	0.02
Toxaphene	0.2
Chlordane	0.02
Perylene	0.70
Fluorene	0.90
Phenanthene	0.70
Anthracene	0.70
Fluoranthrene	1.1
Pyrene	1.0
Benz(a)anthracene	1.7
Chrysene	0.7
Arsenic	3.0
Cadmium	2.0
Chromium, total	3.0
Copper	2.0
Lead	2.0
Mercury	0.2
Nickel	5.0
Selenium	3.0
Zinc	5.0

Table 3.3 Analytical methods used for organic and inorganic analysis in water samples. The following abbreviations are used: GC-EC (Gas Chromatography - Electron Capture), GC-MS (Gas Chromatography - Mass Spectrometry), Atomic Emission - ICP (AE-ICP), AA-H (Atomic Absorption - Hydride), AA-F (Atomic Absorption - Furnace) and AA-DA (Atomic Absorption - Direct Aspiration) and AA-CV (Atomic Absorption - Cold Vapor).

Contaminant	Method	Method #	Reference
Halogenated Hydrocarbon Pesticides	GC-EC	608	U. S. EPA, 1984
Polychlorinated Biphenyls	GC-EC	608	U. S. EPA, 1984
Base-Neutral Extractable Organic Compounds	GC-MS	625	U. S. EPA, 1984
Arsenic	AA-H	206.3	U. S. EPA, 1979
Cadmium	AA-F	213.2	U. S. EPA, 1979
Chromium, Total	AA-F	218.2	U. S. EPA, 1979
Copper	AA-F	220.2	U. S. EPA, 1979
Lead	AA-F	239.2	U. S. EPA, 1979
Mercury	AA-CV	245.1	U. S. EPA, 1979
Nickel	AA-F	249.2	U. S. EPA, 1979
Selenium	AA-H	270.3	U. S. EPA, 1979
Zinc	AA-DA	289.1	U. S. EPA, 1979

quality parameters (Hall et al., 1991) until the end of the test. On day 10 of the *S. benedicti*, *L. plumulosus*, and *L. dytiscus* tests, mortalities were recorded, and the animals were returned to the original test containers. The organisms were then monitored daily for an additional 10 days. Numbers of live animals were recorded on day 20. Any living organisms were preserved for length and weight measurements.

The sediment samples were collected from two sites in the Wye River (Manor House, Quarter Creek), two sites in the Middle River (Wilson Point, Frog Mortar), and two sites in the Nanticoke River (Bivalve Harbor, Sandy Hill Beach). The salinity at all sites was between 8-14 parts per thousand (ppt) at sampling, except for the Middle River stations (Frog Mortar and Wilson Point) which were 5.1 ppt at sampling. All samples were adjusted to 15 ppt prior to testing by sieving with 15 ppt control water. Control sediments for each species consisted of native sediments from the area in which the test organisms were collected or naturally occur. Control and reference sediments (see below) were tested with each set of test samples. Reference sediments were employed to assist in determining any possible naturally occurring geochemical and physical conditions inherent to the sediment being tested which may influence mortality.

Sediment for performing particle size analysis was collected from each of the test stations several weeks prior to initiation of the toxicity tests, in order to select a reference sediment for each set of test samples. It was determined from the initial sediment collection and particle size analysis that the test sites ranged from 8.83 percent to 90.65 percent sand (Table 3.4). The initial sediment samples from Manor House and Quarter Creek were 36.20 percent and 8.83 percent sand, respectively. Particle size analysis of samples from Wilson Point and Frog Mortar revealed 90.65 percent and 81.41 percent sand, respectively, and Bivalve and Sandy Hill Beach had 80.67 percent and 68.60 percent sand, respectively. Because of the large range in particle size between test sites, two reference sediments were used with each organism per test. These reference sediments bracketed the sediment particle sizes found at the selected test sites; i.e., one reference sediment most closely matched the test site with highest sand proportion and one reference most closely matched the test site with highest silt/clay proportion. Reference and control sediments were designated as follows: (1) Lynnhaven sand, (2) Lynnhaven mud, and (3) Poropatank sediment. Lynnhaven mud was used as the control sediment for *S. benedicti* and *C. variegatus* eggs, Lynnhaven sand was used as the control for *L. dytiscus*, and Poropatank sediment was used as the control for *L. plumulosus*. Lynnhaven sand (100 percent sand) and Poropatank sediment (1.79 percent sand) bracket the particle size of all test samples and were therefore considered suitable as reference sediments as well. The actual test sediment samples were collected and again analyzed for sand, silt, and clay content. The particle size/composition of the test sediments (Table 3.5) were quite variable between replicates but median values were similar to those collected and

Table 3.4 Initial particle size analysis of sediments from six stations, references and controls used in toxicity tests. Samples were collected 9/16-9/22/92.

Station	% Sand	% Silt	% Clay
Manor House	36.20	25.45	38.35
Quarter Creek	8.83	34.01	57.15
Wilson Point	90.65	4.73	4.62
Frog Mortar	81.41	14.27	8.32
Bivalve	80.67	4.88	14.45
Sandy Hill Beach	68.60	7.48	23.92
Poropatank	1.78	36.76	61.46
Lynnhaven Mud	24.69	61.90	13.41
Lynnhaven Sand	100.00	0.00	0.00

Table 3.5 Particle size analysis of sediments from six stations and references and controls used in toxicity tests. Set #1 was collected 10/7/92. Set #2 was collected 4/15/93.

Station	% Sand	% Silt	% Clay
Set #1:			
Manor House R1	68.60	14.62	16.77
Manor House R2	85.89	5.62	8.48
Manor House R3	42.12	22.58	35.29
Manor House R4	40.57	21.26	38.17
Manor House R5	14.96	33.08	51.96
Quarter Creek R1	3.03	47.50	49.47
Quarter Creek R2	3.79	46.68	49.54
Quarter Creek R3	5.07	44.63	50.29
Quarter Creek R4	66.75	13.42	19.82
Quarter Creek R5	8.81	45.26	45.93
Wilson Point R1	79.54	11.41	9.05
Wilson Point R2	73.40	15.23	11.36
Wilson Point R3	22.38	46.88	30.74
Wilson Point R4	20.70	49.58	29.72
Wilson Point R5	7.37	44.81	47.81
Frog Mortar R1	85.27	9.92	4.81
Frog Mortar R2	84.50	10.34	5.15
Frog Mortar R3	23.73	34.19	42.07
Frog Mortar R4	42.20	28.69	29.12
Frog Mortar R5	3.05	65.04	31.92
Bivalve R1	78.88	9.30	11.82
Bivalve R2	76.12	10.96	12.92
Bivalve R3	67.51	14.64	17.85
Bivalve R4	51.66	33.80	14.54
Bivalve R5	30.72	33.46	35.82
Sandy Hill B. R1	58.68	20.34	20.98
Sandy Hill B. R2	7.22	45.56	47.22
Sandy Hill B. R3	6.35	44.34	49.31
Sandy Hill B. R4	17.65	25.33	54.02
Sandy Hill B. R5	8.64	42.69	48.67
Poropatank	1.78	36.76	61.46
Lynnhaven Mud	24.69	61.90	13.41
Lynnhaven Sand	100.00	0.00	0.00

Table 3.5 continued

Station	% Sand	% Silt	% Clay
Set #2:			
Manor House R1	85.97	7.20	6.82
Manor House R2	53.40	20.94	25.66
Manor House R3	31.73	31.81	36.46
Manor House R4	12.62	33.69	53.69
Manor House R5	14.41	36.13	49.46
Quarter Creek R1	3.11	50.13	46.77
Quarter Creek R2	90.87	3.18	5.96
Quarter Creek R3	9.27	38.98	51.75
Quarter Creek R4	78.81	7.20	13.99
Quarter Creek R5	82.86	4.91	12.23
Wilson Point R1	51.19	22.95	25.87
Wilson Point R2	65.06	16.77	18.18
Wilson Point R3	87.67	3.36	8.97
Wilson Point R4	71.28	15.40	13.32
Wilson Point R5	17.20	37.93	44.87
Frog Mortar R1	87.82	6.71	5.47
Frog Mortar R2	21.96	44.58	33.46
Frog Mortar R3	3.96	54.40	41.64
Frog Mortar R4	0.54	45.39	54.07
Frog Mortar R5	1.31	49.24	49.45
Bivalve R1	83.00	7.26	9.75
Bivalve R2	82.64	6.43	10.93
Bivalve R3	92.81	2.38	4.81
Bivalve R4	58.47	23.28	18.25
Bivalve R5	66.26	14.56	19.18
Sandy Hill B. R1	8.83	44.80	46.37
Sandy Hill B. R2	52.08	23.48	24.44
Sandy Hill B. R3	8.47	42.96	48.57
Sandy Hill B. R4	4.63	49.54	45.83
Sandy Hill B. R5	25.02	46.75	28.23
Poropatank	9.72	69.19	21.08
Lynnhaven Mud	3.60	40.65	55.75
Lynnhaven Sand	100.00	0.00	0.00

analyzed initially.

Culture and maintenance procedures used for *S. benedicti* and the amphipod *Lepidactylus dytiscus* are as described in Hall et al. (1991). *Leptocheirus plumulosus* and the sheepshead minnow egg test were not used in year 2 of this study, therefore, culture and maintenance procedures for this organism are described below.

3.3.2.1 *Cyprinodon variegatus*

Cyprinodon variegatus adults were maintained in accordance with laboratory tested methods and guidance from general literature. Animals were cultured at 20 ppt salinity in 20 gallon holding tanks maintained at ambient laboratory light and temperature (approx. 20°C). Adult breeders were maintained in a 200 gallon tank in an elevated "breeder" basket at 20 ppt salinity 25 C and a 16L:8D photoperiod. Breeders were fed a commercial marine blend flake food by automated apparatus 10 times per day and supplemented with *Artemia* nauplii twice daily. Eggs were collected daily below the baskets and transferred to clean one gallon aquaria. These aquaria were then placed into 25°C incubators and aerated. Approximately 90 percent water changes were performed until the eggs were 48 hours old when they were ready for placement into test chambers.

A series of test containers was set up according to the methods outlined in the ASTM "Standard Guide for conducting solid-phase 10 day static sediment toxicity tests with marine and estuarine amphipods" (ASTM, 1990). Two centimeters of sediment were placed into each of five replicate 2 liter test containers with 750 ml of overlying water. Ten 48 hour old embryos were placed into a cylindrical mesh egg chamber. The chamber was then gently placed into the sediment such that the sediment passed through the bottom mesh and was allowed to contact the eggs. Control sediment consisted of mud (Lynnhaven mud). Test containers were monitored daily for oxygen, temperature, and pH. Number of animals live/dead eggs, live/dead larvae, and number hatched was also recorded. The fish were not fed. The test was performed a total of ten days from test initiation or two days post hatch for all controls whichever occurred first.

3.3.2.2 *Leptocheirus plumulosus*

Leptocheirus plumulosus cultures were maintained in accordance with laboratory tested methods and guidance from DeWitt et al (1992). Animals were cultured at 20 ppt salinity in 20 gallon tanks maintained at ambient laboratory light and temperature (approx. 20°C). One to two cm of native sediment was placed on the bottom of the culture tanks and enriched with food supplement weekly. Food consisted of approximately 50:50 mixture of ground commercial marine flake food and powdered alfalfa. Fifty percent water changes were performed weekly. Animals were harvested on a monthly basis and were either used for testing, culture expansion, or simply culled. Culture tanks are constantly gently aerated and filtered. Test animals were collected for testing by siphoning the culture sediment from the tanks and passing it through a stacked series of sieves. Those animals which passed through a 710 micron sieve but were retained on a 500 micron sieve were used for the tests. When insufficient numbers of organisms were obtained from ongoing cultures, animals were collected from the field. Field collected animals were brought to the laboratory, acclimated, and held for a minimum of 48 hours for observation before being used in tests. The general health of the population was assessed, and any unhealthy or damaged organisms were discarded. All tanks holding amphipods were fed as described above. Fifty percent weekly water changes were also performed. Field collected animals were used in tests evaluating toxicity of sediments collected in the fall 1992 sampling period, while lab reared animals were used in the spring tests.

A series of test containers was set up according to the methods outlined in the ASTM "Standard Guide for conducting solid-phase 10 day static sediment toxicity tests with marine and estuarine amphipods" (ASTM, 1990). Two centimeters of sediment were placed into each of five replicate 1 liter test containers with 700 ml of overlying water. Twenty animals were added to each test vessel and monitored for 10 days. Control sediment consisted of mud (Poropatank). A subset of the test animal population was selected for initial length and weight measurements. All length measurements were conducted using the Optimas Image Analysis system. Test containers were monitored daily for oxygen, temperature, and pH. Number of animals emerged from the sediment was also recorded. The amphipods were fed 25 mg of ground *Ulva* spp./Tetramin flake food in a 3:1 ratio per test container every three days throughout the duration of the test. At the end of ten days, animals were sieved from test containers and mortality was recorded. Surviving animals were then returned to the test containers for an additional 10 day period. On day twenty, animals were again sieved from the containers and mortality recorded. Any live amphipods were then placed into vessels containing control sediment and allowed to rebury. Reburial behavior was recorded after one hour. Animals were then resieved from the containers and preserved for growth measurements.

3.3.3 Statistical Analysis of Sediment Data

The goal of this study was not to generate LC50 data from dilution series tests. The main objective was to evaluate for each test species, the response (mortality, growth, etc) when tested in 100 percent ambient sediment, as compared to a control. Statistical differences between the responses of species exposed to control and ambient sediments were used to determine the toxicity. Evaluations relative to particle size effects were made based on the response seen in the reference sediments. Sheepshead egg data were evaluated using ANOVA contrasts and compared to the controls. Evaluation of total mortality was assessed by combining egg mortality, larval mortality, and unhatched eggs remaining at the termination of the test. Unhatched eggs were included as mortality based upon previous observations and the assumption that probability of hatching and thus survival decreases essentially to zero by test termination.

For all other tests the statistical approaches that were employed in the first two years of the study (Hall et al., 1992) were again utilized in the third year. Basically, the analyses consisted of analysis of variance (ANOVA) models with *A. priori* tests of each treatment contrasted to the controls. Arcsine transformations were used for the percent mortality data. Mortality was corrected for particle size effects using the regression equations presented in year 2 of the study. Length and weight were expressed as percentage of change from the initial length and weight measurements.

3.3.4 Sample Collection, Handling and Storage

The general sediment sample collection, handling, and storage procedures described in Hall et al. 1991 were used in this study. Sediment samples were collected at each site by Applied Marine Research Laboratory (AMRL) personnel and returned to the laboratory for testing. The first set of sediments was collected October 7, 1992 by petite ponar grab. The second set of sediment samples was collected by petite ponar grab on April 15, 1993 at the same sites.

Unlike the 1990 and 1991 studies in which composite samples were collected, true field replicates were maintained separately for transport to the laboratory. Sediment was collected at each site by first randomly identifying 5 grab sample locations along a 100 meter square grid. At each site a discrete field subsample was collected for bioassays and stored on ice. A separate subset from the same ponar grab series was placed into a handling container. Subsamples from all 5 sites within a station were serially placed into the same handling container. When all 5 sites within the station had been sampled, the entire batch was homogenized and distributed into the sample containers designated for chemical analyses. All samples were transported on ice, out of direct sunlight. Bioassay samples were held in refrigerators at 4°C until initiation of the toxicity tests. Samples for chemical analysis were frozen and stored until tested. All samples were analyzed within EPA recommended holding times.

3.3.5 Quality assurance

All quality assurance procedures submitted previously to the sponsoring agency were implemented following the testing protocols and associated SOPs (Standard Operating Procedures). Laboratory quality assurance procedures for sediment and pore water and inorganic and organic chemical analyses followed EPA Standard Quality Assurance Guidelines.

Toxicity test sediment controls consisted of sediment from sites where either the animals were collected, or the animals are naturally resident. Reference sediments were used to compare the effects non-toxicity related parameters such as sediment particle size, ammonia, nitrate, and total organic carbon (TOC) had on the test animals. Because of the apparent notable effect particle size has upon survival, and the large heterogeneity of particle size at the sites, two references sediments (high percent sand, high percent silt/clay) were used for *C. variegatus* and *S.*

benedicti to bracket the particle sizes encountered at the test sites. Only one reference was used for each of the amphipods. It was necessary to use only one reference because the control sediment for each animal represented one end of the particle size scale in each case. The control for the *L. dytiscus* was at the high end of the sand scale, while the control for L. plumulosus represented the high end of the silt/clay scale. Other physico-chemical parameters were measured for comparison, but not controlled for in the references.

Static acute non-renewal water-only reference toxicant tests were performed for each species during each sampling period. Cadmium chloride was used as a reference toxicant for each animal because the existing laboratory data base is available for this chemical. Reference toxicant information was used to establish the validity and sensitivity of the populations of animals used in the sediment test. Seasonal changes in sensitivity has been observed previously in *L. dytiscus* (Deaver and Adolphson, 1990), therefore consideration of this QA reference data is paramount to proper interpretation.

3.3.6 Contaminant and Sediment Quality Evaluations

Contaminants were evaluated concurrently with toxicity tests. It was not our intention to suggest that the presence of inorganic and organic contaminants provide an absolute "cause and effect" relationship between contaminants and any observed biological effects. Information on suspected contaminants does however, provide valuable insights if high concentrations of potentially toxic contaminants were reported in conjunction with biological effects.

Sediment samples for organic contaminants analysis were collected in conjunction with bioassay sediment samples. The contaminants assayed are listed in Tables 3.6 and 3.7. Organic analytical procedures used were in accordance with USEPA methods 3550 and 8270 (USEPA, 1986) and are detailed in Hall et al. (1991). Samples were analyzed for organochlorine pesticides (OCP) as well as polychlorinated biphenyls (PCBs) in accordance with USEPA Methods 3550 and 8080 (Tables 3.6 and 3.7). Organic analysis was conducted at both samplings (Set 1 and Set 2) for all sites.

All sediment samples were analyzed for acid volatile sulfides (AVS) and Total Organic Carbon (TOC). Samples were frozen until analysis, at which time they were thawed, then homogenized by gently stirring. Sediment samples were analyzed for AVS using the method of DiToro et al., (1990). Details of the analytical procedures for both AVS and TOC are described in Hall et al., 1991. Pore water samples were removed from all sediment samples by squeezing with a nitrogen press. All pore water samples were filtered then frozen until analyses of ammonia, nitrite and sulfides were conducted. These analyses were conducted on all samples. Details of the methods are described in Hall et al., 1991.

All sediment samples were analyzed for the following bulk metals: aluminum, cadmium, chromium, copper, lead, nickel, tin and zinc, using an ICP following USEPA/SW-846, Method 6010 (see Hall et

Table 3.6 Semi-volatile organic compounds analyzed, utilizing a user-created calibration library. Sediment method detection limits (MDL) are reported in µg/kg dry weight.

CAS NO.	COMPOUND	SEDIMENT MDL
65-53-3	Aniline	14.5
95-57-8	2-chlorophenol	13.2
111-44-4	Bis(2-chloroethyl)ether	11.2
108-95-2	Phenol	11.9
541-73-1	1,3-dichlorobenzene	11.9
106-46-7	1,4-dichlorobenzene	12.5
95-50-1	1,2-dichlorobenzene	11.9
100-51-6	Benzyl alcohol	27.1
39638-32-9	Bis(2-chloroisopropyl)ether	5.9
95-48-7	2-methylphenol	15.8
91-57-6	2-methylnaphthalene	9.2
67-72-1	Hexachloroethane	21.8
621-64-7	n-nitroso-di-n-propylamine	13.2
106-44-5	4-methylphenol	13.9
98-95-3	Nitrobenzene	11.2
78-59-1	Isophorone	6.6
88-75-7	2-nitrophenol	27.1
65-85-0	Benzoic acid	18.5
105-67-9	2,4-dimethylphenol	15.8
111-91-1	Bis(2-chloroethoxy)methane	9.9
120-83-2	2,4-dichlorophenol	21.8
120-82-1	1,2,4-trichlorobenzene	15.2
91-20-3	Naphthalene	4.6
106-47-8	4-chloroaniline	26.4
87-68-3	Hexachlorobutadiene	22.4
59-50-7	4-chloro-3-methylphenol	20.5
77-47-4	Hexachlorocyclopentadiene	25.7
88-06-2	2,4,6-trichlorophenol	37.0
95-95-4	2,4,5-trichlorophenol	44.9
88-74-4	2-nitroaniline	37.6
91-58-7	2-chloronaphthalene	9.9
208-96-8	Acenaphthalene	5.9
84-66-2	Dimethylphthalate	9.9
606-20-2	2,6-dinitrotoluene	48.2
99-09-2	3-nitroaniline	247
83-32-9	Acenaphthene	9.9
51-28-5	2,4-dinitrophenol	43.6
132-64-5	Dibenzofuran	7.9
100-02-7	4-nitrophenol	268

Table 3.6 continued

CAS NO.	COMPOUND	SEDIMENT MDL
121-14-2	2,4-dinitrophenol	43.6
86-73-7	Fluorene	9.9
7005-72-3	4-chlorophenylphenylether	20.5
84-66-2	Diethylphthalate	9.9
100-01-6	4-nitroaniline	279
534-52-1	4,6,-dinitro-2-methylphenol	122
86-30-6	n-nitrosodiphenylamine	19.1
101-55-3	4-bromophenylphenylether	41.6
85-01-8	Phenanthrene	9.2
118-74-1	Hexachlorobenzene	37.6
87-86-5	Pentachlorophenol	136
120-12-7	Anthracene	9.9
84-74-2	Di-n-butylphthalate	5.9
206-44-0	Fluoranthene	10.6
129-00-0	Pyrene	10.6
85-68-7	Butylbenzylphthalate	17.8
56-55-3	Benzo(a)anthracene	17.8
218-01-9	Chrysene	14.5
91-94-1	3,3'-dichlorobenzidine	101
117-81-7	Bis(2-ethylhexyl)phthalate	12.5
117-84-0	Di-n-octylphthalate	7.3
205-99-2	Benzo(b)fluoranthene	13.9
207-08-9	Benzo(k)fluoranthene	13.9
50-32-8	Benzo(a)pyrene	15.2
193-39-5	Indeno(1,2,3-cd)pyrene	16.5
53-70-3	Dibenz(a,h)anthracene	17.8
191-24-2	Benzo(ghi)perylene	16.5
103-33-3	Azobenzene	7.3
92-87-5	Benzidine	24.4

Table 3.7 Method detection limits for organochlorine pesticides and PCBs. Detection limits for sediment are reported in µg/kg dry weight.

CAS NO.	COMPOUND	SEDIMENT MDL
391-84-6	α-BHC	0.714
301-85-7	β-BHC	0.559
391-86-8	δ-BHC	1.062
58-89-9	Lindane	0.616
76-44-8	Heptachlor	0.819
309-00-2	Aldrin	0.608
1024-57-3	Heptachlor epoxide	0.570
959-98-8	Endosulfan I	0.859
60-57-1	Dieldrin	0.898
72-55-9	4,4'-DDE	0.528
33213-65-9	Endosulfan II	0.745
72-20-8	Endrin	1.240
72-54-8	4,4'-DDD	0.469
1031-07-8	Endosulfan sulfate	1.500
50-29-3	4,4'-DDT	3.420
72-43-5	Methoxychlor	5.0
57-74-5	Chlordane	5.0
80001-35-2	Toxaphene	10.0
2385-85-5	Mirex	1.000
7421-93-4	Endrin aldehyde	2.410
12574-11-2	Aroclor 1016	16.6
11104-28-2	Aroclor 1221	16.6
11141-16-5	Aroclor 1232	16.6
53469-21-9	Aroclor 1242	16.6
12672-29-6	Aroclor 1248	16.6
11097-69-1	Aroclor 1254	16.6
11096-82-5	Aroclor 1260	16.6

al., 1991). In addition, a Simultaneously Extractable Metals (SEM) analysis was conducted on all samples to use with the AVS data to determine the potential toxicity of the sediment due to metals. The sample for the SEM analysis was obtained from a step in the AVS procedure. The AVS method was detailed in Hall et al. 1991. The SEM sample was the sediment suspension remaining in the generation flask after the cold acid extraction had been completed. The sediment suspension was filtered through a 0.2 micron membrane filter into a 250 ml volumetric flask. The sample was then diluted to volume with deionized water. The concentrations of the SEM were determined by EPA-600/4-79-020 Methods for Chemical Analysis of Water and Wastes (U.S. EPA, 1979). Cadmium, lead, copper, nickel, and zinc were determined by inductively coupled plasma atomic emission spectroscopy (ICP) following USEPA method number 200.7. Mercury was determined by cold vapor generation following USEPA method number 245.1. The concentrations were then converted to micromoles per gram dry sediment and were added together to give total SEM.

3.4 Analysis of Three Year Data Base

A series of summary statistical analyses were conducted in order to provide environmental managers with summary information concerning the relative toxicity of water and sediments from the collection areas. These analyses also provide quantitative indicators of the degree of confidence which may be given to differences between responses observed for "clean" ("reference") conditions and those seen for test media (water or sediments) of unknown quality. These analyses are based upon the summary composite indicies first developed for the toxicity axis of the "sediment quality triad" (Long and Chapman, 1985; Chapman, 1986; Chapman et al 1987, Chapman 1990). Recently, this approach has been modified to provide confidence limits on several optional composite indicies (Alden, 1992).

Although details of the approach can be found in Alden (1992), the overall approach can be summarized as follows. The entire toxicity data base (i.e., all lethal and sublethal data for all species) is utilized to form a composite index for each collection site, which is compared to a similar index for the reference sites(s). The "ratio-to-reference mean" (RTRM) method described in Alden (1992) involves a three step process (see Figure 3.5). In the first step, the values of the endpoints or their reciprocals (depending on direction of response, to make increasing values representative of a greater "impact") from the combined set of "test" and "reference" toxicity data are standarized by dividing the "reference" site means for each variable. Thus, the standardized reference site toxicity data should average to a value of 1, while the mean of the test site data will be variable, depending upon the degree of impact.

The second step in the process involves bootstrap simulations (see, for example, Efron, 1979a,b; Diaconis and Efron, 1983). The computer assembles "new" data sets containing randomly selected samples (with n = the number of samples in the original data sets) from both the "test" and "reference" groups. Mean values are

Figure 3.5 General Procedure for Calculating RTRM Indices and Confidence Limits

Assemble Data from Reference and Test Sites

⇓

Step 1: Data Standardization

- Standardize Data To RTRM Values by Dividing All Data By Means of Reference Data.

⇓

Step 2: Bootstrap Simulations

- Randomly Select 5 Replicates from Each Data Set;
- Calculate Means for Each Endpoint;
- Calculate Grand Mean Across Enpoints;
- Repeat 1,000 times;
- Calculate Median, 5^{th} and 95^{th} percentiles for Grand Means; These Represent the RTRM Index and 95% Confidence Limits.

⇓

Step 3: Plotting RTRM Indices

- Plot RTRM Index and Confidence Limits for Reference and Test Stations;
- Observe Whether Confidence Limits Overlap (No Overlap ≈ Statistically Significant Differences)

calculated for each variable in each group of the simulated data sets. The simulation process is repeated 1,000 times. The resulting output represents a rough approximation of the "universe" of possible mean values that could be produced by the data distributions of the two groups. Thus, the medians of grand means (i.e. 50^{th} percentile of the 1,000 grand means of all variable means) and probabilities representing confidence limits can be determined empirically (i.e. the 95% confidence limits are set by the 5^{th} and 95^{th} percentiles), without assumptions concerning the data distributions.

For an example of steps 1 & 2 of the procedure, hypothetical data sets for mortality of organisms in replicate treatments exposed to sediments could be 5%, 10%, 15%, 5%, and 10% for a "reference" site (mean = 9%) and 30%, 40%, 50%, 30%, and 55% for a "test" site (mean = 41%). All data are divided by the mean of the "reference" mortalities (9%) to produce RTRM-standardized data: 0.55, 1.11, 1.67, 0.55, and 1.11 (mean = 1.0) for the "reference" data set; and 3.33, 4.44, 5.55, 3.33, and 6.11 (mean = 4.56) for the "test" site. Randomly selected groups of 5 values (i.e. random selection with replacement) are taken from each of these two standardized data sets by the process of Bootstrap Simulation. Mean values are calculated for the simulated "reference" and "test" data sets and the process is repeated at least 1,000 times. The median, 5^{th} percentile, and 95^{th} percentile are calculated for the two data sets consisting of the 1,000 simulated means for each site. For the hypothetical example, the method produced values of 0.99 (confidence limits = 0.77 to 1.44) for the "reference" site and 4.53 (confidence limits = 3.76 to 5.42) for the "test" site. Thus, for this example, the median RTRM index for the "test" data set is well above 1.0 and the confidence limits do not overlap with those of the "reference" site, so this difference is presumed to be statistically significant. In an actual example, more than one endpoint would have been processed at the same time and the data set of means would have been for the grand means of the means of all endpoints (i.e., the mean of the five replicates for each endpoint would have been averaged with the means of all other endpoints during each of the 1,000 simulation runs to produce a data set of grand means).

The third step of the process involves plotting the medians of the grand means and confidence limits of the "reference" and "test" data sets for comparison purposes. Highly impacted "test" sites should have medians which are higher than those of "reference" sites (i.e., >>1), with no overlap in the confidence limits. If these graphs are plotted on the same scale for various sites, they provide a visual summary of the relative degree of impact, as well as the variability of the responses. The summary composite indices for each site were calculated and plotted for the water column and sediment toxicity data sets.

Several deviations from the original method (Alden, 1992) were mandated by the structure of certain data sets. During the 1990 and 1991 studies, the sediments were collected as composites of numerous grabs and then split for testing as laboratory replicated. This is the traditional method of handling sediments for toxicity testing which is reflected in numerous ASTM and U.S. Army Corps of Engineers methods (e.g. ASTM, 1990; UASCOE, 1991). However, true field replicates were collected in 1992-1993 to comply more closely with the process and philosophy of the new method (Alden, 1992) for calculating the summary composite indices and confidence limits. Each of the true replicates for the 1992-93 data were compared to the reference site that most closely matched its particle size characteristics (e.g. sandy versus muddy). The degree of spatial variability incorporated in the 1992-1993 data would be expected to be greater than for the previous two years. Likewise, the water column testing protocols were for a renewal experimental design, so true field replicates cannot be followed through the experiment. Furthermore, laboratory replicates could not be followed through each of the experiments (i.e., replicate #1 in one experiment was not directly connected to replicate #1 in another; etc.) and the number of replicates for various experiments was variable due to a variety of logistical reasons. Therefore, the computer program for the bootstrap simulations was modified to randomly select each endpoint independently from the others in the simulation of each of the 1,000 observations.

SECTION 4

RESULTS

4.1 Water Column Tests

The following results from water column tests are presented below: toxicity data, contaminants data, water quality data and toxicity data from reference toxicant tests.

4.1.1 Toxicity Data

Survival, growth, percent normal shell development and reproduction data from the four estuarine tests conducted from 10/6/92 to 10/14/92 are presented in Tables 4.1 - 4.4. Control survival from the *E. affinis* tests (19 percent) were not acceptable. Therefore, comparisons of survival and reproduction data from the controls with various stations was not warranted. The reason(s) for poor control survival can not be definitively explained. Our speculation is that low survival in the controls may be related to the presence of metals in this water (see Section 4.1.2) or stressed cultures of this copepod. The source for the metals contamination is not known but to our knowledge this has not occurred before. The occurrence of stressed cultures of this copepod is another factor that may have contributed to the low survival. Survival was less than 66 percent (mean of 43 percent at all stations) at all test locations. This is unusually low survival for this species based on our previous studies (Hall et al., 1991; Hall et al., 1992).

Survival of sheepshead minnow larvae at all stations except the controls and Wye River-Manor House was greater than 85 percent after 8 days. Although the control survival was below an acceptable level (55 percent), the test was still valid according to our SOP because of the high survival in the other test conditions (Fisher et al., 1988). Low survival in the controls may have been related to contamination of the control water as previously discussed or unhealthy stock of larvae. The low survival of larvae in the Wye River-Manor House test condition (10 percent) was likely related to the presence of nematocysts from jellyfish that were found in the sample. There was no significant difference in growth when comparing controls with the various other test conditions.

Survival and growth of grass shrimp were not significantly reduced in ambient water from any of the stations when compared with the controls (Tables 4.1 and 4.2). The percent normal shell development for the coot clam was significantly reduced at both Middle River stations when compared with the controls (Table 4.3). This significant reduction in percent normal shell development at both Middle River stations occurred in both tests.

Survival, growth, percent normal shell development and reproduction data from the second set of experiments conducted from 4/13/93 to 4/21/93 are presented in Tables 4.5 to 4.8. A significant reduction in survival of *E. affinis* was reported at the Wye River-Quarter Creek station. Survival of this copepod at all other locations was not significantly different than the controls.

Table 4.1 Survival data from *E. affinis*, sheepshead minnow and grass shrimp after 8 d tests conducted at two stations in each of the following rivers: Nanticoke River, Wye River and Middle River. Experiments were conducted on 10/6/92 to 10/14/92.

		Cumulative Percent Survival Per Day							
Species	Station	1	2	3	4	5	6	7	8
E. affinis	Control								19
	Nanticoke - Sandy Hill								47
	Nanticoke - Bivalve								66
	Wye - Manor House								39
	Wye - Quarter Cr.								0
	Middle - Wilson Pt.								61
	Middle - Frog Mortar								46
Sheepshead Minnows	Control	100	100	100	100	90	70	60	55
	Nanticoke - Sandy Hill	100	100	90	90	90	90	90	85[a]
	Nanticoke - Bivalve	100	100	98	98	98	98	95	93[a]
	Wye - Manor House	38	18	18	15	15	13	13	10[ab]
	Wye - Quarter Cr.	100	100	100	100	95	93	90	88[a]
	Middle - Wilson Pt.	100	100	100	100	100	100	100	93[a]
	Middle - Frog Mortar	100	100	100	100	100	95	88	88[a]
Grass Shrimp	Control	100	100	100	100	100	100	100	94
	Nanticoke - Sandy Hill	100	100	100	100	100	100	100	96
	Nanticoke - Bivalve	100	100	100	100	100	100	100	96
	Wye - Manor House	100	100	100	100	96	96	96	96
	Wye - Quarter Cr.	100	100	100	100	100	100	100	100
	Middle - Wilson Pt.	96	96	96	96	96	96	96	92
	Middle - Frog Mortar	100	100	100	100	100	100	100	100

[a] Significantly different at $p \leq 0.05$ using the Dunnett's test
[b] Mortality likely caused by nematocysts from jelly fish.

Table 4.2 Growth data from sheepshead minnow larvae and grass shrimp larvae from the 10/6/92 to 10/14/92 experiments.

Sheepshead larvae dry weight (initial weight at day 0=0.14 mg)

Station	n	$\bar{x}$ (mg at d=8)	± S.E.
Control	20	0.27	0.17
Nanticoke-Sandy Hill	20	0.21	0.02
Nanticoke-Bivalve	20	0.40	0.08
Wye-Manor House	10	0.31	0.19
Wye-Quarter Cr.	20	0.31	0.04
Middle-Wilson Point	20	0.36	0.08
Middle-Frog Mortar	20	0.27	0.08

Grass Shrimp larvae dry weight (initial weight at day 0 = 0.13 mg)

Station	n	$\bar{x}$ (mg at d=8)	± S.E.
Control	20	0.62	0.02
Nanticoke-Sandy Hill	16	0.54	0.04
Nanticoke-Bivalve	20	0.63	0.05
Wye-Manor House	20	0.70	0.02
Wye-Quarter Cr.	20	0.69	0.05
Middle-Wilson Point	20	0.60	0.02
Middle-Frog Mortar	20	0.58	0.03

Table 4.3 Percent normal shell development from two 48h coot clam embryo/larval tests conducted from 10/9/92 to 10/11/92 (test 1) and from 10/12/92 to 10/14/92 (test 2).

Station	Test 1 Percent Normal ± S.E.		Test 2 Percent Normal ± S.E.	
Control	41	5	85	5
Nanticoke-Sandy Hill	63	8	92	2
Nanticoke-Bivalve	38	10	90	1
Wye-Manor House	50	2	91	2
Wye-Quarter Cr.	59	12	88	2
Middle-Wilson Pt.	0[a]	0	8[a]	2
Middle-Frog Mortar	0[a]	0	31[a]	13

[a] indicates significant difference with Kruskall Wallis or Dunnetts Test ($p \leq 0.05$).

Table 4.4 Reproduction (brood size) and proportion of gravid females for *E. affinis* for various test conditions from the 10/6/92 to 10/14/92 experiments.

E. affinis brood size comparisons following 8-d exposures.

Station	n	x nauplii produced	S.E.
Control	0	-	-
Nanticoke-Sandy Hill	4	39.5	4.6
Nanticoke-Bivalve	5	34.2	4.6
Wye-Manor House	5	41.6	6.5
Wye-Quarter Cr.	0	-	-
Middle-Wilson Pt.	0	-	-
Middle-Frog Mortar	2	54.5	1.5

Proportion of gravid females

Station	n	x percent females	± S.E.
Control	3	0	0
Nanticoke-Sandy Hill	3	24.7	2.6
Nanticoke-Bivalve	3	38.7	0.7
Wye-Manor House	3	34	8.7
Wye-Quarter Cr.	0	-	-
Middle-Wilson Pt.	3	51.0[a]	4.9
Middle-Frog Mortar	3	42.0	4.9

[a] Significant difference with Kruskal-Wallis Test ($p \leq 0.05$).

Table 4.5 Survival data from *E. affinis*, sheepshead minnow larvae and grass shrimp larvae after 8d tests conducted at 6 stations from 4/13/93 to 4/21/93.

Species	Station	Cumulative percent Survival per Day 1	2	3	4	5	6	7	8
E. affinis	Control								81
	Nanticoke-Sandy Hill								60
	Nanticoke-Bivalve								70
	Wye-Manor House								59
	Wye-Quarter Cr.								52[a]
	Middle-Wilson Pt.								64
	Middle-Frog Mortar								65
Sheepshead Minnows	Control	100	100	100	100	100	100	100	100
	Nanticoke-Sandy Hill	100	100	100	100	100	95	95	95
	Nanticoke-Bivalve	100	100	100	100	100	100	100	98
	Wye-Manor House	100	100	100	100	100	100	98	98
	Wye-Quarter Cr.	100	100	100	100	100	100	100	100
	Middle-Wilson Pt.	100	100	100	100	100	98	98	95
	Middle-Frog Mortar	100	100	100	100	100	100	100	100
Grass Shrimp	Control	100	96	96	92	92	88	88	88
	Nanticoke-Sandy Hill	100	100	100	100	100	96	96	96
	Nanticoke-Bivalve	100	96	96	96	96	96	96	92
	Wye-Manor House	100	92	92	92	92	92	92	84
	Wye-Quarter Cr.	100	100	100	100	100	96	84	76
	Middle-Wilson Pt.	100	96	96	96	96	96	96	96
	Middle-Frog Mortar	92	88	88	88	88	88	88	88

[a] significantly different at $p \leq 0.05$ using the Dunnett's Test.

Table 4.6 Growth data from sheepshead minnow larvae and grass shrimp larvae from the 4/13/93 to 4/21/93 experiments.

Sheepshead larvae dry weight (initial weight at day 0=0.16 mg)

Station	n	$\bar{x}$ (mg at d=8)	± S.E.
Control	18	1.79	0.12
Nanticoke-Sandy Hill	18	1.74	0.11
Nanticoke-Bivalve	18	1.53	0.08
Wye-Manor House	18	1.56	0.05
Wye-Quarter Cr.	18	1.43	0.07
Middle-Wilson Pt.	18	1.45	0.10
Middle-Frog Mortar	18	1.68	0.13

Grass shrimp larvae dry weight (initial weight at day 0=0.10)

Station	n	$\bar{x}$ (mg at d=8)	± S.E.
Control	22	0.41	0.02
Nanticoke-Sandy Hill	24	0.39	0.01
Nanticoke-Bivalve	24	0.40	0.01
Wye-Manor House	18	0.39	0.01
Wye-Quarter Cr.	19	0.38	0.02
Middle-Wilson Pt.	22	0.41	0.01
Middle-Frog Mortar	22	0.40	0.02

Table 4.7 Percent normal shell development from two 48h coot clam embryo/larval tests conducted from 4/16/93 to 4/18/93 (test 1) and 4/19/93 to 4/21/93 (test 2).

Station	Test 1 Percent Normal	±	Test 2 Percent Normal	±
Control	94.3	1.2	95.7	1.8
Nanticoke-Sandy Hill	72.7	16.4	59.3	15.8
Nanticoke-Bivalve	90.0	3.5	93.7	2.8
Wye-Manor House	92.3	2.4	96.0	1.2
Wye-Quarter Cr.	86.0	5.9	94.7	1.2
Middle-Wilson Point	22[a]	19.1	22.7[a]	16.5
Middle-Frog Mortar	0[a]	0	52.7[a]	17.7

[a] significantly different with Dunnett's Test ($p \leq 0.05$).

Table 4.8 Reproduction (brood size) and proportion of gravid females for *E. affinis* exposed to various test conditions from the 4/13/93 to 4/21/93 experiments.

E. affinis brood size comparisons following 8-d exposure.

Station	n	x nauplii produced	S.E.
Control	5	29.6	6.7
Nanticoke-Sandy Hill	4	35.8	6.8
Nanticoke-Bivalve	5	35.0	6.0
Wye-Manor House	5	36.4	6.9
Wye-Quarter Cr.	3	12.3	6.2
Middle-Wilson Pt.	5	33	6.0
Middle-Frog Mortar	5	35.8	3.6

Proportion of gravid females

Station	n	x % females	± S.E.
Control	3	36.6	8.0
Nanticoke-Sandy Hill	3	25.9	13.3
Nanticoke-Bivalve	3	32.6	7.7
Wye-Manor House	3	56.0	9.7
Wye-Quarter Cr.	3	45.6	18.5
Middle-Wilson Pt.	3	42.9	0
Middle-Frog Mortar	3	41.6	15.4

There was no statistical difference in mean number of nauplii produced or mean number of gravid females when all test conditions were compared with the controls (Table 4.8). However, it is noteworthy that the station with the lowest survival (Wye River-Quarter Creek) also had the lowest mean number of nauplii produced (12.3) when compared with the control value of 29.6.

Survival and growth of both sheepshead minnow larvae and grass shrimp larvae were not significantly lower in any of the ambient conditions when compared with the controls (Tables 4.5 and 4.6). The percent normal shell development for the coot clam was significantly lower in both tests at the Middle River-Wilson Point and Middle River-Frog Mortar stations when compared with the controls (Table 4.7). The percent normal shell development for the controls in both tests (>94 percent) was excellent.

4.1.2 Contaminants Data

Inorganic contaminants (trace metals) data from the six stations during both the fall and spring experiments are presented in Table 4.9. Concentrations exceeding recommended U.S. EPA chronic marine water quality criterion were underlined in the table (U.S. EPA, 1987). Detection limits for all metals were less than the EPA recommended chronic water quality criteria. Both copper and nickel were reported at potentially stressful concentrations in the fall control sample (exceeding recommended U.S. EPA marine chronic criteria) from one grab sample. This is the first time we have observed any potentially stressful concentrations of contaminants from the Wye Research and Education Center's laboratories' seawater system. As mentioned previously, we do not know the source of these metals.

Arsenic was below detection limits or only slightly above them at all stations. Cadmium was also below detection limits at all locations with the exception of the fall sample measured from the Middle River-Wilson Point station (2.7 ug/L). Total chromium ranging from 1.5 to 9.0 ug/L was detected at all stations during both experiments; however, none of these concentrations exceeded the EPA recommended water quality criterion of 50 ug/L. Concentrations of copper exceeding the EPA recommended marine chronic criterion of 2.9 ug/L were reported at both Middle River stations during the fall and spring. The State of Maryland's estuarine acute copper criterion of 6.1 ug/L was exceeded twice at Wilson Point and once at Frog Mortar (Maryland Department of the Environment, 1991).

Lead was detected at Sandy Hill, Quarter Creek, Wilson Point and Frog Mortar. The recommended EPA marine water quality criteria (5.6 ug/L) for this metal was exceeded at Wilson Point during the fall sample (9.8 ug/L). Values for both mercury and selenium were below detection limits at all stations. Nickel was detected at all six stations; water quality criterion was exceeded at both Middle River stations during the fall. Zinc was also detected at all stations and the criterion was exceeded at the Wilson Point station during the fall.

None of the organic contaminants listed in Table 3.2 were measured above detection limits in any of the samples collected

Table 4.9 Inorganic contaminants data from the six stations during the Fall (10/6/92 - 10/14/92) and Spring (4/13/93 - 4/21/93) experiments. Metals were measured in the control water in the Fall. The suite of metals was measured twice at Wilson Pt. and Frog Mortar during the Spring. All underlined values exceed the U.S. EPA chronic marine water quality criteria (WQC) (U.S. EPA, 1987).

		Station and Test													
Metals (ug/L)	WQC (ug/L)	Estuarine Control	Nanticoke Sandy Hill		Nanticoke Bivalve		Wye Manor House		Wye Quarter Cr.		Middle Wilson Pt.		Middle Frog Mortar	
		Fall	Fall	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall	Spr
As	-	1.6	<1.0	<2.0	1.1	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0	<2.0,<2.0	<1.0	<2.0,<2.0
Cd	9.3	<1.0	<1.0	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0	<2.0	2.7	<2.0,<2.0	<1.0	<2.0,<2.0
Cr	50.0	3.3	5.8	4.0	2.6	2.5	2.8	9.0	1.5	3.5	3.3	2.5, 2.5	2.1	2.5, 2.0
Cu	2.9	7.5	2.0	<2.0	<1.0	<2.0	<1.0	<2.0	<1.0	<2.0	10.1	3.3, 6.4	4.7	9.9, 4.8
Pb	5.6	<5.0	1.1	4.3	<1.0	<1.5	<1.0	<1.5	<1.0	2.8	9.8	<1.5, 3.5	<1.0	2.1, 1.5
Hg	0.025	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2,<0.2	<0.2	<0.2,<0.2
Ni	8.3	8.4	6.6	<5.0	3.0	<5.0	3.6	<5.0	2.4	<5.0	25.5	<5.0,13.9	10.4	<5.0,<5.0
Se	54	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0,<2.0	<2.0	<2.0,<2.0
Zn	86	20.8	48.1	10.5	10.5	3.2	27.5	<2.0	28.6	12.0	134.0	12.9,36.6	37.6	17.2,12.1

from the six stations during either the fall or spring experiments. Detection limits were generally below U.S. EPA recommended water quality criteria for those organics with published criteria. A minimum of one sample was analyzed from each station for each experiment.

4.1.3 Water Quality Data

Water quality parameters reported from grab samples collected three times at all stations during both experiments are presented in Table 4.10. The temperature and salinity of ambient water collected from all stations was adjusted to 25°C and 15 ppt before testing. Ambient water quality conditions appeared adequate for the survival of test species. Water quality conditions reported in test containers during testing are reported in Appendix A. All parameters appeared adequate for survival of test species.

4.1.4 Reference Toxicant Data

Forty-eight hour LC50 or EC50 values for the four test species exposed to cadmium chloride during reference toxicant tests are presented in Table 4.11. These toxicity values were compared with the values from the two previous years (except for the coot clam). Toxicity values for grass shrimp larvae, sheepshead minnow larvae and *E. affinis* nauplii in this study were similar to values reported in the first two years. Since the coot clam has not been tested in previous years, we can not make any annual comparisons from data collected in our laboratory. However, another investigator has previously reported a 48 hour EC50 of 0.010 mg/L for cadmium chloride with the embryo/larval stage of the coot clam (George Morrison, personal communication). This value is similar to our 48 hour EC50 of 0.005 mg/L. Data from the reference toxicant tests generally indicate that test species from various sources were healthy and ambient toxicity data were valid.

4.2 Sediment Tests

The following results from sediment toxicity tests are presented below: toxicity data, contaminants data, and data from reference toxicant tests. A summary of the water quality parameters monitored during each sediment toxicity test and the range of each parameter is included in Appendix B.

4.2.1 Toxicity Data

Survival results from toxicity tests of the six estuarine sediments from the Wye, Nanticoke, and Middle Rivers for amphipods, worms and Sheepshead minnow eggs are included in Tables 4.12 through 4.15. Those stations that were significantly different from the controls are so indicated. Growth data (mean length and dry weight) for amphipods and worms after 20 day exposure to sediments are included in Tables 4.16 and 4.17. Amphipod reburial data are shown in Tables 4.18 and 4.19.

Survival and growth data from toxicity tests conducted 10/17/92-11/6/92 on the first set of sediments from the six stations are summarized in Tables 4.12, 4.13 and 4.16. Survival in controls was greater than 92 percent and 65 percent at day 10 and

Table 4.10 Water quality parameters reported in the field during water sample collection for Fall 1992 and Spring 1993 ambient toxicity experiments. Stations were Nanticoke River Bivalve Harbor (NR-BH), Nanticoke River Sandy Hill Beach (NR-SHB), Wye River-Manor House (WR-MH), Wye River Quarter Creek (WR-QC), Middle River Wilson Point (MR-WP), and Middle River Frog Mortar Creek (MR-FMC).

Date	Station	Temp (C)	Salinity (ppt)	Cond umhos/cm	DO (mg/L)	pH
10/6/92	NR-SHB	16.0	10.0	13000	--	7.30
	NR-BH	16.0	14.0	14000	--	7.80
	WR-QC	17.0	13.5	18000	8.6	7.89
	WR-MH	17.0	11.1	16500	8.5	7.81
	MR-WP	14.0	5.5	6000	9.6	6.50
	MR-FMC	14.5	6.0	6500	9.6	6.58
10/9/92	NR-SHB	16.5	9.0	12500	9.2	7.31
	NR-BH	17.0	13.5	18000	9.4	7.85
	WR-QC	18.0	13.0	17500	9.0	7.86
	WR-MH	17.5	12.0	17000	8.6	7.85
	MR-WP	16.0	4.5	6000	9.2	6.25
	MR-FMC	16.5	4.5	6500	9.0	6.58
10/12/92	NR-SHB	16.5	9.0	12000	--	7.20
	NR-BH	16.0	13.0	17000	--	7.83
	WR-QC	17.0	13.5	18000	8.6	7.87
	WR-MH	17.5	13.5	17000	8.0	7.88
	MR-WP	15.0	4.5	6500	9.2	7.58
	MR-FMC	16.0	4.5	6500	9.0	7.49
4/13/93	NR-SHB	11.0	3.5	3900	10.2	6.9
	NR-BH	10.5	7.0	9000	11.0	7.3
	WR-QC	13.0	10.0	14000	11.1	8.1
	WR-MH	13.0	10.0	13000	10.7	7.8
	MR-WP	11.0	1.5	1450	10.6	7.5
	MR-FMC	11.0	1.25	1400	10.4	7.5
4/16/93	NR-SHB	15.0	4.5	6500	8.7	7.2
	NR-BH	15.0	8.9	12000	9.2	8.0
	WR-QC	15.0	11.0	15000	10.6	8.3
	WR-MH	14.9	9.9	14000	10.2	8.0
	MR-WP	14.0	1.0	1000	9.0	7.7
	MR-FMC	14.0	0.9	850	9.0	7.6
4/19/93	NR-SHB	14.0	3.0	4000	9.7	7.2
	NR-BH	14.0	7.5	10000	10.2	7.8
	WR-QC	16.0	10.5	14000	11.4	8.5
	WR-MH	16.0	8.0	12000	9.1	7.9
	MR-WP	13.0	1.0	1020	9.4	7.3
	MR-FMC	13.5	1.0	1200	9.6	7.6

Table 4.11 Toxicity data (48h LC50s or EC50s mg/L) from reference toxicant tests conducted with cadmium chloride for the four test species. Previous values from year 1 and 2 are reported.

Date	Species	48h LC50	Previous 48h LC50s Yr 1	Yr 2
12/1/92	Grass shrimp	1.34	0.502	0.23
11/17/92	Sheepshead minnow	1.18	0.510	1.54
11/17/92	*E. affinis*	0.12	0.021	0.095
1/27/93	Coot clam	0.005[a]	-----	-----

[a]value is an EC50 (percent normal shell development is the endpoint).

Table 4.12 Survival data from *L. dytiscus*, *L. plumulosus*, and *S. benedicti* at the six stations. Tests were conducted from 10/17/92 to 11/6/92. "(R)" = Reference, "(C)" = Control, "SE" = Standard Error.

Species	% Survival							
	Day 10				Day 20			
L. dytiscus	**Unadjusted**	**SE**	**Adjusted**	**SE**	**Unadjusted**	**SE**	**Adjusted**	**SE**
Station								
Manor House	51.00	12.79	60.74	13.30	37.00	10.91	51.71	13.69
Quarter Creek	44.00	7.31	62.21	6.97	22.00	8.60	48.42	7.37
Wilson Point	61.00	9.00	76.04	8.76	46.00	11.11	68.78	11.34
Frog Mortar	48.00	15.30	56.52	14.74	25.00	10.49	41.42	13.97
Bivalve	77.00	5.39	90.66	4.40	56.00	9.41	84.25	5.20
Sandy Hill Beach	49.00	11.34	70.32	16.75	25.00	6.32	62.58	17.59
Poropatank (R)	45.00	6.89	70.02	10.54	20.00	8.66	57.63	14.10
Lynnhaven Sand (C)	97.00	2.00	97.60	1.68	93.00	2.55	93.74	2.30
L. plumulosus								
Station								
Manor House	90.00	2.74			68.00	6.25		
Quarter Creek	97.00	2.00			86.00	6.60		
Wilson Point	96.00	2.45			87.00	5.15		
Frog Mortar	91.00	2.92			80.00	7.42		
Bivalve	94.00	2.92			79.00	4.85		
Sandy Hill Beach	87.00	5.61			71.00	5.34		
Poropatank (C)	95.00	2.24			82.00	3.39		
Lynnhaven Sand (R)	99.00	1.00			98.00	1.22		

Table 4.12 continued

Species	% Survival							
	Day 10				Day 20			
S. benedicti	**Unadjusted**	**SE**	**Adjusted**	**SE**	**Unadjusted**	**SE**	**Adjusted**	**SE**
Station								
Manor House	61.33	13.06	62.71	15.97	52.00	15.97	53.37	15.63
Quarter Creek	81.33	6.46	81.33	6.46	60.00	6.67	60.00	6.67
Wilson Point	86.67	5.96	88.21	5.26	78.67	6.46	79.44	6.74
Frog Mortar	86.67	5.58	89.33	6.53	73.33	5.96	81.33	8.27
Bivalve	77.33	5.42	80.17	5.48	68.00	11.04	78.51	10.32
Sandy Hill Beach	81.33	7.42	81.33	7.42	77.33	6.18	77.33	6.18
Poropatank (R)	89.33	7.48	89.33	7.48	73.33	5.96	73.33	5.96
Lynnhaven Mud (C)	92.00	3.27	92.00	3.27	65.33	4.90	65.33	4.90
Lynnhaven Sand (R)	60.00	10.95	77.65	13.40	42.67	12.04	73.35	17.04

* Significantly less than controls ($p<0.05$).

NOTE: Adjusted *L. dytiscus* and *S. benedicti* survival is percent survival adjusted for predicted particle size effects.

Table 4.13 Survival data from *C. variegatus* at the six stations. Tests were conducted from 10/17/92 to 11/6/92. "(R)" = Reference, "(C)" = Control, "SE" = Standard Error.

Species / *C. variegatus* / Station	% Survival	SE	%Hatched	SE	% Live Fish	SE	% Live Eggs	SE
Manor House	2.0	2.0	2.0	2.0	100.0	0.0	48.0	9.70
Quarter Creek	2.0	2.0	2.0	2.0	100.0	0.0	60.0	8.94
Wilson Point	12.0	12.0	12.0	12.0	100.0	0.0	38.0	13.93
Frog Mortar	0.0	0.0	0.0	0.0	*	*	46.0	10.30
Bivalve	10.0	7.8	10.0	7.8	100.0	0.0	54.0	4.00
Sandy Hill Beach	0.0	0.0	0.0	0.0	*	*	54.0	10.77
Poropatank (R)	0.0	0.0	0.0	0.0	*	*	78.0	5.83
Lynnhaven Sand (R)	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0
Lynnhaven Mud (C)	0.0**	0.0	0.0	0.0	0.0	0.0	35.0	11.90

Note: Survival = number of live larvae at termination of the test. Remaining live eggs were not included.

* Indicates no fish hatched in these replicates.

** Mortality presumed a result of insufficient oxygenation in high silt/clay sediment sites.

Table 4.14 Survival data from *L. dytiscus*, *L. plumulosus*, and *S. benedicti* at the six stations. Tests were conducted from 5/25/93 to 6/14/93. "(R)" = Reference, "(C)" = Control, "SE" = Standard Error.

Species	% Survival							
	Day 10				Day 20			
L. dytiscus	**Unadjusted**	**SE**	**Adjusted**	**SE**	**Unadjusted**	**SE**	**Adjusted**	**SE**
Station								
Manor House	46.00	10.54	63.16*	15.40	17.00	5.39	48.42	15.31
Quarter Creek	65.00	4.47	79.83	2.61	23.00	10.07	54.84	8.22
Wilson Point	69.00	6.78	81.50	5.46	27.00	7.18	61.20	12.64
Frog Mortar	62.00	8.46	83.08	8.57	17.00	4.06	67.44	13.59
Bivalve	83.00	4.64	91.79	3.75	31.00	5.79	71.19	6.79
Sandy Hill Beach	75.00	5.00	94.70	5.30	15.00	5.24	87.42	12.58
Poropatank (R)	22.00	10.32	32.96*	15.46	13.00	6.44	27.36*	13.71
Lynnhaven Sand (C)	90.00	3.54	91.13	3.37	77.00	6.44	80.24	5.53
L. plumulosus								
Station								
Manor House	74.00	9.41			37.00	4.64		
Quarter Creek	94.00	2.92			76.00	5.10		
Wilson Point	84.00	6.20			36.00	12.39		
Frog Mortar	63.00	4.06			27.00	16.55		
Bivalve	70.00	9.75			48.00	7.52		
Sandy Hill Beach	71.00	10.30			24.00	5.79		
Poropatank (C)	63.00	4.06			20.00	5.24		
Lynnhaven Sand (R)	9.00*	4.30			0.00*	0.00		

Table 4.14 continued

Species	% Survival							
	Day 10				Day 20			
S. benedicti	**Unadjusted**	**SE**	**Adjusted**	**SE**	**Unadjusted**	**SE**	**Adjusted**	**SE**
Station								
Manor House	96.00	2.67	96.00	2.67	93.33	2.11	93.33	2.11
Quarter Creek	98.67	1.33	100.00	0.00	96.00	1.63	97.33	1.63
Wilson Point	97.33	1.63	97.33	1.63	94.67	2.49	94.67	2.49
Frog Mortar	90.67	7.77	92.00	8.00	88.00	8.79	89.33	9.09
Bivalve	98.67	1.33	100.00	0.00	97.33	1.63	98.67	1.33
Sandy Hill Beach	90.67	3.40	90.67	3.40	86.67	4.22	86.67	4.22
Poropatank (R)	82.67	8.06	82.67	8.06	77.33	10.02	77.33	10.02
Lynnhaven Mud (C)	93.33	6.67	93.33	6.67	66.67	30.06	66.67	30.06
Lynnhaven Sand (R)	57.33	9.33	75.58	11.69	44.00	10.24	69.72	13.76

* Significantly less than the controls ($p<0.05$).

NOTE: Adjusted L. dytiscus and S. benedicti survival is percent survival adjusted for predicted particle size effects.

Table 4.15. Survival data from *C. variegatus* at the six stations. Tests were conducted from 5/25/93 to 6/14/93. "(R)" = Reference, "(C)" = Control, "SE" = Standard Error.

Species / *C. variegatus* / Station	% Survival	SE	%Hatched	SE	% Live Fish	SE	% Live Eggs	SE
Manor House	86.0	6.8	88.0	7.4	89.4	5.30	94.0	4.0
Quarter Creek	84.0	7.5	84.0	7.5	93.3	6.67	88.0	4.90
Wilson Point	90.0	3.2	94.0	4.0	96.0	2.45	94.0	4.0
Frog Mortar	90.0	4.5	94.0	4.0	95.8	2.59	94.0	4.0
Bivalve	88.0	3.7	94.0	2.5	91.6	3.81	96.0	2.45
Sandy Hill Beach	90.0	0.0	94.0	2.5	89.3	0.27	100.0	0.0
Poropatank (R)	90.0	3.2	92.0	2.0	97.8	2.22	92.0	2.0
Lynnhaven Sand (R)	92.0	3.7	94.0	4.0	95.5	2.78	96.0	2.45
Lynnhaven Mud (C)	90.0	4.5	96.0	2.5	93.6	2.64	96.0	2.45

Note: Survival = number of live larvae at termination of the test. Remaining live eggs were not included.

Table 4.16 Growth data (dry weight and length) for *L. dytiscus*, *L. plumulosus* and *S. benedicti* after 20-day exposure to Set 1 sediments. Initial weight and length represent the mean and SD of 5 replicates of 20 animals each species at the start of the test. Data for each replicate is the mean of the surviving animals from each. Tests were conducted 10/17/92 through 11/6/92. "(R)" = Reference, "(C)"= Control.

Site	# of True Replicates	Weight (mg)	S.E.	Length (mm)	S.E.
L. dytiscus					
Initial	5	0.623	0.034	4.61	0.168
Manor House	5	0.807	0.162	5.08	0.203
Quarter Creek	5	0.863	0.247	4.64	0.428
Wilson Point	5	1.016	0.178	5.00	0.242
Frog Mortar	5	0.778	0.138	4.52	0.264
Bivalve	5	0.862	0.146	4.99	0.252
Sandy Hill Beach	4	0.518	0.173	4.76	0.260
Poropatank (R)	4	1.357	0.139	5.49	0.151
Lynnhaven Sand (C)	5	0.919	0.101	4.81	0.161
L. plumulosus					
Initial	5	0.017	0.003	2.55	0.179
Manor House	5	0.044	0.004	3.76	0.157
Quarter Creek	5	0.036*	0.006	3.69*	0.199
Wilson Point	5	0.048	0.004	3.99	0.125
Frog Mortar	5	0.054	0.006	4.36	0.119
Bivalve	5	0.060	0.005	4.20	0.145
Sandy Hill Beach	5	0.041*	0.005	3.73*	0.140
Poropatank (C)	5	0.047	0.004	3.79	0.125
Lynnhaven Sand (R)	5	0.100	0.006	4.57	0.069

Table 4.16 continued

Site	# of True Replicates	Weight (mg)	S.E.	Length (mm)	S.E.
S. benedicti					
Initial	5	0.042	0.013	4.22	0.260
Manor House	4	0.085	0.017	7.65	0.383
Quarter Creek	5	0.090	0.022	7.31	0.380
Wilson Point	5	0.073	0.008	7.26	0.173
Frog Mortar	5	0.129	0.007	8.85	0.226
Bivalve	4	0.069	0.013	6.71	0.479
Sandy Hill Beach	5	0.070	0.007	7.15	0.351
Poropatank (R)	5	0.140	0.014	7.53	0.367
Lynnhaven Mud (C)	5	0.095	0.006	7.68	0.345
Lynnhaven Sand (R)	4	0.078	0.014	5.87*	0.135

* Significantly less than controls ($p < 0.05$).

Table 4.17 Growth data (dry weight and length) for *L. dytiscus*, *L. plumulosus* and *S. benedicti* after 20-day exposure to Set 2 sediments. Initial weight and length represent the mean and SD of 5 replicates of 20 animals each species at the start of the test. Data for each replicate is the mean of the surviving animals from each. Tests were conducted 5/25/93 through 6/14/93. "(R)" = Reference, "(C)"= Control

Site	# of True Replicates	Weight (mg)	S.E.	Length (mm)	S.E.
L. dytiscus					
Initial	5	0.535	0.091	4.34	0.058
Manor House	4	0.395	0.054	4.43	0.173
Quarter Creek	4	0.561	0.351	4.59	0.104
Wilson Point	5	0.325	0.067	4.87	0.091
Frog Mortar	5	0.271	0.053	4.55	0.366
Bivalve	5	0.467	0.093	4.44	0.116
Sandy Hill Beach	5	0.246	0.017	4.60	0.128
Poropatank (R)	3	0.250	0.010	4.53	0.234
Lynnhaven Sand (C)	5	0.400	0.012	4.25	0.064
L. plumulosus					
Initial	5	0.030	0.003	3.11	0.094
Manor House	5	0.064	0.006	3.87	0.121
Quarter Creek	5	0.089	0.024	3.75	0.267
Wilson Point	5	0.040	0.009	3.63	0.137
Frog Mortar	5	0.071	0.012	3.77	0.224
Bivalve	5	0.060	0.006	3.71	0.077
Sandy Hill Beach	5	0.065	0.024	3.55	0.131
Poropatank (C)	5	0.059	0.010	3.27	0.218
Lynnhaven Sand (R)	0	--	--	--	--

Table 4.17 continued

Site	# of True Replicates	Weight (mg)	S.E.	Length (mm)	S.E.
S. benedicti					
Initial	5	0.150	0.040	5.35	0.100
Manor House	5	0.129	0.005	7.84	0.086
Quarter Creek	5	0.118	0.010	7.58	0.276
Wilson Point	5	0.130	0.009	7.89	0.271
Frog Mortar	5	0.130	0.016	8.31	0.267
Bivalve	5	0.137	0.007	7.66	0.205
Sandy Hill Beach	5	0.135	0.016	7.65	0.314
Poropatank (R)	5	0.170	0.027	8.58	0.722
Lynnhaven Mud (C)	4	0.132	0.009	7.40	0.434
Lynnhaven Sand (R)	5	0.059*	0.004	5.31*	0.109

* Significantly less than controls ($p < 0.05$).

Table 4.18 Amphipod (Lepidactylus dytiscus) reburial data after 10 day exposure to sediments. Table shows percent of surviving animals able to rebury within one hour.

Station	% Reburial	S.E.
Set 1:		
Manor House	100.00	0.00
Quarter Creek	100.00	0.00
Wilson Point	97.08	4.06
Frog Mortar	100.00	0.00
Bivalve	100.00	0.00
Sandy Hill Beach	100.00	0.00
Poropatank	100.00	0.00
Lynnhaven Sand	100.00	0.00
Set 2:		
Manor House	95.00	5.00
Quarter Creek	90.00	10.0
Wilson Point	84.00	7.48
Frog Mortar	73.33	12.5
Bivalve	80.00	12.2
Sandy Hill Beach	97.14	2.86
Poropatank	100.00	0.00
Lynnhaven Sand	97.13	1.86

* Significantly less than control ($p<0.05$).
Percent sand is listed beside control and reference.

Table 4.19 Amphipod (*Leptocheirus plumulosus*) reburial data after 10 day exposure to sediments. Table shows percent of surviving animals able to rebury within one hour.

Station	% Reburial	S.E.
Set 1:		
Manor House	100.00	0.00
Quarter Creek	100.00	0.00
Wilson Point	100.00	0.00
Frog Mortar	--	--
Bivalve	--	--
Sandy Hill Beach	100.00	0.00
Poropatank	--	--
Lynnhaven Sand	100.00	0.00
Set 2:		
Manor House	100.00	0.00
Quarter Creek	100.00	0.00
Wilson Point	100.00	0.00
Frog Mortar	100.00	0.00
Bivalve	100.00	0.00
Sandy Hill Beach	100.00	0.00
Poropatank	100.00	0.00
Lynnhaven Sand	--	--

*Significantly less than control ($p<0.05$).
NOTE: Percent sand is listed beside control and reference.

day 20, respectively, for both amphipods and the polychaete worm. No test sites had significantly less survival than the controls. Only the survival in the Poropatank reference sediment was significantly reduced in the *L. dytiscus* tests. *L. dytiscus* is a sand dwelling amphipod, which would be more likely to be impacted by the high percent of silt/clay associated with this sediment than any associated toxics. Sheepshead egg data are summarized in Table 4.13. Poor hatching success and egg survival was seen throughout the tests with the exception of the Lynnhaven sand reference. Although overlying oxygen levels remained within test criteria, it is suspected that, in those sites with higher levels of silt/clay, low oxygen conditions were present near the sediment surface where the eggs rested. Therefore, no significant difference between sites and the controls could therefore be distinguished. Further modification of aeration was instituted during the spring 1993 test period.

Growth data indicated significant reduction in growth both in the Quarter Creek and Sandy Hill Beach sites in the *L. plumulosus* tests for length and weight. *S. benedicti* experienced a significant reduction in length in the Lynnhaven Sand sediment. This is presumed to be as a result of the low silt/clay composition and associated low TOC of this sediment which may have presented food limitations, despite the feeding regime employed for this animal. No other sites exhibited significant growth reduction. All sites did show some growth over the initial population length and weight parameters with the exception of *L. dytiscus* weight at Sandy Hill Beach and length at Frog Mortar. However, growth rates of *L. dytiscus* are relatively slow and small growth differences are expected. Reburial data are shown in Table 4.18. No significant differences were observed between sites.

Survival and growth data from toxicity tests conducted 5/25/93-5/14/93 on the second set of sediments from the six stations are summarized in Tables 4.14, 4.15 and 4.17. Control survival at day 10 was 90 and >93 percent in the *L. dytiscus* and *S. benedicti* tests, respectively. Slightly reduced but acceptable control survival was seen at day 20. *L. plumulosus* experienced reduced control survival at day 10 and day 20. A possible hypotheses is a sudden increase in pore water ammonia concentrations at test initiation. This cause is suspected because the over-wintering sediment would have contained high TOC and associated but as yet undegraded nitrogenous detrital matter. The unnatural sudden increase in sediment temperature prescribed by the testing protocol would cause rapid increase in bacterial degradation, elevating ammonia concentrations to stressful levels. These hypotheses are currently being investigated. *L. plumulosus* also exhibited high mortality in the Lynnhaven sand reference sediment, however this was attributed to two other factors: 1) the inability of the juvenile amphipods to effectively scavenge among the larger grained sand particles with associated low TOC and 2) the insufficient food particle size offered during the test. Food availability appeared to have been limited. Subsequent investigations demonstrated that this assumption was correct.

Of the test sites, only Manor House resulted in reduced survival, as indicated at day 10 adjusted for particle size effects (63.16 percent survival). *L. dytiscus* also showed reduced survival in the Poropatank reference sediment compared with controls. This is again attributed to the high percentage of silt/clay present in the site compared to their native sediment (100 percent sand).

No reduction was seen in growth at any of the sites compared with controls. Only the reference site for the *S. benedicti* showed significant reduction in growth compared to controls. The rate was not only reduced, but the polychaetes lost weight compared to the initial length and weight data. This observation is attributed to the low food availability, despite feeding during the test. Similarly, because of limited food availability in the Lynnhaven sand, reference sediment survival and therefore growth data for *L. plumulosus* were not available. Reburial data indicated that no significant differences existed between test sites and controls. It is notable that Frog Mortar and Bivalve Harbor had noticeable effects in several of the replicates in the *L. dytiscus* test; others showed little response, thus producing large standard errors (Table 4.18). This variability in response may reflect spatial heterogeneity in sediment quality at these sites.

4.2.2 Contaminants Data

Toxicity of chemicals in sediments is determined by the extent to which chemicals bind to the sediments. There are many factors that influence the binding capabilities of a particular sediment. The toxicity of non-ionic organic chemicals is related to the organic content of the sediments, and it appears that the bioavailability of sediment-associated metals is related to the concentration of Acid Volatile Sulfides (AVS) present in the sediment (DiToro, 1990). Sediment samples from the six stations and the controls were analyzed for Total Organic Carbon (TOC) and Acid Volatile Sulfides (AVS). The results are shown in Tables 4.20 and 4.21. At present, there is no readily accessible data base for comparison of TOC normalized data, therefore the TOC analysis from this study was included to allow for future comparisons. The AVS approach to sediment contaminants evaluation is still developmental and has been published only recently (DiToro, 1990). To appropriately interpret the AVS data, simultaneously extractable metals (SEM) must also be analyzed. The data for SEM are presented in Table 4.22. In evaluating the AVS values, a ratio of the sum of the SEM to the total AVS is calculated. If the ratio is greater than one (1), toxicity is predicted, although if the total concentration of metals is very low, toxic effects may not be observed. If the SEM:AVS ratio produces a value less than one, it is assumed that there is sufficient AVS present in the sediment to bind with the metals, rendering them non-bioavailable and therefore non-toxic. Evaluation of the SEM to AVS ratio is included in Table 4.23. All stations had ratios much less than one, therefore toxicity due to metals was not indicated.

Inorganic contaminants data from the eight stations are presented in Table 4.24. All test sites had concentrations above the detection limits for ten of the eleven metals analyzed. The

Table 4.20 Total Organic Carbon for sediment samples from the six stations and the controls. All data is on a dry weight basis. Set 1 was tested October 17 through November 6, 1992. Set 2 was tested May 25 through June 14, 1993.

Station	Total Organic Carbon (%) Set 1:	Set 2:
Manor House	3.12	2.65
Quarter Creek	2.19	1.07
Wilson Point	1.24	1.38
Frog Mortar	2.07	1.68
Bivalve	1.02	1.04
Sandy Hill Beach	3.04	2.79
Lynnhaven Sand	0.37	<0.37
Lynnhaven Mud	1.44	3.08
Poropatank	3.62	2.69

Table 4.21 Acid Volitile Sulfides for sediment samples from the six stations and the reference and controls. All data are on a dry weight basis. Set 1 was tested October 17 through November 6, 1992. Set 2 was tested May 25 through June 14, 1993.

Station	AVS (μ mol/g)	
	Set 1:	Set 2:
Manor House	12.6	4.6
Quarter Creek	15.3	3.7
Wilson Point	6.5	2.3
Frog Mortar	11.0	3.3
Bivalve	5.4	4.1
Sandy Hill Beach	19.9	10.5
Lynnhaven Sand	4.9	3.4
Lynnhaven Mud	12.0	26.8
Poropatank	11.2	7.8

Table 4.22 Simultaniously Extractable Metals analysis for sediments for Set 1 (Aug. '92) and Set 2 (Apr. '93). Mean concentrations for each metal are expressed in μ mol/g of sediment.

Set 1

Site	Cadmium	Mercury	Lead	Copper	Nickel	Zinc	Sum
Manor House	0.014	<0.00005	0.082	0.065	0.064	0.493	0.729
Quarter Creek	0.016	<0.00005	0.095	0.070	0.056	0.075	1.003
Wilson Point	0.011	<0.00005	0.112	0.146	0.080	0.742	1.087
Frog Mortar	0.022	<0.00005	0.217	0.200	0.159	1.460	2.027
Bivalve	0.005	<0.00005	0.031	0.020	0.030	0.274	0.359
Sandy Hill Beach	0.019	<0.00005	0.077	0.025	0.054	0.706	0.880
Lynnhaven Sand	0.000	<0.00005	0.005	0.004	0.000	0.030	0.039
Lynnhaven Mud	0.005	<0.00005	0.045	0.041	0.015	0.736	0.847
Poropatank	0.018	<0.00005	0.045	0.005	0.069	0.787	0.923

Table 4.22 continued

Set 2

Site	Cadmium	Mercury	Lead	Copper	Nickel	Zinc	Sum
Manor House	0.016	<0.00005	0.073	0.095	0.086	0.504	0.774
Quarter Creek	0.011	<0.00005	0.049	0.069	0.069	0.492	0.690
Wilson Point	0.018	<0.00005	0.128	0.284	0.156	0.771	1.356
Frog Mortar	0.031	<0.00005	0.211	0.503	0.254	1.844	2.843
Bivalve	0.007	<0.00005	0.023	0.028	0.033	0.287	0.377
Sandy Hill Beach	0.025	<0.00005	0.080	0.074	0.129	1.126	1.434
Lynnhaven Sand	0.000	<0.00005	0.000	0.005	0.000	0.039	0.044
Lynnhaven Mud	0.020	<0.00005	0.073	0.128	0.073	1.192	1.525
Poropatank	0.030	<0.00005	0.052	0.053	0.107	0.981	1.223
Detection limits	0.0003	0.00005	0.0050	0.0006	0.0004	0.0005	

Table 4.23 Average total SEM and AVS values and the SEM:AVS ratio for sediment samples tested in 1992/1993.

	Mean AVS	Mean SEM	Ratio
Set 1:			
Manor House	12.6	0.73	0.057
Quarter Creek	15.3	1.00	0.065
Wilson Point	6.5	1.09	0.168
Frog Mortar	11.0	2.03	0.187
Bivalve	5.4	0.36	0.067
Sandy Hill Beach	19.9	0.88	0.044
Lynnhaven Sand	4.9	0.04	0.008
Lynnhaven Mud	12.0	0.85	0.071
Poropatank	11.2	0.92	0.082
Set 2:			
Manor House	4.6	0.77	0.167
Quarter Creek	3.7	0.69	0.186
Wilson Point	2.3	1.36	0.591
Frog Mortar	3.3	2.84	0.861
Bivalve	4.1	0.38	0.093
Sandy Hill Beach	10.5	1.43	0.136
Lynnhaven Sand	3.4	0.04	0.012
Lynnhaven Mud	26.8	1.53	0.057
Poropatank	7.8	1.22	0.156

Table 4.24 Inorganic contaminants for sediment samples from the six stations and the controls. (Note: single underlined values represent concentrations exceeding "Effects Range-Low", and double underlined values represent concentrations exceeding "Effects Range-Median" levels listed below as defined in Long and Morgan, 1990). NA = not available; -- = not listed; < = values were less than those listed. BDL = Below detection limit.

Set 1:

Site	Contaminant (µg/g)										
	Al	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Sn	Zn
Manor House	17,800	3.973	0.256	23.9	10.0	0.042	13.2	11.6	0.557	BDL	54.6
Quarter Creek	22,200	4.542	0.299	33.8	12.9	0.043	17.3	13.8	0.576	BDL	76.9
Wilson Point	12,800	8.889	0.310	24.1	22.3	0.050	15.2	22.0	0.372	BDL	83.7
Frog Mortar	12,300	10.783	0.296	29.3	29.1	0.118	18.3	34.0	0.486	BDL	112
Bivalve	11,000	2.394	0.160	13.5	4.68	0.026	8.01	5.90	0.223	BDL	35.4
Sandy Hill Beach	19,100	4.417	0.327	24.9	8.09	<u>0.430</u>	14.8	9.86	0.526	BDL	63.0
Lynnhaven Sand	282	0.253	<0.005	0.578	<0.05	<0.006	0.410	<0.5	<0.01	BDL	1.88
Lynnhaven Mud	10,800	3.394	0.251	20.6	11.3	0.048	10.3	9.61	0.210	BDL	67.2
Poropatank	32,200	14.815	0.629	51.1	14.5	0.027	21.5	5.00	0.489	BDL	105
Detection limit	25	0.01	0.005	0.1	0.05	0.006	0.2	0.5	0.01	2	0.1

Table 4.24 continued

Set 1:

Site	Contaminant (μg/g) Al	As	Cd	Cr	Cu	Hg	Ni	Pb	Se	Sn	Zn
Manor House	18,500	4.55	0.237	22.2	25.4	0.052	11.9	15.2	0.418	BDL	51.4
Quarter Creek	11,900	2.49	0.183	18.2	18.7	0.047	8.4	11.2	0.120	BDL	41.5
Wilson Point	12,100	5.65	0.618	27.3	72.9	0.140	15.5	46.0	0.427	BDL	99
Frog Mortar	19,200	8.96	0.528	35.7	108	0.190	22.7	53.9	0.663	BDL	143.8
Bivalve	6,110	1.64	0.054	6.8	7.40	0.018	4.4	4.70	0.050	BDL	19.1
Sandy Hill Beach	20,500	7.84	0.166	22.4	25.5	0.071	13.20	17.28	0.210	BDL	64.0
Lynnhaven Sand	306	0.673	0.032	0.608	0.4	<0.006	0.3	5.00	<0.01	BDL	1.76
Lynnhaven Mud	20,000	4.45	0.264	35.1	49.6	0.099	19.200	20.100	0.497	BDL	107.8
Poropatank	32,500	11.47	0.187	43.4	41.6	0.551	15.5	15.00	0.412	BDL	88.1
Detection limit	25	0.01	0.005	0.1	0.05	0.006	0.2	0.5	0.01	2	0.1
Effects range:											
Low	--	33	5	80	70	0.15	30	35	--	NA	120
Median	--	85	9	145	390	1.3	50	110	--	NA	270

eleventh metal, tin, was below detection limit at all sites. The Lynnhaven sand site had concentrations below detection limits for cadmium, copper, mercury, lead, selenium and tin in the first set of sediments. The Lynnhaven sand sediment tested with the second set of sediments also had concentrations of mercury, selenium, and tin below detection limits. Sediment-sorbed contaminants have been extensively studied by Long and Morgan (1990). They have established a table of concentrations at which biological effects would be expected if these contaminants were present in the sediment. The lower ten percentile of data for which biological effects were observed was established as the "Effects Range-Low" (ER-L); and median concentrations for which biological effects were observed were identified as the "Effects Range-Median" (ER-M). Long and Morgan (1990) indicate that the ER-L and ER-M values can be used for comparisons between sites. The concentrations of toxicants in the sediments of the sites are compared with the ER-L or ER-M values, which are used simply as "benchmarks" for the relative degree of contamination. Those contaminants with concentrations exceeding the ER-L fall into a category that Long and Morgan (1990) consider to be the "possible" effects range for toxic effects. Contaminant concentrations above the ER-M fall in the category of "probable" toxic effects. Of course, many biogeochemical factors influence biological availability of contaminants in sediments, so comparisons of "bulk" chemical concentrations against these benchmark values represent rough attempts at ranking the relative potential of various sediments for toxicity. These comparisons are believed to be overly conservative in many cases, so theoretically-based approaches such as the SEM/AVS method described above should be given more weight in the interpretation of the data.

The fall (set 1) sampling period revealed one site (Sandy Hill Beach) which exceeded the ER-L values for mercury. No other site/metal combination exceeded these values, although lead was suspect at the Frog Mortar site with a concentration of 34.0 ug/g. The spring 1993 sampling analysis revealed concentrations for copper and lead above the ER-L values at Wilson Point and Frog Mortar. Mercury and zinc also surpassed the ER-L values at Frog Mortar. Elevated concentrations of mercury (0.551 ug/g) were also observed at the sediment collected from the Poropotank control/reference site. Many of these concentrations were substantially higher during the spring sampling compared with the fall period. No sediments had levels at the median effects range or greater.

The results of semi-volatile organic compounds and pesticides analyses in sediment samples are presented in Appendix C. The Wye River Manor House sediment was the only sample with compound concentrations above the detection limit with 4-methylphenol concentration of 541 ug/Kg dry sediment weight. Neither fall or spring sampling events resulted in the collection of sediments containing pesticide or semi-volatile organic contaminants which exceeded the ER-L values (Long and Morgan 1990).

4.2.3 Pore Water Data

Sediment pore water was analyzed for sulfide, ammonia, and nitrite for all stations and the controls. The pore water data are shown in Table 4.25. Ammonia concentrations were converted to percent unionized ammonia for comparison with EPA criteria continuous concentrations for saltwater aquatic life.

4.2.4 Reference Toxicant Data

The relative sensitivities of each set of test organisms was evaluated with reference toxicant tests. The results of each reference toxicant test conducted with each batch of amphipod, worms and Sheepshead minnows are shown in Table 4.26. All organisms were tested using cadmium chloride ($CdCl_2$). All test LC50's were within the range of the previous reference toxicant tests conducted, with the exception of the fall (set 1) data for *S. benedicti* which exhibited higher LC50's than previous reference tests. Because the survival in the control sediment was 92 percent at day ten, the increased sensitivity was attributed to the marked difference in initial size of the animals used in the tests as compared to the spring (set 2) animals. Although this increased sensitivity did seem to decrease overall survival when compared with the results of the spring sampling, it did not elucidate additional statistically significant results.

Table 4.25 Chemical data for pore water samples from the six stations and the references and controls (expressed in mg/L).

	Total Ammonia	Nitrite	Sulfide	Unionized Ammonia	*Unionized Ammonia Criteria
Set 1:					
Manor House	3.913	0.0063	0.015	0.028	0.035
Quarter Creek	7.368	0.0048	0.016	**0.061****	0.035
Wilson Point	6.197	0.0105	0.008	**0.040****	0.035
Frog Mortar	4.818	0.0099	0.010	0.001	0.035
Bivalve	7.742	0.0141	0.011	**0.067****	0.035
Sandy Hill Beach	3.913	0.0199	0.016	0.025	0.035
Lynnhaven Sand	10.011	0.5496	0.045	**0.063****	0.035
Lynnhaven Mud	22.843	0.0090	0.051	**0.125****	0.035
Poropatank	4.537	0.0150	0.018	0.027	0.035
Set 2:					
Manor House	2.066	0.0090	<0.007	0.011	0.035
Quarter Creek	2.636	0.0075	0.0089	0.012	0.035
Wilson Point	1.017	0.0108	0.0089	0.022	0.035
Frog Mortar	1.131	0.0054	0.0250	0.001	0.035
Bivalve	2.157	0.0123	0.0112	0.009	0.035
Sandy Hill Beach	1.291	0.0108	0.0135	0.022	0.035
Lynnhaven Sand	1.223	0.0084	0.0110	0.013	0.035
Lynnhaven Mud	16.527	0.0093	0.0733	0.026	0.035
Poropatank	5.089	0.0135	0.0089	0.033	0.035

* USEPA Water Quality Criteria for saltwater aquatic life based upon unionized ammonia (mg/L) Criteria Continuous concentrations.

** Indicates concentrations which exceed EPA criteria

Table 4.26 Reference toxicant data results from 96-hr, water only, reference toxicant tests for the third year of the ambient toxicity project. Cadmium chloride ($CdCl_2$) was used for all organisms.

Organism	Test Set #	Chemical	LC50 & CIs (mg/L)		Historical Mean
L. plumulosus	1	$CdCl_2$	0.73	1.01-0.53	1.16
	2	$CdCl_2$	0.95	1.26-0.71	
L. dytiscus	1	$CdCl_2$	3.49	4.47-2.72	4.18
	2	$CdCl_2$	3.43	4.81-2.46	
S. benedicti	1	$CdCl_2$	1.97	2.49-1.55	4.80
	2	$CdCl_2$	5.53	6.18-4.95	
C. variegatus	1	$CdCl_2$	0.64	0.83-0.49	0.58
	2	$CdCl_2$	0.47	0.50-0.44	

SECTION 5

DISCUSSION

5.1 Nanticoke River

The Nanticoke River represents a typical eastern shore river bordered by wetland habitats, agricultural activity (non-point source inputs), few point sources and low population density. The Nanticoke River is one of the four major spawning areas for striped bass in Maryland waters of Chesapeake Bay. The ambient stations used in this river were generally downstream from the primary spawning area of this anadromous species although the Sandy Hill Beach and Bivalve Harbor areas are potential habitats for larvae or young juvenile life stages.

This was the first year we conducted ambient toxicity tests in the Nanticoke River; therefore, comparisons with previous data collected during this pilot study were not possible. Previous ambient toxicity data from this river were generated from *in situ* and on-site studies from 1984 to 1990 with striped bass prolarvae in the spawning area approximately 6 to 10 miles upriver from our ambient toxicity stations (Hall et al., 1993). Results from these studies have demonstrated that acidic conditions (low pH, monomeric aluminum and other metals) in habitat water during the spring can reduce survival of prolarval striped bass although these conditions are not present every year. Ambient toxicity data from water column tests during this study with the four test species did not demonstrate the presence of adverse water quality or contaminant conditions at either station during the fall or spring tests. Organic contaminants were not detected in the water column during our experiments and concentrations of all metals were below the EPA recommended water quality criteria. It is noteworthy, however, that concentrations of chromium, lead, nickel and zinc were consistently detected at our stations. Maximum concentrations of lead 4.3 ug/L (spring sample from Sandy Hill Beach) and nickel 6.6 ug/L (spring sample from Sandy Hill Beach) were only slightly lower than the EPA recommended chronic water quality criterion.

The sediment data obtained from the 1992-1993 sampling period indicated no significant decrease in survival in any of the four test species during sediment testing. Although not statistically significant, a potential pattern of reduced survival was observed in the amphipods and worms during the fall sampling. Growth data also indicated that significant reduction in *L. plumulosus* length and weight occurred compared with controls. Although AVS/SEM ratios were determined to be below one, total mercury concentrations from this site were determined to be three times the ER-L. Organic compound and pesticide analyses indicated the presence of Aldrin 5.04 ug/kg sediment dry weight for sediment collected at the Bivalve site. Traces of several organics and pesticides were also confirmed in both Bivalve Harbor and Sandy Hill Beach sites' sediments. Unionized ammonia was greater at the Bivalve site than at any other test sites in the fall sampling, although Lynnhaven Mud (control and reference) was nearly twice as high. The values may be indicative of the high TOC associated with these sites. The ammonia concentration did exceed the saltwater quality continuous criteria, but these concentrations are not strictly comparable. The AMRL has investigated ammonia toxicity tolerances for several estuarine sediment dwelling organisms and has concluded that higher ammonia tolerances may be the rule for benthic species, as sediment pore water ammonia is often greater than the overlying water column ammonia concentrations.

5.2 Wye River

The Wye River was selected for testing during the first two years of this study to represent a reference or relatively "clean" background area (absence of point sources). Both Wye River stations tested during this study (Manor House and Quarter Creek) were located in rural areas where the major land-use is dominated by agricultural activity. This is the third year that ambient toxicity tests have been conducted at the Manor House station but the first year for testing at the Quarter Creek station. Results from our previous water column testing during 1990 (first year) did not demonstrate the presence of toxic conditions at the Manor House station although both sediment and suborganismal testing did suggest adverse conditions (Hall et al., 1991). Contrasting data were reported during the second year of water column testing as toxic conditions were reported during two separate tests using two different test species (Hall et al., 1992). A significant reduction in survival of sheepshead minnows was reported during the first test in 1991 while significant reductions in survival of *E. affinis* were reported during the second test. In the present study, we reported significant reductions in survival of sheepshead minnow larvae at the Manor House station in the fall experiment and a significant reduction in survival of *E. affinis* in the spring at the Quarter Creek station. The reported mortality for sheepshead minnows was likely related to the presence of cnidarian nematocysts from jellyfish (David Nemazie, personal communication) and not the presence of adverse contaminants or water quality conditions. The reduction in survival of *E. affinis* was likely related to a stressful condition in the water. Based on three years of data at the Manor House station, it appears that the biological effects from water column toxicity data from the third year (significant biological effects from one species and one test) were more severe than the first year (no biological effects) but less pronounced than the second year. Water column contaminants data collected during this study do not suggest the presence of adverse conditions as all organic compounds measured were below detection limits and all metals values were below the EPA recommended chronic marine water quality criteria.

Wye River Manor House sediment results produced significantly reduced survival of *L. dytiscus* at both 10 and 20 days at the fall sampling. No growth effects were observed at Manor House site, however, Quarter Creek did exhibit some reduction in growth by *L. plumulosus* at the fall sampling. No growth or survival effects were seen in *L. plumulosus* in the spring sampling event.

Concentrations of metals were well below ER-L's for all metals analyzed. Unionized ammonia values for these sites were also below toxicity limits for freshwater and were, therefore, not considered a factor, however, Quarter Creek ammonia values were nearly twice that of the EPA continuous criteria for saltwater at the fall sampling. Organic compounds and pesticide analyis indicated the presence of 4-Methylphenol at the Manor house site during the spring sampling, however, this did not seem to effect test survival in any species. The pesticide 4,4-DDT was also detected at the Manor House site during the fall sampling period, but was not confirmed by secondary GC/MS analysis because it was below the detection limit.

5.3 Middle River

The Middle River was selected for this study to represent a perceived "marginally" polluted area with a dense urban population, various point sources and numerous marinas. Both the Wilson Point and Frog Mortar stations were located in a salinity transition zone where seasonal salinity ranges from 2 to 7 ppt. This was the first year for ambient toxicity experiments in Middle River; therefore, comparisons of data from previous studies is not possible. Background data collected by Maryland Department of the Environment has shown that "fish kills" occur in this area and various metals have been reported at potentially stressful conditions in both the water column and sediment (Charles Poukish, personal communication, and Deirdre Murphy, personal communication).

Significant biological effects were not reported from *E. affinis*, sheepshead minnow or grass shrimp water column toxicity tests. However, water column toxicity data from 8 coot clam experiments showed consistent toxicity (reduced normal shell development) at both the Wilson Point and Frog Mortar Creek stations during the first and second tests in the fall and the spring. These biological effects were consistent with concentrations of various metals reported at potentially toxic concentrations in the water column. Water column concentrations of copper (10.1, 3.3 and 6.4 ug/L), lead (9.8 ug/L), nickel (25.5 and 13.9 ug/L) and zinc (134 ug/L) were reported to exceed the EPA recommended water quality criteria in the fall and/or spring at Wilson Point (U.S. EPA, 1987). The zinc value of 134 ug/L is greater than the 48 hour EC50 value of 116 ug/L previously reported for the coot clam and the maximum copper (10.1 ug/L) and nickel (25.5 ug/L) concentrations are approximately half the 48 hour EC50s for this species (Morris and Petrocelli, 1990b). At Frog Mortar Creek, copper (4.7, 9.9 and 4.8 ug/L) and nickel (10.4 ug/L) were reported to exceed the EPA recommended chronic marine criteria.

Neither survival nor growth data from sediment tests suggested the presence of adverse conditions in sediment at either the Frog Mortar or Wilson Point sites at either sampling time. However, lead, zinc, mercury and copper were above the ER-L values at both sites during the spring sampling. The AVS/SEM values indicate the lack of bioavailability of these metals. The metabolic byproduct of DDT, 4,4-DDE, was measured (1.65 ug/Kg dry) and confirmed at

Frog Mortar, however, no effects were observed over the short test duration. Ammonia concentrations at Frog Mortar were low at both sampling times, however, the unionized ammonia concentrations at Wilson point (0.040 mg/L) exceeded the EPA continuous criteria of 0.035 mg/L in the fall sampling.

SECTION 6

ANALYSIS OF THREE YEAR DATA BASE

6.1 Water Column Toxicity

The results of multivariate composite index calculations for water column toxicity for the 1990, 1991 and 1992-93 experiments are summarized in Figures 6.1, 6.2 and 6.3, respectively. The species tested and the number of endpoints used varied slightly from year to year (i.e., three water column tests for 1990, four tests for 1991 and 1992-93). Therefore, comparisons of index values within the figures for same year are more comparable than those of different years. The composite index calculations generated for each station and year from concurrent reference (control value) and test conditions, therefore, provide interpretation on the relative magnitude of the toxic response of the various sites. This analysis also provided a degree of confidence that could be given to differences between reference and test values. A summary of comparison of RTRM indices for control (or reference) and test sites is presented in Table 6.1.

The RTRM analysis for the the 1990 data in Figure 6.1 showed that the Elizabeth River was clearly the most toxic site tested as the median for the index of the test condition was clearly greater than the reference (control). The confidence limits for the reference and test condition did not overlap at this location. The results from the Elizabeth River are not surprising since significant mortality was observed in two of the three tests that were conducted. The second most toxic station identified with the RTRM analysis was the Patapsco River as significant mortality was reported in one out of three tests. However, the confidence interval was wide (indicating variability) for this station and there was no difference in the median values for the reference and test site. The results from the Indian Head, Freestone Point, Possum Point, Morgantown, Dahlgren and Wye River stations indictated no significant difference with index values between the reference and test conditions for the 1990 tests. Both Morgantown and Dahlgren stations did show limited biological effects with one of the tests (significant mortality with the sheepshead minnow test). However, these results from the test condition were not significantly different than the reference when all endpoints from all tests were combined for the final index calculations.

The multivariate composite index calculations for the 1991 experiments are presented in Figure 6.2. Four water column tests with two endpoints for each test were used to determine the final values for two testing periods (summer and fall). The Wye River site showed the most significant effects as significant mortality was reported for two different test species during different testing periods. Although the median values from the reference and test sites were different there was overlap of confidence limits with these two conditions. A comparison of reference and test index values for the Patapsco River, Morgantown and Dahlgren sites showed no significant differences. However, reduced growth of the

Figure 6.1 RTRM analysis for the 1990 water column data (see Section 3.4 for details).

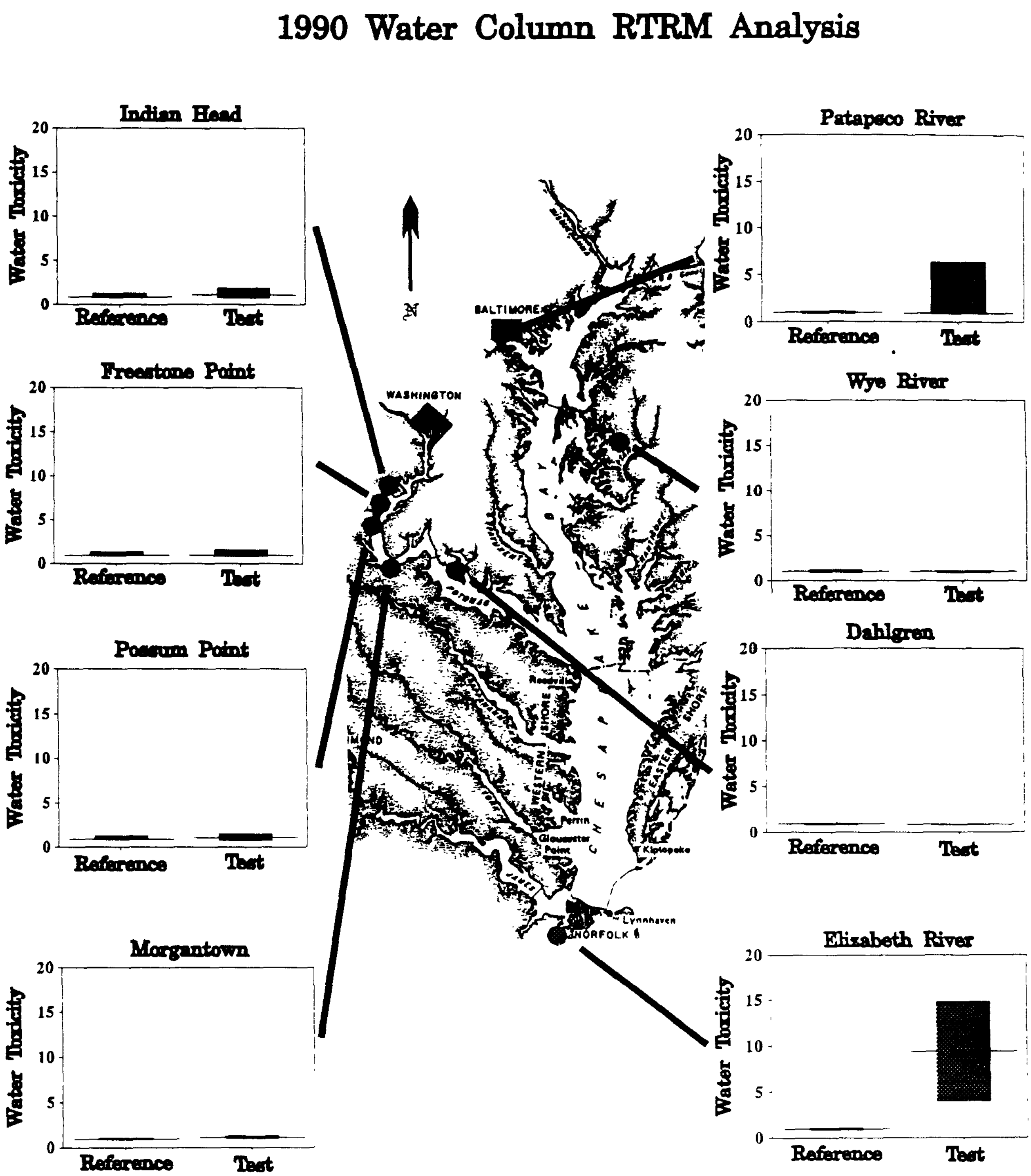


Figure 6.2 RTRM analysis for the 1991 water column data (see Section 3.4 for details).

1991 Water Column RTRM Analysis

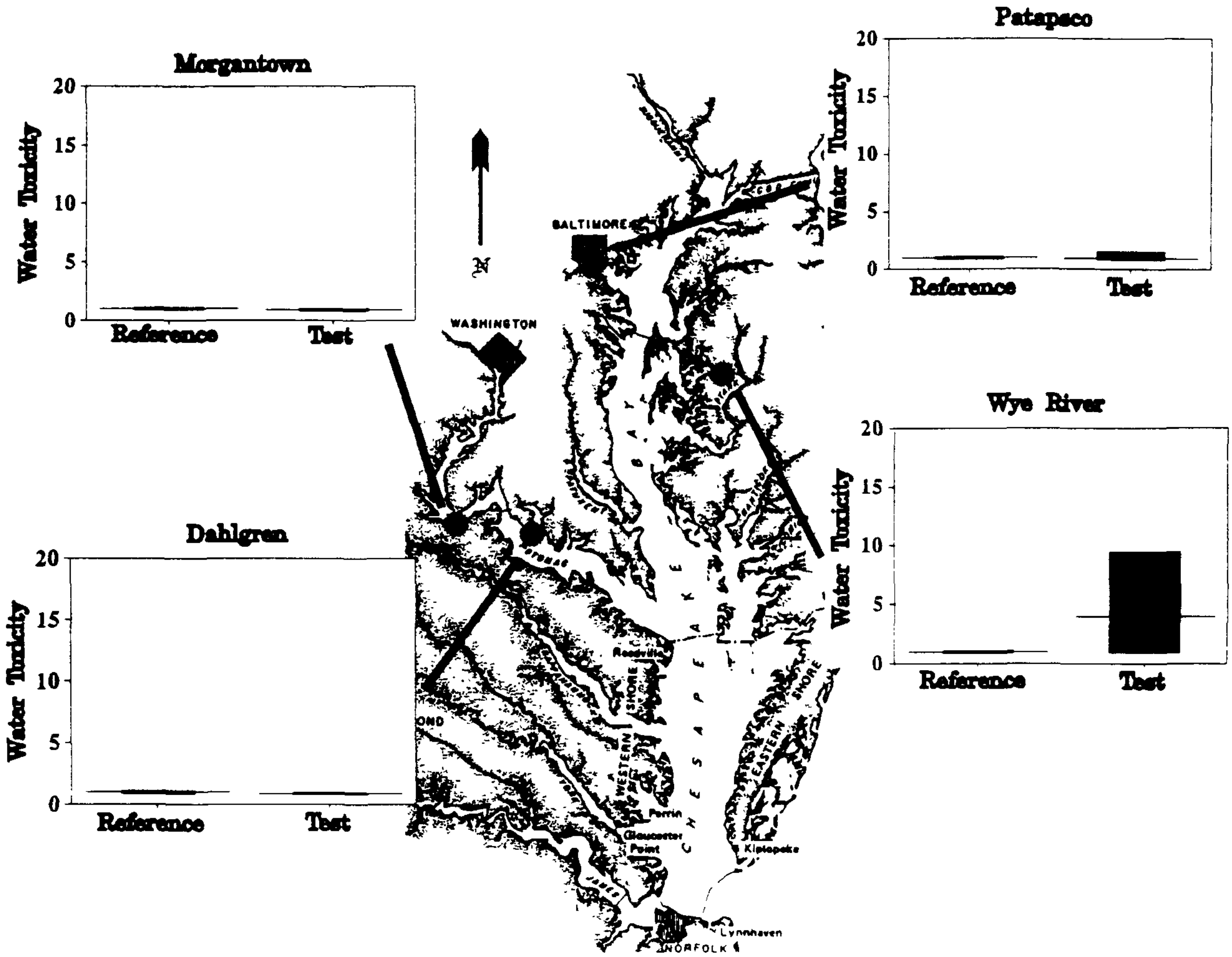


Figure 6.3 RTRM analysis for the 1992-93 water column data (see Section 3.4 for details).

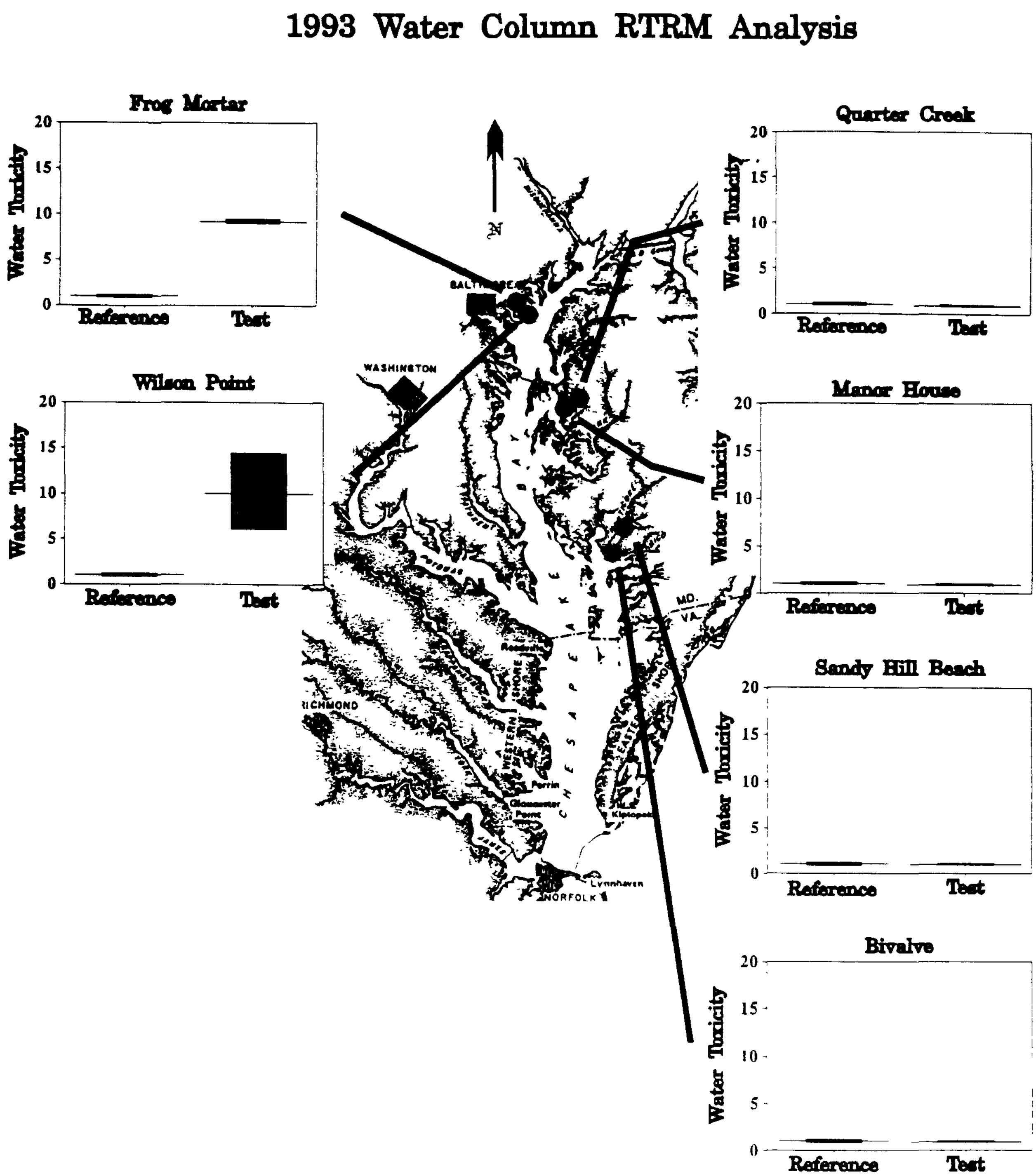


Table 6.1 Summary of comparisons of RTRM indices for reference and test sites presented in Figures 6.1 - 6.6. Comparisons for which confidence limits overlap are indicated by "O", those for which the confidence limits do not overlap are indicated by "X", while "--" indicates no data taken for the period.

STATION	WATER COLUMN			SEDIMENT		
	1990	1991	1992-3	1990	1991	1992-3
BALTIMORE HARBOR	O	O	--	X	X	--
ELIZABETH RIVER	X	--	--	X	--	--
MIDDLE RIVER: FROG MORTAR	--	--	X	--	--	O
WILSON POINT	--	--	X	--	--	O
NANTICOKE RIVER: BIVALVE	--	--	O	--	--	O
SANDY HILL BEACH	--	--	O	--	--	O
POTOMAC RIVER: DAHLGREN	O	O	--	X	X	--
FREESTONE POINT	O	--	--	X	--	--
INDIAN HEAD	O	--	--	X	--	--
MORGANTOWN	O	O	--	X	X	--
POSSUM POINT	O	O	--	X	--	--
WYE RIVER: MANOR HOUSE	O	O	O	X	X	O
QUARTER CREEK	--	--	O	--	--	O

sheepshead minnow was reported at both the Morgantown and Dahlgren sites during the summer experiments.

The results from the 1992-93 experiments presented in Figure 6.3 include experiments conducted during the fall (1992) and spring (1993) at each of the 6 sites (2 sites per river). The most toxic sites were reported at both Middle River stations (Wilson Point and Frog Mortar Creek). Results from the coot clam toxicity tests (2 tests per experiment conducted in the fall and spring) showed consistent toxicity at both sites. Although median values were similar for both Middle River sites, the variability at Wilson Point was much greater than at Frog Mortar. The results from RTRM analysis at the other 4 sites showed no difference between the reference and the test condition. The only other biological effect reported at any of these 4 sites was significant mortality of E. affinis at the Quarter Creek site during the spring experiments.

A summary of the three year water column data base using the RTRM analysis showed the following ranking of toxicity for the various sites:

- the Elizabeth River (1990) and the Middle River (1992-93) were the most toxic sites tested during the first three years of the Ambient Toxicity Testing Program

- the Wye River test site in 1991 had a median value for the composite index greater than the control value but there was an ovelap with the confidence interval between the test and reference sites

- the Patapsco River tested in 1990 showed some toxicity as evidenced by the wide confidence interval; however, the test condition on the average was not significantly different than the control.

- the five Potomac River sites (Indian Head, Freestone Point, Possum Point, Morgantown and Dahlgren) tested in 1990 and two sites tested in 1991 (Morgantown and Dahlgren) generally showed no significant effects.

- the composite index for the reference and test conditions at both Nanticoke River sites (1992-93) were similar, thus suggesting no significant effects.

6.2 Sediment Toxicity

The results of the multivariate composite index calculations for sediment toxicity for the 1990, 1991, and 1992-93 studies are summarized in Figures 6.4, 6.5 and 6.6, respectively. All index values except those from the Elizabeth River are plotted on the same scale for comparison purposes. The Elizabeth River toxicity responses were so great (100 percent mortality for all species tested) that the index values for this site had to be plotted on a greater scale. It should be noted that the species and the number of endpoints tested varied slightly from year to year, so

Figure 6.4 RTRM analysis for the 1990 sediment data (see Section 3.4 for details).

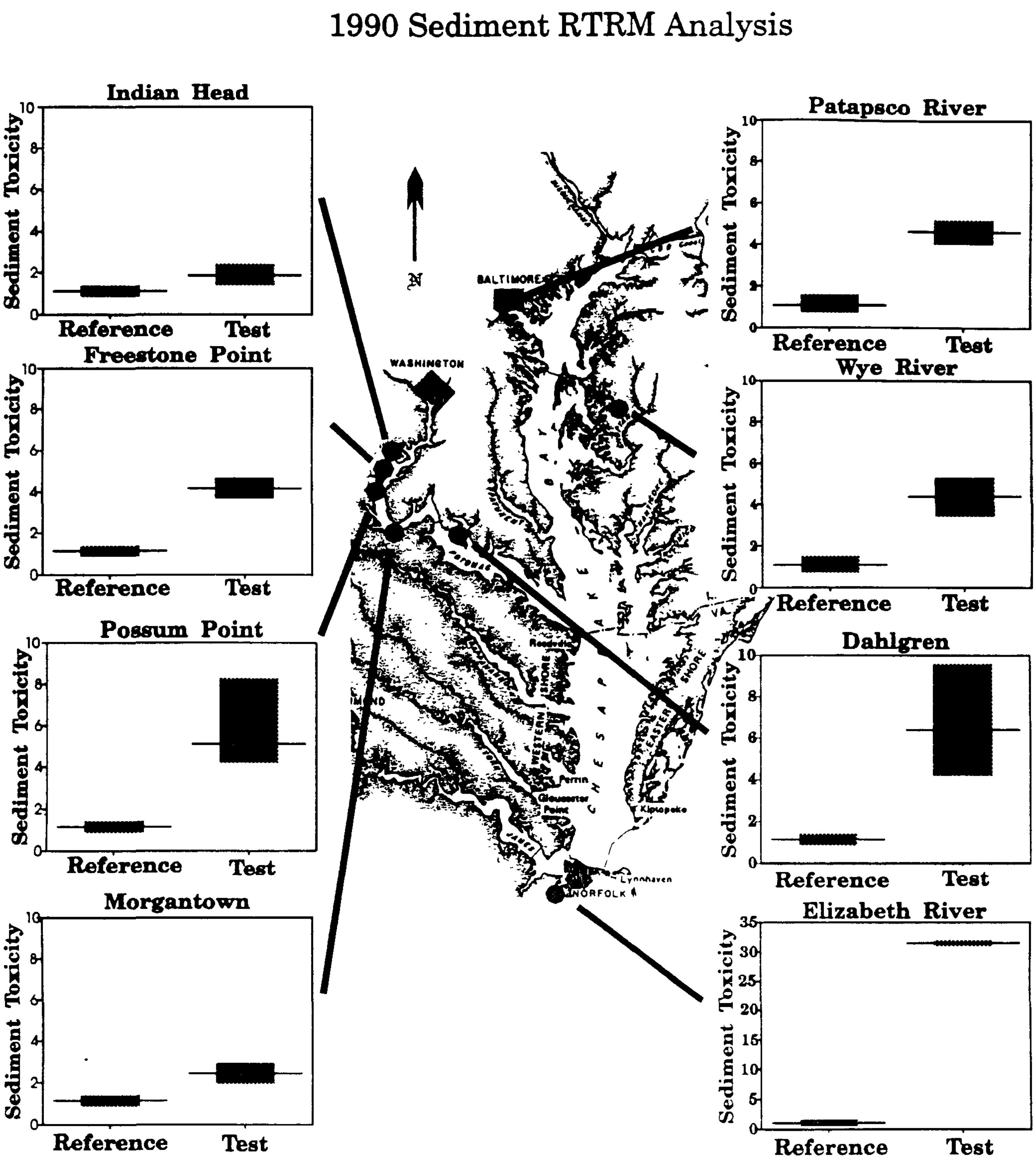


Figure 6.5 RTRM analysis for the 1991 sediment data (see Section 3.4 for details).

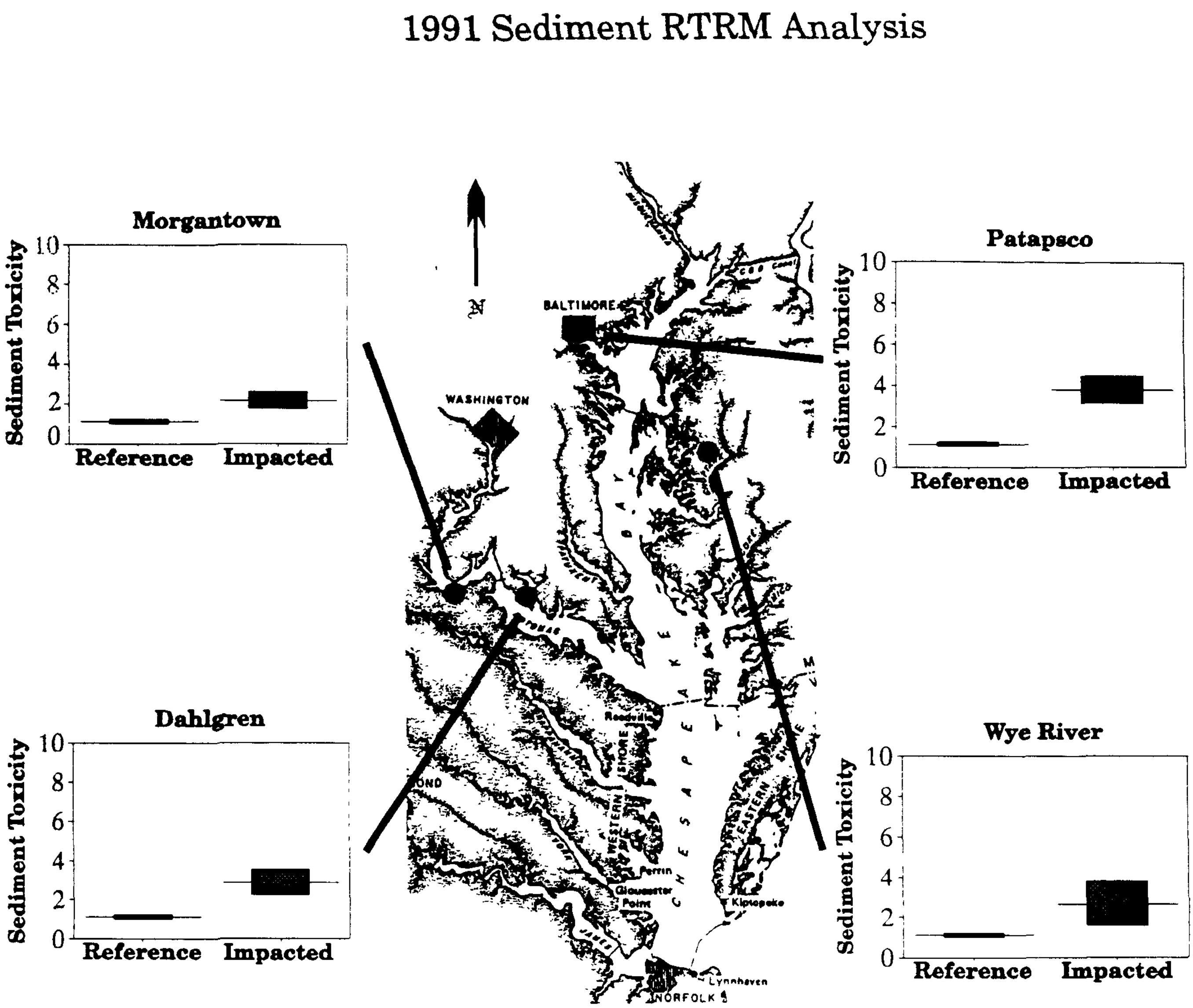
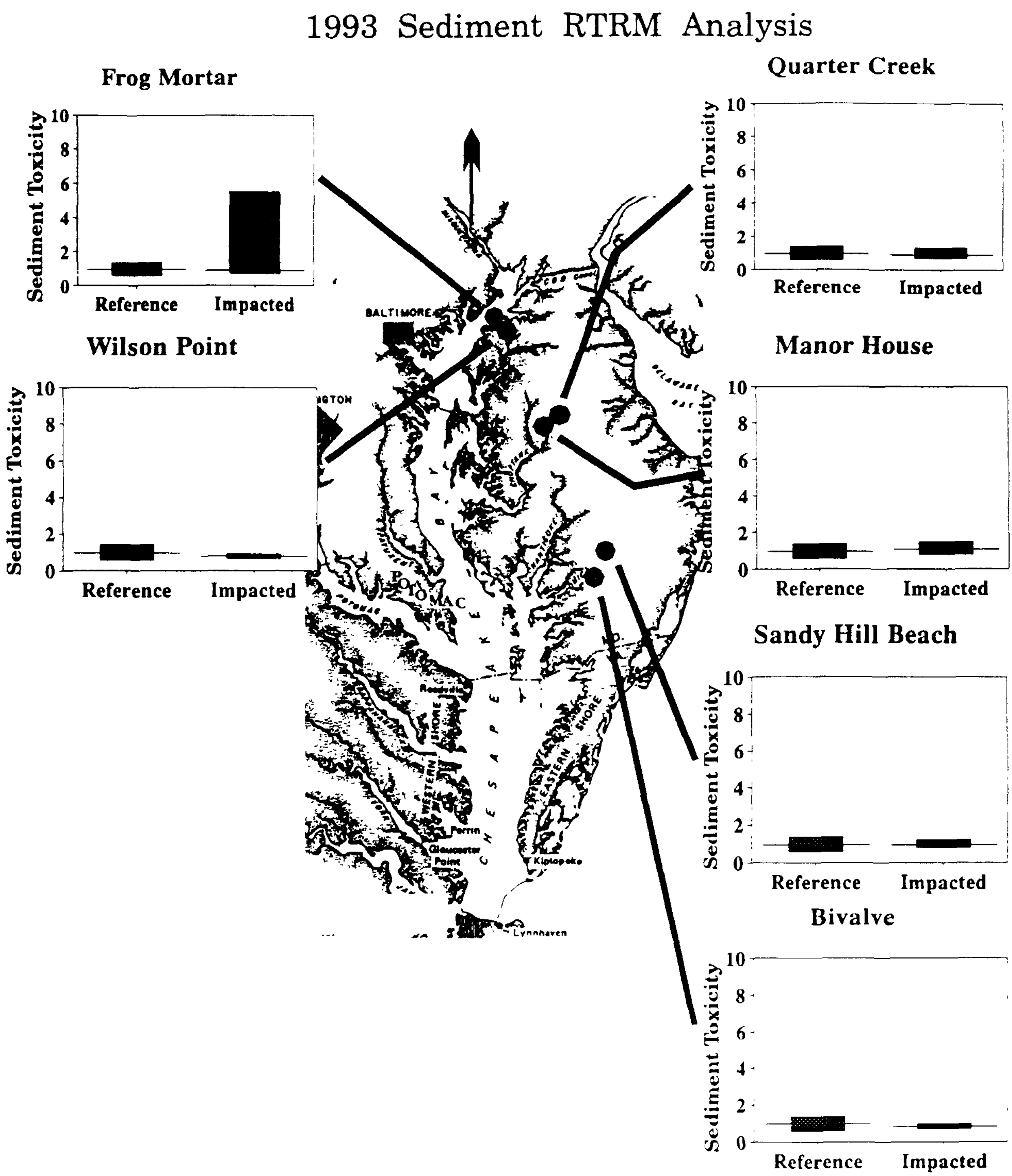


Figure 6.6 RTRM analysis for the 1992-93 sediment data (see Section 3.4 for details).



comparisons of index values within the figures (within the same year) are more [1]comparable than those between figures*. Nonetheless, the comparisons of concurrent reference and test experiments provide insight into the relative magnitude of the toxic responses of the various sites. Table 6.1 summarizes the comparisons presented in Figures 6.1 - 6.6.

During the 1990 study, the Elizabeth River was clearly the most toxic of the sites, since all species displayed 100 percent mortality during the first 10 days of the experiment (i.e., the median for the index for the test data was greatly separated from the median for the reference data, with no variation; Figure 6.4). The confidence limits of the test data index values were well separated from those of the corresponding reference sites for a number of other sites: Patapsco River; Wye River; and the Freestone Point, Possum Point and Dahlgren sites on the Potomac River (although the latter two sites displayed a considerable degree of variation in index values). The Indian Head and Morgantown sites on the Potomac River displayed only slight separation between the median multivariate index values for the test and reference conditions, even though some of the individual endpoints were significantly different from the controls for these sites. Thus, the magnitude of potential toxicity appears to be less for the Indian Head and Morgantown sites than for the others. It should be noted, however, that all sites selected for the first year of the study were those considered "suspect" due to the results of previous studies, so it is not surprising that most displayed significant deviations from the reference conditions.

The 1991 study involved an assessment of the effects of short-term temporal variability (a summer versus a fall collection) on the apparent toxicity of sediments from four sites. The separation between test and reference treatments was greatest for the Patapsco River site, with less separation being displayed for Dahlgren, Morgantown, and the Wye (Figure 6.5). The results of the Patapsco River index comparison were remarkably similar to those observed for the 1990 study. The Dahlgren site index values, which were quite variable in the 1990 study, were less variable but still separated from the reference values in the 1991 study. The small degree of separation observed between the Morgantown index limits and reference limits in 1990 was also observed for 1991. The Wye River index limits were only slightly separated from the reference limits due to the fact that only one of the two sets of experiments

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[1]* Mathematical methods are currently being explored to allow the scaling of all values between zero and the maximum possible score for any given experimental series (e.g. a scale expressed as a percent of maximum impact; but a numerical benchmark for the reference condition should be maintained). If successful, such a scaling system should allow a more direct comparison between studies employing differing numbers of endpoints. However, differences in the **sensitivity** of different endpoints would not be resolved by scaling.

displayed significant differences between test and control treatments. This slight variability in responses could be due to temporal variation in toxicity, but is more likely due to small scale spatial heterogeneity (i.e., sediments were taken from the same general station, but there may have been patchiness in sediment quality in the grabs composited for the two sets of tests). Overall, the degree of variability observed in the index limits for the combination of the two sampling events was quite small for all four sites. The patterns were remarkably consistent with those observed at these same sites during the previous year.

The 1992-93 study also involved two sampling periods during the Fall and Spring. The test and reference index limits overlapped for all of the sites selected for testing (Figure 6.6). Thus, the sites in the Middle River (Frog Mortar and Wilson Point), the Wye River (Quarter Creek and Manor House), and the Nanticoke River (Sandy Hill Beach and Bivalve) appeared to contain sediment displaying little or no overall toxicity compared to reference conditions. It should be noted, however, that the Frog Mortar sediments were quite heterogenous in character (as evidenced by particle sizes ranging from approximately from 0.5 to nearly 90 percent in replicate samples shown in Table 3.5; and by the large confidence limits for responses in Figure 6.6). Furthermore, this site displayed somewhat elevated metals in the composite samples (as evidenced by values of copper, mercury, lead, and zinc which exceeded ER-L levels in the second set composite sample; Table 4.24). Therefore, there may be patches of contaminated sediments at this site, which may have produced responses in a few of the field replicates. The purpose of taking true field replicates at two different times during the 1992-93 study was to produce confidence limits to indicate the probability of observing the same sort of response if the site were sampled again, so the observed variability provides insight into the variation in sediment quality expected for this site.

The results of the 1992-3 studies on the two Wye River sites (Quarter Creek and Manor House) displayed little difference from the reference conditions, which is in contrast to the apparent toxicity observed in 1990 and one of the sampling period of the 1991 study. The Wye River Manor House site was sampled during all three years of testing.

To summarize, an overview of the multivariate index results produces a qualitative ranking of sediment quality of the sites from most toxic to least toxic, as follows:

- the Elizabeth River site contained sediments that were, by far, the most toxic of those studied during the first three years of the Ambient Toxicity Program;

- the Baltimore Harbor (Patapsco River) site contained sediments which were the second most consistently toxic among the sites studied;

- the Freestone Point, Possum Point, and Dahlgren sites on the

Potomac River had sediments that produced the next greatest separation between test and reference responses, although the responses in the Dahlgren site experiments displayed a large degree of variability in 1990 and a diminished level of apparent toxicity in 1991, suggesting spatial heterogeneity in sediment quality;

- the sediments from the Wye River Manor House collection site exhibited some apparent toxicity in 1990 and in one of the two experiments in 1991, but the Manor House and Quarter Creek sites did not show toxicity in 1992-93.
- the Indian Head and Morgantown sites on the Potomac River had sediments which produced responses which were only slightly different from the reference conditions, but these subtle toxic effects displayed a low degree of variability and were observed to be consistent during several sampling events for the latter site;
- the Frog Mortar and Wilson Point sites on the Middle River and the Sandy Hill Beach and Bivalve Harbor sites on the Nanticoke River had sediments that produced responses that were not significantly different from those from the reference site experiments, although the Frog Mortar site replicates did display a considerable degree of variability in the responses, possibly due to small scale heterogeneity in contaminant patterns for certain heavy metals.

SECTION 7

RECOMMENDATIONS

The following recommendations are suggested after three years of ambient toxicity tests in Chesapeake Bay:

- A battery of both water column and sediment tests should be conducted concurrently in ambient areas to maximize our ability to identify "regions of concern" in the Chesapeake Bay watershed

- When selecting suspected contaminated regions for future ambient toxicity testing, background data from chemical monitoring, biological community status assessments and toxicity tests should be used to provide guidance.

- The ambient toxicity testing approach should be used to assess the status of important living resource habitats (ie, spawning areas of anadromous fish). This approach could be added to an array of multi-metric assessment tools that are currently under development with the long term goal of targeting tributaries and watersheds for nonpoint source monitoring and remediation. The goals of such a targeting effort would be to determine where management-based habitat improvement programs should be focused, based on the status of biological communities and other environmental indicators.

- Community metric approaches with fish, invertebrates, or other trophic groups which assess "impact observed responses" should be conducted concurrently with ambient toxicity tests which determine "impact predicted" responses. The use of both test approaches will provide a more complete strategy for assessing the impact of contaminants on specific areas in the Chesapeake Bay watershed.

- Water column and sediment ambient toxicity tests with resident Chesapeake Bay plant species (submerged aquatic vegetation and/or phytoplankton) should be conducted (or developed if needed) in concert with the present battery of animal tests.

- Statistical analysis of ambient toxicity data should be conducted to provide environmental managers with summary information concerning the relative toxicity of water and sediment from the collection sites. These analyses should provide quantitative indicators of the degree of confidence which may be given to observed differences between ambient areas and reference areas (controls).

SECTION 8

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APPENDIX A

Water quality conditions reported in test chambers during all water column tests. Hawaiian (HW) marine synthetic sea salt control was (reconstituted) RO water with HW sea salts; EST control was DeCoursey Cove water and HW sea salts.

Experiments were conducted with *Eurytemura affinis* (Ea), Palaemonetes pugio (Pp), *Cyprinodon variegatus* (Cv) and *Mulinia lateralis* (ML).

Date	Test Species	Station	T	Sal	Do	pH
10/6/92	Ea	NR-SHB	25	15	7.5	8.56
		NR-BH	25	14	7.5	7.91
		MR-FMC	25	15	7.4	9.16
		MR-WP	25	15	7.8	9.18
		WR-MH	26	14	7.2	8.11
		WR-QC	25	15	8.3	8.19
		EST Control	24	15	7.4	8.65
10/6/92	Pp	NR-SHB	25	15	7.5	8.56
		NR-BH	25	14	7.5	7.91
		MR-FMC	25	15	7.4	9.16
		MR-WP	25	15	7.8	9.18
		WR-MH	26	14	7.2	8.11
		WR-QC	25	15	8.3	8.19
		HW Control	25	14	8.2	9.08
10/7/92	Ea	NR-SHB	25	14	8.0	8.38
		NR-BH	25	14	7.9	8.24
		MR-FMC	25	15	7.7	8.57
		MR-WP	25	15	7.8	8.67
		WR-MH	25	14	8.1	8.33
		WR-QC	25	15	8.1	8.32
		EST Control	25	15	7.6	8.42
10/7/92	Pp	NR-SHB	25	14	6.7	8.11
		NR-BH	25	14	6.6	7.99
		MR-FMC	25	15	6.4	8.04
		MR-WP	25	15	6.3	8.31
		WR-MH	25	14	6.7	7.97
		WR-QC	25	15	6.5	7.95
		HW Control	25	14	6.3	8.45
10/8/92	Ea	NR-SHB	25	15	7.6	8.29
		NR-BH	25	14	7.4	8.09
		MR-FMC	25	15	7.6	8.44
		MR-WP	25	15	7.2	8.38
		WR-MH	25	14	7.3	8.19
		WR-QC	25	15	7.2	8.20
		EST Control	25	15	6.8	8.01

10/8/92	Pp	NR-SHB	25	14	6.1	7.82
		NR-BH	25	14	6.3	7.71
		MR-FMC	25	15	6.1	7.72
		MR-WP	25	15	5.6	7.73
		WR-MH	25	14	6.2	7.75
		WR-QC	25	15	6.0	7.80
		HW Control	25	15	5.4	7.80
10/9/92	Ea	NR-SHB	25	15	8.1	8.44
		NR-BH	25	15	7.1	8.05
		MR-FMC	25	15	8.3	8.51
		MR-WP	25	15	7.7	8.35
		WR-MH	25	14	7.1	8.01
		WR-QC	25	15	7.2	8.00
		EST Control	25	16	7.7	8.18
10/9/92	Pp	NR-SHB	25	15	5.9	7.71
		NR-BH	25	14	6.1	7.66
		MR-FMC	25	15	6.6	7.71
		MR-WP	25	15	5.9	7.67
		WR-MH	25	14	6.0	7.66
		WR-QC	25	15	6.1	7.65
		HW Control	25	15	5.3	7.78
10/9/92	Cv	NR-SHB	25	15	7.2	8.19
		NR-BH	25	15	7.6	8.05
		MR-FMC	25	15	7.5	9.08
		MR-WP	25	15	7.2	8.85
		WR-MH	25	15	7.3	8.28
		WR-QC	25	15	7.4	8.20
		HW Control	24	15	7.7	8.20
		EST Control	24	15	7.3	8.03
10/9/92	ML	NR-SHB	25	15	7.2	8.19
		NR-BH	25	15	7.6	8.05
		MR-FMC	25	15	7.5	9.08
		MR-WP	25	15	7.2	8.85
		WR-MH	25	15	7.3	8.28
		WR-QC	25	15	7.4	8.20
		HW Control	24	15	7.7	8.20
10/10/92	Ea	NR-SHB	24	15	8.3	8.54
		NR-BH	24	14	7.1	8.12
		MR-FMC	25	15	8.0	8.60
		MR-WP	25	16	8.0	8.61
		WR-MH	25	15	7.4	8.12
		WR-QC	25	16	7.3	8.24
		EST Control	25	15	7.7	8.11

10/10/92	Pp	NR-SHB	25	15	5.9	7.83
		NR-BH	24	15	5.9	7.74
		MR-FMC	24	15	5.9	7.73
		MR-WP	25	16	5.8	7.71
		WR-MH	25	15	5.3	7.58
		WR-QC	25	16	5.7	7.72
		HW Control	25	15	5.5	7.87
10/10/92	Cv	NR-SHB	25	15	6.8	8.37
		NR-BH	25	15	6.9	8.08
		MR-FMC	24	15	6.7	8.72
		MR-WP	24	16	6.6	8.64
		WR-MH	25	15	6.4	8.07
		WR-QC	24	16	6.7	8.22
		HW Control	24	15	6.8	8.07
		EST Control	24	15	6.5	7.85
10/11/92	Ea	NR-SHB	25	15	8.1	8.40
		NR-BH	25	15	7.5	8.13
		MR-FMC	25	15	7.8	8.44
		MR-WP	25	16	7.6	8.50
		WR-MH	25	15	7.7	8.15
		WR-QC	25	16	7.7	8.25
		EST Control	25	15	7.5	8.11
10/11/92	Pp	NR-SHB	25	15	6.6	7.94
		NR-BH	25	14	6.0	7.74
		MR-FMC	25	15	6.1	7.66
		MR-WP	25	16	5.9	7.74
		WR-MH	25	14	5.6	7.67
		WR-QC	25	16	6.1	7.83
		HW Control	25	15	6.0	7.90
10/11/92	Cv	NR-SHB	24	15	6.7	8.03
		NR-BH	25	15	6.6	7.87
		MR-FMC	24	15	6.4	8.24
		MR-WP	24	16	6.4	8.18
		WR-MH	24	15	5.7	7.73
		WR-QC	24	16	6.3	7.91
		HW Control	24	15	7.1	7.92
		EST Control	25	15	6.7	7.78
10/12/92	Ea	NR-SHB	25	15	8.4	8.54
		NR-BH	25	15	7.8	8.30
		MR-FMC	25	15	7.8	8.50
		MR-WP	25	16	7.7	8.42
		WR-MH	25	15	8.2	8.40
		WR-QC	25	17	8.5	8.10
		EST Control	25	15	8.4	8.30

10/12/92	Pp	NR-SHB	25	15	6.8	8.09
		NR-BH	25	15	6.4	7.84
		MR-FMC	25	16	6.2	7.78
		MR-WP	25	16	5.9	7.83
		WR-MH	25	15	6.5	7.89
		WR-QC	25	17	5.9	7.85
		HW Control	25	15	5.9	7.93
10/12/92	Cv	NR-SHB	25	15	6.6	8.08
		NR-BH	25	15	6.3	7.92
		MR-FMC	25	15	6.6	8.10
		MR-WP	25	17	6.5	8.09
		WR-MH	25	15	6.2	7.88
		WR-QC	25	17	6.4	7.97
		HW Control	25	15	6.3	7.99
		EST Control	25	15	6.1	7.83
10/12/92	ML	NR-SHB	25	15	6.8	8.45
		NR-BH	25	15	7.0	7.95
		MR-FMC	25	15	7.5	9.05
		MR-WP	25	15	7.8	9.10
		WR-MH	25	15	7.9	8.20
		WR-QC	25	15	8.3	8.19
		HW Control	25	15	7.4	8.22
10/13/92	Ea	NR-SHB	25	16	8.1	8.54
		NR-BH	25	15	7.5	8.27
		MR-FMC	25	15	7.7	8.47
		MR-WP	25	15	7.9	8.48
		WR-MH	25	15	7.8	8.33
		WR-QC	25	15	7.9	8.32
		EST Control	25	15	8.0	8.28
10/13/92	Pp	NR-SHB	25	15	7.1	8.11
		NR-BH	25	15	6.2	7.85
		MR-FMC	25	15	5.9	7.76
		MR-WP	25	15	5.6	7.77
		WR-MH	25	14	6.4	7.84
		WR-QC	25	16	6.0	7.78
		HW Control	25	15	5.6	7.80
10/13/92	Cv	NR-SHB	25	15	6.3	8.03
		NR-BH	25	15	5.6	7.83
		MR-FMC	25	15	6.0	8.13
		MR-WP	25	16	6.0	8.15
		WR-MH	25	15	5.9	7.82
		WR-QC	25	16	5.4	7.79
		HW Control	25	15	6.1	7.97
		EST Control	25	15	5.6	7.70

10/14/92	Ea	NR-SHB	25	16	8.1	8.50
		NR-BH	25	15	7.3	8.15
		MR-FMC	25	15	7.6	8.33
		MR-WP	25	15	7.5	8.30
		WR-MH	25	15	7.5	8.21
		WR-QC	25	15	7.4	8.21
		EST Control	25	16	7.5	8.15
10/14/92	Pp	NR-SHB	25	16	7.8	8.22
		NR-BH	25	15	6.1	7.74
		MR-FMC	25	15	5.8	7.57
		MR-WP	25	15	6.2	7.67
		WR-MH	25	14	7.6	8.07
		WR-QC	25	15	6.2	7.76
		HW Control	25	16	5.5	7.78
10/14/92	Cv	NR-SHB	25	16	6.0	7.96
		NR-BH	25	15	5.6	7.75
		MR-FMC	25	15	6.1	7.90
		MR-WP	25	15	5.6	7.80
		WR-MH	25	15	6.0	7.79
		WR-QC	25	15	5.4	7.68
		HW Control	25	16	5.4	7.84
		EST Control	25	16	5.5	7.67
10/15/92	Cv	NR-SHB	25	15	6.4	8.17
		NR-BH	25	15	5.6	7.85
		MR-FMC	25	15	6.8	8.18
		MR-WP	25	15	6.3	8.13
		WR-MH	25	15	7.3	8.10
		WR-QC	25	15	6.4	7.91
		HW Control	25	16	5.9	7.97
		EST Control	25	16	6.0	7.90
10/16/92	Cv	NR-SHB	26	15	6.1	8.07
		NR-BH	25	15	5.8	7.86
		MR-FMC	25	15	6.8	8.27
		MR-WP	25	15	6.4	8.13
		WR-MH	25	15	7.5	8.21
		WR-QC	25	15	6.8	8.00
		HW Control	25	16	6.2	8.01
		EST Control	25	16	6.0	7.94
10/17/92	Cv	NR-SHB	25	15	6.7	8.20
		NR-BH	25	15	5.7	7.82
		MR-FMC	25	14	7.8	8.65
		MR-WP	24	15	7.4	8.44
		WR-MH	25	15	8.1	8.52
		WR-QC	24	15	7.0	8.13
		HW Control	24	16	5.9	8.11
		EST Control	25	16	5.9	8.00

4/13/93	Ea	NR-SHB	25	14	7.4	9.14
		NR-BH	25	14	7.6	8.94
		MR-FMC	25	14	7.5	9.22
		MR-WP	25	15	7.5	9.22
		WR-MH	25	13	7.8	8.64
		WR-QC	25	13	8.1	8.58
		Control	24	15	7.2	7.98
4/13/93	Pp	NR-SHB	25	14	7.4	9.14
		NR-BH	25	14	7.6	8.94
		MR-FMC	25	14	7.5	9.22
		MR-WP	25	15	7.5	9.22
		WR-MH	25	13	7.8	8.64
		WR-QC	25	13	8.1	8.58
		Control	24	15	7.2	7.98
4/13/93	Cv	NR-SHB	25	14	7.4	9.14
		NR-BH	25	14	7.6	8.94
		MR-FMC	25	14	7.5	9.22
		MR-WP	25	15	7.5	9.22
		WR-MH	25	13	7.8	8.64
		WR-QC	25	13	8.1	8.58
		Control	24	15	7.2	7.98
4/14/93	Ea	NR-SHB	25	14	8.0	8.67
		NR-BH	25	14	8.0	8.44
		MR-FMC	25	14	9.1	8.90
		MR-WP	25	15	8.7	8.87
		WR-MH	25	14	9.0	8.61
		WR-QC	25	14	9.2	8.62
		Control	25	14	8.5	8.30
4/14/93	Pp	NR-SHB	25	14	5.5	8.47
		NR-BH	25	14	6.2	8.44
		MR-FMC	25	14	6.1	8.77
		MR-WP	25	15	5.7	8.72
		WR-MH	25	14	6.4	8.19
		WR-QC	25	14	6.6	8.27
		Control	26	14	5.5	7.51
4/14/93	Cv	NR-SHB	25	14	6.3	8.42
		NR-BH	25	14	5.6	8.03
		MR-FMC	25	14	5.8	8.63
		MR-WP	25	15	5.4	8.62
		WR-MH	25	14	5.6	7.92
		WR-QC	25	14	6.0	7.98
		Control	25	14	6.3	7.54

4/15/93	Ea	NR-SHB	26	14	9.6	8.75
		NR-BH	26	14	9.5	8.70
		MR-FMC	26	14	10.2	8.99
		MR-WP	25	15	10.0	8.89
		WR-MH	25	14	10.7	8.86
		WR-QC	25	14	10.2	8.87
		Control	26	15	9.8	8.63
4/15/93	Pp	NR-SHB	25	14	5.5	7.76
		NR-BH	24	14	6.6	7.87
		MR-FMC	24	14	6.0	7.99
		MR-WP	25	15	5.5	8.07
		WR-MH	24	14	5.9	7.67
		WR-QC	24	14	5.9	7.84
		Control	24	15	5.8	7.42
4/15/93	Cv	NR-SHB	25	14	5.6	8.09
		NR-BH	25	14	6.3	8.00
		MR-FMC	24	14	6.1	8.38
		MR-WP	24	15	5.7	8.35
		WR-MH	24	14	5.9	7.75
		WR-QC	24	14	6.1	7.76
		Control	24	15	5.8	7.41
4/16/93	Ea	NR-SHB	24	14	9.7	8.84
		NR-BH	24	14	9.3	8.79
		MR-FMC	24	14	11.0	9.14
		MR-WP	24	15	10.8	9.12
		WR-MH	24	14	10.8	9.05
		WR-QC	24	14	10.7	9.03
		Control	24	15	10.5	8.93
4/16/93	Pp	NR-SHB	24	14	6.1	7.85
		NR-BH	24	14	7.3	8.10
		MR-FMC	24	14	6.3	8.07
		MR-WP	25	15	6.4	8.12
		WR-MH	25	14	5.9	7.79
		WR-QC	25	14	7.8	8.13
		Control	24	15	6.2	7.70
4/16/93	Cv	NR-SHB	24	14	5.4	7.99
		NR-BH	24	14	6.1	7.93
		MR-FMC	24	14	5.5	8.21
		MR-WP	24	15	5.9	8.37
		WR-MH	24	14	6.1	7.81
		WR-QC	24	14	6.4	7.92
		Control	24	15	5.5	7.50

4/16/93	ML	NR-SHB	23	14	8.0	9.16
		NR-BH	23	15	8.1	8.80
		MR-FMC	23	14	8.2	9.32
		MR-WP	23	14	8.4	9.33
		WR-MH	23	14	8.6	8.71
		WR-QC	23	15	9.1	8.81
		Control	25	15	7.3	7.95
4/17/93	Ea	NR-SHB	24	14	8.7	8.92
		NR-BH	24	15	8.4	8.80
		MR-FMC	24	14	8.8	9.00
		MR-WP	24	15	9.0	8.99
		WR-MH	24	14	8.8	8.86
		WR-QC	24	15	9.4	8.96
		Control	24	15	9.6	8.72
4/17/93	Pp	NR-SHB	24	14	5.3	7.87
		NR-BH	24	14	7.2	8.14
		MR-FMC	23	14	5.8	8.06
		MR-WP	24	15	6.0	8.10
		WR-MH	25	14	6.4	7.91
		WR-QC	24	15	7.6	8.31
		Control	25	15	5.6	7.68
4/17/93	Cv	NR-SHB	24	14	5.1	7.86
		NR-BH	24	14	5.9	8.06
		MR-FMC	24	14	4.8	8.26
		MR-WP	24	15	4.9	8.31
		WR-MH	24	14	5.6	7.87
		WR-QC	24	15	5.7	7.99
		Control	24	15	4.6	7.37
4/18/93	Ea	NR-SHB	24	15	9.2	8.75
		NR-BH	24	15	8.9	8.57
		MR-FMC	24	14	9.5	8.82
		MR-WP	24	15	9.6	8.75
		WR-MH	24	14	9.2	8.61
		WR-QC	24	15	9.8	8.74
		Control	24	15	9.2	8.59
4/18/93	Pp	NR-SHB	24	14	7.1	7.87
		NR-BH	24	15	8.8	8.18
		MR-FMC	24	14	7.0	8.04
		MR-WP	24	14	7.8	8.16
		WR-MH	24	14	7.6	7.84
		WR-QC	24	15	7.9	8.20
		Control	24	15	6.7	7.71

4/18/93	Cv	NR-SHB	24	14	6.1	8.14
		NR-BH	24	14	6.8	8.36
		MR-FMC	24	14	6.3	8.23
		MR-WP	24	15	6.3	8.31
		WR-MH	24	14	6.2	7.81
		WR-QC	24	15	6.9	7.99
		Control	24	15	5.8	7.82
4/19/93	Ea	NR-SHB	25	14	9.6	8.77
		NR-BH	24	15	9.3	8.64
		MR-FMC	24	14	9.7	8.74
		MR-WP	24	14	10.2	8.80
		WR-MH	25	15	9.5	8.62
		WR-QC	24	15	10.0	8.76
		Control	24	15	9.8	8.57
4/19/93	Pp	NR-SHB	24	14	6.8	7.94
		NR-BH	24	15	8.8	8.24
		MR-FMC	24	14	7.5	8.11
		MR-WP	24	15	9.8	8.59
		WR-MH	25	14	9.4	8.48
		WR-QC	24	15	8.0	8.26
		Control	25	15	5.8	7.63
4/19/93	Cv	NR-SHB	24	14	4.9	7.80
		NR-BH	24	15	8.2	8.35
		MR-FMC	24	14	4.8	8.06
		MR-WP	24	15	5.5	8.17
		WR-MH	24	15	5.4	7.71
		WR-QC	24	15	5.6	7.85
		Control	24	15	4.0	7.42
4/19/93	ML	NR-SHB	23	14	8.7	9.23
		NR-BH	23	14	8.6	8.95
		MR-FMC	23	14	8.8	9.27
		MR-WP	23	15	8.8	9.22
		WR-MH	24	14	8.8	8.71
		WR-QC	23	14	9.1	8.78
		Control	25	15	7.4	8.01
4/20/93	Ea	NR-SHB	25	14	8.6	8.72
		NR-BH	24	15	8.6	8.65
		MR-FMC	24	15	8.8	8.83
		MR-WP	25	15	8.9	8.82
		WR-MH	25	14	8.4	8.57
		WR-QC	25	14	8.8	8.67
		Control	25	15	8.5	8.40

4/20/93	Pp	NR-SHB	24	14	7.1	8.03
		NR-BH	24	15	7.6	8.12
		MR-FMC	24	14	8.5	8.38
		MR-WP	24	15	11.2	8.86
		WR-MH	24	14	10.2	8.70
		WR-QC	24	15	7.8	8.15
		Control	24	15	6.3	7.79
4/20/93	Cv	NR-SHB	24	14	4.9	7.83
		NR-BH	24	14	8.1	8.46
		MR-FMC	24	14	5.4	8.21
		MR-WP	24	15	5.6	8.28
		WR-MH	24	14	5.0	7.68
		WR-QC	24	15	5.4	7.81
		Control	23	15	4.5	7.27
4/21/93	Ea	NR-SHB	25	14	8.4	8.76
		NR-BH	24	14	8.3	8.66
		MR-FMC	24	14	8.5	8.80
		MR-WP	25	15	8.3	8.82
		WR-MH	24	14	8.7	8.63
		WR-QC	23	14	8.4	8.55
		Control	25	15	8.1	8.43
4/21/93	Pp	NR-SHB	24	14	9.2	8.47
		NR-BH	24	14	9.1	8.40
		MR-FMC	24	15	11.2	8.84
		MR-WP	24	15	13.6	9.10
		WR-MH	25	14	14.0	9.20
		WR-QC	24	14	7.1	8.10
		Control	25	15	6.5	7.84
4/21/93	Cv	NR-SHB	24	14	5.9	7.78
		NR-BH	24	14	11.5	8.78
		MR-FMC	25	14	6.5	8.17
		MR-WP	25	15	7.7	8.40
		WR-MH	25	14	5.5	7.69
		WR-QC	25	14	6.0	7.80
		Control	24	15	5.1	7.32

APPENDIX B

Water quality conditions reported during sediment toxicity tests

Sediment Water Quality Conditions Reported in Tests

Date	Test Species	Station	T	D.O.	pH
10/17/92	Ld	WR-MH	20	7.7	7.7
		NR-SHB	20	7.7	7.6
		WR-QC	20	7.8	7.4
		PR-MR	20	7.6	7.6
		MR-FM	20	7.5	7.8
		MR-WP	20	7.7	7.6
		NR-B	20	7.4	7.5
		BB-Control	20	7.6	7.8
10/18/92	Ld	WR-MH	24	7.1	7.2
		NR-SHB	25	7.1	7.1
		WR-QC	25	7.1	7.0
		PR-MR	25	6.8	7.2
		MR-FM	25	7.0	7.4
		MR-WP	25	6.0	7.2
		NR-B	25	7.0	7.2
		BB-Control	25	7.0	7.4
10/19/92	Ld	WR-MH	25	6.7	7.5
		NR-SHB	25	2.8	7.4
		WR-QC	25	7.1	7.6
		PR-MR	25	7.0	7.3
		MR-FM	25	7.0	7.4
		MR-WP	25	6.0	7.3
		NR-B	25	7.0	7.4
		BB-Control	25	7.0	7.6
10/20/92	Ld	WR-MH	25	6.8	7.5
		NR-SHB	25	7.0	7.1
		WR-QC	25	7.3	6.9
		PR-MR	25	7.7	7.3
		MR-FM	25	7.1	7.1
		MR-WP	25	6.9	7.2
		NR-B	25	7.2	7.1
		BB-Control	25	7.2	7.6
10/21/92	Ld	WR-MH	25	6.9	7.0
		NR-SHB	25	6.5	7.3
		WR-QC	25	6.6	7.0
		PR-MR	25	6.9	7.2
		MR-FM	25	6.7	7.1
		MR-WP	25	6.8	6.9
		NR-B	25	7.0	6.5
		BB-Control	25	6.7	7.5
10/22/92	Ld	WR-MH	25	7.0	7.4
		NR-SHB	25	6.9	7.2
		WR-QC	25	6.6	7.4
		PR-MR	25	7.0	6.8
		MR-FM	25	6.8	7.0
		MR-WP	25	6.7	6.8
		NR-B	25	6.4	7.1
		BB-Control	25	7.2	7.8

10/23/92	Ld	WR-MH	25	6.2	7.3
		NR-SHB	25	7.2	7.1
		WR-QC	25	7.0	7.3
		PR-MR	25	6.7	6.9
		MR-FM	25	6.3	7.2
		MR-WP	25	6.5	7.3
		NR-B	25	7.3	7.2
		BB-Control	25	7.1	7.7
10/24/92	Ld	WR-MH	25	6.5	7.2
		NR-SHB	25	6.8	7.2
		WR-QC	25	7.0	7.3
		PR-MR	25	7.1	6.2
		MR-FM	25	6.6	7.3
		MR-WP	25	6.7	7.4
		NR-B	25	6.5	6.9
		BB-Control	25	6.2	7.5
10/25/92	Ld	WR-MH	25	6.6	7.3
		NR-SHB	25	6.9	7.1
		WR-QC	25	6.5	7.0
		PR-MR	25	7.0	6.8
		MR-FM	25	6.2	7.2
		MR-WP	25	6.3	7.1
		NR-B	25	7.1	6.9
		BB-Control	25	6.4	7.8
10/26/92	Ld	WR-MH	25	6.5	7.4
		NR-SHB	25	6.2	7.0
		WR-QC	25	6.1	7.2
		PR-MR	25	6.1	6.6
		MR-FM	25	6.5	7.0
		MR-WP	25	6.4	7.0
		NR-B	25	6.7	7.1
		BB-Control	25	6.3	8.1
10/27/92	Ld	WR-MH	25	6.2	7.2
		NR-SHB	25	6.8	6.8
		WR-QC	25	6.6	7.3
		PR-MR	25	7.0	6.9
		MR-FM	25	6.8	7.4
		MR-WP	25	6.8	7.3
		NR-B	25	6.8	7.3
		BB-Control	25	6.7	7.7
10/28/92	Ld	WR-MH	25	7.2	7.4
		NR-SHB	25	7.0	7.5
		WR-QC	25	7.4	7.5
		PR-MR	24	7.9	7.7
		MR-FM	25	7.6	7.3
		MR-WP	25	7.4	7.5
		NR-B	25	7.5	7.4
		BB-Control	25	7.4	7.3
10/29/92	Ld	WR-MH	25	7.1	7.8
		NR-SHB	25	7.1	7.7
		WR-QC	25	7.2	7.1
		PR-MR	24	7.2	7.4
		MR-FM	25	6.6	7.5
		MR-WP	25	7.0	6.8

		NR-B	25	7.1	6.9
		BB-Control	25	7.2	7.8
10/30/92	Ld	WR-MH	25	6.6	8.0
		NR-SHB	25	6.6	8.0
		WR-QC	25	6.7	8.0
		PR-MR	25	6.8	8.1
		MR-FM	25	6.6	7.6
		MR-WP	24	6.9	7.9
		NR-B	25	6.7	7.8
		BB-Control	25	6.5	7.6
11/1/92	Ld	WR-MH	25	7.4	7.7
		NR-SHB	25	7.2	8.0
		WR-QC	25	6.8	7.6
		PR-MR	25	6.7	7.6
		MR-FM	25	6.7	7.4
		MR-WP	25	6.5	7.2
		NR-B	25	6.9	7.5
		BB-Control	25	6.7	7.5
11/2/92	Ld	WR-MH	25	7.1	7.3
		NR-SHB	25	7.2	7.5
		WR-QC	25	6.9	7.7
		PR-MR	25	6.6	8.0
		MR-FM	25	6.6	7.6
		MR-WP	25	6.6	7.9
		NR-B	25	6.8	7.5
		BB-Control	25	6.8	7.6
11/3/92	Ld	WR-MH	25	6.2	7.1
		NR-SHB	25	6.1	6.9
		WR-QC	25	7.1	7.1
		PR-MR	25	7.1	6.9
		MR-FM	25	7.0	7.1
		MR-WP	25	7.3	7.2
		NR-B	25	6.7	7.1
		BB-Control	25	7.1	7.7
11/4/92	Ld	WR-MH	25	7.2	7.1
		NR-SHB	25	6.6	6.6
		WR-QC	25	7.0	7.0
		PR-MR	25	7.0	7.1
		MR-FM	25	7.1	6.8
		MR-WP	25	7.2	6.9
		NR-B	25	7.1	7.2
		BB-Control	25	7.0	6.7
11/5/92	Ld	WR-MH	25	6.9	7.3
		NR-SHB	25	7.2	7.2
		WR-QC	25	7.3	7.1
		PR-MR	25	7.0	7.1
		MR-FM	25	7.1	7.3
		MR-WP	25	7.2	7.1
		NR-B	25	6.9	7.2
		BB-Control	25	6.9	7.5
11/6/92	Ld	WR-MH	25	7.1	7.2
		NR-SHB	25	7.1	7.2
		WR-QC	25	6.8	7.2
		PR-MR	25	6.9	7.1

		MR-FM	25	7.0	7.2
		MR-WP	25	6.7	7.2
		NR-B	25	6.9	7.2
		BB-Control	25	7.1	7.9
11/7/92	Ld	WR-MH	24	7.0	7.7
		NR-SHB	24	7.0	7.8
		WR-QC	24	7.1	7.9
		PR-MR	24	7.1	7.7
		MR-FM	24	6.7	7.6
		MR-WP	24	6.9	7.2
		NR-B	24	7.1	7.1
		BB-Control	24	7.1	8.0
10/17/92	Sb	PR-MR	20	7.7	7.8
		MR-WP	20	7.8	7.9
		BB-SR	20	7.9	7.6
		PC-Control	20	7.9	7.7
		WR-QC	20	7.7	7.7
		WR-MH	20	7.8	7.6
		NR-B	20	7.8	7.5
		MR-FM	20	7.8	7.7
		NR-SHB	20	7.8	7.4
10/18/92	Sb	PR-MR	23	7.3	7.2
		MR-WP	23	7.5	7.4
		BB-SR	23	7.6	7.3
		PC-Control	23	7.6	7.1
		WR-QC	24	7.4	7.0
		WR-MH	24	7.5	7.2
		NR-B	23	7.5	7.4
		MR-FM	23	7.3	7.3
		NR-SHB	24	7.8	7.3
10/19/92	Sb	PR-MR	24	7.2	7.3
		MR-WP	24	7.3	7.3
		BB-SR	24	7.3	7.6
		PC-Control	24	7.2	7.0
		WR-QC	24	7.0	7.6
		WR-MH	24	6.6	7.5
		NR-B	24	7.1	7.4
		MR-FM	24	7.3	7.4
		NR-SHB	24	6.2	7.4
10/20/92	Sb	PR-MR	25	6.8	7.3
		MR-WP	25	7.1	7.2
		BB-SR	25	7.2	7.6
		PC-Control	25	7.1	7.3
		WR-QC	25	6.7	6.9
		WR-MH	25	6.3	7.5
		NR-B	25	7.1	7.1
		MR-FM	25	6.3	7.1
		NR-SHB	25	7.1	7.1
10/21/92	Sb	PR-MR	25	6.5	7.2
		MR-WP	25	6.7	6.9
		BB-SR	25	7.2	7.5
		PC-Control	25	6.9	7.1
		WR-QC	25	7.0	7.0
		WR-MH	25	6.1	7.0

		NR-B	25	7.0	6.5
		MR-FM	25	7.1	7.1
		NR-SHB	25	7.2	7.3
10/22/92	Sb	PR-MR	25	7.0	6.8
		MR-WP	25	6.7	6.8
		BB-SR	25	6.6	7.8
		PC-Control	25	6.5	7.4
		WR-QC	25	6.8	7.4
		WR-MH	25	6.7	7.4
		NR-B	25	7.4	7.1
		MR-FM	25	7.2	7.0
		NR-SHB	25	7.1	7.2
10/23/92	Sb	PR-MR	25	7.1	6.9
		MR-WP	25	6.9	7.3
		BB-SR	25	7.3	7.7
		PC-Control	25	7.0	7.3
		WR-QC	25	7.5	7.3
		WR-MH	25	7.0	7.3
		NR-B	25	6.9	7.2
		MR-FM	25	7.4	7.2
		NR-SHB	25	6.4	7.1
10/24/92	Sb	PR-MR	25	7.2	6.2
		MR-WP	25	7.1	7.4
		BB-SR	25	7.2	7.5
		PC-Control	25	7.0	7.3
		WR-QC	25	7.0	7.3
		WR-MH	25	6.8	7.2
		NR-B	25	6.8	6.9
		MR-FM	25	7.2	7.3
		NR-SHB	25	6.8	7.2
10/25/92	Sb	PR-MR	25	6.7	6.8
		MR-WP	25	6.9	7.1
		BB-SR	25	6.6	7.8
		PC-Control	25	6.9	7.0
		WR-QC	24	6.9	7.0
		WR-MH	24	6.4	7.3
		NR-B	25	6.6	6.9
		MR-FM	25	6.5	7.2
		NR-SHB	25	7.0	7.1
10/26/92	Sb	PR-MR	25	6.7	6.6
		MR-WP	25	7.0	7.0
		BB-SR	25	6.7	8.1
		PC-Control	25	4.7	7.3
		WR-QC	25	6.7	7.2
		WR-MH	25	6.6	7.4
		NR-B	25	7.2	7.1
		MR-FM	25	7.3	7.0
		NR-SHB	25	7.0	7.0
10/27/92	Sb	PR-MR	24	7.1	7.2
		MR-WP	24	7.0	7.3
		BB-SR	24	7.3	7.7
		PC-Control	24	6.5	7.3
		WR-QC	25	6.7	7.3
		WR-MH	25	5.8	7.2

		NR-B	25	7.0	7.3
		MR-FM	25	6.7	7.4
		NR-SHB	25	5.9	6.8
10/28/92	Sb	PR-MR	25	6.8	7.6
		MR-WP	25	7.1	7.7
		BB-SR	25	7.0	7.5
		PC-Control	25	6.8	7.6
		WR-QC	25	6.3	7.5
		WR-MH	25	7.0	7.1
		NR-B	25	6.7	7.2
		MR-FM	25	6.2	7.5
		NR-SHB	25	6.0	6.8
10/29/92	Sb	PR-MR	25	6.9	6.9
		MR-WP	25	7.1	7.4
		BB-SR	25	7.1	7.9
		PC-Control	25	6.0	7.8
		WR-QC	25	6.8	7.3
		WR-MH	25	6.9	6.9
		NR-B	25	6.0	7.2
		MR-FM	25	7.0	7.2
		NR-SHB	25	7.1	7.2
10/30/92	Sb	PR-MR	25	6.4	7.9
		MR-WP	25	6.3	7.3
		BB-SR	25	6.8	7.8
		PC-Control	25	6.3	7.7
		WR-QC	25	6.8	7.7
		WR-MH	25	6.6	7.7
		NR-B	25	7.0	7.6
		MR-FM	25	6.7	7.6
		NR-SHB	25	6.7	7.5
11/1/92	Sb	PR-MR	25	7.0	7.7
		MR-WP	25	6.7	7.3
		BB-SR	25	7.0	6.9
		PC-Control	25	7.1	6.8
		WR-QC	25	6.9	7.4
		WR-MH	25	6.9	7.1
		NR-B	25	7.0	8.0
		MR-FM	25	6.8	7.1
		NR-SHB	25	7.2	7.5
11/2/92	Sb	PR-MR	25	6.9	7.8
		MR-WP	25	6.8	8.0
		BB-SR	25	7.1	8.1
		PC-Control	25	7.0	7.1
		WR-QC	25	7.0	7.5
		WR-MH	25	6.8	7.4
		NR-B	25	6.8	7.2
		MR-FM	25	7.0	7.8
		NR-SHB	25	7.0	7.9
11/3/92	Sb	PR-MR	25	6.5	6.9
		MR-WP	25	6.8	7.2
		BB-SR	25	6.9	7.7
		PC-Control	25	6.5	7.7
		WR-QC	25	7.0	7.1
		WR-MH	25	5.6	7.1

		NR-B	25	6.8	7.1
		MR-FM	25	6.8	7.1
		NR-SHB	25	7.1	6.9
11/4/92	Sb	PR-MR	25	6.7	7.1
		MR-WP	25	7.0	6.9
		BB-SR	25	6.8	6.7
		PC-Control	25	6.7	6.9
		WR-QC	25	6.7	7.0
		WR-MH	25	6.6	7.1
		NR-B	25	6.9	7.2
		MR-FM	25	7.1	6.8
		NR-SHB	25	6.8	6.6
11/5/92	Sb	PR-MR	25	7.2	7.1
		MR-WP	25	6.5	7.1
		BB-SR	25	7.2	7.5
		PC-Control	25	7.3	7.5
		WR-QC	25	6.1	7.1
		WR-MH	25	7.3	7.3
		NR-B	25	7.3	7.2
		MR-FM	25	7.1	7.3
		NR-SHB	25	7.3	7.2
11/6/92	Sb	PR-MR	25	6.8	7.1
		MR-WP	25	7.0	7.2
		BB-SR	25	5.9	7.9
		PC-Control	25	6.8	8.0
		WR-QC	25	7.0	7.2
		WR-MH	25	7.2	7.2
		NR-B	25	7.2	7.2
		MR-FM	25	7.2	7.2
		NR-SHB	25	7.1	7.2
11/7/92	Sb	PR-MR	25	6.4	7.1
		MR-WP	25	7.0	7.8
		BB-SR	25	7.1	7.9
		PC-Control	25	7.1	7.7
		WR-QC	25	7.0	7.2
		WR-MH	25	5.9	8.0
		NR-B	25	7.0	8.1
		MR-FM	25	6.9	8.0
		NR-SHB	25	7.1	7.2
10/17/92	Lp	WR-MH	20	7.4	7.9
		WR-QC	20	7.7	7.7
		MR-WP	20	7.6	7.6
		PR-Control	20	7.7	7.4
		NR-SHB	20	7.5	7.9
		MR-FM	20	7.7	7.6
		NR-B	20	7.8	7.5
		BB-SR	20	7.9	7.7
10/18/92	Lp	WR-MH	25	7.1	7.4
		WR-QC	25	7.1	7.2
		MR-WP	25	7.2	6.9
		PR-Control	25	7.3	7.0
		NR-SHB	25	7.2	7.6
		MR-FM	25	7.0	7.4
		NR-B	25	7.2	7.4

		BB-SR	25	7.1	7.3
10/19/92	Lp	WR-MH	25	6.6	7.4
		WR-QC	25	6.7	7.5
		MR-WP	25	7.0	7.3
		PR-Control	25	6.7	7.3
		NR-SHB	25	7.2	7.3
		MR-FM	25	6.8	7.3
		NR-B	25	6.1	7.4
		BB-SR	25	6.6	7.7
10/20/92	Lp	WR-MH	25	7.1	7.2
		WR-QC	25	6.0	7.3
		MR-WP	25	6.9	7.3
		PR-Control	25	7.2	7.2
		NR-SHB	25	7.2	6.8
		MR-FM	25	7.4	7.4
		NR-B	25	6.8	7.3
		BB-SR	25	6.1	7.6
10/21/92	Lp	WR-MH	25	7.0	7.0
		WR-QC	25	6.6	7.0
		MR-WP	25	7.1	6.9
		PR-Control	25	4.6	7.2
		NR-SHB	25	6.1	7.3
		MR-FM	25	6.8	7.1
		NR-B	25	7.1	6.5
		BB-SR	25	6.1	7.5
10/22/92	Lp	WR-MH	25	6.9	7.4
		WR-QC	25	5.2	7.4
		MR-WP	25	6.8	6.8
		PR-Control	25	6.8	6.8
		NR-SHB	25	6.1	7.2
		MR-FM	25	6.7	7.0
		NR-B	25	6.7	7.1
		BB-SR	25	7.1	7.7
10/23/92	Lp	WR-MH	25	6.2	7.3
		WR-QC	25	7.2	7.3
		MR-WP	25	7.0	7.3
		PR-Control	25	6.7	6.9
		NR-SHB	25	6.3	7.1
		MR-FM	25	6.5	7.2
		NR-B	25	7.3	7.2
		BB-SR	25	7.1	7.7
10/24/92	Lp	WR-MH	25	6.9	7.2
		WR-QC	25	6.3	7.3
		MR-WP	25	7.1	7.4
		PR-Control	25	6.6	6.2
		NR-SHB	25	7.0	7.2
		MR-FM	25	6.6	7.3
		NR-B	25	7.1	6.9
		BB-SR	25	6.3	7.5
10/25/92	Lp	WR-MH	25	6.7	7.3
		WR-QC	25	6.6	7.0
		MR-WP	25	6.4	7.1
		PR-Control	25	6.3	6.8
		NR-SHB	25	6.3	7.1

		MR-FM	25	6.7	7.2
		NR-B	25	7.2	6.9
		BB-SR	25	6.9	7.8
10/26/92	Lp	WR-MH	25	6.7	7.4
		WR-QC	25	6.6	7.2
		MR-WP	25	6.8	7.0
		PR-Control	25	6.0	6.6
		NR-SHB	25	7.3	7.0
		MR-FM	25	6.8	7.0
		NR-B	25	6.9	7.1
		BB-SR	25	6.2	8.1
10/28/92	Lp	WR-MH	25	6.8	7.6
		WR-QC	26	7.0	7.7
		MR-WP	26	6.9	7.3
		PR-Control	26	7.2	7.6
		NR-SHB	26	7.2	7.9
		MR-FM	25	7.3	7.8
		NR-B	26	6.9	7.6
		BB-SR	25	7.0	6.9
10/29/92	Lp	WR-MH	25	7.2	7.2
		WR-QC	25	7.1	7.8
		MR-WP	25	6.7	7.5
		PR-Control	25	7.0	6.9
		NR-SHB	25	7.1	7.1
		MR-FM	25	6.8	7.8
		NR-B	25	6.9	7.2
		BB-SR	25	7.1	7.1
10/30/92	Lp	WR-MH	25	6.8	7.6
		WR-QC	25	6.4	8.0
		MR-WP	25	6.5	8.1
		PR-Control	25	6.3	7.3
		NR-SHB	25	6.7	7.2
		MR-FM	25	6.4	7.7
		NR-B	25	6.7	7.4
		BB-SR	25	6.8	6.9
11/1/92	Lp	WR-MH	25	7.0	7.5
		WR-QC	25	6.1	7.8
		MR-WP	25	7.0	7.8
		PR-Control	25	7.1	7.6
		NR-SHB	25	6.7	8.0
		MR-FM	25	6.9	8.1
		NR-B	25	6.9	6.9
		BB-SR	25	6.5	7.2
11/2/92	Lp	WR-MH	25	6.9	8.0
		WR-QC	25	6.4	7.2
		MR-WP	25	6.6	7.5
		PR-Control	25	6.9	7.6
		NR-SHB	25	6.8	7.7
		MR-FM	25	7.0	7.7
		NR-B	25	6.8	7.8
		BB-SR	25	6.5	7.2
11/3/92	Lp	WR-MH	25	6.7	7.1
		WR-QC	25	7.0	7.1
		MR-WP	25	6.2	7.2

		PR-Control	25	7.1	6.9
		NR-SHB	25	6.7	6.9
		MR-FM	25	7.0	7.1
		NR-B	25	6.6	7.1
		BB-SR	25	6.9	7.7
11/4/92	Lp	WR-MH	25	7.0	7.1
		WR-QC	25	6.9	7.0
		MR-WP	25	7.2	6.9
		PR-Control	25	6.9	7.1
		NR-SHB	25	7.1	6.6
		MR-FM	25	6.8	6.8
		NR-B	25	7.0	7.2
		BB-SR	25	6.8	6.7
11/5/92	Lp	WR-MH	25	7.3	7.3
		WR-QC	25	6.7	7.1
		MR-WP	25	7.1	7.1
		PR-Control	25	6.6	7.1
		NR-SHB	25	7.1	7.2
		MR-FM	25	6.6	7.3
		NR-B	25	7.4	7.2
		BB-SR	25	7.4	7.5
11/6/92	Lp	WR-MH	25	7.0	7.2
		WR-QC	25	7.0	7.2
		MR-WP	25	7.2	7.2
		PR-Control	25	7.3	7.1
		NR-SHB	25	7.0	7.2
		MR-FM	25	7.2	7.2
		NR-B	25	7.1	7.2
		BB-SR	25	7.1	7.9
11/7/92	Lp	WR-MH	25	7.0	7.9
		WR-QC	25	6.5	7.6
		MR-WP	25	6.9	7.7
		PR-Control	25	7.1	7.8
		NR-SHB	25	6.8	7.7
		MR-FM	25	7.1	7.8
		NR-B	25	7.1	8.1
		BB-SR	25	7.2	8.2
10/20/92	Cv	PR-MR	22	7.2	7.3
		NR-B	22	7.7	7.5
		MR-WP	22	7.5	7.5
		PC-Control	22	7.3	7.4
		NR-SHB	22	6.6	7.3
		MR-FM	22	7.5	7.4
		WR-QC	22	7.6	7.6
		WR-MH	22	7.5	7.4
		BB-SR	22	7.7	7.5
10/21/92	Cv	PR-MR	24	6.1	6.8
		NR-B	24	7.1	7.3
		MR-WP	24	7.0	7.4
		PC-Control	24	6.2	7.3
		NR-SHB	24	7.1	7.3
		MR-FM	24	7.2	7.4
		WR-QC	24	7.2	7.6
		WR-MH	24	7.3	7.4

		BB-SR	24	7.5	7.8
10/22/92	Cv	PR-MR	25	6.3	7.1
		NR-B	25	6.2	7.2
		MR-WP	25	6.7	7.3
		PC-Control	25	6.7	7.4
		NR-SHB	24	6.0	7.2
		MR-FM	24	4.3	7.3
		WR-QC	24	4.8	7.4
		WR-MH	24	6.9	7.6
		BB-SR	24	7.3	7.7
10/23/92	Cv	PR-MR	24	6.5	7.3
		NR-B	24	6.8	7.1
		MR-WP	24	6.8	7.2
		PC-Control	24	6.1	7.3
		NR-SHB	24	6.1	7.1
		MR-FM	24	4.5	7.1
		WR-QC	24	6.3	6.9
		WR-MH	24	7.0	7.0
		BB-SR	24	7.3	7.6
10/24/92	Cv	PR-MR	25	6.6	7.2
		NR-B	25	7.0	6.5
		MR-WP	25	6.7	6.9
		PC-Control	25	6.3	7.1
		NR-SHB	25	6.2	7.3
		MR-FM	25	5.9	7.1
		WR-QC	25	6.1	7.0
		WR-MH	25	6.5	7.0
		BB-SR	25	7.3	7.5
10/25/92	Cv	PR-MR	25	6.8	6.8
		NR-B	25	3.8	7.1
		MR-WP	25	6.8	6.8
		PC-Control	25	6.5	7.3
		NR-SHB	25	7.1	7.2
		MR-FM	25	7.2	7.0
		WR-QC	25	6.5	7.4
		WR-MH	25	6.5	7.4
		BB-SR	25	7.3	7.8
10/26/92	Cv	PR-MR	25	5.8	6.9
		NR-B	25	6.1	7.2
		MR-WP	25	5.2	7.3
		PC-Control	25	6.7	7.3
		NR-SHB	24	7.1	7.1
		MR-FM	24	7.1	7.0
		WR-QC	24	7.1	7.3
		WR-MH	24	7.4	7.3
		BB-SR	25	7.3	7.7
10/27/92	Cv	PR-MR	25	6.5	6.2
		NR-B	25	6.2	6.9
		MR-WP	25	6.0	7.4
		PC-Control	25	6.5	7.3
		NR-SHB	24	6.2	7.2
		MR-FM	24	6.0	7.3
		WR-QC	25	7.0	7.3
		WR-MH	24	6.8	7.2

		BB-SR	25	7.4	7.5
10/28/92	Cv	PR-MR	25	6.8	6.8
		NR-B	25	3.8	6.9
		MR-WP	25	6.8	7.1
		PC-Control	25	6.5	7.0
		NR-SHB	25	7.1	7.1
		MR-FM	25	7.2	7.2
		WR-QC	24	6.5	7.0
		WR-MH	24	6.5	7.3
		BB-SR	24	7.3	7.8
10/29/92	Cv	PR-MR	25	4.5	6.6
		NR-B	25	2.4	7.1
		MR-WP	25	2.9	7.0
		PC-Control	25	6.2	7.3
		NR-SHB	25	6.0	7.0
		MR-FM	24	6.2	7.0
		WR-QC	24	6.2	7.2
		WR-MH	24	2.3	7.4
		BB-SR	24	6.0	8.1
10/30/92	Cv	PR-MR	24	5.6	6.9
		NR-B	25	6.0	7.1
		MR-WP	25	5.8	7.3
		PC-Control	25	6.7	7.3
		NR-SHB	24	5.9	6.8
		MR-FM	25	6.2	7.4
		WR-QC	24	6.2	7.3
		WR-MH	25	2.3	7.2
		BB-SR	25	6.0	7.7

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Date	Test Species	Station	T	D.O.	pH
4/29/93	C.v.	MR-WP	25	7.4	8.1
		MR-FM	25	7.4	8.2
		WR-QC	25	7.2	8.0
		WR-MH	25	7.1	8.0
		NR-SHB	25	7.2	7.5
		NR-B	25	7.0	7.9
		BB-SR	25	7.4	8.2
		PC-MR	25	7.0	8.0
		PR-MC	25	7.0	8.1
4/30/93	C.v.	MR-WP	25	7.2	7.0
		MR-FM	25	7.3	7.2
		WR-QC	25	7.4	7.1
		WR-MH	25	7.2	7.0
		NR-SHB	25	7.1	7.2
		NR-B	25	7.2	7.1
		BB-SR	25	7.3	7.5
		PC-MR	25	7.3	7.4
		PR-MC	25	7.1	7.1
5/1/93	C.v.	MR-WP	25	7.3	7.5
		MR-FM	25	7.2	7.6

		WR-QC	25	7.3	7.8
		WR-MH	25	7.4	7.2
		NR-SHB	25	7.3	7.3
		NR-B	25	7.2	7.2
		BB-SR	25	7.2	7.8
		PC-MR	25	7.2	7.4
		PR-MC	25	6.8	7.2
5/2/93	C.v.	MR-WP	25	7.1	7.5
		MR-FM	25	7.1	7.1
		WR-QC	25	7.4	7.3
		WR-MH	25	7.3	7.1
		NR-SHB	25	7.2	7.2
		NR-B	25	7.1	7.1
		BB-SR	25	7.1	7.6
		PC-MR	25	7.1	7.3
		PR-MC	25	7.0	7.1
5/3/93	C.v.	MR-WP	25	7.2	6.8
		MR-FM	26	7.2	6.3
		WR-QC	25	7.3	6.8
		WR-MH	25	7.2	7.2
		NR-SHB	25	7.2	7.0
		NR-B	25	7.3	6.8
		BB-SR	26	7.1	7.8
		PC-MR	25	7.3	7.1
		PR-MC	25	7.2	7.2
5/4/93	C.v.	MR-WP	25	7.2	7.1
		MR-FM	25	7.3	6.4
		WR-QC	25	7.2	6.8
		WR-MH	25	7.2	7.0
		NR-SHB	24	7.3	6.9
		NR-B	25	7.3	6.9
		BB-SR	25	7.3	7.5
		PC-MR	25	7.2	7.1
		PR-MC	25	7.1	7.2
5/5/93	C.v.	MR-WP	25	7.0	6.8
		MR-FM	25	6.9	6.5
		WR-QC	25	7.2	6.7
		WR-MH	25	7.3	6.9
		NR-SHB	25	7.3	6.7
		NR-B	25	7.3	6.8
		BB-SR	25	7.3	7.4
		PC-MR	25	7.1	6.7
		PR-MC	25	7.2	7.1
5/6/93	C.v.	MR-WP	25	7.3	7.1
		MR-FM	25	7.3	6.8
		WR-QC	25	7.3	6.7
		WR-MH	25	7.2	7.0
		NR-SHB	25	7.4	6.8
		NR-B	25	7.3	6.9
		BB-SR	25	7.4	7.2
		PC-MR	25	7.1	6.7
		PR-MC	25	7.1	7.1
5/25/93	Ld0	MR-WP	20	7.3	7.6
		MR-FM	20	7.9	7.8

		WR-QC	20	7.9	7.6
		WR-MH	20	7.8	7.6
		NR-SHB	20	5.5	7.5
		NR-B	20	7.4	7.6
		PR-MR	20	7.9	7.6
		BB-SC	20	8.0	7.8
5/26/93	Ld1	MR-WP	25	6.7	7.9
		MR-FM	25	6.7	7.9
		WR-QC	25	6.8	8.0
		WR-MH	25	6.6	7.6
		NR-SHB	25	6.8	7.7
		NR-B	25	6.8	7.8
		PR-MR	25	6.4	7.9
		BB-SC	25	6.8	8.1
5/27/93	Ld2	MR-WP	25	6.7	7.9
		MR-FM	25	6.8	8.0
		WR-QC	25	6.8	8.0
		WR-MH	25	6.7	7.8
		NR-SHB	25	6.8	7.8
		NR-B	25	6.9	7.9
		PR-MR	25	6.8	7.9
		BB-SC	25	6.9	8.1
5/28/93	Ld3	MR-WP	25	7.1	7.9
		MR-FM	25	7.0	7.6
		WR-QC	25	7.1	7.8
		WR-MH	25	7.0	7.7
		NR-SHB	25	6.9	7.5
		NR-B	25	7.0	7.9
		PR-MR	25	7.0	8.0
		BB-SC	25	7.1	8.1
5/29/93	Ld4	MR-WP	25	7.0	7.8
		MR-FM	25	7.0	7.6
		WR-QC	25	7.2	7.8
		WR-MH	25	7.3	7.8
		NR-SHB	25	7.7	7.6
		NR-B	25	7.3	7.9
		PR-MR	25	7.2	8.1
		BB-SC	25	7.1	8.1
5/30/93	Ld5	MR-WP	25	7.2	7.9
		MR-FM	25	7.3	7.6
		WR-QC	25	7.1	7.8
		WR-MH	25	7.4	7.7
		NR-SHB	25	7.1	7.6
		NR-B	25	7.4	7.8
		PR-MR	25	7.4	8.1
		BB-SC	25	7.3	8.1
5/31/93	Ld6	MR-WP	25	7.2	8.0
		MR-FM	25	7.1	7.6
		WR-QC	25	7.3	7.8
		WR-MH	25	7.3	7.8
		NR-SHB	25	7.2	7.7
		NR-B	25	7.2	7.7
		PR-MR	25	7.4	8.0
		BB-SC	25	7.4	8.1

6/1/93	Ld7	MR-WP	25	7.3	7.9
		MR-FM	25	7.2	7.8
		WR-QC	25	7.2	7.8
		WR-MH	25	7.2	7.8
		NR-SHB	25	7.3	7.8
		NR-B	25	7.2	7.8
		PR-MR	25	7.5	8.0
		BB-SC	25	7.4	8.1
6/2/93	Ld8	MR-WP	25	7.2	7.9
		MR-FM	25	7.3	7.7
		WR-QC	25	7.3	7.8
		WR-MH	25	7.3	7.8
		NR-SHB	25	7.2	7.9
		NR-B	25	7.1	7.8
		PR-MR	25	7.2	7.9
		BB-SC	25	7.1	8.0
6/3/93	Ld9	MR-WP	25	7.1	7.5
		MR-FM	25	7.1	6.9
		WR-QC	25	6.8	7.5
		WR-MH	25	6.1	7.3
		NR-SHB	25	6.9	6.7
		NR-B	25	6.8	7.7
		PR-MR	25	6.7	7.7
		BB-SC	25	7.1	8.0
6/4/93	Ld10	MR-WP	25	7.1	7.4
		MR-FM	25	7.1	7.0
		WR-QC	25	7.0	7.4
		WR-MH	25	6.7	7.4
		NR-SHB	25	7.1	6.2
		NR-B	25	7.0	7.3
		PR-MR	25	7.0	7.4
		BB-SC	25	6.6	7.9
6/5/93	Ld11	MR-WP	25	7.2	7.6
		MR-FM	25	7.2	7.8
		WR-QC	25	7.0	7.5
		WR-MH	25	7.2	7.7
		NR-SHB	25	7.2	7.5
		NR-B	25	7.2	7.6
		PR-MR	25	7.0	7.7
		BB-SC	25	7.1	7.9
6/6/93	Ld12	MR-WP	25	7.2	7.7
		MR-FM	25	7.3	7.6
		WR-QC	25	7.0	7.8
		WR-MH	25	7.4	7.6
		NR-SHB	25	7.3	7.4
		NR-B	25	7.3	7.5
		PR-MR	25	7.3	7.6
		BB-SC	25	7.3	7.9
6/7/93	Ld13	MR-WP	25	7.2	7.9
		MR-FM	25	7.0	7.4
		WR-QC	25	7.1	7.4
		WR-MH	25	7.2	7.4
		NR-SHB	25	7.2	7.1
		NR-B	25	7.0	7.6

		PR-MR	25	7.1	7.7
		BB-SC	25	7.1	7.9
6/8/93	Ld14	MR-WP	25	7.1	7.7
		MR-FM	25	7.2	7.6
		WR-QC	25	7.1	7.5
		WR-MH	25	7.2	7.5
		NR-SHB	25	7.3	7.4
		NR-B	25	7.1	7.7
		PR-MR	25	6.9	7.2
		BB-SC	25	7.2	7.9
6/9/93	Ld15	MR-WP	25	7.0	7.4
		MR-FM	25	7.1	7.1
		WR-QC	25	6.7	7.4
		WR-MH	25	7.1	7.5
		NR-SHB	25	7.1	6.4
		NR-B	25	7.1	7.5
		PR-MR	25	6.9	7.6
		BB-SC	25	7.2	7.9
6/10/93	Ld16	MR-WP	25	7.0	7.3
		MR-FM	25	7.1	7.8
		WR-QC	25	7.1	7.2
		WR-MH	25	7.2	7.5
		NR-SHB	25	7.2	6.8
		NR-B	25	7.2	7.3
		PR-MR	25	7.1	7.5
		BB-SC	25	7.3	7.9
6/11/93	Ld17	MR-WP	25	7.2	7.4
		MR-FM	25	7.2	5.9
		WR-QC	25	7.2	7.5
		WR-MH	25	7.2	6.9
		NR-SHB	25	7.1	5.9
		NR-B	25	7.2	7.2
		PR-MR	25	7.0	7.6
		BB-SC	25	7.2	7.9
6/12/93	Ld18	MR-WP	25	7.2	7.3
		MR-FM	25	7.2	6.1
		WR-QC	25	7.2	7.1
		WR-MH	25	7.1	6.6
		NR-SHB	25	7.1	5.7
		NR-B	25	7.2	7.0
		PR-MR	25	7.2	7.3
		BB-SC	25	7.2	7.8
6/13/93	Ld19	MR-WP	25	7.1	7.3
		MR-FM	25	7.2	5.8
		WR-QC	25	7.3	7.0
		WR-MH	25	7.2	6.5
		NR-SHB	25	7.2	5.5
		NR-B	25	7.1	7.1
		PR-MR	25	7.2	7.0
		BB-SC	25	7.2	7.7
6/14/93	Ld20	MR-WP	25	7.2	7.2
		MR-FM	25	7.2	6.9
		WR-QC	25	7.2	7.3
		WR-MH	25	7.2	7.4

		NR-SHB	25	7.2	5.3
		NR-B	25	7.2	7.4
		PR-MR	25	7.1	7.5
		BB-SC	25	7.3	7.9
5/25/93	Sb0	MR-WP	20	5.2	7.4
		MR-FM	20	6.9	7.7
		WR-QC	20	6.3	7.6
		WR-MH	20	6.4	7.6
		NR-SHB	20	7.0	7.6
		NR-B	20	6.8	7.6
		PR-MR	20	7.4	7.6
		BB-SR	20	7.4	7.8
		PC-MC	25	7.3	7.7
5/26/93	Sb1	MR-WP	25	7.3	8.0
		MR-FM	25	7.0	8.0
		WR-QC	25	7.0	8.0
		WR-MH	25	7.1	7.8
		NR-SHB	25	7.0	7.8
		NR-B	25	7.1	7.9
		PR-MR	25	7.0	7.8
		BB-SR	25	7.1	8.0
		PC-MC	25	7.0	8.1
5/27/93	Sb2	MR-WP	25	7.1	7.9
		MR-FM	25	7.0	7.9
		WR-QC	25	6.9	8.0
		WR-MH	25	7.2	7.8
		NR-SHB	25	7.1	7.9
		NR-B	25	7.0	7.9
		PR-MR	25	7.0	7.9
		BB-SR	25	6.8	8.1
		PC-MC	25	7.0	8.0
5/28/93	Sb3	MR-WP	25	7.3	7.9
		MR-FM	25	7.3	7.6
		WR-QC	25	7.4	7.9
		WR-MH	25	7.4	7.8
		NR-SHB	25	7.3	7.7
		NR-B	25	7.2	7.9
		PR-MR	25	7.4	7.8
		BB-SR	25	7.3	8.1
		PC-MC	25	7.0	8.0
5/29/93	Sb4	MR-WP	25	7.1	7.9
		MR-FM	25	7.2	7.6
		WR-QC	25	7.4	7.9
		WR-MH	25	7.4	7.8
		NR-SHB	25	7.4	7.6
		NR-B	25	7.3	7.9
		PR-MR	25	7.2	7.8
		BB-SR	25	7.4	8.0
		PC-MC	25	7.1	8.1
5/30/93	Sb5	MR-WP	25	7.0	8.0
		MR-FM	25	7.2	7.5
		WR-QC	25	7.5	7.8
		WR-MH	25	7.4	7.8
		NR-SHB	25	7.3	7.7

		NR-B	25	7.4	7.8
		PR-MR	25	7.3	7.8
		BB-SR	25	7.4	8.0
		PC-MC	25	7.1	8.1
5/31/93	Sb6	MR-WP	25	7.1	8.0
		MR-FM	25	7.3	7.6
		WR-QC	25	7.4	7.8
		WR-MH	25	7.4	7.8
		NR-SHB	25	7.4	7.6
		NR-B	25	7.3	7.9
		PR-MR	25	7.3	7.9
		BB-SR	25	7.3	8.0
		PC-MC	25	7.0	8.0
6/1/93	Sb7	MR-WP	25	7.0	8.0
		MR-FM	25	7.2	7.7
		WR-QC	25	7.4	7.8
		WR-MH	25	7.4	7.8
		NR-SHB	25	7.3	7.7
		NR-B	25	7.2	7.9
		PR-MR	25	7.3	8.0
		BB-SR	25	7.4	8.0
		PC-MC	25	7.1	8.0
6/2/93	Sb8	MR-WP	25	7.0	7.9
		MR-FM	25	7.1	7.7
		WR-QC	25	7.3	7.9
		WR-MH	25	7.3	7.8
		NR-SHB	25	7.2	7.7
		NR-B	25	7.1	7.8
		PR-MR	25	7.3	8.0
		BB-SR	25	7.4	7.9
		PC-MC	25	7.2	8.0
6/3/93	Sb9	MR-WP	25	7.1	7.6
		MR-FM	25	7.0	7.0
		WR-QC	25	7.1	7.7
		WR-MH	25	6.9	7.8
		NR-SHB	25	7.0	6.9
		NR-B	25	7.0	7.7
		PR-MR	25	7.1	7.2
		BB-SR	25	7.0	8.0
		PC-MC	25	7.1	7.9
6/4/93	Sb10	MR-WP	25	7.2	7.9
		MR-FM	25	7.0	7.6
		WR-QC	25	7.1	7.8
		WR-MH	25	7.0	7.8
		NR-SHB	25	7.0	7.5
		NR-B	25	7.0	7.8
		PR-MR	25	7.1	7.9
		BB-SR	25	7.2	8.0
		PC-MC	25	7.1	7.8
6/5/93	Sb11	MR-WP	25	7.1	7.7
		MR-FM	25	7.2	7.7
		WR-QC	25	7.1	7.6
		WR-MH	25	7.2	7.7
		NR-SHB	25	7.2	7.5

		NR-B	25	7.0	7.6
		PR-MR	25	7.3	7.6
		BB-SR	25	7.3	7.9
		PC-MC	25	7.2	7.9
6/6/93	Sb12	MR-WP	25	7.1	7.8
		MR-FM	24	7.1	7.8
		WR-QC	25	7.2	7.8
		WR-MH	25	7.1	7.6
		NR-SHB	25	7.1	7.5
		NR-B	25	7.1	7.7
		PR-MR	25	7.4	7.5
		BB-SR	25	7.2	8.0
		PC-MC	25	7.1	7.9
6/7/93	Sb13	MR-WP	25	7.1	7.9
		MR-FM	25	7.2	7.5
		WR-QC	25	7.1	7.5
		WR-MH	25	7.1	7.6
		NR-SHB	25	7.2	7.5
		NR-B	25	6.9	7.7
		PR-MR	25	7.3	7.3
		BB-SR	25	7.0	7.8
		PC-MC	25	7.1	7.7
6/8/93	Sb14	MR-WP	25	7.1	7.8
		MR-FM	25	7.2	7.6
		WR-QC	25	7.1	7.5
		WR-MH	25	7.2	7.6
		NR-SHB	25	7.1	7.4
		NR-B	25	7.1	7.8
		PR-MR	25	7.2	7.3
		BB-SR	25	7.0	7.9
		PC-MC	25	7.2	7.6
6/9/93	Sb15	MR-WP	25	6.9	7.3
		MR-FM	25	6.9	7.2
		WR-QC	25	6.8	7.7
		WR-MH	25	6.0	7.6
		NR-SHB	25	6.9	7.4
		NR-B	25	6.9	7.7
		PR-MR	25	6.9	7.1
		BB-SR	25	7.0	7.9
		PC-MC	25	6.8	7.8
6/10/93	Sb16	MR-WP	25	7.0	7.6
		MR-FM	25	7.3	7.9
		WR-QC	25	7.0	7.7
		WR-MH	25	6.9	7.6
		NR-SHB	25	7.0	7.3
		NR-B	25	7.2	7.7
		PR-MR	25	7.3	7.4
		BB-SR	25	7.1	7.8
		PC-MC	25	7.0	7.9
6/11/93	Sb17	MR-WP	25	7.0	7.8
		MR-FM	25	6.9	7.5
		WR-QC	25	7.1	7.8
		WR-MH	25	7.0	7.6
		NR-SHB	25	7.0	7.2

		NR-B	25	6.8	7.5
		PR-MR	25	7.1	7.3
		BB-SR	25	7.1	7.9
		PC-MC	25	7.0	7.9
6/12/93	Sb18	MR-WP	25	7.0	7.5
		MR-FM	25	7.2	7.0
		WR-QC	25	7.2	7.6
		WR-MH	25	7.2	7.4
		NR-SHB	25	7.1	6.8
		NR-B	25	7.1	7.1
		PR-MR	25	7.1	7.3
		BB-SR	25	7.1	7.9
		PC-MC	25	7.2	7.7
6/13/93	Sb19	MR-WP	25	6.8	7.6
		MR-FM	25	6.6	6.9
		WR-QC	25	7.0	7.0
		WR-MH	25	7.0	7.2
		NR-SHB	25	7.0	6.8
		NR-B	25	7.2	7.0
		PR-MR	25	7.2	7.2
		BB-SR	25	7.1	7.8
		PC-MC	25	7.2	7.8
6/14/93	Sb20	MR-WP	24	7.2	7.5
		MR-FM	24	7.2	7.1
		WR-QC	24	7.2	7.6
		WR-MH	25	7.2	7.9
		NR-SHB	24	7.3	6.8
		NR-B	25	7.2	7.7
		PR-MR	24	7.3	6.8
		BB-SR	25	7.3	7.9
		PC-MC	25	7.2	7.8
5/25/93	Lp0	MR-WP	20	7.7	7.7
		MR-FM	20	7.9	7.8
		WR-QC	20	7.9	7.7
		WR-MH	20	8.0	7.8
		NR-SHB	20	7.9	7.7
		NR-B	20	8.1	7.7
		BB-SR	20	8.1	7.8
		PR-MC	20	8.1	7.7
5/26/93	Lp1	MR-WP	25	6.7	7.9
		MR-FM	25	7.0	7.9
		WR-QC	25	6.9	7.9
		WR-MH	25	7.1	7.8
		NR-SHB	25	7.1	7.7
		NR-B	25	7.4	7.9
		BB-SR	25	7.2	8.0
		PR-MC	25	6.8	7.6
5/27/93	Lp2	MR-WP	25	6.9	7.9
		MR-FM	25	7.1	7.7
		WR-QC	25	7.0	7.9
		WR-MH	25	7.0	7.9
		NR-SHB	25	7.0	7.8
		NR-B	25	7.0	7.9
		BB-SR	25	6.9	8.0

		PR-MC	25	7.0	7.6
5/28/93	Lp3	MR-WP	25	7.5	7.9
		MR-FM	25	7.4	7.7
		WR-QC	25	7.4	7.8
		WR-MH	25	7.5	7.8
		NR-SHB	25	7.4	7.7
		NR-B	25	7.2	7.8
		BB-SR	25	7.5	8.0
		PR-MC	25	7.3	7.7
5/29/93	Lp4	MR-WP	25	7.4	7.9
		MR-FM	25	7.4	7.7
		WR-QC	25	7.3	7.8
		WR-MH	25	7.4	7.8
		NR-SHB	25	7.4	7.7
		NR-B	25	7.4	7.8
		BB-SR	25	7.1	7.9
		PR-MC	25	7.2	7.6
5/30/93	Lp5	MR-WP	25	7.3	7.9
		MR-FM	25	7.5	7.7
		WR-QC	25	7.5	7.8
		WR-MH	25	7.3	7.8
		NR-SHB	25	7.3	7.6
		NR-B	25	7.4	7.8
		BB-SR	25	7.4	7.9
		PR-MC	25	7.4	7.6
5/31/93	Lp6	MR-WP	25	7.3	7.9
		MR-FM	25	7.3	7.6
		WR-QC	25	7.4	7.8
		WR-MH	25	7.2	7.7
		NR-SHB	25	7.3	7.6
		NR-B	25	7.3	7.8
		BB-SR	25	7.3	7.8
		PR-MC	25	7.2	7.7
6/1/93	Lp7	MR-WP	25	7.3	7.8
		MR-FM	25	7.4	7.8
		WR-QC	25	7.3	7.8
		WR-MH	25	7.2	7.8
		NR-SHB	25	7.3	7.7
		NR-B	25	7.3	7.8
		BB-SR	25	7.3	7.9
		PR-MC	25	7.2	7.8
6/2/93	Lp8	MR-WP	25	7.1	7.7
		MR-FM	25	7.2	7.8
		WR-QC	25	7.3	7.8
		WR-MH	25	7.3	7.9
		NR-SHB	25	7.2	7.8
		NR-B	25	7.4	7.8
		BB-SR	25	7.3	7.8
		PR-MC	25	7.2	7.8
6/3/93	Lp9	MR-WP	26	7.0	7.3
		MR-FM	26	6.9	7.3
		WR-QC	26	7.0	7.4
		WR-MH	26	7.1	7.6
		NR-SHB	26	7.3	7.8

		NR-B	26	7.2	7.7
		BB-SR	26	7.0	8.0
		PR-MC	26	6.9	7.1
6/4/93	Lp10	MR-WP	25	7.0	7.1
		MR-FM	25	6.9	7.3
		WR-QC	25	7.1	6.9
		WR-MH	25	7.1	7.1
		NR-SHB	25	6.9	7.7
		NR-B	25	7.1	7.7
		BB-SR	25	7.1	7.8
		PR-MC	25	7.0	7.9
6/5/93	Lp11	MR-WP	26	7.0	7.6
		MR-FM	26	7.1	7.8
		WR-QC	26	7.1	7.6
		WR-MH	26	7.1	7.7
		NR-SHB	26	7.1	7.6
		NR-B	26	7.2	7.8
		BB-SR	26	7.1	7.9
		PR-MC	26	7.2	7.5
6/6/93	Lp12	MR-WP	26	7.2	7.8
		MR-FM	25	7.2	7.7
		WR-QC	26	7.2	7.8
		WR-MH	26	7.3	7.7
		NR-SHB	25	7.3	7.6
		NR-B	25	7.2	7.7
		BB-SR	25	7.3	8.0
		PR-MC	25	7.2	7.5
6/7/93	Lp13	MR-WP	25	7.0	7.8
		MR-FM	26	7.2	7.5
		WR-QC	26	7.2	7.6
		WR-MH	26	7.2	7.5
		NR-SHB	25	7.2	7.5
		NR-B	25	7.2	7.7
		BB-SR	25	7.2	7.9
		PR-MC	25	7.2	7.7
6/8/93	Lp14	MR-WP	25	7.1	7.7
		MR-FM	26	7.1	7.5
		WR-QC	26	7.2	7.7
		WR-MH	26	7.1	7.6
		NR-SHB	25	7.2	7.6
		NR-B	25	7.2	7.7
		BB-SR	25	7.3	7.9
		PR-MC	25	7.2	7.2
6/9/93	Lp15	MR-WP	26	6.9	7.6
		MR-FM	26	6.9	7.4
		WR-QC	26	6.8	7.5
		WR-MH	26	7.0	7.5
		NR-SHB	26	6.8	7.2
		NR-B	26	7.0	7.6
		BB-SR	26	7.0	7.9
		PR-MC	26	7.1	7.1
6/10/93	Lp16	MR-WP	26	7.1	7.5
		MR-FM	26	7.1	7.8
		WR-QC	26	7.2	7.3

		WR-MH	26	7.1	7.7
		NR-SHB	26	7.1	7.3
		NR-B	25	7.2	7.6
		BB-SR	25	6.6	7.7
		PR-MC	25	7.1	7.1
6/11/93	Lp17	MR-WP	26	7.0	7.7
		MR-FM	26	7.2	7.2
		WR-QC	26	7.2	7.7
		WR-MH	26	7.2	7.3
		NR-SHB	26	7.1	6.8
		NR-B	26	7.2	7.6
		BB-SR	26	7.2	8.0
		PR-MC	26	7.1	6.7
6/12/93	Lp18	MR-WP	26	7.0	7.6
		MR-FM	26	7.1	7.0
		WR-QC	26	7.0	7.5
		WR-MH	26	7.1	7.1
		NR-SHB	26	7.1	6.6
		NR-B	26	7.1	7.5
		BB-SR	26	7.2	7.8
		PR-MC	26	7.0	6.7
6/13/93	Lp19	MR-WP	26	7.1	7.4
		MR-FM	26	7.2	6.9
		WR-QC	26	7.2	7.3
		WR-MH	26	7.2	7.2
		NR-SHB	26	7.1	6.9
		NR-B	26	7.1	7.4
		BB-SR	26	7.1	7.7
		PR-MC	25	7.1	6.7
6/14/93	Lp20	MR-WP	25	7.2	7.5
		MR-FM	25	7.2	7.4
		WR-QC	25	7.2	7.6
		WR-MH	25	7.2	7.4
		NR-SHB	26	7.2	7.1
		NR-B	25	7.3	7.4
		BB-SR	25	7.2	7.9
		PR-MC	25	7.2	5.3

APPENDIX C

Organics and pesticide data from sediment toxicity tests

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42321
Sample ID:	Wilson Point		

Dates:

Collected:	04/15/93	Extracted:	04/30/93
Received:	4/16/93	Analyzed:	06/15/93
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.03	% Moisture:	≈43.7

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
106-44-54	4-Methylphenol	19.2	J	370
91-20-3	Naphthene	35.0	J	152
91-57-3	2-Methylnaphthalene	27.9	J	304
132-64-5	Dibenzofuran	6.9	J	149
86-73-7	Fluorene	12.2	J	227
85-01-8	Phenanthrene	71.0	J	290
84-74-2	Di-n-butylphthalate	25.0	J,B	195
206-44-0	Fluoranthene	142	J	350
129-00-0	Pyrene	149	J	350
218-01-9	Chrysene	58.9	J	479
117-81-7	Bis(2-ethylhexyl)phthalate	62.0	J,B	413
205-99-2	Benzo(B)Fluoranthene	83.8	J	459

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in QC blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42322
Sample ID:	Frog Mortar		

Dates:

Collected:	04/15/93	Extracted:	04/30/93
Received:	04/16/93	Analyzed:	06/15/93
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.04	% Moisture:	≈54.0

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
91-20-3	Naphthene	55.8	J	152
91-57-3	2-Methylnaphthalene	44.6	J	304
132-64-5	Dibenzofuran	10.9	J	149
86-73-7	Fluorene	18.7	J	227
85-01-8	Phenanthrene	97.9	J	290
120-12-7	Anthracene	28.1	J	265
84-74-2	Di-n-butylphthalate	32.7	J,B	195
206-44-0	Fluoranthene	173	J	350
129-00-0	Pyrene	184	J	350
218-01-9	Chrysene	77.6	J	479
117-81-7	Bis(2-ethylhexyl)phthalate	104	J,B	413
205-99-2	Benzo(B)Fluoranthene	115	J	459

N/A - not applicable
J - Compound detected below the calculated method detection limit.

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42323
Sample ID:	Quarter Creek		

Dates:

Collected:	04/15/93	Extracted:	04/30/93
Received:	04/16/93	Analyzed:	06/15/93
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.01	% Moisture:	≈43.9

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
120-12-7	Anthracene	10.9	J	265
84-74-2	Di-n-butylphthalate	142	J,B	195
206-44-0	Fluoranthene	21.8	J	350
129-00-0	Pyrene	23.1	J	350
117-81-7	Bis(2-ethylhexyl)phthalate	74.5	J,B	413

N/A - not applicable
J - Compound detected below the calculated method detection limit.

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42324
Sample ID:	Manor House		

<u>Dates</u>:

Collected:	04/15/93	Extracted:	04/30/93
Received:	04/16/93	Analyzed:	06/15/93
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.01	% Moisture:	≈57.7

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
106-44-4	4-Methylphenol	541		370
84-66-2	Diethylphthalate	26.5	J	226
120-12-7	Anthracene	11.7	J	265
84-74-2	Di-n-butylphthalate	39.7	J,B	195
206-44-0	Fluoranthene	36.5	J	350
129-00-0	Pyrene	36.6	J	350
117-81-7	Bis(2-ethylhexyl)phthalate	50.6	J,B	413

N/A - not applicable
J - Compound detected below the calculated method detection limit.

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42325
Sample ID:	Sandy Hill Beach		

Dates:

Collected:	04/15/93	Extracted:	04/30/93
Received:	04/16/93	Analyzed:	06/15/93
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.05	% Moisture:	≈63.0

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
120-12-7	Anthracene	25.0	J	265
84-74-2	Di-n-butylphthalate	39.8	J,B	195
206-44-0	Fluoranthene	59.8	J	350
129-00-0	Pyrene	60.1	J	350
56-55-3	Benzo(A)Anthracene	19.4	J	587
117-81-7	Bis(2-ethylhexyl)phthalate	42.9	J,B	413

N/A - not applicable
J - Compound detected below the calculated method detection limit.

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42326
Sample ID:	Bivalve		

Dates:

Collected:	04/15/93	Extracted:	04/30/93
Received:	04/16/93	Analyzed:	06/15/93
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.08	% Moisture:	≈35.2

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
84-66-2	Dithylphthalate	15.2	J	226
84-74-2	Di-n-butylphthalate	23.8	J,B	195
129-00-0	Pyrene	19.1	J	350
56-55-3	Benzo(A)Anthracene	13.6	J	587
117-81-7	Bis(2-ethylhexyl)phthalate	33.1	J,B	413

N/A - not applicable
J - Compound detected below the calculated method detection limit.

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42327
Sample ID:	Poropatank		

Dates:

Collected:	04/08/93	Extracted:	04/30/93
Received:	04/16/93	Analyzed:	06/15/93
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.05	% Moisture:	≈59.3

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
106-44-5	4-Methylphenol	139	J	370
84-74-2	Di-n-butylphthalate	39.0	J,B	195
206-44-0	Fluoranthene	20.2	J	350
129-00-0	Pyrene	24.3	J	350
117-81-7	Bis(2-ethylhexyl)phthalate	99.6	J,B	413

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42328
Sample ID:	Lynnhaven Mud		

Dates:

Collected:	04/08/93	Extracted:	04/30/93
Received:	04/16/93	Analyzed:	06/15/93
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.08	% Moisture:	≈53.3

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
84-66-2	Diethylphthalate	25.2	J	226
84-74-2	Di-n-butylphthalate	32.8	B	195
206-44-0	Fluoranthene	56.1	J	350
129-00-0	Pyrene	49.3	J	350
117-81-7	Bis(2-ethylhexyl)phthalate	119	J,B	413
205-99-2	Benzo(B)Fluoranthene	37.3	J	459

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42329
Sample ID:	Lynnhaven Sand		

Dates:

Collected:	04/08/93	Extracted:	04/30/93
Received:	04/16/93	Analyzed:	06/15/93
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.09	% Moisture:	≈19.1

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
84-74-2	Di-n-butylphthalate	32.8	B,J	195
117-81-7	Bis(20ethylhexyl)phthalate	38.2	B,J	413

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41273
Sample ID:	Manor House		

Dates:

Collected:	10/07/92	Extracted:	10/13/92
Received:	10/08/92	Analyzed:	10/29/92
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.06	% Moisture:	≈57.58

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
106-46-7	1,4-Dichlorobenzene	226	J,B	241
84-74-2	Di-n-butylphthalate	11.8	J	195

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41274
Sample ID:	Quarter Creek		

Dates:

Collected:	10/07/92	Extracted:	10/13/92
Received:	10/08/92	Analyzed:	10/29/92
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.05	% Moisture:	≈57.91

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
106-46-7	1,4-Dichlorobenzene	194	J,B	241

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41275
Sample ID:	Frog Mortar		

Dates:

Collected:	10/07/92	Extracted:	10/13/92
Received:	10/08/92	Analyzed:	10/29/92
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.15	% Moisture:	≈49.01

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
106-46-7	1,4-Dichlorobenzene	163	J,B	241
84-74-2	Di-n-butylphthalate	20.2	J	195

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41276
Sample ID:	Wilson Point		

Dates:

Collected:	10/07/92	Extracted:	10/13/92
Received:	10/08/92	Analyzed:	10/29/92
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.05	% Moisture:	≈40.78

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
106-46-7	1,4-Dichlorobenzene	94.3	J,B	241

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41277
Sample ID:	Bivalve		

Dates:

Collected:	10/07/92	Extracted:	10/13/92
Received:	10/08/92	Analyzed:	10/29/92
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.13	% Moisture:	≈41.60

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
84-74-2	Di-n-butylphthalate	7.6	J	195

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41278
Sample ID:	Sandy Hill Beach		

Dates:

Collected:	10/07/92	Extracted:	10/13/92
Received:	10/08/92	Analyzed:	10/29/92
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	µg/Kg dry
Sample w/v:	30.03	% Moisture:	≈61.54

CAS No.	Compound	Conc. (µg/Kg dry)	Tag	Detection Limit (µg/Kg dry)
106-46-7	1,4-Dichlorobenzene	121	J,B	241
84-74-2	Di-n-butylphthalate	10.5	J	195

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41279
Sample ID:	Lynnhaven Mud		

Dates:

Collected:	10/07/92	Extracted:	10/13/92
Received:	10/08/92	Analyzed:	10/29/92
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.06	% Moisture:	≈52.10

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
106-46-7	1,4-Dichlorobenzene	125	J,B	241

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41280
Sample ID:	Lynnhaven Sand		

Dates:

Collected:	10/07/92	Extracted:	10/13/92
Received:	10/08/92	Analyzed:	10/29/92
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.04	% Moisture:	≈22.39

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
106-46-7	1,4-Dichlorobenzene	102	J,B	241

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED SEMI-VOLATILE COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41417
Sample ID:	Poropatank		

Dates:

Collected:	10/14/92	Extracted:	10/20/92
Received:	10/15/92	Analyzed:	10/29/92
Method:	EPA 8270	Instrument:	INCOS 50
Analyst:	RJM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	µg/Kg dry
Sample w/v:	30.05	% Moisture:	≈69.16

CAS No.	Compound	Conc. (µg/Kg dry)	Tag	Detection Limit (µg/Kg dry)
None detected				

N/A - not applicable
J - Compound detected below the calculated method detection limit.
B - Compound detected in blank

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41273
Sample ID:	Manor House		

<u>Dates</u>:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	µg/Kg dry
Sample w/v:	30.18	% Moisture:	≈57.58

CAS No.	Compound	Conc. (µg/Kg dry)	Tag	Detection Limit (µg/Kg dry)
50-29-3	4,4'-DDT	27.7	U	3.83
1031-07-8	Endosulfan Sulfate	9.03	B,U	0.66

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41274
Sample ID:	Quarter Creek		

Dates:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.46	% Moisture:	≈57.91

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
1031-07-8	Endosulfan Sulfate	23.2	B,U	0.66

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41275
Sample ID:	Frog Mortar		

Dates:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.15	% Moisture:	≈49.01

CAS No.	Compound (μg/Kg dry)	Conc.	Tag	Detection Limit (μg/Kg dry)
72-55-9	4,4'-DDE	1.65	C	0.594
1031-07-8	Endosulfan Sulfate	4.91	B,U	0.66

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41276
Sample ID:	Wilson Point		

Dates:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.07	% Moisture:	≈40.78

CAS No.	Compound (μg/Kg dry)	Conc.	Tag	Detection Limit (μg/Kg dry)
959-98-8	Endosulfan I	10.7	U	0.99
1031-07-8	Endosulfan Sulfate	4.91	B,U	0.66

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41277
Sample ID:	Bivalve		

Dates:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.61	% Moisture:	≈41.60

CAS No.	Compound (μg/Kg dry)	Conc.	Tag	Detection Limit (μg/Kg dry)
309-00-2	Aldrin	5.04	C	0.66
959-98-8	Endosulfan I	8.49	U	0.99
1031-07-8	Endosulfan Sulfate	3.13	B,U	0.66

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41278
Sample ID:	Sandy Hill Beach		

Dates:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.11	% Moisture:	≈61.54

CAS No.	Compound (μg/Kg dry)	Conc.	Tag	Detection Limit (μg/Kg dry)
76-44-8	Heptachlor	0.465	J,U	0.924
959-98-8	Endosulfan I	12.2	U	0.990
1031-07-8	Endosulfan Sulfate	3.30	B,U	0.660

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

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ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41273
Sample ID:	Manor House		

Dates:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.18	% Moisture:	≈57.58

CAS No.	Compound (μg/Kg dry)	Conc.	Tag	Detection Limit (μg/Kg dry)
50-29-3	4,4-DDT	27.7	U	3.83
1031-07-8	Endosulfan Sulfate	9.03	B,U	0.660

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41274
Sample ID:	Quarter Creek		

Dates:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.46	% Moisture:	≈57.91

CAS No.	Compound (μg/Kg dry)	Conc.	Tag	Detection Limit (μg/Kg dry)
1031-07-8	Endosulfan Sulfate	23.2	B,U	0.660

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

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ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41279
Sample ID:	Lynnhaven Mud		

Dates:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.01	% Moisture:	≈52.10

CAS No.	Compound (μg/Kg dry)	Conc.	Tag	Detection Limit (μg/Kg dry)
391-85-7	beta-BHC	5.57	C	0.627
309-00-2	Aldrin	5.60	U	0.660
1031-07-8	Endosulfan Sulfate	2.71	B,U	0.660

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

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ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41280
Sample ID:	Lynnhaven Sand		

Dates:

Collected:	10/07/92	Extracted:	10/14/92
Received:	10/12/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.02	% Moisture:	≈22.39

CAS No.	Compound (μg/Kg dry)	Conc.	Tag	Detection Limit (μg/Kg dry)
309-00-2	Aldrin	4.44	U	0.660

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

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ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	41417
Sample ID:	Poropatank		

Dates:

Collected:	10/14/92	Extracted:	10/21/92
Received:	10/19/92	Analyzed:	10/23/92
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.04	% Moisture:	≈69.16

CAS No.	Compound (μg/Kg dry)	Conc.	Tag	Detection Limit (μg/Kg dry)
391-86-8	delta-BHC	8.35	U	0.693
1024-57-3	Heptachlor Epoxide	2.26	C	0.627

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

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ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42321
Sample ID:	Wilson Point		

<u>Dates</u>:

Collected:	04/15/93	Extracted:	04/26/93
Received:	04/16/93	Analyzed:	05/24/93
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.03	% Moisture:	≈43.70

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
58-89-9	Lindane	0.00414	J,C	1.19
72-55-9	4,4'-DDE	0.0473	J,C	0.594
72-54-8	4,4'-DDD	0.375	J,U	0.528
1031-07-8	Endosulfan Sulfate	0.129	J,U	0.660

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

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ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42322
Sample ID:	Frog Mortar		

Dates:

Collected:	04/15/93	Extracted:	04/26/93
Received:	04/16/93	Analyzed:	05/24/93
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	µg/Kg dry
Sample w/v:	30.02	% Moisture:	≈54.00

CAS No.	Compound	Conc. (µg/Kg dry)	Tag	Detection Limit (µg/Kg dry)
72-55-9	4,4'-DDE	0.0434	J,C	0.594
72-54-8	4,4'-DDD	0.0366	J,U	0.528
1031-07-8	Endosulfan Sulfate	0.124	J,U	0.660
72-43-5	Methoxychlor	0.0525	J,U	50.0

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42323
Sample ID:	Quarter Creek		

Dates:

Collected:	04/15/93	Extracted:	04/26/93
Received:	04/16/93	Analyzed:	05/24/93
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.06	% Moisture:	≈43.90

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
72-55-9	4,4'-DDE	0.0434	J,C	0.594
33213-65-9	Endosulfan II	0.0125	J,U	0.825
1031-07-8	Endosulfan Sulfate	0.0641	J,C	0.660

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

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ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42324
Sample ID:	Manor House		

Dates:

Collected:	04/15/93	Extracted:	04/26/93
Received:	04/16/93	Analyzed:	05/24/93
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.04	% Moisture:	≈57.70

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
391-84-6	alpha-BHC	0.00658	J,U	0.0792
1024-57-3	Heptachlor Epoxide	0.0186	J,U	0.627
1031-07-8	Endosulfan Sulfate	0.0711	J,C	0.660
53494-70-5	Endrin Kepone	0.0131	B,J,U	0.825

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42325
Sample ID:	Sandy Hill Beach		

Dates:

Collected:	04/15/93	Extracted:	04/26/93
Received:	04/16/93	Analyzed:	05/24/93
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.10	% Moisture:	≈63.00

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
72-54-8	4,4'-DDD	0.0126	J,U	0.528
1031-07-8	Endosulfan Sulfate	0.0561	J,C	0.660
72-43-5	Methoxychlor	0.0269	J,C	50.0

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

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ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42326
Sample ID:	Bivalve		

Dates:

Collected:	04/15/93	Extracted:	04/26/93
Received:	04/16/93	Analyzed:	05/24/93
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.05	% Moisture:	≈35.20

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
1031-07-8	Endosulfan Sulfate	0.0895	J,C	0.660

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42327
Sample ID:	Poropatank		

Dates:

Collected:	04/08/93	Extracted:	04/26/93
Received:	04/16/93	Analyzed:	05/24/93
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.19	% Moisture:	≈59.30

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
1031-07-8	Endosulfan Sulfate	0.0683	J,C	0.660
53494-70-5	Endrin Kepone	0.00203	J,C	0.825

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

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ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42328
Sample ID:	Lynnhaven Mud		

Dates:

Collected:	04/12/93	Extracted:	04/26/93
Received:	04/16/93	Analyzed:	05/24/93
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.06	% Moisture:	≈53.30

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
72-55-9	4,4'-DDE	0.00200	J,U	0.594
53494-70-5	Endrin Kepone	0.00582	J,U,B	0.825

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis

AMRL
ORGANIC ANALYSIS DATA SHEET
IDENTIFIED PESTICIDE/PCB COMPOUNDS

Laboratory:	Organics	Contractor:	MAES
Project ID:	Ambient Toxicity	Sample No.:	42329
Sample ID:	Lynnhaven Sand		

Dates:

Collected:	04/09/93	Extracted:	04/23/93
Received:	04/16/93	Analyzed:	05/24/93
Method:	Modified 3550/8080/8140	Instrument:	PE Autosystem
Analyst:	SGM	Data Released By:	T.L. Price Jr
Matrix:	Sediment	Units:	μg/Kg dry
Sample w/v:	30.12	% Moisture:	≈19.10

CAS No.	Compound	Conc. (μg/Kg dry)	Tag	Detection Limit (μg/Kg dry)
58-89-9	Lindane	0.00645	J,C	1.19
33213-65-9	Endosulfan II	0.00826	J,U	0.825

U - Compound not confirmed by secondary GC analysis
C - Compound confirmed by secondary GC column analysis, but concentration not sufficient for GC/MS confirmation.
M - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, but failed GC/MS confirmation.
P - Compound confirmed by secondary GC column analysis, concentration sufficient for GC/MS analysis, and GC/MS confirmed presence.
J - Compound detected below calculated method detection limit.
B - Retention time match to component in QC blank primary GC column analysis