Assessment of *In Situ* Stressors and Sediment Toxicity in the Lower Housatonic River

Prepared by:

EVS Environment Consultants

195 Pemberton Ave.
North Vancouver, B.C
Canada V7P 2R4

Adapted from a report by:

G. Allen Burton, Jr.

Institute for Environmental Quality
3640 Colonel Glenn Highway
Wright State University
Dayton, Ohio 45435

April 2003

Lower Housatonic River Project
Pittsfield, MA

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF APPENDICES

ABSTRACT

As part of a comprehensive ecosystem assessment, the effects of sediment-associated polychlorinated biphenyl (PCBs) contamination in the Lower Housatonic River, near Pittsfield, Massachusetts, USA, were evaluated. This assessment measured sediment toxicity in laboratory and field (*in situ*) exposures of surrogate test organisms and determined which class of chemicals contributed to toxicity using the Toxicity Identification Evaluation (TIE) approach. Each approach provided unique information useful in assessments of ecosystem degradation. Total PCB concentrations in reference site sediments ranged from 0.0001 to 5.4 mg/Kg (dry weight), and test site sediments ranged from 0.7 to 521.7 mg/Kg, depending on the exposure and test type. Organisms for *in situ* studies were housed in flow-through chambers for 2 to 10 days and placed against the sediments, in the water column, or in chambers filled partially with sediment and water. In the laboratory, life-cycle assessment tests were conducted with *Hyalella azteca* and *Chironomus tentans* for 4 to 6 weeks, following U.S. Environmental Protection Agency (USEPA) methods. For laboratory exposures, organism response (*e.g.*, mortality) increased with PCB contamination. For *in situ* exposures, organism responses also increased with PCB contamination for several species (*i.e.*, significantly reduced survival at sites with low mg/Kg dry PCB concentrations); however, this response was observed primarily for sediment exposures and was not readily apparent in the water-only exposures. Adverse effects were observed in laboratory exposures with sediments containing 8.7 mg/Kg dry PCB, or greater, at 20 to 42 d. The USEPA Phase I TIE approach showed acute toxicity was significantly reduced by treatments that reduce organic compounds and metals in pore water of the two most contaminated sites. Using both *in situ* and laboratory assays provided useful information on the source compartment (*i.e.,* sediments) and acute-to-chronic effect thresholds, thereby contributing to the weight-of-evidence assessment process.

1.0 INTRODUCTION

The following report describes the approaches used for identifying major stressors and associated concentrations in the Lower Housatonic River that cause adverse effects to benthic invertebrates. A weight of evidence approach was used that combined laboratory and field assessments of physical, chemical, and biological conditions with standard and non-standard test methods.

This study consisted of assessments of: 1) sediment toxicity using USEPA chronic test methods for *Hyalella azteca* and *Chironomus tentans* (USEPA 2000a, 2000b)*;* 2) *in situ* exposures (2 – 10 day) with *Daphnia magna, C. tentans, H. azteca, a*nd *Lumbriculus variegatus* to determine effects and/or contaminant uptake from overlying water, suspended solids, and bedded sediment; and 3) a laboratory Toxicity Identification Evaluation (Phase I) using *Ceriodaphnia dubia* to fractionate chemical stressor types. This study was coordinated with, and supported the outcomes of, other Roy F. Weston, Inc. (now WestonSolutions, Inc.) project tasks, including: 1) benthic macroinvertebrate community surveys; 2) storm flow and transport modeling; 3) habitat and physical-chemical sampling; and 4) food-web modeling.

Hyalella azteca are routinely used to assess the toxicity of chemicals in sediments (e.g., Burton *et al*., 1989; Burton 1991; Burton *et al*. 1996a,b). Test durations and endpoints recommended in standardized methods for sediment testing with *H. azteca* include 10-day (d) survival and 10- to 28-d survival and growth. Short-term exposures that only measure effects on survival can be used to identify high levels of contamination, but may not be able to identify moderately contaminated sediments. The method used in this study, however, can evaluate potential effects of contaminated sediment on survival, growth and reproduction occurring at lower stressor concentrations for *H. azteca* in a 42-d test.

The 42-d sediment exposure starts at Day 0 with 7- to 8-d-old amphipods. On Day 28, amphipods are isolated from the sediment and placed in water-only chambers where reproduction is measured on Day 35 and 42. Typically, amphipods are first in amplexus

at about Day 21 to 28 with release of the first brood between Day 28 to 42. Endpoints measured include survival (Day 28, 35 and 42), growth (dry weight measured on Day 28 and 42), and reproduction (number of young/female produced from Day 28 to 42). Reproduction in amphipods is measured by exposing them in sediment until a few days before the release of the first brood. The amphipods are then sieved from the sediment and held in water to determine the number of young produced. This test design allows a quantitative measure of reproduction. One limitation to this design is that amphipods might recover from effects of sediment exposure during this holding period in clean water. However, amphipods are exposed to sediment during critical developmental stages before release of the first brood in clean water. The USEPA and ASTM state that a subset of endpoints may be measured with minor method modifications (USEPA 1998, ASTM 1999).

The midge *Chironomus tentans* has been used extensively in the short-term assessment of chemicals in sediments (*e.g.,* Burton 1991, Burton *et al*. 1996a,b), and standard methods have been developed for testing with this species using 10-d exposures (USEPA 1994). *Chironomus tentans* is a good candidate for long-term toxicity testing because it normally completes its life cycle in a relatively short period of time (25 to 30 d at 23°C), and a variety of developmental (growth, survivorship) and reproductive (fecundity) endpoints can be monitored. In addition, emergent adults can be readily collected so it is possible to transfer organisms from the sediment test system to clean, overlying water for direct quantification of reproductive success. In Europe and Canada, the chronic midge method ends before emergence and the USEPA gives the option for test termination (USEPA 1998). Survival is determined at 20 d and at test termination (about 50 to 65 d). Growth is determined at 20 d, which corresponds to the 10-d endpoint in the 10-d *C. tentans* growth test started with 10-d old larvae. From Day 23 to the end of the test, emergence is monitored daily. Each treatment of the life-cycle test is ended separately when no additional emergence has been recorded for 7 consecutive days (the 7-d criterion). When no emergence is recorded from a treatment, ending of that treatment should be based on the control sediment using this 7-d

criterion. USEPA and ASTM state that minor modifications to the basic methods and a subset of endpoints may be used (USEPA 1998; ASTM 1999).

There are no standardized methods for toxicity and bioaccumulation testing of aquatic organisms in the field (*in situ*). However, there have been many investigators who have shown the usefulness of *in situ* testing of caged organisms for determinations of site toxicity and bioaccumulation (see citations in Burton *et al*. 1996c). *In situ* testing of indicator organisms provides some advantages over laboratory testing or surveys of indigenous community structure. Exposures are more realistic than laboratory testing, which reduces laboratory-to-field extrapolation uncertainties, and thereby provides simplified interpretations. As with laboratory tests, the *in situ* toxicity tests address varying species sensitivity to stressors (*e.g.,* amphipods, midges, oligochaetes, mussels, and/or fish). They have the further advantages of addressing both the source of stressor exposures (water, suspended solids, and bedded sediment) and also the specific stressor categories *(e.g.,* flow, suspended solids, photo-induced toxicity, ammonia, metals, and nonpolar organics) and relative importance of each. The exposure partitioning and resulting effects can be used to link effects in the indigenous communities. The information provided from *in situ* exposures can be used to validate and refine contaminant transport, fate, and bioaccumulation models. This information is coupled with laboratory toxicity, indigenous communities, tissue residues, habitat, physicochemical characterizations, and modeling predictions to provide a more comprehensive assessment of exposure and effects relationships.

The Toxicity Identification Evaluation (TIE) is a process by which water, effluent, or pore water samples are fractionated to isolate various classes of contaminants and then tested for toxicity. This process allows one to determine which groups of contaminants are primarily responsible for toxicity (USEPA 1991a). These groups of contaminants include pH-sensitive and volatile compounds (such as ammonia), metals, and nonpolar organics. Toxicity is determined by exposing *Ceriodaphnia dubia* for 48 h and then measuring survival. The TIE Phase I approach used in this study followed modified draft USEPA guidelines for sediment evaluation (USEPA 1991b). The pore water treatments

included initial toxicity tests (within 24 h of sample receipt), baseline ambient pore water, pH adjusted with aeration, pH adjusted with filtration, pH adjusted with C18 solid phase extraction (SPE), sodium thiosulfate addition, and ethylene-diamine-tetra-acetate (EDTA) addition fractions. The graduated pH test (which tests for ammonia) was excluded due to insufficient sample volume.

The results and discussion presented in this report are limited to the data obtained from chemical and bioassay analyses performed on samples collected specifically for this project. The relationships between these data and the information collected from other related EPA investigations (e.g., benthic invertebrate surveys, additional chemical sampling and analyses) are addressed in detail in the Ecological Risk Assessment (Weston 2003), along with more complex statistical analyses and consideration of the uncertainties associated with these data.

.

2.0 MATERIALS AND METHODS

The Housatonic River study sites were chosen on the basis of historic sediment contamination levels and sediment type, as well as proximity to known point source areas of concern. A total of seven test sites were chosen for assessment and evaluated for potential toxicity in laboratory and/or field (*in situ*) investigations. These stations are displayed on Figure 1 (sites with asterisks); the toxicity testing stations formed a subset of a larger number of stations that were sampled for benthic community structure and other sediment quality data. For the purpose of this report, stations are referenced by the last three digits of the Weston ID for that sampling location. For the laboratory sediment toxicity tests, Sites 398 and 011 (reference sites) and 019, 389, 023 and 031 (contaminated sites) were chosen for testing. For the *in situ* toxicity and bioaccumulation exposures, Site 023 was replaced with Site 428 (located upstream of Site 389) because of the close proximity of Site 023 to Site 031. Weston personnel recommended replacement of Site 023 with Site 428, since Site 428 was farther upstream from Site 031; this allowed sediment toxicity to be evaluated on a larger spatial scale, while still retaining a similar range of sediment PCB concentrations as was used for the laboratory testing. The remaining sites used for laboratory testing were used for *in situ* testing as well.

2.1 Sampling Methods

Sediment samples for chemical analyses and laboratory toxicity testing were collected from the seven test site locations by R.F. Weston personnel following project-approved protocols. These samples were collected over a period of several weeks in May 1999. These methods included standard quality assurance and quality control measures to ensure that the sediment samples were not significantly altered and that cross contamination did not occur (ASTM 1999; Burton 1997; USEPA 1991a, 1991b, 1994, 1998, Weston 2000). The sediment samples were collected using a standard core tube. The core tube was used to take five separate 4- to 5-cm-deep sediment samples from each of the locations where *in situ* toxicity testing took place. A composite of five separate sediment portions was then homogenized in a sterilized stainless steel bowl

and placed in 8-oz amber jars. Portions of each sediment sample were either used for chemical analysis of total PCBs or shipped to Wright State University (WSU) on ice for laboratory testing.

Sediment samples were collected for chemical analyses in concordance with the *in situ* portion of the study; however, these were not collected on the same day as sediments collected for laboratory toxicity testing. For the *in situ* exposures, sediment samples were collected by WSU and Roy F. Weston personnel, using the same protocols stated above, but at the end of each exposure period (*i.e.,* 3 times, when *in situ* chambers were retrieved at 48 h, 7 d and 10 d). In addition, unfiltered overlying site water was simultaneously collected from each site in 1-L amber bottles and maintained at 4°C until shipment. Water and sediment samples were stored at 4°C, and shipped to Dr. Tiernan's laboratory at WSU within 24 h of collection. The 48-h, 7-d and 10-d sediment and water samples were analyzed for total PCBs. In addition, the 7-d water and sediment samples were also analyzed for all 209 PCB congeners by Dr. Tiernan's laboratory, and were then sent to Severn Trent Laboratories (STL) where they were analyzed for semi-volatile organic compounds (SVOCs), including polycyclic aromatic hydrocarbons (PAHs), pesticides, metals and total organic carbon (TOC, only sediments). Throughout collection and shipment of the samples to WSU and STL, chain-of-custody procedures were followed for all samples.

2.2 Culturing

For all toxicity tests (*i.e.,* laboratory and *in situ* tests), early life stages of test organisms (except *Lumbriculus variegatus* where adult worms were used) were implemented as prescribed. Culturing procedures followed USEPA methods for *Hyalella azteca*, *Chironomus tentans, Daphnia magna* and *Lumbriculus variegatus* (e.g., USEPA 1993, 1994).

2.3 Task 1. Sediment Laboratory Toxicity Testing – Summer 1999

Laboratory life cycle testing began on May 27, 1999 for *Hyalella azteca* and July 9, 1999 for *Chironomus tentans*. At the time the laboratory tests were conducted, there were no formalized test methods for chronic toxicity testing of sediments. However, the U.S. Environmental Protection Agency (USEPA) and the American Society for Testing and Materials (ASTM) had identical draft methods that were in the process of final review. These methods were finalized in early 2000 (USEPA 2000b). Therefore, testing for this project followed the latest draft guidance, as of 1998, for chronic toxicity testing of *H. azteca* and *C. tentans* (USEPA 1998). Because these methods provide evidence of the effects of chronic exposures, they were deemed as a useful evaluation tool for this site.

2.3.1 Hyalella azteca Life Cycle Assessment

Conditions for evaluating sublethal endpoints in a sediment toxicity test with *H. azteca* are summarized in Table 1 and a general activity schedule is outlined in Table 2. The 42-d sediment toxicity test with *H. azteca* was conducted at 23°C with a 16:8 hr light:dark photoperiod at an illuminance of about 500 to 1000 lux (Table 1). Test chambers were 300-mL high-form lipless beakers containing 100 mL of sediment and 175 mL of overlying water. Amphipods in each test chamber were fed 1.0 mL of YCT (yeast-cerophyl-trout chow) daily (USEPA 1998). Each test chamber received two volume additions of overlying water daily.

Controls sediments included autoclaved Trout Farm sediment (from Fairborn, OH) and Ottawa sand. The latter material is quartz sand (U.S. Silica, Berkeley Springs, WV) that has been used previously for freshwater sediment toxicity testing (e.g., Tucker et al. 1999). In addition to these laboratory controls, two field-collected reference sediments (Sites 011 and 398) were used for evaluating test performance and site differences.

A total of 12 replicates, each containing 10 amphipods (7- to 14-d old) were tested for each treatment. Twelve replicates were initiated on Day –1 to assess 28-d survival, of which four replicates were used for 28-d growth. The remaining eight replicates were

reused for measurement of survival and reproduction on Day 35, and survival, reproduction, and growth on Day 42.

Placement of Sediment into Test Chambers: The day before the sediment test was started (Day -1), each sediment was thoroughly homogenized and added to the test chambers. Each test chamber contained the same amount of sediment, determined by volume. Overlying water (diluted Perrier brand mineral water, per EPA-approved methods) was gently added to each chamber on Day -1 in a manner that minimized suspension of sediment. The test began when the organisms were added to the test chambers (Day 0).

Acclimation: Test organisms were cultured and tested at the same temperature. Test organisms were cultured in the same water that was used in testing; therefore no acclimation was necessary.

Placing Organisms in Test Chambers: Amphipods were gently introduced into the overlying water below the air-water interface. Dry weight was measured on a subset of 30 amphipods prior to test initiation.

Feeding: For each beaker, 1.0 mL of YCT was added daily from Day 0 to Day 42 according to USEPA protocol. Dissolved oxygen (DO) sag was briefly encountered during testing but was not due to food fouling. Detailed records of feeding rates and the appearance of the sediment surface were made daily.

Monitoring a Test: All chambers were checked daily and observations made to assess test organism behavior, such as sediment avoidance. However, monitoring effects on burrowing activity of test organisms is often difficult because the test organisms are often not visible during the exposure. The operation of the exposure system was monitored daily.

Overlying water quality was measured for: dissolved oxygen (mg/L), temperature (°C), conductivity (μmhos/cm) hardness (mg/L $CaCO_3$), alkalinity (mg/L $CaCO_3$), ammonia (mg/L total ammonia) and pH at the beginning of the sediment exposure portion of the test, weekly thereafter, then at the end of the test. Water quality measurements were also measured at the beginning and end of the reproductive phase (Day 29 to Day 42) (Appendices 1 and 2).

Dissolved oxygen was measured daily to ensure that chambers maintained a minimum reading of 2.5 mg/L. Aeration was used (as specified in the test methods) whenever dissolved oxygen fell below 4.0 mg/L ensure that dissolved oxygen in the overlying water was maintained above 2.5 mg/L.

Temperature was measured daily in at least one test chamber from each treatment. The daily mean test temperature was required to be 23 ± 1°C. The instantaneous temperature was required to be 23 ± 3°C. Aquarium heaters were used to maintain water bath temperatures within this range.

Ending a Test: Endpoints monitored included 28-d survival and growth of amphipods, 35-d survival and reproduction, and 42-d survival, growth, and reproduction (number of young/female from Days 28 to 42) of amphipods.

On Day 28, the sediment from four of the replicate beakers was sieved with an ASTM U.S. Standard #45 mesh sieve (355-μm mesh) to remove surviving amphipods for growth determinations. Growth of amphipods was reported as mean dry weight/organism. The dry weight of amphipods in each replicate was determined on Days 28 and 42. Dry weight of amphipods was determined by transferring rinsed amphipods to aluminum pans, drying these samples for 24 h at 60°C, and weighing the dried amphipods on a balance to the nearest 0.01 mg. The mean dry weight of individual amphipods in each replicate was calculated from these data.

On Day 28, sediments from the remaining eight beakers were sieved. The surviving amphipods from each sediment beaker were placed in 300-mL beakers containing approximately 250 mL of overlying water and a 5-cm x 5-cm piece of Nitex® screen or 3M® fiber mat. Each water-only beaker received 1.0 mL of YCT and two volume additions of water daily.

Due to the large number of Zumwalt dilutors required to accommodate all the sediment treatments, it was necessary to use several water baths to maintain the test temperature. Each bath was equipped with an aquarium heater and a power head to circulate water in the bath. The water for each water bath was derived from the same source, and differences among blocks of baths would have only minute differences with respect to temperature.

Reproduction of amphipods was measured on Day 35 and Day 42 in the water-only beakers by removing and counting the adults and young (neonates) in each beaker. On Day 35, the adults were then returned to the same water-only beakers. The number of adult females was determined by simply counting the adult males (mature male amphipods will have an enlarged second gnathopod) and assuming all other adults were females. The number of females was used to determine number of young/female from Day 28 to Day 42. Growth (dry weight) was also measured for these adult amphipods on Day 42.

2.3.2 Chironomus tentans Life Cycle Assessment

Conditions for conducting a long-term sediment toxicity test with *C. tentans* are summarized in Table 3 and a general activity schedule is outlined in Table 4. The long-term sediment toxicity test with *C. tentans* was conducted at 23°C with a 16:8 h light:dark photoperiod at an illuminance of about 500 to 1000 lux (Table 3). Test chambers, sediment addition, water renewal, and water quality monitoring were as described above for *H. azteca* (see Section 2.3.1).

A total of 8 replicates, each containing 10 <24-h old larvae were tested for each sample. On Day -1, eight replicates were set up, of which four replicates were used for 20-d growth and survival endpoints and four replicates for determination of emergence. Midges in each test chamber were fed 1.0 mL of a 4 g/L Tetrafin® suspension daily for the first week and then 1.5 mL thereafter for the remainder of the test. Endpoints monitored included 20-d survival, dry weight, ash free dry weight and percent emergence (adults).

Control sediments included: Trout Farm sediment (Fairborn, OH), alpha-cellulose formulated sediment (USEPA 1998), and Florissant soil. Alpha-cellulose is an organic carbon source used in formulated sediments (USEPA 2000b). Florissant soil is a Missouri River flood plain soil from Florissant, MO (Adams et al. 1985) that has been used by other researchers for freshwater sediment testing. Florissant soil is a fine-grained (silt and clay) material containing approximately 1 to 1.5% TOC (Ingersoll and Nelson 1990; Kemble et al. 1999). In addition to these laboratory controls, two field-collected reference sediments (Sites 011 and 398) were used for evaluating test performance and site differences.

Collection of Egg Cases: Egg cases were obtained from cultures of adult midges that were held in a male:female sex ratio of 1:3. Adults were collected four days before starting a test. The day after collection of adults, six to eight of the larger egg cases were transferred to a petri dish with culture water and incubated (at 23°C). Hatching typically begins around 48 h and larvae typically leave the egg case 24 h after the first hatch.

Hatching of Eggs: After the first 72-h period and upon the first visible migration of larvae out of egg cases, which indicates hatching, the cases were transferred from the incubation petri dish to another dish with clean test water. The action of transferring the egg case stimulates the remaining larvae to leave the egg case within a few hours. These larvae were used to start the test.

Placing Organisms in Test Chambers: To start the test, larvae were carefully collected with a Pasteur pipette from the bottom of the incubation dish with the aid of a dissecting microscope. Test organisms were then gently pipetted directly into overlying water beneath the air/water interface. All larvae were transferred to exposure chambers within 4 h of emerging from the egg case.

Feeding: Each beaker received a daily addition of 1.5 mL of Tetrafin® (4 mg/mL dry solids).

Dissolved Oxygen: Routine chemistries were taken on Day 0 before organisms were placed in the test beakers. Test beakers were maintained at a DO concentration of greater than 2.5 mg/L to insure satisfactory performance. If the DO level of the water fell below 2.5 mg/L for any one treatment, aeration was provided to all replicates for the duration of the test (Appendices 3 and 4).

Monitoring Survival and Growth: At Day 20, four of the initial eight replicates were selected for use in growth and survival measurements. *C. tentans* were collected using an ASTM #45 sieve (355-μm mesh) to remove larvae from sediment. Surviving larvae were kept separated by replicate for dry weight measurements; if pupae were recovered, those organisms were included in survival data but not included in the growth data. The ash free dry weight (AFDW) of midges was determined for the growth endpoint. All living larvae per replicate were combined and dried to a constant weight (*e.g.,* 60°C for 24 h). The sample was brought to room temperature in a dessicator and weighed to the nearest 0.01 mg to obtain mean weights per surviving organism per replicate. The dried larvae in the pan were then ashed at 550°C for 2 h. The pan with the ashed larvae was then re-weighed and the tissue mass of the larvae was determined as the difference between the weight of the dried larvae plus the pan and the weight of the ashed larvae plus the pan.

Monitoring Emergence: Emergence traps were placed on the reproductive replicates on Day 20. Emergence in control sediments typically begins on or about Day 23 and

continues for about two weeks. For this portion of the test complete emergence and partial emergence were recorded. Complete emergence occurs when an organism has shed the pupal exuvia completely and escapes the surface tension of the water. If complete emergence has occurred but the adult has not escaped the surface tension of the water, the adult will die within 24 h. Therefore, 24 h elapses before this death is recorded. Partial emergence occurs when an adult has only partially shed the pupal exuvia. Between Day 23 and the end of the test, emergence of males and females, pupal and adult mortality were recorded daily for the reproductive replicates.

Ending a Test: The point at which the life cycle test is ended depends upon the sediments being evaluated. In clean sediments, the test typically requires 40 to 50 d from initial set up to completion if all possible measurement endpoints are evaluated. However, test duration will increase in the presence of environmental stressors that act to reduce growth and delay emergence. Where a strong gradient of sediment contamination exists, emergence patterns between treatments will likely become asynchronous, in which case each treatment needs to be ended separately. In this study, testing lasted for a total of 43 days. At that time, all beakers of the treatment were sieved through an ASTM #45 mesh screen (355 μm) to recover remaining larvae, pupae, or pupal castes. According to draft chronic guidance criteria, a treatment may be terminated after one week elapses since the last adult has emerged from that test treatment (USEPA 1998). Test acceptability criteria require that survival in the control treatment must be ≥60% of the initial stocked quantity (USEPA [2000] specifies ≥50% control emergence).

2.4 Task 2. *In situ* Toxicity and Bioaccumulation

The Task 2 activities were divided into three low-flow testing periods, a 48-h, a 7-d and a 10-d exposure. The 7-d and 10-d exposures were initiated simultaneously. Testing periods were to include a high-flow exposure period, in addition to the low-flow period, but due to an uncharacteristically dry summer, the high-flow sampling period was not conducted. The midge, *Chironomus tentans* (8 - 12 days post hatch), the amphipod, *Hyalella azteca* (7 - 14 days old), the oligochaete worm, *Lumbriculus variegatus*

(multiple ages), and the daphnid, *Daphnia magna* (48-hours old) were chosen for *in situ* evaluation. The age of the organisms, handling, and culturing followed USEPA toxicity test methods (USEPA 1993, 1994). Due to organism health concerns related to shipping-induced stress, organisms were purchased from a nearby test organism supplier (Aquatic Research Organisms, Hampton, NH), transported to the on-site laboratory 24 hours prior to test initiation, and monitored for health prior to deployment. All test organisms were from USEPA reference toxicant tested stocks. Quadruplicate chambers containing the early life stages of each organism were deployed and exposed for 2 - 10 days. Ten individuals of each species were used for each replicate; however, *C. tentans* and *H. azteca* were grouped together and *D. magna* and *L. variegatus* were exposed individually. Ground up laboratory paper toweling was provided as a substrate for the amphipod/midge chambers (Chappie and Burton 1997).

Sample sites in Task 2 included: a laboratory control for each organism, two reference sites (Sites 011, 398), and four test sites (Sites 019, 428, 389, 031). The purpose of the laboratory controls was to verify the health of the test organisms. Site selection criteria included the following: sediments with grain sizes typical of the site, sediments from sites where PCB concentrations were likely to be at high levels, sites of previous sampling, and sites near proposed sampling for physicochemical characterizations, habitat, indigenous benthic communities, and storm water sampling. As previously discussed, Site 428 was substituted for Site 023 for the *in situ* tests.

A 48-h low-flow test was conducted with *D. magna, H. azteca, C. tentans* and *L. variegatus to* evaluate potential toxic responses for each species. A 10-d low-flow test, also for survival, was conducted after completion of the 48-h screening test and included *H. azteca* and *C. tentans* only. The third test was a 7-d *L. variegatus* bioaccumulation assay initiated on the same day as the 10-d midge/amphipod survival assay.

The *in situ* chambers used for this study were constructed of clear core sampling tubes (cellulose acetate butyrate) cut to a length of approximately 15-cm polyethylene

closures capped each end. Two rectangular windows (~85% of the core surface area) covered with 80-μm Nitex® mesh were placed on opposite sides of the core tube. Organism exposures were limited to: (1) the water column, via placement of the chamber in the top tray of the *in situ* basket; (2) interaction with both sediments and overlying water via placement of the chamber against the sediment surface by securing it to the lower *in situ* basket with one window facing the sediment and one mesh window facing the overlying water column (Photo 1a); or (3) in the sediment, via filling chambers approximately one-third with sediment and the rest with overlying water (the third method was only used for the *in situ* bioaccumulation exposures with *L. variegatus*). The *in situ* baskets were weighted down with bricks and anchored to the stream bottom with rebar. Each set of baskets was covered by a stainless steel flow deflector designed to divert strong currents of water and turbulence around the *in situ* chambers should a high-flow event have occurred during exposure (Photo 1b). The functional design of the flow deflector would thus prevent the baskets from being swept away during short periods of high-flow conditions. All treatments were conducted in replicates of four chambers per test species.

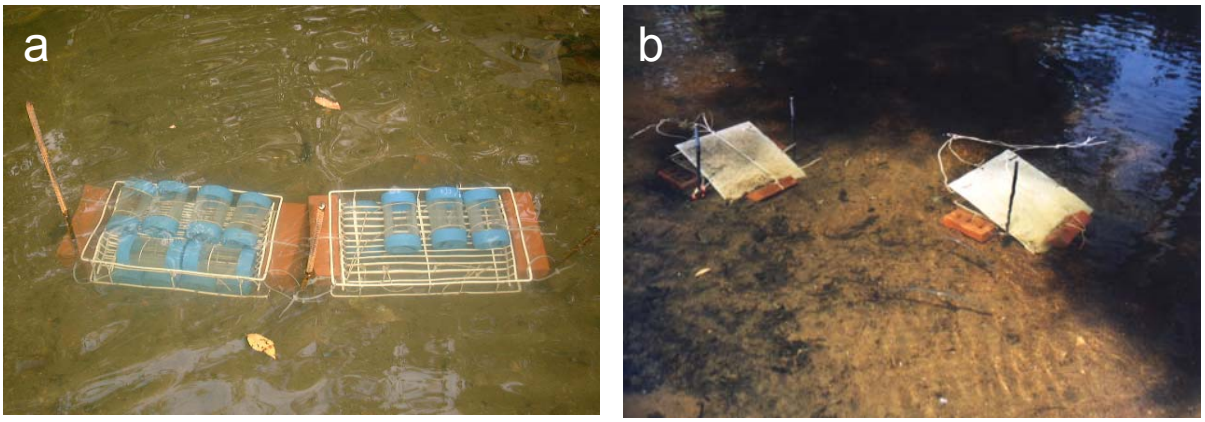


Photo 1: a) *In situ* chambers deployed in wire baskets and b) *in situ* chambers/baskets protected with flow deflectors.

Prior to chamber deployment, 10 individuals of each test species (*H. azteca, C. tentans and D. magna*) were gently added to 50-mL test tubes of culture water for ease of transport to field locations (each test tube contained one species only). Transportation of organisms to field sites by this method has proven to minimize handling and travel-

related stresses. For the 7-d *L. variegatus* bioaccumulation assay, either 1 or 2 g of tissue (equal to an approximate animal wet weight:sediment organic carbon ratio of 1:10) was used in each chamber. In the field, site water temperatures were measured and additional acclimation took place in the field when necessary. Upon acclimation, *in situ* chambers (capped on one end) were immersed into the river, allowing water to fill the chamber by infiltration through the mesh, and test organisms were slowly delivered from the test tubes into the open end. The chambers were then capped. Before placement into *in situ* baskets, chambers were held below the water surface and purged of all internal air. After 2, 7 or 10 days of exposure, *in situ* chambers were gently lifted out of the river and placed into coolers of site water for the return trip to the Roy F. Weston laboratory for enumeration. Upon arrival at the laboratory, chambers were inspected for damage, rinsed on the outside and individually emptied into crystallizing dishes. The survivors of each species were enumerated and logged.

In situ chambers were deployed at all field locations on two occasions in which stream conditions were considered to be at base flow. The 48-h *in situ* assay began on the afternoon of June 14, 1999 and included *H. azteca, C. tentans, L. variegatus* and *D. magna*. Chambers were retrieved in the afternoon of June 16, 1999 after 48 h of exposure. The second group of chambers was deployed on the morning of June 17, 1999 and included *H. azteca*, *C. tentans* and *L. variegatus*. The *L. variegatus* chambers were retrieved on the morning of June 24, 1999 after 7 days of exposure for tissue bioaccumulation. *L. variegatus* tissue samples collected after the exposure were allowed to depurate in diluted mineral water (DMW) for 12 h; wet weights were determined and then the tissue samples were transferred to dry scintillation vials and stored at -15^{o}C at Roy F. Weston's facilities. The tissue samples were then shipped on dry ice to Dr. Tiernan's laboratory at WSU for chemical analysis.

H. azteca and *C. tentans* chambers were retrieved on the morning of June 27, 1999 after 10 d of exposure. A laboratory water control was maintained for standard quality control purposes for each of the test organisms deployed in the field during all of the exposure periods.

For each field site, water quality measurements were made at test initiation and again upon test termination. Physicochemical measurements included: temperature, DO, pH, hardness, alkalinity, turbidity, conductivity and total ammonia (Appendices 5 and 6). All field water quality monitoring equipment was calibrated prior to each use according to USEPA, instrument specifications and/or the Weston QAPP.

2.5 Task 3. Toxicity Identification Evaluation (TIE)

The Toxicity Identification Evaluation (TIE) is a process by which effluent or pore water samples are fractionated into various classes of contaminants and then tested for toxicity. Toxicity is determined by exposing *Ceriodaphnia dubia* to a dilution series of the test water for 48 h and then measuring survival. There are two primary objectives in the Phase I TIE: (1) to detect the presence of toxicants; and (2) broadly define the physical/chemical characteristics of the toxicant(s). If a significant change in toxicity is seen following these characterization procedures, additional tests are needed to further characterize the nature of toxicity. If toxicity is not removed, other types of contaminants (not addressed by Phase I) may be present or a single toxicant may be present at such high levels that only a partial toxicity decrease is achieved. If several Phase I tests succeed in partially removing toxicity, there may be several toxicants, each with different physicochemical characteristics, or a single toxicant that can be removed by more than one Phase I test (*e.g.*, increased pH can cause a metal to precipitate out and EDTA can also remove the metal toxicity by chelation). The difference in Toxicity Units (TUs) for each fractionation helps determine which chemical class is the cause of toxicity (USEPA 1991a). Separating contaminant classes allows one to characterize which class of contaminants is primarily responsible for toxicity (USEPA 1991a,b). Commonly detected contaminants are pH-sensitive and volatile compounds (*e.g.,* ammonia), metals, oxidants/reductants, and nonpolar organics.

For this project, a Phase I TIE was conducted using draft USEPA guidelines for pore water (USEPA 1991b). Previous studies with non-ionic organics, such as PCBs, have shown that bioavailability of contaminants to benthic organisms is strongly correlated

with pore water concentrations in this freely dissolved fraction (Adams et al., 1985; Swartz et al., 1985, 1990; DiToro et al., 1990, 1991 and Ankley et al., 1993, 1994). Pore water aliquots were used for initial toxicity tests (within 24 h of sample receipt), baseline ambient pore water (tested concurrently with each TIE fraction), pH adjusted with aeration, pH adjusted with filtration, pH adjusted with C_{18} SPE filtration, sodium thiosulfate addition, and EDTA addition fractions. Diluted mineral water (DMW) was used for all pore water dilutions and tests. The graduated pH test (for ammonia) could not be performed due to insufficient sample volume.

Roy F. Weston personnel collected sediment samples from five of the *in situ* study sites for Phase I TIE tests. The top 5 cm of sediment at Sites 398, 019, 428, 389 and 031 was collected the week of September 9, 1999 and shipped to Soil Technologies, Inc. (STI). Because of the range of grain sizes associated with these samples, pore water was extracted from these sediments using either the centrifuge method or nitrogen pressure. Samples 031 and 389 (fine grained sediments) were centrifuged at 7,000 rpm for 30 minutes, while pore waters from Samples 428, 019 and 398 were extracted anaerobically in a nitrogen chamber. In addition, Samples 428, 019 and 398 (sandy sediments) were also centrifuged for 30 minutes at 5,500 rpm to further remove particulates. All pore water samples were stored in 1-L glass amber bottles and shipped to WSU on September 13, 1999 for TIE test manipulations. The samples were delayed in shipment for one day and were received at WSU on September 15, 1999. The pore water sample container for Site 428 was broken in transit so no TIE testing was performed on this sample.

2.5.1 DAY 1

On Day 1 (September 15, 1999), initial toxicity tests of the four intact pore water samples were started. Prior to beginning the initial toxicity tests, the temperature of each pore water sample was raised in a 24°C water bath and water quality measurements were recorded on all samples. *Ceriodaphnia dubia* were introduced into test dilutions of a control treatment (i.e., culture water and no pore water) and five pore water treatments (6.25, 12.5, 25, 50 and 100% [v/v]). Dilute mineral water (DMW) was

used as the negative control and dilution water for all treatments. There were two replicates per treatment, each containing five <24-h old neonates. *C. dubia* were fed a mixture of *Selenastrum capricornutum* and cereal leaves (Sel-Cero) on Day 0 (30 µL of food per 10-mL test solution volume). These initial toxicity tests were terminated after a 24-h exposure, and 24-h LC_{50} values were determined. Only the pore water samples that showed acute toxicity after 24 h were used in the Day 2 and Day 3 TIE manipulations.

2.5.2 DAY 2

Day 2 test manipulations were performed on September 16, 1999 and included: oxidant reduction (sodium thiosulfate), pH-adjusted aeration, and pH-adjusted filtration. Up to three types of "controls" were used to check for artifact toxicity: "toxicity blanks" (no manipulation), the baseline toxicity test, and dilution water (DMW) controls (Table 5). The same test manipulations were performed on the dilution water controls (except baseline and initial tests) to determine if test manipulations contributed to toxicity. If toxicity was affected by the sample matrix, a toxicity control or blank would not help in identifying artifact toxicity. Concurrently performed baseline tests (*i.e.,* unaltered pore water aliquots) served as controls for all treatment manipulations while providing information on temporally changing toxicity relative to the initial (Day 1) tests.

Since the 24-h LC_{50} values from the Day 1 initial tests were >25% (v/v), a sample dilution series of either 12.5, 25, 50 and 100% (v/v), the same as that used for the Day 1 tests, or 15, 30, 60 and 100% (v/v), was used for the Day 2 test manipulations. Each treatment consisted of one or two replicates of five <24-h old *C. dubia* neonates. Day 2 tests were conducted for 48 h, but LC_{50} values were calculated using both the 24-h and 48-h observations. Since the Day 1 initial toxicity tests only used a 24-h exposure, the 24-h observations from the Day 2 test results were used for comparison with the Day 1 initial toxicity test results to determine if toxicity had changed over time.

The oxidant reduction (sodium thiosulfate) addition test was performed to identify toxicity due to oxidants and cationic metals. Oxidants generally reduced or neutralized

in this test are chlorines, ozone, bromine, iodine, manganous ions and some electrophilic organics. In addition, some cationic metals can be chelated by sodium thiosulfate, (e.g., Cd, Cu, Ag and Hg) but complexation can be slow (up to 96 h). Two methods of sodium thiosulfate additions are recommended and the dilution/3 X 3 matrix (pore water and thiosulfate concentrations) approach was used in this test (USEPA 1991a,b). In this test, the pore water samples were treated with 0.05, 0.1 or 0.2 mL of a 20.5 g/L $Na_2S_2O_3$ solution, and then each sodium thiosulphate treatment was tested at 15, 30, 60 and 100% (v/v). Treatment blanks consisted of control water treated with the same amounts of sodium thiosulfate.

The pH-adjusted aeration characterization test for volatile, sublatable or oxidizable compounds was also conducted. Aeration was performed at three pH levels (pH 3, unadjusted pH, and pH 11) because some compounds can be oxidized or removed more easily at a particular pH.

The pH-adjusted filtration test was conducted to identify the effects of filterable compounds. Although positive pressure filtration is recommended, the vacuum method was required due to sample turbidity and to achieve holding time requirements. This method modification may have reduced concentrations of volatile compounds from the subsequent toxicity assays. The three pH levels were pH 3, unadjusted pH, and pH 11.

2.5.3 DAY 3

USEPA methods suggest all characterization tests be performed at approximately the same time to avoid confounding results due to degradation of sample toxicity over time. Due to the late arrival of the pore water samples at WSU and the need to have 24-h LC_{50} results from the Day 1 initial toxicity tests, it was necessary to perform the pH-adjusted/C_{18} solid phase extraction and EDTA chelation tests on Day 3 (September 17, 1999). Therefore, the baseline pore water toxicity test was repeated on Day 3 to determine storage effects. While the Day 3 TIE manipulations used a 48-h exposure, the Day 3 baseline toxicity test used only a 24-h exposure. Due to the 24-h wait for the initial toxicity test results, the pH-adjusted aliquots were allowed an additional

equilibration time (as suggested in USEPA 1991a) and pH-adjustments were made as necessary when pH drift was detected. Corresponding Day 3 baseline test results were compared to the Day 1 initial toxicity test results and Day 2 baseline test results (24-h observations) to determine toxicity changes.

The pH-adjusted/C_{18} SPE characterization test was conducted for non-polar organics, pesticides and some metal chelates that are relatively non-polar. The C_{18} column (an octadecyl resin) can also extract organic acids and bases. By adjusting sample pH to low (pH = 3) and high (pH = 9), the un-ionized form of some of these compounds predominates and sorbs in the column.

The 48-h EDTA chelation test was conducted to identify toxicity due to certain cationic metals. The pore water samples were treated with 0.0125, 0.05 or 0.2 mL of an EDTA solution (approximately 2.75 g/L EDTA). The EDTA addition test dilution water blanks are not considered relevant as "controls", instead the baseline test is used as a control (USEPA 1991a). However, EDTA was added to DMW as a treatment control (Table 5).

2.6 Statistical Analysis

For the laboratory and *in situ* toxicity tests (Sections 2.3 and 2.4), statistical analyses were performed to identify statistically significant differences relative to the control and reference sediments. For each test endpoint, data meeting the assumptions of normality and homogeneity of variance were analyzed by analysis of variance (ANOVA) followed by Dunnett's test (ToxCalc Version 5.0.23). Data not meeting assumptions of normality were analyzed using Steel's many-one rank test. Mean responses from all six Housatonic River sediments (i.e., the four contaminated sites and two reference sites) were first compared to the applicable laboratory control; then the mean responses for the four contaminated sites were compared to each of the two reference sites. These comparisons were made at a statistical significance level of $p = 0.05$. All reported mean values were calculated as arithmetic means.

For the TIE toxicity tests (Section 2.5), the LC_{50} values were estimated via the Spearman-Karber model with 95% confidence levels. As test exposure durations varied between 24 and 48 h, LC_{50} values were calculated for both exposure periods where applicable. Toxic Units (TUs) were calculated as $TU = 100/LC_{50}$ for each TIE manipulation.

More detailed statistical analyses of the sediment toxicity and bioaccumulation data are provided in the ERA (Weston 2003). These included estimation of concentration-response relationships using median sediment concentrations that incorporated other sediment chemistry data collected in the vicinity of the stations used for this study.

2.7 Quality Assurance

Protocols for the chronic toxicity test methods were followed as outlined (ASTM 1999, USEPA 1998). Other quality assurance issues are addressed in the Quality Assurance Project Plan for the U.S. Environmental Protection Agency's Freshwater Sediment Toxicity Methods Evaluation (Burton 1997) and as described in the study SOP in the Supplemental Investigative Work Plan (SIWP).

3.0 RESULTS AND DISCUSSION: TASKS 1 AND 2

During sediment homogenization of *in situ* sediment samples and when replicate beakers were sieved at test termination (see Lab test methods) the sediments from Sites 031 and 389 produced an oil sheen on the water surface and an organic odor. This was not observed in any of the other collected samples.

3.1 Task 1. Sediment Macroinvertebrate Laboratory Toxicity Testing – Summer 1999

Total PCB concentrations in sediments from the upstream reference sites were 0.028 mg/Kg (dry weight) PCB (Site 011) and 0.28 mg/Kg dry PCB (Site 398) in the laboratory testing. Total PCB concentrations in sediments from the four contaminated sites ranged from 8.7 to 213.0 mg/Kg dry PCB (Table 6). A concentration gradient of total PCBs made it possible to compare exposure gradients with effect levels observed in the laboratory tests. Total organic carbon (TOC) content ranged from <0.012% (Site 011) to 5.58% (Site 023); TOC was highest at the two most downstream sites. Organic carbon-normalized PCB concentrations could not be calculated for reference Site 011 because TOC was undetected. OC-normalized PCB concentrations were 19.2 mg/Kg OC for reference Site 398, and ranged from 559.1 to 4570.8 mg/Kg OC for the other four sites.

3.1.1 Hyalella azteca Life Cycle Assessment

Water quality parameters measured in the overlying water during the *Hyalella* life cycle assessment test are summarized in Table 7, and complete data are provided in Appendix 1 and 2. All water quality parameters were within acceptable ranges, although the temperature range (20.3 – 26.0°C) was slightly outside the target of 23 $\pm$ 1°C specified by the EPA testing protocol.

Survival in the Ottawa sand laboratory control was poor during the first 28 days of testing, so the results of that treatment have not been reported. Therefore, only the Trout Farm sediment treatment was used as the laboratory control.

Both the laboratory control (Trout Farm sediment) and upstream reference Site 398 met the 28-d *H. azteca* acceptable control survival criterion of 80% (USEPA 1998; 2000b). Site 398 was located on the West Branch and consistently had high survival in all Task 1 and Task 2 assessments. Site 011 was also chosen as an upstream reference but was located on the East Branch in the town of Dalton. The sediment at Site 011 was larger grained than downstream sediments and contained no detectable total organic carbon (TOC; <0.012%). It had consistently lower survival than reference Site 398, but higher survival than at the four downstream test sites.

The 28-d mean survival of *H. azteca* was 81.8% in the laboratory control sediment and 83.3% in reference Site 398, but only 65.8% in reference Site 011. Mean 28-d survival in the remaining sediment exposures was: 48.3% (Site 019), 0% (Site 389), 25.8% (Site 023), and 22.5% (Site 031). Mean survival in the four test sediments and reference Site 011 sediment (Table 8, Figure 2) was significantly lower than in the laboratory control sediment. Mean survival in the four test sediments was significantly lower relatively to both reference site sediments.

Mean survival in the Trout Farm control sediment was 82, 81 and 78% at Days 28, 35 and 42, respectively, while it was 83%, 80% and 75%, respectively, in reference Site 398 (Tables 8 and 9, Figure 2). For the remaining sites, including reference Site 011, mean survival between Days 35 and 42 varied less than 4%. Exposure to sediment from Site 389 (which had the highest PCB concentration, 213 mg/Kg dry PCB) resulted in 100% *Hyalella* mortality in less than 28 d. Site 019 had the lowest PCB contamination (8.7 mg/Kg dry PCB), but had approximately 50% mortality between Days 28 and 42. Mean survival in all the test sediments was significantly lower than the laboratory control and both reference sediments at Day 35; this was also the case on Day 42, except when Site 019 was compared to reference Site 011.

Growth, represented as dry weight, was measured on a subset of organisms from each location at Days 0, 28 and 42 (Tables 10 and 11, Figures 3 and 4). The average initial dry weight (Day 0) of amphipods was 0.011 mg/organism. The 28-d mean dry weight of

the Trout Farm control sediment was 0.56 mg/organism; the 28-d mean dry weight for the reference sites was 0.57 mg/organism (Site 398) and 0.47 mg/organism (Site 011). The control performance acceptability criterion required that control organism dry weight average 0.15 mg/organism after 28 d of sediment exposure. There were no surviving animals in Site 389 after 28 d of exposure, so dry weight could not be determined. At the other three test sites, mean organism dry weights ranged from 0.33 to 0.50 mg/organism on Day 28. With one exception, there was very little change in dry weight between Day 28 and Day 42 for the control, reference and test sites. The only exception was Site 023 (31.2 mg/Kg dry PCB), which had a mean dry weight of 0.33 mg/organism on Day 28 and a mean dry weight of 0.52 mg/organism on Day 42. Apart from Site 389 (which had no survival after 28 days), there were no statistically significant differences in dry weight relative to the laboratory control or reference site sediments at Days 28 or 42.

Following 28 d of sediment exposure, surviving amphipods were transferred to clean culture water and allowed to recuperate for two additional weeks while reproductive success (mean number of neonates/female) was evaluated. The control performance acceptability criterion for neonate production is 2 neonates/female between Days 28 and 42. The Trout Farm control treatment averaged 13.4 neonates/female between Days 28 to 42, reference Site 398 averaged 9 neonates/female, and reference Site 011 averaged 7.7 neonates/female. Site 389 yielded 100% mortality within the first 28 days of sediment exposure, so could not be continued in the water-only exposure. Sites 019, 023 and 031 averaged 6.3, 2.7 and 0.1 neonates/female, respectively (Table 9, Figure 5). Total neonate production was significantly lower in these three test sediments relative to the laboratory control and reference Site 398; Site 019 was not significantly different when compared to reference Site 011. Reproductive success (neonates per female) was also significantly lower in the three test sediments relative to the laboratory control; Site 031 was significantly lower than reference Site 011, while Sites 023 and 031 were significantly lower than reference Site 398.

3.1.2 Chironomus tentans Life Cycle Assessment

Water quality parameters measured in the overlying water during the *Chironomus* life cycle assessment test are summarized in Table 7, and complete data are provided in Appendix 3 and 4. All water quality parameters were within acceptable ranges, although the temperature range (20.0 – 25.6°C) was slightly outside the target of 23 ± 1°C specified by the EPA testing protocol. There was one low dissolved oxygen (DO) measurement of 2.1 mg/L (DO should remain ≥2.5 mg/L), but this was in the Florissant soil control treatment; all other DO measurements were ≥3.9 mg/L.

Although results for the alpha-cellulose formulated sediment and Florissant soil controls are included in the tables, figures and appendices, these treatments were not used for evaluation of test acceptability or statistical comparison of responses in the test sediments. Only the Trout Farm sediment treatment was used as the laboratory control for that purpose.

The acceptability criterion of 70% for *C. tentans* 20-d survival was met for both the laboratory control (Trout Farm sediment) and reference Site 398, but not for reference Site 011. Mean 20-d survival was 85% in the control sediment and 77.5% in reference Site 398, but only 52.5% in reference Site 011. The 20-d survival was substantially reduced in the four test sediments, and was 5.0% at Site 019, 0% at Site 389, 0% at Site 023, and 7.5% at Site 031 (Table 12, Figure 6). This reduced survival was statistically significant relative to the laboratory control and both reference sediments. Site 019 (8.7 mg/Kg dry PCB) had the lowest level of PCB contamination but showed significant adverse effects on 20-d survival.

The 20-d dry weight endpoint was reported in terms of both dry weight and ash free dry weight (AFDW). The 20-d mean dry weights of surviving organisms in the control and reference sediments were 2.20 (Trout Farm control sediment), 1.97 (reference Site 398) and 1.82 mg/organism (reference Site 011); these values were well above the minimum performance acceptability control criterion (0.6 mg/organism). Surviving organisms from Sites 019 and 031 yielded mean dry weights of 0.035 and 0.04 mg/organism,

respectively. Complete mortality resulted following exposure to sediments from Sites 389 and 023, so there were no dry weight measurements for these sites (Table 13, Figure 7). As with survival, dry weight was reduced at Sites 019 and 031 relative to the control and reference sediments.

In terms of AFDW, surviving control organisms averaged 0.56 mg/organism, which is above the minimum performance acceptability criterion (0.48 mg/organism). Organisms exposed to reference Site 398 had a higher mean AFDW (0.81 mg/organism) than organisms exposed to the laboratory control sediment, but the organisms from reference Site 011 had an AFDW of only 0.28 mg/organism (Table 14, Figure 8). Exposure to sediments from Site 019 resulted in a mean AFDW of 0.02 mg/organism. Only one organism was retrieved from the Site 031 treatment and the balance was not sensitive enough to detect the AFDW of this sample. There was complete midge mortality in sediments collected from Sites 389 and 023. Growth (AFDW) for midges exposed to all test site sediments for 20 d was substantially lower than growth in the control or reference site sediments.

C. tentans emergence was 67.5% in the Trout Farm control sediment, 35% in reference Site 398, and 30% in reference Site 011. The control performance acceptability criterion for emergence of $\geq$50% was met. Adult emergence was only 2.5% in sediment from Site 023, while Sites 019, 031 and 389 had no adult emergence and no pupae recovered (Table 15, Figure 9). The emergence endpoint was evaluated using a different set of replicates from those used for evaluate 20-d survival and growth, so slight differences in responses were possible (e.g., Site 023 had 0% survival after 20 d, but the emergence replicates had 2.5% emergence).

3.2 Task 2. *In situ* Toxicity and Bioaccumulation

From the upstream reference sites (Sites 398 and 011) to the most downstream test site (Site 031), total PCB concentrations measured in sediments on three occasions at the *in situ* sites ranged from 0.0001 to 521.7 mg/Kg dry PCB (Table 16). Total PCB concentrations measured in overlying water at the same sampling intervals ranged from

3.2 to 299.2 ng/L PCB. Results from the various *in situ* tests are presented in terms of the sediment PCB concentrations reported for each exposure duration (i.e., 48-h, 7-d, 10-d). However, results from the sediment chemical analyses indicate a high degree of intra-site variability in sediment PCB and TOC concentrations measured for both the laboratory and *in situ* exposures (i.e., Tables 6 and 16). This is discussed further in Section 3.2.3 with regard to the 7-d *in situ* bioaccumulation test results.

A more detailed analysis of sediment PCB chemistry data, including consideration of data from other samples collected in close proximity to the stations used in this study, is provided in the ERA (Weston 2003).

Water quality parameters measured in the overlying water at the beginning and end of the 48-h, 7-d and 10-d *in situ* tests are summarized in Table 7, and complete data are provided in Appendix 5 and 6. All water quality parameters were within acceptable ranges, with the exception of temperature. This was not unexpected as *in situ* testing conditions cannot be subjected to the same constraints as controlled laboratory conditions. The temperature range in the 48-h *in situ* tests was 14.7 – 24.0°C; the lowest temperature occurred at Site 011 (the most remote upstream reference station) while all other values were ≥18.9°C. The temperature range in the 7-d and 10-d tests was 16.4 – 28.3°C; Site 011 had the largest temperature range, but similar values were reported at other sites. The observance of *in situ* temperatures within 4 - 6°C of recommended laboratory test conditions (23 ± 1°C) suggests that temperature was unlikely to be a confounding factor in the study.

3.2.1 48-h Low Flow In situ

The 48-h laboratory control survival results were as follows: 75% for *H. azteca* (Figure 10), 92.5% for the *D. magna* (Figure 11) and 97.5% for both *L. variegatus* (Figure 12) and *C. tentans* (Figure 13, Table 17). The 48-h *in situ* tests included both “against sediment” and “water column” exposures for all four test species.

In the 48-h *in situ* sediment exposures, daphnids and amphipods were the most sensitive species. *D. magna* and *H. azteca* mean survival was ≥82.5% at reference Sites 398 and 011, and Site 019 (0.9 mg/Kg dry PCB) in the sediment exposures. However, daphnids exposed to sediments at Sites 428 (7.3 mg/Kg dry PCB), 389 (139.3 mg/Kg dry PCB) and 031 (521.7 mg/Kg dry PCB) exhibited markedly reduced survivals. Average daphnid survival was 47.5% at Site 428 and 0% at Sites 031 and 389. Decreased *D. magna* survival following sediment exposure correlated with increasing sediment PCB concentration (Figure 14). Amphipod survival in the sediment exposures was similar to *D. magna* at Sites 428 (40%) and 389 (22.5%), but higher at Site 031 (72.5%). *C. tentans* and *L. variegatus* did not appear to be severely affected following 48 h of exposure at any of the sites and survival was ≥85% for both species in the sediment exposures. During this exposure, slightly lower survivals occurred primarily in sediment chambers rather than water column chambers.

None of the test species were adversely affected by the 48-h *in situ* water column exposures. *D. magna* and *H. azteca* mean survival was ≥80% at all six sites, *C. tentans* and *L. variegatus* had ≥90% survival at all six sites. Total PCBs in overlying water after the 48-h *in situ* exposure were 3.2 and 5.0 ng/L PCB, respectively, at reference Sites 398 and 011, and ranged from 92.3 to 293.1 ng/L PCB at the four test sites.

3.2.2 10-d Low Flow In situ

The 10-d *in situ* exposures with *H. azteca* and *C. tentans* were initiated on June 17, 1999. As with the 48-h *in situ* tests, these species were exposed to both the overlying water column and the surficial sediments. The results for both species are presented in Table 18, and illustrated in Figure 15 (for *H. azteca*) and Figure 16 (for *C. tentans*). The 10-d laboratory control mean survival was 100% for *H. azteca* and 95% for *C. tentans*.

Sediment exposure at reference Sites 398 and 011 (0.1 and 0.0014 mg/Kg dry PCB, respectively), and at Site 019 (14.0 mg/Kg dry PCB) yielded ≥80% mean survival for both species. However, at Site 428 (which had a sediment PCB concentration of only 1.4 mg/Kg dry PCB), *H. azteca* and *C. tentans* survival declined to 52.5% and 77.5%,

respectively. Following the 10-d *in situ* sediment exposures, 0% of *H. azteca* and 7.5% of *C. tentans* survived at Site 389 (52.3 mg/Kg dry PCB), and only 2.5% of *H. azteca* and 20% of *C. tentans* survived at Site 031 (112 mg/Kg dry PCB). Decreasing survival and increasing total PCB concentration correlated for both *H. azteca* and *C. tentans* exposed against sediments (Figures 17 and 18).

In general, amphipod and midge mean survival following water column exposure was higher when compared to mean survival associated with the sediment exposure. Exposures at upstream sites (reference Sites 398 and 011 at 5.8 and 5.7 ng/L PCB, respectively, and Site 019 at 129.1 ng/L PCB) resulted in ≥80% survival for each species. At Site 428 (143.8 ng/L PCB), *H. azteca* showed 70% survival and *C. tentans* had 60% survival. *H. azteca* survival dropped to 62.5% at Site 389 (299.2 ng/L PCB), but was 85% at Site 031 (98.7 ng/L PCB). Midge survival, however, was 92.5% at Site 031 and 97.5% at Site 389 in the water. There was a relationship between decreased *H. azteca* survival following water column exposures and total PCB concentrations in overlying water (Figure 19).

3.2.3 7-d Bioaccumulation In situ

Total PCB concentrations measured in sediment and overlying water at each site at the end of the 7-d *in situ* exposure are reported in Table 16. Total PCB concentrations in sediment ranged from 0.0071 mg/Kg dry PCB at reference Site 011 to 17.0 mg/Kg dry PCB at Site 428. Total PCB concentrations in overlying water ranged from 4.6 ng/L PCB at reference Site 011 to 238.8 ng/L PCB at Site 389. Mean total PCB concentrations (based on analysis of 4 – 6 replicate samples per site) in *L. variegatus* tissues after the 7-d *in situ* exposure were 57 and 156 µg/Kg wet PCB for reference Sites 011 and 398, respectively; mean tissue PCB concentrations for the four test sites ranged from 1,463 to 4,409 µg/Kg wet PCB. Mean lipid content of the tissue samples ranged from 0.75 to 1.72% (Table 19).

In addition to measuring total PCB concentrations, the sediment, overlying water and tissue samples from the 7-d *L. variegatus* test were also analysed for concentrations of

individual PCB congeners and isomers (Table 19). PCB congeners were classified as being second priority or highest priority, as well as whether they were considered "dioxin-like" according to the US EPA (note that a congener could be both highest priority and dioxin-like). There were 14 dioxin-like and 19 highest priority congeners included in the suite of congeners analysed for these sediment, water and tissue samples, but they were not all detected in every sample. In the six Housatonic River sediment samples, dioxin-like congeners accounted for 14.9 – 36.5% and highest priority congeners accounted for 59.2 – 69.0% of the total congener concentration. The proportions of dioxin-like and highest priority congeners in the overlying water samples were 12.9 – 19.4% and 48.1 – 59.1%, respectively. In tissues, dioxin-like PCB congeners accounted for 5.4 – 13.4% of the total congener concentrations, while 47.5 – 56.5% of the total was made up of highest priority congeners. For all three media, these congener types were not necessarily least abundant at the reference sites.

The relationship between total PCB tissue concentrations in *L. variegatus* and total PCB sediment concentrations is shown in Figure 20. Tissue PCB residues were normalized to lipid content and total sediment PCB concentrations were normalized to TOC content. Sites 398 and 389 were not included in Figure 20 because TOC was undetected in the 7-d sediment samples from these locations.

A large degree of both spatial and temporal heterogeneity in sediment PCB concentrations was detected for sites and sediment samples. Total PCB sediment concentrations at Site 031, for example, were 72 mg/Kg dry for the lab studies, and 521.7 mg/Kg dry for the 48-h, 16.9 mg/Kg dry for the 7-d and 112 mg/Kg dry for the 10-d *in situ* studies (Tables 6 and 16). For the purpose of this report, only the 7-d sediment PCB data were used for analysis of the 7-d *in situ* bioaccumulation results.

There was also uncertainty and variability in the sediment TOC concentrations reported for the Housatonic River sediment samples (Tables 6 and 16). The TOC concentrations presented in this report are those obtained from the Weston database, and differ in some cases from TOC concentrations included in previous drafts of this report. For Site

389, TOC was measured at 4.66% for the laboratory life-cycle studies, 2.5 and 2.6% for the 48-h and 10-d *in situ* tests, and 6.0% for the TIE tests, but was reported as undetected (<0.012%) for the 7-d *in situ* study. Similarly, the sediment TOC content of reference Site 398 was reported as undetected (<0.013%) for the 7-d *in situ* study, but ranged from 0.1 to 1.46% in sediments from the laboratory and other *in situ* tests. This meant that calculations requiring OC-normalization of the 7-d *in situ* sediment PCB data could not be performed for Sites 389 and 398.

3.2.3.1 PCBs in Pore Water

The equilibrium partitioning approach (Di Toro *et al*. 1990) was used to estimate pore water PCB concentrations based on site-specific measurements of PCB congeners and TOC in sediment samples from Sites 011, 019, 428 and 031 that were collected following the 7-d *in situ* exposure (Tables 20 and 21). According to equilibrium partitioning theory, the freely dissolved pore water concentrations of nonpolar organic compounds can be estimated using the following relationships:

$$C_{pw} = C_s/K_p \quad (1),$$

where C_{pw} = concentration in the pore water (mg/L), C_s = concentration in the sediment (mg/Kg dry), and K_p = the sediment-pore water partition coefficient (L/kg). K_p is determined by the equation:

$$K_p = f_{oc} \bullet K_{oc} \quad (2),$$

where f_{oc} = fraction organic carbon in the sediments and K_{oc} = the organic carbon-water partition coefficient. K_{oc} is determined from the octanol-water partition coefficient (K_{ow}) by the following relationship:

$$\log K_{oc} = 0.00028 + (0.983 \bullet \log K_{ow}) \quad (3).$$

The values of K_{ow} were taken from the published literature (Veith *et al.* 1979; Hawker and Connell 1988; Gabric et al. 1990; Boese *et al.* 1997; Fisher *et al.* 1999; USEPA 2000a). Values of log K_{ow} and log K_{oc} for each PCB congener, and K_p for each Housatonic River site, are presented in Table 20. Estimated pore water concentrations were calculated using the K_p values and sediment concentrations of each PCB isomer for each site, and then summed to yield an estimate of the total PCB pore water concentration for the site (Table 21). Concentration units were converted from "mg/L" to "ng/L" for final presentation. Pore water concentrations were not estimated for Sites 398 and 389 because TOC concentrations measured concurrently with the sediment contaminant analyses were reported as undetected.

3.2.3.2 Bioconcentration of PCBs From Pore Water

The estimated pore water concentrations (Table 21) were used to calculate site-specific bioconcentration factors (BCFs) for *L. variegatus* tissues (Table 22). The BCF is determined from the following relationship:

$$BCF = C_{a,ss}/C_{pw} \quad (4),$$

where $C_{a,ss}$ = steady-state tissue concentration of contaminant in the organism (mg/Kg wet) and C_{pw} = concentration of contaminant in the pore water (mg/L). The BCFs reported in Table 22 were calculated using the mean total PCB tissue concentrations (Table 19) and are reported on both a whole-body, wet weight basis (BCF_{ww}) and a lipid weight basis (BCF_{lipid}). The assumptions of the BCF are that the tissue concentrations are at steady-state with environmental concentrations and, for PCBs, that the contaminants are not metabolized.

The values of BCF for total PCBs in the oligochaetes in the present study (log BCF_{ww} = 4.38 – 5.80; log BCF_{lipid} = 6.40 - 7.57; Table 22) are similar to published BCFs for total PCBs in field-collected macroinvertebrates (*e.g.,* zooplankton, amphipods) (log BCF_{ww} = 3.55 - 5.42, log BCF_{lipid} = 4.23 - 6.14; Kucklick *et al*. 1996). For oligochaetes exposed in the laboratory to anthropogenically contaminated sediments containing di-, tri-, tetra-,

penta-, hexa- and octachlorinated PCBs, individual congener log BCF_{ww} values ranged from 3.17 (dichlorobiphenyl) to 5.45 (octachlorobiphenyl) (Connell *et al.* 1988).

Although BCF values provide an index of contaminant accumulation from aqueous exposures, they do not account for uptake from other exposure routes (e.g., ingestion). Therefore, sediment-exposed species will have higher BCFs than those species exposed only to pore water in the same exposure area. More general bioaccumulation factors that consider aqueous and all other routes of exposure have been developed and are described for *L. variegatus* below.

3.2.3.3 Bioaccumulation Factors

Site-specific bioaccumulation factors (BAF; Table 23) for *L. variegatus* were determined from measured sediment and mean tissue levels of total PCBs. The BAF is calculated from the following equation:

$$BAF = C_{a,ss}/C_s \quad (5),$$

where $C_{a,ss}$ = steady-state tissue concentration of contaminant in the organism (mg/Kg wet) and C_s = concentration of contaminant in the sediments (mg/Kg dry). The BAFs reported in Table 23 were calculated on both a whole-body, wet weight basis (BAF_{ww}) and a lipid weight basis (BAF_{lipid}). The assumptions of the BAF are the same as those listed previously for the BCF. Note that the BAF is not calculated based on organic carbon-normalized sediment concentrations, which is useful in that any available sediment concentrations can be used. Therefore, the BAF as calculated above represents the simplest model of bioaccumulation and will vary with sediment type. The accuracy of any predictions for a given organism will be limited if the organic matter or other sediment characteristics differ between sites (Lee 1992).

BAF_{lipid} values reported in Table 23 range from 3.8 - 746. These values for *L. variegatus* tissues in the present study are within or above the ranges measured in oligochaetes (BAF_{lipid}, 0.882 - 14.9) and chironomid larvae (BAF_{lipid}, 2.08 - 17.1) collected from a

PCB-contaminated lake (Bremle and Ewald 1995). However, the highest BAFs occurred at the least contaminated reference site (Site 011; 0.0071 mg/Kg dry PCB), which illustrates, in general, the limited utility of the BAF.

A more useful indicator of bioaccumulation is the biota/sediment accumulation factor (BSAF), which is the quotient of the lipid-normalized, steady-state tissue concentration in an organism and the organic-carbon normalized sediment concentration of a contaminant. As previously noted, sediment TOC measurements for each site varied between the different laboratory and *in situ* components of this study, but TOC was reported as undetected (<0.012%) for Sites 398 and 389 in the 7-d *in situ* study (meaning BSAFs could not be calculated). This variability in TOC concentrations is illustrated in Figure 21, which shows all detected and undetected TOC measurements made on sediments from the *in situ* study sites for the whole project. To provide a means of estimating BSAFs for all six sites, median sediment TOC concentrations were calculated for each site using all the available data. Where TOC was reported as undetected, a value equal to half the detection limit was used. In addition to providing a TOC value for Sites 398 and 389, this approach also served to integrate the variation in TOC measurements observed for all sites. Median sediment TOC concentrations ranged from 0.10 to 6.94% (Table 23). BSAFs for *L. variegatus* were calculated by two methods, first using lipid-normalized mean total PCBs in tissues and the sediment TOC values determined concurrently with the 7-d *in situ* sediment PCB analyses (this yielded BSAF values for Sites 011, 019, 428 and 031), and then using median sediment TOC values to generate BSAFs for all six sites (Table 23).

The assumptions of the BSAF model, as applied to total PCBs, are that the concentrations of PCBs are at steady-state between organism lipids and sediment organic carbon and that PCBs are not metabolized. A theoretical maximum BSAF (g_{oc}/g_{lipid}) of 1.7, based on the partitioning of neutral organic compounds between organic carbon and lipids, has been proposed (McFarland and Clarke 1986). A BASF less than 1.7 indicates less partitioning into lipids than theoretically predicted, whereas a

BSAF greater than 1.7 indicates greater uptake than can be explained by simple partitioning.

BSAFs calculated using 7-d sediment TOC data ranged from 0.80 - 6.07 (Table 23) for four sites, with the lowest value for sediment-exposed *L. variegatus* at Site 031 ($C_{s,oc}$ = 392 mg/Kg OC) and the highest BSAF occurring at Site 019 ($C_{s,oc}$ = 38.3 mg/Kg OC). BSAFs calculated using the median sediment TOC data ranged from 0.02 – 1.40 (Table 23) for six sites; Site 398 ($C_{s,oc}$ = 981.8 mg/Kg OC) had the lowest BSAF and Site 019 ($C_{s,oc}$ = 166.7 mg/Kg OC) had the highest BSAF. Regardless of the calculation method, these values are within the range of mean BSAFs for total PCBs in nine species of bivalves (0.4 - 10.9), chironomid larvae (0.11 - 2.41), and oligochaete worms (0.07 - 1.01) sampled elsewhere (Lee 1992; Bremle and Ewald 1995).

The BAFs and BSAFs (Table 23) were highest at reference Site 011 and Site 019 in the 7-d bioaccumulation study using *L. variegatus* as a surrogate infaunal invertebrate. These two sites had the lowest sediment total PCB concentrations measured following the 7-d exposure. Similar observations were made in the Bremle and Ewald (1986) study on indigenous midge larvae and oligochaetes collected from PCB-contaminated lakes. Such results are not surprising because it has been frequently observed, in field studies and in laboratory-spiked sediment tests, that an inverse relationship exists between BSAF and sediment contaminant concentration and/or TOC (Rubenstein *et al*. 1987; McElroy and Means 1988; Ferraro *et al.* 1990a,b). Thus, “cleaner” sites often result in higher BSAFs than more contaminated sites. This may be due to a sublethal physiological response or a change in organism behavior (*e.g.,* decreased feeding rate, decreased sediment reworking, contaminant avoidance) with increasing levels of sediment contamination (Keilty *et al*. 1988a,b).

4.0 RESULTS OF TASK 3: TOXICITY IDENTIFICATION EVALUATION

Results for all of the Phase I Toxicity Identification Evaluation (TIE) tests are summarized in Tables 24 and 25. Detailed results and water quality data for each TIE treatment are provided in Appendix 7 through 9.

4.1 Day 1 – Initial Toxicity Tests

Pore water samples from Sites 031, 389, 019 and 398 were extracted on September 13, 1999 and received in good condition at WSU on September 15, 1999, after a one-day shipping delay by the courier. The sample container for Site 428 was broken during shipment and was reported to Roy F. Weston, Inc. and Soil Technologies, Inc. (STI). All custody seals were intact. Sample temperatures ranged from 8 to 11^{o}C. Samples from Sites 031 and 389 were turbid, colored and exhibited an oily sheen and odor. Samples from Sites 019 and 398 were relatively clear and without color, oil or odor. This was consistent with observations of sediment characteristics noted during the other Task 1 and 2 tests (see Section 3.0).

Initial water quality parameters measured for each of the four pore water samples were within the following ranges: temperature, 2.0 – 25.7°C; pH, 6.75 – 7.89; conductivity, 475 – 900 μS; dissolved oxygen, 0.97 – 5.49 mg/L; alkalinity, 160 – 340 mg/L; hardness, 206 – 339 mg/L; and total ammonia, 1.21 – 23.4 mg/L. Samples 031 and 389 had the lowest initial dissolved oxygen concentrations (0.97 and 1.11 mg/L) and the highest initial total ammonia concentrations (15.6 and 23.4 mg/L).

Toxicity tests were performed on all four pore water samples were initiated on September 15, 1999. These initial tests used a dilution series of 0, 6.25, 12.5, 25, 50 and 100% (v/v) pore water, and had a 24-h duration. The results indicated that only the pore water samples from Sites 031 and 389 were acutely toxic to *C. dubia,* with 24-h LC_{50} values of 30% (v/v) and 31% (v/v), respectively (Tables 24 and 25). Pore water samples from Sites 398 and 019 showed ≥80% survival after 24-h exposure, so they were not used for further TIE testing.

4.2 Day 2

Day 2 test manipulations were conducted on September 16, 1999. These tests consisted of the baseline, pH-adjusted filtration, oxidant reduction, and pH-adjusted aeration tests. The Day 2 TIE tests were conducted for 48 h, but LC_{50} values were calculated based on both 24-h and 48-h results (Tables 24 and 25).

4.2.1 Baseline Test

The 24-h Day 2 baseline LC_{50} values were 79% (v/v) for Site 031 and 61% (v/v) for Site 389. The 48-h Day 2 baseline LC_{50} values were 27% (v/v) for Site 31 and 26% (v/v) for Site 389. These results indicate that sample toxicity was not consistent between Day 1 and Day 2 for either sample. The 24-h LC_{50} values from the Day 2 baseline test were twice has high as the 24-h LC_{50} values from the Day 1 initial toxicity test. Day 2 baseline toxicity did increase between 24 h and 48 h.

4.2.2 pH-adjusted Filtration

Sample 031 turned golden yellow and a brown, cloudy precipitate formed in the pH 3 treatment while adding HCl. Organisms exposed to this sample showed a marked increase in survival in the pH 3 and pH 11 adjusted treatments (≥80% survival in undiluted pore water after 48 h), as compared to the pHi (initial pH, 6.75) treatment (which had 0% survival in undiluted pore water after 48 h). The 24-h LC_{50} value for the pHi treatment of Sample 031 were 16% (v/v), which was five times lower than the 24-h Day 2 baseline value. The 48-h LC_{50} value for the pHi treatment was 14% (v/v), which was half the Day 2 baseline 48-h LC_{50}. Although sample toxicity decreased with filtration at high and low pH, it increased with filtration at the unadjusted pH level.

For Sample 389, survival increased to 100% at 24 h and 48 h for all three pH-adjusted filtration treatments (pH 3, pHi and pH 11). In this sample, survival in the pHi (initial pH, 6.80) filtered treatment was higher than in both the initial toxicity and baseline tests, indicating that toxicity was decreased by the manipulation treatment (Table 25).

Overall, toxicity decreased considerably in the pH 3 and pH 11 filtration treatments for both Samples 031 and 389 compared to the initial and Day 2 baseline tests. In the pHi treatments, toxicity increased for Sample 031 but decreased for Sample 389. The graduated pH treatment, which is used to identify toxicants such as ammonia, was not conducted due to a lack of sufficient sample volume.

4.2.3 Oxidant Reduction Addition Test

When Sample 031 was treated with 0.2 mL or 0.1 mL of sodium thiosulfate, survival results were somewhat anomalous at 24 h with ≥80% survival at the highest and lowest pore water dilutions but only 10 – 20% survival in the 30% (v/v) dilution, so 24-h LC_{50} values could not be calculated. At 48 h, toxicity in the 0.2-mL addition treatment had increased two-fold relative to the baseline test (i.e., 48-h LC_{50} value of <15% [v/v] as compared to 27% [v/v]), whereas toxicity in the 0.1-mL and 0.05-mL addition treatments was similar to the baseline test (i.e., 48-h LC_{50} values of 23 and 18% [v/v], as compared to 27% [v/v]).

For Sample 389, there was little or no change in toxicity (24- or 48-h) relative to baseline in the 0.2-mL sodium thiosulfate addition, however toxicity increased relative to baseline in the 0.1-mL and 0.05-mL addition treatments. The 48-h LC_{50} values for the treated samples were 17% (v/v) for the 0.2-mL addition and <12.5% (v/v) for the 0.1-mL and 0.05-mL additions, as compared to the 48-h baseline LC_{50} value of 26% (v/v). Survival in undiluted pore water was 0% after 48 h in the baseline test and all three thiosulfate treatments.

The negative control (DMW) yielded 100% survival, as did the treatment blanks (DMW treated with the same amounts of sodium thiosulfate as the pore water samples) that were conducted to determine whether thiosulfate additions caused toxicity.

4.2.4 pH-adjusted/Aeration

In Sample 031, survival in all three pH treatments (pH 3, pHi, pH 11) increased relative to baseline at 24 h; the 24-h LC_{50} values were >100% (v/v) and survival in undiluted

pore water was 80 – 100%. The 48-h comparisons to the baseline test results for Sample 031 showed that the pH 3 treatment increased survival (48-h LC_{50} >100% [v/v], and 80% survival in undiluted pore water) and the pH 11 treatment decreased survival (48-h LC_{50} <15% [v/v], and 20% survival in undiluted pore water). Survival in the pHi treatments was anomalous, with 20% survival in the 12.5 and 100% (v/v) dilutions and 60% survival in the 50% (v/v) dilution (a 48-h LC_{50} value could not be calculated).

Sample 389 survival results were variable for the pH adjustment aeration treatments. At 24 h, toxicity in the pH 3 and pHi treatments increased relative to the baseline test, whereas toxicity was slightly reduced in the pH 11 treatment. After 48 h, toxicity relative to the baseline test had increased in the pH 3 treatment, decreased in the pH 11 treatment, and remained unchanged in the pHi treatment. The 48-h LC_{50} values for these three treatments were <12.5, 47 and 27% (v/v), respectively, as compared to the baseline 48-h LC_{50} value of 26% (v/v).

A reduction in toxicity could indicate the presence of volatile, surfactant or oxidizable toxic materials in the pore water samples. No toxicity was observed in the negative control; pH treatment blanks were not included for this TIE manipulation.

4.3 Day 3

Day 3 test manipulations were conducted on September 17, 1999. These tests consisted of the baseline, pH-adjusted C18 SPE filtration, and EDTA chelation tests. Although the Day 3 TIE manipulations were conducted for 48 h, the Day 3 baseline test had only a 24-h duration. As with the Day 2 TIE tests, LC_{50} values were calculated based on both 24-h and 48-h results (Tables 24 and 25).

4.3.1 Baseline Test

All dilutions had golden colored water with a gradation in intensity from highest to lowest sample concentration. The 24-h LC50 value for the Day 3 baseline test for Sample 031 was 12% (v/v), which was lower than the 24-h LC50 values obtained for the Day 1 initial toxicity test (30% [v/v]) and the Day 2 baseline test (79% [v/v]). A similar trend was also

observed for Sample 389. The 24-h LC50 value was 14% (v/v), which was lower than the 24-h LC50 values obtained for the Day 1 initial toxicity test (31% [v/v]) and the Day 2 baseline test (61% [v/v]). The toxicity of both pore water samples fluctuated during this TIE, decreasing from Day 1 to Day 2, and then increasing to their highest levels on Day 3. Because of these temporal fluctuations, it is very important that comparisons of results from the TIE manipulations be made to concurrent baseline test results.

4.3.2 pH-adjusted/C_{18} Solid Phase Extraction (SPE)

A golden yellow precipitate was observed in the 100%, 50% and 25% (v/v) dilutions of the pH 3 adjusted/C_{18} SPE treatment of Sample 031. The toxicity of Samples 031 and 389 was reduced in all three pH treatments, relative to the Day 3 baseline test, although this reduction in toxicity was not as large in the pH 9 treatment of Sample 031. Although the Day 3 baseline test was only a 24-h exposure, this observation would still apply at 48 h regardless of whether baseline toxicity would have increased or remained unchanged. Both samples had the following Day 3 baseline results: 24-h LC_{50} values of 12 and 14% (v/v), and 0% survival in undiluted pore water. With one exception, the pH-adjusted C18 SPE treatments of Samples 031 and 389 resulted in 48-h LC_{50} values of >100(v/v) and survival in undiluted pore water ranging from 60 to 100%. The pH 9 treatment of Sample 031 had a 48-h LC50 of 71% (v/v), and 0% survival in undiluted pore water, but this was still less toxic than the Day 3 baseline result.

The results of this manipulation indicate that the pH adjustment/C_{18} SPE filtration reduced the toxicity of both pore water samples at all three pH treatments. The pH adjustment/C_{18} SPE treatment blanks were filtered dilution water at each pH adjustment (pH 3, pH_i, pH 9). These blanks indicated artifact toxicity, likely as a result of toxics leached from the C_{18} column in the pH 3 treatment. Toxicity was observed in the pH 3 treatment blank for both Samples 031 and 389, whereas little or no toxicity was observed when either pore water sample was subjected to the pH 3 treatment.

4.3.3 EDTA Chelation Addition

In Sample 031, a golden yellow precipitate was observed in the 100% and 60% (v/v) dilutions, the 30% (v/v) dilution was yellow colored with a yellow film on the cup bottom, and the pore water in the 15% (v/v) dilution was yellow. After 24 h, survival in all three EDTA treatments was better than in the Day 3 baseline test; although there was 0% survival in undiluted pore water the 24-h LC_{50} values were 35% (v/v), as compared to the baseline LC_{50} value of 12% (v/v). If it was assumed that baseline toxicity did not changed between 24 and 48 h, then the addition of 0.2 mL or 0.05 mL of EDTA had little or no effect on reducing toxicity but the lowest EDTA treatment (0.0125 mL addition) reduced the toxicity of Sample 031 by at least a factor of two (48-h LC_{50} value of 27% [v/v]).

In Sample 389, the pore water in the 60% (v/v) dilution was yellow, the 30% (v/v) dilution was slightly colored, and the 15% (v/v) dilution was slightly cloudy. The results for Sample 389 differed from those obtained for Sample 031 with this TIE manipulation. After 24 h, survival in undiluted pore water was still 0% regardless of the amount of EDTA added, but a comparison of the 24-h LC_{50} values showed that the lowest EDTA treatment (0.0125 mL addition) had reduced toxicity relative to baseline (24-h LC50 of 62% [v/v] as compared to 14% [v/v]). However, after a 48-h exposure the LC_{50} values for all three EDTA treatments of Sample 389 were <15% (v/v) and it was not possible to determine how these results would have compared to baseline.

The LC_{50} values for Sample 031 showing increased toxicity as EDTA addition concentrations increased, whereas the final results for Sample 389 were inconclusive. Overall, the EDTA chelation treatment did not appear to be effective at reducing toxicity. Little or no toxicity was observed in the EDTA treatment blanks.

4.4 Task 3: Discussion and Conclusions

When samples are manipulated during the TIE procedures, the pore water aliquots should not become more toxic; however, this was observed in some treatments. Artifacts that may occur and contribute to toxicity are: excessive ion strength from

acid/base addition during pH adjustment, formation of toxic products by addition of acids/bases, inadequate mixing of the solutions, contaminants leached from filters, pH probes, SPE columns, and reagents added and their contaminants (USEPA 1991a,b).

Although not likely to be an issue in actual pore water because of its comparatively low pH (initial pH values for Samples 031 and 389 were 6.75 and 6.80, respectively), the total ammonia concentrations in these two pore water samples could have been a factor in the TIE where pH was allowed to increase to in excess of 8.3 (the unionized ammonia fraction reaches 10% at pH 8.3 and 15% at pH 8.5). The potential for ammonia toxicity cannot be determined because the graduated pH manipulation was not conducted (due to insufficient sample volume). Moreover, potential changes in the unionized ammonia fraction over time could not be estimated because pH was not always measured at 24 h.

Acute toxicity was clearly eliminated or substantially reduced by the pH-adjusted/filtration and pH-adjusted/C18 SPE filtration manipulations (although filtration did not reduce toxicity at ambient pH for Sample 031). The pH-adjusted/filtration test decreased TUs by 3 points in both pH manipulated pore water samples, indicating a significant decrease in toxicity. Only the pHi treatment of Sample 031 was not improved by the filtration test (toxicity actually increased); this result could be attributed to artifact toxicity and/or, as this treatment was not pH adjusted, that organic compounds were not degraded. The pH-adjusted/C_{18} SPE filtration test also implicates non-polar organics, pesticides and some metals, if present. The pH-adjusted/C_{18} SPE filtration test TUs for Samples 031 and 389 were decreased from 6 to 7 points when compared to Day 3 baseline test results (assuming no change in baseline toxicity from 24 to 48 h). The pH-adjusted/C_{18} SPE test removed up to 100% of toxicity in both samples.

Both of these TIE manipulations remove particulate fractions, either present naturally, or related to precipitate formed by changes in pH. In addition, the C18 SPE filtration preferentially binds non-polar organics (such as PCBs) as well as some metals. Conversely, depending on the substrate used for the 0.45-μm filter, organics could have

been sorbed to the filter material during vacuum filtration. Removal of organic contaminants by the C18 SPE treatment, rather than particulate or sorbed metals, can be confirmed by eluting the column with methanol and then testing the eluate for toxicity. This verification step was not performed so it is difficult to conclusively confirm that toxicity was due to a non-polar organic constituent.

Adjustment of pH followed by precipitation is frequently indicative of metals, but the precipitate could also scavenge organics from the water column, particularly if sorbed onto small particulates or suspended as small colloids. Metal ions form bridging compounds that will flocculate at higher pH and can be filtered out. At higher pH, negatively charged particles (e.g., colloids) will bind with metals and form larger molecules that are removed by filtration (Manahan 1994). Increasing pH may remove toxicity by causing metal(s) to precipitate and become filterable or unavailable. Speciation of compounds may or may not affect toxicity but changes in solution pH (test manipulations) may affect toxicity of any of the compounds tested. Returning the manipulated sample pH to its initial pH may still alter its toxicity. These pH adjustments can cause a reduction, loss, or increase in toxicity (USEPA 1991a,b) (Table 26).

A finding of metals toxicity would typically be supported by corroborating evidence from another TIE treatment, such as EDTA chelation, but this was not the case in this study, because the EDTA chelation treatment did not appear to be effective at reducing toxicity. The confounding results of the oxidant reduction and EDTA chelation tests do not strongly support metals as a cause of acute toxicity. However, several metals of concern were detected in the sediment samples and extracted pore waters used for the TIE tests (Tables 27 and 28). Concentrations of some of these metals exceed recommended SQGs, in sediments, and WQC, in pore waters (Table 29).

In addition, concentrations of total PAHs were detected at Site 389 and Site 031 for sediment (5.54 and 9.62 mg/Kg dry, respectively) and pore water (71.7 and 18.4 μg/L, respectively). When sediment PAH concentrations were OC-normalized, total PAH concentrations at Sites 389 and 031 were below the SQG (Table 29) for total PAHs

(threshold effects concentration [TEC], 290 mg/kg OC; Swartz 1999), whereas Site 398, 019 and 428 sediments exceeded this SQG. Total PAH concentrations in pore water exceeded the WQC (2.0 μg/L) at Sites 389 and 031. Detection of total PCBs in sediments (Site 031 = 210 mg/Kg dry and Site 389 = 93 mg/Kg dry) and pore water (Site 031 = 100 μg/L and Site 389 = 180 μg/L) far exceeded both the SQG and WQC values (Table 29).

It difficult to quantify the degree to which ammonia may have confounded the results for the contaminants of greatest concern, such as metals and organics. The fact that two treatments effectively removed toxicity suggests that it is possible to characterize the cause of toxicity. However, the absence of corroborating treatments (e.g., solvent elution of the C18 column) and analytical results taken before and after the treatments makes it difficult to conclusively attribute toxicity to metals or organics. Although the overall weight-of-evidence from the TIE and toxicity studies suggests that non-polar organic compounds are the dominant toxic agent, a more comprehensive Phase II or Phase III TIE would be required to definitively identify compounds that were associated with altered biological responses.

5.0 PROJECT SUMMARY

The *H. azteca* and *C. tentans* laboratory life-cycle assessment tests showed lethal to sublethal toxicity existed in the study area for both test species. The strong and consistent relationships between PCB sediment contamination and species responses suggest PCBs were a major stressor. Based on whole sediment PCB concentrations, adverse biological effects to *H. azteca* and *C. tentans* were in the low parts per million ranges. However, there was significant sediment heterogeneity of PCBs and TOC at the test sites, which resulted in some uncertainty in the establishment of concentration-response relationships. It is likely that the dynamics of the river and sediment environments result in varying degrees of contaminant exposure over time. Downstream sites are more likely to have a wider range of contaminant levels. The TIE and *in situ* studies supported the laboratory toxicity test conclusions.

Chemical contaminants other than PCBs, such as PAHs, metals and chlorinated benzenes, were detected in samples of sediment and surface water collected from the study area as part of the 7-d *in situ* tests (Tables 30 and 31). Although the results of this project did not establish a relationship between sediment or surface water concentrations of other contaminants (PAHs, metals or chlorinated benzenes) and tissue residues or organism responses, other contaminants were observed at potential levels of concern based on screening to conservative screening criteria. Several of the PAHs, metals and chlorinated benzene detections were above SQGs or WQC (Table 32). Therefore, it is possible that these chemicals may also have contributed to sediment toxicity. These other contaminants are summarized below:

- Total PAH exceedances in sediment samples from the 7-d bioaccumulation test were observed for Sites 011, 019 and 389. However, survival of the test organisms was high at Sites 011 and 019 even though the total PAH threshold effects concentration (TEC, 290 mg/kg OC; Swartz 1999) was exceeded. In samples of sediments and pore water from Sites 389 and 031 used for TIE testing, the sediment TEC was not exceeded but the acute WQC (2.0 μg/L) was

exceeded. Although it is possible that PAH levels at Sites 389 and 031 contributed to the toxicity observed in the 48-h and 10-d *in situ* exposures, the weight-of-evidence supports the conclusion that PCBs are the primary toxicant in the Housatonic River study area.

- Metals exceedances in sediment and pore water samples were noted at some downstream sites. No SQGs for metals in the 7-d bioaccumulation sediment samples were exceeded for Sites 011 and 389, and only mercury and lead exceeded an SQG at Sites 398 and Site 019, respectively. However, sediment levels at Sites 428 and 031 exceeded consensus TECs for six and five metals, respectively. Chemical analysis of the TIE samples resulted in exceedances of seven SQGs and six WQC for Site 389, and eight SQGs and four WQC for Site 031. Therefore, it is possible that metals also contributed to the toxicity observed in the 48-h and 10-d *in situ* exposures.

- The chlorinated benzenes, 1,2,4-trichlorobenzene (Site 389 only) and 1,4-dichlorobenzene (Sites 398, 428, 389 and 031), were detected in sediment samples from the 7-d bioaccumulation study. The level of 1,2,4-trichlorobenzene at Site 389 (0.16 mg/Kg dry) was above the reported threshold (0.092 mg/Kg dry), acute (0.091 mg/Kg dry) and chronic (0.0091 mg/Kg dry) effects SQGs for this contaminant (NYDEC 1994; USEPA 1996). Concentrations of 1,4-dichlorobenzene at Sites 398 (0.041 mg/Kg dry) and 389 (0.11 mg/Kg dry) were above reported threshold (0.0035 mg/Kg dry), acute (0.012 mg/Kg dry) and chronic (0.0012 mg/Kg dry) effects levels (NYDEC 1994; USEPA 1996). TOC-normalized chlorinated benzene concentrations were calculated for 1,4-dichlorobenzene at Sites 428 (2.13 mg/Kg OC) and 031 (1.41 mg/Kg OC). These concentrations were above the site-specific threshold, acute and chronic effects levels for Sites 428 (0.068, 0.23 and 0.023 mg/Kg OC, respectively) and 031 (0.081, 0.28 and 0.028 mg/Kg OC, respectively) (NYDEC 1994; USEPA 1996). A probabilistic model of chlorobenzene sediment effects concentrations predicts that 1,4-dichlorobenzene at Sites 428 and 031 would have been toxic at the 20th -

30th and the 10th - 20th percentiles of effects distributions, respectively (Fuchsman *et al*. 1999). Thus, it is possible that chlorinated benzenes contributed to the observed toxicity if it is assumed that their levels in the sediments during the 48-h and 10-d *in situ* toxicity exposures were similar to the concentrations measured in the 7-d bioaccumulation test samples.

In summary, there are modest indications that other chemicals may have contributed to toxic responses at some of the test locations. However, the frequency and magnitude of criteria exceedances for these other chemicals was much lower than for PCBs in sampled media. The concentration-response relationships (Weston 2003), combined with the outcome of the TIE, point to PCBs and possibly other non-polar organic chemicals as the dominant toxic agents within the Housatonic River PSA.

It has been established in the laboratory that PCBs are acutely toxic to aquatic invertebrate species through narcosis. However, in the field tests conducted in the study area, *H. azteca*, *C. tentans* and *D. magna* mortality was observed even at low exposure levels. Thus, it appears that within the complex mixture of sediment-associated chemicals detected in the present *in situ* study, PCBs may not have been acting by only narcosis to cause the observed mortality endpoint. Landrum *et al.* (1989) observed similar results with amphipods in a study of mixtures of narcotic chlorinated hydrocarbons, and non-narcotic chemicals. It is unknown whether other suspect contaminants in the study sediments (*e.g.,* PAHs, metals, chlorinated benzenes) acted additively, antagonistically, or synergistically with the PCBs. When xenobiotics exist in contaminated environments, they are often in mixtures with several other chemical classes, so the effective concentrations of individual compounds are difficult to determine (Burton 1991). The BRs of PCBs accumulated *in situ* were below laboratory-derived values for acute lethality of single PCB congeners or Aroclor® mixtures. Because the PCBs existed in a complex mixture of other chemicals in the study area, it was not unexpected that deleterious effects in aquatic organisms occurred despite lower than acute PCB body residue levels.

The weight of evidence supports the conclusion that PCBs are causing toxicity in the study area. In addition to the results of the laboratory and *in situ* toxicity and bioaccumulation studies, that used a number of different species, the sediment and water chemistry data supported this conclusion. Measured sediment and water concentrations of total PCBs at the study sites exceeded recently published consensus-based sediment effects concentrations. Because these are empirically based, conservative single chemical guidelines, they merely suggest that effects will not be observed at lower levels. However, when predictions from SQGs are combined with the biological data from *in situ* and laboratory toxicity, bioaccumulation testing and TIE Phase I exposures, a strong case is presented that implicates PCBs as a dominant causative agent in the observed mortality. This study has demonstrated that the PCBs in the study area are present at levels that are sufficient to cause toxicity to aquatic organisms.

6.0 LITERATURE CITED

Adams, W.J., R.A. Kimerle and R.G. Mosher. 1985. Aquatic safety assessment of chemicals sorbed to sediments. In R.E. Cardwell, R. Purdy and R.C. Bahner, eds., *Aquatic Toxicology and Hazard Assessment: Seventh Symposium*. STP 854. American Society for Testing Materials, Philadelphia, PA, USA, pp. 429-453.

Ankley, G.T., V.R. Mattson, E.N. Leonard, C.W. West and J.L. Bennett. 1993. Predicting the acute toxicity of copper in freshwater sediments: Evaluation of the role of acid volatile sulfide. *Environ. Toxicol. Chem*. 12(2):315-320.

Ankley, G.T., D.J. Call, J.S. Cox, M.D. Kahl, R.A. Hoke and P.A. Kosian. 1994. Organic carbon partitioning as a basis for prediction the toxicity of chlorpyrifos in sediments. *Environ. Toxicol. Chem*. 13:621-626.

ASTM. 1999. Standard Test Methods for Measuring the Toxicity of Sediment Associated Contaminants with Freshwater Invertebrates. E1706-95b, revision in press. American Society for Testing and Materials. Philadelphia, PA.

Boese, B.L., H. Lee II and S. Echols. 1997. Evaluation of a first-order model for the prediction of the bioaccumulation of PCBs and DDT from sediment into the marine deposit-feeding clam *Macoma nasuta*. *Environ. Toxicol. Chem.* 16(7):1545-1553.

Bremle, G. and G. Ewald. 1995. Bioconcentration of polychlorinated biphenyls (PCBs) in chironomid larvae, oligochaete worms and fish from contaminated lake sediment. *Mar. Freshwater Res*. 46:267-273.

Burton, G.A., Jr. 1991. Assessing freshwater sediment toxicity. *Environ. Toxicol. Chem*. 10:1585-1627.

Burton, G.A., Jr., C.G. Ingersoll, L.C. Burnett, M. Henry, M.L. Hinman, S.J. Klaine, P.F. Landrum, P. Ross, and M. Tuchman. 1996a. A comparison of sediment toxicity test methods at three Great Lakes Areas of Concern*. J. Great Lakes Res.* 22:495-511.

Burton, G.A., Jr., T.J. Norberg-King, C.G. Ingersoll, G.T. Ankley, P.V. Winger, J. Kubitz, J.M. Lazorchak, M.E. Smith, I.E. Greer, F.J. Dwyer, D.J. Call, K.E. Day, P. Kennedy, M. Stinson. 1996b. Interlaboratory study of precision: *Hyalella azteca* and *Chironomus tentans* freshwater sediment toxicity assay. *Environ. Toxicol. Chem*. 15:1335-1343.

Burton, G.A., Jr., C. Hickey, T. DeWitt, D. Morrison, D. Roper, and M. Nipper. 1996c. *In situ* toxicity testing: Teasing out the environmental stressors. SETAC NEWS 16(5):20-22.

Burton, G.A., Jr. 1997. Quality Assurance Project Plan for the U.S. Environmental Protection Agency's Freshwater Sediment Toxicity Methods Evaluation. EPA Cooperative Agreement No. CR-824161. U.S. EPA Office of Science and Technology. Washington, DC.

Burton, G.A., Jr., B.L. Stemmer, K.L. Winks, P.E. Ross, and L.C. Burnett. 1989. A multitrophic level evaluation of sediment toxicity in Waukegan and Indiana Harbors. *Environ. Toxicol. Chem*. 8:1057-1066.

Chappie, D.J. and G.A. Burton, Jr. 1997. Optimization of *in situ* bioassays with *Hyalella azteca* and *Chironomus tentans*. *Environ. Toxicol. Chem*. 16:559-564.

Cauchie, H.M., M.F. Jspar-Versali, L. Hoffman and J.P. Thome. 1999. Analysis of the seasonal variation in biochemical composition of *Daphnia magna* Strauss (Crustacea: Branchiopoda: Anomopoda) from an aerated wastewater stabilization pond. *Annal. de Limnol.-Int. J. Limnol*. 35(4):223-231.

Connell, D.W., M. Bowman and D.W. Hawker. 1988. Bioconcentration of chlorinated hydrocarbons from sediments by oligochaetes. *Ecotoxicol. Environ. Saf*. 16:293-302.

Di Toro, D.M., J.D. Mahoney, D.J. Hansen, K.J. Scott, M.B. Hicks, S.M. Mayr and M.S. Redmond. 1990. Toxicity of cadmium in sediments: The role of acid volatile sulfide. *Environ. Toxicol. Chem*. 9:1487-1502.

Di Toro, D.M., C.S. Zarba, D.J. Hansen, W.J. Berry, R.C. Swartz, C.E. Cowan, S.P. Pavlou, H.E. Allen, N.A. Thomas and P.R. Paquin. 1991. Technical basis for establishing sediment quality criteria for non-ionic organic chemicals using equilibrium partitioning. *Environ. Toxicol. Chem.* 10(12):1541-1583.

Ferraro, S., H. Lee II, R. Ozretich, D.T Specht. 1990a. Predicting bioaccumulation potential: A test of a fugacity-based model approach. *Arch. of Environ. Contam. Toxicol.* 19:386-394.

Ferraro, S., H. Lee II, L. Smith, R. Ozretich, D.T Specht. 1990b. Accumulation factors for eleven polychlorinated biphenyl congeners. *Bull. Environ. Contam. Toxicol.* 46:276-283.

Fisher, S.W., S.W. Chordas III and P.F. Landrum. 1999. Lethal and sublethal body residues for PCB intoxication in the oligochaete, *Lumbriculus variegatus*. *Aquatic Toxicol.* 45:115-126.

Fuchsman, P.C., D.J. Duda and T.R. Barber. 1999. A model to predict threshold concentrations for toxic effects of chlorinated benzenes in sediment. *Environ. Toxicol. Chem.* 19(9):2100-2109.

Gabric, A.J., D.W. Connell and P.R.F. Bell. 1990. A kinetic model for bioconcentration of lipophilic compounds by oligochaetes. *Wat. Res.* 24(10):1225-1231.

Hawker, D.W. and D.W. Connell. 1988. Influence of partition coefficient of lipophilic compounds on bioconcentration kinetics with fish. *Wat. Res*. 22(6):701-707.

Ingersoll, C.G. and M.K. Nelson. 1990. Testing sediment toxicity with Hyalella azteca (Amphipoda) and Chironomus riparius (Diptera). In W.G. Landis and W.H. van der Schalie, eds., *Aquatic Toxicology and Hazard Assessment: Thirteenth Symposium*. STP 1096. American Society for Testing Materials, Philadelphia, PA, USA, pp. 93-109.

Keilty, T.J., D.S. White and P.F. Landrum. 1988a. Sublethal responses to Endrin in sediment by *Limnodrilus hoffmeisteri* (Tubificidae), and in mixed-culture with *Stylodrilus Heringianus* (Lumbriculidae). *Aquatic Toxicology*. 13(3):227-250.

Keilty, T.J., D.S. White and P.F. Landrum. 1988b. Sublethal responses to Endrin in sediment by *Stylodrilus heringianus* (Lumbriculidae) as measured by a ^{137}Cesium marker layer technique. *Aquatic Toxicology* 13(3):251-270.

Kemble, N.E., F.J. Dwyer, C.G. Ingersoll, T.D. Dawson and T.J. Norberg-King. 1999. Tolerance of freshwater test organisms to formulated sediments for use as control materials in whole-sediment toxicity tests. *Environ. Toxicol. Chem. 18(2):222-230.*

Kucklick, J.R., H.R. Harvey, P.H. Ostrom, N.E. Ostrom and J.E. Baker. 1996. Organochlorine dynamics in the pelagic food web of Lake Baikal. *Environ. Toxicol. Chem*. 15(8):1388-1400.

Landrum, P.F., et al. 1989. Bioavailability and toxicity of a mixture of sediment-associated chlorinated hydrocarbons to the amphipod, *Pontoporeia hoyi*. Pp. 315-329 *in* Aquatic Toxicology and Hazard Assessment: 12th Volume. ASTM STP 1027. U.M. Cowgill and L.R. Williams (eds.). American Society for Testing and Materials, Philadelphia, PA, USA.

Lee, H., II. 1992. Models, muddles, and mud: Predicting bioaccumulation of sediment-associated pollutants. Pp. 267-293 *in* Sediment Toxicity Assessment, G. A. Burton, Jr. (ed.). Lewis Publishers, Inc. Chelsea, MI.

Lotufo, G.R., P.F. Landrum, M.L. Gedeon, E.A. Tigue and L.R. Herche. 1999. Comparative toxicity and toxicokinetics of DDT and its major metabolites in freshwater amphipods. *Environ. Toxicol. Chem.* 19(2):368-379.

Manahan, S.E. 1994. Environmental Chemistry, 6th Edition. CRC Press, Boca Raton, FL.

MacDonald, D.D., L.M. DiPinto, J. Field, C.G. Ingersoll, E.R. Long and R.C. Swartz. 2000a. Development and evaluation of consensus-based sediment effect concentrations for polychlorinated biphenyls. *Environ. Toxicol. Chem*. 19(5):1403-1413.

MacDonald, D.D., C.G. Ingersoll and T.A. Berger. 2000b. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. *Arch. Environ. Contam. Toxicol*. 39(1):20-31.

McCarty, L.S. and D. Mackay. 1993. Enhancing ecotoxicological modeling and assessment. *Environ. Sci. Technol*. 27:1719-1728.

McElroy, A.E. and J.C. Means. 1988. Factors affecting the bioavailability of hexachlorobiphenyls to benthic organisms. Pp. 149-158 in Aquatic Toxicology and Hazard Assessment: 10th Vol., ASTM STP 971. W.J. Adams, G.A. Chapman and W.G. Landis (eds.). American Society for Testing and Materials. Philadelphia, PA, USA.

McFarland, V.A. and J.U. Clarke. 1986. Testing bioavailability of polychlorinated biphenyls using a two-level approach. Pp. 220-229 *in* Water Quality R & D: Successful Bridging between Theory and Application. R. G. Wiley (ed.). Hydrologic Engineering Research Center. Davis, CA, USA.

NYDEC (NY State Department of Environmental Conservation). 1994. Technical guidance for screening contaminated sediments. Division of Fish and Wildlife and Division of Marine Resources, Albany, NY, USA.

Phipps, G.L., G.T. Ankley, D.A. Benoit and V.R. Mattson. 1993. Use of the aquatic oligochaete *Lumbriculus variegatus* for assessing the toxicity and bioaccumulation of sediment-associated contaminants. *Environ. Toxicol. Chem*. 12:269-279.

Rubenstein, N.I., J.L. Lake, R.J. Pruell, H. Lee II, B. Taplin, J. Heltshe, R. Bowen and S. Pavignano. 1987. Predicting bioaccumulation of sediment-associated organic contaminants: Development of a regulatory tool for dredged material evaluation. U.S. EPA 600/x-87/368.

Schuytema, G.S., D.F. Krawczyk, W.L. Griffis, A.V. Nebeker, M.L. Robideaux. 1990. Hexachlorobenzene uptake by fathead minnows and macroinvertebrates in recirculating sediment/water systems. *Arch. Envrion. Contam. Toxicol.* 19:1-9.

Stumm, W. and J.J. Morgan. 1981. Aquatic Chemistry – An Introduction Emphasizing Chemical Equilibria in Natural Waters. John Wiley & Sons, Inc., New York, NY.

Swartz, R.C., G.R. Ditsworth, D.W. Schults and J.O. Lamberson. 1985. Sediment toxicity to a marine infaunal amphipod: Cadmium and its interaction with sewage sludge. *Mar. Environ. Res.*18:133-153.

Swartz, R.C., D.W. Schults, T.H. DeWitt, G.R. Ditsworth and J.O. Lamberson. 1990. Toxicity of fluoranthene in sediment to marine amphipods: A test of the equilibrium partitioning approach to sediment quality criteria. *Environ. Toxicol. Chem*. 9:1071-1080.

Swartz, R.C. 1999. Consensus sediment quality guidelines for polycyclic aromatic hydrocarbon mixtures. *Environ. Toxicol. Chem*. 18(4):780-787.

Tucker, K.A. and G.A. Burton, Jr. 1999. Assessment of nonpoint-source runoff in a stream using *in situ* and laboratory approaches. *Environ. Toxicol. Chem*. 18(12):2797-2803.

USEPA (US Environmental Protection Agency). 1986. Quality criteria for water 1986. EPA 440/5-86-001. Office of Water. Washington, DC. May 1, 1986.

USEPA. 1987. Update #2 to Quality criteria for water 1986. Office of Water. Washington, DC. May 1, 1987.

USEPA. 1991a. Methods for aquatic toxicity identification evaluations. Phase 1, Toxicity characterization procedures 2nd edition. EPA/600/6-91/003. Office of Research and Development, Washington, DC.

USEPA. 1991b. Sediment toxicity identification evaluations: Phase 1 (characterization), phase 2 (identification), and phase 3 (confirmation). Modification of effluent procedures. EPA 600/6-91-007. Environmental Research Laboratory, Duluth, MN. Tech Report No. 08-91.

USEPA. 1993. Methods for measuring the acute toxicity of effluents and receiving waters to freshwater and marine organisms, 4th edition. EPA/600/4-90/027F. Environmental Monitoring and Support Laboratory. US Environmental Protection Agency, Cincinnati, OH. August 1993.

USEPA. 1994. Procedures for assessing the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. EPA 600/R-94/024. U.S. Environmental Protection Agency, Duluth, MN.

USEPA. 1996. Eco Update: Ecotox thresholds. EPA 540/F-95/083. Office of Solid Waste and Emergency Response. Washington, DC.

USEPA. 1998. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. Duluth, MN, Draft.

USEPA. 2000a. Appendix to bioaccumulation testing and interpretation for the purpose of sediment quality assessment. Status and needs. Chemical specific summary tables. EPA-823-R-00-002. Office of Water (4305) and Office of Solid Waste (5307W). Washington, DC. Feb 2000. 816 pp.

USEPA. 2000b. Methods for measuring the toxicity and bioaccumulation of sediment-associated contaminants with freshwater invertebrates. Second edition. EPA/600/R-99/064. Office of Water, Washington, DC. March 2000. 192 pp.

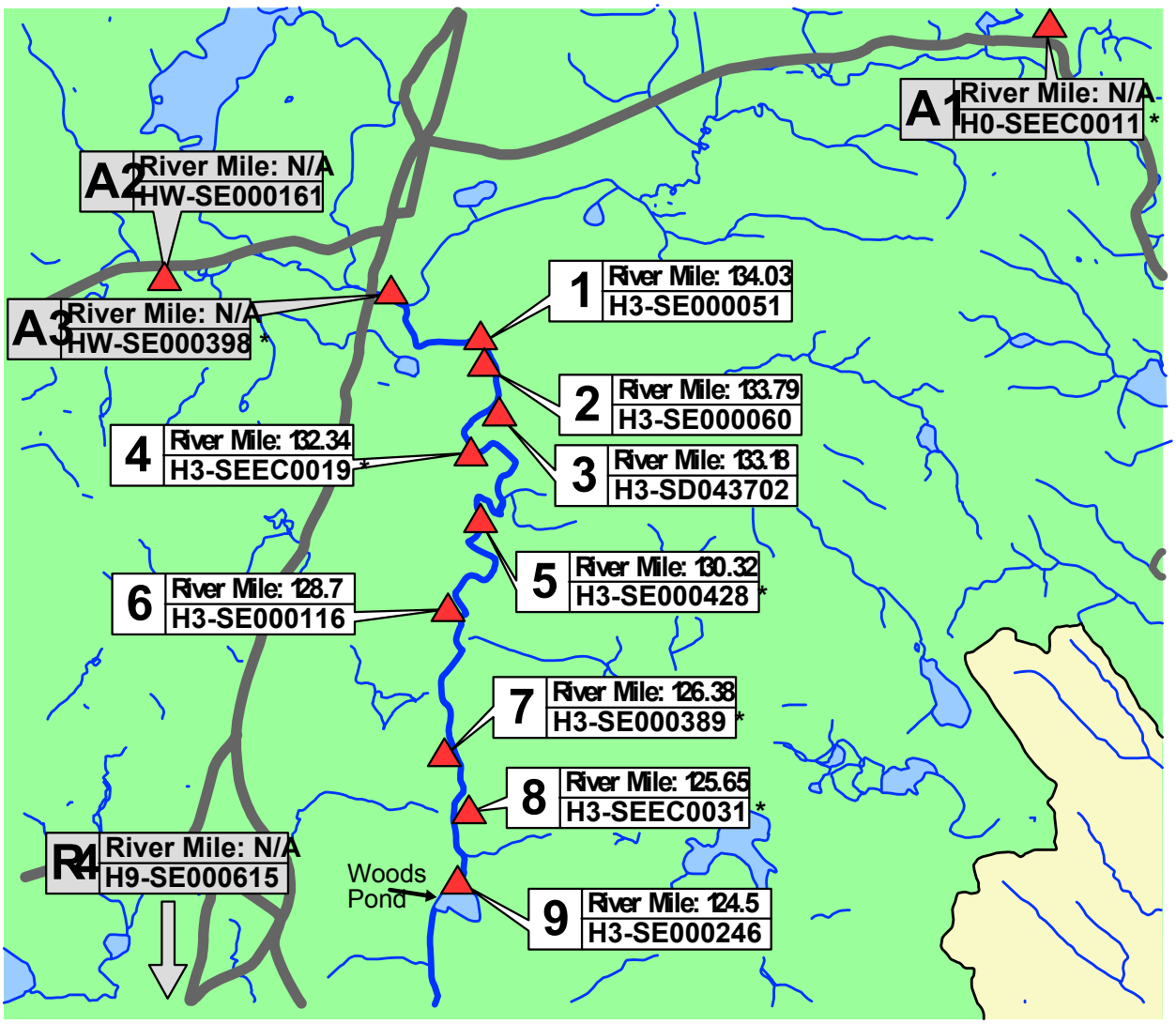
Veith, G.D., D.L. DeFoe and B.V. Bergstedt. 1979. Measuring and estimating the bioconcentration factor of chemicals in fish. *J. Fish. Res. Board Can.* 36:1040-1048.

West, C.W., G.T. Ankley, J.W. Nichols, G.E. Elonen and D.E. Nessa. 1997. Toxicity and bioaccumulation of 2,3,7,8-tetrachlorodibenzo-p-dioxin in long-term tests with the freshwater benthic invertebrates *Chironomus tentans* and *Lumbriculus variegatus*. *Environ. Toxicol. Chem*. 16(6):1287-1294.

Weston. 2000. Final Quality Assurance Project Plan, General Electric (GE) Housatonic River Project, Pittsfield, Massachusetts. Roy F. Weston, Inc., West Chester, PA.

Weston. 2003. Draft Ecological Risk Assessment for the General Electric (GE) Housatonic River Site, Rest of River. Weston Solutions, West Chester, PA. DCN: GE-030703-ABMH. Contract No. DACW33-00-D-0006. Task Order 0003.

Figure 1: Locations of Wright State University toxicity sampling stations (Sites 011, 398, 019, 428, 389, 031; marked with asterisks) in relation to benthic invertebrate sampling locations.



* = Wright State University (WSU) sediment toxicity sampling station.

NOTE: WSU stations use last three digits of Weston IDs shown above (e.g., H3-SEEC0031 is the Weston ID for WSU Station 031). Station 023 (not shown) was located within 15 m of Station 031, and was used for the laboratory portion of the testing only.

Figure 2: Survival of *Hyalella azteca* in chronic laboratory toxicity test, at three time periods (28-d, 35-d, 42-d). Value in *italics* represents total PCB concentration in mg/kg.

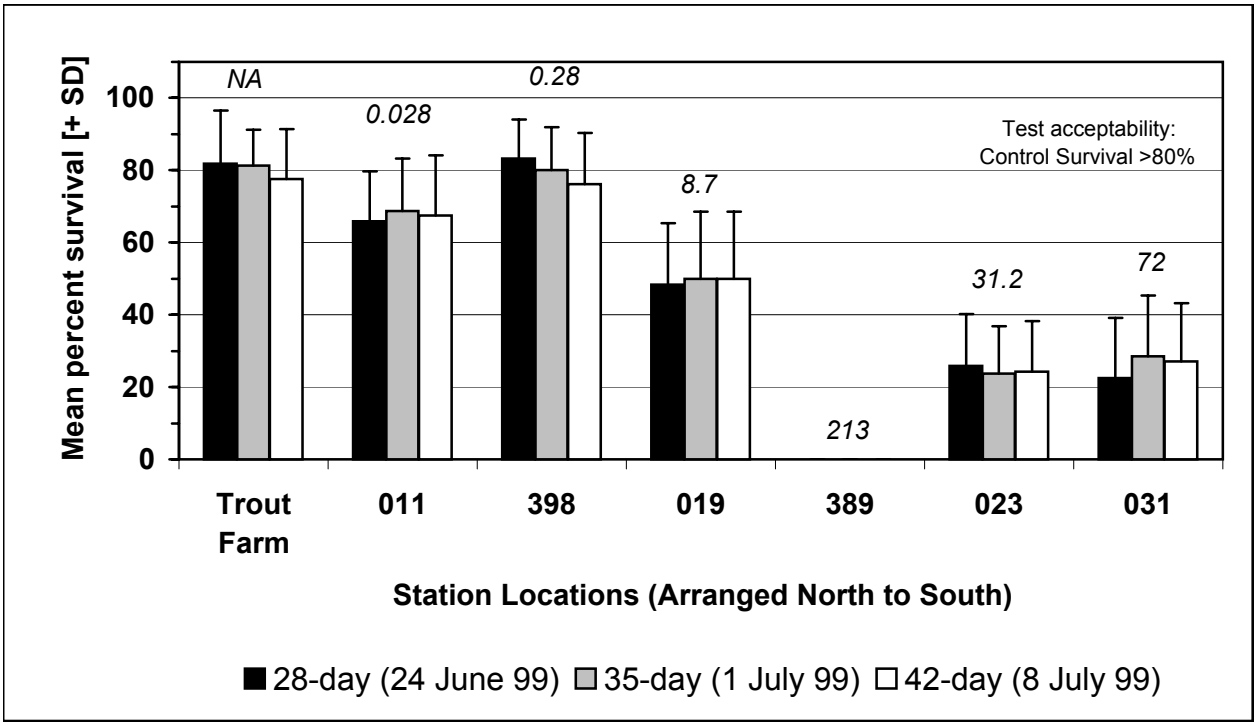


Figure 3: *Hyalella azteca* 28-day dry weights in chronic laboratory toxicity test. Value in *italics* represents total PCB concentration in mg/kg.

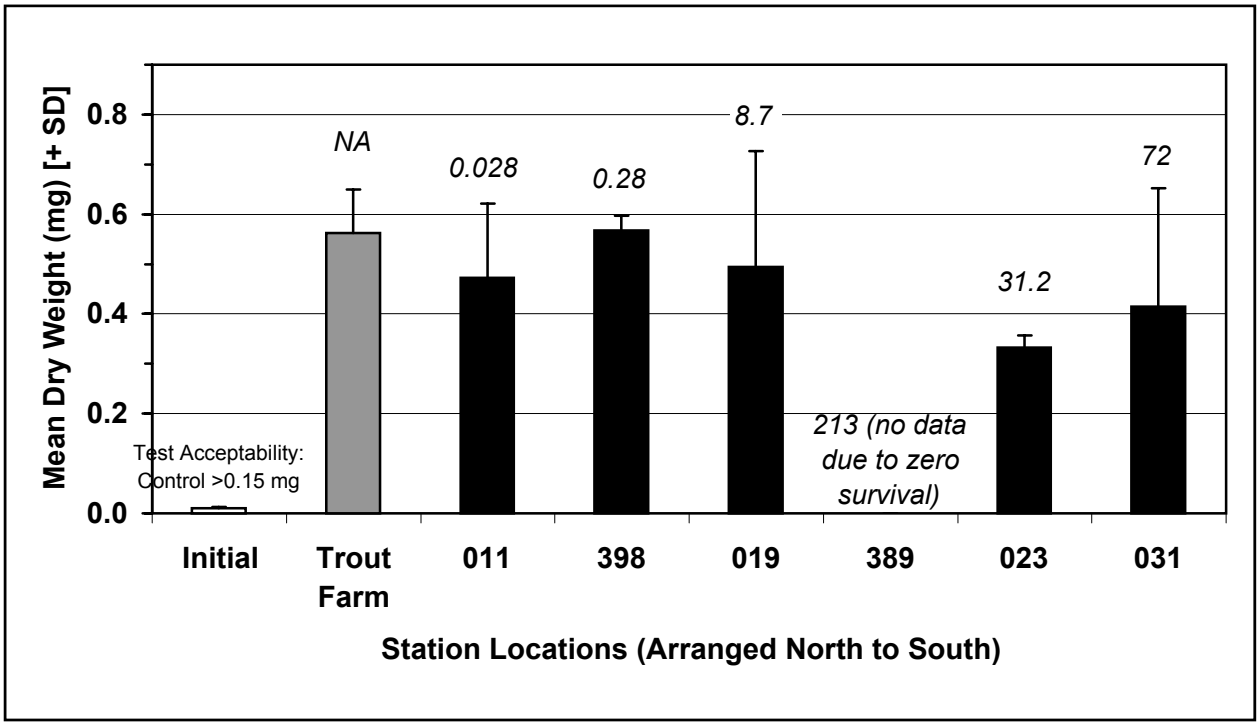


Figure 4: *Hyalella azteca* 42-day dry weights in chronic laboratory toxicity test. Value in *italics* represents total PCB concentration in mg/kg.

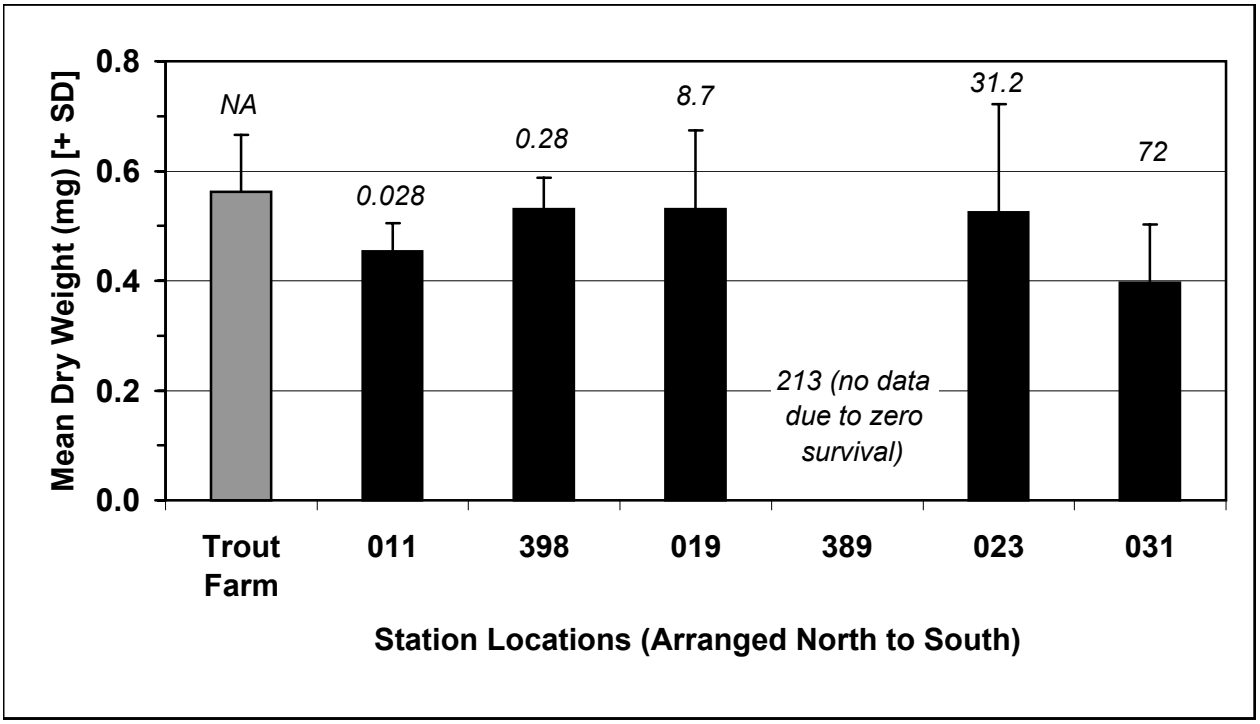


Figure 5: Reproduction of *Hyalella azteca* in chronic laboratory toxicity test, based on mean number of neonates (totals and numbers per female). Value in *italics* represents total PCB concentration in mg/kg.

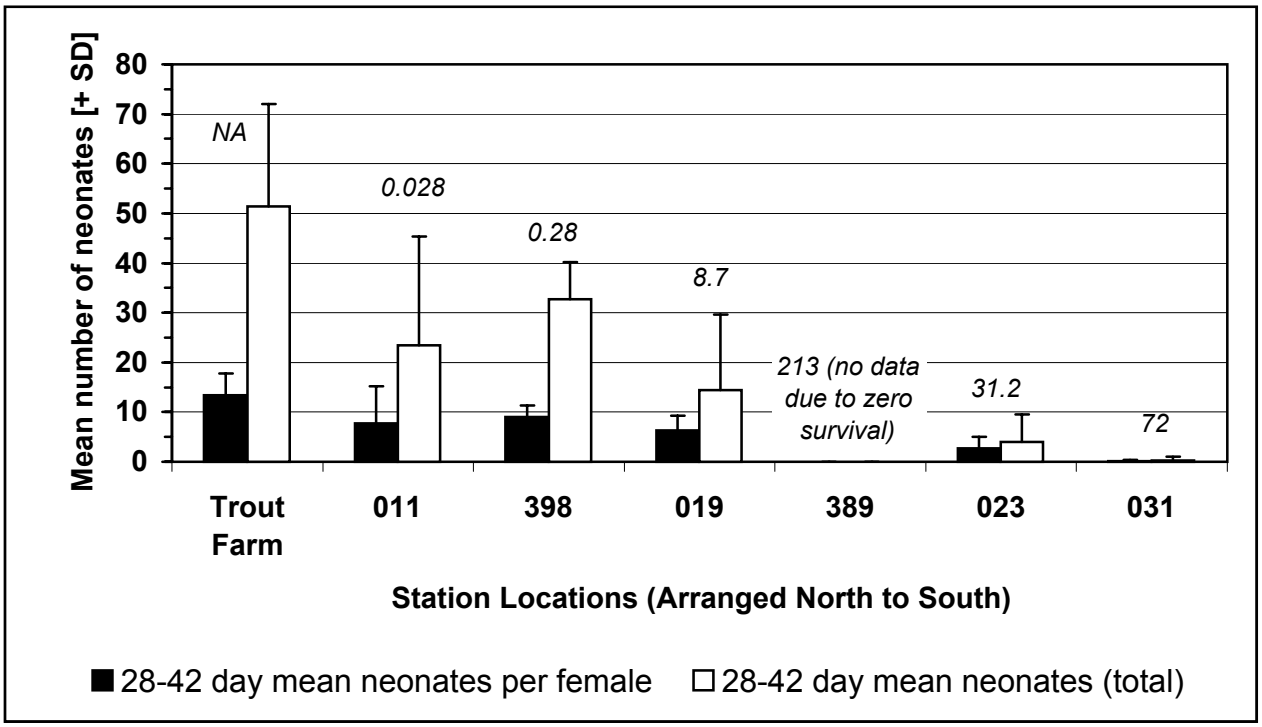


Figure 6: Survival of *Chironomus tentans* in chronic laboratory toxicity test (20-day). Value shown in *italics* represents total PCB concentration in mg/kg.

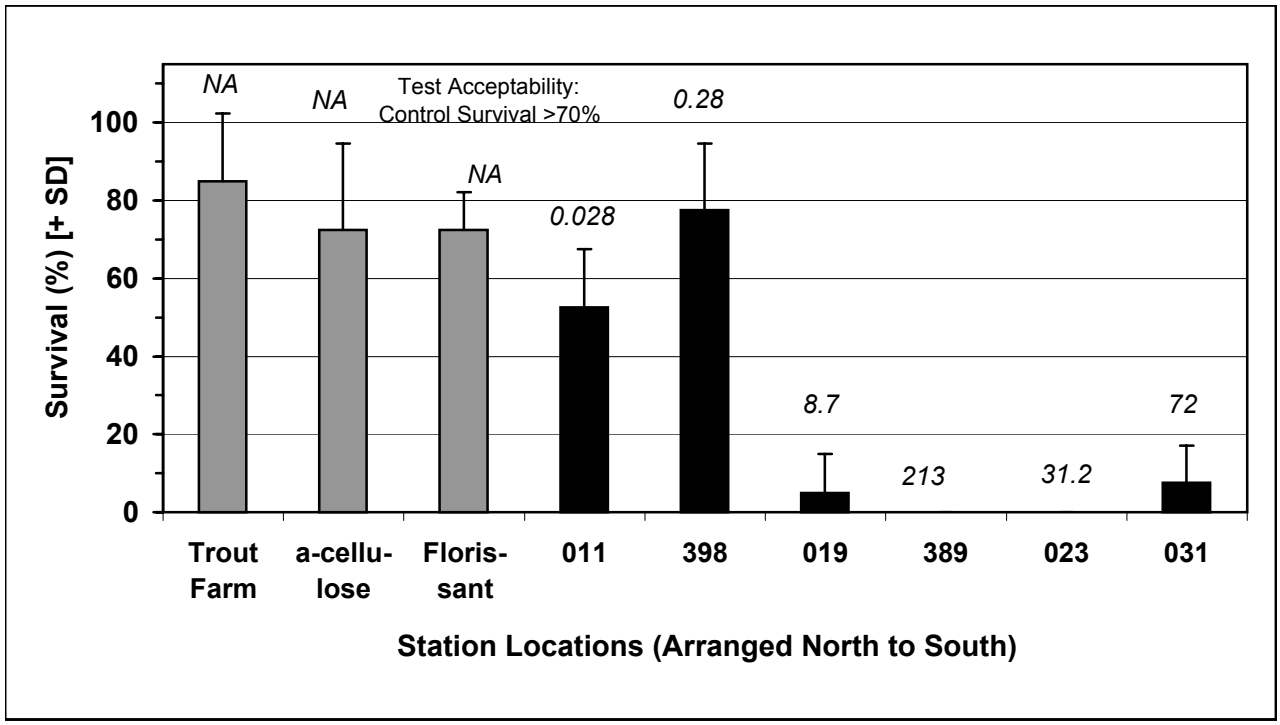


Figure 7: Dry weights for *Chironomus tentans* in chronic laboratory toxicity test (20-day). Value shown in *italics* represents total PCB concentration in mg/kg.

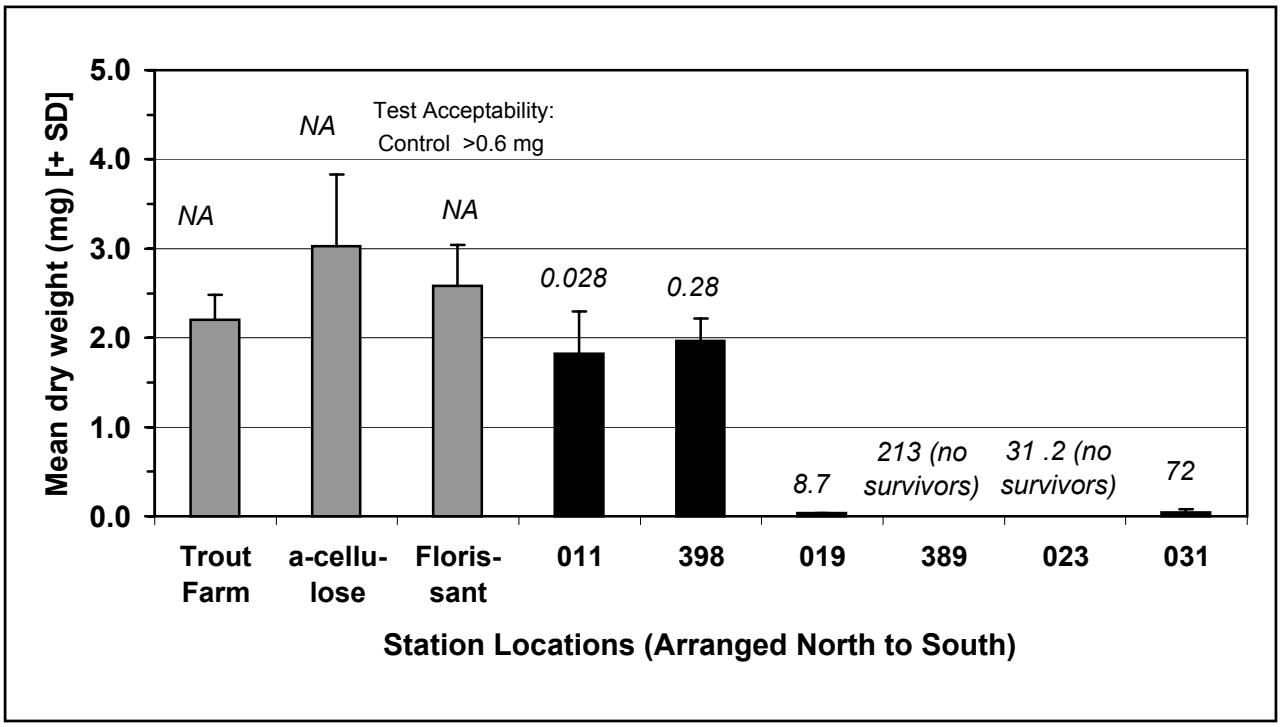


Figure 8: Ash-free dry weights for *Chironomus tentans* in chronic laboratory toxicity test (20-day). Value shown in *italics* represents total PCB concentration in mg/kg.

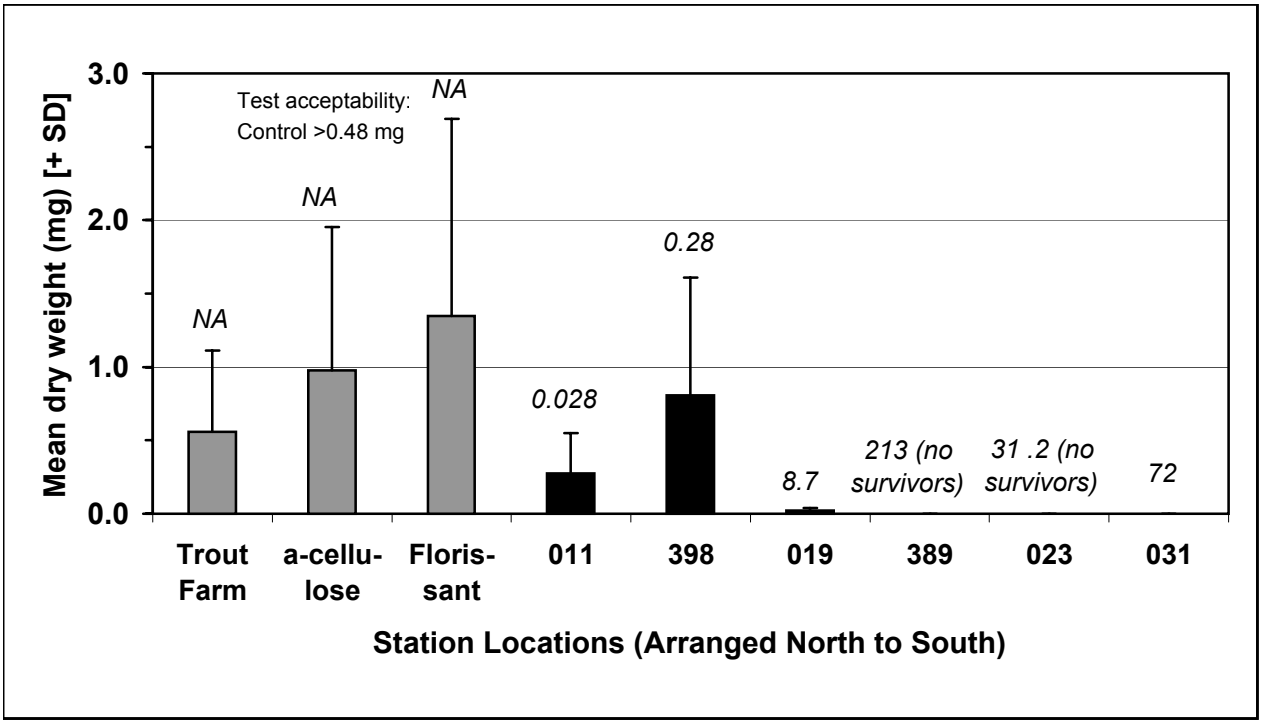


Figure 9: Emergence of *Chironomus tentans* in chronic laboratory toxicity test (20-day). Value shown in *italics* represents total PCB concentration in mg/kg.

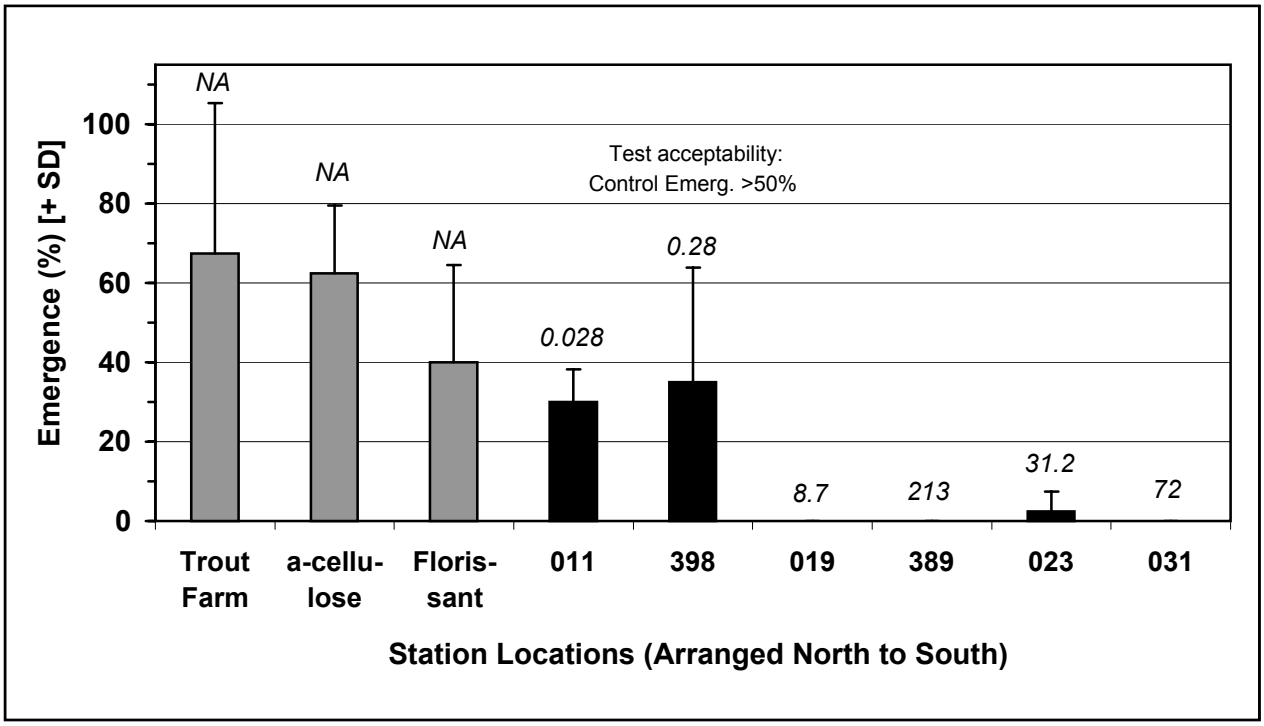


Figure 10: Survival of *Hyalella azteca* in 48-h low flow *in situ* toxicity tests conducted 14-16 June 1999. Value shown in *italics* represents total PCB concentration in mg/kg.

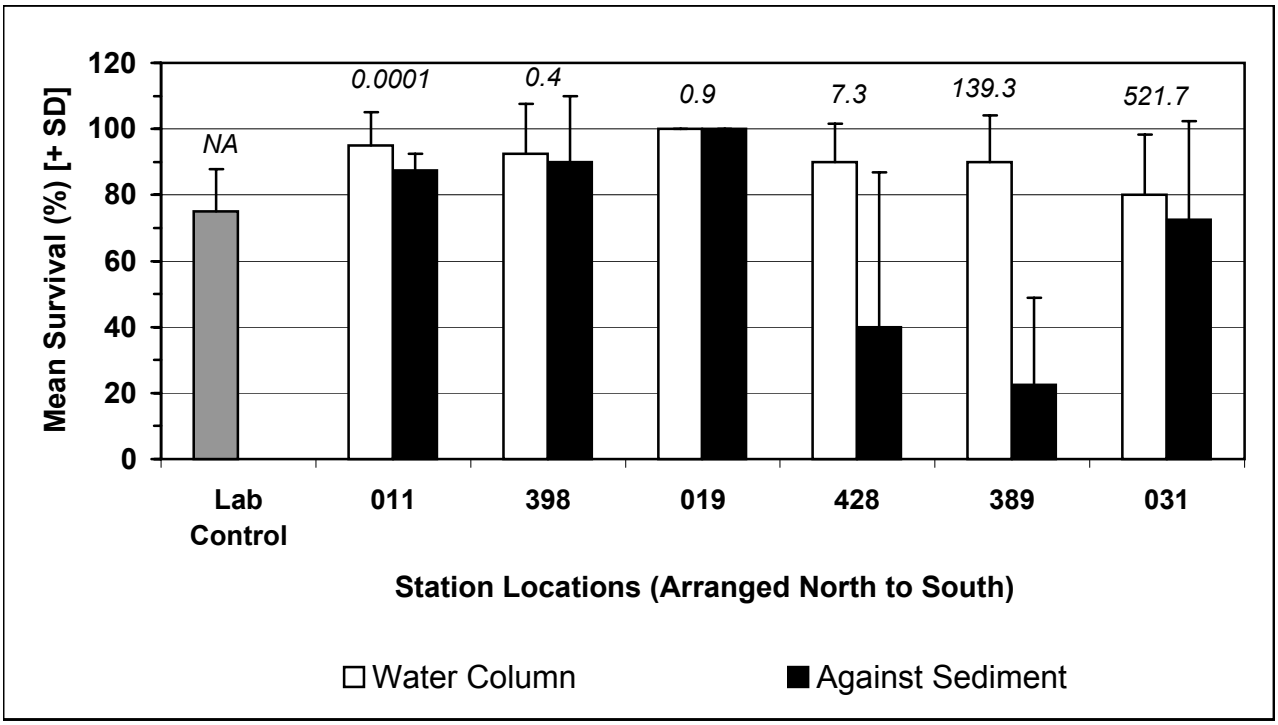


Figure 11: Survival of *Daphnia magna* in 48-h low flow *in situ* toxicity tests conducted 14-16 June 1999. Value shown in *italics* represents total PCB concentration in mg/kg.

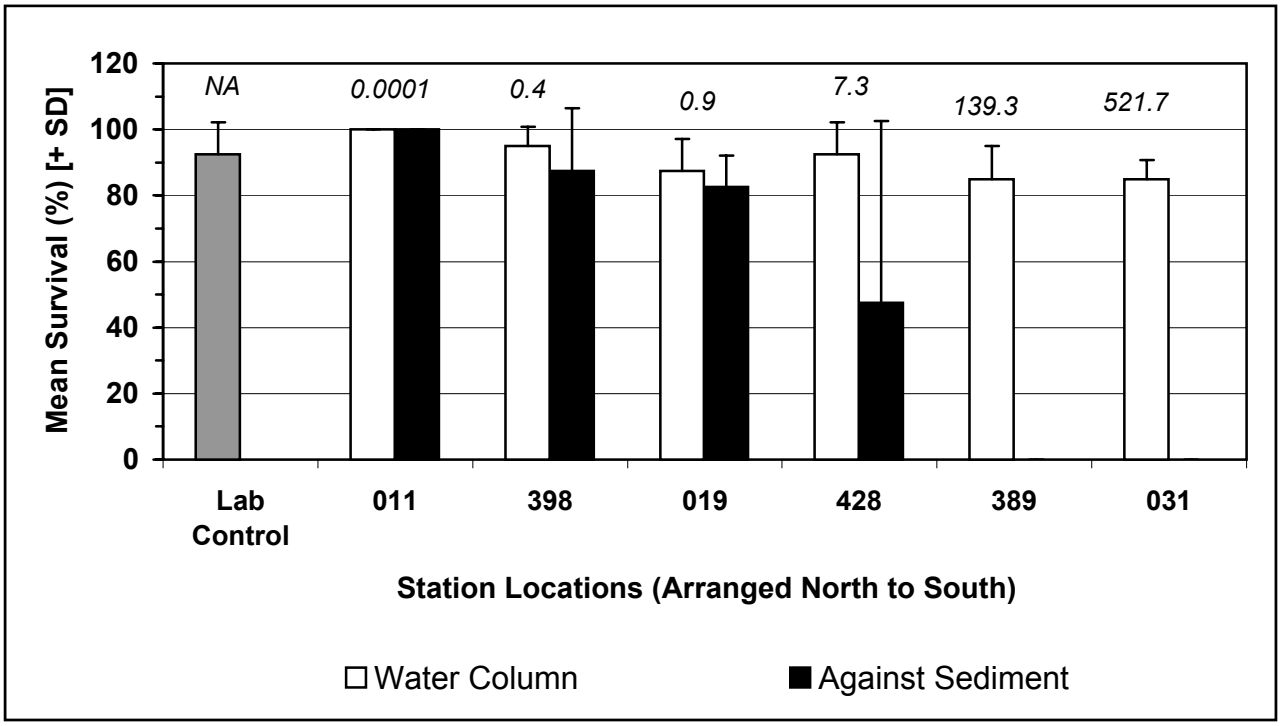


Figure 12: Survival of *Lumbriculus variegatus* in 48-h low flow *in situ* toxicity tests conducted 14-16 June 1999. Value shown in *italics* represents total PCB concentration in mg/kg.

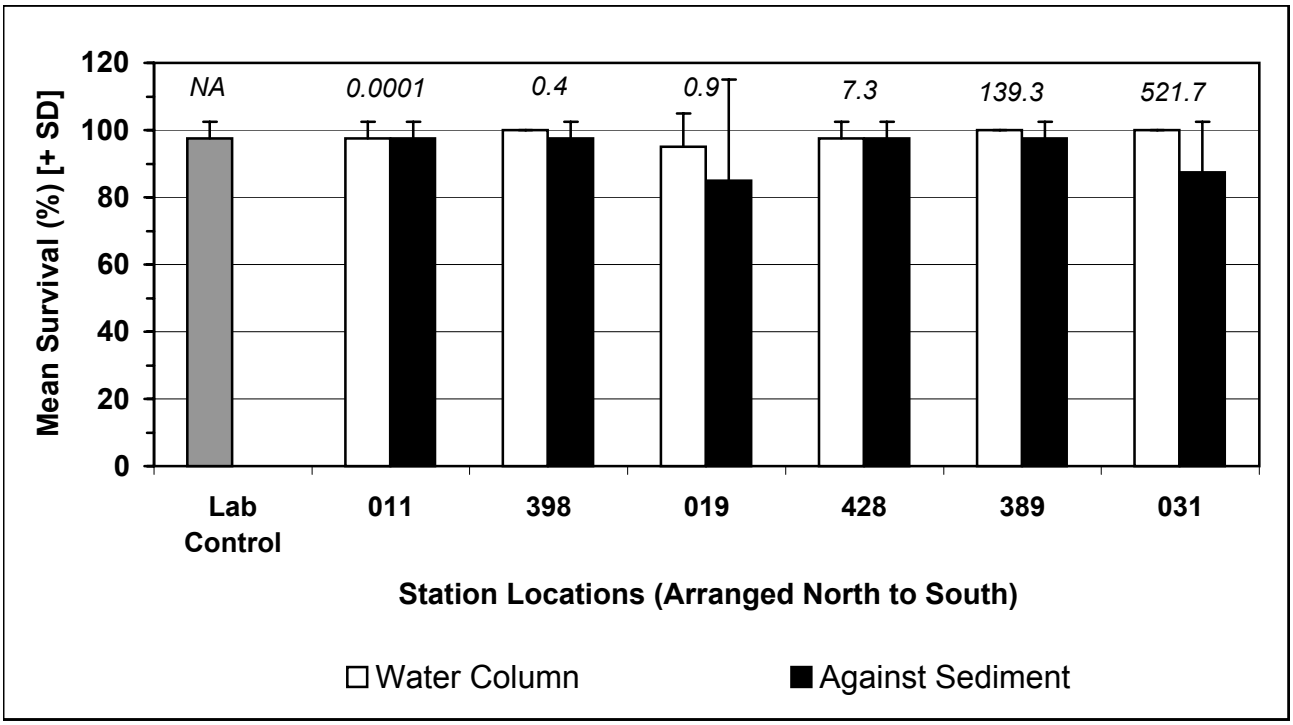


Figure 13: Survival of *Chironomus tentans* in 48-h low flow *in situ* toxicity tests conducted 14-16 June 1999. Value shown in *italics* represents total PCB concentration in mg/kg.

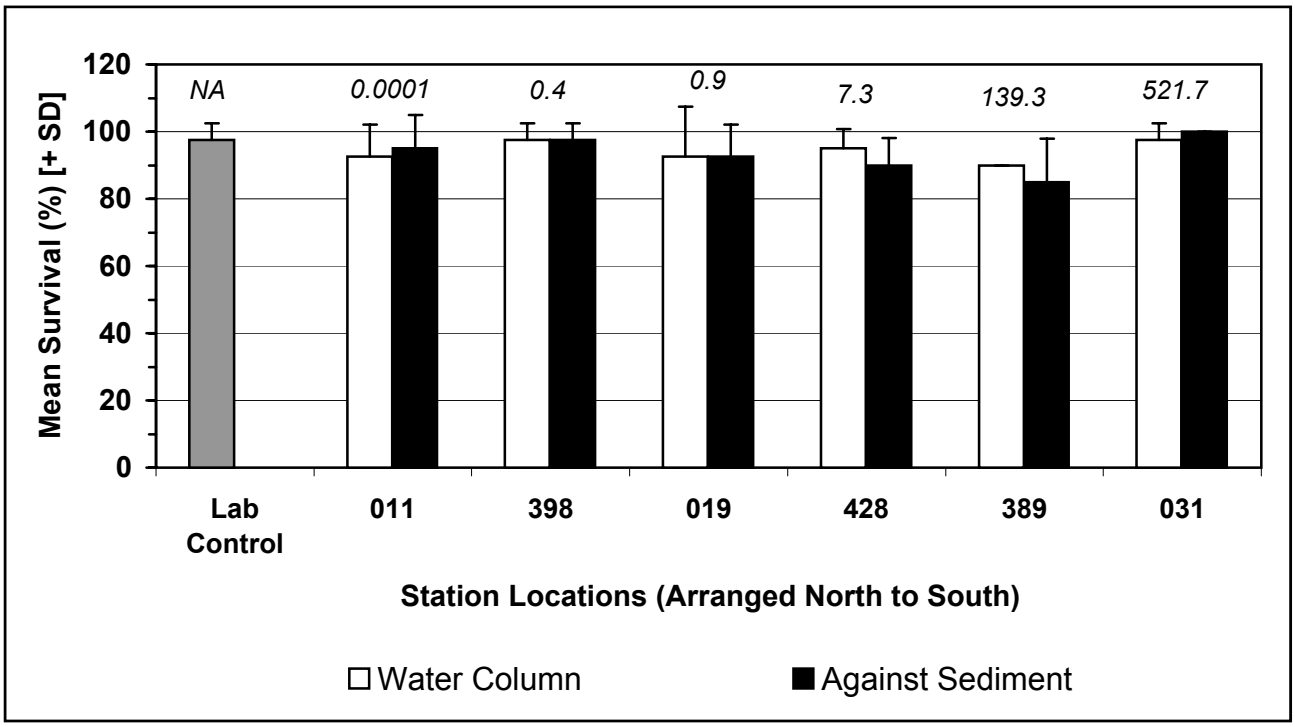


Figure 14: *Daphnia magna* survival versus total sediment PCB concentrations in 48-hour low flow *in situ* (sediment) exposures.

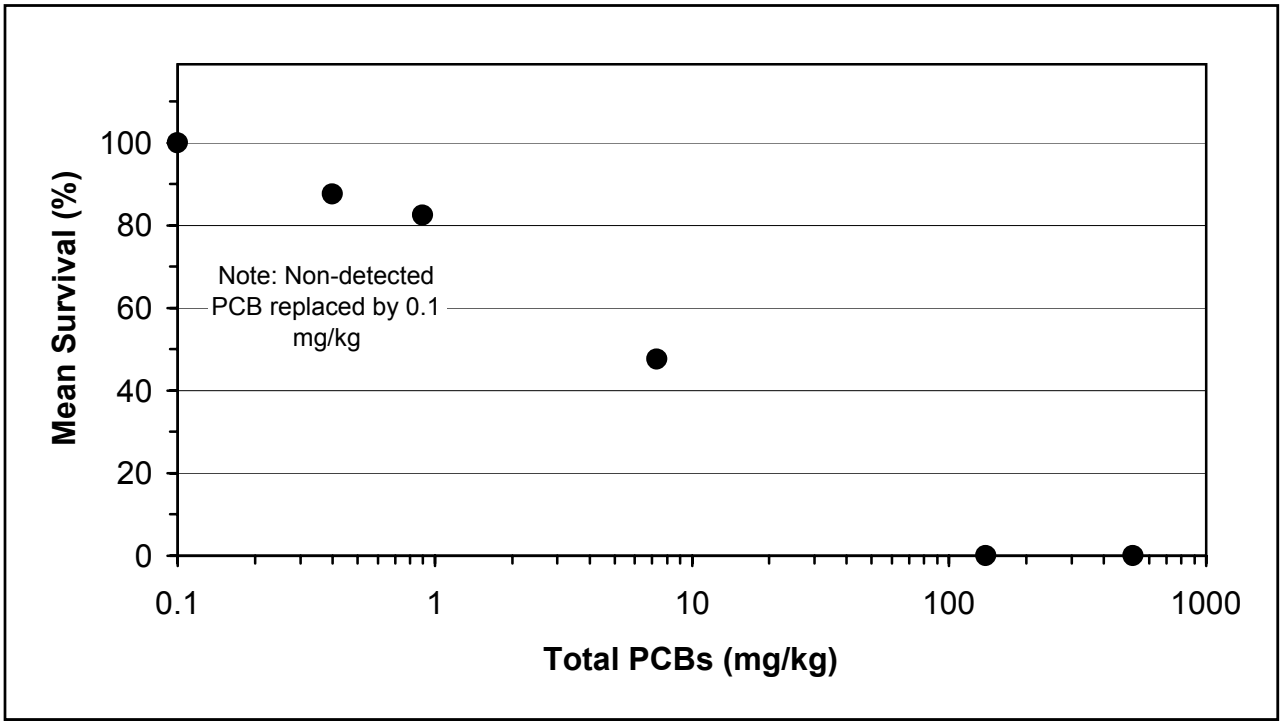


Figure 15: Survival of *Hyalella azteca* in 10-d low flow *in situ* toxicity tests conducted 17-27 June 1999. Value shown in *italics* represents total PCB concentration in mg/kg.

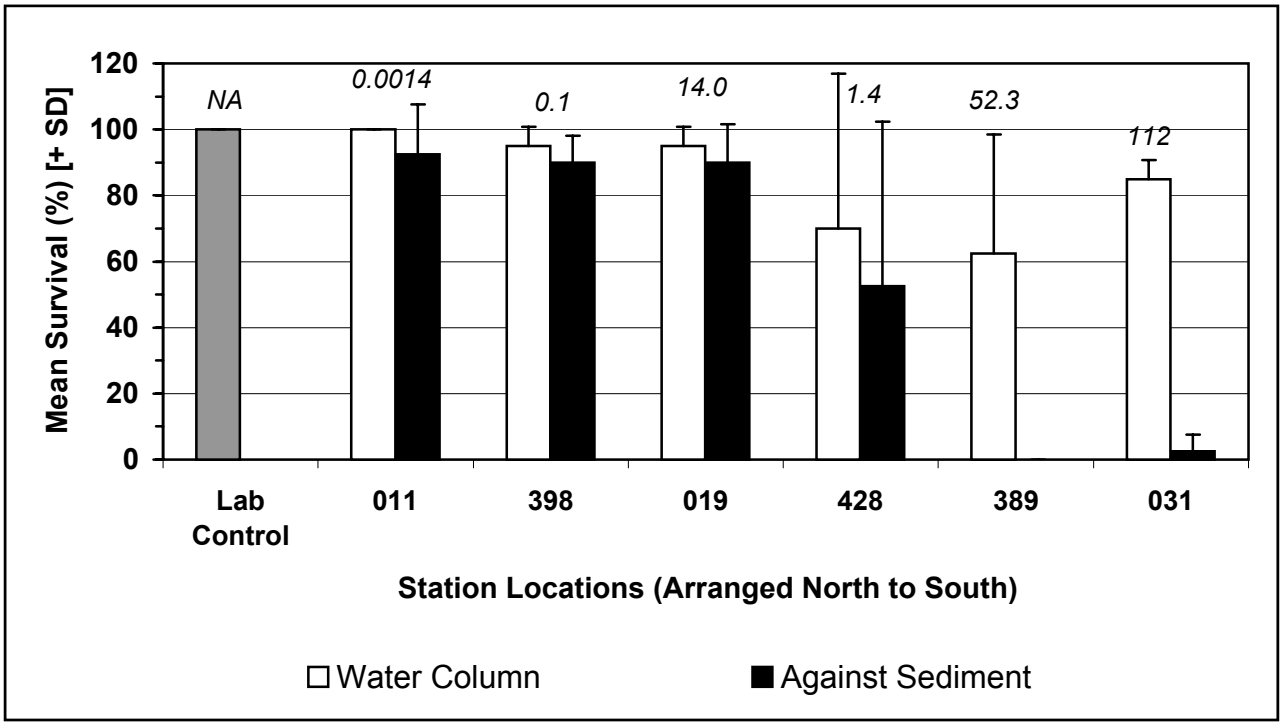


Figure 16: Survival of *Chironomus tentans* in 10-d low flow *in situ* toxicity tests conducted 17-27 June 1999. Value shown in *italics* represents total PCB concentration in mg/kg.

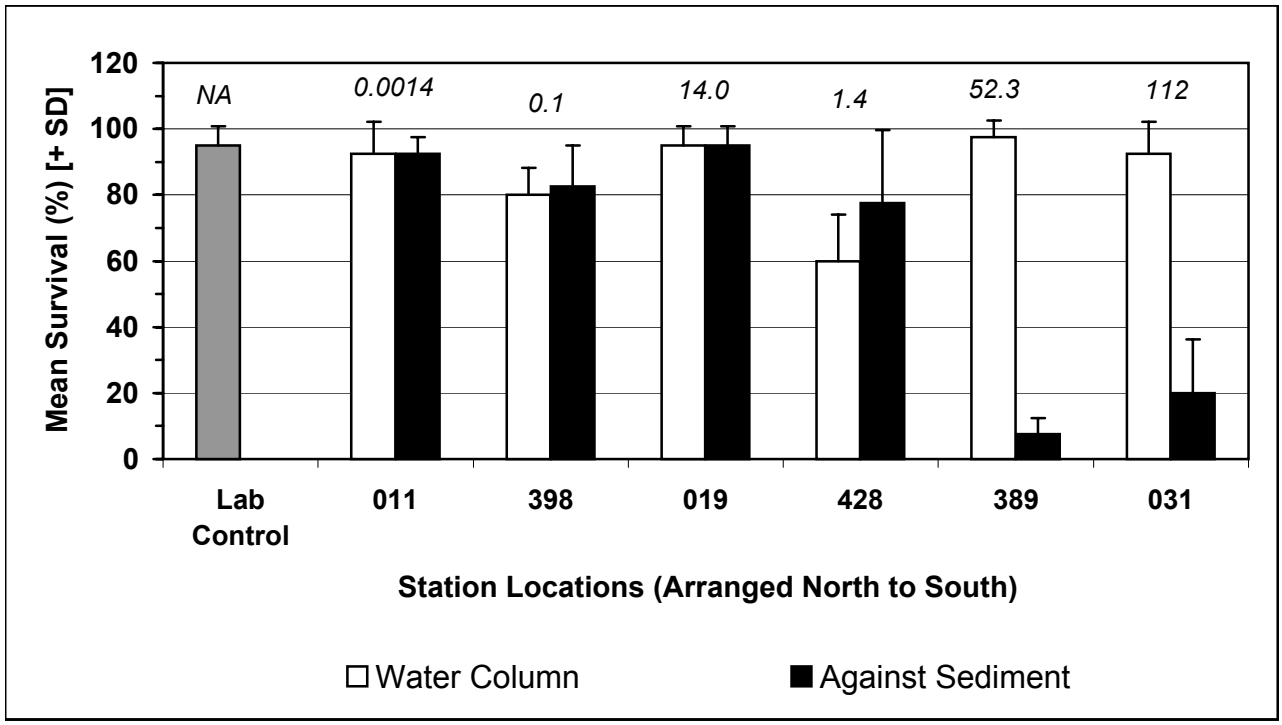


Figure 17: *Hyalella azteca* survival versus total sediment PCB concentrations in 10-day low flow *in situ* (sediment) exposures.

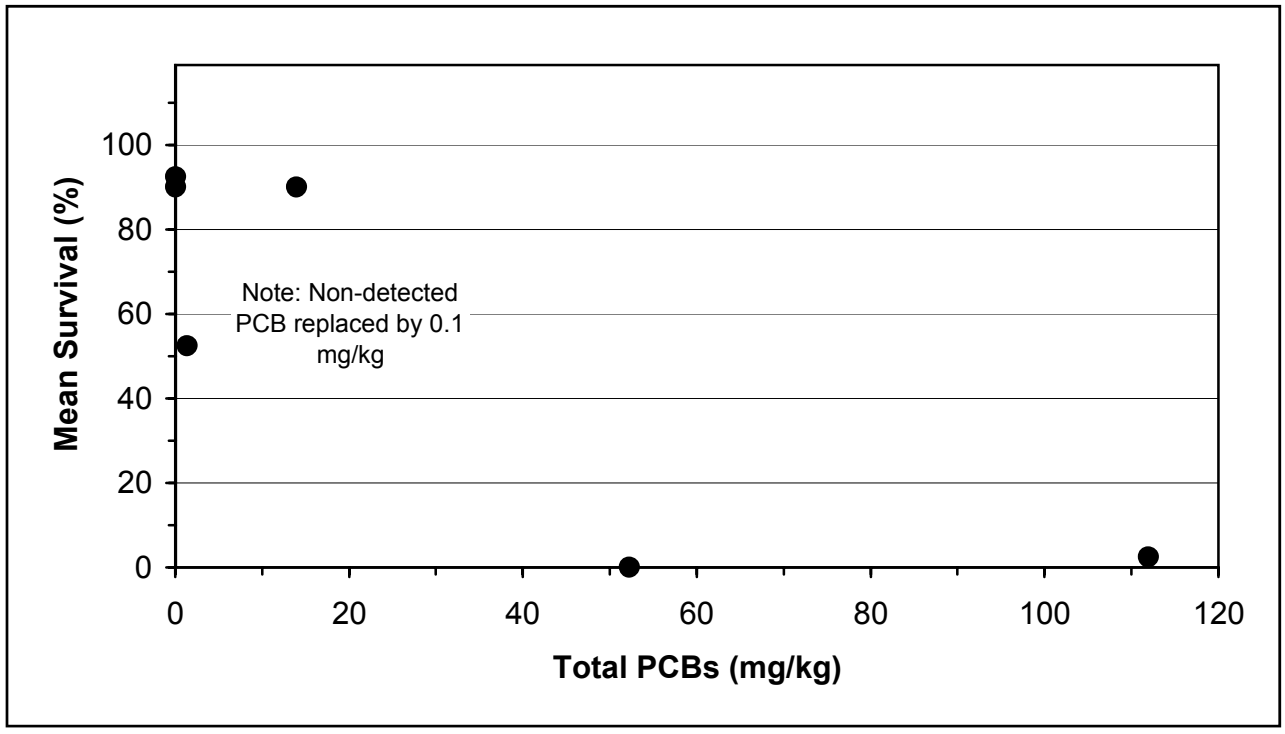


Figure 18: *Chironomus tentans* survival versus total sediment PCB concentrations in 10-day low flow *in situ* (sediment) exposures.

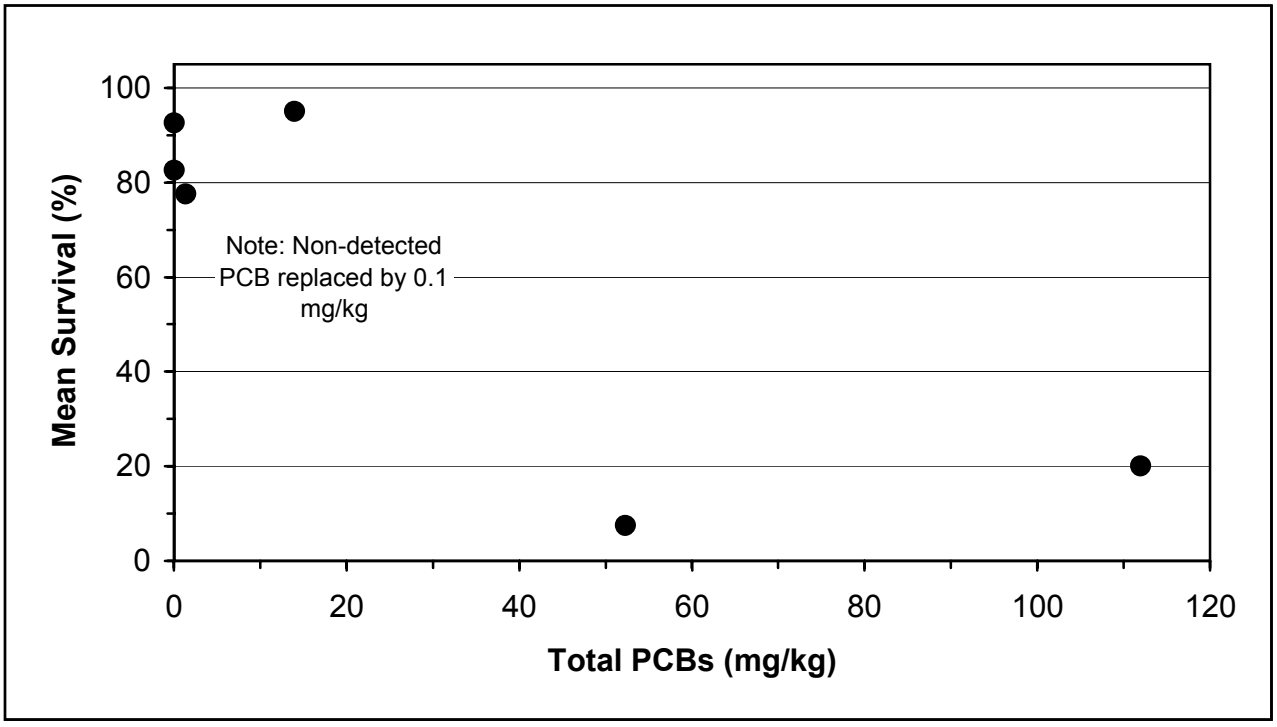


Figure 19: *Hyalella azteca* survival versus total water column PCB concentrations in 10-day low flow *in situ* (water only) exposures.

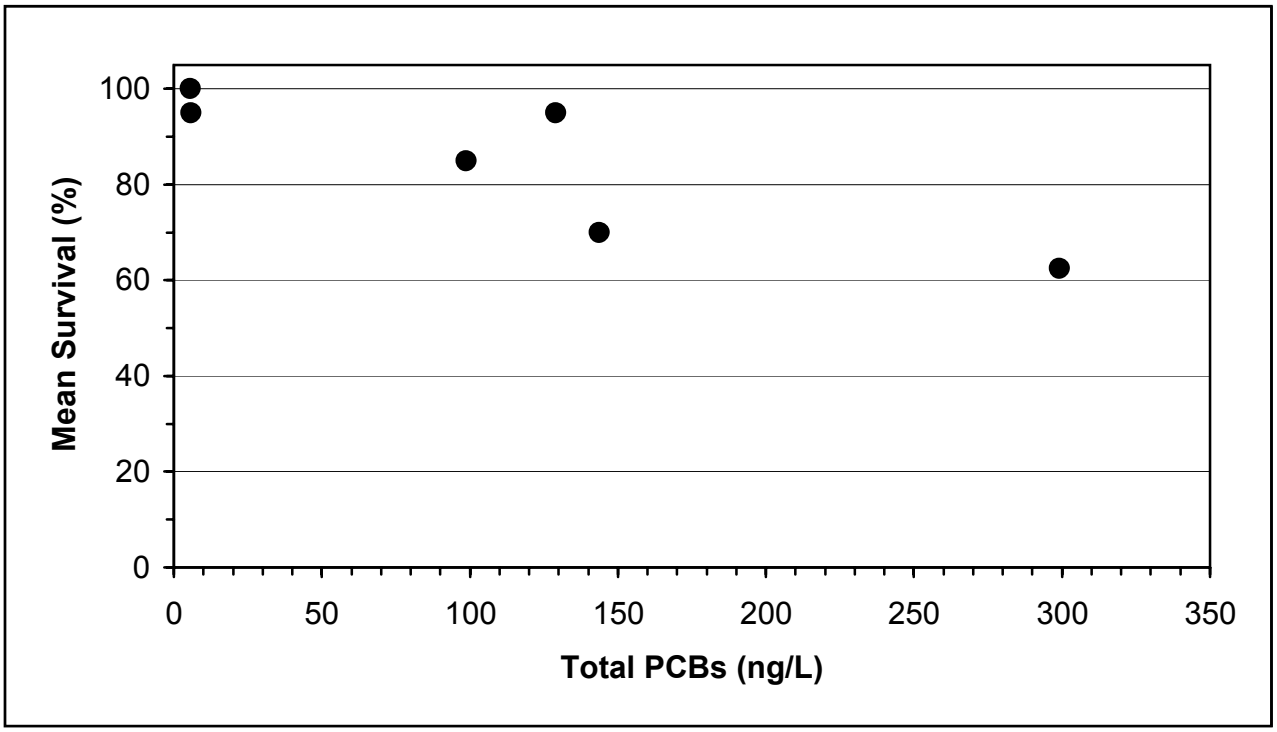


Figure 20: *Lumbriculus variegatus* PCB tissue burdens versus total sediment PCB concentrations in the 7-day *in situ* bioaccumulation test.

[Note: Stations 398 and 389 not shown due to non-detected OC in sediment sample]

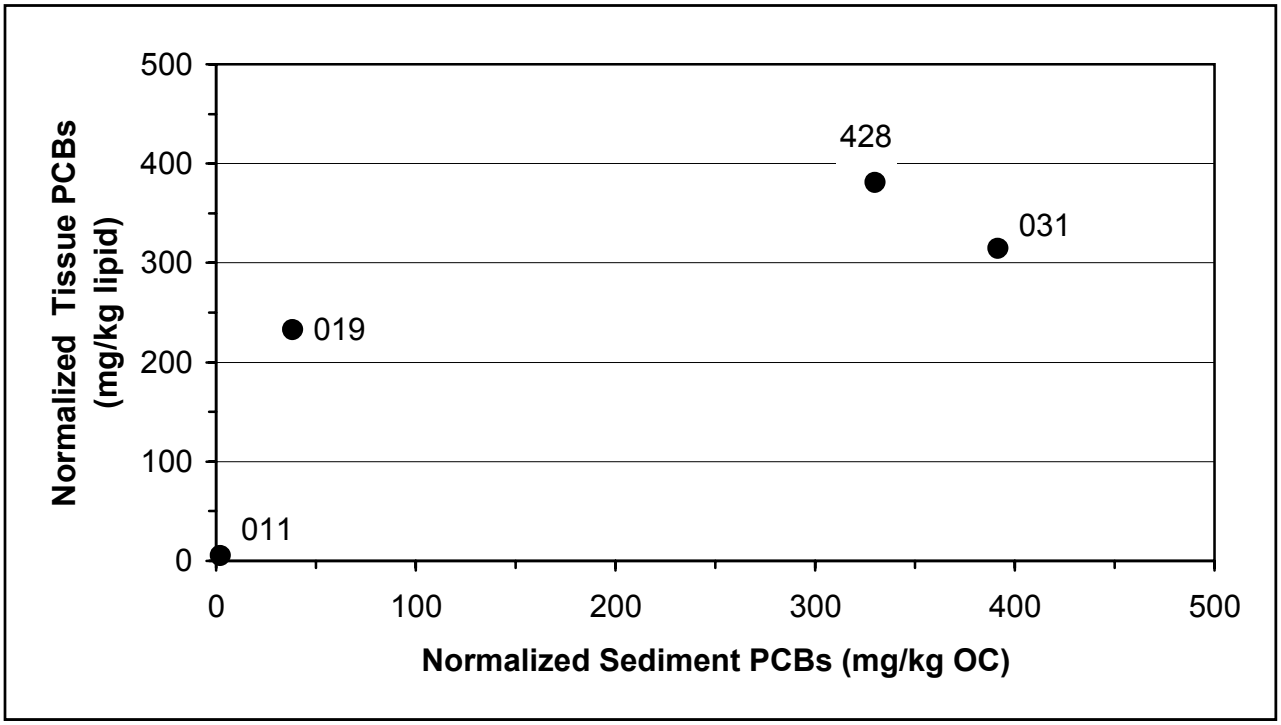
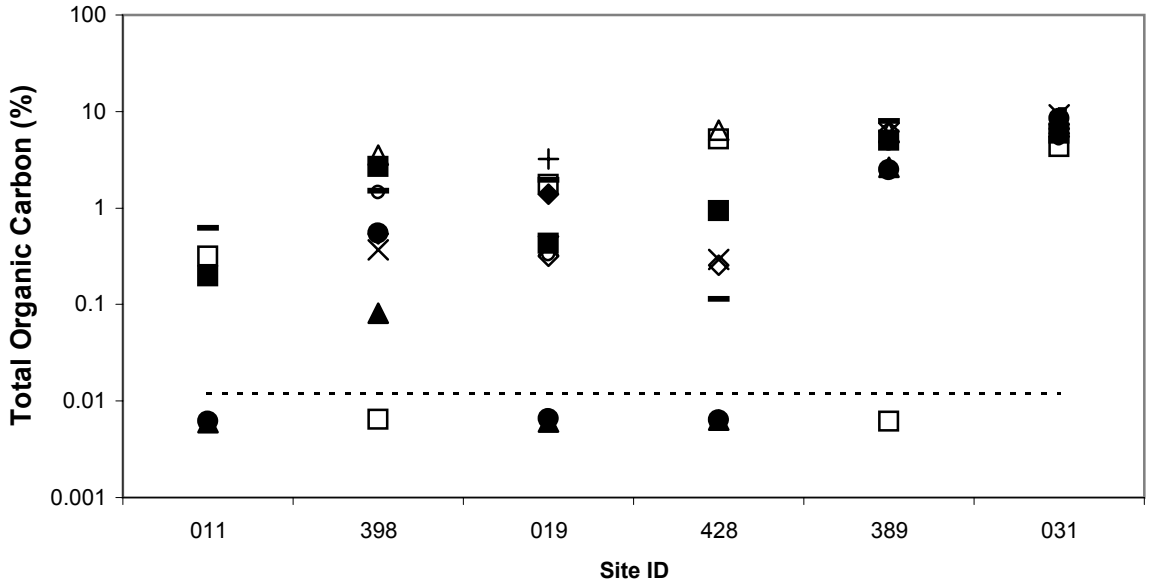


Figure 21: Sediment TOC measurements from all studies conducted on sediment samples from the *in situ* testing sites. Concentrations in % dry weight.



- 48-h in situ WSU toxicity (June 1999)
- 7-day in situ WSU toxicity (June 1999)
- 10-day in situ WSU toxicity (June 1999)
- Laboratory Toxicity - WSU (May 1999)
- Benthic Macroinvertebrate (Median of 12; June 1999)
- Porewater TIE (AD) - WSU (Sept. 1999)
- Porewater TIE (AW) - WSU (Sept. 1999)
- Mussel Study (May 1999)
- Mussel Study (July 1999)
- Discrete River Sampling (October 1999)
- Pre-Toxicity Screening (March-May 1999)
- Tree Swallow Study (March 1999)
- TOC Detection Limit

Table 1: Test conditions for conducting a 42-d sediment toxicity test with *Hyalella azteca*.

Parameter	Conditions
Test type	Whole-sediment toxicity test with renewal of overlying water
Temperature	23 ± 1ºC
Light quality	Wide-spectrum fluorescent lights
Illuminance	500-1000 lux
Photoperiod	16 h light: 8 h dark
Test chamber	300 mL high-form lipless beaker
Sediment volume	100 mL
Overlying water volume	175 mL in sediment exposure from Day 0-28 (175-275 mL in the water-only exposure from Day 28-42)
Renewal of overlying water	2 volume additions per 24 hours; continuous or intermittent (e.g., one volume addition every 12 hours)
Age of organism	7-8 days old at the start of the test
Number of organisms	10 per replicate
Number of replicate chambers/treatment	12 (4 for 28-d survival and growth and 8 for 35-d and 42-d survival, growth and reproduction). Reproduction is more variable than growth or survival; hence, more replicates might be needed to establish statistical differences among treatments
Feeding	1.0 mL YCT (1800 mg/L stock) daily to each test beaker
Aeration	None, unless dissolved oxygen in overlying water drops below 2.5 mg/L
Overlying water	Culture water, well water, surface water or site water (use of reconstituted water is not recommended)
Test chamber cleaning	If screens clog during test, gently brush from outside beaker
Overlying water quality	Initial and final hardness, alkalinity, conductivity and total ammonia (at Day 0 and 28). Daily temperature and weekly conductivity. DO and pH 3 times/week (DO should be measured more often if it drops 1 mg/L below last measurement)
Test duration	42 days
Endpoints	28-d survival and growth; 35-d survival and reproduction, and 42-d survival, growth and reproduction
Test acceptability	Minimum mean control survival of 80% on Day 28. At Day 28 the minimum control mean dry weight must be at least 0.15 mg.

Table 2: General activity schedule for conducting a 42-d sediment toxicity test with *Hyalella azteca* .

Day	Activity
Pre-Test	
-8	Separate known-age amphipods from the cultures and place in holding chambers. Begin preparing food for the test. The <24-h amphipods are fed 10 mL of YCT (1800 mg/L stock solution) and 10 mL of *Selanastrum capricornutum* (about 3.0 x 10E7 cells/mL) on the first day of isolation and 5 mL of both YCT and *S. capricornutum* on the 3rd and 5th d after isolation.
-7	Remove adults and isolate <24-h-old amphipods (if procedures outlined in Section 10.3.4 of EPA [2000] are followed).
-6 to -2	Feed and observe isolated amphipods, monitor water quality (e.g., temperature and dissolved oxygen).
-1	Feed and observe isolated amphipods, monitor water quality. Add sediment into each test chamber, place chambers into exposure system, and start renewing overlying water.
Sediment Test	
0	Measure total water quality (pH, temperature, dissolved oxygen, hardness, alkalinity, conductivity, ammonia). Transfer ten 7- to 8-d-old amphipods into each test chamber. Release organisms under the surface of the water. Add 1.0 mL of YCT (1800 mg/L stock) into each test chamber. Archive 20 organisms for length determination or archive 80 test organisms for dry weight determination. Observe behavior of test organisms.
1 to 27	Add 1.0 mL of YCT to each test beaker. Measure temperature daily, conductivity weekly, and dissolved oxygen (DO) and pH three times per week. Observe behavior of test organisms.
28	Measure temperature, dissolved oxygen, pH, hardness, alkalinity, conductivity, and ammonia. End the sediment-exposure portion of the test by collecting the amphipods with a #40 mesh sieve (425-micron mesh; U.S. standard sieve size). Use four replicates for growth measurements: count survivors and preserve organisms in sugar formalin for growth measurements. Use eight replicates for reproduction measurements: place survivors in individual replicate water-only beakers and add 1.0 mL of YCT to each test beaker/d and 2 volume additions/d of overlying water.
Reproduction Phase	
29 to 35	Feed daily (1.0 mL of YCT). Measure temperature daily, conductivity weekly, and DO and pH three times a week. Measure hardness and alkalinity weekly. Observe behavior of test organisms.
35	Record the number of surviving adults and remove offspring. Return adults to their original individual beakers and add food.
36 to 41	Feed daily (1.0 mL of YCT). Measure temperature daily, conductivity weekly, and DO and pH three times a week. Measure hardness and alkalinity weekly. Observe behavior of test organisms.
41	Measure total water quality (pH, temperature, dissolved oxygen, hardness, alkalinity, conductivity, ammonia).
42	Record the number of surviving adults and offspring. Surviving adult amphipods on Day 42 are preserved in sugar formalin solution. The number of adult males in each beaker is determined from this archived sample. This information is used to calculate the number of young produced per female per replicate from Day 28 to Day 42.

Table 3: Test conditions for conducting a long-term sediment toxicity test with *Chironomus tentans*.

Parameter	Conditions
Test type	Whole-sediment toxicity test with renewal of overlying water
Temperature	23 ± 1ºC
Light quality	Wide-spectrum fluorescent lights
Illuminance	500-1000 lux
Photoperiod	16 h light: 8 h dark
Test chamber	300-mL high-form lipless beaker
Sediment volume	100 mL
Overlying water volume	175 mL
Renewal of overlying water	2 volume additions/d; continuous or intermittent (*e.g.,* one volume addition every/12h)
Age of organism	<24-h-old larvae
Number of organisms	10 per replicate chamber - Note that USEPA (2000) advocates 12
Number of replicate chambers/treatment	8 used in this study - Note that USEPA (2000) advocates 16 (12 at Day -1 and 4 for auxillary males on Day 10)
Feeding	1.5 ml (initially 1.0 ml) Tetrafin® fish food (6.0 mg dry solid) daily per test beaker
Aeration	None, unless dissolved oxygen in overlying water drops below 2.5 mg/L
Overlying water	Culture water, well water, surface water or site water (use of reconstituted water is not recommended)
Test chamber cleaning	If screens clog during test, gently brush from *outside* beaker
Overlying water quality	Initial and final hardness, alkalinity, conductivity and total ammonia (at Day 0 and Day 20). Daily temperature and weekly conductivity. DO and pH 3 times/week (DO should be measured more often if it drops 1 mg/L below last measurement)
Test duration	About 40 - 50 days. Each treatment is ended separately when no additional emergence has been recorded for seven consecutive days. When no emergence is recorded from a treatment, termination of that treatment should be based on the control sediment using this 7-d criterion
Endpoints	20-d survival and growth; female and male emergence, and adult mortality
Test acceptability	Minimum average size of *C. tentans* in the control sediment at 20 d must be at least 0.6 mg/surviving organism as dry weight or 0.48 mg/surviving organism as ash-free dry weight. Emergence should be ≥50%. Time to death after emergence is < 6.5 d for males and < 5.1 d for females.

Table 4: General activity schedule for conducting a long-term sediment toxicity test with *Chironomus tentans* .

Day	Activity
-4	Start reproduction flask with cultured adults (1:3 male:female ratio). For example for 15 to 25 egg cases, 10 males and 30 females are typically collected. Egg cases typically range from 600 to 1500 egg/case.
-3	Collect egg cases (a minimum of 6 to 8) and incubate at 23 ºC.
-2	Check egg cases for viability and development.
-1	1. Check egg cases for hatch and development. 2. Add 100 mL of homogenized test sediment to each replicate beaker and place in corresponding treatment holding tank. After sediment has settled for at least 1 h, add 1.5 mL Tetrafin slurry (4g/L solution) to each beaker. Overlying water renewal begins at this time.
0	1. Transfer all egg cases to a crystallizing dish containing control water. Discard larvae that have already left the egg cases in the incubation dishes. Add 1.5 mL food to each test beaker with sediment before the larvae are added. Add 10 larvae to each replicate beaker (beakers are chosen by random block assignment). Let beakers sit (outside the test system) for 1 h following addition of the larvae. After this period, gently immerse all beakers into their respective treatment holding tanks. 2. Measure temperature, pH, hardness, alkalinity, dissolved oxygen, conductivity and ammonia at start of test.
1-End	On a daily basis, add 1.5 mL food to each beaker. Measure temperature daily. Measure the pH and dissolved oxygen three times a week during the test. If the DO has declined more than 1 mg/L since previous reading, increase frequency of DO measurements and aerate if DO continues to be less than 2.5 mg/L. Measure hardness, alkalinity, conductivity, ammonia weekly.
6	For auxiliary male production, start reproduction flask with culture adults (e.g., 10 males and 30 females; 1:3 male to female ratio).
7-10	Set up schedule for auxiliary male beakers (4 replicates/treatment) same as that described above for Day - 3 to Day 0.
19	In preparation for weight determinations, ash weigh-pans at 550 ºC for 2 h. Note that the weigh boats should be ashed before use to eliminate weighing errors due to the pan oxidizing during ashing of samples.
20	Randomly select four replicates from each treatment and sieve the sediment to recover larvae for growth and survival determinations. Pool all living larvae per replicate and dry the sample to a constant weight (e.g., 60 °C for 24 h). Install emergence traps on each of the remaining reproductive replicate beakers. Measure temperature, pH, hardness, alkalinity, dissolved oxygen, conductivity, and ammonia.
21	The sample with dried larvae is brought to room temperature in a dessicator and weighed to the nearest 0.01 mg. The dried larvae in the pan are then ashed at 550ºC for 2 h. The pan with the ashed larvae is then reweighed and the tissue mass of the larvae determined as the difference between the weight of the dried larvae plus pan and the weight of the ashed larvae plus pan.
23-End	Record daily emergence of males and females, pupal, and adult mortality, and time to death for previously collected adults.
33-End	Transfer males emerging from the auxiliary male replicates to individual inverted petri dishes. The auxiliary males are used for mating with females from corresponding treatments from which most of the males had already emerged or in which no males emerged.
40-End	After 7 d of no recorded emergence in a given treatment, end the treatment by sieving the sediment to recover larvae, pupae, or pupal exuviae. When no emergence occurs in a test treatment, that treatment can be ended once emergence in the control sediment has ended using the 7-d criterion.

Table 5: Toxicity Identification Evaluation (TIE) tests and controls

Day	TIE Test	Control	Blank
September (Day 1)	Initial Toxicity	DMW	DMW
September 16 (Day 2)	Baseline	DMW	DMW
	Sodium Thiosulfate	Baseline & DMW + Sodium Thiosulfate	DMW
	pH/Aeration	Baseline	DMW
	pH/Filtration	Baseline	DMW
September 17 (Day 3)	Baseline	DMW	DMW
	EDTA	Baseline & DMW + EDTA	DMW
	pH/C_{18} SPE	DMW + pH adjust	DMW

DMW = dilute mineral water

Table 6: Sediment chemical measurements for laboratory life-cycle assessments: Total PCBs, % TOC and normalized PCB levels for each test site.

		Total PCB Levels (n=1)		
WSU Site No.	**River Mile**	**mg/Kg**	**TOC (%)**	**mg/Kg OC**
011	N/A	0.028	<0.012	NC[a]
398	N/A	0.28	1.46	19.2
019	132.34	8.7	0.33	2636.4
389	126.38	213.0	4.66	4570.8
023[b]	Upstream of 125.65	31.2	5.58	559.1
031	125.65	72.0	5.24	1374.0

[a] NC = not calculated.
[b] Site 023 was used for the laboratory exposures and Site 428 was used for *in situ* exposures.

Table 7: Summary of water quality parameters measured in laboratory and *in situ* sediment bioassays.

Test Type	Temperature (°C)	pH	Conductivity (μmhos)	DO (mg/L)	Alkalinity (mg/L)	Total NH_3 (mg/L)	Hardness (mg/L)
42-d *Hyalella azteca* (lab exposure)[1]	23 (20.3 – 26.0)	8.2 (8.0 – 8.4)	322 (250 – 400)	7.5 (4.7 – 10.4)	133 (92 – 176)	0.4 (0 – 2.3)	179 (139 – 228)
42-d *Chironomus tentans* (lab exposure)[1]	23 (20 – 25.6)	8.1 (7.5 – 8.3)	329 (280 – 400)	7.4 (2.1 – 9.5)	126 (100 – 176)	0.4 (0 – 5.2)	174 (148 – 234)
48-h *in situ* tests[2]	21.2 (14.7 – 24.0)	7.7 (7.1 – 8.4)	328 (217 – 409)	7.8 (6.4 – 9.1)	125 (96 – 144)	0.7 (0.4 – 1.1)	140 (112 – 165)
7-d and 10-d *in situ* tests[3]	22.7 (16.4 – 28.3)	7.6 (7.2 – 8.4)	317 (168 – 469)	7.4 (5.3 – 10.3)	136 (92 – 168)	0.3 (0.1 – 0.7)	148 (112 – 169)

1. Temperature and DO were monitored daily; other water quality parameters were monitored weekly.
2. One set of water quality measurements was made at the start and end of the 48-h *in situ* tests with *Daphnia magna*, *Hyalella azteca*, *Chironomus tentans*, and *Lumbriculus variegatus* (i.e., separate measurements were not made for each species).
3. One set of water quality measurements was made on Days 0, 7 and 10 for the 7-d *Lumbriculus* test and the 10-d *Hyalella* and *Chironomus* tests (i.e., separate measurements were not made for each species).

Table 8: *Hyalella azteca* 28-d survival following exposure to six Housatonic River sediments and one control sediment (27 May - 24 June 1999).

		28d Survival (%)		
Treatment	**Replicate**	**Per Replicate**	**Mean**	**St Dev**
Trout Farm	4	100	81.8	14.71
(Control)	6	80		
	11	100		
	9	70		
	8	70		
	7	80		
	12	90		
	10	80		
	2	90		
	3	50		
	5	90		
011	9	90	65.8	13.79
	10	80		
	11	60		
	1	70		
	2	60		
	5	60		
	12	70		
	6	50		
	8	70		
	7	40		
	4	80		
	3	60		
398	8	80	83.3	10.73
	3	90		
	10	80		
	1	70		
	5	90		
	7	90		
	9	90		
	2	80		
	11	60		
	4	90		
	12	100		
	6	80		
019	9	70	48.3	16.97
	8	20		
	11	30		
	7	50		
	6	50		
	2	70		
	10	40		
	12	60		
	5	30		
	1	70		
	3	50		
	4	40		

Table 8 (cont'd): *H. azteca* 28-d survival following exposure to six Housatonic River sediments and one control sediment (27 May - 24 June 1999).

		28d Survival (%)		
Treatment	**Replicate**	**Per Replicate**	**Mean**	**St Dev**
389	11	0	0.0	0.00
	12	0		
	9	0		
	10	0		
	2	0		
	3	0		
	5	0		
	1	0		
	4	0		
	8	0		
	7	0		
	6	0		
023	12	20	25.8	14.43
	9	20		
	11	40		
	10	20		
	1	20		
	5	10		
	2	40		
	6	60		
	8	30		
	3	20		
	7	10		
	4	20		
031	2	20	22.5	16.58
	8	30		
	4	0		
	3	10		
	6	50		
	11	20		
	12	50		
	9	10		
	1	10		
	7	40		
	10	10		
	5	20		

Table 9: *Hyalella azteca* 35-d (1 July 1999) and 42-d (8 July 1999) survival and reproduction (total number of young from Day 35-42) following exposure to six Housatonic River sediments and one control sediment. (Site 389 was also tested, but yielded 0% survival following 28 days.)

		35-d Survival (%)			42-d Survival (%)			# Young			Females/	Young/	Mean # Young	
Treatment	**Replicate#**	**Replicate**	**Mean**	**St Dev**	**Replicate**	**Mean**	**St Dev**	**35d**	**42d**	**Total**	**Replicate**	**Female**	**Treatment**	**St Dev**
Trout	2	80	81.3	9.91	60	77.5	13.9	30	26	56	3	18.7	13.4	4.5
Farm	11	100			100			23	27	50	5	10.0		
(Control)	4	80			80			45	20	65	4	16.3		
	12	90			90			22	29	51	4	12.8		
	6	70			60			15	21	36	3	12.0		
	5	80			80			30	42	72	5	14.4		
	7	80			80			33	38	71	4	17.8		
	10	70			70			5	5	10	2	5.0		
011	12	70	68.8	14.6	70	67.5	16.7	21	2	23	5	4.6	7.7	7.5
	1	70			70			2	4	6	3	2.0		
	9	90			90			5	4	9	2	4.5		
	10	80			80			0	2	2	4	0.5		
	3	50			50			18	7	25	2	12.5		
	8	50			40			21	51	72	3	24.0		
	4	80			80			16	11	27	5	5.4		
	5	60			60			13	11	24	3	8.0		
398	10	70	80.0	12.0	70	76.3	14.1	34	9	43	4	10.8	9.0	2.4
	12	80			70			19	16	35	3	11.7		
	6	60			50			9	25	34	3	11.3		
	7	100			100			29	4	33	4	8.3		
	5	80			80			22	20	42	4	10.5		
	9	80			80			11	16	27	5	5.4		
	4	90			80			20	3	23	3	7.7		
	3	80			80			18	7	25	4	6.3		
019	1	70	50.0	18.5	70	50.0	18.5	11	6	17	4	4.3	6.3	3.0
	2	60			60			32	17	49	4	12.3		
	3	20			20			0	0	0	0	-		
	6	50			50			0	10	10	2	5.0		
	7	40			40			8	0	8	1	8.0		
	9	70			70			10	9	19	3	6.3		
	11	30			30			8	0	8	2	4.0		
	12	60			60			4	0	4	1	4.0		
023	9	10	23.8	13.0	10	24.3	14.0	0	0	0	1	0.0	2.7	2.3
	1	10			10			0	0	0	0	-		
	4	20			20			1	0	1	1	1.0		
	6	50			50			8	4	12	4	3.0		
	2	30			30			0	-	0	-	-		
	11	30			30			2	10	12	2	6.0		
	3	20			20			1	6	7	2	3.5		
	10	20			-			0	0	0	0	-		
031	8	30	28.6	16.8	30	27.1	16.0	0	0	0	3	0.0	0.1	0.3
	6	50			50			0	0	0	3	0.0		
	7	40			40			0	2	2	3	0.7		
	11	20			20			0	0	0	2	0.0		
	5	0			0			0	-	0	-	-		
	2	20			20			0	0	0	1	0.0		
	12	40			30			0	0	0	0	-		

Table 10: *Hyalella azteca* dry weights following a 28-d exposure to six Housatonic River sediments and one control sediment (27 May - 24 June 1999). (Site 389 was also tested but yielded 0% survival, and no dry weight data exist for this treatment.)

Treatment	Replicate	Animals Per Pan	Mean *H. azteca* Dry Wt. (mg)		Standard Deviation
			Per Individual	Per Treatment	
Initial	1	8	0.010	0.011	0.00
	2	9	0.013		
	3	10	0.009		
Trout Farm	9	7	0.451	0.562	0.09
	8	5	0.624		
	1	7	0.640		
	3	5	0.532		
011	6	5	0.364	0.472	0.15
	2	6	0.640		
	11	6	0.555		
	7	4	0.330		
398	11	6	0.582	0.568	0.03
	8	7	0.589		
	2	7	0.524		
	1	7	0.577		
019	10	4	0.373	0.495	0.23
	5	3	0.347		
	8	2	0.840		
	4	4	0.420		
023	5,7*	2	0.350	0.333	0.02
	12	2	0.315		
031	1	1	0.600	0.415	0.24
	10	1	0.620		
	9	1	0.310		
	3	1	0.130		

*two replicates combined since each had 1 amphipod and were too small to measure individual weights.

Table 11: *Hyalella azteca* dry weights following a 42-d exposure to six Housatonic River sediments and one control sediment (27 May - 8 July 1999). (Site 389 was also tested but yielded 0% survival, and no dry weight data exist for this treatment.)

Treatment	Replicate	Animals Per Pan	Mean *H. azteca* Dry Wt. (mg)		Standard Deviation
			Per Individual	Per Treatment	
Initial	1	8	0.0100	0.0108	0.00
	2	9	0.0133		
	3	10	0.0090		
Trout Farm	2	4	0.7600	0.5617	0.10
	4	8	0.5362		
	5	8	0.5150		
	6	6	0.6666		
	7	7	0.5528		
	10	6	0.4833		
	11	10	0.4360		
	12	9	0.5433		
011	1	6	0.4350	0.4542	0.05
	3	5	0.5020		
	4	7	0.4371		
	5	6	0.4650		
	8	4	0.5425		
	9	9	0.4444		
	10	7	0.4328		
	12	8	0.3750		
398	3	8	0.4975	0.5310	0.06
	4	8	0.4500		
	5	7	0.4928		
	6	4	0.6150		
	7	10	0.5130		
	9	8	0.5537		
	10	7	0.5228		
	12	6	0.6033		
019	1	6	0.3766	0.5304	0.14
	2	7	0.4885		
	3	2	0.7950		
	6	5	0.4480		
	7	4	0.6050		
	9	7	0.4085		
	11	3	0.6600		
	12	6	0.4616		
023	1	1	0.9100	0.5245	0.20
	2	3	0.3866		
	3	2	0.3750		
	4	2	0.5550		
	6	6	0.3350		
	9	1	0.5100		
	11	3	0.6000		
031	2	2	0.3900	0.3964	0.11
	6	4	0.3425		
	7	4	0.3225		
	8	3	0.2800		
	11	2	0.5600		
	12	3	0.4833		

Table 12: *Chironomus tentans* survival following a 20-d exposure to six Housatonic River sediments and three control sediments (10 - 30 July 1999).

Treatment	Survival (%) Replicate	Mean	Standard Deviation
Trout Farm (Control)	90 100 90 60	85	17.3
α–Cellulose (Control)	50 80 60 100	72.5	22.2
Florissant (Control)	60 80 70 80	72.5	9.6
011	60 40 40 70	52.5	15.0
398	80 70 60 100	77.5	17.1
019	0 0 20 0	5	10.0
389	0 0 0 0	0	-
023	0 0 0 0	0	-
031	20 0 10 0	7.5	9.6

Table 13: *Chironomus tentans* dry weights following a 20-d exposure to six Housatonic River sediments and three control sediments (10 - 30 July 1999). (Sites 023 and 389 were tested but yielded 0% survival, and no dry weight data exist for these treatments.)

Treatment	Replicate	Animals Per Pan	Mean *C.tentans* Dry Wt. (mg)		Standard Deviation
			Per Individual	Per Treatment	
Trout Farm	1	9	2.152	2.201	0.28
(Control)	3	8	1.966		
	6	9	2.082		
	8	6	2.602		
α–Cellulose	2	5	4.228	3.028	0.80
(Control)	3	7	2.704		
	5	6	2.567		
	7	8	2.615		
Florissant	2	7	2.273	2.583	0.46
(Control)	4	7	3.064		
	5	7	2.883		
	8	8	2.114		
011	1	5	1.594	1.823	0.47
	3	4	1.900		
	6	4	2.450		
	8	7	1.349		
398	1	8	2.250	1.966	0.25
	4	8	1.643		
	5	6	2.018		
	7	10	1.954		
019	6	2	0.035	0.035	-
031	1	2	0.070	0.040	0.04
	5	1	0.010		

Table 14: *Chironomus tentans* ash free dry weight (AFDW) following a 20-d exposure to six Housatonic River sediments and three control sediments (10 - 30 July 1999). (Sites 023 and 389 were tested but yielded 0% survival, so no dry weight data exist for these treatments.)

Treatment	Replicate	Animals Per Pan	Mean *C. tentans* Dry Wt. (mg)		Standard Deviation
			Per Individual	Per Treatment	
Trout Farm	8	6	0.640	0.557	0.07
(Control)	6	9	0.563		
	3	8	0.474		
	1	9	0.550		
α–Cellulose	7	8	0.898	0.976	0.31
(Control)	5	6	0.718		
	3	7	0.856		
	2	5	1.432		
Florissant	8	8	1.031	1.345	0.31
(Control)	5	7	1.610		
	4	7	1.613		
	2	7	1.127		
011	6	4	0.340	0.275	0.11
	8	7	0.327		
	3	4	0.317		
	1	5	0.116		
398	7	10	0.848	0.805	0.13
	5	6	0.823		
	4	8	0.628		
	1	8	0.921		
019	6	2	0.020	0.020	-
031	5	1	0.000	0.000	-

Table 15: *Chironomus tentans* emergence following exposure to six Housatonic River sediments and one control sediment (10 July - 16 August 1999). (All emergence took place between 1 - 13 August 1999).

Treatment/Site	Replicate	Number Emerged	Date of Last Emergence	Mean Emergence (%)	Standard Deviation
Trout Farm	1	3	7-Aug	67.5	37.7
(Control)	2	10	8-Aug		
	3	4	7-Aug		
	4	10	9-Aug		
α–Cellulose	1	8	9-Aug	62.5	1.71
(Control)	2	4	7-Aug		
	3	7	6-Aug		
	4	6	7-Aug		
Florissant	1	3	13-Aug	40.0	2.45
(Control)	2	6	9-Aug		
	3	6	11-Aug		
	4	1	13-Aug		
011	1	3	9-Aug	30.0	8.2
	2	2	2-Aug		
	3	3	11-Aug		
	4	4	5-Aug		
398	1	7	11-Aug	35.0	28.9
	2	4	12-Aug		
	3	0	-		
	4	3	8-Aug		
019	1	0	-	0.0	
	2	0	-		
	3	0	-		
	4	0	-		
023	1	0	-	2.5	5.0
	2	0	-		
	3	1	4-Aug		
	4	0	-		
031	1	0	-	0.0	-
	2	0	-		
	3	0	-		
	4	0	-		
389	1	0	-	0.0	-
	2	0	-		
	3	0	-		
	4	0	-		

Table 16: Chemical measurements for *in situ* test sediments (total PCBs, % TOC and normalized PCB levels [where available] for each test site) and overlying water (total PCBs).

		Whole Sediment - Total PCB Levels (n=1)								
		48 h			7 d			10 d		
Wright State ID	**River Mile**	**mg/Kg**	**TOC (%)**	**mg/Kg OC**	**mg/Kg**	**TOC (%)**	**mg/Kg OC**	**mg/Kg**	**TOC (%)**	**mg/Kg OC**
011	N/A	0.0001	<0.012	NC[a]	0.0071	0.32	2.22	0.0014	<0.012	NC
398	N/A	0.4	0.1	378.2	5.4	<0.013	NC	0.1	0.5	16.5
019	132.34	0.9	<0.012	NC	0.7	1.75	38.3	14.0	<0.013	NC
428[b]	130.32	7.3	<0.012	NC	17.0	5.16	329.5	1.4	<0.013	NC
389	126.38	139.3	2.6	5357.7	7.1	<0.012	NC	52.3	2.5	2092.0
031	125.65	521.7	8.3	6285.5	16.9	4.31	392.1	112.0	8.5	1317.6

		Overlying Water (ng/L) - Total PCB Levels (n=1)		
Wright State ID	**River Mile**	**48 h**	**7 d**	**10 d**
011	N/A	5.0	4.6	5.8
398	N/A	3.2	9.3	5.7
019	132.34	92.3	133.7	129.1
428[b]	130.32	118.1	141.0	143.8
389	126.38	293.1	238.8	299.2
031	125.65	199.0	110.3	98.7

[a]NC = Not calculated.

[b]Site 428 was used for *in situ* exposures in place of Site 023 that was used for laboratory tests.

Table 17: Survival for four species following a 48-h *in situ* test at six sites on the Housatonic River (14-16 June 1999).

		H. azteca Survival (%)			*C. tentans* Survival (%)			*L. variegatus* Survival (%)			*D. magna* Survival (%)		
Treatment	**Site**	**Replicate**	**Mean**	**St Dev**	**Replicate**	**Mean**	**St Dev**	**Replicate**	**Mean**	**St Dev**	**Replicate**	**Mean**	**St Dev**
Laboratory Control	-	70	75	12.9	100	97.5	5.0	100	97.5	5.0	100	92.5	9.6
		80			100			90			90		
		60			90			100			100		
		90			100			100			80		
Water Column	011	100	95	10.0	100	92.5	9.6	100	97.5	5.0	100	100	0.0
		100			100			90			100		
		80			90			100			100		
		100			80			100			100		
	398	100	92.5	15.0	100	97.5	5.0	100	100	0.0	90	95	5.8
		100			100			100			100		
		70			90			100			90		
		100			100			100			100		
	019	100	100	0.0	100	92.5	15.0	100	95	10.0	100	87.5	9.6
		100			100			100			90		
		100			100			80			80		
		100			70			100			80		
	428	80	90	11.5	100	95	5.8	100	97.5	5.0	100	92.5	9.6
		100			100			100			100		
		80			90			100			80		
		100			90			90			90		
	389	90	90	14.1	90	90	0.0	100	100	0.0	70	85	10.0
		100			90			100			90		
		70			90			100			90		
		100			90			100			90		
	031	60	80	18.3	90	97.5	5.0	100	100	0.0	90	85	5.8
		90			100			100			80		
		70			100			100			90		
		100			100			100			80		

Table 17 (cont.): Survival for four species following a 48-h *in situ* test at six sites on the Housatonic River (14-16 June 1999).

		H. azteca Survival (%)			*C. tentans* Survival (%)			*L. variegatus* Survival (%)			*D. magna* Survival (%)		
Treatment	**Site**	**Replicate**	**Mean**	**St Dev**	**Replicate**	**Mean**	**St Dev**	**Replicate**	**Mean**	**St Dev**	**Replicate**	**Mean**	**St Dev**
Against Sediment	011	80	87.5	5.0	100	95	10.0	100	97.5	5.00	100	100	0.0
		90			80			100			100		
		90			100			100			100		
		90			100			90			100		
	398	100	90	20.0	100	97.5	5.0	100	97.5	5.00	90	87.5	18.9
		100			90			100			60		
		100			100			90			100		
		60			100			100			100		
	019	100	100	0.0	100	92.5	9.6	100	85	30.00	90	82.5	9.6
		100			80			100			80		
		100			90			40			70		
		100			100			100			90		
	428	70	40	46.9	90	90	8.2	100	97.5	5.00	100	47.5	55.0
		0			80			100			0		
		90			100			100			0		
		0			90			90			90		
	389	60	22.5	26.3	100	85	12.9	100	97.5	5.00	0	0	0.0
		0			90			90			0		
		10			70			100			0		
		20			80			100			0		
	031	100	72.5	29.9	100	100	0.0	70	87.5	15.00	0	0	0.0
		80			100			100			0		
		80			100			100			0		
		30			100			80			0		

Table 18: Survival for two species following a 10-d *in situ* test at six sites on the Housatonic River (17-27 June 1999).

		***H. azteca* Survival (%)**			***C. tentans* Survival (%)**		
Treatment	**Site**	**Replicate**	**Mean**	**St Dev**	**Replicate**	**Mean**	**St Dev**
Laboratory Control	-	100	100	0.0	90	95	5.8
		100			100		
		100			100		
		100			90		
Water Column	011	100	100	0.0	90	92.5	9.6
		100			100		
		100			100		
		100			80		
	398	90	95	5.8	80	80	8.2
		100			80		
		90			90		
		100			70		
	019	90	95	5.8	90	95	5.8
		100			100		
		90			90		
		100			100		
	428	100	70	46.9	70	60	14.1
		0			70		
		90			60		
		90			40		
	389	10	62.5	35.9	100	97.5	5.0
		90			100		
		70			90		
		80			100		
	031	80	85	5.8	100	92.5	9.6
		90			80		
		90			100		
		80			90		

Table 18 (cont.): Survival for two species following a 10-d *in situ* test at six sites on the Housatonic River (17-27 June 1999).

		***H. azteca* Survival (%)**			***C. tentans* Survival (%)**		
Treatment	**Site**	**Replicate**	**Mean**	**St Dev**	**Replicate**	**Mean**	**St Dev**
Against Sediment	011	100	92.5	15.0	90	92.5	5.0
		70			100		
		100			90		
		100			90		
	398	100	90	8.2	80	82.5	12.6
		80			80		
		90			100		
		90			70		
	019	80	90	11.5	90	95	5.8
		100			100		
		100			90		
		80			100		
	428	0	52.5	49.9	50	77.5	22.2
		100			90		
		90			70		
		20			100		
	389	0	0	0.0	0	7.5	5.0
		0			10		
		0			10		
		0			10		
	031	0	2.5	5.0	0	20	16.3
		0			20		
		0			20		
		10			40		

Table 19: Concentrations of individual PCB isomers and congeners measured in sediment, overlying water and tissue samples collected following the 7-d *Lumbriculus variegatus in situ* bioaccumulation exposure.

PCB Isomer / Congener		011	398	019	428	389	031
Sediment PCB Data (mg/Kg dry)							
PCB Region/Isomer							
MonoCB		<0.000044	<0.000078	<0.000049	<0.000082	<0.000045	0.000236
DiCB		<0.000036	0.00664	<0.000041	0.0121	0.00292	0.0108
TriCB		0.0000355	0.0204	0.00135	0.074	0.0138	0.161
TetraCB		0.0000717	0.2	0.0238	0.882	0.178	2.048
PentaCB		0.000727	0.578	0.0734	2.785	0.671	2.074
HexaCB		0.00322	1.968	0.174	6.619	2.946	6.429
HeptaCB		0.00287	2.114	0.33	5.73	2.645	5.023
OctaCB		0.000198	0.45	0.057	0.844	0.578	1.05
NanoCB		<0.000034	0.0537	0.0108	0.0857	0.0554	0.0826
DecaCB		<0.000025	0.000804	0.00241	0.00363	0.000796	0.00253
Region/Isomer Total		**0.0071**	**5.3915**	**0.6728**	**17.0354**	**7.0909**	**16.8812**
PCB Congeners							
2-Chlorobiphenyl	Mono 1	<0.00005	<0.000089	<0.000056	<0.00021	<0.00013	0.00013
3-Chlorobiphenyl	Mono 3	<0.000039	<0.000069	<0.000043	<0.000072	<0.0001	0.000106
2,4'-Dichlorobiphenyl	Di 8	<0.00003	0.00111	<0.000034	0.00149	0.00042	0.000997
4,4'-Dichlorobiphenyl	Di 15	<0.000045	0.00321	<0.000052	0.0072	0.00187	0.00682
2,2',5-Trichlorobiphenyl	Tri 18	<0.000035	0.00147	<0.000055	<0.000043	0.0007	0.0046
2,4,4'-Trichlorobipenyl	Tri 28	0.0000355	0.00321	0.000349	0.0154	0.00197	0.0459
3,4,4'-Trichlorobipenyl	Tri 37	<0.000024	0.000868	<0.000045	0.0033	0.000574	0.00294
2,2',5,5'-Tetrachlorobiphenyl	Tetra 52	0.0000717	0.033	0.00714	0.206	0.0543	0.29
2,2',4,5'-Tetrachlorobiphenyl	Tetra 49	<0.000039	0.0306	0.00314	0.177	0.0352	0.545
2,2',3,5'-Tetrachlorobiphenyl	Tetra 44	<0.00005	0.00591	<0.0001	0.0504	0.012	0.0655
2,3',4',5-Tetrachlorobiphenyl	Tetra 70	<0.000019	0.00211	0.000466	<0.000027	0.00254	<0.000053
2,4,4',5-Tetrachlorobiphenyl	Tetra 74	<0.00002	0.0101	0.00143	0.0377	0.0105	0.0449
2,3',4',4'-Tetrachlorobiphenyl	Tetra 66	<0.00002	0.0105	<0.00003	0.033	0.00652	0.0924
3,4,4',5-Tetrachlorobiphenyl	Tetra 81	<0.000023	<0.000056	<0.000034	<0.000032	<0.000095	<0.000065
3,3',4',4'-Tetrachlorobiphenyl	Tetra 77	<0.000031	<0.00235	0.00164	0.00759	0.00152	0.0045
2,2',3,4',5-Pentachlorobiphenyl							
2,3,3',4,6-Pentachlorobiphenyl	Penta 90/101	0.000319	0.171	0.0235	0.998	0.291	0.525
2,2',4,4',5-Pentachlorobiphenyl	Penta 99	<0.000059	<0.00018	0.0166	0.333	0.0457	0.229
2,3',4,4',6-Pentachlorobiphenyl	Penta 119	<0.000046	<0.00015	<0.000049	0.0678	0.00856	0.0593
2,2',3,4,5'-Pentachlorobiphenyl	Penta 87	<0.000043	0.038	0.00231	0.1	0.0256	0.0802
2,3,4,4',6-Pentachlorobiphenyl	Penta 115	<0.000023	<0.00015	<0.000013	<0.000025	0.000542	<0.000051
2,3,3',4',6-Pentachlorobiphenyl	Penta 110	0.000171	0.125	0.00618	0.378	0.0832	0.268
2,3',4,4',5'-Pentachlorobiphenyl	Penta 123	<0.000029	<0.00019	<0.000017	0.00226	<0.000006	<0.000065
2,3',4,4',5-Pentachlorobiphenyl	Penta 118	0.000103	0.0401	0.00616	0.192	0.0475	0.169
2,3,4,4',5-Pentachlorobiphenyl	Penta 114	<0.00003	<0.000078	<0.000014	<0.000025	<0.000004	<0.00004
2,3,3',4,4'-Pentachlorobiphenyl	Penta 105	<0.000032	0.0097	0.00259	0.0437	0.0141	0.0278
3,3',4,4',5-Pentachlorobiphenyl	Penta 126	<0.000014	<0.00004	<0.000009	<0.000014	<0.000003	0.00182
2,2',3,5,5',6-Hexachlorobiphenyl	Hexa 151	0.000175	0.0891	0.00683	0.336	0.157	0.478
2,2',3,4',5',6-Hexachlorobiphenyl	Hexa 149	0.000487	0.115	0.02	0.911	0.487	1
2,2',4,4',5,6'-Hexachlorobiphenyl							
2,3',4,4',5',6-Hexachlorobiphenyl	Hexa 153/168	0.00095	0.696	0.0525	1.852	0.913	1.594
2,2',3,4,4',5'-Hexachlorobiphenyl	Hexa 138	0.00101	0.627	0.0489	1.795	0.736	1.451
2,3,3',4,4',6-Hexachlorobiphenyl	Hexa 158	0.000122	0.0414	<0.000015	0.136	0.0566	0.135
2,2',3,3',4,4'-Hexachlorobiphenyl	Hexa 128	<0.000031	<0.000039	<0.000018	0.123	0.0233	0.114
2,3',4,4',5,5'-Hexachlorobiphenyl	Hexa 167	0.0000543	0.0228	<0.000013	0.0688	0.0191	0.0574
2,3,3',4,4',5-Hexachlorobiphenyl	Hexa 156	0.0000848	0.0288	0.00302	0.0535	0.0235	0.0528
2,3,3',4,4',5'-Hexachlorobiphenyl	Hexa 157	<0.000019	0.00323	<0.00079	0.0114	0.00208	0.0129
3,3',4,4',5,5'-Hexachlorobiphenyl	Hexa 169	<0.000018	<0.000023	<0.000011	<0.000011	<0.000023	<0.000065
2,2',3,4,4',6,6'-Heptachlorobiphenyl	Hepta 184	<0.000047	<0.000054	<0.000028	<0.000039	<0.000023	<0.000094
2,2',3,4',5,5',6-Heptachlorobiphenyl	Hepta 187	0.000494	0.337	0.0353	1.026	0.514	0.915
2,2',3,4,4',5',6-Heptachlorobiphenyl	Hepta 183	0.000298	0.139	0.0151	0.429	0.211	0.327
2,2',3,3',4,5',6'-Heptachlorobiphenyl	Hepta 177	0.000304	0.21	0.0231	0.753	0.339	0.408
2,2',3,4,4',5,5'-Heptachlorobiphenyl	Hepta 180	0.000909	0.828	0.122	1.552	0.668	1.368
2,2',3,3',4,4',5-Heptachlorobiphenyl	Hepta 170	0.000382	<0.000045	0.0455	<0.000031	<0.000016	0.497
2,3,3',4,4',5,5'-Heptachlorobiphenyl	Hepta 189	<0.000026	0.00999	0.00161	0.0166	0.00706	0.0162
2,2',3,4,4',5,5',6-Octochlorobiphenyl	Octa 202	<0.000021	0.0123	0.00141	<0.00002	0.0202	0.0453
2,2',3,3',4,5',6,6'-Octochlorobiphenyl	Octa 201	<0.000073	0.0771	0.0113	0.186	0.13	0.271
2,2',3,3',4,4',5,6- Octochlorobiphenyl	Octa 195	<0.000075	0.0529	0.00785	0.0993	0.0708	0.106
2,2',3,3',4,4',5,5'-Octochlorobiphenyl	Octa 194	0.000198	0.185	0.0222	0.294	0.173	0.261
2,2',3,3',4,4',5,6,6'-Nonachlorobyphenyl	Nona 207	<0.000031	0.00572	0.00112	0.00952	0.0067	0.0105
2,2',3,3',4,4',5,5',6-Nonachlorobyphenyl	Nona 206	<0.000036	0.0434	0.00787	0.0638	0.0405	0.0569
Decachlorobiphenyl	Deca 209	<0.000025	0.000804	0.00241	0.00363	0.000796	0.00253
Grand Total of Congeners		**0.0062**	**4.0104**	**0.4995**	**12.3734**	**5.2430**	**11.6434**
Total Dioxin-like Congeners		**0.0015**	**0.9426**	**0.1825**	**1.9479**	**0.7829**	**2.2074**
% Dioxin-like Congeners		**24.9**	**23.5**	**36.5**	**15.7**	**14.9**	**19.0**
Total for Summation (NOAA)		**0.0043**	**2.7640**	**0.3456**	**7.8956**	**3.2843**	**7.1665**
% for Summation (NOAA)		**69.3**	**68.9**	**69.2**	**63.8**	**62.6**	**61.5**
Total Highest Priority		**0.0041**	**2.7053**	**0.3445**	**7.4895**	**3.1018**	**6.9226**
% Highest Priority		**65.8**	**67.5**	**69.0**	**60.5**	**59.2**	**59.5**
Total Second Priority		**0.0019**	**1.3301**	**0.1332**	**4.3333**	**1.9337**	**4.1757**
% Second Priority		**30.3**	**33.2**	**26.7**	**35.0**	**36.9**	**35.9**

Table 19 (cont'd): Concentrations of individual PCB isomers and congeners measured in sediment, overlying water and tissue samples collected following the 7-d *Lumbriculus variegatus in situ* bioaccumulation exposure.

PCB Isomer / Congener		011	398	019	428	389	031
Overlying Water (ng/L PCB)							
PCB Region/Isomer							
MonoCB		0.0986	0.0960	0.4460	0.3030	0.1730	ND
DiCB		0.0817	0.7520	2.6900	1.9300	1.3200	0.4650
TriCB		0.4570	0.5880	5.9900	6.1500	4.4200	1.9700
TetraCB		0.6650	1.4600	23.8000	26.5000	27.3000	14.9000
PentaCB		1.4600	1.9600	19.3000	22.3000	35.2000	24.2000
HexaCB		1.1000	2.6600	39.9000	40.2000	84.1000	33.1000
HeptaCB		0.6110	1.5100	32.7000	35.1000	69.8000	28.9000
OctaCB		0.0837	0.2890	8.1600	7.9200	15.3000	6.2500
NanoCB		ND	ND	0.7030	0.5380	1.1800	0.5400
DecaCB		ND	ND	0.0250	0.0177	0.0372	0.0200
Region/Isomer Total		**4.5570**	**9.3150**	**133.7140**	**140.9587**	**238.8302**	**110.3450**
PCB Congeners							
2-Chlorobiphenyl	Mono 1	0.0986	0.096	0.146	0.108	0.116	ND
3-Chlorobiphenyl	Mono 3	ND	ND	0.0607	0.0635	0.0571	ND
2,4'-Dichlorobiphenyl	Di 8	0.0817	0.0752	0.0907	0.118	0.108	0.107
4,4'-Dichlorobiphenyl	Di 15	ND	ND	0.343	0.433	0.346	0.233
2,2',5-Trichlorobiphenyl	Tri 18	0.109	0.12	0.69	0.689	0.55	0.242
2,4,4'-Trichlorobipenyl	Tri 28	0.112	0.142	0.386	0.487	0.692	0.479
3,4,4'-Trichlorobipenyl	Tri 37	0.0161	ND	0.0436	0.0425	0.0865	ND
2,2',5,5'-Tetrachlorobiphenyl	Tetra 52	0.284	0.514	5.62	6.09	5.12	3.29
2,2',4,5'-Tetrachlorobiphenyl	Tetra 49	0.102	0.173	3.84	4.82	4.88	3.1
2,2',3,5'-Tetrachlorobiphenyl	Tetra 44	0.11	0.162	1.06	1.04	1.24	1
2,3',4',5-Tetrachlorobiphenyl	Tetra 70	0.0282	0.0415	0.134	ND	0.215	ND
2,4,4',5-Tetrachlorobiphenyl	Tetra 74	0.104	0.119	0.676	0.675	0.882	0.411
2,3',4',4'-Tetrachlorobiphenyl	Tetra 66	0.0364	0.0319	0.415	0.477	0.842	0.395
3,4,4',5-Tetrachlorobiphenyl	Tetra 81	ND	ND	ND	ND	ND	ND
3,3',4',4'-Tetrachlorobiphenyl	Tetra 77	ND	ND	ND	ND	0.069	0.0899
2,2',3,4',5-Pentachlorobiphenyl; 2,3,3',4,6-Pentachlorobiphenyl	Penta 90/101	0.314	0.483	4.26	5.54	10.1	6.55
2,2',4,4',5-Pentachlorobiphenyl	Penta 99	0.105	0.161	1.14	1.48	2.74	2.37
2,3',4,4',6-Pentachlorobiphenyl	Penta 119	ND	0.0402	0.343	0.403	0.698	0.516
2,2',3,4,5'-Pentachlorobiphenyl	Penta 87	0.13	0.139	1.14	1.32	1.78	1.29
2,3,4,4',6-Pentachlorobiphenyl	Penta 115	ND	ND	ND	ND	ND	ND
2,3,3',4',6-Pentachlorobiphenyl	Penta 110	0.284	0.409	2.67	3.42	5.2	3.78
2,3',4,4',5'-Pentachlorobiphenyl	Penta 123	ND	ND	ND	ND	ND	ND
2,3',4,4',5-Pentachlorobiphenyl	Penta 118	0.197	0.208	1.3	1.45	2.4	1.72
2,3,4,4',5-Pentachlorobiphenyl	Penta 114	ND	ND	ND	ND	ND	ND
2,3,3',4,4'-Pentachlorobiphenyl	Penta 105	0.0694	0.0994	0.497	0.422	0.609	0.403
3,3',4,4',5-Pentachlorobiphenyl	Penta 126	ND	ND	ND	ND	ND	ND
2,2',3,5,5',6-Hexachlorobiphenyl	Hexa 151	0.0601	0.163	2.7	2.82	5.72	2.17
2,2',3,4',5',6-Hexachlorobiphenyl	Hexa 149	0.169	0.343	5.22	5.8	11.4	4.45
2,2',4,4',5,6'-Hexachlorobiphenyl 2,3',4,4',5',6-Hexachlorobiphenyl	Hexa 153/168	0.291	0.594	9.17	8.9	20.3	6.53
2,2',3,4,4',5'-Hexachlorobiphenyl	Hexa 138	0.413	0.798	11.1	10.5	23.8	8.1
2,3,3',4,4',6-Hexachlorobiphenyl	Hexa 158	0.0726	0.1	1.24	1.38	2.35	1.44
2,2',3,3',4,4'-Hexachlorobiphenyl	Hexa 128	ND	0.0667	0.752	0.798	1.3	0.858
2,3',4,4',5,5'-Hexachlorobiphenyl	Hexa 167	ND	0.0362	0.427	0.541	1.2	0.69
2,3,3',4,4',5-Hexachlorobiphenyl	Hexa 156	ND	0.029	0.434	0.429	0.772	0.434
2,3,3',4,4',5'-Hexachlorobiphenyl	Hexa 157	ND	ND	ND	ND	ND	ND
3,3',4,4',5,5'-Hexachlorobiphenyl	Hexa 169	ND	ND	ND	ND	ND	ND
2,2',3,4,4',6,6'-Heptachlorobiphenyl	Hepta 184	ND	ND	ND	ND	ND	ND
2,2',3,4',5,5',6-Heptachlorobiphenyl	Hepta 187	0.153	0.374	6.64	7.49	13.7	4.73
2,2',3,4,4',5',6-Heptachlorobiphenyl	Hepta 183	0.0522	0.131	2.48	2.72	5.59	2.04
2,2',3,3',4,5',6'-Heptachlorobiphenyl	Hepta 177	0.0731	0.149	2.59	2.62	5.51	1.9
2,2',3,4,4',5,5'-Heptachlorobiphenyl	Hepta 180	0.165	0.385	7.68	8.08	16.9	8.1
2,2',3,3',4,4',5-Heptachlorobiphenyl	Hepta 170	0.0552	0.197	2.98	3.16	6.63	3.15
2,3,3',4,4',5,5'-Heptachlorobiphenyl	Hepta 189	ND	ND	0.154	0.134	0.328	0.199
2,2',3,4,4',5,5',6-Octochlorobiphenyl	Octa 202	ND	0.024	0.481	0.467	0.871	0.356
2,2',3,3',4,5',6,6'-Octochlorobiphenyl	Octa 201	0.0583	0.087	2.07	1.83	3.78	1.83
2,2',3,3',4,4',5,6- Octochlorobiphenyl	Octa 195	0.0254	ND	0.825	0.854	1.43	0.799
2,2',3,3',4,4',5,5'-Octochlorobiphenyl	Octa 194	ND	0.097	1.89	1.83	3.64	1.93
2,2',3,3',4,4',5,6,6'-Nonachlorobyphenyl	Nona 207	ND	ND	0.0824	0.0628	0.132	0.0738
2,2',3,3',4,4',5,5',6-Nonachlorobyphenyl	Nona 206	ND	ND	0.495	0.379	0.853	0.466
Decachlorobiphenyl	Deca 209	ND	0.0316	0.025	0.0177	0.0372	0.02
Grand Total of Congeners		**3.7693**	**6.6197**	**84.2904**	**89.8905**	**164.9738**	**76.2417**
Total Dioxin-like Congeners		**0.4866**	**0.9546**	**13.472**	**14.216**	**28.908**	**14.7859**
% Dioxin-like Congeners		**12.9**	**14.4**	**16.0**	**15.8**	**17.5**	**19.4**
Total for Summation (NOAA)		**2.3907**	**4.2502**	**52.6407**	**55.241**	**104.36**	**45.7439**
% for Summation (NOAA)		**63.43**	**64.21**	**62.45**	**61.45**	**63.26**	**60.00**
Total Highest Priority		**1.8142**	**3.3347**	**46.978**	**49.3897**	**97.4502**	**43.6499**
% Highest Priority		**48.13**	**50.38**	**55.73**	**54.94**	**59.07**	**57.25**
Total Second Priority		**1.3913**	**2.5119**	**32.1076**	**33.5145**	**58.9095**	**25.418**
% Second Priority		**36.91**	**37.95**	**38.09**	**37.28**	**35.71**	**33.34**

Table 19 (cont'd): Concentrations of individual PCB isomers and congeners measured in sediment, overlying water and tissue samples collected following the 7-d *Lumbriculus variegatus in situ* bioaccumulation exposure.

PCB Isomer / Congener		011	398	019	428	389	031
Tissue (ug/Kg PCB) (Results are the mean of 4 - 6 replicates per sample)							
Lipid Content (%) (Mean)		1.08	0.75	1.72	1.16	1.14	0.97
PCB Region/Isomer (Mean)							
MonoCB		ND	ND	ND	ND	0.1490	0.0690
DiCB		0.112	0.138	3.105	3.410	6.060	3.015
TriCB		0.555	0.866	33.250	36.083	60.525	56.350
TetraCB		3.248	12.595	300.333	384.833	285.750	416.500
PentaCB		10.728	34.150	572.667	527.167	343.500	763.500
HexaCB		21.067	60.050	1851.167	1996.667	565.000	1163.250
HeptaCB		17.118	40.525	1012.667	1168.333	165.450	539.750
OctaCB		2.655	5.078	209.667	271.667	33.600	95.350
NanoCB		1.052	1.658	13.882	20.133	2.490	4.768
DecaCB		0.477	0.764	0.692	0.630	0.399	0.400
Sum total of means ug/Kg tissue		57.01	155.82	3997.43	4408.92	1462.92	3042.95
LIPID NORMALIZED sum total of means mg/Kg lipid		5.30	20.71	232.63	380.63	128.33	314.52
PCB Congeners (Mean)							
2-Chlorobiphenyl	Mono 1	ND	ND	0.0811	0.1509	0.0803	0.0441
3-Chlorobiphenyl	Mono 3	ND	ND	0.0654	0.0764	0.0688	0.0373
2,4'-Dichlorobiphenyl	Di 8	0.0964	0.0706	0.2448	0.2270	1.1078	0.4308
4,4'-Dichlorobiphenyl	Di 15	ND	0.0481	1.3233	1.5450	2.8425	1.3725
2,2',5-Trichlorobiphenyl	Tri 18	0.0875	0.1048	1.7133	2.1217	4.4350	4.8775
2,4,4'-Trichlorobipenyl	Tri 28	0.2175	0.2608	3.0867	5.0300	11.8825	13.3000
3,4,4'-Trichlorobipenyl	Tri 37	0.0337	0.0452	0.4613	0.4020	1.2670	1.2675
2,2',5,5'-Tetrachlorobiphenyl	Tetra 52	0.7747	3.6975	56.6667	55.5833	58.6750	106.6250
2,2',4,5'-Tetrachlorobiphenyl	Tetra 49	0.3988	1.9275	56.2167	75.2000	61.3750	96.1500
2,2',3,5'-Tetrachlorobiphenyl	Tetra 44	0.3187	0.6190	8.6617	9.6767	12.8100	25.4250
2,3',4',5-Tetrachlorobiphenyl	Tetra 70	0.1978	0.2878	1.3700	1.0385	1.6298	2.6725
2,4,4',5-Tetrachlorobiphenyl	Tetra 74	0.4813	0.7055	9.1217	6.7350	7.6150	14.3750
2,3',4',4'-Tetrachlorobiphenyl	Tetra 66	0.4103	0.6635	7.5017	6.9900	8.4700	13.3000
3,4,4',5-Tetrachlorobiphenyl	Tetra 81	ND	ND	ND	ND	ND	ND
3,3',4',4'-Tetrachlorobiphenyl	Tetra 77	ND	ND	0.4922	0.5645	0.6240	1.4025
2,2',3,4',5-Pentachlorobiphenyl 2,3,3',4,6-Pentachlorobiphenyl	Penta 90/101	2.7933	8.0075	164.3333	166.6667	102.6000	253.5000
2,2',4,4',5-Pentachlorobiphenyl	Penta 99	1.5580	3.1000	37.1000	40.9667	32.1250	77.1000
2,3',4,4',6-Pentachlorobiphenyl	Penta 119	0.2080	0.9255	7.8967	8.9950	7.4250	15.6000
2,2',3,4,5'-Pentachlorobiphenyl	Penta 87	0.5600	1.5450	26.7167	19.5500	12.6150	27.5750
2,3,4,4',6-Pentachlorobiphenyl	Penta 115	ND	ND	ND	ND	ND	ND
2,3,3',4',6-Pentachlorobiphenyl	Penta 110	1.7133	5.5275	82.7833	59.8000	44.6500	101.4750
2,3',4,4',5'-Pentachlorobiphenyl	Penta 123	ND	ND	0.4927	0.3568	0.2920	0.5108
2,3',4,4',5-Pentachlorobiphenyl	Penta 118	1.6300	2.8125	40.6667	28.5500	16.2850	46.5250
2,3,4,4',5-Pentachlorobiphenyl	Penta 114	ND	ND	ND	ND	ND	ND
2,3,3',4,4'-Pentachlorobiphenyl	Penta 105	0.5238	1.0878	9.6883	6.7283	3.6175	8.4575
3,3',4,4',5-Pentachlorobiphenyl	Penta 126		0.0464	0.6183	0.5860	0.0724	0.4433
2,2',3,5,5',6-Hexachlorobiphenyl	Hexa 151	1.4238	5.6000	134.4000	131.6000	45.8500	105.4500
2,2',3,4',5',6-Hexachlorobiphenyl	Hexa 149	2.8733	8.8275	311.0000	288.8333	90.2750	193.7500
2,2',4,4',5,6'-Hexachlorobiphenyl 2,3',4,4',5',6-Hexachlorobiphenyl	Hexa 153/168	6.4550	13.4250	512.3333	611.6667	155.4000	253.7500
2,2',3,4,4',5'-Hexachlorobiphenyl	Hexa 138	5.6367	4.5575	457.0000	537.5000	131.1000	271.7500
2,3,3',4,4',6-Hexachlorobiphenyl	Hexa 158	0.3920	1.3023	33.6667	30.9167	7.8050	24.9500
2,2',3,3',4,4'-Hexachlorobiphenyl	Hexa 128	0.5325	1.4465	23.6500	21.9667	6.2825	19.9250
2,3',4,4',5,5'-Hexachlorobiphenyl	Hexa 167	0.2273	0.6223	12.9717	12.2333	2.6500	10.2275
2,3,3',4,4',5-Hexachlorobiphenyl	Hexa 156	0.2666	0.6105	12.3700	10.7000	2.3050	7.5850
2,3,3',4,4',5'-Hexachlorobiphenyl	Hexa 157	ND	0.2190	1.9583	1.6667	0.6200	1.6250
3,3',4,4',5,5'-Hexachlorobiphenyl	Hexa 169	ND	ND	ND	ND	ND	0.0886
2,2',3,4,4',6,6'-Heptachlorobiphenyl	Hepta 184	ND	ND	0.1100	ND	ND	0.0437
2,2',3,4',5,5',6-Heptachlorobiphenyl	Hepta 187	5.4600	13.8950	338.1667	431.5000	64.0000	143.5000
2,2',3,4,4',5',6-Heptachlorobiphenyl	Hepta 183	1.3585	2.3025	65.1333	66.6500	8.6375	34.4250
2,2',3,3',4,5',6'-Heptachlorobiphenyl	Hepta 177	2.1643	4.1125	93.7500	108.3667	15.4450	44.8750
2,2',3,4,4',5,5'-Heptachlorobiphenyl	Hepta 180	1.4945	3.7925	75.0667	77.7667	14.2850	76.6750
2,2',3,3',4,4',5-Heptachlorobiphenyl	Hepta 170	1.9550	4.4450	109.0333	100.6667	11.0125	53.7000
2,3,3',4,4',5,5'-Heptachlorobiphenyl	Hepta 189	0.1810	0.1410	3.8067	4.6000	0.5713	1.7600
2,2',3,4,4',5,5',6-Octochlorobiphenyl	Octa 202	0.3102	0.4478	12.3050	15.8333	2.2940	5.7650
2,2',3,3',4,5',6,6'-Octochlorobiphenyl	Octa 201	0.8468	1.6525	67.7167	84.2000	10.0925	31.1250
2,2',3,3',4,4',5,6- Octochlorobiphenyl	Octa 195	0.3255	0.5498	20.8833	27.9500	3.3625	8.8800
2,2',3,3',4,4',5,5'-Octochlorobiphenyl	Octa 194	0.5762	0.9590	35.1833	50.0500	6.0750	15.7500
2,2',3,3',4,4',5,6,6'-Nonachlorobyphenyl	Nona 207	0.1170	0.1300	1.7983	2.6750	0.3015	0.6190
2,2',3,3',4,4',5,5',6-Nonachlorobyphenyl	Nona 206	0.5617	0.9070	9.4767	13.7350	1.4593	3.0050
Decachlorobiphenyl	Deca 209	0.4765	0.7635	0.6922	0.6297	0.3988	0.3995
sum total of congener means ug/Kg tissue		45.64	102.19	2849.77	3129.25	972.79	2122.09
mean of congener rep TOTAL ug/Kg tissue		44.65	101.36	2849.33	3128.57	972.68	2121.97
SD of rep totals (below)		16.49	23.68	826.06	626.03	409.14	475.39
Total Dioxin-like Congeners		5.97	13.47	266.92	243.92	52.26	208.93
% Dioxin-like Congeners		13.4	13.3	9.4	7.8	5.4	9.8
Total Highest Priority		24.83	48.19	1584.39	1766.70	531.43	1164.19
% Total Highest Priority		55.6	47.5	55.6	56.5	54.6	54.9
mean congener rep totals mg/Kg tissue (below)		4.15	13.47	165.82	270.09	85.32	219.33
SD of rep totals (below)		1.53	3.15	48.07	54.05	35.89	49.14
Total Dioxin-like Congeners		0.55	1.79	15.53	21.06	4.58	21.60
Total Highest Priority		2.31	6.40	92.21	152.52	46.62	120.33

ND = Not detected

Table 20: Values of octanol-water partitioning coefficient (K_{ow}), organic carbon-water partitioning coefficent (K_{oc}) and sediment-pore water partitioning coefficient (K_p) used to calculate pore water concentrations using equilibrium partitioning theory[a].

				K_p at stations[d]			
PCB #	**Common Name**	**log Kow[b]**	**log Koc[c]**	**011**	**019**	**428**	**031**
5	2,3-DiCB	5.00	4.92	259	1440	4246	3546
9	2,5-DiCB	5.10	5.01	325	1806	5324	4447
14	3,5-DiCB	5.30	5.21	511	2839	8372	6993
15	4,4'-DiCB	5.33	5.24	547	3039	8960	7484
	Mean DiCB	*5.18*	*5.09*	*411*	*2281*	*6725*	*5618*
	St Dev	*0.16*	*0.16*	*140*	*779*	*2296*	*1918*
18	2,2',5-TriCB	5.24	5.15	446	2479	7309	6105
28	2,4,4'-TriCB	5.60	5.51	1008	5599	16509	13790
31	2,5,4'-TriCB	5.60	5.51	1008	5599	16509	13790
	Mean TriCB	*5.48*	*5.39*	*821*	*4559*	*13443*	*11228*
	St Dev	*0.21*	*0.20*	*324*	*1802*	*5312*	*4437*
40	2,2',3,3'-TetraCB	5.90	5.80	1987	11041	32556	27193
47	2,2',4,4'-TetraCB	6.10	6.00	3125	17363	51195	42762
52	2,2',5,5'-TetraCB	5.84	5.74	1735	9639	28422	23740
53	2,2,5,6'-TetraCB	5.90	5.80	1987	11041	32556	27193
66	2,3',4,4'-TetraCB	5.90	5.80	1987	11041	32556	27193
77	3,3',4,4'-TetraCB	6.10	6.00	3125	17363	51195	42762
	Mean TetraCB	*5.96*	*5.86*	*2325*	*12915*	*38080*	*31807*
	St Dev	*0.11*	*0.11*	*628*	*3488*	*10284*	*8590*
101	2,2',4,5,5'-PentaCB	6.38	6.27	5890	32723	96487	80593
105	2,2',3',4,4'-PentaCB	6.65	6.54	10853	60293	177779	148493
118	2,3',4,4',5-PentaCB	6.74	6.63	13305	73916	217946	182044
126	3,3',4,4',5-PentaCB	6.53	6.41	8178	45435	133969	111901
	Mean PentaCB	*6.57*	*6.46*	*9557*	*53092*	*156545*	*130758*
	St Dev	*0.16*	*0.15*	*3218*	*17879*	*52718*	*44034*
128	2,2',3,3',4,4'-HexaCB	6.74	6.63	13305	73916	217946	182044
138	2,2',3,4,4',5'-HexaCB	6.83	6.71	16311	90617	267190	223176
151	2,2',3,5,5',6-HexaCB	6.64	6.53	10610	58944	173800	145170
153	2,2',4,4',5,5'-HexaCB	6.92	6.80	19996	111091	327559	273601
155	2,2',4,4',6,6'-HexaCB	6.40	6.29	6163	34239	100955	84325
156	2,3,3',4,4',5-HexaCB	7.00	6.88	23966	133143	392581	327912
169	3,3',4,4',5,5'-HexaCB	7.40	7.27	59264	329244	970800	810881
	Mean HexaCB	*6.85*	*6.73*	*21374*	*118742*	*350119*	*292444*
	St Dev	*0.31*	*0.31*	*17712*	*98399*	*290136*	*242343*
170	2,2',3,3',4,4',5-HeptaCB	7.27	7.15	44157	245317	723335	604181
180	2,2',3,4,4',5,5'-HeptaCB	7.36	7.24	54134	300745	886767	740691
	Mean HeptaCB	*7.32*	*7.19*	*49146*	*273031*	*805051*	*672436*
	St Dev	*0.06*	*0.06*	*7055*	*39193*	*115564*	*96527*
194	2,2',3,3',4,4',5,5'-OctaCB	7.80	7.67	146552	814176	2400655	2005198
	NanoCB[e]	7.99	7.85	246457	1369205	4037199	3372157
209	2,2',3,3',4,4',5,5'6,6'-DecaCB	8.18	8.04	346362	1924235	5673744	4739115

[a]Equilibrium Partition equation for sediments: $C_{pw} = C_s/K_p$, where C_{pw} is conc. in pore water (mg/L), C_s is conc. in sediments (mg/Kg) and K_p is frac OC*K_{oc} (L/Kg)

[b]K_{ow} values from: Boese et al. (1997), Gabric et al. (1990), Hawker and Connell (1988), Veith et al. (1979), Fisher et al. (1999), USEPA (2000)

[c]log K_{oc} = 0.00028 + 0.983*(log K_{ow})

[d]K_p not calculable for Sites 398 or 389 because sediment TOC was undetected (<0.012%).

[e]Estimated as mean of OctaCB and DecaCB values

Table 21: Estimated freely dissolved PCB pore water concentrations (C_{pw}) for sediments from the 7-d *Lumbriculus variegatus in situ* bioaccumulation test (C_{pw} calculated using equilibrium partitioning equations [a,b]).

	C_{pw} (ng/L)[c]			
PCB Congener	**011**	**019**	**428**	**031**
MonoCB[d]	0	0	0	0.0420
DiCB	0	0	1.80	1.92
TriCB	0.0433	0.296	5.50	14.3
TetraCB	0.0308	1.84	23.2	64.4
PentaCB	0.0761	1.38	17.8	15.9
HexaCB	0.151	1.47	18.9	22.0
HeptaCB	0.0584	1.21	7.12	7.47
OctaCB	0.00135	0.0700	0.352	0.524
NanoCB	0	0.00789	0.0212	0.0245
DecaCB	0	0.00125	0.000640	0.000534
Total	*0.3606*	*6.275*	*74.65*	*126.6*

[a]Equilibrium Partition equation for sediments: $C_{pw} = C_s/K_p$, where C_{pw} is concentration in pore water (mg/L), C_s is concentration in sediments (mg/Kg) and K_p is frac OC*K_{oc} (L/Kg). Final estimated pore water concentrations have been converted to units of ng/L.

[b]Sediment concentrations used in these calculations were from samples collected at the end of the 7-d *in situ* bioaccumulation test.

[c]Pore water concentrations could not be estimated for Sites 398 and 389 because sediment TOC was undetected (<0.012%).

[d]MonoCB C_{pw} were calculated using K_p values for DiCB (see Table 20)

Table 22: Pore water Bioconcentration Factors (BCF) for total PCBs in *Lumbriculus variegatus* tissue following 7-d *in situ* bioaccumulation test.

		Site (Upstream to Downstream)			
		011	**019**	**428**	**031**
Estimated Pore Water Concentration[a,b]	ug/L: C_{pw}[d]	0.0004	0.0063	0.0747	0.1266
Tissue Residues	ug/Kg wet: C_a[e]	57	3997	4409	3043
	ug/Kg Lipid: C_l[f]	5295	232634	380626	314517
BCF[c]	wet wt. basis	158111	637076	59060	24044
	lipid basis	14685210	37075220	5098662	2485215
Log BCF	wet wt. basis	5.20	5.80	4.77	4.38
	lipid basis	7.17	7.57	6.71	6.40

[a]Pore water concentrations were estimated based on equilibrium partitioning theory using sediment data from this study, and published K_{ow} values.

[b]Pore water concentrations were not estimated for Sites 398 or 389 because sediment TOC was undetected (<0.012%).

[c]BCF = C_a/C_{pw} (wet wt. basis) or C_l/C_{pw} (lipid wt. basis)

[d]C_{pw} = concentration in the pore water

[e]C_a = concentration in the animal (wet weight basis)

[f]C_l = concentration in the lipid

Table 23: Sediment Bioaccumulation and Biota/Sediment Accumulation Factors[a] (BAF and BSAF) for total PCBs in *Lumbriculus variegatus* tissue following 7-d *in situ* bioaccumulation test.

		Site (Upstream to Downstream)					
		011	**398**	**019**	**428**	**389**	**031**
Sediment Concentration	mg/Kg: C_s[b]	0.0071	5.4	0.7	17.0	7.1	16.9
Sediment TOC[c]	% (7-d data)	0.32	<0.012	1.75	5.16	<0.012	4.31
	% (median of all data)	0.10	0.55	0.42	0.29	4.98	6.94
OC-normalized Sediment Concentration	mg/Kg OC (7-d TOC): $C_{s,oc}$[d]	2.22	NC[e]	38.3	330	NC	392
	mg/Kg OC (median TOC): $C_{s,oc}$[d]	7.1	981.8	166.7	5862.1	142.6	243.2
Tissue Residues	mg/Kg wet: C_a[f]	0.057	0.156	4.00	4.41	1.46	3.04
	mg/Kg lipid: C_{lipid}[g]	5.30	20.71	233	381	128	315
BAF[h]	wet wt. basis	8.03	0.03	5.71	0.26	0.21	0.18
	lipid basis	745.8	3.8	332.3	22.4	18.1	18.6
Log BAF	wet wt. basis	0.90	-1.54	0.76	-0.59	-0.69	-0.74
	lipid basis	2.87	0.58	2.52	1.35	1.26	1.27
BSAF[i]	mg lipid/mg OC (7-d TOC)	2.39	NC	6.07	1.16	NC	0.80
	mg lipid/mg OC (median TOC)	0.75	0.02	1.40	0.06	0.90	1.29
Log BSAF	(7-d TOC)	0.38	NC	0.78	0.06	NC	-0.10
	(median TOC)	-0.13	-1.68	0.14	-1.19	-0.05	0.11

[a]BAF and BSAF assume tissue PCB levels are at steady state with the environment

[b]C_s = concentration in the sediment

[c]Sediment TOC data presented for 7-d *in situ* study only, and as the median of all TOC analyses performed on these sediments.

[d]$C_{s,oc}$ = concentration in the sediment, organic carbon (OC) normalized using both 7-d and median sediment TOC data.

[e]NC = not calculable because sediment TOC was undetected

[f]C_a = concentration in the animal (wet weight basis)

[g]C_{lipid} = concentration in the lipid

[h]BAF = C_a/C_s (wet wt. basis) or C_l/C_s (lipid wt. basis)

[i]BSAF = $C_{lipid}/C_{s,oc}$. BSAFs calculated using both 7-d and median sediment TOC values.

Table 24: LC_{50} values (%) and Toxic Units (TUs) resulting from TIE test manipulations of the Site 031 pore water sample.

		24-h Results			48-h Results		
Date	**Test**	**LC_{50} (%)[a]**	**Toxic Units[c]**	**Survival (%)[b]**	**LC_{50} (%)**	**Toxic Units**	**Survival (%)**
15-Sep-99	*Initial toxicity test (24 h)*	30	3.3	0	NM	NM	NM
16-Sep-99	*Baseline (48 h)*	79	1.3	40	27	3.7	0
	Filtration (48 h)						
	pH 3	>100	<1	80	>100	<1	80
	pH i (6.75)	16	6.2	0	14	7.1	0
	pH 11	>100	<1	100	>100	<1	80
	Oxidant Reduction (48 h)						
	0.2 ml	NC	NC	100	<15	>6.7	0
	0.1 ml	NC	NC	80	23	4.3	20
	0.05 ml	78	1.3	60	18	5.6	20
	Aeration (48 h)						
	pH 3	>100	<1	100	>100	<1	80
	pH i (6.75)	>100	<1	80	NC	NC	20
	pH11	>100	<1	80	<15	>6.7	20
17-Sep-99	*Baseline (24 h)*	12	8.6	0	NM	NM	NM
	C18 SPE (48 h)						
	pH 3	>100	<1	100	>100	<1	80
	pH i (6.75)	>100	<1	60	>100	<1	60
	pH 9	71	1.4	0	71	1.4	0
	EDTA Chelation (48 h)						
	[0.056] - 0.2 ml	35	2.9	0	14	7.1	0
	[0.014] - 0.05 ml	35	2.9	0	18	5.6	0
	[0.004] - 0.0125 ml	35	2.9	0	27	3.7	0

[a]LC_{50} values calculated with Spearman-Karber

[b]Survival from 100% pore water (no dilution)

[c]Toxic Units = 100 / LC_{50} value

NM = not measured; NC = not calculated

Table 25: LC_{50} values (%) and Toxic Units (TUs) resulting from TIE test manipulations of the Site 389 pore water sample.

		24-h Results			48-h Results		
Date	**Test**	**LC_{50} (%)[a]**	**Toxic Units[c]**	**Survival (%)[b]**	**LC_{50} (%)**	**Toxic Units**	**Survival (%)**
15-Sep-99	*Initial toxicity test (24 h)*	31	3.2	0	NM	NM	NM
16-Sep-99	*Baseline (48 h)*	61	1.6	30	26	3.8	0
	Filtration (48 h)						
	pH 3	>100	<1	100	>100	<1	100
	pH i (6.80)	>100	<1	100	>100	<1	100
	pH11	>100	<1	100	>100	<1	100
	Oxidant Reduction (48 h)						
	0.2 ml	65	1.5	0	17	5.9	0
	0.1 ml	29	3.5	20	<12.5	>8	0
	0.05 ml	35	2.8	40	<12.5	>8	0
	Aeration (48 h)						
	pH 3	40	2.5	40	<12.5	>8	20
	pH i (6.80)	47	2.1	0	27	3.7	0
	pH11	71	1.4	0	47	2.1	0
17-Sep-99	*Baseline (24 h)*	14.4	6.9	0	NM	NM	NM
	C18 SPE (48 h)						
	pH 3	>100	<1	100	>100	<1	100
	pH i (6.80)	>100	<1	100	>100	<1	100
	pH 9	>100	<1	80	>100	<1	80
	EDTA Chelation (48 h)						
	[0.056] - 0.2 ml	21	4.8	0	<15	>6.7	0
	[0.014] - 0.05 ml	21	4.8	0	<15	>6.7	0
	[0.004] - 0.0125 ml	62	1.6	0	<15	>6.7	0

[a]LC_{50} values calculated with Spearman-Karber

[b]Survival from 100% pore water (no dilution)

[c]Toxic Units = 100 / LC_{50} value

NM = not measured; NC = not calculated

Table 26: Summary of results and conclusions for samples used for TIE test manipulations.

	Site 31 (Sample 771)		Site 389 (Sample 772)	
Test	**Result**	**Conclusion**	**Result**	**Conclusion**
Filtration	decreased toxicity in pH 3 & pH 11 (pH 3 formed precipitate)	likely, some toxicity related to filterable solids (neutral toxicity solubilization, pHi)	decreased toxicity for all pH treatments	likely, some toxicity related to filterable solids (acidic toxicity solubilization, pH 3)
EDTA Addition	decreased toxicity slightly at lowest EDTA addition (precipitate w/addition)	possible artifact toxicity, metals toxicity unlikely	increased toxicity	possible artifact toxicity, metals toxicity unlikely
Oxidant Reduction	increased toxicity	possible artifact toxicity, oxiding toxicity unlikely	increased toxicity	possible artifact toxicity, oxiding toxicity unlikely
Aeration	decreased toxicity at pH 3 only (pH 3 & pH 11 precipitated)	possible artifact toxicity, oxidizing, volatile, surfactant toxicity possible	decreased toxicity for pH 11 only	possible artifact toxicity, oxidizing, volatile, surfactant toxicity possible
C_{18} SPE	reduced toxicity for all pHs	likely, organic toxicants present and causing toxicity	reduced toxicity for all pHs	likely, organic toxicants present and causing toxicity

Table 27: Summary of analytical results for parameters detected in sediments collected for TIE testing.

PARAMETER GROUP	PARAMETER	UNITS	Site 398 9-Sep-99		Site 019 7-Sep-99		Site 428 7-Sep-99		Site 389 7-Sep-99		Site 031 2-Sep-99	
Organic	Total Organic Carbon	mg/Kg	3660		4050		2930		60000		92600	
PCBs	Aroclor 1254	mg/Kg	0.022	J	2.3	U	1.1	U	14		66	
PCBs	Aroclor 1260	mg/Kg	0.043		14		8.7		79		140	
PCBs	PCB, Total	mg/Kg	0.065	J	14		8.7		93		210	
Metals	Antimony	mg/Kg	0.36	U	0.67		0.35	U	2.9		8	
Metals	Arsenic	mg/Kg	4.5		2.1		1.4		4.7		10.7	
Metals	Barium	mg/Kg	21.9		17.3		15.9		127		172	
Metals	Beryllium	mg/Kg	0.41		0.28		0.26		0.79		0.87	
Metals	Cadmium	mg/Kg	0.06	U	0.12	U	0.07	U	6.8		16.6	
Metals	Chromium	mg/Kg	19.6		11.4		12.9		114		459	
Metals	Cobalt	mg/Kg	8.1		6.1		6.1		12.6		11.9	
Metals	Copper	mg/Kg	16.5		11.1		7.7		197		268	
Metals	Lead	mg/Kg	34.4		11.9		12.1		157		308	
Metals	Mercury	mg/Kg	0.03	J	0.03	J	0.02	UJ	0.89		2.5	
Metals	Nickel	mg/Kg	13.7		11.7		11.4		26.3		28.3	
Metals	Silver	mg/Kg	0.2	UJ	0.34	U	0.23	UJ	9.1		6.4	
Metals	Thallium	mg/Kg	2.8	U	1	U	1.5	U	2.4		1.9	U
Metals	Tin	mg/Kg	14		2.3	U	2.5	U	17.8		33.2	
Metals	Vanadium	mg/Kg	10.1		6.7		7.1		25.1		22.4	
Metals	Zinc	mg/Kg	89.2		69.3		63.5		408		948	
Semivolatiles	1,2,4-Trichlorobenzene	mg/Kg	0.4	UJ	0.024	J	0.06	J	0.76	UJ	0.27	J
Semivolatiles	1,2-Dichlorobenzene	mg/Kg	0.4	UJ	0.45	UJ	0.43	UJ	0.76	UJ	0.087	J
Semivolatiles	1,3,5-Trinitrobenzene	mg/Kg	1.2	U	0.45	R	0.43	R	0.76	R	0.84	R
Semivolatiles	1,3-Dichlorobenzene	mg/Kg	0.4	U	0.45	U	0.43	U	0.12	J	0.11	J
Semivolatiles	1,4-Dichlorobenzene	mg/Kg	0.4	UJ	0.021	J	0.12	J	0.46	J	0.63	J
Semivolatiles	2-Methylnaphthalene	mg/Kg	0.13	J	0.036	J	0.083	J	0.038	J	0.17	J
Semivolatiles	2-Methylphenol (o-Cresol)	mg/Kg	0.4	UJ	0.45	UJ	0.43	UJ	0.76	UJ	0.043	J
Semivolatiles	4-Methylphenol	mg/Kg	0.4	UJ	0.45	U	0.43	UJ	0.093	J	0.4	J
Semivolatiles	4-Nitroquinoline-1-oxide	mg/Kg	1.2	U	0.45	R	0.43	R	0.76	R	0.84	R
Semivolatiles	Acenaphthene	mg/Kg	0.14	J	0.038	J	0.079	J	0.063	J	0.84	U
Semivolatiles	Acenaphthylene	mg/Kg	0.07	J	0.04	J	0.12	J	0.76	UJ	0.84	UJ
Semivolatiles	Anthracene	mg/Kg	0.32	J	0.16	J	0.32	J	0.76	UJ	0.14	J
Semivolatiles	Benzo(a)anthracene	mg/Kg	1.8		0.63	J	1.7	J	0.36	J	0.54	J
Semivolatiles	Benzo(a)pyrene	mg/Kg	2		0.52	J	1.4	J	0.45	J	0.9	J
Semivolatiles	Benzo(b)fluoranthene	mg/Kg	1.6		0.49		1.2		0.46	J	0.92	
Semivolatiles	Benzo(ghi)perylene	mg/Kg	1.2		0.31	J	0.8		0.32	J	0.84	J
Semivolatiles	Benzo(k)fluoranthene	mg/Kg	1.7		0.52		1.4		0.39	J	0.89	
Semivolatiles	Bis(2-ethylhexyl) phthalate	mg/Kg	7.8		0.45	U	0.43	U	0.47	J	0.097	J
Semivolatiles	Chrysene	mg/Kg	2.1		0.64		1.7		0.55	J	1	
Semivolatiles	Dibenzo(a,h)anthracene	mg/Kg	0.33	J	0.1	J	0.22	J	0.047	J	0.17	J
Semivolatiles	Dibenzofuran	mg/Kg	0.08	J	0.032	J	0.077	J	0.76	UJ	0.84	UJ
Semivolatiles	Di-N-butyl phthalate	mg/Kg	0.52	J	0.45	UJ	0.43	UJ	0.76	UJ	0.84	UJ
Semivolatiles	Fluoranthene	mg/Kg	3.5		1		3.1		1.1		1.1	
Semivolatiles	Fluorene	mg/Kg	0.15	J	0.083	J	0.21	J	0.76	U	0.076	J
Semivolatiles	Indeno(1,2,3-c,d)pyrene	mg/Kg	1.4		0.37	J	0.98		0.33	J	0.9	
Semivolatiles	Naphthalene	mg/Kg	0.16	J	0.079	J	0.18	J	0.062	J	0.26	J
Semivolatiles	Phenanthrene	mg/Kg	2.1		0.65	J	1.8	J	0.56	J	0.68	J
Semivolatiles	Phenol	mg/Kg	0.4	U	0.45	U	0.43	U	0.76	U	0.29	J
Semivolatiles	p-Phenylenediamine	mg/Kg	1.2	U	0.45	R	0.43	R	0.76	R	0.84	R
Semivolatiles	Pyrene	mg/Kg	3.4		1.2		2.6		0.85		1.2	
Semivolatiles	Total PAH	mg/Kg	21.97		6.83		17.809		5.542		9.616	
Semivolatiles	Total PAH (High MW)	mg/Kg	15.53		4.78		12		3.757		7.36	
Semivolatiles	Total PAH (Low MW)	mg/Kg	6.44		2.05		5.809		1.785		2.256	
Dioxins/Furans	1,2,3,4,6,7,8-HPCDD	pg/g	12.1		30.7		21.4		1220		1400	
Dioxins/Furans	1,2,3,4,6,7,8-HPCDF	pg/g	3.67		40.8	J	21.6		306		7260	J
Dioxins/Furans	1,2,3,4,7,8,9-HPCDF	pg/g	0.387		19		7.29		34.2		136	
Dioxins/Furans	1,2,3,4,7,8-HXCDD	pg/g	0.282		0.651	J	1	J	12		27.5	
Dioxins/Furans	1,2,3,4,7,8-HXCDF	pg/g	0.747	J	33.8		16.4		69.2		278	
Dioxins/Furans	1,2,3,6,7,8-HXCDD	pg/g	0.773	J	1.41	J	1.77	J	49.8		109	
Dioxins/Furans	1,2,3,6,7,8-HXCDF	pg/g	0.733	J	9.41		5.24		29.3	J	177	J
Dioxins/Furans	1,2,3,7,8,9-HXCDD	pg/g	0.503	J	0.919	J	1.29	J	30.2		49.8	
Dioxins/Furans	1,2,3,7,8,9-HXCDF	pg/g	0.249	U	4.51		1.84	J	9.13		59.6	
Dioxins/Furans	1,2,3,7,8-PECDD	pg/g	0.342	J	0.848		0.932	J	10.5		33.9	
Dioxins/Furans	1,2,3,7,8-PECDF	pg/g	0.435	J	9.63		16.6		34.9		59.6	
Dioxins/Furans	2,3,4,6,7,8-HXCDF	pg/g	2.27	J	7.29		5.18		43.1		329	
Dioxins/Furans	2,3,4,7,8-PECDF	pg/g	2.74	J	19.2		20.8		96.5		367	
Dioxins/Furans	2,3,7,8-TCDD	pg/g	0.143	J	0.407	J	0.61		4.97		5.96	
Dioxins/Furans	2,3,7,8-TCDF	pg/g	1.88		15.8		37.3		82.4		128	
Dioxins/Furans	HPCDD (Total)	pg/g	30.7		68.3		47		2290		2680	
Dioxins/Furans	HPCDF (Total)	pg/g	10.3		126	J	56.9	J	788		13100	J
Dioxins/Furans	HXCDD (Total)	pg/g	6.21		15.6		23.7		388		852	
Dioxins/Furans	HXCDF (Total)	pg/g	29.3		115		76.6		726	J	6860	J
Dioxins/Furans	OCDD	pg/g	118		575		138		7770	J	9870	J
Dioxins/Furans	OCDF	pg/g	6.62		213		53.4		492		3650	
Dioxins/Furans	PECDD (Total)	pg/g	1.73		2.5		5		57.9		196	
Dioxins/Furans	PECDF (Total)	pg/g	29.7		130	J	168		1020	J	4380	J
Dioxins/Furans	TCDD (Total)	pg/g	0.918		2.39		3.29		42.3		73.1	
Dioxins/Furans	TCDF (Total)	pg/g	18.6		125		275		955	J	2210	J
Dioxins/Furans	Total Dioxins	pg/g	157.558		663.79		216.99		10548.2		13671.1	
Dioxins/Furans	Total Furans	pg/g	94.52		709		629.9		3981		30200	

Table 28: Summary of analytical results for parameters detected in pore water samples used for TIE testing.

Parameter Group	Parameter	Units	Site 398 20-Sep-99		Site 019 17-Sep-99		Site 428 21-Sep-99		Site 389 16-Sep-99		Site 031 15-Sep-99	
Organic	Total Organic Carbon (TOC)	mg/L	13.9		11.5		11.7		138		22.1	
Inorganics	Ammonia as N	mg/L	0.4		2		1		20.3		14.9	
Inorganics	pH	pH	8.1		7.3		7.7		7.1		7.1	
PCBs	Aroclor 1254	ug/L	0.025	UJ	0.22	J	0.14	J	21		29	
PCBs	Aroclor 1260	ug/L	0.025	J	1.4		1		160		72	
PCBs	PCB, Total	ug/L	0.025	J	1.6	J	1.1	J	180		100	
Metals	Antimony	ug/L	8.5		3.7	U	2.7	U	3.7	U	3.7	U
Metals	Arsenic	ug/L	6.2		2.5	UJ	1.9	U	5.4	J	4.5	J
Metals	Barium	ug/L	31.6		68.3		74.4		210		162	
Metals	Beryllium	ug/L	0.6		2.4		1		1.6		3.6	
Metals	Cadmium	ug/L	0.6	U	0.9	U	0.6	U	13.7		2.1	
Metals	Chromium	ug/L	6		9.9		4.5		147		163	
Metals	Cobalt	ug/L	2	U	3.4	U	2	U	8.1		7.7	
Metals	Copper	ug/L	14.1		11.1		5.6		339		122	
Metals	Lead	ug/L	13.7		15.5		11.5		278		181	
Metals	Mercury	ug/L	0.1	U	0.1	U	0.18	U	0.95		0.6	
Metals	Nickel	ug/L	5.9		14.9		17.2		31.2		12.3	
Metals	Selenium	ug/L	2.5		2.9	UJ	2.9		2.9	UJ	2.9	UJ
Metals	Silver	ug/L	1.9	U	3.8	U	1.9	U	19.2		10.6	U
Metals	Thallium	ug/L	6.5	U	20.1	J	9.1	U	11.3	J	31.2	
Metals	Tin	ug/L	1.6	U	2.1	U	1.6	U	17.9		9.6	
Metals	Vanadium	ug/L	1.5	U	2.5	U	1.5	U	22.6		9.1	
Metals	Zinc	ug/L	17.6		28.9		18.9		486		224	
Semivolatiles	1,3,5-Trinitrobenzene	ug/L	37	R	10	R	13	R	24	U	11	R
Semivolatiles	1,3-Dichlorobenzene	ug/L	37	U	10	U	13	U	1.1	J	11	U
Semivolatiles	1,4-Dichlorobenzene	ug/L	37	U	10	U	13	U	3.2	J	0.58	J
Semivolatiles	4-Nitroquinoline-1-oxide	ug/L	37	R	10	R	13	R	24	U	11	R
Semivolatiles	Benzo(a)anthracene	ug/L	37	U	10	U	13	U	5	J	1.4	J
Semivolatiles	Benzo(a)pyrene	ug/L	37	U	10	U	13	U	5.2	J	2	J
Semivolatiles	Benzo(b)fluoranthene	ug/L	37	U	10	U	13	U	5.1	J	2	J
Semivolatiles	Benzo(ghi)perylene	ug/L	37	U	10	U	13	U	2.8	J	1.9	J
Semivolatiles	Benzo(k)fluoranthene	ug/L	37	U	10	U	13	U	5	J	1.9	J
Semivolatiles	Bis(2-ethylhexyl) phthalate	ug/L	37	U	10	U	13	U	14		11	U
Semivolatiles	Chrysene	ug/L	37	U	10	U	13	U	7.6	J	2.3	J
Semivolatiles	Diethyl phthalate	ug/L	2.6	J	0.52	J	13	U	12	U	11	U
Semivolatiles	Fluoranthene	ug/L	37	U	10	U	13	U	16	J	1.7	J

Table 28: Summary of analytical results for parameters detected in pore water samples used for TIE testing.

Parameter Group	Parameter	Units	Site 398 20-Sep-99		Site 019 17-Sep-99		Site 428 21-Sep-99		Site 389 16-Sep-99		Site 031 15-Sep-99	
Semivolatiles	Indeno(1,2,3-c,d)pyrene	ug/L	37	U	10	U	13	U	3	J	1.9	J
Semivolatiles	Phenanthrene	ug/L	37	U	10	U	13	U	11	J	11	U
Semivolatiles	P-Phenylenediamine	ug/L	37	R	10	R	13	R	24	U	11	R
Semivolatiles	Pyrene	ug/L	37	U	10	U	13	U	11	J	3.3	J
Semivolatiles	Total PAH	ug/L	37	U	10	U	13	U	71.7		18.4	
Semivolatiles	Total PAH (High MW)	ug/L	37	U	10	U	13	U	44.7		16.7	
Semivolatiles	Total PAH (Low MW)	ug/L	37	U	10	U	13	U	27		1.7	
Dioxins/Furans	1,2,3,4,6,7,8-HPCDD	pg/L			23.8		4.34		3980		2070	
Dioxins/Furans	1,2,3,4,6,7,8-HPCDF	pg/L			28.1		4.06		1130		3680	
Dioxins/Furans	1,2,3,4,7,8,9-HPCDF	pg/L			3.11	U	2.24	U	97.6		129	
Dioxins/Furans	1,2,3,4,7,8-HXCDD	pg/L			3.6	U	6.09	U	48.7		43.7	
Dioxins/Furans	1,2,3,4,7,8-HXCDF	pg/L			7.86		1.72	U	356		379	
Dioxins/Furans	1,2,3,6,7,8-HXCDD	pg/L			3.51	U	5.94	U	206		136	
Dioxins/Furans	1,2,3,6,7,8-HXCDF	pg/L			4.16		1.55	U	143		249	
Dioxins/Furans	1,2,3,7,8,9-HXCDD	pg/L			3.3	U	5.6	U	110		67.3	
Dioxins/Furans	1,2,3,7,8,9-HXCDF	pg/L			2.53	U	2	U	47.5		71.9	
Dioxins/Furans	1,2,3,7,8-PECDD	pg/L			1.59	U	1.46	U	79.1		126	
Dioxins/Furans	1,2,3,7,8-PECDF	pg/L			4.66		2	U	179		145	
Dioxins/Furans	2,3,4,6,7,8-HXCDF	pg/L			4.56		1.81	U	179		375	
Dioxins/Furans	2,3,4,7,8-PECDF	pg/L			7.82		1.95	U	411		542	
Dioxins/Furans	2,3,7,8-TCDD	pg/L			3.01	U	4.28	U	12.7		10.3	
Dioxins/Furans	2,3,7,8-TCDF	pg/L			6.24		3.19	U	703		321	
Dioxins/Furans	HPCDD (Total)	pg/L			46.2		4.34		8120		4370	
Dioxins/Furans	HPCDF (Total)	pg/L			49.6		7.62		2650		6970	
Dioxins/Furans	HXCDD (Total)	pg/L			3.6	U	6.09	U	1900		1310	
Dioxins/Furans	HXCDF (Total)	pg/L			57.1		2	U	3350		7860	
Dioxins/Furans	OCDD	pg/L			168		51.8	U	23500		13200	
Dioxins/Furans	OCDF	pg/L			29.6		8.59	U	2440		2650	
Dioxins/Furans	PECDD (Total)	pg/L			1.59	U	1.7		236		372	
Dioxins/Furans	PECDF (Total)	pg/L			78		2	U	4800		6500	
Dioxins/Furans	TCDD (Total)	pg/L			3.01	U	4.28	U	168		179	
Dioxins/Furans	TCDF (Total)	pg/L			51.9		3.19	U	7040		5810	
Dioxins/Furans	Total Dioxins	pg/L			214.2		6.04		33924		19431	
Dioxins/Furans	Total Furans	pg/L			266.2		7.62		20280		29790	

Table 29: Total PCB, total PAH and metals levels relative to consensus-based Sediment Quality Quidelines (SQG) and Water Quality Criteria (WQC) for sediments and extracted pore water used for TIE testing.

		Site 389 (TIE Sample 772)		Site 031 (TIE Sample 771)	
Group	**Compound**	**SQG[a]**	**WQC[b]**	**SQG**	**WQC**
Total PCBs		>EEC	>A	>EEC	>A
Total PAHs		<TEC	NA[c]	<TEC	NA
Metals	Arsenic	<TEC		TEC-PEC	
	Cadmium	>PEC	>A	>PEC	
	Chromium	>PEC	>A	>PEC	>A
	Copper	>PEC	>A	>PEC	>A
	Lead	>PEC	>A	>PEC	C-A
	Mercury	TEC-PEC[d]	C-A[d]	>PEC	C-A
	Nickel	TEC-PEC		TEC-PEC	
	Zinc	TEC-PEC	>A	>PEC	

[a]Consensus-based SQGs for Total PAHs (Swartz 1999), Total PCBs (MacDonald *et al.* 2000a) and metals (MacDonald *et al.* 2000b):
PCBs = Threshold Effect Concentration (TEC), Midrange Effect Concentration (MEC) or Extreme Effect Concentration (EEC)
PAHs = Threshold Effect Concentration (TEC) or Probable Effects Concentration (PEC)

[b]WQC (USEPA 1987):
Freshwater values = Acute Criteria (A) or Chronic Criteria (C)

[c]NA = no available WQC for Total PAHs

[d]Chemical concentration lies between the noted SQGs or WQCs

Table 30: Summary of analytical results for other contaminants detected in sediments from the 7-d *in situ* test.

Parameter[1]	Units	Site ID					
		011	398	019	428	389	031
Metals							
Antimony	mg/Kg	<0.57	<0.61	<0.57	2.0	<0.44	0.94
Arsenic	mg/Kg	<1.9	<1.7	3.9	<5.5	<1.8	4.4
Barium	mg/Kg	21.1	16.7	42.6	95.7	12.5	71.8
Beryllium	mg/Kg	0.29	0.21	0.45	0.78	0.26	0.73
Cadmium	mg/Kg	<0.04	<0.05	<0.4	1.6	<0.03	0.77
Chromium	mg/Kg	5.3	11.9	36.2	86.3	10.7	55.1
Cobalt	mg/Kg	4.7	6.9	7.6	14.6	5.9	12
Copper	mg/Kg	6.3	9.2	27.1	94.4	9.1	70.4
Lead	mg/Kg	5.4	12.9	303	111	11.4	81.2
Mercury	mg/Kg	<0.02	0.03	0.14	0.84	<0.02	0.43
Nickel	mg/Kg	8.6	11.8	14.1	26.4	11.3	21
Thallium	mg/Kg	0.57	0.35	0.59	2	0.69	3.4
Tin	mg/Kg	<0.66	<2.2	8.1	<10	<1.5	<6.9
Vanadium	mg/Kg	6.4	7.1	12.8	24.4	7.6	19.8
Zinc	mg/Kg	43.9	73.1	140	275	61.6	196
Semi-Volatile Organic Compounds (SVOCs)							
Benzo(a)anthracene	mg/Kg	0.074	2.6	4.9	0.18	20	0.15
Benzo(a)pyrene	mg/Kg	0.052	1.4	3.8	0.23	15	0.18
Benzo(b)fluoranthene	mg/Kg	0.061	1.6	5.1	0.25	14	0.2
Benzo(ghi)perylene	mg/Kg	0.03	0.47	1.5	0.15	4.9	0.12
Benzo(k)fluoranthene	mg/Kg	0.052	0.9	2.3	0.3	12	0.22
Chrysene	mg/Kg	0.079	1.8	4.2	0.23	14	0.2
Dibenzo(a,h)anthracene	mg/Kg	<0.38	0.2	0.56	<0.86	2.3	<0.7
Fluoranthene	mg/Kg	0.12	3.1	9.7	0.41	40	0.31
Pyrene	mg/Kg	0.19	3.7	10	0.64	36	0.53
Indeno(1,2,3-c,d)pyrene	mg/Kg	0.029	0.44	1.5	0.13	5	0.1
Acenaphthene	mg/Kg	<0.38	0.064	0.77	<0.86	3.9	<0.7
Acenaphthylene	mg/Kg	<0.38	0.14	<2.1	0.039	4.3	<0.7
Anthracene	mg/Kg	0.02	0.84	1.9	0.049	14	0.036
Fluorene	mg/Kg	<0.38	<0.85	0.89	<0.86	10	<0.7
Naphthalene	mg/Kg	<0.38	0.14	0.47	0.062	6	0.038
Phenanthrene	mg/Kg	0.096	1.8	9.4	0.25	54	0.21
2-Methylnaphthalene	mg/Kg	<0.38	<0.85	<2.1	<0.86	2.2	<0.7
1,2,4-Trichlorobenzene	mg/Kg	<0.38	<0.85	<2.1	<0.86	0.16	<0.7
1,4-Dichlorobenzene	mg/Kg	<0.38	0.041	<2.1	0.11	0.11	0.062
Acetophenone	mg/Kg	<0.38	<0.85	<2.1	<0.068	<2	0.7
Bis(2-ethylhexyl) phthalate	mg/Kg	<0.38	<0.85	0.22	0.2	<2	0.14
Dibenzofuran	mg/Kg	<0.38	0.066	0.57	<0.86	5	<0.7
Pesticides							
4,4'-DDD	mg/Kg	<0.004	<0.44	0.023	<0.44	<0.41	<0.36
Dioxins							
Tetra CDD	pg/g	0.371	2.11	0.842	58.4	1.64	48.2
Penta CDD	pg/g	<0.1	1.55	1.44	31.8	<0.21	16.2
Hexa CDD	pg/g	<0.15	11.4	16.3	184	4.84	124
Hepta CDD	pg/g	2.18	36.1	50.3	622	18.5	404
Octa CDD	pg/g	10.2	162	144	2044	84.5	1434
Total CDD	pg/g	12.751	213.16	212.882	2940.2	109.48	2026.4
Furans							
Tetra CDF	pg/g	0.489	164	41.2	1707	106	1970
Penta CDF	pg/g	0.465	83.8	54.6	1058	39.5	1230
Hexa CDF	pg/g	1.06	72	75.8	774	36.3	769
Hepta CDF	pg/g	1.45	58	21.7	679	30.3	386
Octa CDF	pg/g	<0.72	46.1	10.6	524	33.5	183
Total CDF	pg/g	3.464	423.9	203.9	4742	245.6	4538
Total CDD and CDF	pg/g	16.215	637.06	416.782	7682.2	355.08	6564.4
Substituted Dioxins and Furans							
2378 TCDD	pg/g	0.371	<0.26	0.284	2.27	<0.21	2.66
12378 PcCDD	pg/g	<0.1	<0.45	0.827	4.2	<0.22	3.39
123478 HxCDD	pg/g	<0.15	0.49	0.595	6.8	<0.47	4.68
123678 HxCDD	pg/g	<0.15	1.11	1.63	21.3	<0.56	14.4
123789 *HxCDD	pg/g	<0.16	0.541	2.24	11.9	<0.54	8.08
1234678 HpCDD	pg/g	1.21	18	22.2	329	9.19	220
OCDD	pg/g	10.2	162	144	2044	84.5	1434
2378 *TCDF	pg/g	0.164	18.9	3.03	117	10.6	215
12378*PeCDF	pg/g	<0.11	8.35	0.762	59.1	4.82	127
23478 *PeCDF	pg/g	<0.13	11.8	1.56	105	6.35	161
123478 *HxCDF	pg/g	<0.095	15.3	2.86	90.8	9.32	131
123678 *HxCDF	pg/g	<0.073	4.86	1.88	39.6	2.59	58.8
234678 *HxCDF	pg/g	<0.086	2.93	2.67	28.6	1.44	34.1
123789 *HxCDF	pg/g	<0.092	0.22	0.157	1.25	<0.17	4.59
1234678 HpCDF	pg/g	0.606	25.7	9.22	333	11.3	178
1234789 HpCDF	pg/g	<0.23	5.49	0.795	20.5	3.04	19.9
OCDF	pg/g	<0.72	46.1	10.6	254	33.5	183

1. The following parameters were analysed but were undetected in any of the sediment samples.

Metals: selenium, silver.

Pesticides and Herbicides: 4,4'-DDE, 4,4'-DDT, Aldrin, alpha-BHC, beta-BHC, Chlordane, delta-BHC, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, gamma BHC (Lindane), Heptachlor, Heptachlor epoxide, Isodrin, Kepone, Methoxychlor, Toxaphene, Dimethoate, Disulfoton, Famphur, O,O,O-Triethylphosphorothioate, Ethyl parathion, Methyl parathion, Phorate, Sulfotep, Zinophos, 2,4,5-T, 2,4,5-TP (Silvex), 2,4-D.

SVOCs: 1,2,4,5-Tetrachlorobenzene, 1,2-Dichlorobenzene, 1,3,5-Trinitrobenzene, 1,3-Dichlorobenzene, 1,3-Dinitrobenzene, 1,4-Naphthoquinone, 1-Naphthylamine, 2,3,4,6-Tetrachlorophenol, 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol, 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2,4-Dinitrotoluene, 2,6-Dichlorophenol, 2,6-Dinitrotoluene, 2-Acetylaminofluorene, 2-Chloronaphthalene, 2-Chlorophenol, 2-Methylphenol (o-Cresol), 2-Naphthylamine, 2-Nitroaniline, 2-Nitrophenol, 2-Picoline (alpha-Picoline), 3,3'-Dichlorobenzidine, 3,3'-Dimethylbenzidine, 3-Methylchloranthrene, 3-Nitroaniline, 4,6-Dinitro-2-methylphenol, 4-Aminobiphenyl, 4-Bromophenyl phenyl ether, 4-Chloro-3-methylphenol, 4-Chloroaniline, 4-Chlorophenyl phenyl ether, 4-Methylphenol, 4-Nitroaniline, 4-Nitrophenol, 4-Nitroquinoline-1-oxide, 5-Nitro-o-toluidine, 7,12-Dimethylbenz(a)anthracene, A,A-Dimethylphenethylamine, Aniline, Aramite, Azobenzene, Benzyl alcohol, Bis(2-Chloroethoxy) methane, Bis(2-Chloroethyl) ether, Bis(2-Chloroisopropyl) ether, Butylbenzylphthalate, Chlorobenzilate, Diallate, Diethyl phthalate, Dimethyl phthalate,

Di-n-butyl phthalate, Di-n-octyl phthalate, Dinoseb, Ethyl methanesulfonate, Hexachlorobenzene, Hexachlorobutadiene, Hexachlorocyclopentadiene, Hexachloroethane, Hexachloropropene, Isophorone, Isosafrole, Methapyrilene, Methyl methanesulfonate, Nitrobenzene, Nitrosomethylethylamine, n-Nitrosodiethylamine, n-Nitrosodimethylamine, n-Nitroso-di-n-butylamine, n-Nitroso-di-n-propylamine, n-Nitrosodiphenylamine, n-Nitrosomorpholine, n-Nitrosopiperidine, n-Nitrosopyrrolidine, o-Toluidine, p-Dimethylaminoazobenzene, Pentachlorobenzene, Pentachloroethane, Pentachloronitrobenzene, Pentachlorophenol, Phenacetin, Phenol, p-Phenylenediamine, Pronamide, Pyridine, Safrole.

Table 31: Summary of analytical results for other contaminants detected in overlying water from the 7-d *in situ* test.

Parameter[1]	Units	Site ID					
		011	398	019	428	389	031
Metals							
Arsenic	mg/L	ND	ND	ND	ND	0.0031	ND
Barium	mg/L	0.0203	ND	0.0207	0.0212	0.0215	0.0199
Calcium	mg/L	32.2	34.4	38.3	38.9	35.8	35.3
Copper	mg/L	ND	ND	ND	ND	0.005	0.0057
Magnesium	mg/L	12.7	11.1	15.5	15.9	14.4	14.1
Mercury	mg/L	ND	ND	0.0001	ND	ND	ND
Tin	mg/L	ND	ND	ND	ND	0.0023	ND
Vanadium	mg/L	ND	ND	ND	0.0030	0.0035	0.0041
Zinc	mg/L	0.0045	0.0032	0.0031	0.0049	0.0090	0.0071
Semi-Volatile Organic Compounds							
Acetophenone	mg/L	ND	ND	ND	0.002	ND	ND
Bis(2-ethylhexyl) phthalate	mg/L	ND	ND	ND	ND	ND	0.001
Diethyl phthalate	mg/L	ND	ND	ND	0.0007	ND	ND
Pesticides							
delta-BHC	mg/L	ND	ND	ND	ND	0.0001	ND
Herbicides							
2,4,5-T (Trichlorophenoxyacetic acid)	mg/L	0.0001	ND	ND	ND	ND	ND
Furans							
Tetra CDF	pg/L	ND	ND	52.1	83.3	71.6	58.2
Penta CDF	pg/L	ND	5.94	16.6	39.1	39.2	23.1
Hexa CDF	pg/L	ND	ND	ND	ND	12.7	8.77
Hepta CDF	pg/L	ND	ND	ND	ND	ND	ND
Octa CDF	pg/L	ND	ND	ND	ND	ND	ND
Total CDF	pg/L	0	5.94	68.7	122.4	123.5	90.07
Substituted Furans							
2378 *TCDF	pg/L	ND	ND	3.36	4.64	9.97	5.43

ND = Not detected

1. The following parameters were analysed but were undetected in any of the water samples.

Inorganics and Metals: Cyanide, Sulfide, Antimony, Beryllium, Cadmium, Chromium, Cobalt, Lead, Nickel, Selenium, Silver, Thallium.

Pesticides and Herbicides: 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, Aldrin, alpha-BHC, beta-BHC, Chlordane, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Endrin aldehyde, gamma BHC (Lindane), Heptachlor, Heptachlor epoxide, Isodrin, Kepone, Methoxychlor, Toxaphene, Dimethoate, Disulfoton, Famphur, O,O,O-Triethylphosphorothioate, Ethyl parathion, Methyl parathion, Phorate, Sulfotep, Zinophos, 2,4,5-TP (Silvex), 2,4-D.

SVOCs: 1,2,4,5-Tetrachlorobenzene, 1,2,4-Trichlorobenzene 1,2-Dichlorobenzene, 1,3,5-Trinitrobenzene, 1,3-Dichlorobenzene, 1,3-Dinitrobenzene, 1,4-Naphthoquinone, 1-Naphthylamine, 1-Naphthylamine 2,3,4,6-Tetrachlorophenol, 2,4,5-Trichlorophenol, 2,4,6-Trichlorophenol, 2,4-Dichlorophenol, 2,4-Dimethylphenol, 2,4-Dinitrophenol, 2,4-Dinitrotoluene, 2,6-Dichlorophenol, 2,6-Dinitrotoluene, 2-Acetylaminofluorene, 2-Aminonaphthalene 2-Chloronaphthalene, 2-Chlorophenol, 2-Methylnaphthalene 2-Methylphenol Cresol), 2-Nitroaniline, 2-Nitrophenol, 2-Picoline (alpha-Picoline), 3,3'-Dichlorobenzidine, 3,3'-Dimethylbenzidine, 3-Methylchloranthrene, 3-Nitroaniline, 4,6-Dinitro-2-methylphen 4-Aminobiphenyl, 4-Bromophenyl phenyl ether, 4-Chloro-3-methylphenol, 4-Chloroaniline, 4-Chlorophenyl phenyl ether, 4-Methylphenol, 4-Nitroaniline, 4-Nitrophenol, 4-Nitroquinoline-1-oxide, 5-Nitro-o-toluidine,

7,12-Dimethylbenz(a)anthracene, Acenaphthene, Acenaphthylene, A,A-Dimethylphenethylamine, Aniline, Anthracene, Aramite, Azobenzene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(ghi)perylene, Benzo(k)fluoranthene, Benzyl alcohol, Bis(2-Chloroethoxy) methane, Bis(2-Chloroethyl) ether, Bis(2-Chloroisopropyl) ether, Butylbenzylphthalate, Chlorobenzilate, Chrysene, Diallate, Dibenzo(a,h)anthracene, Dibenzofuran, Dimethyl phthalate, Di-n-butyl phthalate, Di-n-octyl phthalate, Dinoseb, Ethyl methanesulfonate, Fluoranthene, Fluorene, Hexachlorobenzene, Hexachlorobutadiene, Hexachlorocyclopentadiene, Hexachloroethane, Hexachloropropene, Indeno(1,2,3-c,d)pyrene, Isophorone, Isosafrole, Methapyrilene, Methyl methanesulfonate,

Naphthalene, Nitrobenzene, Nitrosomethylethylamine, n-Nitrosodiethylamine, n-Nitrosodimethylamine, n-Nitroso-di-n-butylamine, n-Nitroso-di-n-propylamine, n-Nitrosodiphenylamine, n-Nitrosomorpholine, n-Nitrosopiperidine, n-Nitrosopyrrolidine, o-Toluidine, p-Dimethylaminoazobenzene, Pentachlorobenzene, Pentachloroethane, Pentachloronitrobenzene, Pentachlorophenol, Phenacetin, Phenanthrene, Phenol, p-Phenylenediamine, Pronamide, Pyrene, Pyridine, Safrole.

Dioxins and Furans: TCDD (total), PeCDD (total), HxCDD (total), HpCDD (total), OCDD, 2378 TCDD, 12378 PcCDD, 123478 HxCDD, 123678 HxCDD, 123789 HxCDD, 1234678 HpCDD, 12378 PeCDF, 23478 PeCDF, 123478 HxCDF, 123678 HxCDF, 234678 HxCDF, 123789 HxCDF, 1234678 HpCDF, 1234789 HpCDF, HpCDF (total), OCDF.

Table 32: Sediment Quality Guideline (SQG) or Water Quality Criteria (WQC) exceedances for samples from the 48-h, 7-d and 10-d *in situ* tests.

Guidelines/ Criteria	Test	Group	Compound	Site (Upstream to Downstream) 398	011	019	428	389	031
Sediment Quality Guidelines (SQGs)[a]	7-d	PAHs	Total PAHs (mg/Kg OC)		TEC-MEC[f]	MEC-EEC		<TEC[b]	
		Metals	Arsenic						
			Cadmium				TEC-PEC		
			Mercury	TEC-PEC[f]		<TEC[b]	TEC-PEC		TEC-PEC
			Chromium				TEC-PEC		TEC-PEC
			Copper				TEC-PEC		TEC-PEC
			Lead			>PEC	TEC-PEC		TEC-PEC
			Nickel				TEC-PEC		<TEC[b]
			Zinc				TEC-PEC		TEC-PEC
		CBnz[c]	1,4-DiCBnz	>ECT, >NY-A			>ECT, >NY-A	>ECT, >NY-A	>ECT, >NY-A
			1,2,4-TriCBnz					>ECT, >NY-A	
		PCBs	Total (mg/Kg)	>EEC		TEC-MEC	>EEC	>EEC	>EEC
	48-h	PCBs	Total (mg/Kg)	MEC-EEC		MEC-EEC[f]	>EEC	>EEC	>EEC
	10-d	PCBs	Total (mg/Kg)			>EEC	MEC-EEC	>EEC	>EEC
Water Quality Criteria (WQC)[d]	48-h	PCBs	Total (ug/L)			C-A[f]	C-A	C-A	C-A
	7-d Surface Water	PCBs	Total (ug/L)			C-A	C-A	C-A	C-A
	7-d Pore Water[e]	PCBs	Total (ug/L)				C-A		C-A
	10-d	PCBs	Total (ug/L)			C-A	C-A	C-A	C-A

[a]SQG definitions (MacDonald *et al.* 2000a; MacDonald *et al.* 2000b; Swartz 1999; USEPA 1996; NYDEC 1994):
TEC = Threshold Effect Conmcentration
MEC = Median Effect Concentration
EEC = Extreme Effect Concentration
PEC = Probable Effect Concentration
ECT = Ecotox Thresholds
NY-A = New York Department of Environ. Conservation Acute *and* Chronic Sediment values exceeded

[b]Approaches or is very near noted SQG

[c]CBnz = chlorinated benzenes

[d]WQC definitions (USEPA 1986, 1987):
A = Acute Criteria (no exceedances)
C = Chronic Criteria

[e]pore water concentrations estimated using equilibrium partitioning (see Table 21)

[f]Concentration lies between noted SQG or WQC

Appendix 1: Weekly water chemistry measurements for the 42-d *Hyalella azteca* life-cycle assessment exposure to six Housatonic River sediments and one control sediment (27 May - 8 July 1999).

Date	Treatment	Temperature (^{0}C)	pH	Conductivity (umhos/cm)	DO (mg/L)	Alkalinity (mg/L)	Total NH_3 (mg/L)	Hardness (mg/L)
27-May-99	Trout Farm	22.4	8.15	400	7.6	164	2.180	210
	398	23.0	8.26	320	7.4	120	0.398	169
	11	22.0	8.31	330	7.4	136	0.252	173
	19	21.7	8.21	325	7.5	108	0.472	167
	23	21.7	8.21	290	7.7	128	0.838	156
	31	22.4	8.15	285	7.5	104	1.230	139
	389	22.5	8.13	325	7.2	128	2.270	156
8-Jun-99	Trout Farm	22.9	7.99	360	7.3	160	0.306	213
	398	22.7	8.17	250	7.2	152	0.308	193
	11	23.4	8.29	350	7.3	140	0.184	191
	19	23.7	8.15	360	7.2	136	0.161	185
	23	23.1	8.24	350	7.4	136	0.130	177
	31	23.2	8.12	310	7.0	132	0.128	177
	389	23.2	8.09	300	7.3	136	0.113	173
15-Jun-99	Trout Farm	22.2	8.40	390	7.4	176	0.184	228
	398	22.2	8.27	290	7.4	148	0.224	195
	11	22.8	8.39	310	7.6	132	0.184	187
	19	22.9	8.34	310	7.5	128	1.020	175
	23	22.8	8.34	300	7.8	128	0.111	175
	31	22.8	8.14	300	7.1	116	0.158	167
	389	22.7	8.23	300	7.0	124	0.234	179
22-Jun-99	Trout Farm	21.6	8.39	390	6.1	172	0.169	227
	398	21.5	8.28	350	6.2	148	0.258	197
	11	21.7	8.26	350	6.4	138	0.308	187
	19	22.1	8.24	330	6.2	134	0.234	185
	23	21.9	8.30	370	6.3	122	0.313	182
	31	22.2	8.24	300	6.0	124	0.127	170
	389	22.1	8.29	330	6.1	136	0.180	183
24-Jun-99	Trout Farm	23.0	8.34	395	7.5	173	0.173	211
	398	23.0	8.26	340	7.5	140	0.449	175
	11	24.0	8.29	315	7.5	128	0.215	182
	19	26.0	8.30	310	7.3	120	0.202	187
	23	24.0	8.26	330	7.3	92	0.123	175
	31	23.0	8.21	305	7.2	124	0.110	175
	389	23.0	8.09	300	7.0	124	0.134	163

Date	Treatment	Temperature (^{0}C)	pH	Conductivity (umhos/cm)	DO (mg/L)	Alkalinity (mg/L)	Total NH_3 (mg/L)	Hardness (mg/L)
1-Jul-99	Trout Farm	22.5	8.21	330	7.5	160	1.370	172
	398	22.5	8.36	310	7.5	152	0.793	184
	11	23.0	8.37	300	7.4	136	0.706	168
	19	23.0	8.36	300	7.5	132	0.689	172
	23	23.5	8.40	310	7.4	136	0.925	172
	31	23.5	8.35	310	7.5	132	0.627	168
	389*	-	-	-	-	-	-	-
8-Jul-99	Trout Farm	23.0	8.07	310	6.8	128	0.012	177
	398	23.0	8.16	300	7.0	120	0.009	165
	11	23.0	8.12	300	6.8	120	0.008	165
	19	23.0	8.21	300	7.0	124	0.006	161
	23	23.0	8.21	290	7.0	116	0.006	165
	31	23.0	8.23	300	7.0	100	0.005	157
	389*	-	-	-	-	-	-	-

*The Site 389 treatment was not continued beyond June 25 due to 100% mortality.

Appendix 2: Daily temperature and dissolved oxygen measurements for the 42-d *Hyalella azteca* life-cycle assessment of six Housatonic River sediments and one control sediment (27 May - 8 July 1999).

		May-99					Jun-99	
Parameter	**Site**	**27**	**28**	**29**	**30**	**31**	**1**	**2**
Temperature	Trout Farm	22.4	23.2	22.2	24.5	23.5	21.5	21.9
(^{o}C)	398	23.0	22.7	21.8	24.5	23.3	21.5	21.9
	11	22.0	23.4	22.2	25.0	22.8	21.5	21.4
	19	21.7	22.9	21.8	24.5	23.8	21.5	22.4
	23	21.7	22.6	22.2	24.3	23.3	21.0	22.5
	31	22.4	22.9	21.8	24.3	23.1	21.0	22.1
	389	22.5	22.6	22.2	24.0	23.2	21.0	22.3
Dissolved	Trout Farm	7.6	7.5	7.5	4.9	7.2	8.1	8.5
Oxygen (mg/L)	398	7.4	7.5	7.6	4.7	6.9	8.1	8.5
	11	7.4	7.5	7.6	4.9	7.1	7.9	8.3
	19	7.5	7.5	7.4	4.9	6.8	8.0	8.4
	23	7.7	7.6	7.5	5.0	6.9	8.1	8.3
	31	7.5	7.5	7.4	5.0	6.9	8.1	8.2
	389	7.2	7.5	7.5	5.0	6.9	8.1	8.1

		Jun-99 continued							
		3	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Temperature	Trout Farm	22.8	24.2	22.0	24.0	22.6	22.9	22.8	23.0
(^{o}C)	398	22.6	24.2	22.1	24.1	22.5	22.7	22.6	23.5
	11	23.1	24.6	22.2	24.7	23.5	23.4	22.2	24.0
	19	23.4	24.6	22.2	24.2	23.2	23.7	23.1	24.0
	23	22.7	24.0	22.3	23.8	23.3	23.1	22.9	23.5
	31	22.5	24.0	21.7	24.2	23.1	23.2	23.0	24.0
	389	22.9	24.0	21.7	24.2	23.3	23.2	22.9	23.5
Dissolved	Trout Farm	8.3	7.9	7.0	8.0	7.6	7.3	7.4	-
Oxygen (mg/L)	398	8.2	7.6	6.8	7.8	7.7	7.2	6.6	-
	11	8.3	7.7	6.9	8.0	7.4	7.3	7.4	-
	19	8.0	7.5	6.6	8.0	7.5	7.2	7.0	-
	23	8.3	7.2	6.6	8.0	7.4	7.4	7.4	-
	31	7.9	7.0	6.5	7.9	7.3	7.0	6.6	-
	389	7.6	7.5	6.7	7.9	7.4	7.3	6.9	-

		Jun-99 continued							
		11	**12**	**13**	**15**	**16**	**17**	**18**	**19**
Temperature	Trout Farm	24.0	22.2	23.2	22.2	23.5	22.1	20.5	21.0
(^{o}C)	398	24.0	22.2	23.1	22.2	24.0	22.0	20.3	21.0
	11	22.5	22.4	23.5	22.8	25.0	22.8	21.1	21.3
	19	22.5	22.3	23.6	22.9	24.0	22.7	20.9	21.0
	23	22.5	22.4	23.6	22.8	24.5	22.5	21.0	21.0
	31	25.0	22.4	23.5	22.8	23.5	22.8	20.9	21.0
	389	25.0	22.4	23.4	22.7	24.0	22.6	21.0	21.0
Dissolved	Trout Farm	7.6	7.6	7.7	7.4	7.0	6.7	9.2	8.2
Oxygen (mg/L)	398	7.4	7.8	7.8	7.4	6.2	7.0	9.2	8.2
	11	7.7	7.9	7.9	7.6	7.2	7.1	8.8	8.2
	19	7.6	7.9	7.8	7.5	7.1	6.6	9.0	8.0
	23	7.6	7.8	7.9	7.8	7.3	7.1	9.0	7.8
	31	7.2	7.8	7.8	7.1	7.1	6.9	9.1	8.1
	389	7.6	7.8	7.8	7.0	7.0	6.9	8.9	8.2

Appendix 2: DO/Temperature (continued)

		Jun-99 continued							
		20	**21**	**22**	**23**	**24**	**25***	**26**	**27**
Temperature	Trout Farm	24.0	22.0	21.6	22.0	23.0	23	24.0	24.5
(^{o}C)	398	24.0	22.1	21.5	22.0	23.0	23	23.8	24.5
	11	24.0	22.0	21.7	22.5	24.0	24	24.5	25.0
	19	24.3	22.7	22.1	22.5	26.0	24	25.0	25.0
	23	24.3	22.5	21.9	23.0	24.0	24	24.5	25.0
	31	24.0	22.1	22.2	22.5	23.0	24	24.5	25.0
	389	24.0	22.2	22.1	22.5	23.0	-	-	-
Dissolved	Trout Farm	8.0	7.7	6.1	7.0	7.5	7.7	7.7	7.8
Oxygen (mg/L)	398	8.0	7.8	6.2	6.9	7.5	7.7	7.8	7.6
	11	8.0	7.6	6.4	7.2	7.5	7.4	7.6	7.5
	19	8.0	7.1	6.2	7.0	7.3	7.5	7.7	7.4
	23	7.5	7.6	6.3	6.6	7.3	7.5	7.7	7.5
	31	8.0	7.7	6.0	6.9	7.2	7.5	7.7	7.5
	389	7.8	7.5	6.1	-	7.0	-	-	-

		Jun-99 continued				Jul-99			
		28	**29**	**30**		**1**	**2**	**3**	**4**
Temperature	Trout Farm	23.0	23.0	22.0		22.5	22.0		24.0
(^{o}C)	398	23.0	22.5	21.0		22.5	22.0	23.0	24.0
	11	23.0	24.0	22.0		23.0	22.5	23.0	24.0
	19	24.0	24.0	22.0		23.0	22.0	23.0	24.0
	23	24.0	24.0	22.0		23.5	23.0	24.0	24.5
	31	24.0	24.0	22.0		23.5	23.0	23.0	24.5
	389	-	-	-		-	-	-	-
Dissolved	Trout Farm	7.5	8.0	6.7		7.5	7.7	7.3	7.4
Oxygen (mg/L)	398	7.5	7.9	6.0		7.5	7.8	7.5	7.6
	11	7.4	8.0	5.6		7.4	7.5	7.2	7.4
	19	7.3	8.0	5.5		7.5	7.7	7.4	7.5
	23	7.3	7.9	5.4		7.4	7.7	7.4	7.5
	31	7.3	8.0	5.4		7.5	7.6	7.3	7.4
	389	-	-	-		-	-	-	-

		Jul-99 cont.			
		5	**6**	**7**	**8**
Temperature	Trout Farm	24.5	24.0	23.0	23.0
(^{o}C)	398	24.5	24.0	23.0	23.0
	11	24.5	24.0	23.0	23.0
	19	24.5	23.5	23.0	23.0
	23	24.8	24.0	23.0	23.0
	31	24.8	24.0	23.0	23.0
	389	-	-	-	-
Dissolved	Trout Farm	8.5	7.7	7.5	6.8
Oxygen (mg/L)	398	8.4	7.8	7.7	7.0
	11	8.3	7.8	7.4	6.8
	19	10.4	7.8	7.6	7.0
	23	8.9	7.8	7.5	7.0
	31	9.3	7.8	7.5	7.0
	389	-	-	-	-

*The Site 389 treatment was not continued beyond June 25 due to 100% mortality.

Appendix 3: Weekly water chemistry measurements for the 42-d *Chironomus tentans* life-cycle assessment exposure to six Housatonic River sediments and three control sediments (9 July - 20 August 1999).

Date	Sample	Temperature (^{0}C)	pH	Conductivity (umhos/cm)	D.O. (mg/L)	Alkalinity (mg/L)	Total NH_3 (mg/L)	Hardness (mg/L)
9-Jul-99	Trout Farm	21.8	7.78	340	3.90	136	0.006	193
	Florrisant	21.2	7.70	330	7.60	112	0.000	189
	α–Cellulose	21.2	8.23	350	8.10	166	0.000	177
	398	21.5	7.89	350	6.70	154	0.001	195
	11	21.5	8.25	300	8.05	128	0.000	181
	19	21.5	7.78	300	6.65	116	0.000	179
	23	21.8	7.65	310	6.60	116	0.000	175
	31	21.6	7.45	290	6.30	102	0.000	151
	389	22.0	7.68	340	6.30	132	0.004	169
16-Jul-99	Trout Farm	22.0	8.18	325	7.60	164	0.350	177
	Florrisant	23.0	8.22	325	8.10	120	0.054	169
	α–Cellulose	22.5	8.26	300	8.10	140	0.056	177
	398	22.5	8.26	340	7.80	140	0.010	181
	11	23.0	8.25	400	7.80	136	0.039	173
	19	23.0	8.25	310	7.70	120	0.007	169
	23	23.5	8.25	300	7.50	116	0.009	169
	31	23.0	8.23	280	7.70	100	0.008	157
	389	23.0	8.28	300	7.70	116	0.008	161
23-Jul-99	Trout Farm	23.0	8.23	350	6.75	160	3.470	180
	Florrisant	23.0	8.19	330	6.70	136	1.320	168
	α–Cellulose	23.0	8.23	340	7.00	148	0.794	184
	398	23.0	8.26	360	7.22	148	0.231	200
	11	24.0	8.26	360	7.50	140	0.118	180
	19	24.0	8.23	345	7.41	136	0.251	184
	23	24.0	8.28	320	7.35	128	0.117	176
	31	24.0	8.26	310	7.33	120	0.105	160
	389	24.0	8.31	330	7.26	136	0.072	172
30-Jul-99	Trout Farm	23.0	8.10	350	7.52	122	5.160	184
	Florrisant	22.5	8.08	320	7.50	106	0.628	160
	α–Cellulose	22.6	8.16	330	7.64	128	0.741	168
	398	22.7	8.27	340	7.76	120	0.427	188
	11	22.7	8.20	310	7.43	124	0.315	164
	19	22.9	8.18	330	7.56	104	0.120	168
	23	22.8	8.14	320	7.54	104	0.078	164
	31	22.9	8.16	310	7.64	101	0.078	156
	389	23.0	8.21	320	7.60	108	0.084	164

Date	Treatment	Temperature (^{0}C)	pH	Conductivity (umhos/cm)	DO (mg/L)	Alkalinity (mg/L)	Total NH_3 (mg/L)	Hardness (mg/L)
6-Aug-99	Trout Farm	23.0	7.91	310	6.82	108	0.386	160
	Florrisant	23.0	8.01	300	7.21	112	1.240	160
	α–Cellulose	23.0	7.89	310	6.38	124	0.959	168
	398	23.0	8.01	310	7.19	120	0.386	168
	11	23.0	8.13	305	7.28	108	0.290	160
	19	23.0	8.06	295	7.20	104	0.260	160
	23	24.0	8.06	290	7.37	100	0.184	152
	31	23.0	8.08	295	7.41	104	0.140	148
	389	24.0	8.21	300	7.39	108	0.117	160
13-Aug-99	Trout Farm	23.0	8.27	325	7.46	120	0.337	170
	Florrisant	23.0	8.13	325	7.12	128	0.382	166
	α–Cellulose	23.0	8.07	350	6.84	144	0.469	182
	398	23.0	8.18	325	7.46	140	0.670	174
	11	23.0	8.18	310	7.67	108	1.020	162
	19	23.0	8.23	325	7.36	116	0.518	182
	23	23.0	8.28	300	7.46	108	0.347	150
	31	23.0	8.28	300	7.25	108	0.390	162
	389	23.0	8.33	325	7.04	168	0.378	162
20-Aug-99	Trout Farm	23.0	8.33	380	7.39	144	0.107	194
	Florrisant	23.0	8.18	400	7.52	132	0.489	194
	α–Cellulose	23.0	8.19	400	6.90	176	0.140	234
	398	22.5	8.33	390	7.40	140	0.225	198
	11	23.0	8.33	375	7.44	136	0.189	190
	19	23.0	8.33	380	7.38	132	0.106	194
	23	23.0	8.31	350	7.39	132	0.075	182
	31	23.0	8.27	310	7.22	124	0.062	182
	389	23.0	8.34	380	7.30	140	0.048	198

Appendix 4: Daily temperature and dissolved oxygen measurements for the 42-d *Chironomus tentans* life-cycle assessment of six Housatonic River sediments and three control sediments (9 July - 19 August 1999).

		Jul-99							
Parameter	Site	9	10	11	12	13	14	15	16
Temperature	Trout Farm	21.8	22.0	21.0	21.0	22.0	22.0	22.0	22.0
(°C)	Florrisant	21.2	22.0	20.8	20.8	22.0	22.0	22.0	23.0
	α–Cellulose	21.2	22.0	21.0	21.0	22.0	22.0	21.5	22.5
	398	21.5	22.5	22.0	22.0	22.0	23.0	22.0	22.5
	11	21.5	22.5	22.3	22.3	22.0	23.0	22.0	23.0
	19	21.5	23.0	22.5	22.5	23.0	23.0	23.0	23.0
	23	21.8	23.0	22.5	22.5	23.0	23.0	23.0	23.5
	31	21.6	23.0	23.0	23.0	23.0	23.0	23.0	23.0
	389	22.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0
Dissolved	Trout Farm	3.90	7.70	7.50	7.50	7.50	7.10	7.40	7.60
Oxygen (mg/L)	Florrisant	7.60	7.70	7.90	7.90	7.70	7.40	7.90	8.10
	α–Cellulose	8.10	7.90	7.90	7.90	7.80	7.50	7.80	8.10
	398	6.70	7.85	7.70	7.70	7.70	7.50	7.60	7.80
	11	8.05	8.00	8.25	8.25	7.40	7.60	7.70	7.80
	19	6.65	7.90	7.85	7.85	7.70	7.00	7.60	7.70
	23	6.60	7.90	7.70	7.70	7.70	7.20	7.60	7.50
	31	6.30	7.80	7.60	7.60	7.70	7.20	7.60	7.70
	389	6.30	7.80	7.50	7.50	7.80	7.10	7.60	7.70

		Jul-99 continued							
		17	18	19	20	21	22	23	24
Temperature	Trout Farm	21.0	22.0	23.0	21.0	22.0	22.0	23.0	23.5
(°C)	Florrisant	21.0	22.0	22.9	21.0	22.0	23.0	23.0	23.5
	α–Cellulose	21.0	22.0	22.0	21.5	22.0	23.0	23.0	23.6
	398	22.0	23.0	23.0	22.0	23.0	23.0	23.0	24.1
	11	22.0	22.0	24.0	22.5	23.0	24.0	24.0	24.2
	19	22.0	23.0	23.2	22.5	24.0	23.0	24.0	24.1
	23	22.0	23.0	23.9	22.5	24.0	24.0	24.0	24.1
	31	22.0	23.0	21.9	22.5	24.0	24.0	24.0	24.1
	389	22.0	23.0	23.0	22.5	24.0	24.0	24.0	24.1
Dissolved	Trout Farm	-	-	6.77	6.72	7.10	6.89	6.75	6.83
Oxygen (mg/L)	Florrisant	-	-	7.50	7.36	7.93	7.15	6.70	6.94
	α–Cellulose	-	-	7.76	7.23	7.62	7.10	7.00	6.74
	398	-	-	7.41	7.19	7.60	7.03	7.22	6.82
	11	-	-	7.30	7.48	7.69	7.34	7.50	6.93
	19	-	-	7.78	7.39	8.03	7.26	7.41	6.80
	23	-	-	7.59	7.76	7.63	7.33	7.35	6.90
	31	-	-	8.35	7.50	7.59	7.25	7.33	6.88
	389	-	-	7.83	7.41	7.55	7.32	7.26	7.01

		Jul-99						
		25	26	27	28	29	30	31
Temperature	Trout Farm	24.6	23.1	22.2	23.0	24.0	23.0	24.6
(°C)	Florrisant	24.6	23.0	22.3	23.0	23.0	22.5	24.3
	α–Cellulose	24.9	23.0	22.3	23.0	23.0	22.6	24.5
	398	25.1	23.4	22.5	23.0	-	22.7	24.6
	11	25.2	23.9	22.9	24.0	24.0	22.7	24.8
	19	25.4	23.9	23.0	23.0	25.0	22.9	24.9
	23	25.4	24.1	23.1	24.0	25.0	22.8	24.7
	31	25.4	24.3	23.2	24.0	25.0	22.9	24.8
	389	25.6	24.2	23.3	24.0	25.0	23.0	24.8
Dissolved	Trout Farm	7.41	6.85	7.27	7.12	6.81	7.52	6.93
Oxygen (mg/L)	Florrisant	7.01	7.57	7.50	7.58	7.24	7.50	6.46
	α–Cellulose	7.11	7.43	7.23	7.35	7.13	7.64	7.16
	398	7.18	7.36	7.36	7.52	-	7.76	6.88
	11	7.31	7.56	7.47	7.83	7.15	7.43	7.02
	19	7.07	7.39	7.37	7.54	7.04	7.56	7.17
	23	7.35	7.46	7.36	7.49	7.32	7.54	7.21
	31	7.27	7.20	7.36	7.51	7.24	7.64	7.29
	389	7.39	7.41	7.35	7.68	7.20	7.60	7.32

Appendix 4: DO/Temperature continued

		Aug-99							
		1	2	3	4	5	6	7	8
Temperature	Trout Farm	24.0	22.0	20.0	23.0	23.0	23.0	24.0	24.0
(°C)	Florrisant	24.0	22.0	20.0	23.0	23.0	23.0	24.0	24.0
	α–Cellulose	24.0	21.0	20.0	23.0	23.0	23.0	24.0	24.0
	398	23.0	22.0	20.0	23.0	23.0	23.0	24.0	24.0
	11	24.0	22.0	20.0	23.0	23.0	23.0	24.0	24.0
	19	25.0	24.0	24.0	23.0	23.0	23.0	24.0	24.0
	23	25.0	24.0	24.0	24.0	24.0	23.0	24.0	24.0
	31	25.0	24.0	24.0	24.0	23.0	23.0	25.0	24.0
	389	25.0	24.0	24.0	24.0	24.0	23.0	25.0	24.0
Dissolved	Trout Farm	7.99	7.80	9.53	7.34	6.82	7.69	7.57	7.02
Oxygen (mg/L)	Florrisant	8.28	4.30	8.36	2.09	7.21	7.77	7.49	6.93
	α–Cellulose	7.85	8.59	9.29	6.57	6.38	7.13	7.25	6.35
	398	8.29	8.90	9.48	7.35	7.19	7.90	7.48	6.89
	11	8.38	8.80	9.53	7.45	7.28	8.10	7.60	7.24
	19	7.92	7.11	8.43	7.33	7.20	8.00	7.62	7.01
	23	8.00	7.05	8.40	7.37	7.37	7.92	7.60	6.93
	31	7.94	2.85	8.45	6.28	7.41	8.00	7.56	6.91
	389	7.87	7.22	8.48	7.43	7.39	7.96	7.56	6.93

		Aug-99							
		9	10	11	12	13	14	15	16
Temperature	Trout Farm	23.0	23.0	23.0	23.0	22.0	24.7	24.0	22.0
(°C)	Florrisant	23.0	23.0	23.0	23.0	22.0	24.0	24.0	22.0
	α–Cellulose	23.0	23.0	23.0	23.0	22.0	24.0	24.0	22.0
	398	23.0	23.0	23.0	23.0	23.0	24.0	24.0	22.0
	11	23.0	23.0	23.0	23.0	23.0	24.0	24.0	22.0
	19	23.0	23.0	23.0	23.0	24.0	24.0	24.0	22.0
	23	23.0	23.0	23.0	23.0	23.0	24.0	24.0	22.0
	31	23.0	23.0	23.0	23.0	23.0	25.0	24.0	22.0
	389	23.0	23.0	23.0	23.0	23.0	24.0	24.0	22.0
Dissolved	Trout Farm	7.50	6.19	6.64	7.46	7.50	6.85	7.49	7.47
Oxygen (mg/L)	Florrisant	7.27	5.23	6.33	7.12	7.50	7.30	7.51	7.50
	α–Cellulose	6.85	5.46	6.23	6.84	7.17	6.50	7.11	7.05
	398	7.43	6.04	6.73	7.46	7.20	7.13	7.50	7.50
	11	7.97	6.15	6.70	7.67	6.40	7.15	7.58	7.48
	19	8.11	6.49	6.85	7.36	7.00	7.14	7.48	7.54
	23	7.99	6.33	6.87	7.46	6.40	7.12	7.50	7.53
	31	7.94	6.47	6.78	7.25	7.30	7.03	7.47	7.61
	389	8.13	6.44	6.86	7.04	7.30	6.95	7.44	7.60

		Aug-99 continued		
		17	18	19
Temperature	Trout Farm	22.0	23.0	23.0
(°C)	Florrisant	22.0	23.0	23.0
	α–Cellulose	22.0	23.0	23.0
	398	22.0	22.5	22.5
	11	22.0	23.0	23.0
	19	22.0	23.0	23.0
	23	22.0	23.0	23.0
	31	23.0	23.0	23.0
	389	22.0	23.0	23.0
Dissolved	Trout Farm	7.48	7.60	7.39
Oxygen (mg/L)	Florrisant	7.47	7.88	7.52
	α–Cellulose	7.28	7.30	6.90
	398	7.36	7.77	7.40
	11	7.38	7.49	7.44
	19	7.30	7.77	7.38
	23	7.29	7.80	7.39
	31	7.30	7.70	7.22
	389	7.31	7.78	7.30

Appendix 5: Water chemistry measurements for a 48-h exposure of *Hyalella azteca, Chironomus tentans, Lumbriculus variegatus and Daphnia magna* at six Housatonic River sites and one laboratory control treatment.

Date	Sample	Temperature (°C)	pH	Conductivity (umhos/cm)	DO (mg/L)	Alkalinity (mg/L)	Total NH_3 (mg/L)	Hardness (mg/L)	Turbidity (NTU)	Flow (ft/s)
14-Jun-99	Laboratory Control	24.0	7.83	217	7.17	96	0.374	116	0.68	-
	398	24.0	8.09	321	7.98	120	0.611	132	1.60	-
	11	24.0	7.74	275	8.71	116	0.436	120	1.42	-
	19	24.0	7.58	389	7.34	140	0.989	149	1.84	-
	428*	21.1	7.59	385	7.10	140	1.103	165	1.80	-
	31*	21.2	7.80	404	6.45	128	0.718	157	5.10	-
	389*	20.9	8.35	409	6.40	128	0.643	153	4.10	-
16-Jun-99	Laboratory Control	21.9	7.70	241	7.01	96	0.718	112	3.60	-
	398	18.9	7.52	261	9.13	112	0.635	125	3.00	0.98
	11	14.7	7.45	219	9.03	112	0.366	129	1.25	0.22
	19	19.2	7.10	362	8.39	144	1.040	161	2.40	0.48
	428	20.2	7.50	364	8.75	144	0.769	152	2.00	1.15
	31	21.9	7.54	376	8.92	144	0.615	144	1.00	0.03
	389	20.4	7.35	375	7.04	124	0.656	144	5.00	0.03

*Chemistry measurements determined early morning 15-June-99 due to chamber deployment after 12 AM

Appendix 6: Water chemistry measurements for a 7-d (*Lumbriculus variegatus*) and 10-d (*Hyalella azteca* and *Chironomus tentans*) exposure at six Housatonic River sites and one laboratory control treatment.

Date	Sample	Temperature (°C)	pH	Conductivity (umhos/cm)	DO (mg/L)	Alkalinity (mg/L)	NH_3 (mg/L)	Hardness (mg/L)	Turbidity (NTU)
17-Jun-99	Laboratory Control	20.6	7.40	235	10.25	92	0.244	112	3.00
	398	21.2	7.66	354	9.42	124	0.283	140	2.50
	11	21.2	7.62	279	9.52	112	0.098	128	0.85
	19	21.2	7.39	421	8.48	144	0.399	152	2.40
	428	17.5	7.64	358	8.79	136	0.373	160	2.20
	31	19.3	7.50	365	8.50	160	0.429	140	22.00
	389	18.4	7.58	378	7.61	136	0.446	157	7.00
24-Jun-99	11	28.2	7.88	168	6.43	144	0.069	141	-
	398	26.0	7.67	174	7.04	120	0.100	137	-
	19	25.3	7.37	221	7.23	148	0.135	161	-
	428	26.5	7.29	222	6.65	148	0.254	169	-
	31	28.3	7.39	247	6.43	132	0.108	149	-
	389	25.6	7.20	251	6.75	116	0.166	153	-
27-Jun-99	Laboratory Control	27.0	8.04	264	6.56	128	0.714	124	0.74
	398	22.4	7.60	349	6.02	140	0.480	153	1.68
	11	16.4	7.76	306	5.30	132	0.258	148	0.90
	19	19.4	7.59	421	5.76	156	0.252	168	-
	428	20.3	7.63	411	6.90	168	0.178	168	2.40
	31	24.7	8.41	444	6.69	128	0.195	148	3.63
	389	23.5	7.72	469	7.37	148	0.167	156	-

Appendix 7: Data from Phase I TIE initial toxicity tests performed on four porewater samples.

Sample ID	Concentration (%)	Survival (out of 5)[1]		DO (mg/L)		pH	
		0 h	24 h	0 h	24 h	0 h	24 h
031	100	5 // 5	0 // 0	6.79	NR[2]	8.41	NR
	50	5 // 5	1 // 1	6.73	NR	8.21	NR
	25	5 // 5	3 // 3	7.05	NR	8.2	NR
	12.5	5 // 5	5 // 5	6.95	NR	8.06	NR
	6.25	5 // 5	5 // 4	7.2	NR	7.99	NR
	Control	5 // 5	5 // 5	7.42	NR	7.72	NR
389	100	5 // 5	0 // 0	6.57	NR	8.41	NR
	50	5 // 5	1 // 0	6.28	NR	8.21	NR
	25	5 // 5	5 // 4	6.81	NR	8.17	NR
	12.5	5 // 5	3 // 5	6.95	NR	8.2	NR
	6.25	5 // 5	5 // 5	6.99	NR	8.28	NR
	Control	5 // 5	5 // 5	7.42	NR	7.72	NR
019	100	5 // 5	5 // 4	7.27	NR	8.39	NR
	50	5 // 5	5 // 5	7.34	NR	8.26	NR
	25	5 // 5	5 // 5	7.28	NR	8.14	NR
	12.5	5 // 5	5 // 5	7.25	NR	8.17	NR
	6.25	5 // 5	5 // 5	7.56	NR	8.23	NR
	Control	5 // 5	5 // 4	7.42	NR	7.72	NR
398	100	5 // 5	5 // 4	6.99	NR	8.36	NR
	50	5 // -	5 // -	7.14	NR	8.39	NR
	25	5 // 5	5 // 4	7.31	NR	8.27	NR
	12.5	5 // 5	5 // 5	7.36	NR	8.23	NR
	6.25	5 // 5	5 // 5	7.45	NR	8.29	NR
	Control	5 // 5	5 // 5	7.42	NR	7.72	NR

1. Survival results for two replicates are separated by "//". A dash (-) indicates the replicate was not seeded with test organisms.
2. NR = not reported.

Appendix 8: Data from Phase I TIE manipulations performed on pore water from Site 031.

Start Date	TIE Manipulation	Treatment	Pore Water Concentration (%)	Survival (out of 5)[1]			DO (mg/L)			pH		
				0 h	24 h	48 h	0 h	24 h	48 h	0 h	24 h	48 h
16-Sep-99 (Day 2)	Baseline	None	100	5 // 5	0 // 4	0 // 0	7.15	NR[2]	7.45	7.43	NR	8.64
			50	5 // 5	3 // 4	1 // 1	7.21	NR	7.44	7.46	NR	8.7
			25	5 // 5	5 // 4	1 // 3	8.2	NR	7.46	7.64	NR	8.63
			12.5	5 // 5	5 // 5	5 // 5	8.28	NR	7.56	7.71	NR	8.62
			6.25	5 // 5	5 // 5	5 // 5	8.36	NR	7.51	7.85	NR	8.38
			Control	5 // 5	5 // 5	4 // 5	8.03	NR	7.97	7.99	NR	8.23
16-Sep-99 (Day 2)	pH Adjusted / Filtration	pH 3	100	5	4	4	NR	NR	7.7	7.76	6.98	8.03
			50	5	5	5	NR	NR	7.76	NR	7.75	8.23
			25	5	5	5	NR	NR	7.92	NR	7.87	8.35
			12.5	5	5	5	NR	NR	8.13	NR	7.99	8.35
		pHi	100	5	0	0	NR	NR	8.14	7.73	8.43	8.83
			50	5	0	0	NR	NR	8.31	NR	8.36	8.71
			25	5	0	0	NR	NR	7.87	NR	8.29	8.7
			12.5	5	4	3	NR	NR	8.1	NR	8.25	8.62
		pH 11	100	5	5	4	NR	NR	7.93	7.76	8.4	8.95
			50	5	5	5	NR	NR	8.03	NR	8.36	8.88
			25	5	5	5	NR	NR	7.77	NR	8.25	8.7
			12.5	5	5	5	NR	NR	7.7	NR	8.22	8.68
			Control	5	5	5	NR	NR	7.75	NR	8.22	8.42
16-Sep-99 (Day 2)	Oxidant Reduction (20.5 g/L sodium thiosulfate addition)	0.2 mL	100	5	5	0	NR	NR	6.62	NR	NR	8.63
			60	5	4	0	NR	NR	7.18	NR	NR	8.7
			30	5	2	0	NR	NR	7.52	NR	NR	8.54
			15	5	4	2	NR	NR	7.52	NR	NR	8.44
			Blank[3]	5	5	5	NR	NR	8.16	NR	NR	8.64
		0.1 mL	100	5	4	1	NR	NR	7.11	NR	NR	8.32
			60	5	5	2	NR	NR	7.03	NR	NR	8.59
			30	5	1	0	NR	NR	7.27	NR	NR	8.56
			15	5	5	5	NR	NR	7.15	NR	NR	8.56
			Blank	5	5	5	NR	NR	7.75	NR	NR	8.5
		0.05 mL	100	5	3	1	NR	NR	7.44	NR	NR	8.68
			60	5	2	1	NR	NR	7.27	NR	NR	8.6
			30	5	4	1	NR	NR	7.57	NR	NR	8.7
			15	5	3	3	NR	NR	7.43	NR	NR	8.48
			Blank	5	5	5	NR	NR	7.58	NR	NR	8.69
			Control (from baseline)	5 // 5	5 // 5	4 // 5	8.03	NR	7.97	7.99	NR	8.23

Appendix 8 (cont'd): Data from Phase I TIE manipulations performed on pore water from Site 031.

Start Date	TIE Manipulation	Treatment	Pore Water Concentration (%)	Survival (out of 5)[1]			DO (mg/L)			pH		
				0 h	24 h	48 h	0 h	24 h	48 h	0 h	24 h	48 h
16-Sep-99 (Day 2)	pH Adjusted / Aeration	pH 3	100	5	5	4	NR	NR	7.8	7.6	7.00	7.34
			50	5	5	3	NR	NR	7.8	NR	7.40	8.15
			25	5	4	4	NR	NR	7.9	NR	7.75	8.24
			12.5	5	5	3	NR	NR	8.0	NR	7.84	8.32
		pHi	100	5	4	1	NR	NR	7.6	8.8	8.26	8.54
			50	5	4	3	NR	NR	7.8	NR	8.29	8.50
			25	5	4	2	NR	NR	7.8	NR	8.20	8.60
			12.5	5	4	1	NR	NR	7.8	NR	8.09	8.51
		pH 11	100	5	4	1	NR	NR	7.7	7.4	8.40	8.87
			50	5	4	2	NR	NR	7.8	NR	8.25	8.52
			25	5	4	1	NR	NR	7.8	NR	8.20	8.53
			12.5	5	3	1	NR	NR	7.7	NR	8.12	8.59
			Control	5	5	5	NR	NR	7.6	8.57	7.65	8.66
17-Sep-99 (Day 3)	Baseline	None	100	5 // 5	0 // 0	-[4]	NR	NR	-	8.16	8.44	-
			50	5 // 5	0 // 0	-	NR	NR	-	8.16	8.50	-
			25	5 // 5	0 // 0	-	NR	NR	-	8.15	8.45	-
			12.5	5 // 5	3 // 2	-	NR	NR	-	8.15	8.32	-
			6.25	5 // 5	4 // 4	-	NR	NR	-	8.15	8.23	-
			Control	5 // 5	4 // 5	-	NR	NR	-	8.15	8.17	-
17-Sep-99 (Day 3)	EDTA Chelation (2.856 g/L EDTA addition)	0.2 mL	100	5	0	0	NR	NR	7.61	NR	8.33	8.68
			60	5	1	0	NR	NR	7.71	NR	8.33	8.68
			30	5	4	0	NR	NR	7.78	NR	8.20	8.58
			15	5	5	3	NR	NR	7.78	NR	8.07	8.51
			Blank	5	5	5	NR	NR	8.29	NR	8.00	8.49
		0.05 mL	100	5	0	0	NR	NR	7.62	NR	8.22	8.69
			60	5	1	0	NR	NR	8	NR	8.31	8.66
			30	5	4	1	NR	NR	8.15	NR	8.20	8.62
			15	5	5	4	NR	NR	7.74	NR	8.12	8.58
			Blank	5	5	4	NR	NR	8.55	NR	8.06	8.51
		0.0125 mL	100	5	0	0	NR	NR	7.79	NR	8.22	8.68
			60	5	1	0	NR	NR	7.96	NR	8.26	8.61
			30	5	4	3	NR	NR	7.98	NR	8.14	8.63
			15	5	5	5	NR	NR	7.81	NR	7.86	8.58
			Blank	5	NR	NR	NR	NR	NR	NR	NR	NR
			Control (from baseline)	5 // 5	4 // 5	-	NR	NR	-	8.15	8.17	-

Appendix 8 (cont'd): Data from Phase I TIE manipulations performed on pore water from Site 031.

Start Date	TIE Manipulation	Treatment	Pore Water Concentration (%)	Survival (out of 5)[1]			DO (mg/L)			pH		
				0 h	24 h	48 h	0 h	24 h	48 h	0 h	24 h	48 h
17-Sep-99 (Day 3)	pH Adjusted / C_{18}SPE	pH 3	100	5	5	4	NR	NR	7.79	7.83	NR	8.06
			50	5	5	4	NR	NR	8.12	7.97	NR	8.13
			25	5	5	4	NR	NR	8.23	8.06	NR	8.22
			12.5	5	5	3	NR	NR	8.00	8.03	NR	8.22
			Blank	5	5	1	NR	NR	NR	7.81	NR	8.26
		pHi	100	5	3	3	NR	NR	7.65	8.36	NR	8.56
			50	5	5	5	NR	NR	7.81	8.13	NR	8.45
			25	5	5	5	NR	NR	8.02	8.06	NR	8.36
			12.5	5	5	5	NR	NR	7.97	8.21	NR	8.40
			Blank	5	5	5	NR	NR	NR	8.13	NR	8.38
		pH 9	100	5	0	0	NR	NR	7.77	8.38	NR	8.68
			50	5	5	5	NR	NR	7.62	8.43	NR	8.54
			25	5	5	5	NR	NR	7.83	8.2	NR	8.31
			12.5	5	5	5	NR	NR	8.14	8.11	NR	8.30
			Blank	5	5	4	NR	NR	NR	8.17	NR	8.31
			Control (from baseline)	5 // 5	4 // 5	-	NR	NR	-	8.15	8.17	-

1. Survival results for two replicates are separated by "//". A dash (-) indicates the replicate was not seeded with test organisms.
2. NR = not reported
3. Blank = control water subjected to the same manipulation as the pore water sample (not included for all manipulations).
4. Dash (-) indicates the treatment was not tested.

Appendix 9: Data from Phase I TIE manipulations performed on pore water from Site 389.

Start Date	TIE Manipulation	Treatment	Pore Water Concentration (%)	Survival (out of 5)[1]			DO (mg/L)			pH		
				0 h	24 h	48 h	0 h	24 h	48 h	0 h	24 h	48 h
16-Sep-99 (Day 2)	Baseline	None	100	5 // 5	1 // 2	0 // 0	8.37	NR[2]	NR	8.01	NR	8.64
			50	5 // 5	4 // 4	1 // 1	7.44	NR	NR	7.97	NR	8.63
			25	5 // 5	2 // 3	1 // 3	7.97	NR	NR	7.98	NR	8.58
			12.5	5 // 5	4 // 4	5 // 5	7.98	NR	NR	7.88	NR	8.54
			6.25	5 // 5	5 // 4	5 // 4	7.48	NR	NR	7.80	NR	8.40
			Control	5 // 5	5 // 5	5 // 5	8.07	NR	NR	7.54	NR	8.48
16-Sep-99 (Day 2)	pH Adjusted / Filtration	pH 3	100	5	5	5	NR	NR	7.64	7.76	7.58	7.91
			50	5	4	4	NR	NR	7.74	NR	7.82	8.32
			25	5	5	4	NR	NR	7.71	NR	7.93	8.41
			12.5	5	5	5	NR	NR	7.61	NR	8.01	8.43
		pHi	100	5	5	5	NR	NR	7.73	8.12	8.39	8.78
			50	5	5	5	NR	NR	7.47	NR	8.33	8.71
			25	5	5	5	NR	NR	7.92	NR	8.22	8.64
			12.5	5	5	5	NR	NR	8.05	NR	8.23	8.56
		pH 11	100	5	5	5	NR	NR	7.78	7.76	8.3	8.83
			50	5	5	5	NR	NR	7.88	NR	8.25	8.73
			25	5	5	5	NR	NR	7.8	NR	8.2	8.7
			12.5	5	5	5	NR	NR	7.82	NR	8.17	8.63
			Control	5	5	5	NR	NR	7.75	NR	8.22	8.42
16-Sep-99 (Day 2)	Oxidant Reduction (20.5 g/L sodium thiosulfate addition)	0.2 mL	100	5	0	0	NR	NR	7.08	NR	NR	8.79
			50	5	4	0	NR	NR	7.55	NR	NR	8.74
			25	5	4	0	NR	NR	7.78	NR	NR	8.58
			12.5	5	4	3	NR	NR	7.69	NR	NR	8.44
			Blank[3]	5	5	5	NR	NR	8.16	NR	NR	8.64
		0.1 mL	100	5	1	0	NR	NR	7.18	NR	NR	8.81
			50	5	0	0	NR	NR	7.36	NR	NR	8.72
			25	5	3	1	NR	NR	7.63	NR	NR	8.64
			12.5	5	3	1	NR	NR	7.57	NR	NR	8.58
			Blank	5	5	5	NR	NR	7.75	NR	NR	8.5
		0.05 mL	100	5	2	0	NR	NR	7.51	NR	NR	8.69
			50	5	0	0	NR	NR	7.22	NR	NR	8.64
			25	5	5	1	NR	NR	7.64	NR	NR	8.49
			12.5	5	3	0	NR	NR	7.34	NR	NR	8.56
			Blank	5	5	5	NR	NR	7.58	NR	NR	8.69
			Control (from baseline)	5 // 5	5 // 5	4 // 5	8.03	NR	7.97	7.99	NR	8.23

Appendix 9 (cont'd): Data from Phase I TIE manipulations performed on pore water from Site 389.

Start Date	TIE Manipulation	Treatment	Pore Water Concentration (%)	Survival (out of 5)[1]			DO (mg/L)			pH		
				0 h	24 h	48 h	0 h	24 h	48 h	0 h	24 h	48 h
16-Sep-99 (Day 2)	pH Adjusted / Aeration	pH 3	100	5	2	1	NR	NR	7.6	6.93	7.22	7.75
			50	5	1	1	NR	NR	7.6	NR	7.70	8.31
			25	5	5	2	NR	NR	7.9	NR	7.62	8.16
			12.5	5	4	2	NR	NR	7.8	NR	7.85	8.48
		pHi	100	5	0	0	NR	NR	7.6	8.77	8.36	8.64
			50	5	4	2	NR	NR	7.7	NR	8.29	8.70
			25	5	3	1	NR	NR	7.7	NR	8.15	8.66
			12.5	5	5	5	NR	NR	7.6	NR	8.12	8.56
		pH 11	100	5	0	0	NR	NR	7.7	6.98	8.25	8.86
			50	5	5	4	NR	NR	7.7	NR	8.29	8.64
			25	5	4	3	NR	NR	7.8	NR	8.20	8.54
			12.5	5	5	5	NR	NR	7.6	NR	8.14	8.54
			Control	5	5	5	NR	NR	7.6	8.57	7.65	8.66
17-Sep-99 (Day 3)	Baseline	None	100	5 // 5	0 // 0	-[4]	NR	NR	-	7.74	8.45	-
			50	5 // 5	0 // 0	-	NR	NR	-	8.01	8.43	-
			25	5 // 5	1 // 1	-	NR	NR	-	8.1	8.34	-
			12.5	5 // 5	3 // 2	-	NR	NR	-	8.19	8.3	-
			6.25	5 // 5	5 // 5	-	NR	NR	-	8.2	7.96	-
			Control	5 // 5	5 // 5	-	NR	NR	-	8.2	8.23	-
17-Sep-99 (Day 3)	EDTA Chelation (2.674 g/L EDTA addition)	0.2 mL	100	5	0	0	NR	NR	7.55	NR	NR	8.7
			60	5	0	0	NR	NR	7.66	NR	NR	8.54
			30	5	2	0	NR	NR	7.83	NR	NR	8.39
			15	5	3	2	NR	NR	7.77	NR	NR	8.05
			Blank	5	5	4	NR	NR	8.29	NR	7.88	8.5
		0.05 mL	100	5	0	0	NR	NR	7.56	NR	NR	8.69
			60	5	2	0	NR	NR	7.94	NR	NR	8.62
			30	5	3	1	NR	NR	8.04	NR	NR	8.56
			15	5	2	0	NR	NR	7.93	NR	NR	8.55
			Blank	5	5	5	NR	NR	8.55	NR	7.99	8.54
		0.0125 mL	100	5	0	0	NR	NR	7.65	NR	NR	8.63
			60	5	3	0	NR	NR	8.21	NR	NR	8.62
			30	5	3	2	NR	NR	8.24	NR	NR	8.5
			15	5	2	1	NR	NR	8.39	NR	NR	8.56
			Blank	5	5	NR	NR	NR	NR	NR	7.96	NR
			Control (from baseline)	5 // 5	4 // 5	-	NR	NR	-	8.2	8.23	-

Appendix 9 (cont'd): Data from Phase I TIE manipulations performed on pore water from Site 389.

Start Date	TIE Manipulation	Treatment	Pore Water Concentration (%)	Survival (out of 5)[1]			DO (mg/L)			pH		
				0 h	24 h	48 h	0 h	24 h	48 h	0 h	24 h	48 h
17-Sep-99 (Day 3)	pH Adjusted / C_{18}SPE	pH 3	100	5	5	5	NR	NR	7.79	7.73	NR	7.77
			50	5	5	5	NR	NR	8.12	8.01	NR	8.07
			25	5	5	5	NR	NR	8.23	8.1	NR	8.09
			12.5	5	5	5	NR	NR	8.00	8.19	NR	8.3
			Blank	5	0	0	NR	NR	7.81	8.2	NR	8.16
		pHi	100	5	5	5	NR	NR	7.65	8.24	NR	8.56
			50	5	5	5	NR	NR	7.81	8.28	NR	8.43
			25	5	5	5	NR	NR	8.02	8.14	NR	8.32
			12.5	5	5	5	NR	NR	7.97	8.25	NR	8.29
			Blank	5	5	spilled	NR	NR	7.98	8.19	NR	NR
		pH 9	100	5	4	4	NR	NR	7.77	8.22	NR	8.62
			50	5	4	4	NR	NR	7.62	8.21	NR	8.45
			25	5	5	4	NR	NR	7.83	8.19	NR	8.39
			12.5	5	5	5	NR	NR	8.14	8.23	NR	8.35
			Blank	5	5	4	NR	NR	8.07	8.11	NR	8.4
			Control (from baseline)	5 // 5	4 // 5	-	NR	NR	-	8.15	8.17	-

1. Survival results for two replicates are separated by "//". A dash (-) indicates the replicate was not seeded with test organisms.
2. NR = not reported
3. Blank = control water subjected to the same manipulation as the pore water sample (not included for all manipulations).
4. Dash (-) indicates the treatment was not tested.