

**BIOASSAY ANALYSES CONDUCTED ON  
SEDIMENTS COLLECTED FROM  
JAMAICA BAY, FAR ROCKAWAY, NEW YORK  
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**Prepared for**

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**and**

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## EXECUTIVE SUMMARY

Cape Environmental, Inc. and Barry A. Vittor & Associates, Inc. (Vittor & Associates) collected three test sediments, from Jamaica Bay in Far Rockaway, New York during June 2002, for bioassay, chemistry, and physical analyses. Bioassay testing included 10-day whole-sediment tests with *Eohaustorius esturarius*, *Ampelisca abdita*, and *Mysidopsis bahia*; 96-hour (hr) water column tests with *Menidia beryllina* and *Mysidopsis bahia*; and 48-hr water column tests with *Mytilus californicus* larvae. Bioaccumulation (28-day) tests were conducted with *Nereis virens*.

For all Jamaica Bay sediment samples, PAHs, PCBs, dioxins, and pesticides were absent or occurred at concentrations below detection limits. However, heavy metals were present, including aluminum, antimony, arsenic, barium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, vanadium, and zinc. Norton Basin (NB3), Little Bay (LB3), and Grass Hassock Reference (GH Ref 1) contained levels of arsenic, cadmium, chromium, copper, lead, mercury, and zinc above established effects range low (ERL) levels. NB3 and LB3 contained levels of copper and lead that were above established probable effects levels (PEL), and that were significantly greater ( $p < 0.05$ ) than concentrations found in Grass Hassock Reference sediments.

In the 10-day whole sediment tests with *Mysidopsis bahia*, survivorship in all of the test sediments was 90% or greater. There was no statistical difference in survivorship between the project sediments and Grass Hassock Reference sediment ( $p > 0.05$ ).

In the 10-day whole sediment tests, *Eohaustorius esturarius*, survivorship was 92% in both Grass Hassock and Norton Basin sediments. *E. estuarius* survivorship in Little Bay sediment was 62%, and was significantly less than ( $p < 0.05$ ) survivorship in Grass Hassock Reference. Point Aux Pins (Alabama) Control sediments and Culture Control sediments exhibited 94% and 100% survivorship, respectively.

In the 10-day whole sediment tests with *Ampelisca abdita*, survivorship was 80% in Norton Basin, 90% in Little Bay, and 81% in Grass Hassock Reference sediment. There was no statistical difference in survivorship between the project sediments and the reference sediment ( $p > 0.05$ ). Control sediment survivorship was 71%, but the Culture Control was 90%, indicating a preference for substrates with an organic, muddy content.

In the 96-hr water column bioassays (liquid phase), survivorship of *Menidia beryllina* and *Mysidopsis bahia* was 90% or above in all elutriate concentrations for Control, Little Bay, Norton Basin and Grass Hassock Reference sediments.

At the end of the 48-hr mussel larvae test, normal mussel development was 94% and above for all concentrations in all test sediments, and larvae survivorship ranged from 19% (Little Bay, 100%) to 84% (Control). LC50's calculated for the test sediments were not less than the LC50 calculated for the Control.

In the 28-day bioaccumulation tests, *Nereis virens* survivorship in Little Bay and Norton Basin sediments was 100% and 96%, respectively. Survivorship in Grass Hassock Reference sediment was 87%, and survivorship in the Control sediment was 92%.

At the end of the 28-day bioaccumulation, *Nereis* tissues were analyzed for the following metals detected above back ground levels: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, vanadium, zinc, and mercury. Statistical analyses revealed that *N. virens* exposed to Norton Basin sediment contained significantly higher amounts of mercury than did *N. virens* exposed to Grass Hassock Reference sediment ( $p < 0.05$ ). However, none of the metals including mercury exceeded the Food and Drug Administration (FDA) action levels.

These bioassay and bioaccumulation tests indicate that the sediments collected from Norton Basin and Little Bay are not acutely toxic to aquatic organisms, nor is there significant potential for bioaccumulation of heavy metals that are present in those sediments.

## **1.0 INTRODUCTION**

Vittor & Associates evaluated sediments collected from Jamaica Bay, Far Rockaway, New York, June 2002 as part of a feasibility analysis of benthic habitat restoration through bathymetric recontouring of Norton Basin and Little Bay borrow pits, in Jamaica Bay.

Evaluation of the sediments from the pits included biological, chemical and physical testing of the sediments. Bioassays and bioaccumulation tests were performed by Vittor & Associates in Mobile, Alabama. The bioassays included 10-day whole-sediment tests with *Ampelisca abdita*, *Eohaustorius estuarius*, and *Mysidopsis bahia*; 96-hr water column (elutriate) tests with *Menidia beryllina* and *Mysidopsis bahia*; and a 48-hr mussel larvae development test with elutriates, using gametes from *Mytilus californicus*. Bioaccumulation tests (28-day) were conducted with *Nereis virens*. The sediment samples from Norton Basin, Little Bay, and Grass Hassock were analyzed by Severn Trent Laboratories (STL) Savannah, Georgia for heavy metals, PAHs, PCBs, chlorinated pesticides, dioxin/furans, Total Organic Carbon, SVOCs, VOCs, AVS, nitrites, nitrates, ammonia and total coliform bacteria. Physical analyses included grain size distribution, bulk density, and Atterburg limits. Control sediment for this study was collected by Vittor & Associates from the Mobile District Corps of Engineers' designated control site at Point Aux Pins, Alabama on May 12, 2002.

## **2.0 SEDIMENT AND SITE WATER COLLECTION PROCEDURES**

### **2.1 COLLECTION SITES**

The collection regime consisted of sampling sediments from three sites in the Jamaica Bay, Far Rockaway, New York area: Norton Basin station 3 (NB3); Little Bay station 3 (LB3), and Grass Hassock Reference station 1 (GH Ref 1). Figure 1 presents the location of all stations sampled.

### **2.2 COLLECTION METHODS**

Collection of sediments followed the guidelines in QA/QC Guidance for Sampling and Analysis of Sediments, Water, and Tissues for Dredged Material Evaluations (USEPA, 1995) (USEPA 823-B-001) and the Region II Guidance Manual, Guidance for Performing

Tests on Dredged Material Proposed for Ocean Disposal. Prior to collection of each test sediment, sampling gear and containers were decontaminated. Stainless steel spoons, stainless steel pans, coolers, and brushes were washed with Alconox®, rinsed with distilled water, rinsed with 10% nitric acid, rinsed with methanol and then rinsed with distilled water again. Stainless steel spoons, pans and brushes were wrapped with foil until they were used to collect sediments. Samples from each site were composited to comprise 10 gallons. Ten-gallon coolers were lined with sterile plastic bags to hold and store the sediment once it was collected.

A stainless steel Ted Young modified Van Veen grab was used to collect sediments from each station. This grab was decontaminated prior to use at each site and a new set of foil-wrapped spoon and pan was used for each site. Several grabs were made (4-6) at each station and emptied into a steel pan. The spoons were used to clear out the grab once its contents were emptied into the pan. The contents from each grab were then inspected for large objects such as rocks and shells. These objects were discarded from the grab samples before the samples were stored in the coolers. Sediment samples were immediately stored on ice until delivered to Vittor & Associates' laboratory in Mobile, Alabama. Chain of Custody sheets for all sediment samples are presented in Appendix A.

### 2.3 FIELD DATA

A Hypack® GPS/GIS data recorder was used to plot station locations for each site (Figure 1). The salinity and depth at each station were recorded using a YSI SCT meter and Raytheon® L365 depth finder.

### 3.0 BULK SEDIMENT CHEMISTRY

Bulk sediment chemistry analyses were performed according to the QA/QC Guidance for Sampling and Analysis of Sediments, Water, and Tissues for Dredged Material Evaluations (USEPA, 1995) (USEPA 823-B-001). STL in Savannah, Georgia performed the following analyses on whole sediment collected from Norton Basin, Little Bay and Grass Hassock reference stations: ICP Heavy Metals (Solid Waste 6010, 7471); Moisture content (105C); (PAH low levels by 8270C); Chlorinated Pesticides (8081A); Dioxins (8290); PCBs (Aroclors) (8082); Total Organic Carbon (9060); Ammonia-N

(350.1); Nitrate (EPA/CE-81-1 (3-193)), Nitrite-N (EPA/CE-81-1 (3-183)); TKN (351.2); Total Cyanide (9012); SVOCs (8270), VOCs (8260), AVS (EPA 68-03-3534).

### 3.1 WHOLE SEDIMENT CHEMISTRY RESULTS

PAHs, PCBs, dioxins, and pesticides were not detected in any of the test sediments. However, the following metals were detected above background levels: aluminum, antimony, arsenic, barium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, vanadium, and zinc. Norton Basin (NB3), Little Bay (LB3), and Grass Hassock Reference (GH Ref 1) contained levels of arsenic, cadmium, chromium, copper, lead, mercury, and zinc above established ERL levels (Table 1). NB3 and LB3 contained levels of copper and lead above established PELs, and were significantly greater than concentrations found in Grass Hassock Reference sediment ( $p < 0.05$ ; Tables 2 and 3).

## 4.0 BIOASSAYS AND BIOACCUMULATION TESTING

### 4.1 GENERAL PROCEDURES

Sediment samples for bioassays were collected and composited for each of the following stations: Norton Basin station 3 (NB3); Little Bay station 3 (LB3); and Grass Hassock Reference station 1 (GH Ref 1); June 6, 2002. Test sediments were received in Vittor & Associates' laboratory on June 8, 2002, and stored at 4° C until processed. Control sediment was collected May 12, 2002 from Point Aux Pins, Alabama. Control and test sediments were press-sieved using a 1500-micron Nytex® screen. Sediments were then refrigerated at approximately 4°C until used for bioassay testing. Bioassays and bioaccumulation testing were conducted in accordance with the U.S. Environmental Protection Agency (USEPA) and U.S. Army Corps of Engineers (USACE) standard testing manual, Guidance for Performing Tests on Dredged Material Proposed for Ocean Disposal (1992).

### 4.2 ELUTRIATE BIOASSAYS

Elutriate bioassays were performed to determine the potential impact of dissolved and suspended contaminants in sediments collected from Jamaica Bay on test organisms. Organisms for these tests included the inland silverside, *Menidia beryllina*, the mysid

shrimp, *Mysidopsis bahia*, and larvae of the mussel, *Mytilus californicus*. *M. beryllina* were purchased from Aquatic Indicators in St. Augustine, Florida, *M. bahia* were purchased from Aquatic Research Organisms in Hampton, New Hampshire, and *Mytilus californicus* were purchased from Carlsbad Aqua Farms, in Carlsbad, California.

*M. bahia* were six days old and *M. beryllina* were 13 days old at test initiation. Elutriate testing with *M. bahia* and *M. beryllina* was initiated June 20, 2002 and was terminated June 24, 2002. A retest with *M. bahia* for Little Bay sediments was initiated July 11, 2002 and terminated July 15, 2002. The *Mytilus californicus* larvae development test was initiated July 17, 2002 and terminated July 19, 2002.

#### 4.2.1 Silverside and Mysid Shrimp Elutriate Test Methods

The elutriate solution for *M. bahia* and *M. beryllina* was prepared by combining sediment and seawater at a ratio of 1:4. The solution was mixed for 30 minutes on a magnetic stir-plate then allowed to settle 1 hour. The supernatant was poured off and became the 100% stock solution for all elutriate tests. Elutriates for the mussel larvae test were refrigerated and allowed to settle for four hours to obtain a clear test solution so that larvae could be seen under a dissecting scope.

Natural, filtered seawater (29 ppt) was used as dilution water for the silverside and mysid shrimp elutriate tests. Norton Basin (NB3), Little Bay (LB3), Control sediment, and a seawater Control were tested. Each test sediment was comprised of five replicates of each of the three elutriate concentrations (10%, 50%, 100%). The seawater Control (0% elutriate) also consisted of five replicates for both species. Glass jars (1 liter capacity) were used as test chambers for each replicate. Twenty test animals were placed in each test chamber.

Test temperature ( $20 \pm 1^\circ\text{C}$ ) was regulated by means of ambient temperature control. Aeration was supplied by a laboratory air blower through microbore tubing at a rate of approximately  $50 \text{ cm}^3/\text{min}$  for *M. bahia* and *M. beryllina* tests. All test organisms were fed *Artemia* once daily.

Water quality parameters measured daily during the 96-hr elutriate tests were dissolved oxygen, pH, temperature, and salinity. Dissolved oxygen was measured with a YSI Model 57 DO meter, pH and temperature were measured with an Orion Model 230A

meter with pH/temperature probe, and salinity was measured with an Aquafauna® temperature-compensated refractometer. All instruments were calibrated daily. At test termination, counts of surviving test organisms were recorded for *M. bahia* and *M. beryllina*.

Statistical comparisons with the mean survival in the elutriate concentrations of the test and Control sediment were conducted for *M. bahia* and *M. beryllina*. If the mortality rate reached 50% or more in any one of the test concentrations, then median lethal concentration (LC50) would be calculated using the Spearman -Karber method.

#### 4.2.2 Bivalve Larvae Test Methods

Natural, filtered seawater (30 ppt) was used as dilution water for the mussel larvae elutriate test. Norton Basin (NB3), Little Bay (LB3), and Control sediment samples, as well as a seawater Control, were tested. Each test sediment was comprised of five replicates of each of the three elutriate concentrations (10%, 50%, 100%). The seawater Control (0% elutriate) also consisted of five replicates. 400-ml glass jars were used as the test chambers.

Mussel eggs and sperm were obtained from adult *Mytilus californicus* by raising their temperature 8-10 degrees above their normal habitat temperature. The males started to release their sperm first, which then stimulated the females to release their eggs. After the males released sperm for two minutes, they were put into a five-gallon aquaria (for males only), with approximately two gallons of seawater, and aerated vigorously. The temperature of the male holding tank was maintained at 25°C. Subsequently, when the females released eggs, they were allowed to release for two minutes, and were then put into another five-gallon tank (for females only), with approximately 2-3 gallons of water, and aerated vigorously. The female tank was maintained at 25°C. The males and females were removed from their tanks after 15-20 minutes and, approximately 25-30 mls of sperm suspension was poured into the female/egg tank. The egg suspension was kept up in the water column by gently stirring the water with a large plastic spoon. After approximately one hour, the egg suspension was sampled for density and for fertilization frequency. It was determined that nearly 98% of the eggs were fertilized. At this point the egg suspension was adjusted so that there were 1500 embryos per ml. Approximately 6,000 embryos (4 mls) were then added to each test vessel containing 200 mls of elutriate. Percent normal development was determined by counting the number of veligers with fully formed shells vs. abnormal shell development

in a 1-ml suspension placed on a Sedgewick-Rafter. Percent live larvae was determined by counting the number of live vs. dead larvae in the 1-ml suspension. The number of live larvae recovered after the 48-hr exposure was calculated by multiplying the number of larvae in the 1 ml suspension by the volume in the test chamber.

Water quality parameters were recorded for 100% elutriates and Control seawater just prior to test initiation (addition of larvae to elutriate vials). Dissolved oxygen was measured with a YSI Model 57 DO meter, pH and temperature were measured with an Orion Model 230A meter with pH/temperature probe, and salinity was measured with an American Optical temperature-compensated refractometer.

Percent mean normal development in the elutriate concentrations of the test and Control sediment were compared statistically. LC50s were estimated using the Spearman-Kärber method, and were used to evaluate test sediment elutriate concentration effects in comparison to the Control.

#### 4.2.3 Elutriate Bioassay Results

Elutriate bioassay test conditions that were monitored included temperature, dissolved oxygen, pH, and salinity. Test temperatures for *M. bahia*, *M. beryllina*, and *M. californicus* were maintained at 20° C during testing ( $\pm 1^\circ$  C). Complete laboratory and statistical data are provided in Appendix B for *M. bahia*, *M. beryllina*, and *M. californicus*.

##### *Mysidopsis bahia* (Batch #s Mb-0602-02, Mb-0602-03, and Mb-0702-01)

Survival of *M. bahia* was 98% in the seawater Control (0% elutriate) and 98%, 98%, and 99% in the 10, 50, and 100% elutriate Controls, respectively. Survival in all concentrations of elutriates of test sediment ranged from 90% to 99% (Table 4).

Menidia beryllina (Batch # Mb-0702-01)

Survival of *M. beryllina* was 95% in the seawater Control (0% elutriate), and 100%, 97%, and 99% in the 10, 50, and 100% elutriate Controls, respectively. *Menidia* survival ranged from 93% to 97% in all concentrations of elutriates from the test sediments (Table 5).

Mytilus californicus (Batch # Mc-0702-01)

Normal mussel larvae development was 94% or greater for all concentrations of all the test sediments. At 48 hrs, the percentage of live larvae present and counted in each concentration of the test sediments was 90% or greater (Table 6). Mortalities among larvae were estimated from differences between culture density and test chamber densities at 48 hrs. Larvae survivorship was calculated from mean number recovered, and ranged from 19% (Little Bay, 100%) to 84% (Control). Control elutriate LC<sub>50</sub> was 49.20%, Norton Basin was 63.58% and Little Bay was 52.78%.

Median Lethal Concentration

LC<sub>50</sub> values could not be computed for the sediment elutriates tested with *M. bahia* or *M. beryllina* since mortalities were not less than 50% in any of the test concentrations.

4.3 WHOLE SEDIMENT BIOASSAYS

Whole sediment bioassays were performed to determine the potential impact of chemical constituents in Norton Basin (NB3), Little Bay (LB3) and Grass Hassock Reference (GH Ref 1) sediments on the infaunal amphipods *Eohaustorius estuarius* and *Ampelisca abdita*, and on the mysid shrimp *Mysidopsis bahia*. *E. estuarius* were obtained from Northwestern Aquatic Sciences and *A. abdita* were obtained from Brezina and Associates. Five-day old *M. bahia* were obtained from Aquatic Research Organisms. Whole sediment tests with *M. bahia* and *E. estuarius* were conducted June 14-24, 2002, and with *A. abdita*, June 21-July 1, 2002. Point aux Pins Control and Culture Control sediments were also tested.

#### 4.3.1 Whole Sediment Bioassay Test Methods

Natural, filtered seawater ( $28 \pm 1$  ppt) was used as the water medium. Each test was comprised of five replicates for each species. Two-liter test chambers (Kerr<sup>®</sup> jars) were used for all test species. Twenty amphipods and 15 mysids were loaded into each test chamber. All test chambers were aerated at a rate of less than 100 bubbles/minute. The air was supplied by a Gast<sup>®</sup> air blower through a fine bore tube. Amphipods were not fed during the course of the test period. *M. bahia* were fed *Artemia* (brine shrimp) once per day during the test period.

Water quality parameters measured daily during the 10-day test were dissolved oxygen (DO), pH, temperature, and salinity. Ammonia levels were monitored three times during the course of the test period. Dissolved oxygen was measured with a YSI Model 57 DO meter. Temperature and pH were measured with an Orion Model 230A meter. Salinity was measured with a temperature-compensating Aquafauna<sup>®</sup> Refractometer. Ammonia was measured using a LaMotte Ammonia-Nitrogen test kit (Model NANR). All instruments were calibrated daily. Water temperature was maintained at approximately  $20 \pm 1^\circ\text{C}$  on average.

Sediment was added to each container to form a layer approximately 3.5 cm deep. Filtered seawater was then added to each test chamber to cover the sediment, making a total test volume of 1000 ml. Approximately 24-hr later, this water was siphoned from the test chambers and replaced with fresh filtered seawater at a slow rate so as not to disturb the sediment. Water quality measurements were then taken, after which the test organisms were introduced to each test chamber. Subsequently, water renewal was performed daily after water quality measurements were taken. Water was siphoned from the test chambers with airline tubing fitted with Nytex<sup>®</sup> screen (250  $\mu\text{m}$ ), to prevent inadvertent removal of test organisms. Filtered, natural seawater was then siphoned into the test chambers with small-bore vinyl tubing, taking care not to resuspend sediment.

Sediment bioassay data were evaluated using Dunnett's T-test procedure (USEPA/600/4-89/001). Statistical comparisons of mean survival in each test sediment and the control were conducted for each species.

#### 4.3.2 Whole Sediment Bioassay Results

Sediment bioassay test conditions were generally constant, with respect to DO, pH, temperature, and salinity. Total ammonia (NH<sub>3</sub>) in the tests with *M. bahia*, *E. estuarius*, and *A. abdita* ranged from 0.096 to 0.72 ppm. Control sediments exhibited the highest NH<sub>3</sub> concentrations, which can be attributed to the fact that this sediment is richer in micro-interstitial organisms than the test sediments. Generally, ammonia concentrations decreased over the 10-day period. Complete laboratory and statistical data are provided in Appendix C for *M. bahia*, *E. estuarius*, and *A. abdita*.

##### *Mysidopsis bahia* Batch #Mb-0602-01

*Mysidopsis bahia* exhibited at least 90% survivorship in all test sediments (Table 7). There was no statistical differences in survivorship in any of the test sediments compared to Grass Hassock Reference ( $p > 0.05$ , Table 10).

##### *Eohaustorius* Batch #Ee-0602-01

*Eohaustorius estuarius* exhibited above 90% survivorship in all test sediments except Little Bay, where its survivorship was 62% (Table 8). Survivorship in Little Bay sediments was significantly less than the Grass Hassock Reference ( $p > 0.05$ , Table 11).

##### *Ampelisca abdita* Batch# Aa-0602-01

*Ampelisca abdita* exhibited 80% survivorship in Norton Basin and 90% survivorship in Little Bay sediments (Table 9). Their survivorship in NB and LB test sediments did not differ significantly from the Grass Hassock Reference sediment, where *A. abdita* survivorship was 81% ( $p > 0.05$ , Table 12).

#### 4.4 BIOACCUMULATION TESTS

Bioaccumulation tests were performed to determine if organisms would bioaccumulate significant amounts of metals when exposed to Norton Basin and Little Bay sediments during a 28-day period. Test organisms were also exposed to Control sediment. The levels of metals found in the test organism tissues were compared to those levels found

in Grass Haddock Reference exposed test organisms. Additionally, Food and Drug Administration (FDA) action levels were used to evaluate the levels of certain metals found in the test organism tissues. The polychaete *Nereis virens* was used for this test and was obtained from Aquatic Research Organisms in Hampton. Bioaccumulation testing with *N. virens* began June 12, 2002, and was terminated July 10, 2002.

#### 4.4.1 Bioaccumulation Test Methods

The test chambers consisted of 10-gallon glass aquaria with five replicates per test sediment and three replicates for the control. An average of 5 cm of sediment was placed in each aquarium, which were then filled to volume with filtered seawater at a salinity of  $29 \pm 1$  ppt. Water quality was recorded before test organisms were introduced to the test chambers (20 *N. virens* per chamber).

Test temperature ( $20 \pm 1^\circ\text{C}$ ) was maintained by means of ambient temperature control, and averaged  $19.93^\circ\text{C}$  for *N. virens* test chambers. Aeration was supplied to all test chambers for the duration of the test by two 1-inch air stones at a rate of approximately  $50 \text{ cm}^3/\text{min}$ .

Water quality parameters measured daily during the 28-day bioaccumulation tests were dissolved oxygen, pH, temperature, and salinity. Dissolved oxygen was measured with a YSI Model 57 DO meter, pH and temperature were measured with an Orion Model 230A meter with pH/temperature probe, and salinity was measured with an Aquafauna® temperature-compensated refractometer. All instruments were calibrated daily.

At test termination, 28 days after initiation, *N. virens* were removed from their test chambers and counted. On July 10, 2002 the test organisms from each sediment replicate were placed in trays of clean sand and filtered seawater and allowed to depurate (void their gut of digested material) for approximately 24 hours. On July 11, 2002, the test animals were rinsed with deionized water to remove any external debris from their bodies. Animals from each replicate for each test sediment were composited into a single sample (for a total of 18 samples) and placed in pre-cleaned, pre-labeled glass jars and stored frozen until analyzed.

#### 4.4.2 Bioaccumulation Survivorship

*Nereis virens* survivorship in all test sediments was not significantly lower than survivorship in the Control and Grass Haddock Reference sediments (Table 13). Survivorship for *N. virens* was 96% and 100% in Norton Bay and Little Bay sediments, respectively. Control and Grass Haddock Reference sediments exhibited 92% and 87% survivorship, respectively. Complete laboratory and statistical data for *N. virens* are presented in Appendix D.

#### 4.4.3 Tissue Chemistry Results

Frozen *N. virens* tissues from 28-day exposure to Norton Basin, Little Bay, Grass Haddock Reference, and Control sediments were transported on ice to STL Mobile, Alabama for the following analyses: aluminum, antimony, arsenic, barium, chromium, cobalt, copper, iron, lead, nickel, manganese, vanadium, zinc, mercury (7471A), moisture (USEPA 1986a, 1987), and lipids (Lee et al, 1989).

Aluminum, arsenic, copper, lead, mercury, and zinc were detected in the *Nereis virens* tissues. However, only mercury concentrations in Norton Basin exposures were found to be significantly greater than in Grass Haddock Reference exposures ( $p < 0.05$ ). None of the metals detected in the *N. virens* tissues, including mercury, exceeded the FDA action levels. Tissue chemistry results are summarized in Table 14 and tissue chemistry data are presented in Appendix E.

#### 4.4.4 Tissue Chemistry Quality Assurance /Quality Control

Replicate analyses were performed for every 10 samples analyzed. Matrix spike and matrix duplicates (MS/MSD) were performed for every 20 samples analyzed. In addition, procedural blanks were run for the different analysis, and triplicate analyses were performed on 10% of all samples tested. QA/QC data can be found in Appendix E.

### **5.0 REFERENCE TOXICANT TESTS**

24-hr static reference toxicant tests were conducted on each species used for short term tests to document the health of the organisms. Results of these tests are summarized

as follows: *Mysidopsis bahia*, Batch #Myb-0602-01, 24-hr LC<sub>50</sub> = 21.44 ppm Sodium Dodecyl Sulfate (SDS) (Trimmed Spearman Karber); *Menidia beryllina*, Batch #Meb-0602-01, 24-hr LC<sub>50</sub> = 1.74 ppm SDS (Trimmed Spearman Karber); *Eohaustorius estuarius*, Batch# 0602-01, 24-hr LC50= 58.56 ppm SDS; *Ampelisca abdita*, Batch # Aa 0602-01, 24-hr LC50 = 12.60 ppm SDS; *Mytilus californicus*, Batch # Mc 0702-01, 24-hr estimate using probit analyses, LC50=30.71 µg/L Copper Sulfate. Reference toxicant data sheets and LC<sub>50</sub> calculations are located in Appendix F.

## **6.0 SUMMARY**

The results of the June -July evaluation of sediment collected from borrow pits in Norton Basin and Little Bay can be summarized as follows:

1. The whole sediment tests reveal that none of the project sediments were acutely toxic to the three test organisms. *Mysidopsis bahia* survivorship in all of the test samples was above 90%. *Eohaustorius estuarius* exhibited survivorship above 90% in all of the test sediments except in Little Bay, where its survivorship was 62%, which was significantly lower than in the Control and Reference sediments. In contrast, *Ampelisca abdita* exhibited 90% survivorship in Little Bay sediments, and *Ampelisca* survivorship in the project sediments and Grass Hassock Reference sediment did not differ significantly. The differences in survivorship in Little Bay sediments between *Ampelisca* and *Eohaustorius* may be due to *Eohaustorius*'s preference for fine sand substrates. In addition, a condition existed where due to the silty nature of the test sediments, *Eohaustorius* would swim erratically in the Little Bay test chambers with silt attached to their bodies. This also occurred in Norton Basin and Grass Hassock Reference chambers, but not as frequently.
2. The results from the water column tests revealed that none of the test elutriates were acutely toxic to *Mysidopsis bahia*, *Menidia beryllina*, or *Mytilus californicus*. Survivorship was 90% or above in all concentrations for all test sediments for *Mysidopsis* and *Menidia*. Normal mussel larvae development was 90% and above for all concentrations for all sediments

(Control, Norton Basin and Little Bay). LC50's calculated for the test sediments were not less than the LC50 calculated for the Control.

3. The results from the 28-day bioaccumulation test revealed that none of the project sediments were acutely toxic to *Nereis virens*. *Nereis* survivorship was 87% in Grass Hassock Reference, 100% in Little Bay, and 96% in Norton Basin sediments.
4. For all Jamaica Bay sediment samples, PAHs, PCBs, dioxins, and pesticides were absent or occurred at concentrations below detection limits. However, the following heavy metals were detected above background levels: aluminum, antimony, arsenic, barium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, vanadium, and zinc. Norton Basin (NB3), Little Bay (LB3), and Grass Hassock Reference (GH Ref 1) sediments contained levels of arsenic, cadmium, chromium, copper, lead, mercury, and zinc above established effects range low (ERLs) levels. NB3 and LB3 sediments contained levels of copper and lead that were above established probable effects levels (PELs), and that were significantly greater in concentration than in the Grass Hassock Reference sediment.
5. Aluminum, arsenic, copper, lead, mercury, and zinc were detected in the *Nereis virens* tissues. However, only mercury concentrations in NB 3 exposures were found to be significantly greater than in Grass Hassock Reference exposures. None of the metals detected in the *N. virens* tissues, including mercury, exceeded the FDA action levels.

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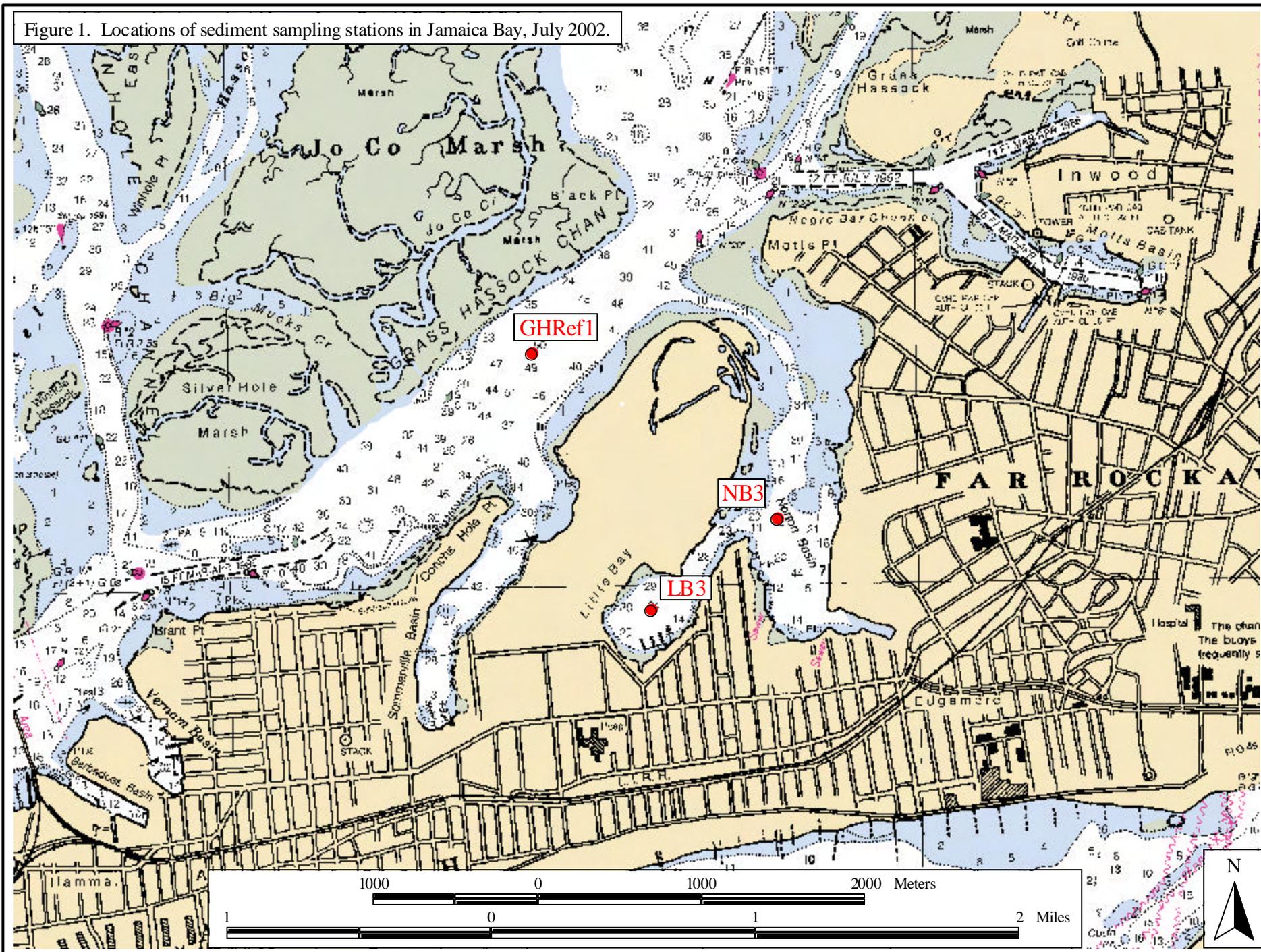
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## **FIGURES**

Figure 1. Locations of sediment sampling stations in Jamaica Bay, July 2002.



## **TABLES**

**TABLE 1. Summary of metals content (mg/kg) dry wt. in sediments collected from Jamaica Bay, Far Rockaway, NY, June 6, 2002. Only those metals detected are presented in this table and were analyzed in the *Nereis virens* tissues.**

METAL	Control	GH1	NB3	LB3	ERL	PEL
Aluminum	3000	11333	1250	9800	ND	ND
Antimony	<2.0	<8.7	<15	<23	ND	ND
Arsenic	2.4	10.2	8.6	<11	8.2	41.6
Barium	NA	51	59	150	ND	ND
Cadmium	<.30	<2.2	<3.8	<5.7	1.2	4.2
Chromium	3.6	58	52	43	81	160.4
Cobalt	<1.0	7.5	8.1	<11	ND	ND
Copper	<2.0	85.33	110	160	34	108.2
Iron	4300	28333	35000	38000	ND	ND
Lead	2.7	87	133	193	46.7	112.2
Manganese	19	263	248	190	ND	ND
Mercury	<.020	0.61	0.43	0.53	0.15	0.70
Nickel	<4.0	26	28	<45	20.9	42.8
Vanadium	NA	44	53	52	ND	ND
Zinc	3.4	203	307	45	150	271

GH1 = Grass Haddock Reference station 1; values are an average of three samples

NB3 = Norton Basin Station 3; values are an average of 4 samples

LB3 = Little Bay Station 3; values are an average of 3 samples

ERL - Effects Range Low Level- in ppm dry wt

PEL - Probable Effects Level - in ppm dry wt

ND = No Data available

**TABLE 2. Summary of ANOVA and Bonferroni t-Test for differences in sediment Copper content between test and reference samples collected from New York, June 6, 2002.**

**ANOVA for Differences between Means**

Source of Variation	df	Sum of Squares	Mean Squares	F
Between Means	2	8747.733	4373.867	16.616
Within Means	7	1842.667	263.238	
Total	9	10590.400		

Critical F-value = 4.74, with  $\alpha = 0.05$  and  $df = 2,7$   
 Since F is greater than the Critical F-value, reject  $H_0$ : all equal

**Bonferroni t-Test for Differences between Sediments**

Test Condition	<sup>a</sup> Reference vs. Sediments		Mean Copper Concentration $\mu\text{g}/\text{kg}$
	t	Conclusion	
Grass Hassock (Ref)	-	-	85.333
Norton Basin	1.991	$\nlessgtr$	110.000
Little Bay	5.636*	$>$	160.000

<sup>a</sup>Bonferroni t-table value = 2.36, with  $\alpha = 0.05$ ,  $df = 2,7$

**TABLE 3. Summary of ANOVA and Bonferroni t-Test for differences in sediment lead content between test and reference samples collected from New York, June 6, 2002.**

**ANOVA for Differences between Means**

Source of Variation	df	Sum of Squares	Mean Squares	F
Between Means	2	17201.667	8600.833	38.834
Within Means	7	1550.333	221.476	
Total	9	18752.000		

Critical F-value = 4.74, with  $\alpha = 0.05$  and  $df = 2,7$   
 Since F is greater than the Critical F-value, reject  $H_0$ : all equal

**Bonferroni t-Test for Differences between Sediments**

Test Condition	<sup>a</sup> Reference vs. Sediments		Mean Lead Concentration mg/kg
	t	Conclusion	
Grass Hassock (Ref)	-	-	86.667
Norton Basin	4.032*	>	132.500
Little Bay	8.778*	>	193.333

<sup>a</sup>Bonferroni t-table value = 2.36, with  $p = 0.05$ ,  $df = 2,7$

**TABLE 4. Summary of *Mysidopsis bahia* survivorship in the 96-hr. elutriate test on sediments collected from New York, June 6, 2002**

<b>Elutriate ID</b>	<b>Elutriate Concentration</b>	<b>Number Exposed</b>	<b>Number Survived</b>	<b>Percent Survivorship</b>
Control Sea Water	0%	100	98	98
Control Sediment	10%	100	98	98
	50%	100	98	98
	100%	100	99	99
Norton Basin	10%	100	97	97
	50%	100	98	98
	100%	100	99	99
Little Bay*	10%	100	94	98
	50%	100	97	98
	100%	100	49	90

\* Little Bay water column test results are presented from a test repeat. Control sea water exhibited the same result.

**TABLE 5. Summary of *Menidia beryllina* survivorship in the 96-hr. elutriate test on sediments collected from New York, June 6, 2002**

<b>Elutriate ID</b>	<b>Elutriate Concentration</b>	<b>Number Exposed</b>	<b>Number Survived</b>	<b>Percent Survivorship</b>
Control Sea Water	0%	100	95	95
Control Sediment	10%	100	100	100
	50%	100	97	97
	100%	100	99	99
Norton Basin	10%	100	96	96
	50%	100	95	95
	100%	100	96	96
Little Bay	10%	100	93	93
	50%	100	97	97
	100%	100	97	97

**TABLE 6. Summary of percent recovery of *Mytilus californicus* larvae; and abnormal vs. normal larvae development in the 48-hour bivalve test with sediments collected from New York, June 6, 2002.**

Elutriate ID	Mean No. of Larvae Recovered	% Larvae Recovered	Percent Larval Development		
			Mean % Abnormal	Mean % Normal	Mean % Alive
Control SW	5040	84	1	99	98
Cont 10%	3780	63	2	98	98
Cont 50%	2040	34	3	97	98
Cont 100%	2040	34	3	97	96
NB 10%	4680	78	3	97	98
NB 50%	2820	47	3	97	97
NB 100%	1980	33	6	94	93
LB 10%	3660	61	5	95	98
LB 50%	3000	50	3	97	99
LB 100%	1140	19	4	96	90

**LC50 Data for the number of larvae recovered at the end of 48 hours**

Control Elutriate LC50= 49.20

Norton Basin Elutriate LC50 = 63.58

Little Bay Elutriate LC50 = 52.78

SW = Sea Water

NB = Norton Basin

LB = Little Bay

**TABLE 7. Summary of survivorship for *Mysidopsis bahia* in the 10-day whole sediment test on sediments collected from New York, June 6, 2002.**

Sediment I.D.	Sediment Type	Organic Debris	No. Exposed	No. Survived	Percent Survivorship
<sup>a</sup> Control Sediment	sandy/clay	very low	100	96	96
Norton Basin	silt/fine sand	moderate	100	95	95
Grass Hassock (Ref)	silt/fine sand	moderate	100	92	92
Little Bay	silt	moderate	100	90	90
Sea Water Control	-----	-----	100	94	94

**TABLE 8. Summary of survivorship for *Eohaustorius estaurius* in the 10-day whole sediment test on sediments collected from New York, June 6, 2002.**

Sediment I.D.	Sediment Type	Organic Debris	No. Exposed	No. Survived	Percent Survivorship
<sup>a</sup> Control Sediment	sandy/clay	very low	100	94	94
Norton Basin	silt/fine sand	moderate	100	92	92
Grass Hassock (Ref)	silt/fine sand	moderate	100	92	92
Little Bay	silt	moderate	100	62	62
<sup>b</sup> Culture Control	fine sand	very low	100	100	100

**TABLE 9. Summary of survivorship for *Ampelisca abdita* in the 10-day whole sediment test on sediments collected from New York, June 6, 2002.**

Sediment I.D.	Sediment Type	Organic Debris	No. Exposed	No. Survived	Percent Survivorship
<sup>a</sup> Control Sediment	sand/clay	very low	100	71	71
Norton Basin*	silt/fine sand	moderate	80	71	80
Grass Hassock (Ref)	silt/fine sand	moderate	100	81	81
Little Bay	silt	moderate	100	90	90
<sup>b</sup> Culture Control	muddy/silt	moderate	100	90	90

\* Replicate B in Norton Basin was thrown out due to an accidental spill. Therefore, Bonferroni t-Test was performed for this test group.

<sup>a</sup> - Sediment collected from a clean site designated by the COE.

<sup>b</sup> - Sediment collected from the site where the test organism is collected.

**TABLE 10. Summary of ANOVA and Dunnett's t-Test for Norton Basin 10-day whole sediment test with *Mysidopsis bahia* June 14-24, 2002.**

**ANOVA for Differences between Means**

Source of Variation	df	Sum of Squares	Mean Squares	F
Between Means	3	4.550	1.517	1.517
Within Means	16	16.000	1.000	
Total	19	20.550		

Critical F-value = 3.24, with  $\alpha = 0.05$  and  $df = 3,16$   
 Since F is less than Critical F-value, Fail to reject  $H_0$ : all equal

**Dunnett's t-Test for Differences between Sediments**

Test Condition	Reference vs. Sediments		Mean Survivorship
	t	Conclusion	
Grass Hassock (Ref)	-	-	18.400
Norton Basin	-0.949	✗	19.000
Little Bay	0.632	✗	18.000
Control Sediment	-1.265	✗	19.200

Dunnett's t-table value = 2.23, with  $p = 0.05$ ,  $df = 16,3$

**TABLE 11. Summary of ANOVA and Dunnett's t-Test for Norton Basin 10-day whole sediment test with *Eohaustorius estuarius* June 14-24, 2002.**

**ANOVA for Differences between Means**

Source of Variation	df	Sum of Squares	Mean Squares	F
Between Means	3	141.600	47.200	16.276*
Within Means	16	46.400	2.900	
Total	19	188.000		

Critical F-value = 3.24, with  $\alpha = 0.05$  and  $df = 3,16$   
 Since F is greater than the Critical F-value, reject  $H_0$ : all equal

**Dunnett's Test for Differences between Sediments**

Test Condition	<sup>a</sup> Reference vs. Sediments		Mean Survivorship
	t	Conclusion	
Grass Hassock (Ref)	-	-	18.400
Norton Basin	0.000	≠	18.400
Little Bay	5.571*	>	12.400
Control Sediment	-0.371	≠	18.800

Dunnett's t-table value = 2.23, with  $p = 0.05$ ,  $df = 16,3$

**TABLE 12. Summary of ANOVA and Bonferroni t-Test for Norton Basin 10-day whole sediment test with *Ampelisca abdita* June 21-July 1, 2002.**

**ANOVA for Differences between Means**

Source of Variation	df	Sum of Squares	Mean Squares	F
Between Means	4	53.608	13.402	2.488
Within Means	19	102.350	5.387	
Total	23	155.958		

Critical F-value = 2.90, with  $\alpha = 0.05$  and  $df = 4,19$

Since F is less than the Critical F-value, Fail to reject  $H_0$ : all equal

**Bonferroni's t-Test for Differences between Sediments**

Test Condition	<sup>a</sup> Reference vs. Sediments		Mean Survivorship
	t	Conclusion	
Grass Hassock (Ref)	-	-	16.200
Norton Basin	-0.996	✗	17.750
Little Bay	-1.226	✗	18.000
Control Sediment	1.362	✗	14.200
Culture Control	-1.226	✗	18.000

<sup>a</sup>Bonferroni t-table value = 2.43;  $p = 0.05$ ,  $df = 4,19$

**TABLE 13. Summary of *Nereis virens* survivorship in the 28-day bioaccumulation test with sediments collected from New York, June 6, 2002.**

<b>Elutriate ID</b>	<b>Number Exposed</b>	<b>Number Survived</b>	<b>Percent Survivorship</b>
Control Sediment	60	55	92
Norton Basin	100	96	96
Grass Gray Hassock	100	87	87
Little Bay	100	100	100

**TABLE 14. Summary of metals content (mg/kg) wet wt. in *Nereis virens* tissues from the bioaccumulation test with sediments collected from NY, June 6, 2002. Only those metals detected are presented in this table.**

<b>METAL</b>	<b>Control</b>	<b>GH1</b>	<b>NB3</b>	<b>LB3</b>	<b>FDA Action Level (ppm)</b>
Aluminum	<3.3	3.94*J	3.8*J	3.4	No Action Level
Arsenic	3.1	3.12	3.06	3.0	86
Copper	1.8	2.22	6.04	2.92	No Action Level
Lead	0.35*J	0.37*J	0.38*J	0.39*J	1.7
Mercury	0.0071	0.0096	0.013	0.0089	1.0
Zinc	14.7	19.4	25.4	26.4	No Action Level

\*J = indicates the presence of a compound that meets the identification criteria, but the result is less than the reporting limit and greater than the method detection limit.

**TABLE 15. Summary of Bonferroni t-Test for significant differences in *Nereis virens* metals content between test sediments and the reference sediment.**

Sediment ID	Metal	<sup>a</sup> Sediment Vs. Reference Conclusion	Mean Concentration (mg/kg)
Grass Hassock Ref	Aluminum	-----	24.800
	Arsenic	-----	22.800
	Copper	-----	16.200
	Lead	-----	2.740
	Mercury	-----	0.070
Norton Basin	Aluminum	>	24.600
	Arsenic	>	21.600
	Copper	>	43.400
	Lead	>	2.660
	Mercury	>	0.088
Little Bay	Aluminum	>	16.800
	Arsenic	>	21.400
	Copper	>	20.800
	Lead	>	2.760
	*Mercury	>	0.063
Control	Aluminum	>	14.000
	Arsenic	>	22.333
	Copper	>	13.333
	Lead	>	2.533
	Mercury	>	0.053

\* Mercury is the only metal which was significantly greater in concentration in Norton Basin exposed *N. virens* than in the Grass Hassock Reference exposed *N. virens*.

<sup>a</sup>Bonferroni t-table value = 2.36; p = 0.05, df = 3,14