Dredged Material Management Plan

NOVEMBER 2000 BASELINE CHARACTERIZATION OF SEDIMENT CHEMISTRY AT TWO CANDIDATE DREDGED MATERIAL DISPOSAL SITES IN BUZZARDS BAY

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NOVEMBER 2000 BASELINE CHARACTERIZATION OF SEDIMENT CHEMISTRY AT TWO CANDIDATE DREDGED MATERIAL DISPOSAL SITES IN BUZZARDS BAY

Dredged Material Management Plan Phase 2C
MEPA Scope Item III

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EXECUTIVE SUMMARY

A comprehensive survey effort was undertaken in November 2000 to characterize baseline physical, chemical, and biological conditions at two candidate dredged material disposal sites in eastern Buzzards Bay and two nearby reference areas. As part of this effort, grab samples were collected to characterize sediment grain size and chemical contaminant concentrations within candidate Sites 1 and 2 and reference areas REF-NEW and REF-2. Using a 0.04 m^2 van Veen grab, surface sediments were collected at a total of 18 sampling stations: six stations within each of Sites 1 and 2 and three stations within each reference area. A single grab sample was collected at each station, and subsamples of the sediment surface (upper 2 to 4 cm) were removed for subsequent laboratory analysis of grain size, total organic carbon (TOC), selected polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, and trace metals.

On average, surface sediments at candidate disposal Site 1 were predominantly muddy (silt-clay), with a minor component of fine to medium sand. Sediments at candidate Site 2 were predominantly sandy, with lesser amounts of silt-clay. Surface sediments at reference areas REF-NEW and REF-2 had very high proportions of silt-clay (90% or more) and small amounts of fine to medium sand. Because the sediments at both of these reference areas were considerably more fine-grained than those at the two candidate disposal sites, it was recommended that one or more new reference areas be established in the future to provide a better grain size match.

Total organic carbon (TOC) concentrations at the two candidate disposal sites and two reference areas were within typical ranges for fine-grained, coastal marine sediments (1% to 2%) and comparable to average TOC concentrations in other areas of Buzzards Bay located away from pollution sources. Concentrations of metals and organic contaminants (PAHs, pesticides, and PCBs) in the sediment samples from Sites 1 and 2 and nearby reference areas were generally low and comparable to concentrations existing in unpolluted areas of Buzzards Bay. The concentrations of all of the chemical contaminants of concern measured at the four sites in the present study were at or below Effects Range Low (ERL) and considerably below Effects Range Median (ERM) guideline values. Such concentrations are considered highly unlikely to be causing any adverse effects to resident biota. In general, the surface sediments at candidate Sites 1 and 2 and the two reference areas are relatively free of chemical contamination.

Samples of surface sediments previously collected at the REF-2 reference area in March 1990 were predominantly sandy, while those collected in the present study of November 2000 were predominantly muddy. This difference in grain size distribution was attributed to natural spatial heterogeneity at this reference area. Although the comparison was hindered by differences in analytical methodology and detection limits, there were no appreciable changes detected at the REF-2 reference area in the concentrations of metals, pesticides, PCBs or PAHs between the 1990 and 2000 surveys. This suggests an absence of any long-term trends of either decreasing or increasing sediment contamination levels in this part of Buzzards Bay over this ten-year period.

1.0 INTRODUCTION

1.1 Background

In 1995, the Massachusetts Department of Environmental Management (DEM) proposed to designate an open-water dredged material disposal site within the area of the former Cleveland Ledge Disposal Site (CLDS) in eastern Buzzards Bay (Figure 1-1). On 8 March 1995, the DEM filed an Environmental Notification Form (ENF) describing the proposed site, a circular area having a diameter of 500 yards centered at 41° 36.00' N, 70° 41.00' W, corresponding to the location of the former Buzzards Bay Disposal Site (BBDS) used by U.S. Army Corps of Engineers (Figure 1-2). In the ENF, the DEM indicated that the proposed new BBDS would be designated for the receipt of coarse-grained dredged material only (i.e., silt-clay fraction of 20% or less). Following regulatory response and public comment, the Secretary of Environmental Affairs issued a Certificate on the ENF on May 10, 1995, requiring the preparation of an Environmental Impact Report (EIR) pursuant to the Massachusetts Environmental Policy Act (MEPA). The required scope for the EIR is described in the Certificate (referred to herein as the MEPA Scope).

As part of a larger project to develop a Dredged Material Management Plan (DMMP) for the state of Massachusetts, the Massachusetts Coastal Zone Management Agency (MCZM) has assumed responsibility for addressing the MEPA Scope and preparing the EIR. In March 1998, MCZM filed a Notice of Project Change, proposing to designate the BBDS for all physical categories of dredged material deemed suitable for open ocean disposal (from fine- to coarse-grained), rather than limiting the designation to coarse-grained material only.

In fulfillment of MEPA Scope Item I, MCZM sponsored a Needs Analysis that documented the regional need for a disposal site, estimated the types and quantities of dredged material to be generated, and identified local, regional and state dredged material use and disposal policies (Maguire Group Inc., 1998a). Under MEPA Scope Item II, an Alternatives Analysis was completed to evaluate: 1) the potential environmental benefits and drawbacks of opening an historic disposal site versus identifying a new site, and 2) the feasibility of using the existing Massachusetts Bay Disposal Site (MBDS) or Cape Cod Disposal Site (CCDS; Maguire Group Inc., 1998b).

The Alternatives Analysis concluded that while the CCDS could be used for disposal of material from dredging projects in the northern end of Buzzards Bay, the significant transit distances generally precluded the use of either the CCDS or MBDS as cost-effective options. The Alternatives Analysis also identified several drawbacks to the BBDS as originally proposed by DEM in 1995 (Figure 1-2), including the potential for erosion of fine-grained sediment, limited access by deeper draft hopper dredges, and inadequate long-term capacity. To overcome these drawbacks, it was recommended that deeper and larger areas within and near the historic Cleveland Ledge Disposal Site be considered as potential disposal site locations.

Under MEPA Scope Item III, MCZM is required to collect data to determine the baseline physical and biological characteristics of any proposed disposal site(s), including bathymetry, sediment grain size and chemistry, benthic community structure, bottom currents, fisheries, and

water column chemistry. Under contract to MCZM, SAIC conducted a survey in May 1998 involving high-resolution bathymetry and side-scan sonar across a relatively large area encompassing the southern half of the historic Cleveland Ledge Disposal Site (Maguire Group Inc., 1998c). The objective of this reconnaissance survey was to gather data on the physical characteristics of the seafloor to facilitate optimal siting of the proposed BBDS.

In general, the May 1998 study identified areas having water depths greater than 12 m as being preferred disposal locations, because such areas have the potential to limit sediment resuspension and maximize long-term capacity while accommodating access by deep draft hopper dredges. The May 1998 bathymetric data revealed two locations in the surveyed area having water depths greater than 12 m: a basin located near the eastern boundary of the historic Cleveland Ledge Disposal Site ("eastern basin") and an area near the southern boundary ("southern basin"; Figure 1-3). SAIC conducted a second bathymetric survey in October 2000 to characterize in greater detail the bottom topography in the vicinity of the southern basin. The two candidate disposal sites selected for further study under MEPA Scope Item III are located over the southern and eastern basins and designated as Sites 1 and 2, respectively (Figures 1-3 and 1-4).

Site 2 is a rectangular area with dimensions 1000 m × 1700 m (Figure 1-4). It is under consideration as a potential disposal site because it appears to be a predominantly depositional seafloor environment, having sufficient water depth and capacity, that has already been affected by past dredged material disposal at the historic Cleveland Ledge Disposal Site. However, this site has the drawback of being close to shallow areas (e.g., Gifford Ledge to the east and the historic Cleveland Ledge "dump top" to the west), which could limit access by deeper draft vessels and potentially represent a hazard to navigation.

The deeper parts of the southern basin occur just outside the southern boundary of the Cleveland Ledge Disposal Site (Figures 1-3 and 1-4). Since deeper areas within Buzzards Bay have the greatest potential to act as containment sites for deposited dredged material, a decision was made to establish candidate Site 1 (a square area measuring 1600 m × 1600 m) over this deeper part of the southern basin.

1.2 Survey Objective

The objective of the November 2000 survey reported here was to characterize sediment grain size and chemical contaminant concentrations at candidate Sites 1 and 2 and at two nearby reference areas. The sediment chemistry sampling activities were one part of a larger November 2000 survey effort undertaken to characterize the baseline physical, chemical, and biological features of the candidate sites and reference areas, as part of an on-going disposal site designation effort.

2.0 METHODS

2.1 Sampling locations

SAIC collected sediment samples for grain size and chemical analysis aboard the M/V *Beavertail* on November 13, 2000. Grab samples of surface sediments were collected at a total of 18 sampling stations: six stations within Site 1, six within Site 2, three at the "REF-2" reference area located 3,200 m to the west of the center of Site 1, and three at the "REF-NEW" reference area located 2,250 m to the south of the center of Site 1 (Figure 2-1). The stations within Sites 1 and 2 and the reference areas were selected at random from larger sampling grids used to obtain sediment-profile images at each site.

The stations were distributed throughout Sites 1 and 2 to provide both a basic characterization of the existing grain size and chemical contaminant levels and an evaluation of the potential within-site spatial variability in these parameters. The reference areas were sampled to provide a comparison between the existing conditions at Sites 1 and 2 and those in the immediate surrounding region. The REF-2 reference area was sampled in the past as part of routine environmental monitoring at the former Buzzards Bay Disposal Site conducted by the U.S. Army Corps of Engineers Disposal Area Monitoring System (DAMOS) Program (SAIC 1991). The results from the present study are compared to those from the past (Section 4.6) to evaluate any temporal trends in sediment contaminant levels at this reference area.

Positioning of the vessel at each station was accomplished using differentially corrected Global Positioning System (DGPS) data in conjunction with Coastal Oceanographic's HYPACK® navigation and survey software. A Trimble DSM212L Differential/GPS receiver was used to obtain raw satellite data and provide vessel position information in the horizontal control of North American Datum of 1983 (NAD 83). The Trimble receiver is a dual function unit, bringing in differential corrections as well as GPS data, to improve overall accuracy of the satellite data to the necessary tolerances. The U.S. Coast Guard differential beacon broadcasting from Chatham, MA (325 kHz) was utilized for real-time satellite corrections due to its geographic position relative to the survey area in eastern Buzzards Bay. Overall, the navigation system allowed the samples to be obtained at each station within ±3 m of the target location.

2.2 Sample collection

Sediment grab samples were collected using a stainless steel, 0.04 m^2 Young-modified van Veen grab sampler having a maximum penetration depth of 12 cm. Prior to collection of each grab sample, the sampler and sampling utensils were cleaned with a non-phosphate laboratory detergent (e.g., Alconox®) and rinsed with seawater to remove any sediment, debris, rust or other potential sample contaminants. The sampler and utensils were further decontaminated through successive rinses with dilute nitric acid, seawater, and methanol.

A single grab sample was collected at each station. Upon arrival on the target station, the decontaminated grab sampler was set in an open position and lowered to the seafloor on a stainless steel winch wire. Upon reaching the bottom, the device was retrieved, causing the bucket to close

and retain a surface sediment sample. The grab sampler was raised on the winch wire and placed on a stand secured to the deck of the survey vessel.

After retrieving the grab sampler, the sediment sample was determined to be acceptable or not. An acceptable grab was characterized as having relatively level, intact sediment over the entire area of the grab, and generally a sediment depth at the center of at least 7 cm. Grabs containing little or no sediments were determined to be unacceptable. The time of collection and geographic position of the sample were recorded both in the field logbook and by the navigation system.

A decontaminated stainless steel spoon was used to scoop out subsamples of the surface sediment collected in each grab. The subsamples were taken from the upper 2 to 4 cm of the sediment in the grab (i.e., a surface skim) and placed directly into a pre-cleaned glass jar for chemical analyses and a quartz size resealable plastic bag for grain size analysis. The samples were then stored on ice in an insulated cooler and held at approximately 4° C during the field sampling operation. The coolers were later packed with additional ice and delivered to Woods Hole Group Environmental Laboratories in Raynham, MA for chemical analysis. Samples for grain size analysis were shipped to Applied Marine Sciences in League City, TX.

2.3 Sample Analysis

In the chemistry laboratory, the samples were analyzed for selected polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, trace metals, and total organic carbon (TOC), as listed in Table 2-1. The analytes in Table 2-1 represent common "contaminants of concern" in coastal sediments and are taken from Tables I-A and I-B of the New England regional guidance document for dredged material testing (U.S. Environmental Protection Agency/U.S Army Corps of Engineers, 1989).

PAHs were determined by Gas Chromatography/Mass Spectrometry with Selected Ion Monitoring (EPA SW-846 Method 8270). Analyses for PCBs were performed by Gas Chromatography/Electron Capture Detection (EPA SW-846 Method 8082). The selection of congeners was based on the priority PCBs as determined by the NOAA National Status and Trends program. Pesticide analyses were performed by Gas Chromatography/Electron Capture Detection (EPA SW-846 Method 8081). Analysis of TOC was performed using protocols described in EPA SW-846 Method 9060.

Eight metals were analyzed: arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), lead (Pb), mercury (Hg), nickel (Ni), and zinc (Zn). Sediments were first digested with aqua regia and then submitted for analysis. Sample digestates were analyzed for mercury (Hg) using cold-vapor atomic absorption spectroscopy (CVAA) in accordance with EPA method SWA-846 7471. Arsenic, cadmium and lead were analyzed using EPA method SWA-846 6020, while chromium, copper, nickel and zinc were analyzed using EPA method SWA-846 6010B. The grain size analysis (i.e., sediment particle size distribution) followed the procedures of Plumb (1981)

3.0 RESULTS

This section presents the sediment chemistry and grain size results individually for Site 1, Site 2, Ref-New and Ref-2. Among-site comparisons are discussed in Section 4.0. Sediment grain size is reported as percentages of gravel, sand, and silt-clay. Total organic carbon (TOC) is also reported as a percentage. Trace metal concentrations are reported in parts-per million (mg/kg), while organic compounds (PAHs, pesticides and PCBs) are reported in parts per billion (μg/kg). Trace metal and organic compound concentrations that were below sample-specific detection limits (i.e., non-detects) are reported herein using one-half the detection limit to facilitate statistical calculations.

Concentrations are reported for 23 individual PAH compounds. Presentation of the PAH data includes summations of the concentrations of the 11 low molecular weight PAHs (LMW PAHs), the 12 high molecular weight PAHs (HMW PAHs), and Total PAHs (all 23 compounds combined). Likewise, concentrations are reported for 18 individual PCB congeners, corresponding to those analyzed in the National Oceanic and Atmospheric Administration's National Status and Trends Program (NS&T) and the EPA's Environmental Monitoring and Assessment Program for Estuaries (EMAP-Estuaries). Total PCBs were calculated by summing the concentrations of the 18 congeners. Total pesticides was calculated by summing the concentrations of the 20 individual pesticide compounds.

3.1 Site 1

3.1.1 Sediment Grain Size and Total Organic Carbon

The surface sediments collected at the six stations within Site 1 were composed primarily of silt and clay (Table 3-1 and Figure 3-1). Five of the stations (C3, E4, E6, G3 and G7) had combined silt and clay fractions greater than 57%, with values ranging from 57.6% to 92.8% silt and clay (Table 3-1). In contrast, the sediment at Station B6 was predominately sand (85.0%), with a minor silt-clay fraction of 15.0%. A small amount of gravel (0.04 to 3.50%) was also found in five of the six stations (Stations B6, C3, E4, G3 and G7). Overall, the surface sediments collected at Site 1 averaged 66.3% silt and clay, 33.5% sand, and less than 1% gravel (Table 3-1 and Figure 3-1).

The sediments from Site 1 had an average total organic carbon (TOC) content of 1.57% (Table 3-1 and Figure 3-2). The values at individual stations varied, ranging from 0.5% at Station B6 to 2.3% at Station E6. The lower value from Station B6 is attributed to the higher sand content (lower silt and clay content) of the sediments at this location.

3.1.2 Trace Metals

With the exception of cadmium and mercury at Station B6, all the analyzed metals were detected above method detection limits in all of the samples (Table 3-2 and Figure 3-3). The variability among the six stations for each of the metals was relatively low, as indicated by the standard deviations in Table 3-2. Station B6 consistently had the lowest concentration of each metal, again reflecting the significantly lower silt-clay content at this station. The individual

metal results are discussed in more detail in Section 4.0, where they are compared to standard environmental screening levels for trace metals in marine sediments.

3.1.3 Polycyclic Aromatic Hydrocarbons (PAHs)

The average concentration of the summed LMW PAHs at Site 1 was 214 µg/kg (Table 3-3 and Figure 3-4). Station E4 had considerably higher LMW PAH concentrations than the other five stations, causing the site average to be skewed high. The concentration of summed LMW PAHs ranged from a minimum of 50 µg/kg at Station B6 to a maximum concentration of 839 µg/kg at Station E4.

The average concentration of the summed HMW PAHs at Site 1 was 207 µg/kg, with a standard deviation 129 µg/kg (Table 3-3 and Figure 3-4). Similar to the LMW PAHs, Station E4 consistently had higher HMW PAH concentrations compared to the other stations. The summed HMW PAH values ranged from 54 µg/kg at Station B6 to 395 µg/kg at Station E4.

The average concentration of Total PAHs at Site 1 was 421 µg/kg, with a standard deviation of 414 µg/kg (Table 3-3 and Figure 3-4). The high standard deviation is due primarily to the considerably higher values of PAHs found at Station E4 compared to the other five stations.

3.1.4 Pesticides

No pesticides were detected above the sample-specific method detection limits for the sediment samples collected in Site 1 (Table 3-4). The concentrations of total pesticides (calculated by summing the one-half detection limit values) at the individual stations were all below 35 µg/kg, and the overall site average was 26 µg/kg (Table 3-4 and Figure 3-5). The results of the pesticide analyses are discussed in more detail in Section 4.0, where they are compared to standard environmental screening levels for organic compounds in marine sediments.

3.1.5 Polychlorinated Biphenyls (PCBs)

With the exception of Stations C3 and G3, no PCBs were detected above the sample-specific method detection limits for the sediment samples collected in Site 1 (Table 3-5 and Figure 3-6). The concentrations of PCB 28 at Stations C3 and G3 were 3.30 and 2.80 µg/kg, respectively. The average concentration of total PCBs for the six samples was 12.96 µg/kg, with a maximum concentration of 15.30 µg/kg at Station E6 and a minimum concentration of 8.19 µg/kg at Station B6. An evaluation of these results with respect to standard environmental screening level values is provided in Section 4.0.

3.2 Site 2

3.2.1 Sediment Grain Size and Total Organic Carbon

The sediments collected at Site 2 consisted of varying fractions of sand and silt-clay. Sand was the dominant grain size fraction at 4 of the 6 stations within Site 2 (Table 3-6 and Figure 3-7). At these stations (K12, M10, M12, and N16), the sand content ranged from 66% to 85%. Silt-clay was the dominant fraction at Stations K14 (61%) and J17 (69%). Only minor amounts of gravel were found in the sediment samples from Site 2 (Table 3-6 and Figure 3-7).

The average sediment TOC content for the six stations in Site 2 was 1.1% (Table 3-6 and Figure 3-8). Individual values ranged from 0.82% to 1.8%. As expected, the highest TOC concentrations were found at the stations (K14 and J17) with the highest percentage of fine-grained (i.e., silt and clay) sediment.

3.2.2 Trace Metals

All analyzed trace metals were detected above method detection limits in all of the samples (Table 3-7 and Figure 3-9). There was only a minor amount of variability in metal concentrations among the six samples, as indicated by the relatively low standard deviations in Table 3-7.

3.2.3 Polycyclic Aromatic Hydrocarbons (PAHs)

In general, there was little variability among the six stations in the concentrations of PAHs. The average concentration of LMW PAHs for the six samples was 66 μg/kg (Table 3-8 and Figure 3-10). The concentrations of LMW PAHs ranged from 54 μg/kg at Station K12 to 86 μg/kg at Stations K14 and J17. The average HMW PAH concentration for the six stations was 107 μg/kg, ranging from 67 μg/kg at Station N16 to 88 μg/kg at Station K14 (Table 3-8 and Figure 3-10). The average Total PAHs for Site 2 was 174 μg/kg, with a standard deviation of 57 μg/kg. The minimum Total PAH concentration of 123 μg/kg was observed at Station N16, and the maximum concentration of 274 μg/kg was found at Station K14.

3.2.4 Pesticides

All of the pesticides were undetected at the sample-specific method detection limits for the sediments collected in Site 2. The values reported in Table 3-9 and displayed graphically in Figure 3-11 represent concentrations of one-half the method detection limit for all of the compounds. The pesticide results are discussed in relation to standard environmental screening levels in Section 4.0.

3.2.5 Polychlorinated Biphenyls (PCBs)

With the exception of Station K14, none of the PCB congeners were detected above the sample-specific method detection limit in the samples collected in Site 2 (Table 3-10 and Figure 3-12). Only trace amounts of four PCB congeners (PCBs 8, 66, 101 and 153) were detected at

Station K14. The average Total PCBs for Site 2 was 11.22 µg/kg, with a standard deviation of 4.76 µg/kg.

3.3 Ref-New

3.3.1 Sediment Grain Size and Total Organic Carbon

The sediments collected at the reference area Ref-New were comprised predominantly of silt and clay (Table 3-11 and Figure 3-13). The average silt and clay content of the sediments was 93%, with relatively minor average amounts of both sand (6.8%) and gravel (0.4%). There was very little variability in grain size distribution among the three samples at the Ref-New reference area: the silt and clay fraction ranged from 91% to 96%, the amount of sand ranged from 4.5% to 8.4%, and only very small amounts of gravel were found at stations RNCTR and RN100N (Table 3-11). The average TOC concentration at Ref-New was 2.17% (21,667 ppm), with very low variability among the three stations (Table 3-11 and Figure 3-14).

3.3.2 Trace Metals

All of the analyzed trace metals were detected above method detection limits in all of the samples (Table 3-12 and Figure 3-15). There was very little variability in trace metal concentrations among the three stations at Ref-New. A discussion of these results in relation to those from candidate Sites 1 and 2 and in comparison to standard environmental screening levels is provided in Section 4.

3.3.3 Polycyclic Aromatic Hydrocarbons (PAHs)

The average concentration of LMW PAHs at Ref-New was 117 µg/kg, with a standard deviation of 18 µg/kg (Table 3-13 and Figure 3-16). Station RN-CNTR had a slightly elevated concentration of naphthalene (45 µg/kg) compared to Stations RN-100N and RN-200W (8 µg/kg), which slightly skewed the Ref-New average and standard deviation for this compound. Otherwise, concentrations of the LMW PAH compounds were comparable among the three stations. The average HMW PAH concentration was 132 µg/kg; the low standard deviation of 5 µg/kg indicates the high degree of comparability among the three stations (Table 3-13 and Figure 3-16). The average Total PAHs for the three stations was 249 µg/kg, with a standard deviation of 15 µg/kg.

3.3.4 Pesticides

Pesticides were not detected above the sample-specific method detection limits at any of the three stations at Ref- New. The values reported in Table 3-14 and displayed graphically in Figure 3-17 represent concentrations of one-half the method detection limit for all of the compounds. The pesticide results are discussed in relation to standard environmental screening levels in Section 4.0.

3.3.5 Polychlorinated Biphenyls (PCBs)

With the exception of PCB congeners 8 and 101, which were detected at very low levels at Stations RN-100N and RN-200W, the PCB congeners were not detected at the three Ref-New stations (Table 3-15). The average Total PCB concentration for the Ref-New reference area was 16.20 μg/kg, with a standard deviation of 2.35 μg/kg (Table 3-15 and Figure 3-18). Overall, there was very little variation among the three samples in the concentrations of individual congeners or Total PCBs.

3.4 Ref-2

3.4.1 Sediment Grain Size and Total Organic Carbon

Sediments at all three of the stations at Ref-2 were predominantly silt-clay (Table 3-16 and Figure 3-19). The average silt and clay content for the three samples was 90.7%, while sand content averaged 9.1% and gravel was less than 1%. There was very little variability in grain size distribution among the three stations (Table 3-16 and Figure 3-19). The average TOC concentration for the three Ref-2 stations was 2.2%, with individual values ranging from 2.1% at Stations 2R-200S and 2R-200E to 2.4% at Station 2R-CENTER (Table 3-16 and Figure 3-20).

3.4.2 Trace Metals

All of the analyzed trace metals were detected above method detection limits in all three of the samples at Ref-2 (Table 3-17 and Figure 3-21). There was little variability among the three samples in the concentrations of each of the metals, as indicated by the low standard deviations (Table 3-17).

3.4.3 Polycyclic Aromatic Hydrocarbons (PAHs)

The average LMW PAH concentration for the three stations at Ref-2 was 102 μg/kg, with a low standard deviation of 4 μg/kg (Table 3-18 and Figure 3-22). Phenanthrene was the highest reported LMW PAH, averaging 22 μg/kg. The remaining LMW PAHs were undetected at the sample detection limit of 16 μg/kg; concentrations are presented using one-half of this value (Table 3-18). The average HMW PAH concentration was 139 μg/kg, with a standard deviation of 15 μg/kg (Table 3-18 and Figure 3-22). The HMW PAH compounds were either not detected or detected at relatively low levels. The average Total PAH concentration at Ref-2 was 216 μg/kg, with little variation among the three samples.

3.4.4 Pesticides

The analyzed pesticides were not detected above the sample-specific method detection limit at any of the three stations at Ref-2 (Table 3-19). A total pesticides value for each station was calculated by summing the one-half detection limit values. There was essentially no difference among the stations in the concentration of total pesticides (Table 3-19 and Figure 3-23).

3.4.5 Polychlorinated Biphenyls (PCBs)

Eight PCB congeners were detected at relatively low levels at Station 2R-200S and one congener was detected at Station 2R-CENTER (Table 3-20). The remaining PCBs at the three stations were undetected. The average Total PCBs for Ref-2 was 28.2 µg/kg, with a standard deviation of 22 µg/kg (Table 3-20 and Figure 3-24). The relatively large standard deviation is attributed to the higher reported PCBs at Station 2R-200S compared to the other two stations. Total PCBs ranged from 14.4 µg/kg at Station 2R-200E to 53.6 µg/kg at Station 2R-200S.

4.0 DISCUSSON

The objective of the November 2000 survey was to provide a baseline characterization of sediment grain size, TOC and chemical concentrations at candidate disposal Sites 1 and 2 in Buzzards Bay. In the following the discussion, the results at the two candidate sites are evaluated in several ways. One approach involves comparing the two sites both to each other and to the nearby reference areas. This addresses the question of whether the physical or chemical properties of sediments at either candidate site are appreciably different from nearby areas. In particular, elevated chemical concentrations at either site might be due to the influence of past dredged material disposal at the former Cleveland Ledge or Buzzards Bay Disposal Sites. Such comparisons also serve to address the overall suitability of the reference areas for potential future use in monitoring the environmental impacts of dredged material disposal at either candidate site. Ideally, reference areas should initially possess characteristics similar to those of "impact" areas to facilitate detection of any impact-related changes.

The National Oceanic and Atmospheric Administration's National Status and Trends Program (NS&T) and the EPA's Environmental Monitoring and Assessment Program for Estuaries (EMAP-Estuaries) are two large, on-going monitoring programs that have measured concentrations of a variety of inorganic and organic chemicals in surface sediments throughout U.S. coastal waters. Chemistry data have been collected under both programs at several stations located in Buzzards Bay, comprising a representative mix of both sandy and muddy sediments (Figure 4-1). These data are useful for characterizing "average" sediment chemistry conditions within Buzzards Bay, allowing the results of the present study to be interpreted within a wider, regional context. In addition, sediment chemistry data collected by SAIC at the Ref-2 reference area in 1990 can be compared to the results of the present study to assess temporal changes at this location.

Finally, several different screening values are available for use in evaluating the potential for adverse biological effects of different inorganic and organic chemical contaminants in marine sediments. Buchman (1999) has assembled a set of Screening Quick Reference Tables (SQuiRTS) that list several of these values, including Apparent Effects Thresholds (AETs), Threshold Effects Level/Probable Effects Level (TEL/PEL), and Effects Range Low/Effects Range Median (ERL/ERM). Each set of values was developed using an "effects-based" approach wherein two screening values are identified: a low value below which adverse biological impacts are rarely anticipated and a high value frequently associated with adverse impacts to resources (e.g., toxicity to benthic organisms or change in benthic community structure). Concentrations falling between the low and high values are occasionally associated with biological effects. None of the different sets of screening values is considered superior to the others; each as its merits and drawbacks. In the following discussion, the ERL/ERM values of Long et al. (1995) were selected for use in providing a screening level assessment of the results from the present study.

4.1 Sediment grain size and TOC

In general, surface sediments at the two candidate disposal sites and two nearby reference areas consisted of various proportions of fine-grained material (silt-clay) and sand. The sand

was predominantly very fine to medium in size (4 to 1 phi). The surface sediments collected at Site 2 had a higher average sand content than those at Site 1 (Figure 4-2). In four of the six samples at Site 2, sand was the dominant grain size fraction, while the other two samples were predominantly silt-clay. Three of the four stations with the higher sand content (K12, M10, and M12) occurred in the shallower, northern half Site 2, and the fourth station (N16) was located on a topographic high point associated with Gifford Ledge. The two stations with predominantly muddy (i.e., silt-clay) sediments (K14 and J17) were both located in the broad basin comprising the southern half of Site 2. At Site 1, all of the stations except B6 were dominated by mud and located within the broad topographic depression at depths greater than about 12 m. In general, these results suggest that the deeper areas within each site are conducive to deposition of fine-grained sediments.

Surface sediments at the two reference areas were considerably muddier (i.e., significantly higher silt-clay content) than those at either of the candidate disposal sites (Figure 4-2). The silt-clay content in each of the reference area samples (>89%) was higher than any of the candidate disposal site samples. Both reference areas are located in water depths similar to those at the candidate disposal sites (Ref-New = 14 m and Ref-2 = 12 m) and presumably experience the same general hydrodynamic regime within eastern Buzzards Bay. Therefore, the comparisons in this report of the chemistry results from Sites 1 and 2 against those from the reference areas are considered valid. However, in any future environmental monitoring, it may be desirable to establish one or more new reference areas having average sediment grain sizes more closely matching those at candidate disposal sites.

The average sediment total organic carbon (TOC) concentrations at the reference areas and Sites 1 and 2 were generally comparable, ranging between 1.1% and 2.2% (Figure 4-3). These values are considered typical of fine-grained, coastal marine sediments located in areas away from organic-loading point sources, such as wastewater treatment plant outfalls or combined sewer overflows. The TOC values in the present study are likewise comparable to the average value of 1.2% calculated for the EMAP stations shown in Figure 4-1 (identified in Figure 4-3 as the “Buzzards Bay region” value). The results of the present study serve to illustrate how organic matter in marine sediments typically is associated with the fine-grained fraction: the higher silt-clay content at the reference area stations corresponds with their higher TOC concentrations. Likewise, sediments at Site 1 had both higher average silt-clay content and higher average TOC than Site 2. Overall, TOC concentrations at the candidate sites and reference areas are considered typical for coastal marine sediments in areas that are generally unaffected by anthropogenic inputs.

4.2 Trace Metals

Average metal concentrations at the two reference areas were consistently higher than those at the two candidate disposal sites (Figure 4-4). A statistical test of the equality of average values was performed, assuming heterogeneous variances. This test involved unplanned comparisons among each pair of means using the Games and Howell method (Sokal and Rohlf 1981). This test showed that the differences in the average metal concentrations among the sites were generally not statistically significant at the $P = 0.05$ level, with the following exceptions: each reference area had a significantly higher average concentration of arsenic and chromium

than Site 2, and the average concentration of nickel at REF-NEW was significantly higher than that at Site 2. These differences are attributed more readily to the significantly higher silt-clay content of the reference area sediments rather than any anthropogenic influences.

As indicated in Figure 4-4, the average metal concentrations at the Buzzards Bay regional stations (i.e., EMAP and NS&T stations) are generally comparable to and not statistically different from those at two reference areas and two candidate sites ($P > 0.05$; unplanned comparisons among pairs of means by the Games and Howell method). It is concluded that sediment metal concentrations measured within Sites 1 and 2 and nearby reference areas are generally low and consistent with background concentrations that exist in the wider surrounding Buzzards Bay region.

With the exception of arsenic, the average metal concentrations measured at Sites 1 and 2 and the reference areas were considerably below the ERL screening values (Figure 4-4). As previously indicated, chemical concentrations at or below the ERL have been found to be rarely associated with adverse biological effects. In the case of arsenic, the average concentrations at Ref-New and Ref-2 (10 and 9.8 mg/kg, respectively) slightly exceeded the ERL value of 8.2 mg/kg, while the candidate disposal sites were below this threshold. The reference area values were considerably below the arsenic ERM value of 70 mg/kg, and the slight ERL exceedance is again attributed to the high reference area silt-clay content rather than an anthropogenic enrichment effect. Overall, the comparisons to the ERL/ERM values serves to support the conclusion that metal concentrations at the candidate disposal sites and reference areas are relatively low. These concentrations are considered representative of background levels within Buzzards Bay, typical of areas that have not experienced significant inputs of chemical contaminants as a result of anthropogenic activities.

4.3 Polycyclic Aromatic Hydrocarbons (PAHs)

The unplanned comparisons among pairs of means by the Games and Howell method (Sokal and Rohlf 1981) detected no statistically significant differences among the four study locations (two candidate disposal sites and two reference areas) in the average concentrations of LMW, HMW or Total PAHs. Likewise, the average PAH concentrations at the four sites did not differ significantly from those at the Buzzards Bay regional stations. More significantly, all of the average PAH concentrations were considerably below the ERL values (Figure 4-5). It is concluded that there were no significant elevations of PAHs at the two candidate disposal sites and two reference areas. The average concentrations at all four study locations were very low and comparable to background concentrations in the wider Buzzards Bay region.

4.4 Pesticides and PCBs

All of the pesticides were reported as not detected at both the candidate disposal sites and the reference areas. With the exception of toxaphene, the detection limit for each pesticide in each sample was less than 2 µg/kg. Toxaphene was not detected in any of the samples at sample-specific detection limits ranging from 18 to 34 µg/kg. These results are consistent with those of the EMAP and NS&T programs showing only very low or non-detected levels of pesticides in Buzzards Bay. The average total pesticide values for the candidate sites and

reference areas presented previously were based on summing one-half detection limit values. As such, these total values have no real environmental significance. It is concluded that the candidate disposal sites and reference areas show no elevations of any pesticides above regional background levels.

Likewise, with the exception of a few congeners measured at very low levels, PCBs were essentially not detected in the candidate disposal site and reference area samples. In general, there were more PCB congeners detected at low levels at the reference area station than at the candidate disposal site stations. This again is considered a reflection of the higher silt-clay and TOC content of the reference area sediments. The average total PCB concentrations at the two candidate disposal sites and Ref-New were below both the ERL value and the average total concentration for the regional stations (Figure 4-6). The average total PCB value for Ref-2 was slightly above the ERL value, but this is primarily an artifact of summing the one-half the detection limit values to calculate the total. All of the average total PCB values for the present study were less than the average total for the regional stations (Figure 4-6), but there were no statistically significant differences found between any pair of average values ($P > 0.05$; unplanned comparisons among pairs of means by the Games and Howell method). Overall, Figure 4-6 suggests a slight elevation of PCB congeners at the regional stations, but at levels considerably below the ERM value of 180 μg/kg (i.e., a minor increase in the potential for adverse biological effects might be expected at the regional station total PCB concentration). It is concluded that the candidate disposal sites and reference areas are essentially free of PCB contamination: total PCB concentrations at these sites are barely above detection and less than concentrations found on average in the wider surrounding Buzzards Bay region.

4.5 Comparison with Historical Data at Ref-2

This section compares the November 2000 sediment chemistry and grain size results from Ref-2 with similar data collected by SAIC in March 1990 within the same reference area (SAIC 1991). The purpose of this comparison is to provide insight into the temporal changes and variability of the sediment composition in the Buzzards Bay region.

Surface sediments collected at Ref-2 in 1990 were comprised predominantly of sand, with a minor silt-clay component, while the results of the 2000 survey showed the sediment to be composed principally of silt-clay (Figure 4-7). The 2000 survey involved sampling at the Ref-2 center station, as well as stations located 200 m south and east of the center (Stations 2R-200S and 2R-200E). The 1990 survey involved sampling at the center station and Station 200W. Although the center station ostensibly was occupied in both 1990 and 2000, differences in navigational precision make it unlikely that exactly the same seafloor location was sampled. The difference in the 1990 and 2000 results is attributed to natural spatial heterogeneity in sediment grain size characteristics at this location. As a result of the difference in sediment grain size, the average TOC concentration in 1990 (0.18%) was considerably lower than that measured in 2000 (2.2%).

With the exception of cadmium, concentrations of metals measured at Ref-2 in 1990 were lower than those in 2000, again attributed to the grain size difference (Figure 4-8). Because cadmium was reported as not detected in 1990 at a much higher detection limit than in 2000, the

apparent difference in Figure 4-8 is an artifact. Pesticides and PAHs were reported as not detected at Ref-2 in 1990, although the PAH detection limits were considerably higher than those in 2000. Total PCBs likewise were not detected in 1990, although the analytical methodology was different from 2000 and the detection limits higher. Overall, the comparison of the 1990 and 2000 chemistry results support the conclusion that there have been no significant changes in any of the measured contaminant levels at this location over the 10-year time period.

5.0 CONCLUSIONS

- On average, surface sediments at candidate disposal Site 1 were predominantly muddy (silt-clay), with a minor component of fine to medium sand. Sediments at candidate Site 2 were predominantly sandy, with lesser amounts of silt-clay.

- Surface sediments at reference areas Ref-New and Ref-2 had very high proportions of silt-clay (90% or more) and small amounts of fine to medium sand. Because sediments at both reference areas were considerably more fine-grained than those at the two candidate disposal sites, one or more new reference areas might be established in the future to provide a better grain size match.

- Total organic carbon (TOC) concentrations at the two candidate disposal sites and two reference areas were within typical ranges for fine-grained, coastal marine sediments (1% to 2%) and comparable to average TOC concentrations in other areas of Buzzards Bay located away from pollution sources.

- Sediment metal concentrations measured within Sites 1 and 2 and nearby reference areas were generally low and comparable to concentrations existing in unpolluted areas of Buzzards Bay. All metal concentrations were at levels considered very unlikely to result in any adverse biological effects.

- Concentrations of organic chemicals (PAHs, pesticides and PCBs) in surface sediments at the two candidate disposal sites and two reference areas were very low and comparable to background levels found in unpolluted areas of Buzzards Bay.

- Surface sediments collected at Ref-2 in March 1990 were predominantly sandy, while those collected in November 2000 were predominantly muddy. The difference in grain size distribution was attributed to natural spatial heterogeneity at this reference area.

- Although the comparison was hindered by differences in analytical methodology and detection limits, there were no changes detected at Ref-2 in the concentrations of metals, pesticides, PCBs or PAHs between the 1990 and 2000 surveys.

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Tables

Table 2-1

Target Sediment Contaminants for Chemical Analyses

PAHs	PCBs	Pesticides	Trace Metals
LMW PAHs	PCB008	4,4´ DDD	Arsenic (As)
Naphthalene	PCB018	4,4´ DDE	Cadmium (Cd)
2-Methylnaphthalene	PCB028	4,4´ DDT	Chromium (Cr)
1-Methylnaphthalene	PCB044	Aldrin	Mercury (Hg)
Biphenyl	PCB052	Alpha-BHC	Lead (Pb)
2,6-Dimethylnaphthalene	PCB066	Alpha Chlordane	Copper (Cu)
Acenaphthylene	PCB101	Beta-BHC	Nickel (Ni)
Acenaphthene	PCB105	Delta-BHC	Zinc (Zn)
Fluorene	PCB118	Dieldrin	
Phenanthrene	PCB128	Endosulfan I	
Anthracene	PCB138	Endosulfan II	
1-Methylphenanthrene	PCB153	Endosulfan Sulfate	
	PCB170	Endrin	
HMW PAHs	PCB180	Endrin Aldehyde	
Fluoranthene	PCB187	Gamma-BHC	
Pyrene	PCB170	Gamma Chlordane	
Benzo[a]anthracene	PCB180	Heptachlor	
Chrysene	PCB187	Heptachlor Epoxide	
Benzo[b]fluoranthene	PCB 195	Methoxychlor	
Benzo[k]fluoranthene	PCB 206	Toxaphene	
Benzo[e]pyrene	PCB 209		
Benzo[a]pyrene			
Perylene			
Indeno[1,2,3-cd]pyrene			
Dibenz[a,h]anthracene			
Benzo[g,h,i]perylene			

Table 3-1
Sediment Grain Size and Total Organic Carbon (TOC) at the Site 1 Stations

Site 1 - Grain Size and TOC							
	Station Results						
	B6	**C3**	**E4**	**E6**	**G3**	**G7**	**Average**
% **Gravel**	0.09	0.37	0.04	0.00	0.16	3.50	**0.13**
% **Sand**	84.95	23.50	15.56	7.22	36.45	38.95	**33.53**
% **Silt**	7.63	42.26	44.22	48.43	33.40	33.43	**35.19**
% **Clay**	7.33	33.88	40.18	44.35	29.99	24.13	**31.15**
% Silt and Clay	14.97	76.14	84.40	92.78	63.39	57.56	**66.33**
% TOC	0.5	1.9	1.8	2.3	1.4	1.5	**1.6**

Table 3-2
Concentrations of Metals at the Site 1 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Site 1 - Metals											
	Station Results (mg/Kg)										
	B6	**C3**	**E4**	**E6**	**G3**	**G7**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
Arsenic	2.7	7.5	7.8	9.4	5.9	7.5	6.8	2.3	2.4	2.7	9.4
Cadmium	**0.013**	0.099	0.13	0.14	0.11	0.11	0.100	0.046	0.048	0.013	0.140
Chromium	7.8	28	32	37	26	22	25.5	10	10.6	8	37
Copper	2.8	11	13	15	11	7.6	10.1	4.3	4.5	2.8	15.0
Lead	6.2	21	23	25	20	12	17.9	7	7.6	6	25
Mercury	**0.007**	0.044	0.052	0.063	0.046	0.027	0.040	0.020	0.021	0.007	0.063
Nickel	3.6	14	15	17	12	11	12.1	5	4.9	4	17
Zinc	17	57	64	74	54	42	51.3	20	20.9	17	74

Table 3-3
Concentrations of PAHs at the Site 1 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Site 1 - PAHs											
	Station Results (µg/Kg)										
Low Molecular Weight PAHs (LMW)	**B6**	**C3**	**E4**	**E6**	**G3**	**G7**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
Naphthalene	**4.5**	**7.0**	200.0	**8.5**	**6.5**	**6.0**	38.8	79.0	82.9	4.5	200.0
2-Methylnaphthalene	**4.5**	**7.0**	160.0	**8.5**	**6.5**	**6.0**	32.1	62.7	65.8	4.5	160.0
1-Methylnaphthalene	**4.5**	**7.0**	90.0	**8.5**	**6.5**	**6.0**	20.4	34.1	35.8	4.5	90.0
Biphenyl	**4.5**	**7.0**	16.0	**8.5**	**6.5**	**6.0**	8.1	4.1	4.3	4.5	16.0
2,6-Dimethylnaphthalene	**4.5**	**7.0**	37.0	**8.5**	**6.5**	**6.0**	11.6	12.5	13.1	4.5	37.0
Acenaphthylene	**4.5**	**7.0**	28.0	19.0	**6.5**	**6.0**	11.8	9.5	10.0	4.5	28.0
Acenaphthene	**4.5**	**7.0**	80.0	**8.5**	**6.5**	**6.0**	18.8	30.0	31.5	4.5	80.0
Fluorene	**4.5**	**7.0**	28.0	**8.5**	**6.5**	**6.0**	10.1	8.9	9.3	4.5	28.0
Phenanthrene	**4.5**	31.0	140.0	29.0	20.0	25.0	41.6	49.1	51.6	4.5	140.0
Anthracene	**4.5**	**7.0**	52.0	**8.5**	**6.5**	**6.0**	14.1	18.6	19.5	4.5	52.0
1-Methylphenanthrene	**4.5**	**7.0**	**8.0**	**8.5**	**6.5**	**6.0**	6.8	1.4	1.5	4.5	8.5
Sum LMW PAHs	**49.5**	**101.0**	**839.0**	**124.5**	**85.0**	**85.0**	**214.0**	**307.2**	**322.3**	**49.5**	**839.0**
	B6	**C3**	**E4**	**E6**	**G3**	**G7**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
High Molecular Weight PAHs (HMW)											
Fluoranthene	**4.5**	35.0	57.0	38.0	26.0	26.0	31.1	17.3	18.1	4.5	57.0
Pyrene	**4.5**	40.0	59.0	44.0	23.0	21.0	31.9	19.5	20.4	4.5	59.0
Benzo(a)anthracene	**4.5**	23.0	43.0	29.0	**6.5**	**6.0**	18.7	15.7	16.4	4.5	43.0
Chrysene	**4.5**	23.0	42.0	29.0	13.0	13.0	20.8	13.5	14.1	4.5	42.0
Benzo(b)fluoranthene	**4.5**	20.0	33.0	27.0	14.0	**6.0**	17.4	11.4	12.0	4.5	33.0
Benzo(k)fluoranthene	**4.5**	20.0	29.0	23.0	13.0	**6.0**	14.8	10.5	11.0	4.5	29.0
Benzo(e)pyrene	**4.5**	16.0	25.0	21.0	**6.5**	**6.0**	13.2	8.7	9.2	4.5	25.0
Benzo(a)pyrene	**4.5**	22.0	41.0	29.0	**6.5**	**6.0**	18.2	15.0	15.7	4.5	41.0
Perylene	**4.5**	**7.0**	**8.0**	**8.5**	**6.5**	**6.0**	6.8	1.4	1.5	4.5	8.5
Indeno[1,2,3-cd]pyrene	**4.5**	16.0	26.0	22.0	**6.5**	**6.0**	13.5	9.2	9.6	4.5	26.0
Dibenz[a,h]anthracene	**4.5**	**7.0**	**8.0**	**8.5**	**6.5**	**6.0**	6.8	1.4	1.5	4.5	8.5
Benzo[g,h,i]perylene	**4.5**	16.0	24.0	22.0	**6.5**	**6.0**	13.2	8.7	9.1	4.5	24.0
Sum HMW PAHs	**54.0**	**245.0**	**395.0**	**301.0**	**134.5**	**114.0**	**207.3**	**128.8**	**135.2**	**54.0**	**395.0**
Sum Total PAHs	**103.5**	**346.0**	**1234.0**	**425.5**	**219.5**	**199.0**	**421.3**	**414.1**	**434.5**	**103.5**	**1234.0**

Table 3-4
Concentrations of Pesticides at the Site 1 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Site 1 - Pesticides											
	Station Results (µg/Kg)										
	B6	C3	E4	E6	G3	G7	Average	S.D.	C.I.	Min	Max
Pesticides											
aldrin	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
alpha-BHC	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
alpha-chlordane	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
beta-BHC	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
delta-BHC	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
gamma-BHC	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
gamma-chlordane	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
dieldrin	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
endosulfan I	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
endosulfan II	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
endosulfan sulfate	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
endrin	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
endrin aldehyde	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
heptachlor	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
heptachlor epoxide (B)	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
methoxychlor	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
4,4'-DDD	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
4,4'-DDE	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
4,4'-DDT	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
toxaphene	**9.00**	**14.00**	**15.50**	**17.00**	**12.50**	**12.00**	13.33	2.82	2.96	9.00	17.00
Total Pesticides	**17.65**	**27.30**	**30.70**	**33.15**	**24.85**	**23.40**	**26.17**	**5.52**	**5.80**	**4.42**	**17.65**

Table 3-5
Concentrations of PCBs at the Site 1 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Site 1 - PCBs											
	Station Results (µg/Kg)										
	B6	C3	E4	E6	G3	G7	Average	S.D.	C.I.	Min	Max
PCB Congeners											
PCB 8	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 18	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 28	**0.46**	3.30	**0.80**	**0.85**	2.80	**0.60**	1.47	1.24	1.31	0.46	3.30
PCB 44	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 52	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 66	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 101	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 105	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 118	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 128	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 138	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 153	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 170	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 180	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 187	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 195	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 206	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
PCB 209	**0.46**	**0.70**	**0.80**	**0.85**	**0.65**	**0.60**	0.68	0.14	0.15	0.46	0.85
Total PCB Congeners	**8.19**	**15.20**	**14.40**	**15.30**	**13.85**	**10.80**	**12.96**	**2.86**	**3.00**	**8.19**	**15.30**

Table 3-6
Sediment Grain Size and Total Organic Carbon (TOC) at the Site 2 Stations

Site 2 - Grain Size and TOC							
	Station Results						
	K12	**K14**	**J17**	**M10**	**M12**	**N16**	**Average**
% **Gravel**	3.28	0.97	0.17	1.65	2.04	3.44	**1.62**
% **Sand**	74.96	37.76	31.17	72.03	66.27	84.91	**56.44**
% **Silt**	12.06	35.45	37.34	14.59	16.58	6.11	**23.20**
% **Clay**	9.71	25.82	31.32	11.73	15.11	5.54	**18.74**
% Silt and Clay	21.76	61.26	68.66	26.32	31.69	11.65	**41.94**
% TOC	0.9	1.8	1.5	0.9	0.9	0.8	**1.1**

Table 3-7
Concentrations of Metals at the Site 2 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Site 2 - Metals											
	Station Results (mg/Kg)										
	K12	**K14**	**J17**	**M12**	**M10**	**N16**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
Arsenic	2.9	6.1	6.6	4.0	3.4	2.5	4.3	1.7	1.8	2.5	6.6
Cadmium	0.052	0.13	0.14	0.088	0.068	0.058	0.089	0.038	0.039	0.052	0.14
Chromium	10	26	26	14	12	8.7	16	7.9	8.3	8.7	26
Copper	4.7	13	12	6.6	5.6	3.6	7.6	3.9	4.1	3.6	13
Lead	8.2	22	20	14	10	7.6	13.6	6.2	6.5	7.6	22
Mercury	0.021	0.050	0.055	0.035	0.026	0.020	0.035	0.015	0.016	0.02	0.055
Nickel	4.6	13	12	6.6	5.6	4.3	7.7	3.8	4.0	4.3	13
Zinc	23	58	54	31	27	20	36	16.4	17.2	20	58

Table 3-8
Concentrations of PAHs at the Site 2 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Site 2 - PAHS											
	Station Results (µg/Kg)										
Low Molecular Weight PAHs (LMW)	**K12**	**K14**	**J17**	**M10**	**M12**	**N16**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
Naphthalene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
2-Methylnaphthalene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
1-Methylnaphthalene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
Biphenyl	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
2,6-Dimethylnaphthalene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
Acenaphthylene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
Acenaphthene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
Fluorene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
Phenanthrene	9.0	21.0	16.0	**5.0**	11.0	11.0	12.2	5.6	5.9	5.0	21.0
Anthracene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
1-Methylphenanthrene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
Sum LMW PAHs	**54.0**	**86.0**	**86.0**	**55.0**	**61.0**	**56.0**	**66.3**	**15.4**	**16.2**	**54.0**	**86.0**
	K12	**K14**	**J17**	**M10**	**M12**	**N16**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
High Molecular Weight PAHs (HMW)											
Fluoranthene	15.0	31.0	24.0	13.0	16.0	12.0	18.5	7.4	7.8	12.0	31.0
Pyrene	20.0	26.0	21.0	12.0	14.0	10.0	17.2	6.1	6.4	10.0	26.0
Benzo(a)anthracene	9.0	15.0	**7.0**	**5.0**	**5.0**	**4.5**	7.6	4.0	4.2	4.5	15.0
Chrysene	10.0	18.0	**7.0**	**5.0**	**5.0**	**4.5**	8.3	5.2	5.5	4.5	18.0
Benzo(b)fluoranthene	10.0	18.0	**7.0**	**5.0**	**5.0**	**4.5**	8.3	5.2	5.5	4.5	18.0
Benzo(k)fluoranthene	9.0	17.0	**7.0**	**5.0**	**5.0**	**4.5**	7.9	4.8	5.0	4.5	17.0
Benzo(e)pyrene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
Benzo(a)pyrene	12.0	15.0	**7.0**	**5.0**	**5.0**	**4.5**	8.1	4.4	4.6	4.5	15.0
Perylene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
Indeno[1,2,3-cd]pyrene	10.0	15.0	**7.0**	**5.0**	**5.0**	**4.5**	7.8	4.1	4.3	4.5	15.0
Dibenz[a,h]anthracene	**4.5**	**6.5**	**7.0**	**5.0**	**5.0**	**4.5**	5.4	1.1	1.1	4.5	7.0
Benzo[g,h,i]perylene	10.0	13.0	**7.0**	**5.0**	**5.0**	**4.5**	7.4	3.4	3.6	4.5	13.0
Sum HMW PAHs	**118.5**	**187.5**	**115.0**	**75.0**	**80.0**	**67.0**	**107.2**	**44.8**	**47.0**	**67.0**	**187.5**
Sum Total PAHs	**172.5**	**273.5**	**201.0**	**130.0**	**141.0**	**123.0**	**173.5**	**57.0**	**59.8**	**123.0**	**273.5**

Table 3-9
Concentrations of Pesticides at the Site 2 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Site 2 - Pesticides											
Station Results (µg/Kg)											
	K12	K14	J17	M10	M12	N16	Average	S.D.	C.I.	Min	Max
Pesticides											
aldrin	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
alpha-BHC	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
alpha-chlordane	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
beta-BHC	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
delta-BHC	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
gamma-BHC	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
gamma-chlordane	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
dieldrin	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
endosulfan I	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
endosulfan II	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
endosulfan sulfate	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
endrin	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
endrin aldehyde	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
heptachlor	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
heptachlor epoxide (B)	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
methoxychlor	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
4,4'-DDD	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
4,4'-DDE	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
4,4'-DDT	0.44	0.65	0.70	0.50	0.50	0.44	0.54	0.11	0.11	0.44	0.70
toxaphene	9.00	13.00	13.50	9.50	10.00	9.00	10.67	2.04	2.14	9.00	13.50
Total Pesticides	17.36	25.35	26.80	19.00	19.50	17.45	20.91	4.11	4.32	3.29	17.36

Table 3-10
Concentrations of PCBs at the Site 2 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Site 2 - PCBs											
	Station Results (µg/Kg)										
	K12	**K14**	**J17**	**M10**	**M12**	**N16**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
PCB Congeners											
PCB 8	**0.44**	5.70	**0.70**	1.00	**0.50**	**0.44**	1.46	2.09	2.19	0.44	5.70
PCB 18	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 28	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 44	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 52	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 66	**0.44**	1.50	**0.70**	**0.50**	**0.50**	**0.44**	0.68	0.41	0.43	0.44	1.50
PCB 101	**0.44**	2.20	**0.70**	**0.50**	**0.50**	**0.44**	0.80	0.69	0.73	0.44	2.20
PCB 105	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 118	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 128	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 138	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 153	**0.44**	1.80	**0.70**	**0.50**	**0.50**	**0.44**	0.73	0.53	0.56	0.44	1.80
PCB 170	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 180	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 187	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 195	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 206	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
PCB 209	**0.44**	**0.65**	**0.70**	**0.50**	**0.50**	**0.44**	0.54	0.11	0.11	0.44	0.70
Total PCB Congeners	**7.92**	**20.30**	**12.60**	**9.50**	**9.00**	**8.01**	**11.22**	**4.76**	**5.00**	**7.92**	**20.30**

Table 3-11
Sediment Grain Size and Total Organic Carbon (TOC) at the Ref New Stations

Ref New - Grain Size and TOC				
	Station Results			
	RNCTR	RN100N	RN200W	Average
% **Gravel**	1.29	0.03	0.00	**0.44**
% **Sand**	7.60	8.39	4.45	**6.82**
% **Silt**	48.53	49.82	51.76	**50.04**
% **Clay**	42.58	41.76	43.79	**42.71**
% Silt and Clay	91.11	91.58	95.55	**92.74**
% TOC	2.1	2.2	2.2	**2.2**

Table 3-12
Concentrations of Metals at the Ref New Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Ref New - Metals								
	Station Results (mg/Kg)							
	RNCTR	RN200W	RN100N	Average	S.D.	C.I.	Min	Max
Arsenic	9.5	11	9.6	10.0	0.8	2.1	9.5	11
Cadmium	0.16	0.18	0.16	0.17	0.01	0.029	0.16	0.18
Chromium	34	39	34	35.7	2.9	7.2	34	39
Copper	13	16	14	14.3	1.5	3.8	13	16
Lead	22	26	23	23.7	2.1	5.2	22	26
Mercury	0.041	0.05	0.041	0.044	0.005	0.013	0.041	0.05
Nickel	17	19	16	17.3	1.5	3.8	16	19
Zinc	69	76	68	71.0	4.4	10.8	68	76

Table 3-13
Concentrations of PAHs at the Ref New Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit

Ref New - PAHs								
	Station Results (µg/Kg)							
	RNCTR	**RN100N**	**RN200W**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
Low Molecular Weight PAHs (LMW)								
Naphthalene	45.0	**8.0**	**8.0**	20.3	21.4	53.1	8.0	45.0
2-Methylnaphthalene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
1-Methylnaphthalene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Biphenyl	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
2,6-Dimethylnaphthalene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Acenaphthylene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Acenaphthene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Fluorene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Phenanthrene	20.0	21.0	32.0	24.3	6.7	16.6	20.0	32.0
Anthracene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
1-Methylphenanthrene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Sum LMW PAHs	**137.0**	**101.0**	**112.0**	**116.7**	**18.4**	**45.9**	**101.0**	**137.0**
	RNCTR	**RN100N**	**RN200W**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
High Molecular Weight PAHs (HMW)								
Fluoranthene	25.0	28.0	30.0	27.7	2.5	6.3	25.0	30.0
Pyrene	22.0	25.0	26.0	24.3	2.1	5.2	22.0	26.0
Benzo(a)anthracene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Chrysene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Benzo(b)fluoranthene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Benzo(k)fluoranthene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Benzo(e)pyrene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Benzo(a)pyrene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Perylene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Indeno[1,2,3-cd]pyrene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Dibenz[a,h]anthracene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Benzo[g,h,i]perylene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Sum HMW PAHs	**127.0**	**133.0**	**136.0**	**132.0**	**4.6**	**11.4**	**127.0**	**136.0**
Sum Total PAHs	**264.0**	**234.0**	**248.0**	**248.7**	**15.0**	**37.3**	**234.0**	**264.0**

Table 3-14
Concentrations of Pesticides at the Ref New Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit

Ref New - Pesticides								
	Station Results (µg/Kg)							
	RNCTR	RN100N	RN200W	Average	S.D.	C.I.	Min	Max
Pesticides								
aldrin	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
alpha-BHC	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
alpha-chlordane	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
beta-BHC	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
delta-BHC	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
gamma-BHC	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
gamma-chlordane	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
dieldrin	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
endosulfan I	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
endosulfan II	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
endosulfan sulfate	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
endrin	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
endrin aldehyde	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
heptachlor	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
heptachlor epoxide (B)	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
methoxychlor	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
4,4'-DDD	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
4,4'-DDE	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
4,4'-DDT	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
toxaphene	**15.50**	**15.50**	**16.50**	15.83	0.58	0.86	15.50	16.50
Total Pesticides	**29.75**	**30.70**	**31.70**	**30.72**	**0.98**	**1.45**	**29.75**	**31.70**

Table 3-15
Concentrations of PCBs at the Ref New Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Ref New - PCBs								
	Station Results (µg/Kg)							
	RNCTR	RN100N	RN200W	Average	S.D.	C.I.	Min	Max
PCB Congeners								
PCB 8	**0.75**	2.90	4.20	2.62	1.74	2.59	0.75	4.20
PCB 18	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 28	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 44	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 52	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 66	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 101	**0.75**	1.60	**0.80**	1.05	0.48	0.71	0.75	1.60
PCB 105	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 118	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 128	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 138	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 153	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 170	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 180	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 187	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 195	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 206	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
PCB 209	**0.75**	**0.80**	**0.80**	0.78	0.03	0.04	0.75	0.80
Total PCB Congeners	**13.50**	**17.30**	**17.80**	**16.20**	**2.35**	**3.49**	**13.50**	**17.80**

Table 3-16
Sediment Grain Size and Total Organic Carbon (TOC) at the Ref New Stations

	2RCENTER	2R200S	2R200E	Average
% **Gravel**	0.25	0.12	0.10	**0.16**
% **Sand**	7.35	9.67	10.29	**9.10**
% **Silt**	46.54	46.38	46.37	**46.43**
% **Clay**	45.86	43.83	43.25	**44.31**
% Silt and Clay	92.40	90.21	89.61	**90.74**
% TOC	2.4	2.1	2.1	**2.2**

Table 3-17
Concentrations of Metals at the Ref 2 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Ref 2 - Metals								
	Station Results (mg/Kg)							
	2RCENTER	2R200S	2R200E	Average	S.D.	C.I.	Min	Max
Arsenic	10	9.7	9.7	9.8	0.2	0.4	9.7	10
Cadmium	0.15	0.14	0.14	0.14	0.01	0.014	0.14	0.15
Chromium	39	34	36	36	2.5	6.3	34	39
Copper	16	11	14	14	2.5	6.3	11	16
Lead	29	22	25	25	3.5	8.7	22	29
Mercury	0.070	0.038	0.062	0.057	0.017	0.041	0.038	0.07
Nickel	17	15	16	16	1.0	2.5	15	17
Zinc	76	65	70	70	5.5	13.7	65	76

Table 3-18
Concentrations of PAHs at the Ref 2 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit

Ref 2 - PAHs								
	Station Results (µg/Kg)							
	2R200S	2R200E	2RCENTER	Average	S.D.	C.I.	Min	Max
Low Molecular Weight PAHs (LMW)								
Naphthalene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
2-Methylnaphthalene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
1-Methylnaphthalene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Biphenyl	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
2,6-Dimethylnaphthalene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Acenaphthylene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Acenaphthene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Fluorene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Phenanthrene	20.0	27.0	19.0	22.0	4.4	10.8	19.0	27.0
Anthracene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
1-Methylphenanthrene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Sum LMW PAHs	**100.0**	**107.0**	**99.0**	**102.0**	**4.4**	**10.8**	**99.0**	**107.0**
	2R200S	**2R200E**	**2RCENTER**	**Average**	**S.D.**	**C.I.**	**Min**	**Max**
High Molecular Weight PAHs (HMW)								
Fluoranthene	26.0	31.0	27.0	28.0	2.6	6.6	26.0	31.0
Pyrene	23.0	28.0	24.0	25.0	2.6	6.6	23.0	28.0
Benzo(a)anthracene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Chrysene	**8.0**	17.0	**8.0**	11.0	5.2	12.9	8.0	17.0
Benzo(b)fluoranthene	**8.0**	16.0	**8.0**	10.7	4.6	11.5	8.0	16.0
Benzo(k)fluoranthene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Benzo(e)pyrene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Benzo(a)pyrene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Perylene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Indeno[1,2,3-cd]pyrene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Dibenz[a,h]anthracene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Benzo[g,h,i]perylene	**8.0**	**8.0**	**8.0**	8.0	0.0	0.0	8.0	8.0
Sum HMW PAHs	**129.0**	**156.0**	**131.0**	**138.7**	**15.0**	**37.4**	**129.0**	**156.0**
Sum Total PAHs	**201.0**	**245.0**	**203.0**	**240.7**	**24.8**	**61.8**	**201.0**	**245.0**

Table 3-19
Concentrations of Pesticides at the Ref 2 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit

Ref 2 - Pesticides								
Station Results (µg/Kg)								
	2R200S	2R200E	2RCENTER	Average	S.D.	C.I.	Min	Max
Pesticides								
aldrin	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
alpha-BHC	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
alpha-chlordane	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
beta-BHC	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
delta-BHC	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
gamma-BHC	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
gamma-chlordane	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
4,4'-DDD	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
4,4'-DDE	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
4,4'-DDT	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
dieldrin	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
endosulfan I	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
endosulfan II	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
endosulfan sulfate	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
endrin	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
endrin aldehyde	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
heptachlor	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
heptachlor epoxide (B)	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
methoxychlor	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
toxaphene	**15.50**	**16.00**	**16.00**	15.83	0.29	0.43	15.50	16.00
Total Pesticides	**30.70**	**31.20**	**31.20**	**31.03**	**0.29**	**0.43**	**30.70**	**31.20**

Table 3-20
Concentrations of PCBs at the Ref 2 Stations
S.D. = Standard Deviation, C.I. = 95% confidence interval.
Bold type indicates the analyte was not detected; the value shown represents one-half the detection limit.

Ref 2 - PCBs								
	Station Results (µg/Kg)							
	2R200S	2R200E	2RCENTER	Average	S.D.	C.I.	Min	Max
PCB Congeners								
PCB 8	5.00	**0.80**	**0.80**	2.20	2.42	3.60	0.80	5.00
PCB 18	2.50	**0.80**	**0.80**	1.37	0.98	1.46	0.80	2.50
PCB 28	12.00	**0.80**	3.00	5.27	5.93	8.82	0.80	12.00
PCB 44	4.40	**0.80**	**0.80**	2.00	2.08	3.09	0.80	4.40
PCB 52	11.00	**0.80**	**0.80**	4.20	5.89	8.75	0.80	11.00
PCB 66	5.30	**0.80**	**0.80**	2.30	2.60	3.86	0.80	5.30
PCB 101	3.30	**0.80**	**0.80**	1.63	1.44	2.15	0.80	3.30
PCB 105	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
PCB 118	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
PCB 128	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
PCB 138	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
PCB 153	2.10	**0.80**	**0.80**	1.23	0.75	1.12	0.80	2.10
PCB 170	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
PCB 180	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
PCB 187	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
PCB 195	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
PCB 206	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
PCB 209	**0.80**	**0.80**	**0.80**	0.80	0.00	0.00	0.80	0.80
Total PCB Congeners	**53.60**	**14.40**	**16.60**	**28.20**	**22.02**	**32.73**	**14.40**	**53.60**

Figures

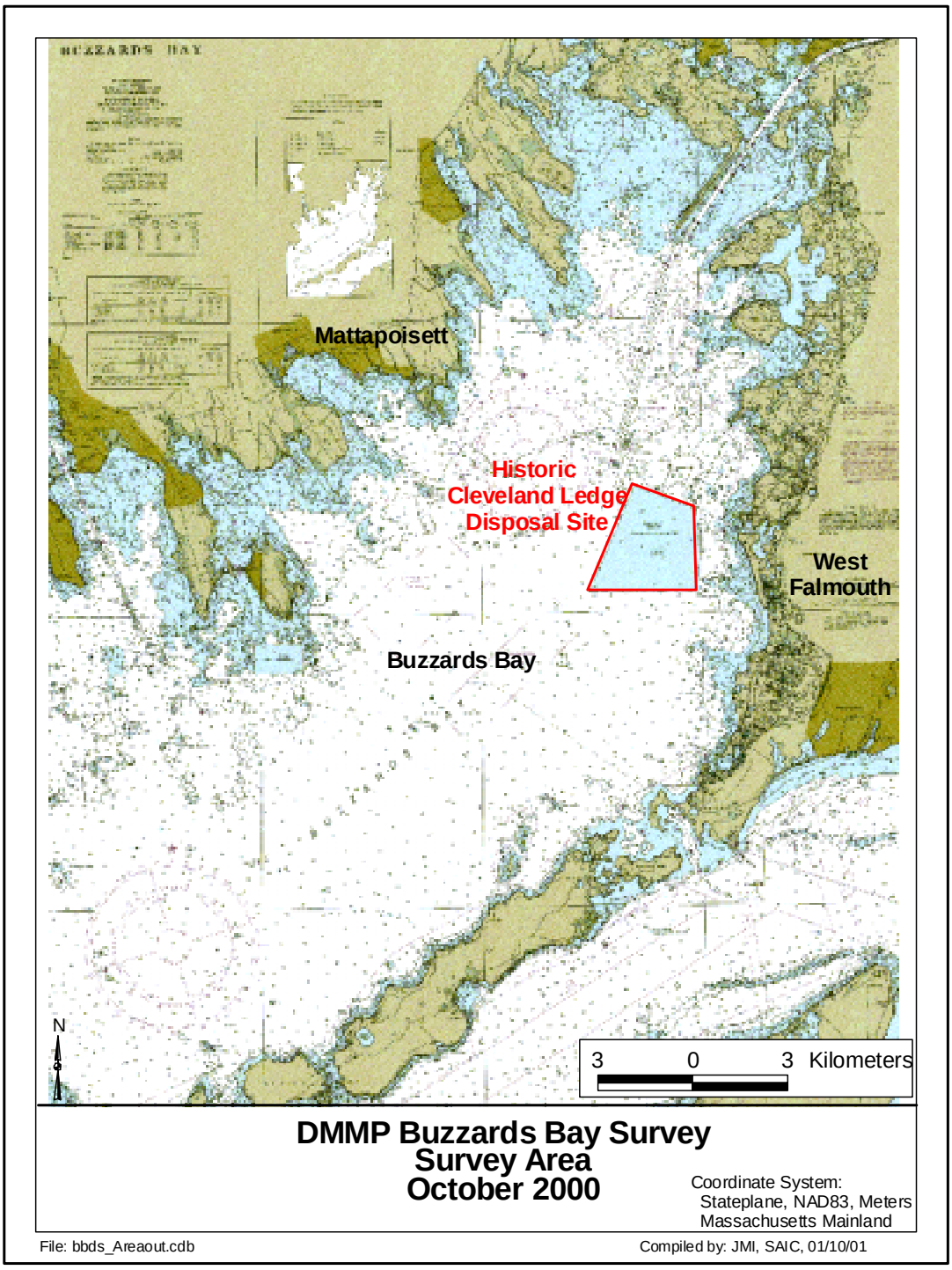

Figure 1-1. General location map showing the boundary of the historic Cleveland Ledge Disposal Site on the eastern side of Buzzards Bay, off of West Falmouth (from NOAA Nautical Chart 13229).

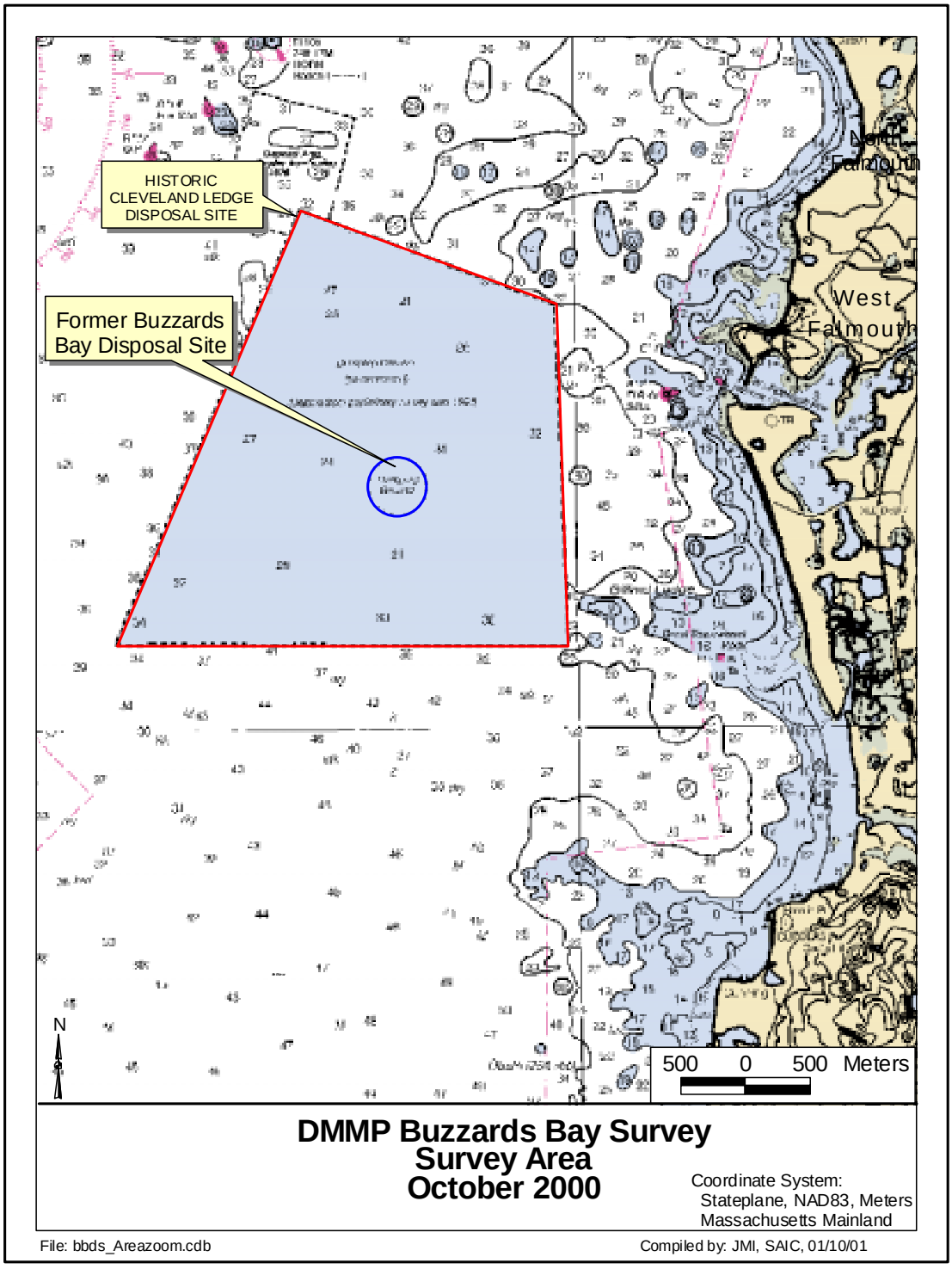

Figure 1-2. Map of the historic Cleveland Ledge Disposal Site showing the location of the former Buzzards Bay Disposal Site (BBDS). In 1995, Massachusetts DEM proposed the designation of a new BBDS in the same location.

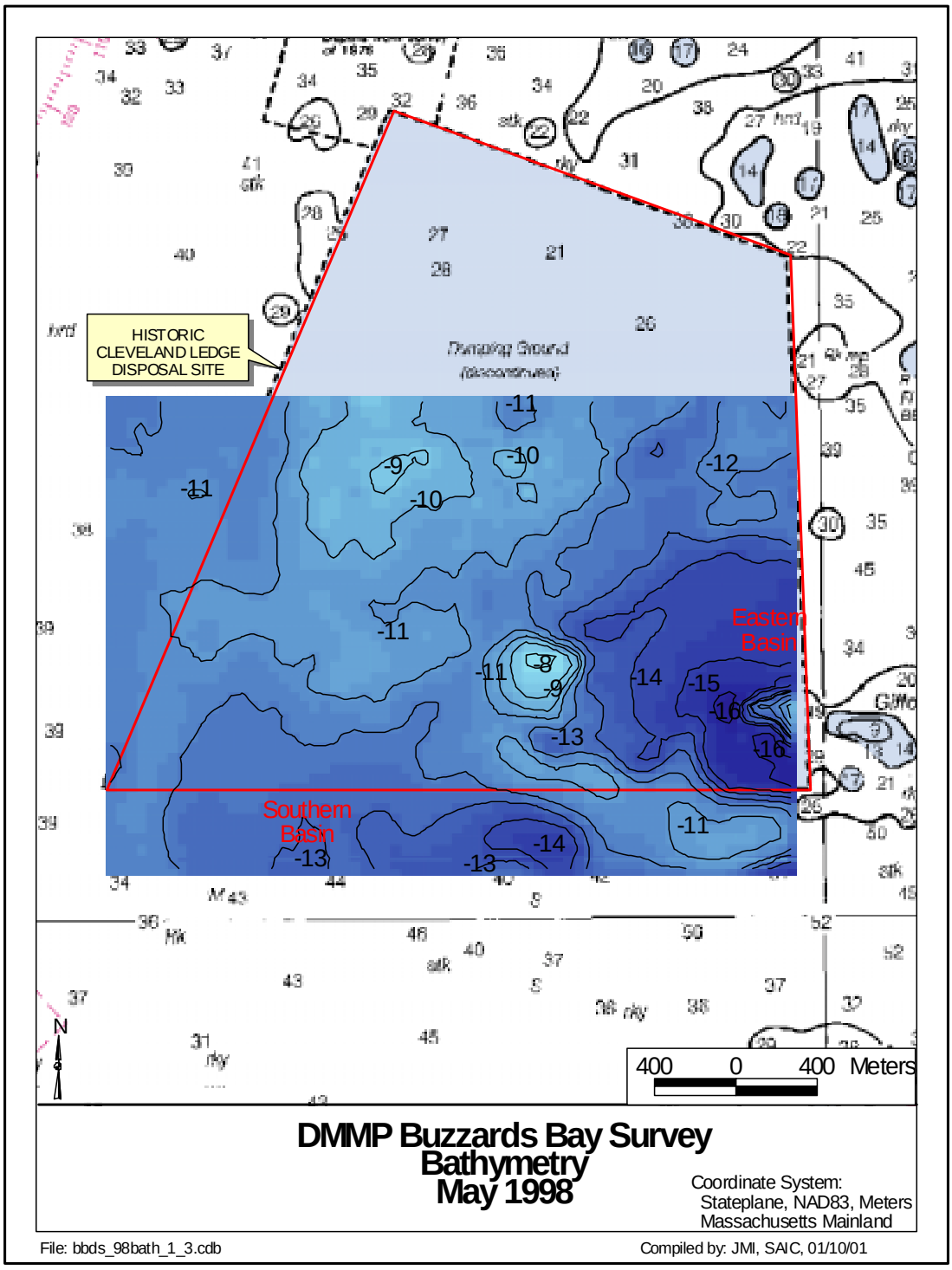

Figure 1-3. Results of the high-resolution bathymetric survey conducted across the southern half of the Cleveland Ledge Disposal Site in May 1998, superimposed on NOAA Nautical Chart 13229. Depths from the bathymetric survey are in meters; nautical chart depth soundings are in feet.

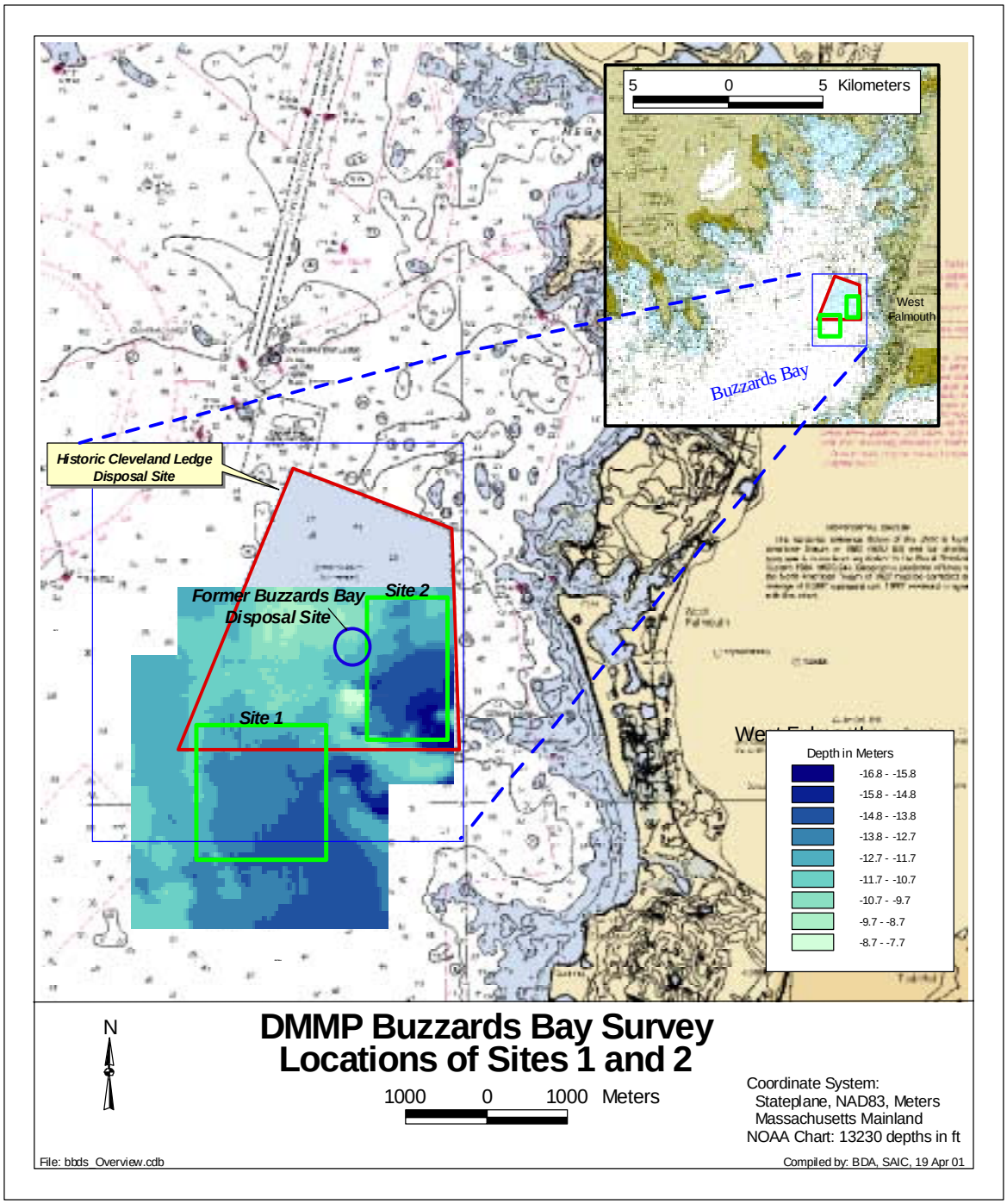

Figure 1-4. Map showing the general location of candidate disposal Sites 1 and 2 within Buzzards Bay and in relation to the historic Cleveland Ledge Disposal Site. Depth contours (in meters) underlying Sites 1 and 2 are from SAIC surveys conducted in May 1998 and October 2000.

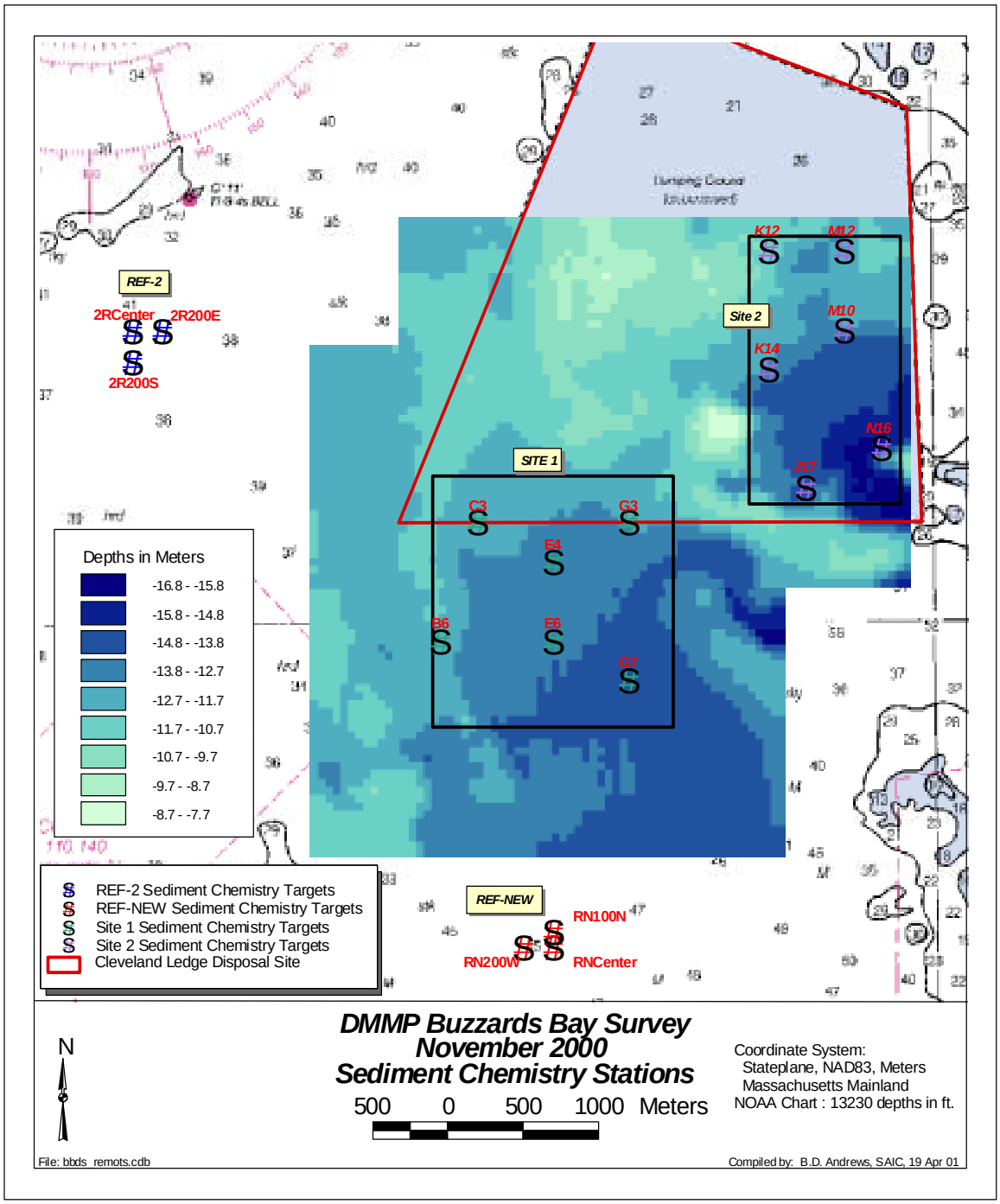

Figure 2-1. Map showing the location of sediment chemistry sampling stations at candidate disposal Sites 1 and 2 and reference areas Ref-New and Ref-2. Color bathymetry results underlying Sites 1 and 2 are in meters, from SAIC surveys conducted in May 1998 and October 2000. Depth values on the underlying NOAA chart are in feet.

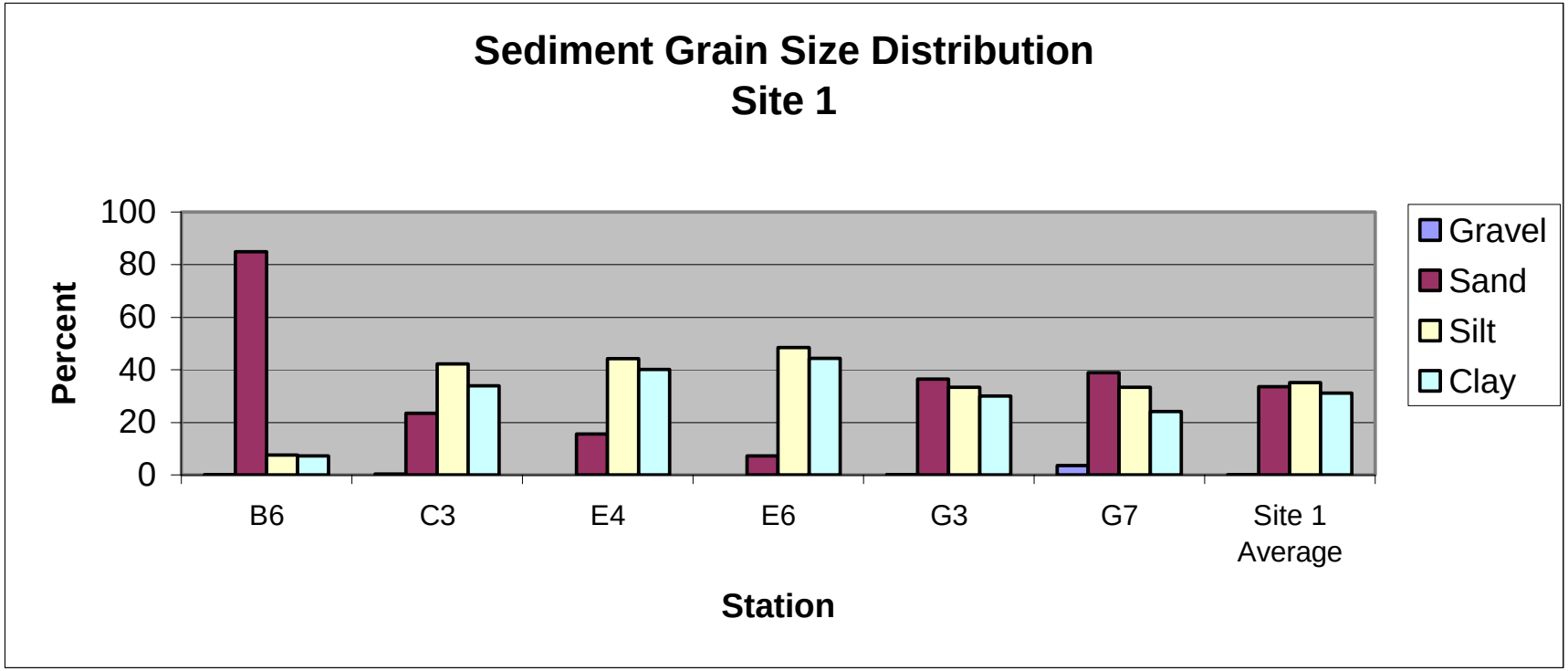

Figure 3-1. Grain size distribution for the six sediment samples collected within Site 1.

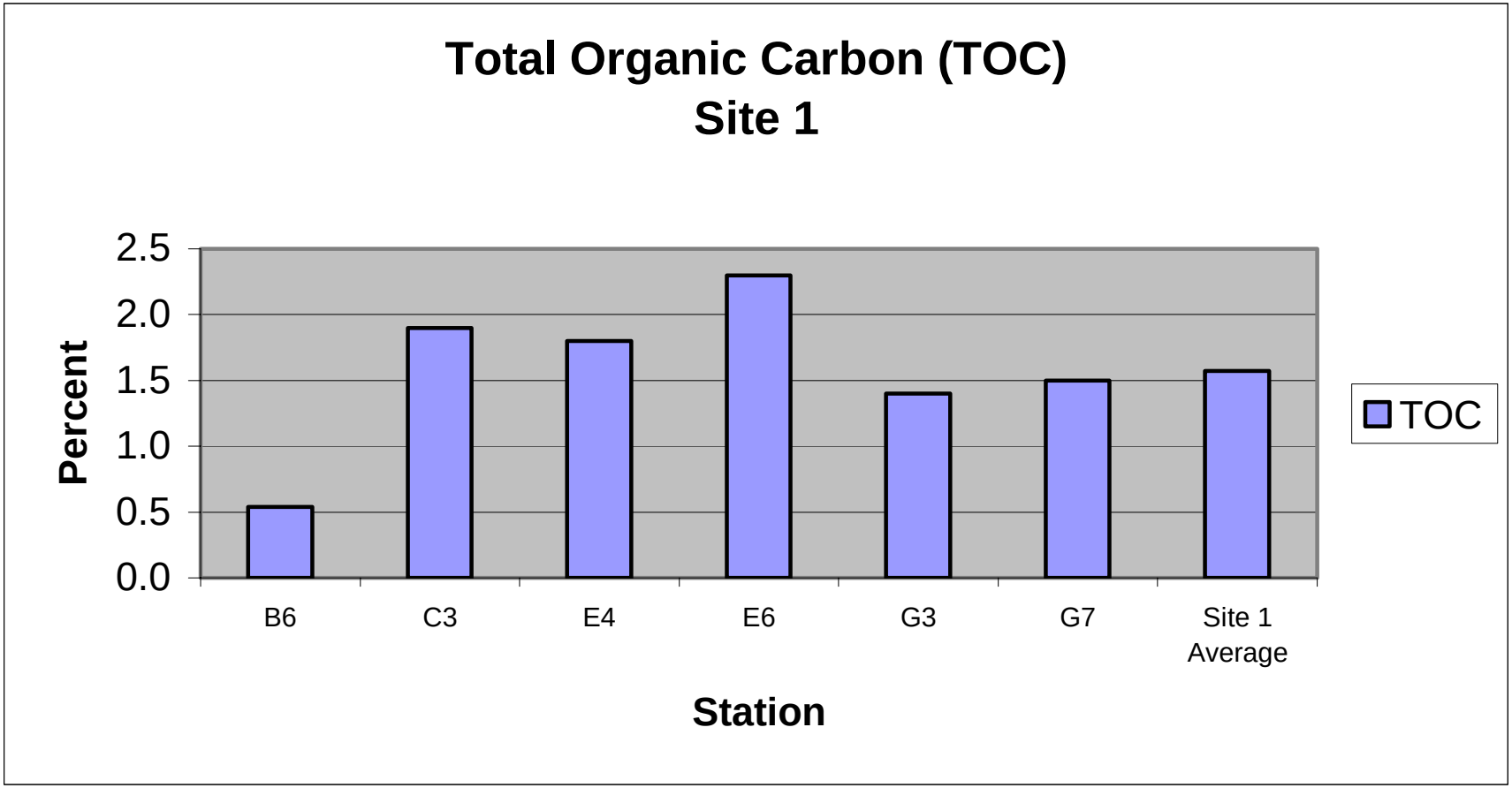

Figure 3-2. Concentrations of TOC in the six sediment samples collected within Site 1.

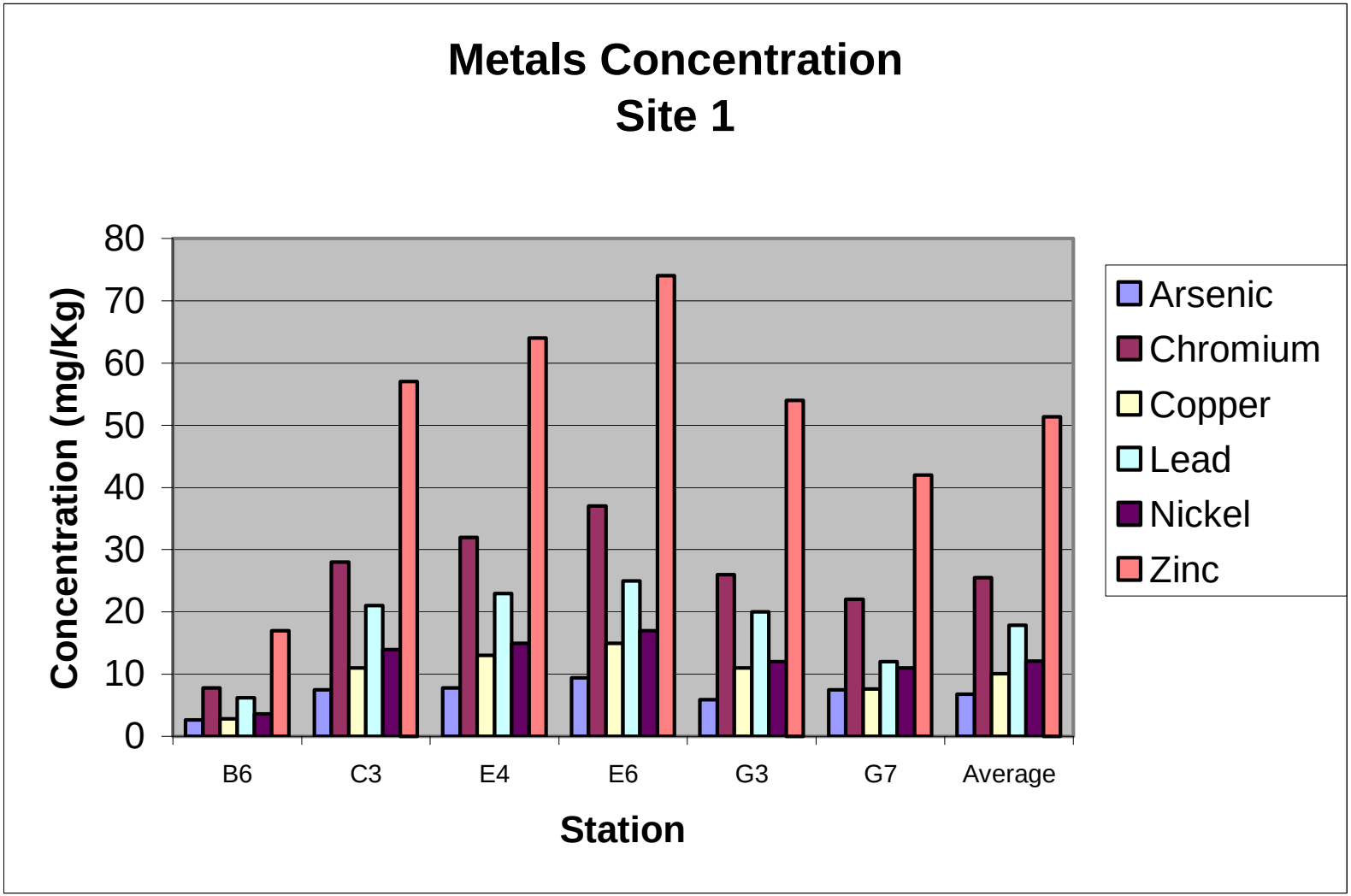

Figure 3-3. Metals concentrations in the six sediment samples collected within Site 1 (cont. on next page).

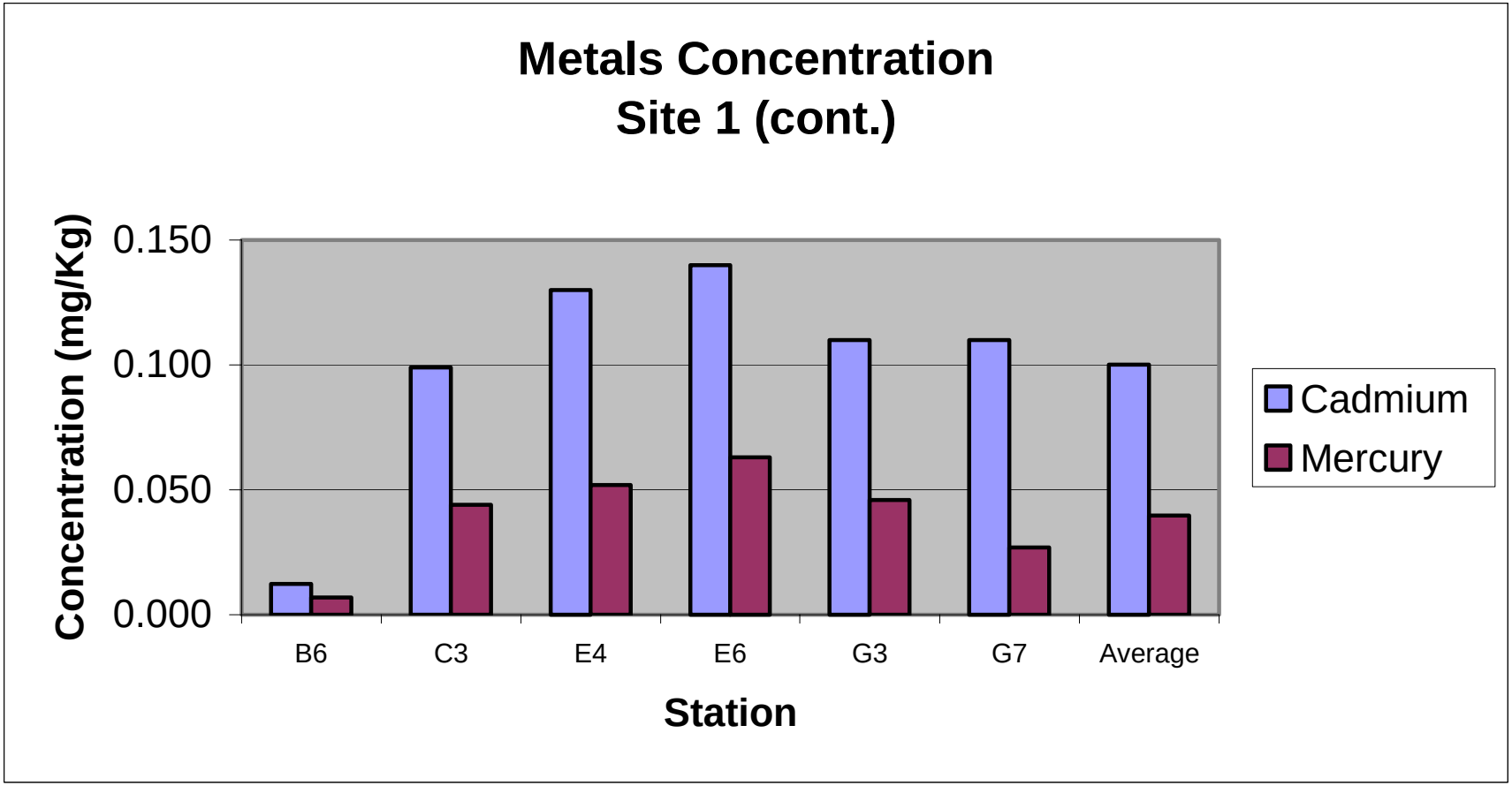

Figure 3-3 (cont.). Metals concentrations in the six sediment samples collected within Site 1.

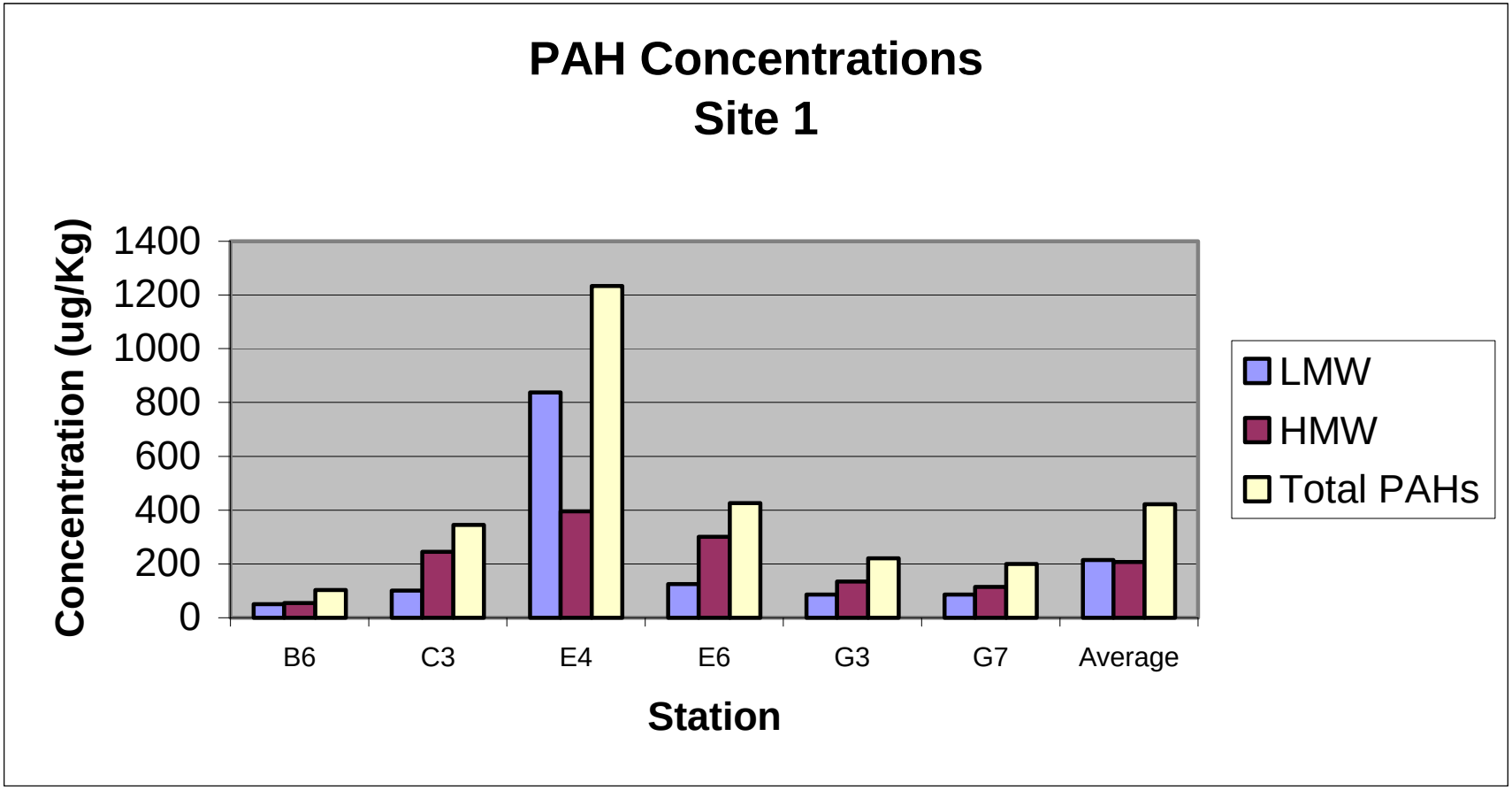

Figure 3-4. Concentrations of LMW PAHs, HMW PAHs, and Total PAHs in the six sediment samples collected within Site 1.

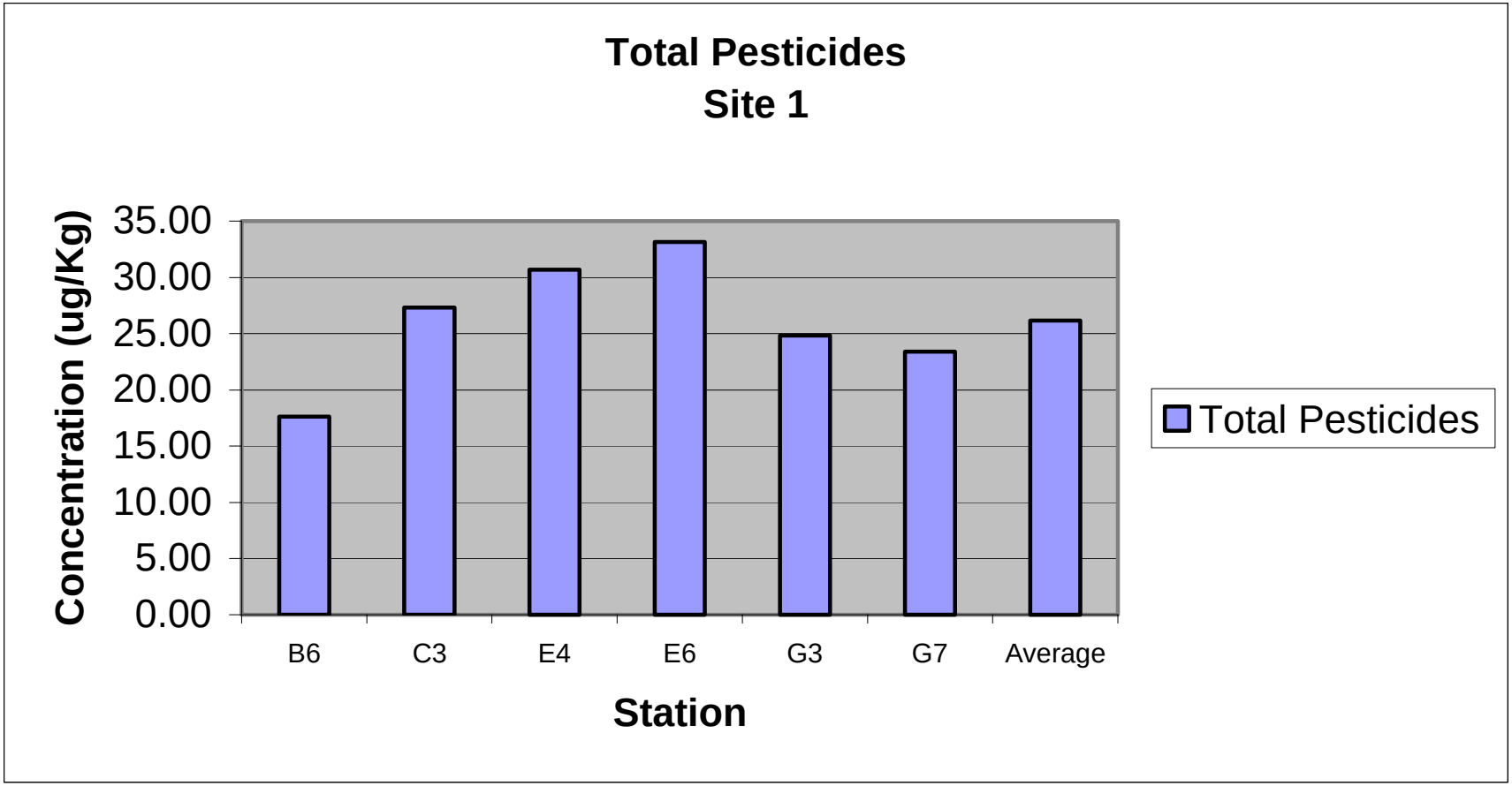

Figure 3-5. Concentrations of Total Pesticides in the six sediment samples collected within Site 1.

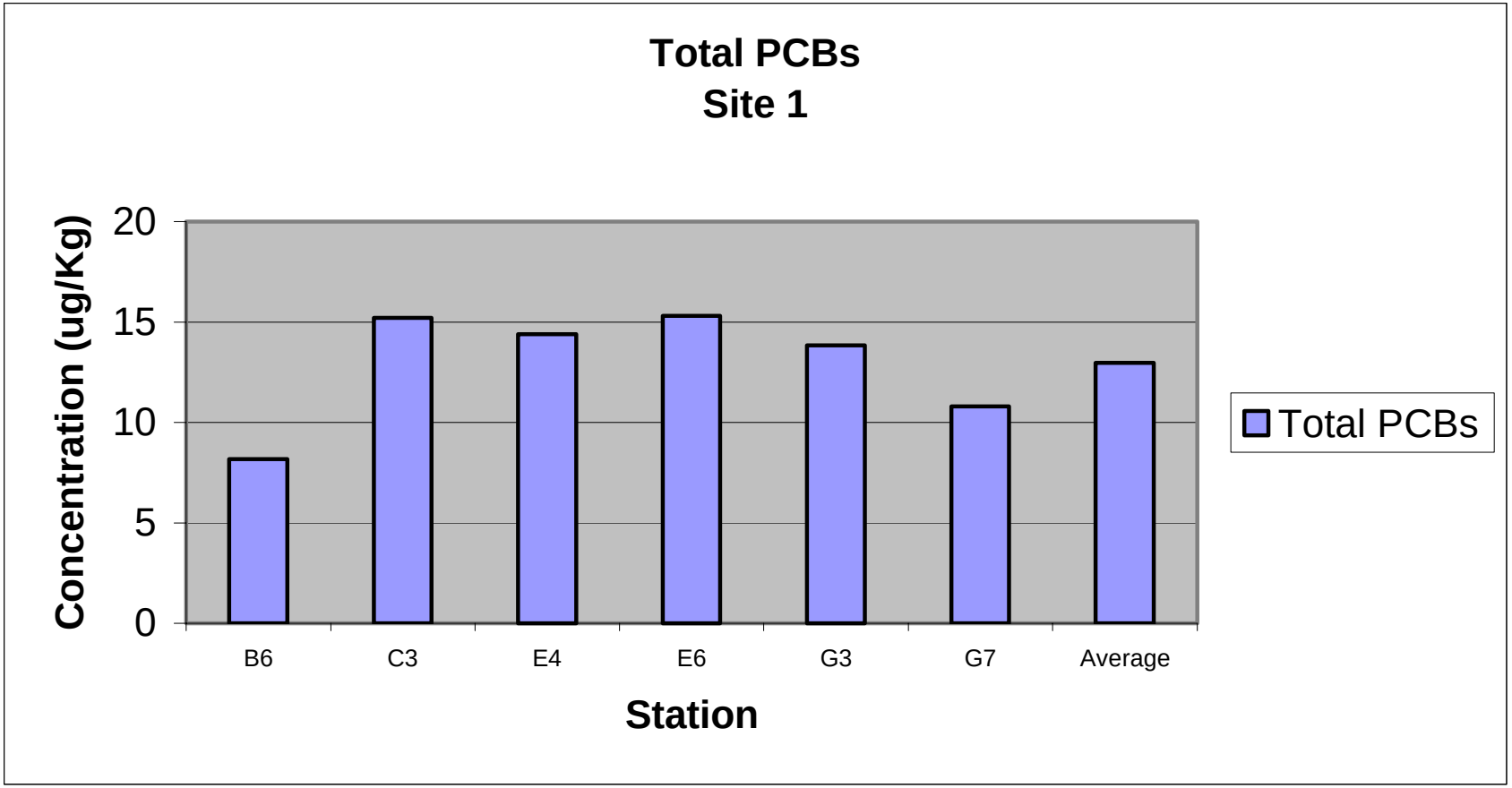

Figure 3-6. Concentrations of Total PCBs in the six sediment samples collected within Site 1.

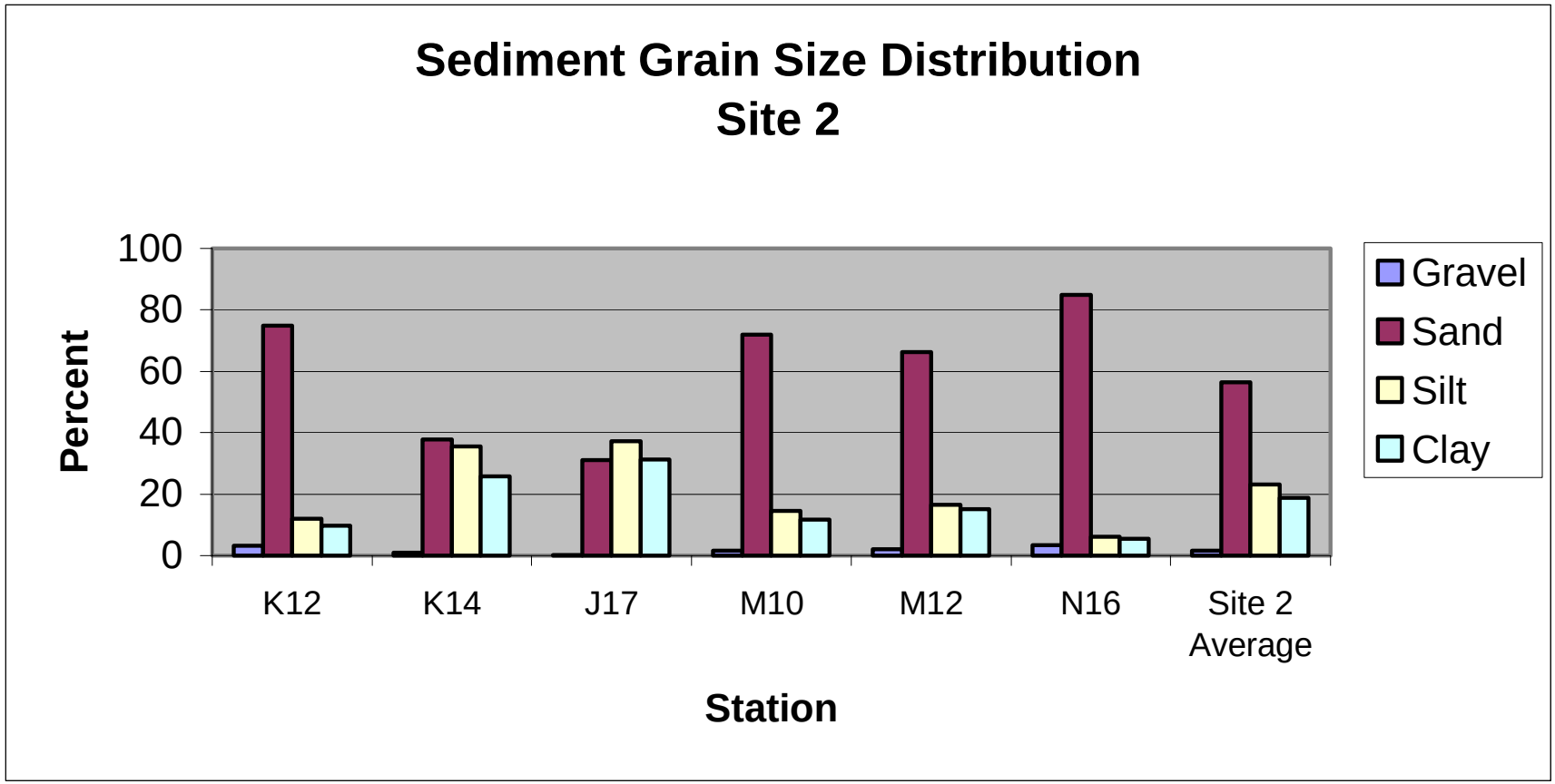

Figure 3-7. Grain size distribution for the six sediment samples collected within Site 2.

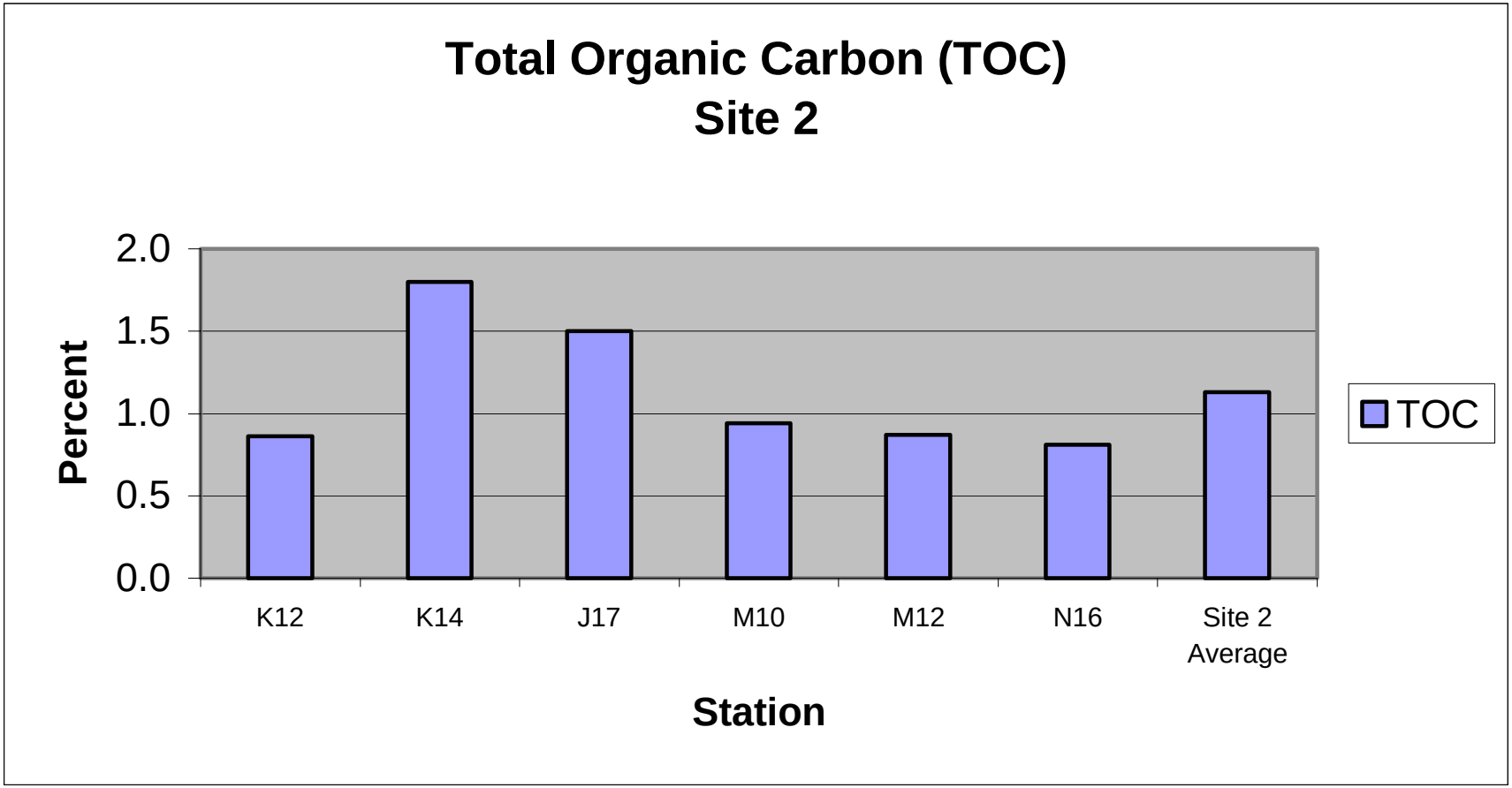

Figure 3-8. Concentrations of TOC in the six sediment samples collected within Site 2.

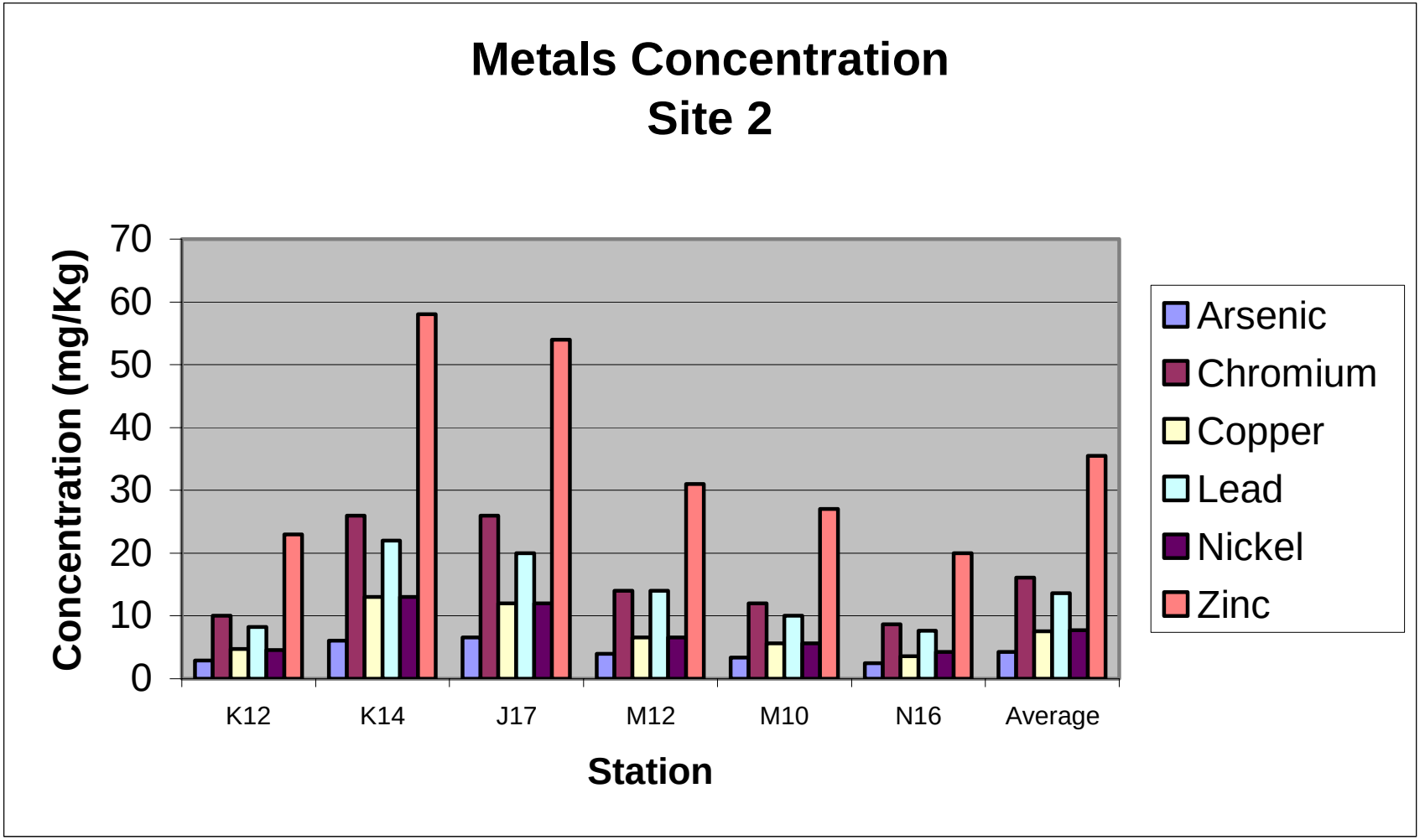

Figure 3-9. Metals concentrations in the six sediment samples collected within Site 2.(cont. on next page)

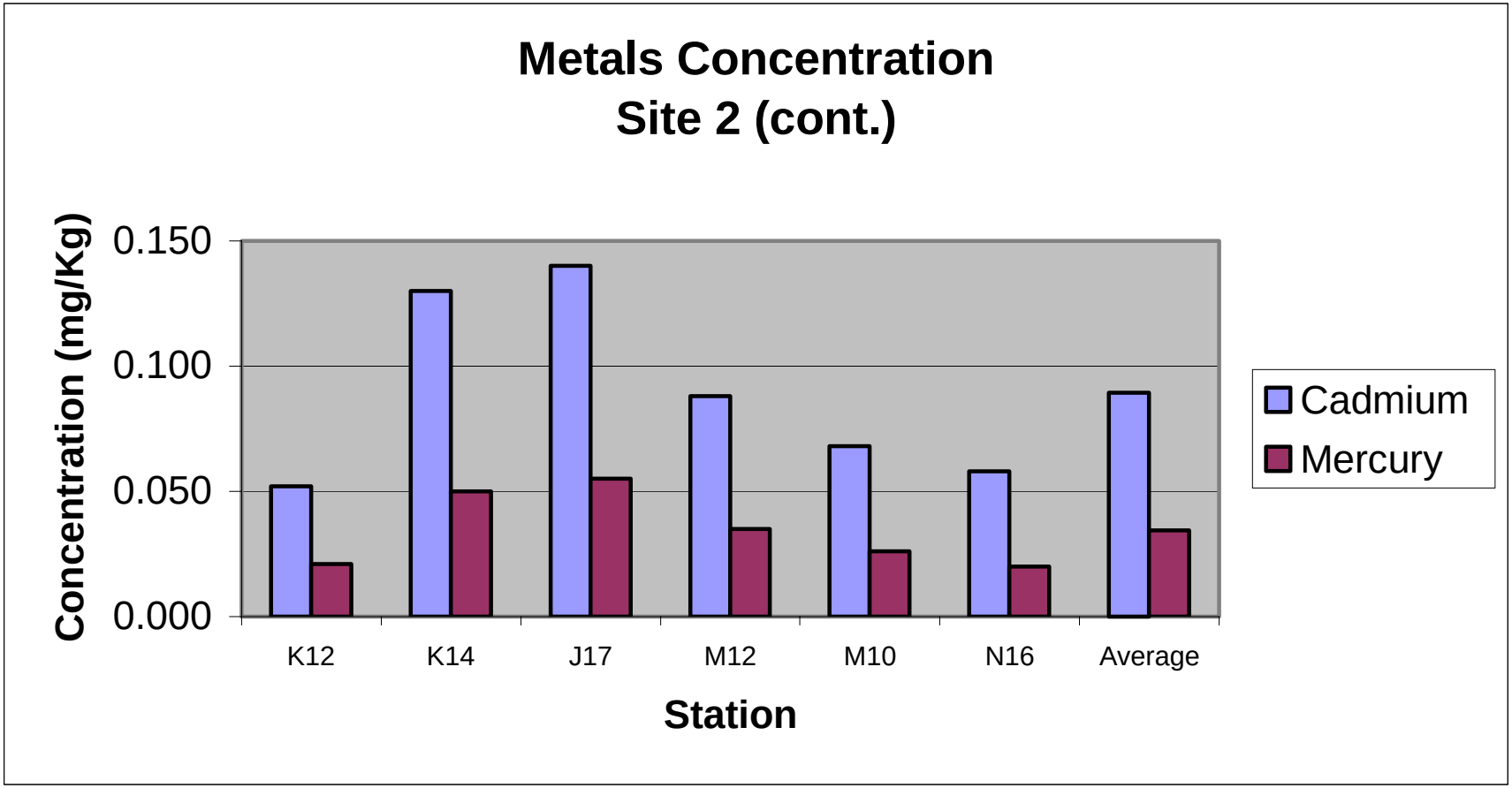

Figure 3-9 (cont.). Metals concentrations in the six sediment samples collected within Site 2.

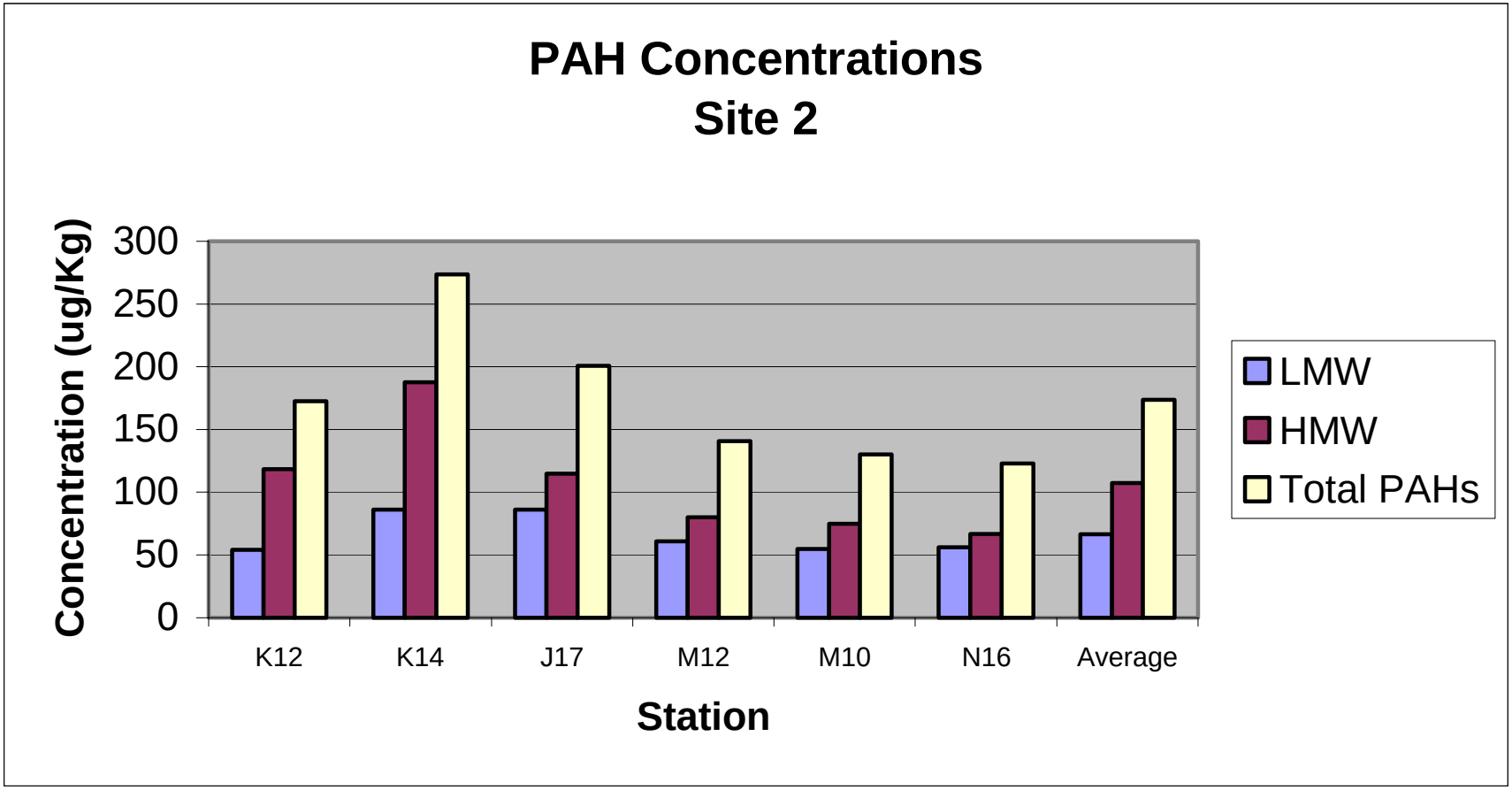

Figure 3-10. Concentrations of LMW PAHs, HMW PAHs, and Total PAHs in the six sediment samples collected within Site 2.

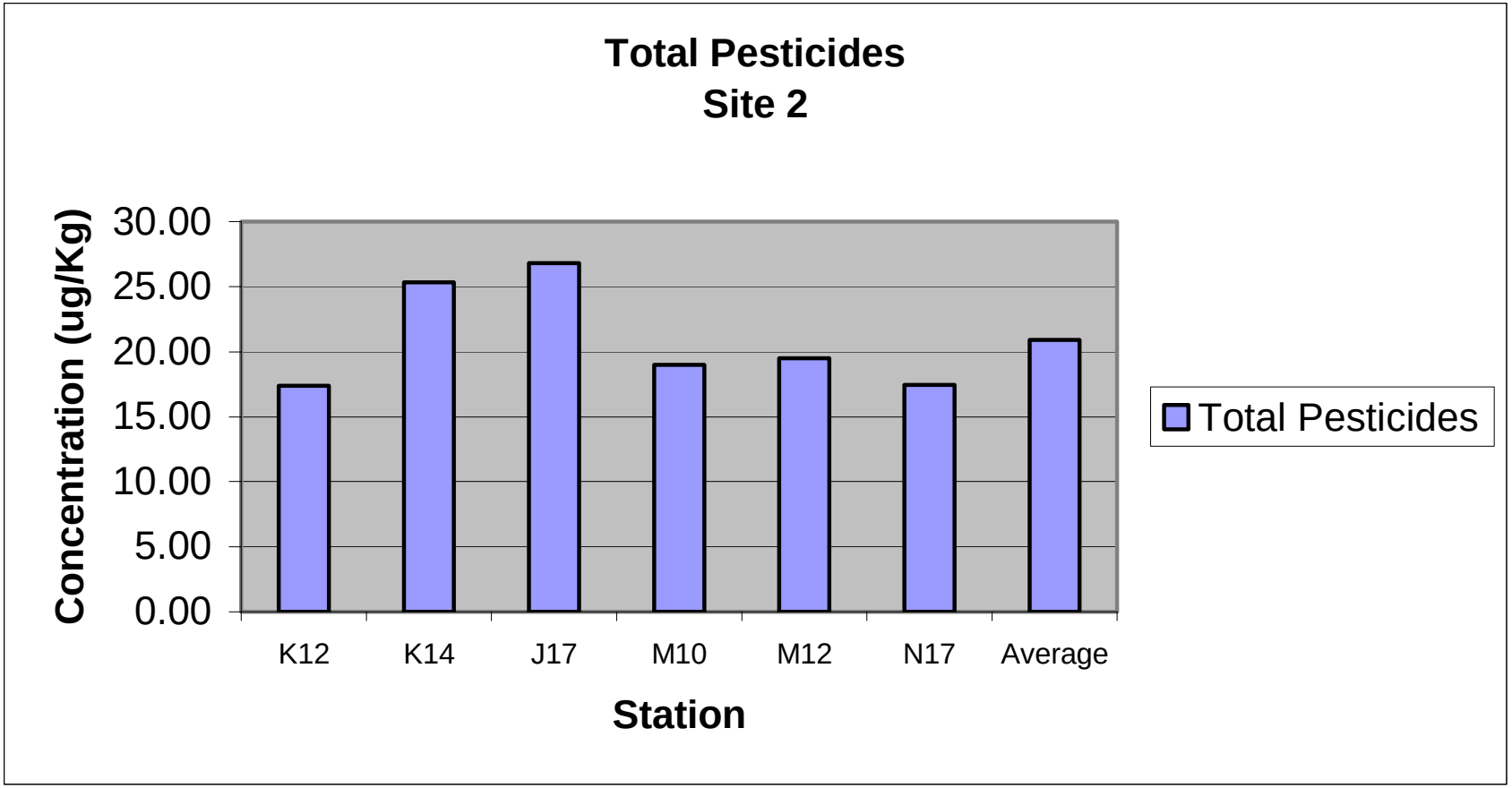

Figure 3-11. Concentrations of Total Pesticides in the six sediment samples collected within Site 2.

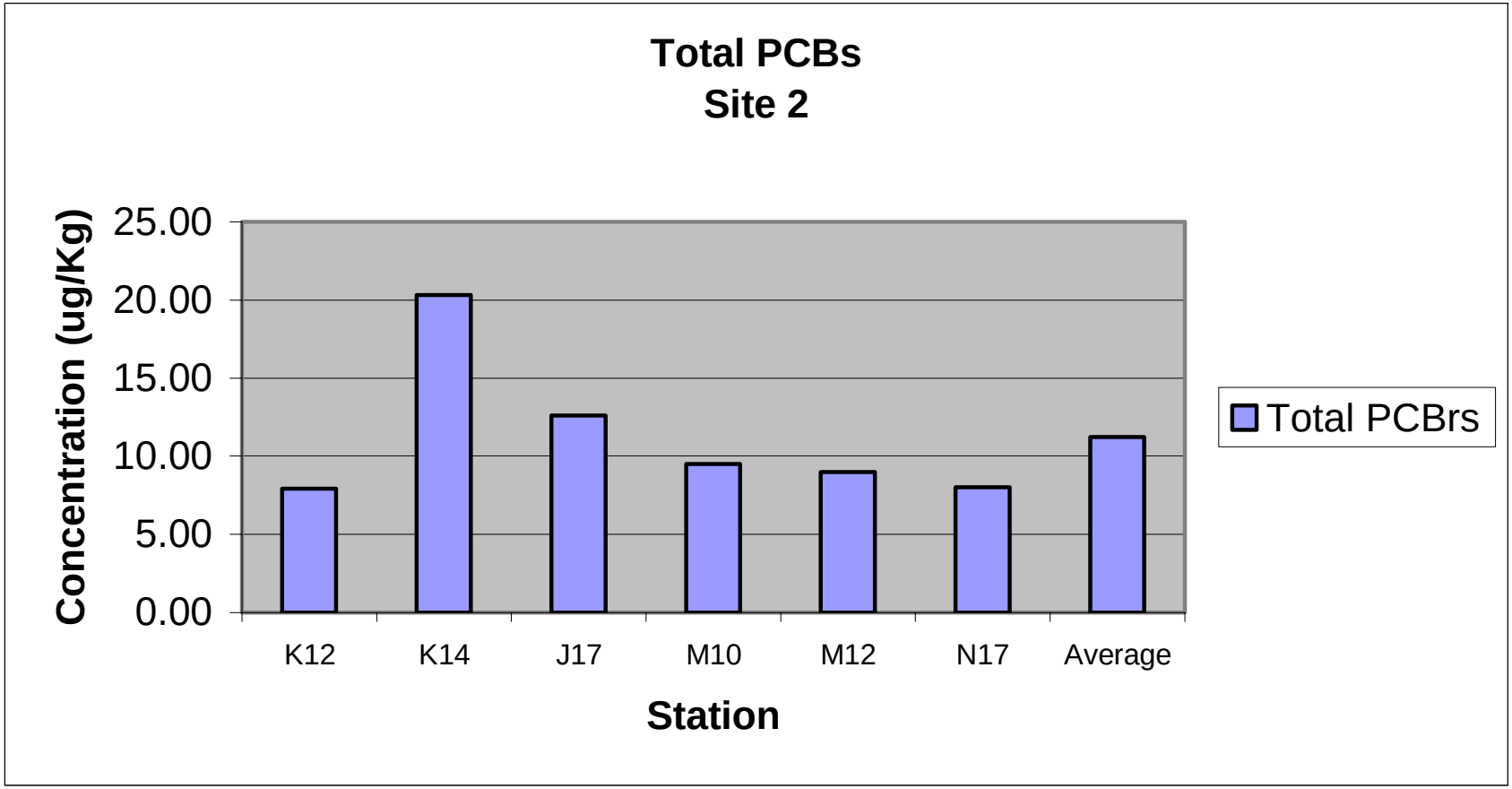

Figure 3-12. Concentrations of Total PCBs in the six sediment samples collected within Site 2.

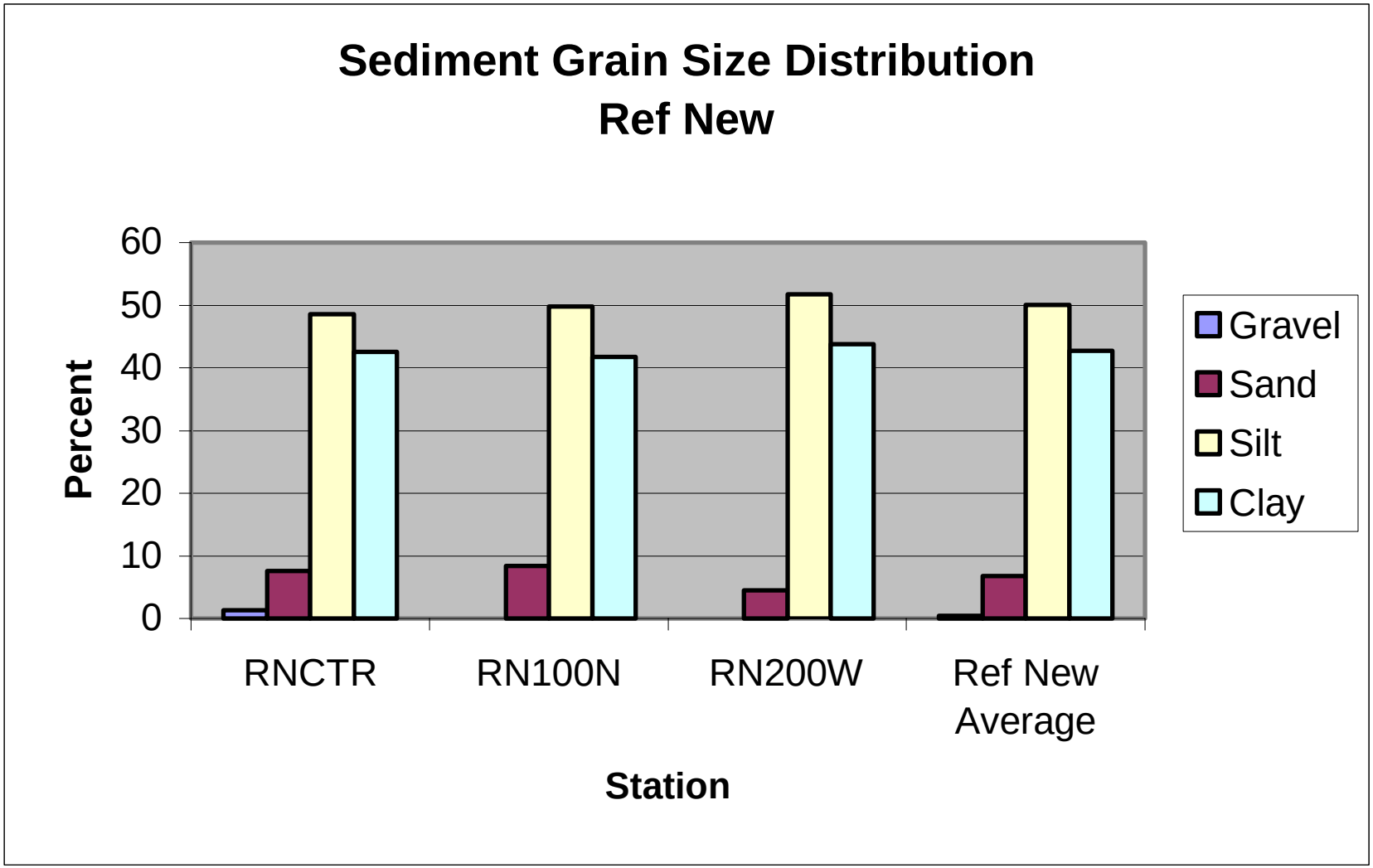

Figure 3-13. Grain size distribution for the three sediment samples collected at the Ref-New reference area.

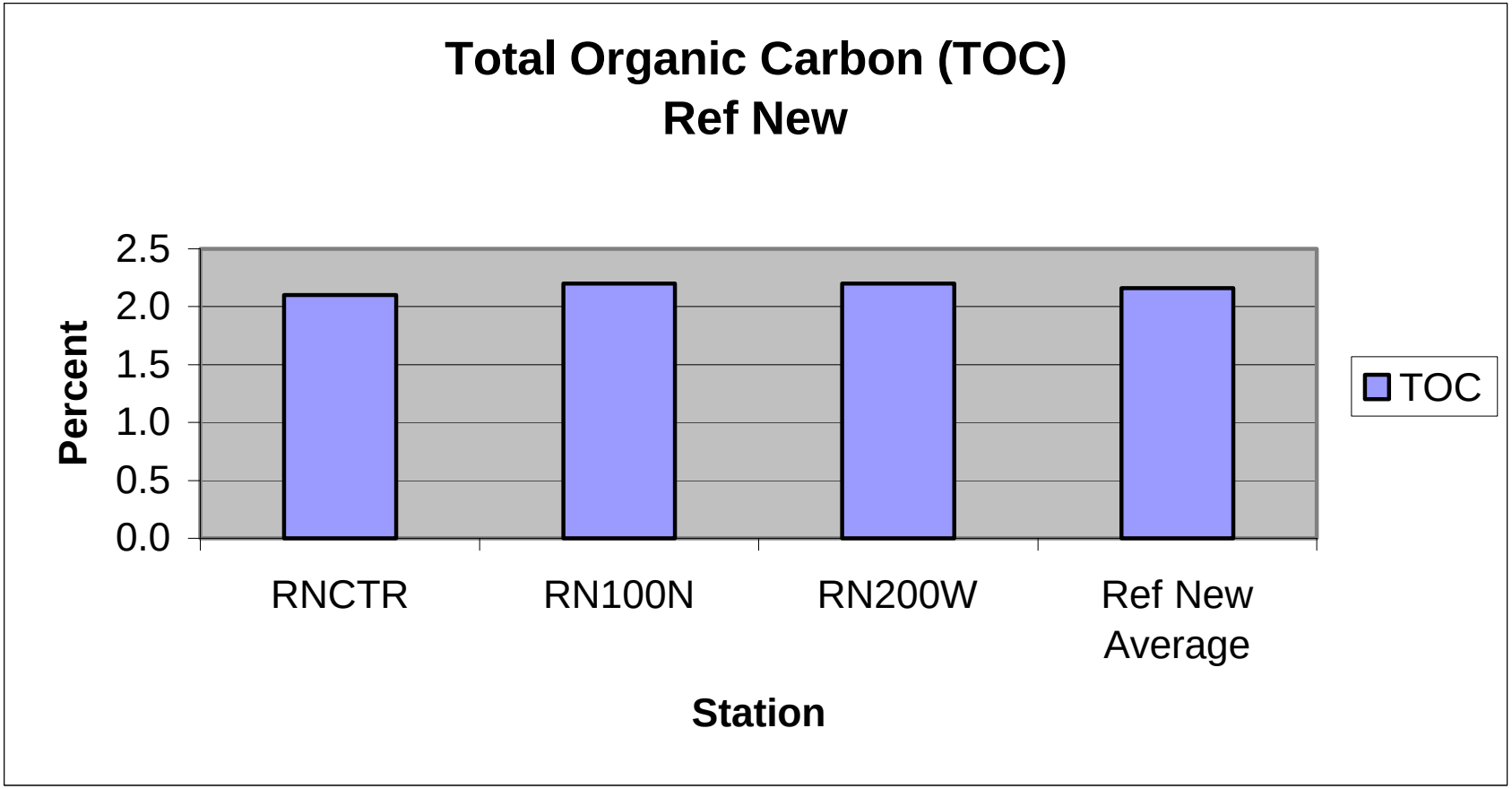

Figure 3-14. Concentrations of TOC in the three sediment samples collected at the Ref-New reference area.

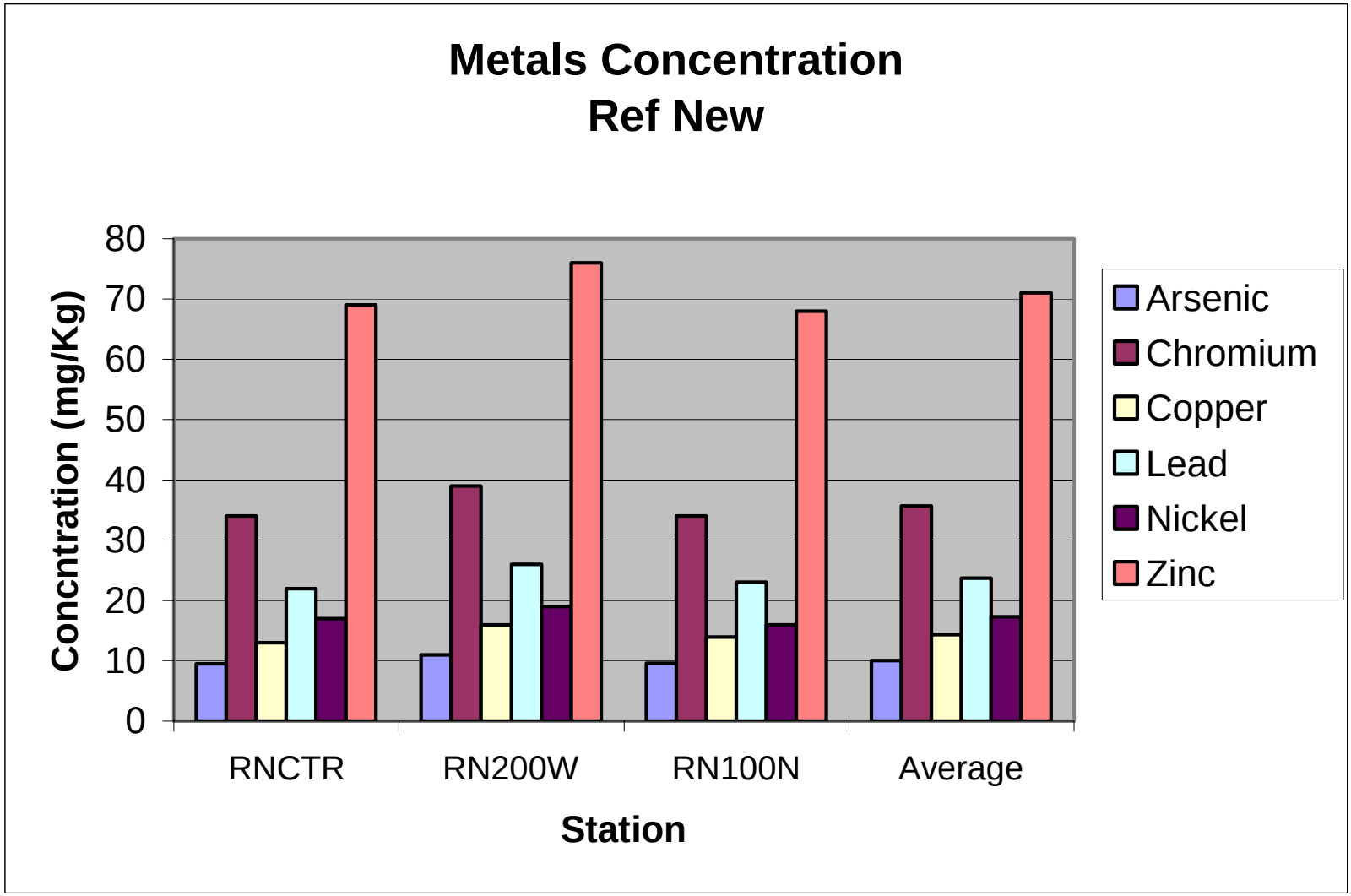

Figure 3-15. Metals concentrations in the three sediment samples collected at the Ref-New reference area (cont. on next page).

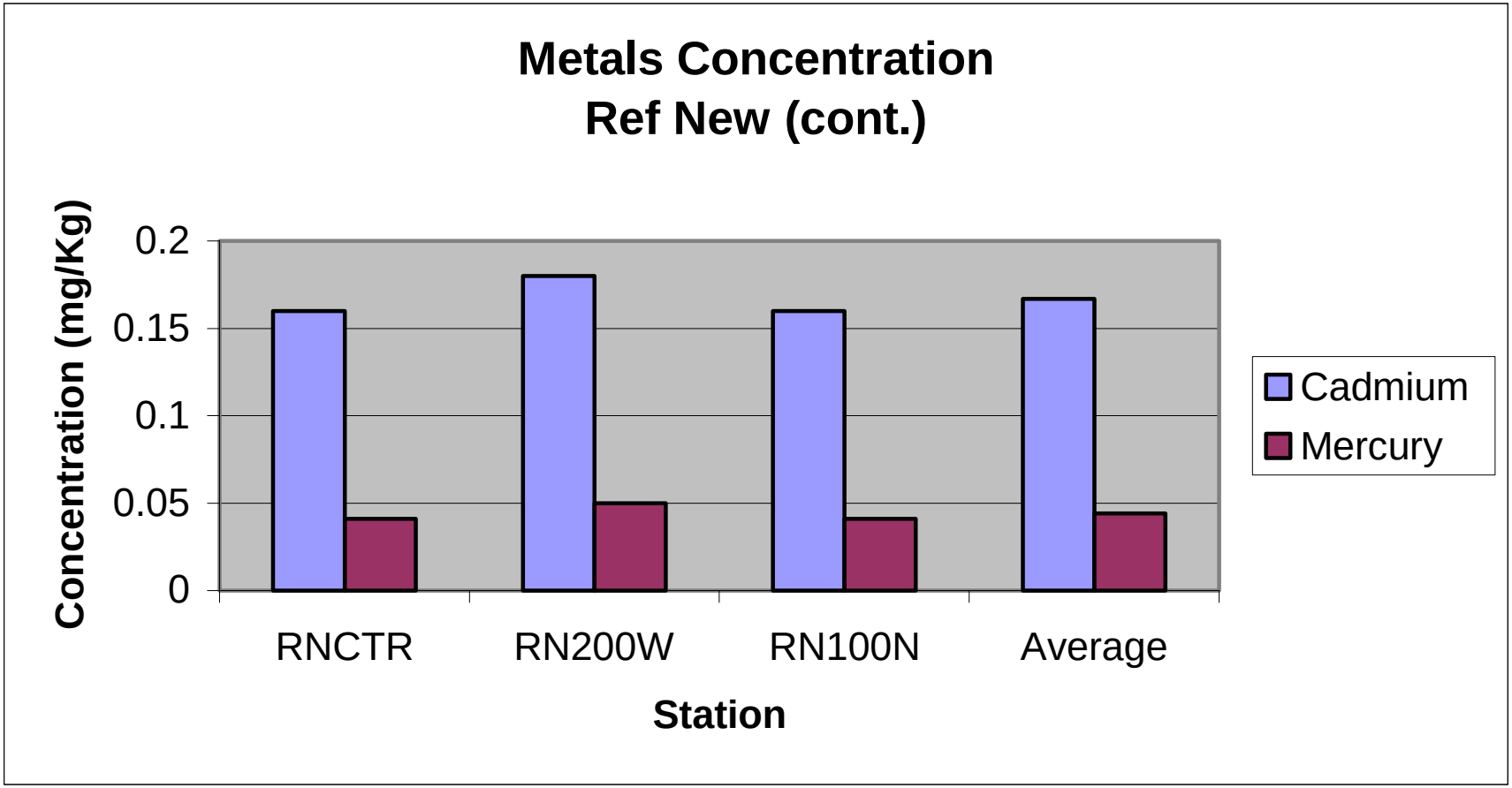

Figure 3-15 (cont.). Metals concentrations in the three sediment samples collected at the Ref-New reference area.

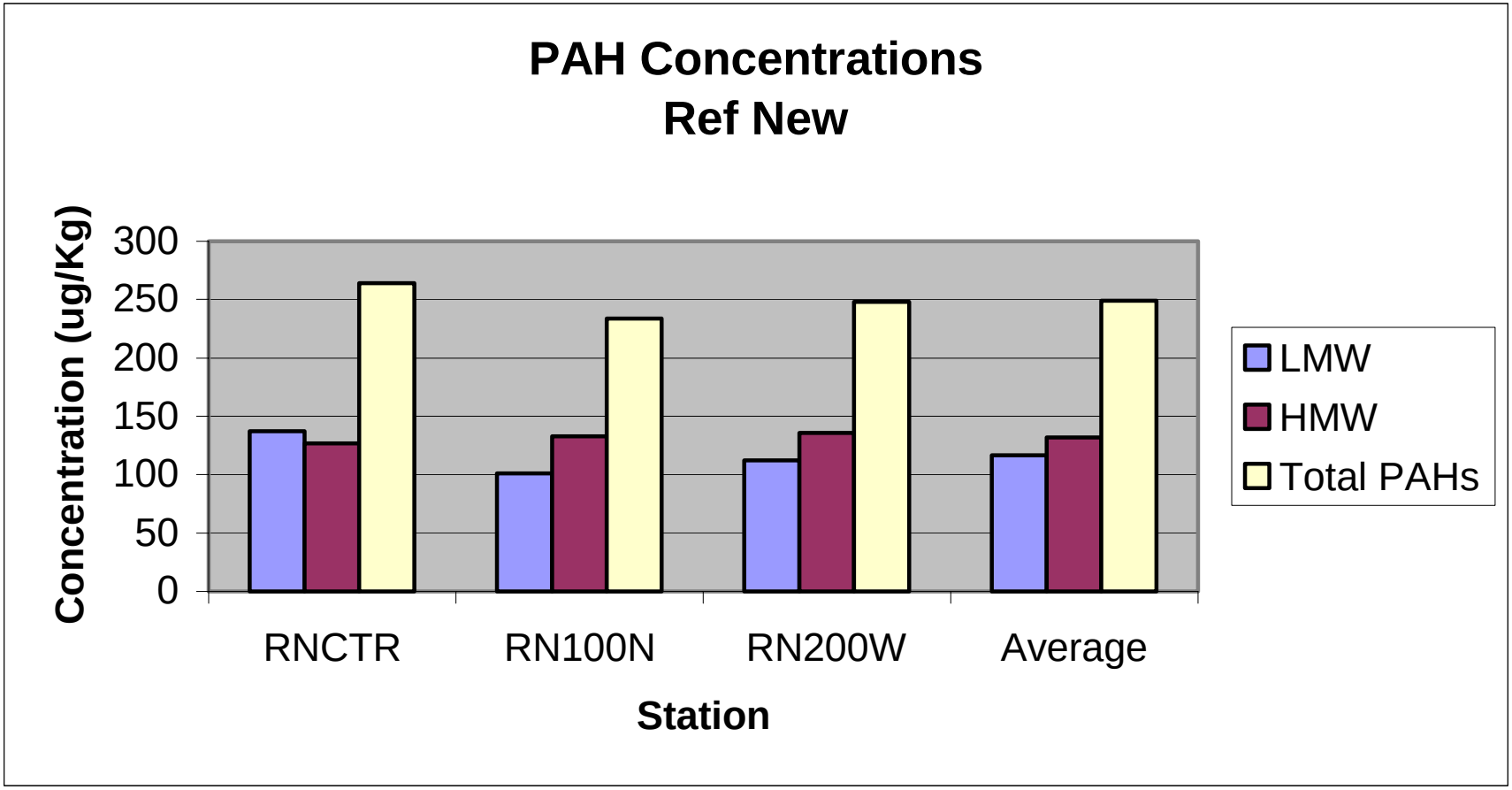

Figure 3-16. Concentrations of LMW PAHs, HMW PAHs, and Total PAHs in the three sediment samples collected at the Ref-New reference area.

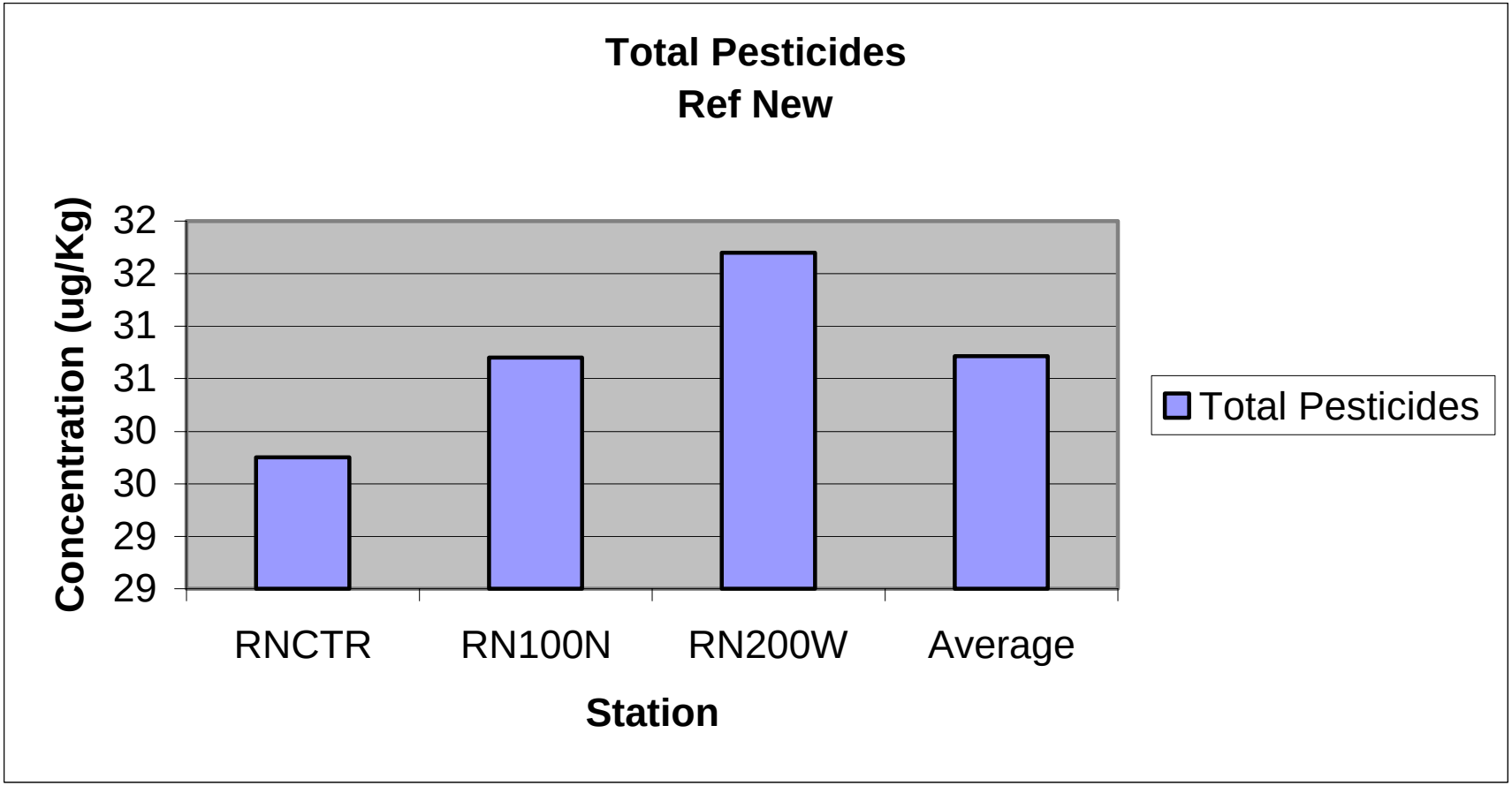

Figure 3-17. Concentrations of Total Pesticides in the three sediment samples collected at the Ref-New reference area.

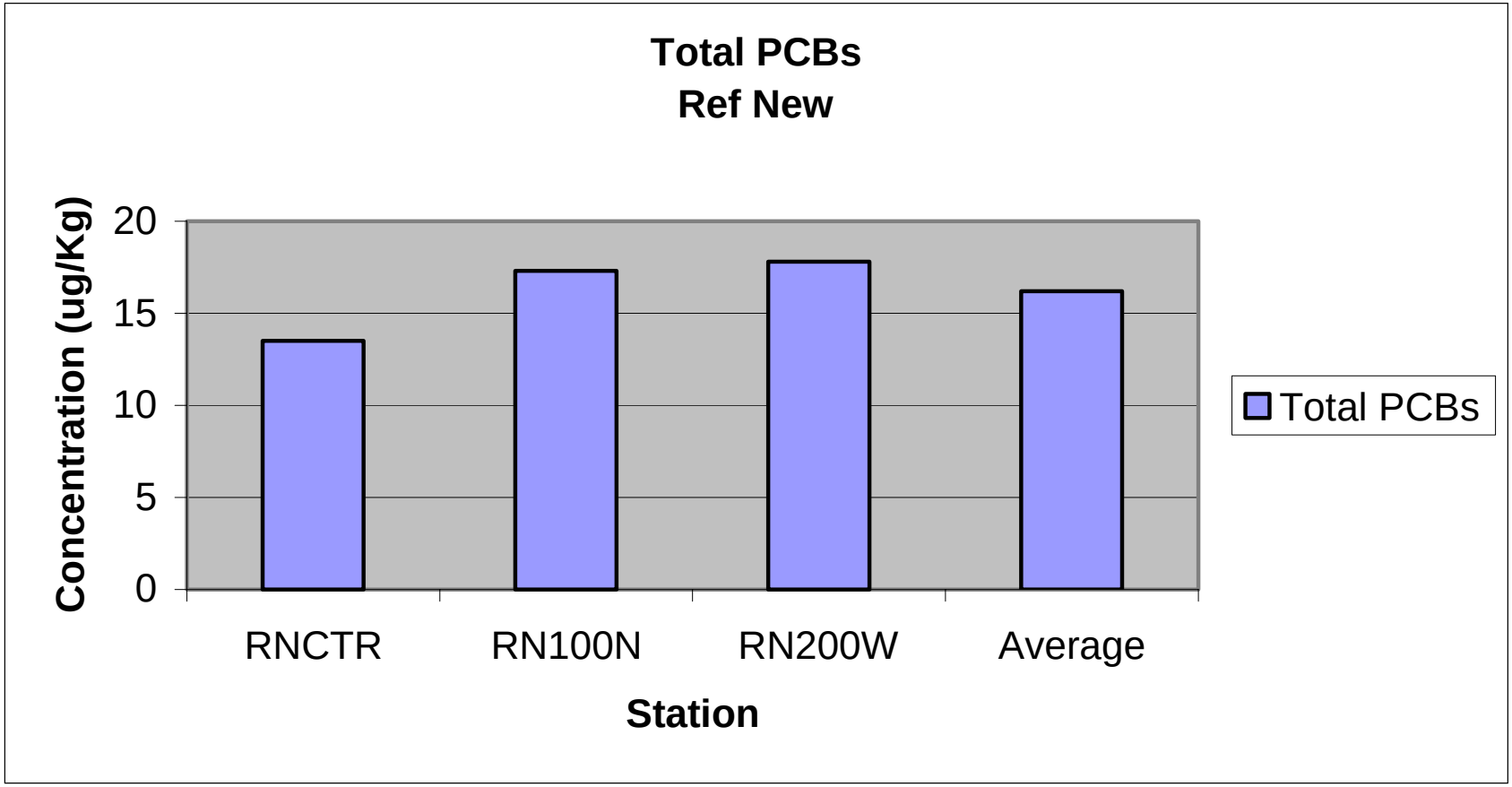

Figure 3-18. Concentrations of Total PCBs in the three sediment samples collected at the Ref-New reference area.

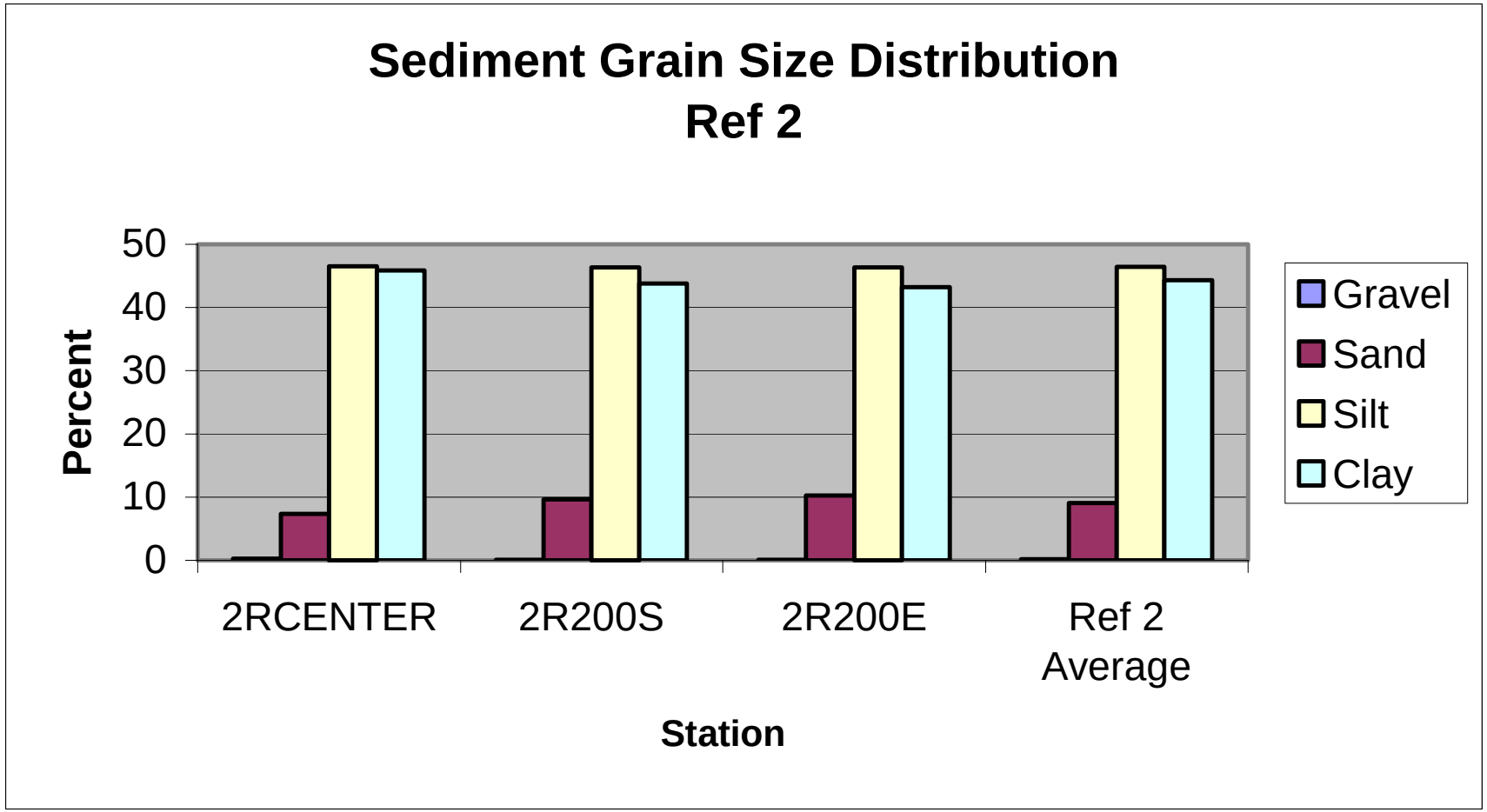

Figure 3-19. Grain size distribution for the three sediment samples collected at the Ref-2 reference area.

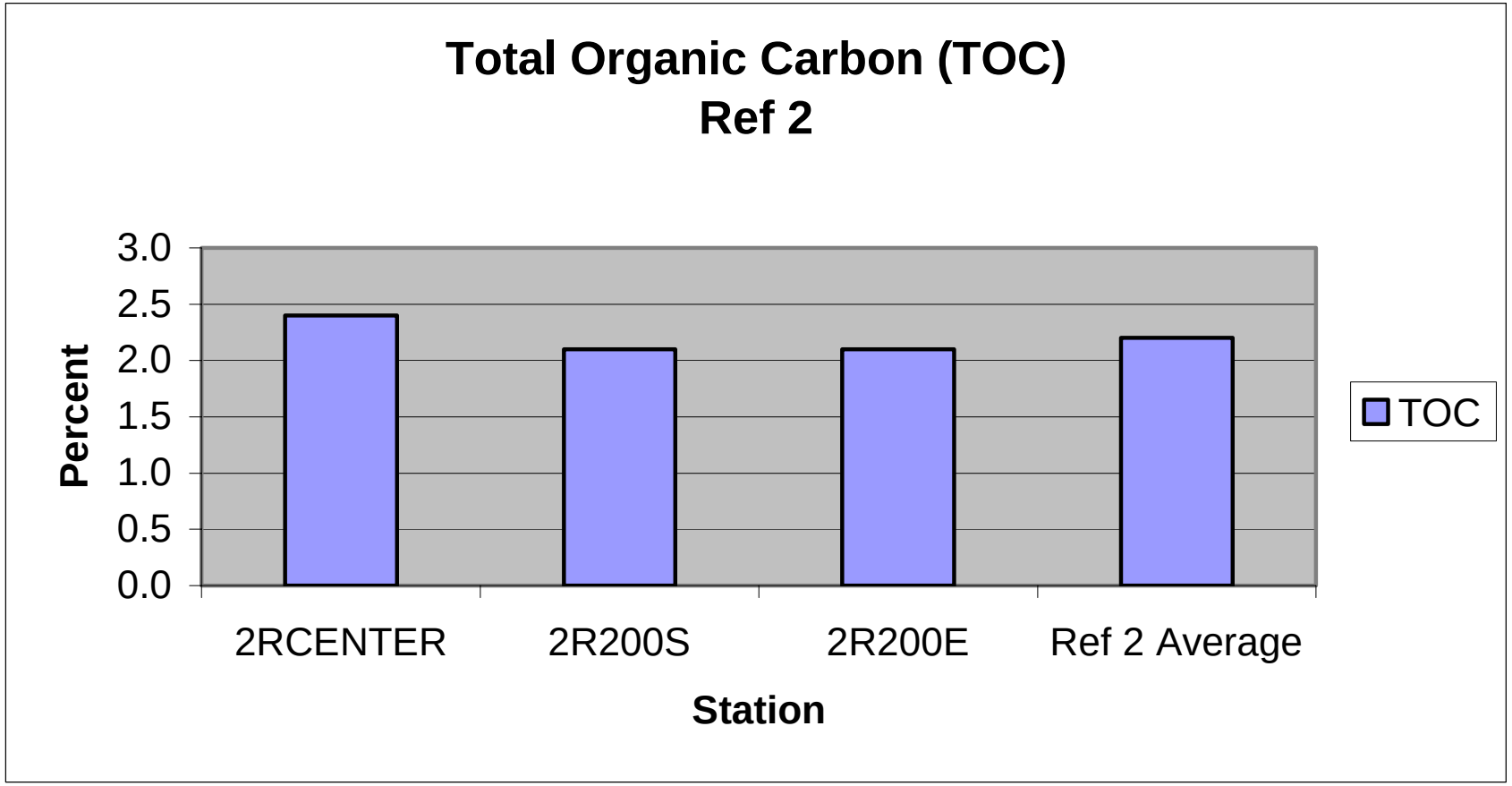

Figure 3-20. Concentrations of TOC in the three sediment samples collected at the Ref-2 reference area.

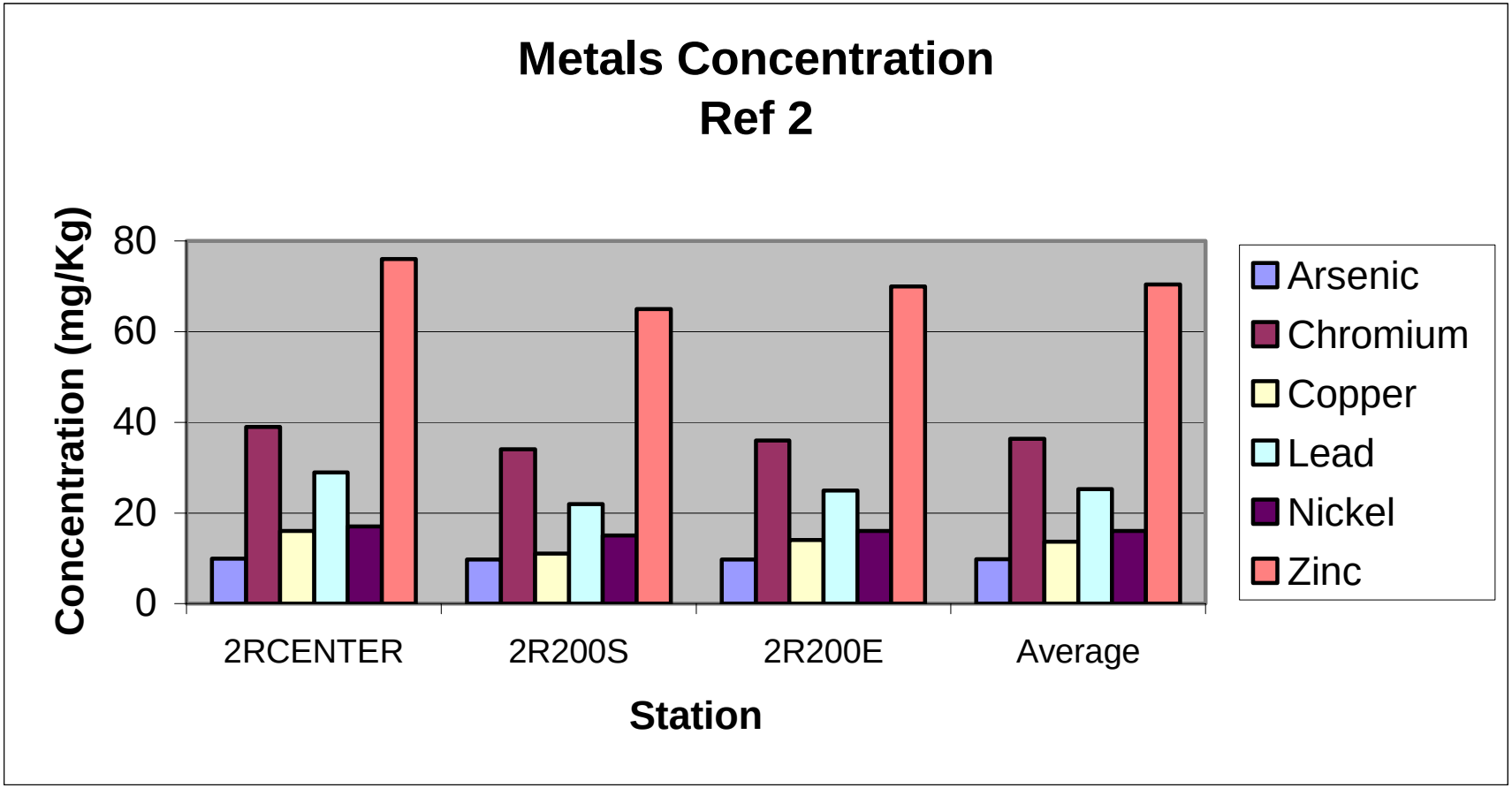

Figure 3-21. Metals concentrations in the three sediment samples collected at the Ref-2 reference area (cont. on next page).

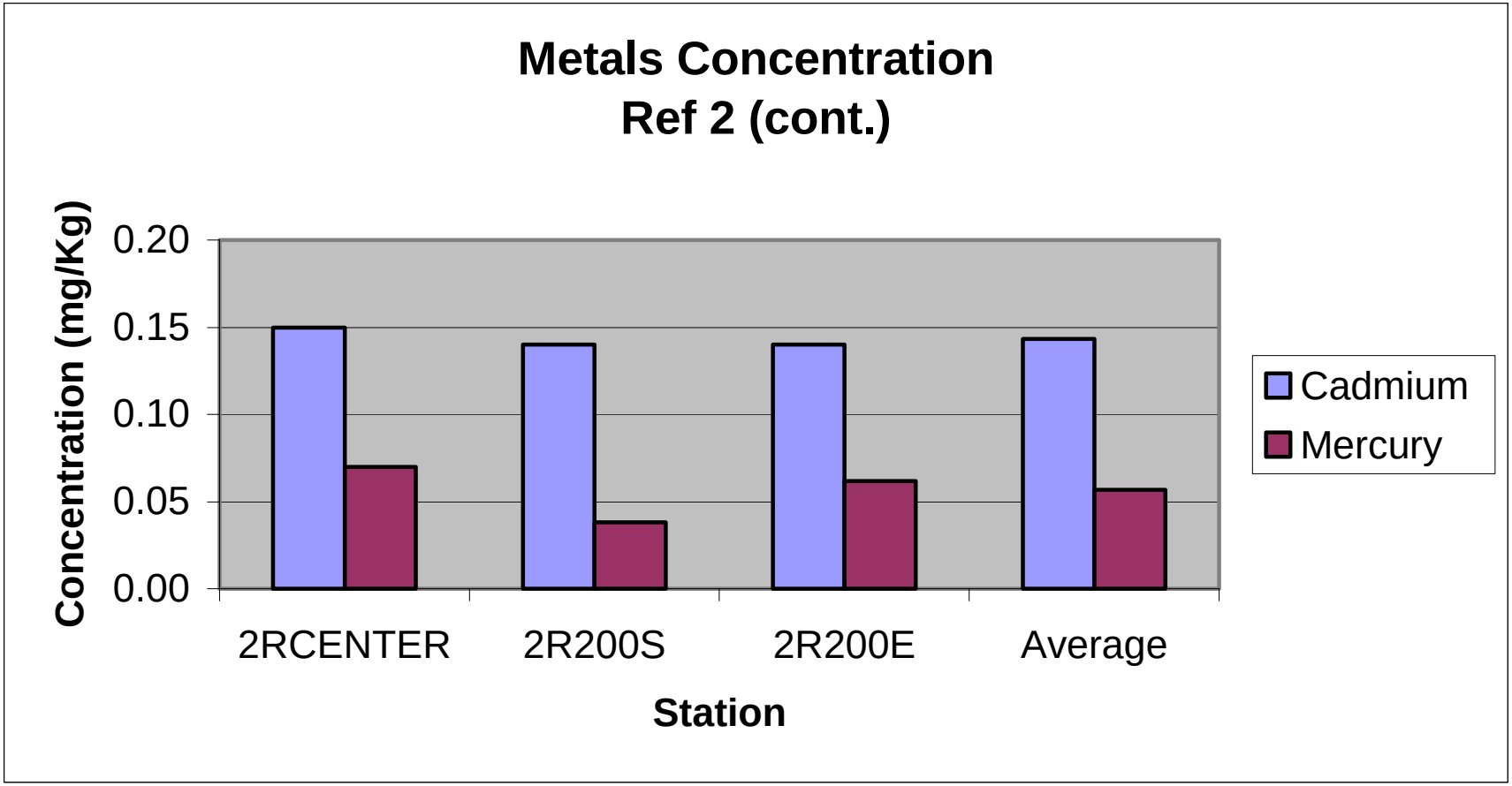

Figure 3-21 (cont.). Metals concentrations in the three sediment samples collected at the Ref-2 reference area.

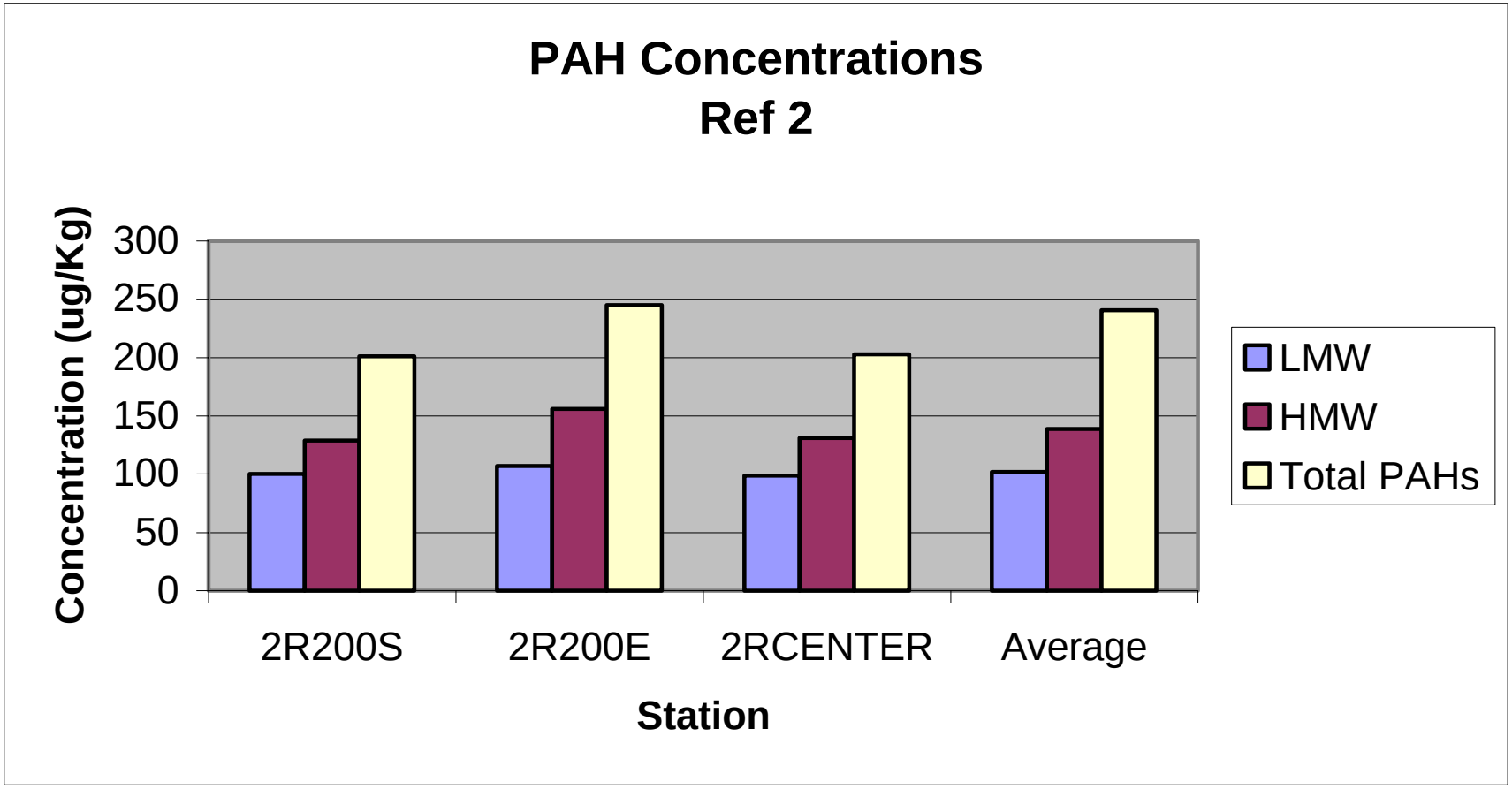

Figure 3-22. Concentrations of LMW PAHs, HMW PAHs, and Total PAHs in the three sediment samples collected at the Ref-2 reference area.

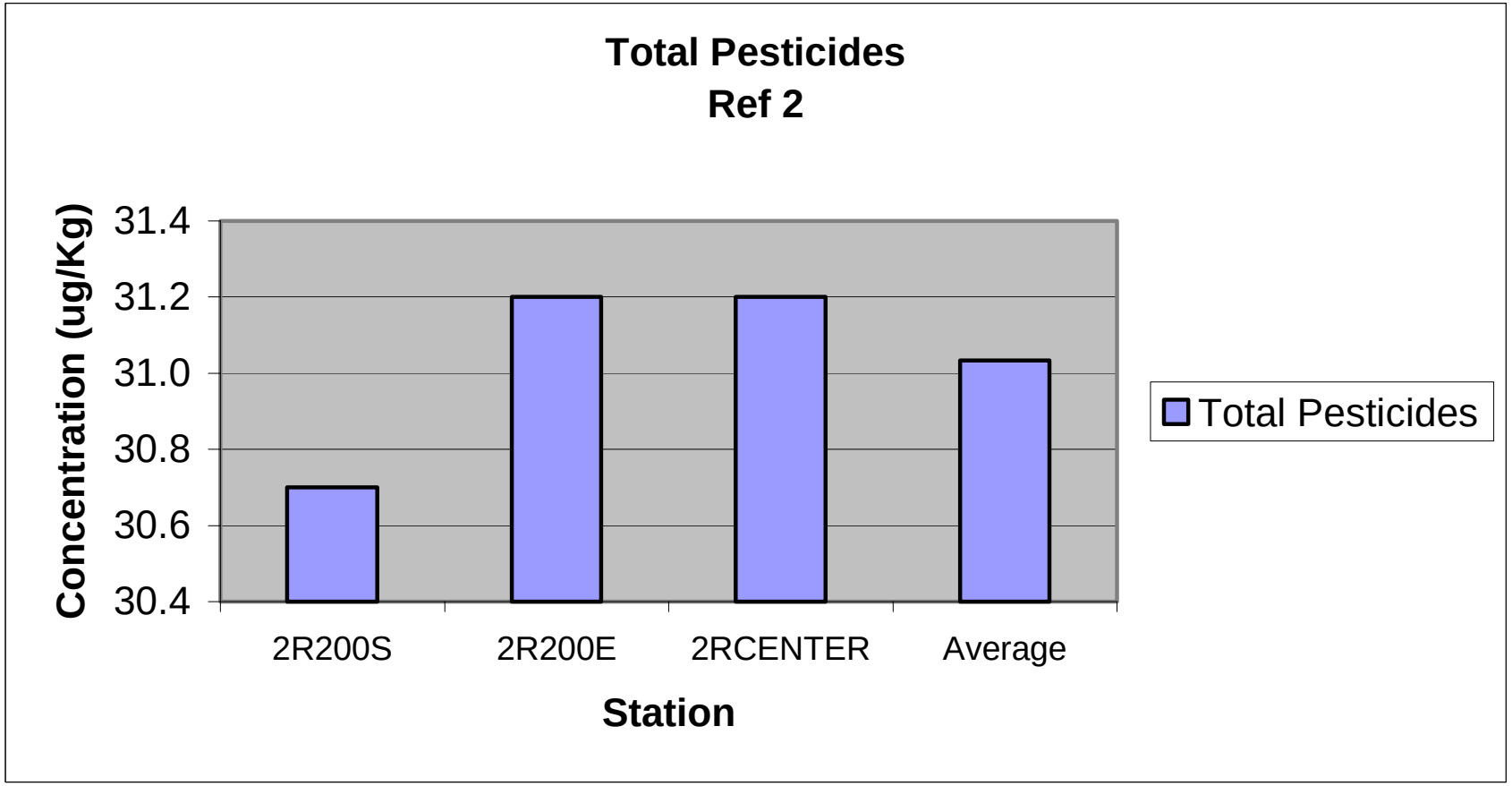

Figure 3-23. Concentrations of Total Pesticides in the three sediment samples collected at the Ref-2 reference area.

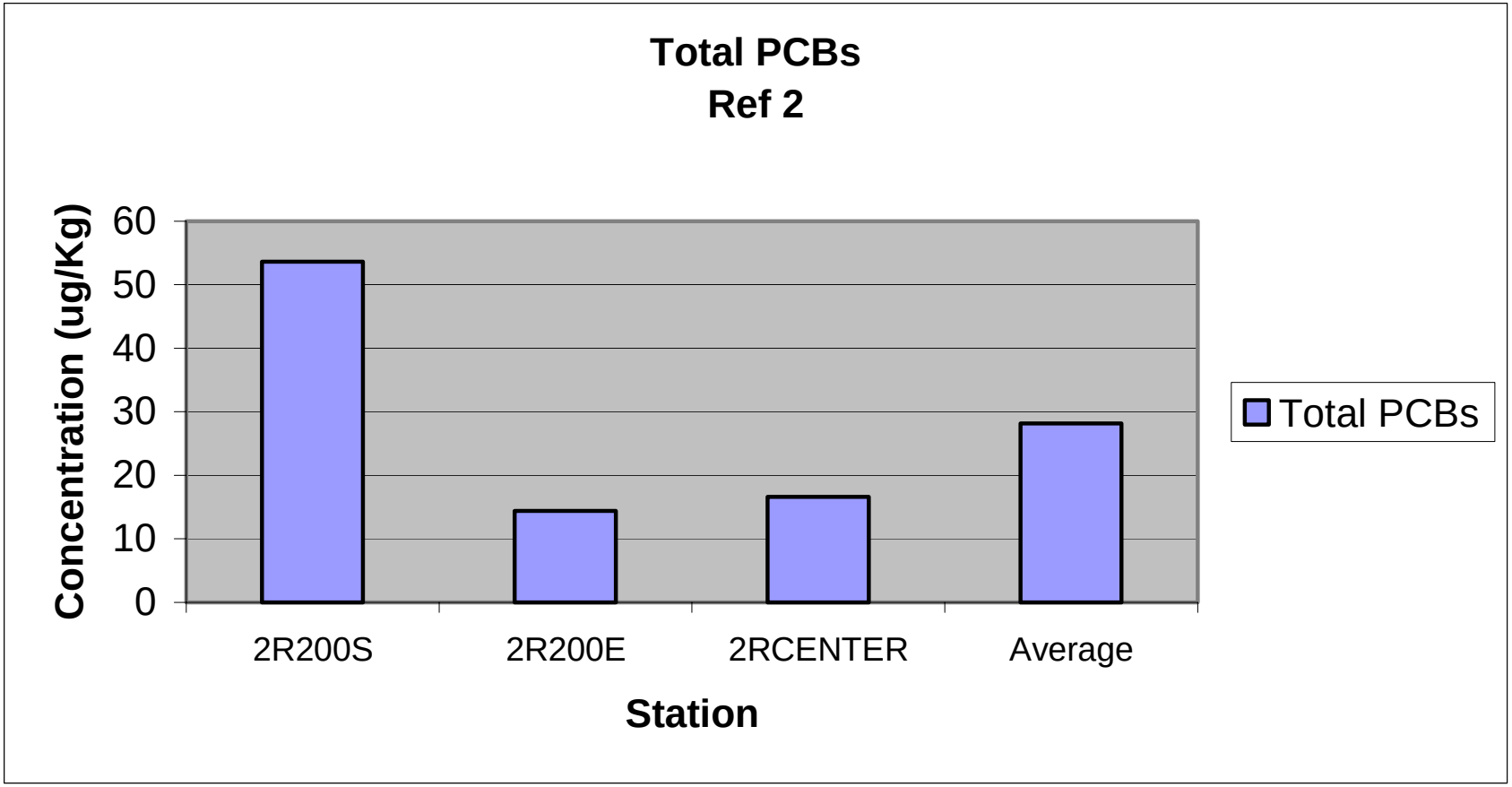

Figure 3-24. Concentrations of Total PCBs in the three sediment samples collected at the Ref-2 reference area.

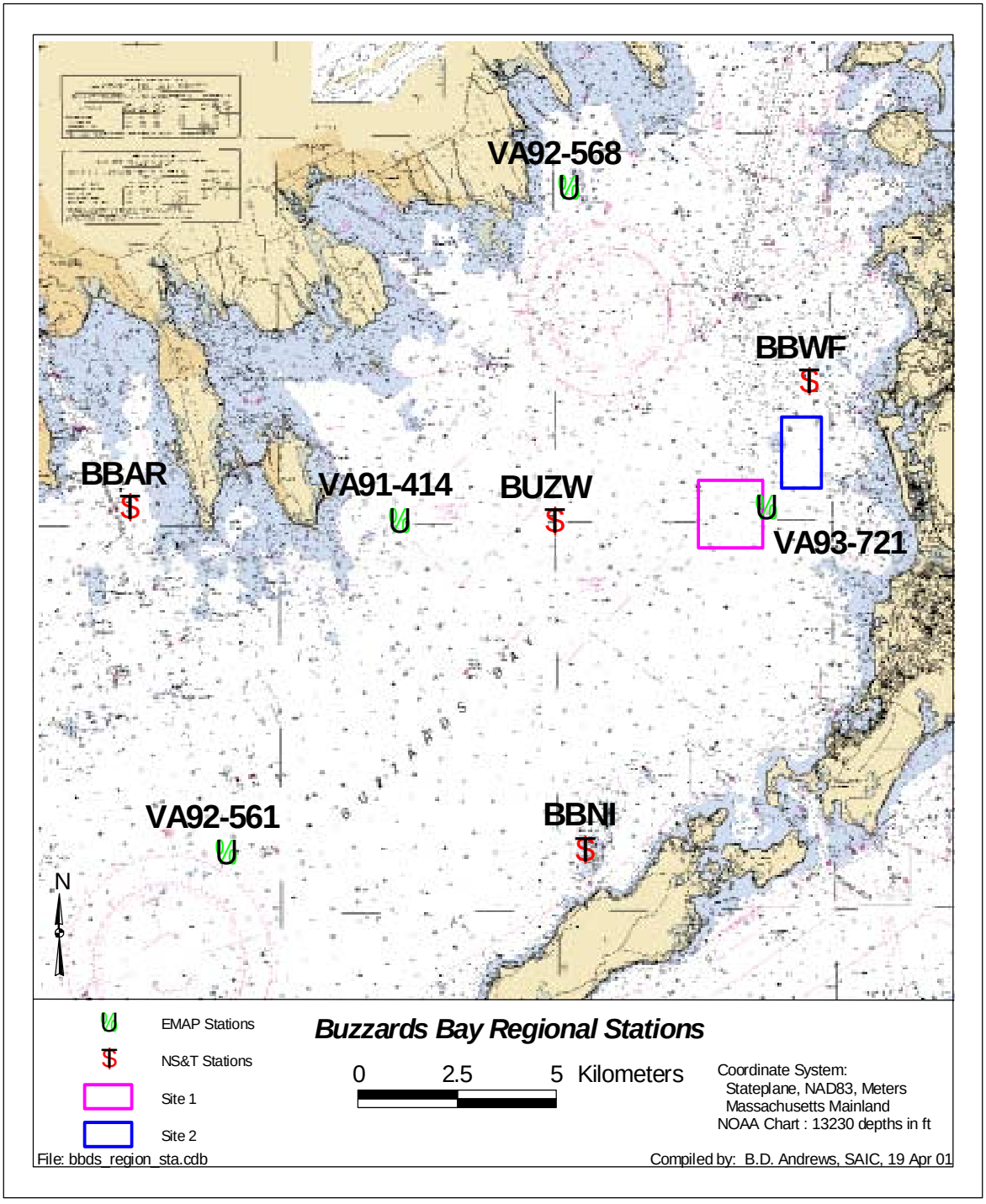

Figure 4-1. Map of stations in Buzzards Bay where sediment chemistry data have been collected under the NOAA NS&T and EPA EMAP monitoring programs.

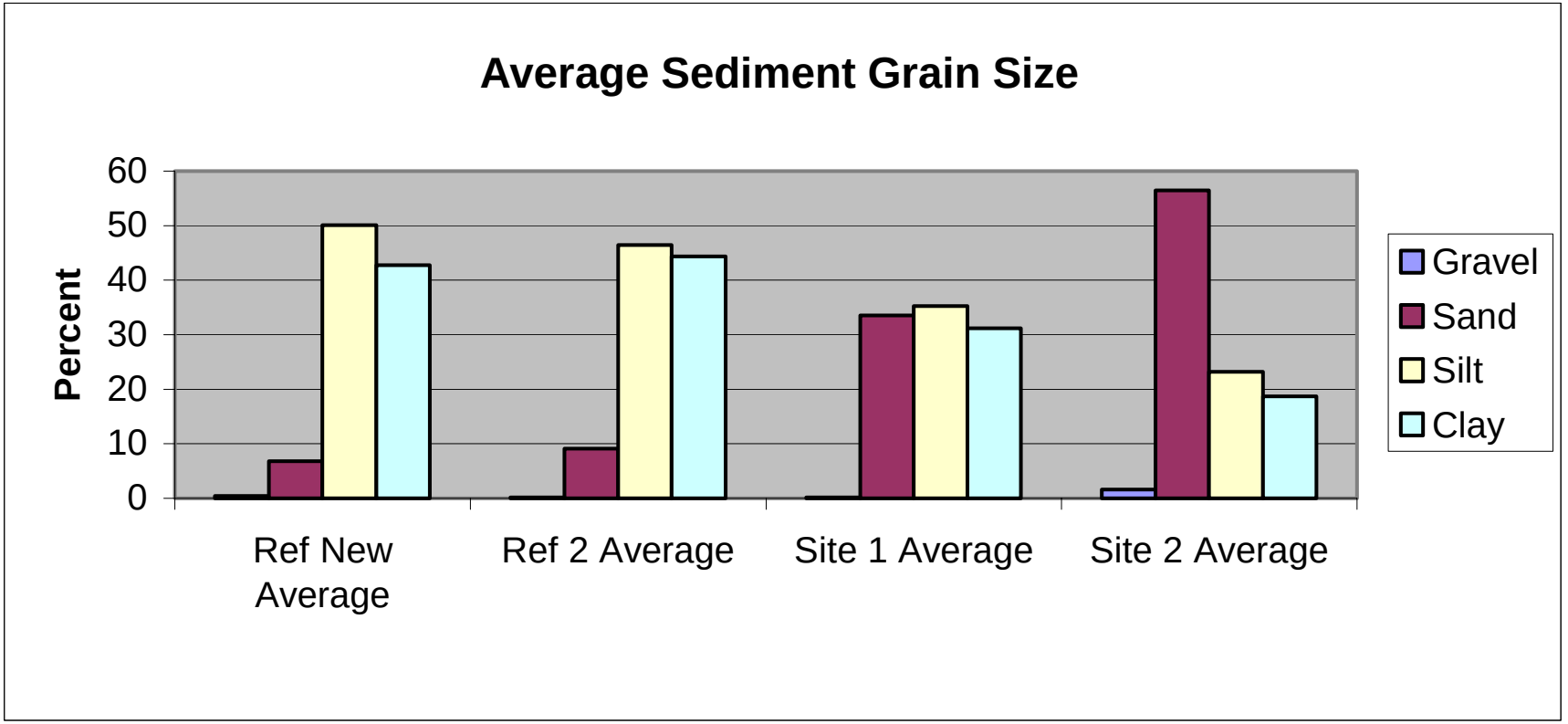

Figure 4-2. Average sediment grain size distributions at the two candidate disposal sites and two reference areas.

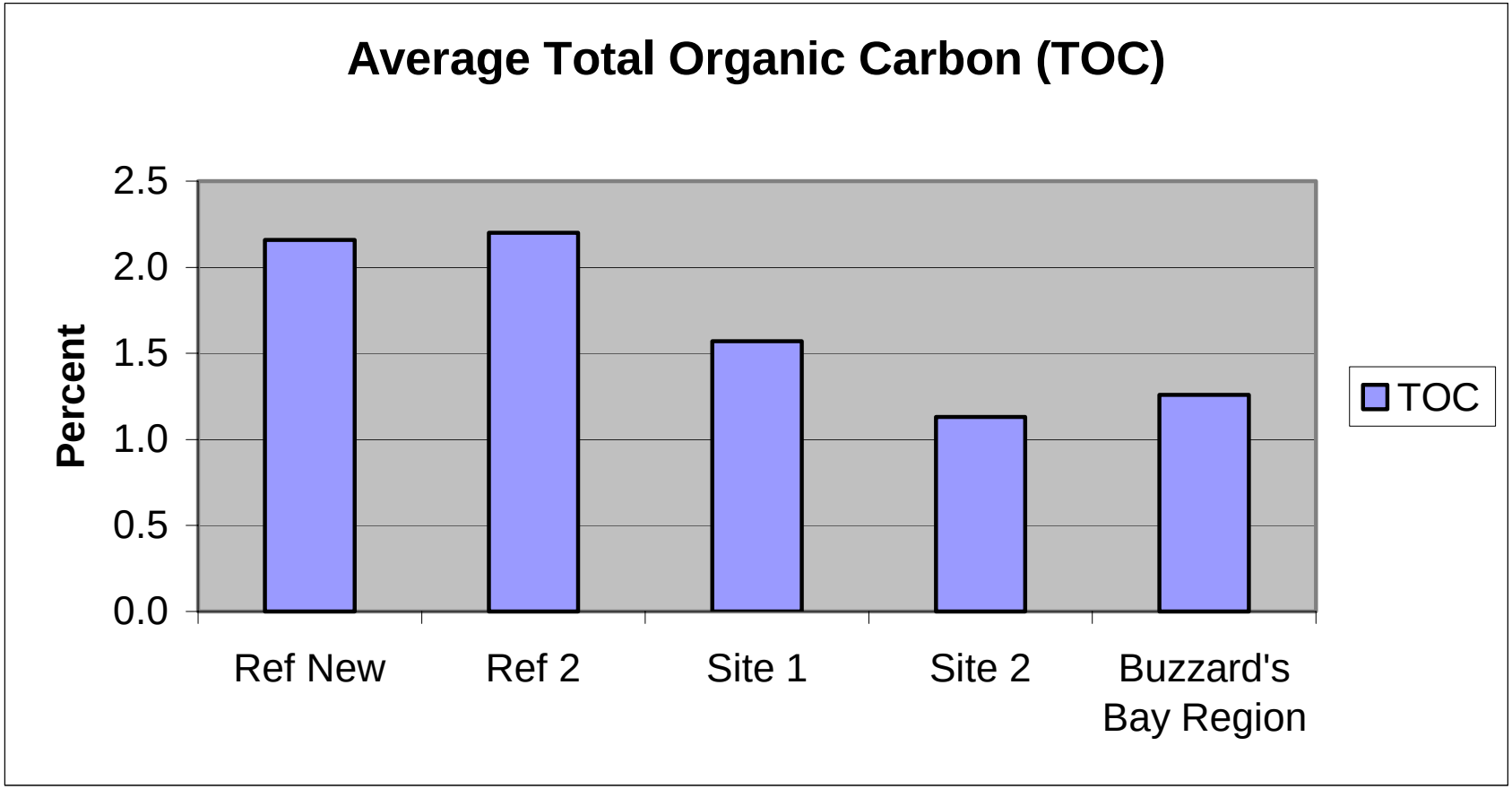

Figure 4-3. Average sediment total organic carbon (TOC) concentrations at the two candidate disposal sites, two reference areas, and Buzzards Bay regional stations.

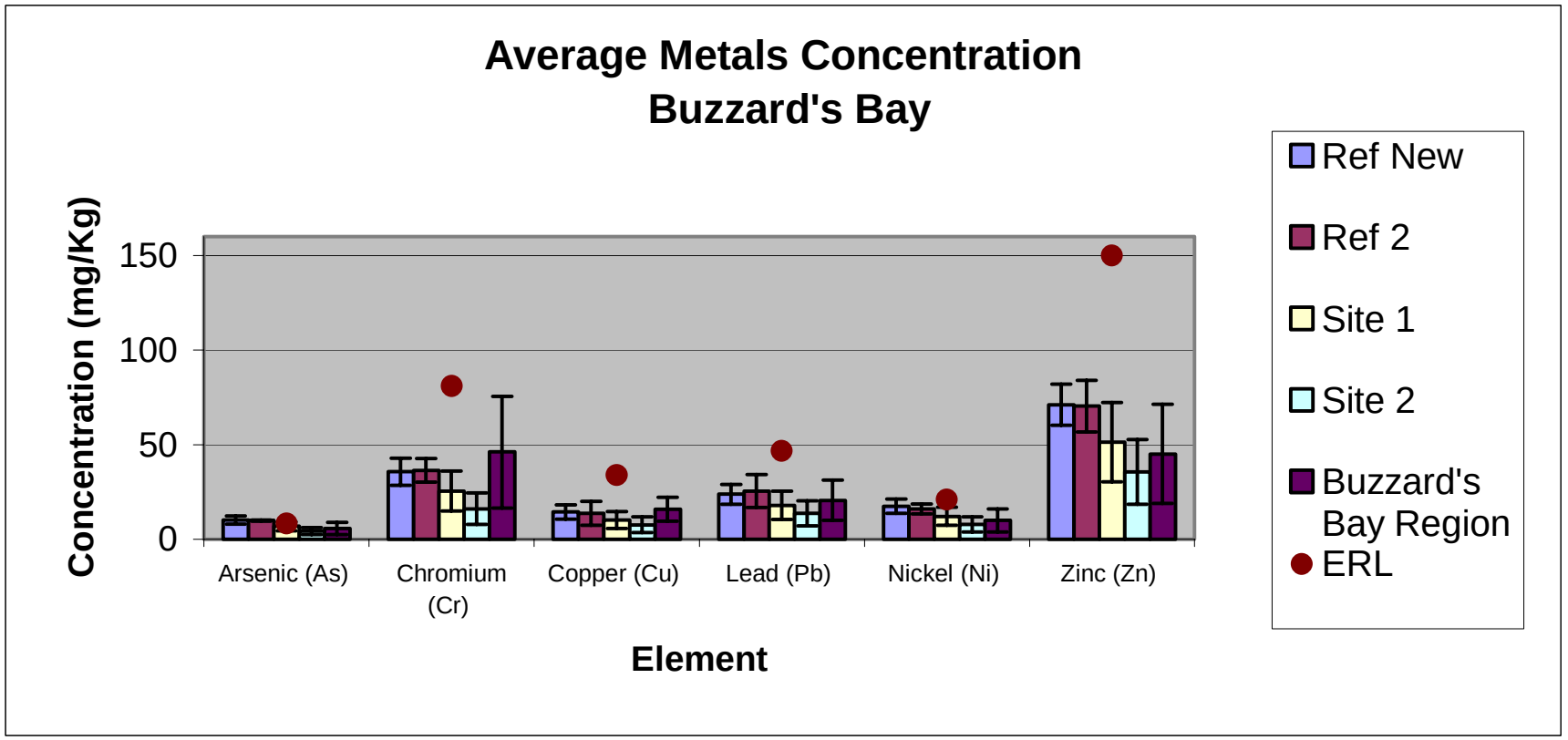

Figure 4-4. Average sediment concentrations of various metals at the two candidate disposal sites, two reference areas, and Buzzards Bay regional stations. Error bars represent 95% confidence intervals. Effects Range Low (ERL) screening values from Long et al. (1995) also are shown (cont. on next page).

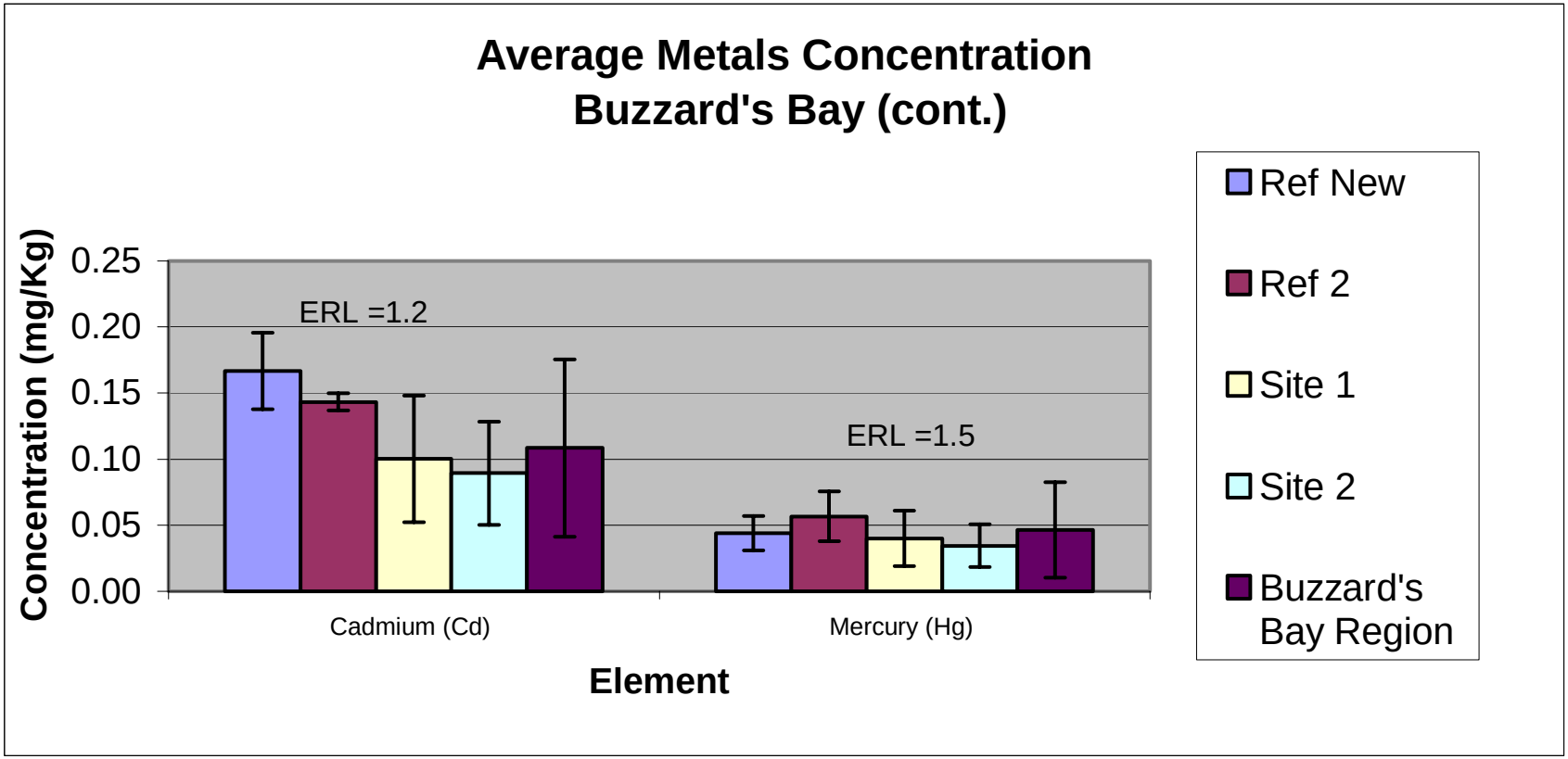

Figure 4-4 (cont). Average sediment concentrations of various metals at the two candidate disposal sites, two reference areas, and Buzzards Bay regional stations. Error bars represent 95% confidence intervals. Effects Range Low (ERL) screening values from Long et al. (1995) also are shown.

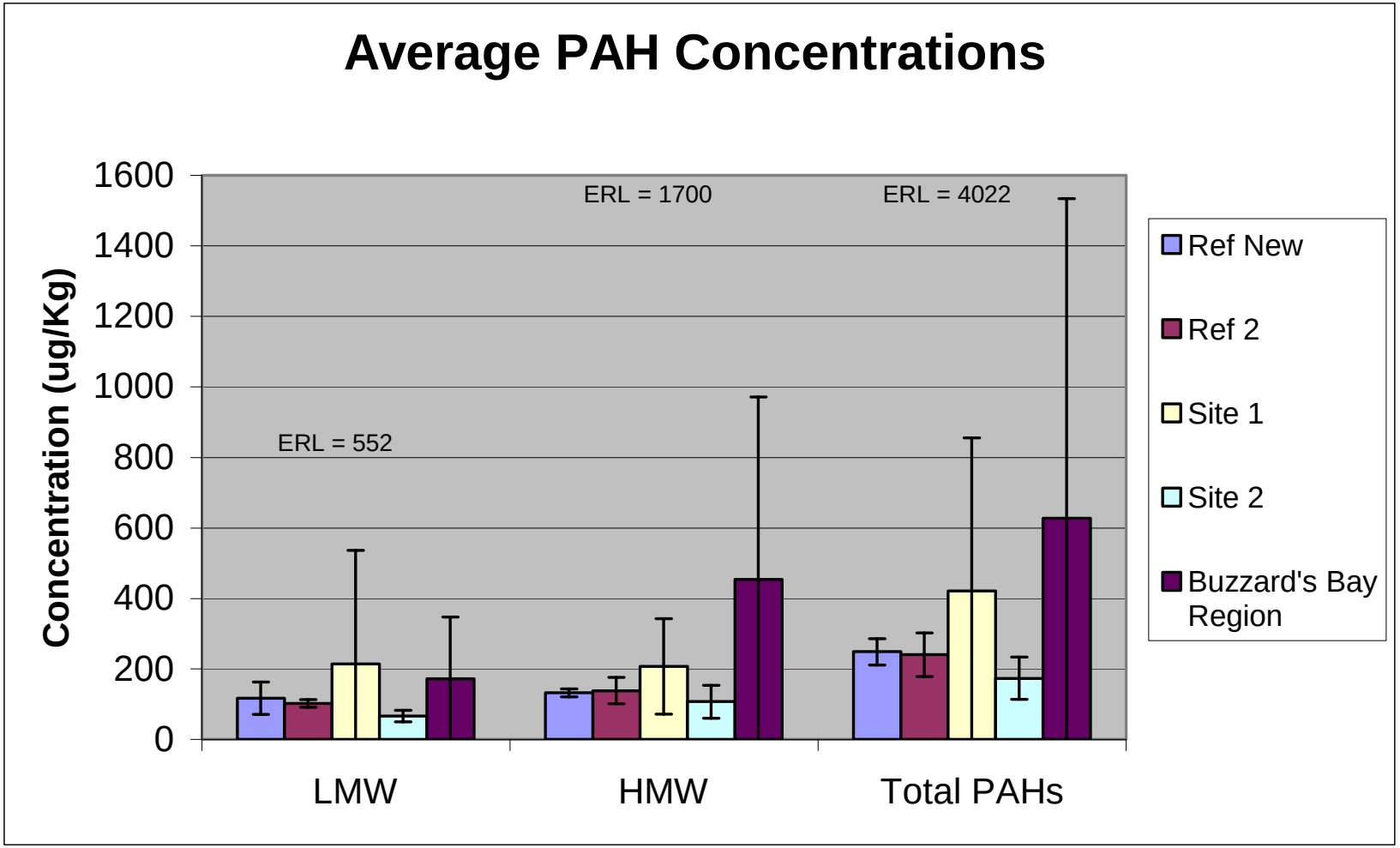

Figure 4-5. Average sediment concentrations of LMW PAHs, HMW PAHs, and Total PAHs at the two candidate disposal sites, two reference areas, and Buzzards Bay regional stations. Error bars represent 95% confidence intervals. Effects Range Low (ERL) screening values from Long et al. (1995) also are shown.

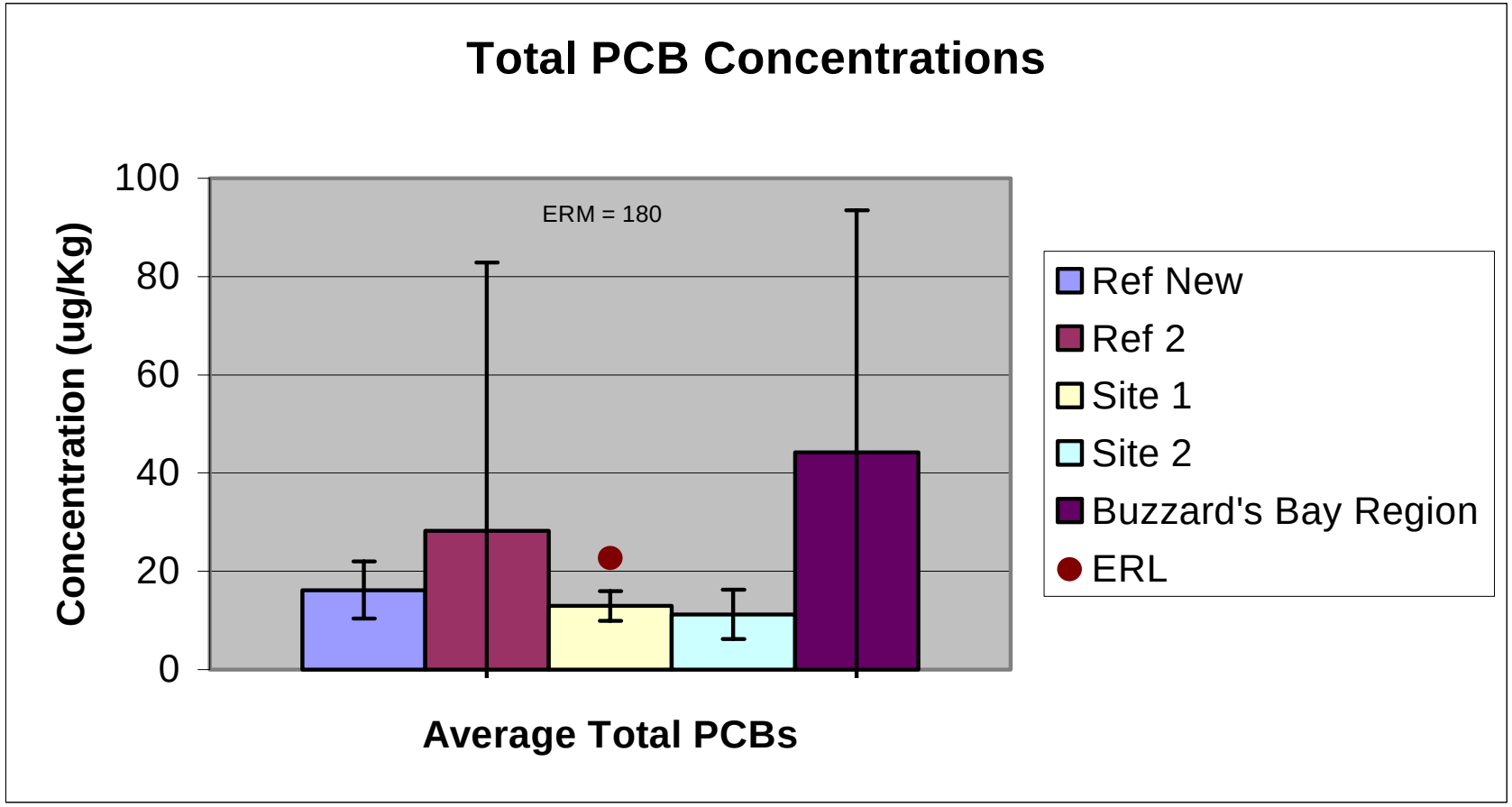

Figure 4-6. Average sediment concentrations of total PCBs at the two candidate disposal sites, two reference areas, and Buzzards Bay regional stations. Error bars represent 95% confidence intervals.

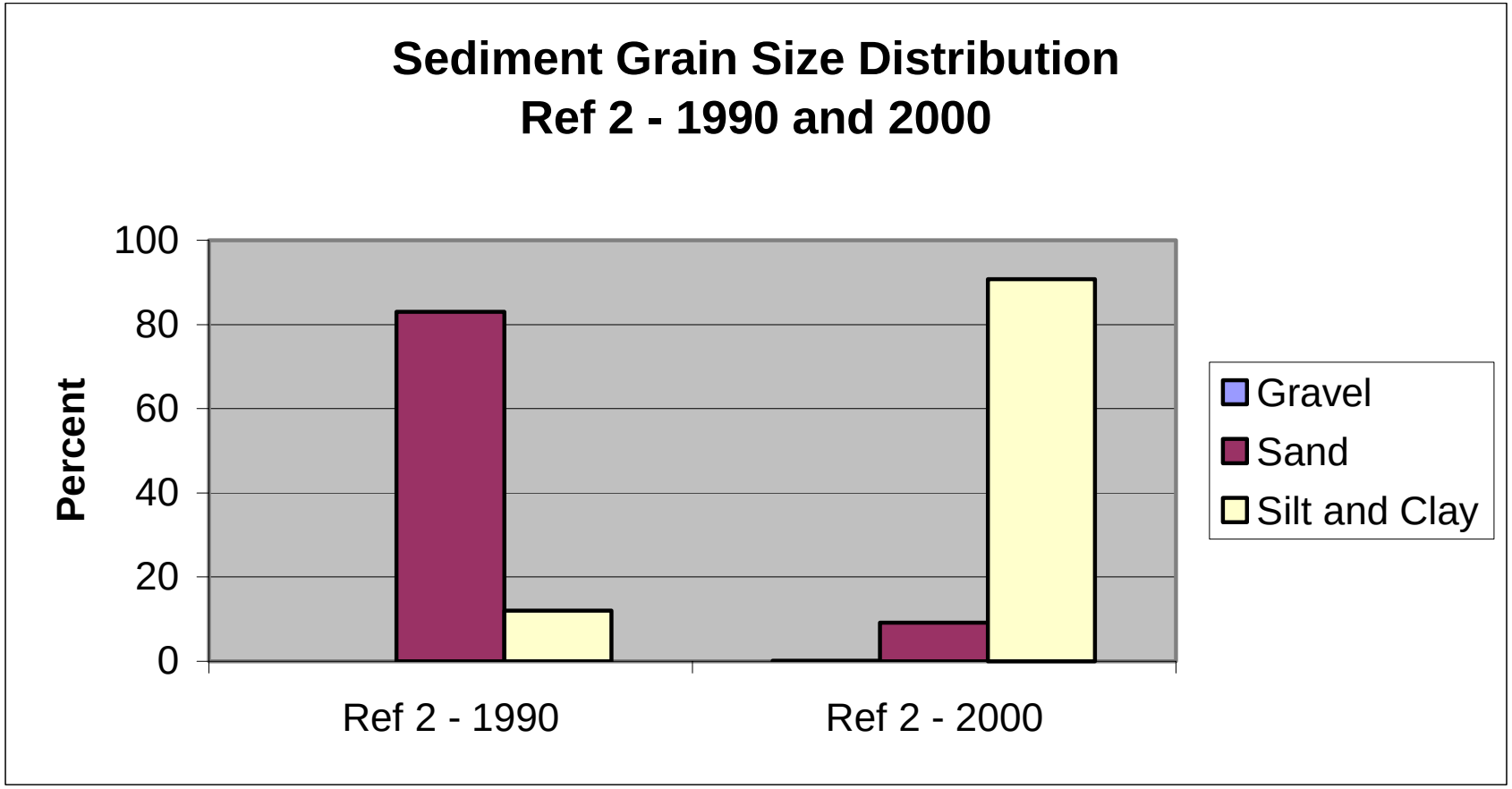

Figure 4-7. Comparison of sediment grain size distribution at Ref-2 in 1990 and 2000.

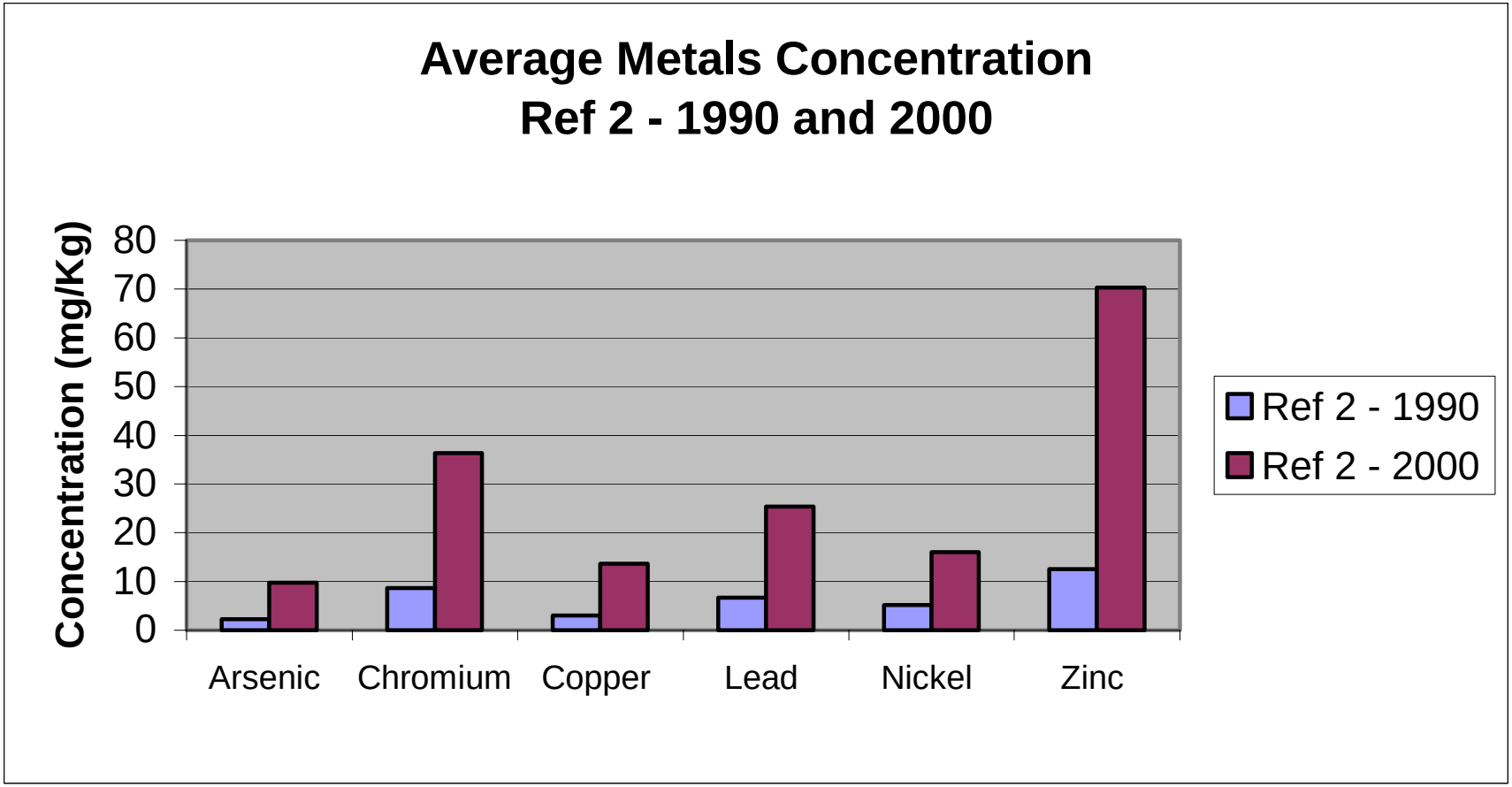

Figure 4-8. Comparison of average sediment metal concentrations at Ref-2 in 1990 and 2000 (cont. on next page).

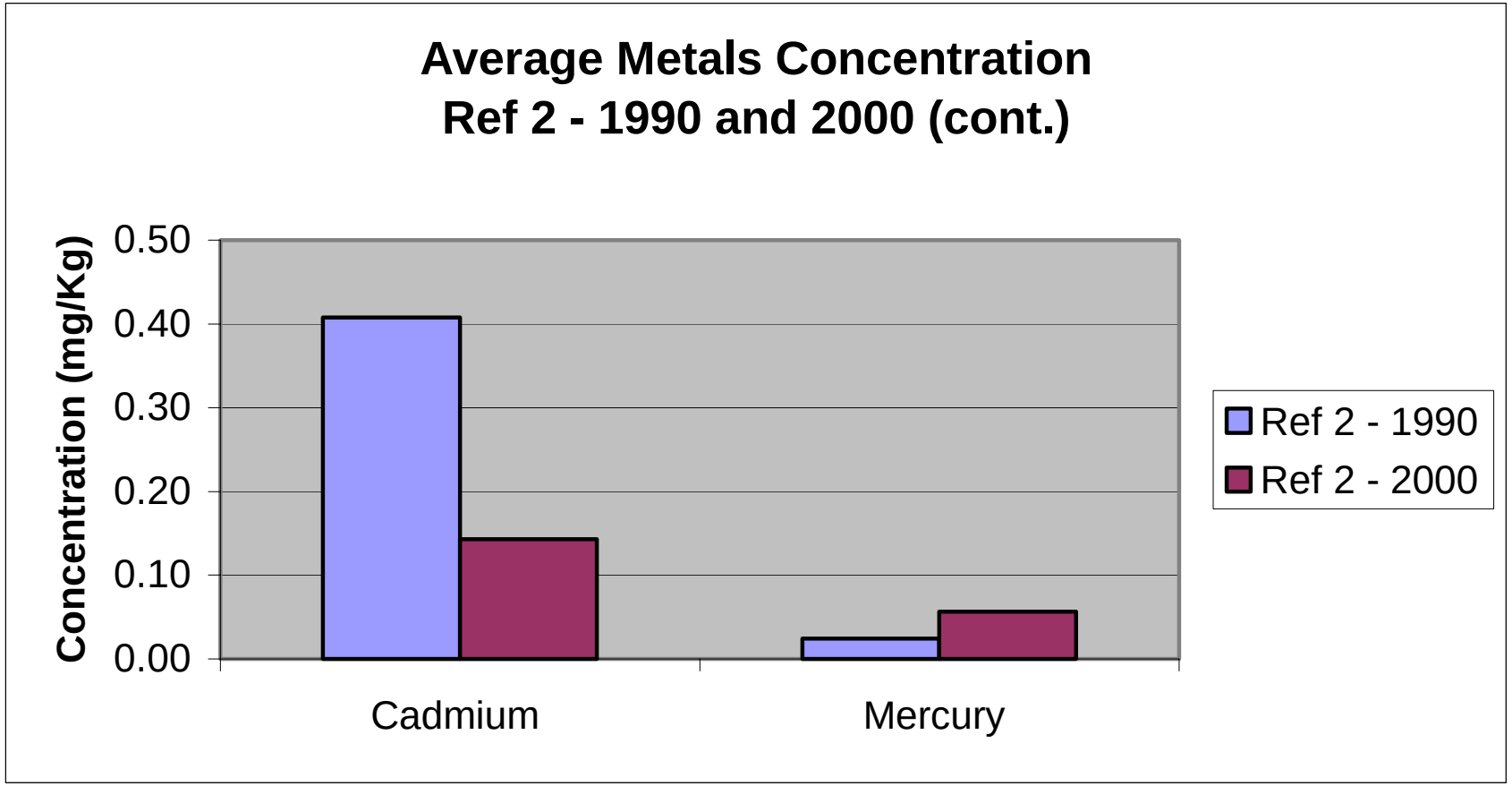

Figure 4-8 (cont.). Comparison of average sediment metal concentrations at Ref-2 in 1990 and 2000.