An evaluation of sediment quality conditions in Presque Isle Bay and tributaries of the Bay: assessing compliance with ecosystem health and delisting targets (2005 - 2009)

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1.0 Abstract

Presque Isle Bay is a 3,655-acre embayment located in northwestern Pennsylvania on the southern shore of Lake Erie. In 1991, due to a legacy of industrial and wastewater problems the bay was listed as an Area of Concern. In 1993, the first Remedial Action Plan for the AOC was published. The plan identifiedfish tumors or other deformities and restrictions on dredging activities beneficial-use impairments (BUI) as present in the bay. In 2005, in an effort to move towards delisting the restrictions on dredging impairment, a comprehensive sediment evaluation was implemented. Results of the study indicated that additional requirements did not need to be placed on dredging or disposal activities due to contaminants in the sediment, and the contaminants in the sediment did not appear to be toxic to benthic organisms or negatively impacting fish or aquatic-dependent wildlife. In July 2007, EPA approved the petition to delist the restrictions on dredging BUI in the bay. As a result of the delisting, a long-term sediment monitoring plan was developed to evaluate sediment quality as it relates to the delisting targets and ecosystem health of Presque Isle Bay. In 2009, surficial sediment samples were collected from nine sites in accordance with the long-term monitoring plan to determine if delisting and ecosystem health targets were being met in the bay. The delisting target is met if material from at least 90% of samples can be placed in the Confined Disposal Facility (CDF) without exceeding 15-minute acute or 12-hour chronic water quality criteria. Dredged materials from all the sites assessed in 2009 would meet water quality criteria in the discharge from the CDF. Therefore, the delisting target for the restrictions on dredging BUI is being met. The ecosystem health of Presque Isle Bay was measured by comparing contaminant concentrations to sediment quality guidelines (SQGs) and evaluating the potential impact of contaminant mixtures on benthic organisms and fish as well as the expected bioavailabilty of Contaminants of Potential Concern (COPCs). Samples from the majority of sites in the 2009 survey met ecosystem health targets. While concentrations of COPCs did exceed SQGs for four metals and nine PAHs, including total PAHs, at a limited number of locations measures of the availability of the compounds for uptake by benthic organisms indicated that these contaminants are not bioavailable. Metals would bind to organic carbon and PAHs partition into pore-water only at a limited number of sites. As a result, COPCs are not expected to adversely impact the benthic community. The ecosystem health target that evaluates whether COPCs could impact fish health, was met for eight of the nine long-term monitoring sites. Samples collected from the tributaries above the mixing zone with the bay had more exceedances of SQGs for PAHs than locations in the bay. However, measures of bioavailabilty were similar to that found at the long-term monitoring sites, indicating particle size and total organic carbon are limiting the availability of the contaminants to benthic organisms. Samples collected at locations where brown bullhead catfish are monitored did not exceed SQGs for any COPCs and met all ecosystem health targets. Although it is difficult to ascertain trends based on two sampling events, evaluation of the delisting target and ecosystem health measures, indicates sediment quality in Presque Isle Bay is improving. Continued monitoring is recommended with a focus on the sediment entering the bay from the tributaries.

2.0 Introduction

Presque Isle Bay is a 3,655-acre embayment located in northwestern Pennsylvania on the southern shore of Lake Erie (***Map 1***). The bay is 4.9 miles long, 1.8 miles wide, has an average depth of 13.1 feet, and connects to Lake Erie through a shipping channel maintained by the U.S. Army Corps of Engineers. Presque Isle Bay is formed to the north by Presque Isle State Park and to the south by the City of Erie and Millcreek Township. The Presque Isle Bay watershed drains a highly urbanized area of approximately 26.22 square miles, including portions of Millcreek Township, City of Erie, Harborcreek Township, Summit Township, and Greene Township in Erie County, Pennsylvania. Tributaries of the bay include, from west to east, Scott Run, Unnamed Tributary One, Unnamed Tributary Two, Cascade Creek, Mill Creek, and its tributary Garrison Run (***Map 2***).

The City of Erie, founded in 1792, grew around Presque Isle Bay. Like so many Great Lakes communities, Erie's history and bayfront are characterized by industrial and wastewater problems. Changes to the city's bayfront began in the 1980s, as it transitioned from an industrial-dominated zone to one of tourism and recreation. As industry began to fade from the Erie area in the early 1980s, environmentally minded citizens banded together with the common goal of restoring and protecting Presque Isle Bay. In 1991, their efforts ultimately lead to Presque Isle Bay being listed as the 43rd and final Area of Concern (AOC) under the Great Lakes Water Quality Agreement (GLWQA) (***Map 3***).

In 1993, the Pennsylvania Department of Environmental Protection (DEP) published the first Remedial Action Plan (RAP) for the AOC. Based on existing data, the document identified chemicals of potential concern including ten heavy metals, nutrients, and polycyclic aromatic hydrocarbons (PAHs). The RAP also identified two of the 14 beneficial-use impairments (BUIs) listed under the GLWQA as present: fish tumors or other deformities, and restrictions on dredging activities; both of which were considered to be a result of the legacy of pollution to Presque Isle Bay. IJC guidelines define the BUI for restrictions on dredging activities when contaminants in sediments exceed standards, criteria, or guidelines such that there are restrictions on dredging or disposal activities (IJC, 1991).

In 2002, due to a decreasing trend of tumors in brown bullhead and "natural capping" of contaminated sediment, Presque Isle Bay became the first U.S. AOC to be listed as an Area of Recovery, catalyzing a change in effort from remediation to monitoring (Boughton 2002). Research supported this decision by suggesting a shift in focus from evaluating historic contaminant levels in the bay toward an approach that stresses improving the quality of sediment transport and nonpoint loading from the watershed. In 2005, in an effort to move towards delisting, the restrictions on dredging BUI in Presque Isle Bay, a comprehensive United States Environmental Protection Agency (USEPA)-funded sediment evaluation was conducted to determine whether limitations or additional requirements should be placed on dredging or disposal activities due to contaminants in the sediment and whether the contaminants in the sediment were toxic to benthic organisms or negatively impacting fish or aquatic-dependent wildlife. Results of the sediment evaluation indicated that there were no "chemical hotspots" within the bay, sediment is not toxic to aquatic life, sediment being deposited from the watershed is less contaminated than existing sediment, ecosystem health targets were being met, and the restrictions on dredging were related to State Regulations and not to contaminated sediment (Boughton 2006).

To make decisions regarding disposal of material dredged from within the AOC boundary, DEP followed the procedures outlined in the United States Army Corps of Engineers (USACE) Great Lakes Testing and Evaluation Manual (USEPA and USACE 1998). To evaluate potential water column impacts from disposal of sediments, the manual recommends that a suspension of water and sediment known as an elutriate sample be prepared. The elutriate sample represents the expected release of contaminants during the dredging and disposal operations. The elutriate concentrations are adjusted to reflect the dilution from mixing and dispersion at the disposal site (USEPA and USACE, 1998). The adjusted chemical concentrations are then compared to Pennsylvania's Water Quality Standards (25 Pa. Code Chapters 16 and 93). The USACE CDFate model was used to estimate the amount of dilution and dispersion expected in the vicinity of the Combined Disposal Facility (CDF). The model uses elutriate data and CDF-related information to calculate the concentrations of COPCs in the adjacent receiving waters as a function of time (Boughton 2006). The delisting target for the restrictions on dredging activities BUI is met when the concentrations of COPCs at the edge of the mixing zone, as calculated by CDFate, are below acute criteria at 15 minutes and below chronic criteria at 12 hours. Using elutriate data collected between 1999 and 2005 from areas routinely dredged within the AOC, it was determined that the delisting target for the restrictions on dredging BUI was being met in Presque Isle Bay (Boughton 2006).

Even though dredging in areas other than those already permitted is not expected, it is important to evaluate the delisting target at sampling locations throughout the AOC. Because elutriate data was not available, DEP used the *Screening Evaluations for Upland Confined Disposal Facility Effluent Quality* methodology developed by Schroeder *et al.* (2006), to predict effluent quality at the edge of the mixing zone. The methodology uses whole sediment chemistry data to conduct an initial screening based on equilibrium partitioning and the bioavailability of the contaminants. It is a conservative approach to estimating the concentration of COPCs in the discharge from the CDF. The methodology calculates a ratio of the predicted concentration to the appropriate water quality standard. When the ratio is greater than 1.0, the concentration of the contaminant in the sediment is predicted to exceed water quality standards in the discharge from the CDF. In 2005, no exceedances of acute or chronic water quality criteria were predicted in the discharge from the CDF. In July 2007, EPA approved the petition to delist the restrictions on dredging BUI in Presque Isle Bay.

As a result of the delisting, a long-term sediment monitoring plan was developed to evaluate sediment quality as it relates to the delisting targets and ecosystem health of Presque Isle Bay. The delisting target is met if material from at least 90% of samples can be placed in the CDF (i.e. concentrations of COPCs are below acute criteria at 15 minutes and chronic criteria at 12 hours). Based on the long-term monitoring plan, the ecosystem health targets are met if at least 90% of the sediment samples from Presque Isle Bay have the conditions necessary to support healthy benthic invertebrate, fish, and aquatic-dependent wildlife, as indicated by:

- a mean probable effects concentration quotient (PEC-Q) less than 1.0;
- the molar concentration of simultaneously extracted metals (SEM) is less than the molar concentration of acid volatile sulfides (AVS);
- SEM-AVS/f_{oc} is less than 3,000 μmol g^{-1};
- Equilibrium partitioning sediment benchmarks toxic units (ESB-TU) less than 1.0;
- toxicity to the freshwater amphipod *Hyalella azteca* or the midge *Chironomus dilutus* for the survival or growth endpoints: and
- less than six effects range median (ERM) are exceeded in a sample.

Calculating the mean PEC-Q provides a measure for assessing whole-sediment chemistry that considers complex mixtures of contaminants. The mean PEC-Q for a chemical is a measure of the level of contamination in sediment relative to the sediment quality guideline for that substance. The mean PEC-quotient is well correlated with sediment toxicity, based on the information contained in the national database (USEPA 2000). For sediment with a mean PEC-Q greater than 1.0, the probability of observing significantly reduced survival or growth of the amphipod *Hyallela azteca* in 10- to 28-day toxicity tests is above 50% (USEPA 2000; Ingersoll *et al.* 2005; Long *et al.* 2006).

Although COPCs may be detected in sediments, adverse impacts on benthic organisms may not be observed depending on the bioavailability of the chemical. Bioavailability refers to the extent to which contaminants are available for uptake by benthic organisms. It depends on the presence of other substances in the sediment and the potential for a contaminant to partition into the water between sediment particles. Contaminants may be present in the sediment at concentrations exceeding toxicity thresholds but not be bioavailable to benthic organisms. In such cases, sediment samples predicted to be toxic based on whole-sediment chemistry may not be toxic when toxicity test are conducted. The presence of organic carbon and/or acid volatile sulfides in sediments can bind COPCs, making them less available to benthic organisms. To assess bioavailability, two measures were evaluated.

The first measure considers the dissolved metal concentration in the water between sediment particles or pore-water. Heavy metals can bind with sulfur to form sulfides that are not soluble in water. To measure this, SEM and AVS were quantified to determine if sediment pore-water concentrations for cadmium, copper, nickel, lead, and zinc were likely to contribute to sediment toxicity. When the amount of AVS exceeds the amount of SEM, the concentrations of metals in the sediment pore-water are likely to be low due to the limited solubility of the metal sulfides formed. As a result, the metals are predicted to be less available for uptake by organisms. In addition, metals can also be bound up by the organic carbon in the sediment, which results from the decomposition of leaf litter or other organic matter. For this reason, the SEM-AVS tool has been further modified to account for the amount of organic carbon (OC) in the sediment (i.e., fraction OC or f_{oc}). Metals are not expected to be toxic when the SEM-AVS/ f_{oc} is less than 3,000 umol g^{-1} OC (USEPA 2005).

The second measure of bioavailability considers the concentration of PAHs in the pore-water. ESB-TUs are used to predict the bioavailability of non-polar organic chemicals such as PAHs. ESB-TUs are based on the partitioning of organic chemicals between sediment and the pore-water. The concentrations of various semi-volatile organics (SVOCs) in the pore-water are predicted based on the concentrations of these substances in whole sediment, the physical-chemical properties of each substance, and the fraction of organic carbon in the sediment. The benchmark for ESB-TUs is based on 34 PAHs. Sediment with low total organic carbon concentrations generally does not bind the PAHs and results in higher ESB-TU values. Sensitive benthic organisms may be negatively affected by non-polar organic chemicals when ESB-TUs are greater than 1.0 (USEPA 2003).

ERM guidelines are used to assess the potential impacts of exposure to contaminated sediment on fish. Long *et al.* (1995) and Long and Morgan (1991) developed these guidelines primarily to evaluate the effects of sediment associated COPCs on benthic organisms; however, the underlying database that was used to derive the ERMs included matching data on sediment chemistry and adverse effects in fish. Results of toxicity tests conducted on invertebrates and fish indicate that fish may exhibit similar or lower levels of sensitivity to sediment-associated COPCs than do invertebrates.

The primary objective of this study was to assess compliance with the delisting target for the restrictions on dredging BUI in Presque Isle Bay. A secondary objective of the study was to evaluate changes in the health of the ecosystem. The ecosystem target for toxicity to amphipods and midges was not assessed due to resource constraints. In August and September 2009, surficial sediment samples were collected from seven historical sampling locations within Presque Isle Bay, two historical sampling sites outside of the bay, and three locations within the bay where brown bullhead are routinely collected for tumor analysis to assess both the delisting and ecosystem targets. In addition, benthic sediment samples were collected from the mouths of the four streams discharging into Presque Isle Bay in an effort to characterize the concentrations of COPCs being deposited in the streams following rain events. This report presents the results of the 2009 Presque Isle Bay sediment quality evaluation, compares the results to those observed in 2005, and assesses compliance with the ecosystem health and delisting targets for the bay.

3.0 Methods

3.1 Sampling Sites

In July 2009, surficial sediment samples were collected from seven sites within Presque Isle Bay and two sites outside of Presque Isle Bay in accordance with the long-term monitoring plan, and from three additional sites within Presque Isle Bay where brown bullhead are routinely collected for tumor analysis. In August and September 2009, benthic-sediment stream samples were collected near the mouths (outside the mixing-zone with Presque Isle Bay) of Scott Run, Cascade Creek, Mill Creek, and Garrison Run following a rain event. Between July and September 2009, a total of 20 sediment samples were collected from 16 sites (***Table 1***; ***Map 4***).

3.2 Sample Collection

Presque Isle Bay and Lake Erie sampling locations were confirmed using a nautical GPS unit aboard the sampling vessels, Gannon University's 50-foot steel hull research vessel the *Environnaut* or the Pennsylvania Department of Environmental Protection's 17.5-foot aluminum hull jon boat. The boat was anchored at each sampling site and the engine was turned off to avoid sample contamination from exhaust fumes. Sediment samples were collected by lowering either a Van Veen® Grab Sampler or Petite Ponar® to the benthos until the sampler was tripped. Once tripped, the sampler was gently retrieved and placed upright in a stainless steel pan (> 35 cm) onboard the *Environaut* or jon boat. Prior to deployment, the sampler was rinsed with site water, Acetone, and again with site water. The Petite Ponar® was only used due to temporary mechanical issues associated with the Van Veen® Grab sampler. When sampling with the Van Veen® sampler, the top 10.0 cm of the sediment sample was collected and transferred to a labeled (site location and date) 7-quart plastic container. The remainder of the sample was discarded back to the water. When using the Petite Ponar®, the entire sediment sample was collected and transferred to a labeled seven-quart plastic container. For each sampling location, two samples were collected and homogenized using a stainless steel spoon. Prior to sampling at the next location, all sampling equipment was decontaminated by removing any residual sediment; scrubbing with a long bristle brush and rinsing with site water; scrubbing the equipment with Alconox® and rinsing with site water; rinsing with Acetone; and rinsing with de-ionized water. All samples were stored in 48-L coolers with Blue Ice® and transferred to the Tom Ridge Environmental Center for processing.

Sediment samples from near the mouth of Mill Creek were collected by lowering a Petite Ponar® to the streambed until the sampler was tripped. Once tripped, the sampler was gently retrieved and placed upright in a stainless steel pan onshore. The entire sediment sample was transferred to a labeled (site location and date) 7-quart plastic container. Two samples were collected and homogenized using a stainless steel spoon. Sediment samples from near the mouth of Scott Run, Cascade Creek, and Garrison Run were collected by scooping the upper 1.0 cm of sediment from the streambed using a stainless steel spoon and transferred to a labeled 7-quart plastic container. Sediment was collected across the cross section of the stream. Prior to sampling at the next location, all sampling equipment was decontaminated by rinsing with site water; scrubbing the equipment with Alconox® and rinsing with site water; rinsing with Acetone; and rinsing with de-ionized water. All stream samples were stored in 48-L coolers with Blue Ice® and transferred to the Tom Ridge Environmental Center for processing.

3.3 Sample Processing

All samples were processed at the Tom Ridge Environmental Center. Prior to processing, each sample was logged in on a chain of custody form provided by Test America, Inc. Sediment samples were transferred from the 7-quart plastic container to the properly labeled (site, date, and analysis) glass amber container for analysis. Glass amber containers for each sample included: 1 - 4 oz (AVS/SEM); 1 - 4 oz (TKN/P); 1 - 8 oz (TOC, oil and grease, metals, nitrite, and nitrate); 1 - 8 oz (pesticides, PCBs, SVOCs, TS); and 1 - 32 oz (grain size and PAHs). The glass amber jars were filled with no headspace remaining and the lids were sealed with duct tape prior to shipping. The samples were wrapped in bubble wrap and packed in 48-L coolers with Blue Ice® and the chain of custody form. The coolers were sealed with duct tape and shipped overnight to Test America, Inc. in Pittsburgh, Pennsylvania. Prior to processing each sample, all sampling equipment was decontaminated by rinsing with water; scrubbing the equipment with Alconox® and rinsing with site water; rinsing with Acetone; and rinsing with de-ionized water. All remaining sample from the 7-quart plastic containers were archived at the Tom Ridge Environmental Center following processing.

3.4 *Sample Analysis*

All stream sediment samples were analyzed for acid volatile sulfides (AVS) and simultaneously extracted metals (SEM) ratio, total kjeldahl nitrogen, phosphorus, total organic carbon (TOC), oil and grease, metals, nitrite and nitrate, pesticides, polychlorinated biphenyls (PCBs), semi-volatile organic carbons (SVOCs – nitrosamines,; total solids (TS), grain size, and polycyclic aromatic hydrocarbons (PAHS) (***Table 2***). Presque Isle Bay and Lake Erie sediment samples were analyzed for the same COPCs as the stream samples except TKN and phosphorus. All sample analysis was performed by Test America, Inc. All data are presented in ***Appendix D***.

3.5 *Assessing Ecosystem Health Targets*

The mean PEC-Q for metals was calculated by dividing the concentration of a metal by its PEC, summing the PEC-Q for each metal, and dividing by the total number of metals assessed. The mean PEC-Q for PAHs was calculated by dividing the total PAH concentration by its PEC. The mean PEC-Q for PCBs was calculated by dividing the total PCB concentration by its PEC. The total mean PEC-Q for each site was calculated by adding the quotients for metals, PAHs, and PCBs and dividing by three.

The SEM-AVS ratio was calculated by subtracting the AVS value from the SEM value. The SEM-AVS ratio was adjusted for organic carbon by dividing the difference between the SEM and AVS values by the fraction of organic carbon of the sample (f_{oc}).

The ESB-TU for an individual PAH was calculated by dividing the PAH concentration by the fraction of organic carbon (f_{oc}),and dividing by 1,000 to account for differences in units, which results in the organic carbon normalized PAH concentration ($C_{oc,\ PAHi}$) (reviewed by Burgess 2009). The $C_{oc,\ PAHi}$ was then divided by an organic carbon normalized toxicity value ($C_{oc,\ PAHi,FCVi}$) (EPA 2003), resulting in an ESB-TU for the PAH. The individual ESB-TUs for the 34 PAHs (recommended by USEPA Environmental Monitoring and Assessment Program) were summed, resulting in a ∑ESB-TU for each site.

3.6 *Assessing Delisting Targets*

Because elutriate analysis was not included in the 2005 and 2009 surveys, a screening methodology developed by USACE was used to predict the concentration of COPCs in CDF effluent (Schroeder *et al.* 2006). The methodology uses whole sediment chemistry data to conduct an initial screening based on equilibrium partitioning and the bioavailability of the contaminants. It is a conservative approach to estimating the concentration of COPCs in the discharge from the CDF. Whole sediment chemistry and default values for other parameters were used to calculate predicted effluent quality at the edge of the mixing zone for a given COPC concentration. Only COPCs that exceeded sediment quality guidelines were assessed. The expected concentration of the COPC was calculated at the 15-minute acute and 12-hour chronic mixing zones, and compared to Pennsylvania water quality standards (***Table 3***). The resulting ratio was used to assess compliance with the standards. When the ratio exceeds 1.0, the concentration of the COPC is predicted to exceed water quality standards in the discharge from the CDF.

In 2005, the methodology was applied to data from eighteen sampling locations. These locations were chosen because the concentrations of one or more COPCs exceeded the consensus based probable effects concentrations used to evaluate ecosystem health. Additionally, because contaminant concentrations across the AOC are relatively homogeneous, the methodology was also applied to a hypothetical sample containing the mean concentration for each of the COPCs from sampling locations in Presque Isle Bay. In 2009, the methodology was applied to the seven Presque Isle Bay long-term monitoring sites and a hypothetical sample containing the mean concentrations of COPCs from the seven sites. For comparison, the methodology was also applied to the seven long-term monitoring sites from the 2005 survey.

4.0 Results

4.1 Sediment Quality Guidelines

COPC concentrations were evaluated against sediment quality guidelines (SQGs) published by MacDonald *et al.* (2000) (***Table 4***). Non-detect (ND) concentrations of COPCs were substituted with the method detection limit (MDL) to reflect the highest possible concentration. The number of sites that had COPCs at concentrations greater than the selected SQGs varied among the sites assessed in 2009 and 2005 (***Table 5***).

In 2009, five metals exceeded SQGs. Barium concentrations exceeded the heavily polluted threshold (HPT) at sites PIB-07, PIB-19, PIB-35, MB-46, SR-BH, MB-BH, and GR-01 (***Figure 1***). Cadmium concentrations exceeded the probable effects concentration (PEC) at sites PIB-07, PIB-19, and PIB-35 (***Figure 2***). Nickel concentrations exceeded the PEC at sites PIB-07 and PIB-35 (***Figure 3***). Lead concentrations exceeded the PEC at site PIB-07 (***Figure 4***). Mercury concentrations exceeded the PEC at site MB-BH (***Figure 5***). In 2005, two metals exceeded SQGs. The sites were not assessed for Barium in 2005. Cadmium concentrations exceeded the PEC at sites PIB-07, PIB-19, and PIB-35. Nickel concentrations exceeded the PEC at sites PIB-19 and PIB-35.

In 2009, eight PAHs exceeded SQGs. PAH concentrations did not exceed SQGs at the bullhead sampling sites. The eight PAHs include acenaphthene, phenanthrene, fluoranthene, pyrene, benz(a) anthracene, chrysene, benz(a)pyrene, and dibenz(a,h)anthracene. ***Figures 6-13*** show the sampling locations where SQGs were exceeded. Additionally, total PAH concentrations exceeded the PEC at sites CC-26 and MC-02 (***Figure 14***). In 2005, the same eight PAHs exceeded SQGs but not always at the same locations as the 2009 sampling. In both events samples collected at the mouths of Mill Creek and Cascade Creek consistently exceeded SQGs for these eight PAHs. Benthic sediment stream samples also had exceedences for these eight PAHs. Sampling locations in the center of the bay in proximity to Dobbins Landing (PIB-07, PIB-19, and PIB-35) also had more exceedences for these PAH compounds than other locations in the bay. None of the samples taken where brown bullhead are collected had concentrations of PAHs higher than SQGs.

In 2009, oil and grease concentrations exceeded the severe effect level (SEL) at sites PIB-25, MB-26, CC-26, MB-BH, GR-01, and GR-02 (***Figure 15***). Oil and grease was not assessed in 2005. Concentrations of total PCBs, and the pesticides chlordane, sum DDD, sum DDE, sum DDT, total DDT, deildrin, and endrin did not exceed PECs at the long-term monitoring, bullhead, or stream sampling sites. In 2005, chlordane concentrations exceeded the PEC at sites MB-26, CC-26, and MC-27 (***Figure 16***).

4.2 Mean Probable Effects Concentration Quotient

Consistent with the ecosystem health targets, individual sediment samples were designated as having COPC concentrations sufficient to result in significantly reduced survival or growth of freshwater amphipods if the mean PEC-Q was greater than 1.0 (***Table 6; Figure 17***). In 2009 and 2005, the mean PEC-Q did not exceed 1.0 at any site.

4.3 Simultaneously Extracted Metals-Acid Volatile Sulfides

The bioavailability of metals was assessed using SEM-AVS and SEM-AVS/f_{oc} measurements (***Table 7***).

Metals present in the sediment are considered to be potentially bioavailable when SEM-AVS is greater than zero and/or when SEM-AVS/f_{oc} is greater than 3,000 µmol g^{-1} OC. In 2009, SEM-AVS values exceeded zero at two long-term monitoring sites and seven stream sites (***Figure 18***). None of the bullhead sites had SEM-AVS values exceed zero. In 2005, SEM-AVS values exceed zero at two sites. In 2009 and 2005, SEM-AVS/f_{oc} values did not exceed 3,000 µmol g^{-1} OC at any site (***Figure 19***).

4.4 Equilibrium Sediment Benchmark Toxicity Unit

Bioavailability of PAHs was assessed by calculating ESB-TUs (***Table 8; Figure 20***). PAHs present in the sediment are considered to be potentially bioavailable when the ESB-TU value exceeds 1.0. In 2009, ESB-TUs exceeded 1.0 at three long-term monitoring sites and seven stream sites. None of the bullhead sites had ESB-TU values exceed 1.0. In 2005, ESB-TUs values exceeded 1.0 at five sites.

4.5 Effects Range Median Guidelines

To assess potential impacts of exposure to contaminated sediment on fish, concentrations of COPCs were compared to ERMs (***Table 9***). In evaluating Presque Isle Bay whole-sediment, samples with concentrations of six or more COPCs exceeding the selected toxicity thresholds were designated as having conditions sufficient to injure fish. Non-detect concentrations of COPCs were substituted with the MDL to reflect the highest possible concentration. The number of sites that had six or more COPCs at concentrations greater than the ERMs varied among the sites assessed in 2009 and 2005 (***Table 10***). In 2005, site MC27 had nine COPCs exceed ERM guidelines. In 2009, concentrations of nine COPCs exceeded ERM guidelines at site CC26 and eight COPC concentrations exceeded ERM guidelines at site MC02. None of the bullhead sampling sites had COPC concentrations exceed ERM guidelines.

4.6 Delisting Target

In 2005 and 2009, the delisting target for the restriction on dredging BUI was assessed using USACE screening methods (Schroeder *et al.* 2006). In 2009, results of the screening methods revealed no exceedance of 15-minute acute (***Table 11***) or 12-hour chronic (***Table 12***) water quality criteria in the discharge from the CDF. In 2005, results of the screening methods revealed cadmium concentrations from site MC27 and the 18-site mean sample exceeded 15-minute acute water quality criteria in the discharge from the CDF (***Table 13***). Cadmium concentrations at site MC27 also exceeded the 12-hour chronic water quality criteria in the discharge from the CDF (***Table 14***).

5.0 Discussion

SQGs were used as a screening tool to indicate whether individual COPCs in Presque Isle Bay were present at concentrations that could be toxic to benthic organisms. In 2009, barium, cadmium, nickel, lead were detected at the long-term monitoring sites at concentrations greater than SQGs; whereas, in 2005, only cadmium and nickel were detected at concentrations greater than SQGs. However, barium was not assessed in 2005 and lead only exceeded SQGs at one site in 2009. Overall, the concentrations detected for cadmium, lead, and nickel were only slightly higher than the SQG values. None of the samples from the bullhead monitoring sites contained metals in concentrations above the SQGs. It's important to note that arsenic concentrations did not exceed the PEC for any samples at any locations in either sampling event.

Acenaphthene, phenanthrene, benzo(a)anthracene, benzo(a)pyrene, and crysene concentrations exceeded SQGs at fewer sites in 2009 compared to 2005; however, fluoranthene, pyrene, and dibenz(a,h) anthracene exceeded SQGs at fewer sites in 2005. In 2005, anthracene, fluorine, and chlordane concentrations exceeded SQGs; however, no sites assessed in 2009 had these COPCs exceed SQGs. The results indicate that eight PAHs, total PAHs, and four metals continue to be detected at concentrations that could potentially be toxic to benthic organisms in Presque Isle Bay. Samples containing contaminant concentrations exceeding SQGs were predominantly from near the mouths of the tributaries and upstream of the mixing zone within the tributaries. Generally, there was little variability between the two sampling events in terms of the specific contaminants and concentrations detected. However, in 2009, two fewer PAHs exceeded SQGs, five PAHs exceeding SQGs were detected at fewer sites, and chlordane concentrations greater than SQGs were not detected at any of the sites. Additionally, total PCBs and pesticide compounds were not detected in any samples in the 2009 investigation at levels above SQGs.

While the evaluation of SQGs is useful for identifying areas needing further investigation, it does not take into account the mixture of contaminants actually present in the sediment or the bioavailability of COPCs. To investigate the potential impact of mixtures of contaminants on benthic organisms and fish and the bioavailability of COPCs, a series of ecosystem health indicators were evaluated, including the mean PEC-Q, SEM-AVS, SEM-AVS/f_{oc}, ESB-TUs, and ERM.

Mean PEC-Qs were calculated to determine if mixtures of contaminants (i.e. metals, PAHs, and PCBs) in Presque Isle Bay would contribute to sediment toxicity. The ecosystem health target for the mean PEC-Q is met when 90% of sites have a mean PEC-Q less than 1.0. In both 2009 and 2005, none of the long-term monitoring sites had a mean PEC-Q exceed 1.0; therefore, the ecosystem health target is being met. Based upon this measure, the concentrations of contaminants in the sediment are below levels that would be expected to have an adverse impact on benthic organisms.

SEM-AVS and SEM-AVS/f_{oc} values were calculated to determine if sediment pore-water concentrations of metals are likely to contribute to sediment toxicity in Presque Isle Bay. The ecosystem health target for SEM-AVS is met when 90% of sites have a SEM-AVS less than zero. In 2009, seven of nine (77.8%) long-term monitoring sites had a SEM-AVS less than zero. In 2005, eight of the nine (88.9%) long-term monitoring sites had a SEM-AVS value less than zero. The ecosystem health target for SEM-AVS is not being met. While the SEM-AVS ecosystem health target is not being met, the results suggest that the concentrations of metals in the sediment pore-water at the majority of sites are likely to be low due to the limited solubility of the metal sulfides formed. As a result, the metals are predicted to be less available for uptake by organisms. Metals can also be bound up by organic carbon present in the sediment. The ecosystem health target for SEM-AVS/f_{oc} is met when 90% of the sites have a SEM-AVS/f_{oc} value less than 3,000 µmol g^{-1} OC. In both 2009 and 2005, none of the long-term monitoring sites had a SEM-AVS/f_{oc} value exceed 3,000 µmol g^{-1} OC; therefore, the ecosystem health target is being met. These results indicate that metals present in the sediment are likely binding with organic carbon and are not available to benthic organisms.

ESB-TUs were calculated to determine if sediment pore-water concentrations of PAHs are likely to contribute to sediment toxicity in Presque Isle Bay. The ecosystem health target for ESB-TUs is met when 90% of sites have an ESB-TU less than 1.0. In 2009, six of the nine (66.7%) long-term monitoring sites had an ESB-TU less than 1.0. In 2005, four of the nine (44.4%) long-term monitoring sites had an ESB-TU less than 1.0. The ecosystem health target for ESB-TUs is not being met. These results suggest that PAHs partition into the pore-water and could result in toxicity to benthic organisms at one-third of the long-term monitoring sites. However, the ecosystem appears to be improving as two fewer sites had ESB-TUs exceed 1.0 when assessed in 2009.

ERM guidelines were used to assess the potential impacts of exposure to contaminated sediment on fish. The ecosystem health target for ERM guidelines is met when 90% of sites have less than six COPCs exceed the selected toxicity threshold. In both 2009 and 2005, eight of the nine (88.9%) long-term monitoring sites had less than six COPCs exceed ERM guidelines. The ecosystem health target for ERM is not being met. These results indicate that COPCs continue to be detected at concentrations that could be toxic to fish in Presque Isle Bay.

Delisting targets for Presque Isle Bay were established to ensure that dredged materials could be safely deposited in the Erie Harbor CDF without exceeding 15-minute acute or 12-hour chronic water quality criteria. The *Screening Evaluations for Upland Confined Disposal Facility Effluent Quality* methodology was used to predict effluent quality at the edge of the mixing zone. When the calculated ratio of the predicted concentration to the appropriate water quality standard is greater than 1.0, the concentration of the COPC in the sediment is predicted to exceed water quality standards in the discharge from the CDF. The delisting target is met if material from at least 90% of samples can be placed in the CDF (i.e. predicted concentration to water quality standard is less than 1.0). In 2005, exceedances of 15-minute acute water quality criteria in the discharge from the CDF were observed in two samples and exceedances of 12-hour chronic water quality criteria were observed in one sample. In 2009, there were no calculated exceedances of 15-minute acute or 12-hour chronic water quality criteria in the discharge from the CDF. While this methodology is used to conservatively predict the concentration of the COPCs in the CDF discharge, it shows that sediment from Presque Isle Bay would not be expected to exceed water quality standards should dredging and disposal in the CDF be required. Therefore, the delisting target for the restrictions on dredging BUI in Presque Isle Bay is being met.

6.0 Conclusions

The long-term sediment monitoring plan for Presque Isle Bay called for sampling every three years following the delisting of the restrictions on dredging activities in 2007. Sediment quality was used to answer two questions: (1) is the primary delisting target for the restrictions on dredging BUI being met and (2) is the ecosystem health showing any change. In addition to answering these questions, the 2009 data were compared to data collected in the comprehensive sediment survey conducted in 2005. Additionally, samples were collected at brown bullhead monitoring locations to evaluate sediment conditions and upstream from the bay's mixing zone within the tributaries to the bay to determine the quality of sediment coming from the watershed.

Conclusions include:

- The delisting target for the restrictions on dredging BUI continues to be met. There were no exceedances calculated for the discharge from the CDF using the 2009 data.
- The sedimentation rate in the bay averages one centimeter per year, suggesting that approximately four centimeters of new sediment accumulated in the four years between sampling events. As a result, a significant change in sediment quality was not expected or observed. Concentrations of COPCs varied between sampling events and the same PAH compounds were found to exceed SQGs in both events. Overall, sediment quality was seen to improve as evidenced by the fewer number of samples with contaminants exceeding SQGs in 2009.
- PCBs, pesticides, and arsenic were not detected in concentrations exceeding SQGs in any of the 2009 samples indicating these compounds are not present at levels that would impact ecosystem health.
- The contaminant mixtures present do not contain COPCs in concentrations that would cause adverse impacts on benthic organisms. Metals present are binding to organic carbon and not bioavailable.
- There is a potential for PAHs to be bioavailable to benthic organisms. However, this measure has improved since 2005 where a higher number of sites exceeded the ecosystem health target.
- The ecosystem health target evaluating the potential of COPCs to be present at levels toxic to fish remains unchanged between the two sampling events.

- Samples collected from the tributaries above the mixing zone with the bay had more exceedances of SQGs for PAHs than locations in the bay. However, measures of bioavailability were similar to that found at the long-term monitoring sites, indicating particle size and total organic carbon are limiting the availability of the contaminants to benthic organisms.

Although it is difficult to evaluate trends based on two sampling events, evaluation of the delisting target and ecosystem health measures, indicates sediment quality in Presque Isle Bay is improving. Continued monitoring is recommended with a focus on the sediment entering the bay from the tributaries.

7.0 References

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APPENDIX A: FIGURES

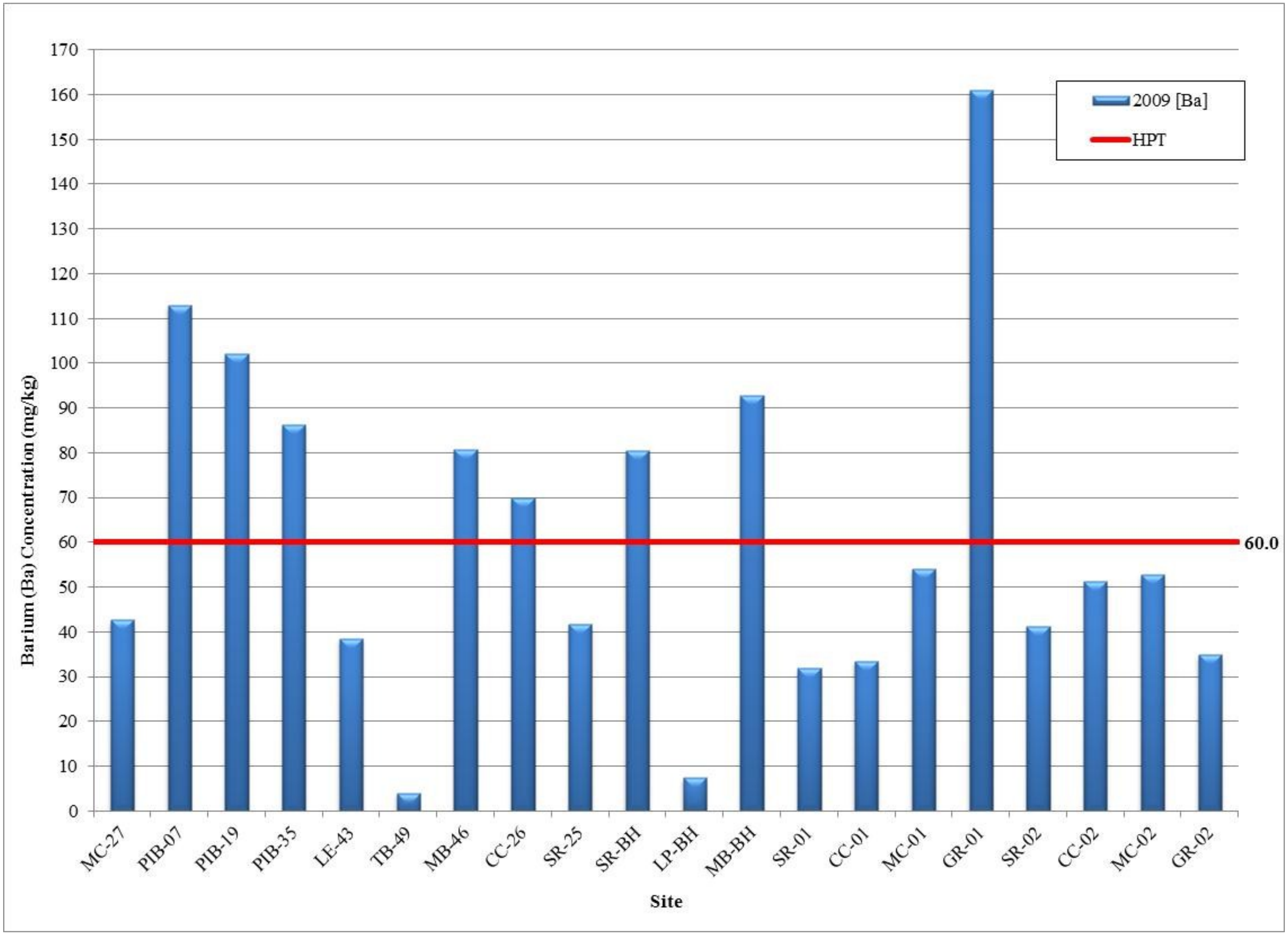

Figure 1. Barium concentrations in Presque Isle Bay: 2009

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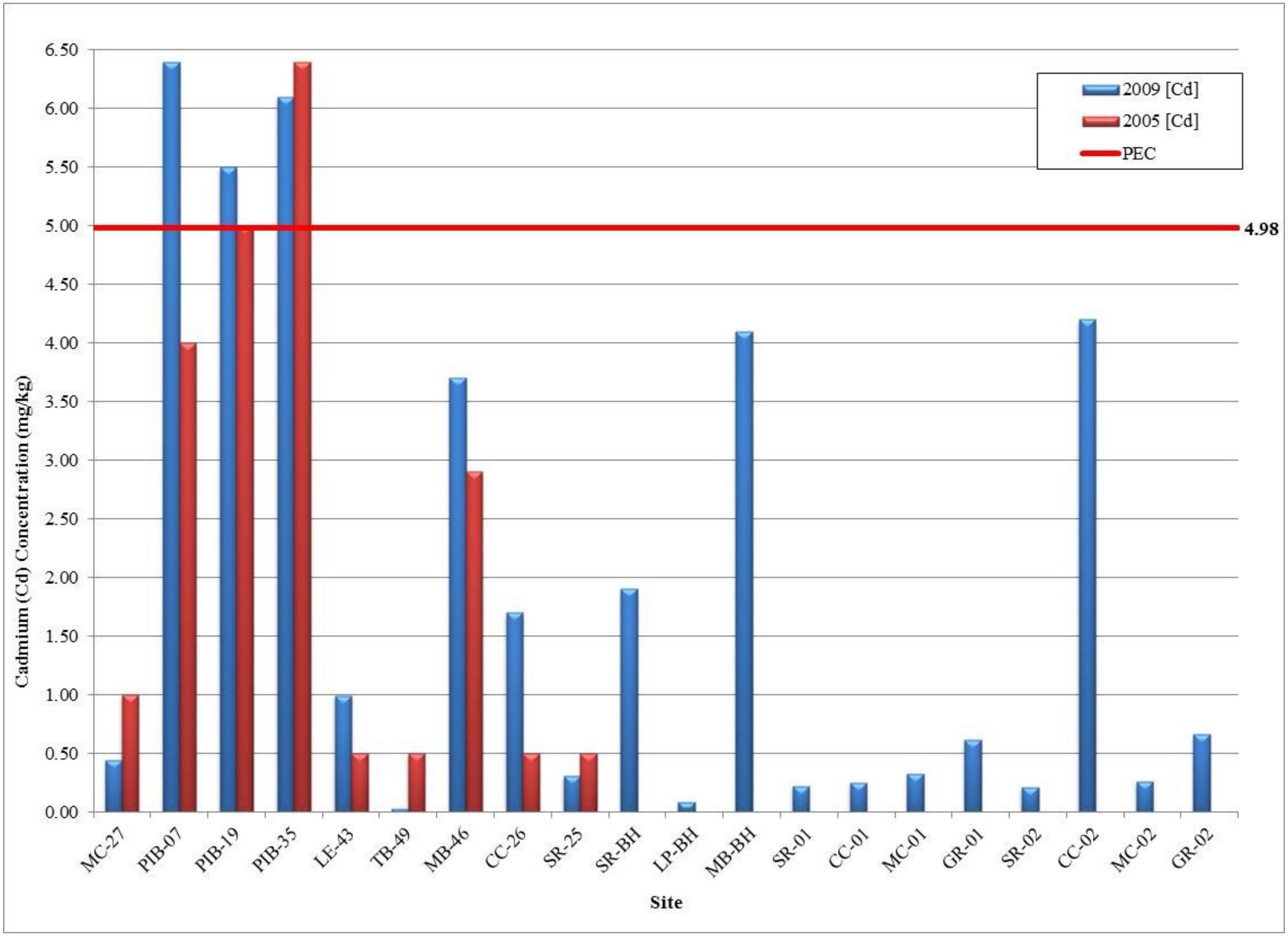

Figure 2. Cadmium concentrations in Presque Isle Bay: 2005—2009

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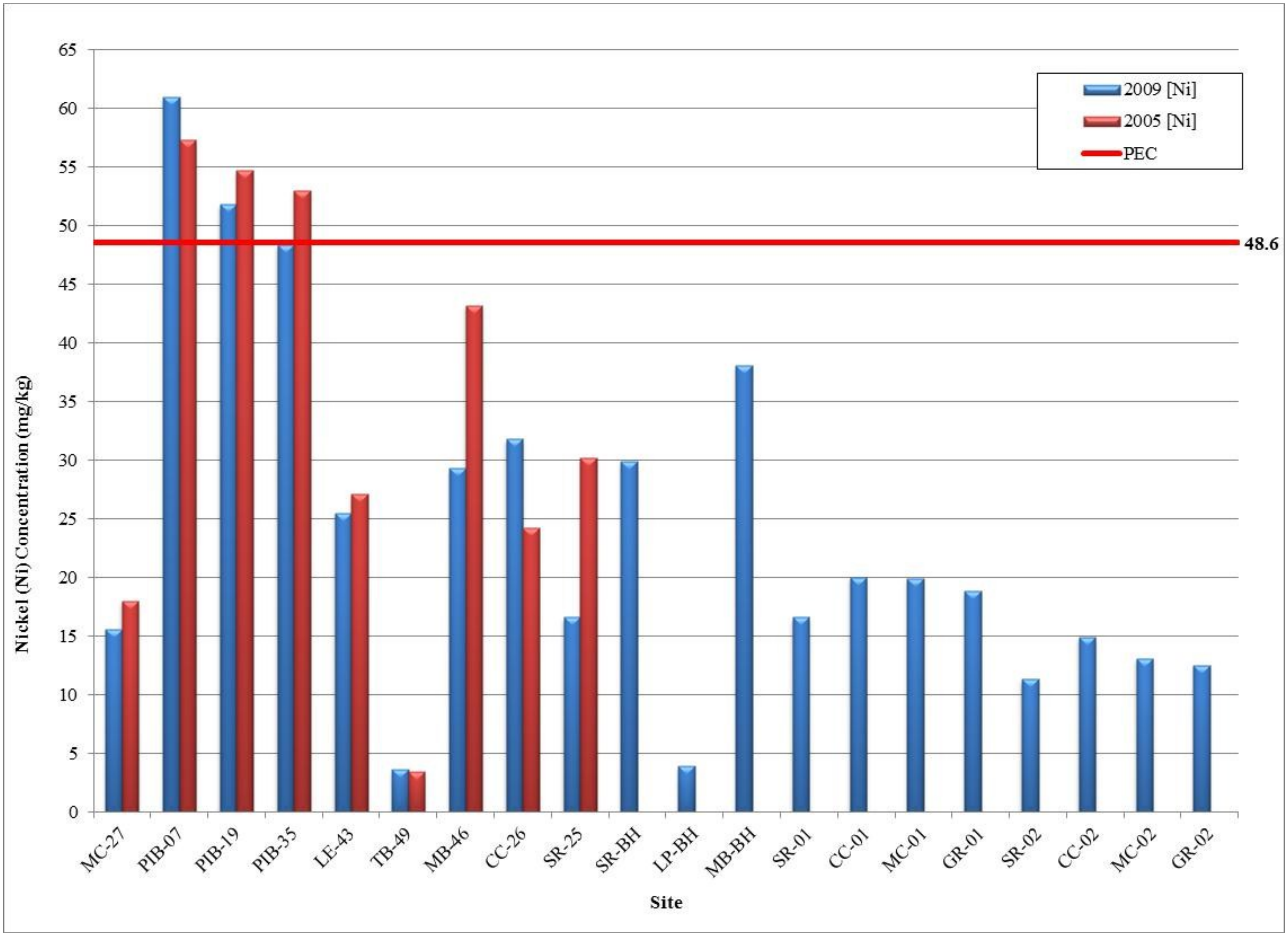

Figure 3. Nickel concentrations in Presque Isle Bay: 2005—2009

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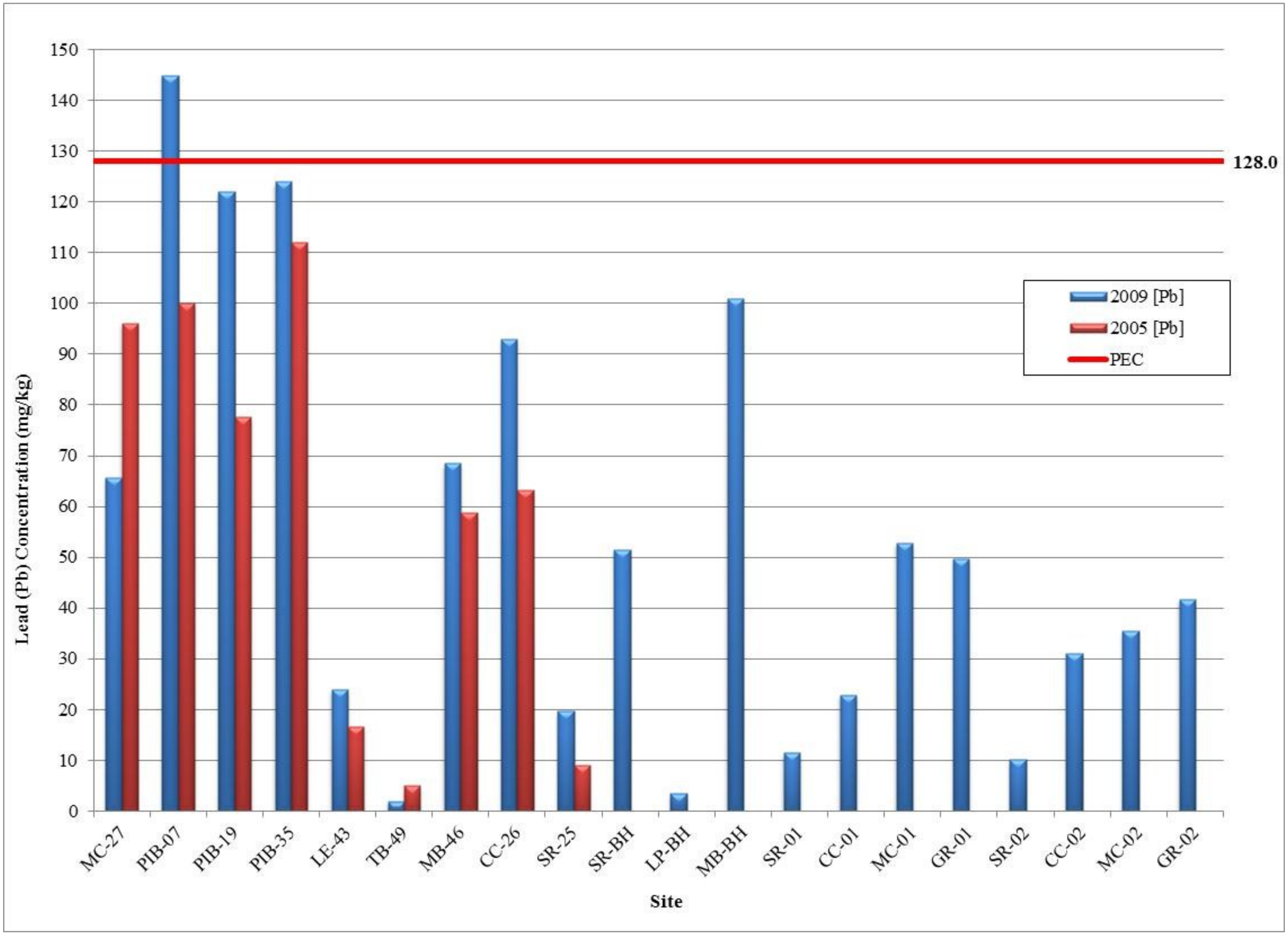

Figure 4. Lead concentrations in Presque Isle Bay: 2005—2009

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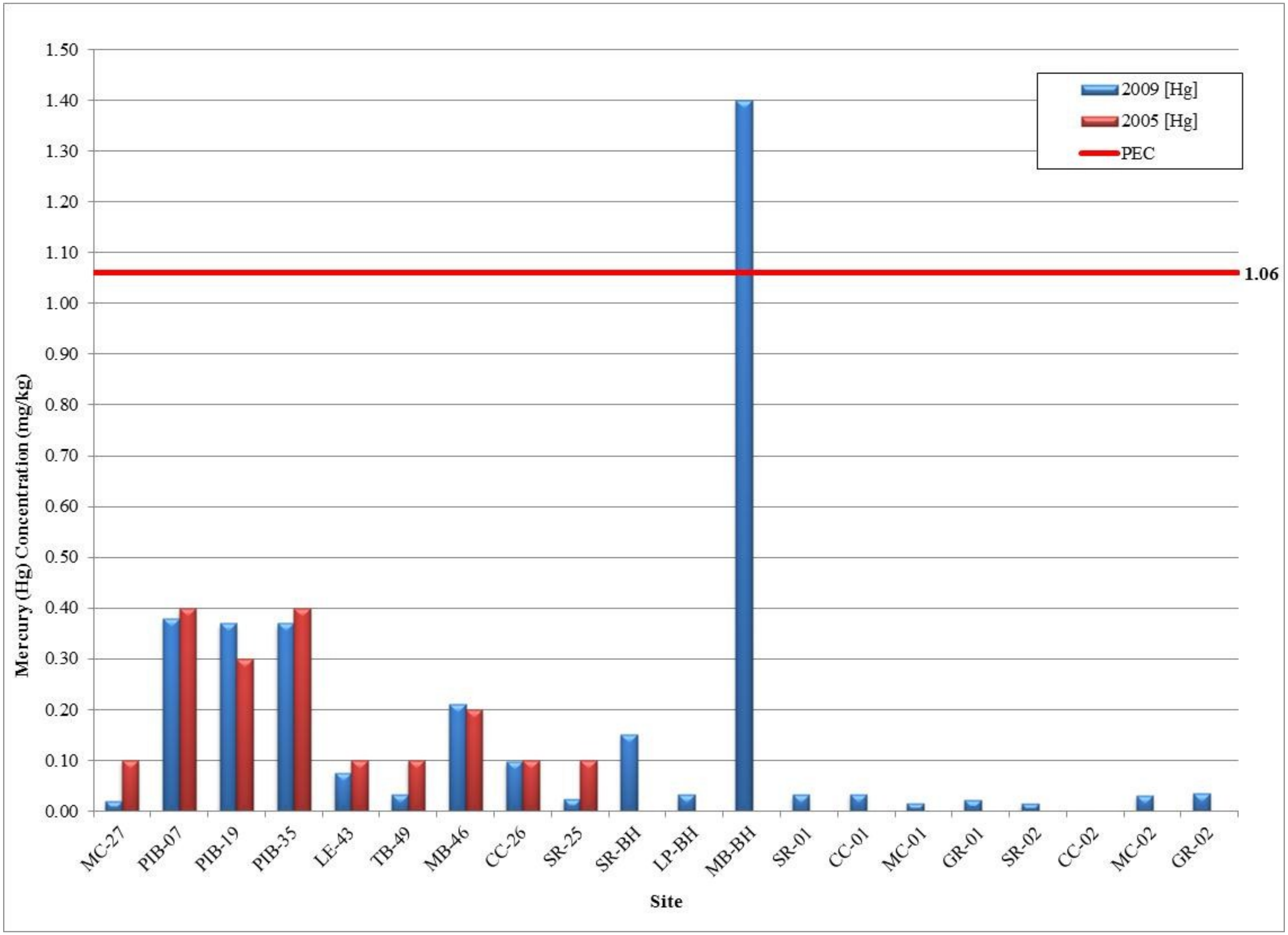

Figure 5. Mercury concentrations in Presque Isle Bay: 2005—2009

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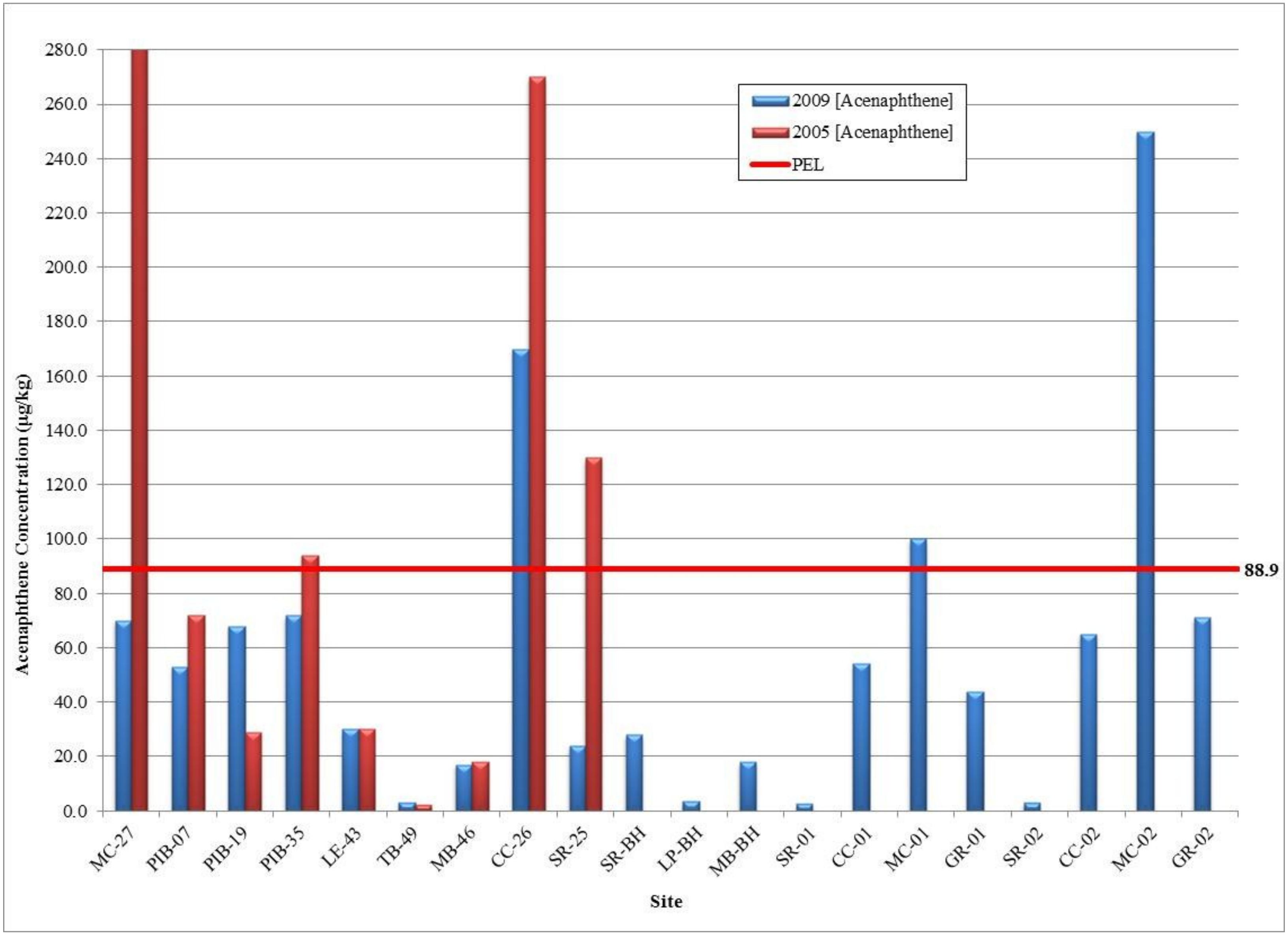

Figure 6. Acenaphthene concentrations in Presque Isle Bay: 2005—2009

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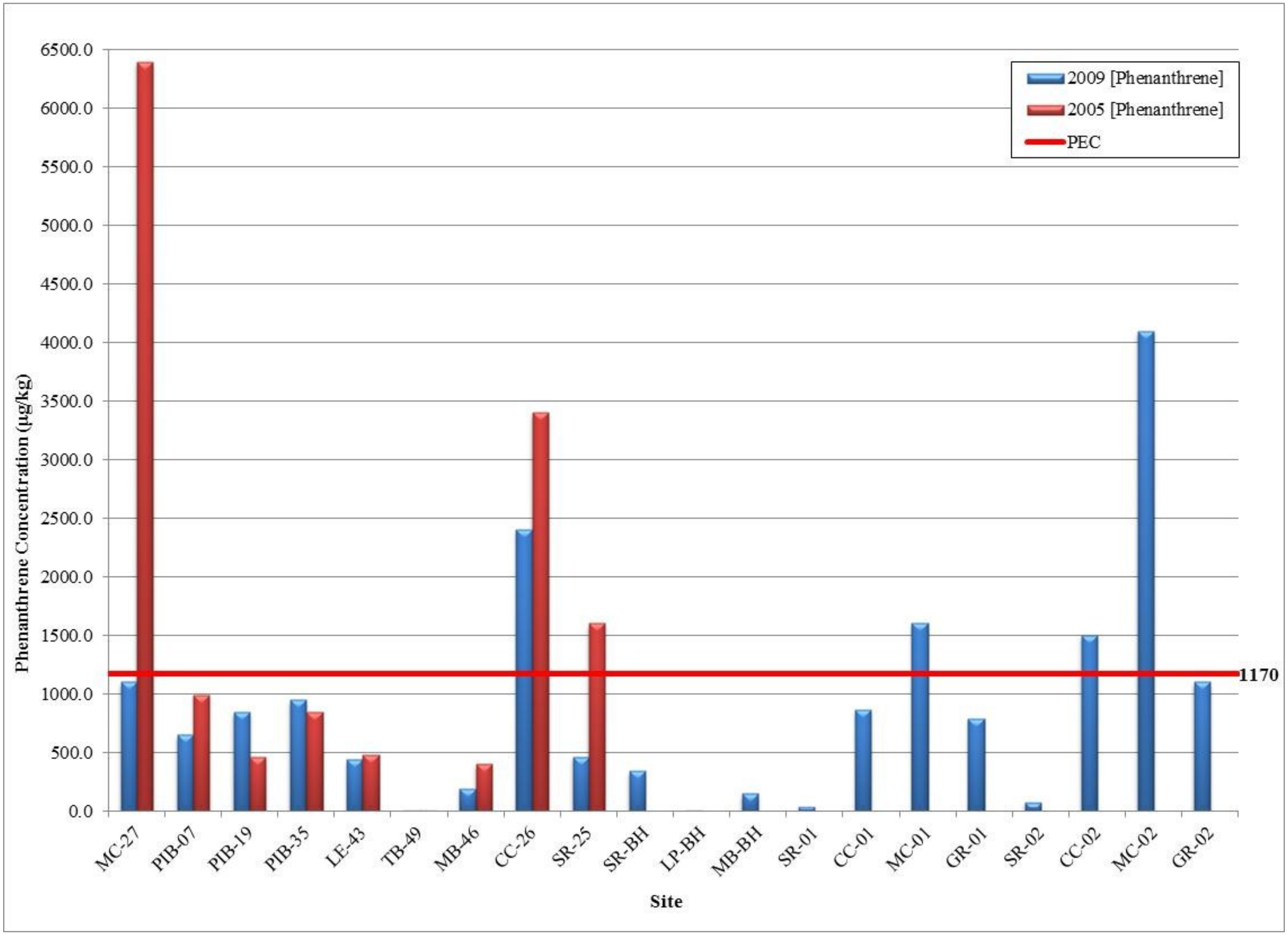

Figure 7. Phenanthrene concentrations in Presque Isle Bay: 2005—2009

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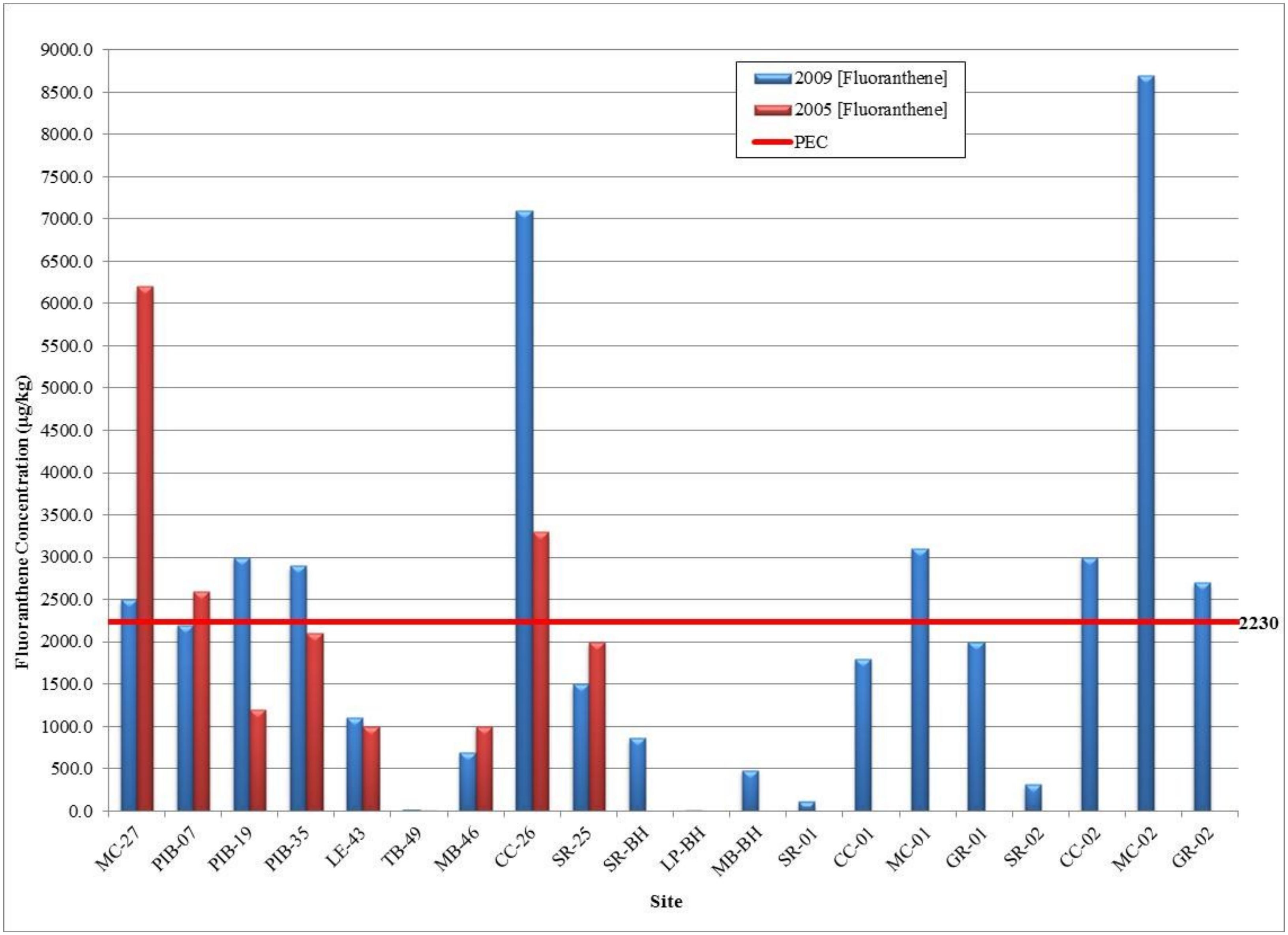

Figure 8. Fluoranthene concentrations in Presque Isle Bay: 2005—2009

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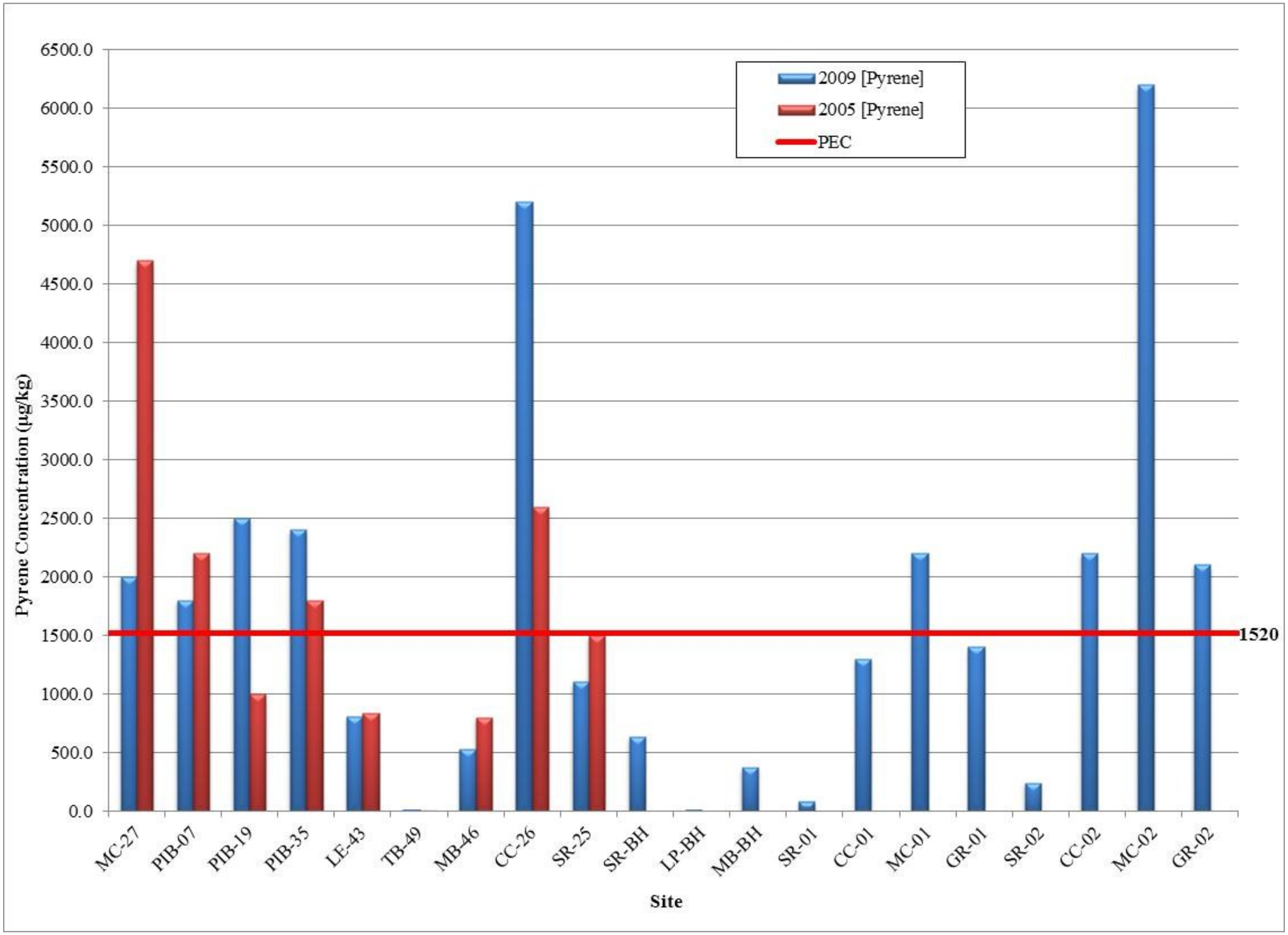

Figure 9. Pyrene concentrations in Presque Isle Bay: 2005—2009

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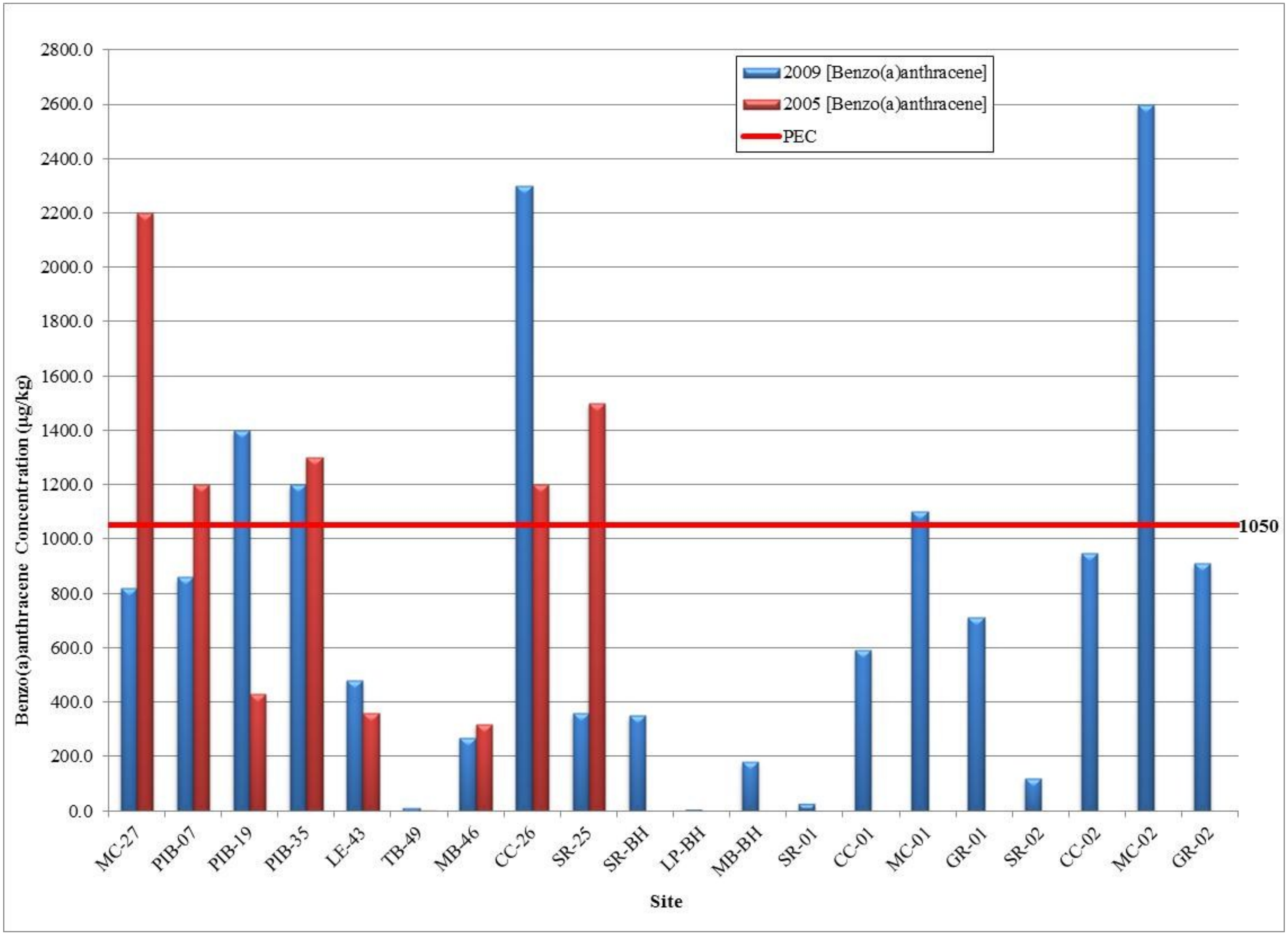

Figure 10. Benzo(a)anthracene concentrations in Presque Isle Bay: 2005—2009

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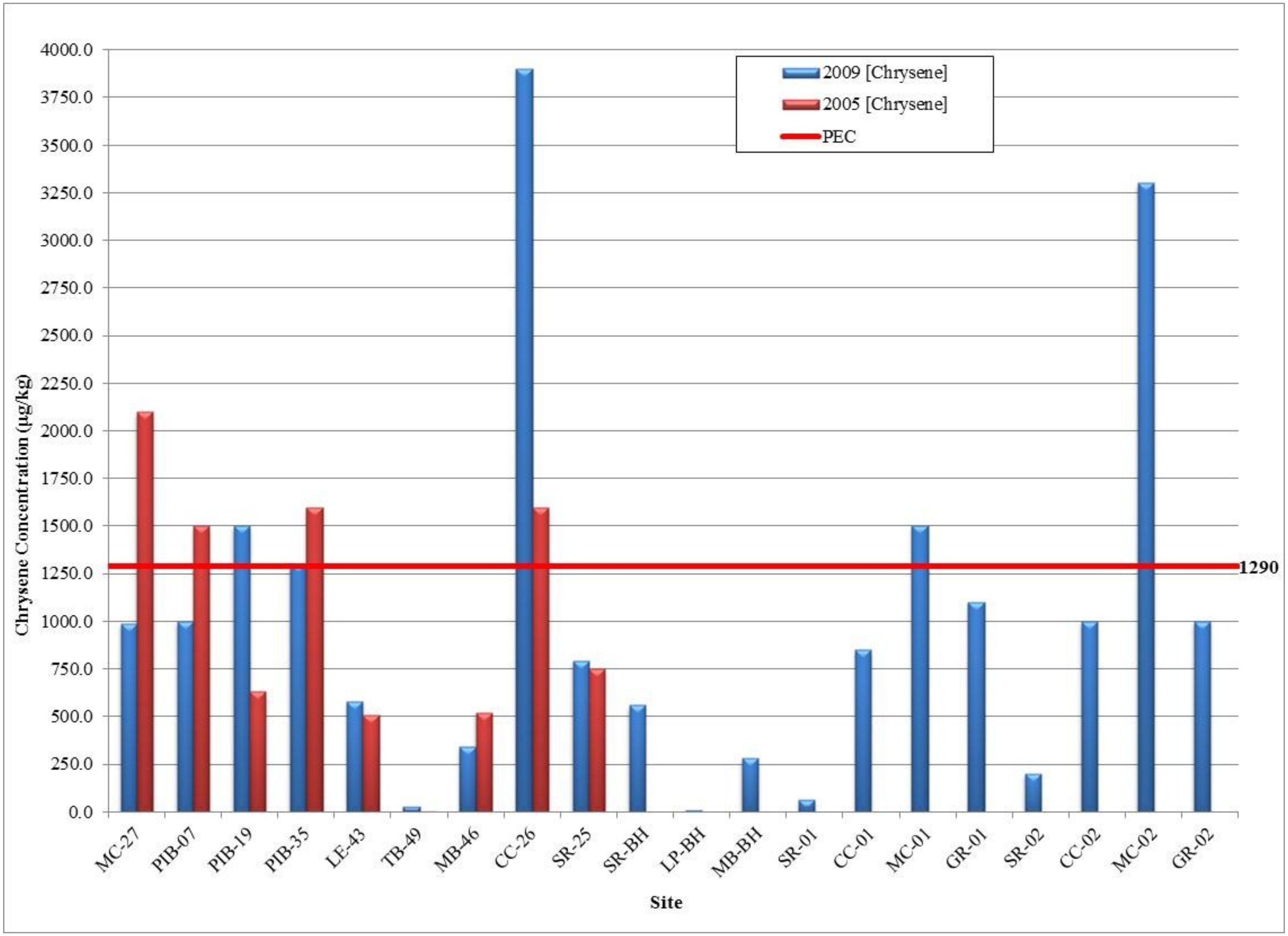

Figure 11. Chrysene concentrations in Presque Isle Bay: 2005—2009

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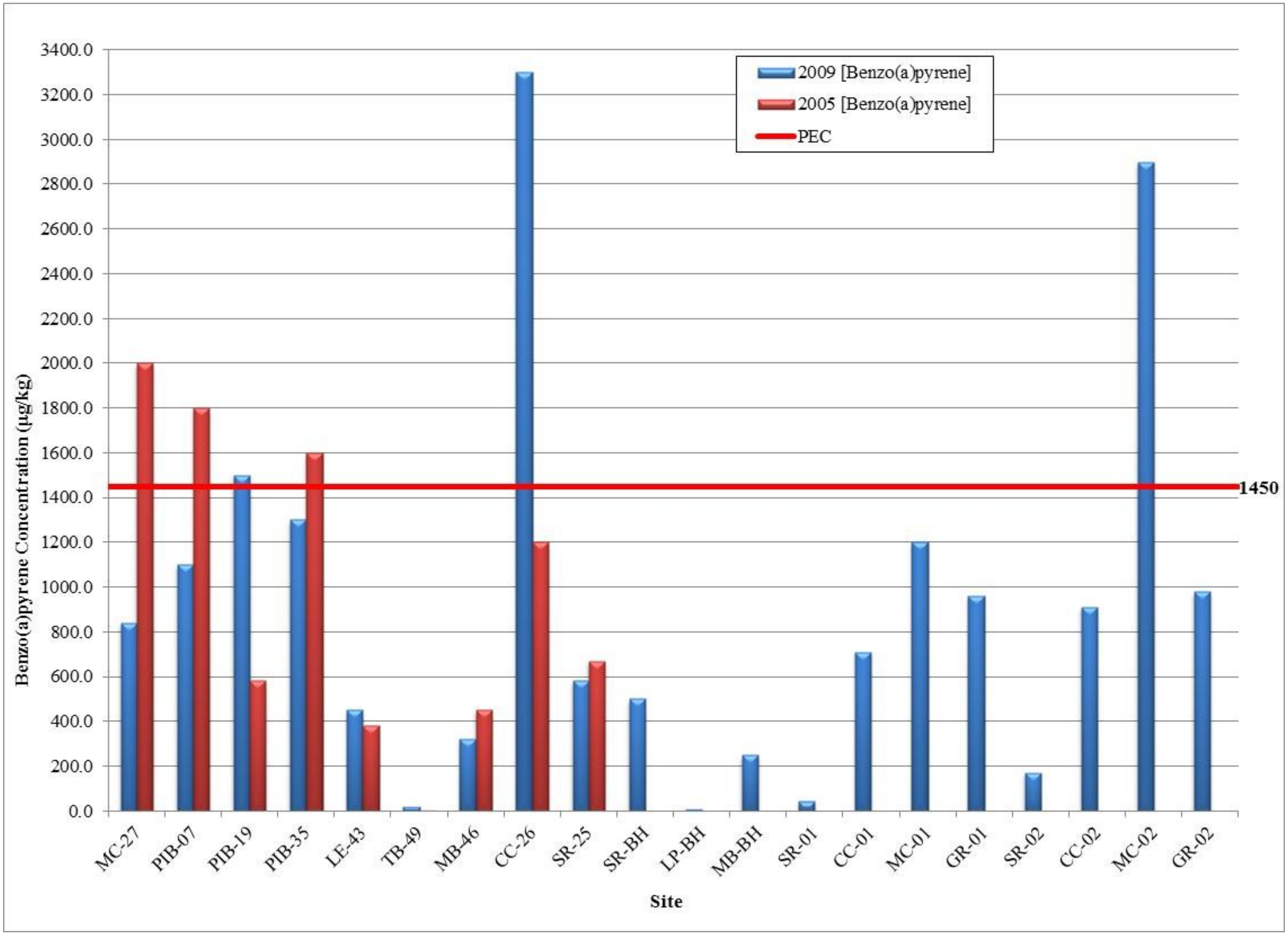

Figure 11. Benzo(a)pyrene concentrations in Presque Isle Bay: 2005—2009

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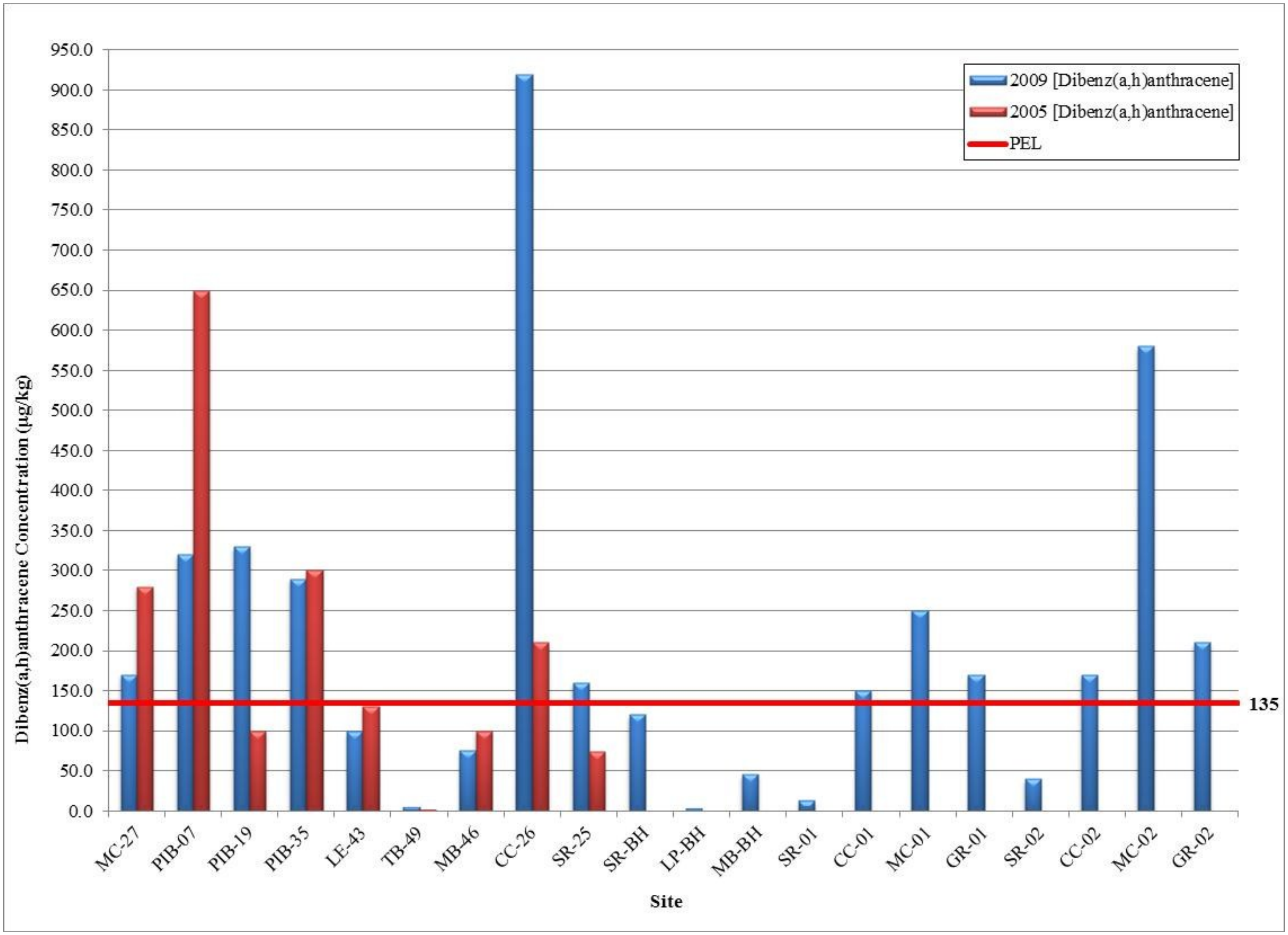

Figure 13. Dibenz(ah)anthracene concentrations in Presque Isle Bay: 2005—2009

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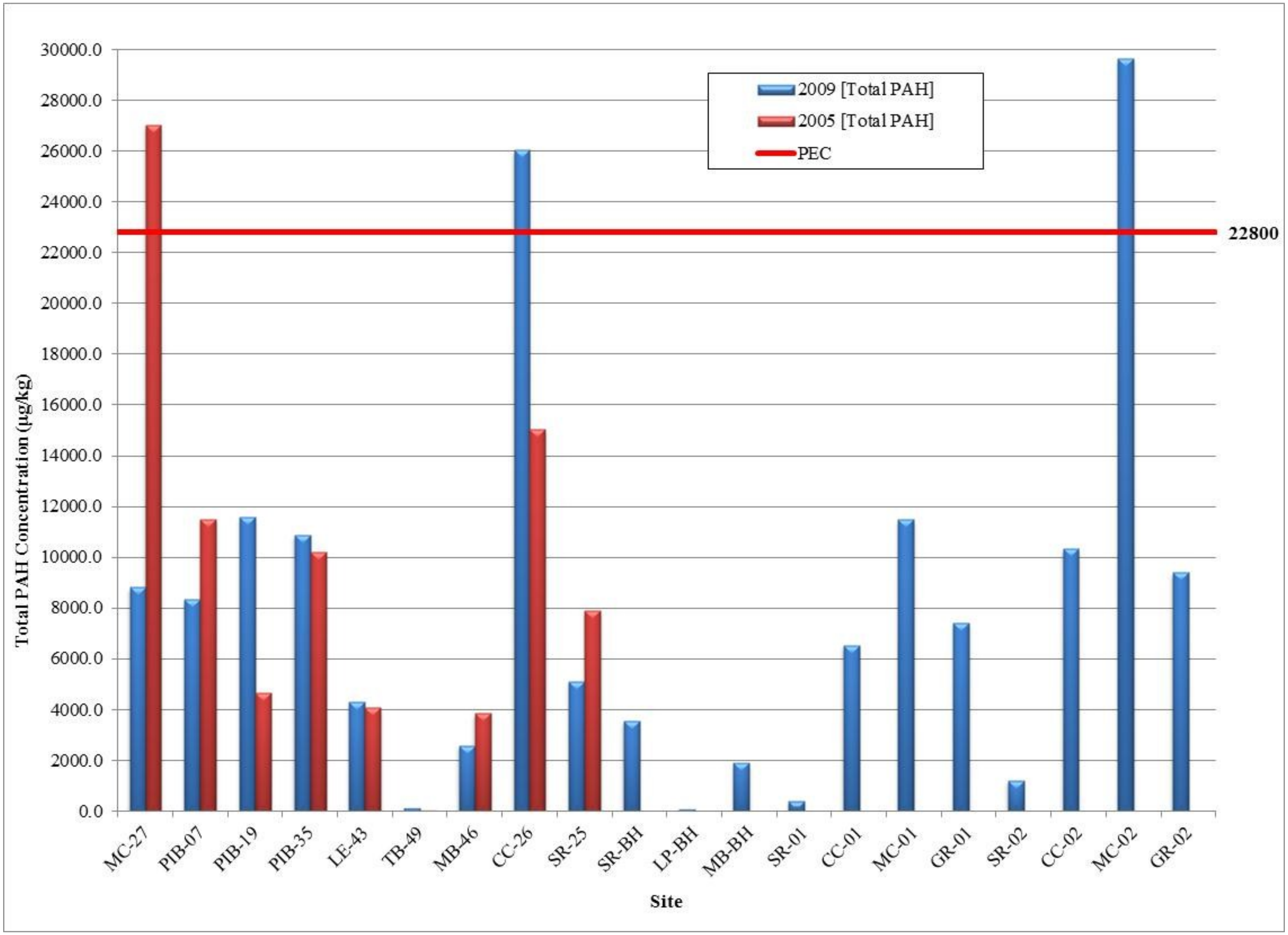

Figure 14. Total PAH concentrations in Presque Isle Bay: 2005—2009

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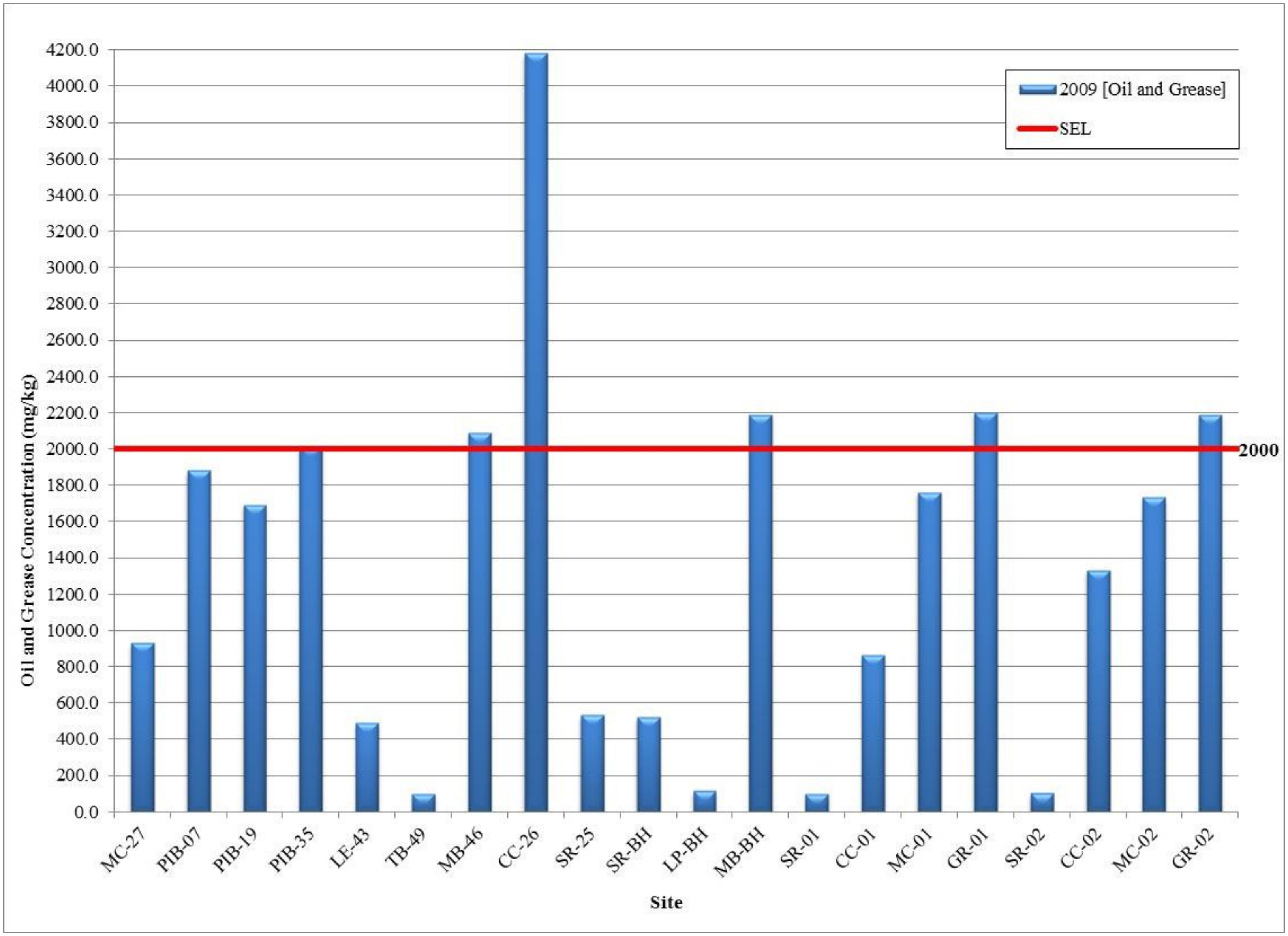

Figure 15. Oil and grease concentrations in Presque Isle Bay: 2009

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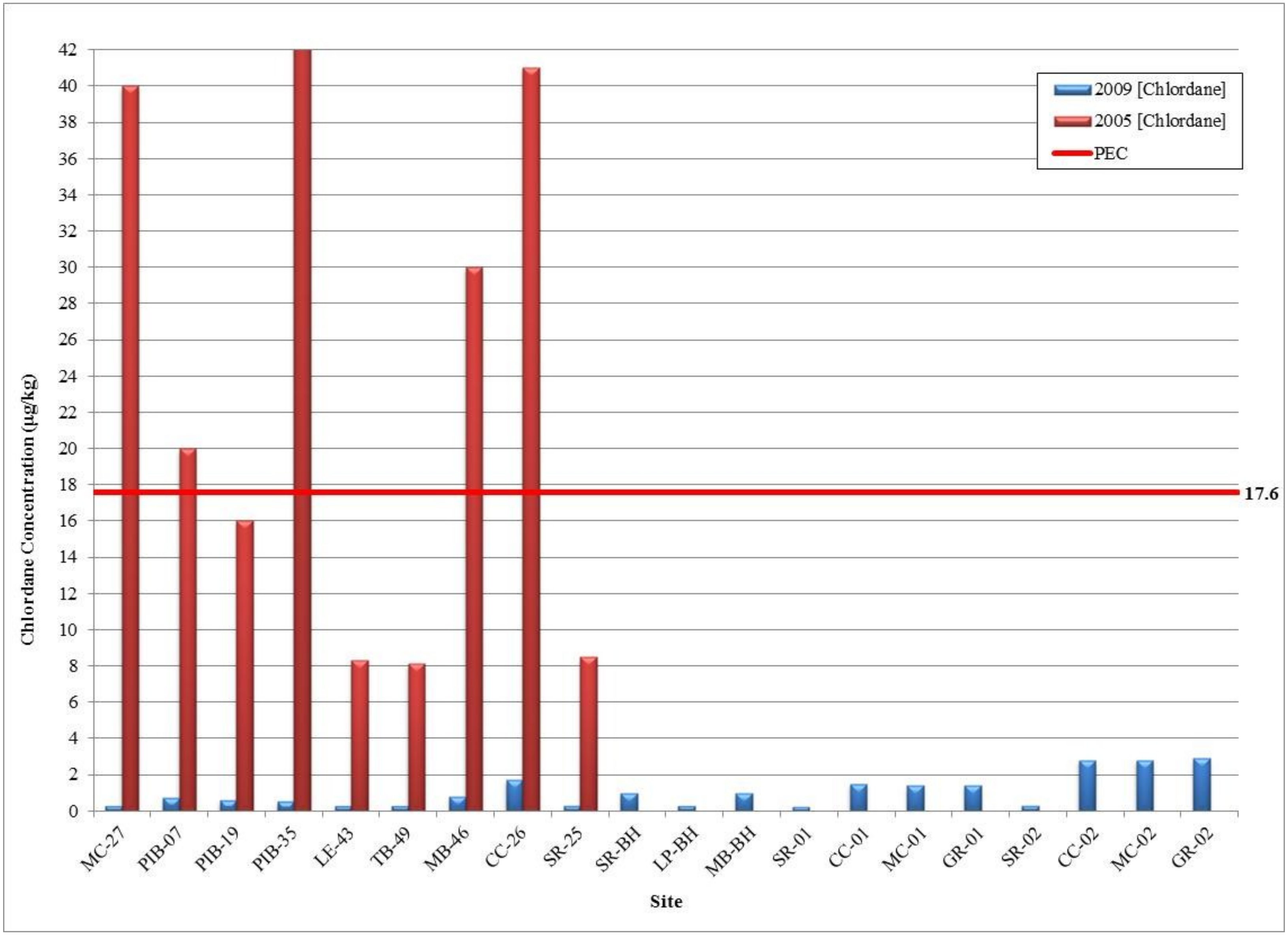

Figure 16. Chlordane concentrations in Presque Isle Bay: 2005—2009

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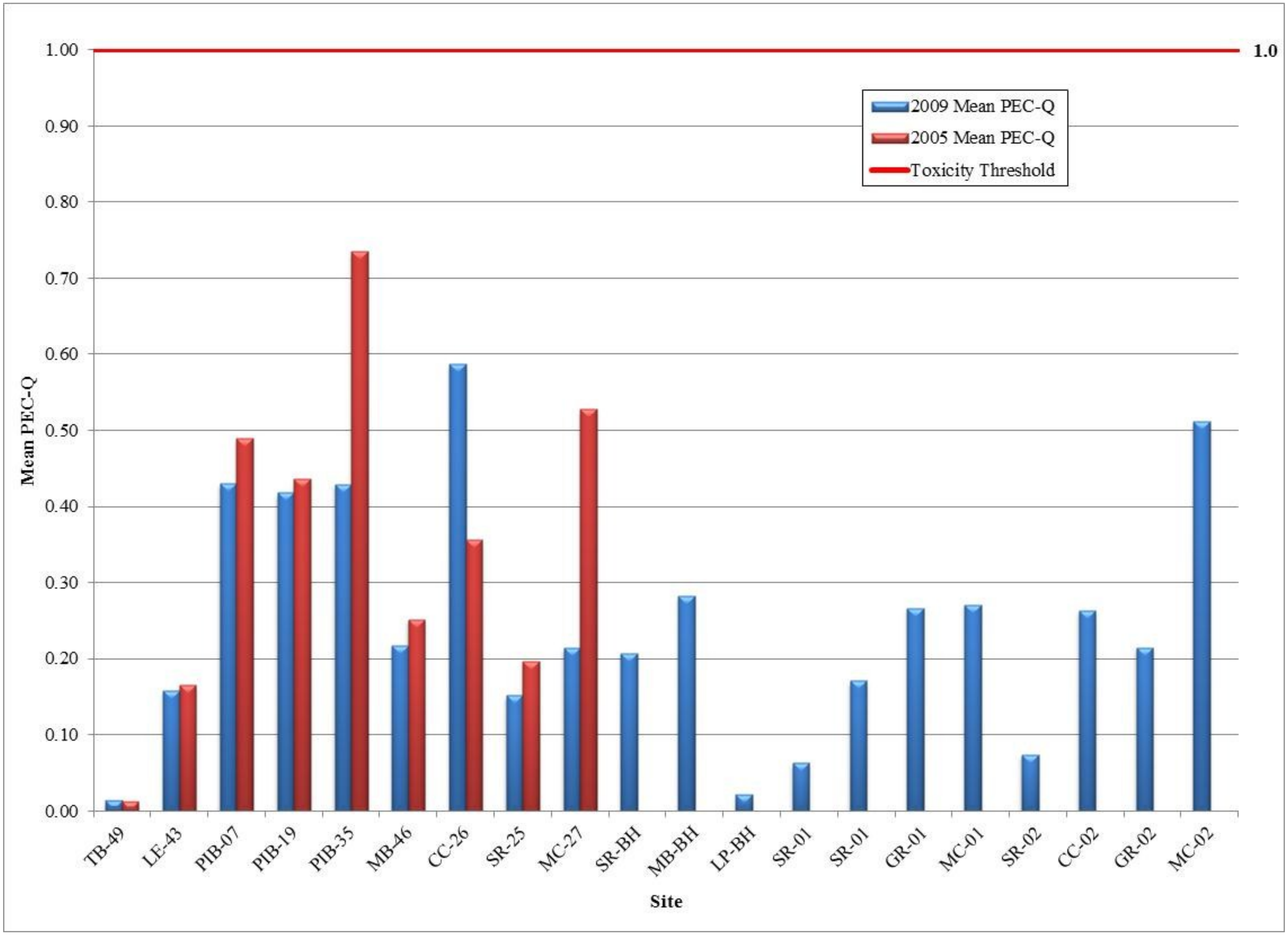

Figure 17. Mean PEC-Q values in Presque Isle Bay: 2005—2009

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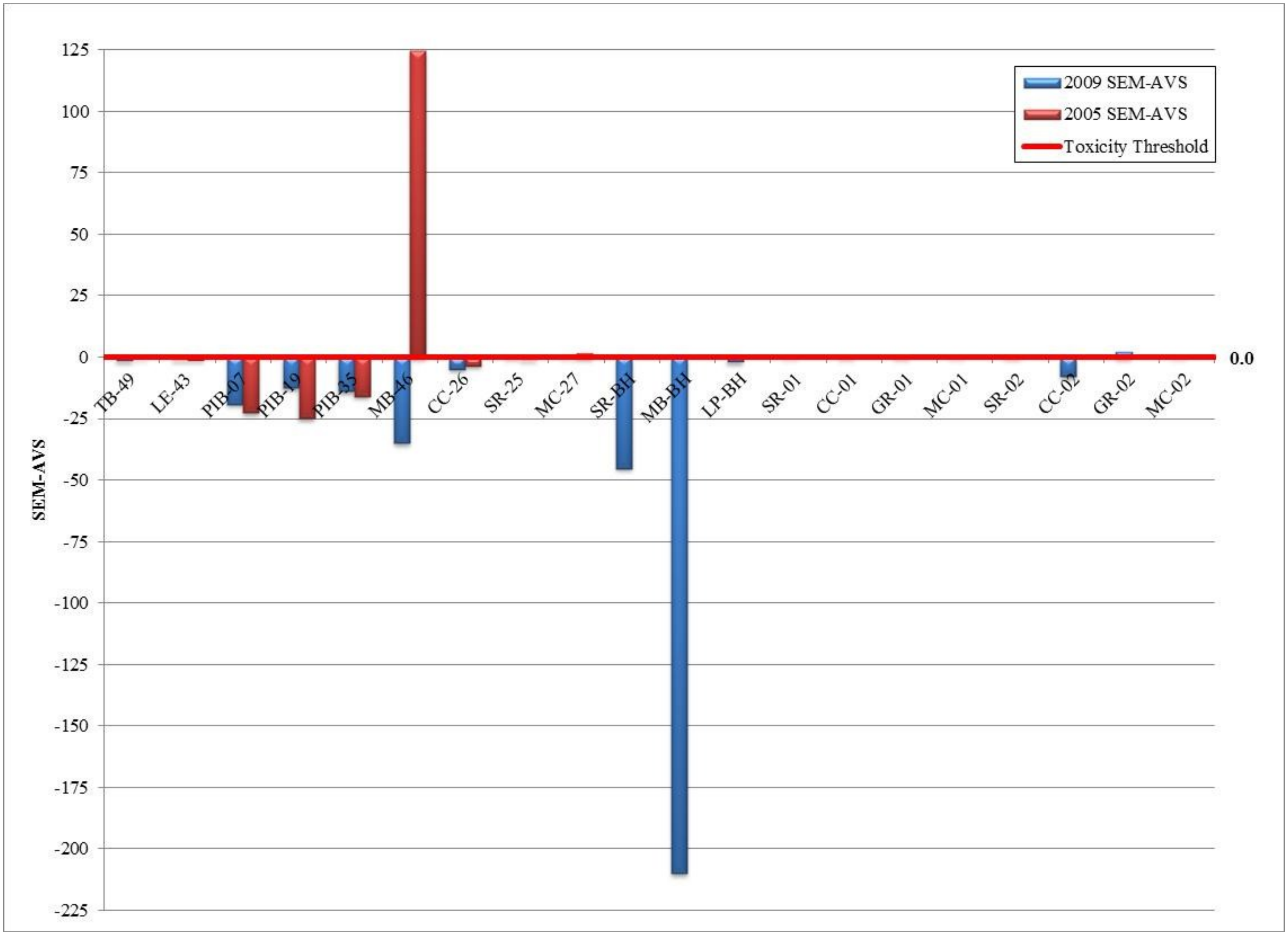

Figure 18. SEM-AVS values in Presque Isle Bay: 2005—2009

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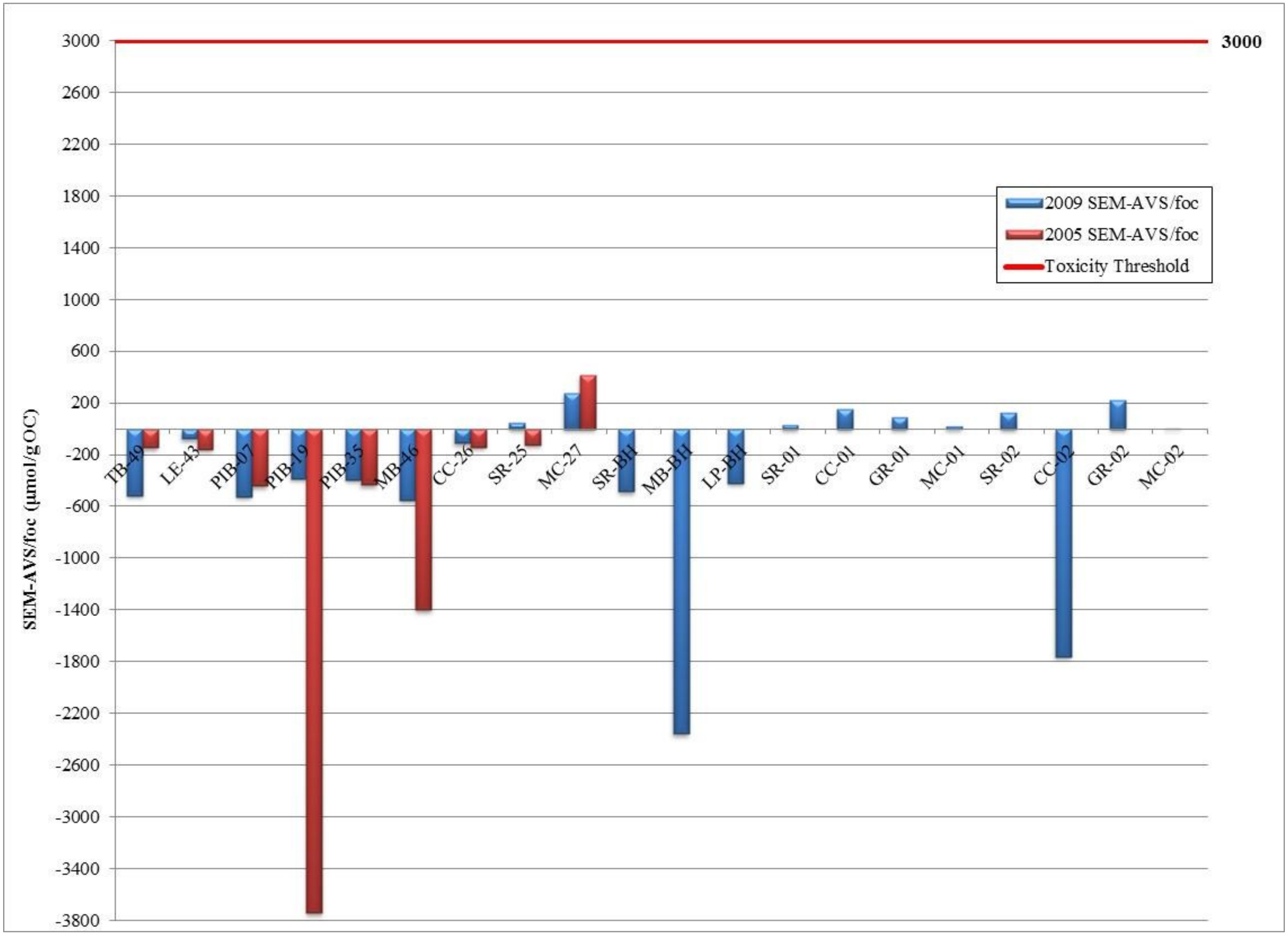

Figure 19. SEM-AVS/f_{oc} values in Presque Isle Bay: 2005—2009

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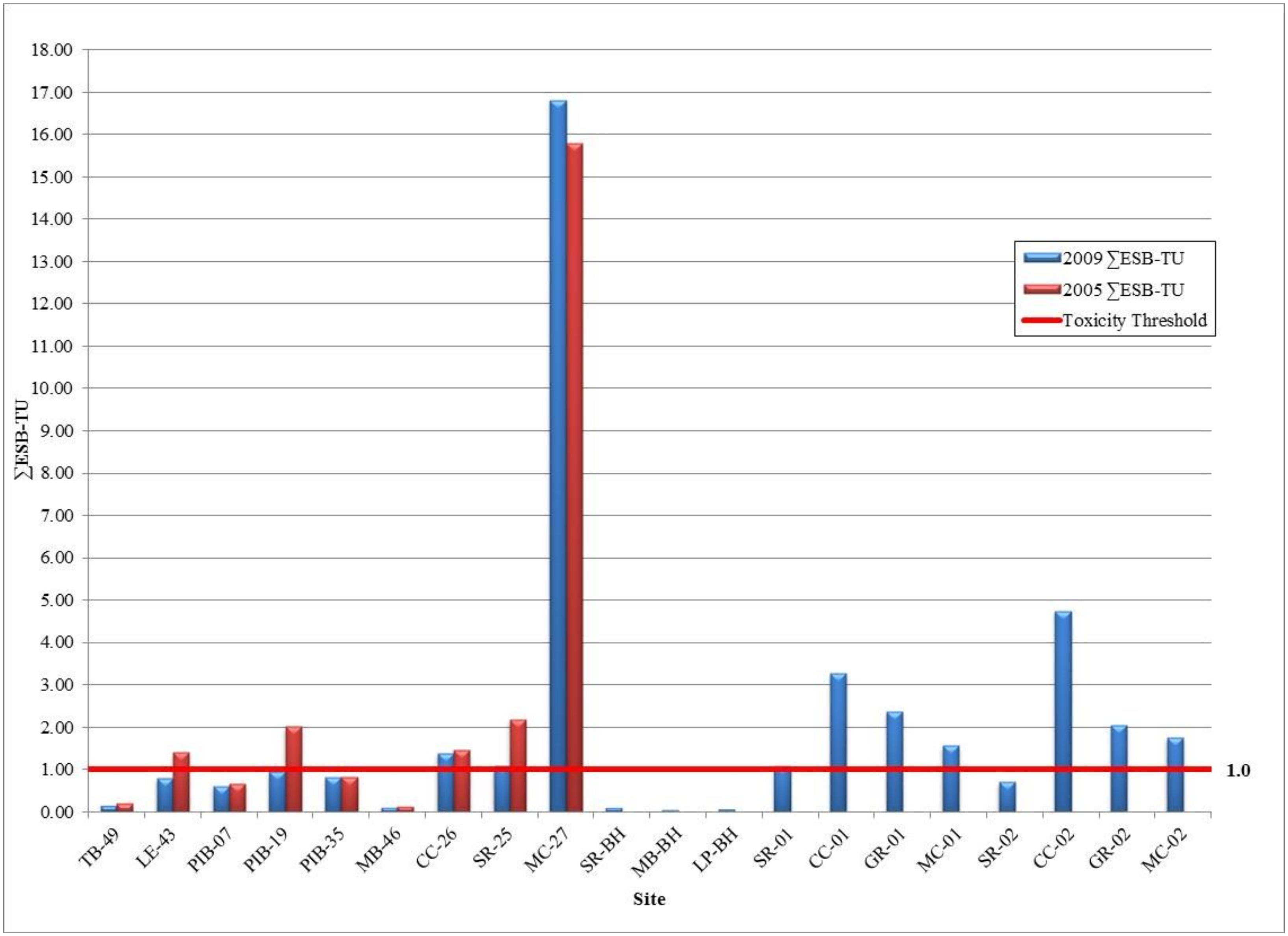

Figure 20. ESB-TU values in Presque Isle Bay: 2005—2009

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APPENDIX B: TABLES

Table 1. Presque Isle Bay sediment quality evaluation sampling locations (2009)

Site	Date	Latitude	Longitude
Long-term Monitoring Sampling Sites			
TB-49	July 28, 2009	42.16583	-80.075556
LE-43	July 29, 2009	42.14905	-80.0713
PIB-07	July 29, 2009	42.13193	-80.1236
PIB-19	July 29, 2009	42.134616	-80.10783
PIB-35	July 29, 2009	42.135016	-80.0995
MB-46	July 29, 2009	42.15883	-80.08768
CC-26	July 30, 2009	42.12936	-80.11497
SR-25	July 30, 2009	42.11403	-80.15059
MC-27	July 29, 2009	42.14388	-80.083386
Brown Bullhead Sampling Sites			
SR-BH	July 30, 2009	42.11679	-80.14848
MB-BH	July 29, 2009	42.15529	-80.09084
LP-BH	July 29, 2009	42.15556	-80.10415
Stream Sampling Sites			
SR-01	August 5, 2009	42.11169	-80.15495
CC-01	August 5, 2009	42.12631	-80.11092
GR-01	August 5, 2009	42.14359	-80.07574
MC-01	August 5, 2009	42.14112	-80.07858
SR-02	September 24, 2009	42.11169	-80.15495
CC-02	September 24, 2009	42.12631	-80.11092
GR-02	September 24, 2009	42.14359	-80.07574
MC-02	September 24, 2009	42.14112	-80.07858

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Table 2. Chemicals of potential concern (COPC) (2009)

Anaytles
Nitrosamines (µg/kg)
N-Nitrosodiethylamine; N-Nitrosodimethylamine; N-Nitrosodi-n-propylamine; N-Nitrosodi-n-butylamine; N-Nitrosomethylethylamine; N-Nitrosomorpholine; N-Nitrosopiperidine; N-Nitrosopyrrolidine; and N-Nitrosodiphenylamine
Pesticides (µg/kg)
Aldrin; gamma-BHC; Chlordane; 4,4'-DDD; 2,4'-DDD; 4,4'-DDE; 2,4'-DDE; 4,4'-DDT; 2,4'-DDT; Dieldrin; Endosulfan I, Endosulfan II; Endrin; Heptachlor; Heptachlor epoxide; Hexachlorobenzene; Hexachlorocyclopentadiene; Methoxychlor; Mirex, Hexachlorobenzene; and trans-nonachlor
Metals (mg/kg)
Antimony; Arsenic; Barium; Beryllium; Cadmium; Chromium; Copper; Lead; Mercury; Nickel; and Zinc
Polychlorinated Biphenyls (PCBs) (µg/kg)
PCB-8; PCB-18; PCB-28; PCB-44; PCB-52; PCB-66; PCB-87; PCB-101; PCB-105; PCB-118; PCB-128; PCB-138; PCB-153; PCB-170; PCB-180; PCB-187; PCB-195; PCB-206; and PCB-209
Polycyclic Aromatic Hydrocarbons (PAHs) (µg/kg)
Acenaphthene; Acenaphthylene; Anthracene; C1-phenan/anthracenes; C2-phenan/anthracenes; C3-phenan/anthracenes; C4-phenan/anthracenes; Benz(a)anthracene; Benzo(a)pyrene; Benzo(b)fluoranthene; Benzo(e)pyrene; Benzo(g,h,i)perylene; Benzo(k)fluoranthene; Chrysene; C1-chrysenes; C2-chrysenes; C3-chrysenes; C4-chrysenes; Dibenz(a,h)anthracene; Fluoranthene; Fluorene; C1-fluorenes; C2-fluorenes; C3-fluorenes; Indeno(1,2,3-c,d)pyrene; Naphthalene; C1-naphthalenes; C2-naphthalenes; C3-naphthalenes; C4-naphthalenes; 2-methylnaphthalene; 1-methylnaphthalene; 2,3,5 trimethylnaphthalne; 2,6 dimethylnaphthalene; Biphenyl; Perylene; Phenanthrene; 1-methylphenanthrene; Pyrene; C1-fluoran/pyrenes; C2; fluoran/pyrenes; C3-fluoran/pyrenes; Dibenzothiophene; C1-dibenzothiophene; C2-dibenzothiophene; and C3-debenzothiophene; total PAHs
General Chemistry
AVS/SEM; n-hexane extractible material (oil and grease); nitrate/nitrite as N; total nitrogen; total kjeldahl nitrogen[a]; percent solids; total organic carbon; phosphorus[a]; and grain size

[a] total kjeldahl nitrogen and phosphorus were only assessed at the stream sampling sites

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Table 3. Pennsylvania water quality standards[a]

Chemical of Potential Concern	Acute Standard	Chronic Standard
	Metals (µg/L)	
Barium	21000.0	4100.0
Cadmium	13.0	2.6
Lead	79.0	3.1
Mercury	1.4	0.8
Nickel	550.0	61.0
	PAHs (µg/L)	
Acenaphthene	83.0	17.0
Acenaphthylene	NA	NA
Anthracene	NA	NA
Benz(a)anthracene	0.5	0.1
Benzo(a)pyrene	NA	NA
Chrysene	NA	NA
Dibenz(a,h)anthracene	NA	NA
Fluoranthene	200.0	40.0
Fluorene	NA	NA
Phenanthrene	5.0	1.0
Pyrene	NA	NA
Total PAHs	NA	NA
	Nickel	
Total PCBs	NA	NA

[a] NA = not applicable

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Table 4. Selected toxicity thresholds for whole sediment for evaluating the effects of chemicals of potential concern on the benthic invertebrate community[a]

Chemical of Potential Concern	Toxicity Threshold	Type[b]	Source
Metals (mg/kg)			
Antimony	25	SEL	NYSDEC 1999
Arsenic	33	PEC	MacDonald *et al. 2000*
Barium	60	HPT	USEPA 1977
Cadmium	4.98	PEC	MacDonald *et al. 2000*
Chromium	111	PEC	MacDonald *et al. 2000*
Copper	149	PEC	MacDonald *et al. 2000*
Lead	128	PEC	MacDonald *et al. 2000*
Mercury	1.06	PEC	MacDonald *et al. 2000*
Nickel	48.6	PEC	MacDonald *et al. 2000*
Zinc	459	PEC	MacDonald *et al. 2000*
PAHs (µg/kg)			
Acenaphthene	88.9	PEL	CCME 1999
Acenaphthylene	128	PEL	CCME 1999
Anthracene	845	PEC	MacDonald *et al. 2000*
Benz(a)anthracene	1050	PEC	MacDonald *et al. 2000*
Benzo(a)pyrene	1450	PEC	MacDonald *et al. 2000*
Chrysene	1290	PEC	MacDonald *et al. 2000*
Dibenz(a,h)anthracene	135	PEL	CCME 1999
Fluoranthene	2230	PEC	MacDonald *et al. 2000*
Fluorene	536	PEC	MacDonald *et al. 2000*
2-Methylnaphthalene	201	PEL	CCME 1999
Napthalene	561	PEC	MacDonald *et al. 2000*
Phenanthrene	1170	PEC	MacDonald *et al. 2000*
Pyrene	1520	PEC	MacDonald *et al. 2000*
Total PAHs	22800	PEC	MacDonald *et al. 2000*
PCBs (µg/kg)			
Total PCBs	676	PEC	MacDonald *et al. 2000*
Organochlorine Pesticides (µg/kg)			
Chlordane	17.6	PEC	MacDonald *et al. 2000*
Sum DDD	28	PEC	MacDonald *et al. 2000*
Sum DDE	31.3	PEC	MacDonald *et al. 2000*
Sum DDT	62.9	PEC	MacDonald *et al. 2000*
DDT (total)	572	PEC	MacDonald *et al. 2000*
Dieldrin	61.8	PEC	MacDonald *et al. 2000*
Endrin	207	PEC	MacDonald *et al. 2000*
Other (mg/kg)			
Oil and Grease	2000	SEL	USEPA 1977

[a] Table was adapted from MacDonald *et al. 2000*

[b] SEL = severe effect level; PEC = probable effect concentration; HTP = heavily polluted threshold; PEL = probable effect level

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Table 5. Exceedances of selected toxicity thresholds (2005 - 2009)

	Chemical of Potential Concern Concentrations																																			
	Metals (mg/kg)										PAHs (µg/kg)																		(mg/kg)		(µg/kg)	
Site	Barium		Cadmium		Nickel		Lead		Mercury		Acenaphthene		Phenanthrene		Fluoranthene		Pyrene		Benz(a)anthracene		Chrysene		Benzo(a)pyrene		Dibenz(a,h)anthracene		Total PAHs		Oil and Grease		Chlordane	
	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005
Long-term Monitoring Sampling Sites																																				
TB-49	4.0		0.031	0.5	3.6	3.4	1.9	5.0	ND	0.1	3.1	2.4	3.3	2.4	19.0	3.9	15.0	3.3	13.0	2.4	30.0	2.5	20.0	2.4	4.9	2.4	123.8	21.7	ND		0.28	8.1
LE-43	38.5		0.990	0.5	25.5	27.1	24.0	16.6	0.075	0.1	30.0	30.0	440.0	480.0	1100.0	1000.0	810.0	830.0	480.0	360.0	580.0	510.0	450.0	380.0	99.0	130.0	4278.0	4073.0	488.0		0.27	8.3
PIB-07	113		6.400	4.0	61.0	57.3	145.0	100.0	0.380	0.4	53.0	72.0	650.0	990.0	2200.0	2600.0	1800.0	2200.0	860.0	1200.0	1000.0	1500.0	1100.0	1800.0	320.0	650.0	8334.0	11490.0	1880.0		0.73	20.0
PIB-19	102		5.500	5.0	51.8	54.7	122.0	77.6	0.370	0.3	68.0	29.0	840.0	460.0	3000.0	1200.0	2500.0	1000.0	1400.0	430.0	1500.0	630.0	1500.0	580.0	330.0	100.0	11600.0	4667.0	1690.0		0.59	16.0
PIB-35	86.3		6.100	6.4	48.4	53.0	124.0	112.0	0.370	0.4	72.0	94.0	950.0	840.0	2900.0	2100.0	2400.0	1800.0	1200.0	1300.0	1300.0	1600.0	1300.0	1600.0	290.0	300.0	10884.0	10192.0	2010.0		0.52	70.0
MB-46	80.6		3.700	2.9	29.3	43.2	68.5	58.7	0.210	0.2	17.0	18.0	190.0	400.0	690.0	1000.0	530.0	800.0	270.0	320.0	340.0	520.0	320.0	450.0	75.0	100.0	2564.0	3839.0	2090.0		0.81	30.0
CC-26	70.0		1.700	0.5	31.8	24.2	93.0	63.2	0.098	0.1	170.0	270.0	2400.0	3400.0	7100.0	3300.0	5200.0	2600.0	2300.0	1200.0	3900.0	1600.0	3300.0	1200.0	920.0	210.0	26051.0	15032.0	4180.0		1.7	41.0
SR-25	41.6		0.310	0.5	16.6	30.2	19.7	9.0	0.023	0.1	24.0	130.0	460.0	1600.0	1500.0	2000.0	1100.0	1500.0	360.0	1500.0	790.0	750.0	580.0	670.0	160.0	74.0	5106.7	7901.3	530.0		0.29	8.5
MC-27	42.7		0.440	1.0	15.6	18.0	65.6	96.1	0.020	0.1	70.0	590.0	1100.0	6400.0	2500.0	6200.0	2000.0	4700.0	820.0	2200.0	990.0	2100.0	840.0	2000.0	170.0	280.0	8820.0	27040.0	928.0		0.28	40.0
Brown Bullhead Sampling Sites																																				
SR-BH	80.5		1.900		29.9		51.5		0.150		28.0		340.0		860.0		630.0		350.0		560.0		500.0		120.0		3547.0		ND		0.99	
MB-BH	92.7		4.100		38.1		101.0		1.400		18.0		150.0		480.0		370.0		180.0		280.0		250.0		46.0		1886.0		2190		1.0	
LP-BH	7.4		0.084		3.9		3.4		ND		3.7		5.9		16.0		13.0		6.0		11.0		8.8		3.7		86.6		ND		0.28	
Stream Sampling Sites																																				
SR-01	31.8		0.220		16.6		11.4		ND		2.8		39.0		110.0		82.0		26.0		66.0		45.0		13.0		399.7		ND		0.26	
CC-01	33.5		0.250		20.0		22.9		ND		54.0		860.0		1800.0		1300.0		590.0		850.0		710.0		150.0		6525.8		863		1.5	
MC-01	54.1		0.320		19.9		52.9		0.016		100.0		1600.0		3100.0		2200.0		1100.0		1500.0		1200.0		250.0		11479.6		1760		1.4	
GR-01	161		0.610		18.8		49.7		0.022		44.0		790.0		2000.0		1400.0		710.0		1100.0		960.0		170.0		7407.0		2200		1.4	
SR-02	41.3		0.210		11.3		10.1		0.015		3.0		75.0		310.0		240.0		120.0		200.0		170.0		40.0		1204.3		ND		0.29	
CC-02	51.2		4.200		14.9		31		0.000		65.0		1500.0		3000.0		2200.0		950.0		1000.0		910.0		170.0		10355.5		1330		2.80	
MC-02	52.7		0.260		13.1		35.4		0.031		250.0		4100.0		8700.0		6200.0		2600.0		3300.0		2900.0		580.0		29678.0		1730		2.80	
GR-02	34.9		0.660		12.5		41.7		0.034		71.0		1100.0		2700.0		2100.0		910.0		1000.0		980.0		210.0		9382.5		2190		2.90	

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Table 6. Mean PEC-Qs (2005 - 2009)

Site	*Parameter* Metal Mean PEC-Q (2009)	PCB Mean PEC-Q (2009)	PAH Mean PEC-Q (2009)	Mean PEC-Q (2009)	Mean PEC-Q (2005)
Long-term Monitoring Sampling Sites					
TB-49	0.03430	0.00229	0.00543	0.014	0.013
LE-43	0.25801	0.02968	0.18763	0.158	0.166
PIB-07	0.83958	0.08577	0.36553	0.430	0.489
PIB-19	0.73071	0.01430	0.50877	0.418	0.436
PIB-35	0.70374	0.10621	0.47737	0.429	0.735
MB-46	0.49041	0.04914	0.11246	0.217	0.252
CC-26	0.47442	0.14437	1.14259	0.587	0.356
SR-25	0.21493	0.01690	0.22398	0.152	0.197
MC-27	0.23948	0.01561	0.38684	0.214	0.528
Brown Bullhead Sampling Sites					
SR-BH	0.42350	0.04056	0.15557	0.207	
MB-BH	0.72717	0.03901	0.08272	0.283	
LP-BH	0.05880	0.00256	0.00380	0.022	
Stream Sampling Sites					
SR-01	0.16931	0.00281	0.01753	0.063	
CC-01	0.21071	0.01627	0.28622	0.171	
GR-01	0.45801	0.01704	0.32487	0.267	
MC-01	0.26860	0.04166	0.50349	0.271	
SR-02	0.16652	0.00306	0.05282	0.074	
CC-02	0.32099	0.01537	0.45419	0.264	
GR-02	0.21268	0.01980	0.41151	0.215	
MC-02	0.22092	0.01159	1.30167	0.511	

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Table 7. SEM-AVS ratios (2005 - 2009)

Site	SEM (2009)	AVS (2009)	SEM-AVS (2009)	SEM/AVS (2009)	f_{oc} (2009)	SEM-AVS/ f_{oc} (2009)	SEM-AVS (2005)	SEM-AVS/ f_{oc} (2005)
	Parameter							
Long-term Monitoring Sampling Sites								
TB-49	0.2011	1.6	-1.3989	0.1257	0.00272	-514.3015	-0.0604	-144.4976
LE-43	1.2204	2.3	-1.0796	0.5306	0.0139	-77.6691	-1.2531	-158.0999
PIB-07	5.8241	24.9	-19.0759	0.2339	0.0365	-522.6274	-22.588	-442.5549
PIB-19	5.5748	18.1	-12.5252	0.3080	0.0324	-386.5802	-24.96	-3741.007
PIB-35	5.2383	19.0	-13.7617	0.2757	0.0348	-395.4511	-15.819	-430.5661
MB-46	3.0704	38.0	-34.9296	0.0808	0.0633	-551.8104	124.637	-1398.216
CC-26	4.3516	9.2	-4.8484	0.4730	0.0441	-109.9410	-3.4742	-143.0301
SR-25	1.266	0.71	0.556	1.7831	0.0112	49.6429	-0.9971	-125.2481
MC-27	1.5226	1.2	0.3226	1.2688	0.00116	278.1034	1.7284	417.6897
Bullhead Sampling Sites								
SR-BH	4.2224	49.5	-45.2776	0.0853	0.0932	-485.8112		
MB-BH	4.945	215	-210.055	0.0230	0.0892	-2354.8767		
LP-BH	0.2748	2.2	-1.9252	0.1249	0.0046	-418.5217		
Stream Sampling Sites								
SR-01	0.6799	0.64	0.0399	1.0623	0.00115	34.6957		
CC-01	1.8751	1.2	0.6751	1.5626	0.00439	153.7813		
GR-01	1.9443	1.3	0.6443	1.4956	0.00714	90.2381		
MC-01	1.1854	0.8	0.3854	1.4818	0.0157	24.5478		
SR-02	1.0249	0.48	0.5449	2.1352	0.00442	123.2805		
CC-02	1.9433	9.8	-7.8567	0.1983	0.00446	-1761.5919		
GR-02	3.0798	0.88	2.1998	3.4998	0.00991	221.9778		
MC-02	2.4134	2.2	0.2134	1.0970	0.0351	6.0798		

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Table 8. ESB-TUs (2005 - 2009)

	Parameter	
Site	∑ESB-TU (2009)	∑ESB-TU (2005)
Long-term Monitoring Sampling Sites		
TB-49	0.13930	0.200
LE-43	0.79922	1.410
PIB-07	0.61089	0.671
PIB-19	0.94823	2.010
PIB-35	0.81331	0.828
MB-46	0.11217	0.130
CC-26	1.38983	1.450
SR-25	1.08420	2.180
MC-27	16.81238	15.800
Brown Bullhead Sampling Sites		
SR-BH	0.09753	
MB-BH	0.05891	
LP-BH	0.05966	
Stream Sampling Sites		
SR-01	1.07892	
CC-01	3.27354	
GR-01	2.36850	
MC-01	1.56438	
SR-02	0.70003	
CC-02	4.72564	
GR-02	2.04241	
MC-02	1.74374	

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Table 9. Selected toxicity thresholds for whole sediment for evaluating the effects of chemicals of potential concern on the fish[a]

Chemical of Potential Concern	Toxicity Threshold[b]	Type[c]	Source
Metals (mg/kg)			
Barium	NB		
Cadmium	9.6	ERM	Long *et al. 1995*
Lead	218	ERM	Long *et al. 1995*
Mercury	0.71	ERM	Long *et al. 1995*
Nickel	51.6	ERM	Long *et al. 1995*
PAHs (µg/kg)			
Acenaphthene	500	ERM	Long *et al. 1995*
Acenaphthylene	640	ERM	Long *et al. 1995*
Anthracene	1100	ERM	Long *et al. 1995*
Benz(a)anthracene	1600	ERM	Long *et al. 1995*
Benzo(a)pyrene	1600	ERM	Long *et al. 1995*
Chrysene	2800	ERM	Long *et al. 1995*
Dibenz(a,h)anthracene	260	ERM	Long *et al. 1995*
Fluoranthene	5100	ERM	Long *et al. 1995*
Fluorene	540	ERM	Long *et al. 1995*
Phenanthrene	1500	ERM	Long *et al. 1995*
Pyrene	2600	ERM	Long *et al. 1995*
Total PAHs	44792	ERM	Long *et al. 1995*
ESBTU	1.0	ERM	USEPA 2003
PCBs (µg/kg)			
Total PCBs	180	ERM	Long *et al. 1995*
Organochlorine Pesticides (µg/kg)			
Chlordane			Long and Morgan 1991

[a] Table was adapted from Boughton (2006)

[b] NB = no benchmark

[c] ERM = Effects range median

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Table 10. Exceedances of ERM guidelines (2005 - 2009)

Site	Chemical of Potential Concern Exceedance																															
	Barium		Cadmium		Nickel		Lead		Mercury		Acenaphthene		Phenanthrene		Fluoranthene		Pyrene		Benz(a)anthracene		Chrysene		Benzo(a)pyrene		Dibenz(a,h)anthracene		Total PAHs		ESB-TU		Chlordane	
	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005	2009	2005
Long-term Monitoring Sampling Sites																																
TB-49																																X
LE-43																														X		X
PIB-07					X	X																			X	X						X
PIB-19					X	X																			X					X		X
PIB-35						X																		X	X	X						X
MB-46																																X
CC-26													X	X	X		X	X	X		X		X		X		X		X	X		X
SR-25																											X		X	X		X
MC-27												X		X		X		X		X				X		X	X		X	X		X
Brown Bullhead Sampling Sites																																
SR-BH																																
MB-BH																																
LP-BH																																
Stream Sampling Sites																																
SR-01																													X			
CC-01																													X			
GR-01																													X			
MC-01													X																X			
SR-02																																
CC-02													X																X			
GR-02																													X			
MC-02													X		X		X		X		X		X		X				X			

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Table 11. 15-minute acute mixing zone effluent criteria analysis (2009)

	Effluent at Mixing Zone to Target Screening Criteria Ratio							
COPC	PIB-07	PIB-19	PIB-35	MB-46	CC-26	SR-25	MC-27	Mean
Metals								
Barium[a]	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.99988	0.99985	0.99987	0.99983	0.99963	0.99948	0.999760	0.99974
Lead	0.01451	0.01426	0.01436	0.01434	0.01413	0.01298	0.027055	0.01430
Mercury	0.69422	0.69421	0.69420	0.69403	0.69413	0.69406	0.693835	0.69410
Nickel	0.09089	0.09089	0.09088	0.09087	0.09088	0.09087	0.091248	0.09088
PAHs								
Acenaphthene	0.00002	0.00003	0.00003	0.00000	0.00006	0.00003	0.000982	0.00003
Acenaphthylene[b]	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene[b]	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.00640	0.01007	0.00937	0.00116	0.01418	0.00816	0.128655	0.00877
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	0.00005	0.00008	0.00007	0.00001	0.00014	0.00011	0.001894	0.00008
Fluorene[b]	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	0.00159	0.00231	0.00243	0.00027	0.00485	0.00342	0.086639	0.00263
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA
PCBs								
Total PCBs[b]	NA	NA	NA	NA	NA	NA	NA	NA

[a] Barium was not assessed in 2005

[b] Acenaphthylene, anthracene, fluorene, and total PCBs did not exceed SQGs in 2009

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Table 12. 12-hour chronic mixing zone effluent criteria analysis (2009)

	Effluent at Mixing Zone to Target Screening Criteria Ratio							
COPC	PIB-07	PIB-19	PIB-35	MB-46	CC-26	SR-25	MC-27	Mean
Metals								
Barium[a]	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.999967	0.999957	0.99996	0.99995	0.99990	0.999855	0.99993	0.99993
Lead	0.335662	0.333874	0.33457	0.33447	0.33295	0.324834	0.42405	0.33415
Mercury	0.999911	0.999907	0.99990	0.99984	0.99987	0.999849	0.99976	0.99986
Nickel	0.819623	0.819616	0.81961	0.81958	0.81959	0.819566	0.82052	0.81959
PAHs								
Acenaphthene	0.000030	0.000043	0.00004	0.00001	0.00008	0.000041	0.00133	0.00004
Acenaphthylene[b]	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene[b]	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.008856	0.013921	0.01296	0.00160	0.01960	0.011281	0.17791	0.01213
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	0.000073	0.000111	0.00010	0.00001	0.00019	0.000151	0.00262	0.00011
Fluorene[b]	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	0.002196	0.003198	0.00337	0.00037	0.00671	0.004735	0.11981	0.00364
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA
PCBs								
Total PCBs[b]	NA	NA	NA	NA	NA	NA	NA	NA

[a] Barium was not assessed in 2005

[b] Acenaphthylene, anthracene, fluorene, and total PCBs did not exceed SQGs in 2009

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Table 13. 15-minute acute mixing zone effluent criteria analysis (2005)

	Effluent at Mixing Zone to Target Screening Criteria Ratio								
COPC	PIB-07	PIB-19	PIB-35	MB-46	CC-26	SR-25	MC-27	Mean A[c]	Mean B[d]
Metals									
Barium[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.99981	0.99984	0.99988	0.99971	0.99935	0.99935	1.007731	1.00125	0.99970
Lead	0.01385	0.01358	0.01418	0.01351	0.01595	0.01299	0.040192	0.01454	0.01412
Mercury	0.69424	0.69423	0.69420	0.69415	0.69392	0.69394	0.694088	0.69405	0.69408
Nickel	0.09089	0.09089	0.09089	0.09088	0.09088	0.09088	0.091676	0.09088	0.09088
PAHs									
Acenaphthene	0.00002	0.00007	0.00004	0.00000	0.00017	0.00025	0.002201	0.00004	0.00008
Acenaphthylene[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.00639	0.01754	0.00962	0.00098	0.01343	0.05126	0.128655	0.00653	0.01007
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	0.00004	0.00016	0.00005	0.00001	0.00012	0.00022	0.001308	0.00005	0.00007
Fluorene[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	0.00114	0.01127	0.00231	0.00019	0.00882	0.00517	0.023855	0.00280	0.00267
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCBs									
Total PCBs[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a] Barium was not assessed in 2005

[b] Acenaphthylene, anthracene, fluorene, and total PCBs did not exceed SQGs in 2009

[c] Mean A represents mean ratio of 18 sites with SQG exceedances in 2005 (Boughton 2006)

[d] Mean B represents mean ratio of long-term monitoring sites (PIB07, PIB19, PIB35, MB46, CC26, SR25, MC27)

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Table 14. 12-hour chronic mixing zone effluent criteria analysis (2005)

	Effluent at Mixing Zone to Target Screening Criteria Ratio								
COPC	PIB-07	PIB-19	PIB-35	MB-46	CC-26	SR-25	MC-27	Mean A[c]	Mean B[d]
Metals									
Barium[a]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.99995	0.99995	0.99997	0.99992	0.99982	0.99982	1.002138	0.00898	0.99992
Lead	0.33098	0.32905	0.33331	0.32857	0.34578	0.32489	0.516638	0.33587	0.33290
Mercury	0.99992	0.99992	0.99990	0.99988	0.99979	0.99980	0.999858	0.99984	0.99985
Nickel	0.81962	0.81962	0.81961	0.81960	0.81960	0.81960	0.821583	0.81960	0.81959
PAHs									
Acenaphthene	0.00003	0.00009	0.00005	0.00000	0.00023	0.00034	0.002972	0.00005	0.00011
Acenaphthylene[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(a)anthracene	0.00884	0.02425	0.01330	0.00135	0.01857	0.07088	0.177907	0.00904	0.01392
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	0.00006	0.00022	0.00007	0.00001	0.00016	0.00030	0.001808	0.00007	0.00010
Fluorene[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenanthrene	0.00157	0.01558	0.00319	0.00026	0.01219	0.00715	0.032987	0.00388	0.00369
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA
PCBs									
Total PCBs[b]	NA	NA	NA	NA	NA	NA	NA	NA	NA

[a] Barium was not assessed in 2005

[b] Acenaphthylene, anthracene, fluorene, and total PCBs did not exceed SQGs in 2009

[c] Mean A represents mean ratio of 18 sites with SQG exceedances in 2005 (Boughton 2006)

[d] Mean B represents mean ratio of long-term monitoring sites (PIB07, PIB19, PIB35, MB46, CC26, SR25, MC27)

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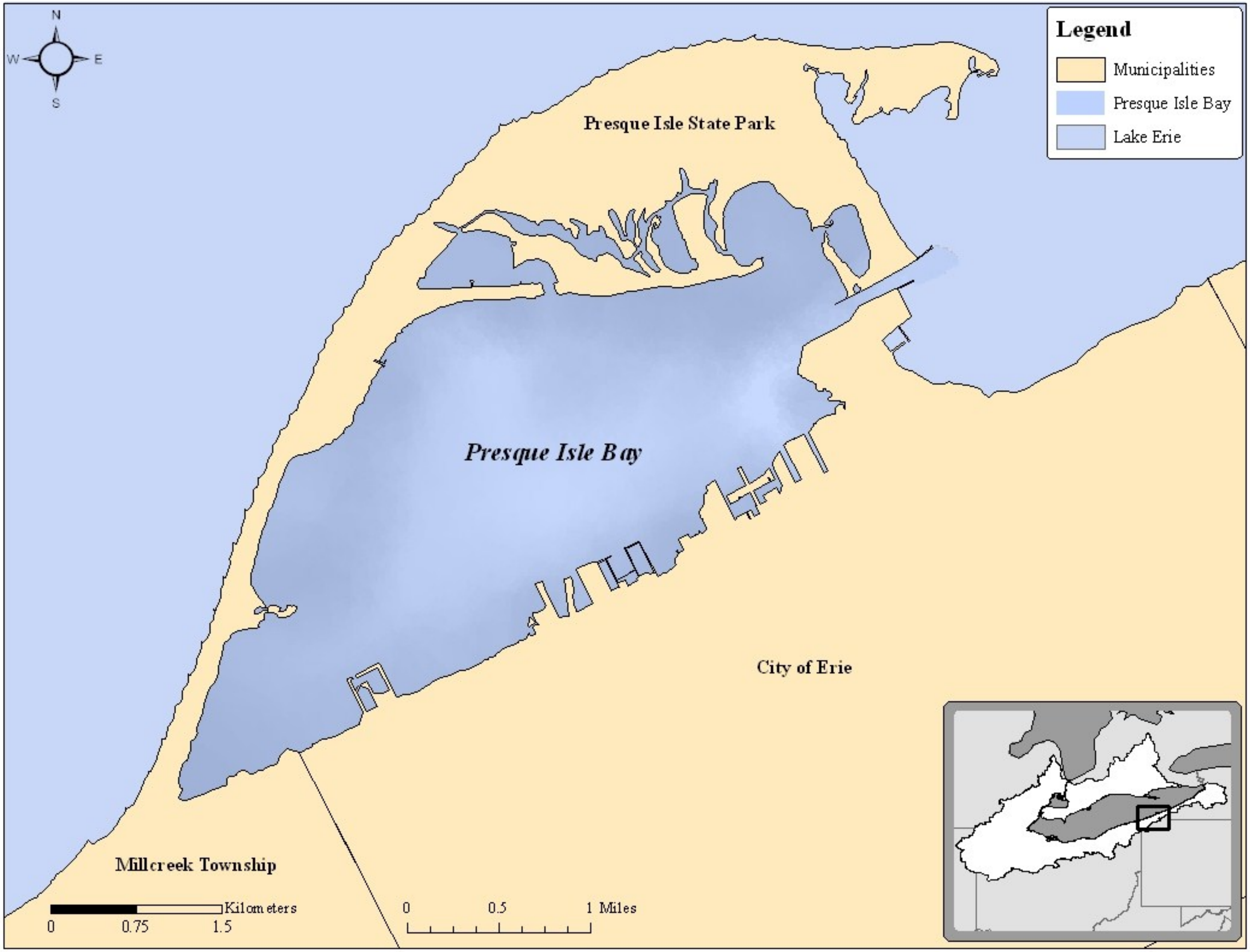
APPENDIX C: MAPS

Map 1: Presque Isle Bay



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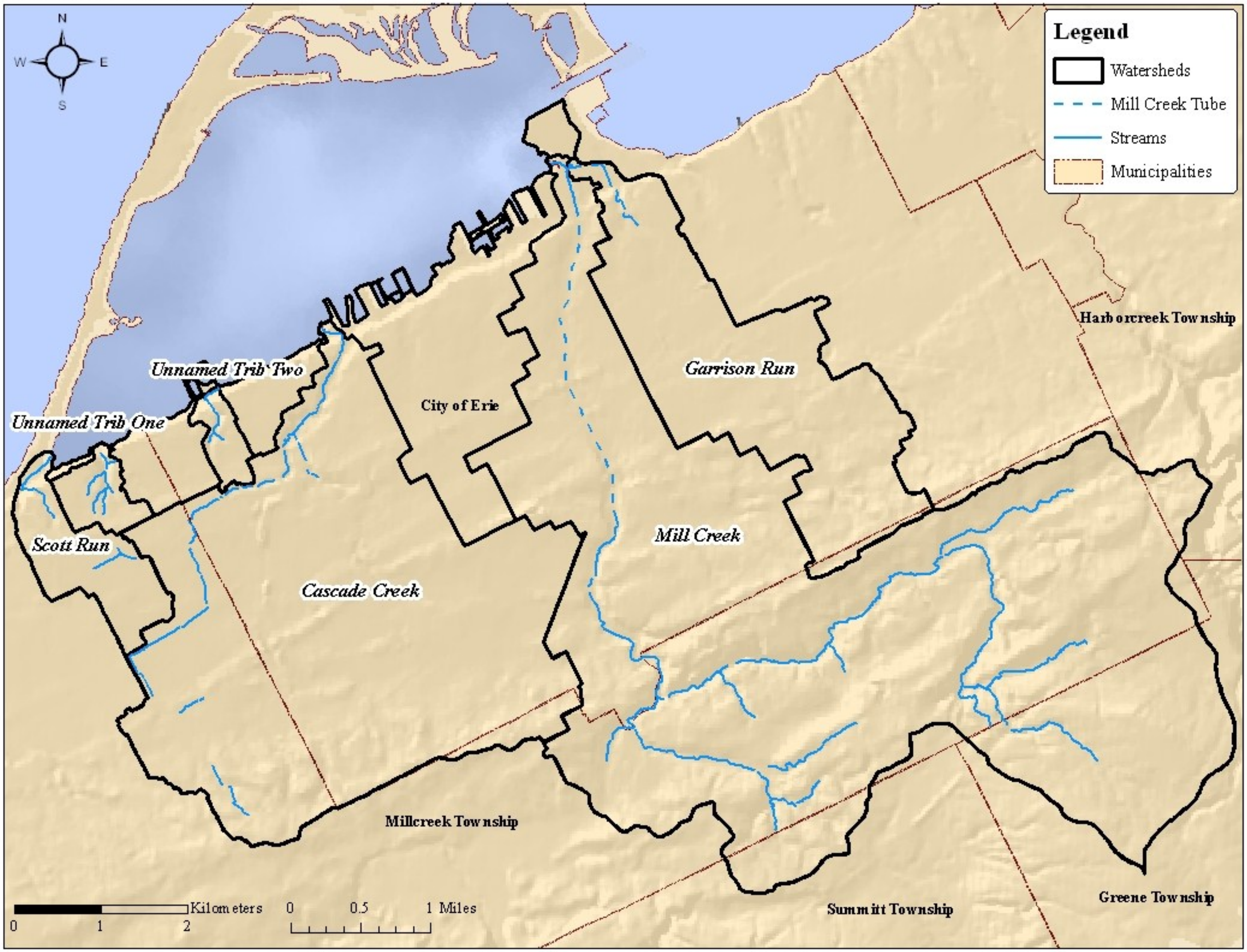
Map 2: Tributaries of Presque Isle Bay



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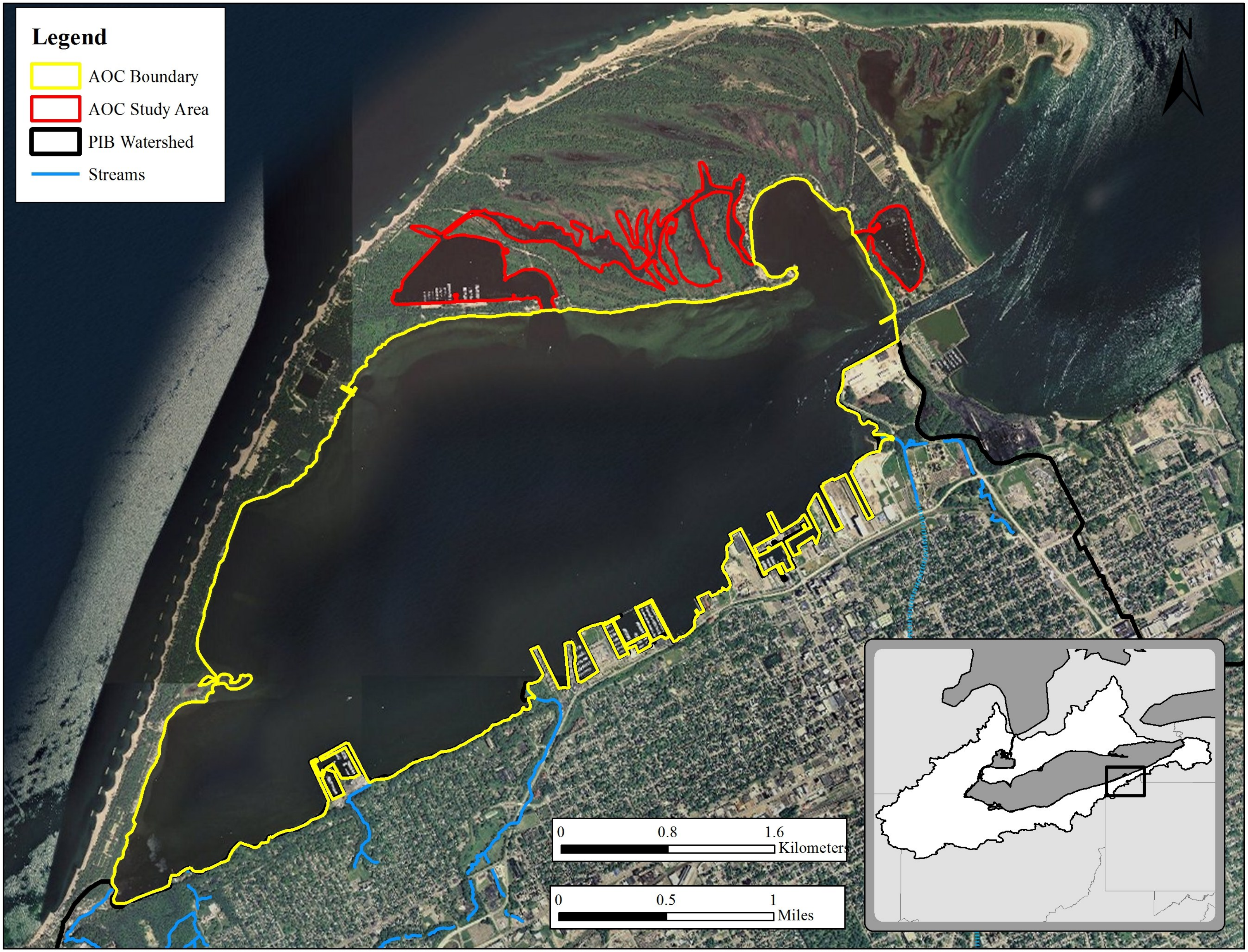
Map 3: Presque Isle Bay Area of Concern



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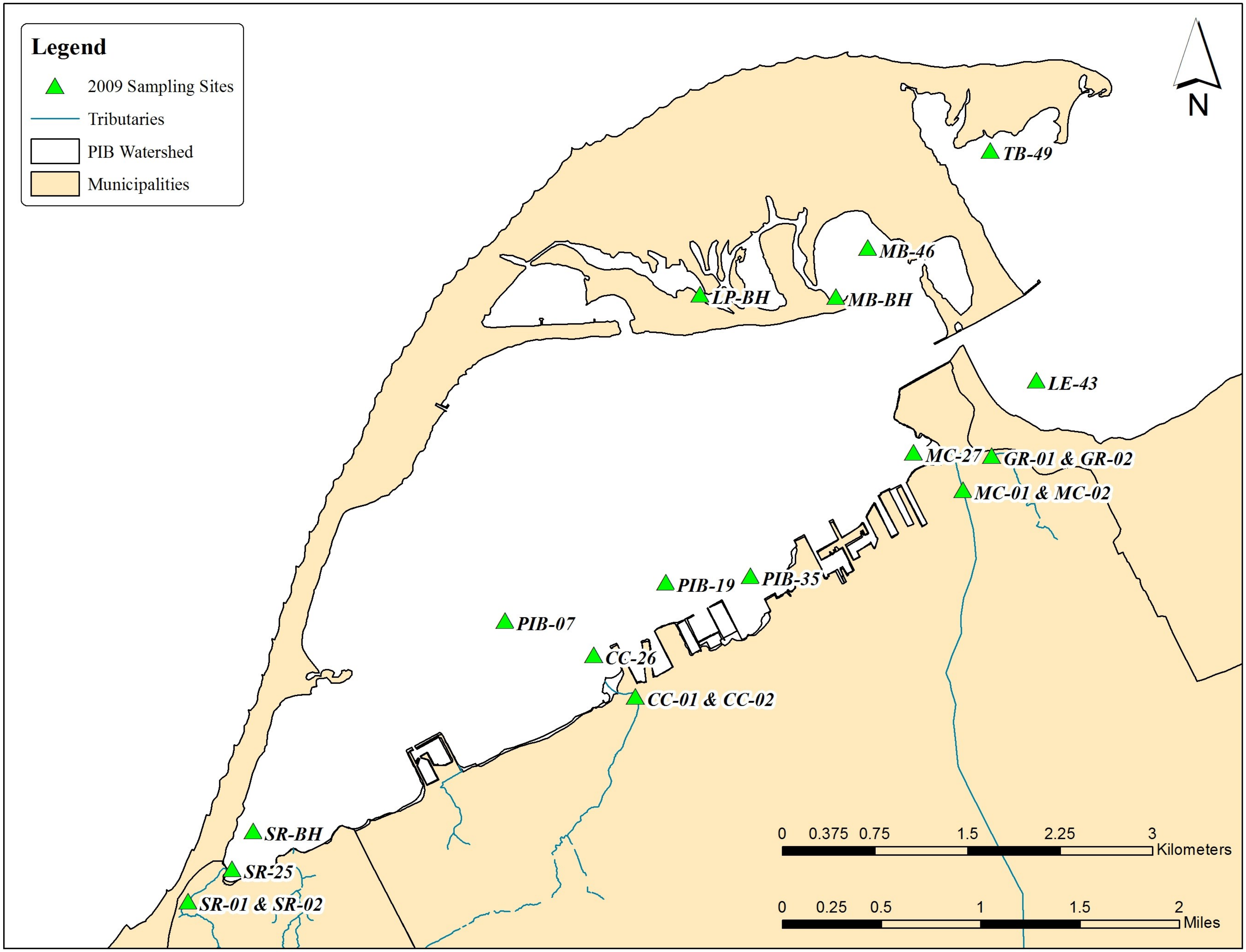
Map 4: 2009 Sediment Sampling Locations



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APPENDIX D: 2011 SEDIMENT CHEMISTRY DATA

Appendix D-1. Pesticide data (2009)

Site	Aldrin	gamma-BHC	Chlordane	4,4'-DDD	2,4'-DDD	Sum DDD	4,4'-DDE	2,4'-DDE	Sum DDE	4,4'-DDT	2,4'-DDT	Sum DDT	Total DDT
	Pesticide (µg/kg)												
Brown Bullhead Sampling Sites													
SR-BH	1.00	2.20	ND	1.20	ND	1.330	3.00	ND	3.210	4.10	ND	4.290	8.830
LP-BH	ND	0.18	ND	ND	ND	0.123	0.20	ND	0.260	0.18	ND	0.236	0.619
MB-BH	ND	1.70	ND	0.85	3.10	3.950	3.60	ND	3.820	6.00	ND	6.200	13.970
Long-term Monitoring Sampling Sites													
MC-27	ND	2.70	ND	0.45	0.92	1.370	1.30	ND	1.360	7.80	0.65	7.856	10.586
PIB-07	0.51	1.60	ND	2.20	6.40	8.600	6.10	ND	6.250	11.00	ND	11.140	25.990
PIB-19	1.00	1.60	ND	2.20	ND	2.280	6.20	ND	6.320	9.50	ND	9.620	18.220
PIB-35	ND	ND	ND	3.20	7.60	10.800	8.70	ND	8.810	12.00	ND	12.100	31.710
LE-43	0.20	1.20	ND	0.59	1.90	2.490	1.70	ND	1.757	3.10	ND	3.153	7.400
TB-49	ND	0.16	ND	ND	ND	0.123	ND	ND	0.157	ND	ND	0.151	0.431
MB-46	ND	1.50	ND	0.83	2.40	3.230	1.40	ND	1.570	5.10	ND	5.260	10.060
CC-26	ND	0.87	ND	3.30	17.00	20.300	8.10	ND	8.460	20.00	ND	20.330	49.090
SR-25	29.00	4.90	ND	1.60	ND	1.639	0.41	ND	0.471	ND	ND	0.155	2.265
Stream Sampling Sites													
SR-01	ND	0.48	ND	0.13	ND	0.166	ND	ND	0.145	ND	ND	0.140	0.451
CC-01	ND	13.00	ND	ND	0.95	1.380	ND	ND	0.810	ND	ND	0.770	2.960
MC-01	ND	1.60	ND	5.60	0.47	6.070	ND	ND	0.790	ND	ND	0.760	7.620
GR-01	ND	4.30	ND	2.40	0.63	3.030	ND	ND	0.770	ND	ND	0.750	4.550
SR-02	ND	0.80	ND	ND	ND	0.130	ND	ND	0.160	ND	ND	0.160	0.450
CC-02	ND	1.40	ND	ND	ND	1.230	ND	ND	0.700	ND	ND	1.510	3.440
MC-02	ND	10.00	ND	ND	ND	1.200	ND	ND	1.530	ND	ND	1.480	4.210
GR-02	ND	8.30	ND	ND	ND	1.270	ND	ND	1.620	ND	ND	1.560	4.450

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Appendix D-1 (*cntd). Pesticide data (2009)*

Site	Dieldrin	Endosulfan I	Endosulfan II	Endrin	Heptachlor	Heptachlor epoxide	Hexachlorobenzene	Hexachlorocyclopentadiene	Methoxychlor
	Pesticide (µg/kg)								
Brown Bullhead Sampling Sites									
SR-BH	0.69	ND	ND	ND	ND	ND	ND	ND	ND
LP-BH	ND	ND	ND	ND	0.45	ND	ND	ND	30.0
MB-BH	0.63	ND	ND	ND	1.30	ND	ND	ND	ND
Long-term Monitoring Sampling Sites									
MC-27	1.80	ND	ND	ND	0.92	ND	ND	ND	ND
PIB-07	1.30	ND	ND	ND	ND	0.35	ND	ND	ND
PIB-19	1.40	ND	ND	ND	ND	ND	ND	ND	ND
PIB-35	2.10	ND	0.65	ND	1.40	ND	ND	ND	9.6
LE-43	0.34	ND	ND	ND	ND	ND	ND	ND	2.7
TB-49	ND	ND	ND	ND	0.34	ND	ND	ND	ND
MB-46	0.45	ND	ND	ND	ND	ND	ND	ND	ND
CC-26	5.50	ND	ND	ND	1.90	ND	ND	ND	19.0
SR-25	3.30	ND	3.60	1.20	12.00	0.39	2400	ND	ND
Stream Sampling Sites									
SR-01	1.40	ND	ND	ND	0.72	0.15	ND	ND	ND
CC-01	2.30	ND	ND	1.30	1.60	ND	ND	ND	ND
MC-01	1.40	ND	ND	1.20	0.96	ND	2.0	ND	ND
GR-01	2.10	ND	ND	0.86	1.10	ND	ND	ND	ND
SR-02	0.95	ND	ND	ND	0.43	0.15	ND	ND	ND
CC-02	2.80	ND	ND	ND	ND	ND	ND	ND	ND
MC-02	1.10	ND	ND	ND	ND	ND	ND	ND	ND
GR-02	2.20	ND	ND	ND	2.30	ND	ND	ND	ND

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Appendix D-1 (*cntd*). *Pesticide data (2009)*

Site	Pesticide (µg/kg) Mirex	Hexachlorobutadi-ene	trans-nonachlor
Brown Bullhead Sampling Sites			
SR-BH	ND	ND	0.51
LP-BH	ND	ND	ND
MB-BH	ND	ND	ND
Long-term Monitoring Sites			
MC-27	0.43	ND	0.89
PIB-07	ND	ND	2.40
PIB-19	ND	ND	2.40
PIB-35	0.81	ND	2.80
LE-43	ND	ND	ND
TB-49	ND	ND	ND
MB-46	ND	ND	ND
CC-26	2.00	ND	7.50
SR-25	ND	ND	ND
Stream Sampling Sites			
SR-01	ND	ND	0.10
CC-01	ND	ND	0.57
MC-01	0.88	ND	0.96
GR-01	ND	ND	0.78
SR-02	ND	ND	ND
CC-02	ND	ND	ND
MC-02	ND	ND	ND
GR-02	ND	ND	ND

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Appendix D-2: Polychlorinated biphenyl (PCB) data (2009)

	PCB (µg/kg)												
Site	PCB 8	PCB 18	PCB 28	PCB 44	PCB 52	PCB 66	PCB 87	PCB 101	PCB 105	PCB 118	PCB 128	PCB 138	PCB 153
Brown Bullhead Sampling Sites													
SR-BH	ND	ND	1.80	1.80	2.30	1.500	1.600	3.300	1.800	ND	2.000	4.800	1.300
LP-BH	ND	ND	0.11	ND	ND	ND	0.075	0.160	ND	ND	ND	0.260	0.210
MB-BH	ND	0.86	2.80	ND	1.20	2.900	1.600	2.100	1.200	ND	1.400	5.400	0.310
Long-term Monitoring Sampling Sites													
MC-27	ND	1.20	1.60	1.20	1.30	0.760	0.500	1.000	0.380	ND	0.350	0.860	0.320
PIB-07	ND	ND	3.80	2.80	4.00	3.900	3.000	5.900	3.900	ND	5.400	8.300	ND
PIB-19	ND	ND	6.00	ND	ND	ND	0.220	ND	ND	ND	ND	ND	ND
PIB-35	ND	ND	4.40	3.70	5.90	4.500	3.600	8.500	3.300	ND	5.200	10.000	ND
LE-43	ND	ND	2.20	1.30	1.50	1.700	1.300	2.200	2.400	ND	1.300	3.500	ND
TB-49	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MB-46	ND	ND	2.50	1.50	2.00	2.400	1.500	3.300	2.000	ND	2.900	6.500	ND
CC-26	ND	ND	1.40	5.80	12.00	ND	11.000	12.000	10.000	ND	8.300	23.000	ND
SR-25	ND	1.70	2.10	1.10	1.00	0.700	0.330	0.620	0.220	ND	0.670	0.920	0.280
Stream Sampling Sites													
SR-01	ND	0.43	0.34	ND	0.17	0.088	0.058	0.090	ND	ND	ND	ND	0.120
CC-01	ND	ND	ND	0.56	1.30	ND	1.100	1.900	0.750	ND	0.850	1.500	ND
MC-01	ND	0.64	0.92	0.69	0.91	ND	0.820	1.900	ND	ND	4.700	4.200	ND
GR-01	ND	1.00	1.40	1.20	1.10	ND	0.660	1.000	0.380	ND	0.760	1.300	ND
SR-02	0.23	0.27	0.36	0.18	0.17	0.130	0.055	0.084	0.047	ND	0.072	0.099	ND
CC-02	ND	0.13	0.15	0.52	1.00	ND	1.100	1.700	0.840	ND	0.910	2.400	ND
MC-02	ND	0.45	0.78	0.72	0.87	0.740	0.520	0.740	0.500	ND	0.540	0.990	ND
GR-02	ND	1.00	1.40	1.20	1.30	0.920	0.680	1.100	0.530	ND	0.860	2.000	ND

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Appendix D-2 (*cntd): Polychlorinated biphenyl (PCB) data (2009)*

	PCB (µg/kg)						
Site	PCB 170	PCB 180	PCB 187	PCB 195	PCB 206	PCB 209	Total PCB
Brown Bullhead Sampling Sites							
SR-BH	1.50	ND	1.800	ND	ND	ND	27.420
LP-BH	0.10	ND	0.081	ND	ND	ND	1.728
MB-BH	1.40	ND	3.100	ND	ND	ND	26.370
Long-term Monitoring Sampling Sites							
MC-27	0.33	ND	0.370	ND	0.08	ND	10.549
PIB-07	4.80	ND	5.700	1.000	3.00	1.500	57.980
PIB-19	0.77	ND	ND	ND	ND	ND	9.670
PIB-35	6.90	ND	6.700	2.500	4.50	1.400	71.800
LE-43	0.85	ND	0.960	ND	0.32	ND	20.062
TB-49	0.58	ND	ND	ND	ND	ND	1.140
MB-46	2.60	ND	3.000	0.390	1.10	ND	33.220
CC-26	5.00	ND	4.500	0.890	2.60	0.560	97.593
SR-25	0.57	ND	0.670	0.088	0.19	ND	11.422
Stream Sampling Sites							
SR-01	0.06	ND	ND	ND	0.11	ND	1.902
CC-01	0.42	ND	0.580	ND	ND	ND	11.000
MC-01	4.90	ND	4.900	1.300	0.74	ND	28.160
GR-01	0.44	ND	0.490	ND	0.29	ND	11.520
SR-02	0.06	ND	ND	ND	ND	ND	2.069
CC-02	0.58	ND	0.460	0.130	0.18	0.080	10.393
MC-02	0.36	ND	ND	0.110	0.19	0.076	7.835
GR-02	0.69	ND	0.630	0.190	0.58	0.150	13.388

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Appendix D-3: Metal data (2009)

Site	Metal (mg/kg)										
	Arsenic	Barium	Berrylium	Cadmium	Chromium	Copper	Nickel	Lead	Antimony	Zinc	Mercury
Brown Bullhead Sampling Sites											
SR-BH	12.8	80.5	0.400	1.900	24.1	55.1	29.9	51.5	0.680	161.0	0.150
LP-BH	7.6	7.4	0.058	0.084	3.1	2.2	3.9	3.4	0.089	15.7	ND
MB-BH	25.2	92.7	0.500	4.100	33.4	63.5	38.1	101.0	1.100	218	1.400
Long-term Monitoring Sampling Sites											
MC-27	7.7	42.7	0.250	0.440	17.8	23.4	15.6	65.6	0.190	84.5	0.020
PIB-07	17.2	113	0.940	6.400	57.5	97.5	61.0	145.0	1.000	343.0	0.380
PIB-19	15.4	102	0.780	5.500	48.4	81.9	51.8	122.0	0.880	297.0	0.370
PIB-35	14.0	86.3	0.710	6.100	47.7	80.7	48.4	124.0	1.100	285.0	0.370
LE-43	10.9	38.5	0.440	0.990	18.3	29.5	25.5	24.0	0.270	116.0	0.075
TB-49	2.5	4.0	0.054	0.031	2.5	3.1	3.6	1.9	0.084	13.1	ND
MB-46	17.1	80.6	0.460	3.700	28.8	47.6	29.3	68.5	0.900	160.0	0.210
CC-26	11.4	70.0	0.430	1.700	29.1	82.8	31.8	93.0	1.100	255.0	0.098
SR-25	11.4	41.6	0.230	0.310	10.6	29.8	16.6	19.7	0.280	103.0	0.023
Stream Sampling Sites											
SR-01	8.9	31.8	0.190	0.220	9.5	18.9	16.6	11.4	0.190	77.3	ND
CC-01	7.8	33.5	0.220	0.250	17.2	29.7	20.0	22.9	0.350	125.0	ND
MC-01	6.3	54.1	0.300	0.320	20.3	30.2	19.9	52.9	0.400	133.0	0.016
GR-01	9.6	161	0.210	0.610	24.1	25.3	18.8	49.7	0.380	131.0	0.022
SR-02	9.7	41.3	0.220	0.210	6.5	16.1	11.3	10.1	0.110	66.2	0.015
CC-02	6.1	51.2	0.280	4.200	13	21.5	14.9	31	0.270	219.0	ND
MC-02	7.4	52.7	0.320	0.260	15.1	20.8	13.1	35.4	0.270	88.4	0.031
GR-02	6.7	34.9	0.310	0.660	16.7	25.8	12.5	41.7	0.510	115.0	0.034

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Appendix D-4: Polycyclic Aromatic Hydrocarbon (PAH) data (2009)

	PAH (µg/kg)						
Site	Naphthalene	C1-Naphthalenes	C2-Naphthalenes	C3-Naphthalenes	C4-Naphthalenes	2-Methylnaphthalene	1-Methylnaphthalene
Brown Bullhead Sampling Sites							
SR-BH	28.0	17.0	74.0	49.0	45.0	28.0	28.0
LP-BH	3.7	3.7	6.0	3.7	3.7	3.7	3.7
MB-BH	24.0	28.0	92.0	59.0	52.0	23.0	19.0
Long-term Monitoring Sampling Sites							
MC-27	17.0	29.0	170.0	220.0	130.0	22.0	24.0
PIB-07	65.0	84.0	320.0	300.0	180.0	73.0	58.0
PIB-19	82.0	110.0	420.0	410.0	270.0	95.0	75.0
PIB-35	91.0	100.0	360.0	420.0	220.0	92.0	74.0
LE-43	87.0	41.0	170.0	210.0	190.0	33.0	28.0
TB-49	3.1	3.1	3.1	3.1	3.1	3.1	3.1
MB-46	25.0	28.0	110.0	110.0	69.0	24.0	20.0
CC-26	84.0	100.0	380.0	230.0	240.0	79.0	69.0
SR-25	17.0	15.0	44.0	32.0	55.0	11.0	9.2
Stream Sampling Sites							
SR-01	2.8	2.8	6.0	7.2	46.0	2.8	2.8
CC-01	7.3	12.0	51.0	40.0	44.0	9.7	7.7
MC-01	19.0	26.0	96.0	67.0	66.0	22.0	19.0
GR-01	7.1	15.0	66.0	56.0	71.0	13.0	8.7
SR-02	9.9	9.9	7.1	9.7	25.0	9.9	9.9
CC-02	6.5	16.0	65.0	58.0	51.0	13.0	11.0
MC-02	30.0	65.0	170.0	120.0	61.0	49.0	43.0
GR-02	13.0	19.0	65.0	55.0	60.0	15.0	14.0

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Appendix D-4 (*cntd)*: *Polycyclic Aromatic Hydrocarbon (PAH) data (2009)*

	PAH (µg/kg)						
Site	Biphenyl	2,6 Dimethylnaphthalene	Acenaphthylene	Acenaphthene	2,3,5 Trimethylnaphthalene	Fluorene	C1-Fluorenes
Brown Bullhead Sampling Sites							
SR-BH	28.0	28.0	28.0	28.0	28.0	36.0	24.0
LP-BH	3.7	3.7	3.7	3.7	3.7	3.7	3.7
MB-BH	18.0	19.0	18.0	18.0	18.0	21.0	18.0
Long-term Monitoring Sampling Sites							
MC-27	6.3	22.0	14.0	70.0	33.0	97.0	50.0
PIB-07	56.0	47.0	23.0	53.0	49.0	80.0	54.0
PIB-19	17.0	60.0	29.0	68.0	64.0	96.0	71.0
PIB-35	17.0	58.0	29.0	72.0	55.0	100.0	64.0
LE-43	7.2	24.0	12.0	30.0	38.0	60.0	35.0
TB-49	3.1	3.1	3.1	3.1	3.1	3.1	3.1
MB-46	17.0	19.0	17.0	17.0	17.0	27.0	23.0
CC-26	25.0	55.0	28.0	170.0	55.0	210.0	92.0
SR-25	4.6	6.4	3.7	24.0	6.4	41.0	24.0
Stream Sampling Sites							
SR-01	2.8	2.8	2.8	2.8	2.8	3.0	6.2
CC-01	3.0	7.7	4.8	54.0	8.5	60.0	21.0
MC-01	7.1	16.0	8.6	100.0	15.0	130.0	39.0
GR-01	54.0	12.0	6.9	44.0	12.0	56.0	28.0
SR-02	9.9	9.9	9.9	3.0	2.6	4.6	5.1
CC-02	3.3	12.0	81.0	65.0	16.0	110.0	22.0
MC-02	16.0	32.0	19.0	250.0	27.0	380.0	78.0
GR-02	4.7	12.0	4.5	71.0	13.0	89.0	22.0

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Appendix D-4 (*cntd): Polycyclic Aromatic Hydrocarbon (PAH) data (2009)*

Site	PAH (µg/kg) C2-Fluorenes	C3-Fluorenes	Dibenzothiophene	C1-Dibenzothiophenes	C2-Dibenzothiophenes	C3-Dibenzothiophenes	Phenanthrene
Brown Bullhead Sampling Sites							
SR-BH	27.0	59.0	19.0	19.0	27.0	34.0	340.0
LP-BH	3.7	3.7	3.7	3.7	3.7	3.7	5.9
MB-BH	24.0	27.0	18.0	18.0	24.0	23.0	150.0
Long-term Monitoring Sampling Sites							
MC-27	54.0	50.0	64.0	44.0	64.0	38.0	1100.0
PIB-07	73.0	56.0	47.0	53.0	86.0	99.0	650.0
PIB-19	95.0	120.0	60.0	67.0	120.0	150.0	840.0
PIB-35	94.0	96.0	61.0	67.0	96.0	120.0	950.0
LE-43	56.0	81.0	30.0	35.0	54.0	62.0	440.0
TB-49	3.1	3.1	3.1	3.1	3.1	3.1	3.3
MB-46	30.0	38.0	17.0	18.0	32.0	43.0	190.0
CC-26	130.0	270.0	140.0	93.0	130.0	150.0	2400.0
SR-25	35.0	66.0	28.0	20.0	33.0	36.0	460.0
Stream Sampling Sites							
SR-01	16.0	30.0	3.3	6.4	12.0	9.0	39.0
CC-01	24.0	33.0	47.0	33.0	43.0	35.0	860.0
MC-01	36.0	52.0	79.0	34.0	35.0	24.0	1600.0
GR-01	35.0	41.0	43.0	27.0	35.0	41.0	790.0
SR-02	13.0	36.0	4.3	8.4	14.0	14.0	75.0
CC-02	25.0	41.0	80.0	40.0	33.0	22.0	1500.0
MC-02	75.0	130.0	200.0	110.0	79.0	59.0	4100.0
GR-02	26.0	42.0	54.0	41.0	42.0	38.0	1100.0

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Appendix D-4 (*cntd*): *Polycyclic Aromatic Hydrocarbon (PAH) data (2009)*

	PAH (µg/kg)					
Site	Anthracene	C1-Phenan/anthracenes	C2-Phenan/anthracenes	C3-Phenan/anthracenes	C4-Phenan/anthracenes	1-Methylphenanthrene
Brown Bullhead Sampling Sites						
SR-BH	39.0	160.0	120.0	84.0	39.0	26.0
LP-BH	3.7	4.7	5.8	5.5	3.7	3.7
MB-BH	26.0	100.0	110.0	86.0	45.0	22.0
Long-term Monitoring Sampling Sites						
MC-27	180.0	390.0	260.0	160.0	58.0	87.0
PIB-07	110.0	400.0	350.0	280.0	150.0	92.0
PIB-19	160.0	520.0	480.0	380.0	210.0	120.0
PIB-35	160.0	500.0	430.0	330.0	180.0	96.0
LE-43	97.0	230.0	210.0	150.0	81.0	61.0
TB-49	3.1	3.1	3.1	3.1	3.1	3.1
MB-46	39.0	130.0	130.0	110.0	54.0	29.0
CC-26	360.0	790.0	560.0	390.0	200.0	130.0
SR-25	60.0	160.0	140.0	120.0	54.0	27.0
Stream Sampling Sites						
SR-01	4.5	34.0	47.0	49.0	22.0	5.4
CC-01	130.0	240.0	160.0	95.0	35.0	49.0
MC-01	250.0	370.0	200.0	100.0	28.0	69.0
GR-01	150.0	250.0	160.0	100.0	43.0	47.0
SR-02	12.0	39.0	36.0	41.0	25.0	9.4
CC-02	350.0	300.0	100.0	62.0	29.0	66.0
MC-02	570.0	810.0	250.0	120.0	43.0	180.0
GR-02	190.0	310.0	130.0	72.0	35.0	68.0

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Appendix D-4 (*cntd):* *Polycyclic Aromatic Hydrocarbon (PAH) data (2009)*

Site	PAH (µg/kg) Fluoranthene	Pyrene	C1-Fluoran/pyrenes	C2-Fluoran/pyrenes	C3-Fluoran/pyrenes	Benzo(a)anthracene	Chrysene	C1-Chrysenes
Brown Bullhead Sampling Sites								
SR-BH	860.0	630.0	320.0	110.0	56.0	350.0	560.0	240.0
LP-BH	16.0	13.0	8.4	3.8	3.7	6.0	11.0	8.7
MB-BH	480.0	370.0	220.0	88.0	50.0	180.0	280.0	180.0
Long-term Monitoring Sampling Sites								
MC-27	2500.0	2000.0	790.0	240.0	140.0	820.0	990.0	400.0
PIB-07	2200.0	1800.0	970.0	400.0	260.0	860.0	1000.0	590.0
PIB-19	3000.0	2500.0	1300.0	540.0	350.0	1400.0	1500.0	820.0
PIB-35	2900.0	2400.0	1200.0	460.0	290.0	1200.0	1300.0	710.0
LE-43	1100.0	810.0	410.0	150.0	91.0	480.0	580.0	250.0
TB-49	19.0	15.0	7.9	3.1	3.1	13.0	30.0	7.6
MB-46	690.0	530.0	310.0	130.0	80.0	270.0	340.0	210.0
CC-26	7100.0	5200.0	2100.0	790.0	410.0	2300.0	3900.0	1300.0
SR-25	1500.0	1100.0	400.0	140.0	73.0	360.0	790.0	220.0
Stream Sampling Sites								
SR-01	110.0	82.0	33.0	16.0	11.0	26.0	66.0	26.0
CC-01	1800.0	1300.0	510.0	180.0	74.0	590.0	850.0	350.0
MC-01	3100.0	2200.0	630.0	190.0	69.0	1100.0	1500.0	420.0
GR-01	2000.0	1400.0	550.0	200.0	96.0	710.0	1100.0	450.0
SR-02	310.0	240.0	74.0	44.0	28.0	120.0	200.0	80.0
CC-02	3000.0	2200.0	570.0	180.0	100.0	950.0	1000.0	390.0
MC-02	8700.0	6200.0	1500.0	480.0	240.0	2600.0	3300.0	1100.0
GR-02	2700.0	2100.0	630.0	240.0	130.0	910.0	1000.0	430.0

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Appendix D-4 (*cntd): Polycyclic Aromatic Hydrocarbon (PAH) data (2009)*

	PAH (µg/kg)						
Site	C2-Chrysenes	C3-Chrysenes	C4-Chrysenes	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(e)pyrene	Benzo(a)pyrene
Brown Bullhead Sampling Sites							
SR-BH	170.0	70.0	19.0	710.0	480.0	450.0	500.0
LP-BH	7.1	3.7	3.7	9.1	12.0	9.0	8.8
MB-BH	130.0	64.0	18.0	240.0	310.0	220.0	250.0
Long-term Monitoring Sampling Sites							
MC-27	200.0	110.0	17.0	870.0	760.0	660.0	840.0
PIB-07	440.0	250.0	70.0	1400.0	1000.0	990.0	1100.0
PIB-19	600.0	330.0	92.0	1900.0	1600.0	1300.0	1500.0
PIB-35	560.0	270.0	62.0	1900.0	1200.0	1200.0	1300.0
LE-43	170.0	89.0	16.0	610.0	410.0	370.0	450.0
TB-49	3.9	3.1	3.1	33.0	34.0	29.0	20.0
MB-46	160.0	87.0	20.0	480.0	320.0	280.0	320.0
CC-26	790.0	360.0	100.0	4700.0	3100.0	2800.0	3300.0
SR-25	150.0	60.0	15.0	970.0	590.0	590.0	580.0
Stream Sampling Sites							
SR-01	25.0	22.0	4.1	75.0	55.0	47.0	45.0
CC-01	200.0	93.0	18.0	640.0	840.0	560.0	710.0
MC-01	230.0	150.0	33.0	1200.0	1600.0	950.0	1200.0
GR-01	260.0	160.0	51.0	840.0	1100.0	750.0	960.0
SR-02	42.0	22.0	12.0	190.0	240.0	160.0	170.0
CC-02	170.0	77.0	81.0	830.0	1100.0	720.0	910.0
MC-02	470.0	150.0	190.0	2700.0	3700.0	2300.0	2900.0
GR-02	200.0	88.0	39.0	880.0	1300.0	750.0	980.0

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Appendix D-4 (*cntd*): *Polycyclic Aromatic Hydrocarbon (PAH) data (2009)*

Site	PAH (µg/kg) Perylene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,i)perylene	Total PAH
Brown Bullhead Sampling Sites					
SR-BH	130.0	400.0	120.0	440.0	3547.0
LP-BH	5.7	7.6	3.7	9.8	86.6
MB-BH	92.0	170.0	46.0	200.0	1886.0
Long-term Monitoring Sampling Sites					
MC-27	250.0	520.0	170.0	550.0	8820.0
PIB-07	380.0	960.0	320.0	990.0	8334.0
PIB-19	530.0	1200.0	330.0	1300.0	11600.0
PIB-35	410.0	1100.0	290.0	1100.0	10884.0
LE-43	200.0	340.0	99.0	350.0	4278.0
TB-49	6.6	17.0	4.9	22.0	123.8
MB-46	100.0	270.0	75.0	270.0	2564.0
CC-26	890.0	2800.0	920.0	2900.0	26051.0
SR-25	160.0	560.0	160.0	620.0	5106.7
Stream Sampling Sites					
SR-01	17.0	41.0	13.0	45.0	399.7
CC-01	200.0	500.0	150.0	550.0	6525.8
MC-01	340.0	870.0	250.0	950.0	11479.6
GR-01	260.0	660.0	170.0	720.0	7407.0
SR-02	53.0	150.0	40.0	180.0	1204.3
CC-02	270.0	580.0	170.0	690.0	10355.5
MC-02	820.0	2100.0	580.0	2400.0	29678.0
GR-02	280.0	750.0	210.0	870.0	9382.5

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Appendix D-5: Nitrosamine data (2009)

	Nitrosamine (µg/kg)				
Site	N-Nitrosodi-n-butylamine	N-Nitrosodiethylamine	N-Nitrosodimethylamine	N-Nitrosodiphenylamine	N-Nitrosodi-n-propyl-amine
Brown Bullhead Sampling Sites					
SR-BH	ND	ND	ND	ND	ND
LP-BH	ND	ND	ND	ND	ND
MB-BH	ND	ND	ND	ND	ND
Long-term Monitoring Sampling Sites					
MC-27	ND	ND	ND	ND	ND
PIB-07	ND	ND	ND	ND	ND
PIB-06	ND	ND	ND	ND	ND
PIB-19	ND	ND	ND	ND	ND
PIB-35	ND	ND	ND	ND	ND
LE-43	ND	ND	ND	ND	ND
TB-49	ND	ND	ND	ND	ND
MB-46	ND	ND	ND	ND	ND
CC-26	ND	ND	ND	ND	ND
SR-25	ND	ND	ND	ND	ND
Stream Sampling Sites					
SR-01	ND	ND	ND	ND	ND
CC-01	ND	ND	ND	ND	ND
MC-01	ND	ND	ND	ND	ND
GR-01	ND	ND	ND	ND	ND
SR-02	ND	ND	ND	ND	ND
CC-02	ND	ND	ND	ND	ND
MC-02	ND	ND	ND	ND	ND
GR-02	ND	ND	ND	ND	ND

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Appendix D-5: Nitrosamine data (2009)

Site	Nitrosamine (µg/kg)			
	N-Nitrosomethylethylamine	N-Nitrosmorpholine	N-Nitrosopiperidine	N-Nitrospyrrolidine
Brown Bullhead Sampling Sites				
SR-BH	ND	ND	ND	ND
LP-BH	ND	ND	ND	ND
MB-BH	ND	ND	ND	ND
Long-term Monitoring Sampling Sites				
MC-27	ND	ND	ND	ND
PIB-07	ND	ND	ND	ND
PIB-06	ND	ND	ND	ND
PIB-19	ND	ND	ND	ND
PIB-35	ND	ND	ND	ND
LE-43	ND	ND	ND	ND
TB-49	ND	ND	ND	ND
MB-46	ND	ND	ND	ND
CC-26	ND	ND	ND	ND
SR-25	ND	ND	ND	ND
Stream Sampling Sites				
SR-01	ND	ND	ND	ND
CC-01	ND	ND	ND	ND
MC-01	ND	ND	ND	ND
GR-01	ND	ND	ND	ND
SR-02	ND	ND	ND	ND
CC-02	ND	ND	ND	ND
MC-02	ND	ND	ND	ND
GR-02	ND	ND	ND	ND

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Appendix D-6: General chemistry data (2009)

	Parameter						
Site	Oil and Grease (mg/kg)	Nitrate/Nitrite (mg/kg)	Total Nitrogen (mg/kg)	Total Kjeldahl Nitrogen (mg/kg)	Percent Solids (%)	Total Organic Carbon (f_{oc})	Total Phosphorus (mg/kg)
Brown Bullhead Sampling Sites							
SR-BH	ND	3.40			14.4	0.09320	
LP-BH	ND	0.52			54.0	0.00460	
MB-BH	2190	1.90			10.7	0.08920	
Long-term Monitoring Sampling Sites							
MC-27	928	0.82			65.1	0.00116	
PIB-07	1880	3.50			12.4	0.03650	
PIB-19	1690	3.20			15.2	0.03240	
PIB-35	2010	2.90			19.8	0.03480	
LE-43	488	1.10			40.1	0.01390	
TB-49	ND	0.35			64.1	0.00272	
MB-46	2090	3.70			11.6	0.06330	
CC-26	4180	0.91			35.1	0.04410	
SR-25	530	0.44			66.1	0.01120	
Stream Sampling Sites							
SR-01	ND	0.61	459	359	73.0	0.00115	258
CC-01	863	0.92	1080	872	77.8	0.00439	218
MC-01	1760	0.47	948	730	78.6	0.01570	319
GR-01	2200	1.40	1230	966	75.4	0.00714	312
SR-02	ND	1.70	773	589	81.1	0.00442	468
CC-02	1330	1.10	631	480	82.5	0.00446	326
MC-02	1730	0.67	2000	1380	73.2	0.03510	445
GR-02	2190	0.70	504	429	84.4	0.00991	294

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