An evaluation of sediment quality conditions in Presque Isle Bay: assessing compliance with ecosystem health and delisting targets (2005 – 2015)

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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 under the Great Lakes Water Quality Agreement. In 1993, the first Remedial Action Plan for the AOC was published. The plan identified fish 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 BUI, 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, The United States Environmental Protection Agency (USEPA) 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 results of the 2009 study indicated that the delisting targets were being met and sediment quality in Presque Isle Bay was improving.

In August 2015, 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. In addition, three samples were collected from sites where brown bullhead are routinely collected. 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 2015 would meet water quality criteria in the discharge from the CDF. Therefore, the delisting target for the restrictions on dredging BUI is being met. 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. 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 2015 survey met ecosystem health targets. While concentrations of COPCs did exceed SQGs for five metals, eight PAHs, and oil and grease 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. The metals and PAHs would likely bind to organic carbon. 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 at locations where brown bullhead are monitored exceed SQGs for four metals and oil grease; however, all sites met the ecosystem health targets. Evaluation of the delisting target and ecosystem health measures indicates sediment quality in Presque Isle Bay is improving.

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 (COPCs) 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. International Joint Commission (IJC) guidelines define the BUI for restrictions on dredging activities as occurring 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 American AOC to be listed as an Area of Recovery, catalyzing a change in effort from remediation to monitoring (Boughton 2002). 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 follows 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, zinc, and mercury 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 2015, 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. This report presents the results of the 2015 Presque Isle Bay sediment quality evaluation, compares the results to those observed in 2005 and 2009, and assesses compliance with the ecosystem health and delisting targets for the bay.

3.0 METHODOLOGY

3.1 Sampling Sites

In August 2015, 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 (***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, DEP's sampling boat or the Pennsylvania Sea Grant 17.0-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. Prior to deployment, the sampler was rinsed with site water, Acetone, and again with site water. The Petite Ponar® was only used to sample shallow, nearshore locations. When sampling with the Van Veen® sampler, the top 1.0 cm of the sediment sample was collected and transferred to a labeled (site location and date) 6.5-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 6.5-quart plastic container. For each sampling location, samples were 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; and rinsing with Acetone. All samples were stored in 48-L coolers with Blue Ice® and transferred to the Tom Ridge Environmental Center, Erie, Pennsylvania 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 homogenized and then transferred from the 6.5-quart plastic container to the properly labeled (site, date, and analysis) glass container for analysis. Glass containers for each sample included: 1 - 4 oz (AVS/SEM); 1 - 8 oz (pesticides, PCBs, SVOCs, TS, TOC, oil and grease, metals, nitrite/nitrate); and 1 - 32 oz (grain size and PAHs). The glass jars were filled with no headspace remaining. 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., Pittsburgh, Pennsylvania. Prior to processing each sample, all sampling equipment was decontaminated by rinsing with water, scrubbing the equipment with Alconox®, rinsing with Acetone, and rinsing with de-ionized water. All remaining sample from the 6.5-quart plastic containers were archived at the Tom Ridge Environmental Center following processing.

3.4 Sample Analysis

All sediment samples were analyzed for acid volatile sulfides (AVS) and simultaneously extracted metals (SEM) ratio, total organic carbon (TOC), oil and grease, metals, nitrite and nitrate, pesticides, polychlorinated biphenyls (PCBs), total solids (TS), grain size, and polycyclic aromatic hydrocarbons (PAHS) (***Table 2***). 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 ($C_{oc,\ PAHi,FCVi}$) (USEPA 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, 2009, and 2015 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 (MacDonald *et al.* 2000) in 2005, 2009, and/or 2015 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, 2009, and 2015, the methodology was applied to the nine Presque Isle Bay long-term monitoring sites.

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 2015, 2009, and 2005 (***Table 5***).

In 2015, five metals exceeded SQGs. Arsenic concentrations exceeded the probable effect concentration (PEC) at sites MB-BH and LP-BH (***Figure 1***). Barium concentrations exceeded the heavily polluted threshold (HPT) at sites PIB-07, PIB-19, PIB-35, MB-46, and MB-BH (***Figure 2***). Cadmium concentrations exceeded the probable effects concentration (PEC) at sites PIB-07 and PIB-35 (***Figure 3***). Nickel concentrations exceeded the PEC at sites PIB-07, PIB-19, PIB-35, and LP-BH (***Figure 4***). Lead concentrations exceeded the PEC at site PIB-07, PIB-35, and LP-BH (***Figure 5***).

In 2009, five metals exceeded SQGs. Barium concentrations exceeded the HPT at sites PIB-07, PIB-19, PIB-35, MB-46, SR-BH, MB-BH, and GR-01. Cadmium concentrations exceeded the PEC at sites PIB-07, PIB-19, and PIB-35. Nickel concentrations exceeded the PEC at sites PIB-07 and PIB-35. Lead concentrations exceeded the PEC at site PIB-07. Mercury concentrations exceeded the PEC at site MB-BH. 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 2015, eight PAHs exceeded SQGs. PAH concentrations did not exceed SQGs at the brown bullhead sampling sites. Acenaphthene (***Figure 6***), phenanthrene (***Figure 7***), fluoranthene (***Figure 8***), pyrene (***Figure 9***), benz(a)anthracene (***Figure 10***), chrysene (***Figure 11***), and benzo(a)pyrene (***Figure 12***) concentrations exceeded SQGs at site CC-26. Dibenz(a,h)anthracene concentrations exceeded the PEL at sites PIB-35, CC-26, and SR-25 (***Figure 13***). In 2009 and 2005, the same eight PAHs exceeded SQGs. In 2015, total PAH concentrations did not exceed the PEC at any of the sites (***Figure 14***).

In 2015, oil and grease concentrations exceeded the severe effect level (SEL) at sites PIB-07, PIB-35, CC-26, and MB-BH (***Figure 15***). In 2009, oil and grease concentrations exceeded the SEL at sites PIB-25, MB-26, CC-26, MB-BH, GR-01, and GR-02. Oil and grease was not assessed in 2005. In 2005, chlordane concentrations exceeded the PEC at sites MB-26, CC-26, and MC-27 (***Figure 16***). In 2009, chlordane concentrations did not exceed the PEC at the sites sampled. In 2015, chlordane concentrations were not detected (ND) at the reporting limit at any of the sites.

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. Non-detect concentrations of COPCs were substituted with the MDL to reflect the highest possible concentration The mean PEC-Q did not exceed 1.0 at any site sampled in 2005, 2009, or 2015 (***Table 6*; *Figure 17***).

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 2015, SEM-AVS values exceeded zero at site SR-25 (***Figure 18***). None of the bullhead sites had SEM-AVS values exceed zero. In 2009 and 2005, SEM-AVS values exceeded zero at two sites. In 2005, SEM-AVS values exceed zero at two sites. SEM-AVS/f_{oc} values did not exceed 3,000 µmol g^{-1} OC at any site sampled in 2005, 2009, or 2015 (***Figure 19***).

4.4 Equilibrium Sediment Benchmark Toxicity Unit

Bioavailability of PAHs was assessed by calculating ∑ESB-TUs. Non-detect concentrations of PAHs were substituted with the MDL to reflect the highest possible concentration. PAHs present in the sediment are considered to be potentially bioavailable when the ∑ESB-TU value exceeds 1.0. In 2015, none of the sites had ∑ESB-TU values exceed 1.0 (***Table 8; Figure 20***). In 2009, ∑ESB-TUs exceeded 1.0 at three sites. 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 2005, 2009, and 2015 (***Table 10***). In 2015, concentrations of seven COPCs exceeded ERM guidelines at site CC-26. In 2009, concentrations of nine COPCs exceeded ERM guidelines at site CC-26. None of the bullhead sampling sites had COPC concentrations exceed ERM guidelines. In 2005, nine COPCs exceed ERM guidelines at site MC-27.

4.6 Delisting Target

In 2015, results of the screening methods revealed no exceedances of 15-minute acute (***Table 11***) or 12-hour chronic (***Table 12***) water quality criteria in the discharge from the CDF. In 2009, results of the screening methods revealed no exceedance of 15-minute acute (***Table 13***) or 12-hour chronic (***Table 14***) water quality criteria in the discharge from the CDF. In 2005, cadmium concentrations from sites MC27 and TB49 exceeded 15-minute acute water and 12-hour chronic water quality criteria in the discharge from the CDF (Table 15), and lead concentrations from site MC27 exceeded 12-hour chronic water quality criteria (***Table 16***).

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 2015, arsenic, barium, cadmium, nickel, and lead were detected at the long-term monitoring and brown bullhead sites at concentrations greater than SQGs. In 2009, barium, cadmium, nickel, and lead were detected at the long-term monitoring sites at concentrations greater than SQGs. None of the samples from the brown bullhead monitoring sites contained metals in concentrations above the SQGs. In 2005, only cadmium and nickel were detected at concentrations greater than SQGs (barium was not assessed in 2005). In 2015, acenaphthene, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(a)pyrene, and dibenz(a,h)anthracene exceeded SQGs at fewer sites compared to both 2009 and 2005. Acenaphthene, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(a)pyrene, and total PAHs concentrations only exceeded SQGs at site CC-26. Dibenz(a,h)anthracene concentrations exceeded SQGs at sites CC-26, PIB-35, and SR-25. In 2015, oil and grease concentrations exceeded SQGs at one more site compared to 2009 (PIB-07). Oil and grease was not assessed in 2005. The results indicate that eight PAHs, five metals, and oil and grease continue to be detected at concentrations that could potentially be toxic to benthic organisms in Presque Isle Bay.

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) at the long-term monitoring sites 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. None of the sites had a mean PEC-Q exceed 1.0 in 2015, 2009, or 2005. The ecosystem health target for PEC-Q 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 at the long-term monitoring sites. The ecosystem health target for SEM-AVS is met when 90% of sites have a SEM-AVS less than zero. In 2015, eight of nine (88.9%) sites had an SEM-AVS less than zero. In 2009, seven of nine (77.8%) had an SEM-AVS less than zero. In 2005, eight of nine (88.9%) 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 2015, 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 at the long-term monitoring sites. The ecosystem health target for ESB-TUs is met when 90% of sites have an ESB-TU less than 1.0. In 2015, none of the sites had an ESB-TU value exceed 1.0. In 2009, six of nine (66.7%) sites had an ESB-TU less than 1.0. In 2005, four of nine (44.4%) sites had an ESB-TU less than 1.0. The ecosystem health target for ESB-TUs is being met. The results suggest that PAHs are unlikely to result in toxicity to benthic organisms.

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 2015, 2009, and 2005, eight of 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 and

12-hour chronic water quality criteria were observed in two samples (MC27 and TB49). In 2009 and 2015, 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 2015 data were compared to data collected in the comprehensive sediment surveys conducted in 2009 and 2005.

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 2015 data.
- The ecosystem health target for mean PEC-Q is being met. None of the sites had a mean PEC-Q exceed 1.0 in 2015, 2009, or 2005. The results suggest that concentrations of contaminants in the sediment are below levels that would be expected to have an adverse impact on benthic organisms.
- The ecosystem health target for SEM-AVS is not being met. However, the ecosystem health target for SEM-AVS/f_{oc} is being met. SEM-AVS/f_{oc} values did not exceed guidelines at any site sampled in 2005, 2009, or 2015. These results indicate that metals present in the sediment are likely binding with organic carbon and are not available to benthic organisms.
- The ecosystem health target for ESB-TUs is being met. In 2015, none of the sites had ∑ESB-TU values exceed 1.0. In 2009, ∑ESB-TUs exceeded 1.0 at three sites. In 2005, ∑ESB-TUs values exceeded 1.0 at five sites. These results suggest that PAHs are unlikely to result in toxicity to benthic organisms.
- The number of sites that had six or more COPCs at concentrations greater than the ERMs varied among the sites assessed in 2005, 2009, and 2015. The ecosystem health target for ERM is not being met. These results indicate that COPCs are being detected at concentrations that could be toxic to fish in Presque Isle Bay. The ecosystem health target evaluating the potential of COPCs to be present at levels toxic to fish remains unchanged among the three sampling events.

7.0 References

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Appendix A: Figures

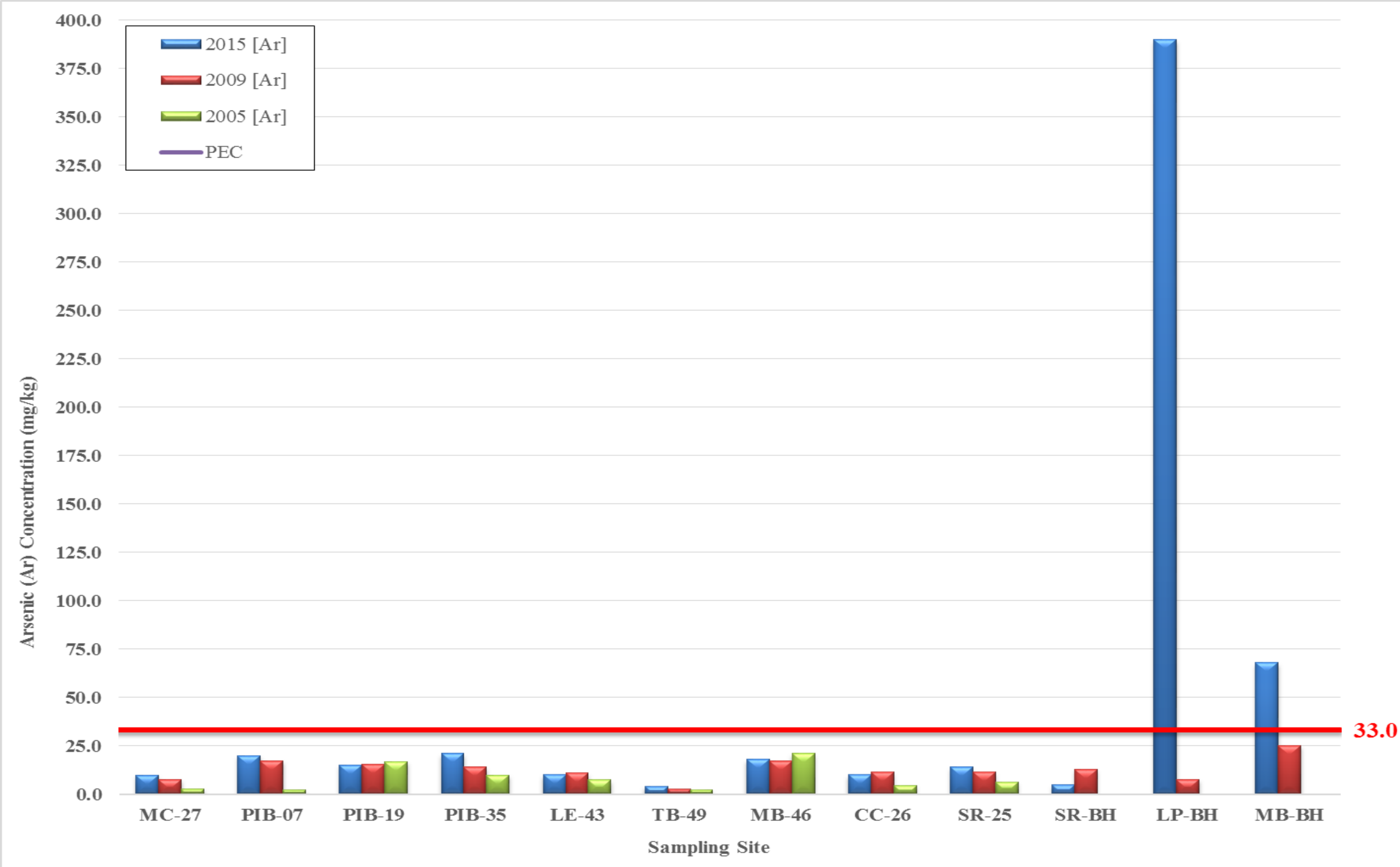

Figure 1. Arsenic concentrations in Presque Isle Bay: 2005-2015

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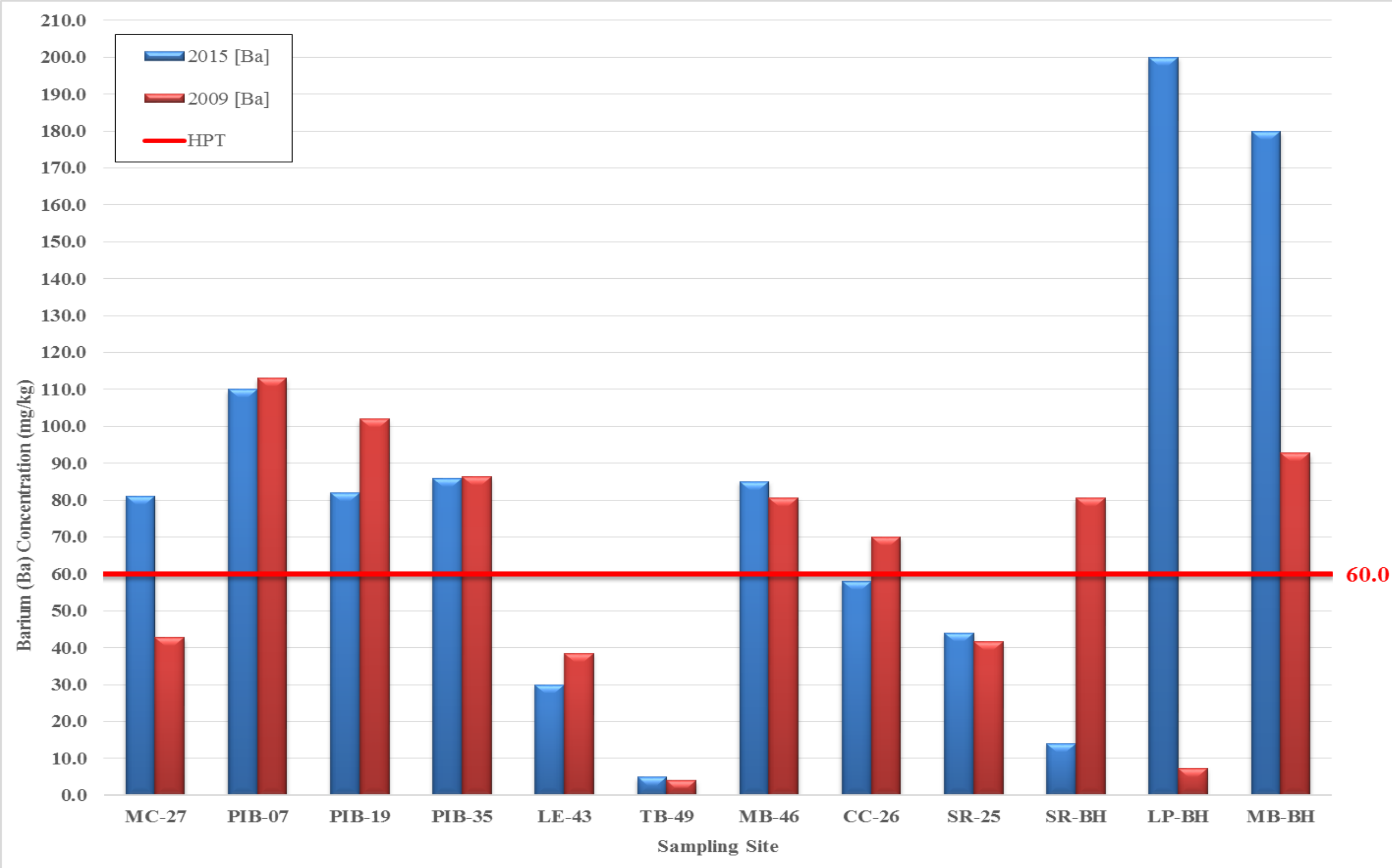

Figure 2. Barium concentrations in Presque Isle Bay: 2009-2015

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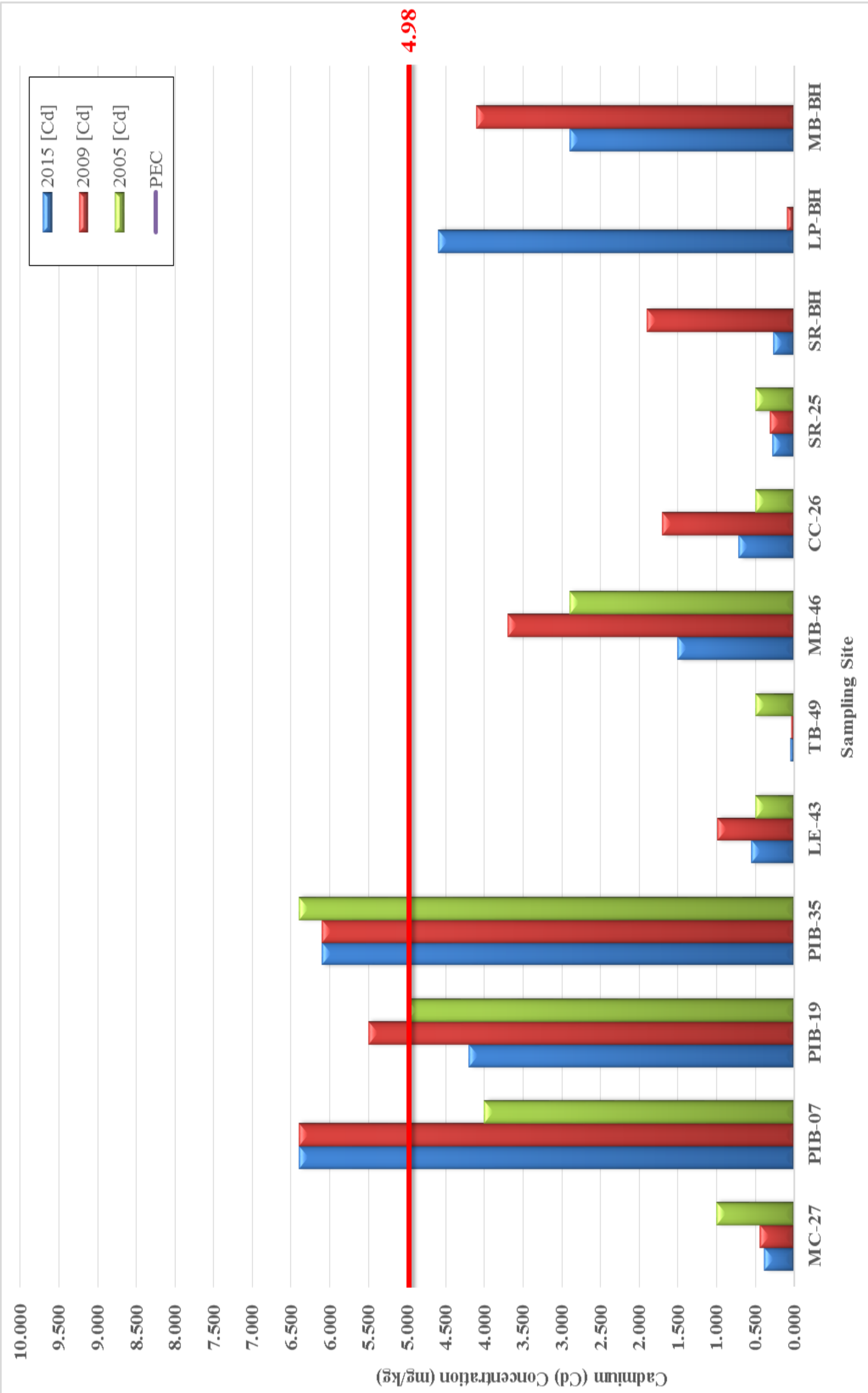

Figure 3. Cadmium concentrations in Presque Isle Bay: 2005-2015

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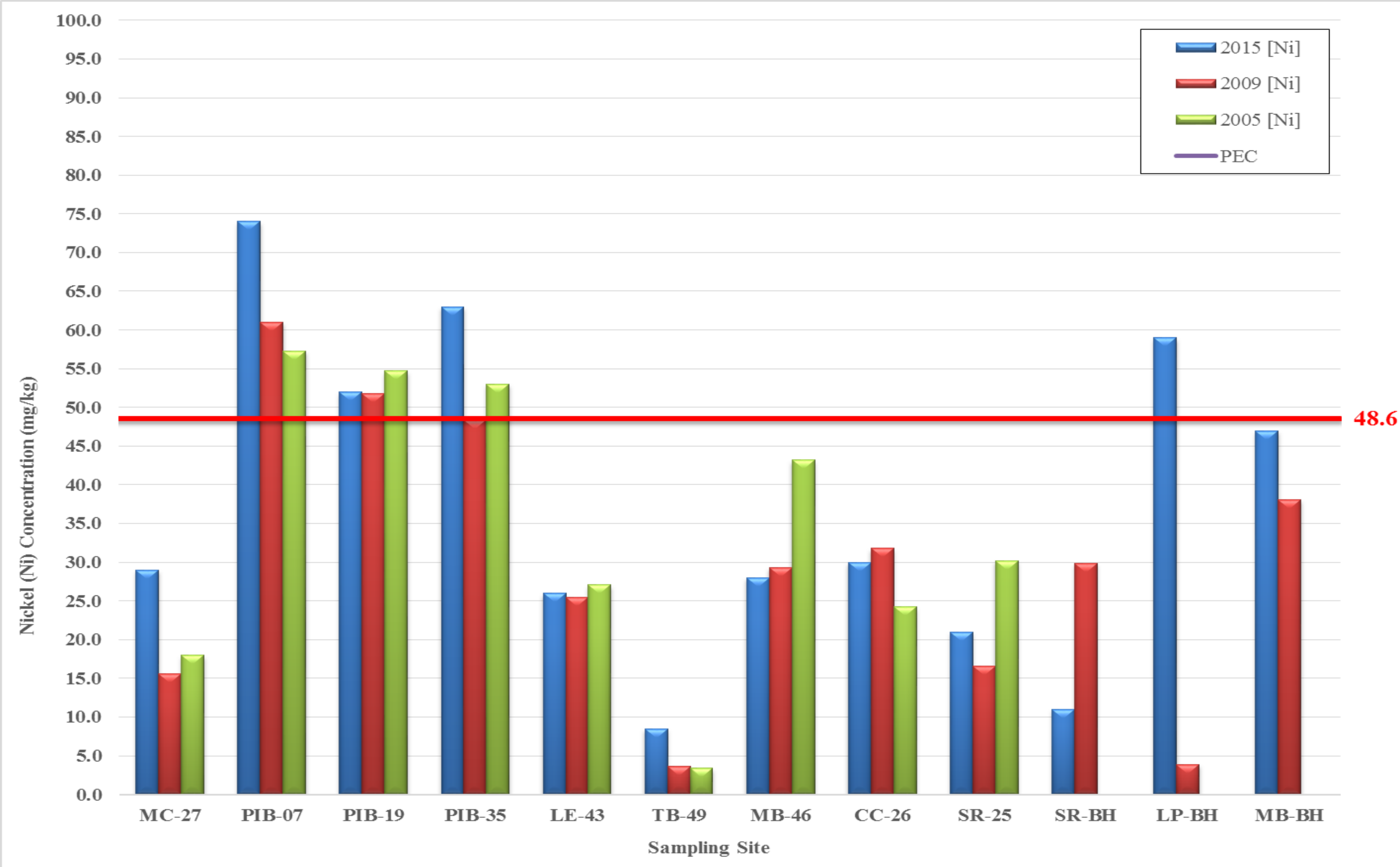

Figure 4. Nickel concentrations in Presque Isle Bay: 2005—2015

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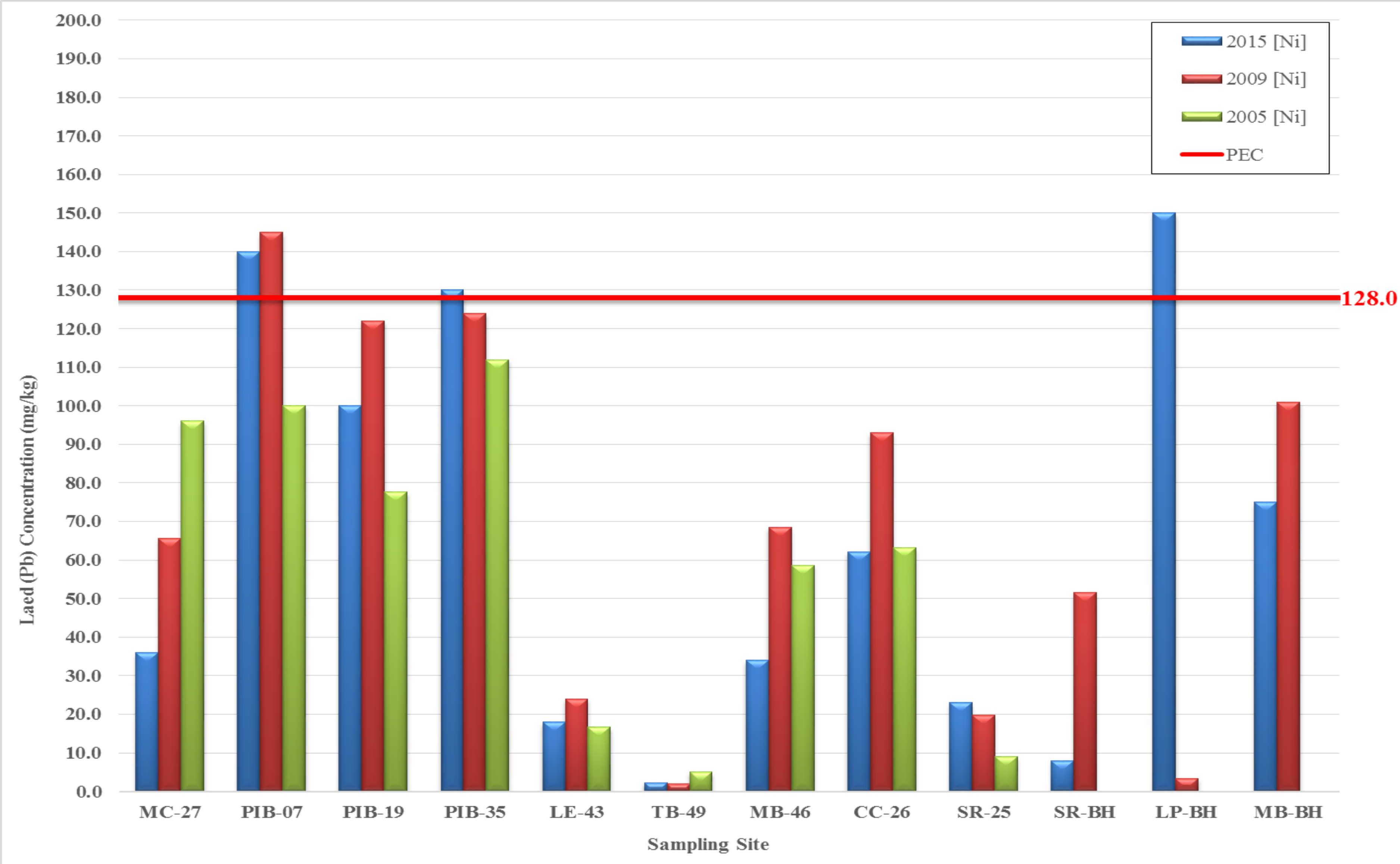

Figure 5. Mercury concentrations in Presque Isle Bay: 2005—2009

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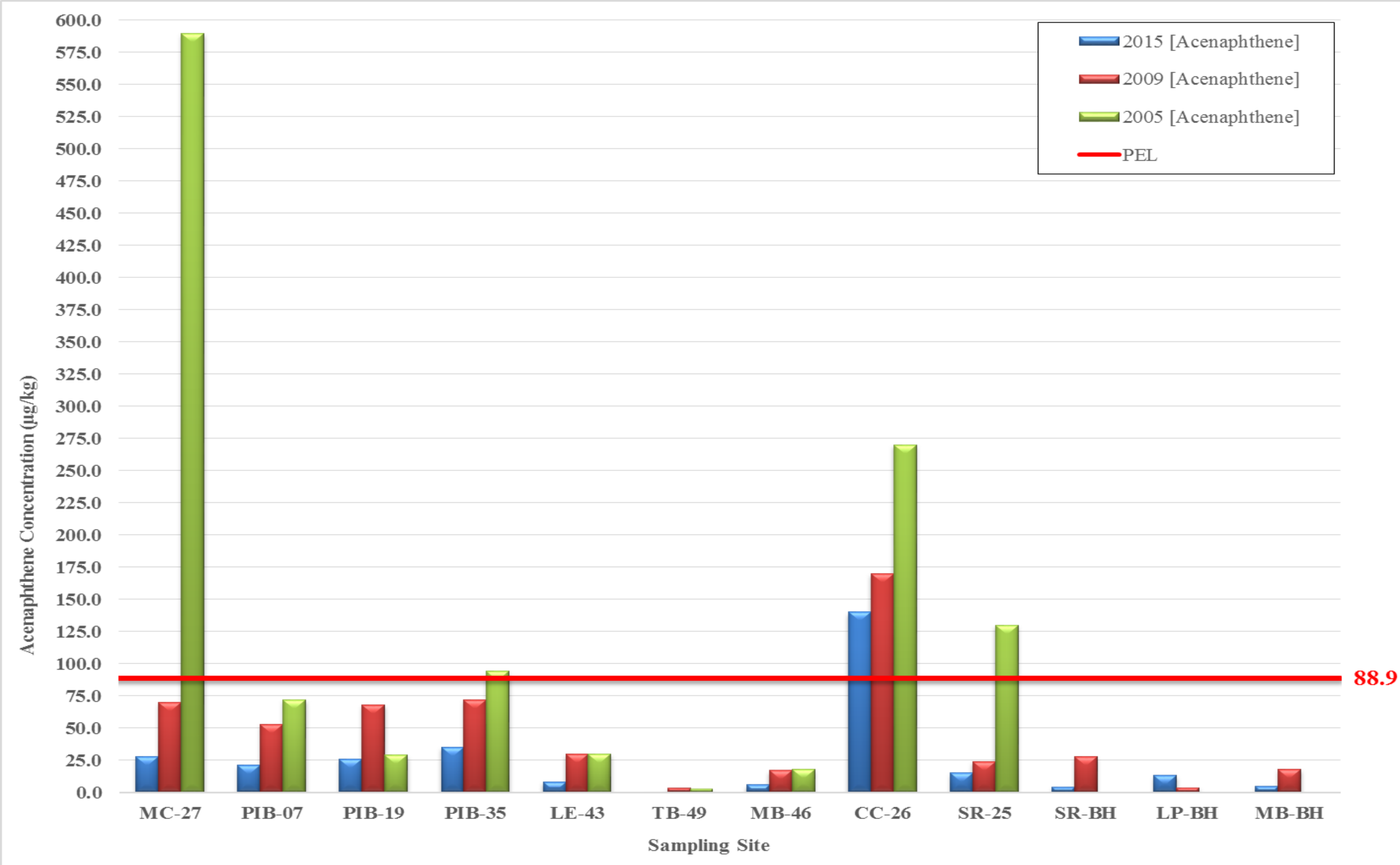

Figure 6. Acenaphthene concentrations in Presque Isle Bay: 2005—2015

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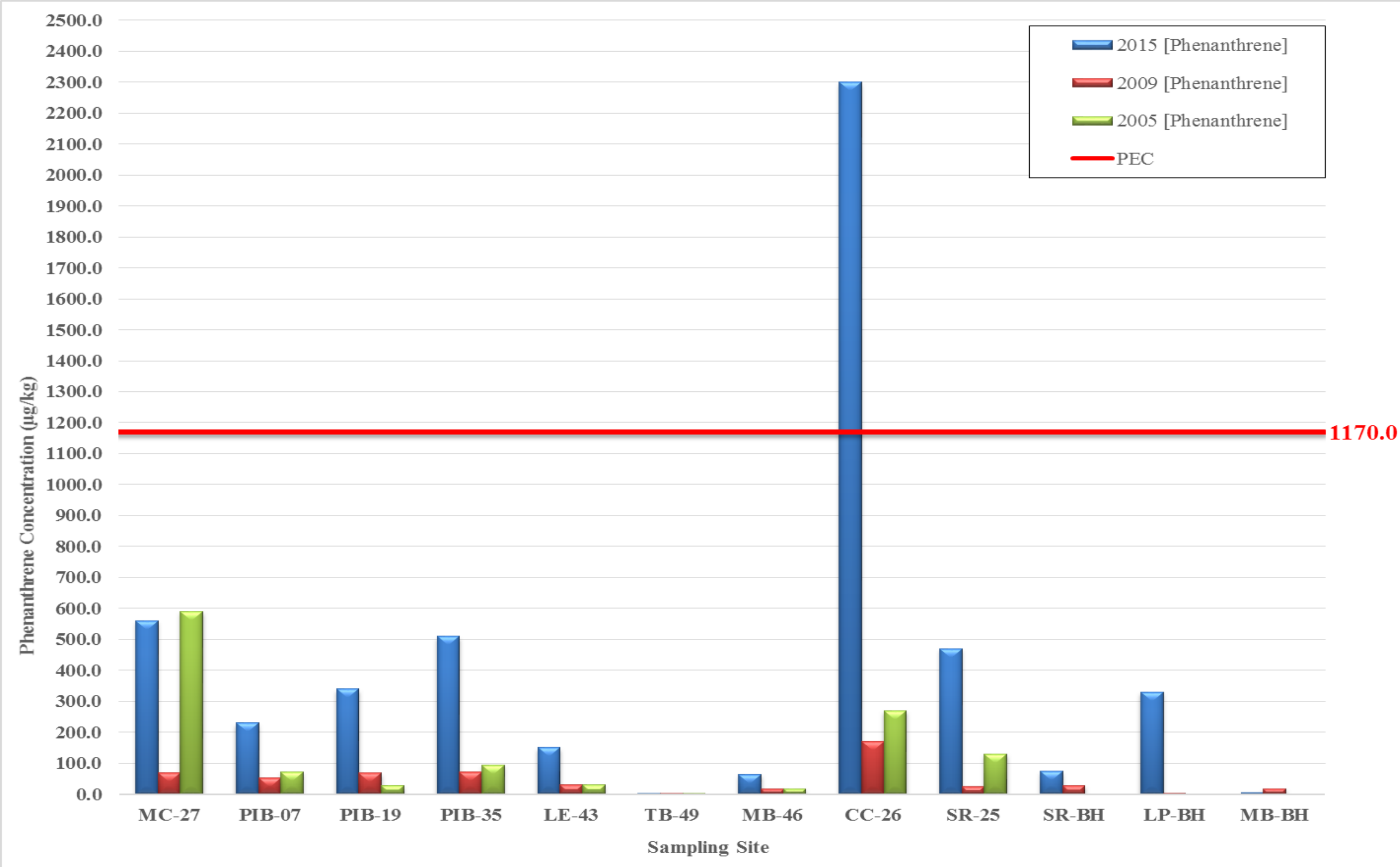

Figure 7. Phenanthrene concentrations in Presque Isle Bay: 2005—2015

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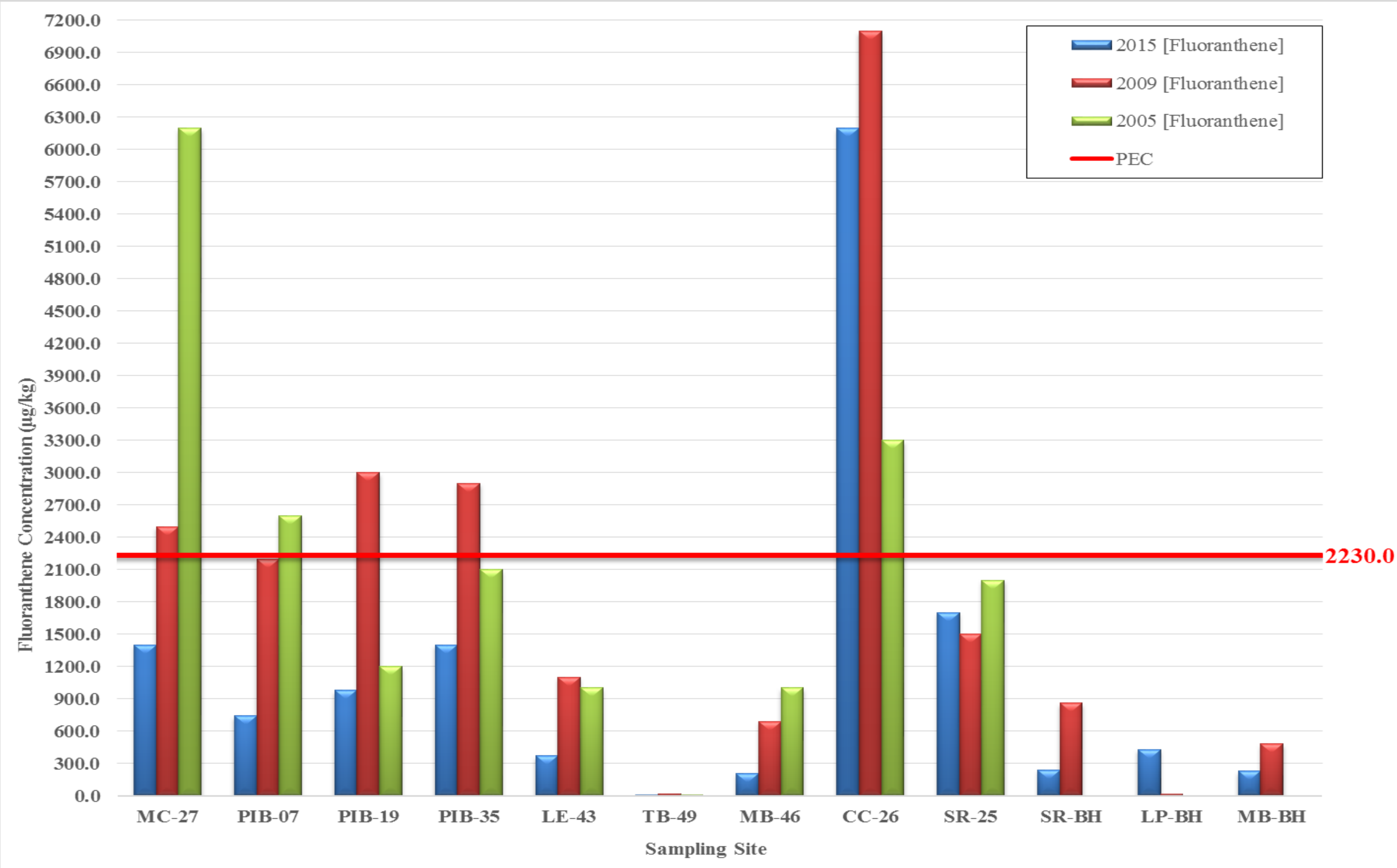

Figure 8. Fluoranthene concentrations in Presque Isle Bay: 2005—2015

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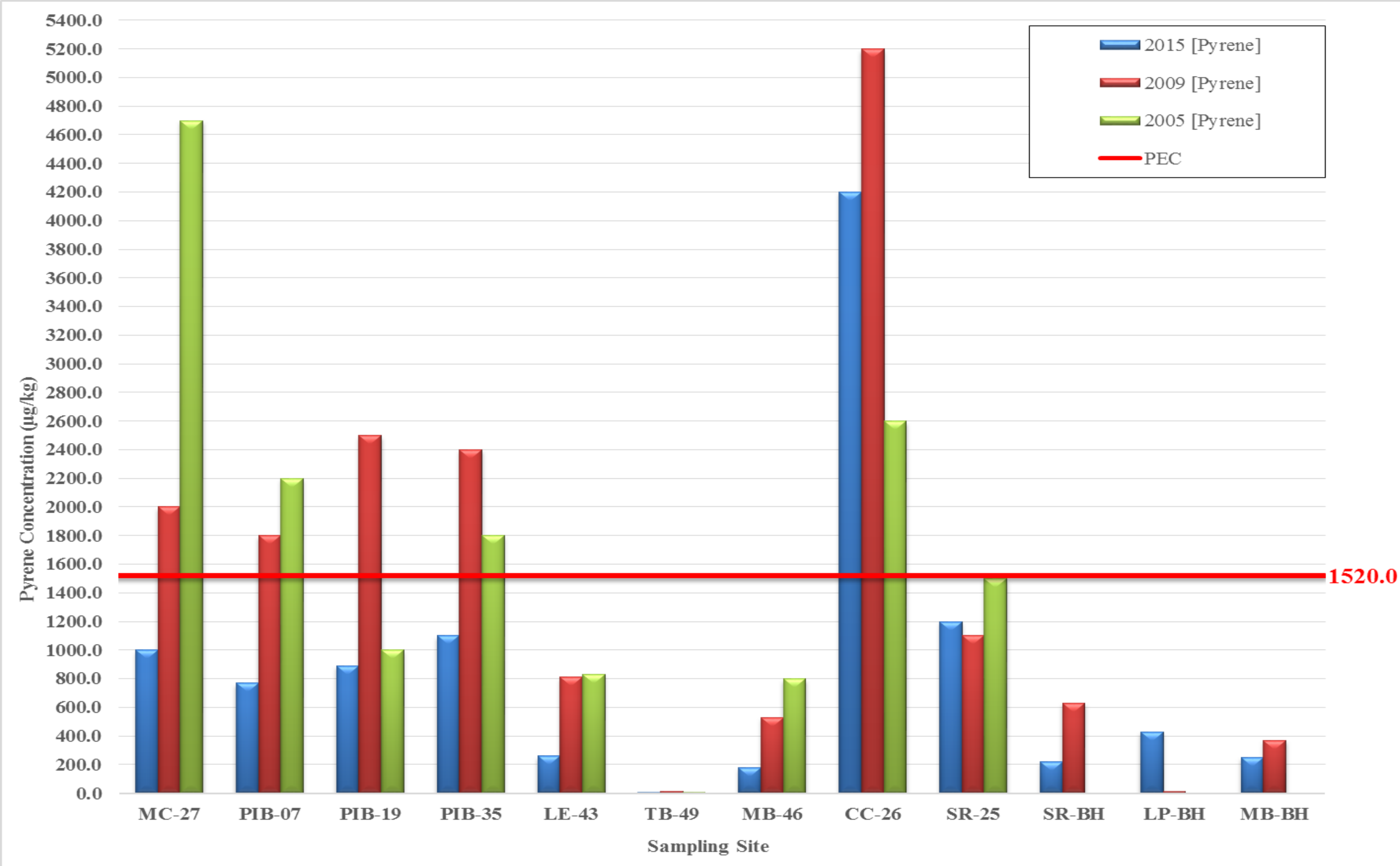

Figure 9. Pyrene concentrations in Presque Isle Bay: 2005—2015

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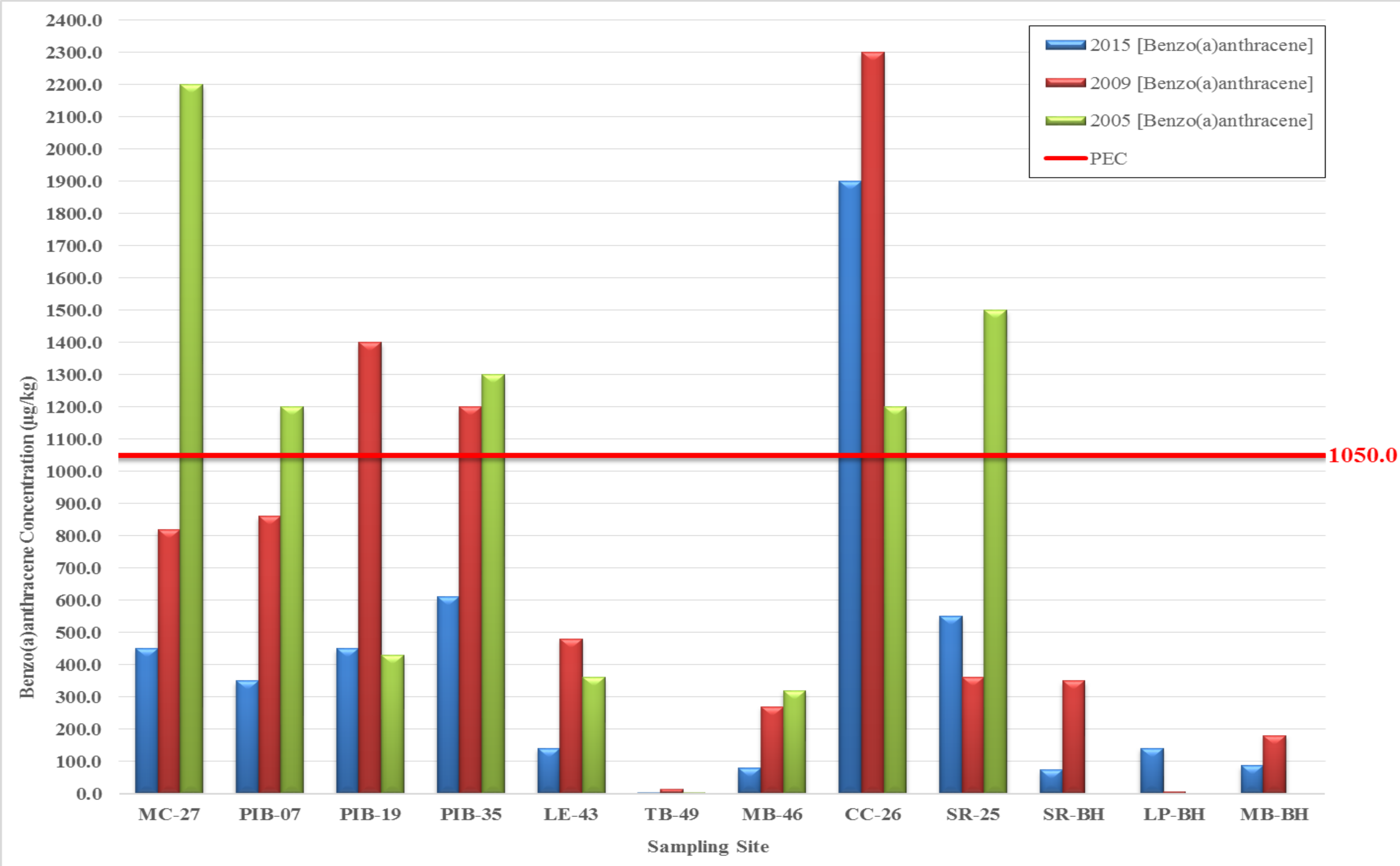

Figure 10. Benzo(a)anthracene concentrations in Presque Isle Bay: 2005—2015

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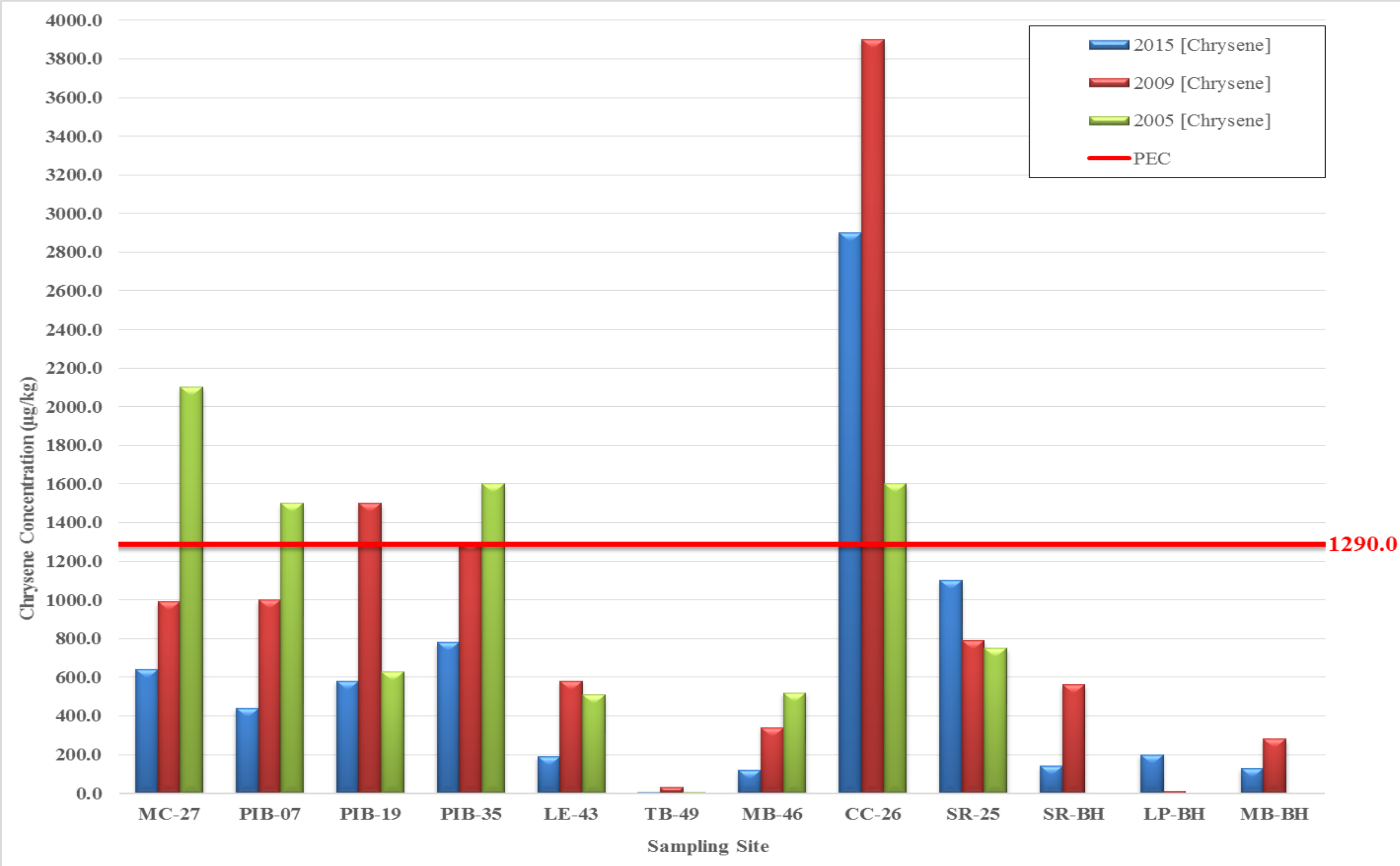

Figure 11. Chrysene concentrations in Presque Isle Bay: 2005—2015

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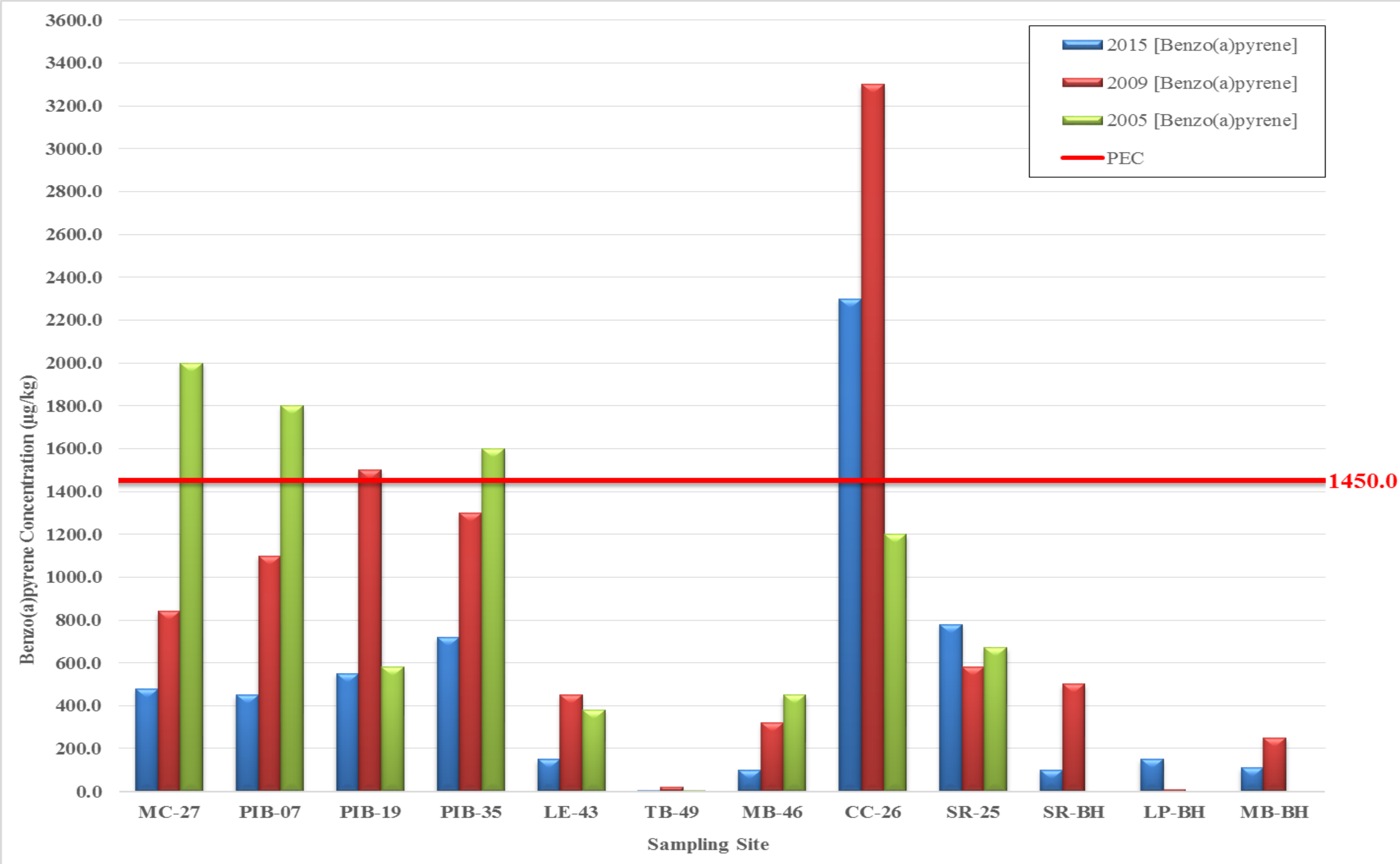

Figure 11. Benzo(a)pyrene concentrations in Presque Isle Bay: 2005—2015

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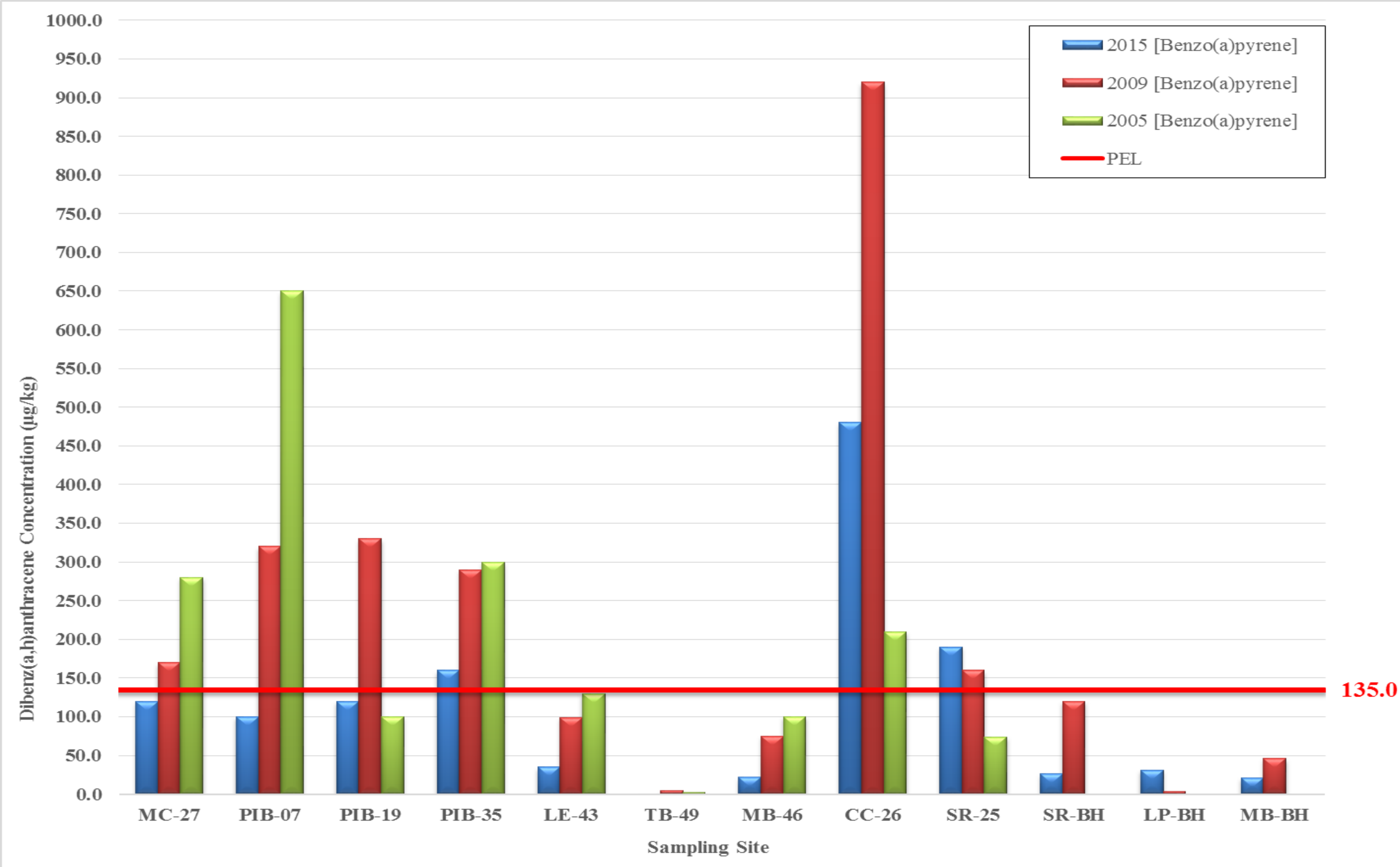

Figure 13. Dibenz(ah)anthracene concentrations in Presque Isle Bay: 2005—2015

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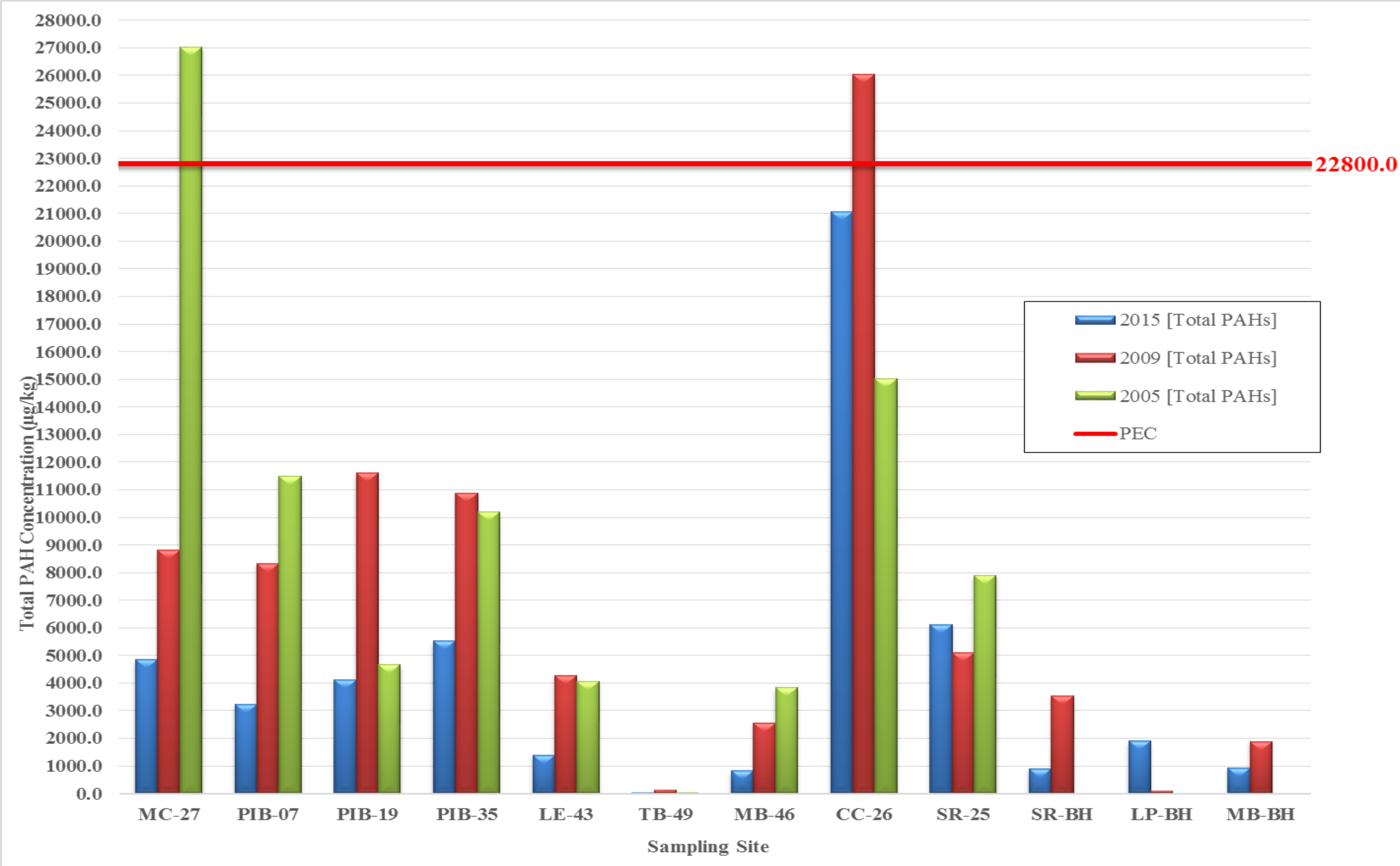

Figure 14. Total PAH concentrations in Presque Isle Bay: 2005—2015

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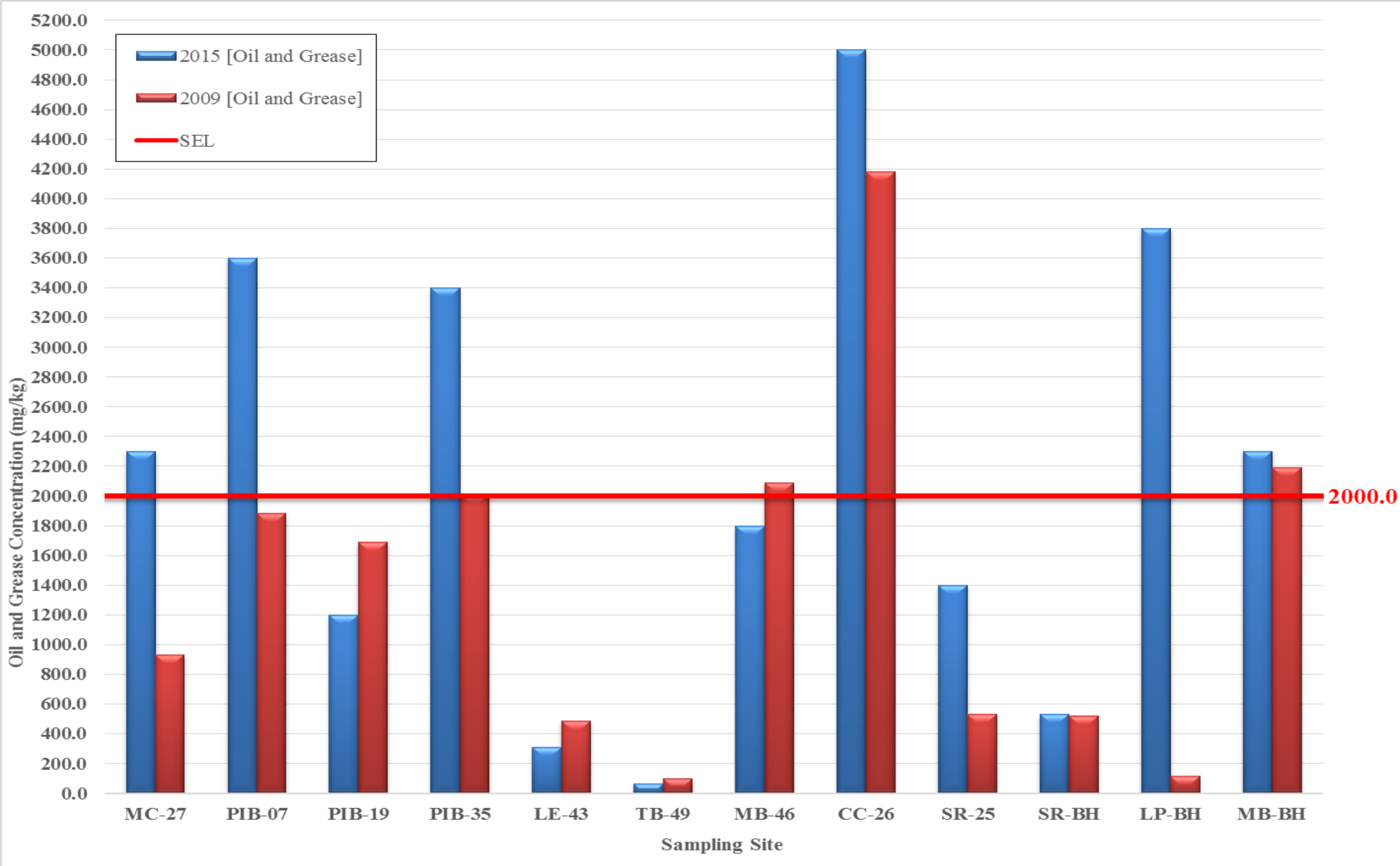

Figure 15. Oil and grease concentrations in Presque Isle Bay: 2009-2015

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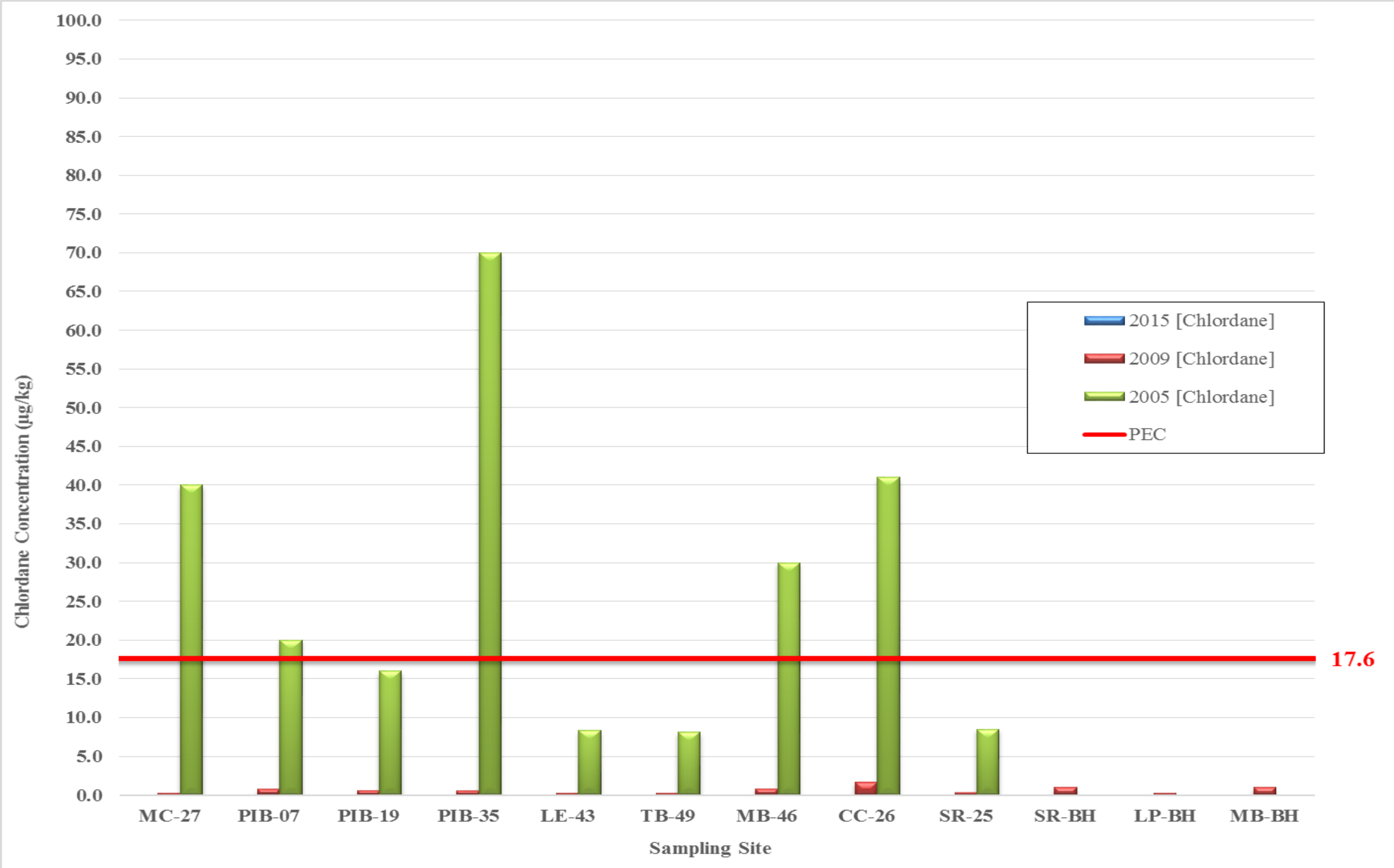

Figure 16. Chlordane concentrations in Presque Isle Bay: 2005—2015

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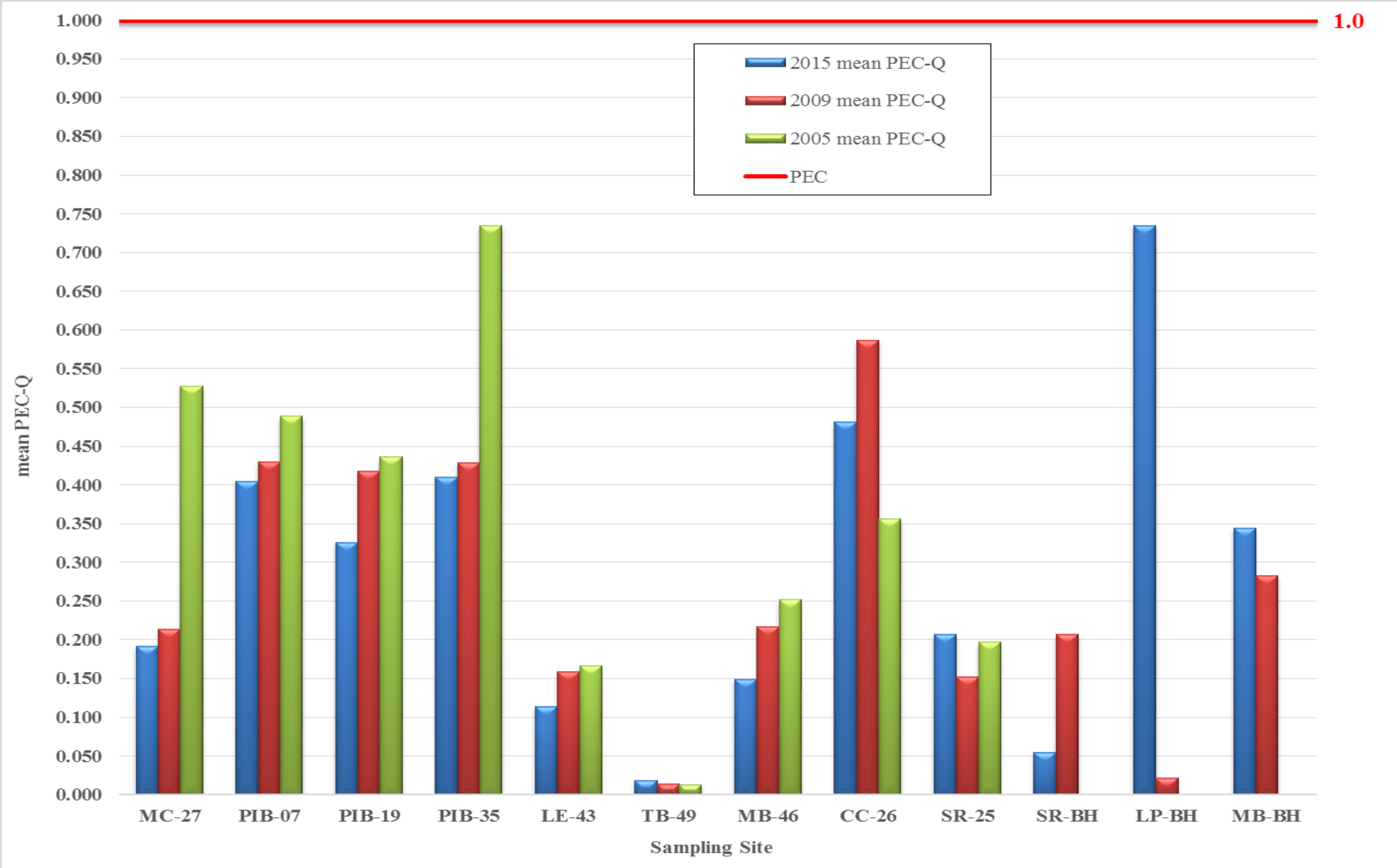

Figure 17. Mean PEC-Q values in Presque Isle Bay: 2005—2015

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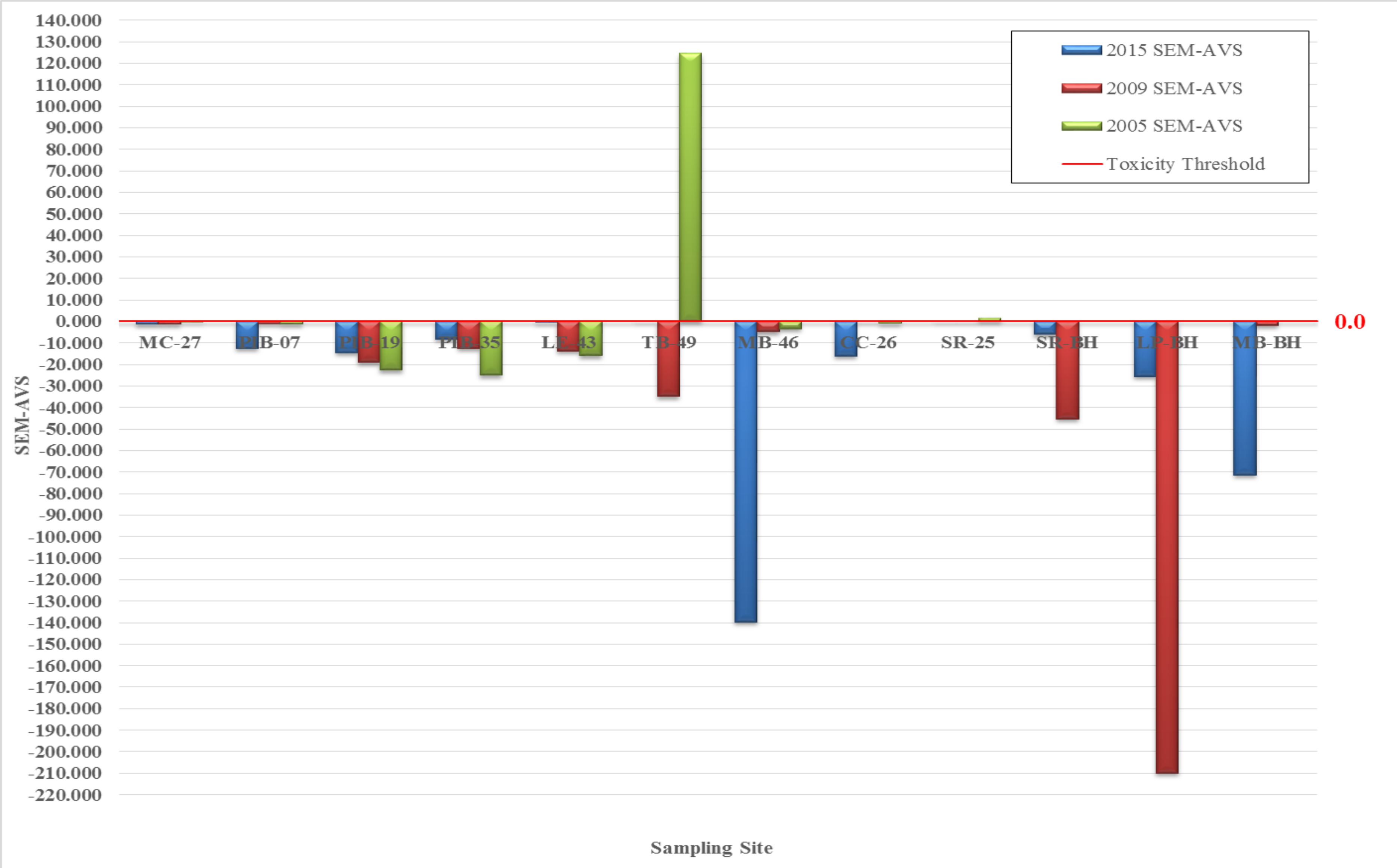

Figure 18. SEM-AVS values in Presque Isle Bay: 2005—2015

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

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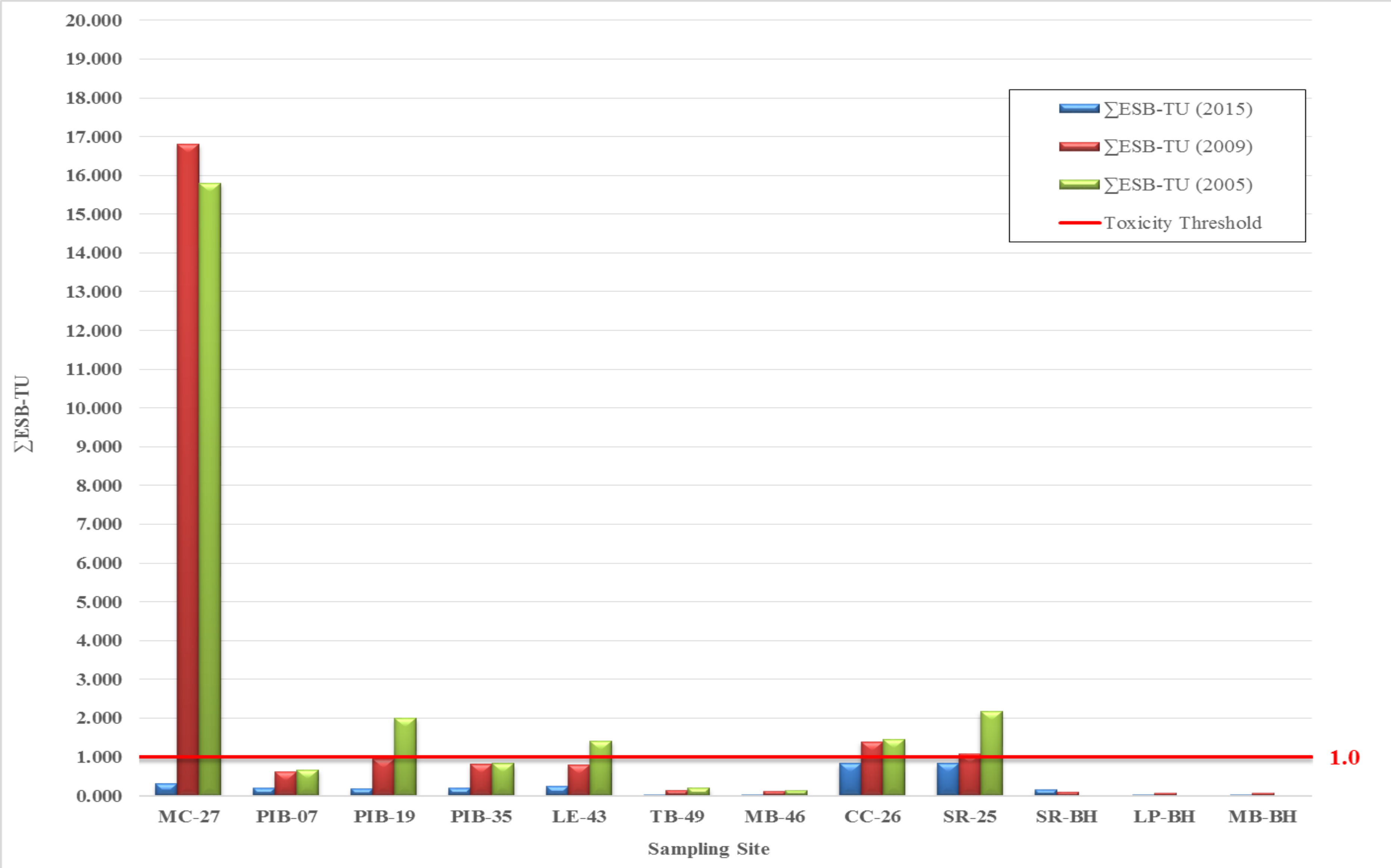

Figure 20. ESB-TU values in Presque Isle Bay: 2005—2015

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APPENDIX B: TABLES

Table 1. Presque Isle Bay sediment quality evaluation sampling locations (2015)

Site	Date	Latitude	Longitude	Sampler
Long-term Monitoring Sampling Sites				
TB-49	August 4, 2015	42.16582	-80.07558	Petite Ponar
LE-43	August 4, 2015	42.14913	-80.07146	Van Veen
PIB-07	August 4, 2015	42.1384	-80.12269	Van Veen
PIB-19	August 4, 2015	42.13474	-80.10791	Van Veen
PIB-35	August 4, 2015	42.13517	-80.09926	Van Veen
MB-46	August 4, 2015	42.15939	-80.08707	Van Veen
CC-26	August 4, 2015	42.12817	-80.11486	Van Veen
SR-25	August 3, 2015	42.11433	-80.15065	Van Veen
MC-27	August 4, 2015	42.14406	-80.08358	Petite Ponar
Brown Bullhead Sampling Sites				
SR-BH	August 3, 2015	42.1167	-80.4848	Petite Ponar
MB-BH	August 3, 2015	42.15595	-80.09076	Van Veen
LP-BH	August 3, 2015	42.15565	-80.10415	Petite Ponar

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Table 2. Chemicals of potential concern (COPC) (2015)

Anayltes
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; Methoxychlor; Mirex, and trans-nonachlor
Metals (mg/kg)
Antimony, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Lead, Nickel, Zinc, Mercury
Polychlorinated Biphenyls (PCBs) (µg/kg)
PCB 209, PCB 101, PCB 105, PCB 118, PCB 128, PCB 138, PCB 153, PCB 170, PCB 18, PCB 180, PCB 187, PCB 195, PCB 206, PCB 28, PCB 44, PCB 52, PCB 66, PCB 8, PCB 87
Polycyclic Aromatic Hydrocarbons (PAHs) (µg/kg)
1,1'-Biphenyl, 1-Methylnaphthalene, 1-Methylphenanthrene, 2,3,5-Trimethylnaphthalene, 2,6-Dimethylnaphthalene, 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Anthracene, Benzo[a]anthracene, Benzo[a]pyrene, Benzo[b]fluoranthene, Benzo[e]pyrene, Benzo[g,h,i]perylene; Benzo[k]fluoranthene, C1-Chrysenes, C1-Dibenzothiophenes, C1-Fluoranthenes/pyrene, C1-Fluorenes, C1-Naphthalenes, C1-Phenanthrenes/Anthracenes, C2-Chrysenes, C2-Dibenzothiophenes, C2-Fluoranthenes/Pyrene, C2-Fluorenes, C2-Naphthalenes, C2-Phenanthrenes/Anthracenes, C3-Chrysenes, C3-Dibenzothiophenes, C3-Fluoranthenes/Pyrene, C3-Fluorenes, C3-Naphthalenes; C3-Phenanthrenes/Anthracenes; C4-Chrysenes; C4-Dibenzothiophenes; C4-Naphthalenes; C4-Phenanthrenes/Anthracenes; Chrysene; Dibenz(a,h)anthracene; Dibenzothiophene; Fluoranthene; Fluorene; Indeno[1,2,3-cd]pyrene; Naphthalene; Perylene; Phenanthrene; Pyrene
General Chemistry
AVS/SEM; n-hexane extractible material; nitrate/nitrite as N; total organic carbon; and grain size

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Table 3. Pennsylvania water quality standards [a]

Chemical of Potential	Acute Standard	Chronic Standard
Metals (µg/L)		
Arsenic	340	148
Barium	21000.0	4100.0
Cadmium	13.0	2.6
Lead	79.0	3.1
Nickel	550.0	61.0
PAHs (µg/L)		
Acenaphthene	83.0	17.0
Benz(a)anthracene	0.5	0.1
Benzo(a)pyrene	*NA*	*NA*
Dibenz(a,h)anthracene	*NA*	*NA*
Fluoranthene	200.0	40.0
Phenanthrene	5.0	1.0
Pyrene	*NA*	*NA*
Total PAHs	*NA*	*NA*

[a] NA = not applicable (no criteria)

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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	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 - 2015)

	Site and Year[1]																																			
	Longterm Monitoring Sites																												Bullhead Sites								
	TB-49			LE-43			PIB-07			PIB-19			PIB-35			MB-46			CC-26			SR-25			MC-27			SR-BH			MB-BH			LP-BH		
COPC	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005
Arsenic																															x			x		
Barium							x	x		x	x		x	x		x	x			x					x				x		x	x		x		
Cadmium							x	x	x		x	x	x	x	x																					
Nickel							x	x		x	x	x	x		x																			x		
Lead							x	x					x																					x		
Mercury																																x				
Acenaphthene									x						x				x	x	x			x			x									
Phenanthrene									x						x				x	x	x			x			x									
Fluoranthene									x		x			x					x	x	x					x	x									
Pyrene								x	x		x			x	x				x	x	x					x	x									
Benzo(a)anthracene									x		x			x	x				x	x	x						x									
Chrysene									x		x			x	x				x	x	x						x									
Benzo(a)pyrene									x		x				x				x	x																
Dibenz(a,h)anthracene								x	x		x		x	x	x				x	x	x	x	x			x	x									
Total PAHs																				x							x									
Oil and Grease							x						x	x			x		x	x					x						x	x		x		
Chlordane									x						x			x			x						x									

[1] X indicates concentration exceeded toxicity threshold

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Table 6. Mean probable effects concentration quotients (PEC-Q) (2005 - 2015)

	Parameter					
Site	Metal Mean PEC-Q (2015)	PCB Mean PEC-Q (2015)	PAH Mean PEC-Q (2015)	Mean PEC-Q (2015)	Mean PEC-Q (2009)	Mean PEC-Q (2005)
Long-term Monitoring Sampling Sites						
TB-49	0.052	0.004	0.000	0.019	0.014	0.013
LE-43	0.256	0.023	0.061	0.113	0.158	0.166
PIB-07	0.900	0.172	0.142	0.405	0.430	0.489
PIB-19	0.654	0.144	0.180	0.326	0.418	0.436
PIB-35	0.798	0.189	0.242	0.410	0.429	0.735
MB-46	0.373	0.039	0.036	0.149	0.217	0.252
CC-26	0.419	0.101	0.924	0.481	0.587	0.356
SR-25	0.237	0.114	0.269	0.207	0.152	0.197
MC-27	0.343	0.020	0.212	0.192	0.214	0.528
Brown Bullhead Sampling Sites						
SR-BH	0.115	0.010	0.040	0.055	0.207	
MB-BH	0.888	0.105	0.041	0.345	0.283	
LP-BH	2.068	0.055	0.083	0.735	0.022	

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Table 7. SEM-AVS ratios (2005 - 2015)

Site	SEM (2015)	AVS (2015)	SEM/AVS (2015)	f_{oc} (2015)	SEM-AVS (2015)	SEM-AVS/ f_{oc} (2015)	SEM-AVS (2009)	SEM-AVS/ f_{oc} (2009)	SEM-AVS (2005)	SEM-AVS/ f_{oc} (2005)
	Parameter									
Long-term Monitoring Sampling Sites										
TB-49	ND	ND	ND	0.002	ND	ND	-1.399	-514.301	-0.060	-144.498
LE-43	0.767	1.30	0.590	0.015	-0.533	-35.533	-1.080	-77.669	-1.253	-158.100
PIB-07	1.400	14.00	0.100	0.045	-12.600	-280.000	-19.076	-522.627	-22.588	-442.555
PIB-19	1.488	16.00	0.093	0.058	-14.512	-250.207	-12.525	-386.580	-24.960	-3741.007
PIB-35	1.700	10.00	0.170	0.071	-8.300	-116.901	-13.762	-395.451	-15.819	-430.566
MB-46	0.392	140.00	0.003	0.160	-139.608	-872.550	-34.930	-551.810	124.637	-1398.216
CC-26	1.980	18.00	0.110	0.055	-16.020	-291.273	-4.848	-109.941	-3.474	-143.030
SR-25	0.957	0.87	1.100	0.017	0.087	-398.080	0.556	49.643	-0.997	-125.248
MC-27	1.032	2.40	0.430	0.034	-1.368	-40.235	0.323	278.103	1.728	417.690
Bullhead Sampling Sites										
SR-BH	0.429	6.40	0.067	0.015	-5.971	5.118	-45.278	-485.811		
MB-BH	0.518	72.00	0.007	0.210	-71.482	-340.389	-210.055	-2354.877		
LP-BH	0.416	26.00	0.016	0.370	-25.584	-69.146	-1.925	-418.522		

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Table 8. ESB-TUs (2005 - 2015)

	Parameter		
Site	**∑ESB-TU (2015)**	**∑ESB-TU (2009)**	**∑ESB-TU (2005)**
Long-term Monitoring Sampling Sites			
TB-49	0.024	0.139	0.200
LE-43	0.249	0.799	1.410
PIB-07	0.193	0.611	0.671
PIB-19	0.183	0.948	2.010
PIB-35	0.190	0.813	0.828
MB-46	0.014	0.112	0.130
CC-26	0.831	1.390	1.450
SR-25	0.834	1.084	2.180
MC-27	0.318	16.812	15.800
Brown Bullhead Sampling Sites			
SR-BH	0.152	0.098	
MB-BH	0.012	0.059	
LP-BH	0.012	0.060	

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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	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	6	ERM	Long and Morgan 1991

[a] *Table was adapted from Boughton (2006)*

[b] *NB = no benchmark*

[c] *ERM = Effects range*

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Table 10. Exceedances of ERM guidelines (2005 - 2015)

	Site and Year[1]																																			
	Longterm Monitoring Sites																											**Bullhead Sites**									
	TB-49			LE-43			PIB-07			PIB-19			PIB-35			MB-46			CC-26			SR-25			MC-27			SR-BH			MB-BH			LP-BH		
COPC	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005	2015	2009	2005
Barium																																				
Cadmium																																				
Nickel							x	x	x	x	x	x	x		x																			x		
Lead																																				
Acenaphthene																											x									
Phenanthrene																			x	x	x						x									
Fluoranthene																			x	x							x									
Pyrene																			x	x	x						x									
Benzo(a)anthracene																			x	x							x									
Chrysene																			x	x																
Benzo(a)pyrene															x				x	x							x									
Dibenz(a,h)anthracene								x	x		x			x	x				x	x							x									
Total PAHs																				x			x			x										
ESB-TU						x						x								x	x		x	x		x	x									
Chlordane			x			x			x			x			x			x			x			x			x									
Threshold Exceeded																			**x**	**x**							**x**									

[1] *x indicates concentration exceeded toxicity threshold*

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Table 11. 15-minute acute mixing zone effluent criteria analysis (2015)

	Effluent at Mixing Zone to Target Screening Criteria Ratio								
COPC	PIB-07	PIB-19	PIB-35	MB-46	CC-26	SR-25	MC-27	TB-49	LE-43
Metals									
Arsenic	0.0130	0.0127	0.0128	0.0130	0.0128	0.0131	0.0124	0.02617	0.01607
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.9999	0.9997	0.9998	0.9995	0.9995	0.9994	0.9994	0.99956	0.99966
Lead	0.0148	0.0143	0.0143	0.0132	0.0143	0.0132	0.0132	0.01461	0.01455
Nickel	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.0909	0.09226	0.09111
PAHs									
Acenaphthene	0.00001	0.00001	0.00001	0.00000	0.00004	0.00001	0.00001	0.00000	0.00001
Benzo(a)anthracene	0.00211	0.00211	0.00233	0.00013	0.00939	0.00880	0.00360	0.06523	0.00254
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	0.00001	0.00001	0.00002	0.00000	0.00010	0.00009	0.00004	0.00000	0.00002
Phenanthrene	0.00046	0.00052	0.00064	0.00004	0.00373	0.00247	0.00147	0.00003	0.00089
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Table 12. 12-hour chronic mixing zone effluent criteria analysis (2015)

	Effluent at Mixing Zone to Target Screening Criteria Ratio								
COPC	PIB-07	PIB-19	PIB-35	MB-46	CC-26	SR-25	MC-27	TB-49	LE-43
Metals									
Arsenic	0.0298	0.0292	0.0295	0.0299	0.0294	0.0301	0.0284	0.06012	0.03692
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.9999	0.9997	0.9998	0.9995	0.9995	0.9994	0.9994	0.99956	0.99966
Lead	0.3770	0.3641	0.3653	0.3366	0.3637	0.3352	0.3360	0.37244	0.37087
Nickel	0.8194	0.8194	0.8194	0.8193	0.8193	0.8193	0.8193	0.83188	0.82150
PAHs									
Acenaphthene	0.00003	0.00003	0.00004	0.00000	0.00019	0.00007	0.00006	0.00000	0.00004
Benzo(a)anthracene	0.01057	0.01054	0.01167	0.00067	0.04694	0.04398	0.01799	0.32614	0.01269
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	0.00007	0.00007	0.00009	0.00001	0.00049	0.00044	0.00018	0.00000	0.00011
Phenanthrene	0.00228	0.00261	0.00320	0.00018	0.01864	0.01234	0.00735	0.00016	0.00446
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Table 13. 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	TB-49	LE-43
Metals									
Arsenic	0.01261	0.01255	0.01250	0.01346	0.01246	0.01261	0.01849	0.02120	0.01233
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.99978	0.99973	0.99979	0.99983	0.99950	0.99940	0.99984	0.99951	0.99944
Lead	0.01451	0.01426	0.01436	0.01434	0.01413	0.01298	0.02706	0.01439	0.01293
Nickel	0.09087	0.09087	0.09087	0.09087	0.09087	0.09086	0.09126	0.09125	0.09086
PAHs									
Acenaphthene	0.00002	0.00003	0.00003	0.00000	0.00006	0.00003	0.00098	0.00005	0.00003
Benzo(a)anthracene	0.00640	0.01175	0.00937	0.00116	0.01418	0.00874	0.12865	0.01390	0.00939
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	0.00005	0.00008	0.00007	0.00001	0.00014	0.00012	0.00189	0.00012	0.00007
Phenanthrene	0.00159	0.00231	0.00243	0.00027	0.00566	0.00367	0.08664	0.00083	0.00283
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Table 14. 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	TB-49	LE-43
Metals									
Arsenic	0.02898	0.02882	0.02872	0.03091	0.02862	0.02897	0.04248	0.04871	0.02832
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	0.99978	0.99973	0.99979	0.99983	0.99950	0.99940	0.99984	0.99951	0.99944
Lead	0.36986	0.36339	0.36590	0.36555	0.36007	0.33072	0.68948	0.36673	0.32950
Nickel	0.81935	0.81932	0.81932	0.81933	0.81928	0.81923	0.82283	0.82279	0.81924
PAHs									
Acenaphthene	0.00011	0.00016	0.00015	0.00002	0.00029	0.00016	0.00479	0.00023	0.00016
Benzo(a)anthracene	0.03202	0.05873	0.04686	0.00580	0.07088	0.04371	0.64327	0.06951	0.04695
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	0.00026	0.00040	0.00036	0.00005	0.00070	0.00058	0.00947	0.00060	0.00034
Phenanthrene	0.00794	0.01156	0.01217	0.00134	0.02831	0.01835	0.43319	0.00417	0.01413
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Table 15. 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	TB-49	LE-43
Metals									
Arsenic	0.01213	0.01256	0.01226	0.01301	0.01266	0.01282	0.01480	0.02257	0.01214
Barium[1]									
Cadmium	0.99961	0.99968	0.99981	0.99959	0.99950	0.99948	**1.00796**	**1.02314**	0.99940
Lead	0.01385	0.01358	0.01418	0.01351	0.01595	0.01299	0.04019	0.01876	0.01283
Nickel	0.09087	0.09087	0.09087	0.09087	0.09089	0.09089	0.09169	0.09145	0.09086
PAHs									
Acenaphthene	0.00002	0.00007	0.00004	0.00000	0.00017	0.00025	0.00220	0.00011	0.00006
Benzo(a)anthracene	0.00639	0.01754	0.00962	0.00098	0.01343	0.01879	0.12865	0.00159	0.01236
Benzo(a)pyrene	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	0.00131	0.00001	0.00011
Phenanthrene	0.00173	0.00617	0.00204	0.00040	0.01249	0.01798	0.13879	0.00055	0.00542
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA

[1] *Samples were not analyzed for Barium in 2005*

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Table 16. 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	TB-49	LE-43
Metals									
Arsenic	0.02786	0.02885	0.02817	0.02990	0.02908	0.01282	0.03401	0.05185	0.02788
Barium									
Cadmium	0.99961	0.99968	0.99981	0.99959	0.99950	0.99948	**1.00796**	**1.02314**	0.99940
Lead	0.35291	0.34596	0.36134	0.34423	0.40648	0.01299	**1.02426**	0.47812	0.32703
Nickel	0.81933	0.81932	0.81933	0.81931	0.81946	0.09089	0.82669	0.82453	0.81924
PAHs									
Acenaphthene	0.00010	0.00033	0.00019	0.00001	0.00082	0.00025	0.01075	0.00053	0.00028
Benzo(a)anthracene	0.03195	0.08768	0.04809	0.00488	0.06715	0.01879	0.64327	0.00797	0.06178
Benzo(a)pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	0.00022	0.00078	0.00025	0.00005	0.00059	0.00022	0.00654	0.00004	0.00055
Phenanthrene	0.00865	0.03085	0.01020	0.00200	0.06245	0.01798	0.69397	0.00275	0.02708
Pyrene	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total PAHs	NA	NA	NA	NA	NA	NA	NA	NA	NA

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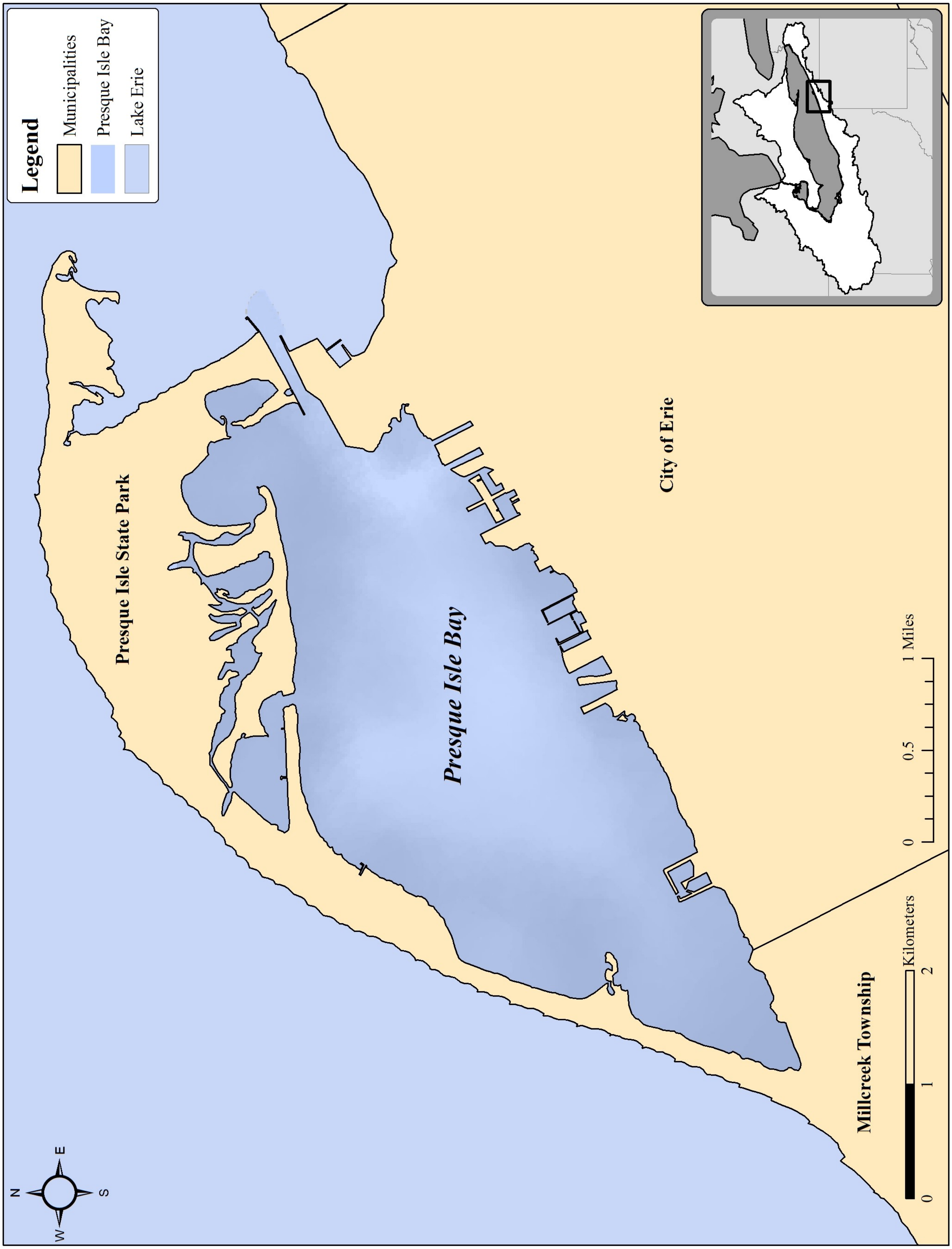
Appendix C: Maps

Map 1: Presque Isle Bay



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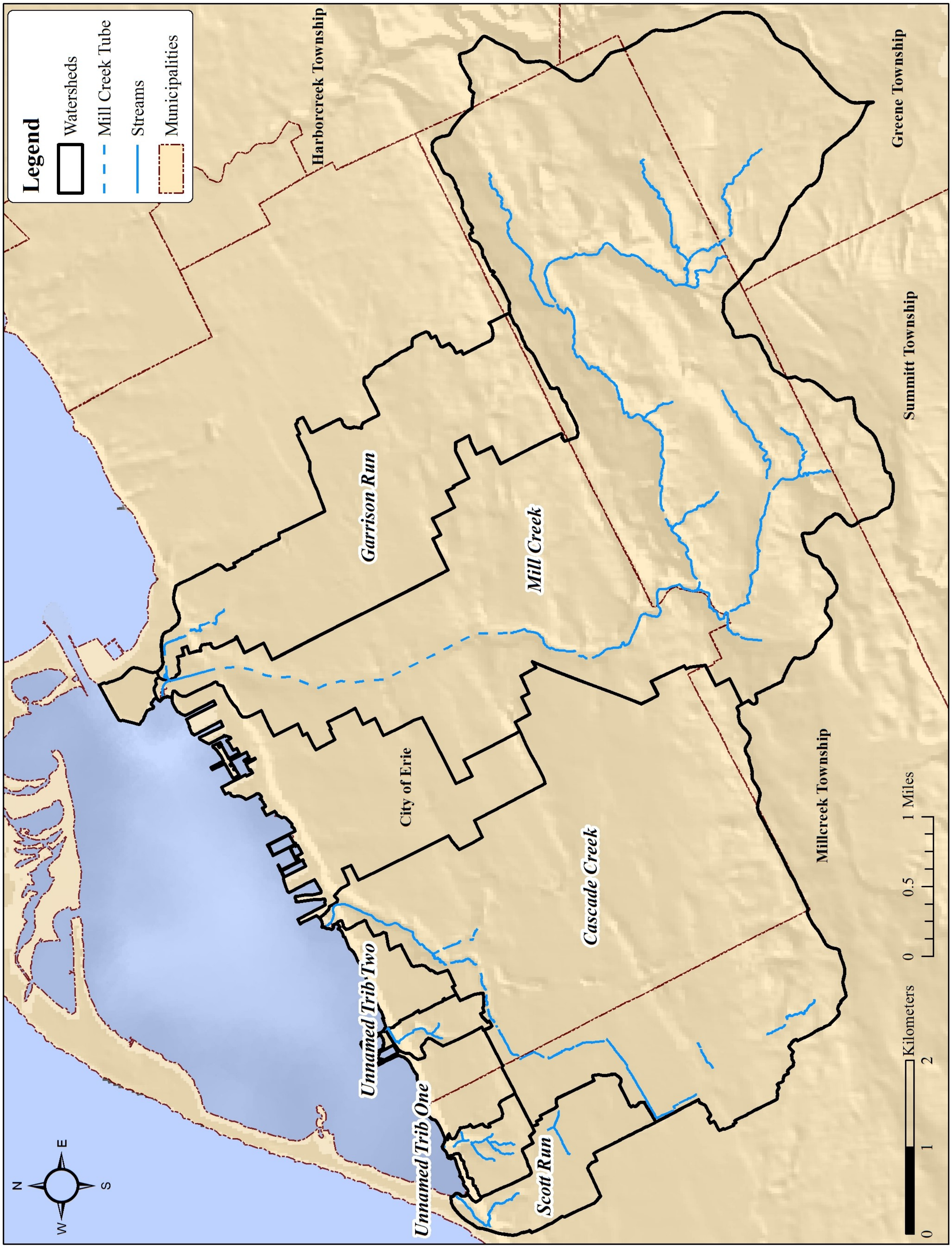
Map 2: Tributaries of Presque Isle Bay



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Map 3: Presque Isle Bay Area of Concern

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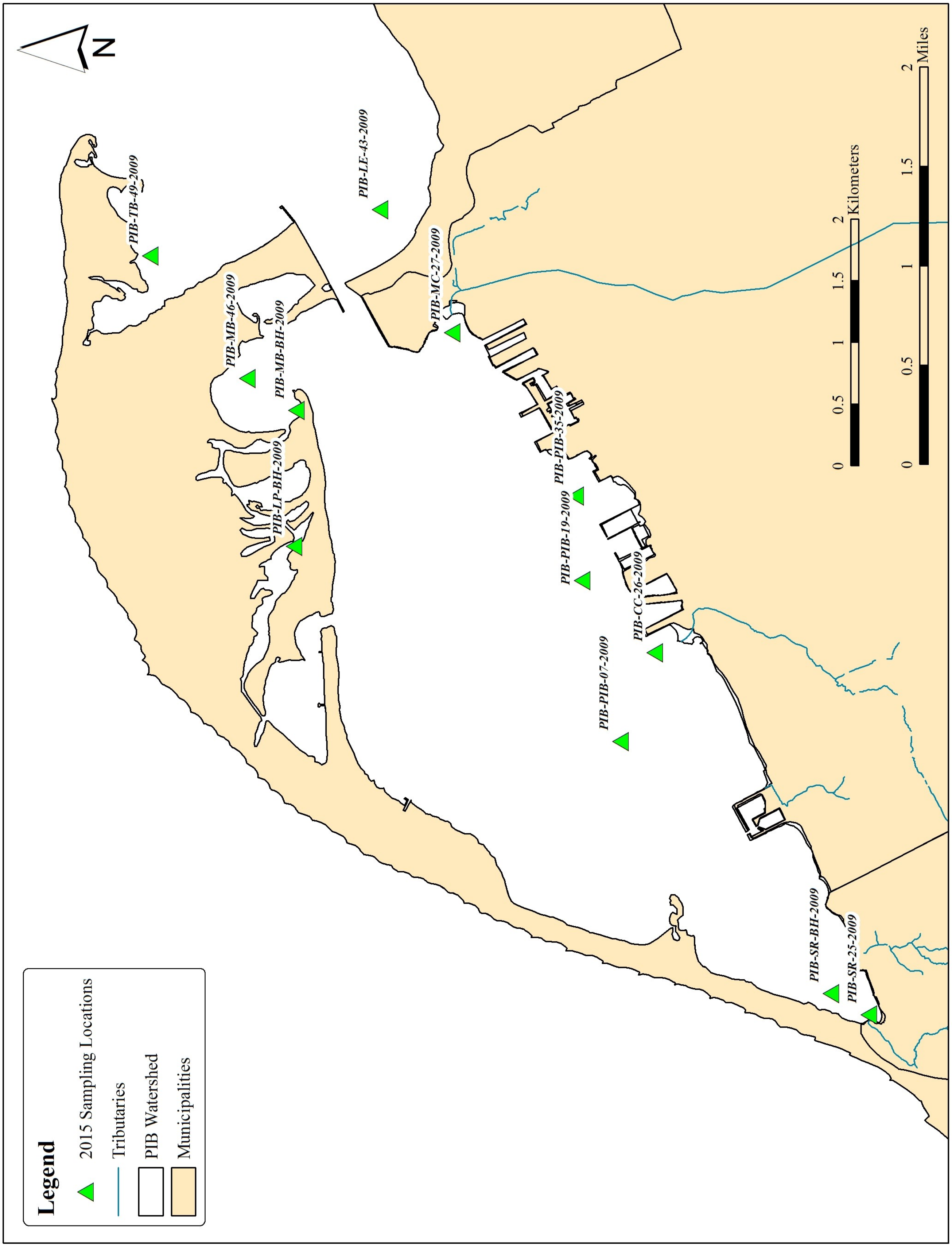
Map 4: 2015 Sediment Sampling Locations



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APPENDIX D: 2015 SEDIMENT CHEMISTRY DATA

Appendix D-1. Pesticide data (2015)

	Site											
Pesticide (µg/kg)[1]	**TB-49**	**LP-BH**	**MB-BH**	**MC-27**	**PIB-07**	**PIB-19**	**PIB-35**	**LE-43**	**MB-46**	**CC-26**	**SR-BH**	**SR-25**
2,4'-DDD	ND	2.6	2.2	ND	4.3	5.9	12	1.1	1.5	ND	0.15	ND
2,4'-DDE	ND	1	1.2	0.12	1.3	1	1.3	0.12	0.78	0.64	0.14	0.59
2,4'-DDT	ND	ND	ND	0.11	ND	ND	ND	0.032	ND	0.095	ND	0.04
4,4'-DDD	ND	0.6	0.69	0.64	1.8	1.8	3.2	0.4	0.64	1.9	0.31	0.93
4,4'-DDE	0.049	4.2	2.3	1.6	4.3	4.1	5.6	1.2	1.8	1.1	0.79	0.56
4,4'-DDT	ND	ND	3.3	1.3	9.3	8.7	13	1.4	2.8	6	0.098	4.1
Aldrin	ND	ND	ND	0.21	0.41	0.45	ND	ND	0.86	0.72	0.096	0.091
Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Dieldrin	ND	ND	ND	1.2	1.1	1.4	2.1	0.28	0.33	4.1	0.25	2.3
Endosulfan I	ND	ND	ND	ND	0.37	0.32	ND	ND	0.31	ND	ND	ND
Endosulfan II	ND	ND	ND	0.089	0.33	0.55	1.1	ND	ND	0.58	ND	ND
Endrin	ND	1.6	1.3	0.66	4.6	3.2	4.5	0.56	ND	1.6	0.53	2.5
gamma-BHC (Lindane)	ND	ND	ND	0.13	0.23	0.4	0.56	ND	ND	1.5	ND	ND
Heptachlor	ND	ND	ND	0.16	ND	0.22	ND	ND	ND	ND	ND	ND
Heptachlor epoxide	ND	0.87	1.5	0.2	1.5	1	1.6	0.43	0.81	ND	0.35	0.76
Hexachlorobenzene	0.027	ND	0.23	0.84	8.5	1.7	0.84	0.46	ND	0.4	0.088	0.36
Methoxychlor	ND	2.8	ND	1.7	7.6	6.2	14	1.2	0.86	13	0.53	3.3
Mirex	ND	ND	ND	0.08	ND	ND	ND	ND	ND	1	ND	ND
trans-nonachlor	ND	ND	ND	1.9	0.58	0.68	1.1	0.23	ND	2.3	0.21	0.65

[1] *ND = non-detect*

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Appendix D-2: Polychlorinated biphenyl (PCB) data (2015)

	Site											
PCB (µg/kg)[1]	**TB-49**	**LP-BH**	**MB-BH**	**MC-27**	**PIB-07**	**PIB-19**	**PIB-35**	**LE-43**	**MB-46**	**CC-26**	**SR-BH**	**SR-25**
PCB 209	ND	0.66	1.4	ND	2	1.3	1.6	0.11	ND	0.75	0.57	ND
PCB 101	ND	3.9	6.6	1.5	11	8.9	12	1.7	2.4	6.8	0.73	9.7
PCB 105	ND	0.66	3.8	ND	4.6	3.2	4	1.5	0.94	2.6	0.24	4.2
PCB 118	ND	2.4	5.2	0.47	8.1	6.5	9.5	0.79	1.9	4.3	0.25	8.3
PCB 128	ND	1.3	3.6	ND	7	5.4	7.7	0.68	1.3	3.9	0.33	3.2
PCB 138	ND	3.6	5.9	0.72	13	12	15	1.7	2.9	9.4	0.44	10
PCB 153	ND	5.3	7.7	1.4	14	11	15	1.4	3.3	7.1	0.73	7.1
PCB 170	ND	2.6	4.8	ND	8.5	6.7	9.9	0.56	1.5	5.5	0.33	2.5
PCB 18	ND	ND	ND	2.1	2.9	3.4	3.6	0.71	ND	3	ND	3.2
PCB 180	ND	3.1	5.3	0.55	10	8.4	12	0.69	2.1	5.3	0.39	3.2
PCB 187	ND	2	2.8	ND	5.8	5	6.8	0.45	1.1	3.3	ND	1.4
PCB 195	ND	ND	ND	ND	1.4	1.2	1.6	ND	ND	0.93	ND	0.44
PCB 206	ND	ND	1.2	ND	4.2	2.6	3.3	0.2	0.48	3.1	ND	0.49
PCB 28	ND	1.1	2.9	2	5.3	6.4	5.4	0.89	1	0.98	0.51	4.2
PCB 44	ND	1.1	3.8	ND	3.7	3.2	4.5	0.63	0.77	1.6	ND	3.8
PCB 52	ND	ND	3.7	1.1	4.7	4	6.3	0.83	1.6	4.5	0.49	6.3
PCB 66	ND	1.7	5.9	1.4	5.3	4.4	5.1	1.5	1.5	1.5	0.3	2.3
PCB 8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.68
PCB 87	ND	1.4	3	0.61	3.9	2.9	3.9	0.82	0.85	3.2	0.28	6.3

[1] *ND = non-detect*

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Appendix D-3: Metal Data (2015)

	Site											
Metal (mg/kg)[1,2]	**TB-49**	**LP-BH**	**MB-BH**	**MC-27**	**PIB-07**	**PIB-19**	**PIB-35**	**LE-43**	**MB-46**	**CC-26**	**SR-BH**	**SR-25**
Antimony	0.038	2.9	1.2	0.47	1.3	1	1.2	0.25	0.8	1.4	0.14	0.45
Arsenic	4.1	**390**	**68**	9.9	20	15	21	10	18	10.0	4.8	14
Barium	5	**200**	**180**	**81**	**110**	**82**	**86**	30	**85**	58	14	44
Beryllium	0.08	0.89	0.65	0.56	1.2	0.92	1	0.43	0.33	0.41	0.11	0.29
Cadmium	0.044	4.6	2.9	0.38	**6.4**	4.2	**6.1**	0.55	1.5	0.71	0.27	0.28
Chromium	3.3	48	40	23	67	48	69	18	20	28	6.5	14
Copper	3.1	99	84	34	110.0	86	110	28	42	74	11	44
Lead	2.3	**150**	75.0	36	**140.0**	100.0	**130.0**	18.0	34	62.0	8	23
Nickel	8.5	**59**	47	29	**74.0**	**52**	**63**	26	28	30	11	21
Zinc	17	320	260	150	400	300	360	110	130	250	49	160
Mercury	ND	0.33	0.15	0.048	0.42	0.34	0.39	0.04	0.095	0.091	0.024	0.036

[1] *ND = non-detect*

[2] *Numbers in bold font indicates concentration exceeded Sediment Quality Guideline (SQG)*

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Appendix D-4: Polycyclic Aromatic Hydrocarbon (PAH) data (2015)

	Site											
PAH (µg/kg)[1,2]	**TB-49**	**LP-BH**	**MB-BH**	**MC-27**	**PIB-07**	**PIB-19**	**PIB-35**	**LE-43**	**MB-46**	**CC-26**	**SR-BH**	**SR-25**
1,1'-Biphenyl	ND	6.9	1.6	ND	4.7	ND	ND	2.3	1.6	ND	ND	ND
1-Methylnaphthalene	ND	25	6.3	11	22	22	22	10	4.8	32	1.9	ND
1-Methylphenanthrene	ND	23	13	45	38	49	61	20	16	160	7.3	36
2,3,5-Trimethylnaphthalene	ND	6.7	3.5	7.1	13	14	15	9.4	3.3	ND	1.5	ND
2,6-Dimethylnaphthalene	ND	16	6.5	ND	18	18	21	11	5.7	ND	2.1	ND
2-Methylnaphthalene	ND	31	9.2	12	27	27	29	12	6.3	40	2.4	ND
Acenaphthene	ND	13	4.7	28	21	26	35	8.3	6	**140**	4.3	15
Acenaphthylene	ND	13	3.2	ND	8.9	9	12	3.7	2.9	ND	ND	ND
Anthracene	0.15	27	12	93	51	77	91	32	14	370	11	64
Benzo[a]anthracene	0.54	140	87	450	350	450	610	140	79	**1900**	73	550
Benzo[a]pyrene	0.57	150	110	480	450	550	720	150	99	**2300**	100	780
Benzo[b]fluoranthene	0.94	180	150	560	580	620	860	170	130	2700	160	1100
Benzo[e]pyrene	0.72	120	100	390	370	440	540	120	82	1800	100	750
Benzo[g,h,i]perylene	0.37	82	63	360	250	310	390	93	54	1300	81	550
Benzo[k]fluoranthene	0.85	200	150	520	480	630	750	170	120	2600	120	980
C1-Chrysenes	ND	65	47	170	180	230	280	63	45	670	37	210
C1-Dibenzothiophenes	ND	14	7.9	ND	23	27	ND	12	6.2	ND	ND	ND
C1-Fluoranthenes/pyrene	1.2	250	160	530	540	640	740	170	130	2000	140	580
C1-Fluorenes	ND	13	ND	ND	21	ND	ND	11	6.3	ND	ND	ND
C1-Naphthalenes	ND	39	11	ND	34	33	37	15	7.6	ND	ND	ND
C1-Phenanthrenes/Anthracenes	13	94	99	180	150	180	240	81	84	600	40	130
C2-Chrysenes	ND	25	21	65	89	110	130	30	22	230	17	76
C2-Dibenzothiophenes	ND	15	12	ND	35	42	45	19	10	ND	8.5	ND
C2-Fluoranthenes/Pyrene	1.2	190	97	340	350	440	500	120	78	1300	78	420
C2-Fluorenes	1.4	19	12	ND	42	50	45	22	12	ND	11	ND
C2-Naphthalenes	0.93	76	32	60	100	100	110	64	29	ND	12	ND
C2-Phenanthrenes/Anthracenes	1.3	56	41	100	120	150	170	69	36	320	28	87
C3-Chrysenes	ND	17	11	40	53	56	62	16	10	ND	8.5	40
C3-Dibenzothiophenes	ND	22	29	ND	54	48	51	23	22	ND	26	ND

[1] *ND = non-detect*

[2] *Numbers in bold font indicates concentration exceeded Sediment Quality Guideline (SQG)*

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Appendix D-4 [continued]: Polycyclic Aromatic Hydrocarbon (PAH) data (2015)

	Site											
PAH (µg/kg)[1,2]	**TB-49**	**LP-BH**	**MB-BH**	**MC-27**	**PIB-07**	**PIB-19**	**PIB-35**	**LE-43**	**MB-46**	**CC-26**	**SR-BH**	**SR-25**
C3-Fluoranthenes/Pyrene	ND	47	34	95	140	170	190	46	31	340	25	120
C3-Fluorenes	0.83	45	29	55	66	72	82	35	22	230	20	84
C3-Naphthalenes	1.7	90	59	67	130	130	140	92	52	140	20	35
C3-Phenanthrenes/Anthracenes	0.96	33	27	46	90	120	110	55	24	180	24	60
C4-Chrysenes	ND	15	6.8	ND	22	ND	ND	13	5.8	ND	5.6	ND
C4-Dibenzothiophenes	ND	11	11	ND	35	44	38	15	7.7	ND	8.2	ND
C4-Naphthalenes	1.2	39	36	48	98	110	110	87	31	ND	23	46
C4-Phenanthrenes/Anthracenes	ND	20	16	ND	64	77	76	39	19	ND	13	41
Chrysene	1.2	200	130	640	440	580	780	190	120	**2900**	140	1100
Dibenz(a,h)anthracene	ND	31	21	120	100	120	**160**	35	22	**480**	26	**190**
Dibenzothiophene	ND	22	4.8	30	18	23	29	11	4.5	120	4	26
Fluoranthene	2.1	430	230	1400	740	980	1400	370	210	**6200**	240	1700
Fluorene	ND	41	7.7	39	25	33	42	16	9.2	150	6.6	25
Indeno[1,2,3-cd]pyrene	0.42	88	68	350	270	330	420	100	59	1400	85	600
Naphthalene	ND	60	8.4	ND	23	25	31	22	6.5	53	2	ND
Perylene	0.42	46	36	150	170	210	210	71	32	600	33	210
Phenanthrene	0.8	330	65	560	230	340	510	150	64	**2300**	74	470
Pyrene	1.5	430	250	1000	770	890	1100	260	180	**4200**	220	1200
Total PAHs	8.22	1896	938.2	4842	3235.9	4107	5520	1389	818.9	21033	899.3	6094

[1] ND = non-detect

[2] Numbers in bold font indicates concentration exceeded Sediment Quality Guideline (SQG)

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Appendix D-5: General Chemistry Data (2015)

	Site											
Parameter[1]	**TB-49**	**LP-BH**	**MB-BH**	**MC-27**	**PIB-07**	**PIB-19**	**PIB-35**	**LE-43**	**MB-46**	**CC-26**	**SR-BH**	**SR-25**
AVS (µM/g)	ND	840	2300	78	460	500	320	42	4600	570	210	28
SEM (uM/g)	ND	13.44	16.56	33.54	46.2	46.5	54.4	24.78	12.88	62.7	14.07	30.8
Oil and Grease (mg/kg)	65	**3800**	**2300**	**2300**	**3600**	1200	**3400**	310	1800	**5000**	530	1400
Nitrate/Nitrite as N (mg/kg)	0.2	6.4	7	ND	1.5	1.7	6.6	0.63	4.2	ND	ND	ND
Total Organic Carbon (mg/kg)	2300	370000	210000	34000	57000	58000	71000	15000	160000	55000	15000	17000
Total Organic Carbon (%)	0.23	37	21	3.4	5.7	5.8	7.1	1.5	16	5.5	1.5	1.7
Total Organic Carbon (f_{oc})	0.0023	0.37	0.21	0.034	0.057	0.058	0.071	0.015	0.16	0.055	0.015	0.017

[1] *ND = non-detect*

[2] *Numbers in bold font indicates concentration exceeded Sediment Quality Guideline (SQG)*

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