Evaluation of Ashtabula Harbor Federal Navigation Channel Sediments With Respect to Their Suitability for Open-Lake Placement, 2010

1.0 Introduction

This Tiered Evaluation on Ashtabula Harbor Federal navigation channel sediments has been performed to determine which sediments, if dredged, meet Federal guidelines for open-lake placement. It has been prepared in accordance with guidance contained in the 1998 U.S. Environmental Protection Agency (USEPA)/U.S. Army Corps of Engineers (USACE) Great Lakes Dredged Material Testing and Evaluation Manual (USEPA/USACE 1998). Figure 1 shows the existing Federal navigation project. This evaluation is based mainly on data collected between 2005 and 2009 on the Federal navigation project within the Lower River Channel (river reach between Station 120+00 and Station 100+00, or Area C within the River channel) and Outer Harbor channels (Areas A, B, C and E) as shown in Figure 1, along with open-lake reference and placement areas. It does not address portions of the Federal navigation project within the Lower River between the Fifth Street Bridge and Station 120+00, and Upper River (harbor reach between Fifth Street Bridge and upstream limit of Federal project) also referred to as Areas F and G of the Federal Navigation Channel (Figure 1).

2.0 Background

The entire Ashtabula Harbor Federal navigation project is situated within the Ashtabula River Area of Concern (AOC) (USEPA 2008). Traditional contaminants in Ashtabula Harbor Federal navigation channel sediments include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), metals and low level radionuclides. Between 2006 and 2007, USEPA conducted a mass removal of contaminated sediments from the Upper River between the upstream end of the Upper River Turning Basin and Fifth Street Bridge, under the Great Lakes Legacy Act of 2002. In 2008, USACE dredged contaminated sediments from the Federal navigation channel and adjacent areas between the Fifth Street Bridge and Station 120+00 in the River, under Section 312 of the Water Resources Development Act of 1990. Currently, primary sources of contamination to harbor sediments in the Lower River (downstream of Station 120+00) and Outer Harbor channels include upstream Ashtabula River sediments and a coal dock along the Lower River Channel.

Although the large-scale dredging projects completed between 2006 and 2008 served to remove a large volume of PCBs from the AOC and harbor, low-level PCB contamination in harbor sediments continues to be an environmental issue. This is of particular concern with respect to the deep-draft channels in the Lower River and Outer Harbor channels activity used by commercial vessels transiting the harbor. When material is dredged from these channels, the typical practice is to place the material at an authorized open-lake area, provided that it meets relevant Federal guidelines (USEPA/USACE 1998). Through 2003, these channels were dredged, on average, about every three years; this dredged material met Federal guidelines, and complied with promulgated Ohio Water Quality Standards, for open-lake placement (USACE 2003). In 2007, minor increases in PCB contamination in Lower River and West Outer Harbor channel sediments evidenced that a portion of the dredged material was no longer suitable for open-lake placement (USACE 2007). A 2008 Tiered Evaluation concluded, based on existing information, that some of the sediments in these channels no longer met Federal guidelines for open-lake placement due to PCB contamination alone (USACE 2008a). Nevertheless, 2009 data on surface samples in the Lower River and West Outer Harbor show a net decline in PCB contamination across these two areas since 2005, suggesting a reduction in PCB migration from upstream areas. Average total PCB concentrations in surface sediments across the years 2003, 2005, 2007 and 2009 are shown in Figure 2. Average total PCB concentrations in core sediment samples for the years 2007 and 2009 in the Lower River and Outer Harbor are shown in Figure 3. PCB concentrations at depth were relatively stable from 2007 to 2009. Figure 4 shows discrete PCB concentrations in surface sediments for the years 2003, 2005, 2007 and 2009, moving downstream from Station 120+00. Note AMU 1A and AMU 1B in the figure refers to management units within the Lower River. Generally, PCB concentrations at the sediment surface decrease within the Lower River Channel, moving from Station 120+00 to Station 100+00 for each of the years evaluated. PCB levels were highest in 2005, with 2009 showing a return to the relatively lower levels observed in 2003. Figure 5 shows PCB concentrations in core samples, moving downstream from station 120+00. As with the surface sediments, total PCB levels decrease with distance downstream.

Ashtabula Harbor was last dredged in 2009 where dredging occurred only in the East Outer Harbor. The Lower River and West Outer Harbor channels were last dredged in 2003. Figure 6 shows current water depths in the Lower River and Outer Harbor channels.

3.0 Scope of Evaluation

The majority of the sampling/analysis efforts described below were tailored toward investigating PCB contamination in Ashtabula Harbor sediments that need to be dredged for maintenance of the Federal navigation channels. This evaluation was based on the following Ashtabula Harbor sediment sampling/testing investigations:

General Bulk Sediment Chemical Analysis, Elutriate Testing and Bioassays (2005, 2007)

In 2005, 13 surface grab samples were collected from Ashtabula Harbor in the Lower River and Outer Harbor channels (Sites AH-3 through AH-15; Figure 7). To represent the lake environs, four surface grab sediment samples were collected from the open-lake reference area (Sites AL-1 through AL-4) and two surface grab samples were collected from the open-lake placement area (Sites AD-1 and AD-2) (Figure 8). Harbor samples from Sites AH-3 through AH-6, AH-12 and AH-13, and AH-14 and AH-15, as well as all lake reference/placement area samples were subjected to bulk particle size analyses, and analyzed for the following: Inorganics—heavy metals, cyanide, ammonia, phosphorus, nitrogen, oil/grease and total organic carbon (TOC); and organics—PAHs, PCBs and pesticides. Subsamples from some of these discrete samples were also composited into the following harbor management units (MU) or lake samples: AB-1 (Sites AH-3 through AH-6) in the River (downstream of Fifth Street Bridge) through the river mouth; AB-2 (Sites AH-12 and AH-13) in the mid-Outer Harbor; AB-3 (Sites AH-14 and AH-15) in the East Outer Harbor (see Figure 7); and AL (Sites AL-1 through AL-4) in the open-lake reference area and AD (Sites AD-1 and AD-2) in the open-lake placement area (see Figure 8). These composite samples were analyzed for PAHs, PCBs and TOC, and subjected to two separate acute toxicity tests (bioassays). In addition, a standard elutriate test (SET) for heavy metals, cyanide, ammonia, phosphorus, nitrogen, oil/grease, TOC, PAHs, PCBs and pesticides was applied to MU composite AB-1 through AB-3 sediment samples. These sediment analyses were completed by Engineering and Environment, Inc. (EEI) (2005) and U.S. Army Engineer Research and Development Center (USAERDC) (2007a) (note that the 2005 bulk sediment PCB data were rejected; reanalysis of archived sediment samples for PCBs was performed by USAERDC in 2007).

PCB Bulk Sediment Analysis (2007)

Based on the results of the 2005 sediment analyses, PCB contamination in the harbor was investigated in greater detail in 2007. The 2007 investigation divided the harbor into seven separate MUs, representing the Lower River (AMU 1) and Outer Harbor channels (AMU 2, AMU 3, AMU 4, AMU 5, AMU 6, and AMU 7). These MU boundaries represent approximate areas within the Federal navigation channels characterized by sampling sites. Figures 9 through 13 show the sampling locations and associated MUs. A total of 65 surface grab and 17 core samples were collected from discrete sites. The core samples were segregated into one foot intervals. These samples focused on the side slopes of the Federal navigation channel in the lower Ashtabula River.

The lake environs was represented by four surface grab sediment samples from an alternative open-lake reference area (Sites ALR-1 through ALR-4) and two from the open-lake placement area (Sites AD-1 and AD-2) (Figure 14). For each MU and the two lake areas, discrete samples were combined to create composite samples. All surface grab, core and composite sediment samples were analyzed for PCBs (Aroclors) and TOC, and grain size analysis was applied to all composite samples. All sediment analysis were completed by (USAERDC 2007b).

PCB Bulk Sediment, Bioaccumulation and Elutriate Testing (2009)

Based on an evaluation of the 2005 and 2007 sediment data, AMU 1, AMU 2, AMU 3 and AMU 4 were selected for additional sediment sampling, and associated bulk sediment PCB and bioaccumulation testing, and PCB SET. For the purposes of this evaluation, AMU 1 was divided into AMU 1A and AMU 1B, and AMU 4 was divided into AMU 4A and AMU 4B. This further delineation separated areas of concern from areas determined to not be of concern with respect to PCB contamination, based on the 2005 and 2007 investigations. Figures 9 through 13 show the locations for the 2009 sediment investigation combined with those of the 2005 and 2007 investigations, within the MUs described above. Eighteen surface grab and six core sediment samples were collected from discrete sites within AMU 1A, AMU 1B, AMU 2, AMU 3, AMU 4A and AMU 4B. These samples targeted mainly the center of the Federal navigation channel within the Lower River. The lake environs was represented by four surface grab sediment samples from an open-lake reference area (Sites ALR-1 through ALR-4) and two from the open-lake placement area (Sites AD-1 and AD-2) (Figure 14).

The primary objective of this investigation was to use biological testing to determine if sediments in areas of concern and adjacent locations were suitable for open-lake placement. Biological testing consisted of exposing the aquatic oligochaete worm *Lumbriculus variegatus* to MU composite sediment samples in the laboratory for 28 days, to assess the bioaccumulation of PCBs in tissue. This test followed standard procedures outlined in USEPA/USACE (1998). Six composite samples were assembled from the discrete sediment samples to test each MU for PCB bioaccumulation. Additionally, composite samples were combined from the discrete samples from each lake area. Five bioaccumulation test replicates were run for each MU and lake area composite sample. All surface grab, core and composite sediment samples were analyzed for PCBs (209 congeners) and TOC, and all composite samples were subjected to grain size analysis, and PCB bioaccumulation and SET. All sediment analyses were completed by USACE (2009).

Sediment Radionuclide Analysis (2008)

In 2008, six archived composited MU sediment samples (AMU-1 through AMU-6) from the 2007 harbor sediment sampling/analyses were subjected to radiological testing. The sediment composites were analyzed for isotopic uranium, isotopic thorium, and for radium-226 and radium-228 (USAERDC 2008). In 2001, sediment samples from an open-lake reference area were analyzed for the same radionuclides (USACE 2001).

4.0 Sediment Testing Results and Evaluation

The toxicological assessment of these Ashtabula Harbor sediments is summarized as follows:

Bulk Sediment Analyses

1. Physical Testing

Table 1 presents the results of sieve analyses performed on sediment samples. The following provides a summary of the physical characterization of sediments within Ashtabula Harbor.

- Outer Harbor Channels (AMU 2, 3, 4A, 4B, 5, 6 and 7): Particle size distribution tests from 2005, 2007 and 2009 show the Outer Harbor sediments to be mainly fine-grained, ranging from 67.3% (AMU-6

[2007]) to 95% (AMU-5 [2007]) clay and silt, with the majority classified as silt. The exception is sample AMU-6 (2009) representing AMU 4B, which was classified as mostly sand (77.3%).

- Lower River Channel (AMU 1A and 1B): Samples from 2005 and 2009 demonstrate AMU 1A sediments to be mainly fine-grained, on the order of 70% silt and 10% clay. AMU 1B was found to be mainly coarse-grained in 2009, at 66.3% sand and 0.3% gravel. However, sample AH-4 in AMU 1B, taken adjacent to AMU 1A in 2005, was mainly fine-grained at 73% silt and 22.9% clay. The 2007 composite sample for the Lower River (AMU-1 [2007]) shows mainly fine-grained sediments at 87.4% silt and clay.
- Lake (AD and ALR): Open-lake placement area (AD) sediments were mainly fine-grained, ranging from 67% (AD-1 [2005]) to 91.2% (AD-COMP [2007]) clay and silt, with the majority classified as silt. The 2007 open-lake reference area sediments were mainly coarse-grained at 60.4% sand (ALR-COMP [2007]), whereas the area selected in 2009 was mainly fine-grained at 69.5% clay and silt. In 2005, four samples were taken in an area similar to 2009, with all but one (AL-3 [2005], 64.9% sand) being mainly fine-grained ranging from 89.6% (AL-2 [2005]) to 98.9% (AL-4 [2005]) clay and silt, with the majority classified as silt.

In summary, Ashtabula Harbor possesses mainly fine-grained sediments, although areas of mainly coarse-grained sediment exist in both the Lower River (AMU 1B) and Outer Harbor channels (AMU 4B). The open-Lake reference and placement areas also consisted of mainly fine-grained sediments; however as in the harbor, some areas of mainly coarse-grained sediments exist.

2. Chemical Testing

Both open-lake reference and placement area sediments were used to represent the lake environs. As such, contaminant concentrations in the harbor were compared to these areas to determine if they significantly exceeded lake sediment concentrations.

A. Inorganic Analyses

Table 2 presents the results of inorganic analyses on the 2005 sediment samples.

Heavy Metals

The vast majority of metal concentrations in the harbor sediment samples were less than those of the open-lake reference and/or placement areas. The few sediment samples and metals that exceeded open-lake reference and/or placement area concentrations were not of toxicological significance.

TOC and Other Inorganic Parameters

TOC results for samples collected in 2005, 2007 and 2009 are shown in Tables 2, 4 and 6, respectively. Generally, higher TOC content is present in the Lower River Channel in comparison to the lake areas and Outer Harbor channels. Mean TOC content within the Lower River Channel across the investigation periods is 1.91%, with a range of 0.38% to 9.60%. Mean TOC content in the Outer Harbor channels was 1.10%, with a range of 0.16% to 3.20%. The open-lake placement area showed a mean TOC of 1.19% (range 0.32% to 2.27%), whereas the open-lake reference area showed a mean TOC of 1.17% (range 0.27% to 2.93%). Areas of very low TOC content (<0.5%) were present in the open-lake, AMU 4A and B, and AMU 1B in mainly sandy areas.

The total ammonia concentration of 323 mg/kg at Site AH-14 in the East Outer Harbor was significantly elevated relative to the open-lake reference area sediments. Based on these data, ammonia was identified as a preliminary contaminant of concern (COC) relative to Site AH-14 within MU AB-3. It should be noted, however, that the average ammonia concentration in sediments across Sites AH-14 and AH-15 within this MU was 236 mg/kg and more comparable to the levels in open-lake reference area sediments.

B. Organic Analyses

PAHs

Table 3 presents the results of these analyses. The 16 USEPA priority pollutant PAH compounds were summed to determine total PAHs (non-detectable concentrations were valued at the laboratory reporting limit [LRL]). Total PAH concentrations in the harbor sediment samples ranged from 0.46 mg/kg (Site AH-4) to 1.60 mg/kg (Site AH-6). At the open-lake reference and placement areas, total PAH levels in the sediment samples ranged from 0.24 mg/kg to 1.80 mg/kg, and 0.63 mg/kg to 1.59 mg/kg, respectively.

PCBs

Figures 10 through 14 show the locations and total PCB concentrations for surface grab and core sediment samples (for core samples, note that average total PCB concentrations are given) collected from Ashtabula Harbor in 2005, 2007 and 2009. Evaluation of PCB contamination in harbor sediments consisted of an integrated assessment from these three investigations. PCB data from 2005 led to a more comprehensive investigation in 2007, which formed the basis for the 2009 PCB bioaccumulation testing. These evaluations are discussed in detail below.

2005 and 2007 Evaluation

Table 4 includes the total PCB results of sediment samples collected in 2005 and 2007. Included in the table are sample depths referenced to the Low Water Datum (LWD)[1]. PCB concentrations in the sediments were quantified as Aroclors. Bulk sediment PCB data relative to EEI (2005) were reanalyzed by USAERDC (2007a). Total PCB concentrations from harbor and open-lake sediments from USAERDC (2007a) were determined by summing Aroclors 1254, 1260 and 1248, and Aroclors 1254 and 1260, respectively (note that all non-detectable Aroclor concentrations were valued at zero for the purposes of summing; consequently, non-detectable concentrations at several of the sites in the East Outer Harbor [i.e., Sites AH-10, and AH-12 through AH-15] are not included in Table 4). Total PCB concentrations in harbor and lake area sediments from USAERD (2007b) were determined by summing Aroclors 1248 and 1260 (all non-detectable Aroclor concentrations were conservatively valued at the LRL for the purposes of summing because they were almost always detected). In 2005, total PCB concentrations in harbor sediments ranged from 92.7 µg/kg (Site AH-9) to 1527 µg/kg (USAERDC 2007a). At the open-lake reference and placement areas, total PCB concentrations in sediments were 95.3 µg/kg and 274 µg/kg, respectively. In 2007, total PCB concentrations in harbor sediments ranged from 5 µg/kg (Site/Sample AMU4-06C 0-1) to 1143 µg/kg (Site/Sample AMU1-01C 5-6) (USAERDC 2007b). Open-lake reference and placement area sediment total PCB concentrations ranged from 62.2 µg/kg to 104 µg/kg, and 38.6 µg/kg to 109 µg/kg, respectively. For the purposes of this evaluation, the reference area total PCB concentration of 96.2 µg/kg (Site AL-1-07-b) was used. Total PCB concentrations in sediments at many sites in the

[1] 569.2 feet above Mean Water Level at Rimouski, Quebec (IGLD 1985) (International Great Lakes Datum 1985)

Lower River (downstream of Station 120+00) and Outer Harbor Channel exceeded this open-lake reference area concentration, ranging from 97.3 µg/kg (Site/Sample AMU4-12S) to 1527 µg/kg (Site AH-8). These sites are shaded in the ninth column of Table 4.

Bioaccumulation is an appropriate biological measurement endpoint for PCBs to evaluate their potential toxicological impacts in the aquatic environment. To ascertain whether total PCB concentrations from dredged harbor sediments at these sites would bioaccumulate to levels higher relative to those at the open-lake reference/placement areas, a theoretical (or thermodynamically-defined) bioaccumulation potential (TBP) model (Equation 1) was employed. TBP is an equilibrium theory-based algorithm used to predict the potential bioaccumulation of neutral, organic compounds, such as PCBs, in sediments into benthic organisms (McFarland 1984). This model is expressed as:

$$TBP = BSAF\ (L)\ (C_s/TOC) \qquad \text{Equation 1}$$

Where:

TBP = Predicted whole body tissue concentration of the neutral organic compound (µg/kg wet weight)
BSAF = Biota-sediment accumulation factor
L = Concentration of lipid in target animals (percent of wet weight)
C_s = Concentration of neutral organic compound in sediment (µg/kg dry weight)
TOC = Total organic carbon concentration in sediment (percent of dry weight)

TBP is a screening tool that tends to err on the conservative side. The target animal used in this case is an oligochaete worm. In this model, a 1% lipid content, an average characteristically representative of oligochaete worms (e.g., Ankley *et al.* 1992, Pickard *et al.* 2001), and TOC data from Tables 3 and 5 were used. A BSAF is a measure of neutral organic compound bioavailability (Ferraro *et al.* 1990) and is a driving variable in TBP. The use of empirical, site-specific BSAFs can substantially improve the predictive capability of the TBP model. Pickard *et al.* (2001) developed BSAFs for total PCBs in Ashtabula Harbor sediments. The data set was unique in that they indicated that the presence of coal soot in harbor sediments played a conspicuous role in PCB bioavailability. The median BSAF of 0.38 for Lower River Channel sediments located adjacent and in the vicinity of a coal dock was less than one-third and significantly lower than the Upper River sediments (median BSAF=1.34). In fact, the difference between the two BSAF data groups was greater than would be expected by

chance alone (Wilcoxon-Mann-Whitney test, U=420; P<0.001). The BSAFs from this study and related data were used to make the TBP predictions in this evaluation, based on the provided rationale:

Harbor/Lake Erie area	BSAF	Rationale
Lower River Channel	0.38	Site-specific value
Outer Harbor Channels	0.47	Site-specific value
Reference	1.20	Site-specific value
Placement (Disposal)	0.47	Represents disposed sediment (conservative assumption)

Table 4 summarizes the TBP predictions for Ashtabula Harbor sediment-associated PCBs. The open-lake reference area TBP for total PCBs (using Site AL-1-07b) was 167 µg/kg (note that the TBP algorithm is not suitable for sediments with TOC concentrations of less than 0.5% [see USEPA/USACE 1998]; since three of the four open-lake reference area sites possessed TOC levels less than 0.5%, only Site AL-1-07b was used to compute TBP for the USAERDC [2007b] data). For those sites at which total PCB concentrations exceeded open-lake reference area sediment concentrations, total PCB TBP estimates ranged from 5.41 µg/kg (Site/Sample AMU1-04S) to 344 µg/kg (Site/Sample AMU1-01C 5-6). Those sites/samples at which total PCB TBP estimates exceeded that of the reference area sediments are shaded in column 13 of Table 4, and include 15 sites collected within the following areas (note that Sites AH-7 and AH-11 were included because they were negligibly lower than the open-lake reference area TBP of 167 ug/kg, and Site AH-3 was also included because it exceeded the USAERDC [2007a] TBP of 0.57 µg/kg):

Harbor area	Sites/samples
Lower River Channel between Stations 120+00 and 108+50	AH-3, AMU1-03C 0-1, AMU1-01C 2-3, AMU1-01C 3-4, AMU1-01C 4-5 and AMU1-01C 5-6
West Outer Harbor Channels inside northwest side of West Breakwater	AH-7, AH-8, AMU4-02C 1-2, AMU4-02C 2-3, AMU4-02C 3-4, AMU4-06C 2-3 and AMU4-06C 3-4
Outer Harbor Channels east of river mouth	AH-11 and AMU2-05C 4-5

Due to predicted elevated bioaccumulation relative to the Lake Erie environs, the 2007 evaluation identified total PCBs as a COC at these 15 sites in Ashtabula Harbor.

2009 Evaluation

The purpose of the 2009 investigation was to further investigate the areas where PCBs in the harbor were determined to be a COC based on the 2005 and 2007 sediment investigations. Additional sediment sampling, and bulk sediment PCB and bioaccumulation testing were conducted to determine if these sediments meet Federal guidelines for open-lake placement. The following table summarizes additional sampling that was performed to investigate the areas of concern identified above.

Management unit	2005 and 2007 sites of concern	2009 sampling sites
AMU 1A	AH-3, AMU1-03C 0-1, AMU1-01C 2-3, AMU1-01C 3-4, AMU1-01C 4-5 and AMU1-01C 5-6	AMU 1-01C, AMU 1-02C, AMU 1-03C, AMU 1-04S, AMU 1-05S
AMU 2	AH-11 and AMU2-05C 4-5	AMU 3-12C, AMU 3-13S, AMU 3-14S
AMU 4A	AH-7, AH-8, AMU4-02C 1-2, AMU4-02C 2-3, AMU4-02C 3-4, AMU4-06C 2-3 and AMU4-06C 3-4	AMU 5-18C, AMU 5-19S, AMU 5-20C, AMU 5-21S, AMU 5-22S

Additional samples collected in 2009 for bioaccumulation testing were to confirm whether sediments in areas adjacent to the areas of concern were suitable for open-lake placement. These include the samples collected from AMU 1B, AMU 3 and AMU 4B.

Bioaccumulation Test Results

Table 5 displays the results of the 2009 PCB bioaccumulation tests along with worm lipid content, and associated bulk sediment concentrations of total PCBs and TOC. Total PCBs in the 2009 sediment and tissue samples were determined from the sum of individual congeners, with non-detectable congeners valued at the LRL. Mean total PCB bioaccumulation from the MU sediments was compared to that associated with the open-lake placement area sediments. Through analysis of variance (ANOVA) followed by planned contrasts, it was determined that sediments in AMU 1A resulted in a statistically higher mean lipid-normalized total PCB concentration in tissue (mean 97.3 ng/g-lipid) when compared to that associated with the open-lake placement area sediments (mean 63.3 ng/g-lipid) (ANOVA $F=31.76$, $P<0.0001$). The same comparison showed that sediments

within AMU 1B, AMU 2, AMU 4A and AMU 4B did not result in statistically higher mean lipid-normalized total PCB concentrations in tissue (range 20 ng/g-lipid to 66.3 ng/g-lipid) when compared to those associated with the open-lake placement area sediments. Figure 15 displays the mean and standard deviation for the worm lipid-normalized tissue concentration data associated with the MU and open-lake placement area sediments. These data were found to be normally distributed through the Shapiro-Wilk normality test with the parameters W=0.946, P=0.0601 and N=39. Additionally, the homogeneity of variances were acceptable with the parameters Levene's F=1.30 and P=0.2847.

Also shown on Table 5 are corresponding biota-sediment bioaccumulation factors (BSAFs) for total PCBs. BSAFs were calculated as follows:

$$BSAF = (C_T/L)/(C_S/TOC) \qquad \text{Equation 2}$$

Where:

C_T = Whole body tissue concentration of the neutral organic compound in replicate (ng/g wet weight)
L = Concentration of lipid in replicate (percent of wet weight)
C_s = Concentration of neutral organic compound in composite sediment sample (ng/g dry weight)
TOC = Total organic carbon concentration in composite sediment sample (percent of dry weight)

The residuals of the total PCB BSAFs for each MU are normally distributed (Shapiro-Wilk W=0.944, P=0.2022, N=24) and the variances are homogeneous (Levene's F=0.85, P=0.5131). The Outer Harbor BSAFs (AMU 2 through AMU 4A), which ranged from 0.30 to 0.64 (mean=0.45), were combined because they did not differ significantly from each other (single factor ANOVA F=1.42, P=0.2826) (Note that the BSAF for AMU 4B was not included in this evaluation as it produced a substantially different mean [0.25] relative to the other Outer Harbor BSAFs, which was likely associated with low TOC [0.534%]. Information suggests that the value does not reflect true bioavailability, and/or factors beyond TOC level may have had a substantial influence on PCB equilibrium distribution [e.g., mineral surface adsorption sites] and bioaccumulation [e.g., uptake/depuration kinetics]. This, combined with the fact that the sample parameters are not representative of general conditions within the Outer Harbor sediments, resulted in the decision to exclude this BSAF). The mean BSAFs for AMU 1A and AMU 1B in the Lower River were statistically higher (0.73 and 1.08,

respectively) when compared to the Outer Harbor mean BSAF (single factor ANOVA F=34.18, P<0.0001 and F=172.23, P<0.0001, respectively). Initially, this result suggests a significant change from past BSAF data on the Lower River (median BSAF of 0.38; Pickard *et al.* 2001) and sediment PCB bioavailability in this area of Ashtabula Harbor. The Outer Harbor BSAFs (AMU 2, 3 and 4A) were very similar to what has been documented across the harbor (median BSAF of 0.47). This BSAF was produced from a C_S range of 134.66 (ng/g) to 213.86 (ng/g) and a TOC range of 1.35% to 1.66%, which compares well to the 2009 discrete samples: C_S range of 94.68 (ng/g) to 215.58 (ng/g); TOC range of 1.46% to 2.27%. The open-lake placement area yielded a mean BSAF of 0.40, which was similar and within the range of the median BSAFs for the Lower River (0.38) and Outer Harbor (0.47). Consistent with past lake reference area BSAF data, the open-lake reference area produced the largest mean BSAF at 1.48.

When compared to a previous study on Ashtabula Harbor BSAFs (Pickard *et al.* 2001), the 2009 BSAF data show stable PCB bioavailability conditions in Outer Harbor sediments, with mean BSAFs of 0.45 to 0.47 being representative of fine-grained sediments. Conversely, the BSAFs calculated for the Lower River were higher than previously documented (Pickard *et al.* 2001). These apparently inconsistent BSAFs observed for the Lower River between 2001 and 2009 can be reconciled. The differences are likely indicative of the depositional environment of Ashtabula Harbor, as well as the contact time between PCB and sediments. The effect of contact time on the bioavailability of sediment-associated polychlorinated organic compound bioavailability has been documented in the literature (e.g., Loonen *et al.* 1997, Kraaij *et al.* 2002a, Kraaij *et al.* 2002b).

Bioaccumulation testing in 2009 consisted mainly of surface grab sediment samples in the Outer Harbor and Lower River channels. The previous samples used for PCB bioaccumulation testing (*Pickard et al.* 2001) consisted mainly of surface grab samples in the Outer Harbor and core samples throughout the river. The breakwater protected Outer Harbor allows for an accumulation area for the black carbon-affected sediments. This leads to an increased contact time between sediments and PCBs, resulting in lower bioavailability in surficial sediments. This would explain the relatively lower total PCB BSAFs for the Outer Harbor, and would hold true regardless of whether the sediment was at the surface or subsurface. While surficial sediments in the Lower River Channel are likely composed of sediments with differing degrees of contact time between PCBs and sediments, the contact time between sediment moving downstream and being further influenced by black carbon (and black carbon-affected sediments) is reduced. This would explain the relatively higher bioavailability of

PCBs measured through the BSAFs in this reach. Conversely, more stable sediments at depth in this reach would have a substantially longer contact time with PCBs, which would translate into a reduction in bioavailability. This is reflected by the lower BSAFs observed from core samples in the Lower River channel (Pickard *et al.* 2001). The fact that more core sediment samples were collected for AMU 1A than AMU 1B may explain why the BSAFs were somewhat lower. In fact, a rough calculation involving all total PCB BSAFs with a longer and shorter contact time with sediments yields a BSAF on the order of 0.73, which is similar to the measured PCB biovailability in this reach, thereby supporting this line of reasoning. Additionally, the relatively higher BSAF for AMU 1B may be partially explained by the more coarse-grained sediments in this reach. Finally, the BSAF of 0.40 observed at the open-lake placement area suggests two findings. First, increased contact time does influence the bioavailability of sediment-associated PCBs. Second, the PCBs sorbed to sediments dredged from Ashtabula Harbor do not become more bioavailable when placed in the open-lake environs.

The following table places the total PCB BSAFs within this perspective:

Area or depth	BSAF or BSAF range	Rationale
Lower River subsurface, Outer Harbor surface or subsurface	0.38 to 0.47	PCB bioavailability substantially influenced by black carbon following longer contact time with sediment
Lower River surface	1.08	PCB bioavailability substantially influenced by black carbon following shorter contact time with sediment
Upper River subsurface	1.34	PCB bioavailability negligibly influenced by black carbon; consistent with laboratory-based PCB BSAFs for benthic organisms (1.28) (see USAERDC 2010).
Open-lake reference	1.2 to 1.48	PCB bioavailability negligibly influenced by black carbon; consistent with laboratory-based PCBs for benthic organisms (1.28) (see USAERDC 2010)
Open-lake placement	0.40	PCB bioavailability substantially influenced by black carbon after longer contact time

Based on this, PCBs substantially affected by black carbon in subsurface sediments in Ashtabula Harbor are more than one-half less bioavailable in comparison to surficial sediments.

Assessment of Sediment-Associated PCB Bioaccumulation

Empirical bioaccumulation data and bioaccumulation modeling were used to assess whether open-lake placement of the dredged Federal navigation channel sediments would result in unacceptable total PCB bioaccumulation in the aquatic environs. Sediments in AMU 1A resulted in a statistically higher mean lipid-normalized total PCB concentration in tissue in comparison to compared to that associated with the open-lake placement area sediments. Therefore, sediments dredged from this MU do not meet Federal guidelines for open-lake placement. The same comparison showed that sediments within AMU 1B, AMU 2, AMU 4A and AMU 4B did not result in statistically higher mean lipid-normalized total PCB concentrations in tissue when compared to those associated with the open-lake placement area sediments. Consequently, with two exceptions detailed below, sediments dredged from these areas meet Federal guidelines for open-lake placement.

TBP modeling predictions employed all Ashtabula Harbor BSAFs to assess site-specific sediment-associated total PCB bioaccumulation within the harbor MUs. Surface sediments from 2005 and 2007, and discrete samples from 2009, were re-evaluated using the TBP model and the 2009 BSAFs. Table 6 summarizes the sediment concentrations and associated TBP results for the 2009 samples. Table 4 (last 2 rows before comments) include the new 2005 and 2007 TBP predictions. The 2009 Lower River BSAFs were used in the TBP model for surface sediments in the Lower River showing higher PCB bioavailability than those at depth. For any other subsurface sediment in the Lower River Channel, the median BSAF of 0.38 was used from Pickard *et al.* (2001) to reflect lower PCB bioavailability. For Outer Harbor sediments irrespective of sediment depth, the 2009 Outer Harbor mean BSAF of 0.45 was used for the TBP model predictions.

The following is a summary of the TBP predictions for the 2009 sediment samples:

- <u>Outer Harbor Channels (AMU 2, 3, 4A, 4B):</u> Total PCB TBP predictions ranged from 13.83 to 52.06 µg/kg, compared to the measured range of 15.12 to 68.97 µg/kg.
- <u>Lower River Channel (AMU 1A and 1B):</u> Total PCB TBP predictions in AMU 1A ranged from 39.18 to 125.37 µg/kg, compared to the measured range of 98.64 to 111.64 µg/kg. AMU 1B showed a total PCB TBP

predicted range of 31.39 to 98.67 µg/kg, compared to a measured range of 37.01 to 41.76 µg/kg.

- Lake Areas (AD and ALR): Total PCB TBP predictions ranged from 18.05 to 72.67 µg/kg, compared to the measured range of 24.04 to 65.31 µg/kg.

The TBP reanalysis of 2005 and 2007 sediment samples indicate additional sites of concern within AMU 1A and AMU 1B with respect to total PCB bioaccumulation (highlighted in Table 4). Site AMU 1-10S within AMU 1B shows a predicted total PCB TBP which exceeds the maximum predicted TBP for the lake. This site was not identified or investigated as an area of concern during the 2009 biological testing due to the use of the lower BSAF in previous TBP modeling (see Table 4). Based on this result, sediments dredged from the Lower River channel in the reach 250 feet downstream of AMU 1A (upper reach of AMU 1B) were determined to not meet Federal guidelines, and are therefore not suitable for open-lake placement. Given the results on the PCB bioaccumulation experiments on the AMU 1B sediments, this is a conservative measure to assure that dredged sediments with the potential to bioaccumulate higher levels of PCBs relative to the lake environs are not open-lake placed. When combined with AMU 1A, it has then been determined that all sediments dredged from the 1,225 foot reach between Ashtabula River Station 120+00 and 107+75 are unsuitable for open-lake placement (see Figure 10).

Bioaccumulation testing did not show unacceptable PCB bioaccumulation from the AMU 4A or AMU 4B sediments relative to the open-lake placement area. However, as shown in Table 4, Site AH-8 on the eastern border of the MU (see Figure 12) predicts a total PCB TBP at the surface of 322.45 µg/kg, which exceeds the maximum predicted level in the lake of 206.34 µg/kg. Therefore, absent further information on this site, sediments dredged from within at least 50 feet of the site has been determined to not meet Federal guidelines, and are therefore not suitable for open lake-placement. This area of PCB contamination was not evidenced in the subsequent 2007 and 2009 sediment investigations. Lastly, given the measured bioaccumulation data, unacceptable total PCB bioaccumulation is no longer presumed at sites AMU4-02C and AMU 4-06C in the Outer Harbor (see Table 4). This presumption was made due to TOC levels unsuitable for the TBP model (<0.5%) along with sediment contaminant concentrations greater than that of the lake. These sites likely represent sandy areas along the West Breakwater. AMU 4B, characterized by coarse-grained sediments in the same general area along the West Breakwater, showed similarly low TOC concentrations (composite sample of 0.536% and discrete sample of

0.403%). Thus, it is not anticipated that the sites represented by AMU4-02C and AMU4-06C will result in unacceptable bioaccumulation of total PCBs relative to the lake environs. Site AMU 2-05C 4-5 in AMU 2 shows a predicted TBP above the maximum lake predicted value (212.44 µg/kg [Table 4]); however, the core as a whole does not show an unacceptable level of total PCB bioaccumulation (101.26 µg/kg [Table 4]). This was confirmed by a core (AMU 3-12C) collected in the same area in 2009 (TBP of 37.30 µg/kg [Table 6]).

Congener Assessment

PCB congener distribution charts are contained in Appendix A. For each MU investigated in 2009, individual PCB congeners are presented as a percent of the total PCB concentration for sediment and tissue (non-detectable congeners valued at the LRL). On each figure, congener chlorination increases from left to right. The sediment data are from the composite samples, and the tissue data represent a mean across five replicates. Additionally, BSAF charts are presented for each MU investigated in 2009. BSAFs were determined for each congener by applying Equation 2 to each bioaccumulation experiment replicate; the mean of these replicate values is presented. BSAFs for congeners that were not detected or had a non-detectable concentration in one or more tissue replicates are not shown. Congeners not detected in the sediment were valued at the LRL.

Congener analysis can be used to establish a site-specific fingerprint of PCBs to distinguish between source areas (DeGrandchamp and Barron 2005). Similar congener distributions are observed in the Lower River and Outer Harbor channels, and open-lake placement area sediments; however, a different distribution is present at the open-lake reference area. Congener distributions in Ashtabula Harbor and open-lake placement area sediments area are skewed to the left, among lesser-chlorinated congeners, while the open-lake reference area shows a more balanced distribution, with an increased occurrence of more chlorinated congeners. Based on these congener distributions, Lower River and Outer Harbor channel, and open-lake placement area sediments show a similar PCB fingerprint, indicative of similar PCB source areas. The open-lake reference area sediments show a different PCB fingerprint, indicative of different PCB source areas relative to Ashtabula Harbor.

Tissue congener distributions show a different fingerprint than the associated sediments, as bioaccumulation in biological systems tends to concentrate congeners of higher chlorine content (DeGrandchamp and Barron 2005). This process is evident in the Lower River and Outer Harbor channel tissue

bioaccumulation tests, as the tissue PCB distributions show an increased occurrence of more highly-chlorinated congeners in comparison to sediment. Additionally, the BSAF data show an increasing trend in BSAFs with increasing congener chlorination for all of the harbor and lake sites. Sites with higher BSAFs for total PCBs showed higher BSAFs across the individual congeners as well. Individual congener BSAFs were highest for the open-lake reference area, with a maximum of 8.0 for PCB 187.

This analysis of PCB congeners shows that the open-lake reference area sediments posses a different PCB fingerprint than the Ashtabula Harbor and open-lake placement area sediments. The increased occurrence of more highly-chlorinated congeners in the open-lake reference area PCB fingerprint may be a contributing factor in the higher total PCB BSAF observed for the area. However, since BSAFs across the individual congeners are also higher than those of the Ashtabula Harbor MUs, the probable overriding factor in the difference between the open-lake reference area BSAFs and those in the harbor is the presence of black carbon in sediments.

Pesticides

Table 7 presents the results of these analyses. Most pesticides in the harbor sediments samples were non-detectable at LRLs ranging from 0.268 to 24.4 µg/kg. The sum of 4,4'-dichlorodiphenyltrichloroethane (DDT) and its metabolites/breakdown products 4,4'-dichlorodiphenyldichloroethylene (DDE) and 4,4'-dichlorodiphenyldichloroethane (DDD) (ΣDDT) (valuing non-detectable concentrations at the LRL) in sediments at Site AH-4 was 4.85 µg/kg, which was somewhat greater than the ranges at the open-lake reference (ΣDDT range = 1.84 µg/kg to 3.39 µg/kg) and placement (ΣDDT=1.54 µg/kg to 1.65 µg/kg) areas. These three compounds were summed for comparison purposes based on the following rationale:

- 4,4'-DDT, 4,4'-DDE and 4,4'-DDD are considered highly hydrophobic, having Log K_{ow}s of 6.91, 6.51 and 6.02 respectively (ATSDR 2002). Hydrophobicities tend to reduce the bioavailability of sediment-associated neutral organic contaminants;

- BSAFs in the literature for sediment-processing benthic organisms show that the bioavailability of DDT, DDE and DDD is similar (Ingersoll *et al.* 2004), or that DDT (Mulsow and Landrum 1995) can be less bioavailable than DDE (Ferraro *et al.* 1990); and

- The sediment samples were processed through gas chromatographic analysis. This has been shown to cause a breakdown of DDT into DDE and DDD, which would tend to make the analytical differentiation of the three compounds based on these sediment data obscure (Forman and Gates 1997).

A ΣDDT of 4.85 µg/kg is not of toxicological significance. Beta-BHC was detected in sediments from Sites AH-3, AH-4 and AH-6, ranging in concentration from 1.72 to 3.58 µg/kg. Such levels of this pesticide in sediments are unremarkable.

Elutriate Testing

Tables 8 through 12 present the results of Standard Elutriate Tests performed on the sediment samples.

1. Inorganic Analyses

The results show low releases of some of the metals from Federal navigation channel sediment samples (Table 8). Regarding total ammonia, it is an atypical COC because it is not persistent. While it is toxic in sediment only at high concentrations, ammonia can temporarily reach high enough concentrations to become acutely toxic to fish in bioassays (invertebrates are typically not as sensitive as fish to ammonia levels [USEPA 1999]). Therefore, ammonia toxicity is most appropriately characterized in the water column. The concentration of ammonia in the elutriate from sediment sample MU AB-3 was 3.49 mg/L, indicating moderate releases from the sediment prior to mixing in the water column. Fairchild *et al.* (2005) exposed several fish species to ammonia in the laboratory over a chronic 28-day duration. The most sensitive fish species was *P. promelas* exposed as 4-day olds. For this species, they reported a no observed effect concentration (NOEC), lowest observed effect concentration (LOEC) and chronic value (ChV; the geometric mean of the NOEC and LOEC) of 0.31, 0.60 and 0.43 mg/L unionized ammonia (NH_3), respectively. At 20°C and the reported pH of 8.34, this ChV equates to a total ammonia concentration of approximately 7.2 mg/L. The ChV is considered a protective value (Adams and Rowland 2002), and this 28-day value should be conservative for a 96-hour *P. promelas* elutriate test conducted at 20°C. In addition, these values are also conservative in terms of a 96-hour elutriate test since this study used water renewal to maintain stable ammonia concentrations over the course of the test, while in a static elutriate exposure the ammonia concentration should decrease

over time, and uses a much shorter exposure period (as in field conditions during the open-lake placement of dredged material). If the *P. promelas* elutriate test were conducted at 25°C, the ChV reported by Fairchild *et al.* (2005) would translate to an approximate total ammonia ChV of 6.3 mg/L. In addition, Fairchild *et al.* (2005) reported no *P. promelas* mortality after 7 days of exposure to 0.31 mg/L NH_3 (or 3.7 mg/L total ammonia at 25°C). USEPA (1999) provides a total ammonia species mean chronic value (SMCV) for *P. promelas* set equal to 3.09 mg/L at a pH of 8. The total ammonia SET concentration of 3.49 mg/L associated with this sediment was comparable to this chronic level, and well below the estimated ChV of 6.3 mg/L at 25°C, indicating that the concentration is likely protective of this surrogate minnow over a relatively short duration such as those which occur during the open-lake placement of dredged material. Therefore, without consideration of mixing in the water column, ammonia was eliminated as a COC relative to the MU AB-3 sediment sample. Just a 50% dilution in the Mixing Zone would remove any concern for short-term fish toxicity attributable to ammonia.

2. Organic Analyses

PAHs

Except for naphthalene in the MU AB-1 sediment sample, no releases of PAH compounds were indicated at or above LRLs ranging from 0.001 µg/L to 0.005 µg/L (Table 9).

PCBs

In 2005, Aroclor analysis showed no releases of PCBs at or above the LRL of 0.5 µg/L (Table 10).

Table 11 shows the total PCB SET results for the 2009 composite samples and includes the total PCB concentration in water collected at the open-lake placement area. Total PCBs were calculated from a sum of congeners with non-detected concentrations valued at zero. The placement area water showed a background total PCB level of 0.23 ng/L, while the MU sediments released concentrations (including background) ranging from 3.32 ng/L (AMU-4B) to 33.7 ng/L (AMU 4A). These measured concentrations are well below the previous PCB detection limit of 500 ng/g.

Appendix A contains the elutriate congener distributions for each harbor MU and placement area water. Generally, the elutriate congener distributions were similar to that observed in sediment.

Pesticides

Most pesticide releases were non-detectable at LRLs ranging from 0.0133 µg/L to 0.9 µg/L (Table 12). In the MU AB-1 and AB-3 sediment samples, 4,4'-DDT in elutriate was measured at 0.078 µg/L and 0.111 µg/L, respectively. In addition, releases of endosulfan I of 0.032 µg/L at Site AH-1, and methoxylchlor of 0.16 µg/L at Site AB-2 were shown.

Bioassays

Standard 10-day solid phase bioassays applied to MU AB-1 through AB-3 sediment samples employed the test species *Hyalella azteca* (amphipod) and *Chironomus tentans* (mayfly nymph) (USEPA/USACE 1998). The biological measurement endpoints for the *H. azteca* and *C. tentans* bioassays were survival, and survival and growth, respectively. The results are presented in Table 13 and are summarized as follows:

1. *H. azteca*

The mean survival of this species across the three management unit sediments ranged from 74±21.9% to 92±13%, and were not statistically different relative to the open-lake reference (88±13%) and placement (68±19.2%) area sediments.

2. *C. tentans*

The mean survival of this species ranged from 78±11% to 84±11.4% across the three MU sediment samples. The mean survivals associated with the MU AB-1 and AB-2 sediment samples were not statistically different relative to the open-lake reference (94±8.9%) and placement (80±12.2%) area sediments. The mean survival of 78±11% from the MU AB-3 sediment sample was statistically lower relative to the open-lake reference area sediments, but not the open-lake placement area sediments. Bulk chemistry on the MU AB-3 sediment sample (including discrete samples collected at Sites AH-14 and AH-15) (Tables 3 through 6) identified no sediment COC(s). Furthermore, the mean survivals associated with the control (West Bearskin) and open-lake reference area

sediments were 98±4.5% and 94±8.9%, respectively, and inordinately high based on the following lines of evidence: (1) *C. tentans* bioassay data on open-lake reference area and control (West Bearskin) sediments from EEI (2000) (the most recent prior bioassays applied to harbor project sediments) showed mean survivals of 74±32% and 82±13%, respectively (see Table 11); and (2) Control-corrected survival rates for *C. dilutis* (i.e., new species name for *C. tentans*) greater than or equal to an arbitrary 75% is an acceptable measurement endpoint for acute toxicity (USEPA 2004). In this case, the actual survival of 78% (and control corrected survival of 80%) is greater than 75%.

The mean (ashed) growth of *C. tentans* across the MU sediment samples ranged from 0.87±0.14 mg to 1.14±0.19 mg, and were not statistically different in comparison to the open-lake reference (0.64±0.31 mg) and placement (0.91±0.21 mg) area sediments.

Radionuclide Testing

Concentrations of eight radionuclides measured in six Ashtabula Harbor MU sediment samples were compared to concentrations of corresponding radionuclides in lake reference area sediments using the methodology established by the USEPA Region V for evaluation of Ashtabula River radionuclide sediment concentrations (see USACE 2008b). This method utilized the T-test and the Wilcoxon-Rank-Sum Test, with the chance for false positive results (alpha) being set at 5%. Table 14 summarizes the radionuclide data. Note that the composite sediment sample from AMU7 (see Figure 13) was purposely not subjected to radionuclide analyses because the main objective of the sediment testing effort was to verify that radionuclide contamination in sediments potentially requiring upland disposal due to PCB contamination (sediments in this MU have low levels of total PCBs) would not preclude their disposal in an Ohio permitted landfill. There is no reason to believe that radionuclide contamination in these sediments would be dissimilar relative to other channels in the Ashtabula Outer Harbor.

The levels of radioactivity in the harbor sediments were also compared to media screening values that are protective of ecological receptors. In 2002, the U.S. Department of Energy (USDOE) developed a *Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (USDOE 2002). The initial step in this approach involves comparing media concentrations of radioactivity to biota concentration guidelines (BCG), which were developed for screening radionuclides of potential concern for effects on biota. The BCGs are

conservative estimates of media concentrations that would produce radiological doses below acceptable dose limits for aquatic and terrestrial organisms (National Council on Radiation Protection [NCRP] 1991; International Atomic Energy Agency [IAEA] 1992). Maximum gross wet weight concentrations of radionuclides found in these sediments were compared to aquatic BCGs since the dredged material may be placed in the open-lake environs. Because radiation doses are considered additive, the concentration of each radionuclide was divided by its BCG, and the fractions were summed. If the sum of the fractions does not exceed 1, then the radiation dose is not expected to harm populations of ecological receptors.

The sediment concentrations of four radionuclides in the harbor sediments were significantly higher relative to those of the open-lake reference area sediments. However, these four radionuclides exceeded those in open-lake reference area sediments by only approximately 0.3 pCi/g for Radium-228, Thorium-228 and Thorium-232, and 0.2 pCi/g for Uranium-238. These very slight exceedances are not toxicologically significant for these radionuclides, and such levels of radioactivity in the sediments are not expected to produce unacceptable radiological doses to aquatic receptors. As shown in Table 14, the maximum concentrations of radionuclides in the harbor sediments are well below their respective aquatic BCGs for aquatic settings. The sums of the fractions are approximately two orders of magnitude below 1, indicating no potential for adverse ecological effects to occur. Therefore, the concentrations of radionuclides in the Ashtabula Harbor are not expected to have a negative environmental impact if placed in the open-lake environs.

The radionuclides analyzed in these investigations are all naturally occurring. The levels of these radionuclides can vary significantly from location to location, based on underlying soil and rock formations. It is not unexpected that naturally occurring levels of radionuclides in harbor sediments may be slightly different (greater or lesser concentrations) than naturally occurring levels of radionuclides in Lake Erie sediments. The differences in radionuclide concentrations between the Ashtabula Harbor and Lake Erie sediments observed in this analysis are most likely due to natural fluctuations in levels of background radioactivity, rather than anthopogenic radiological contamination.

The Ohio Department of Health (ODH), Bureau of Radiation Protection (BRP) concurred with the assessment of these sediments documented in USACE (2008b). In a letter dated August 9, 2008, BRP determined that material dredged from the Ashtabula Lower River and Outer Harbor channels is exempt

from BRP licensure requirements. Therefore, this dredged material is not regulated by BRP, and management of it in an upland or aquatic environment is acceptable from the standpoint of radionuclide contamination.

Quality Assurance (QA)/Quality Control (QC) Documentation

QA/QC information and records on the data contained in this evaluation are available in EEI (2005).

5.0 Conclusions

This evaluation has determined that:

Based on existing information, material dredged from Ashtabula Harbor Federal navigation channels, within the boundaries of the Ashtabula Lower River Channel between Stations 107+75 and 120+00, do not meet Federal guidelines for open-lake placement. This includes material dredged from AMU 1A and the 250 feet upstream reach of AMU 1B (see Figure 10). Additionally, material dredged from within at least 50 feet of Site AH-8 in the West Outer Harbor does not meet Federal guidelines for open-lake placement (see Figure 12).

Based on existing information, material dredged from all other Ashtabula Harbor Federal navigation channels within the scope of this evaluation, as represented by the remainder of the sampling sites, meet Federal guidelines for open-lake placement.

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Figures

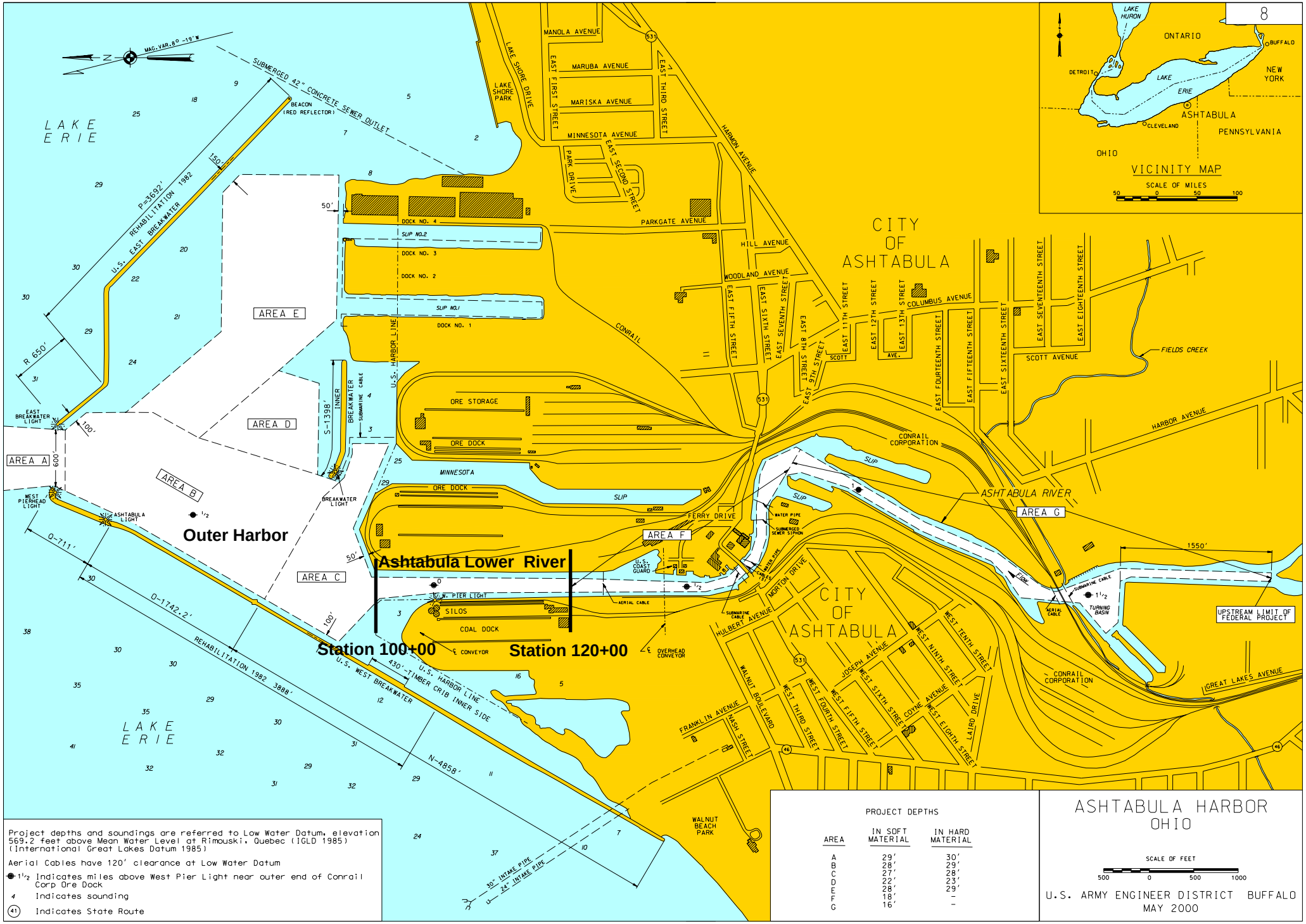


FIGURE 1. Ashtabula Harbor Federal Navigation Project

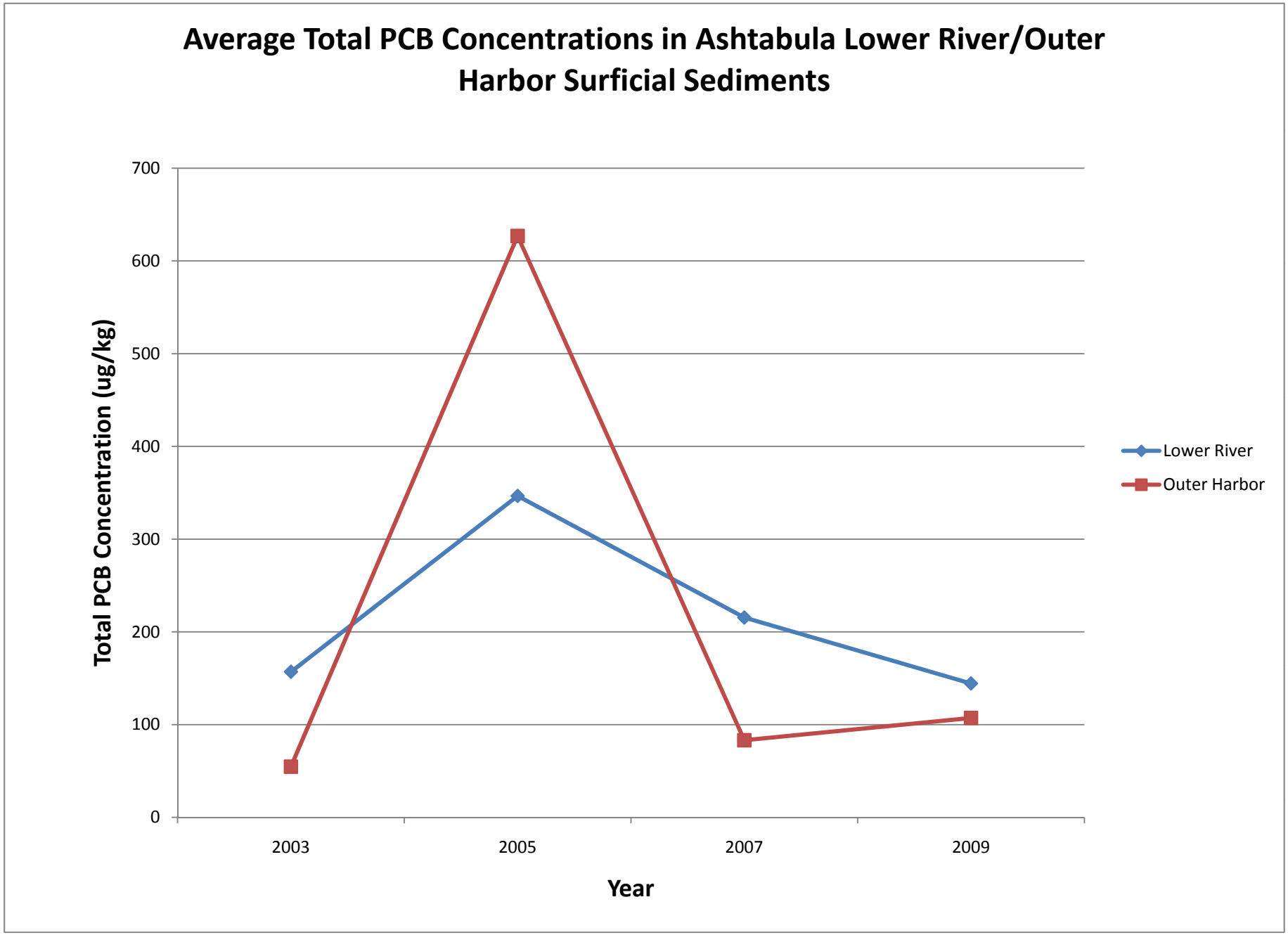


FIGURE 2. Average Total PCB Concentrations in Ashtabula Lower River/Outer Harbor Surficial Sediments

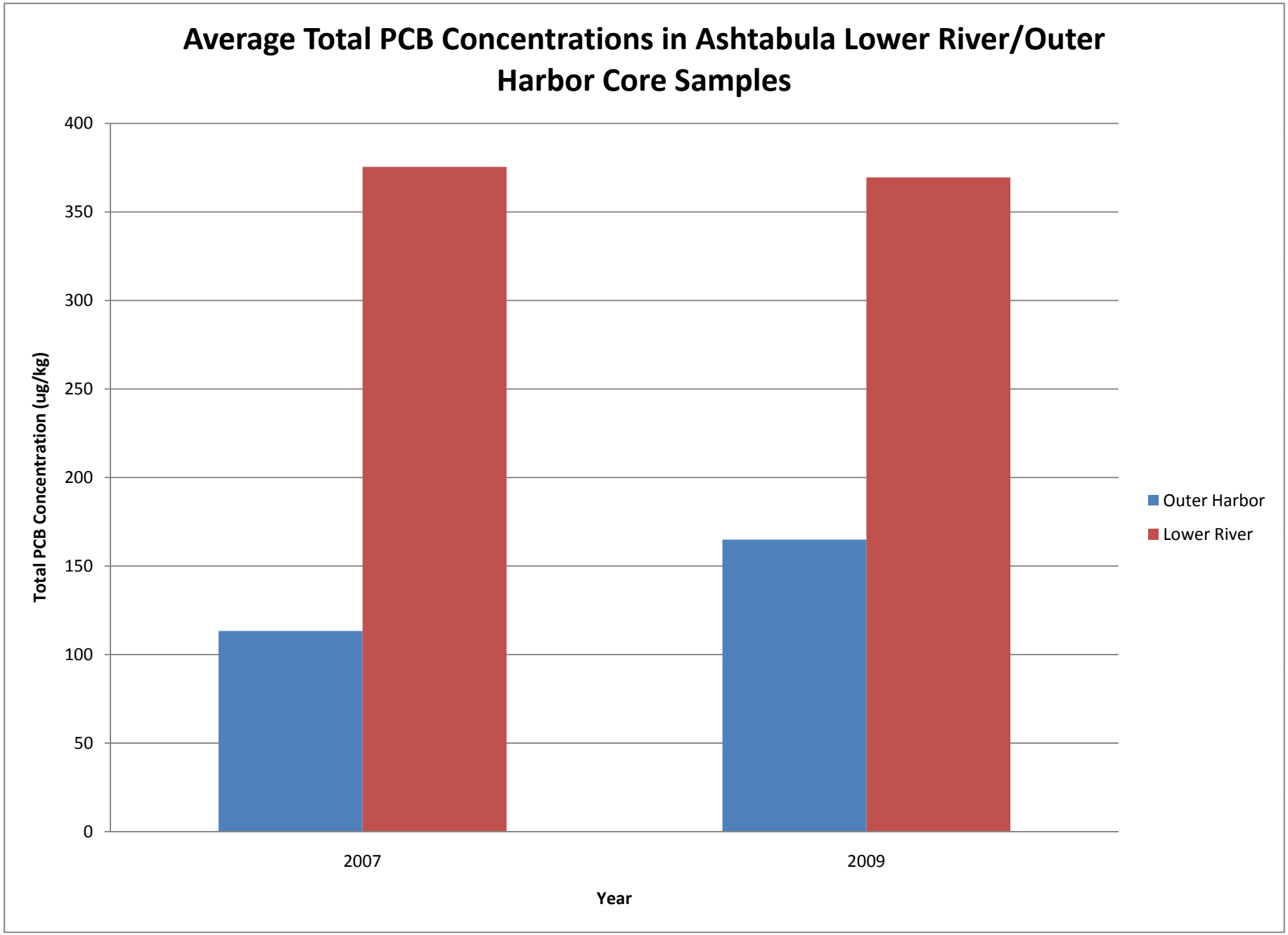


FIGURE 3. Average Total PCB Concentrations in Ashtabula Lower River/Outer Harbor Core Samples

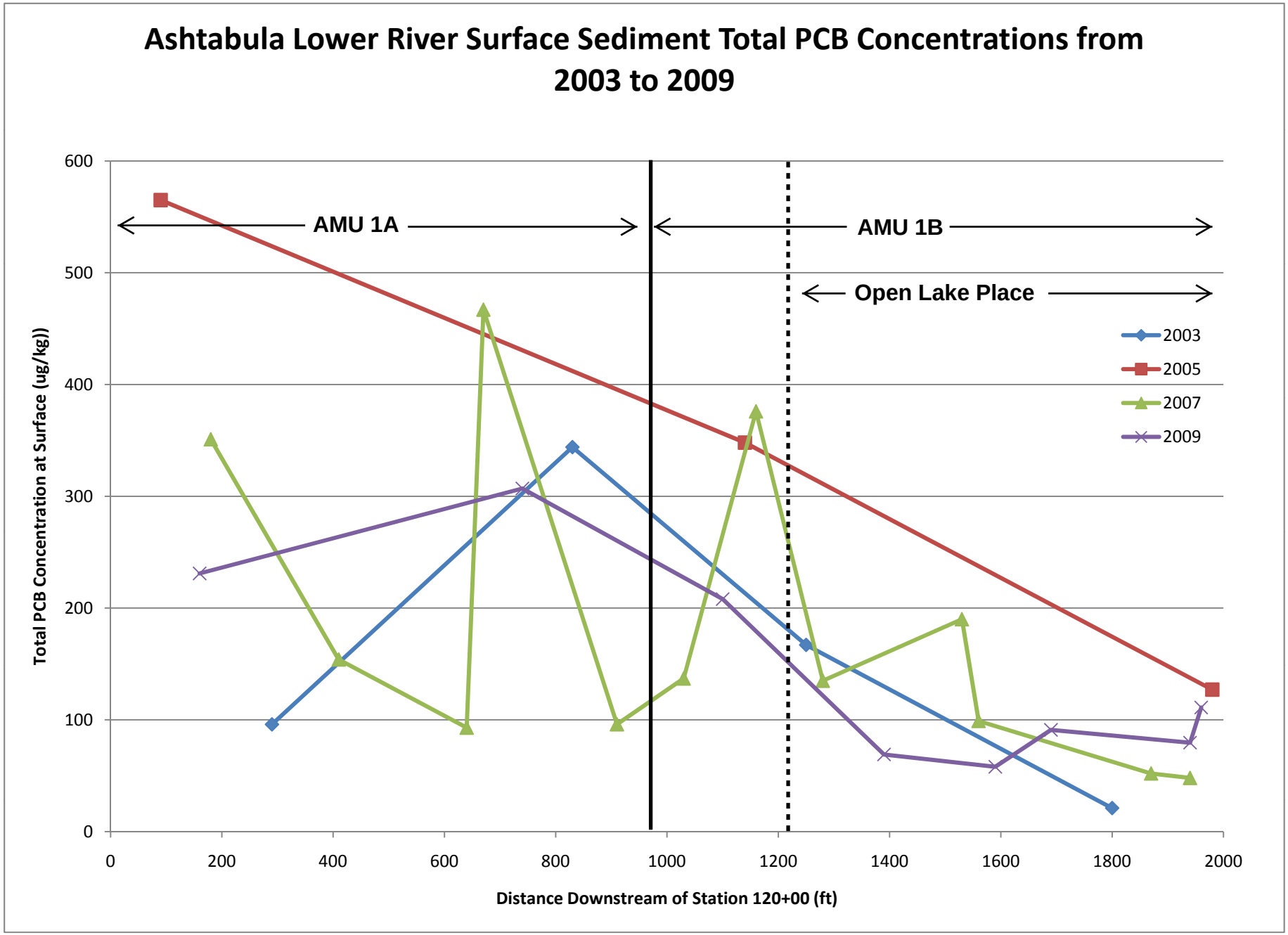


FIGURE 4. Total PCB Concentrations in Ashtabula Lower River Surface Sediments

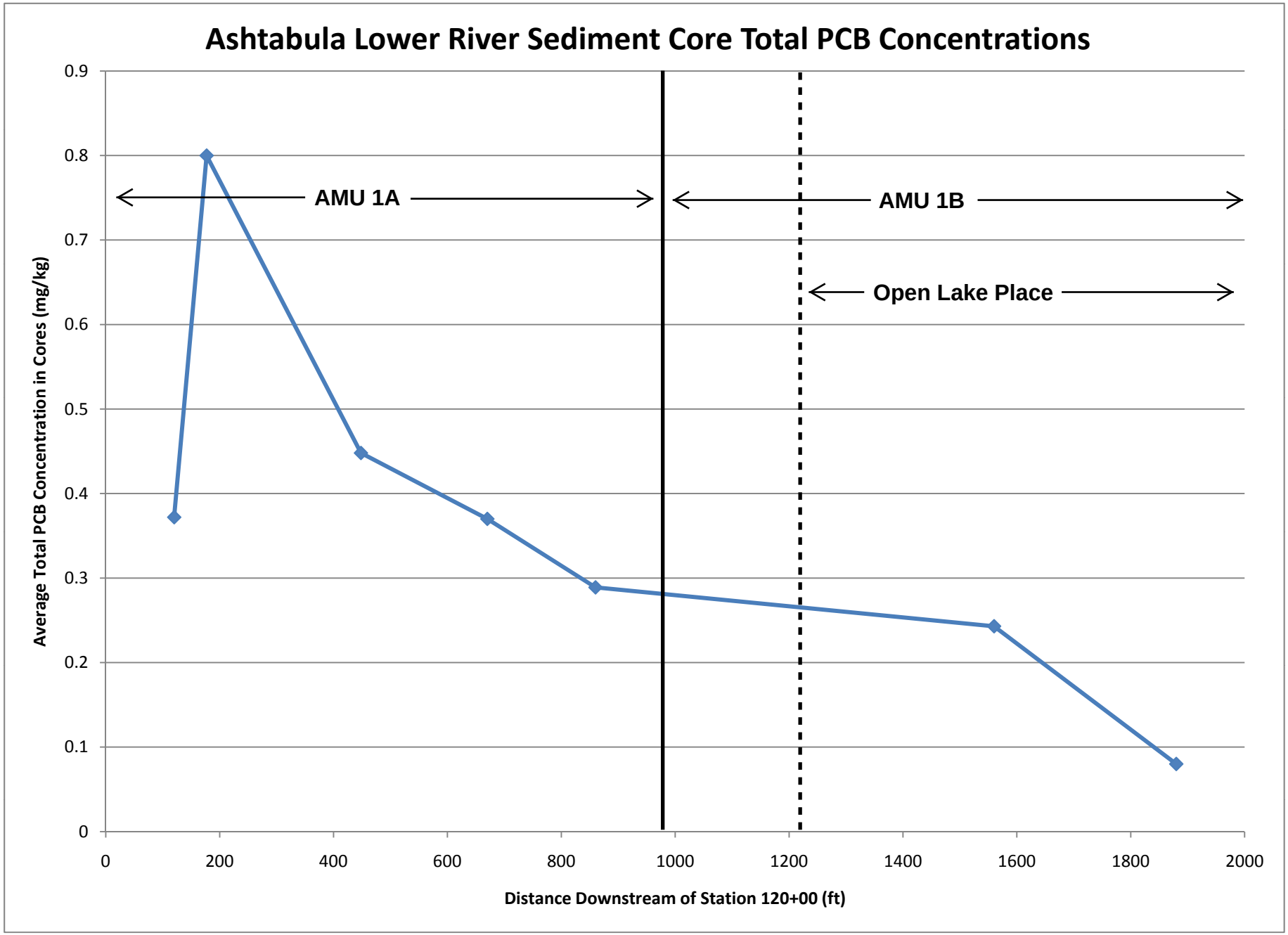
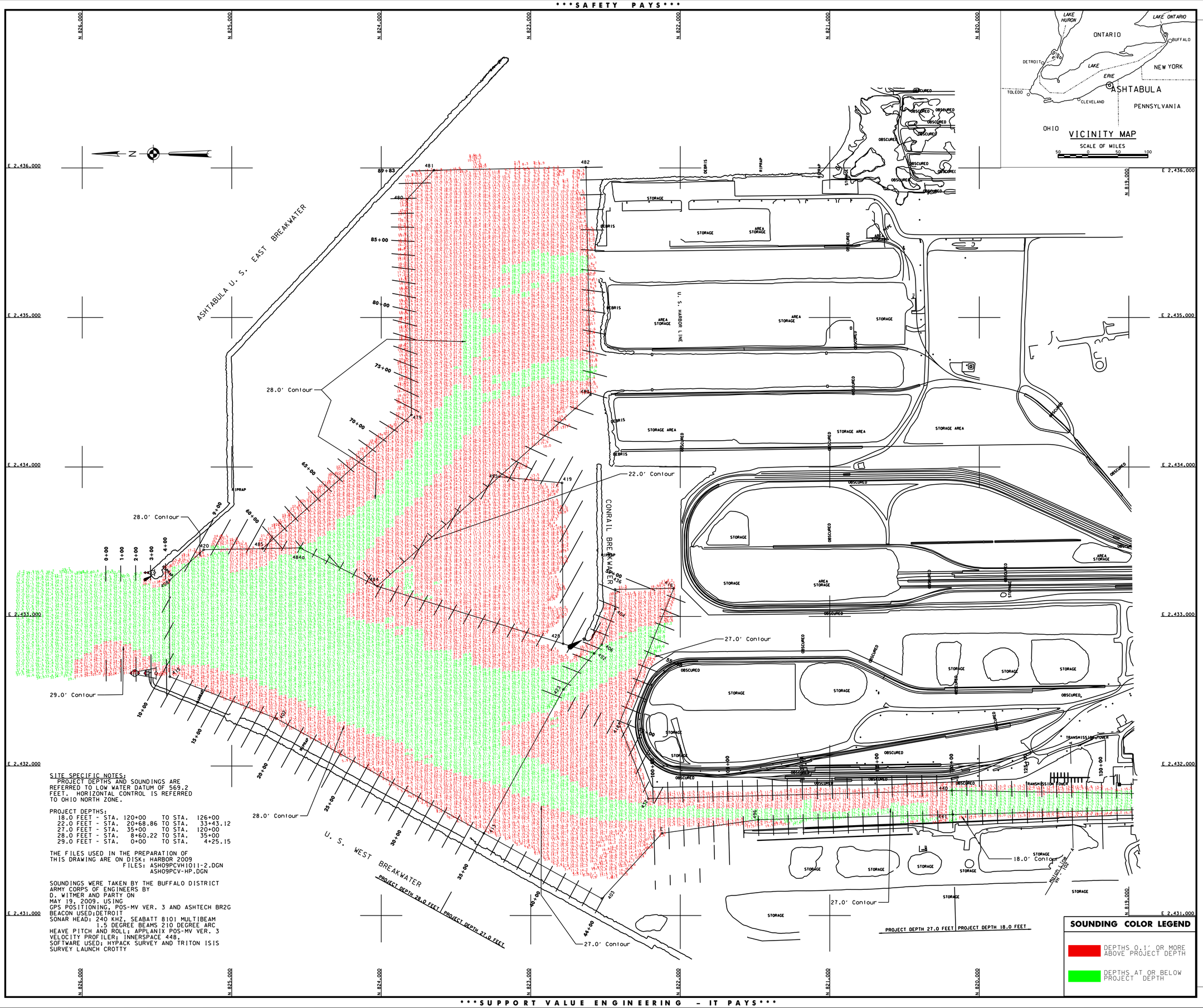


FIGURE 5. Total PCB Concentrations in Ashtabula Lower River Core Sediments (2007 and 2009)



SITE SPECIFIC NOTES:
PROJECT DEPTHS AND SOUNDINGS ARE REFERRED TO LOW WATER DATUM OF 569.2 FEET. HORIZONTAL CONTROL IS REFERRED TO OHIO NORTH ZONE.

PROJECT DEPTHS:
18.0 FEET - STA. 120+00 TO STA. 126+00
22.0 FEET - STA. 20+68.86 TO STA. 33+43.12
27.0 FEET - STA. 35+00 TO STA. 120+00
28.0 FEET - STA. 8+60.22 TO STA. 35+00
29.0 FEET - STA. 0+00 TO STA. 4+25.15

THE FILES USED IN THE PREPARATION OF THIS DRAWING ARE ON DISK: HARBOR 2009
FILES: ASH09PCVH1011-2.DGN
ASH09PCV-HP.DGN

SOUNDINGS WERE TAKEN BY THE BUFFALO DISTRICT ARMY CORPS OF ENGINEERS BY D. WITMER AND PARTY ON MAY 19, 2009. USING GPS POSITIONING, POS-MV VER. 3 AND ASHTECH BR2G BEACON USED:DETROIT
SONAR HEAD: 240 KHZ, SEABATT 8101 MULTIBEAM
1.5 DEGREE BEAMS 210 DEGREE ARC
HEAVE PITCH AND ROLL: APPLANIX POS-MV VER. 3
VELOCITY PROFILER: INNERSPACE 448.
SOFTWARE USED: HYPACK SURVEY AND TRITON ISIS SURVEY LAUNCH CROTTY

SOUNDING COLOR LEGEND

- DEPTHS 0.1' OR MORE ABOVE PROJECT DEPTH
- DEPTHS AT OR BELOW PROJECT DEPTH

US Army Corps of Engineers
Buffalo District

General Notes
The information depicted on the map represents the results of surveys made on the date indicated and can only be considered as indicating the general condition at that time. Unless otherwise noted on this map, all depths and soundings are in feet and referred to the International Great Lakes Datum 1985 (IGLD 1985) and all horizontal positions are referred to North American Datum 1983 (NAD83). See the Site Specific Notes and for appropriate datums. To view a color version of this map, point a web browser to http://www.lrb.usace.army.mil/waterways/surveys/hydro/.
This drawing was prepared using a CADD system. Scaling may be distorted.

Drawn by: CADD
Checked by:
Reviewed by:
Chief, Survey Unit
Approved:
Date:
Chief, NY/PA Navigation and Maintenance Section

U.S. ARMY ENGINEER DISTRICT
CORPS OF ENGINEERS
BUFFALO, NEW YORK 14207-3199

ASHTABULA HARBOR, OHIO
FIGURE 6
PROJECT CONDITION SOUNDINGS 2009
SCALE OF FEET
POS 100 200
SD 1/4 1/2 1
SCALE: 1" = 200'

Sheet reference number:
VH - 101

Sheet **1** of **2**

09S-ASH-1/1

ash09pcvh1011-2.dgn 7/27/2009 6:19:09 AM

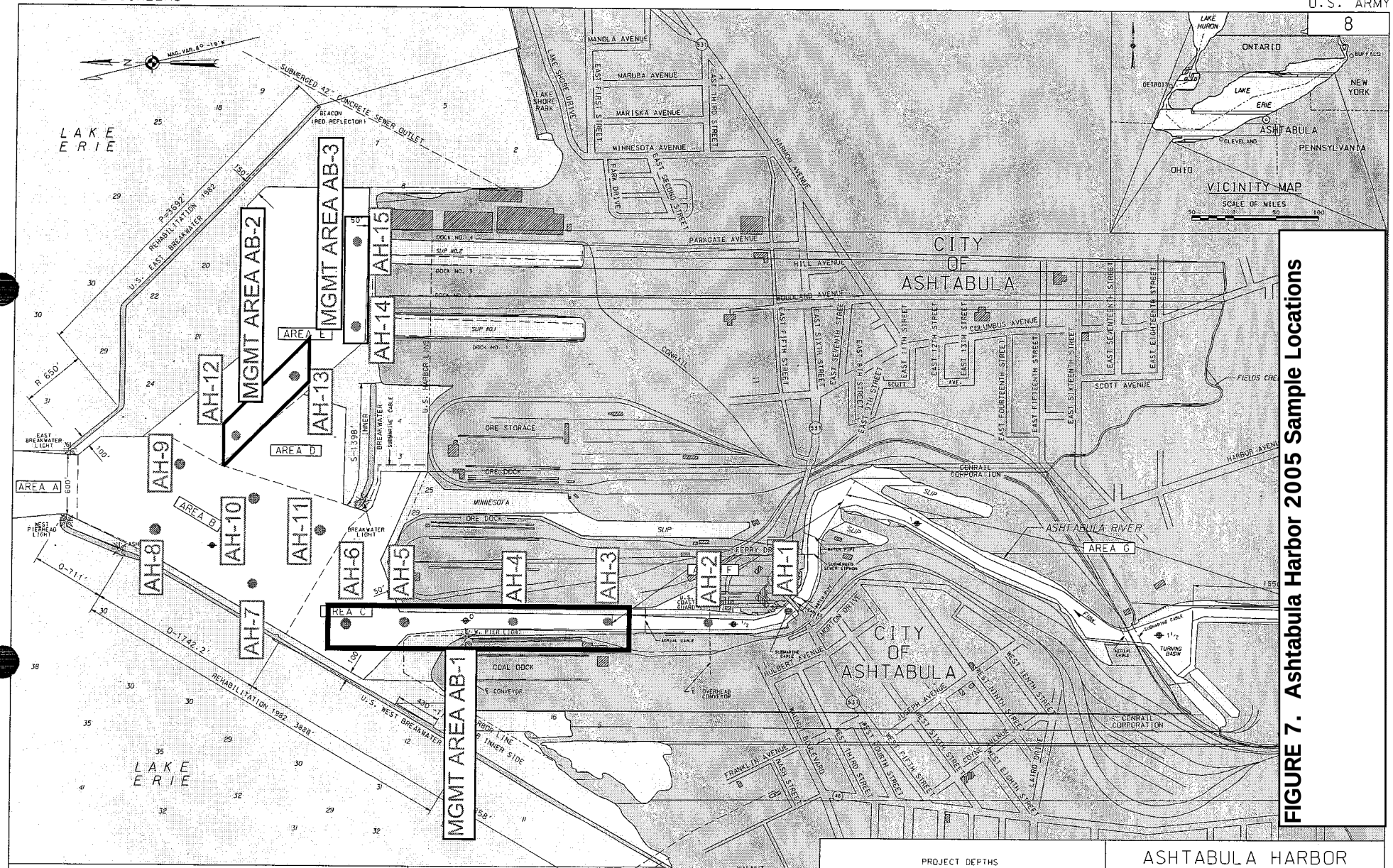


FIGURE 7. Ashtabula Harbor 2005 Sample Locations

Project depths and soundings are referred to Low Water Datum, elevation 569.2 feet above Mean Water Level at Rimouski, Quebec (IGLD 1985) (International Great Lakes Datum 1985)

Aerial Cables have 120' clearance at Low Water Datum

1½ Indicates miles above West Pier Light near outer end of Conrail Corp Ore Dock

4 Indicates sounding

(41) Indicates State Route

PROJECT DEPTHS

AREA	IN SOFT MATERIAL	IN HARD MATERIAL
A	29'	30'
B	28'	29'
C	27'	28'
D	22'	23'
E	28'	29'
F	18'	-
G	16'	-

ASHTABULA HARBOR
OHIO

SCALE OF FEET
500 0 500 1000

U.S. ARMY ENGINEER DISTRICT BUFFALO
MAY 2000

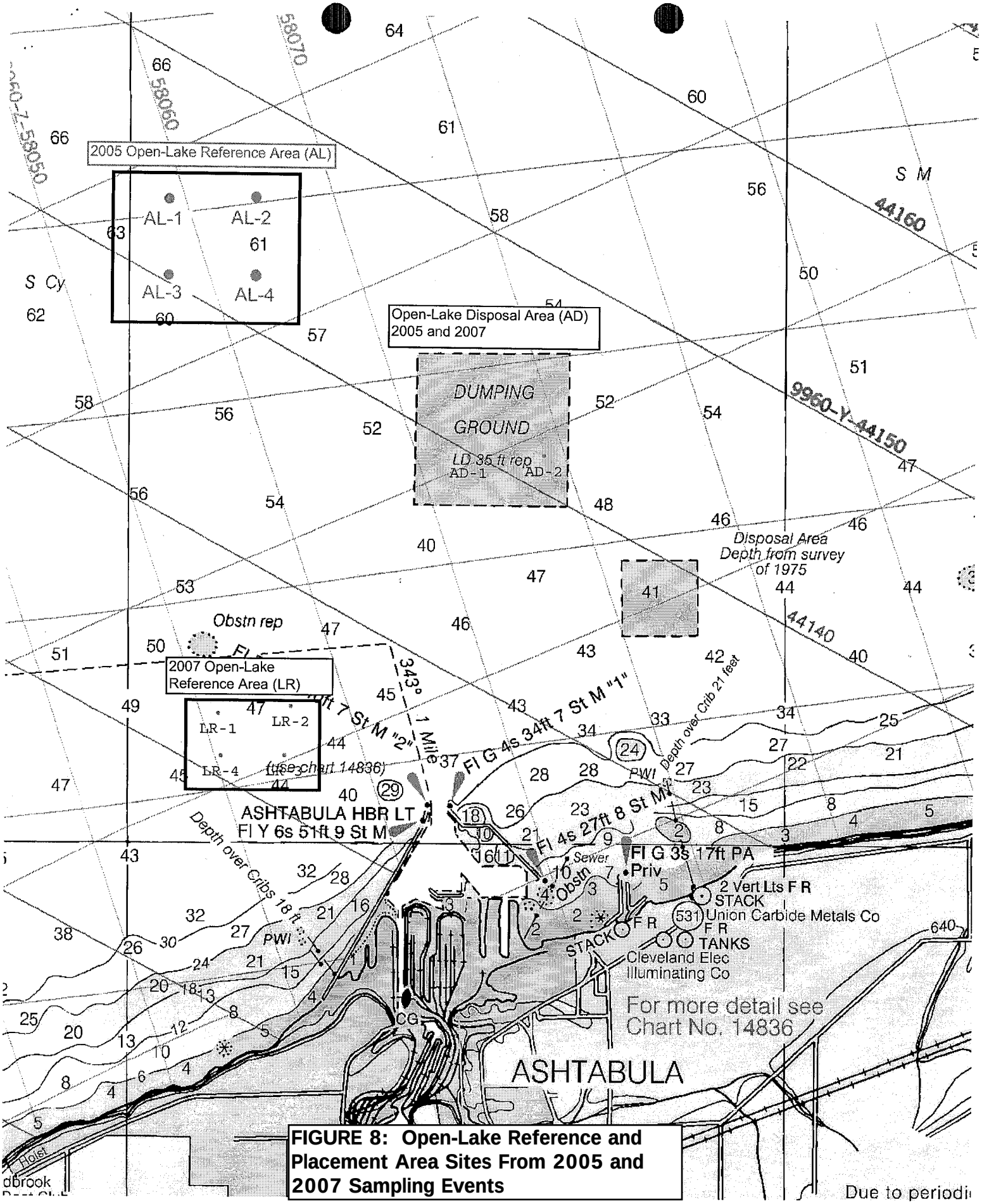


FIGURE 8: Open-Lake Reference and Placement Area Sites From 2005 and 2007 Sampling Events

Chart Name: ASHTABULA TO CHAGRIN RIVER OHIO
Chart ID: 14825_1
Top Left: 41° 59' 41" N 80° 50' 55" W
Bottom Right: 41° 52' 59" N 80° 43' 34" W

® MAPTECH, INC.

FIGURE 9. Ashtabula Harbor Management Units (general areas within the federal navigation channel characterized for PCBs):
Lower Ashtabula River - 1A and 1B (Station 120 + 00 to Station 100 + 00)
Outer Harbor - 2, 3, 4A, 4B, 5, 6, 7

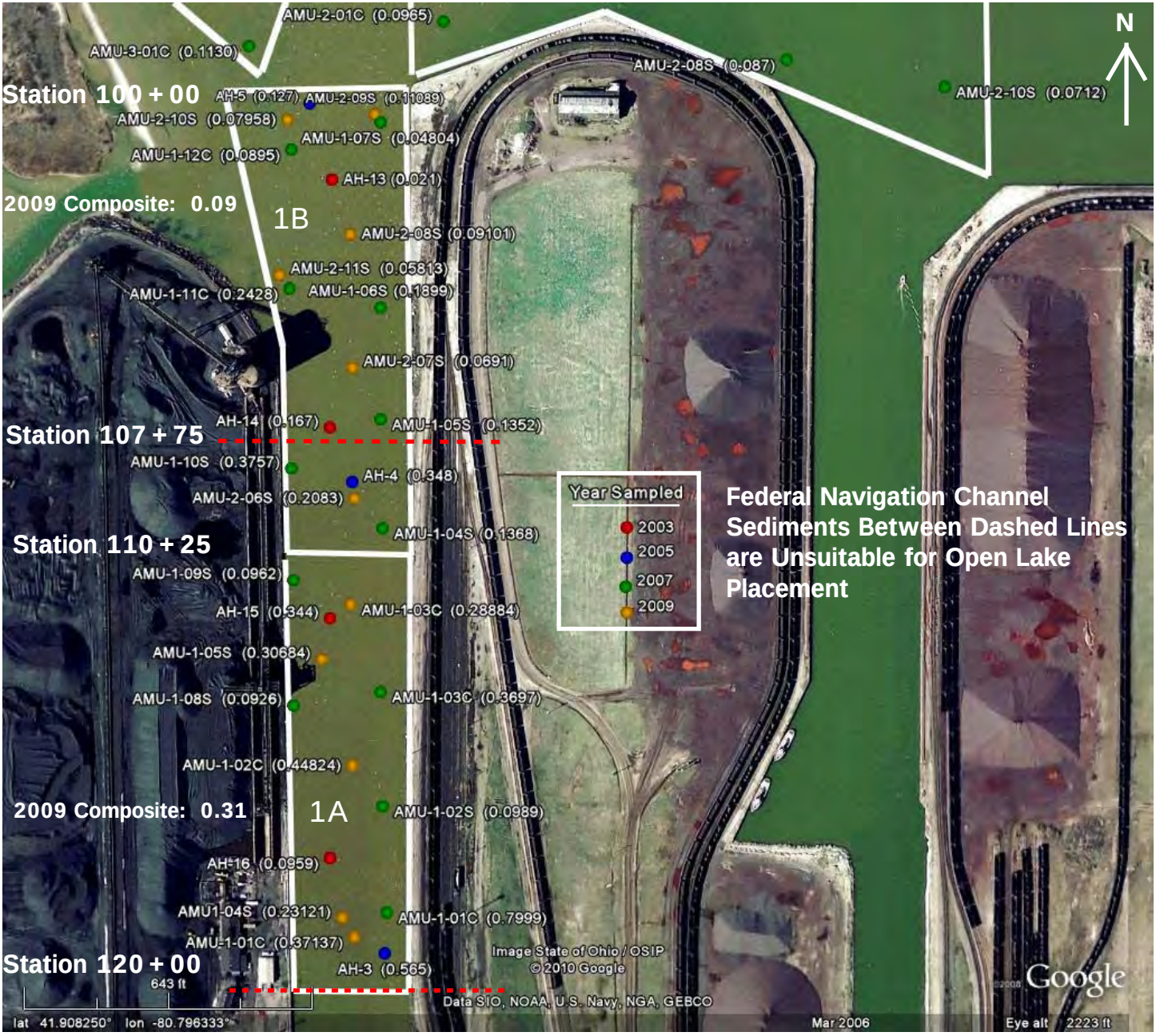


FIGURE 10. Total PCB Concentrations in Ashtabula Lower River Sediment (mg/kg) (Note: 2005 and 2007 points represent sum of Aroclors 1248 & 1260; 2009 points represent sum of congeners. "S" refers to surface samples; "C" refers to core samples.)

FIGURE 11. Total PCB Concentrations in Ashtabula Outer Harbor Sediment (mg/kg) (Note: 2005 and 2007 points represent sum of Aroclors 1248 & 1260; 2009 points represent sum of congeners. "S" refers to surface samples; "C" refers to core samples.)

FIGURE 12. Total PCB Concentrations in Ashtabula Outer Harbor Sediment (mg/kg) (Note: 2005 and 2007 points represent sum of Aroclors 1248 & 1260; 2009 points represent sum of congeners. "S" refers to surface samples; "C" refers to core samples.)

FIGURE 13. Total PCB Concentrations in Ashtabula Outer Harbor Sediment (mg/kg) (Note: 2005 and 2007 points represent sum of Aroclors 1248 & 1260; 2009 points represent sum of congeners. "S" refers to surface samples; "C" refers to core samples.)

FIGURE 14. Total PCB Concentrations in Lake Surface Sediments (mg/kg) (Note: 2005 and 2007 points represent sum of Aroclors 1248 & 1260; 2009 points represent sum of congeners).

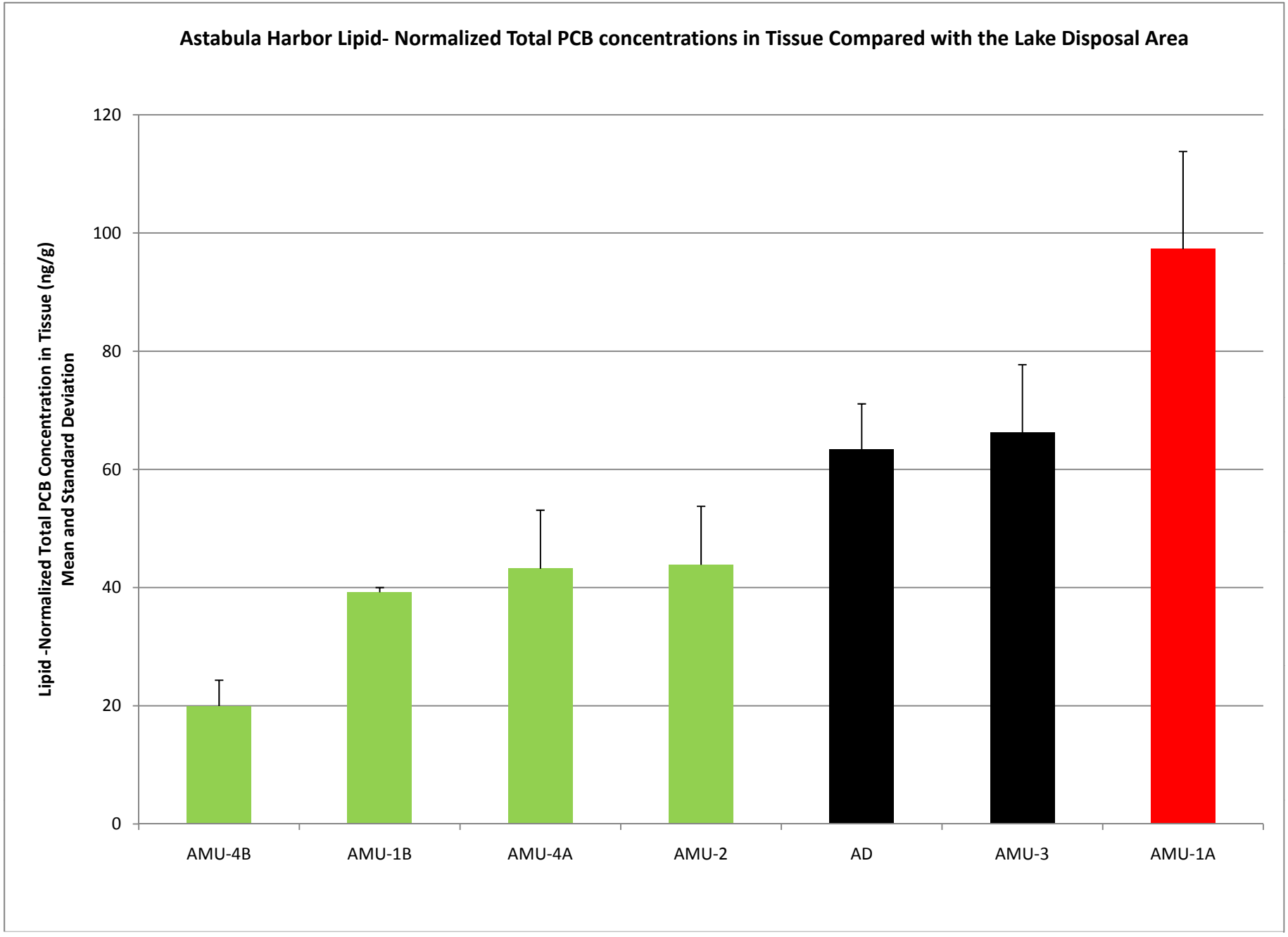


FIGURE 15. Lipid Normalized Total PCB Concentrations in Worm Tissue After Exposure to Ashtabula Management Unit Sediments . Green bars indicate mean tissue concentrations are statistically less than that of the disposal area; black bar indicates mean tissue concentration is not statistically different from the disposal area; red bar indicates mean tissue concentration is statistically greater than that of the disposal area.

Tables

TABLE 1. Particle Size Analyses on Ashtabula Harbor Federal Navigation Channel Sediments (2005 to 2009).

(Note 2005 samples are discrete locations, while 2007 and 2009 samples are composites) (Mostly coarse grained samples are shaded)

Particle Size Distribution (%)					
Harbor Management Unit/Lake Area	Sample	Clay	Silt	Sand	Gravel
1A	AH-3 (2005)	12.9	70.6	16.5	0
1A	AMU-1 (2009)	10.4	71.7	12.0	0
1B	AH-4 (2005)	22.9	73.0	4.1	0
1B	AMU-2 (2009)	4.0	27.8	66.3	0.3
1A/B	AMU1 (2007)	87.4		12.6	0
2	AMU 2 (2007)	91.0		9.0	0
2	AMU-3 (2009)	12.6	74.0	7.5	0
3	AH-6 (2005)	20.3	67.8	11.9	0
3	AMU-3 (2007)	94.6		5.4	0
3	AMU-4 (2009)	7.9	69.7	18.7	0.1
4A	AMU-5 (2009)	10.4	61.7	23.7	0
4B	AMU-6 (2009)	2.1	16.4	77.3	0
4A/B	AMU-4 (2007)	66.0		34.0	0
5	AMU-5 (2007)	95.0		5.0	0
6	AMU-6 (2007)	67.3		32.7	0
7	AMU-7 (2007)	92.4		7.6	0
ALR	AL-1 (2005)	23.1	73.8	3.1	0
ALR	AL-2 (2005)	19.5	70.1	10.4	0
ALR	AL-3(2005)	15.7	19.4	64.9	0
ALR	AL-4 (2005)	16.3	82.6	1.1	0
ALR	ALR-COMP (2007)	39.6		60.4	0
ALR	ALR-COMP (2009)	16.5	53.0	20.5	0
AD	AD-1 (2005)	17.2	49.8	33.0	0
AD	AD-2 (2005)	19.5	70.1	10.4	0
AD	AD-COMP (2007)	91.2		8.8	0
AD	AD-COMP (2009)	10.1	66.8	18.7	0.7

TABLE 2. Bulk Inorganic Analyses on Ashtabula Harbor Federal Navigation Channel Sediments. Boldface/shaded values indicate a concentration that is greater in comparison to the open-lake reference and/or placement area sediments (from EEI 2005).

	Harbor Sediments															Open-Lake Placement Area Sediments		Open-Lake Reference Area Sediments			
	Sampling Sites															Sampling Sites		Sampling Sites			
Metal (mg/kg)	**AH-1**	**AH-2**	**AH-3**	**AH-4**	**AH-5**	**AH-6**	**AH-7**	**AH-8**	**AH-9**	**AH-10**	**AH-11**	**AH-12**	**AH-13**	**AH-14**	**AH-15**	**AD-1**	**AD-2**	**AL-1**	**AL-2**	**AL-3**	**AL-4**
Aluminum			12400	10000	8880	10900						1100	9980	1070	10300	9870	9080	12601	12100	7230	13600
Antimony			1.44	1.16	1.05	1.25						1.45	1.34	1.35	1.27	1.38	1.21	0.887	1.67	1.41	1.39
Arsenic			9.23	7.8	7.57	9.17						10.6	10.9	10.3	10.6	12.2	11.1	4.09	8.11	15.6	7.72
Barium			61.5	42.1	37.5	40.6						36.4	36.1	39.1	55.4	42.1	46.4	46.5	58.9	48.1	66.1
Beryllium			0.551	0.455	0.383	0.454						0.437	0.417	0.443	0.497	0.389	0.514	0.441	0.683	0.406	0.648
Cadmium			0.591	0.496	0.309	0.451						0.633	0.67	0.679	1.11	0.985	2.4	1.06	2.29	0.769	2.04
Calcium			3830	5170	5740	6850						1360	16000	15400	**19000**	16400	7010	8170	9310	4470	9430
Chromium			26.2	19.1	13.7	17.6						17.4	16.6	18.9	17.1	17.6	37.2	17.8	37.1	13.1	33.2
Cobalt			11.6	9.21	7.73	9.55						9.51	8.91	9.51	8.51	9.24	7.97	7.91	9.85	8.41	10.7
Copper			29.9	23.5	18.3	24.3						31.2	31.2	32.1	34.1	32.6	46.4	26.5	45.3	17.3	43.9
Iron			**30100**	24300	21000	27200						2930	28000	29300	26600	28800	22600	26000	27100	29200	29300
Lead			22.2	16.2	14.4	16.1						17.8	17.1	17.4	19.9	18.8	46.8	25.3	45.5	19.5	42.9
Magnesium			5170	4440	4050	5460						757	7740	7610	7400	8280	5150	5440	7340	3960	7930
Manganese			396	292	258	341						48.9	511	**600**	455	445	398	413	402	494	511
Mercury			0.0951	0.0864	0.0413	0.0508						0.0623	0.0525	0.0415	0.0745	0.136	0.214	0.172	0.257	0.1332	0.218
Nickel			27.1	22.1	18.9	23.7						24.6	23.1	24.5	24.9	24.1	27.2	23.1	32.9	22.8	36.5
Potassium			1150	1070	902	1090						1220	1090	1160	1230	1000	1080	1310	1530	910	1830
Selenium			0.247	0.258	0.232	0.218						0.332	0.316	0.298	0.492	0.303	0.37	0.428	0.571	0.281	0.736
Silver			0.164	0.119	0.0632	0.0886						0.146	0.161	0.135	0.175	0.149	0.484	0.171	0.393	0.0942	0.347
Sodium			84.6	76.1	67.1	75.7						90.8	92.3	104	112	106	82.2	91.5	121	73.5	129
Thallium			0.142	0.136	0.103	0.142						0.183	0.171	0.183	0.319	0.218	0.226	0.387	0.542	0.224	0.363
Vanadium			**30.6**	21.1	14.2	17.5						16.4	16.5	18.1	19.2	14.8	16.3	16.5	21.8	18.5	24.9
Zinc			108	90.9	74.9	89.2						98.6	99.8	97.2	111	96.9	297	93.6	221	90.7	166
Misc. (mg/kg)																					
Ammonia			172	136	71	111						104	122	**323**	148	51.3	97.6	90.3	102	45	216
Total cyanide			0.400J*	0.211U**	0.179U	0.321J						0.438	0.228J	0.563	0.359J	0.306J	0.371J	0.266U	0.703	0.349J	0.410J
Oil/grease			57.7U	115	97.8	45.7						48.6U	45.8U	46.8U	42U	41U	44.9U	63.8U	64.8U	53.7U	134
Phosphorous			375	345	336	349						359	397	323	390	405	365	407	424	412	156
TOC	22100	19900	22700	26700	15600	20300	17900	21500	18400	17100	18100	17000	15200	22900	21600	14100	24200	14300	21700	7730	29100

*Estimated value between the detection limit and reporting limit.

**Not detected at or above the specified laboratory reporting limit.

TABLE 3. Bulk PAH Analyses on Ashtabula Harbor Federal Navigation Channel Sediments. Boldface/shaded values indicate total PAH concentrations that are greater in comparison to the open-lake reference and/or placement area sediments (from EEI 2005).

	Harbor Sediments											Open-Lake Placement Area Sediments			Open-Lake Reference Area Sediments				
	Sampling Sites											Sampling Sites			Sampling Sites				
PAH Compound (µg/kg)	**AH-3**	**AH-4**	**AH-5**	**AH-6**	**AB-1**	**AH-12**	**AH-13**	**AB-2**	**AH-14**	**AH-15**	**AB-3**	**AD-1**	**AD-2**	**Comp**	**AL-1**	**AL-2**	**AL-3**	**AL-4**	**Comp**
Acenaphthene	10.4	7.27U*	7.68U	10.6	10.1	8.23U	7.77	10.1	12.3	12.1	9.13	17.5	7.89U	8.31	9.11	11.2	3.52J**	12.5	3.17J
Acenaphthylene	7.48	7.27U	7.68U	20.1	21.3	9.21	18.6	19.3	11.6	17.5	11.2	20.7	16.1	14.8	19.2	40.1	5.36J	37.8	10.2
Anthracene	35.2	8.92	22.8	39.9	42.2	17.1	29.6	35.1	33.2	37.6	29.8	47.4	17.3	23.9	33	40.2	6.57J	43.7	11.1
Benzo(a)Anthracene	102	34.9	59.8	139	117	52.8	93.8	115	84.9	96.9	77	116	47.1	64.4	110	113	15.6	141	30.8
Benzo(a)Pyrene	100	37.5	57.2	147	112	51.6	92.6	112	83.6	94.6	73.5	101	55.6	66.7	106	121	15.6	152	37.2
Benzo(b)Flouranthene	144	58.3	91.1	191	172	79.8	132	155	116	144	103	183	76.1	90.1	172	196	32.3	252	49.1
Benzo(ghi)Perylene	63.3	30.6	40.3	98.8	74.4	37.4	64.1	69.8	55.6	66.9	47.7	92.3	43.1	49.5	83.7	103	19.2	132	25.7
Benzo(k)Fluoranthene	52.3	21.5	29.8	64.1	54	29.1	47.7	56.9	40.8	48.3	36.7	47.9	27.5	31.6	54.6	55.1	8.73	67.9	19.6
Chrysene	111	14.8	71.1	143	135	65.5	108	126	99.9	114	85.3	142	57.3	76.2	118	127	14.8	159	30.1
Dibenzo(a,h)Anthracene	24.9	13.1	16.5	36.6	29.4	15.7	25.7	27.5	22.9	26.5	19.5	37.8	17.8	21.8	31.2	45.1	0.113U	51.8	13.2
Fluoranthene	232	85.2	147	263	280	122	196	249	185	216	173	231	89.3	128	212	195	32	234	54.4
Fluorene	15.2	7.27	11.9	20.6	22.4	11.5	15.9	22.6	22.1	26.5	15.5	39.9	7.89U	13.3	14	14	4.59J	17.8	4.96J
Indeno(1,2,3-cd)Pyrene	63.1	31.2	39.7	96.9	72.7	34.2	62.3	69.5	53.3	64.7	46	74.8	41.1	47.7	81.3	90.3	14.3	116	25.9
Naphthalene	12.3	12.2	16.5	32.4	29.5	15.6	17.6	26.6	42.5	35.4	20.4	30.1	18.3	20.8	28.4	37.9	9.22	42.3	9.69
Phenanthrene	122	36.8	76.6	132	145	65.6	102	127	119	124	98.1	172	43.8	73.9	62.2	94.8	20.1	112	23.8
Pyrene	146	50.4	98.9	167	175	83.2	126	159	121	139	118	232	66.1	94.7	153	189	34.5	229	39.2
Total PAHs	1241	457	795	**1602**	**1492**	699	1140	1380	1104	1264	964	1585	632	826	1288	1473	237	1800	388

*Not detected at or above the specified laboratory reporting limit (LRL); concentration valued at the LRL to sum total PAHs.

**Estimated value between the detection limit and reporting limit.

TABLE 4. Bulk Sediment Total PCB and TOC Data, and Associated Total PCB Theoretical Bioaccumulation Potential (TBP) Predictions for Ashtabula Lower River/Outer Harbor Sediments (Note: yellow highlight - bulk concentration exceeds that of respective reference/disposal area environs;* red highlight - TBP exceeds that of respective reference/disposal area environs; blue highlight - reference/placement area value used) (based on data from USAERDC 2007a and 2007b).

Harbor management unit/lake area	Sample	Year	Sample Depth (ft)	LWD Sample Depth (ft)	LWD Project Depth (ft)	Sediment PCB concentration (ug/kg)			TOC (decimal %)	Lipid (decimal %)	BSAF	TBP (ug/kg)	BSAF (2009)	TBP (ug/kg) (2009)	Comments
						PCB1248	PCB1260	Total							
1-A	AMU1 01C 0-1***	2007b	0-1	21.66	27	322	29.1	351.1	0.0164	0.01	0.38	81.4	0.73	157.14	
1-A	AMU1 01C 1-2	2007b	1-2	22.66	27	569	2.8	571.8	0.0138	0.01	0.38	157.5	0.73	304.13	
1-A	AMU1-01C 2-3	2007b	2-3	23.66	27	914	38.7	952.7	0.0204	0.01	0.38	177.5	0.38	177.46	
1-A	AMU1-01C3-4	2007b	3-4	24.66	27	1040	90.4	1130.4	0.014	0.01	0.38	306.8	0.38	306.82	
1-A	AMU1-01C 4-5	2007b	4-5	25.66	27	648	2.8	650.8	0.0147	0.01	0.38	168.2	0.38	168.23	
1-A	AMU1-01C-5-6	2007b	5-6	26.66	27	1140	2.8	1142.8	0.0126	0.01	0.38	344.7	0.38	344.65	
1A	**AMU1-01C AVE**		**0-6**	**26.66**	**27**			**799.9**	**0.0153**	**0.01**	**0.38**	**198.5**	**0.38**	**198.46**	
1-A	AMU1 03C 0-1	2007b	0-1	13.13	27	385	82.2	467.2	0.0103	0.01	0.38	172.4	0.73	332.94	
1-A	AMU1 03C 1-2	2007b	1-2	14.13	27	303	206	509	0.0126	0.01	0.38	153.5	0.73	296.51	
1-A	AMU1 03C 2-3	2007b	2-3	15.13	27	238	201	439	0.0143	0.01	0.38	116.7	0.38	116.66	
1-A	AMU1 03C 3-4	2007b	3-4	16.13	27	192	205	397	0.0167	0.01	0.38	90.3	0.38	90.34	
1-A	AMU1 03C 4-5	2007b	4-5	17.13	27	162	80.1	242.1	0.019	0.01	0.38	48.4	0.38	48.42	
1-A	AMU1 03C 5-6	2007b	5-6	18.13	27	161	2.8	163.8	0.013	0.01	0.38	47.9	0.38	47.88	
1-A	**AMU1 03C AVE**		**0-6**	**18.13**	**27**			**369.7**	**0.014**	**0.01**	**0.38**	**98.1**	**0.73**	**189.53**	
1-A	AMU1-08S**	2007b	2	27.22	27	78.8	13.8	92.6	0.0123	0.01	0.38	28.6	0.73	55.26	
1-A	AMU1-09S	2007b	2	28.2	27	83	13.2	96.2	0.0113	0.01	0.38	32.4	0.73	62.49	
1-A	AMU1-02S	2007b	2	13.17	27	134	19.7	153.7	0.0121	0.01	0.38	48.3	0.73	93.24	
1-A	AH-3	2007a	2	15.81	27			565	0.0227	0.01	0.38	94.6	0.73	182.69	
1-A	AH-15	2003	2	25	27			344	0.025	0.01	0.38	52.3	0.73	101.00	
1-A	AH-16	2003	2	25	27			95.9		0.01	0.38		0.73		
1-B	AMU1-11C 0-1	2007b	0-1	17.12	27	77.8	20.8	98.6	0.0137	0.01	0.38	27.3	1.08	77.73	
1-B	AMU1-11C 1-2	2007b	1-2	18.12	27	101	40.5	141.5	0.0201	0.01	0.38	26.8	1.08	76.03	
1-B	AMU1-11C 2-3	2007b	2-3	19.12	27	139	49.1	188.1	0.0144	0.01	0.38	49.6	0.38	49.64	
1-B	AMU1-11C 3-4	2007b	3-4	20.12	27	380	142	522	0.0243	0.01	0.38	81.6	0.38	81.63	
1-B	AMU1-11C 4-5	2007b	4-5	21.12	27	133	34.2	167.2	0.0126	0.01	0.38	50.4	0.38	50.43	
1-B	AMU1-11C 5-6	2007b	5-6	22.12	27	326	13.5	339.5	0.011	0.01	0.38	117.3	0.38	117.28	
1-B	**AMU1-11C AVE**		**0-6**	**22.12**	**27**			**242.8**	**0.0160**	**0.01**	**0.38**	**57.6**	**0.38**	**57.61**	
1-B	AMU1-12C 0-1	2007b	0-1	14.3	27	41.1	10.8	51.9	0.0056	0.01	0.38	35.2	1.08	100.09	
1-B	AMU1-12C 1-2	2007b	1-2	15.3	27	42.9	15.4	58.3	0.0038	0.01	0.38	58.3	1.08	165.69	
1-B	AMU1-12C 2-3	2007b	2-3	16.3	27	56.7	26.8	83.5	0.0078	0.01	0.38	40.7	0.38	40.68	
1-B	AMU1-12C 3-4	2007b	3-4	17.3	27	105	29.3	134.3	0.0097	0.01	0.38	52.6	0.38	52.61	
1-B	AMU1-12C 4-5	2007b	4-5	18.3	27	117	2.5	119.5	0.0089	0.01	0.38	51.0	0.38	51.02	
1-B	**AMU1-12C AVE**		**0-5**	**18.3**	**27**			**89.5**	**0.00716**	**0.01**	**0.38**	**47.5**	**0.38**	**47.50**	
1-B	AMU1-04S	2007b	2	15.72	27	120	16.8	136.8	0.096	0.01	0.38	5.4	1.08	15.39	
1-B	AMU1-05S	2007b	2	15.12	27	117	18.2	135.2	0.013	0.01	0.38	39.5	1.08	112.32	
1-B	AMU1-06S	2007b	2	14.06	27	170	19.9	189.9	0.0156	0.01	0.38	46.3	1.08	131.47	
1-B	AMU1-07S	2007b	2	17.38	27	38.2	9.84	48.04	0.0142	0.01	0.38	12.9	1.08	36.54	
1-B	AMU1-10S	2007b	2	25.48	27	293	82.7	375.7	0.0127	0.01	0.38	112.4	1.08	319.49	
1-B	AH-4	2007a	2	21.75	27			348	0.0267	0.01	0.38	49.5	1.08	140.76	
1-B	AH-5	2007a	2	28.8	27			127	0.0156	0.01	0.38	30.9	1.08	87.92	
1-B	AH-13	2003	2	25	27			21		0.01	0.38		1.08		
1-B	AH-14	2003	2	25	27			167	0.021	0.01	0.38	30.2	1.08	85.89	
2	AMU2-01C 0-1	2007b	0-1	17.06	27	90.9	29.9	120.8	0.0105	0.01	0.47	54.1	0.45	52.23	
2	AMU2-01C 1-2	2007b	1-2	18.06	27	81.4	24.3	105.7	0.014	0.01	0.47	35.5	0.45	34.28	
2	AMU2-01C 2-3	2007b	2-3	19.06	27	61.6	11.1	72.7	0.0095	0.01	0.47	36.0	0.45	34.74	
2	AMU2-01C 3-4	2007b	3-4	20.06	27	117	2.5	119.5	0.0102	0.01	0.47	55.1	0.45	53.19	
2	AMU2-01C 4-5	2007b	4-5	21.06	27	61.3	2.3	63.6	0.0173	0.01	0.47	17.3	0.45	16.69	
2	**AMU2-01C AVE**		**0-5**	**21.06**	**27**			**96.46**	**0.0123**	**0.01**	**0.47**	**36.9**	**0.45**	**35.60**	
2	AMU2-05C 0-1	2007b	0-1	22.12	27	134	76.9	210.9	0.0105	0.01	0.47	94.4	0.45	91.19	
2	AMU2-05C 1-2	2007b	1-2	23.12	27	125	11.9	136.9	0.0101	0.01	0.47	63.7	0.45	61.54	
2	AMU2-05C 2-3	2007b	2-3	24.12	27	139	2.8	141.8	0.0101	0.01	0.47	66.0	0.45	63.74	
2	AMU2-05C 3-4	2007b	3-4	25.12	27	177	2.5	179.5	0.0094	0.01	0.47	89.8	0.45	86.69	
2	AMU2-05C 4-5	2007b	4-5	26.12	27	428	2.5	430.5	0.0092	0.01	0.47	219.9	0.45	212.44	
2	**AMU2-05C AVE**		**0-5**	**26.12**	**27**			**219.92**	**0.00986**	**0.01**	**0.47**	**104.8**	**0.45**	**101.26**	
2	AMU2-02S	2007b	2	26.2	27	82.6	16.3	98.9	0.014	0.01	0.47	33.2	0.45	32.07	
2	AMU2-03S	2007b	2	27.16	27	80	20.4	100.4	0.0098	0.01	0.47	48.2	0.45	46.51	
2	AMU2-06S	2007b	2	27.74	27	40.3	17.7	58	0.0093	0.01	0.47	29.3	0.45	28.31	
2	AMU2-07S	2007b	2	26.73	27	62.5	15.6	78.1	0.0087	0.01	0.47	42.2	0.45	40.76	
2	AMU2-08S	2007b	2	27.23	27	67.8	19.2	87	0.0095	0.01	0.47	43.0	0.45	41.58	
2	AMU2-09S	2007b	2	28.42	27	66.8	20.3	87.1	0.0091	0.01	0.47	45.0	0.45	43.45	
2	AMU2-10S	2007b	2	28.12	27	56.6	14.6	71.2	0.0105	0.01	0.47	31.9	0.45	30.79	
2	AH-11	2007a	2	30.86	27			636	0.0181	0.01	0.47	165.1	0.45	159.53	
3	AMU3-O1C 0-1	2007b	0-1	16.37	27	79.5	30.6	110.1	0.014	0.01	0.47	37.0	0.45	35.70	
3	AMU3-01C 1-2	2007b	1-2	17.37	27	113	65.7	178.7	0.019	0.01	0.47	44.2	0.45	42.70	
3	AMU3-01C 2-3	2007b	2-3	18.37	27	119	2.6	121.6	0.0109	0.01	0.47	52.4	0.45	50.65	
3	AMU3-01C 3-4	2007b	3-4	19.37	27	109	2.6	111.6	0.0111	0.01	0.47	47.3	0.45	45.65	
3	**AMU3-01 AVE**		**0-4**	**19.37**	**27**			**130.5**	**0.01375**	**0.01**	**0.47**	**44.6**	**0.45**	**43.09**	
3	AMU3-02C 0-1	2007b	0-1	10.85	27	34.3	11.4	45.7	0.0097	0.01	0.47	22.1	0.45	21.39	
3	AMU3-02C 1-2	2007b	1-2	11.85	27	20.2	8.28	28.48	0.0075	0.01	0.47	17.8	0.45	17.24	
3	AMU3-02C 2-3	2007b	2-3	12.85	27	66.9	6.65	73.55	0.0086	0.01	0.47	40.2	0.45	38.83	
3	AMU3-02C 3-4	2007b	3-4	13.85	27	35.6	5.35	40.95	0.0096	0.01	0.47	20.0	0.45	19.37	
3	**AMU3-02C AVE**		**0-4**	**13.85**	**27**			**47.17**	**0.00885**	**0.01**	**0.47**	**25.1**	**0.45**	**24.20**	
3	AMU3-05C 0-1	2007b	0-1	17.55	27	100	24.7	124.7	0.0097	0.01	0.47	60.4	0.45	58.36	
3	AMU3-05C 1-2	2007b	1-2	18.55	27	106	2.6	108.6	0.0097	0.01	0.47	52.6	0.45	50.83	
3	AMU3-05C 2-3	2007b	2-3	19.55	27	100	13.6	113.6	0.0102	0.01	0.47	52.3	0.45	50.56	
3	AMU3-05C 3-4	2007b	3-4	20.55	27	132	2.6	134.6	0.0102	0.01	0.47	62.0	0.45	59.91	
3	**AMU3-05C AVE**		**0-4**	**20.55**	**27**			**120.375**	**0.00995**	**0.01**	**0.47**	**56.9**	**0.45**	**54.92**	
3	AMU3-07C 0-1	2007b	0-1	17.25	27	67	22.7	89.7	0.0098	0.01	0.47	43.0	0.45	41.55	
3	AMU3-07C 1-2	2007b	1-2	18.25	27	156	75.9	231.9	0.0093	0.01	0.47	117.2	0.45	113.21	
3	AMU3-07C 2-3	2007b	2-3	19.25	27	66.1	2.3	68.4	0.0144	0.01	0.47	22.3	0.45	21.57	
3	AMU3-07C 3-4	2007b	3-4	20.25	27	116	2.6	118.6	0.0099	0.01	0.47	56.3	0.45	54.39	
3	**AMU3-07C AVE**		**0-4**	**20.25**	**27**			**127.15**	**0.01085**	**0.01**	**0.47**	**55.1**	**0.45**	**53.20**	
3	AMU3-04S	2007b	2	17.74	27	79.9	2.7	82.6	0.0091	0.01	0.47	42.7	0.45	41.21	
3	AMU3-06S	2007b	2	19.24	27	68.5	37.4	105.9	0.0087	0.01	0.47	57.2	0.45	55.26	
3	AH-6	2007a	2	20.81	27			246	0.0203	0.01	0.47	57.0	0.45	55.02	
4-A	AMU4-02C 0-1	2007b	0-1	20.06	28	49.1	22.2	71.3	0.0045	0.01	0.47	74.5	0.45	71.93	
4-A	AMU4-02C 1-2	2007b	1-2	21.06	28	166	82.7	248.7	0.0055	0.01	0.47	212.5	0.45	205.29	
4-A	AMU4-02C 2-3	2007b	2-3	22.06	28	121	15.4	136.4	0.0047	0.01	0.47	136.4	0.45	131.76	TBP invalid (TOC<0.5%)
4-A	AMU4-02C 3-4	2007b	3-4	23.06	28	124	7.69	131.69	0.0031	0.01	0.47	199.7	0.45	192.86	TBP invalid (TOC<0.5%)
4A	**AMU4-02C AVE**		**0-4**	**24.06**	**28**			**147.0225**	**0.00445**	**0.01**	**0.47**	**155.3**	**0.45**	**150.00**	**TBP invalid (TOC<0.5%)**
4-A	AMU4-06C 0-1	2007b	0-1	21	28	2.5	2.5	5	0.0026	0.01	0.47	9.0	0.45	8.73	
4-A	AMU4-06C 1-2	2007b	1-2	22	28	93.6	19.4	113	0.0072	0.01	0.47	73.8	0.45	71.25	
4-A	AMU4-06C 2-3	2007b	2-3	23	28	93.6	2.5	96.1	0.0016	0.01	0.47	282.3	0.45	272.68	TBP invalid (TOC<0.5%)
4-A	AMU4-06C 3-4	2007b	3-4	24	28	97.4	2.5	99.9	0.0031	0.01	0.47	151.5	0.45	146.31	TBP invalid (TOC<0.5%)
4A	**AMU4-06C AVE**		**0-4**	**25**	**28**			**78.5**	**0.003625**	**0.01**	**0.47**	**101.8**	**0.45**	**98.31**	
4-A	AMU4-10C 0-1	2007b	0-1	20.01	28	55.1	2.5	57.6	0.032	0.01	0.47	8.5	0.45	8.17	
4-A	AMU4-10C 1-2	2007b	1-2	21.01	28	57	2.5	59.5	0.0175	0.01	0.47	16.0	0.45	15.44	
4-A	AMU4-10C 2-3	2007b	2-3	22.01	28	21	2.5	23.5	0.0175	0.01	0.47	6.3	0.45	6.10	
4-A	AMU4-10C 3-4	2007b	3-4	23.01	28	67.7	2.7	70.4	0.014	0.01	0.47	23.6	0.45	22.83	
4A	**AMU4-10C AVE**		**0-4**	**24.01**	**28**			**52.75**	**0.02025**	**0.01**	**0.47**	**12.2**	**0.45**	**11.83**	
4-A	AMU4-01S	2007b	2	27.18	28	64.3	21.7	86	0.0094	0.01	0.47	43.0	0.45	41.54	
4-A	AMU4-04S	2007b	2	23.46	28	134	26.6	160.6	0.0086	0.01	0.47	87.8	0.45	84.78	
4-A	AMU4-08S	2007b	2	25.17	28	116	34	150	0.0094	0.01	0.47	75.0	0.45	72.45	
4-A	AMU4-12S	2007b	2	24.21	28	33.1	64.2	97.3	0.0286	0.01	0.47	16.0	0.45	15.45	
4-A	AH-7	2007a	2	25.79	28			633	0.0179	0.01	0.47	166.2	0.45	160.55	
4-B	AMU4-14S	2007b	2	25.01	28	41.5	2.3	43.8	0.0076	0.01	0.47	27.1	0.45	26.16	
4-B	AMU4-16S	2007b	2	26.02	28	27.5	9.9	37.4	0.011	0.01	0.47	16.0	0.45	15.44	
4-B	AMU4-17S	2007b	2	29.22	28	18.8	6	24.8	0.0069	0.01	0.47	16.9	0.45	16.32	
4-B	AMU4-18S	2007b	2	28.22	28	22.8	6.58	29.38	0.0058	0.01	0.47	23.8	0.45	23.00	
4-B	AMU4-19S	2007b	2	23.75	28	7.28	2.91	10.19	0.0025	0.01	0.47	19.2	0.45	18.51	
4-B	AH-8	2007a	2	28.78	28			1527	0.0215	0.01	0.47	333.8	0.45	322.45	
5	AMU5-01S	2007b	2	25.2	28	73.7	21.2	94.9	0.0086	0.01	0.47	51.9	0.45	50.10	
5	AMU5-03S	2007b	2	23.89	28	82.6	29.1	111.7	0.0086	0.01	0.47	61.0	0.45	58.97	
5	AMU5-05S	2007b	2	24.21	28	64.6	19.4	84	0.0087	0.01	0.47	45.4	0.45	43.83	
5	AMU5-07S	2007b	2	26.25	28	69.1	21.8	90.9	0.0078	0.01	0.47	54.8	0.45	52.91	
5	AMU5-09S	2007b	2	26.23	28	71.6	23.4	95	0.0054	0.01	0.47	82.7	0.45	79.87	
6	AMU6-01S	2007b	2	27.93	28	45.7	30.3	76	0.0079	0.01	0.47	45.2	0.45	43.68	
6	AMU6-02S	2007b	2	30.23	28	44.3	19.6	63.9	0.0066	0.01	0.47	45.5	0.45	43.96	
6	AMU6-03S	2007b	2	32.26	28	156	2.5	158.5	0.0073	0.01	0.47	102.0	0.45	98.57	
6	AMU6-04S	2007b	2	33.23	28	41.1	2.3	43.4	0.0084	0.01	0.47	24.3	0.45	23.46	
~6	AH-9	2007a	2	30.82	28			92.7	0.0184	0.01	0.47	23.7	0.45	22.87	
7	AMU7-05S	2007b	2	18.36	28	34.2	3.1	37.3	0.0091	0.01	0.47	19.3	0.45	18.61	
7	AMU7-06S	2007b	2	13.04	28	54.2	2.4	56.6	0.0073	0.01	0.47	36.4	0.45	35.20	
7	AMU7-07S	2007b	2	7.95	28	43	2.3	45.3	0.0066	0.01	0.47	32.3	0.45	31.16	
7	AMU7-08S	2007b	2	27.19	28	37.9	3.3	41.2	0.0091	0.01	0.47	21.3	0.45	20.55	
7	AMU7-09S	2007b	2	27.83	28	35.3	3.1	38.4	0.0085	0.01	0.47	21.2	0.45	20.51	
7	AMU7-10S	2007b	2	27.46	28	51.7	3.1	54.8	0.0089	0.01	0.47	28.9	0.45	27.95	
7	AMU7-11S	2007b	2	25.36	28	48.2	3.4	51.6	0.0084	0.01	0.47	28.9	0.45	27.89	
7	AMU7-12S	2007b	2	21.27	28	27.9	9.42	37.32	0.0093	0.01	0.47	18.9	0.45	18.22	
7	AMU7-13S	2007b	2	25.83	28	38.1	3.2	41.3	0.0082	0.01	0.47	23.7	0.45	22.87	
7	AMU7-14S	2007b	2		28	43.1	3.1	46.2	0.007	0.01	0.47	31.0	0.45	29.96	
7	AMU7-15S	2007b	2	25.72	28	60.7	17.1	77.8	0.0072	0.01	0.47	50.8	0.45	49.06	
7	AMU-7-01S	2007b	2	26.75	28	56.1	48.1	104.2	0.0071	0.01	0.47	69.0	0.45	66.63	
7	AMU-7-02S	2007b	2	26.34	28	54.3	3	57.3	0.008	0.01	0.47	33.7	0.45	32.52	
7	AMU 7-03S	2007b	2	26.41	28	30.2	3	33.2	0.0083	0.01	0.47	18.8	0.45	18.16	
7	AMU 7-04S	2007b	2	23.38	28	43.1	3.3	46.4	0.0077	0.01	0.47	28.3	0.45	27.36	
AD (2007b)	AD-1-07b	2007b	2			36.5	2.1	38.6	0.005	0.01	0.47	36.3	0.40	30.49	Marginal TOC level
AD (2007b)	AD-2-07b	2007b	2			106	2.6	108.6	0.0032	0.01	0.47	159.5	0.40	134.05	TBP invalid (TOC<0.5%)
AL (2007b)	AL-1-07b	2007b	2			93.1	3.1	96.2	0.0069	0.01	1.2	167.3	1.48	206.34	
AL (2007b)	AL-2-07b	2007b	2			68.7	19.5	88.2	0.003	0.01	1.2	352.8	1.48	435.12	TBP invalid (TOC<0.5%)
AL (2007b)	AL-3-07b	2007b	2			59.6	2.6	62.2	0.0027	0.01	1.2	276.4	1.48	340.95	TBP invalid (TOC<0.5%)
AL (2007b)	AL-4-07b	2007b	2			73	30.5	103.5	0.003	0.01	1.2	414.0	1.48	510.60	TBP invalid (TOC<0.5%)
AD (2007a)	AD-2-07a	2007a	2					274	0.0227	0.01	0.47	56.7	0.40	47.68	
AL (2007a)	AL-2-07a	2007a	2					95.3	0.0217	0.01	1.2	52.7	1.48	65.00	

Notes:
*Low TOC in most lake sediment samples obtained in USAERDC (2007b) prevented use of TBP algorithm; it was assumed at Tier 2 that potential bioaccumulation of PCBs from sediments is greater relative to reference/disposal area environs.
Tier 3 bioaccumulation testing did not show unacceptable total PCB concentrations in tissue when compared to reference/disposal area environs.
**S designates surface grab sample.
***C designates core sample.

TABLE 5. 2009 Total PCB Bioaccumulation Results for Ashtabula Lower River/Outer Harbor Sediments

Harbor Mangament Unit/Lake Area	Tissue Sample	C_T (ng/g)	Lipid (%)	C_T/(Lipid) (ng/g-lipid)	C_S (ng/g)	TOC (%)	BSAF	Notes
1A	AMU-1 A	98.64	1.2	82.20	309.97	2.34	0.62	**Mean BSAF: 0.73**
1A	AMU-1 B	111.64	1.2	93.03	309.97	2.34	0.70	**Mean Ct/(%Lipid): 97.30**
1A	AMU-1 C	107.89	1.2	89.91	309.97	2.34	0.68	**C_S sample is AMU-1 COMP**
1A	AMU-1 D	105.61	1.1	96.01	309.97	2.34	0.72	
1A	AMU-1 E	110.30	0.88	125.34	309.97	2.34	0.95	
1B	AMU-2 A	39.92	1.0	39.92	88.74	2.45	1.10	**Mean BSAF: 1.08**
1B	AMU-2 B	39.35	1.0	39.35	88.74	2.45	1.09	**Mean Ct/(%Lipid): 39.22**
1B	AMU-2 C	37.01	0.93	39.80	88.74	2.45	1.10	**C_S sample is AMU-2 COMP**
1B	AMU-2 D	38.31	0.98	39.09	88.74	2.45	1.08	
1B	AMU-2 E	41.76	1.1	37.96	88.74	2.45	1.05	
2	AMU-3 A	37.61	1.1	34.19	175.12	1.66	0.32	**Mean BSAF: 0.42**
2	AMU-3 B	45.33	0.77	58.87	175.12	1.66	0.56	**Mean Ct/(%Lipid): 43.86**
2	AMU-3 C	35.96	0.74	48.59	175.12	1.66	0.46	**C_S sample is AMU-3 COMP**
2	AMU-3 D	36.41	0.94	38.73	175.12	1.66	0.37	
2	AMU-3 E	34.24	0.88	38.91	175.12	1.66	0.37	
3	AMU-4 A	68.25	0.82	83.23	213.86	1.64	0.64	**Mean BSAF: 0.51**
3	AMU-4 B	68.97	0.96	71.84	213.86	1.64	0.55	**Mean Ct/(%Lipid): 66.28**
3	AMU-4 C	56.92	1.0	56.92	213.86	1.64	0.44	**C_S sample is AMU-4 COMP**
3	AMU-4 D	61.35	1.1	55.77	213.86	1.64	0.43	
3	AMU-4 E	63.62	1.0	63.62	213.86	1.64	0.49	
4A	AMU-5 A	30.86	0.70	44.09	134.66	1.35	0.44	**Mean BSAF: 0.43**
4A	AMU-5 B	28.62	0.95	30.13	134.66	1.35	0.30	**Mean Ct/(%Lipid): 43.20**
4A	AMU-5 C	33.04	0.61	54.16	134.66	1.35	0.54	**C_S sample is AMU-5 COMP**
4A	AMU-5 D	35.11	0.79	44.44	134.66	1.35	0.45	*Sample destroyed prior to
4A	AMU-5 E*		0.8					PCB analyses
4B	AMU-6 A	15.12	1.0	15.12	43.46	0.536	0.19	**Mean BSAF: 0.25**
4B	AMU-6 B	15.70	0.91	17.25	43.46	0.536	0.21	**Mean Ct/(%Lipid): 19.97**
4B	AMU-6 C	19.88	0.94	21.15	43.46	0.536	0.26	**C_S sample is AMU-6 COMP**
4B	AMU-6 D	15.77	0.80	19.71	43.46	0.536	0.24	
4B	AMU-6 E	19.15	0.72	26.60	43.46	0.536	0.33	
AD	AD A	58.12	1.1	52.84	198.70	1.24	0.33	**Mean BSAF: 0.40**
AD	AD B	56.77	0.90	63.08	198.70	1.24	0.39	**Mean Ct/(%Lipid): 63.34**
AD	AD C	54.49	0.79	68.97	198.70	1.24	0.43	**C_S sample is AD COMP**
AD	AD D	65.31	1.1	59.37	198.70	1.24	0.37	
AD	AD E	54.32	0.75	72.43	198.70	1.24	0.45	
ALR	ALR A	24.04	0.84	28.62	42.99	1.76	1.17	**Mean BSAF: 1.48**
ALR	ALR B	30.35	0.86	35.29	42.99	1.76	1.44	**Mean Ct/(%Lipid): 36.15**
ALR	ALR C	30.46	1.0	30.46	42.99	1.76	1.25	**C_S sample is ALR COMP**
ALR	ALR D	27.56	0.67	41.13	42.99	1.76	1.68	
ALR	ALR E	28.06	0.62	45.26	42.99	1.76	1.85	

TABLE 6. 2009 Total PCB Theoretical Bioaccumulation Potential TBP Predictions for Ashtabula River/Outer Harbor Sediments

Harbor Management Unit/Lake Area	Sample	LWD Sample Depth (ft)	LWD Project Depth (ft)	C_S (ng/g)	TOC (%)	Lipid (%)	BSAF	TBP (ng/g)	Notes
1A	AMU-1-01C	19.81	27	371.37	6.92	1	0.73	39.18	**Measured Tissue Range: 98.64 - 111.64**
1A	AMU-1-02C	24.14	27	448.24	2.61	1	0.73	125.37	**Composite Sample:**
1A	AMU-1-03C	22.56	27	288.84	2.21	1	0.73	95.41	**C_S - 309.97**
1A	AMU-1-04S	20.60	27	231.21	2.84	1	0.73	59.43	**TOC - 2.34%**
1A	AMU-1-05S	27.65	27	306.84	2.46	1	0.73	91.05	
1B	AMU-2-06S	19.76	27	208.30	2.28	1	1.08	98.67	**Measured Tissue Range: 37.01 - 41.76**
1B	AMU-2-07S	16.75	27	69.10	1.86	1	1.08	40.12	**Composite Sample:**
1B	AMU-2-08S	24.74	27	91.01	1.70	1	1.08	57.82	**C_S - 88.74**
1B	AMU-2-09S	17.77	27	110.89	2.23	1	1.08	53.70	**TOC - 2.45%**
1B	AMU-2-10S	13.75	27	79.58	2.44	1	1.08	35.22	
1B	AMU-2-11S	11.74	27	58.13	2.00	1	1.08	31.39	
2	AMU-3-12C	27.03	27	121.01	1.46	1	0.45	37.30	**Measured Tissue Range: 34.24 - 45.33**
2	AMU-3-13S	26.63	27	115.59	1.83	1	0.45	28.68	**C_S - 175.12**
2	AMU-3-14S	29.60	27	140.91	1.59	1	0.45	40.23	**TOC - 1.66%**
3	AMU-4-15S	15.54	27	111.79	2.27	1	0.45	22.36	**Measured Tissue Range: 56.92 - 68.97**
3	AMU-4-16S	15.55	27	109.15	1.73	1	0.45	28.64	**C_S - 213.86**
3	AMU-4-17S	15.55	27	120.97	1.99	1	0.45	27.60	**TOC - 1.64%**
4A	AMU-5-18C	24.60	28	215.58	1.88	1	0.45	52.06	**Measured Tissue Range: 28.62 - 35.11**
4A	AMU-5-19S	25.61	28	146.75	1.99	1	0.45	33.48	**Composite Sample:**
4A	AMU-5-20C	27.64	28	158.12	1.48	1	0.45	48.50	**C_S - 134.66**
4A	AMU-5-21S	25.41	28	139.05	2.12	1	0.45	29.78	**TOC - 1.35%**
4A	AMU-5-22S	25.61	28	94.68	1.47	1	0.45	29.24	
4B	AMU-6-23S	23.68	28	69.69	1.24	1	0.25	13.83	**Measured Tissue Range: 15.12 - 19.88**
4B	AMU-6-24S	21.70	28	22.44	0.403	1	0.25	13.70	**C_S - 43.46 TOC - 0.536%**
AD	AD-1			105.36	1.63	1	0.40	25.53	**Measured Tissue Range: 54.32 - 65.31**
AD	AD-2			213.59	1.22	1	0.40	69.15	**C_S - 198.70 TOC - 1.24%**
ALR	ALR-1			20.86	1.71	1	1.48	18.05	**Measured Tissue Range: 24.04 - 30.46**
ALR	ALR-2			52.76	1.26	1	1.48	61.97	**Composite Sample:**
ALR	ALR-3			143.86	2.93	1	1.48	72.67	**C_S - 42.99**
ALR	ALR-4			16.02	0.894	1	1.48	26.52	**TOC - 1.76%**

TABLE 7. Bulk Pesticides Analyses on Ashtabula Harbor Federal Navigation Channel Sediments. Boldface/shaded values indicate concentrations that are greater in comparison to the open-lake reference and/or placement area sediments (from EEI 2005).

	Harbor Sediments								Open-Lake Placement Area Sediments		Open-Lake Reference Area Sediments			
	Sampling Sites								Sampling Sites		Sampling Sites			
Pesticide (µg/kg)	**AH-3**	**AH-4**	**AH-5**	**AH-6**	**AH-12**	**AH-13**	**AH-14**	**AH-15**	**AD-1**	**AD-2**	**AL-1**	**AL-2**	**AL-3**	**AL-4**
4,4-DDD	0.728U*	1.38U	0.543U	0.360U	0.648U	0.792U	0.609U	0.607U	0.549U	0.586U	0.829U	0.857U	0.657U	1.21U
4,4-DDE	0.360U	1.38U	0.268U	0.537U	0.320U	0.298U	0.301U	0.300U	0.272U	0.290U	0.410U	0.424U	0.325U	0.597U
4,4-DDT	1.26J**	**2.09**	0.827J	0.376J	0.850J	0.850J	0.799J	0.797J	0.721U	0.769U	1.09U	1.12U	0.862U	1.58U
Aldrin	0.468U	1.38U	0.349U	0.420U	0.417U	0.388U	0.392U	0.390U	0.353U	0.377U	0.533U	0.551U	0.423U	0.777U
Alpha-BHC	0.512U	1.38U	0.381U	0.459U	0.455U	0.424U	0.428U	0.426U	0.386U	0.412U	0.583U	1.1U	0.462U	0.849U
Beta-BHC	0.631	1.38U	**1.72**	**2.22**	0.836U	0.778U	0.785U	0.783U	0.708U	0.756U	1.07U	1.07U	0.848U	1.56U
Delta-BHC	0.631U	1.38U	0.631U	0.566U	0.561U	0.523U	0.527U	0.526U	0.476U	0.507U	0.718U	0.742U	0.569U	1.05U
Dieldrin	0.401U	1.38U	0.299U	0.420U	0.356U	0.332U	0.335U	0.334U	0.302U	0.322U	0.456U	0.472U	0.362U	0.665U
Endosulfan I	0.506U	1.38U	0.377U	0.454U	0.454U	0.419U	0.423U	0.423U	0.382U	0.407U	0.576U	0.596U	0.457U	0.840U
Endosulfan II	0.653U	1.38U	0.486U	0.323U	0.580U	0.540U	0.545U	0.544U	0.492U	0.525U	0.743U	0.768U	0.589U	1.08U
Endosulfan Sulfate	1.90U	1.38U	1.42U	0.352U	1.69U	1.58U	1.59U	1.59U	1.44U	1.53U	2.17U	2.24U	1.72U	3.16U
Endrin	0.420U	1.38U	0.313U	0.454U	0.373U	0.348U	0.351U	0.350U	0.316U	0.338U	0.478U	0.494U	0.379U	0.696U
Endrin Aldehyde	1.62U	1.38U	1.21U	21.9U	1.44U	1.34U	1.36U	1.35U	1.22U	1.31U	1.85U	1.91U	1.47U	2.7U
Endrin Ketone	1.70U	1.38U	1.27U	0.362U	1.52U	1.41U	1.42U	1.42U	1.28U	1.37U	1.94U	2.00U	1.54U	2.82U
Gamma-BHC	0.504U	1.38U	0.375U	0.452U	0.448U	0.417U	0.421U	0.421U	0.380U	0.405U	0.573U	0.592U	0.454U	0.836U
Alpha-Chlordane	0.393U	1.38U	0.293U	0.858U	0.349U	0.325U	0.328U	0.327U	0.296U	0.316U	0.477U	0.462U	0.354U	0.651U
Gamma-Chlordane	0.404U	1.38U	0.301U	2.04U	0.359U	0.334U	0.337U	0.336U	0.304U	0.304U	0.459U	0.475U	0.364U	0.669U
Heptachlor	0.607U	1.38U	0.452U	0.544U	0.544U	0.544U	0.507U	0.507U	0.457U	0.488U	0.691U	0.714U	0.547U	1.01U
Heptachlor Epoxide	0.598U	1.38U	0.446U	0.537U	0.537U	0.537U	0.500U	0.500U	0.451U	0.481U	0.681U	0.704U	0.540U	0.993U
Methoxychlor	2.28U	1.38U	1.70U	0.653U	2.02U	2.02U	1.90U	1.90U	1.72U	1.83U	2.59U	2.68U	2.05U	3.78U
Toxaphene	24.4U	1.38U	18.2U	0.585U	21.7U	21.7U	20.4U	20.3U	18.4U	19.6U	27.7U	28.7U	22.0U	40.4U

*Not detected at or above the specified laboratory reporting limit (LRL).

**Not detected at or above the specified laboratory reporting limit.

TABLE 8. Inorganic Standard Elutriate Test (SET) Results (Dissolved Concentrations) on Ashtabula Harbor Federal Navigation Channel Sediments

(from EEI 2005).

	Harbor Sediments		
	Sampling Sites		
Metal (µg/L)	**AB-1**	**AB-2**	**AB-3**
Aluminum	13.1	34.7	3.63U*
Antimony	0.311	0.291	0.351
Arsenic	4.58	6.75	9.03
Barium	60.4	50.1	55.1
Beryllium	0.241U	0.240U	0.240U
Cadmium	0.421	0.301	0.170U
Calcium	39300	33300	33600
Chromium	2.34	4.35	0.310U
Cobalt	3.47	0.440U	2.58
Copper	0.781	0.640U	1.48
Iron	42.4	43.4	48.8
Lead	1.21U	1.21U	1.21U
Magnesium	8480	7230	7030
Manganese	1390	1230	1130
Mercury	0.017U	0.017U	0.017U
Nickel	6.14	5.01	2.85
Potassium	3310	2230	2130
Selenium	2.14	1.61	0.974U
Silver	0.401U	0.400U	0.400U
Sodium	12500	11500	12200
Thallium	5.08	5.67	2.33
Vanadium	1.17U	1.17U	1.17U
Zinc	3.72	1.52U	1.52U
Misc. (mg/L)			
Oil and grease	0.354	0.361	0.194
Phosphorus	0.03	0.03	0.02U
Ammonia	5.18	3.89	3.49
Total cyanide	0.00314J**	0.00361J	0.00312J

*Not detected at or above the specified reporting limit.
**Estimated value between the detection limit and reporting limit.

TABLE 9. PAH SET Results on Ashtabula Harbor Federal Navigation Sediments (from EEI 2005).

PAH compound (µg/L)	Harbor Sediments Sampling Sites		
	AB-1	AB-2	AB-3
Acenaphthene	0.001U*	0.001U	0.001U
Acenaphthylene	0.001U	0.001U	0.001U
Anthracene	0.002U	0.002U	0.002U
Benzo(a)Anthracene	0.001U	0.001U	0.001U
Benzo(a)Pyrene	0.001U	0.001U	0.001U
Benzo(b)Fluoranthene	0.001U	0.001U	0.001U
Benzo(ghi)Perylene	0.005U	0.005U	0.005U
Benzo(k)Fluoranthene	0.001U	0.001U	0.001U
Chrysene	0.001U	0.001U	0.001U
Dibenz(a,h)Anthracene	0.005U	0.005U	0.005U
Fluoranthene	0.001U	0.001U	0.001U
Fluorene	0.001U	0.001U	0.001U
Indeno(1,2,3-cd)Pyrene	0.005U	0.005U	0.005U
Naphthalene	0.064J**	0.001U	0.001U
Phenanthrene	0.001U	0.001U	0.001U
Pyrene	0.002U	0.002U	0.002U

*Not detected at or above the specified reporting limit.
**Estimated value between the detection limit and reporting limit.

TABLE 10. PCB SET Results on Ashtabula Harbor Federal Navigation Sediments (from EEI 2005).

	Harbor Sediments		
	Sampling Sites		
Aroclor (µg/L)	**AB-1**	**AB-2**	**AB-3**
1016	0.500U	0.500U	0.500U
1221	0.500U	0.500U	0.500U
1232	0.500U	0.500U	0.500U
1242	0.500U	0.500U	0.500U
1248	0.500U	0.500U	0.500U
1254	0.500U	0.500U	0.500U
1260	0.500U	0.500U	0.500U

*Not detected at or above the specified reporting limit.
**Estimated value between the detection limit and reporting limit.

TABLE 11. PCB SET Results on Ashtabula Harbor Federal Navigation Sediments

(sum of detected congeners)

	Harbor Management Unit/Lake Area						
	AMU 1A	AMU 1B	AMU2	AMU 3	AMU 4A	AMU 4B	Background (placement site waters)
Total PCBs (ng/L)	32.20	7.94	15.47	6.72	33.69	3.32	0.23

TABLE 12. Pesticide SET results on Ashtabula Harbor Federal navigation sediments (from EEI 2005).

Pesticide (µg/L)	Harbor Sediments		
	Sampling Sites		
	AB-1	AB-2	AB-3
4,4-DDD	0.0269U*	0.0269U	0.0269U
4,4-DDE	0.0133U	0.0133U	0.0133U
4,4-DDT	0.078	0.0353U	0.111
Aldrin	0.0173U	0.0173U	0.0173U
Alpha-BHC	0.0189U	0.0189U	0.0189U
Alpha-Chlordane	0.0145U	0.0145U	0.0145U
Beta-BHC	0.0347U	0.0347U	0.0347U
Delta-BHC	0.0233U	0.0233U	0.0233U
Dieldrin	0.0148U	0.0148U	0.0148U
Endosulfan I	0.032J**	0.0187U	0.0187U
Endosulfan II	0.0241U	0.0241U	0.0241U
Endosulfan Sulfate	0.0703U	0.0703U	0.0703U
Endrin	0.0155U	0.0155U	0.0155U
Endrin Aldehyde	0.060U	0.060U	0.060U
Endrin Ketone	0.0629U	0.0629U	0.0629U
Gamma-BHC	0.0186U	0.0186U	0.0186U
Gamma-Chlordane	0.0186U	0.0186U	0.0186U
Heptachlor	0.0224U	0.0224U	0.0224U
Heptachlor Epoxide	0.0221U	0.0221U	0.0221U
Methoxychlor	0.0841U	0.16	0.0841U
Toxaphene	0.900U	0.900U	0.900U

*Not detected at or above the specified reporting limit.
**Estimated value between the detection limit and reporting limit.

TABLE 13. Results of 10-day solid phase toxicity tests (bioassays) on Ashtabula Harbor Federal navigation channel sediment management units (from EEI 2005 and 2000). Boldface/shaded values indicate statistically significant (P=0.05) differences relative to 2005 open-lake reference and placement area sediments, respectively.

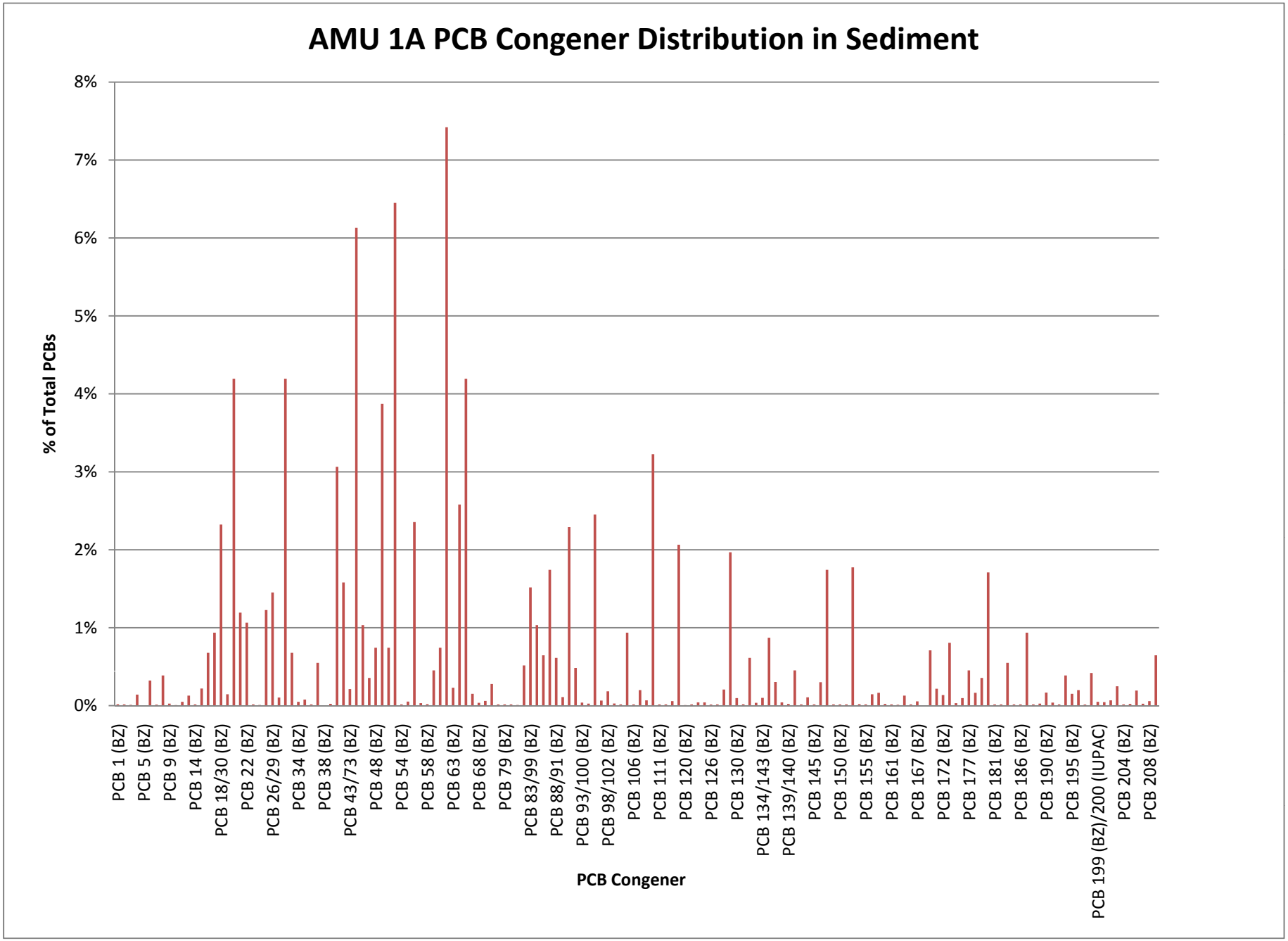
Composite sediment sample	Test species		
	H. azteca	***C. tentans***	
	Mean survival (%)	**Mean survival (%)**	**Mean growth (mg)***
AB-1	86±11.4	84±11.4	1.01±0.19
AB-2	92±13	82±13	1.14±0.19
AB-3	74±21.9	**78±11**	0.87±0.14
AL (2005)	88±13	94±8.9	0.64±0.31
AL (2000)	92±13	74±32	0.87±0.29
AD	68±19.2	80±12.2	0.91±0.21
Control (2005)	94±5.5	98±4.5	0.96±0.15
Control (2000)	98±4	82±13	0.82±0.20

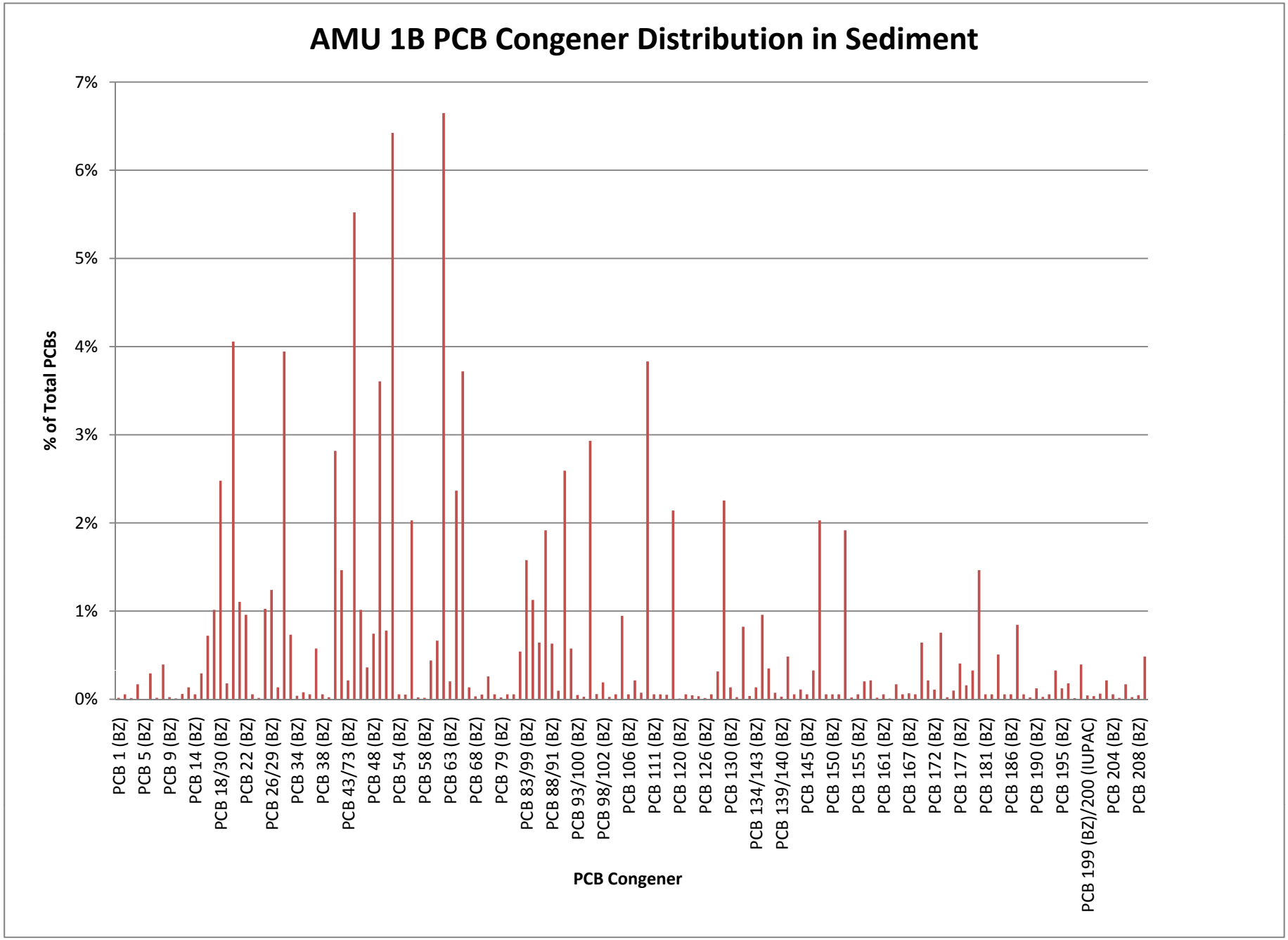
*Ashed weight.

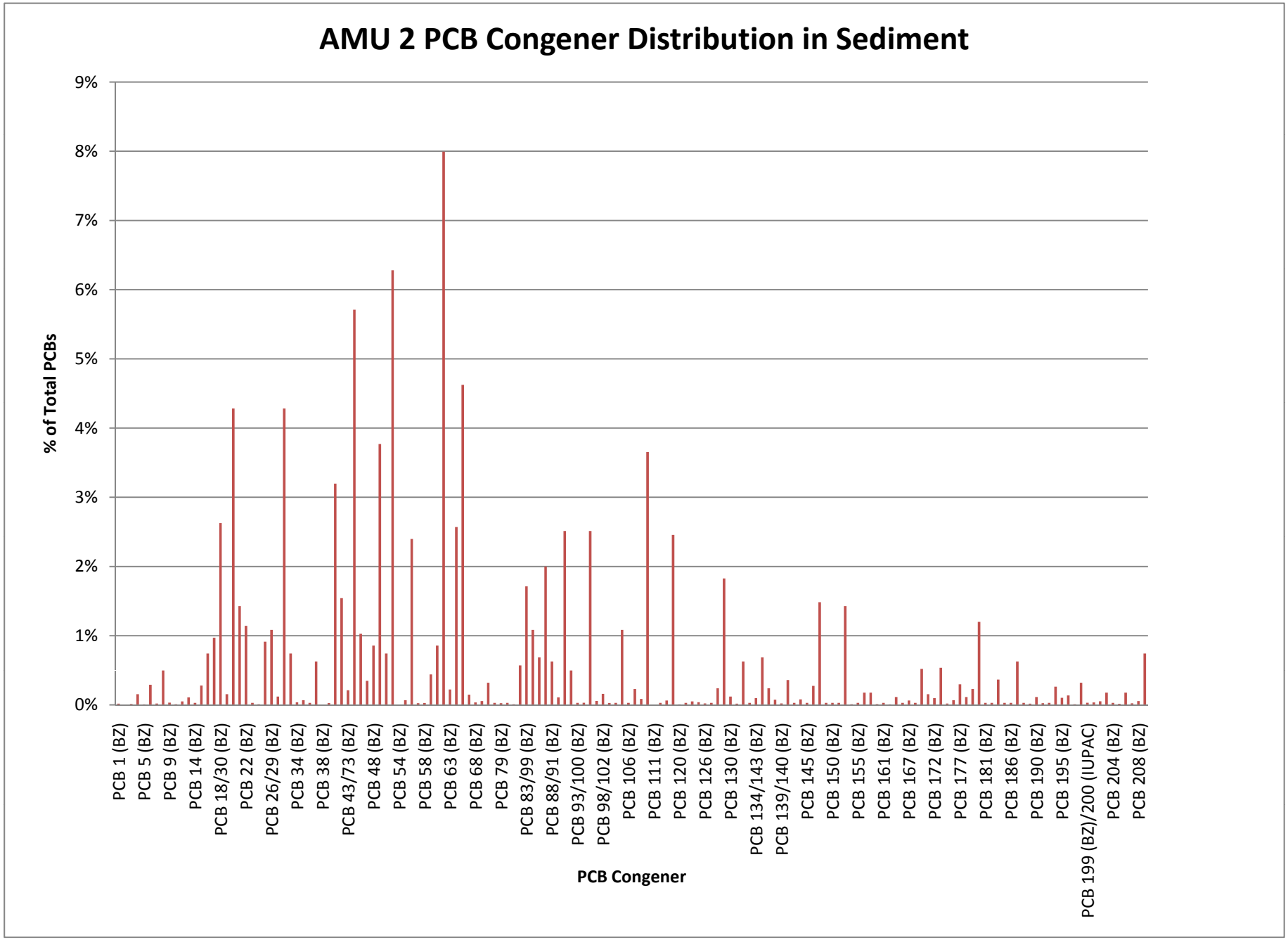
TABLE 14. Bulk sediment radionuclide data on Ashtabula Harbor sediments (from USACE 2008). Boldface/shaded values indicate statistically significant differences between mean 2008 harbor sediment concentrations and 2001 open-lake reference area sediment concentrations (based on both t-test and Wilcoxin rank-sum test).

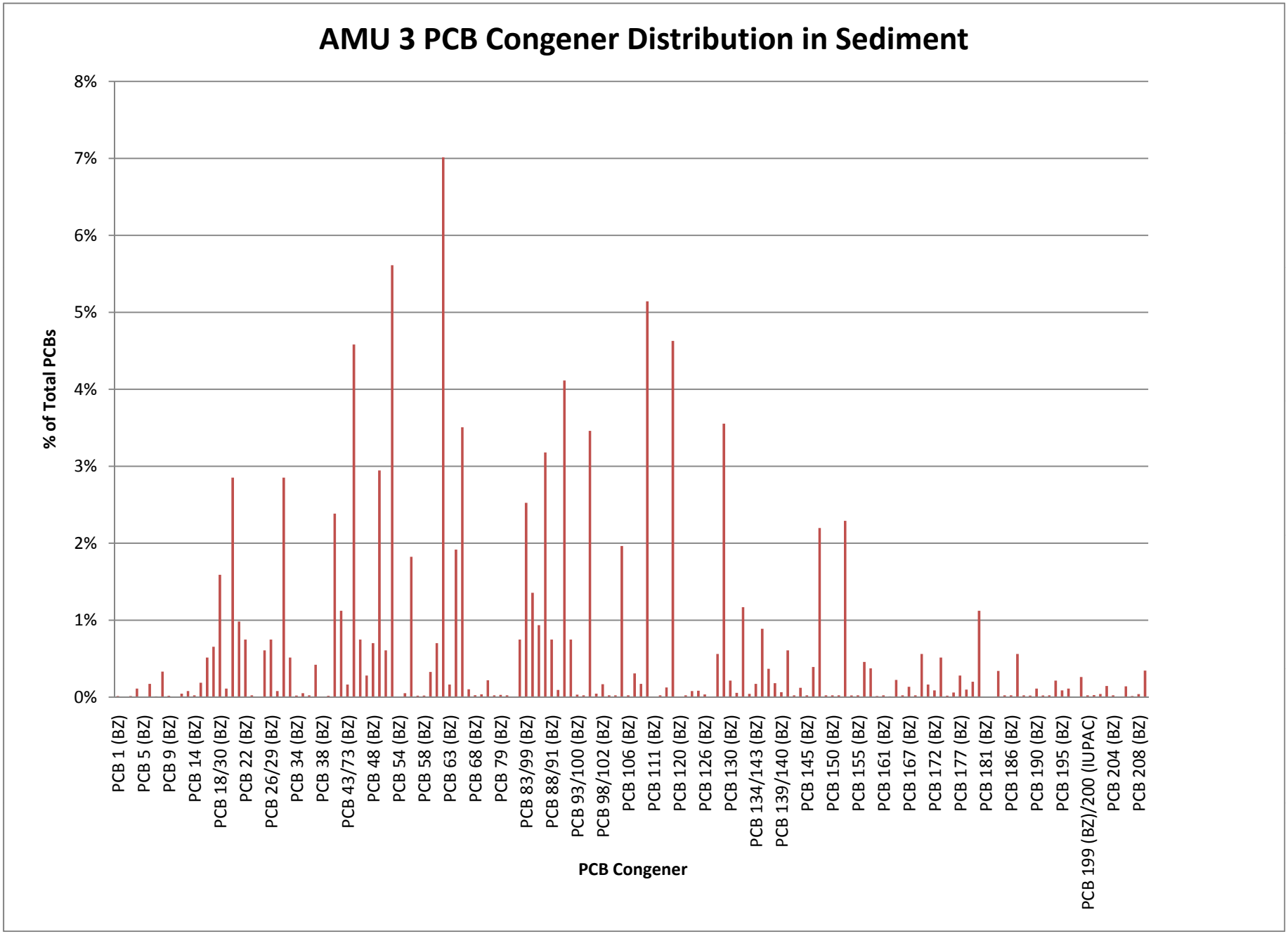
Radionuclide	Mean concentration (±Standard Error) (pCi/g)		Maximum harbor concentration (pCi/g)	Aquatic biota concentration guideline (pCi/g)	Aquatic fraction (pCi/g)
	Harbor (2008) (N=6)	Lake (2001) (N=8)			
Radium-226	0.69485±0.058862	0.5825±0.067896	0.885	101	0.0088
Radium-228	**0.667237±0.059648**	0.37375±0.019994	0.874	87.8	0.01
Thorium-228	**0.762702±0.054658**	0.49375±0.036739	0.967	805	0.0012
Thorium-230	0.760441±0.042175	0.8125±0.05567	0.887	10400	0.000085
Thorium-232	**0.753588±0.041615**	0.44625±0.047582	0.869	1300	0.00067
Uranium-234	0.65809±0.019708	0.6475±0.114233	0.721	5270	0.00014
Uranium-235	0.03036±0.0088	0.0425±0.010308	0.072	3730	0.000019
Uranium-238	**0.674223±0.024994**	0.45±0.036154	0.784	2490	0.00031
				Sum of fractions	0.021224

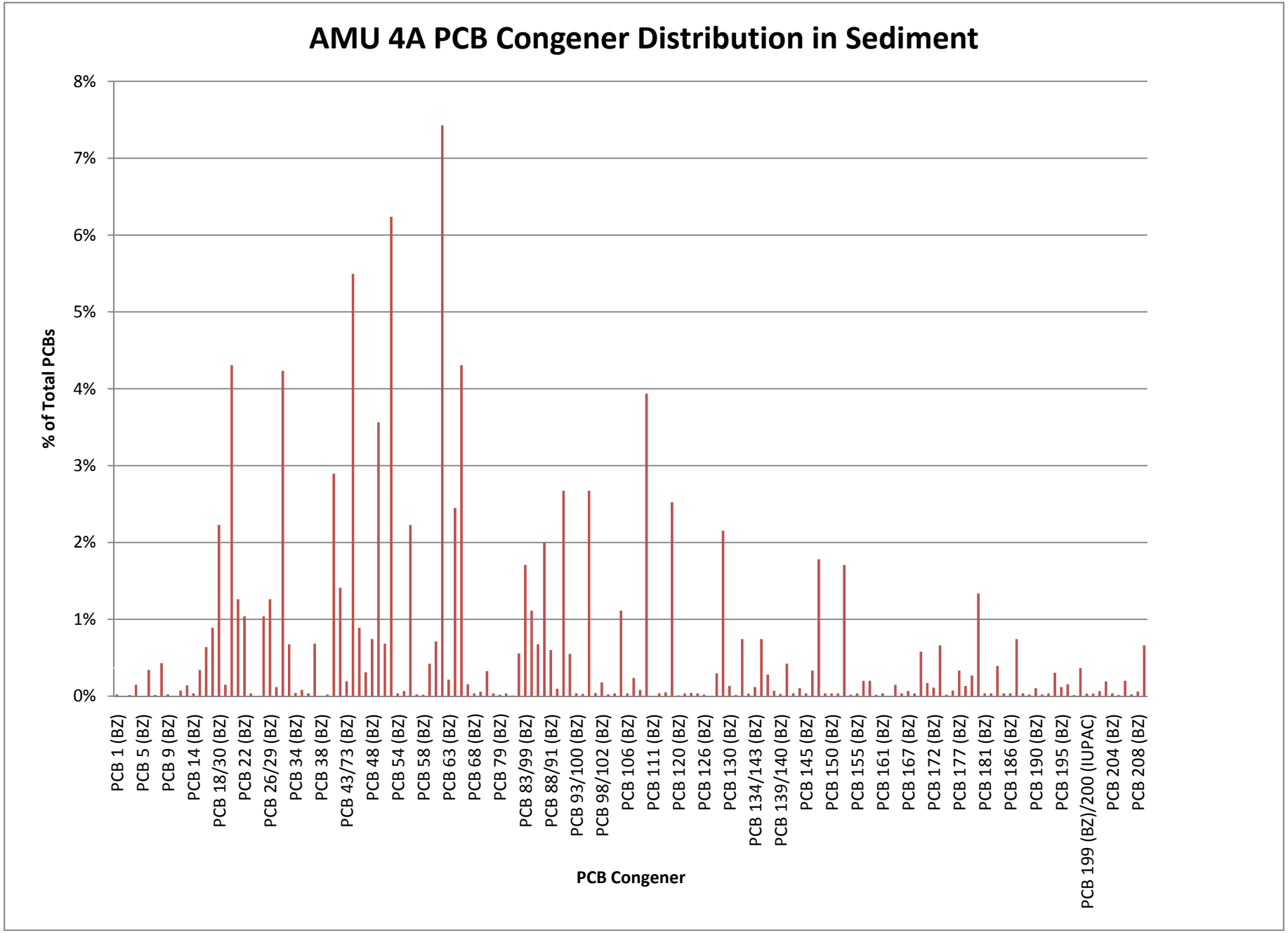
Appendix A: Congener Charts

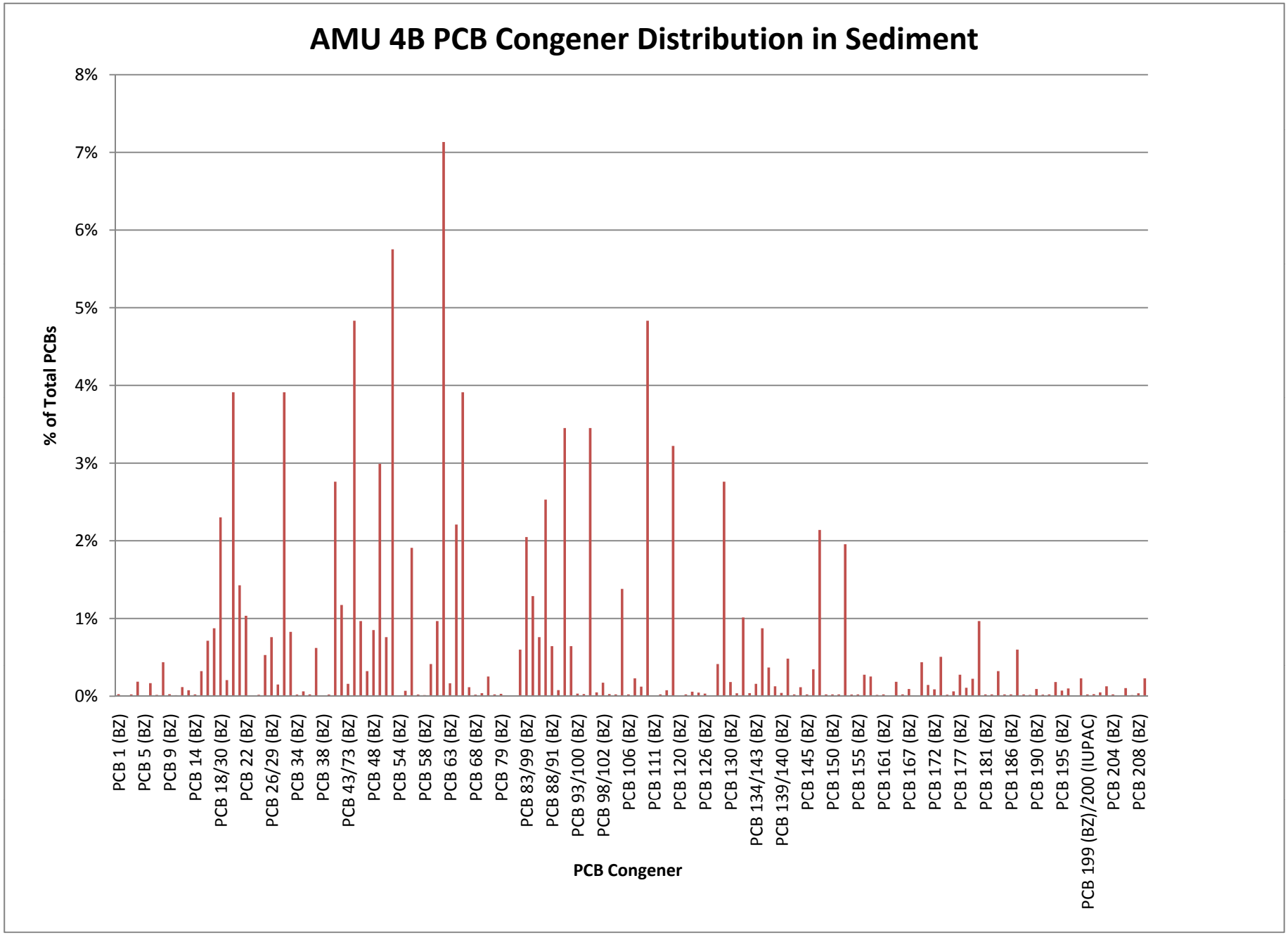

AMU 1A PCB Congener Distribution in Sediment
% of Total PCBs
8%
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

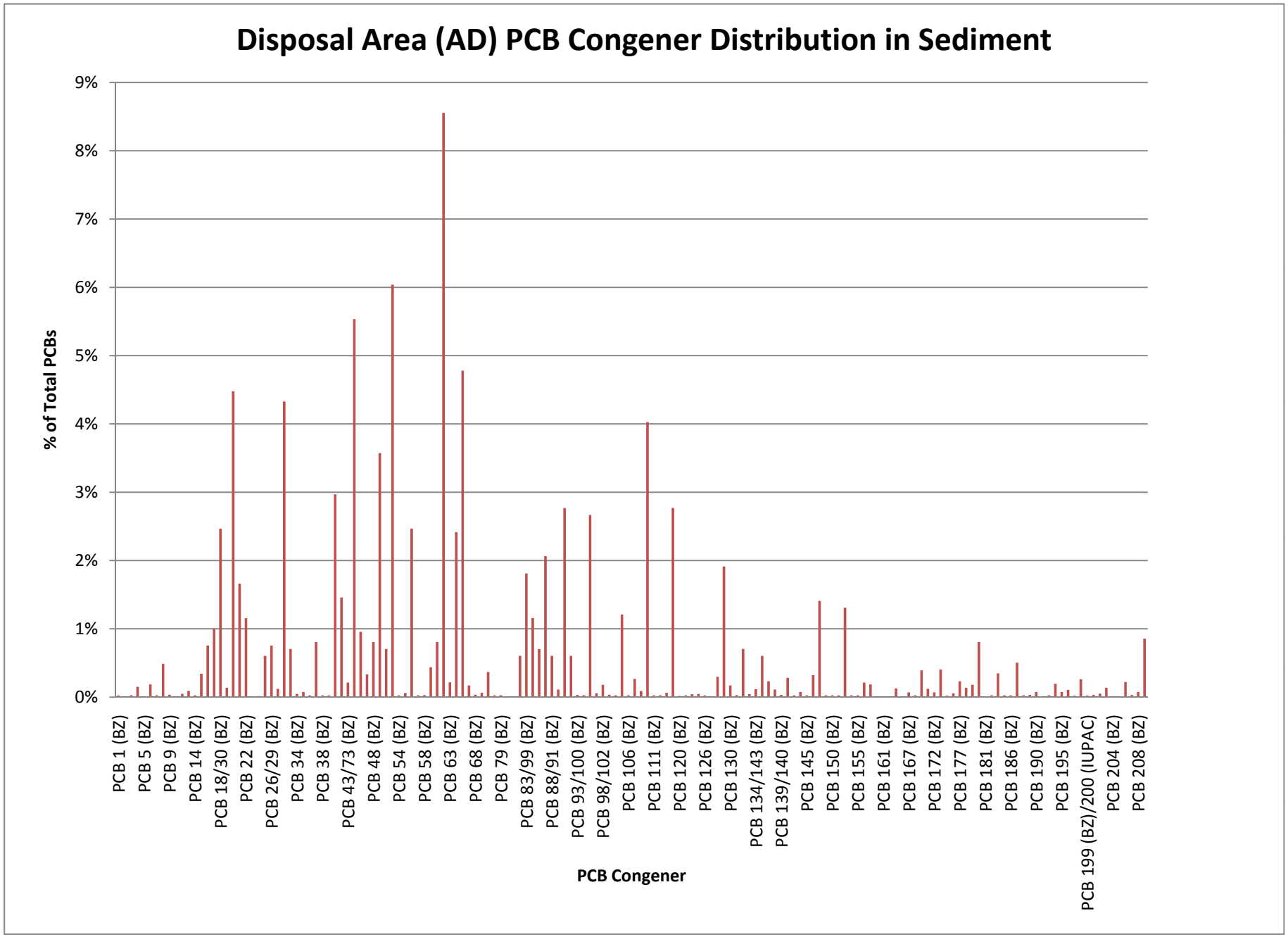

AMU 1B PCB Congener Distribution in Sediment
% of Total PCBs
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

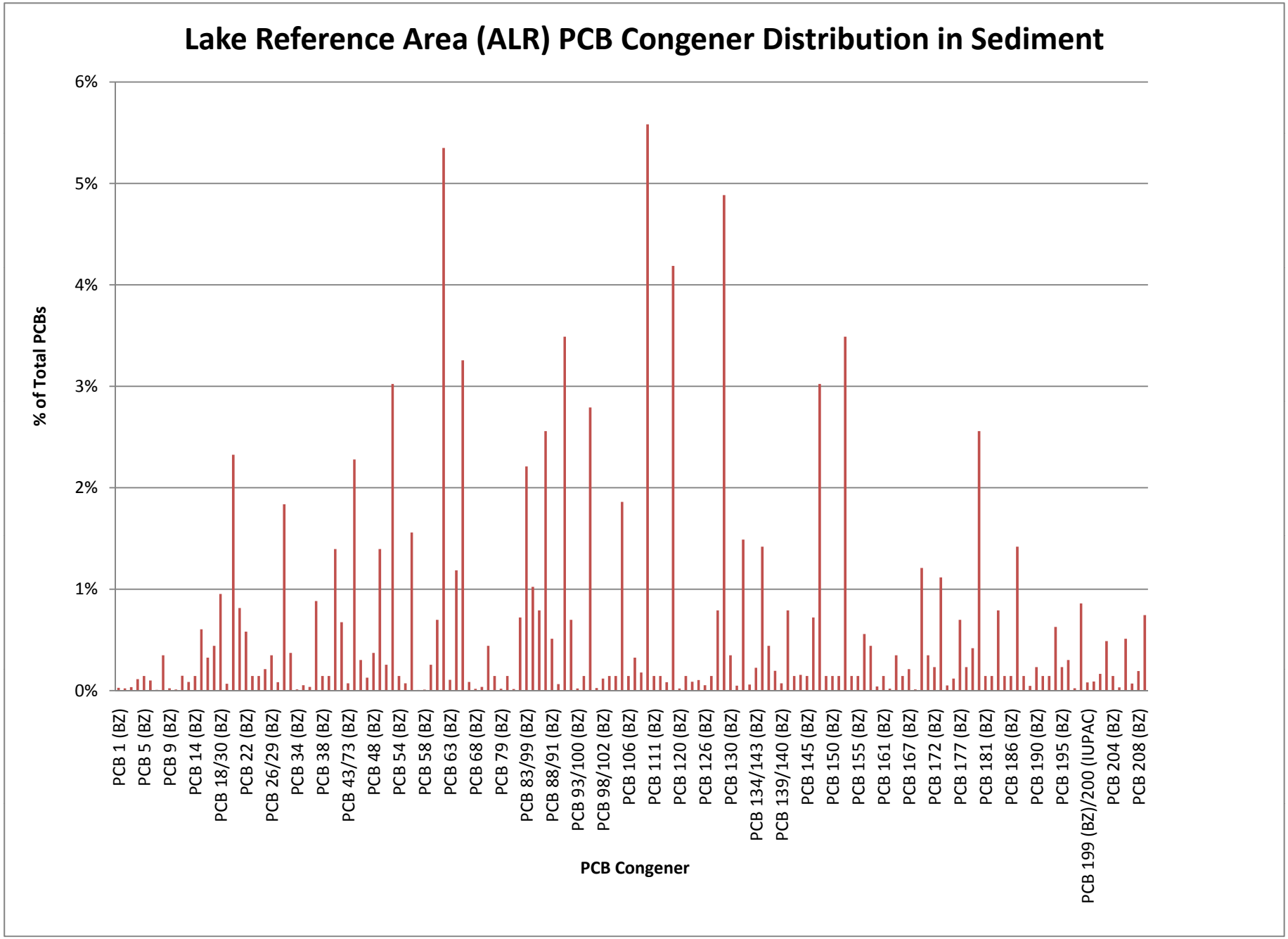

AMU 2 PCB Congener Distribution in Sediment
% of Total PCBs
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

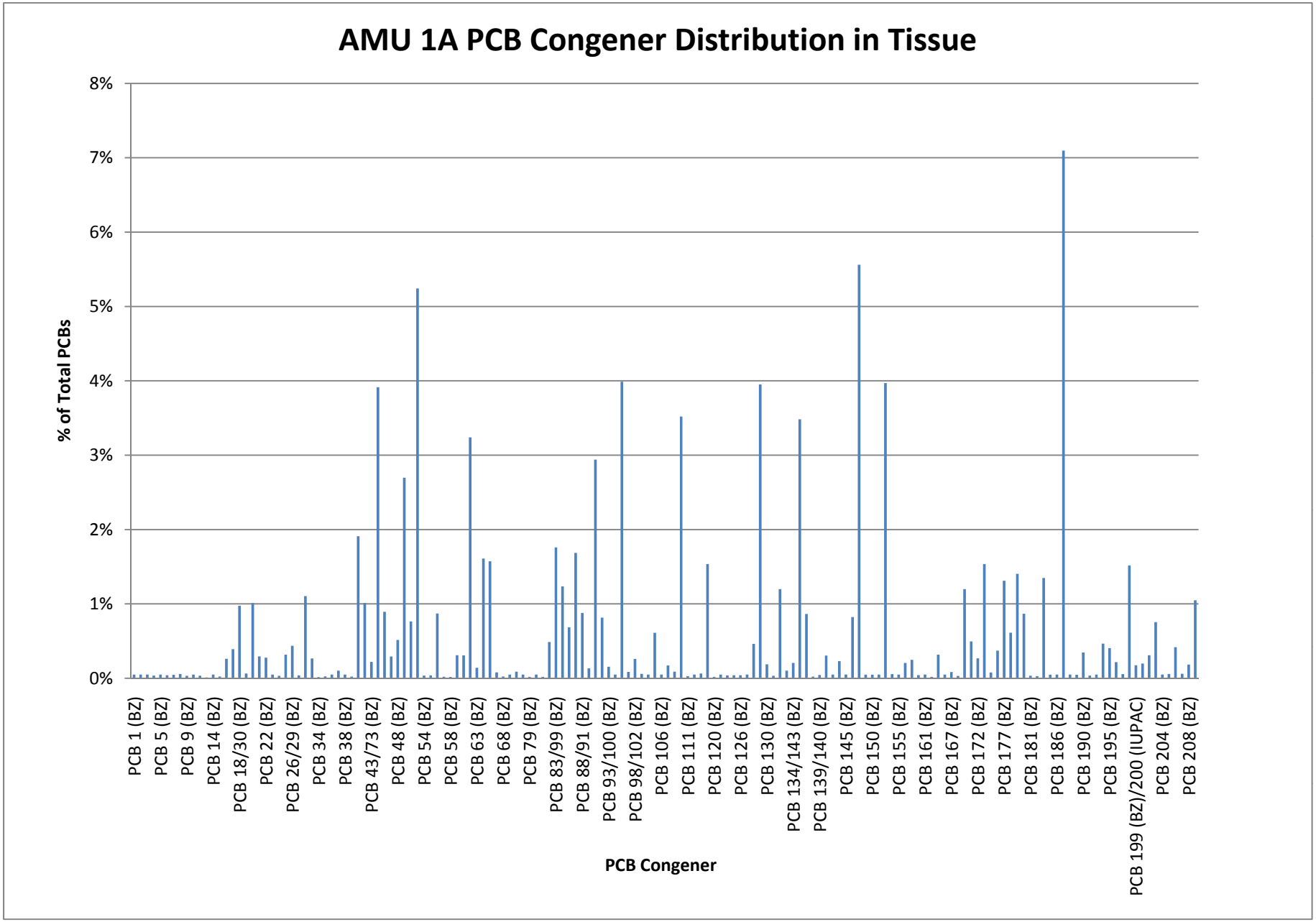

AMU 3 PCB Congener Distribution in Sediment
% of Total PCBs
8%
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

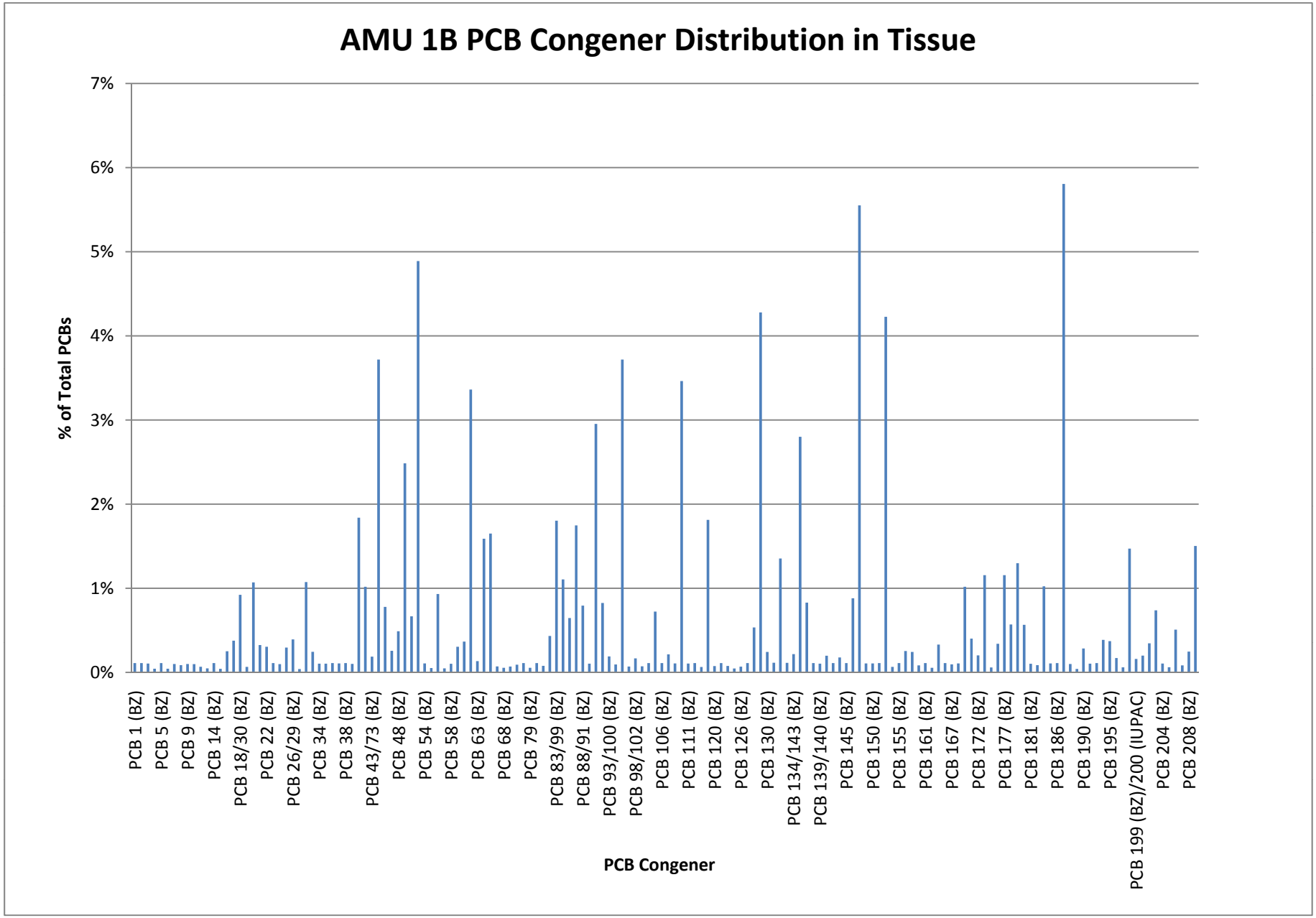

AMU 4A PCB Congener Distribution in Sediment
% of Total PCBs
8%
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

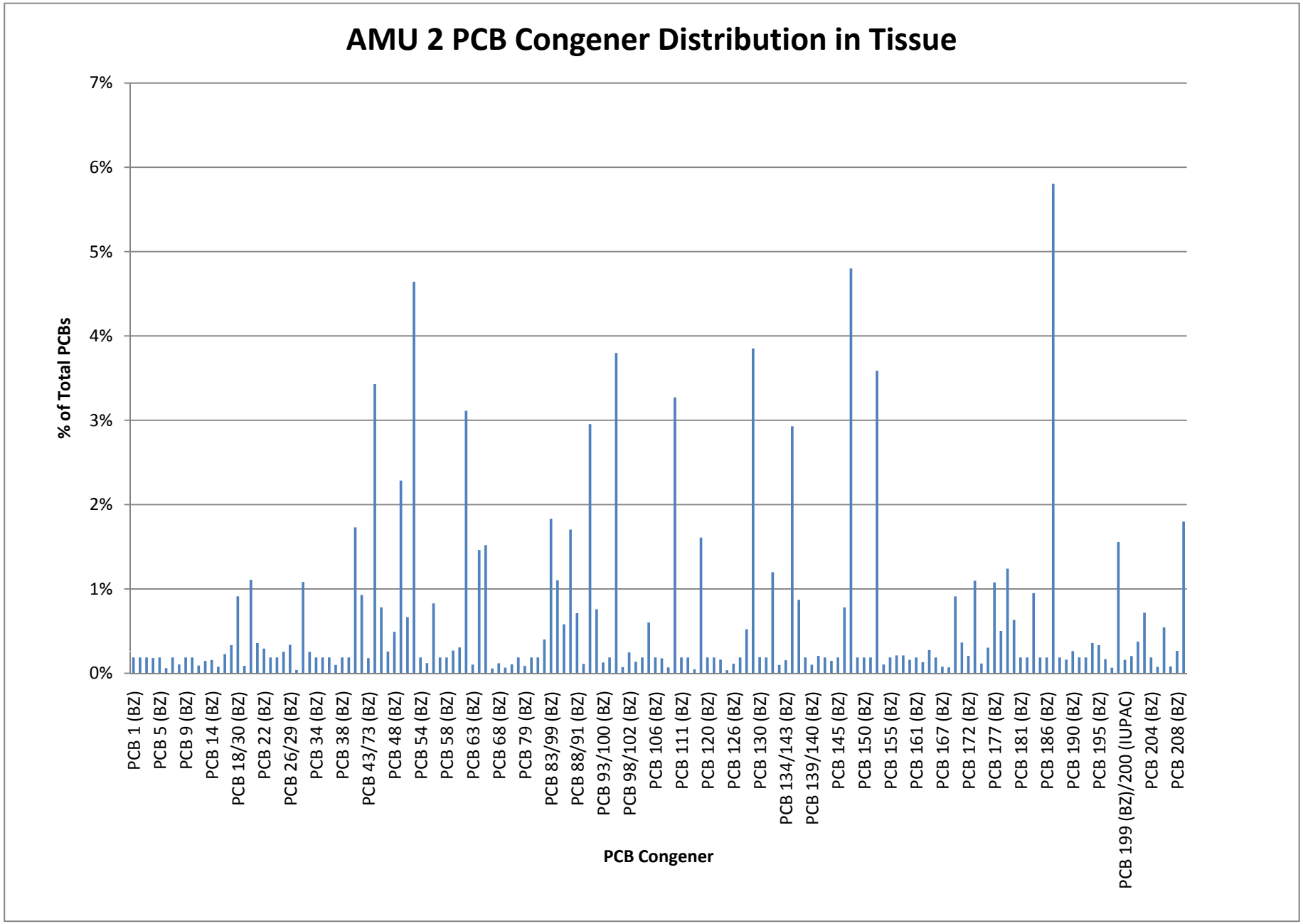

AMU 4B PCB Congener Distribution in Sediment
% of Total PCBs
8%
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

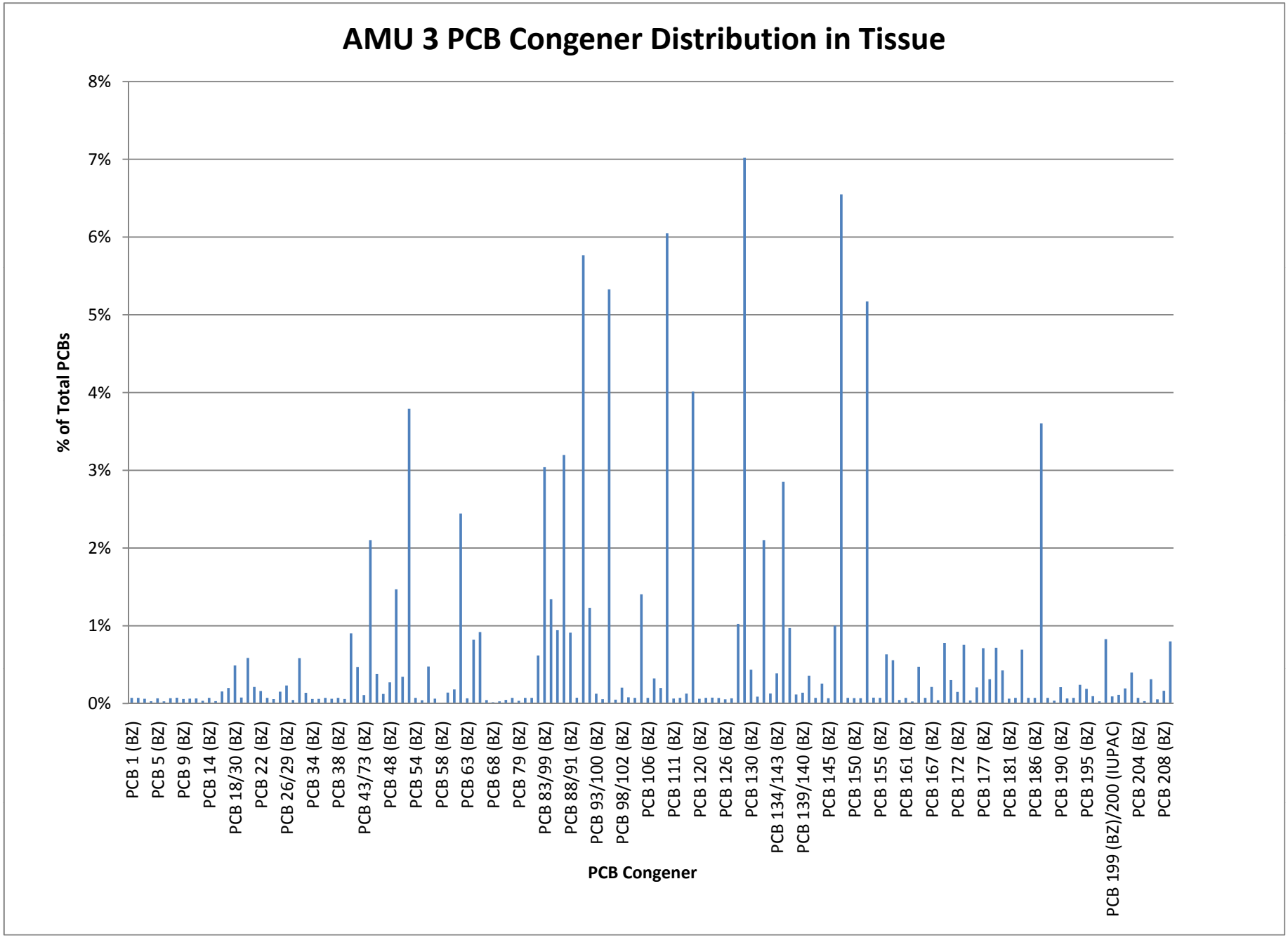

Disposal Area (AD) PCB Congener Distribution in Sediment
% of Total PCBs
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

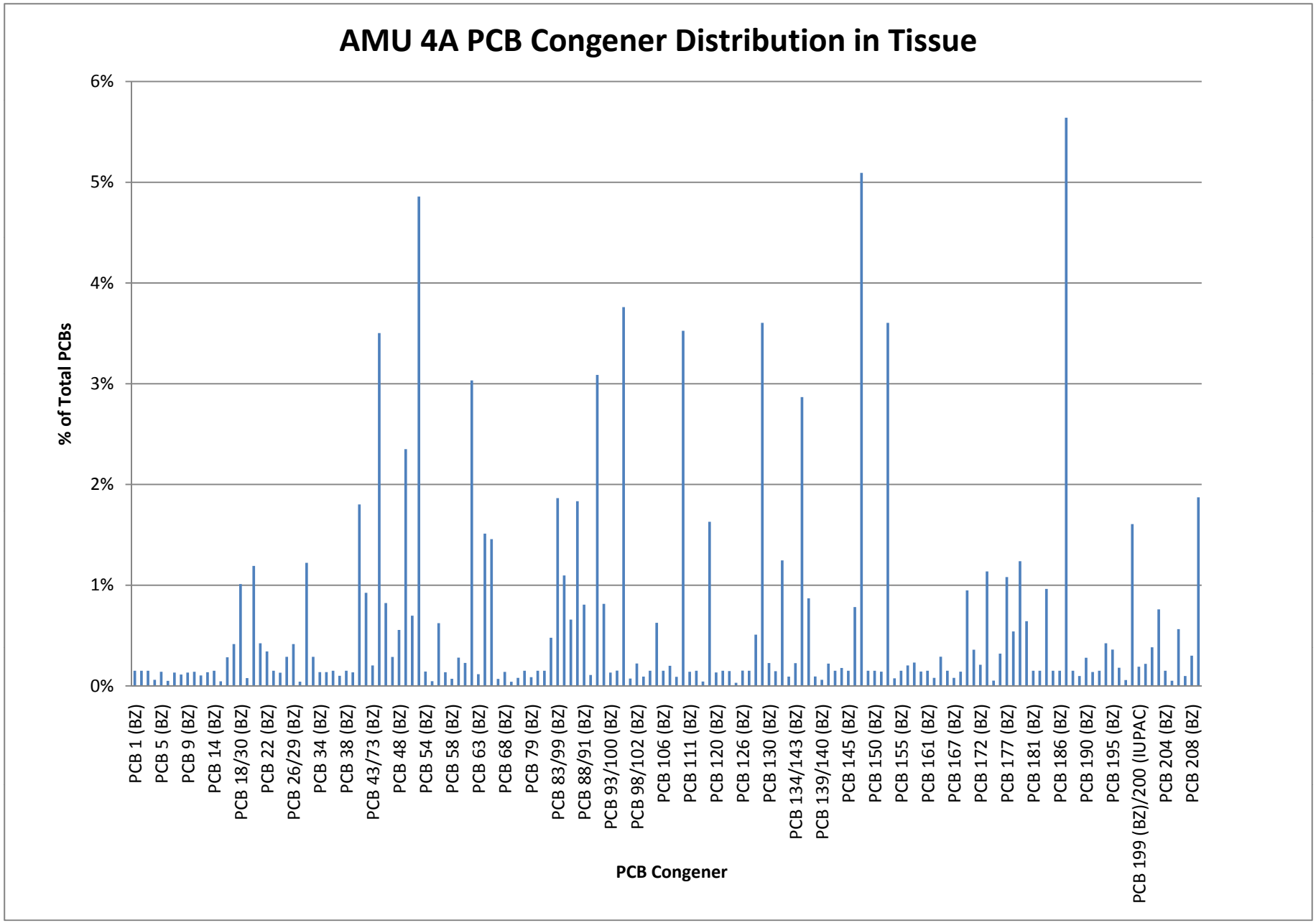

Lake Reference Area (ALR) PCB Congener Distribution in Sediment
% of Total PCBs
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

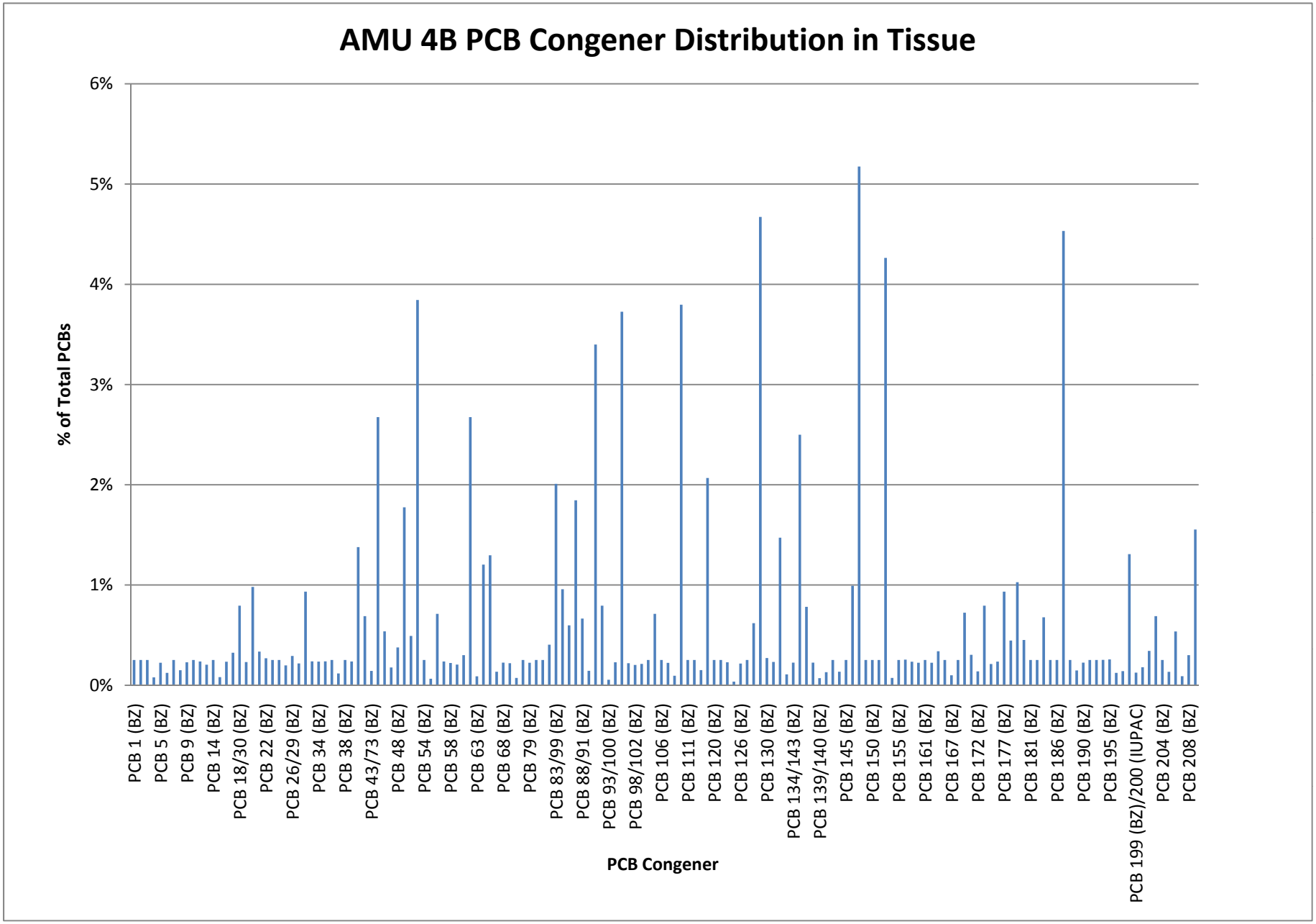

AMU 1A PCB Congener Distribution in Tissue
% of Total PCBs
8%
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

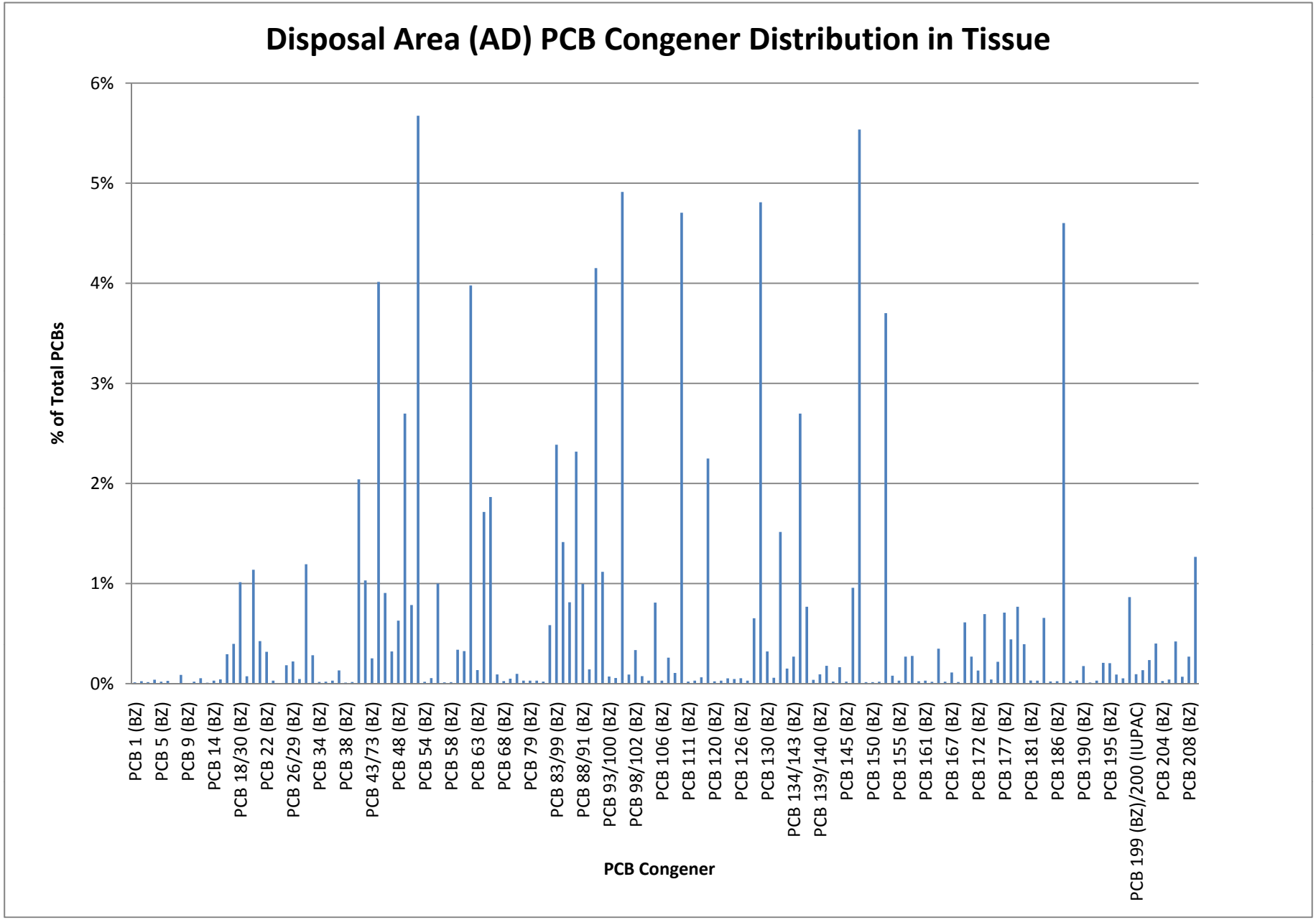

AMU 1B PCB Congener Distribution in Tissue
% of Total PCBs
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

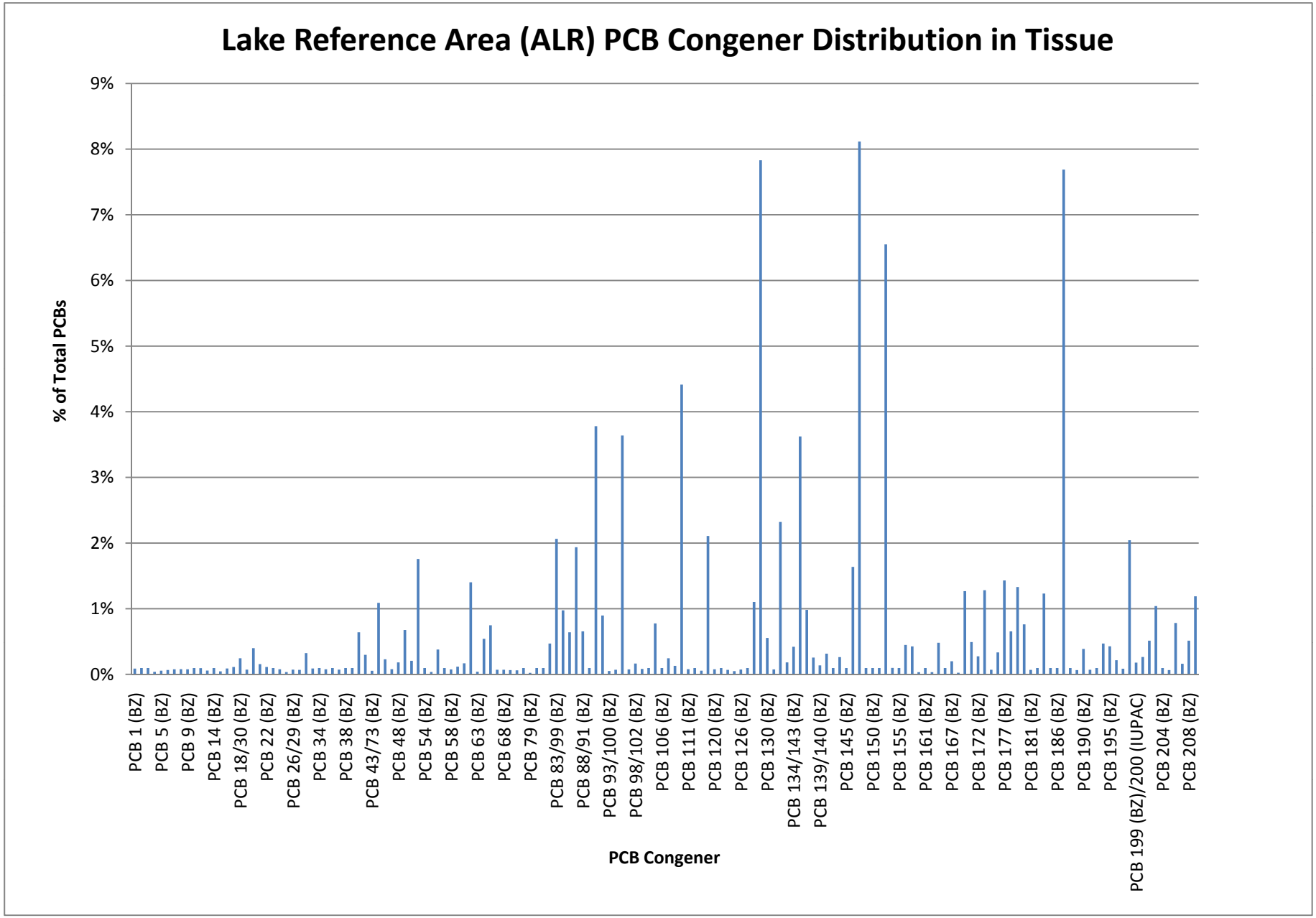

AMU 2 PCB Congener Distribution in Tissue
% of Total PCBs
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

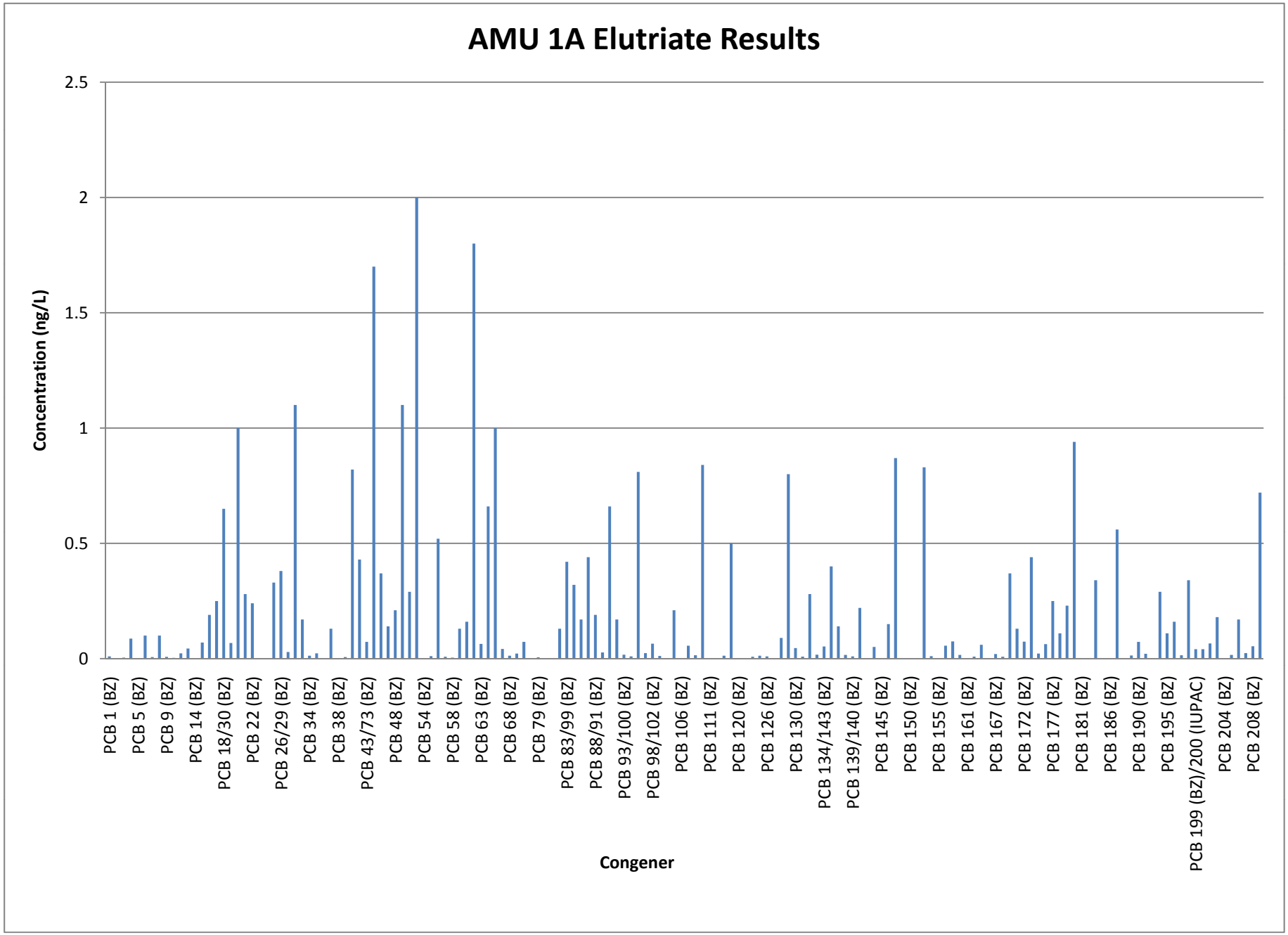

AMU 3 PCB Congener Distribution in Tissue
% of Total PCBs
8%
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

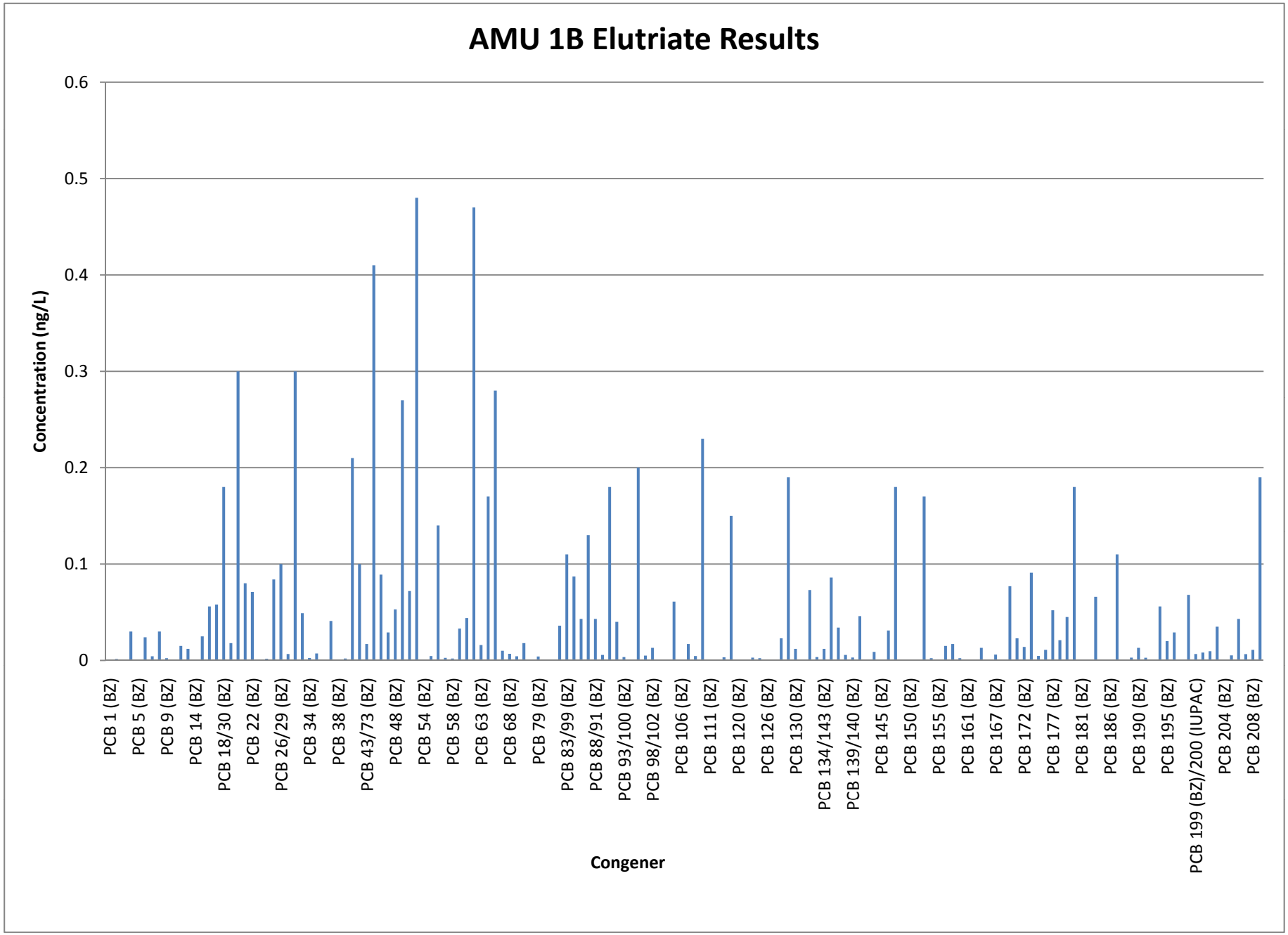

AMU 4A PCB Congener Distribution in Tissue
% of Total PCBs
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

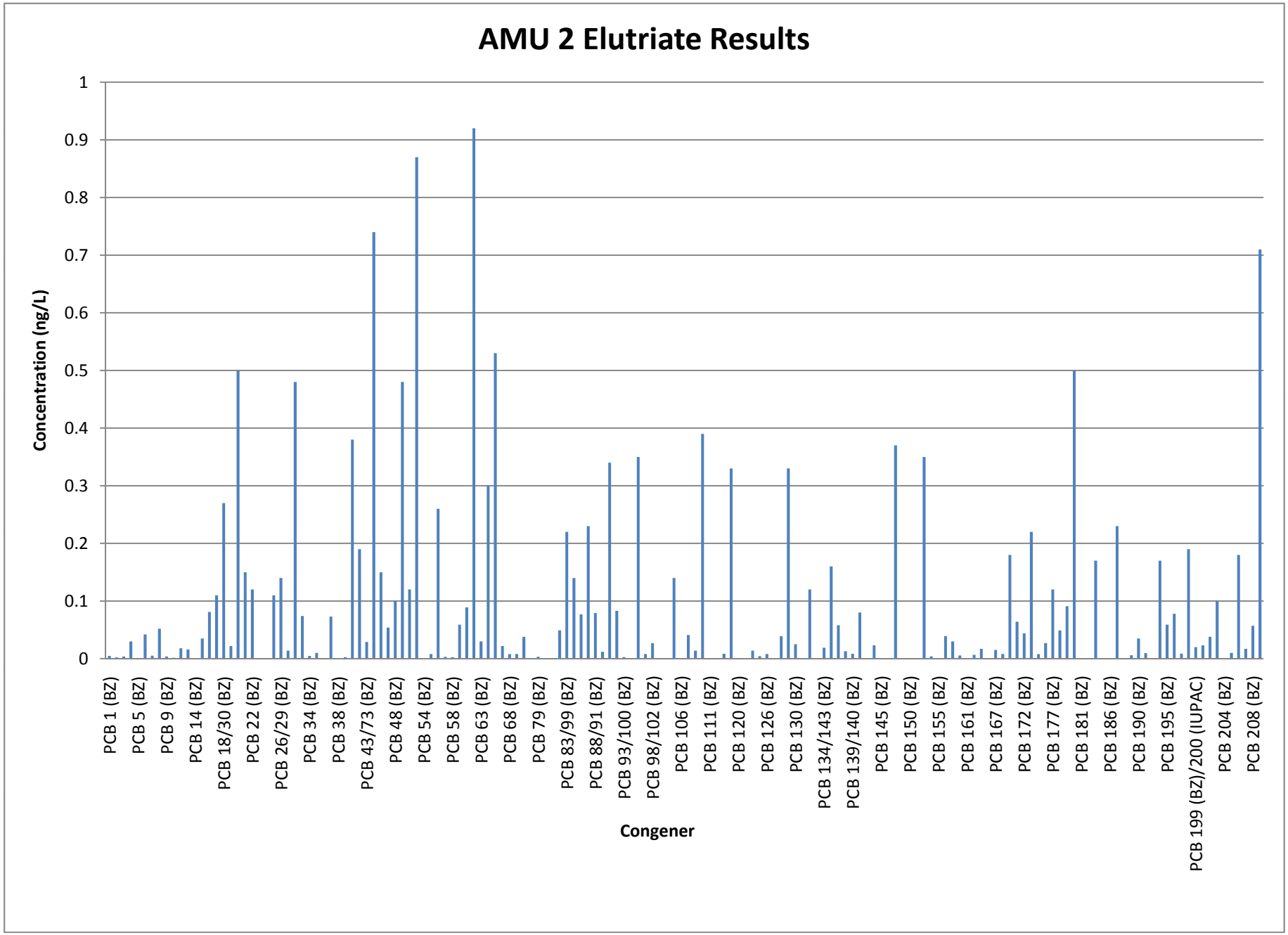

AMU 4B PCB Congener Distribution in Tissue
% of Total PCBs
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

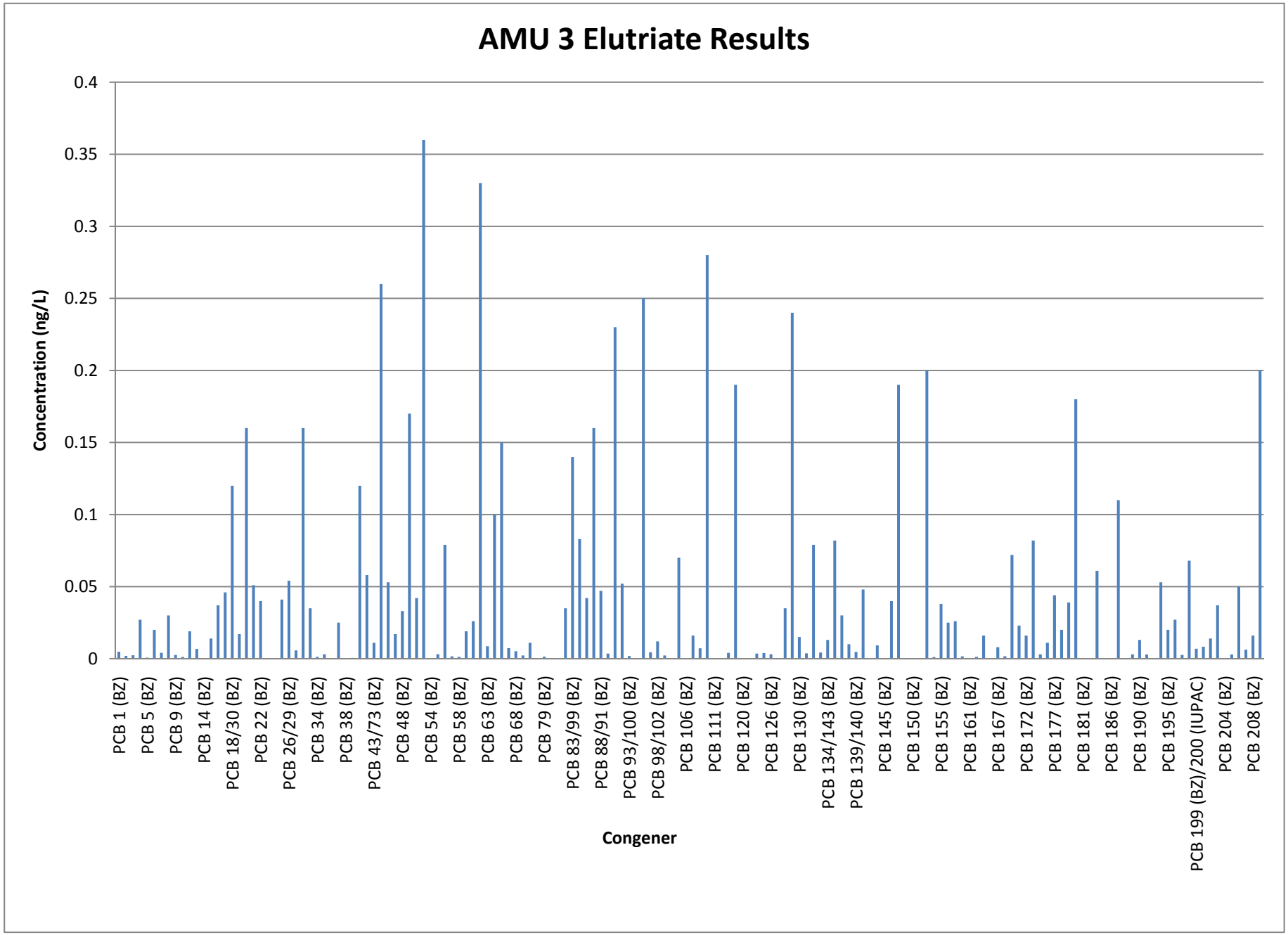

Disposal Area (AD) PCB Congener Distribution in Tissue
% of Total PCBs
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

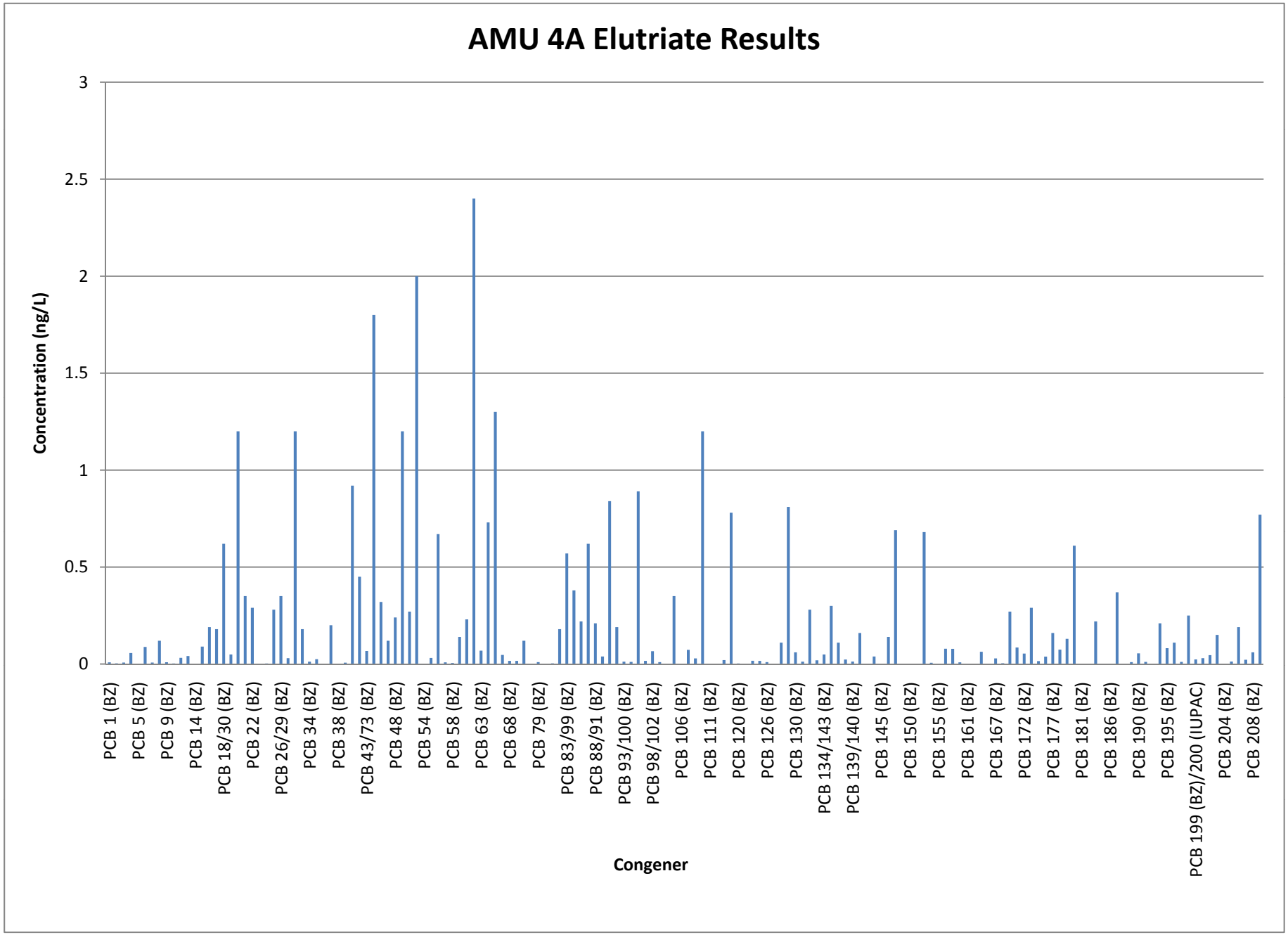

Lake Reference Area (ALR) PCB Congener Distribution in Tissue
% of Total PCBs
9%
8%
7%
6%
5%
4%
3%
2%
1%
0%
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
PCB Congener

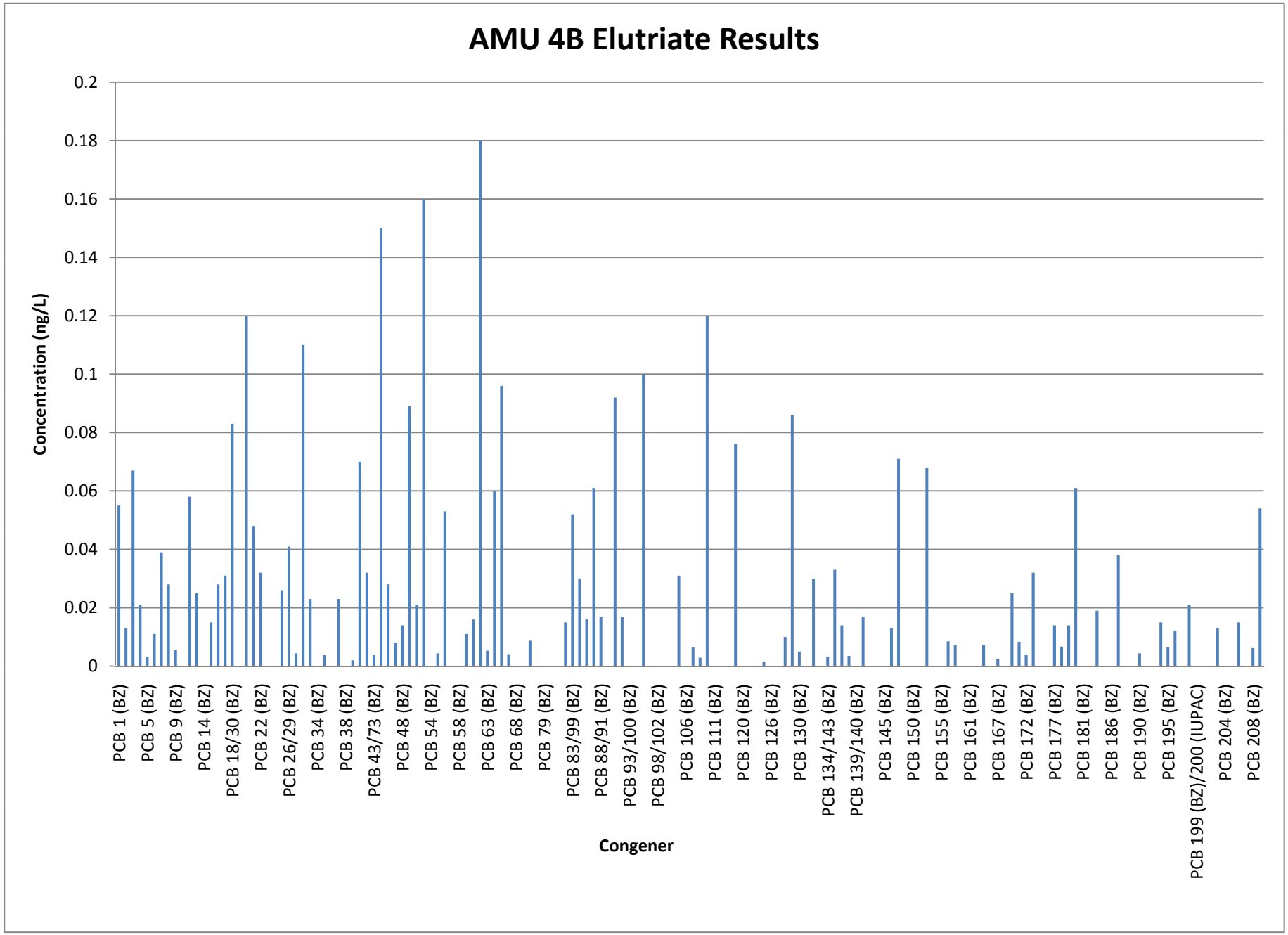

AMU 1A Elutriate Results
Concentration (ng/L)
2.5
2
1.5
1
0.5
0
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC
PCB 204 (BZ)
PCB 208 (BZ)
Congener

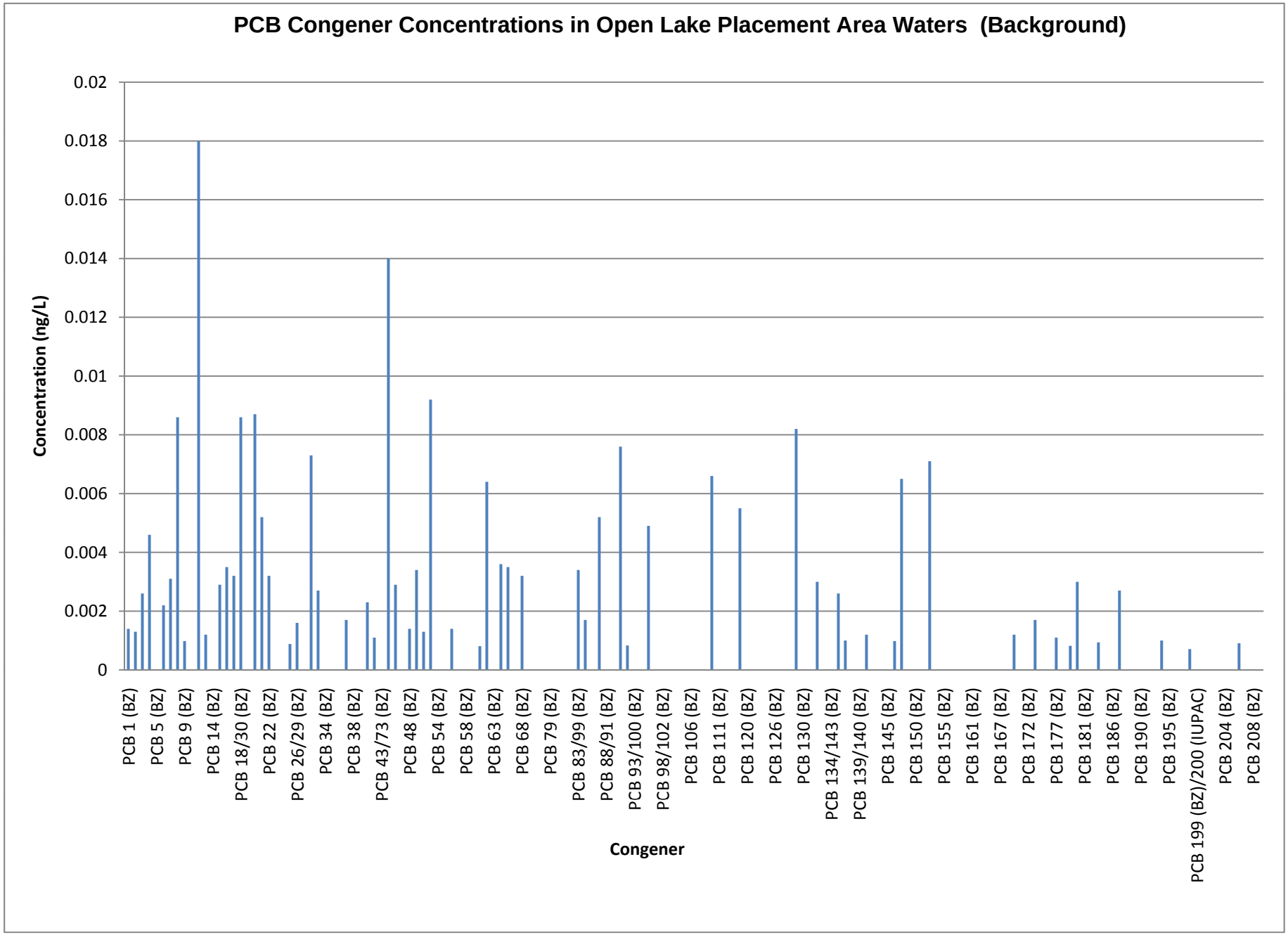

AMU 1B Elutriate Results
Concentration (ng/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
Congener


AMU 2 Elutriate Results
Concentration (ng/L)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
Congener


AMU 3 Elutriate Results
Concentration (ng/L)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC
PCB 204 (BZ)
PCB 208 (BZ)
Congener


AMU 4A Elutriate Results
Concentration (ng/L)
3
2.5
2
1.5
1
0.5
0
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
Congener


AMU 4B Elutriate Results
Concentration (ng/L)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
Congener


PCB Congener Concentrations in Open Lake Placement Area Waters (Background)
Concentration (ng/L)
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
PCB 1 (BZ)
PCB 5 (BZ)
PCB 9 (BZ)
PCB 14 (BZ)
PCB 18/30 (BZ)
PCB 22 (BZ)
PCB 26/29 (BZ)
PCB 34 (BZ)
PCB 38 (BZ)
PCB 43/73 (BZ)
PCB 48 (BZ)
PCB 54 (BZ)
PCB 58 (BZ)
PCB 63 (BZ)
PCB 68 (BZ)
PCB 79 (BZ)
PCB 83/99 (BZ)
PCB 88/91 (BZ)
PCB 93/100 (BZ)
PCB 98/102 (BZ)
PCB 106 (BZ)
PCB 111 (BZ)
PCB 120 (BZ)
PCB 126 (BZ)
PCB 130 (BZ)
PCB 134/143 (BZ)
PCB 139/140 (BZ)
PCB 145 (BZ)
PCB 150 (BZ)
PCB 155 (BZ)
PCB 161 (BZ)
PCB 167 (BZ)
PCB 172 (BZ)
PCB 177 (BZ)
PCB 181 (BZ)
PCB 186 (BZ)
PCB 190 (BZ)
PCB 195 (BZ)
PCB 199 (BZ)/200 (IUPAC)
PCB 204 (BZ)
PCB 208 (BZ)
Congener