Prepared in cooperation with the U.S. Fish and Wildlife Service

Concentration and Spatial Distribution of Selected Constituents in Detroit River Bed Sediment Adjacent to Grassy Island, Michigan, August 2006

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U.S. Department of the Interior
U.S. Geological Survey

Cover. Retrieval of sediment-core sample from bed of Detroit River. (Photograph courtesy of Stephanie Millsap, U.S. Fish and Wildlife Service)

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Conversion Factors and Abbreviations

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
centimeter (cm)	0.3937	inch (in.)
foot (ft)	0.3048	meter (m)
	Area	
acre	4,047	square meter (m^2)
	Volume	
milliliter (mL)	0.0338	fluid ounce (oz)
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
	Mass	
gram (g)	0.03527	ounce (oz)
kilogram (kg)	2.205	pound (lb)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:
°F=(1.8×°C)+32

The symbol µg stands for microgram or 10^{-6} grams.

The symbol kg stands for kilogram or 10^3 grams.

Abbreviations used in this report

CDF - confined disposal facility

ESL - ecological screening level

MDCH - Michigan Department of Community Health

MDEQ - Michigan Department of Environmental Quality

NWQL - National Water-Quality Laboratory

PAH - polycyclic aromatic hydrocarbons

PCB - polychlorinated biphenyls

PEC - probable effect concentration

TEC - threshold effect concentration

USACE - U.S. Army Corps of Engineers

USEPA - U.S. Environmental Protection Agency

USFWS - U.S. Fish and Wildlife Service

USGS - U.S. Geological Survey

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By C.J. Hoard

Abstract

In August 2006, the U.S. Geological Survey, in cooperation with the U.S. Fish and Wildlife Service, collected sediment-core samples from the bed of the Detroit River adjacent to Grassy Island. The goal of the sampling was to assess the distribution and concentration of chemical constituents in sediment adjacent to Grassy Island, which was operated from 1960 to 1982 as a confined disposal facility to hold dredge spoils. On August 31, 2006, seven samples were collected at four locations in the Detroit River on the north, south, east, and west sides of the island. Metals concentrations in the riverbed sediment tended to be higher on the west side of the island, whereas organic-compound concentrations were generally higher on the east side. Comparison of results from this sampling to concentrations reported in previous studies indicates that the concentrations of inorganic constituents, mainly metals, in the riverbed sediment around Grassy Island fell within the range of concentrations found regionally throughout the Detroit River and in most cases have lower mean and median values than found elsewhere regionally in the Detroit River. Comparison of results from the August 31, 2006, sampling to U.S. Environmental Protection Agency risk-based sediment-quality guidelines indicates that 18 organic constituents for which an ecological screening level (ESL), and (or) a threshold effect concentration (TEC), and (or) a probable effect concentration (PEC) has been defined exceeded one or more of these guidelines at least once. Further work would be needed to determine whether constituent concentrations in the river sediment are related to constituent runoff from Grassy Island.

Introduction

Grassy Island is a 72-acre island in the Detroit River near Wyandotte, Mich. (fig. 1). From 1960 to 1982 the island was operated as a confined disposal facility (CDF) by the U.S. Army Corps of Engineers (USACE) to hold dredge spoils, primarily from the River Rouge (Millsap, 2005). These dredge spoils were contaminated with various industrial and municipal pollutants including, but not limited to, heavy metals, iron, oxygen-demanding materials, bacteria, suspended solids, oil, pickling liquor, phenols, chlorides, cyanides, and ammonia (Millsap, 2005). The Grassy Island disposal facility was constructed prior to any legislation regulating the design requirements for a CDF. Consequently, the initial construction did not include protective liners, caps, or rip-rap protection that would act to stabilize the CDF and prevent erosion of the contaminated dredge spoils.

The topography of Grassy Island has changed since it was first used as a dredge-spoil disposal facility. Originally the island was a low-lying marshy area surrounded by shoals. Before operation as a CDF, a 6-ft-high (above water surface) dike wall was constructed around the island. As capacity for dredge spoils of the CDF became limited, a second, 20-ft-high (above water surface) dike was constructed (Millsap, 2005). A weir was built on the northeast end of the island for water to discharge from the island during active disposal operations. Currently (2006), the weir appears to be operational, though the volume of water discharging through it does not appear to be substantial. Although the location of the weir outfall into the Detroit River is unknown, the weir is the most likely area for runoff to leave the island.

The U.S. Fish and Wildlife Service (USFWS) is in the process of identifying the risks to the environment associated with the contaminated material on Grassy Island and developing strategies to mitigate and remediate the risks to the environment. This work includes examining the different pathways by which constituents may leave the island. As part of this process, the U.S. Geological Survey (USGS), in cooperation with the USFWS, sampled the sediment in the Detroit River adjacent to the island in August 2006. Sampling was done to assess the surface-water pathway for the release of constituents as a result of erosion of contaminated island soils and subsequent deposition of that sediment into the Detroit River. This study builds on a large

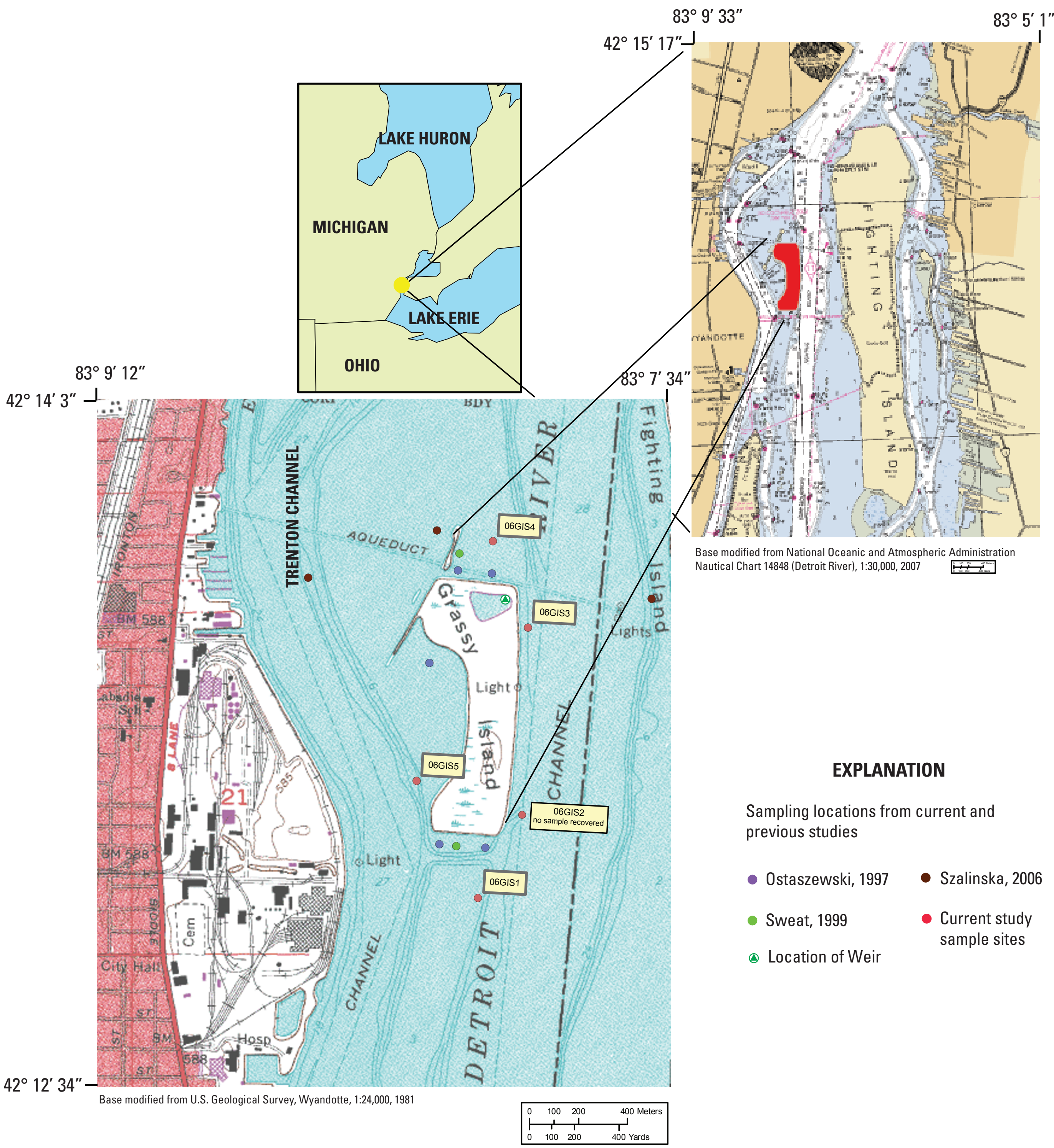

Figure 1. Location of Grassy Island, Michigan, and sediment-sampling points adjacent to the island.

body of work by the USGS Michigan Water Science Center related to the waters connecting Lakes Huron and Erie. This report describes the analytical results from sediment samples collected adjacent to Grassy Island and compares those results to the results from other studies in the Detroit River near Grassy Island. In addition, the results of this sediment survey are compared to risk-based sediment-quality guidelines defined by the U.S. Environmental Protection Agency (USEPA) (Ingersoll and MacDonald, 2002; U.S. Environmental Protection Agency, 2003).

Several previous studies examined the riverbed-sediment chemistry around Grassy Island. Michigan Department of Environmental Quality (MDEQ) collected six sediment samples around Grassy Island as part of a larger study of the Trenton Channel of the Detroit River and the distribution of constituents in the channel (Ostaszewski, 1997). The results of the six samples (fig. 1) indicate that the sediment surrounding Grassy Island was considered affected by contamination, but constituent concentrations greater than USEPA sediment-quality criteria were relatively few with respect to the rest of the samples collected in the Trenton Channel. In general, the highest concentrations of constituents were on the downstream end of the island; however, the highest concentration of polychlorinated biphenyls (PCB) was on the upstream side.

The USGS sampled soil on Grassy Island, along with celery tubers and riverbed sediment, to assess potential exposure of migratory waterfowl to harmful constituents in the sediment (Manny, 1999). As part of this effort, two transects of riverbed-sediment samples were collected. One transect was 300 m upstream from the island, and the other one was 400 m downstream. At each transect, three sites were sampled, the samples were composited together, and the composited sample was analyzed. Exact locations of the transects and samples are unknown. The results of that study show that the number and concentrations of constituents at the upstream sampling sites were greater than at the downstream sampling sites.

Soil and ground water on the island, along with riverbed sediment at two sites adjacent to the island were also sampled by the USGS (Sweat, 1999). One sediment sample was collected upstream from the island and one sample was collected downstream (fig. 1). Very few constituents sampled for were found in either of the samples; however, the upstream sample had higher concentrations of lead and benzo[*a*]pyrene, whereas the downstream sample had a higher concentration of methylene chloride.

A recent study (Szalinska and others, 2006) analyzed 150 riverbed-sediment samples for heavy metals along the Detroit River to help define their distribution. Three separate reaches along the Detroit River were defined and the samples among those reaches compared. Results indicate that the lower reach of the Detroit River, where Grassy Island is situated, generally had the highest concentrations of metals compared to the other reaches of the river. In conjunction with that research, the sediment samples collected were also analyzed for selected polycyclic aromatic hydrocarbons (PAH). The results of the metal and PAH analysis of the three sediment-sample sites near Grassy Island (fig. 1) were provided for comparison with analytical results from the current study (Ewa Szalinska, Politechnika Krakowska, written commun., 2007).

Methods

Flow Model and Sample-Site Determination

Prior to sampling, a two-dimensional hydrodynamic flow model of the Detroit River developed by the USGS (Holtschlag and Koschik, 2004) was used to simulate surface-water flow around Grassy Island. As part of this simulation, hypothetical particles were released in the river upstream from the island and were used to estimate where flow would carry and potentially deposit material released from the island, especially from the overflow weir (D.J. Holtschlag, U.S. Geological Survey, oral commun., 2006). The potential depositional sites downstream from the overflow weir on the island were selected to be sampled for the current study (fig. 1). A sample site was also selected in the shoal area on the west end of the island because of its importance as habitat for fish and wildlife. In addition, a reference sample site was selected upstream from the island.

Sample Collection and Preparation

Sediment-core collection was done in conjunction with U.S. Environmental Protection Agency (USEPA) sediment sampling in close proximity to Grassy Island. The USEPA *Research Vessel Mudpuppy* was outfitted with a vibracoring system to collect riverbed sediment. This system consists of a 4-in.-diameter core barrel loaded into a vibration unit. The unit was lowered to the riverbed and vibrated until the core barrel no longer advanced. The unit was then retrieved and the core barrel removed. If the sediment thickness collected was greater than 30 cm, the core was split into two sections. The upper section consisted of the material from 0–30 cm, and the lower section consisted of the remaining material. The splitting of the core was done to provide samples for a Michigan Department of Community Health (MDCH) human-health consultation and ecological risk assessment. The MDCH was concerned with potential human and wildlife exposure to the surface sediment (Michigan Department of Community Health, 2007).

The sediment retrieved from the riverbed was removed from the core barrel and placed in stainless-steel bowls. This material was homogenized and portioned out using large stainless-steel spoons to four different prelabeled sample bottles. A 500-mL, acid rinsed, polypropylene sample bottle was used for the collection of inorganic constituents. A 1-L glass sample bottle, baked and sterilized at 450°C, was used for the collection of organic constituents. A separate 500-mL polypropylene sample bottle, prewashed once and rinsed 10 times, was used for the collection of the sample for total carbon analysis. Any remaining sediment was placed in a 1-quart glass jar as an archive for potential grain-size determination or other future analyses. All samples collected were then packed in ice, in insulated coolers. Sample bowls were decontaminated by rinsing them with river water. A new core barrel was used each time a sample was collected.

In all, seven samples (fig. 1) were collected from the area adjacent to Grassy Island. Two samples were collected at site 06GIS5, where significant sediment-core material from greater than 30 cm depth was recovered. At this location, the core was split so that the material from 0–30 cm could be analyzed as one sample and the material below 30 cm analyzed as another, separate sample. One sample was collected at 06GIS1 on the south end of the island. Two samples were collected near the suspected weir-overflow discharge at site 06GIS3. One sample was an environmental sample (06GIS3), and the other was a replicate sample (06GIS3 R) for quality-control purposes. Two samples were also collected at site 06GIS4 on the north side of the island; one was an environmental sample (06GIS4) and the other was a replicate (06GIS4 R). At one proposed sampling site (06GIS2) on the southeast side of the island, no sample was retrieved; several attempts were made, but the vibracoring unit was unable to collect a sample, perhaps because of the depth and steepness of the channel or the high flow velocity through that area.

Data Analysis

All samples were shipped to the USGS National Water-Quality Laboratory (NWQL) for analysis. The analytes are listed in tables 1 and 3. Lab methods for the analysis of the collected sediment samples are documented in the following references: Garbarino and others (2006), Noriega and others (2004), Olson and others (2004), and Zaugg and others (2006). Quality-assurance protocols used by the lab are documented in Pirkey and Glodt (1998), Pritt and Raese (1992), and Maloney (2005). Additional quality-assurance procedures were done in the field by collecting replicate samples at locations 06GIS3 and 06GIS4. These replicate samples were used to assess the variability in constituent concentrations as result of sample collection, processing, and analysis. In general, the replicate samples had higher constituent values than the environmental samples, however, this did not affect our interpretation of the data because the values were similar in magnitude.

Constituent concentrations were evaluated against sediment-quality guidelines as defined by the USEPA (Ingersoll and MacDonald, 2002; U.S. Environmental Protection Agency, 2003). The three guidelines used for the comparison were the threshold effect concentration (TEC), probable effect concentration (PEC), and the ecological screening level (ESL). The TEC is defined as the concentration of a chemical in sediment below which adverse biological effects are unlikely to occur (Ingersoll and MacDonald, 2002). The PEC is the concentration of a chemical in sediment above which adverse biological effects are likely to occur. The ESL is a protective benchmark based on sediment-quality guidelines or non-adverse effect concentrations and, is often the same value as the TEC. The ESL is generally used during initial site investigations; if certain constituents of concern are above the ESL concentration, then those constituents may become the focus of future action at the site.

Concentrations of Selected Inorganic Constituents

In all, 19 inorganic constituents were sampled for in the sediment around Grassy Island (table 1). Of these constituents, 18 are metals and 1, selenium, is considered a nonmetal. Only 10 of the 19 constituents sampled for had established ESLs; of those 10, only 8 had defined TECs and PECs (table 1). None of the constituents sampled for were found at concentrations above the PEC, but concentrations of mercury, cadmium, copper, lead, and zinc were above the TEC and ESL at site 06GIS5 (0–30 cm). Concentrations of mercury also were above the TEC and ESL at site 06GIS3. No TEC or PEC has been developed for silver, but silver was above the ESL concentration at sites 06GIS5 0–30 cm, 06GIS5 greater than 30 cm, and 06GIS3. The highest metal concentrations in the sediment around Grassy Island were typically found at site 06GIS5 0–30 cm. All inorganic analytes sampled for with concentrations greater than the TEC, PEC, or ESL are listed in table 3.

Only the six riverbed-sediment samples collected adjacent to Grassy Island in the MDEQ study (Ostaszewski, 1997) were used in the comparison of results to the current study. Those riverbed-sediment samples had a similar range of metals concentrations as the riverbed-sediment samples collected for the current study, although average metals concentrations were slightly lower in the current study. Although the ranges of concentrations were similar between the two studies, the distribution of the constituents was different. In MDEQ's study (Ostaszewski, 1997), the highest concentrations of metals were on the downstream side of the island, whereas the results of the current study show the high metals concentrations were in the shoal area on the west side of the island.

Table 1. Concentrations of inorganic constituents in riverbed-sediment samples collected around Grassy Island, Michigan.

[All concentrations reported as dry weight; cm, centimeter; g, gram; µg/g, microgram per gram; R, replicate; >, greater than; ESL, Ecological Screening Level; PEC, Probable Effect Concentration; TEC, Threshold Effect Concentration; <, less than detection limit; *italics* indicate concentrations greater than ESL or TEC; guideline values are in **bold**; all samples collected 8/31/2006]

Constituent	Site name							Effect concentration or screening level		
	06GIS1	06GIS5 0-30 cm	06GIS5 >30 cm	06GIS3	06GIS3 R	06GIS4	06GIS4 R	TEC[1]	PEC[1]	ESL[2]
Moisture content (percent)	31	39	33	27	26	21	21	-	-	-
Sample weight (g)	20.7	19.5	19.9	22.3	22.5	23.6	23.5	-	-	-
Aluminum (µg/g)	6,600	15,000	11,000	7,100	5,800	6,800	5,300	-	-	-
Antimony (µg/g)	< .6	< .6	< .6	< .6	< .6	< .6	< .6	-	-	-
Arsenic (µg/g)	2.2	5.3	2.9	4.7	4.7	3.5	3.4	**9.79**	**33.00**	**9.79**
Barium (µg/g)	28.3	68.4	41.6	31.7	30.7	30.7	27.2	-	-	-
Cadmium (µg/g)	.31	*2.0*	.21	.53	.66	.52	.61	**.99**	**4.98**	**.99**
Chromium (µg/g)	15.4	35.6	17.7	19.2	16.9	18.7	18.4	**43.40**	**111.00**	**43.40**
Cobalt (µg/g)	5.0	7.2	6.8	4.9	4.1	4.6	4.3	-	-	**50.00**
Copper (µg/g)	12.8	*39.5*	10.8	16.6	13.5	21.5	20.1	**31.60**	**149.00**	**31.60**
Iron (µg/g)	11,000	18,000	15,000	13,000	11,000	13,000	12,000	-	-	-
Lead (µg/g)	10	*42*	8.30	21	25	30	23	**35.80**	**128.00**	**35.80**
Manganese (µg/g)	180	290	250	200	180	190	170	-	-	-
Mercury (µg/g)	.03	*.23*	.02	*.26*	.09	.14	.10	**.18**	**1.06**	**.17**
Molybdenum (µg/g)	.34	.82	.37	.97	1.40	.68	.78	-	-	-
Nickel (µg/g)	12	22	16	13	13	13	13	**22.70**	**48.60**	**22.70**
Selenium (µg/g)	.50	.60	.30	.40	.40	.40	.30	-	-	-
Silver (µg/g)	< .6	*.82*	*.67*	*.81*	< .6	< .6	< .6	-	-	**.50**
Thallium (µg/g)	< .6	< .6	< .6	< .6	< .6	< .6	< .6	-	-	-
Tin (µg/g)	< .6	.61	< .6	.98	< .6	< .6	< .6	-	-	-
Zinc (µg/g)	47	*130*	48	67	76	81	77	**121.00**	**459.00**	**121.00**

[1] Ingersoll and MacDonald, 2002.

[2] U.S. Environmental Protection Agency, 2003.

The mean concentrations of metals in the sediment collected around Grassy Island in the current study were generally lower than the mean concentrations of metals in the lower reach of the Detroit River, with the exception of lead. The mean concentration of lead in sediment collected around Grassy Island in 2006 was 22.87 µg/g, whereas the mean concentration in the lower reach of the Detroit River was 22.81 µg/g (Szalinska and others, 2006). The three sample sites near Grassy Island for which data were provided (Ewa Szalinska, Politechnika Krakowska, written commun., 2007) have a similar range in concentrations as determined in this study. The current study's data are also consistent with the data collected previously by the USGS (Manny, 1999; Sweat, 1999).

Concentrations of Selected Organic Constituents

The sediments collected around Grassy Island in 2006 by the USGS were analyzed for 31 organic constituents (table 2). Of those 31 constituents, 19 had defined ESLs and 10 of those had defined TECs and PECs. A list, by site, of all organic analytes sampled for with concentrations greater than the TEC, PEC, or ESL is provided in table 3. For the 10 constituents with a defined PEC, at least one sampling site had a concentration that was greater than the PEC. The highest organic constituent concentrations were at 06GIS3, on the east side of the island. Generally the concentrations of the organic constituents were higher on the upstream side of the island than on the downstream side. The shoal area on the west side of the island had similar organic constituent concentrations to the upstream sampling site for the shallow sediment. The deeper sediment collected in the shoal area had the lowest concentrations of organic constituents, which in many cases were below detection limits. The three sample sites near Grassy Island for which data were provided (Ewa Szalinska, Politechnika Krakowska, written commun., 2007) have a similar range in concentrations as the samples collected in the current study. The current study's data are also consistent with the data collected previously by the USGS (Manny, 1999; Sweat, 1999).

The riverbed-sediment samples collected by MDEQ (Ostaszewski, 1997) are similar in range and distribution of organic-constituent concentrations as those in this study. Although the distribution was similar between the two studies, the range of concentrations for most organic constituents was much smaller in the MDEQ dataset than in this study. In most cases, the mean concentrations for organic constituents were slightly lower in the samples collected by MDEQ than in the samples collected for the current study; however, the mean concentrations for total PCBs and naphthalene were slightly higher than for the samples collected in the current study. Similar to the inorganic constituents, MDEQ found the highest concentrations of organic constituents at the downstream locations, except for PCB, which was highest on the upstream side of the island (Ostaszewski, 1997).

Spatial Distributions of Selected Constituents

The sediment-chemistry data from the previous studies mentioned above and the current study were combined in a series of boxplots (appendix) to assist in examining the spatial distribution of constituents around the island. The samples were designated as downstream, west, east, or upstream of the island. Boxplots, for lead and pyrene are shown in figure 2. Constituent concentrations that were censored (value below method detection limit) were not used to construct the boxplots. Censored constituent concentrations are listed in tables 1 and 2. The median concentration of lead was very similar in all four regions sampled around the island but was highest on the west side. In most cases, the boxplots indicate that the highest concentrations for the inorganic constituents were on the west side of the island, in the shoal area. This is probably because the low-energy environment there allows deposition of fine suspended sediment that may have high concentrations of metals. The downstream, upstream, and east sampling sites have similar inorganic constituent concentrations; the east usually had the lowest concentrations.

However, concentrations of cadmium, chromium, and mercury were higher downstream of the island than west of the island. This pattern is due to the influence of MDEQ's downstream samples (Ostaszewski, 1997), which had significantly higher concentrations than the other samples collected at downstream locations. MDEQ's samples were collected much closer to the island (fig. 1) than the other downstream samples except for the sample site used by the USGS (Sweat, 1999). One possible reason for the higher concentration near the island is the influence of sediment deposited there after a dike wall ruptured on the southern edge of the island in 1982. However, the sample collected by Sweat (1999) did not show the same pattern of concentrations of inorganic constituents that was found in the other samples taken immediately adjacent to the island. Likewise, in most cases, the downstream locations had similar inorganic-constituent concentrations as the upstream and east locations, except for cadmium, chromium, and mercury.

Table 2. Concentrations of organic constituents in riverbed-sediment samples collected around Grassy Island, Michigan.

[All concentrations reported as dry weight; cm, centimeter; µg/kg, microgram per kilogram; R, replicate; >, greater than; ESL, Ecological Screening Level; PEC, Probable Effect Concentration; TEC, Threshold Effect Concentration; <, less than detection limit; E, estimated value; *italics* indicate ESL or TEC exceedance; ***bold italics*** indicate PEC exceedance; guideline values are in **bold**; all samples collected 8/31/2006]

Constituent	Site name							Effect concentration or screening level		
	06GIS1	06GIS5 0-30 cm	06GIS5 >30 cm	06GIS3	06GIS3 R	06GIS4	06GIS4 R	TEC[1]	PEC[1]	ESL[2]
1,2-Dimethylnaphthalene (µg/kg)	E 14	E 60	E 7	130	140	80	93	-	-	-
1,6-Dimethylnaphthalene (µg/kg)	E 33	67	E 14	240	240	110	100	-	-	-
1-Methyl-9*H*-fluorene (µg/kg)	E 34	150	E 13	360	410	160	180	-	-	-
1-Methylphenanthrene (µg/kg)	E 60	600	E 18	1,400	1,600	470	550	-	-	-
1-Methylpyrene (µg/kg)	93	670	E 20	1,800	2,300	540	580	-	-	-
2,3,6-Trimethylnaphthalene (µg/kg)	E 29	140	E 15	240	250	140	140	-	-	-
2,6-Dimethylnaphthalene (µg/kg)	E 54	150	E 27	360	380	190	200	-	-	-
2-Ethylnaphthalene (µg/kg)	E 31	110	E 11	300	350	130	150	-	-	-
2-Methylanthracene (µg/kg)	62	400	E 16	1,200	1,300	370	440	-	-	-
4*H*-Cyclopenta[*def*]-phenanthrene (µg/kg)	100	510	< 63	1,700	2,100	620	720	-	-	-
Acenaphthene (µg/kg)	*66*	*160*	E 3	*590*	*770*	*390*	*560*	-	-	**6.71**
Acenaphthylene (µg/kg)	*100*	*450*	E 10	*1,400*	*1,700*	*340*	*400*	-	-	**5.87**
Anthracene (µg/kg)	*210*	*770*	E 17	***2,500***	***3,300***	***1,000***	***1,200***	**57.2**	**845.0**	**57.20**
Benz[*a*]Anthracene (µg/kg)	*440*	***1,700***	E 32	***6,000***	***8,600***	***1,500***	***2,200***	**108.0**	**1,050.0**	**108.00**
Benzo[*a*]pyrene (µg/kg)	*480*	***1,900***	E 45	***6,200***	***9,000***	***1,600***	***2,300***	**150.0**	**1,450.0**	**150.00**
Benzo[*b*]fluoranthene (µg/kg)	560	2,100	E 45	6,800	10,000	1,700	2,700	-	-	**10,400.00**
Benzo[*g,h,i*]perylene (µg/kg)	*280*	*790*	E 31	*2,700*	*3,900*	*640*	*880*	-	-	**170.00**
Benzo[*k*]fluoranthene (µg/kg)	210	*770*	E 19	*2,500*	*3,900*	*620*	*800*	-	-	**240.00**
Chrysene (µg/kg)	*450*	***1,700***	E 34	***5,600***	***7,900***	***1,400***	***2,200***	**166.0**	**1,290.0**	**166.00**
Dibenz[*a,h*]anthracene (µg/kg)	*E 95*	*E 290*	< 63	*E 870*	*E 1,000*	*E 240*	*E 310*	**33.0**	-	**33.0**
Fluoranthene (µg/kg)	*760*	*2,200*	E 43	***8,900***	***13,000***	***2,400***	***3,600***	**423.0**	**2,230.0**	**423.0**
Fluorene (µg/kg)	*97*	*280*	E 12	***900***	***1,200***	*490*	***650***	**77.4**	**536.0**	**77.4**
Indeno[1,2,3-*cd*]pyrene (µg/kg)	E 240	E 710	E 24	E 2,600	E 3,000	E 640	E 850	-	-	**200.0**
Isophorone (µg/kg)	< 60	< 64	< 63	< 56	< 57	< 53	< 53	-	-	**432.0**

Table 2. Concentrations of organic constituents in riverbed-sediment samples collected around Grassy Island, Michigan.—*Continued*

[All concentrations reported as dry weight; cm, centimeter; µg/kg, microgram per kilogram; R, replicate; >, greater than; ESL, Ecological Screening Level; PEC, Probable Effect Concentration; TEC, Threshold Effect Concentration; <, less than detection limit; E, estimated value; *italics* indicate ESL or TEC exceedance; ***bold italics*** indicate PEC exceedance; guideline values are in **bold**; all samples collected 8/31/2006]

Constituent	Site name							Effect concentration or screening level		
	06GIS1	06GIS5 0-30 cm	06GIS5 >30 cm	06GIS3	06GIS3 R	06GIS4	06GIS4 R	TEC[1]	PEC[1]	ESL[2]
Naphthalene (µg/kg)	*370*	*230*	E 10	***920***	***1,300***	*430*	*420*	**176.0**	**561.0**	**176.0**
P-Cresol (µg/kg)	*E 49*	*85*	< 63	*100*	*120*	*E 57*	*E 60*	-	-	**20.2**
Inorganic carbon (percent)	2.2	2.6	2.6	1.3	1.2	1.3	1.4	-	-	-
Organic carbon (percent)	1.6	3.0	1.4	2.8	3.0	2.3	1.9	-	-	-
Total carbon (percent)	3.8	5.6	4.0	4.1	4.2	3.6	3.3	-	-	-
PCB, as nonachloro-biphenyl (percent)	66.5	E 51.9	69.2	60.6	59.8	60.7	54.4	-	-	-
Phenanthrene (µg/kg)	*340*	***1,400***	E 39	***5,000***	***7,100***	***2,000***	***2,900***	**204.0**	**1,170.0**	**204.0**
Phenanthridine (µg/kg)	< 60	E 27	< 63	72	120	E 31	E 38	-	-	-
Pyrene (µg/kg)	*700*	***2,600***	E 48	***11,000***	***14,000***	***3,000***	***4,100***	**195.0**	**1,520.0**	**195.0**
Total PCB (µg/kg)	57.7	E 32.7	E 2.1	***1,330***	*443*	*89.4*	*89.0*	**59.8**	**676.0**	**59.8**

[1] Ingersoll and MacDonald, 2002

[2] U.S. Environmental Protection Agency, 2003

The E remark code indicates that a constituent was detected but at a value below the method detection limit, or that a constituent was detected but there was substantial uncertainty in quantifying the value.

Table 3. Location and list of constituents with concentrations greater than an effect concentration or screening level.

[cm, centimeter; R, replicate; >, greater than; ESL, Ecological Screening Level; PEC, Probable Effect Concentration; TEC, Threshold Effect Concentration; --, all concentrations less than PEC, TEC, and ESL]

Constituent	Sample location						
	06GIS1	06GIS5 0-30 cm	06GIS5 >30 cm	06GIS3	06GIS3 R	06GIS4	06GIS4 R
Acenaphthene	> ESL	> ESL	--	> ESL	> ESL	> ESL	> ESL
Acenaphthylene	> ESL	> ESL	> ESL	> ESL	> ESL	> ESL	> ESL
Anthracene	> TEC and ESL	> TEC and ESL	--	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL
Benz[*a*]anthracene	> TEC and ESL	> TEC, PEC and ESL	--	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL
Benzo[*a*]pyrene	> TEC and ESL	> TEC, PEC and ESL	--	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL
Benzo[*g,h,i*]perylene	> ESL	> ESL	--	> ESL	> ESL	> ESL	> ESL
Benzo[*k*]fluoranthene	--	> ESL	--	> ESL	> ESL	> ESL	> ESL
Cadmium	--	> TEC and ESL	--	--	--	--	--
Chrysene	> TEC and ESL	> TEC, PEC and ESL	--	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL
Copper	--	> TEC and ESL	--	--	--	--	--
Dibenz[*a,h*]anthracene	> TEC and ESL	> TEC and ESL	--	> TEC and ESL	> TEC and ESL	> TEC and ESL	> TEC and ESL
Fluoranthene	> TEC and ESL	> TEC and ESL	--	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL
Fluorene	> TEC and ESL	> TEC and ESL	--	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC and ESL	> TEC, PEC and ESL
Indeno[1,2,3-*cd*]pyrene	> ESL	> ESL	--	> ESL	> ESL	> ESL	> ESL
Lead	--	> TEC and ESL	--	--	--	--	--
Mercury	--	> TEC and ESL	--	> TEC and ESL	--	--	--
Naphthalene	> TEC and ESL	> TEC and ESL	--	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC and ESL	> TEC and ESL
P-Cresol	> ESL	> ESL	--	> ESL	> ESL	> ESL	> ESL
Phenanthrene	> TEC and ESL	> TEC, PEC and ESL	--	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL
Pyrene	> TEC and ESL	> TEC, PEC and ESL	--	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL	> TEC, PEC and ESL
Silver	--	> ESL	> ESL	> ESL	--	--	--
Total PCB	--	--	--	> TEC, PEC and ESL	> TEC and ESL	> TEC and ESL	> TEC and ESL
Zinc	--	> TEC and ESL	--	--	--	--	--

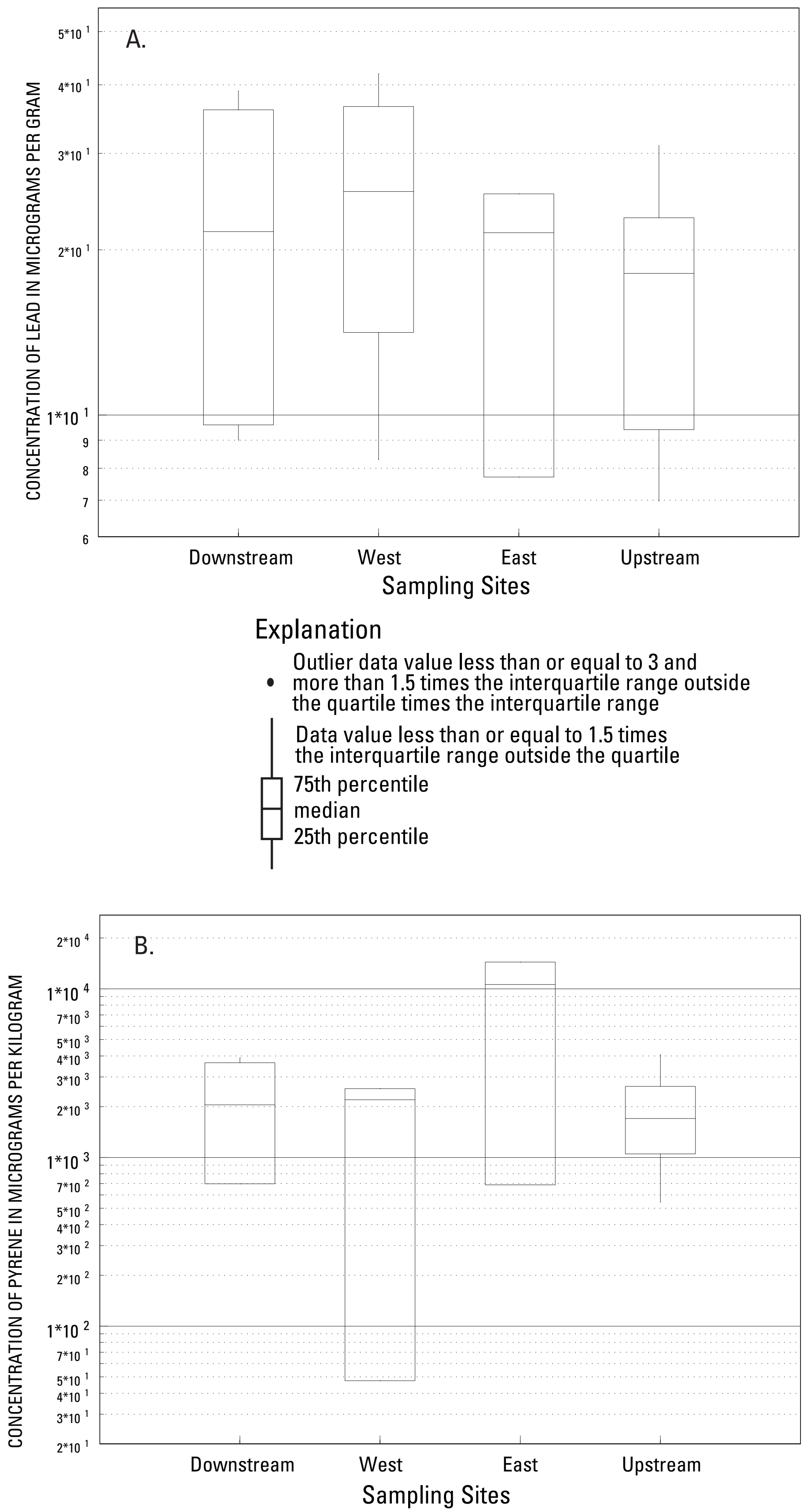

Figure 2. Selected boxplots for lead (***A***) and pyrene (***B***) in sediment adjacent to Grassy Island, Michigan.

The organic-constituent concentrations were generally highest in the sediment on east side of the island (appendix). The boxplot for pyrene (fig. 2) indicates that the east sampling sites had the highest median concentration, with the other sites having very similar median concentrations. The high concentrations on the east side of the island may be related to the overflow weir; however, the location of the weir discharge point is unknown. For most organic constituents, the upstream sampling site had higher median concentrations than the downstream location. This difference may be due to sediment transport from upstream locations and deposition near the head of Grassy Island.

With respect to constituent concentrations throughout the Detroit River, the concentrations near Grassy Island, at least for inorganic constituents, appear to be within the range of those in the river as a whole (Szalinska and others, 2006). In fact, mean concentrations of inorganic constituents around Grassy Island were generally lower than the mean concentrations found elsewhere in the lower reach of the Detroit River. Organic-constituent concentrations throughout the Detroit River also tend to be higher than those around Grassy Island (Ostaszewski, 1997); however, the targets of that larger study were mainly known contaminated sites, which would skew the distribution of concentrations toward the high end. Therefore, it is difficult to compare the organic-constituents sampled in this study to background concentrations for the Detroit River.

With respect to the ESL, TEC, and PEC guidelines, sediment-constituent concentrations were greater than these criteria in many cases. Among the inorganic constituents, concentrations were greater than guidelines for cadmium, copper, lead, mercury, zinc, and silver, mainly in the sample collected from the western shoal area. The PEC—the highest guideline at which adverse effects to biota are likely to occur—was not exceeded in the samples taken for this study. The inorganic constituent concentrations were generally lower than typical concentrations collected throughout the Detroit River (Szalinska and others, 2006). Generally, inorganic constituents in sediments sampled adjacent to the island had a low frequency of exceeding the risk-based guidelines.

Concentrations of the organic constituent benzo[*b*]fluoranthene in sediment collected around Grassy Island did not exceed the established ESL (table 2). Concentrations of the remaining 18 organic constituents for which an ESL, and (or) TEC, and (or) PEC has been defined exceeded one or more of these guidelines at least once (table 2). Most concentrations greater than the PEC were in sediment samples collected adjacent to the island; this finding suggests that the organic constituents in sediment surrounding Grassy Island may have the potential to adversely affect biota that come into contact with the sediment. However, additional work would be needed to determine whether biota that comes in contact with the sediment would be adversely affected.

Summary

On August 31, 2006, the U.S. Geological Survey, in cooperation with the U.S. Fish and Wildlife Service, sampled riverbed sediment in the Detroit River adjacent to Grassy Island, near Wyandotte, Michigan. In all, seven sediment samples were collected at four sites around Grassy Island and were analyzed for inorganic and organic constituents. The constituent distribution in sediment around the island had noticeable trends based on sample site. In general, the inorganic-constituent concentrations were highest in the shoal area on the west side of the island, whereas the organic-constituent concentrations were highest on the east side. In addition, the constituent concentrations were typically higher on the north side of the island (upstream) than on the south side (downstream). Concentrations of constituents in previous studies of Detroit River sediment around Grassy Island (Ostaszewski, 1997; Manny, 1999; Sweat, 1999; Szalinska and others, 2006) were similar to those in samples collected for the present study. Inorganic-constituent concentrations in riverbed sediment analyzed for the current study were generally lower than those found elsewhere in the lower reach of the Detroit River (Szalinska and others, 2006). Organic-constituent concentrations in the current study were generally lower than those in sediment in the Trenton Channel of the Detroit River (Ostaszewski, 1997). Comparison of results from the current sampling effort to U.S. Environmental Protection Agency screening guidelines indicates that organic constituents in the sediment exceeded guidelines more frequently than the inorganic constituents in the sediment. Further work, would be needed to determine whether constituent concentrations in the riverbed sediment adjacent to Grassy Island are related to constituent runoff from the island.

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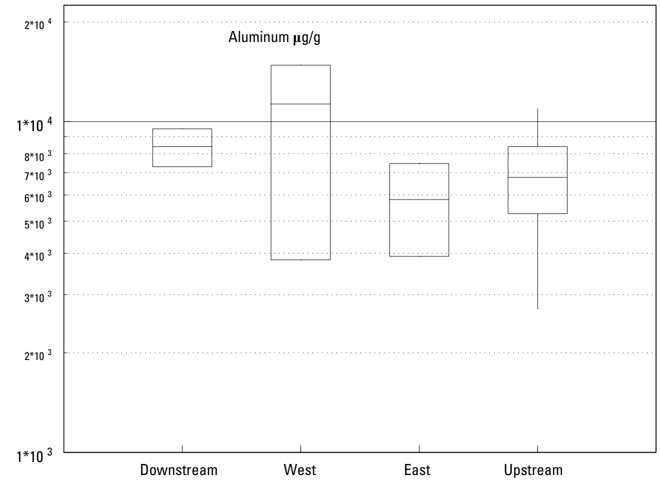
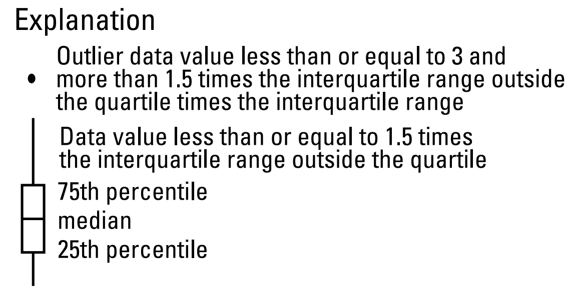
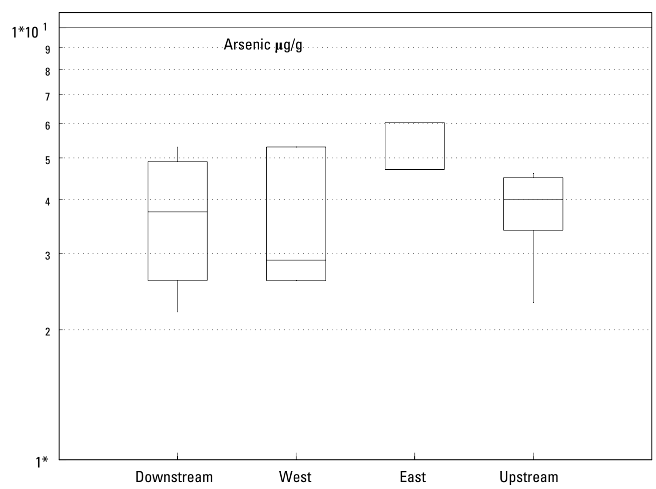
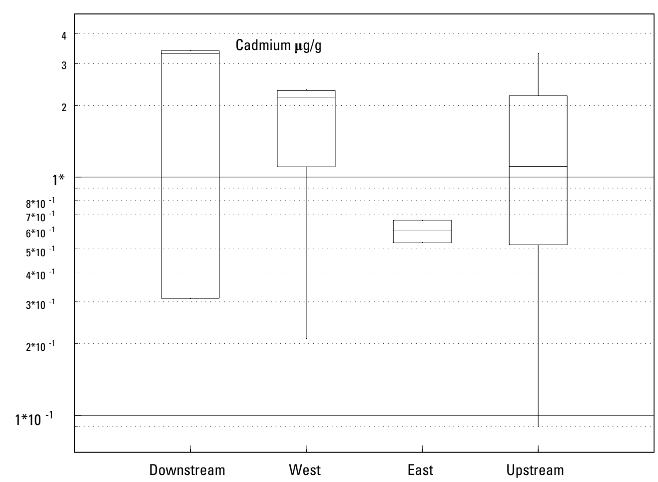
Appendix

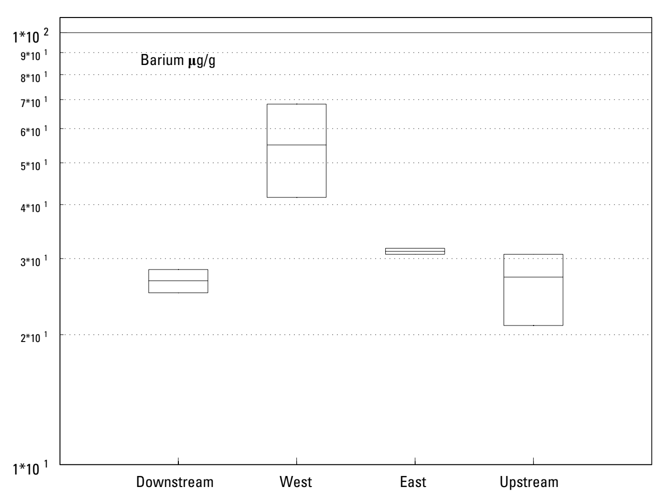
Appendix. Boxplots of various chemical constituents sampled in river bed sediment near Grassy Island, Michigan

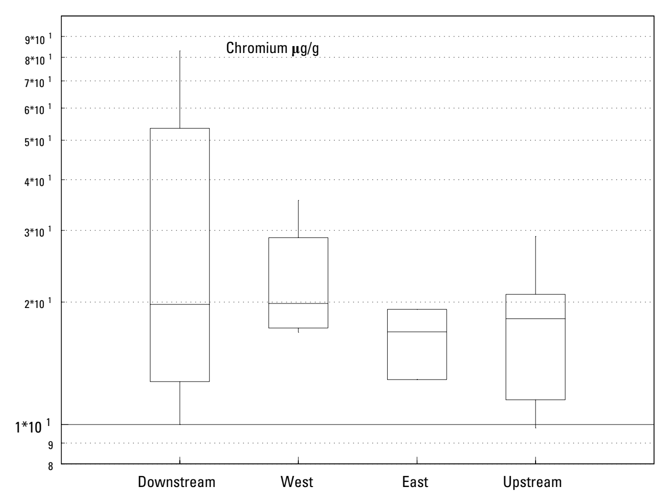


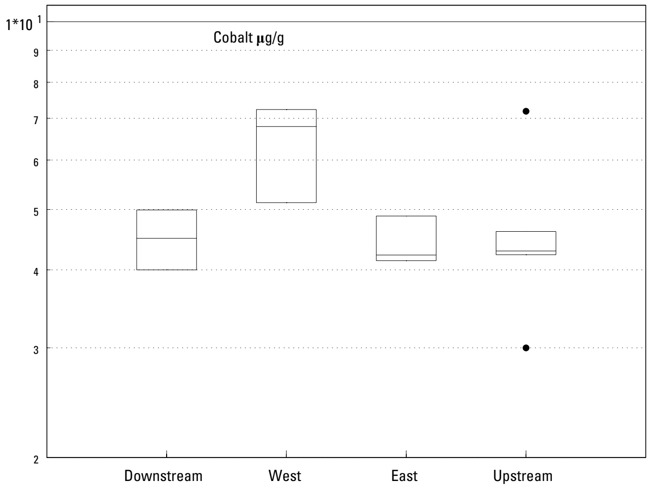


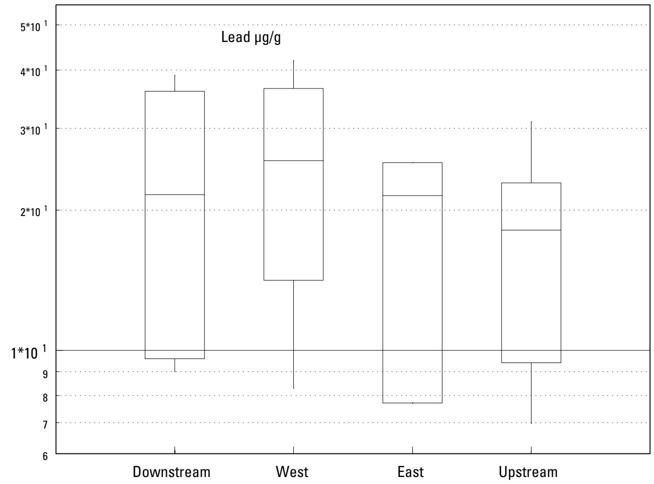


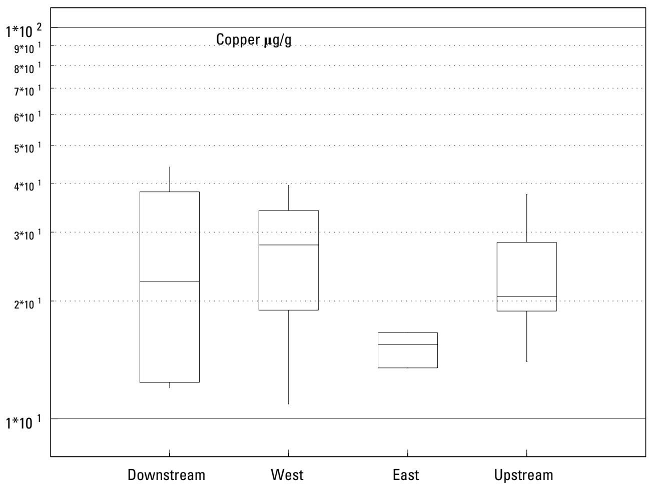


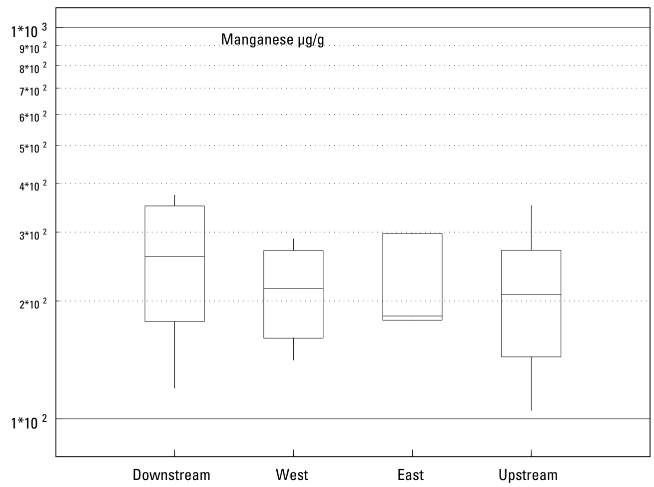


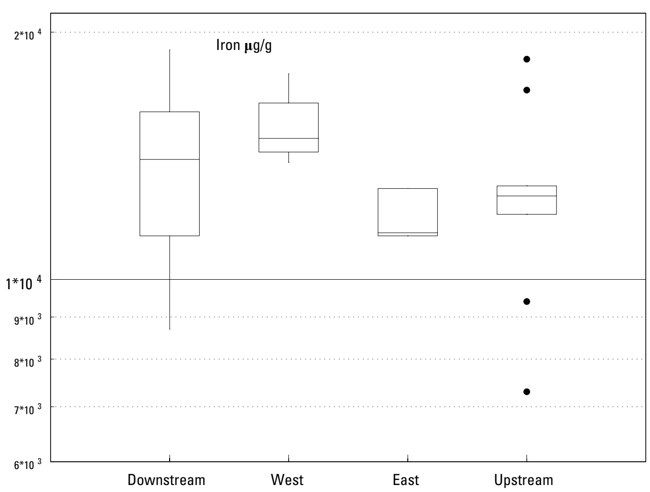


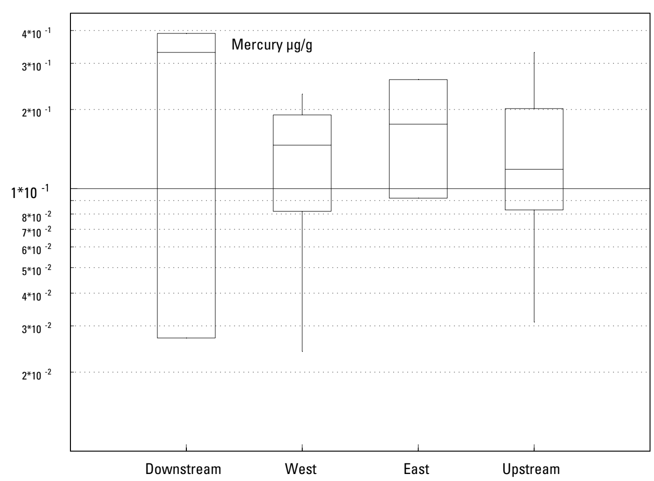

Cobalt µg/g
1*10 1
9
8
7
6
5
4
3
2
Downstream
West
East
Upstream

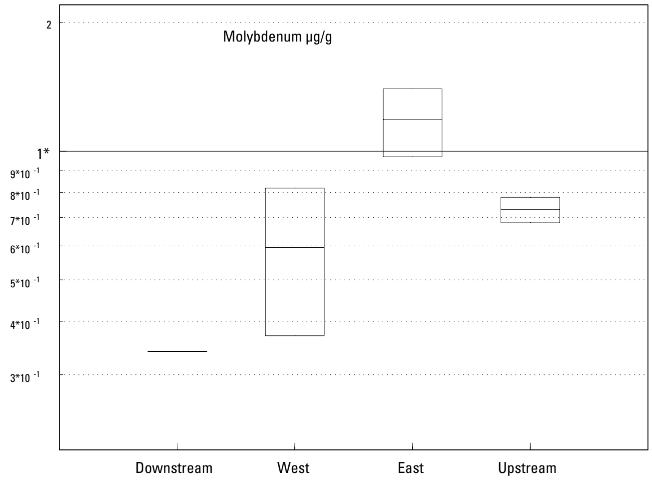

Lead µg/g
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
9
8
7
6
Downstream
West
East
Upstream

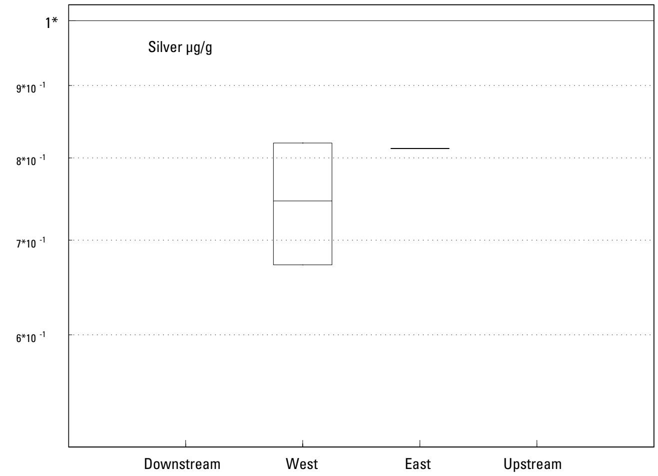

Copper µg/g
1*10 2
9*10 1
8*10 1
7*10 1
6*10 1
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
Downstream
West
East
Upstream

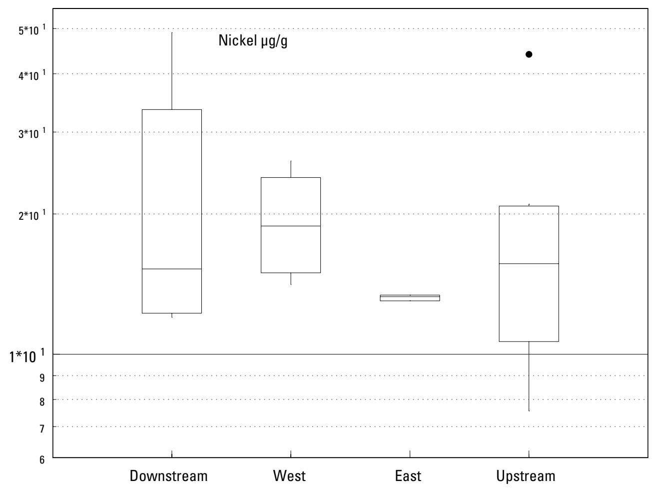

Manganese µg/g
1*10 3
9*10 2
8*10 2
7*10 2
6*10 2
5*10 2
4*10 2
3*10 2
2*10 2
1*10 2
Downstream
West
East
Upstream

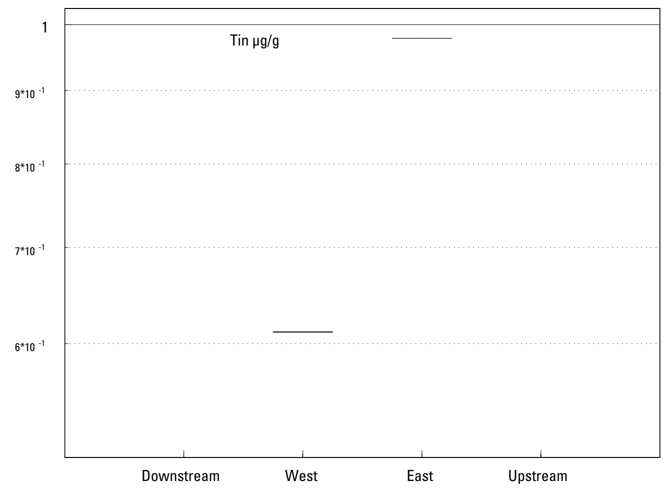

Iron µg/g
2*10 4
1*10 4
9*10 3
8*10 3
7*10 3
6*10 3
Downstream
West
East
Upstream

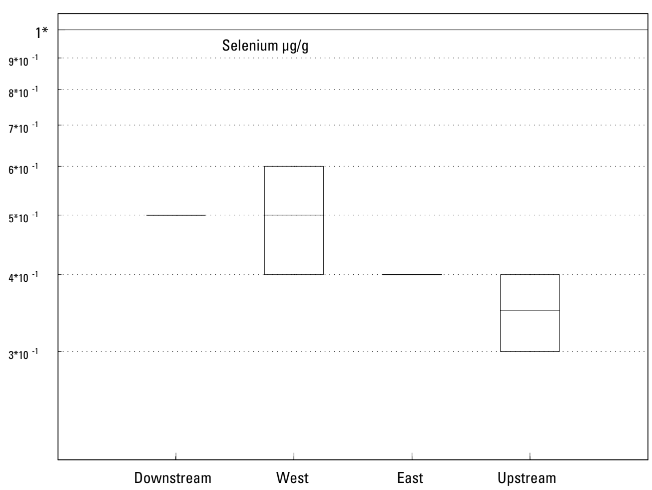

Mercury µg/g
4*10 -1
3*10 -1
2*10 -1
1*10 -1
8*10 -2
7*10 -2
6*10 -2
5*10 -2
4*10 -2
3*10 -2
2*10 -2
Downstream
West
East
Upstream

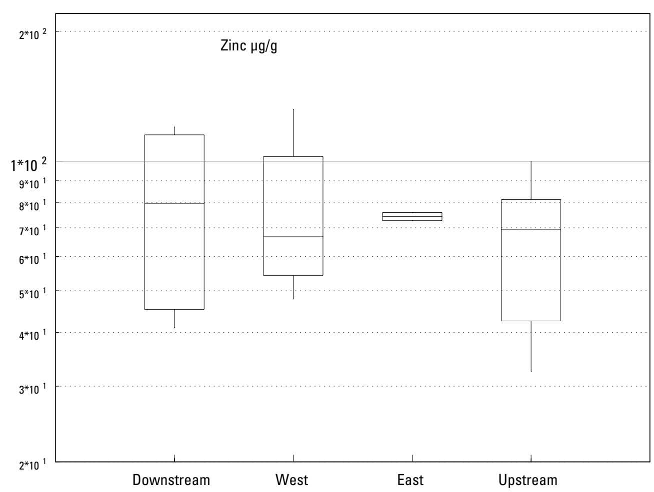

Molybdenum µg/g
2
1*
9*10 -1
8*10 -1
7*10 -1
6*10 -1
5*10 -1
4*10 -1
3*10 -1
Downstream
West
East
Upstream

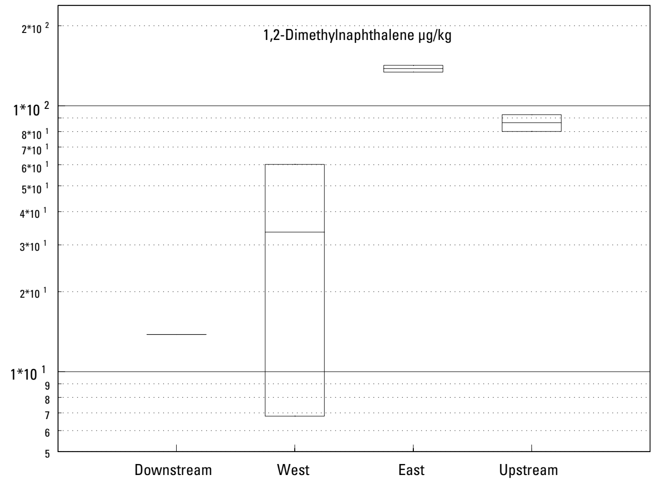

Silver µg/g
1*
9*10 -1
8*10 -1
7*10 -1
6*10 -1
Downstream
West
East
Upstream

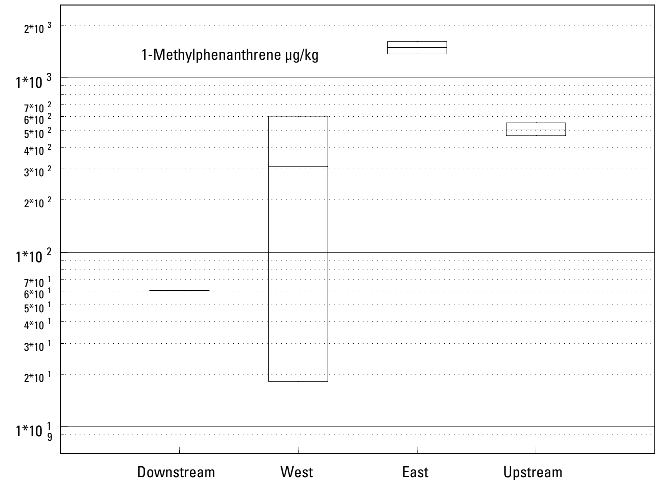

Nickel µg/g
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
9
8
7
6
Downstream
West
East
Upstream

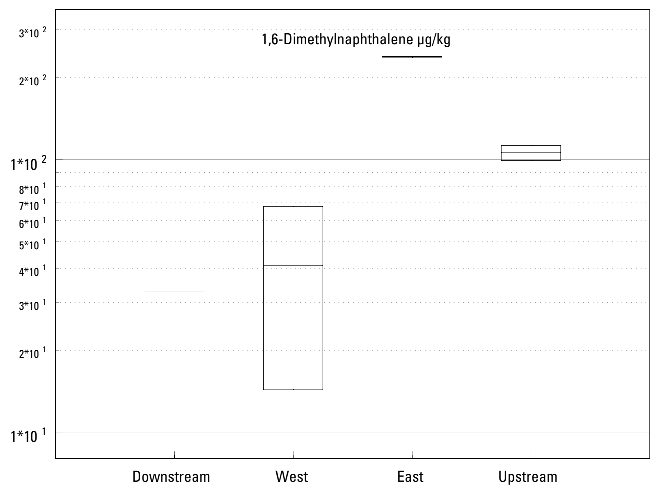

Tin µg/g
1
9*10 -1
8*10 -1
7*10 -1
6*10 -1
Downstream
West
East
Upstream

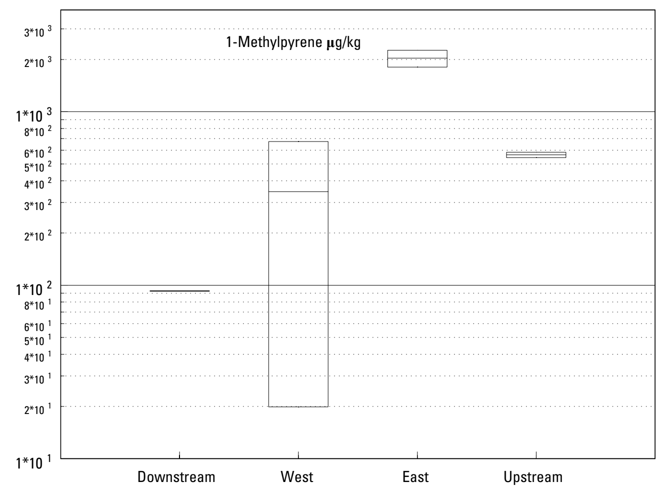

Selenium µg/g
1*
9*10 -1
8*10 -1
7*10 -1
6*10 -1
5*10 -1
4*10 -1
3*10 -1
Downstream
West
East
Upstream

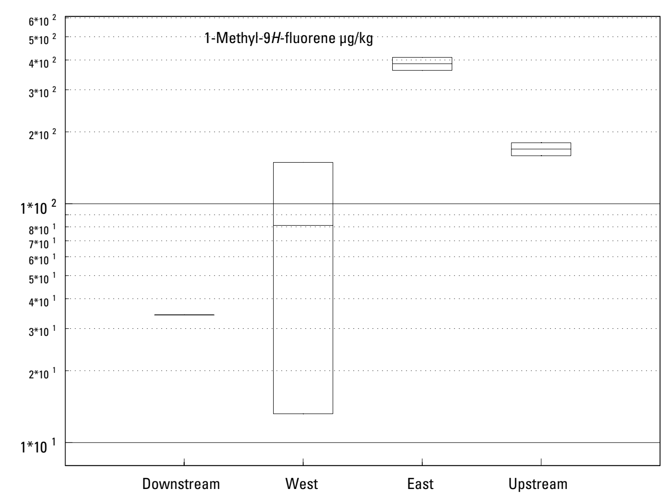

Zinc µg/g
2*10 2
1*10 2
9*10 1
8*10 1
7*10 1
6*10 1
5*10 1
4*10 1
3*10 1
2*10 1
Downstream
West
East
Upstream

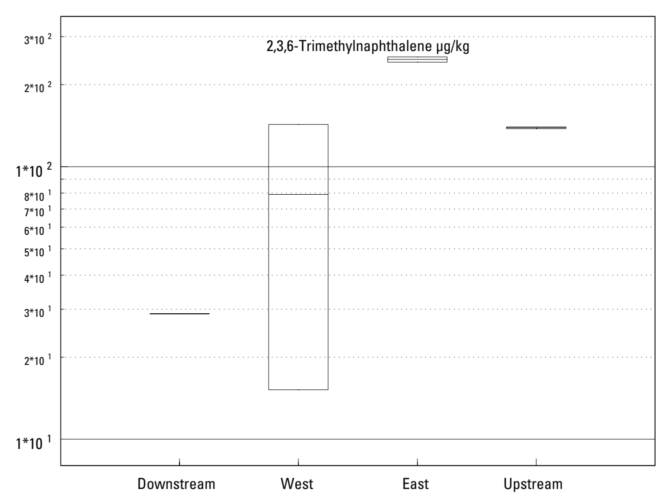

1,2-Dimethylnaphthalene µg/kg
2*10 2
1*10 2
8*10 1
7*10 1
6*10 1
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
9
8
7
6
5
Downstream
West
East
Upstream

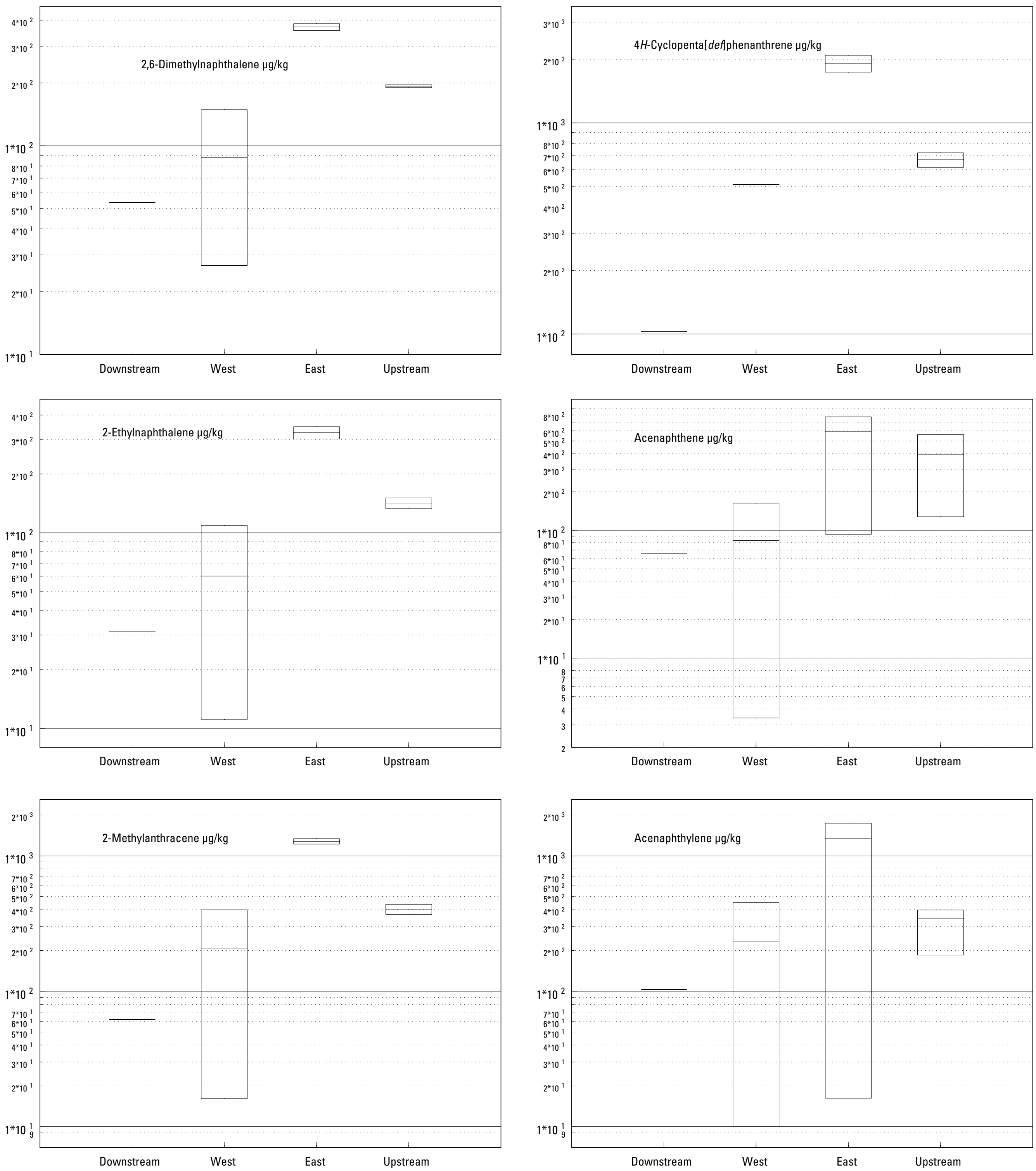

1-Methylphenanthrene µg/kg
2*10 3
1*10 3
7*10 2
6*10 2
5*10 2
4*10 2
3*10 2
2*10 2
1*10 2
7*10 1
6*10 1
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
9
Downstream
West
East
Upstream

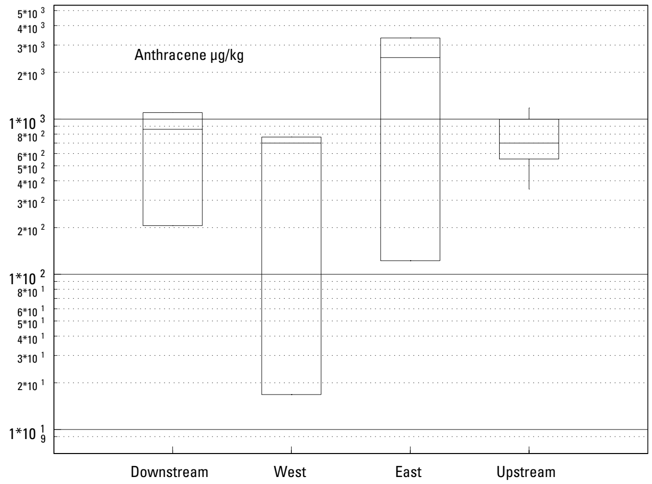

1,6-Dimethylnaphthalene µg/kg
3*10 2
2*10 2
1*10 2
8*10 1
7*10 1
6*10 1
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
Downstream
West
East
Upstream

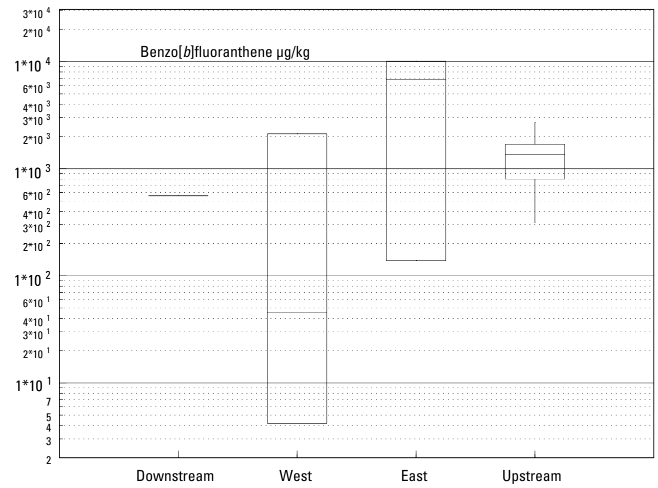

1-Methylpyrene µg/kg
3*10 3
2*10 3
1*10 3
8*10 2
6*10 2
5*10 2
4*10 2
3*10 2
2*10 2
1*10 2
8*10 1
6*10 1
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
Downstream
West
East
Upstream

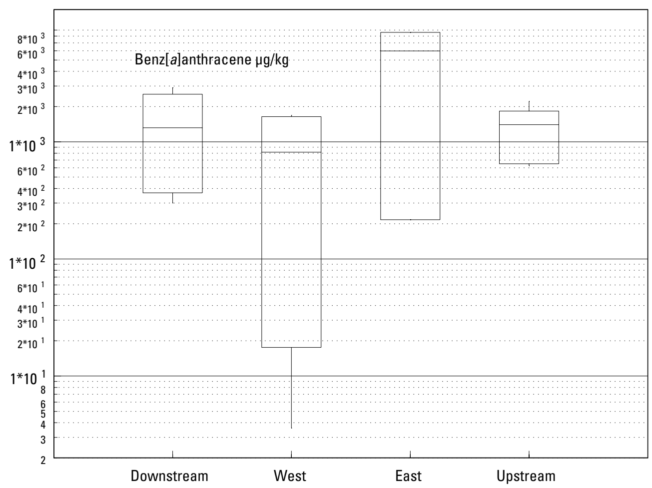

1-Methyl-9*H*-fluorene µg/kg
6*10 2
5*10 2
4*10 2
3*10 2
2*10 2
1*10 2
8*10 1
7*10 1
6*10 1
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
Downstream
West
East
Upstream

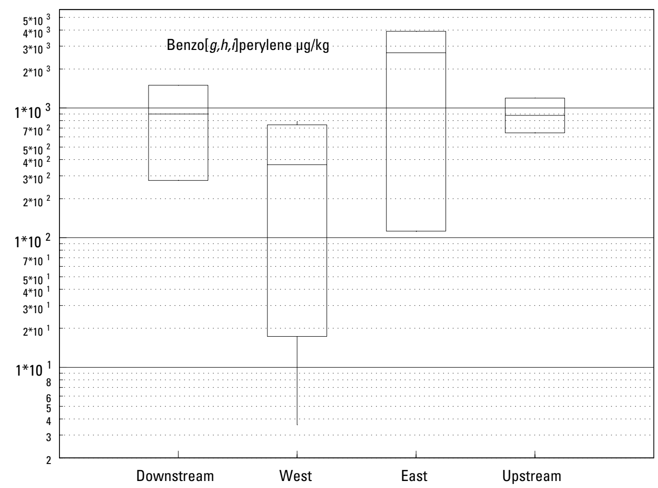

2,3,6-Trimethylnaphthalene µg/kg
3*10 2
2*10 2
1*10 2
8*10 1
7*10 1
6*10 1
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
Downstream
West
East
Upstream

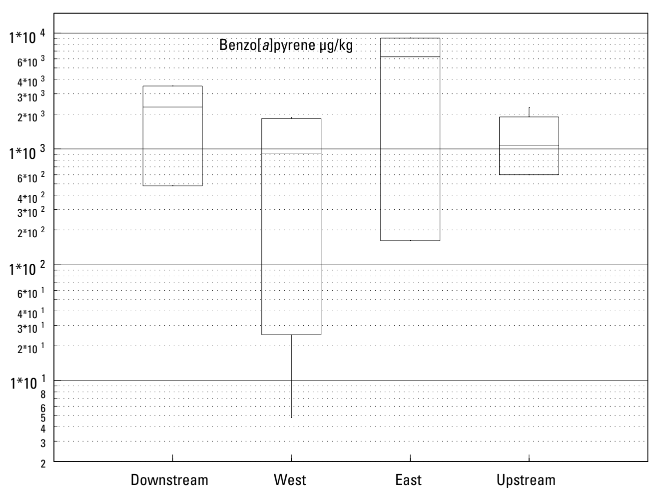

2,6-Dimethylnaphthalene µg/kg
4H-Cyclopenta[def]phenanthrene µg/kg
2-Ethylnaphthalene µg/kg
Acenaphthene µg/kg
2-Methylanthracene µg/kg
Acenaphthylene µg/kg
Downstream
West
East
Upstream

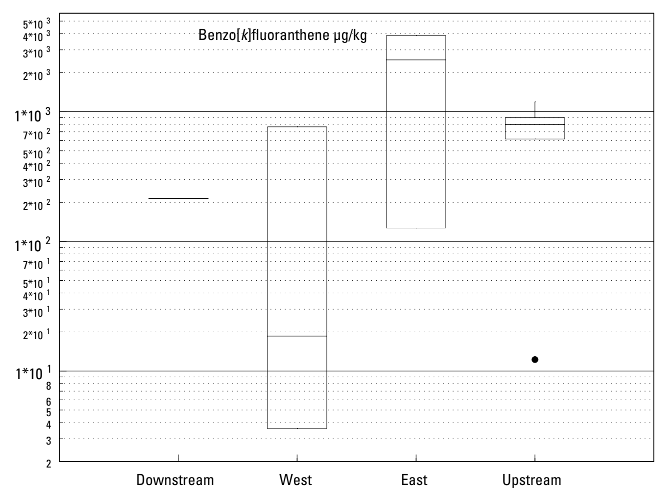

Anthracene µg/kg
Downstream
West
East
Upstream

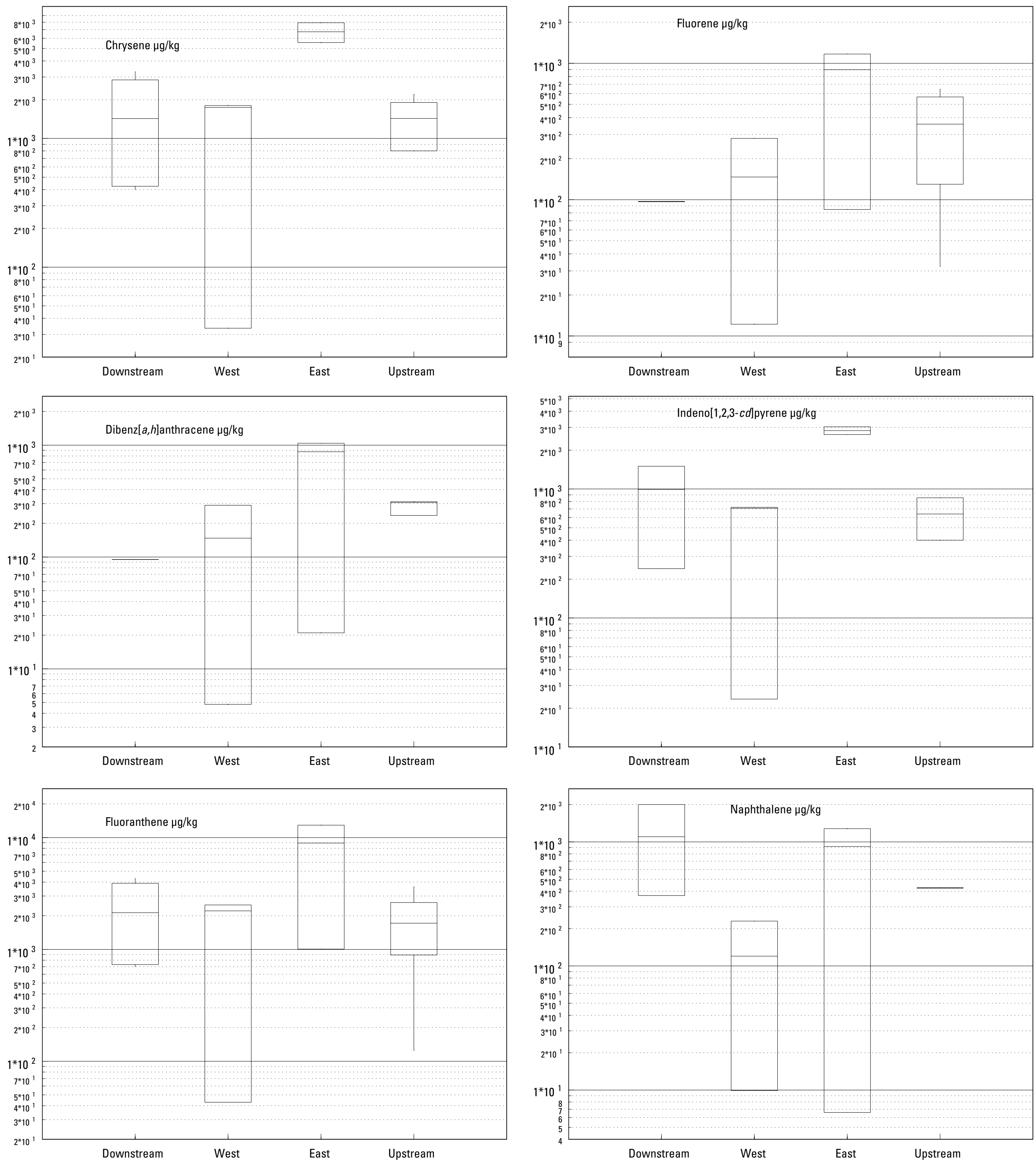

Benzo[b]fluoranthene µg/kg
Downstream
West
East
Upstream

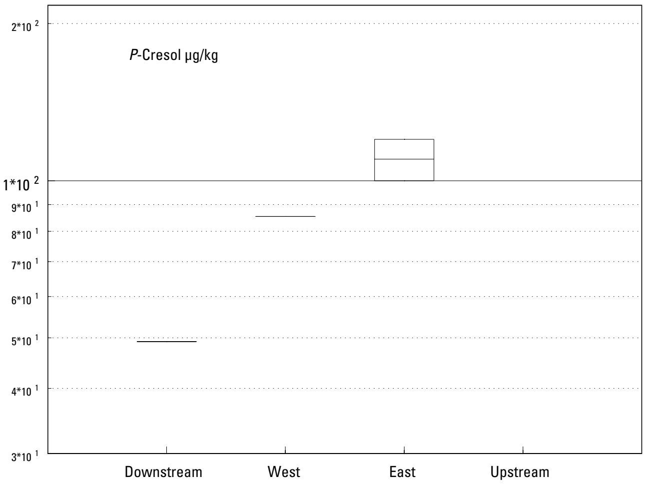

Benz[a]anthracene µg/kg
Downstream
West
East
Upstream

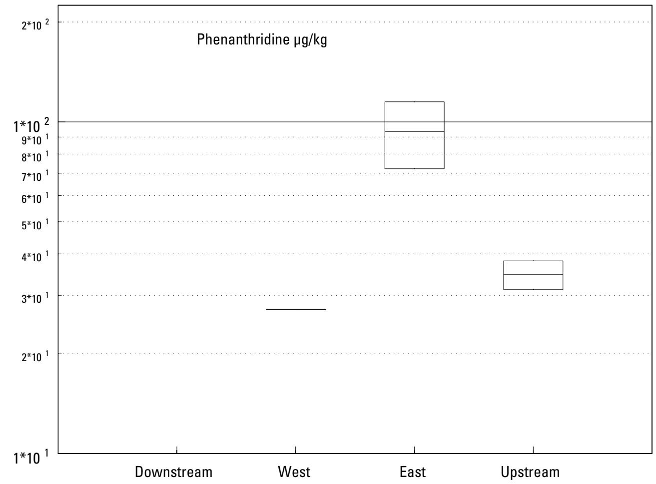

Benzo[g,h,i]perylene µg/kg
Downstream
West
East
Upstream

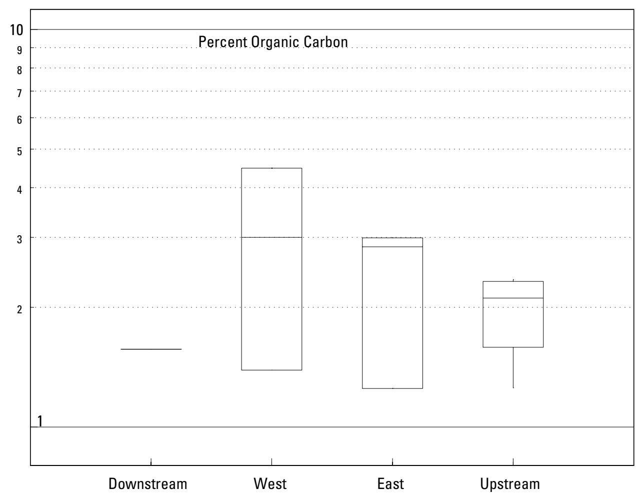

Benzo[a]pyrene µg/kg
Downstream
West
East
Upstream

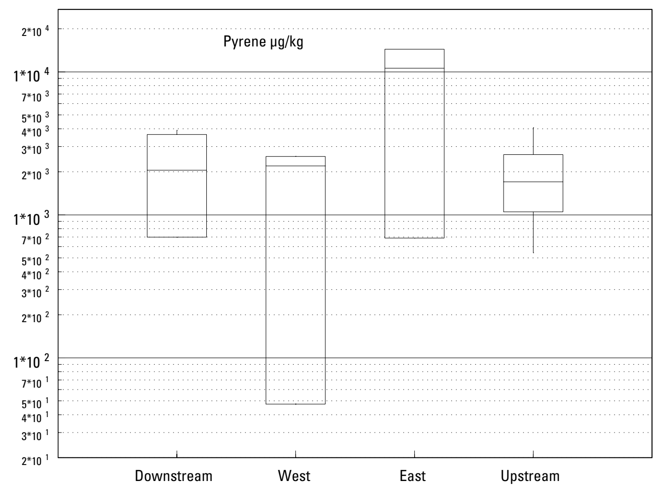

Benzo[k]fluoranthene µg/kg
Downstream
West
East
Upstream

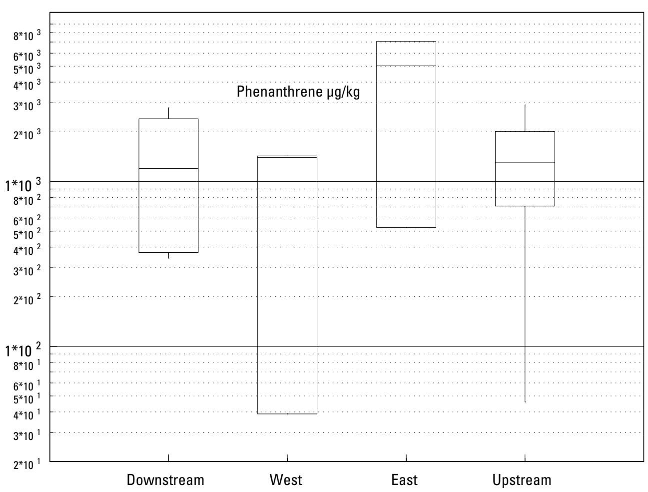

Chrysene µg/kg
Downstream
West
East
Upstream
Fluorene µg/kg
Downstream
West
East
Upstream
Dibenz[a,h]anthracene µg/kg
Downstream
West
East
Upstream
Indeno[1,2,3-cd]pyrene µg/kg
Downstream
West
East
Upstream
Fluoranthene µg/kg
Downstream
West
East
Upstream
Naphthalene µg/kg
Downstream
West
East
Upstream

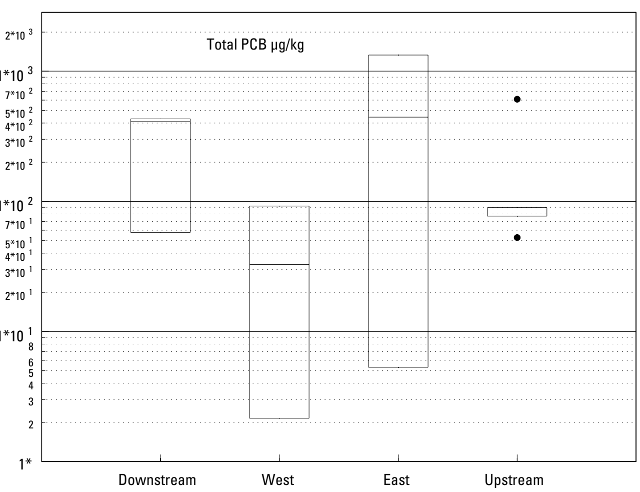

P-Cresol µg/kg
2*10 2
1*10 2
9*10 1
8*10 1
7*10 1
6*10 1
5*10 1
4*10 1
3*10 1
Downstream
West
East
Upstream


Phenanthridine µg/kg
2*10 2
1*10 2
9*10 1
8*10 1
7*10 1
6*10 1
5*10 1
4*10 1
3*10 1
2*10 1
1*10 1
Downstream
West
East
Upstream


Percent Organic Carbon
10
9
8
7
6
5
4
3
2
1
Downstream
West
East
Upstream


Pyrene µg/kg
2*10 4
1*10 4
1*10 3
1*10 2
2*10 1
Downstream
West
East
Upstream


Phenanthrene µg/kg
8*10 3
1*10 3
1*10 2
2*10 1
Downstream
West
East
Upstream


Total PCB µg/kg
2*10 3
1*10 3
1*10 2
1*10 1
1*
Downstream
West
East
Upstream

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