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Sediment Quality in the Mid-Columbia River between Vantage, Washington and McNary Dam

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Office of Environmental Assessment
United States Environmental Protection Agency, Region 10

Index map of the mid-Columbia project area

Sediment Quality in the Mid-Columbia River Between Vantage, Washington and McNary Dam

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Table of Contents

List of Tables..... iii
List of Figures..... iv
List of USEPA Region 10 Personnel Contributing to this Report vii
Acknowledgments..... vii
List of Abbreviations and Acronyms..... x
Units..... xii

Executive Summary..... 1

1.0 Introduction..... 5
1.1. Background……..... 5
1.2. Contaminants of concern..... 6
1.2.1. Other studies..... 6
1.3. Study area……..... 7

2.0 Materials and Methods..... 7
2.1. Strategy and design..... 7
2.2. Sampling locations and field collection..... 8
2.3. Sampling……..... 9
2.3.1. Sample collection..... 9
2.3.2. Equipment decontamination..... 9
2.4 Quality Assurance and Quality Control (QA /QC) requirements..... 10
2.4.1. Sample handling, custody and shipment requirements..... 10
2.4.2. Instrument calibration procedures and frequency.....10
2.4.3. Inspection /acceptance requirements for supplies and consumables..10
2.5. Analytical methods, reporting limits, and holding time requirements…….. 10
2.6. Analytical laboratories involved in this research, and their responsibilities. 11

.
3.0 Results and Discussion..... 11
3.1 Metals. 11
3.1.1 Arsenic..... 12
3.1.2 Cadmium..... 13
3.1.3 Chromium..... 13
3.1.4 Copper..... 13
3.1.5 Lead..... 14
3.1.6 Mercury..... 14
3.1.7 Nickel..... 14
3.1.8 Zinc..... 14
3.1.9 Metals summary 15

3.2 Organic compounds.....15
3.2.1 Pesticides..... 16
3.2.1.1 DDTs…… 16
3.2.1.2 Other organochlorine pesticides…….. 17
3.2.1.3 Organophosphate and carbamate pesticides……. 17
3.2.1.4 Herbicides & fungicides, including halogenated, chlorophenolic, and organonitrogen compounds…….. 18
3.2.1.5 Pesticide summary…… 18
3.2.2 Polychlorinated biphenyl (PCB) Aroclors..... 19
3.2.3 Polychlorinated dibenzo-p-dioxins (PCDD and polychlorinated dibenzo-p-furans (PCDF) 19
3.2.3.1 Dibenzo-p-dioxins..... 19
3.2.3.2 Dibenzo-p-furans..... 19
3.2.3.3 Dioxin and furan summary……. 20
3.2.4 Polybrominated diphenyl ethers (PBDEs)..... 20
3.2.4.1 PBDEs summary……. 21
4.0 Conclusions and Recommendations..... 21
5.0 References Cited..... 24

List of Tables

Table 1. Sample Locations, Mid-Columbia sediments

Table 2. Target compounds, number of samples, analytical laboratories, methods, and reporting limits

Table 3. Geographic comparisons of metals concentrations in Columbia Basin and nationwide

Table 4. Metals: Comparison with ecological guidelines in mid-Columbia sediments

Table 5. Metal concentrations in mid-Columbia sediments

Table 6. Concentrations of detected organic compounds compared to ecological and human health guidelines

Table 7. Organochlorine pesticides

Table 8. Organophosphates and carbaryl

Table 9. Herbicides and fungicides

Table 10. PCB Aroclors

Table 11. Polychlorinated dibenzodioxins and dibenzofurans

Table 12. Polybrominated Diphenyl Ethers (PBDEs)

List of Figures

Figure 1. Mid- Columbia region, and sediment sampling sites
.
Figure 2. Arsenic concentrations in mid-Columbia sediments

Figure 3. Arsenic data sorted by concentration

Figure 4. Arsenic concentrations versus percent fines

Figure 5. Arsenic concentration versus total organic carbon (TOC)

Figure 6. Arsenic geographic comparisons

Figure 7. Cadmium concentrations in mid-Columbia sediments

Figure 8. Cadmium data sorted by concentration

Figure 9. Cadmium concentrations versus percent fines

Figure 10. Cadmium concentrations versus total organic carbon (TOC)

Figure 11. Cadmium geographic comparisons

Figure 12. Chromium concentrations in mid-Columbia sediments

Figure 13. Chromium data sorted by concentration

Figure 14. Chromium concentrations versus percent fines

Figure 15. Chromium concentrations versus total organic carbon (TOC)

Figure 16. Chromium geographic comparisons

Figure 17. Copper concentrations in mid-Columbia sediments

Figure 18. Copper data sorted by concentration

Figure 19. Copper concentrations versus percent fines

Figure 20. Copper concentrations versus total organic carbon (TOC)

Figure 21. Copper geographic comparisons

Figure 22. Lead concentrations in mid-Columbia sediments

Figure 23. Lead data sorted by concentration

Figure 24. Lead concentrations versus percent fines

Figure 25. Lead concentrations versus total organic carbon (TOC)

Figure 26. Lead geographic comparisons

Figure 27. Mercury concentrations in mid-Columbia sediments

Figure 28. Mercury data sorted by concentration

Figure 29. Mercury concentrations versus percent fines

Figure 30. Mercury concentrations versus total organic carbon (TOC)

Figure 31. Mercury geographic comparisons

Figure 32. Nickel concentrations in mid-Columbia sediments

Figure 33. Nickel data sorted by concentration

Figure 34. Nickel concentrations versus percent fines

Figure 35. Nickel concentrations versus total organic carbon (TOC)

Figure 36. Nickel geographic comparisons

Figure 37. Zinc concentrations in mid-Columbia sediments

Figure 38. Zinc data sorted by concentration

Figure 39. Zinc concentrations versus percent fines

Figure 40. Zinc concentrations versus total organic carbon (TOC)

Figure 41. Zinc geographic comparisions

Figure 42. Total DDT concentrations in mid-Columbia sediments

Figure 43. P,p'-DDE concentrations in mid-Columbia sediments

Figure 44. P,p'-DDD concentrations in mid-Columbia sediments

Figure 45. P'p'-DDT concentrations in mid-Columbia sediments

Figure 46. 1,2,3,4,6,7,8,9-Octa-CDD concentrations in mid-Columbia sediments

Figure 47. 1,2,3,4,6,7,8-Hepta-CDD concentrations in mid-Columbia sediments

Figure 48. Sum of PBDE congeners in mid-Columbia sediments

Figure 49. Detected PBDE congeners, mid-Columbia sediments

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List of Abbreviations and Acronyms

BDE	brominated diphenyl ethers (PBDEs)
CAFO	confined animal feeding operations
CDD	chlorinated dibenzo-p-dioxin
CDF	chlorinated dibenzo-p-furan
CRBC	Columbia River Basin Contaminant Study
DDE	1,1-dichloro-2,2-*bis*(p-chlorophenyl)ethylene
DDT	1,1,1-trichloro-2,2-*bis*(p-chlorophenyl)ethane
DDD	1,1-dichloro-2,2-*bis*(p-chlorophenyl)ethane
EMAP	Environmental Assessment and Monitoring Program
GPS	global positioning system
HCB	hexachlorobenzene
HpCDD	heptachloro dibenzo-p-dioxin
HpCDF	heptachloro dibenzo-p-furan
HxCDD	hexachloro dibenzo-p-dioxin
HxCDF	hexachloro dibenzo-p-furan
J	(laboratory qualifier code): The identification of the analyte is acceptable; the reported value is an estimate.
JL	(laboratory qualifier code): The identification of the analyte is acceptable; the reported value is an estimate and may be biased low. The actual value is expected to be greater than the reported value.
U	(laboratory qualifier code): The analyte was not detected at or above the reported value.
UJ	(laboratory qualifier code): The analyte was not detected at or above the reported value. The reported value is an estimate.
MCPA	(4-chloro-2-methylphenoxy) acetic acid
MCPP	2-(4-chloro-2-methylphenoxy) propionic acid
MEL	Manchester Environmental Laboratory (US EPA Region 10, Seattle)
MLD	minimum limit of detection
NAWQA	National Water Quality Assessment Program (USGS)
OCDD	octachloro dibenzo-p-dioxin
OCDF	octachloro dibenzo-p-furan
ODEQ	Oregon Department of Environmental Quality
OEA	Office of Environmental Assessment (USEPA Region 10, Seattle)
PBDE	polybrominated diphenyl ether
PCB	polychlorinated biphenyl
PCP	pentachlorophenol
PEC	Probable Effect Concentration
PeCDD	pentachloro dibenzo-p-dioxin
PeCDF	pentachloro dibenzo-p-furan
QA /QC	Quality Assurance /Quality Control

QAPP	Quality Assurance Project Plan
RL	reporting limit(s)
RM	river mile
SLV	screening level value
SOP	standard operating procedures
STP	sewage treatment plant
2378-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
2378-TCDF	2,3,7,8-tetraclorodibenzo-p-furan
TEC	Threshold Effect Concentration
TOC	total organic carbon
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WDOE	Washington State Department of Ecology
2,4-D	2,4-dichlorophenoxy acetic acid
2,4-DB	4-(2,4-dichlorophenoxy) butyric acid
2,4,5-T	2,4,5-trichlorophenoxy acetic acid
2,4,5-TCP	2,4,5-trichlorophenol
2,4,6-TCP	2,4,6-trichlorophenol

Units

cm	centimeter (one one hundreth of a meter)
ng/kg	nanograms per kilogram (parts per trillion, ppt)
µg/kg	micrograms per kilogram (parts per billion, ppb)
mg/kg	milligrams per kilogram (parts per million, ppm)
kg	kilogram
g	gram
µ	micron (one millionth of a meter)
µl	microliter
ml	milliliter
l	liter
dw	dry weight
ww	wet weight

Executive Summary

During 2004, contaminant analyses were performed on 45 sediment samples taken from 33 pre-selected sites along 280 miles of the mid-Columbia River in Washington State, from Wanapum Dam downstream to McNary Dam (Figure 1, Table 1).

The goals of the study were twofold:

- Identify spatial patterns in sediment-borne contaminants that might be correlated with sources and uptake of some of the contaminants found to be prevalent in mid-Columbia fish tissue in a prior study (USEPA Region 10's Columbia River Basin Contaminants Study; (CRBC; USEPA 2002))

- Identify and prioritize likely contaminated sediment loading sites important to the mid-Columbia River, and evaluate these sites for their potential to act as "hot spots," or sinks, for contaminants within the ecosystem.

This study was designed to gather specific information on the distribution of mid-Columbia sediment contaminants of concern in known or suspected source areas and in areas where sediment might be expected to accumulate. Therefore, the sampling locations were not randomly selected but were based on previous sediment analyses, adjacent industrial and agricultural land uses, and site-specific information obtained during a preliminary field reconnaissance of the mid-Columbia area conducted in 2003 (USEPA, 2003). In general, all sediment samples were taken from sheltered backwater areas, downstream of islands, and in similar riverine locations in which water currents are slowed, favoring accumulation of finer sediment along the channel bottom.

Four types of sampling sites were targeted for study: 1) lower regions of important tributaries such as Crab Creek and the Yakima, Snake, and Walla Walla rivers, 2) areas of greater population and recreational use such as the Tri-Cities region and Lake Wallula, 3) selected sites associated with nearby point sources like pulp mills, sewage treatment outfalls, irrigation returns, and parks, and 4) sediment depositional areas behind three major dams in the mid-Columbia Basin. These included sampling sites directly above Ice Harbor Dam on the lower Snake River, as well as above two main stem Columbia River Dams; Wanapum and McNary.

The sediment samples were tested for various heavy metals, pesticides, herbicides, fungicides, several PCB Aroclors, specific congeners of dibenzo-dioxins and dibenzofurans, and eight different polybrominated diphenyl ethers (PBDEs).

Results

For the majority of the analytes, sediment concentrations were below the reporting levels designed to detect sites which constitute "hot spots," which are unusually elevated concentrations compared to other sites in the Basin. Many of the contaminants that were

detected were found at low levels that could only be estimated rather than quantified with confidence. For specific contaminants, however, the following trends were observed.

Metals

Although metals occur naturally in the environment, they can have harmful effects on organisms at elevated concentrations. Cadmium and zinc were above the threshold effect concentrations (TEC) in about one-third of the samples. The TEC values (MacDonald et al, 2000) are intended to identify contaminant concentrations below which harmful effects on sediment dwelling organisms are not expected. Cadmium and zinc were also above the probable effect concentration (PEC) in 2% of the samples. The PEC values (MacDonald et al, 2000) are intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms were expected to occur frequently. The remaining six metals targeted for analysis were comparable to other areas within the Columbia River Basin and were generally below their respective TECs and all were below their respective PECs.

A few specific sample locations stood out with regard to their metals content. These include: 1) the upper Yakima River Delta region (Station ID 18, the highest sample for mercury, cadmium, and zinc); 2) the Lower Yakima River Delta (Station ID 20, the highest sample for nickel); 3) the area above Priest Rapids Dam (Station ID 6b, the highest sample for both chromium and copper and second highest in cadmium and nickel); 4) Hanford Reach 100-F Area (Station ID 9, the highest in lead, arsenic, and second highest in copper); and 5) the Hanford Slough Site 100 (Station ID 10, the second highest in lead and zinc).

Pesticides

Sediment samples were analyzed for both pesticides that are currently being used and for "legacy" pesticides that were banned many years ago but that are still commonly found in the environment. DDT-related compounds were widespread and were detected in 64% of samples. Hexachlorobenzene was detected in 9% of samples. Three organophosphate pesticides were found: Azinphos- methyl, Ethyl chlorpyrifos, and Malathion. Azinphos methyl was found in 4% of samples and Malathion and Ethyl chlorpyrifos were detected in 7% of samples. Thirty chlorinated acids, chlorophenolic, and organonitrogen herbicides were tested. The only herbicide/fungicide compounds detected were Dacthal (one sample) Pentachlorophenol (two samples), 2,3,4,5-Tetrachlorophenol (one sample), and 2,3,4,6-Tetrachlorophenol (one sample). Although widespread, concentrations of legacy organochlorine pesticides like the DDT series were either below detection limits or, where detected, were generally below ecological or human health sediment guidelines.

PCB Aroclors

Aroclors were commercial mixtures of polychlorinated biphenyls (PCBs) that were widely used for their properties of chemical and thermal stability. They were banned in the 1970s, due to concerns about their toxicity. This study analyzed sediment samples for seven of the commonly

occurring Aroclor mixtures (Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260). None of the seven Aroclors were detected in any of the samples. Analysis of the sediment samples for specific co-planar and dioxin-like PCB congeners were beyond the scope of this study.

Chlorinated dibenzodioxins and dibenzofurans

Dioxins and furans are persistent toxic compounds that are created as a byproduct of combustion and manufacturing processes. This study analyzed sediment samples for 17 individual dioxin and furan compounds. 2,3,7,8-TCDD was not detected in any samples while 2,3,7,8-TCDF was found in one sediment sample. Octa CDD 1,2,3,4,6,7,8,9 was the most commonly found dioxin, occurring in 60% of samples, while HeptaCDD 1,2,3,4,6,7,8 was detected in 19% of samples. The highest concentrations for both Hepta and Octa CDD were found in a single sample taken from above Priest Rapids Dam (Station ID 6a). This location was also the sole occurrence for both Hepta and Octa CDF. The concentrations were generally below the screening levels for humans which represent concentrations in sediment below which chemicals would not be expected to accumulate in fish tissue above levels acceptable for human consumption (ODEQ, 2007).

PBDEs

Polybrominated diphenyl ethers are flame retardants that are present in many consumer products and are increasingly being found in the environment. Samples were analyzed for eight PBDE congeners (PBDEs 28, 47, 99, 100, 153, 154, 183, and 209). Six of the eight congeners were detected. The three most commonly detected PBDE congeners were: PBDE 47 which was found in 60% of samples; PBDE 100 which was found in 56% of samples; and PBDE 99 which was found in 56% of samples. Detected less frequently were: PBDE 28, found in 27% of samples; PBDE 153, found in 20% of samples; and PBDE 154, found in 18% of samples. PBDEs 183 and PBDE 209 were not detected.

Conclusions /recommendations

- No spatial pattern in sediment concentrations was seen that could be correlated to sources of contaminants identified in an earlier Region 10 CRBC study of Columbia River fish contaminants (USEPA 2002).

- No obvious hot spots or sinks for sediment contaminants were found in this area.

- Cadmium and zinc appear to show elevated concentrations compared to other areas within the basin. There are several potential sources of these metals including smelters upstream of the site above Grand Coulee dam as well as other non-point loading sources. Both of these metals merit further study.

- Several organochlorine pesticides, mainly DDTs, were detected, but at low levels near the

reporting limit. Although the concentrations could not be quantified precisely, the estimated levels were generally below ecological guidelines for sediments and screening levels for humans.

- Several organophosphate pesticides, including Azinphos-methyl were detected in a few samples. In addition, although Ethyl chlorpyrifos is known to be one of the more persistent and commonly used organophosphate pesticides, the detection of Ethyl chlorpyrifos and Malathion in a few of the samples raises a concern about the potential impacts of currently used agricultural chemicals on the health of the Columbia Basin aquatic ecosystem.

- Seven of the common PCB Aroclors were analyzed, but none were detected in any of the samples. Several of the chlorinated dibenzo-p-dioxins and furans were detected in a few samples, but were generally below the screening levels for humans.

- The presence of various PBDEs, and especially the more toxic lower brominated PBDE congeners at µg/kg quantities in nearly 60 percent of the sediment samples indicates additional investigation is needed.

- Targeted analytes in future studies should also include herbicides such as Glyphosate, which is associated with aquatic toxicity, and has been recently detected in various urban streams in the US (Kolpin, et al., 2006). Glyphosate was also recently detected in a small urban tributary associated with Portland, Oregon's Clackamas River drainage, Lower Columbia Basin (Carpenter, 2007).

- Future monitoring studies of sediment in the mid-Columbia main stem area should focus on emerging contaminants instead of continuing to focus on legacy organochlorines like DDTs and PCBs. This should include monitoring for PBDEs, pharmaceuticals and personal care products along with pesticides that have a potential for impacts on aquatic species, especially organophosphates such as Azinphos-methyl. Chemicals from storm water runoff from urbanized areas, as well as groundwater and surface water pollutants from large confined animal feeding operations (CAFOs) are also stressors on this ecosystem which will require increased attention.

1.0 Introduction

1.1 Background

The objective of this sediment contaminant survey was to identify the sediment concentration of chemicals that were measured in fish tissue during the Columbia River Fish Contaminant Survey (CRBC; USEPA 2002). In addition to chemicals that were found in fish tissue, other chemicals were added to the list of sediment measurements based on the likelihood of impacts to human health and the environment. Baseline data provided by this study will inform future sediment contaminant studies in the mid-Columbia region.

Many of the chemicals found in fish tissue during the fish tissue survey are no longer permitted for release into the environment. However, they continue to contaminate the food chain. The purpose of continuing to search for legacy pollutants is to ascertain the possible routes of exposure of these chemicals to fish and other aquatic organisms.

The goals of this study were twofold:

1. Identify any spatial patterns in sediment-borne contaminants which might be correlated with sources and uptake of some of the contaminants which were found to be prevalent in mid-Columbia fish tissue in USEPA Region 10's 2002 Columbia River Basin Contaminants Study.

2. Identify and prioritize likely contaminated sediment loading sites important to the mid-Columbia River, and evaluate these sites for their potential to act as "hot spots," or sinks, for contaminants within the ecosystem (USEPA 2003, 2004).

For the CRBC, USEPA Region 10, in collaboration with several tribes, completed an assessment of chemical contaminants in resident and anadromous fish species caught and consumed by four Native American Tribes (Nez Perce, Warm Springs, Umatilla, and Yakama) in the Columbia River Basin. The CRBC study found the highest levels of contamination in four resident fish species collected from the mid-Columbia and lower Yakima Rivers. These species were the white sturgeon (*Acipenser transmontanus*), mountain whitefish (*Prosopium williamsoni*), largescale sucker (*Catostomus macrocheilus*), and channel catfish (*Ictalurus punctatus*). Although there are several dams on the main stem of the Columbia River and its tributaries, the white sturgeon, largescale sucker, and mountain whitefish inhabiting the Hanford Reach and Lake Wallula may also range into the lower Snake and lower Walla Walla Rivers. White sturgeon are known to move downstream through dams (North et al., 1993), and largescale suckers and mountain whitefish have been observed moving both ways through dams (R. Baxter, personal communication February 11, 2003; J.D. Pock, personal communication March 25, 2003).

1.2 Contaminants of concern

For the present study, all sediment samples were analyzed in the laboratory for five major categories of contaminants:

- Metals

- Pesticides, including commonly occurring "legacy" chlorinated pesticides, as well as various organophosphate pesticides, and one carbamate (carbaryl). Samples were also analyzed for 30 selected herbicides and fungicides known to be commonly used in agricultural practices throughout the mid-Columbia Basin.

- PCB Aroclors. (Due to resource limitations, analyses for specific PCB congeners and dioxin-like PCBs were not conducted).

- Polychlorinated dibenzo-p-dioxins and dibenzo-p-furans (PCDD/PCDF).

- Polybrominated diphenyl ethers (PBDEs).

Expanding upon USEPA's 2002 CRBC findings in fish tissue, a more comprehensive list of targeted chemical analytes was developed for the present study of mid-Columbia sediments to include additional contaminants found in recent surveys conducted by the US Geologic Survey (Majewski et al., 2003) and US Department of Energy (2006) and included a few additional chemicals because of their high frequency of use in the mid-Columbia region. See Table 2 for a complete list of analytes along with their reporting limits. In addition, sediment samples were assessed at the laboratory for standard chemistry QA/QC criteria. Total organic carbon (TOC) and percent fines (particle size less than 63 microns diameter) were also assessed for each sediment sample.

1.2.1 Other studies

The existing information on contaminants in water, sediment, and fish tissue in the mid-Columbia Basin is extensive, but is limited to a few localized areas in this large basin. Data on the distribution of pesticides and other organic compounds in water, sediment, and fish tissue in the Yakima River are available (Johnson et al. 1986 & 1988, Rinella et al. 1992 & 1999, and others). Considerable water, sediment, and tissue data on trace metals and radioactive chemicals are available from samples taken along the west bank of the Columbia River, in the Hanford Reach (US Department of Energy, 2006). Multi-year surveys of trace element and organochlorine pesticide contamination in sediment, water and fish tissue in the irrigation return water from the east bank of the Columbia River in and above the Hanford Reach are also available (Embry & Block 1995, Gruber & Munn 1996, Williamson et al. 1998). Less information is available for the Walla Walla River (Seiders, et al., 2007) and for the reservoir above Priest Rapids Dam (Normandeau Associates, 2000). Some fish tissue analysis is available

from the lower Snake River below Ice Harbor Dam, (Beak Consultants, Inc. 1989, Dethloff et al. 2001), and some sediment analyses are available for Lake Wallula (Johnson & Heffner, 1993).

There is spatial and temporal variability among the studies cited above, and some of the reports do not include information on all of the contaminants of interest. The existing information, therefore, is not adequate to identify or evaluate all of the potential sources of the contaminants of concern that were found in the fish tissue analyzed for USEPA's CRBC study (USEPA 2002).

1.3 Study area

The study area is primarily the main stem Columbia River, extending from approximately River Mile (RM) 420 (Vantage area, above Wanapum Dam) to RM 292.2 (McNary Dam) in Washington State, (Figure 1). It also includes parts of the Columbia reservoirs that back up water into the lower parts of some of the tributaries such as the Walla Walla, Snake, and Yakima rivers.

2.0 Materials and Methods

2.1 Strategy and design

This study was designed to gather specific information on the distribution of mid-Columbia sediment contaminants of concern in known or suspected source areas and in areas where sediment might be expected to accumulate. Therefore, the sampling locations were not randomly selected but were based on previous sediment analyses, adjacent industrial and agricultural land uses, and site-specific information obtained during a preliminary field reconnaissance of the mid-Columbia area conducted in 2003 (USEPA, 2003). In general, all sediment samples were taken from sheltered backwater areas, downstream of islands, and in similar riverine locations in which water currents are slowed, favoring accumulation of finer sediment along the channel bottom.

Four types of sampling sites were targeted for study:

- lower regions of important tributaries such as Crab Creek and the Yakima, Snake, and Walla Walla rivers,
- areas of greater population and recreational use such as the Tri-Cities region and Lake Wallula,
- selected sites associated with nearby point sources like pulp mills, sewage treatment outfalls, irrigation returns, and parks, and
- sediment depositional areas behind three major dams in the mid-Columbia Basin.

The presence of fine sediment was used an indicator of chemical concentration since sorption of chemicals tends to increase with increased surface area (fine sediment). Thus, the sites were selected based on the high amount of fine sediment. The inclusion of sediment size and total

organic carbon was to test the theory that these sediment measures could be used to predict high levels of metal and organic concentrations in sediments.

For metals, which occur naturally in sediment, comparisons were made to studies from the upper and lower Columbia River, as well as to a national data set. For organic compounds, comparisons were made with screening values used to evaluate potential risk to ecological and human health.

Summary statistics were calculated for all analytes. For metals, the quartile intervals were compared to other datasets, and the quantities were compared to percent fines and total organic carbon using regression analysis.

2.2 Sampling locations and field collection

Because of the life histories and distributions of the four fish species discussed in the introductory section, the study area for this survey includes all waters of Lake Wallula (McNary Reservoir) including those parts of the reservoir that extend into the Walla Walla, Snake, and Yakima rivers. It also includes the approximately 45-mile Hanford free-flowing reach of the mainstem Columbia.

Samples were also collected from the area just above Ice Harbor Dam, which is the final Snake River dam just prior to its confluence with the mid-Columbia at Pasco. In addition, three areas along the 180 mile mid-Columbia segment examined here, were targeted to represent areas where sedimentation is likely to occur. These are located just above three main-stem Columbia dams (Wanapum, Priest Rapids, and McNary). (See Figure 1, and Table 1). The critical drainage pathway coming from Lower Crab Creek in the upper NE portion of the mid-Columbia study segment is also included, as are possible contributions coming from six other irrigation return sources along the river.

During October of 2004, 45 sediment samples from throughout the study area were collected. These samples were taken from 33 pre-selected sampling stations (Figure 1, Table 1), between river mile (RM) 420 near the City of Vantage, WA, downstream for approximately the next 128 river miles, to just above McNary Dam (RM 292.2).

The 33 sediment sampling stations were targeted to identify contaminant loading sources or potential “hot spots” from a specific drainage area, tributary, or land-based agricultural /industrial activity. For example, sediment areas impacted by contributions from inflow of important tributaries like Lower Crab Creek, Yakima River, Snake River, and Walla Walla River, were chosen in hopes of gaining better understanding of possible contributions from some of the agricultural drainage areas that influence the mid-Columbia. Other targeted areas included several major agricultural return canals and aqueducts.

A variety of other types of potential input sites were also sampled. These included portions of the Hanford reach, as well as specific portions of Lake Wallula in the vicinity of the relatively industrialized "Tri-Cities" (Richland-Kennewick-Pasco, WA), which receive input from POTWs, pulp mill effluent, storm drain runoff, and other typical urban sources. The sampling design also included sediments taken from near shore sampling sites adjacent to a few important public parks and recreational areas, as well as from near shore sediment adjoining a popular small golf and recreational/leisure community along the river.

2.3 Sampling

Most of the contaminants of interest are typically associated with fine sediments, rather than with coarse-grained sandy sediment or rocky substrates. Therefore, the goal of the sampling was to obtain sediments with at least 5% fines (i.e., particle size <63 μm, or passing through a #230 sieve, U.S. Army Corps of Engineers 2000). At some locations, however, larger-sized sediment proved to be all that was available under the field conditions encountered, and were thus collected and analyzed accordingly. In general, every attempt was made to collect sediments which were as high in fine sediment content as possible at each sampling site.

2.3.1 Sample collection

The majority of sediment samples were collected using an Ekman dredge (dimensions 6 in. x 6 in. x 9 in. deep) or a modified Van Veen grab sampler. Sampling devices were deployed via an attached boom, either deployed at dockside (i.e. directly off large dam structures such as McNary or Priest Rapids), or via a boat. Deployment depended on the area(s) being sampled and their widely varying topographic, benthic and water column conditions. Occasionally, samples were collected by wading into shallow near shore areas. In each case, attempts were made to sample the top 15-cm of sediment, but only the sediment in the top 2-cm layer and not touching the sides or bottom of the samplers was collected for analysis. In all cases, precise GPS positions were recorded for each sample.

2.3.2 Equipment decontamination

Sampling equipment and tools were brushed and cleaned prior to use and between sample locations with a phosphate-free detergent (e.g., Liquinox) and rinsed with ambient water and a final rinse of distilled /de-ionized water. Wherever possible, dedicated sampling tools were used in sample collection. Non-dedicated sample collection equipment was cleaned with detergent, rinsed with ambient water, and given a final D/I rinse. Equipment rinsate blanks were collected for non-dedicated sampling equipment at a frequency of at least 5% of the total number of samples.

2.4 Quality Assurance and Quality Control (QA /QC) requirements

QA samples included field duplicates, matrix spikes, duplicate matrix spikes, and rinsate blanks for non-dedicated field sampling equipment. The results of the QC requirements and QA sample analyses were used in data validation to determine the quality, bias and usability of the data generated.

2.4.1 Sample handling, custody and shipment requirements

Sample numbers were recorded on field data sheets immediately after collection. Samples were stored in coolers and kept under the custody of the field team at all times. Field samples were shipped to the laboratory in coolers with ice and cooled to approximately 4° C. Chain of custody records and other sampling documentation were kept in sealed plastic bags (Ziploc) and taped inside the lid of the coolers prior to shipment. A temperature blank accompanied each cooler shipped. Packaging, marking, labeling, and shipping of samples were in compliance with all regulations promulgated by the U. S. Department of Transportation in the Code of Federal Regulations, 49 CFR 171-177 and International Air Transport Association regulations.

2.4.2 Instrument calibration procedures and frequency

The field instruments were calibrated prior to use in accordance with the instrument manufacturer's specifications and/or the analytical methods specified in the quality assurance plan (QAPP) prepared to describe and guide this research (USEPA 2003, 2004). Field instrument calibrations were verified after every ten samples. The instruments used in analyses were calibrated and maintained in accordance with the specified analytical methods and/or the laboratory's standard operating procedures (SOPs).

2.4.3 Inspection/acceptance requirements for supplies and consumables

All sample containers used for this project were new and certified clean by USEPA Region 10 Manchester Environmental Laboratory (MEL). Sample container clean certification and analytical runs were kept in the laboratory files. In each case, the field sampling team made special note of the information on the certificate of analysis that accompanied each sample container to ensure that they met the specifications and guidance for contaminant free sample containers.

2.5 Analytical methods, reporting limits, and holding time requirements

The 45 sediment samples were analyzed for the majority of target compounds at the reporting limits and analytical methods listed in Table 2. Several analytes had only 44 samples analyzed because one sample was lost due to breakage during shipping. These include the organochlorine pesticides, herbicides and fungicides, and the PCBs.

2.6 Analytical laboratories involved in this research, and their responsibilities

PCDD /PCDF analysis for all samples was conducted at the US EPA Region 7 Laboratory (Kansas City, Kansas). Analysis for organochlorine pesticides and PCB Aroclors was conducted by A4 Scientific, Spring, Texas. Individual PCB congeners were not targeted in this study. Analysis was conducted only for seven commonly occurring PCB Aroclors. The remainder of the
project's analytical requirements were performed by the USEPA Region 10 Manchester Environmental Laboratory (MEL), Port Orchard, Washington.

3.0 Results and Discussion

3.1 Metals

The study analyzed sediment samples for several metals including: arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc. The metal results in this study were compared to two other studies on metals in the Columbia Basin and a nation-wide study. The purpose of the comparisons is to place the results from this study in a broader geographic context in order to evaluate whether there are obvious "hot spots" that require further evaluation. The metal results are also compared with ecological and human health guidelines when available.

Several studies have been completed in the Columbia River Basin and nation-wide evaluating the concentrations of metals in sediments. For each metal below, the results from three studies are compared to the 25th percentile, 50th percentile, and 75th percentile from the current study (see Table 3). One of the studies provides a broad national comparison and the other two allow both an upstream and downstream comparison within the Columbia.

The studies used for comparison with the current study are: 1) a USGS National Water-Quality Assessment Program (NAWQA) study that looked at trace-elements concentrations in 541 streambed-sediment samples collected from 20 study areas across the United States (Rice, 1999). 2) an EPA study that collected 77 metal samples from randomly chosen sites in the Lower Columbia as part of the Environmental Monitoring Assessment Program (EMAP study, Hayslip et al, 2007); and 3) a study of five reference sites by the USGS of fine-grained beach and bed sediment to compare with Lake Roosevelt samples (Majewski, et al., 2003).

None of these comparison studies is intended to be used to represent "background" concentrations for comparison with the study data. Each of the comparison studies cited has unique aspects that need to be taken into account when interpreting the data. For example, the NAWQA study's strength as a comparison dataset is that it has a large number of samples and represents a broad range of environments. It does not attempt to characterize unimpacted areas, however, which is why the maximums for that dataset were not used in the comparisons.

The strength of the Lower Columbia EMAP dataset is that the study uses unbiased, randomly-located samples to characterize the area. This sample design allows reporting on the percentage

of the area (rather than the number of samples) within the Lower Columbia that is above or below a certain concentration. However, because these data were collected downstream of the study area reach, concentrations in the Lower Columbia are not independent of concentrations within the study area described in this report.

The USGS reference dataset from the upper Columbia is useful primarily because the data come from upstream in the same watershed, and the samples were located specifically to be outside the area of Lake Roosevelt that is known to be impacted by metals contamination. This study used only a small dataset, however, and the data do not represent as diverse an area as the drainage basin of the mid-Columbia.

In addition to the geographic comparisons described above, the results from this study are compared against several ecological sediment guidelines. The comparisons are intended to show whether any of the metals exceeded ecological sediment guidelines and require additional evaluation. The comparisons are not intended to indicate whether a given location has the potential for elevated human health risk from the metals. A further evaluation would need to be conducted to identify any areas of high risk to humans, if those are present. The ecological sediment guidelines selected for comparison are the Probable Effect Concentration (PEC) and the Threshold Effect Concentrations (TECs) (see Table 4). The PECs were intended to identify contaminant concentrations above which harmful effects on sediment-dwelling organisms are expected to occur frequently. The TECs are intended to identify contaminant concentrations below which harmful effects on sediment-dwelling organisms are not expected. The TECs and PECs used in this report are taken from the consensus-based sediment quality guidelines for freshwater ecosystems developed by MacDonald, Ingersoll, and Berger (2000). When calculating summary statistics for the metals it was assumed that non-detects had a concentration of ½ the MDL.

For human health, no appropriate sediment guidelines or screening level values specific to the Columbia River were found for metals. Finally, the results for the metals are evaluated to see if there is a correlation with the percent sediment fines (particle size less than 63 microns) or Total Organic Carbon (TOC).

3.1.1 Arsenic

Figures 2 - 6, and Tables 3 and 5 show the results for arsenic. The results are reported as total arsenic. Twenty-nine of the 45 samples (64%) had detectible levels of total arsenic (MDL of 4.5 mg/kg). Arsenic concentrations ranged from 4.5 - 20 mg/kg, with a mean of 5.07 mg/kg. The highest level for arsenic (20 mg/kg) was found at Station 9, taken from Hanford 100-F. This sample is elevated in comparison to the rest of the arsenic data (2 times the next highest concentration). As shown in Figures 4 and 5, there is no correlation between arsenic and percent fines (R-squared = 0.02) or with TOC (R-squared = 0.07). The levels of arsenic in this sediment study are comparable to other studies (see Table 3 and Figure 6). Only the highest sample was above the TEC of 9.8 mg/kg and none of the samples were above the PEC of 33 mg/kg (see Table 4 and Figure 2).

3.1.2 Cadmium

Figures 7 - 11, and Tables 3 and 5 show the cadmium results. Cadmium was detected in 26 of the 45 (58%) samples (MDL of 0.5 mg/kg). Cadmium concentrations ranged from 0.5 – 6.0 mg/kg with a mean of 1.09 mg/kg. The highest cadmium concentrations were found at Station 18 from above the Yakima River Delta, which also showed the highest concentrations of mercury and zinc. As shown in Figures 9 and 10, there was no correlation between cadmium and the percent fines (R-squared = 0.002) and only a slight correlation with TOC (R-squared = 0.25).

As shown in Table 3 and Figure 11, the concentrations of cadmium are generally higher than other sites within the Columbia Basin as well as being above those from the national NAWQA study. Seventeen of forty-five samples (38%) exceeded the TEC eco-benchmark (0.99 mg/kg) and one sample exceeded the PEC eco-benchmark of 4.98 mg/kg (Table 4 and Figure 7). Cadmium is one of the metals known to be elevated in the Upper Columbia cleanup site upstream of the study area (Majewski et al., 2003).

3.1.3 Chromium

Figures 12 - 16, and Tables 3 and 5 show the results for chromium. Total chromium was detected in 100 percent of the 45 sediment samples (MDL of 0.5 mg/kg). Levels ranged from 6.13 - 23 mg/kg, with a mean of 14.37 mg/kg. The highest chromium concentrations were found at Station 6b taken from a site immediately above Priest Rapids Dam, which was also the location of the highest copper concentration. As shown in Figures 14 and 15, there was no significant correlation between chromium and percent fines (R-squared = 0.01) or TOC (R-squared = 0.04). As shown in Table 3 and Figure 16, the levels of chromium in this study are below those found in the other comparison studies. As shown in Table 4 and Figure 12, all chromium samples are below the ecological guidelines for TEC (43.4 mg/kg) and PEC (111 mg/kg).

3.1.4 Copper

Figures 17 - 21, and Tables 3 and 5 show the copper results from this study**.** Copper was detected in all of the 45 of the sediment samples (MDL of 0.4 mg/kg). Concentrations ranged from 4.72 to 36.5 mg/kg, with a mean of 17.10 mg/kg. The highest copper concentration (also highest for chromium) was found at Station 6b immediately above Priest Rapids Dam. As shown in Figures 19 and 20, there was no correlation between percent fines and copper (R-squared = 0.06) and only a slight correlation between TOC and copper (R-squared = 0.23).

As shown in Table 3 and Figure 21, the concentrations of copper in most samples in this study are similar to, or below results from other studies. The highest value detected (36.5 mg/kg) exceeded the eco-based TEC of 32 mg/kg. None of the samples exceeded the PEC value of 149 mg/kg (See Table 4 and Figure 17).

3.1.5 Lead

Figures 22 - 26, and Tables 3 and 5 show the lead results from this study. Lead was detected in 44 of the 45 (98%) samples collected (MDL of 2.5 mg/kg). Lead concentrations ranged from 3.0 -75.9 mg/kg, with a mean of 12.43 mg/kg. The highest concentration was found at Station 9 from the Hanford 100-F site. As shown in Figure 24 and 25, there was no correlation between percent fines and lead (R-squared = 0.0004) and a very slight correlation between TOC and lead (R-squared = 0.16). The levels of lead in most of the samples in this study are comparable to those found in other Columbia Basin studies (See Table 3 and Figure 26). Only 1 of 45 samples exceeded the eco-based TEC value of 35.8 and no samples exceeded the eco-based PEC value for lead of 128 mg/kg (See Table 4 and Figure 22).

3.1.6 Mercury

Figures 27 - 31, and Tables 3 and 5 show the mercury results from this study. Mercury results are reported as total mercury and not speciated into methyl mercury or other organic varieties of this metal. Mercury was detected in 18 of the 45 (40%) samples (MDL of 0.04 mg/kg). Mercury concentrations ranged from 0.04 - 0.167 mg/kg, with a mean of 0.04 mg/kg. The highest level of mercury (0.167 mg/kg) was found at Station 18, taken above the Yakima River Delta area. This sample also had the highest levels for both cadmium and zinc. As shown in Figures 29 and 30, there was no correlation between percent fines and mercury (R-squared = 0.001) and only a slight correlation with mercury and TOC (R-squared = 0.20). The levels of mercury in this study are slightly higher than in the upstream and downstream comparison datasets from the Columbia Basin, but less than those found in the national NAQWA study (See Table 3 and Figure 31). Metal smelters upstream are possible sources of mercury as well as of cadmium and zinc. None of the samples exceeded either the eco-based TEC value (0.18 mg/kg) or the PEC (1.06 mg/kg) for mercury (See Table 4 and Figure 27).

3.1.7 Nickel

Figures 32 - 36, and Tables 3 and 5 show the nickel results for this study. Nickel was detected in all of the 45 samples (MDL of 1 mg/kg). Nickel concentrations ranged from 5.6 to 26.9 mg/kg, with a mean of 15.10 mg/kg. The highest level of nickel was found at Station 21 in the Yakima River. As shown in Figures 34 and 35, there was no correlation between nickel and either percent fines (R-squared = 0.003) or TOC (R-squared = 0.03). The levels of nickel in this study are lower than in other Columbia Basin studies (See Table 3 and Figure 36). Five of the 45 samples (11%) exceeded the eco-based TEC value of 22.7. None of the samples exceeded the PEC value of 48.6 mg/kg (See Table 4 and Figure 32).

3.1.8 Zinc

Figures 37 - 41, and Tables 3 and 5 show the zinc results. Zinc was detected in 100% of the 45

sediment samples taken (MDL of 0.4 mg/kg). Zinc concentrations ranged from 25.8 to 558 mg/kg, with a mean of 143.24 mg/kg. The highest concentration for zinc (also for mercury and cadmium) was found at Station 18 taken from the area below the Yakima River Lower Delta. Figures 39 and 40 indicated no correlation between percent fines and zinc (R-squared = 0.01) and some correlation between zinc and TOC (R-squared = 0.29). As shown in Table 3 and Figure 41 the levels of zinc are generally higher than in other study areas in the Basin. Zinc is one of the metals known to be elevated in the Upper Columbia cleanup site upstream of the study area (Majewski et al., 2003). Figure 37 and Table 4 indicate that zinc levels in 15 of the 45 samples (33%) exceeded the TEC of 121 mg/kg and one sample exceeded the PEC of 459 mg/kg (Yakima River Lower Delta, 558 mg/kg)**.**

3.1.9 Metals summary

The concentrations for the majority of metals evaluated in this study were similar to, or lower than two studies within the Columbia Basin and one national study. The exceptions were cadmium which had mean concentrations 3 – 9 times higher than the other studies and zinc which had mean concentrations above those of the other studies. Concentrations of cadmium and zinc were also above the eco-based TEC value in 38% and 33% of samples, respectively. These metals are known to be elevated at upstream locations where metal smelters have historically discharged wastes. There were no significant correlations seen between the metals and percent sediment fines and TOC.

There were several sites that stand out as having the highest concentrations of metals. Station 18 (Yakima River Lower Delta) had the highest concentrations of mercury, cadmium, zinc, and nickel. Station 6b (above Priest Rapids Dam) had the highest concentrations of chromium and copper samples and the second highest concentrations of cadmium and nickel samples. Station 9 (Hanford Reach, 100-F area) had the highest concentrations of lead and arsenic samples and the second highest copper concentrations.

3.2 Organic compounds

The study sampled and analyzed several organic compounds including: organochlorine, organophosphate and carbamate pesticides; herbicides and fungicides; PCB Aroclors; dioxins and furans; and polybrominated diphenyl ethers (PBDEs). The results for the organic compounds are compared against several ecological sediment guidelines and where available, human health sediment screening levels. The comparisons are intended to show whether the organic compounds significantly exceed the guidelines and/or screening levels and if further evaluation is needed. As with the metals, the comparisons are not intended to be used to indicate whether there is potential for elevated human health risk from any of the organic compounds detected in the sediments. The ecological guidelines selected for comparison are the Probable Effect Concentrations and Threshold Effect Concentrations as defined and discussed previously in the metals section. The TECs and PECs used throughout this report are from the consensus-based sediment quality guidelines for freshwater ecosystems developed by MacDonald, Ingersoll, and Berger (2000). PEC and TEC values are not available for all the organic

compounds analyzed for in the study.

For human health, the bioaccumulative screening level values (SLVs) for humans for several compounds are included in Table 6. The SLVs are from the Oregon Department of Environmental Quality document "Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment" (ODEQ, 2007). These values represent concentrations in sediment below which chemicals would not be expected to accumulate in fish tissue above levels acceptable for human consumption. Two values are presented for humans. The lower value is based on a fish consumption rate for the general population of 17.5 grams per day and the higher rate is based on a fish consumption rate of 142 grams per day for subsistence/tribal populations. SLVs are not available for all the compounds tested in this report.

The majority of organic samples analyzed were either not detected (U-values) or were detected, but at a concentration that was estimated (J-values). The exceptions were two dioxin congeners found in several samples at concentrations that were not flagged with either a U- or J-qualifier. Because the majority of results were reported as J-values, the concentrations for the samples are presented as ranges of values. No means or other statistics were calculated with the exception of the two dioxin congeners.

3.2.1 Pesticides

Table 2 provides a list of the pesticides targeted and the analytical reporting limits. For specific results for the different groups of pesticides, see Tables 7 - 9 and Figures 42 – 45. Forty-five sediment samples were collected from 33 sampling sites. However, one sample was lost due to breakage during shipment and therefore only 44 samples were analyzed for the organochlorine pesticides, herbicides, and fungicides.

3.2.1.1 DDTs

Figure 42 and Table 7 show the results for total DDTs. Twenty-nine of the 44 analyzed sediment samples (66%) showed detectible levels of either DDT, DDE, or DDD (reporting limit of 0.1 ug/kg). Estimated sediment concentrations for total DDT ranged from 0.11 µg/kg (as p,p' DDE) at Station 29b (Burbank Backwater) to a maximum of 4.94 µg/kg at Station 25b (Twin Rivers Park). For total DDT, none of the 44 samples exceeded either the TEC (5.3 µg/kg) or the PEC (7 µg/kg) (Figure 42). However, all of the detected samples exceeded the lowest ODEQ SLV of 0.04 ug/kg.

Figure 43 and Table 7 show the results for p,p' DDE. P,p' DDE was detected in 27 of the 44 samples (61%). The estimated concentrations ranged from 0.11 to 1.6 µg/kg, with the highest concentration at Station 26c (Snake River above Ice Harbor Dam). All 44 samples were below the TEC value of 3.2 µg/kg and the PEC value of 31.3 µg/kg (Figure 43 and Table 6).

P,p' DDD was detected in 11 of the 44 (25%) samples. The estimated concentration ranged from 0.13 µg/kg to 0.73 µg/kg. The highest level of p,p' DDD, 0.73 µg/kg, was found at

Station 16 (below the Richland STP Outfall). All the results for p,p' DDD were well below the TEC value (4.9 µg/kg), and the PEC value (28 µg/kg) (Figure 44 and Table 6).

P,p' DDT, was detected in 12 of the 44 (27%) samples. The estimated concentrations ranged from 0.13 ug/kg to 2.80 ug/kg. The highest level of p,p' DDT was found at Station 25b (Twin Rivers Park). P, p' DDT did not exceed the PEC value (62.9 µg/kg), or the TEC value (4.16 µg/kg) (Figure 45 and Table 6).

O,p' DDT was detected in one of the samples (2%), at an estimated concentration of 1.60 µg/kg, at Station 25b (Twin Rivers Park). O,p' DDE**,** and o,p' DDD were not detected in any of the sediment samples.

3.2.1.2 Other organochlorine pesticides

Table 7 shows the results for other organochlorine pesticides, including Alpha Chlordane; Gamma Chlordane; cis-Nonachlor; Mirex; Hexachlorobutadiene; Lindane; Hexachlorobenzene; Toxaphene; and Methoxychlor. The only organochlorine pesticide detected, other than the DDT's, was Hexachlorobenzene (HCB). HCB was found in four of the 44 sediment samples, with estimated concentrations ranging from 0.11 µg/kg (Station 30c, below Boise-Cascade outfall) to 0.24 µg/kg (Station 1 at the Wanapum Dam). The reporting limit for HCB was 0.1 ug/kg. HCB was below the lowest SLV of 2.3 µg/kg. There are no PEC or TEC values for HCB.

3.2.1.3 Organophosphate and carbamate pesticides

A total of 45 sediment samples, taken from 33 different sampling sites were analyzed for organophosphate and carbamate pesticides and organonitrogen herbicides. Results for these groups of pesticides are shown in Table 8. Carbaryl was the only carbamate pesticide analyzed in the study and was not detected in any of the 45 samples analyzed.

The five organophosphates tested for included Malathion, Diazinon, Parathion-methyl, Azinphos-methyl, and Chlorpyrifos-ethyl. Three of the organophosphates were detected in this study: Azinphos-methyl (2 samples), Cholorpyrifos-ethyl (3 samples), and Malathion (3 samples).

Azinphos-methyl was detected in two of the 45 samples (4%), taken from two different sites: Station 13 (Potholes Canal Aqueduct) contained an estimated 11.0 µg/kg, while Station 5a (across the river from Desert Aire Resort) reported an estimated concentration of 17 µg/kg. There are no ODEQ SLVs or TECs/PECs for Azinphos-methyl.

Ethyl chlorpyrifos was detected in three of the 45 analyzed sediment samples (7%), at three sites. None of these three samples contained any of the other organophosphate compounds assessed in this study. Station 3 (Wanapum Dam, near Vantage) had an estimated concentration of 2.0 µg/kg, while Station 12 (Spoils bank near Wahluke Branch) had an estimated concentration of

3.0µg/kg, and Station 19b (Yakima River below the Hwy 240 Bridge) reported an estimated concentration of 3.0 µg/kg. There are no DEQ SLVs or PECs/TECs for Ethyl chlorpyrifos.

Malathion was detected in three of the 45 sediment samples (7%), one from each of three different sampling sites. These were: (1) Wahluke Branch 5 (Station 11, estimated at 4 µg/kg); (2) Ezquatzel (Station 14, estimated at 4 µg/kg); and (3) Yakima River Delta (Station 20, estimated at 3 µg/kg). There are no DEQ SLVs or PECs/TECs for Malathion.

3.2.1.4 Herbicides and fungicides, including halogenated, chlorophenolic, and organonitrogen compounds

A total of 45 samples, from 33 sampling sites, were analyzed for 30 various chlorinated acid, chlorophenolic, and organonitrogen herbicides which are commonly used in agriculture in the Pacific Northwest. All analyses were performed by the USEPA Region 10 MEL. A complete list of the analytes selected from this group of target compounds, and results obtained, can be found in Tables 2 and 9. The only compounds detected from this general group were Dacthal, Pentachlorophenol (PCP), 2,3,4,5-Tetrachlorophenol, and 2,3,4,6-Tetrachlorophenol.

Dacthal (DCPA) was detected in a single sediment sample at Station 30a (below the Boise Cascade outfall). PCP was detected in two of the 45 sediment samples. The highest estimated value was 40.0 µg/kg from Station 6b (above Priest Rapids Dam), with the other sample having an estimated concentration of 3.1 µg/kg from Station 30a (below the Boise-Cascade outfall). This sample also contained measurable DCPA (Dacthal). The estimated 40 µg/kg value for PCP exceeded the 30 ug/kg lowest SLV DEQ human health sediment value listed for that compound (Table 6). Station 6b (above Priest Rapids Dam), which had detectable PCP, also contained 2,3,4,5-tetrachlorophenol at an estimated concentration of 2.7 µg/kg, and 2,3,4,6-tetrachlorophenol at an estimated concentration of 2.3 µg/kg.

3.2.1.6 Pesticide summary

None of the DDT/DDE/DDD samples exceeded the PEC, TEC, or DEQ bioaccumulation screening level value with the exception of total DDT, which exceeded DEQ's lowest bioaccumulation SLV. HCB was the only other organochlorine found, and it was below the DEQ human health SLV. Three organophosphate pesticides were detected, including two samples which were positive for Azinphos- methyl. Three samples contained traces of Malathion, a commonly used insecticide for home and garden purposes. Three other sediment samples contained Ethyl chlorpyrifos. Thirty different herbicidal and fungicidal compounds routinely used in the Columbia Basin were sampled. Dacthal, PCP, 2,3,4,5-tetrachlorophenol, and 2,3,4,6-tetrachlorophenol were the only compounds detected. This may be in part because many of these compounds are comparatively unstable in the aquatic environment and break down relatively quickly compared to more persistent compounds such as organochlorines.

3.2.2 Polychlorinated biphenyl Aroclors (PCBs)

All PCB data are shown in Table 10. Forty-five sediment samples were collected from all 33 sampling sites. However, one sample was lost due to breakage during shipping. Consequently, forty-four samples were analyzed by A4 Analytical Laboratories, in Spring, Texas. The sediment samples were analyzed for seven commonly occurring PCB Aroclors which might be anticipated to occur in sediment samples from this region, and which in the literature, are frequently found in fish tissue. These PCB Aroclors were 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Congener specific PCBs including dioxin-like PCBs were not analyzed due to funding limitations. These seven Aroclors were not detected in any of the samples.

3.2.3 Polychlorinated dibenzo-p-dioxins (PCDD) and dibenzo-p-furans (PCDF)

The results for the PCDDs and PCDFs are shown in Table 11 and Figures 46 and 47. Forty-five samples were collected from 33 sites. All dioxin and furan congener analyses were performed by USEPA Region 7 Laboratory, Kansas City, Kansas. Samples were analyzed for eight dioxin congeners and nine furan congeners.

3.2.3.1 Dibenzo-p-dioxins

Only two dioxin congeners were detected: 1,2,3,4,6,7,8,9 Octachlorodibenzo-p-dioxin (OCDD) and 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin (HpCDD). The most commonly detected dioxin congener was OCDD, occurring in 29 of the 45 (60%) sediment samples (see Figure 46). OCDD levels ranged from 10.6 - 1010.0 ng/kg, with a mean level of 72.8 ng/kg for the detected samples. The highest concentration of OCDD was found at Station 6a (above Priest Rapids Dam). The SLVs for OCDD are 2800 or 23,000 ng/kg depending on the fish consumption level assumed (Table 6), and are both well above the levels detected in this study.

Nine of the 45 samples (18%) contained HpCDD. Concentrations ranged from 5.06 to 91.5 ng/kg, with a mean of 22.6 ng/kg for the detected samples (see Figure 47). As was the case for OCDD, the highest concentration of HpCDD was found at Station 6a (above Priest Rapids Dam). The SLVs for HpCDD are 85 or 690 ng/kg, depending upon which level of fish consumption is assumed.

3.2.3.2 Dibenzo-p-furans

Three of the 45 sediment samples (9%) tested in this study showed positive results for dibenzofurans. Three different dibenzofuran congeners were found in the various samples. Station 6a (above Priest Rapids Dam) contained 1,2,3,4,6,7,8,9-Octachloro dibenzo-p-furan (OCDF) at 39.4 ng/kg. The same sample also contained 1,2,3,4,6,7,8 Heptachloro dibenzo-p-furan (HpCDF) at 5.67 ng/kg A sample from the Yakima River Lower Delta site (Station 20) contained 2,3,7,8-tetrachlorodibenzo-p-furan (TCDF) at an estimated concentration of 1.09 ng/kg. The SLVs for these three congeners are 2800 or 23,000 ng/kg (OCDF), 85 or 690 ng/kg (HpCDF), and 0.09 or 0.8 ng/kg (TCDF), depending upon which level of fish consumption is

assumed (Table 6). Of the three positive detects for dibenzofurans, only TCDF exceeded SLV benchmarks.

3.2.3.3 Dioxin and furan summary

Only two of the eight chlorinated dioxin congeners were detected: OCDD, the most commonly occurring congener, and HpCDD. Three of the nine chlorinated furans were detected: HpCDF, OCDF and TCDF. The highest concentrations for both HpCDD and OCDD, and also for both the single occurrences noted for HpCDF and OCDF, were found in a single sample taken from above Priest Rapids Dam. The concentrations of the dioxins and furans were generally below the SLVs for humans, with the exception of 2,3,7,8-TCDF.

3.2.4 Polybrominated diphenyl ethers (PBDEs)

Table 12 and Figure 48 and 49 show the results for PBDEs. A total of 45 sediment samples, obtained from all the 33 sampling sites were analyzed for PBDEs. Eight PBDE congeners were included in the analysis: PBDE 28 (2,4,4'-tribromo); PBDE 47 (2,2',4,4'-tetrabromo); PBDE 99 (2,2',4,4',5-pentabromo); PBDE 100 (2,2',4,4',6-pentabromo); PBDE 153 (2,2',4,4',5,5'-hexabromo); PBDE 154 (2,2',4,4',5,6'-hexabromo); PBDE 183 (heptabromo); and 209 (decabromo). Of the eight PBDE congeners tested, six were detected.

Total PBDEs were detected in 27 of the 45 samples (60%), but all were detected at low levels and concentrations were estimated. Total PBDEs in samples with detected levels ranged from an estimated low of 0.24 µg/kg (Station 30a, below Boise-Cascade Pulp Mill), to an estimated high of 2.81 µg/kg (Station 23 below the Port of Kennewick).

The most commonly detected congeners were PBDE 47, PBDE 100, and PBDE 99. PBDE 47 was found in 27 of the 45 sediment samples (60%). Estimated levels ranged from 0.082 ug/kg (Station 2, Sand Hollow) to 1.2 ug/kg (Station 23, below Port of Kennewick). PBDE 100 was found in 26 of the 45 samples (56%). Estimated levels ranged from 0.084 (Station 30b, below Boise Cascade outfall) to an estimated concentration of 0.84 ug/kg (Station 23, below Port of Kennewick). PBDE 99 was detected in 25 of the 45 samples tested (56%) with an estimated range of 0.026 ug/kg (Station 30b, below Boise Cascade outfall) to 0.34 ug/kg (Station 23, below Port of Kennewick).

Lower frequencies of detection and lower estimated levels were reported for PBDE 28 (detected in 12 samples), PBDE 153 (detected in 9 samples), and PBDE 154 (detected in 8 samples). PBDEs 183 and 209 were not detected in any of the 45 sediment samples.

Six of the 45 sediment samples (13%) contained estimated amounts of all six of the PBDEs detected in this study. These were: Station 1 (Wanapum-Vantage); Station 23 (below Port of Kennewick); Stations 25a and 25b (Twin Rivers Park); Station 29a (Below Kennewick Industrial Area), and Station 30a (below Boise-Cascade outfall). At this time, there are no TECs, PECs, or SLVs for PBDEs in sediment.

3.2.4.1 PBDEs summary

Of the 209 possible PBDE congeners that exist, PBDEs 47, 99, 100, 153 and 154 are usually part of the mixture which constitutes the commercially produced "Penta PBDE" mixture of fire retardant, which is added to materials such as foam cushions and mattresses. Although US production of this common Penta PBDE mixture was voluntarily stopped in 2004 (Federal Register, 2004), the key ingredients, PBDEs 47 and 99 were still frequently detected in these mid-Columbia sediments.

The more highly brominated PBDE congeners such as the "Hexa" PBDEs 153, 154, and "Hepta" PBDE 183 are typically found as part of commercial PBDE mixtures known commercially as the "Octa PBDE" class of BDE fire retardants. These are added as fire-retarding components to plastic housings and hard plastic materials (Darnerud et al., 2001), and were also phased out in 2004 (Federal Register, 2004). These PBDEs were less prevalent in sediment in the study area than were the "Penta" PBDEs.

The presence of PBDEs, especially the more toxic lower brominated PBDE congeners at µg/kg quantities in nearly 60 percent of the sediment samples indicates additional investigation is needed.

4.0 Conclusions and Recommendations

From the findings of this study, several conclusions and recommendations for future research may be drawn:

1. No spatial patterns in sediment were seen that could be correlated to sources of contaminants identified in the 2002 CRBC study of contaminants in Columbia River fish. Nor do the findings here suggest that sediments are likely to be a sole source of the contaminants seen in the fish. Much additional analysis would be required to determine the percent contributions of sediment-borne contaminants to those seen in the various fish species studied in 2002.

2. This study was not designed to characterize the overall sediment quality of this reach of the mid-Columbia. It involved a relatively small number of samples distributed along 280 river miles and near the mouths of major tributaries, and targeted 33 sites likely to represent sediment loading and sequestration of potentially bio-available contaminants. However, no obvious hot spots or sinks for contaminants were found, even though sites with higher likelihood were targeted for sampling. Possible exceptions to this are cadmium and zinc, which are elevated compared to upstream reference sites and to downstream ambient concentrations and also exceed established threshold effect concentrations in 38% and 32% of samples, respectively. There are several potential sources for these metals including metal smelters upstream and non-point loading sources, both of which merit further study.

3. Several organochlorine pesticides were detected. Sixty-six percent of the samples had detectible levels of either DDT, DDE, or DDD. The vast majority of the DDTs were below the ecological guidelines and human health SLVs for sediments. Hexachlorbenzene was the only other organochlorine pesticide detected and was found in 9% of the samples analyzed.

4. With certain exceptions, most organophosphate pesticides are typically regarded as being relatively "non-persistent" in environmental media. However, in the present study, three organophosphates—Azinphos-methyl, Ethyl chlorpyrifos, and Malathion-- were found in a few sediment samples. Most notable of these was the presence of Azinphos methyl in two samples, at concentrations of 17 and 11 µg/kg. Three other samples contained traces of Ethyl chlorpyrifos, ranging from 2 to 3 µg/kg. Three samples were also positive for Malathion. One of these three samples also was positive for Azinphos- methyl. Detectible levels of organophosphate pesticides in freshwater sediment are not often described in the available literature for the Columbia Basin. The positive findings for these three toxicants is thus added reason for further evaluation, and continued concern, about potential impacts of lingering residues of various current use agricultural chemicals on the health of the Columbia Basin aquatic ecosystem.

5. Seven common PCB Aroclors were analyzed in this study to identify possible "hot spots" indicative of historic PCB Aroclor spills or disposal sites. None of the Aroclors were detected. While small areas of PCB point sources may continue to exist at various places along the river, this study (which was not designed or intended to detect very low levels of PCBs, or to identify specific dioxin- like PCB congeners) did not identify any sites which were indicative of areas of excessive PCB contamination or loading sources. Future work in the area should consider including specific congener analysis.

6. Although 2,3,7,8-TCDF was found in one sample from the Yakima River Lower Delta, 2,3,7,8-TCDD was not detected in any sample. OCDD was the most commonly found dioxin, occurring in 60% of samples, while HpCDD was detected in 19% of samples. The highest concentrations for both HpCDD and OCDD were found in a single sample taken from above Priest Rapids Dam. This location was also the sole occurrence for the polychlorinated dibenzo-p-furans HpCDF and OCDF.

7. The widespread presence of several PBDEs, and especially the more highly toxic lower brominated PBDE congeners, at µg/kg quantities in nearly 60 percent of the sediment samples evokes concern. Rayne et al (2003) have reported that for the period from 1992-2000, total PBDE levels in mountain whitefish from the Columbia River have increased by a factor of twelve, with a doubling period of 1.6 years. In addition to the greater ecotoxicity of the tetra and penta brominated congeners, PBDE compounds in aquatic environments are increasingly being linked to undesirable chronic ecotoxicological endpoints such as endocrine disruption, developmental and reproductive effects. (McDonald, 2002, Legler and Brouwer, 2003, Vos, et al., 2003). In studies of laboratory rodents, PBDEs have been associated with neuro-developmental toxicity (Viberg et al, 2003, Birnbaum and Staskal, 2004).

8. Although most of the sampling efforts here focused upon sediments along the main-stem Columbia, it is important to bear in mind the importance of the greater network of major tributary streams which serve as primary sources for the loading and biogeocycling of Columbia Basin contaminants. In future studies, more attention should be paid to sediment uptake and loading within these major tributaries (i.e., Snake, Walla Walla, Yakima Rivers, etc.). The Yakima Lower Delta, for example, had samples containing the highest sediment concentrations for mercury, cadmium, zinc, and nickel. With such a small number of samples, it is difficult to know whether this spatial pattern is consistent. But even in this preliminary investigation, these findings are a reason to focus future studies on investigating why these elevated metal are reflective of this predominantly agricultural drainage area.

9. It is also recommended that for organic compounds, future studies of sediment-borne contaminants in the mid-Columbia Basin go beyond their traditional focus on legacy organochlorines like DDTs and PCBs. Instead, increased attention should be paid to some of the emerging, new classes of contaminants in water (Kolpin, et al., 2002). This should, of course, include a continued monitoring effort for PBDEs. More emphasis also needs to be placed on certain currently used pesticides, especially the organophosphates such as Azinphos-methyl.

10. Future studies should also include pesticides and herbicides such as Glyphosate, which is associated with aquatic toxicity and-- despite its reputation as being a non-persistent compound -- is being detected in urban streams in the US (Kolpin, et al., 2006). Glyphosate was recently detected in a small urban tributary associated with Portland, Oregon's Clackamas River drainage, Lower Columbia Basin (Carpenter, 2007).

11. More attention should also be paid to the potential of impacts from pharmaceuticals and personal care products (Daughton & Ternes, 1999), as well as chemical and microbiological contaminants from municipal and agricultural waste sources (Tallon, et al., 2005). This would also include municipal sewage. However, consideration should also be extended to large confined animal feeding operations (CAFOs), which are also emerging as important sources for non-traditional chemical and microbiological contaminants with the potential to impact surface water and ground water (Orlando, et al., 2004).

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Table 1. Sample Locations, Mid-Columbia Sediments

Station ID	Sample ID	Latitude	Longitude	Sample date	Location
1	04444208	46.94058963	-119.9829414	28-Oct-04	above Wanapum dam, near Vantage
2	04444209	46.92925277	-119.9568703	28-Oct-04	Sand Hollow
3	04444210	46.90551399	-119.987497	28-Oct-04	above Wanapum dam
4	04444202	46.81835384	-119.9178648	26-Oct-04	Lower Crab Creek
5a	04444203	46.7108687	-119.973006	26-Oct-04	across from Desert Aire
5b	04444204	46.68004984	-119.9545718	27-Oct-04	above Priest Rapids dam
6a	04444205	46.65910259	-119.9428758	27-Oct-04	above Priest Rapids dam
6b	04444206	46.65912389	-119.9120338	27-Oct-04	above Priest Rapids dam
7	04434247	46.63644396	-119.7898294	22-Oct-04	Mattawa drain
8	04434246	46.67646044	-119.4529796	21-Oct-04	Wahluke branch 10
9	04434245	46.63534018	-119.4152388	21-Oct-04	Hanford 100F
10	04434239	46.59575489	-119.391293	19-Oct-04	Hanford slough
11	04434238	46.52974041	-119.2781853	19-Oct-04	Wahluke branch 5
12	04444201	46.5048894	-119.2609968	26-Oct-04	spoils bank
13	04434237	46.37747764	-119.2634028	18-Oct-04	Potholes canal
14	04434236	46.357326	-119.2588186	18-Oct-04	Ezquatzel
15	04434235	46.34988915	-119.2662515	18-Oct-04	Hanford 300
16	04434234	46.29557711	-119.2668859	18-Oct-04	below Richland STP
17	04434241	46.26719212	-119.2584143	20-Oct-04	below W. Richland STP
18	04434230	46.25831301	-119.2391699	17-Oct-04	Yakima River above delta
19a	04434242	46.25411761	-119.2502455	20-Oct-04	Yakima River below 240 bridge
19b	04434243	46.25207188	-119.2511739	20-Oct-04	Yakima River below 240 bridge
20	04434231	46.25125087	-119.2316026	17-Oct-04	Yakima River lower delta
21	04434244	46.24814362	-119.2360573	20-Oct-04	Yakima River below 240 bridge
22	04434233	46.24237381	-119.2203466	17-Oct-04	Yakima River below lower delta
23	04424225	46.21255173	-119.0990141	16-Oct-04	below Port of Kennewick
24a	04424220	46.20432355	-119.0521924	16-Oct-04	below Pasco STP
24b	04424224	46.20717192	-119.0586764	16-Oct-04	below Pasco STP
25a	04424226	46.19419239	-119.0516506	16-Oct-04	Twin Rivers Park
25b	04424227	46.19278552	-119.0504232	16-Oct-04	Twin Rivers Park
26a	04414205	46.25332296	-118.8512999	06-Oct-04	Snake River, above Ice Harbor dam
26b	04414206	46.27540271	-118.8397484	06-Oct-04	Snake River, above Ice Harbor dam
26c	04414207	46.27095811	-118.8281222	06-Oct-04	Snake River, above Ice Harbor dam
27a	04424217	46.19302302	-119.0226416	15-Oct-04	Snake River lower delta

Table 1, Continued

Station ID	Sample ID	Latitude	Longitude	Sample date	Location
27b	04424218	46.198714	-119.0278058	15-Oct-04	Snake River lower delta
28	04424216	46.18668442	-119.0172298	15-Oct-04	Burbank bankwater
29a	04414213	46.16300774	-119.0125559	07-Oct-04	below Kennewick industrial area
29b	04424215	46.18218097	-119.0131914	15-Oct-04	below Kennewick industrial area
30a	04414210	46.06787005	-118.9306041	07-Oct-04	below Boise-Cascade outfall
30b	04414211	46.07249586	-118.9290732	07-Oct-04	below Boise-Cascade outfall
30c	04414212	46.07811736	-118.9240594	07-Oct-04	below Boise-Cascade outfall
31	04414209	46.06245777	-118.9196566	07-Oct-04	Walla Walla River lower delta
32a	04414202	45.93144879	-119.2606112	05-Oct-04	Hat Rock Park
32b	04414203	45.93348958	-119.2616927	05-Oct-04	Hat Rock Park
33	04414200	45.94669649	-119.274646	05-Oct-04	above McNary dam

Table 2. Target Compounds, Number of Samples, Analytical Laboratories, Methods, and Reporting Limits

Group	Analyte	# Samples (1)	Lab	Reporting Limit	Method
Metals	Arsenic	45	MEL (2)	4.5 mg/kg	200.7/6010
	Cadmium	45	MEL	0.5 mg/kg	200.7/6010
	Chromium	45	MEL	0.5 mg/kg	200.7/6010
	Copper	45	MEL	0.4 mg/kg	200.7/6010
	Lead	45	MEL	3 mg/kg	200.7/6010
	Mercury	45	MEL	0.042 mg/kg	245.5
	Nickel	45	MEL	1 mg/kg	200.7/6010
	Zinc	45	MEL	0.4 mg/kg	200.7/6010
Organochlorine Pesticides	See footnote #5	44	A4 Scientific (3)	0.1 ug/kg	8081
					8270C (Methoxychlor)
Herbicides and Fungicides	See footnote #6	44	MEL	8 ug/kg	515.1/8151A
	See footnote #7	44	MEL	20 ug/kg	8270C
	Alachlor and Simazine	44	MEL	5 ug/kg	Modified 8270C
	Atrazine and Trifluralin	44	MEL	2 ug/kg	Modified 8270C
Organophosphate Pesticides	Azinphos-methyl; Chlorpyrifos-ethyl; and Diazinon	45	MEL	5 ug/kg	Modified 8270C
	Parathion-methyl; Malathion	45	MEL	2 ug/kg	Modified 8270C
Carbamate Pesticides	Carbaryl	45	MEL	2 ug/kg	Modified 8270C
Polychlorinated Biphenyls	Aroclors	44	A4 Scientific	2 ug/kg	8082
Polybrominated Dipheyl Ethers	BDE 28, 49, 99, 100, 153, 154, 183, and 209	45	MEL	0.5 ug/kg	8270C

Table 2, Continued

Group	Analyte	# Samples (1)	Lab	Reporting Limit	Method
Polychlorinated dibenzodioxins and Polychlorinated dibenzofurans	2,3,7,8-TCDD	45	EPA Region 7 (4)	0.005 pg/g	1613B
	1,2,3,7,8-PeCDD	45	EPA Region 7	0.05 pg/g	1613B
	1,2,3,4,7,8-HxCDD; 1,2,3,7,8,9-HxCDD; 1,2,3,7,8-PeCDF; 1,2,3,6,7,8-HxCDF; 2,3,4,6,7,8-HxCDF; 1,2,3,4,6,7,8-HpCDF;1,2,3,4,7,8,9-HpCDF	45	EPA Region 7	0.02 pg/g	1613B
	1,2,3,6,7,8-HxCDD	45	EPA Region 7	0.03 pg/g	1613B
	1,2,3,4,6,7,8-HpCDD; OCDF	45	EPA Region 7	0.08 pg/g	1613B
	OCDD	45	EPA Region 7	0.12 pg/g	1613B
	2,3,7,8-TCDF	45	EPA Region 7	0.006 pg/g	1613B
	2,3,4,7,8-PeCDF; 1,2,3,4,7,8-HxCDF; 1,2,3,7,8,9-HxCDF	45	EPA Region 7	0.01 pg/g	1613B
Total Organic Carbon	NA	All samples	EPA Region 7 /MEL	0.01%	PSEP- Plumb 1981

1. Analytes with 44 samples had one sample disqualified due to breakage during shipment.
2. MEL: USEPA Region 10 Manchester Environmental Laboratory, 7411 Beach Drive East, Port Orchard, Washington, USA 98366
3. A4 Scientific, 1544 Sawdust Road, Spring, Texas, USA
4. EPA Region 7 Environmental Laboratory, Environmental Services Division, 901 N. 5th Street, Kansas City, Kansas, USA
5. The following analytes were analyzed: 2,4-DDE; DDD; DDT; a-and g-Chlordane; Oxychlordane; cis-and trans-Nonachlors; Mirex; Hexachlorobutadiene; Lindane, Hexachlorobenzene; Toxaphene; and Methoxychlor.
6. The following analytes were analyzed: Pentachlorophenol; 2,3,4,5-Tetrachlorophenol; Bromoxynil; Chloramben; Clopyralid; Dicamba; 2,4-D; DCPA; , Dichloroprop; Ioxynil; MCPA; MCPP; Picloram; Silvex; 2,4,5-T; Triclopyr
7. The following analytes were analyzed: 2,4,5-TCP; 2,4 6-TCP; 2,3,4,6-Tetrachlorophenol; 4-Nitrophenol; Acifluorfen; Bentazon; Dinoseb; 2,4-DB; 3,5-Dichlorobenzoic acid; Diclofop-methyl.

Table 3: Geographic Comparisons of Metals Concentrations in Columbia Basin and Nationwide

Metal	Study	N	Range, mg/kg	% Detects	MDL, mg/kg	Treatment of Nondetects	Mean	25th percentile mg/kg	50th percentile mg/kg	75th percentile mg/kg
Arsenic	Upper-Col (1)	5	3.2 – 10	100%	NR	NR	NR	NR	6.6	NR
	Mid-Col. (2)	45	4.5 – 20	64%	4.5	½ MDL	5.07	4.8	5.9	7.6
	Lower Col. EMAP (3)	77	0.69 – 20.8	95%	0.69	0	NR	1.9	2.7	3.9
	NAQWA (4)	541	1 - 200	100%	0.01	NA	NR	4.6	6.3	9.2
Cadmium	Upper-Col	5	0.1- 0.4	60%	0.1	NR	NR	NR	0.3	NR
	Mid-Col	45	0.5 – 6.0	58%	0.5	½ MDL	1.09	0.3	1.2	2.13
	Lower Col. EMAP	77	0.09 – 0.85	84%	0.09	0	NR	0.1	0.16	
	NAQWA	541	0.1 – 56	98%	0.1	½ MDL	NR	0.3	0.4	0.8
Chromium	Upper-Col.	5	36 – 130	100%	NR	NR	NR	NR	80	NR
	Mid-Col.	45	6.13-23	100%	0.5	NA	14.37	12	16.6	19.3
	Lower Col. EMAP	77	15.3 – 89.8	100%	15.3	0	NR	26	31.9	84
	NAQWA	541	1.0 – 700	99%	1	½ MDL	NR	51	64	84
Copper	Upper-Col.	5	9 – 25	100%	NR	NR	NR	NR	21	NR
	Mid-Col.	45	4.72 – 36.5	100%	0.4	NA	17.1	15.1	18.4	27.9
	Lower Col. EMAP	77	8.3 – 59	100%	8.3	0	NR	14.4	18.3	23
	NAQWA	541	6 – 620	100%	1	NA	NR	17	27	43
Lead	Upper-Col.	5	14 – 47	100%	NR	NR	NR	NR	18	NR
	Mid-Col.	45	2.5 – 75.9	98%	2.5	½ MDL	12.43	8	12.6	22
	Lower Col. EMAP	77	1.5 – 25.9	100%	1.5	0	NR	7.6	8.8	11
	NAQWA	541	4.0 - 6300	99%	4	½ MDL	NR	18	27	44
Mercury	Upper-Col.	5	0.01- 0.07	100%	NR	NR	NR	NR	0.02	NR
	Mid-Col.	45	0.04 - 0.167	40%	0.04	½ MDL	0.04	0.02	0.044	0.08
	Lower Col. EMAP	77	0.0049 – 0.239	99%	0.0049	0	NR	0.01	0.0197	
	NAQWA	541	0.02 – 14.5	86%	0.02	½ MDL	NR	0.03	0.06	0.13
Nickel	Upper-Col.	5	16 – 65	100%	NR	NR	NR	NR	31	NR
	Mid-Col.	45	5.6-26.9	100%	1	NA	15.1	13.1	17	21.7
	Lower Col. EMAP	77	15.1 – 49.2	100%	15.1	0	NR	21.4	26.6	33
	NAQWA	541	6 – 530	100%	2	NA	NR	20	27	36

Table 3, Continued

Metal	Study	N	Range, mg/kg	% Detects	MDL, mg/kg	Treatment of Nondetects	Mean	25th percentile mg/kg	50th percentile mg/kg	75th percentile mg/kg
Zinc										
	Upper-Col.	5	53 – 130	100%	NR	NR	NR	NR	58	NR
	Mid-Col.	45	25.8 - 558	100%	0.4	NA	143.24	68.7	131	305
	Lower Col. EMAP	77	54.8 - 147	100%	54.8	0	NR	74	84	86
	NAQWA	541	4.0 - 9000	99%	4	½ MDL	NR	81	110	180

1. Concentrations and Distribution of Slag-Related Trace Elements and Mercury in Fine-Grained Beach and Bed Sediments of Lake Roosevelt, Washington, April-May 2001 (Majewski, et al, 2003)
2. Mid-Columbia Report (this report)
3. Lower Columbia Environmental Monitoring and Assessment Program (Hayslip et al., 2008)
4. USGS National Water-Quality Assessment Program (Rice, 1999).

MDL: Method Detection Limit NA: Not Applicable. NR: Not Reported

Table 4: Comparison of Metal Concentrations with Ecological Guidelines in Mid-Columbia Sediments

Analyte	TEC (mg/kg) (1)	% samples > TEC	PEC (mg/kg) (2)	% samples > PEC
Arsenic	9.79	2% (1/45)	33	0%
Cadmium	0.99	38% (17/45)	4.98	2% (1/45)
Chromium	43.4	0%	111	0%
Copper	31.6	2% (1/45)	149	0%
Lead	35.8	2% (1/45)	128	0%
Mercury	0.18	0%	1.06	0%
Nickel	22.7	11% (5/45)	48.6	0%
Zinc	121	33% (15/45)	459	2% (1/45)

1. Threshold Effect Concentrations (MacDonald, D.D., C.G Ingersoll, and T.A. Berger, 2000)
2. Probable Effect Concentrations (MacDonald, D.D., C.G Ingersoll, and T.A. Berger, 2000)

Table 5. Metals Concentrations in mid-Columbia Sediments, mg/kg

Station ID	Sample #	As	qual.	Cr	Cd	qual.	Cu	Hg	qual.	Pb	qual.	Ni	Zn
1	4444208	4.5	U	9	1.2		17.3	0.04	U	13.2		9.76	149
2	4444209	4.4	U	9.5	0.49	U	16.8	0.04	U	4.8		10.8	42.3
3	4444210	5.1		8.3	0.64		18.4	0.04	U	9.4		11.5	111
4	4444202	5.9		10.3	0.49	U	12.8	0.044		3.4		11.4	38.1
5a	4444203	4.9		12.4	1.61		18.3	0.051		12		13.1	178
5b	4444204	4.8		10.1	0.53		15.4	0.04	U	8.8		10.2	104
6a	4444205	7.6		15	2.93		27.1	0.09		23.8		16.6	346
6b	4444206	7.6		23	4.21		36.5	0.11		29.4		26.7	428
7	4434247	4.5	U	11.3	0.5	U	16.4	0.04	U	4.6		9.37	41.8
8	4434246	4.6		16.9	0.5	U	18.2	0.04	U	12		14.6	94.2
9	4434245	20		16.4	1.2		31.5	0.04	U	75.9		15.1	402
10	4434239	6.8		17.9	3.84		27.6	0.096		32.2		18.3	444
11	4434238	4.5	U	13.4	0.6		14.8	0.04	U	6.4		12.9	66
12	4444201	4.5	U	11.6	0.5	U	11.3	0.04	U	7.5		11.5	68.7
13	4434237	4.5	U	14.6	0.98		18.4	0.04	U	9.6		14.2	102
14	4434236	4.5	U	7.9	0.5	U	13.1	0.04	U	4.1		8.44	45
15	4434235	5.5		15.8	2.54		18.7	0.051		18.5		17	305
16	4434234	5.3		17.2	1.4		21.9	0.04	U	22.8		16.2	209
17	4434241	6		16.3	2.26		18.7	0.055		22		14.9	339
18	4434230	6.7		18	5.96		28.4	0.1668		26.7		21.5	558
19a	4434242	4.5	U	20.1	0.5	U	14	0.04	U	5.6		24.04	58.8
19b	4434243	4.5	U	19.6	0.5	U	14.3	0.04		5.4		26.6	54.6
20	4434231	4.5	U	17.8	0.5	U	17.8	0.04	U	10		23.49	91.9
21	4434244	4.5	U	18.7	0.5	U	12.6	0.04	U	4.9		26.9	52.6
22	4434233	4.5	U	14.9	0.63		12.2	0.04	U	8		20.3	117
23	4424225	5.8		18.7	1.4		22.3	0.057		15.4		21.7	195
24a	4424220	4.8		18.3	0.64		14.1	0.04	U	7.8		17.6	94.8
24b	4424224	4.5		14.2	1.3		9.87	0.04	U	7.8		13.9	124
25a	4424226	5.1		21.5	1.2		21.1	0.043		12		24.5	163
25b	4424227	4.5	U	16.1	2.11		17.5	0.054		12.6		19.5	241
26a	4414205	5.7		8.66	0.5	U	7.54	0.04	U	4.3		8.95	38.3
26b	4414206	8		15.3	0.62		18.9	0.055		9		13.78	53.8
26c	4414207	8.9		16.6	0.6		17.5	0.044		9.9		13.9	58.7
27a	4424217	4.5	U	6.13	0.5	U	4.72	0.04	U	2.5	U	5.56	25.8
27b	4424218	4.5	U	10.9	0.5	U	5.94	0.04	U	3.3		8.62	33.2
28	4424216	4.5	U	10.3	0.5	U	7.02	0.04	U	3		8.87	34.7
29a	4414213	7.2		14.4	1.95		30	0.147		15.1		18	247
29b	4424215	7.4		14	0.5	U	13	0.04		6.8		12.8	51.2
30a	4414210	6.3		13	0.5	U	14	0.04	U	7.7		11.3	58
30b	4414211	5.1		10.5	0.5	U	11.9	0.04	U	6.2		9.23	48.7
30c	4414212	5.7		12.8	0.5	U	16	0.04	U	7.9		10.9	57.3
31	4414209	4.6		10.6	0.5	U	10.8	0.04	U	5.8		8.91	46.2
32a	4414202	7.1		14.3	1.4		15.1	0.046		11		13.4	120
32b	4414203	9.6		21.3	2.13		29.2	0.088		19.5		20.9	178
33	4414200	5.5		13.1	0.62		10.6	0.04	U	12		11.7	131
mean concentration, non-detects set to 1/2 MDL		**5.07**		**14.37**	**1.09**		**17.10**	**0.04**		**12.43**		**15.10**	**143.24**

Table 6. Concentrations of Detected Organic Compounds Compared to Ecological and Human Health Guidelines (1)

Chemical	TEC (ug/kg) (2)	% samples > TEC	PEC (ug/kg) (3)	% samples > PEC	Bioaccumulative SLV (ug/kg) (4)	% samples > SLV
Total DDTs	5.3	0%	572	0%	0.04 – 0.3	64% detected samples
Sum DDD (5)	4.9	0%	28	0%	NA	NA
Sum DDE (5)	3.2	0%	31.3	0%	NA	NA
Sum DDT (5)	4.2	0%	62.9	0%	NA	NA
Hexachlorobenzene	NA	NA	NA	NA	2.3 - 19	0%
Pentachlorophenol	NA	NA	NA	NA	30 – 250	0%
Total PCBs	59.8	0%	676	0%	0.048 - 0.39	0%
Chlordane	3.24	0%	17.6	0%	NA	NA
Lindane	2.4	0%	5	0%	NA	NA
OCDD	NA	NA	NA	NA	2800 – 23,000 ng/kg	0%
HpCDD	NA	NA	NA	NA	85 – 690 ng/kg	2%
OCDF	NA	NA	NA	NA	2800 – 23,000 ng/kg	0%
HpCDF	NA	NA	NA	NA	85 – 690 ng/kg	0%
TCDF	NA	NA	NA	NA	0.09- 0.8 ng/kg	2%

1. Several compounds were detected in the study but do not have PEC, TEC, or Bioaccumulative Screening Level Values. These include: Azinphos-methyl; Ethyl chlorpyrifos; Malathion; Dacthal; Tetrachlorophenol; and the Polybrominated diphenyl ethers.

2. TEC: Threshold Effects Concentrations from "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems", MacDonald, D.D., C.G Ingersoll, and T.A. Berger, 2000

3. PEC: Probable Effect Concentrations from "Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems", MacDonald, D.D., C.G Ingersoll, and T.A. Berger, 2000

4. Bioaccumulative Screening Level Values from "Guidance for Assessing Bioaccumulative Chemicals of Concern in Sediment", Oregon Department of Environmental Quality, Environmental Cleanup Program, Final January 31, 2007, updated April 3, 2007. Lower value based on fish consumption of 142 grams/day and higher value based on fish consumption of 17.5 grams/day

5. Assumes Sum DDD = P,p' DDD. Assumes Sum DDE = P,p' DDE. Assumes Sum DDT = P,p' DDT. This was assumed because generally the majority the DDTs are comprised of P,p' DDD, P,p' DDE, or P,p' DDT,

NA: Not available

Table 7. Organochlorine pesticides, ug/kg

Station ID	Sample ID	P,P'-DDD	qual.	O,P'-DDD	qual.	P,P'-DDE	qual.	O,P'-DDE	qual.	P,P'-DDT	qual.	O,P'-DDT	qual.	alpha-Chlordane	qual.	gamma-Chlordane	qual.	cis-Nonachlor	qual	Mirex	qual.	Hexachloro-butadiene	qual.	Lindane	qual.	Hexachloro-benzene	qual.	Toxaphene	qual.	Methoxychlor	qual.
1	4444208	2	U	2.0	U	2	U	2	U	2	U	2	U	2	U	2	U	2	U	2	U	10	U	2	U	0.24	J	100	U	2	U
2	4444209	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	7.4	U	1.5	U	1.5	U	74	U	1.5	U
3	4444210	1.5	U	1.5	U	0.21	J	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	7.3	U	1.5	U	1.5	U	73	U	1.5	U
4	4444202	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	8.5	U	1.7	U	1.7	U	85	U	1.7	U
5a	4444203	2.6	U	2.6	U	0.24	J	2.6	U	2.6	U	2.6	U	2.6	U	2.6	U	2.6	U	2.6	U	13	U	2.6	U	2.6	U	130	U	2.6	U
5b	4444204	0.23	J	1.7	U	0.31	J	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	8.4	U	1.7	U	1.7	U	84	U	1.7	U
6a	4444205	2.3	U	2.3	U	2.3	U	2.3	U	2.3	U	2.3	U	2.3	U	2.3	U	2.3	U	2.3	U	12	U	2.3	U	2.3	U	120	U	2.3	U
6b	4444206	2.6	U	2.6	U	0.67	J	2.6	U	2.6	U	2.6	U	2.6	U	2.6	U	2.6	U	2.6	U	13	U	2.6	U	2.6	U	130	U	2.6	U
7	4434247	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	7.7	U	1.6	U	1.6	U	77	U	1.6	U
8	4434246	1.8	U	1.8	U	1.8	U	1.8	U	0.53	J	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	9.2	U	1.8	U	1.8	U	92	U	1.8	U
9	4434245	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	7.8	U	1.6	U	1.6	U	78	U	1.6	U
10	4434239	3.8	U	3.8	U	3.8	U	3.8	U	3.8	U	3.8	U	3.8	U	3.8	U	3.8	U	3.8	U	19	U	3.8	U	3.8	U	190	U	3.8	U
11	4434238	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	7.8	U	1.6	U	1.6	U	78	U	1.6	U
12	4444201	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	7.6	U	1.6	U	1.6	U	76	U	1.6	U
13	4434237	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	8.9	U	1.8	U	1.8	U	89	U	1.8	U
14	4434236	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	7	U	1.4	U	1.4	U	70	U	1.4	U
15	4434235	0.32	J	1.8	U	0.9	J	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	9.2	U	1.8	U	1.8	U	92	U	1.8	U
16	4434234	0.73	J	1.8	U	1.8	U	1.8	U	0.88	J	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	9.1	U	1.8	U	1.8	U	91	U	1.8	U
17	4434241	0.7	J	1.6	U	0.48	J	1.6	U	2.6	J	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	8.1	U	1.6	U	1.6	U	81	U	1.6	U
18	4434230	0.2	J	1.8	U	0.45	J	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	8.9	U	1.8	U	1.8	U	89	U	1.8	U
19a	4434242	1.6	U	1.6	U	0.55	J	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	7.8	U	1.6	U	1.6	U	78	U	1.6	U
19b	4434243	1.6	U	1.6	U	0.41	J	1.6	U	1.2	J	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	8	U	1.6	U	1.6	U	80	U	1.6	U
20	4434231	1.9	U	1.9	U	0.38	J	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	1.9	U	9.3	U	1.9	U	1.9	U	93	U	1.9	U
21	4434244	1.7	U	1.7	U	0.22	J	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	8.3	U	1.7	U	1.7	U	83	U	1.7	U
22	4434233	1.5	U	1.5	U	0.21	J	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	1.5	U	7.3	U	1.5	U	1.5	U	73	U	1.5	U
23	4424225	0.25	J	2.1	U	0.58	J	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	2.1	U	11	U	2.1	U	2.1	U	110	U	2.1	U
24a	4424220	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	7.8	U	1.6	U	1.6	U	78	U	1.6	U
24b	4424224	1.6	U	1.6	U	0.18	J	1.6	U	0.6	J	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	7.8	U	1.6	U	1.6	U	78	U	1.6	U
25a	4424226	0.15	J	1.7	U	0.36	J	1.7	U	0.54	J	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	8.6	U	1.7	U	1.7	U	86	U	1.7	U
25b	4424227	0.17	J	1.8	U	0.37	J	1.8	U	2.8		1.6	J	1.8	U	1.8	U	1.8	U	1.8	U	8.9	U	1.8	U	1.8	U	89	U	1.8	U
26a	4414205	1.3	U	1.3	U	1.3	U	1.3	U	1.3	U	1.3	U	1.3	U	1.3	U	1.3	U	1.3	U	6.6	U	1.3	U	1.3	U	66	U	1.3	U
26b	4414206	1.8	U	1.8	U	0.41	J	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	8.8	U	1.8	U	0.13	J	88	U	1.8	U
26c	4414207	0.25	J	1.7	U	1.6	J	1.7	U	0.7	J	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	8.3	U	1.7	U	0.21	J	83	U	1.7	U

Table 7, Continued

Station ID	Sample ID	P,P'-DDD	qual.	O,P'-DDD	qual.	P,P'-DDE	qual.	O,P'-DDE	qual.	P,P'-DDT	qual.	O,P'-DDT	qual.	alpha-Chlordane	qual.	gamma-Chlordane	qual.	cis-Nonachlor	qual	Mirex	qual.	Hexachloro-butadiene	qual.	Lindane	qual.	Hexachloro-benzene	qual.	Toxaphene	qual.	Methoxychlor	qual.
27a	4424217	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	7	U	1.4	U	1.4	U	70	U	1.4	U
27b	4424218	1.4	U	1.4	U	**0.14**	**J**	1.4	U	**0.21**	**J**	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	7	U	1.4	U	1.4	U	70	U	1.4	U
28	4424216	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	7.1	U	1.4	U	1.4	U	71	U	1.4	U
29a	4414213	1.6	U	1.6	U	**0.14**	**J**	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	7.7	U	1.6	U	1.6	U	77	U	1.6	U
29b	4424215	1.6	U	1.6	U	**0.11**	**J**	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	8.2	U	1.6	U	1.6	U	82	U	1.6	U
30a	4414210	1.7	U	1.7	U	**0.55**	**J**	1.7	U	**0.15**	**J**	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	8.3	U	1.7	U	1.7	U	83	U	1.7	U
30b	4414211	**0.13**	**J**	1.8	U	**0.59**	**J**	1.8	U	**0.13**	**J**	1.8	U	1.8	U	1.8	U	1.8	U	1.8	U	9	U	1.8	U	1.8	U	90	U	1.8	U
30c	4414212	**0.26**	**J**	1.7	U	**0.78**	**J**	1.7	U	**0.86**	**J**	1.7	U	1.7	U	1.7	U	1.7	U	1.7	U	8.5	U	1.7	U	**0.11**	**J**	85	U	1.7	U
31	4414209	1.6	U	1.6	U	**0.27**	**J**	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	1.6	U	8.2	U	1.6	U	1.6	U	82	U	1.6	U
32	4414203	2.2	U	2.2	U	**0.25**	**J**	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	2.2	U	11	U	2.2	U	2.2	U	110	U	2.2	U
33	4414200	1.4	U	1.4	U	**0.2**	**J**	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	1.4	U	6.9	U	1.4	U	1.4	U	69	U	1.4	U
number of samples with detected concentrations		11		0		27		0		12		1		0		0		0		0		0		0		4		0		0	

Table 8. Organophosphate pesticides and carbaryl, ug/kg

Station ID	Sample #	Azinphos-methyl		Chlorpyrifos, ethyl		Diazinon		Malathion		Parathion-methyl		Carbaryl	
1	4444208	4	U	12	U	12	U	12	U	4	U	19	U
2	4444209	2	U	9	U	4	U	2	U	2	U	12	U
3	4444210	2	U	2	J	2	U	1	U	12	U	12	U
4	4444202	7	U	9	UJ	9	U	4	UJ	3	U	7	U
5a	4444203	7	U	7	UJ	7	U	3	UJ	3	U	7	U
5b	4444204	17	J	7	UJ	7	U	3	UJ	3	U	3	U
6a	4444205	47	UJ	7	UJ	7	U	3	UJ	47	U	no data	U
6b	4444206	5	U	118	UJ	47	UJ	24	UJ	24	UJ	24	U
7	4434247	6	U	9	UJ	9	U	3	UJ	3	U	3	U
8	4434246	9	U	7	UJ	7	U	3	UJ	3	U	3	U
9	4434245	7	U	7	UJ	7	U	3	UJ	3	U	7	U
10	4434239	5	UJ	6	U	6	U	2	UJ	5	U	23	U
11	4434238	6	U	9	U	9	U	4	JL	2	U	2	U
12	4444201	9	U	3	J	6	U	3	UJ	4	U	4	U
13	4434237	11		6	U	6	U	2	UJ	3	U	3	U
14	4434236	6	U	8	U	8	U	4	JL	2	U	2	UJ
15	4434235	8	U	8	U	8	U	3	UJ	3	U	3	UJ
16	4434234	8	U	6	U	6	U	2	UJ	3	U	3	UJ
17	4434241	7	U	11	UJ	5	UJ	2	UJ	3	UJ	3	UJ
18	4434230	6	U	8	U	16	U	16	UJ	2	U	2	UJ
19a	4434242	2	U	7	U	7	U	3	UJ	11	U	11	UJ
19b	4434243	7	U	3	J	6	U	6	U	3	U	7	UJ
20	4434231	8	U	6	U	6	U	3	JL	3	U	3	UJ
21	4434244	7	U	7	UJ	7	U	3	UJ	3	U	7	UJ
22	4434233	6	U	8	U	8	U	3	UJ	2	U	2	UJ
23	4424225	47	U	6	U	13	U	13	UJ	9	U	9	U
24a	4424220	6	U	70	U	70	U	28	UJ	2	U	2	U
24b	4424224	32	U	6	U	6	U	2	UJ	6	U	6	U
25a	4424226	50	U	9	U	19	U	19	UJ	10	U	10	U
25b	4424227	41	U	10	U	20	U	20	UJ	8	U	8	U
26a	4414205	20	U	3	U	16	U	16	U	20	U	20	U
26b	4414206	28	U	2	U	8	U	8	U	28	U	28	U
26c	4414207	30	U	2	U	11	U	11	U	30	U	30	U
27a	4424217	6	U	5	U	5	U	2	UJ	2	U	2	U
27b	4424218	70	U	6	U	6	U	2	UJ	28	U	28	U
28	4424216	5	U	7	U	7	U	3	UJ	2	U	2	U
29a	4414213	32	U	2	U	11	U	11	U	32	U	1	U
29b	4424215	7	U	3	U	13	U	13	U	3	U	3	U
30a	4414210	25	U	2	U	10	U	10	U	25	U	25	U
30b	4414211	25	U	2	U	10	U	10	U	25	U	25	U
30c	4414212	28	U	2	U	10	U	10	U	28	U	28	U
31	4414209	24	U	2	U	12	U	12	U	24	U	24	U
32a	4414202	24	U	2	U	9	U	9	U	24	U	24	U
32b	4414203	41	U	2	U	10	U	10	U	41	U	41	U
33	4414200	22	U	6	U	6	U	12	U	22	U	22	U

Table 9. Herbicides and fungicides, ug/kg

Station ID	Sample #	2,4-D	qual.	2,4-DB	qual.	2,4,5-T	qual.	Silvex	qual.	MCPA	qual.	MCPP	qual.	3,5-Dichloro-benzoic acid	qual.	Acifluorfen	qual.	Alachlor		Atrazine	qual.	Bentazon	qual.	Bromoxynil	qual.	Chloramben	qual.	Clopyralid		DCPA (Dacthal)	qual.	Dicamba	qual.	Dichlorprop	qual.
1	4444208	15	U	37	U	15	U	15	U	15	U	15	U	37	U	37	UJ	9	U	2	U	37	U	15	U	15	UJ	15	U	15	U	15	U	15	U
2	4444209	9.6	U	24	U	9.6	U	9.6	U	9.6	U	9.6	U	24	U	24	UJ	6	U	1	U	24	U	9.6	U	9.6	UJ	9.6	U	9.6	U	9.6	U	9.6	U
3	4444210	9.7	U	24	U	9.7	U	9.7	U	9.7	U	9.7	U	24	U	24	UJ	6	U	2	U	24	U	9.7	U	9.7	UJ	9.7	U	9.7	U	9.7	U	9.7	U
4	4444202	12	U	30	U	12	U	12	U	12	U	12	U	30	U	30	U	7	U	3	U	30	U	12	U	12	UJ	12	U	12	U	12	U	12	U
5a	4444203	17	U	42	U	17	U	17	U	17	U	17	U	42	U	42	U	7	U	3	U	42	U	17	U	17	UJ	17	U	17	U	17	U	17	U
5b	4444204	11	U	28	U	11	U	11	U	11	U	11	U	28	U	28	U	7	U	3	U	28	U	11	U	11	UJ	11	U	11	U	11	U	11	U
6a	4444205	18	U	46	U	18	U	18	U	18	U	18	U	46	U	46	U	118	UJ	24	UJ	46	U	18	U	18	UJ	18	U	18	U	18	U	18	U
6b	4444206	19	U	47	U	19	U	19	U	19	U	19	U	47	U	47	U	12	U	5	U	47	U	19	U	19	UJ	19	U	19	U	19	U	19	U
7	4434247	9.5	U	24	U	9.5	U	9.5	U	9.5	U	9.5	U	24	U	24	U	6	U	3	U	24	U	9.5	U	9.5	UJ	9.5	U	9.5	U	9.5	U	9.5	U
8	4434246	13	U	32	U	13	U	13	U	13	U	13	U	32	U	32	U	9	U	3	U	32	U	13	U	13	UJ	13	U	13	U	13	U	13	U
9	4434245	11	U	28	U	11	U	11	U	11	U	11	U	28	U	28	U	7	U	no data		28	U	11	U	11	UJ	11	U	11	U	11	U	11	U
10	4434239	17	U	42	U	17	U	17	U	17	U	17	U	42	U	42	U	11	UJ	2	UJ	42	U	17	U	17	UJ	17	U	17	U	17	U	17	U
11	4434238	10	U	26	U	10	U	10	U	10	U	10	U	26	U	26	U	6	U	2	U	26	U	10	U	10	UJ	10	U	10	U	10	U	10	U
12	4444201	8.8	U	22	U	8.8	U	8.8	U	8.8	U	8.8	U	22	U	22	U	9	U	4	U	22	U	8.8	U	8.8	UJ	8.8	U	8.8	U	8.8	U	8.8	U
13	4434237	13	U	32	U	13	U	13	U	13	U	13	U	32	U	32	U	9	U	3	U	32	U	13	U	13	UJ	13	U	13	U	13	U	13	U
14	4434236	8.8	U	22	U	8.8	U	8.8	U	8.8	U	8.8	U	22	U	22	U	6	U	2	UJ	22	U	8.8	U	8.8	UJ	8.8	U	8.8	U	8.8	U	8.8	U
15	4434235	12	U	29	U	12	U	12	U	12	U	12	U	29	U	29	U	8	U	3	U	29	U	12	U	12	UJ	12	U	12	U	12	U	12	U
16	4434234	12	U	31	U	12	U	12	U	12	U	12	U	31	U	31	U	8	U	3	U	31	U	12	U	12	UJ	12	U	12	U	12	U	12	U
17	4434241	11	U	26	U	11	U	11	U	11	U	11	U	26	U	26	U	7	U	3	U	26	U	11	U	11	UJ	11	U	11	U	11	U	11	U
18	4434230	5	UJ	15	UJ	5	UJ	5	UJ	5	UJ	5	UJ	5	UJ	10	UJ	6	U	2	U	10	UJ	5	UJ	10	UJ	5	UJ	5	UJ	5	UJ	5	UJ
19a	4434242	10	U	25	U	10	U	10	U	10	U	10	U	25	U	25	U	6	U	2	U	25	U	10	U	10	UJ	10	U	10	U	10	U	10	U
19b	4434243	11	U	26	U	11	U	11	U	11	U	11	U	26	U	26	U	7	U	3	U	26	U	11	U	11	UJ	11	U	11	U	11	U	11	U
20	4434231	12	U	31	U	12	U	12	U	12	U	12	U	31	U	31	U	8	U	3	U	31	U	12	U	12	UJ	12	U	12	U	12	U	12	U
21	4434244	11	U	27	U	11	U	11	U	11	U	11	U	27	U	27	U	7	U	3	U	27	U	11	U	11	UJ	11	U	11	U	11	U	11	U
22	4434233	8.9	U	22	U	8.9	U	8.9	U	8.9	U	8.9	U	22	U	22	U	6	U	2	U	22	U	8.9	U	8.9	UJ	8.9	U	8.9	U	8.9	U	8.9	U
23	4424225	14	U	35	U	14	U	14	U	14	U	14	U	35	U	35	U	9	U	9	U	35	U	14	U	14	UJ	14	U	14	U	14	U	14	U
24a	4424220	9.6	U	24	UJ	9.6	U	9.6	U	9.6	U	9.6	U	24	U	24	U	6	U	2	U	24	U	9.6	U	9.6	UJ	9.6	U	9.6	U	9.6	U	9.6	U
24b	4424224	9	U	22	U	9	U	9	U	9	U	9	U	22	U	22	U	6	U	6	U	22	U	9	U	9	UJ	9	U	9	U	9	U	9	U
25a	4424226	14	U	34	U	14	U	14	U	14	U	14	U	34	U	34	U	10	U	10	U	34	U	14	U	14	UJ	14	U	14	U	14	U	14	U
25b	4424227	12	U	30	U	12	U	12	U	12	U	12	U	30	U	30	U	8	U	8	U	30	U	12	U	12	UJ	12	U	12	U	12	U	12	U
26a	4414205	8.7	U	22	U	8.7	U	8.7	U	8.7	U	8.7	U	22	U	22	U	8	U	1	U	22	U	8.7	U	8.7	UJ	8.7	U	8.7	U	8.7	U	8.7	U
26b	4414206	12	U	31	U	12	U	12	U	12	U	12	U	31	U	31	U	11	U	1	U	31	U	12	U	12	UJ	12	U	12	U	12	U	12	U
26c	4414207	13	U	32	U	13	U	13	U	13	U	13	U	32	U	32	U	12	U	1	U	32	U	13	U	13	UJ	13	U	13	U	13	U	13	U
27a	4424217	8.5	U	21	U	8.5	U	8.5	U	8.5	U	8.5	U	21	U	21	U	6	U	2	U	21	U	8.5	U	8.5	UJ	8.5	U	8.5	U	8.5	U	8.5	U
27b	4424218	8.5	U	21	U	8.5	U	8.5	U	8.5	U	8.5	U	21	U	21	U	70	U	28	U	21	U	8.5	U	8.5	UJ	8.5	U	8.5	U	8.5	U	8.5	U
28	4424216	7.3	U	18	U	7.3	U	7.3	U	7.3	U	7.3	U	18	U	18	U	5	U	2	U	18	U	7.3	U	7.3	UJ	7.3	U	7.3	U	7.3	U	7.3	U
29a	4414213	14	U	34	U	14	U	14	U	14	U	14	U	34	U	34	U	13	U	1	U	34	U	14	U	14	UJ	14	U	14	U	14	U	14	U
29b	4424215	11	U	28	U	11	U	11	U	11	U	11	U	28	U	28	U	7	U	3	U	28	U	11	U	11	UJ	11	U	11	U	11	U	11	U
30a	4414210	8.1	U	20	U	8.1	U	8.1	U	8.1	U	8.1	U	20	U	20	U	10	U	1	U	20	U	8.1	U	8.1	UJ	8.1	U	0.32	J	8.1	U	8.1	U
30b	4414211	9.8	U	25	U	9.8	U	9.8	U	9.8	U	9.8	U	25	U	25	U	10	U	1	U	25	U	9.8	U	9.8	UJ	9.8	U	9.8	U	9.8	U	9.8	U
30c	4414212	10	U	25	U	10	U	10	U	10	U	10	U	25	U	25	U	11	U	1	U	25	U	10	U	10	UJ	10	U	10	U	10	U	10	U
31	4414209	9.3	U	23	U	9.3	U	9.3	U	9.3	U	9.3	U	23	U	23	U	10	U	1	U	23	U	9.3	U	9.3	UJ	9.3	U	9.3	U	9.3	U	9.3	U
32a	4414202	9.5	U	24	U	9.5	U	9.5	U	9.5	U	9.5	U	24	U	24	U	10	U	1	U	24	U	9.5	U	9.5	UJ	9.5	U	9.5	U	9.5	U	9.5	U
32b	4414203	17	U	42	U	17	U	17	U	17	U	17	U	42	U	42	U	16	U	2	U	42	U	17	U	17	UJ	17	U	17	U	17	U	17	U
33	4414200	9.7	U	24	U	9.7	U	9.7	U	9.7	U	9.7	U	24	U	24	U	9	U	1	U	24	U	9.7	U	9.7	UJ	9.7	U	9.7	U	9.7	U	9.7	U

Table 9, Continued

Station ID	Sample #	Diclofop, Methyl	qual.	Dinoseb	qual.	Ioxynil	qual.	Picloram	qual.		Simazine	qual.	Trichlorpyr	qual.	Trifluralin	qual.	2,4,5-TCP	qual.	2,4,6-TCP	qual.	2,3,4,5-TeCP	qual.	2,3,4,6-TeCP	qual.	PCP	qual.	4-Nitro-phenol	qual.
1	4444208	37	U	75	UJ	15	U	37	U		4	U	15	U	2	U	37	U	37	UJ	15	U	37	U	15	U	37	U
2	4444209	24	U	48	UJ	9.6	U	24	U		2	U	9.6	U	1	U	24	U	24	UJ	9.6	U	24	U	9.6	U	24	U
3	4444210	24	U	48	UJ	9.7	U	24	U		6	U	9.7	U	1	U	24	U	24	UJ	9.7	U	24	U	9.7	U	24	U
4	4444202	30	U	180	U	12	U	30	U		7	U	12	U	3	U	30	U	30	U	12	U	30	U	12	U	30	U
5a	4444203	42	U	84	U	17	U	42	U		7	U	17	U	3	U	42	U	42	U	17	U	42	U	17	U	42	U
5b	4444204	28	U	55	U	11	U	28	U		7	U	11	U	3	U	28	U	28	U	11	U	28	U	11	U	28	U
6a	4444205	46	U	92	U	18	U	46	U		47	UJ	18	U	24	UJ	46	U	46	U	2.7	J	2.3	J	40		46	U
6b	4444206	47	U	95	U	19	U	47	U		12	U	19	U	2	U	47	U	47	U	19	U	47	U	19	U	47	U
7	4434247	24	U	24	U	9.5	U	24	U		6	U	9.5	U	3	U	24	U	24	U	9.5	U	24	U	9.5	U	24	U
8	4434246	32	U	45	U	13	U	13	U		9	U	13	U	3	U	32	UJ	32	UJ	13	U	32	U	13	U	32	U
9	4434245	28	U	28	U	11	U	11	U		7	U	11	U	3	U	28	UJ	28	UJ	11	U	28	U	11	U	28	U
10	4434239	42	U	42	U	17	U	17	U		5	UJ	17	U	2	UJ	42	UJ	42	UJ	17	U	42	U	17	U	42	U
11	4434238	26	U	26	U	10	U	10	U		6	U	10	U	2	U	26	UJ	26	UJ	10	U	26	U	10	U	26	U
12	4444201	22	U	44	U	8.8	U	22	U		9	U	8.8	U	4	U	22	U	22	U	8.8	U	22	U	8.8	U	22	U
13	4434237	32	U	32	U	13	U	13	U		9	U	13	U	3	U	32	U	32	U	13	U	32	U	13	U	32	U
14	4434236	22	U	22	U	8.8	U	8.8	U		6	UJ	8.8	U	2	UJ	22	U	22	U	8.8	U	22	U	8.8	U	22	U
15	4434235	29	U	29	U	12	U	18	U		8	U	12	U	3	U	29	U	29	U	12	U	29	U	12	U	29	U
16	4434234	31	U	31	U	12	U	12	U		8	U	12	U	3	U	31	U	31	U	12	U	31	U	12	U	31	U
17	4434241	26	U	32	U	11	U	11	U		7	U	11	U	3	U	26	UJ	26	UJ	11	U	26	U	11	U	26	UJ
18	4434230	5	UJ	10	UJ	5	UJ	5	UJ		6	U	5	UJ	2	U	5	UJ	5	UJ	5	UJ	5	UJ	5	UJ	10	UJ
19a	4434242	25	U	25	U	10	U	25	U		6	U	10	U	1	U	25	UJ	25	UJ	10	U	25	U	10	U	25	U
19b	4434243	26	U	26	U	11	U	11	U		7	U	11	U	3	U	26	UJ	26	UJ	11	U	26	U	11	U	26	U
20	4434231	31	U	31	U	12	U	12	U		8	U	12	U	3	U	31	U	31	U	12	U	31	U	12	U	31	U
21	4434244	27	U	37	U	11	U	32	U		7	U	11	U	3	U	27	UJ	27	UJ	11	U	27	U	11	U	27	U
22	4434233	22	U	22	U	8.9	U	8.9	U		6	U	8.9	U	2	U	22	U	22	U	8.9	U	22	U	8.9	U	22	U
23	4424225	35	U	35	U	14	U	14	U		9	U	14	U	9	U	35	U	35	U	14	U	35	U	14	U	35	UJ
24a	4424220	24	U	24	U	9.6	U	9.6	U		6	U	9.6	U	2	U	24	U	24	U	9.6	U	24	U	9.6	U	24	UJ
24b	4424224	22	U	22	U	9	U	9	U		6	U	9	U	6	U	22	U	22	U	9	U	22	U	9	U	22	UJ
25a	4424226	34	U	34	U	14	U	14	U		10	U	14	U	10	U	34	U	34	U	14	U	34	U	14	U	34	UJ
25b	4424227	30	U	30	U	12	U	12	U		8	U	12	U	8	U	30	U	30	U	12	U	30	U	12	U	30	UJ
26a	4414205	22	U	22	U	8.7	U	8.7	U		8	U	8.7	U	20	U	22	U	22	U	8.7	U	22	U	8.7	U	22	U
26b	4414206	31	U	31	U	12	U	12	U		11	U	12	U	28	U	31	U	31	U	12	U	31	U	12	U	31	U
26c	4414207	32	U	32	U	13	U	13	U		12	U	13	U	30	U	32	U	32	U	13	U	32	U	13	U	32	U
27a	4424217	21	U	21	U	8.5	U	8.5	U		6	U	8.5	U	2	U	21	U	21	U	8.5	U	21	U	8.5	U	21	UJ
27b	4424218	21	U	21	U	8.5	U	8.5	U		70	U	8.5	U	28	U	21	U	21	U	8.5	U	21	U	8.5	U	21	UJ
28	4424216	18	U	18	U	7.3	U	7.3	U		5	U	7.3	U	2	U	18	U	18	U	7.3	U	18	U	7.3	U	18	U
29a	4414213	34	U	34	U	14	U	14	U		3	U	14	U	32	U	34	U	34	U	14	U	34	U	14	U	34	U
29b	4424215	28	U	28	U	11	U	11	U		7	U	11	U	3	U	28	U	28	U	11	U	28	U	11	U	28	U
30a	4414210	20	U	20	U	8.1	U	8.1	U		10	U	8.1	U	25	U	20	U	20	U	8.1	U	20	U	3.1	J	20	U
30b	4414211	25	U	25	U	9.8	U	9.8	U		10	U	9.8	U	25	U	25	U	25	U	9.8	U	25	U	9.8	U	25	U
30c	4414212	25	U	25	U	10	U	10	U		11	U	10	U	28	U	25	U	25	U	10	U	25	U	10	U	25	U
31	4414209	23	U	23	U	9.3	U	9.3	U		10	U	9.3	U	24	U	23	U	23	U	9.3	U	23	U	9.3	U	23	U
32a	4414202	24	U	24	U	9.5	U	9.5	U		10	U	9.5	U	24	U	24	U	24	U	9.5	U	24	U	9.5	U	24	U
32b	4414203	42	U	42	U	17	U	17	U		16	U	17	U	41	U	42	U	42	U	17	U	42	U	17	U	42	U
33	4414200	24	U	24	U	9.7	U	9.7	U		9	U	9.7	U	22	U	24	U	24	U	9.7	U	24	U	9.7	U	24	U

Table 10. PCB Aroclors, ug/kg

Station ID	Sample #	PCB-1016	qual.	PCB-1221	qual.	PCB-1232	qual.	PCB-1242	qual.	PCB-1248	qual.	PCB-1254	qual.	PCB-1260	qual.
1	4444208	2	U	10	U	10	U	2	U	2	U	2	U	2	U
2	4444209	1.5	U	7.4	U	7.4	U	1.5	U	1.5	U	1.5	U	1.5	U
3	4444210	1.5	U	7.3	U	7.3	U	1.5	U	1.5	U	1.5	U	1.5	U
4	4444202	1.7	U	8.5	U	8.5	U	1.7	U	1.7	U	1.7	U	1.7	U
5a	4444203	2.6	U	13	U	13	U	2.6	U	2.6	U	2.6	U	2.6	U
5b	4444204	1.7	U	8.4	U	8.4	U	1.7	U	1.7	U	1.7	U	1.7	U
6a	4444205	2.3	U	12	U	12	U	2.3	U	2.3	U	2.3	U	2.3	U
6b	4444206	2.6	U	13	U	13	U	2.6	U	2.6	U	2.6	U	2.6	U
7	4434247	1.6	U	7.7	U	7.7	U	1.6	U	1.6	U	1.6	U	1.6	U
8	4434246	1.8	U	9.2	U	9.2	U	1.8	U	1.8	U	1.8	U	1.8	U
9	4434245	1.6	U	7.8	U	7.8	U	1.6	U	1.6	U	1.6	U	1.6	U
10	4434239	3.8	U	19	U	19	U	3.8	U	3.8	U	3.8	U	3.8	U
11	4434238	1.6	U	7.8	U	7.8	U	1.6	U	1.6	U	1.6	U	1.6	U
12	4444201	1.6	U	7.6	U	7.6	U	1.6	U	1.6	U	1.6	U	1.6	U
13	4434237	1.8	U	8.9	U	8.9	U	1.8	U	1.8	U	1.8	U	1.8	U
14	4434236	1.4	U	7	U	7	U	1.4	U	1.4	U	1.4	U	1.4	U
15	4434235	1.8	U	9.2	U	9.2	U	1.8	U	1.8	U	1.8	U	1.8	U
16	4434234	1.8	U	9.1	U	9.1	U	1.8	U	1.8	U	1.8	U	1.8	U
17	4434241	1.6	U	8.1	U	8.1	U	1.6	U	1.6	U	1.6	U	1.6	U
18	4434230	1.8	U	8.9	U	8.9	U	1.8	U	1.8	U	1.8	U	1.8	U
19a	4434242	1.6	U	7.8	U	7.8	U	1.6	U	1.6	U	1.6	U	1.6	U
19b	4434243	1.6	U	8	U	8	U	1.6	U	1.6	U	1.6	U	1.6	U
20	4434231	1.9	U	9.3	U	9.3	U	1.9	U	1.9	U	1.9	U	1.9	U
21	4434244	1.7	U	8.3	U	8.3	U	1.7	U	1.7	U	1.7	U	1.7	U
22	4434233	1.5	U	7.3	U	7.3	U	1.5	U	1.5	U	1.5	U	1.5	U
23	4424225	2.1	U	11	U	11	U	2.1	U	2.1	U	2.1	U	2.1	U
24a	4424220	1.6	U	7.8	U	7.8	U	1.6	U	1.6	U	1.6	U	1.6	U
24b	4424224	1.6	U	7.8	U	7.8	U	1.6	U	1.6	U	1.6	U	1.6	U
25a	4424226	1.7	U	8.6	U	8.6	U	1.7	U	1.7	U	1.7	U	1.7	U
25b	4424227	1.8	U	8.9	U	8.9	U	1.8	U	1.8	U	1.8	U	1.8	U
26a	4414205	1.3	U	6.6	U	6.6	U	1.3	U	1.3	U	1.3	U	1.3	U
26b	4414206	1.8	U	8.8	U	8.8	U	1.8	U	1.8	U	1.8	U	1.8	U
26c	4414207	1.7	U	8.3	U	8.3	U	1.7	U	1.7	U	1.7	U	1.7	U
27a	4424217	1.4	U	7	U	7	U	1.4	U	1.4	U	1.4	U	1.4	U

Table 10, Continued

Station ID	Sample #	PCB-1016	qual.	PCB-1221	qual.	PCB-1232	qual.	PCB-1242	qual.	PCB-1248	qual.	PCB-1254	qual.	PCB-1260	qual.
27b	4424218	1.4	U	7	U	7	U	1.4	U	1.4	U	1.4	U	1.4	U
28	4424216	1.4	U	7.1	U	7.1	U	1.4	U	1.4	U	1.4	U	1.4	U
29a	4414213	1.6	U	7.7	U	7.7	U	1.6	U	1.6	U	1.6	U	1.6	U
29b	4424215	1.6	U	8.2	U	8.2	U	1.6	U	1.6	U	1.6	U	1.6	U
30a	4414210	1.7	U	8.3	U	8.3	U	1.7	U	1.7	U	1.7	U	1.7	U
30b	4414211	1.8	U	9	U	9	U	1.8	U	1.8	U	1.8	U	1.8	U
30c	4414212	1.7	U	8.5	U	8.5	U	1.7	U	1.7	U	1.7	U	1.7	U
31	4414209	1.6	U	8.2	U	8.2	U	1.6	U	1.6	U	1.6	U	1.6	U
32b	4414203	2.2	U	11	U	11	U	2.2	U	2.2	U	2.2	U	2.2	U
33	4414200	1.4	U	6.9	U	6.9	U	1.4	U	1.4	U	1.4	U	1.4	U

Table 11. Polychlorinated dibenzodioxins and dibenzofurans, ng/kg

Station ID	Sample #	12346789-OCDD	qual.	1234678-HpCDD	qual.	123478-HxCDD	qual.	123678-HxCDD		123789-HxCDD	qual.	234678-HxCDD	qual.	12378-PCDD	qual.	2378-TCDD	qual.	12346789-OCDF	qual.
1	4444208	83.5		5.06		4.78	U	4.78	U	4.78	U	4.78	U	4.78	U	0.955	UJ	9.55	U
2	4444209	15.1		4.68	U	4.68	U	4.68	U	4.68	U	4.68	U	4.68	U	0.936	UJ	9.36	U
3	4444210	32.4		4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	0.979	UJ	9.79	U
4	4444202	10.6		4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	0.977	UJ	9.77	U
5a	4444203	135		14.2		4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.989	UJ	9.89	U
5b	4444204	9.94	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	0.994	UJ	9.94	U
6a	4444205	1010		91.5		4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.989	UJ	39.4	
6b	4444206	40.8		4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.989	UJ	9.89	U
7	4434247	9.84	U	4.92	U	4.92	U	4.92	U	4.92	U	4.92	U	4.92	U	0.984	UJ	9.84	U
8	4434246	9.88	U	4.94	U	4.94	U	4.94	U	4.94	U	4.94	U	4.94	U	0.988	UJ	9.88	U
9	4434245	9.71	U	4.85	U	4.85	U	4.85	U	4.85	UJ	4.85	U	4.85	U	0.971	UJ	9.71	U
10	4434239	12.1		4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	0.977	U	9.77	U
11	4434238	9.85	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.985	U	9.85	U
12	4444201	78.9		4.74	U	4.74	U	4.74	U	4.74	U	4.74	U	4.74	U	0.949	UJ	9.49	U
13	4434237	11.8		4.97	U	4.97	U	4.97	U	4.97	UJ	4.97	U	4.97	U	0.994	UJ	9.94	U
14	4434236	18.7		4.81	U	4.81	U	4.81	U	4.81	U	4.81	U	4.81	U	0.962	U	9.62	U
15	4434235	14.9		4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	0.993	U	9.93	U
16	4434234	15.3		4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	0.979	U	9.79	U
17	4434241	43.7		5.37		4.96	U	4.96	U	4.96	UJ	4.96	U	4.96	U	0.992	UJ	9.92	U
18	4434230	28.7		4.72	U	4.72	U	4.72	U	4.72	U	4.72	U	4.72	U	0.944	U	9.44	U
19a	4434242	30.5		5.01	U	5.01	U	5.01	U	5.01	UJ	5.01	U	5.01	U	1	UJ	10	U
19b	4434243	25.3		4.88	U	4.88	U	4.88	U	4.88	UJ	4.88	U	4.88	U	0.976	UJ	9.76	U
20	4434231	52.4		5.31		4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	0.979	U	9.79	U
21	4434244	19.7		4.96	U	4.96	U	4.96	U	4.96	UJ	4.96	U	4.96	U	0.991	UJ	9.91	U
22	4434233	13.4		4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.985	U	9.85	U
23	4424225	28.4		4.98	U	4.98	U	4.98	U	4.98	UJ	4.98	U	4.98	U	0.996	UJ	9.96	U
24a	4424220	20.5		4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.99	U	9.9	U
24b	4424224	26.9		4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.986	U	9.86	U
25a	4424226	16.8		4.87	U	4.87	U	4.87	U	4.87	U	4.87	U	4.87	U	0.975	U	9.75	U
25b	4424227	28.2		5.04	U	5.04	U	5.04	U	5.04	U	5.04	U	5.04	U	1.01	U	10.1	U
26a	4414205	18.2	U	4.84	U	4.84	U	4.84	UJ	4.84	UJ	4.84	UJ	4.84	U	0.969	U	9.69	U
26b	4414206	30.6	U	4.98	U	4.98	U	4.98	UJ	4.98	UJ	4.98	UJ	4.98	U	0.996	U	9.96	U
26c	4414207	82	U	7.57	U	4.95	U	4.95	UJ	4.95	UJ	4.95	UJ	4.95	U	0.989	U	9.89	U
27a	4424217	12		4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.986	U	9.86	U
27b	4424218	9.86	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.986	U	9.86	U
28	4424216	125		14.5		5	U	5	U	5	U	5	U	5	U	0.999	U	9.99	U
29a	4414213	98.7		9.59		4.99	U	4.99	U	4.99	U	4.99	U	4.99	U	0.997	U	9.97	U
29b	4424215	61.7		5.01	U	5.01	U	5.01	U	5.01	U	5.01	U	5.01	U	1	U	10	U
30a	4414210	50.5	U	5.54	U	4.9	U	4.9	UJ	4.9	UJ	4.9	UJ	4.9	U	0.98	U	9.8	U
30b	4414211	29.5	U	4.94	U	4.94	U	4.94	UJ	4.94	UJ	4.94	UJ	4.94	U	0.987	U	9.87	U
30c	4414212	26.4	U	4.95	U	4.95	U	4.95	UJ	4.95	UJ	4.95	UJ	4.95	U	0.989	U	9.89	U
31	4414209	337	U	31.3		4.86	U	4.86	UJ	4.86	UJ	4.86	UJ	4.86	U	0.973	U	13.6	U
32a	4414202	93.7	U	6.78	U	4.89	U	4.89	U	4.89	U	4.89	U	4.89	U	0.978	U	12.2	U
32b	4414203	34.7	U	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	0.996	U	9.96	U
33	4414200	78.7	U	26.1		4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	0.993	U	9.93	U

Table 11, Continued

Station ID	Sample #	1234678-HpCDF	qual.	1234789-HpCDF	qual.	123478-HxCDF	qual.	123678-HxCDF		123789-HxCDF	qual.	12378-PCDF	qual.	23478-PCDF	qual.	2378-TCDF	qual.
1	4444208	4.78	U	4.78	U	4.78	U	4.78	U	4.78	U	4.78	U	4.78	U	0.955	U
2	4444209	4.68	U	4.68	U	4.68	U	4.68	U	4.68	U	4.68	U	4.68	U	0.936	U
3	4444210	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	0.979	UJ
4	4444202	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	0.977	UJ
5a	4444203	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.989	UJ
5b	4444204	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	0.994	UJ
6a	4444205	5.67		4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.989	UJ
6b	4444206	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.989	UJ
7	4434247	4.92	U	4.92	U	4.92	U	4.92	U	4.92	U	4.92	U	4.92	U	0.984	UJ
8	4434246	4.94	U	4.94	U	4.94	U	4.94	U	4.94	U	4.94	U	4.94	U	0.988	UJ
9	4434245	4.85	U	4.85	U	4.85	U	4.85	U	4.85	U	4.85	U	4.85	U	0.971	UJ
10	4434239	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	0.977	U
11	4434238	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.985	U
12	4444201	4.74	U	4.74	U	4.74	U	4.74	U	4.74	U	4.74	U	4.74	U	0.949	UJ
13	4434237	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	0.994	UJ
14	4434236	4.81	U	4.81	U	4.81	U	4.81	U	4.81	U	4.81	U	4.81	U	0.962	U
15	4434235	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	0.993	U
16	4434234	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	0.979	U
17	4434241	4.96	U	4.96	U	4.96	U	4.96	U	4.96	U	4.96	U	4.96	U	0.992	UJ
18	4434230	4.72	U	4.72	U	4.72	U	4.72	U	4.72	U	4.72	U	4.72	U	1.09	J
19a	4434242	5.01	U	5.01	U	5.01	U	5.01	U	5.01	U	5.01	U	5.01	U	1	UJ
19b	4434243	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	4.88	U	0.976	UJ
20	4434231	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	0.979	U
21	4434244	4.96	U	4.96	U	4.96	U	4.96	U	4.96	U	4.96	U	4.96	U	0.991	UJ
22	4434233	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.985	U
23	4424225	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	0.996	UJ
24a	4424220	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.99	U
24b	4424224	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.986	U
25a	4424226	4.87	U	4.87	U	4.87	U	4.87	U	4.87	U	4.87	U	4.87	U	0.975	U
25b	4424227	5.04	U	5.04	U	5.04	U	5.04	U	5.04	U	5.04	U	5.04	U	1.01	U
26a	4414205	4.84	U	4.84	U	4.84	U	4.84	U	4.84	U	4.84	U	4.84	U	0.969	U
26b	4414206	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	0.996	U
26c	4414207	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.989	U
27a	4424217	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.986	U
27b	4424218	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	4.93	U	0.986	U
28	4424216	5	U	5	U	5	U	5	U	5	U	5	U	5	U	0.999	U
29a	4414213	4.99	U	4.99	U	4.99	U	4.99	U	4.99	U	4.99	U	4.99	U	0.997	U
29b	4424215	5.01	U	5.01	U	5.01	U	5.01	U	5.01	U	5.01	U	5.01	U	1	U
30a	4414210	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	4.9	U	0.98	U
30b	4414211	4.94	U	4.94	U	4.94	U	4.94	U	4.94	U	4.94	U	4.94	U	0.987	U
30c	4414212	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	4.95	U	0.989	U
31	4414209	4.86	U	4.86	U	4.86	U	4.86	U	4.86	U	4.86	U	4.86	U	0.973	U
32a	4414202	4.89	U	4.89	U	4.89	U	4.89	U	4.89	U	4.89	U	4.89	U	1.02	UJ
32b	4414203	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	4.98	U	0.996	U
33	4414200	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	4.97	U	0.993	U

Table 12. Polybrominated Diphenyl Ethers (PBDE), ug/kg

Station ID	Sample #	PBDE# 28	qual.	PBDE# 47	qual.	PBDE# 99	qual.	PBDE#100	qual.	PBDE#153	qual.	PBDE#154	qual.	PBDE#183	qual.	PBDE#209	qual.	Sum of estimated PBDEs
1	4444208	0.036	J	0.68	J	0.27	J	0.56	J	0.19	J	0.23	J	0.9	U	45	UJ	1.966
2	4444209	0.58	U	0.082	J	0.58	U	0.19	J	0.58	U	0.58	U	0.58	U	29	UJ	0.272
3	4444210	0.58	U	0.26	J	0.13	J	0.21	J	0.58	U	0.58	U	0.58	U	29	UJ	0.6
4	4444202	0.74	U	0.74	U	0.74	U	0.74	U	0.74	U	0.74	U	0.74	U	37	UJ	none
5a	4444203	0.031	J	0.28	J	0.16	J	0.16	J	1	U	1	U	1	U	51	UJ	0.631
5b	4444204	0.69	U	0.69	U	0.69	U	0.69	U	0.69	U	0.69	U	0.69	U	35	UJ	none
6a	4444205	1.2	U	0.33	J	0.19	J	1.2	U	1.2	U	1.2	U	1.2	U	58	UJ	0.52
6b	4444206	0.045	J	0.43	J	0.21	J	0.38	J	1.1	U	1.1	U	1.1	U	57	UJ	1.065
7	4434247	0.59	U	0.59	U	0.59	U	0.59	U	0.59	U	0.59	U	0.59	U	30	UJ	none
8	4434246	0.79	U	0.79	U	0.79	U	0.79	U	0.79	U	0.79	U	0.79	U	39	UJ	none
9	4434245	0.67	U	0.67	U	0.67	U	0.67	U	0.67	U	0.67	U	0.67	U	34	UJ	none
10	4434239	1	U	0.14	J	0.04	J	0.096	J	1	U	1	U	1	U	52	UJ	0.276
11	4434238	0.63	U	0.63	U	0.63	U	0.63	U	0.63	U	0.63	U	0.63	U	31	UJ	none
12	4444201	0.56	U	0.14	J	0.092	J	0.15	J	0.56	U	0.56	U	0.56	U	28	UJ	0.382
13	4434237	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	30	UJ	none
14	4434236	0.56	U	0.56	U	0.56	U	0.56	U	0.56	U	0.56	U	0.56	U	28	UJ	none
15	4434235	0.74	U	0.18	J	0.12	J	0.16	J	0.74	U	0.74	U	0.74	U	37	UJ	0.46
16	4434234	0.76	U	0.18	J	0.14	J	0.16	J	0.76	U	0.76	U	0.76	U	38	UJ	0.48
17	4434241	0.65	U	0.14	J	0.097	J	0.13	J	0.65	U	0.65	U	0.65	U	32	UJ	0.367
18	4434230	0.63	UJ	0.2	J	0.63	UJ	0.15	J	0.63	UJ	0.63	UJ	0.63	UJ	32	UJ	0.35
19a	4434242	0.013	J	0.31	J	0.076	J	0.2	J	0.59	U	0.59	U	0.59	U	29	UJ	0.599
19b	4434243	0.63	U	0.36	J	0.084	J	0.25	J	0.12	J	0.15	J	0.63	U	32	UJ	0.964
20	4434231	0.039	J	0.34	J	0.18	J	0.3	J	0.082	J	0.77	U	0.77	U	39	UJ	0.941
21	4434244	0.66	U	0.29	J	0.094	J	0.19	J	0.66	U	0.66	U	0.66	U	33	UJ	0.574
22	4434233	0.54	U	0.13	J	0.096	J	0.18	J	0.54	U	0.54	U	0.54	U	27	UJ	0.406
23	4424225	0.13	J	1.2		0.34	J	0.84	J	0.12	J	0.18	J	0.87	U	43	UJ	2.81
24a	4424220	0.58	U	0.58	U	0.58	U	0.58	U	0.58	U	0.58	U	0.58	U	29	UJ	none
24b	4424224	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	0.48	U	24	UJ	none
25a	4424226	0.058	J	0.41	J	0.12	J	0.36	J	0.073	J	0.071	J	0.81	U	40	UJ	1.092
25b	4424227	0.053	J	0.4	J	0.2	J	0.35	J	0.1	J	0.098	J	0.77	U	39	UJ	1.201
26a	4414205	0.55	U	0.55	U	0.55	U	0.55	U	0.55	U	0.55	U	0.55	U	27	UJ	none
26b	4414206	0.8	U	0.8	U	0.8	U	0.8	U	0.8	U	0.8	U	0.8	U	40	UJ	none
26c	4414207	0.78	U	0.78	U	0.78	U	0.78	U	0.78	U	0.78	U	0.78	U	39	UJ	none
27a	4424217	0.54	U	0.54	U	0.54	U	0.54	U	0.54	U	0.54	U	0.54	U	27	UJ	none
27b	4424218	0.52	U	0.52	U	0.52	U	0.52	U	0.52	U	0.52	U	0.52	U	26	UJ	none

Table 12, Continued

Station ID	Sample #	PBDE# 28	qual.	PBDE# 47	qual.	PBDE# 99	qual.	PBDE#100	qual.	PBDE#153	qual.	PBDE#154	qual.	PBDE#183	qual.	PBDE#209	qual.	Sum of estimated PBDEs
28	4424216	0.44	U	0.44	U	0.44	U	0.44	U	0.44	U	0.44	U	0.44	U	22	UJ	none
29a	4414213	0.042	J	0.32	J	0.078	J	0.2	J	0.052	J	0.086	J	0.84	U	42	UJ	0.778
29b	4424215	0.66	U	0.66	U	0.66	U	0.66	U	0.66	U	0.66	U	0.66	U	33	UJ	none
30a	4414210	0.025	J	0.21	J	0.052	J	0.16	J	0.03	J	0.037	J	0.65	U	33	UJ	1.057
30b	4414211	0.58	U	0.13	J	0.026	J	0.084	J	0.58	U	0.58	U	0.58	U	29	UJ	0.24
30c	4414212	0.031	J	0.25	J	0.057	J	0.2	J	0.71	U	0.71	U	0.71	U	36	UJ	0.538
31	4414209	0.62	U	0.12	J	0.03	J	0.1	J	0.62	U	0.62	U	0.62	U	31	UJ	0.25
32a	4414202	0.029	J	0.14	J	0.042	J	0.14	J	0.66	U	0.66	U	0.66	U	33	UJ	0.351
32b	4414203	1.1	U	0.4	J	0.11	J	0.36	J	0.098	J	0.087	J	1.1	U	56	UJ	1.055
33	4414200	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	0.6	U	30	UJ	none

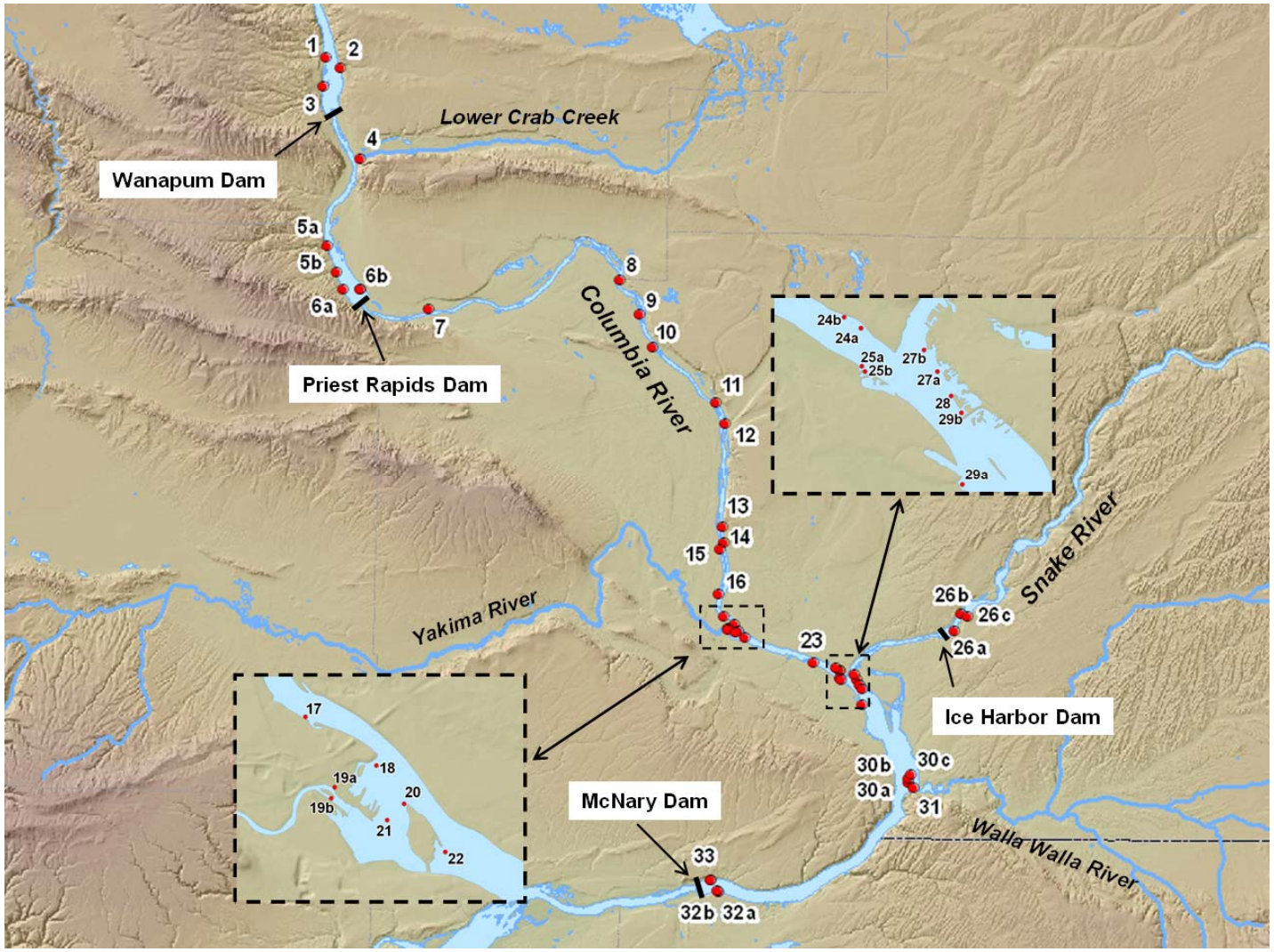


Figure 1. Mid-Columbia region and sediment sampling sites

Figure 2. Arsenic concentrations in mid-Columbia sediments

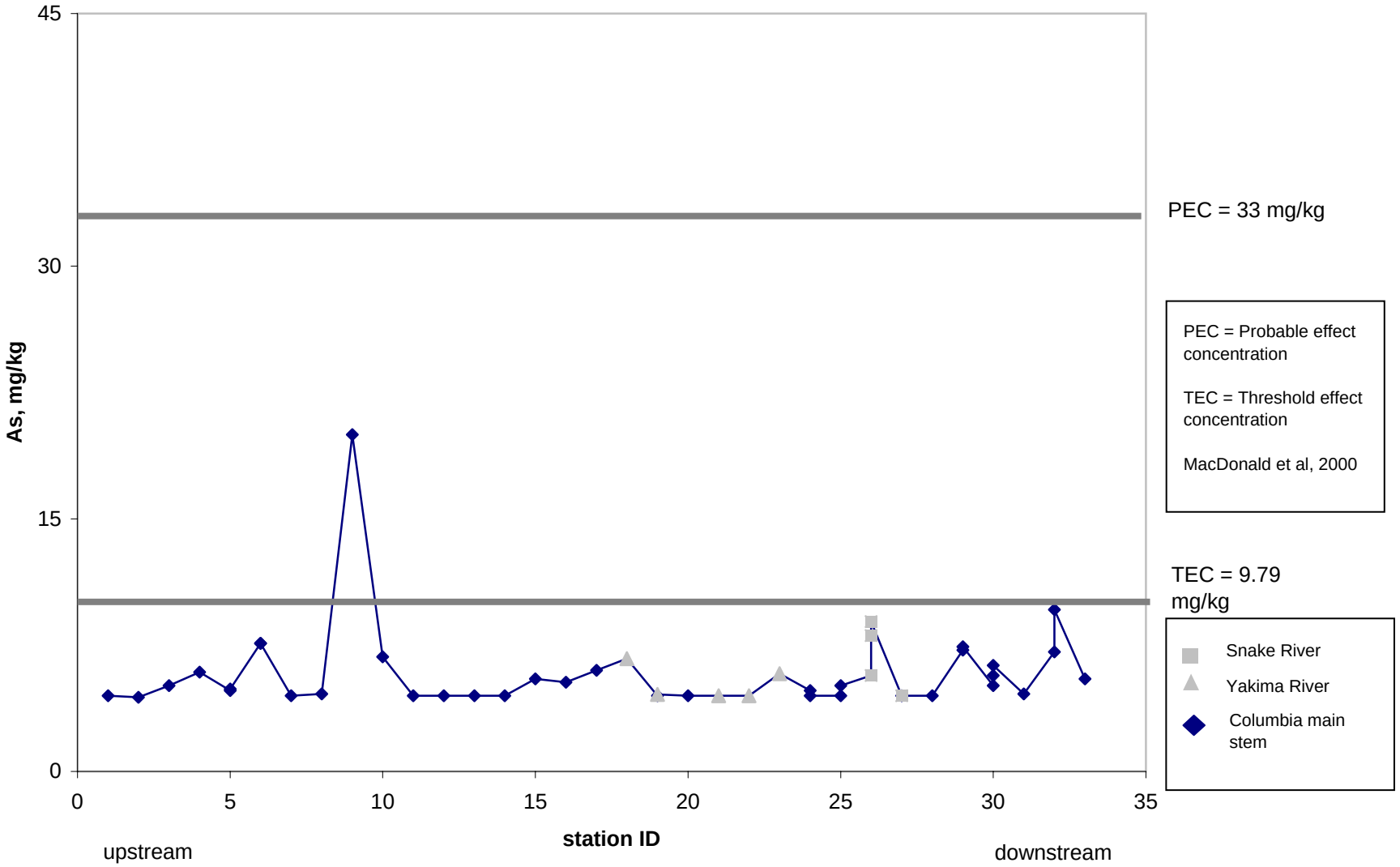


Figure 3. Arsenic data sorted by concentration

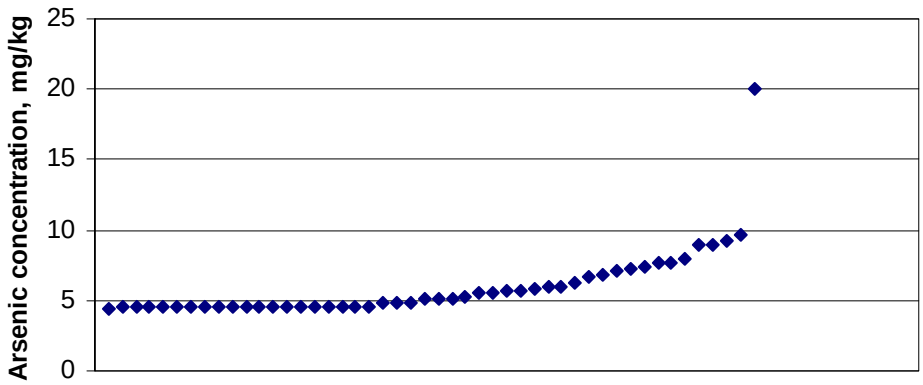


Figure 4. Arsenic concentration vs. per cent fines

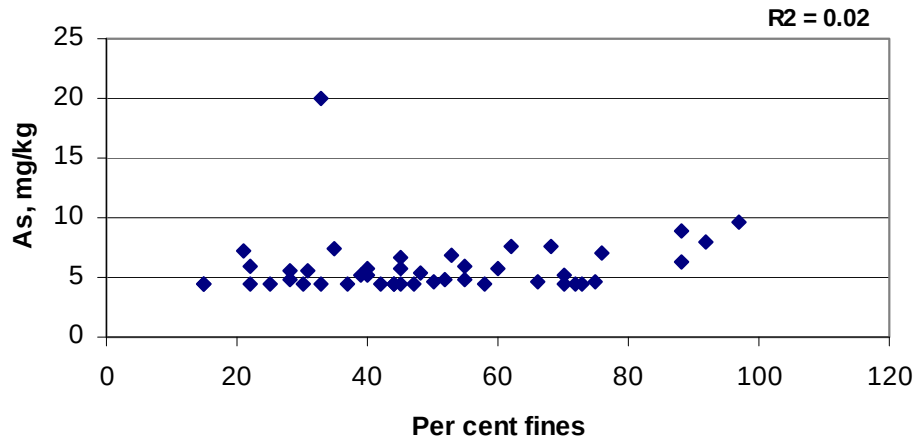


Figure 5. Arsenic concentration vs. total organic carbon (TOC)

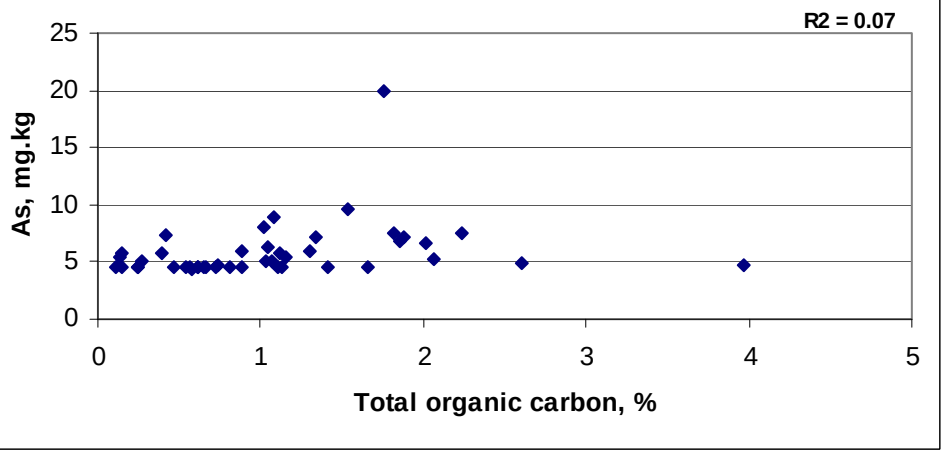


Figure 6. Arsenic geographic comparisons

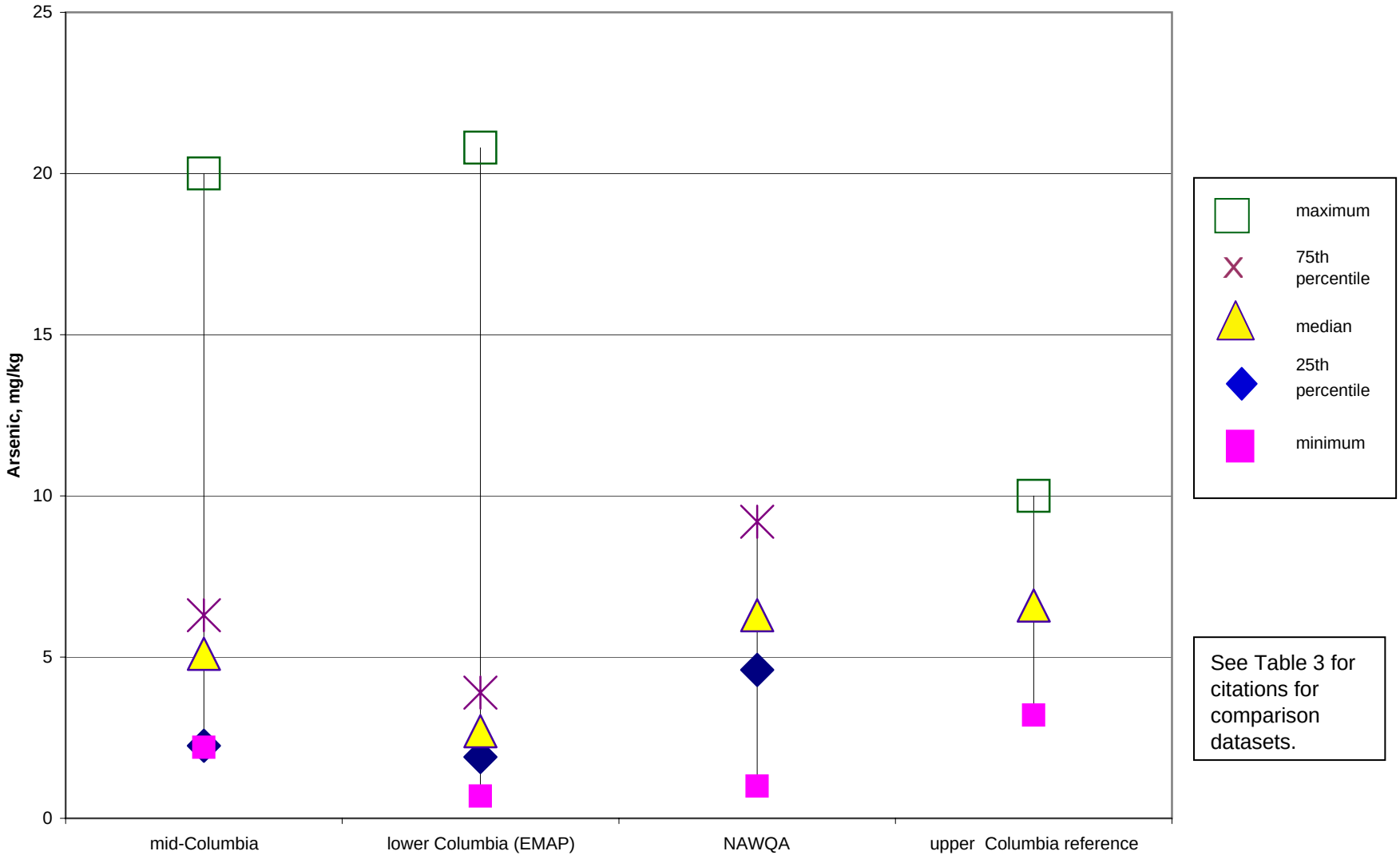


Figure 7. Cadmium concentrations in mid-Columbia sediments

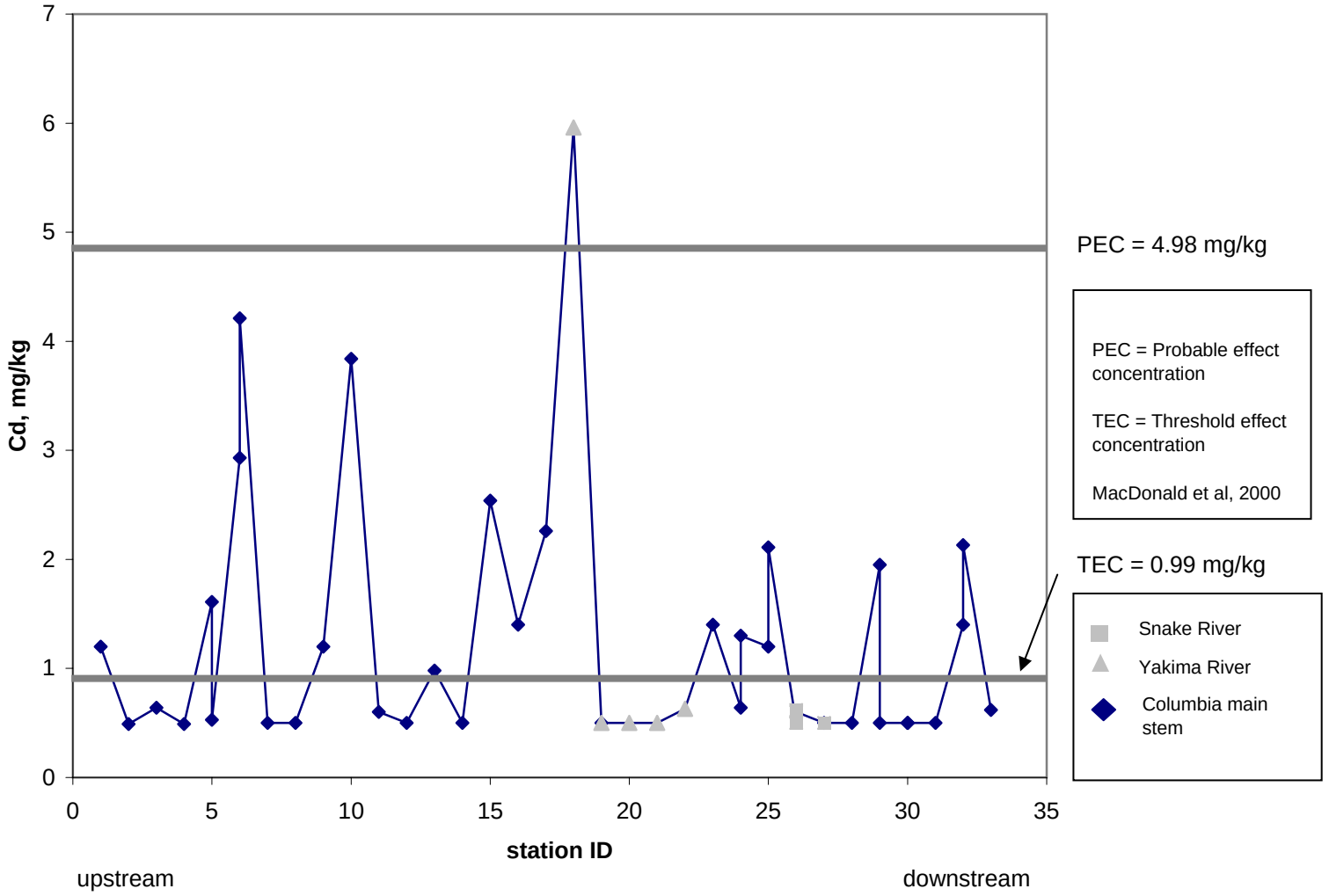


Figure 8. Cadmium data sorted by concentration

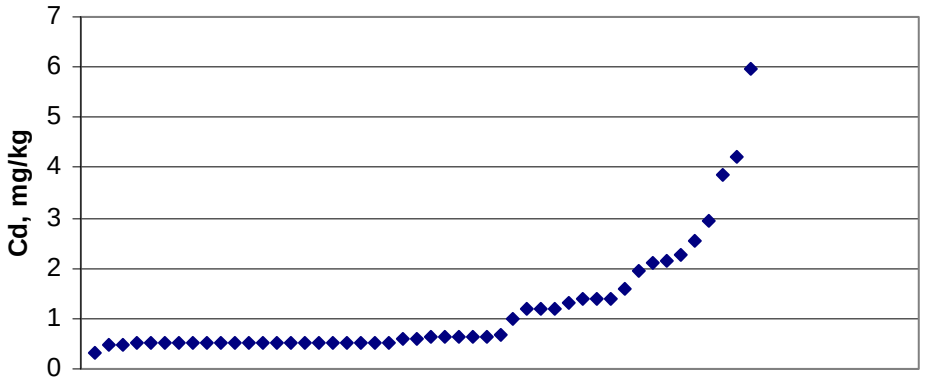


Figure 9. Cadmium concentration vs. per cent fines

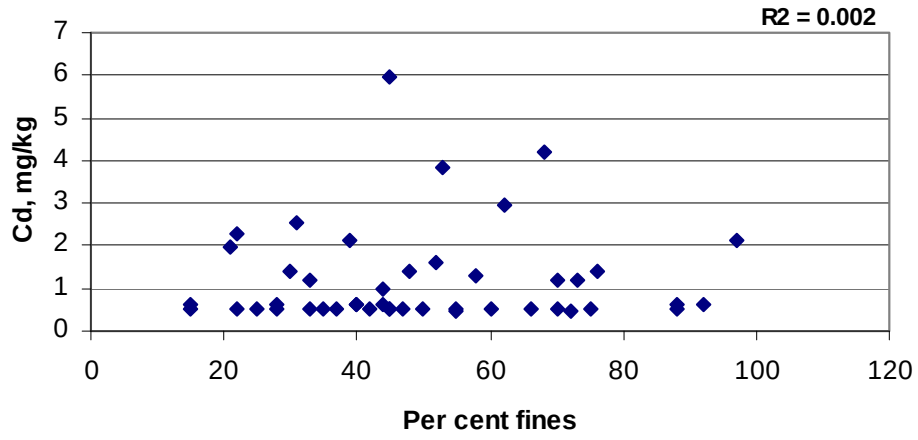


Figure 10. Cadmium concentration vs. total organic carbon (TOC)

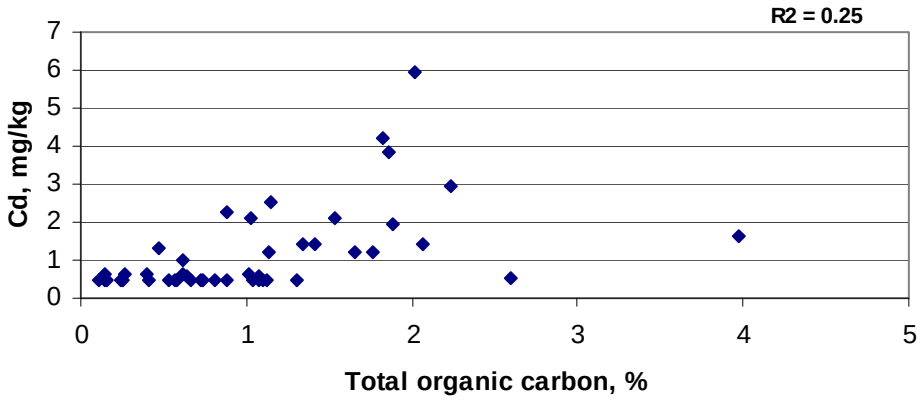


Figure 11. Cadmium geographic comparisons

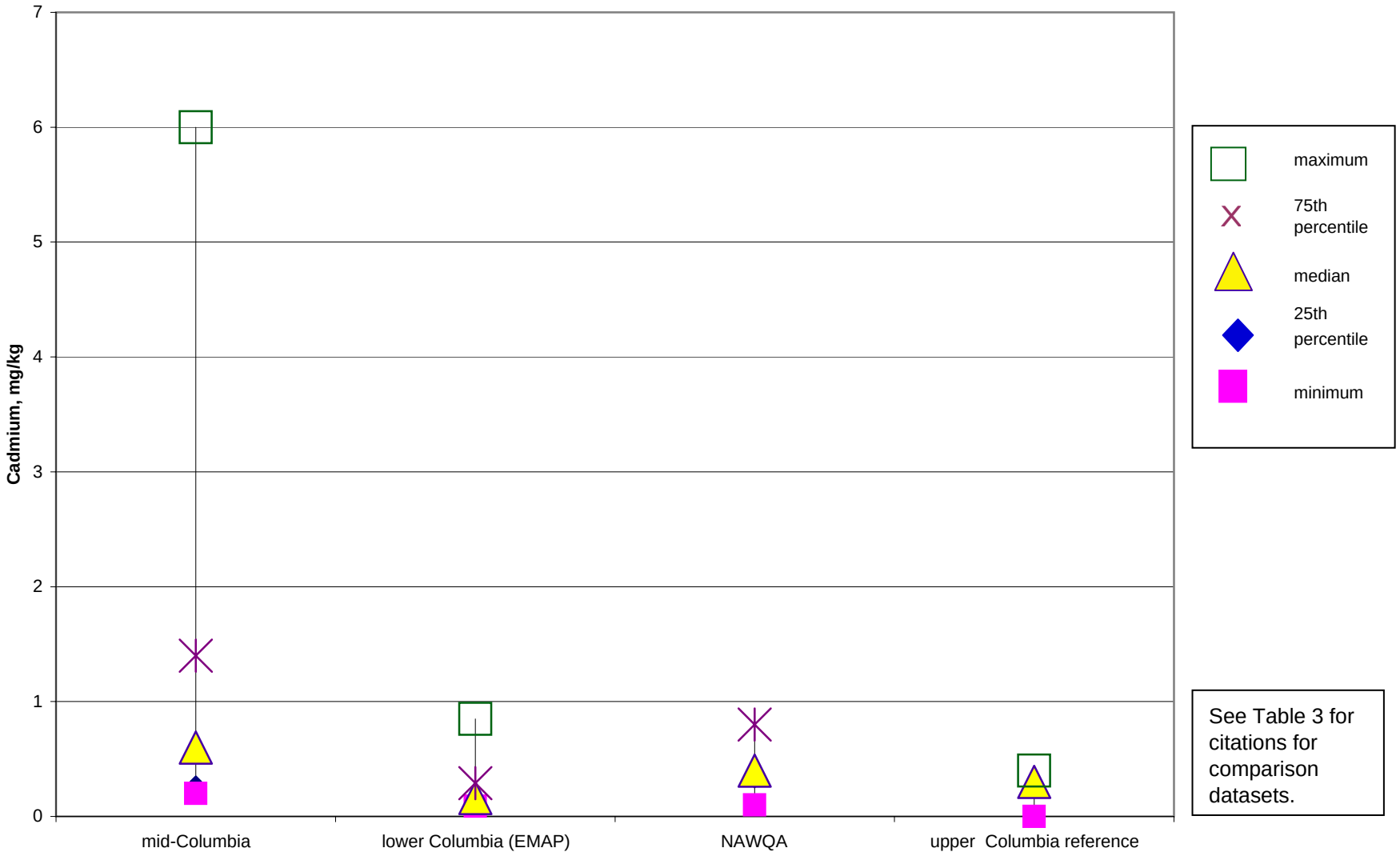


Figure 12. Chromium concentrations in mid-Columbia sediments

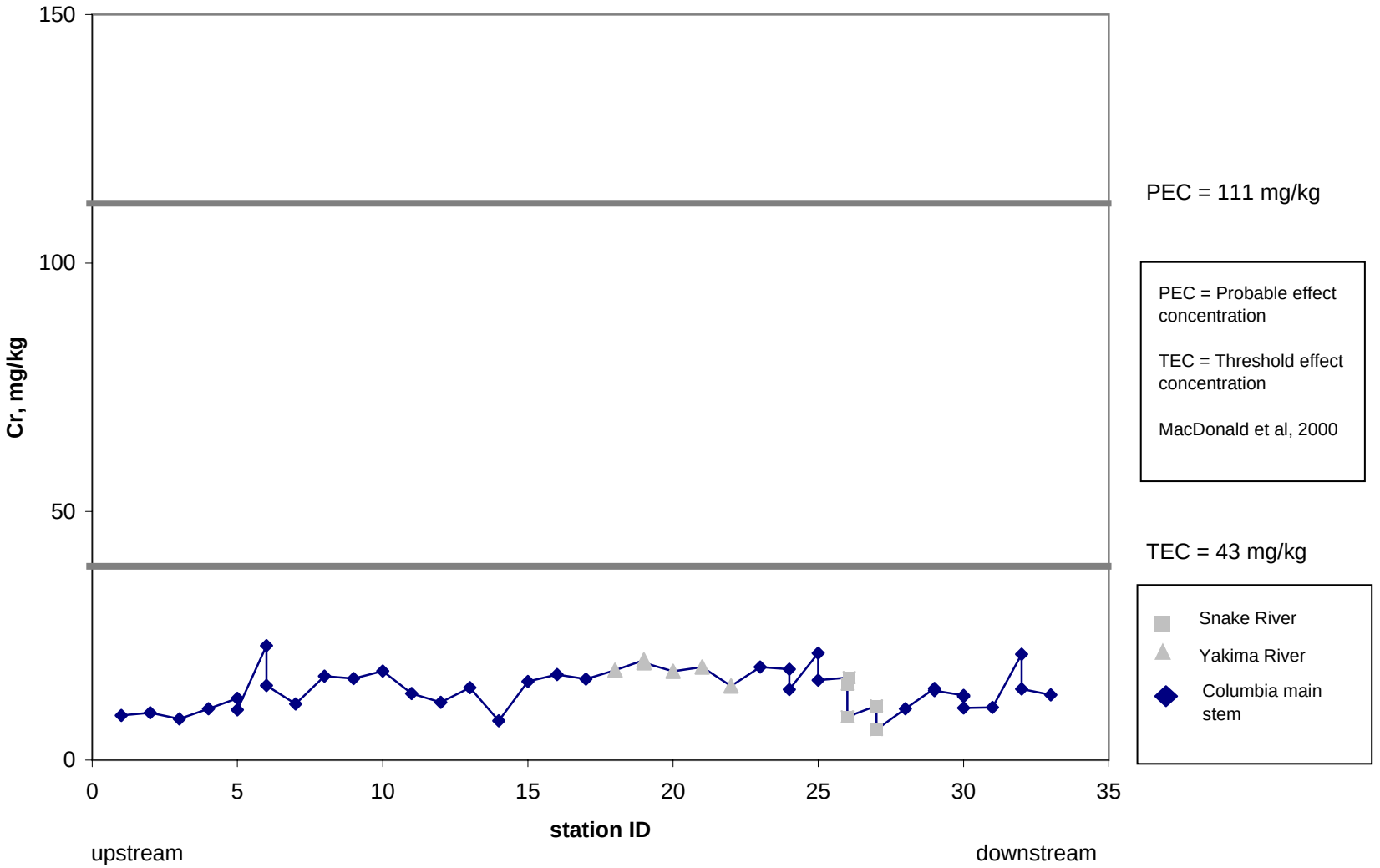


Figure 13. Chromium data sorted by concentration

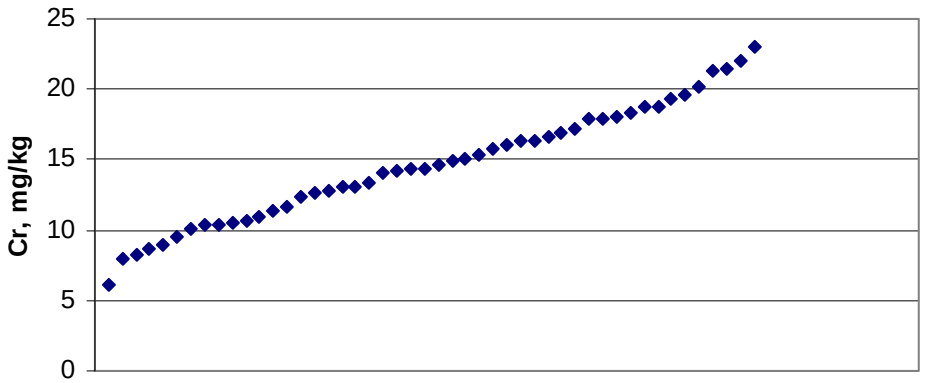


Figure 14. Chromium concentration vs. per cent fines

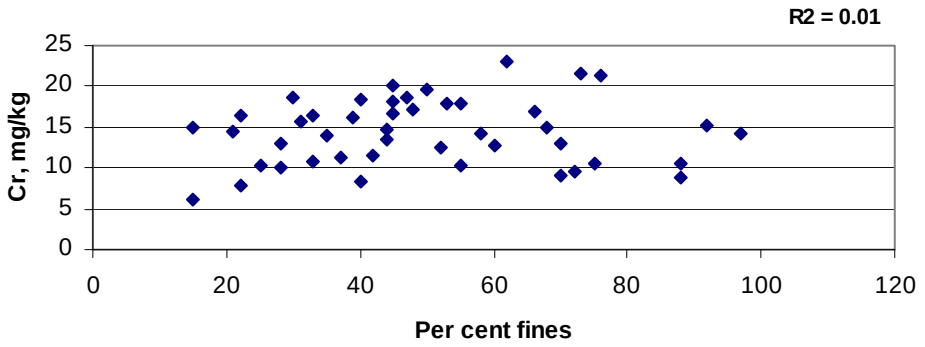


Figure 15. Chromium concentration vs. total organic carbon (TOC)

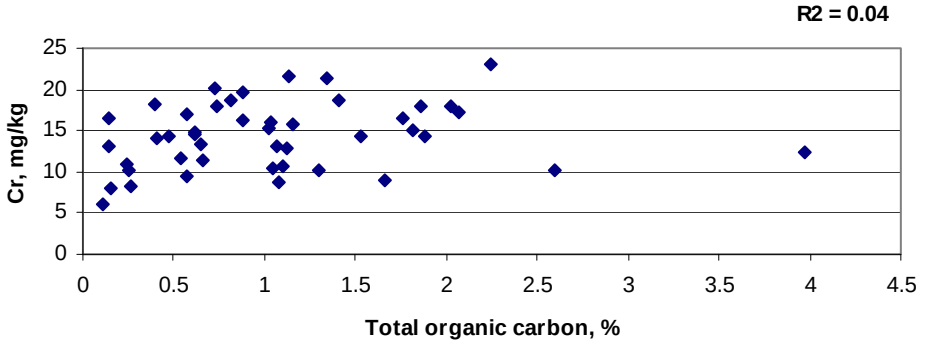


Figure 16. Chromium geographic comparisons

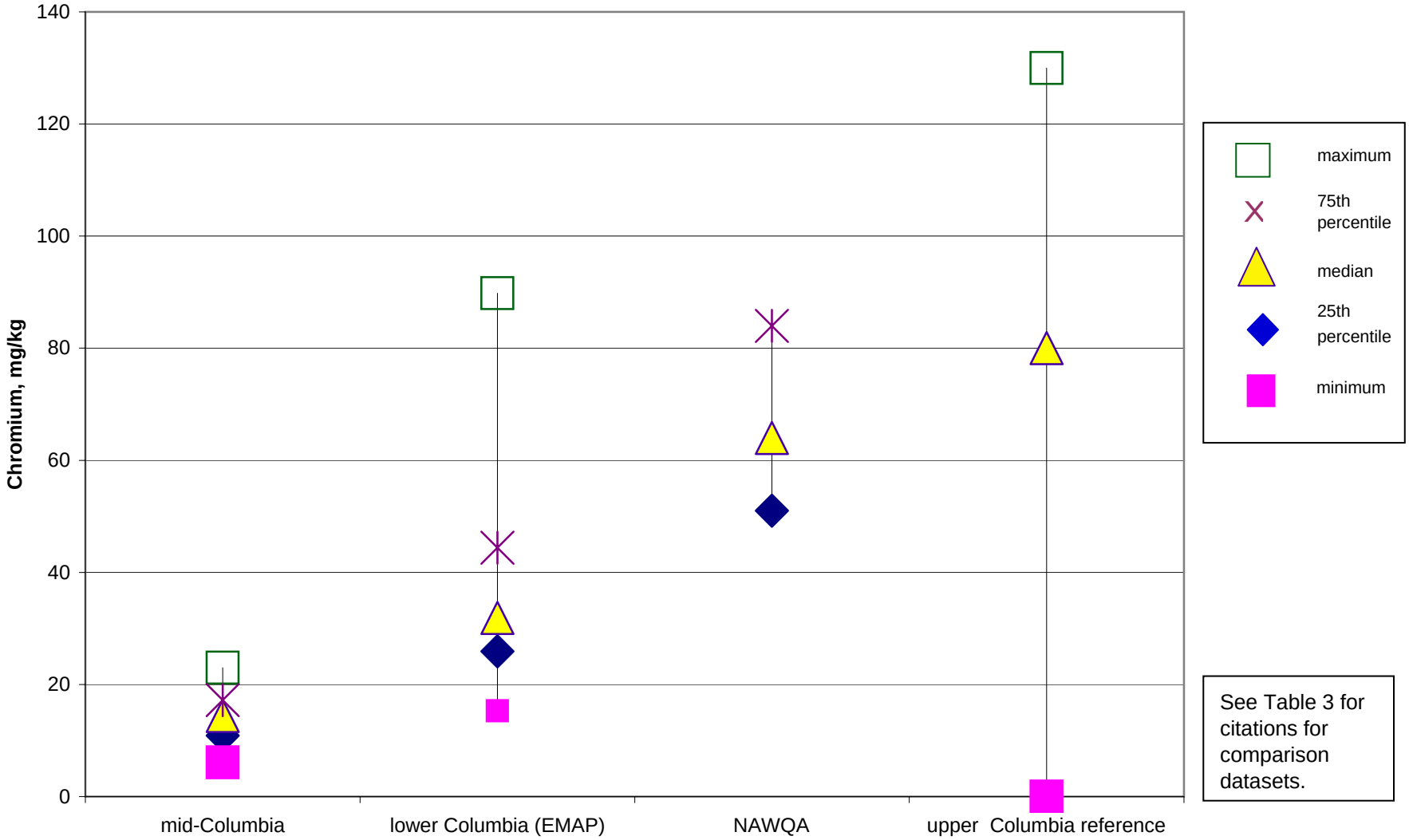


Figure 17. Copper concentrations in mid-Columbia sediments

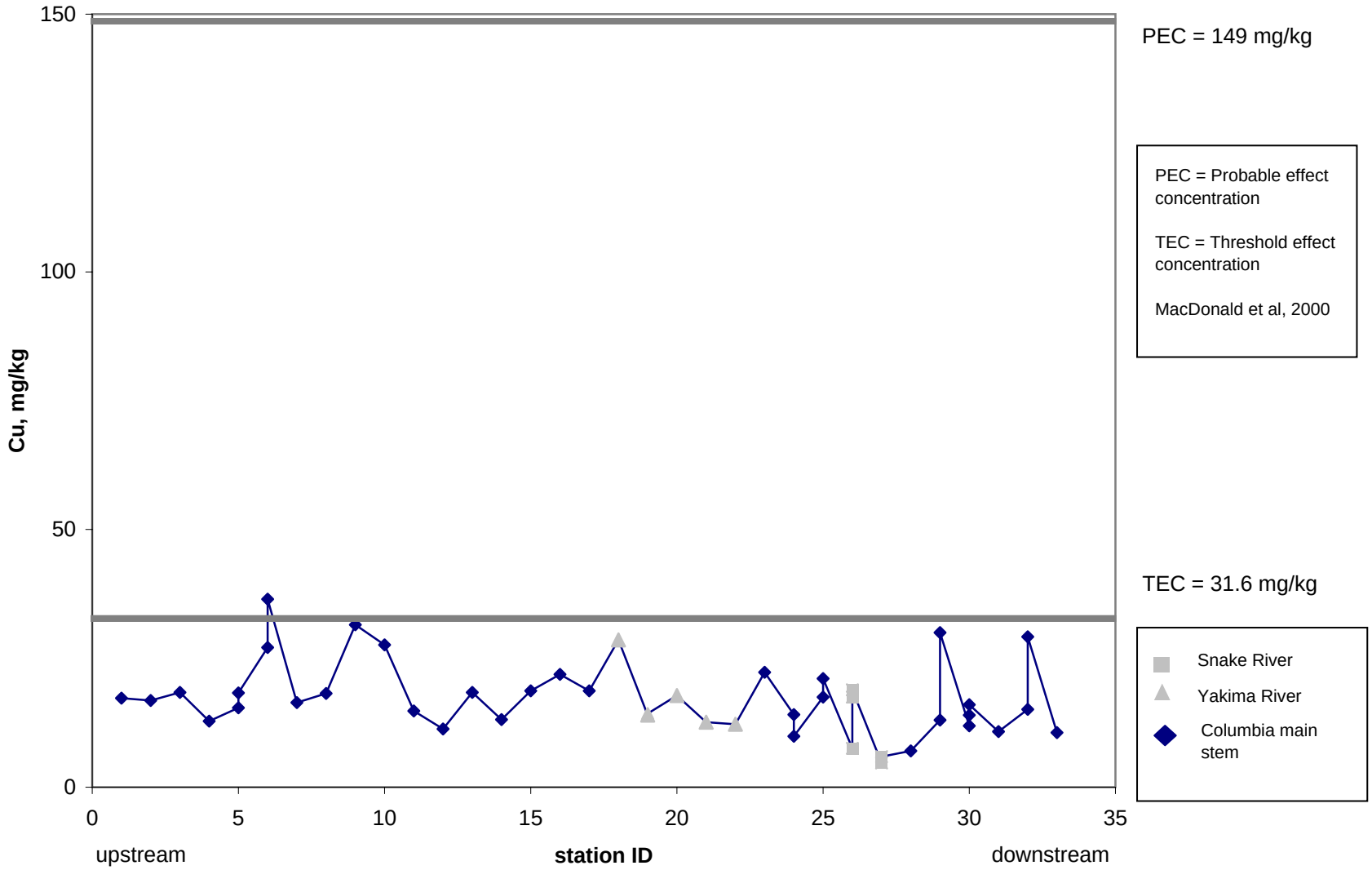


Figure 18. Copper data sorted by concentration

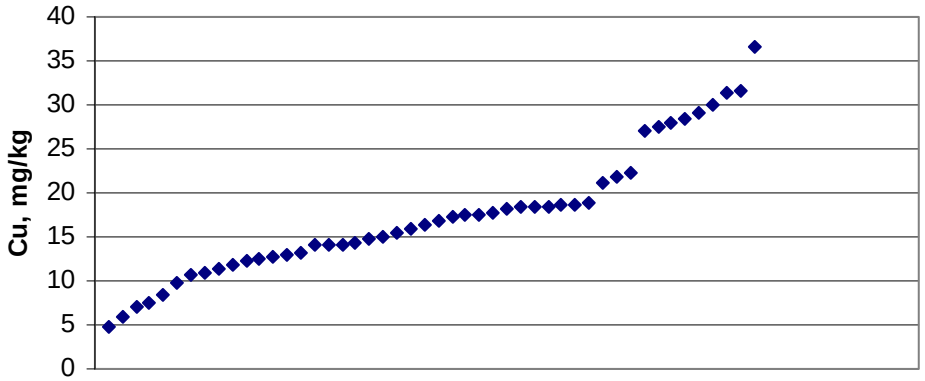


Figure 19. Copper concentration vs. per cent fines

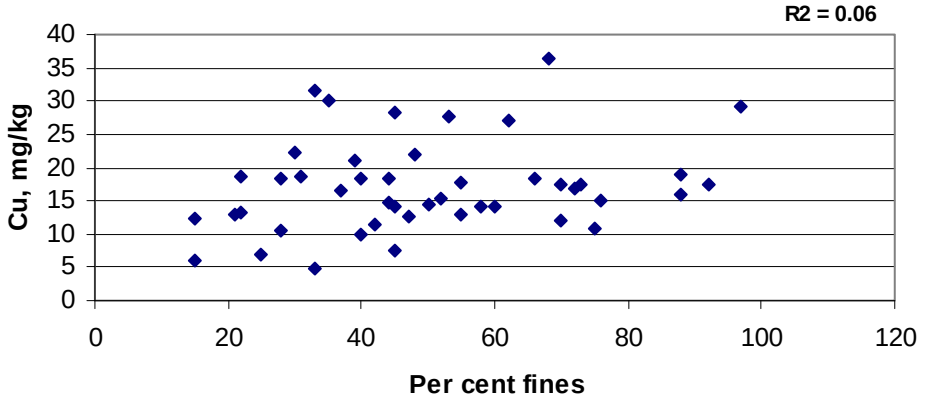


Figure 20. Copper concentration vs. total organic carbon (TOC)

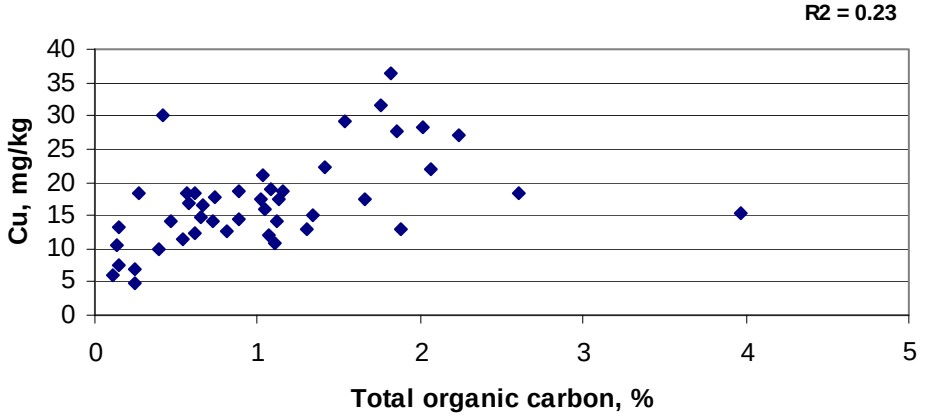


Figure 21. Copper geographic comparisons

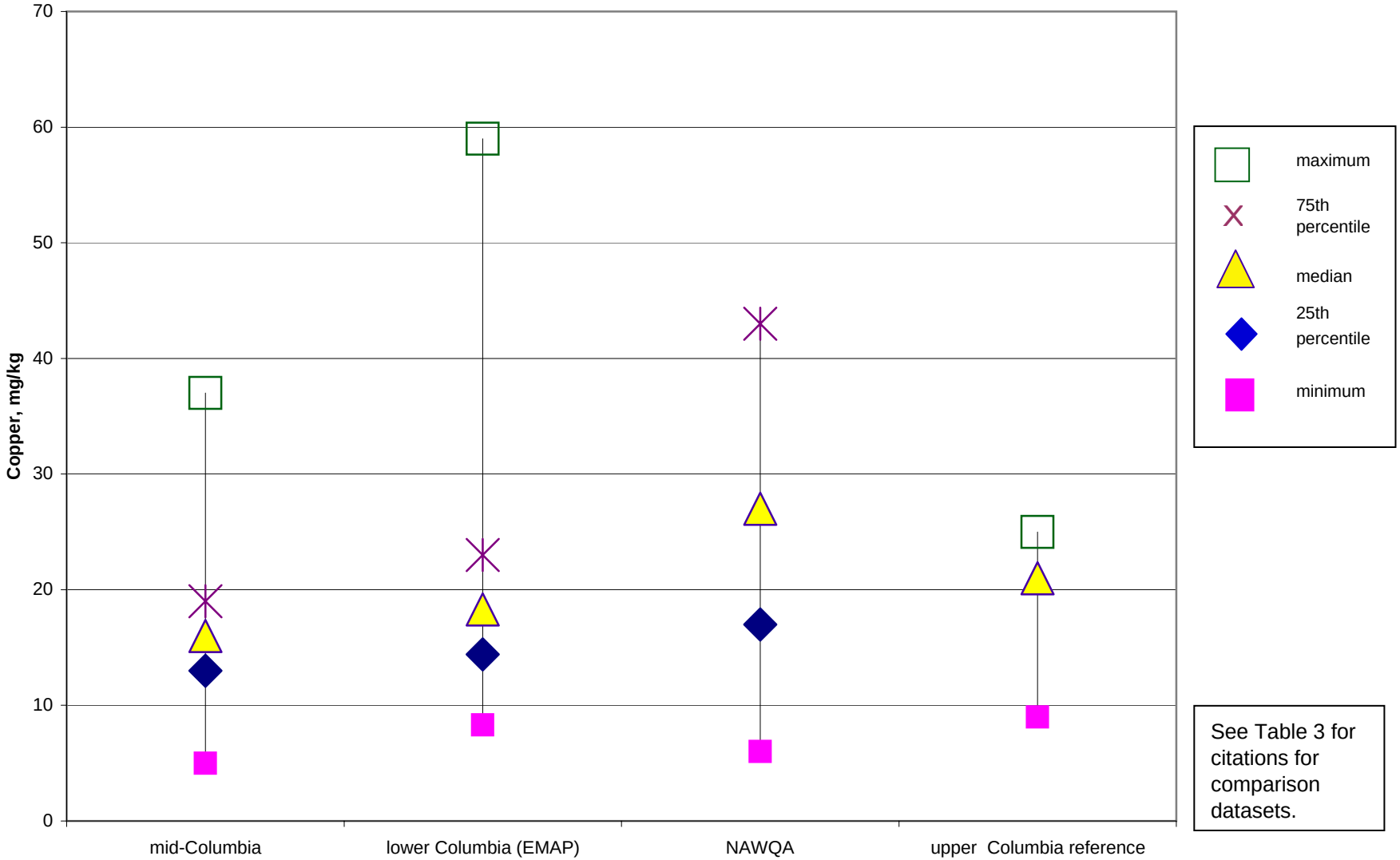
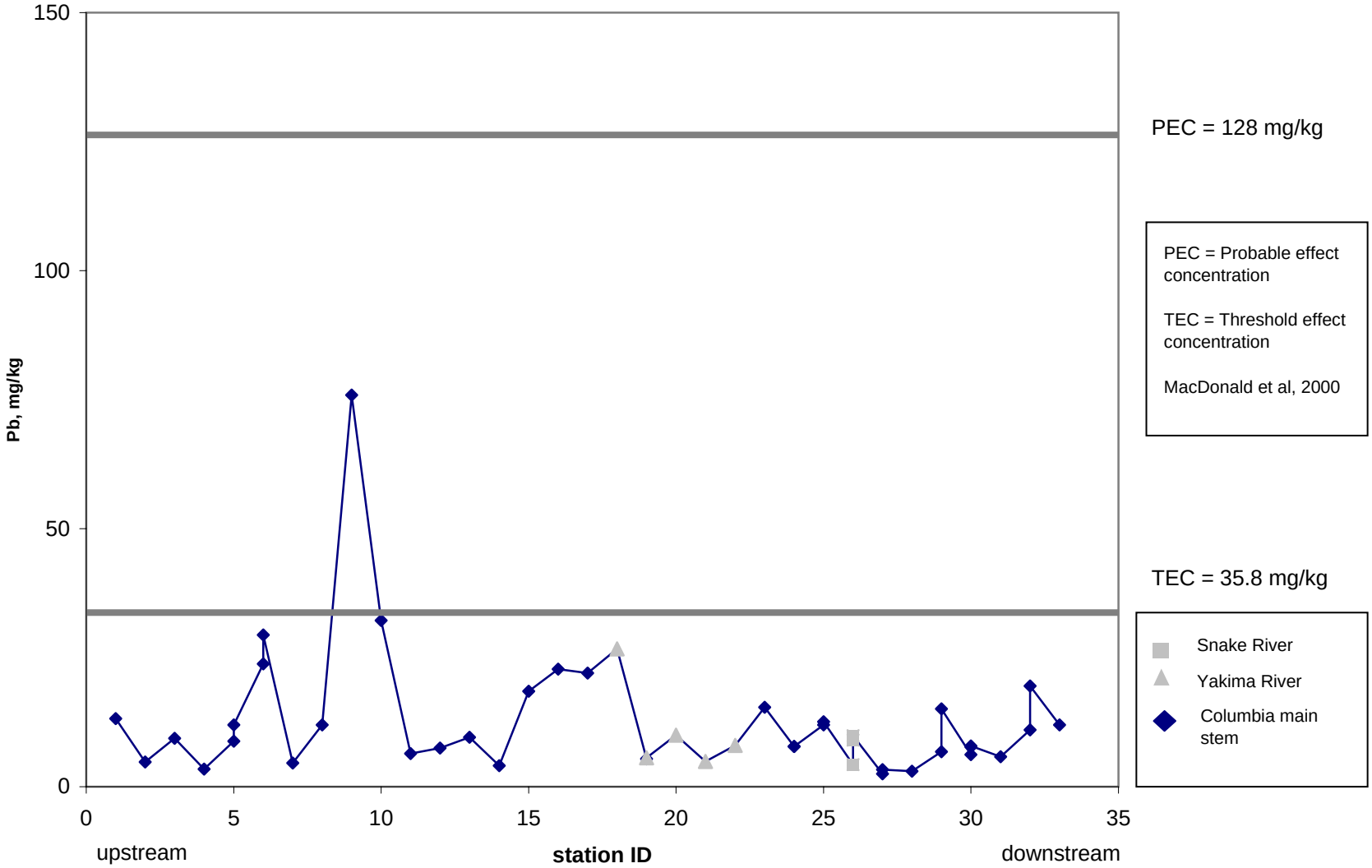


Figure 22. Lead concentrations in mid-Columbia sediments



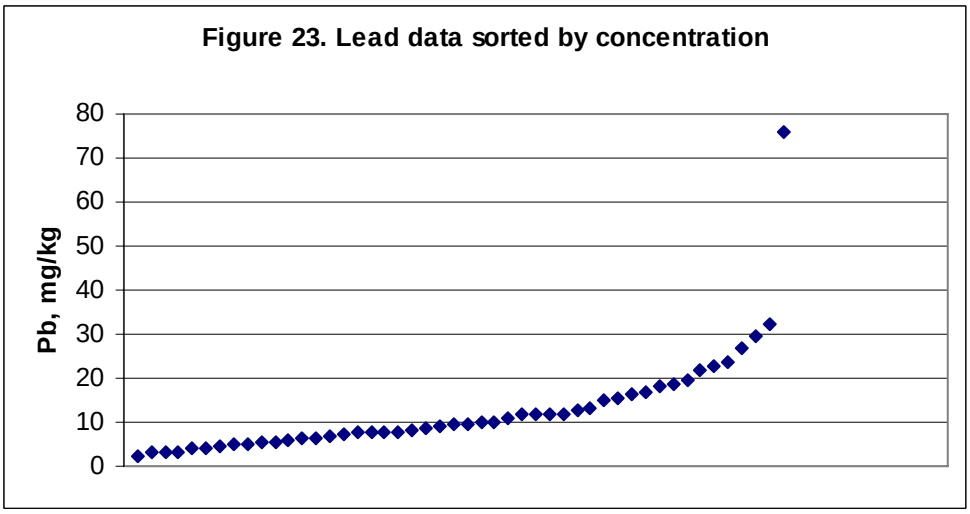


Figure 23. Lead data sorted by concentration
Pb, mg/kg
0
10
20
30
40
50
60
70
80

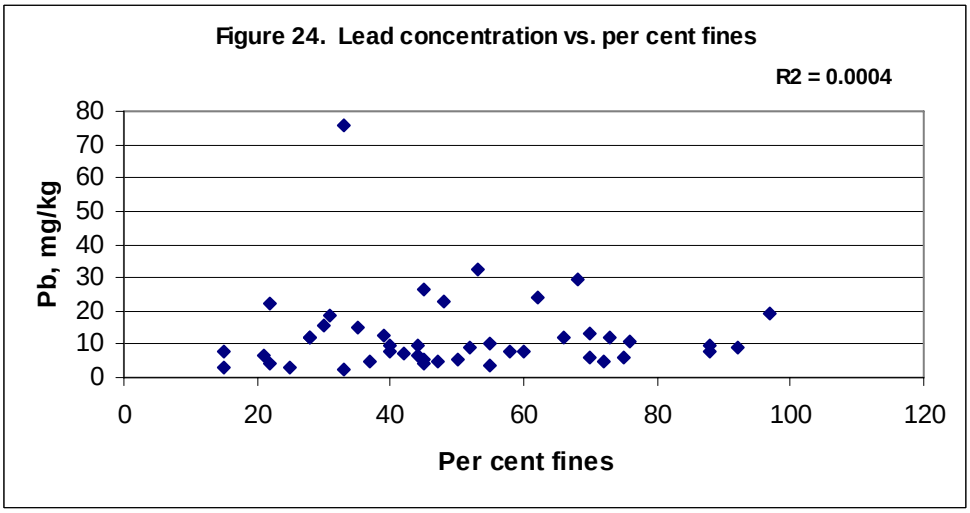


Figure 24. Lead concentration vs. per cent fines
R2 = 0.0004
Pb, mg/kg
0
10
20
30
40
50
60
70
80
0
20
40
60
80
100
120
Per cent fines

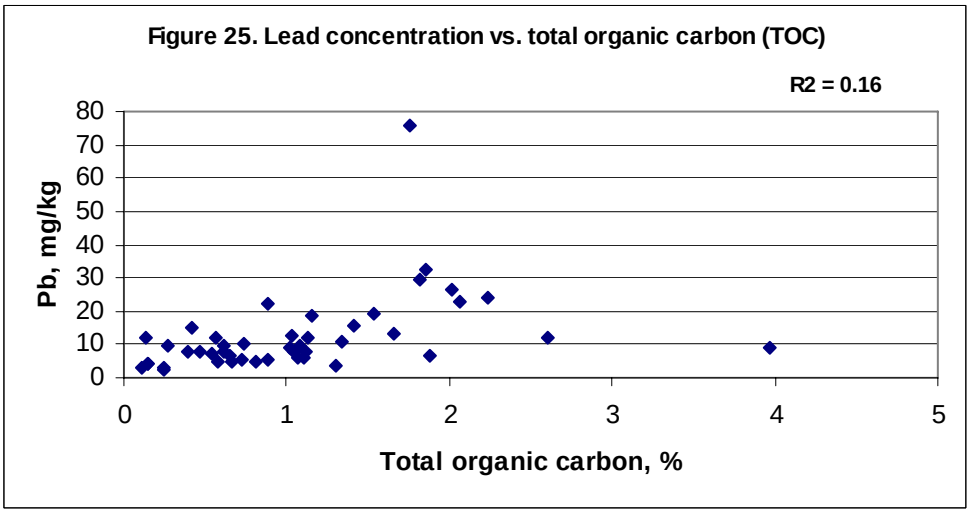


Figure 25. Lead concentration vs. total organic carbon (TOC)
R2 = 0.16
Pb, mg/kg
0
10
20
30
40
50
60
70
80
0
1
2
3
4
5
Total organic carbon, %

Figure 26. Lead geographic comparisons

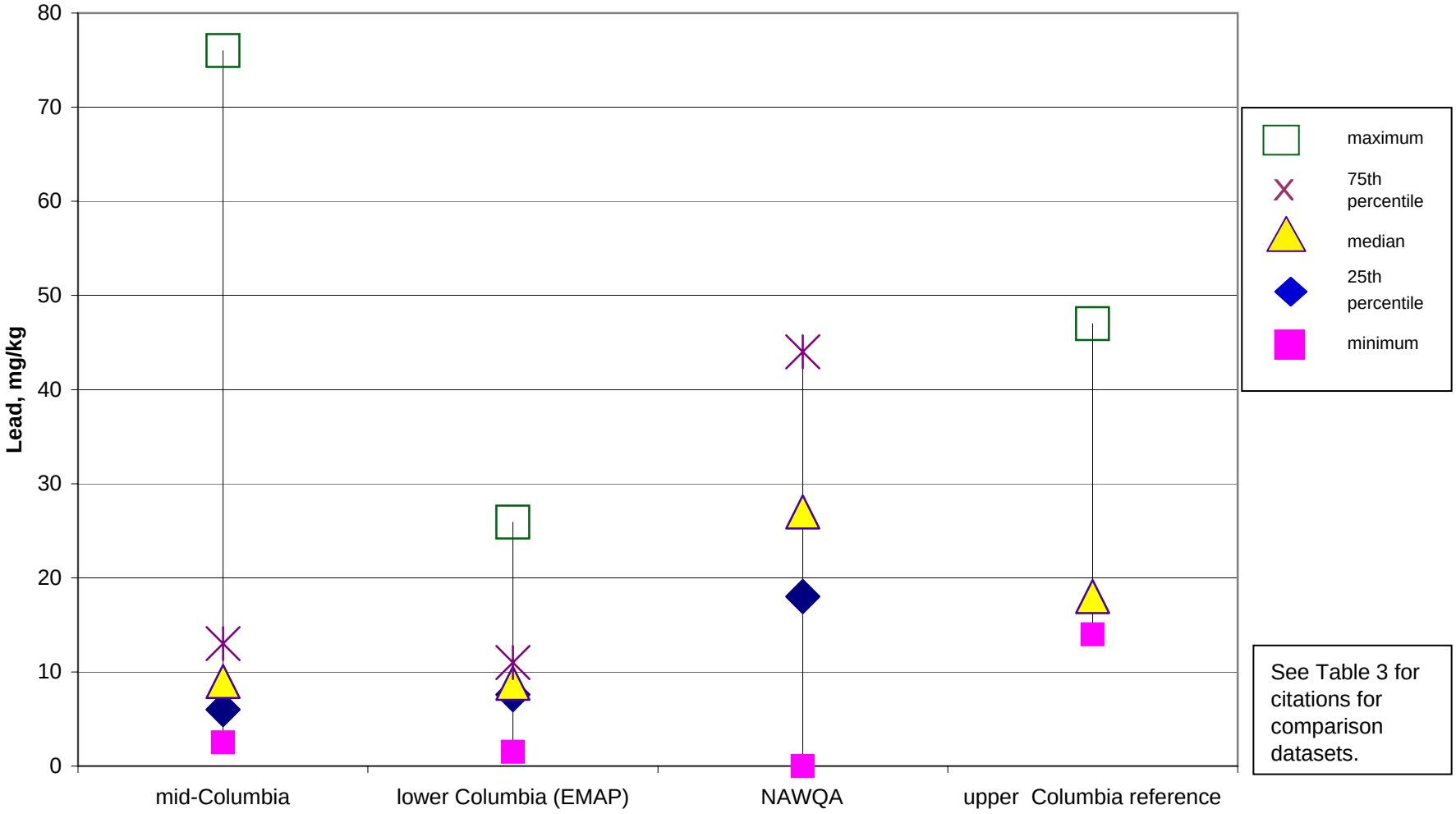


Figure 27. Mercury concentrations in mid-Columbia sediments

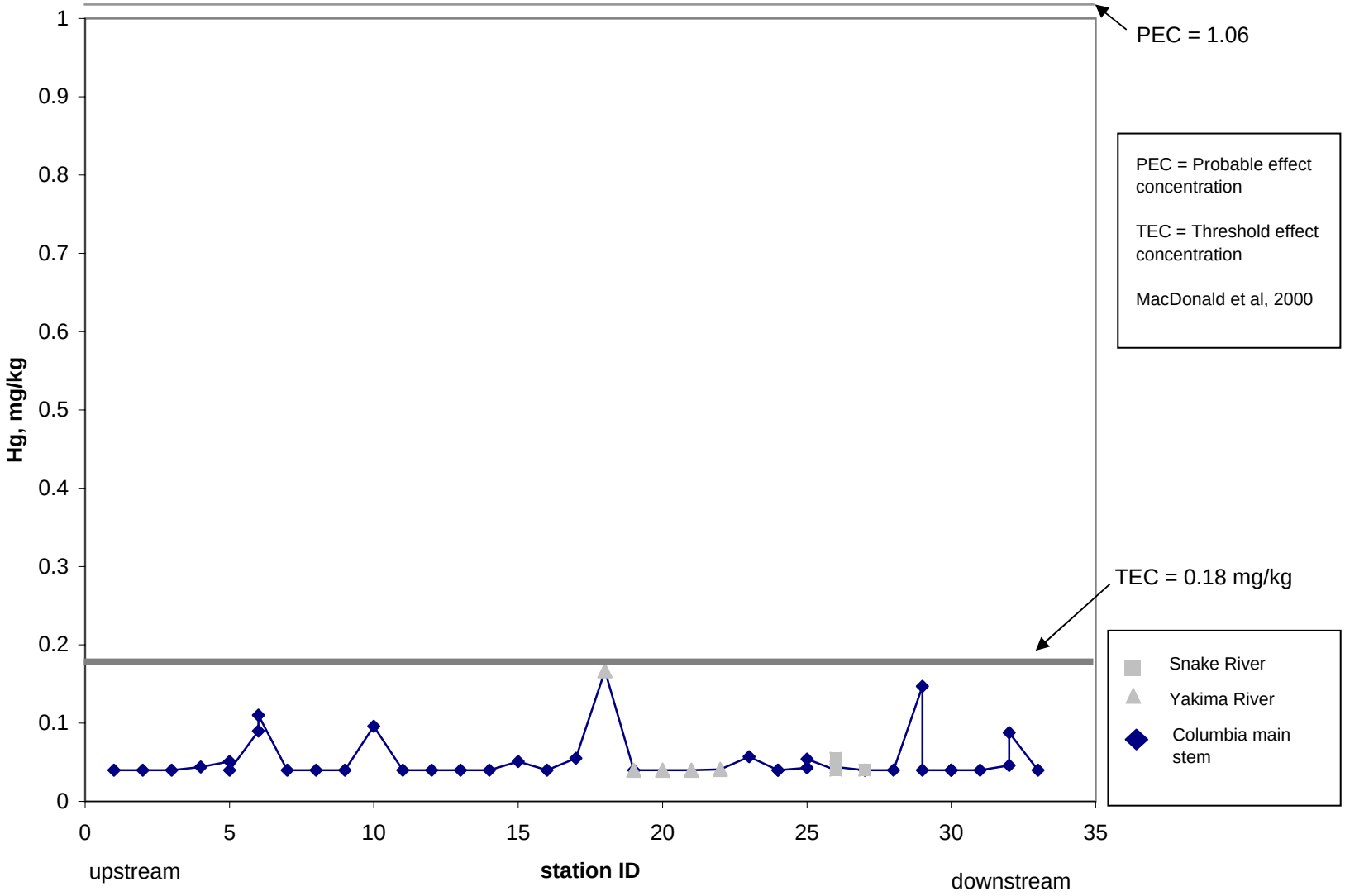


Figure 28. Mercury data sorted by concentration

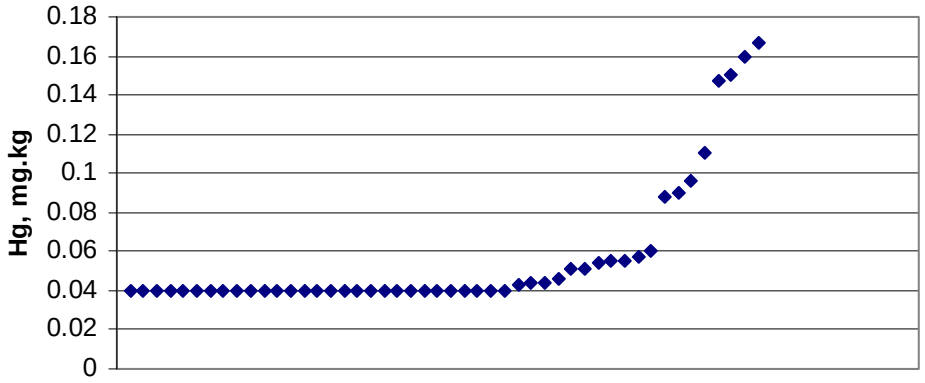


Figure 29. Mercury concentration vs. per cent fines

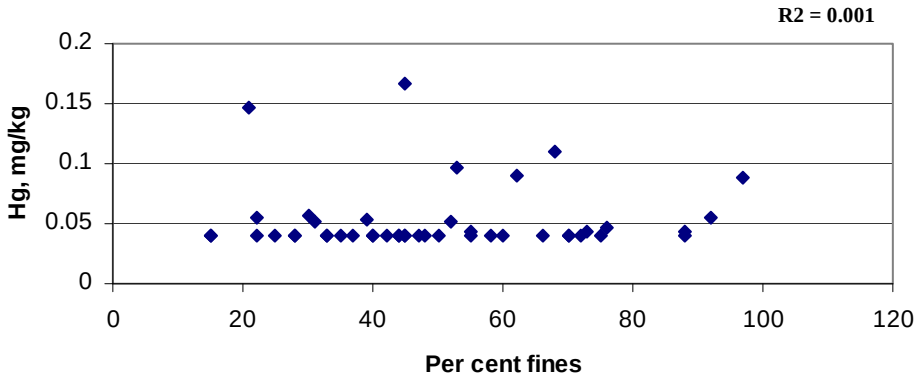


Figure 30. Mercury concentration vs. total organic carbon (TOC)

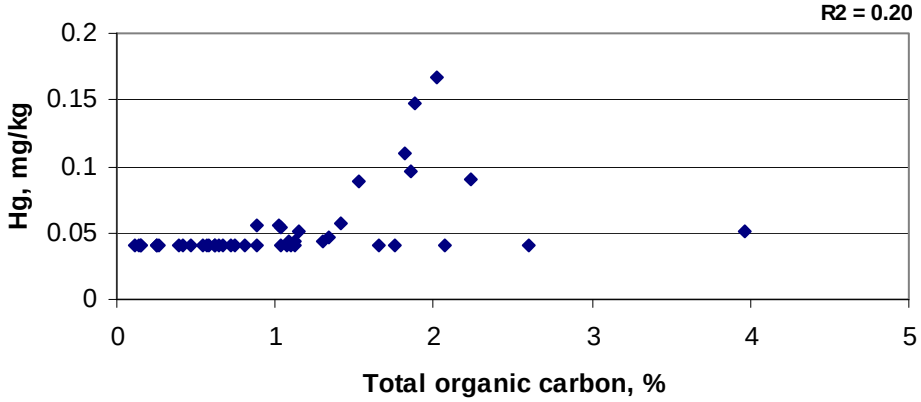


Figure 31. Mercury geographic comparisons

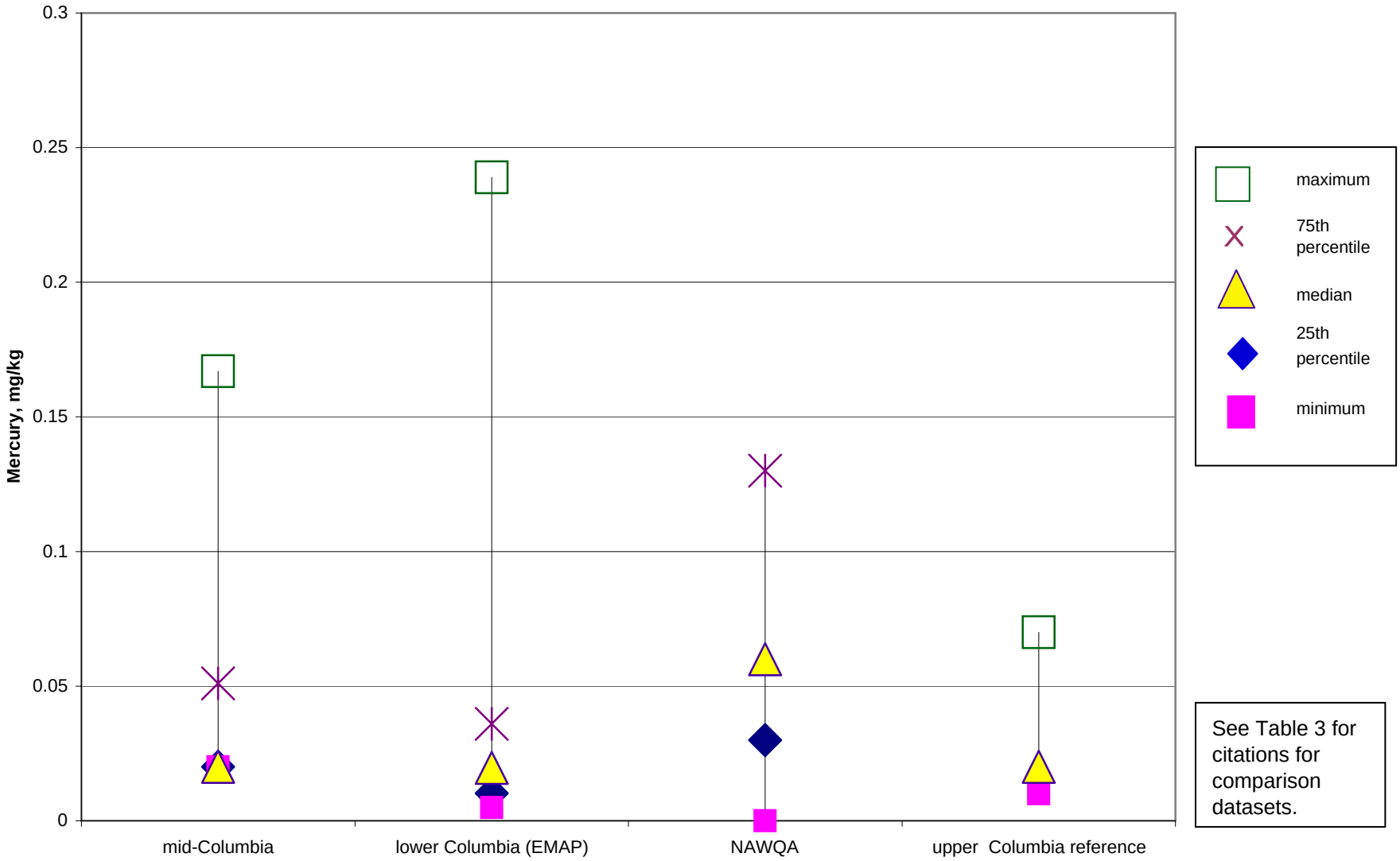
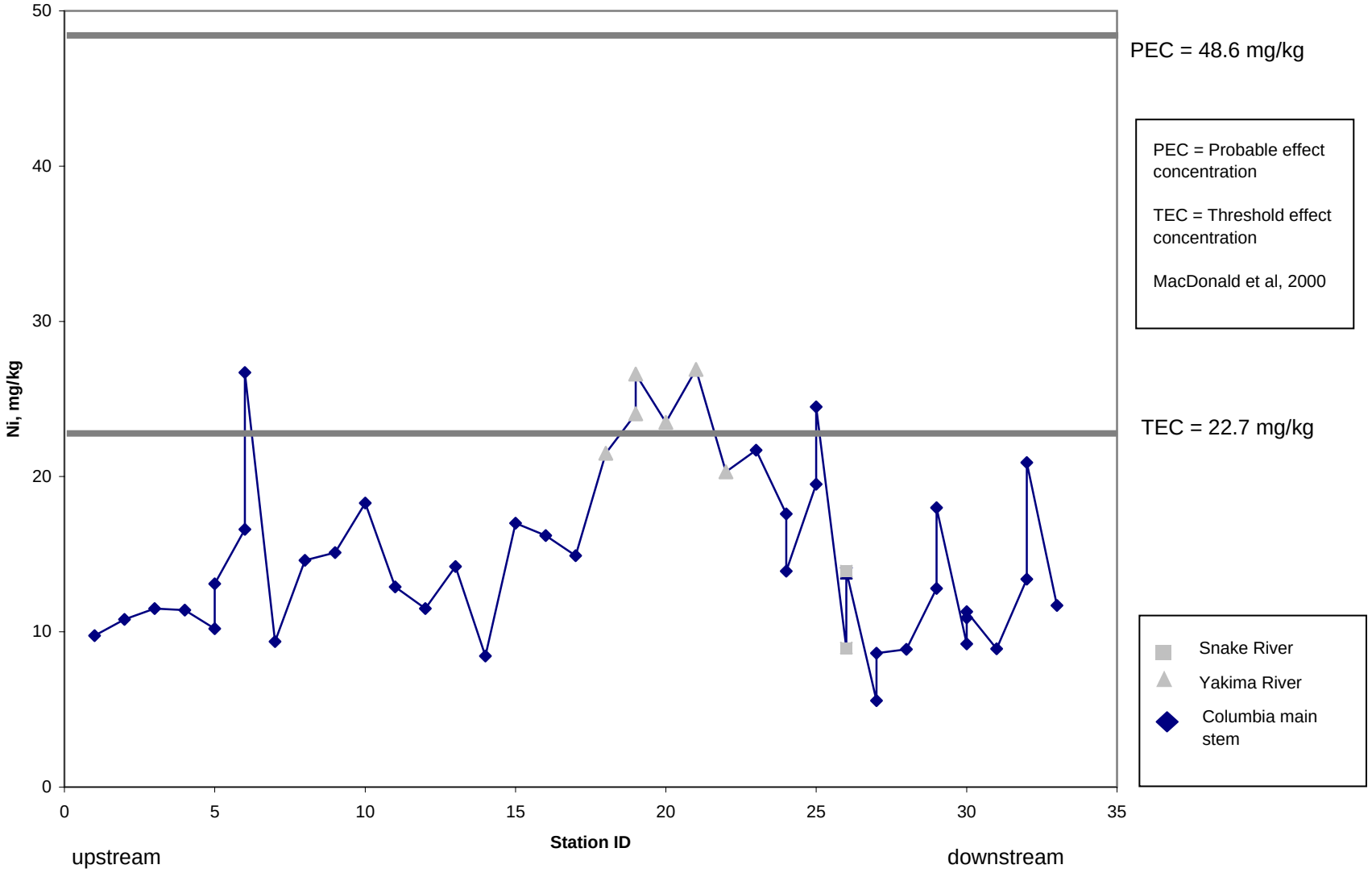


Figure 32. Nickel concentrations in mid-Columbia sediments



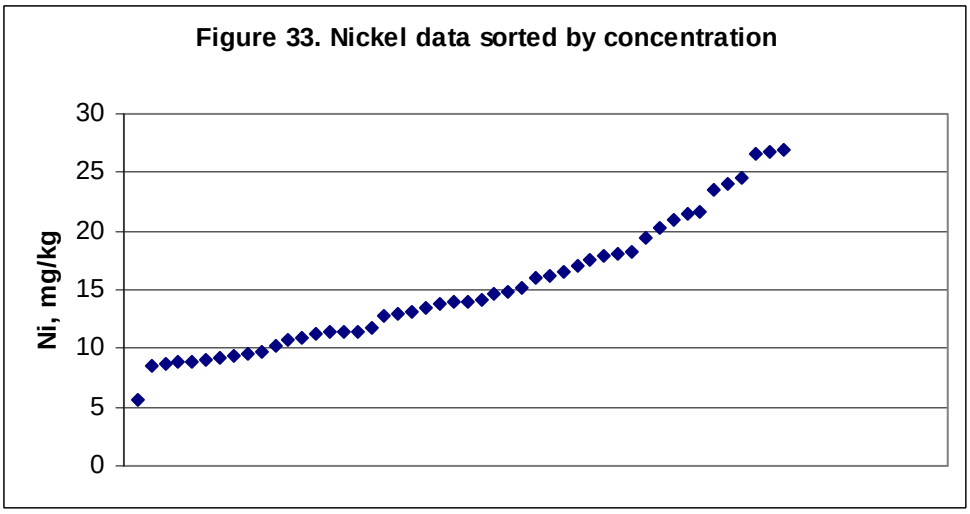


Figure 33. Nickel data sorted by concentration
Ni, mg/kg
0
5
10
15
20
25
30

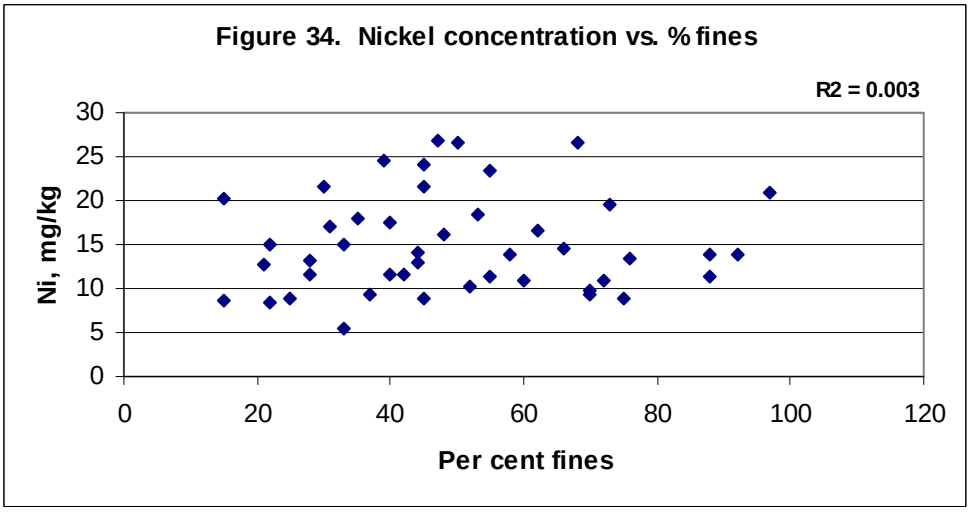


Figure 34. Nickel concentration vs. % fines
R2 = 0.003
Ni, mg/kg
0
5
10
15
20
25
30
0
20
40
60
80
100
120
Per cent fines

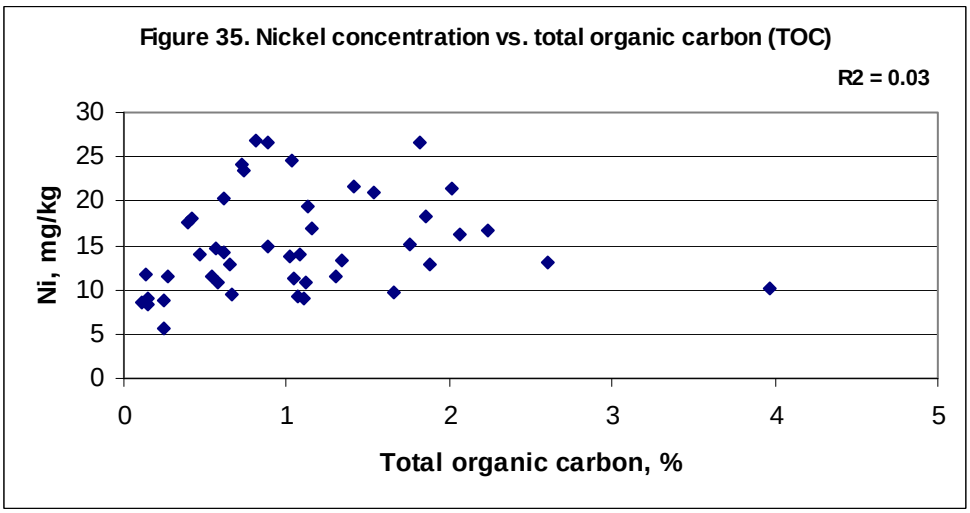


Figure 35. Nickel concentration vs. total organic carbon (TOC)
R2 = 0.03
Ni, mg/kg
0
5
10
15
20
25
30
0
1
2
3
4
5
Total organic carbon, %

Figure 36. Nickel geographic comparisons

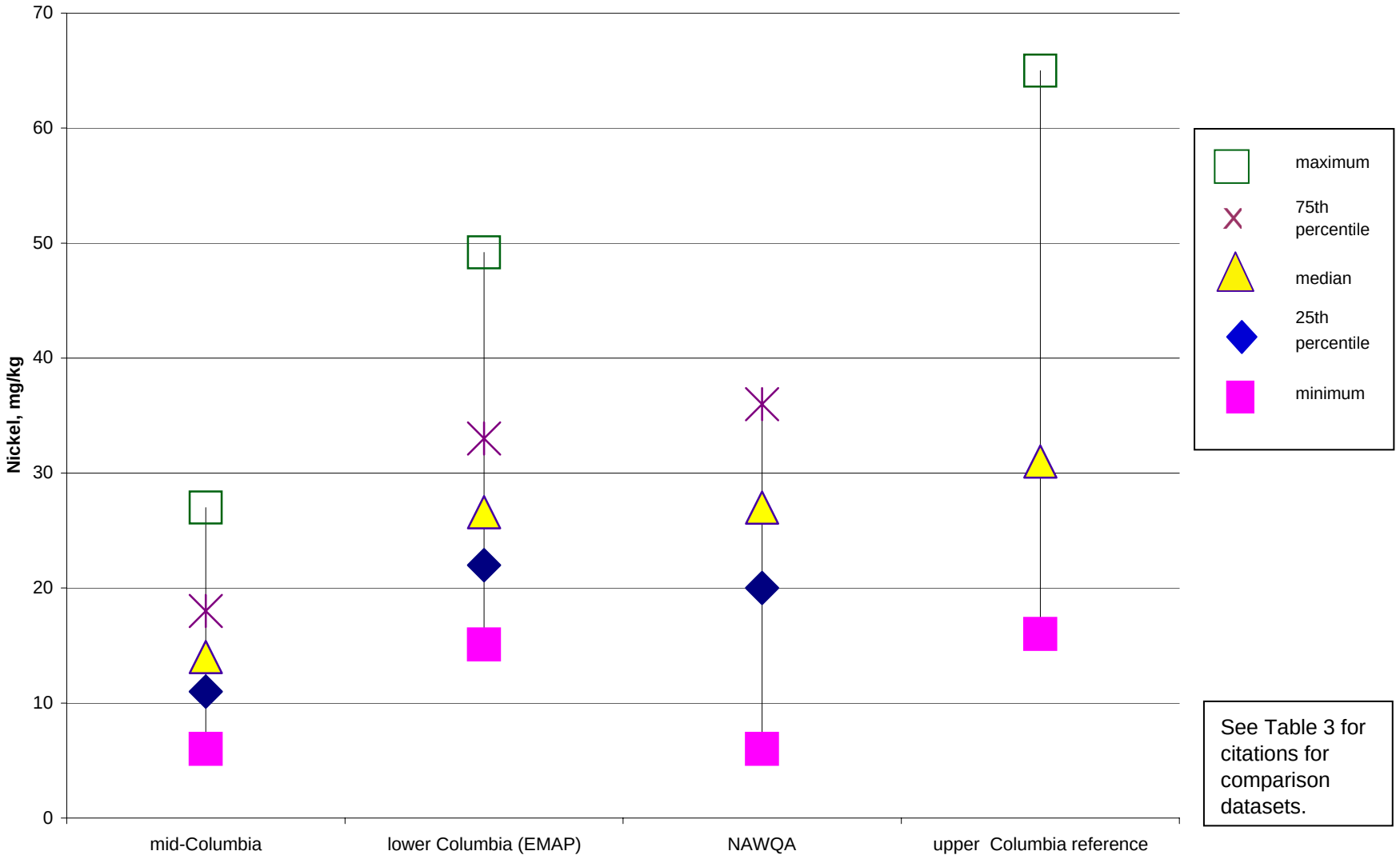
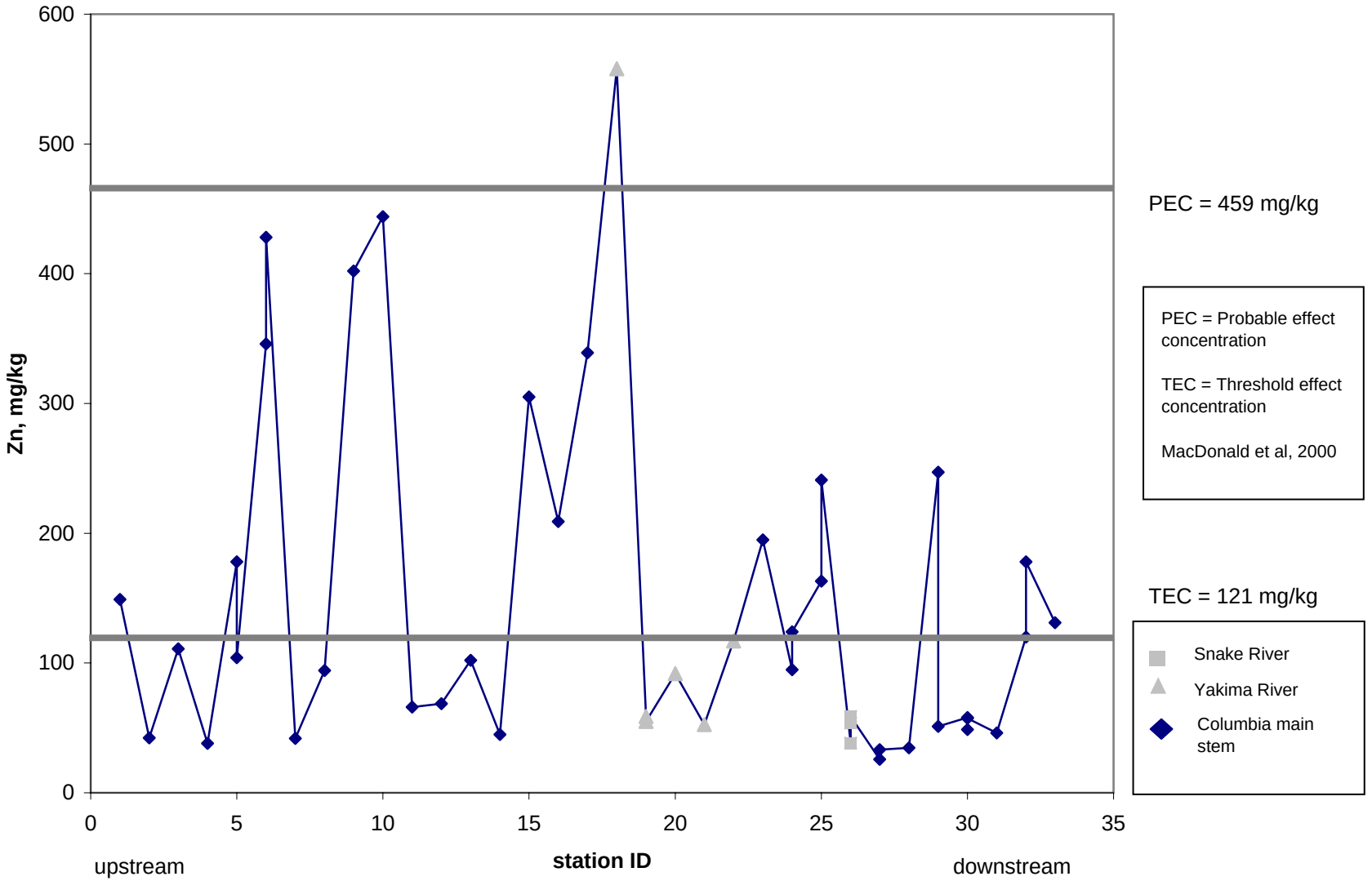


Figure 37. Zinc concentrations in mid-Columbia sediments



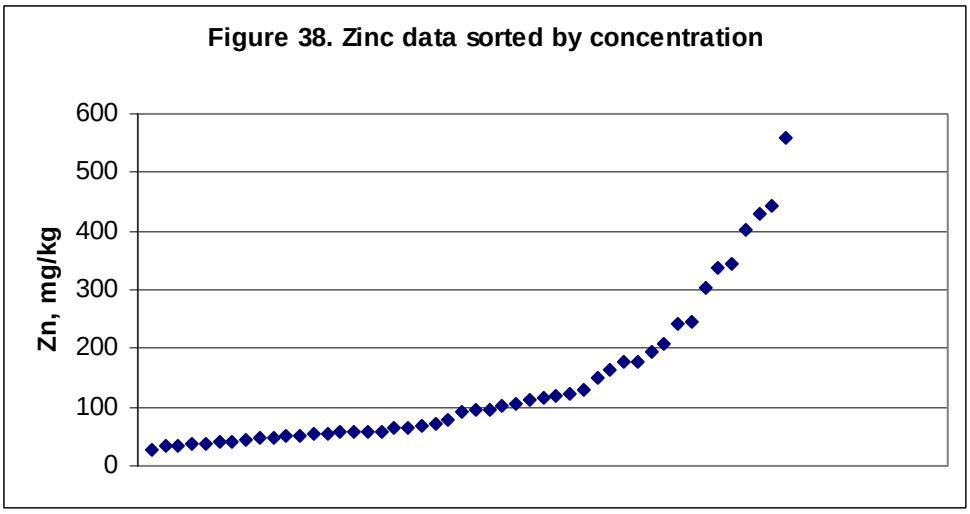


Figure 38. Zinc data sorted by concentration
600
500
400
300
200
100
0
Zn, mg/kg

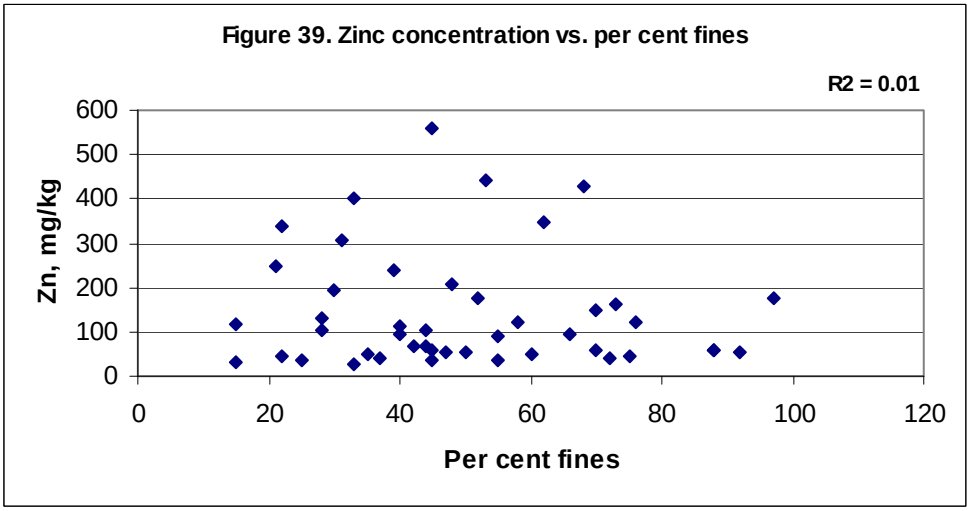


Figure 39. Zinc concentration vs. per cent fines
R2 = 0.01
600
500
400
300
200
100
0
Zn, mg/kg
0
20
40
60
80
100
120
Per cent fines

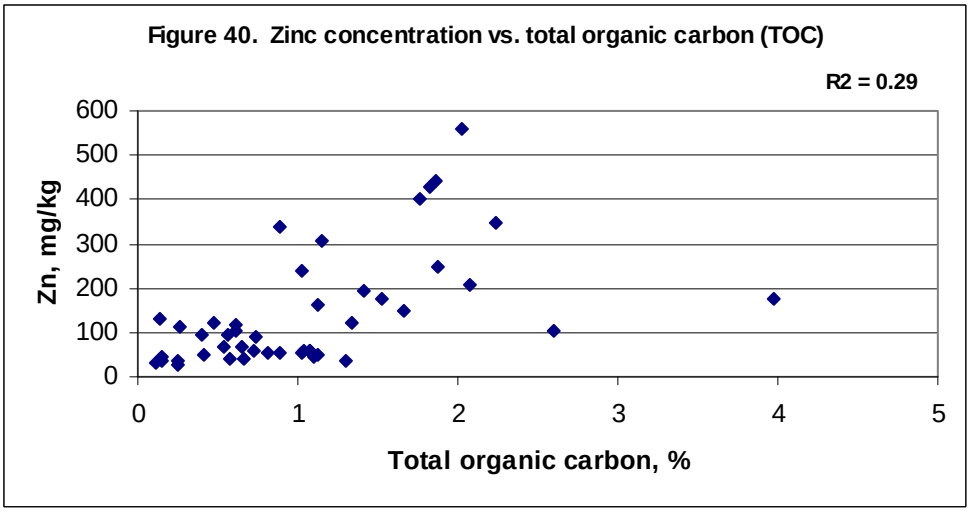


Figure 40. Zinc concentration vs. total organic carbon (TOC)
R2 = 0.29
600
500
400
300
200
100
0
Zn, mg/kg
0
1
2
3
4
5
Total organic carbon, %

Figure 41. Zinc geographic comparisons

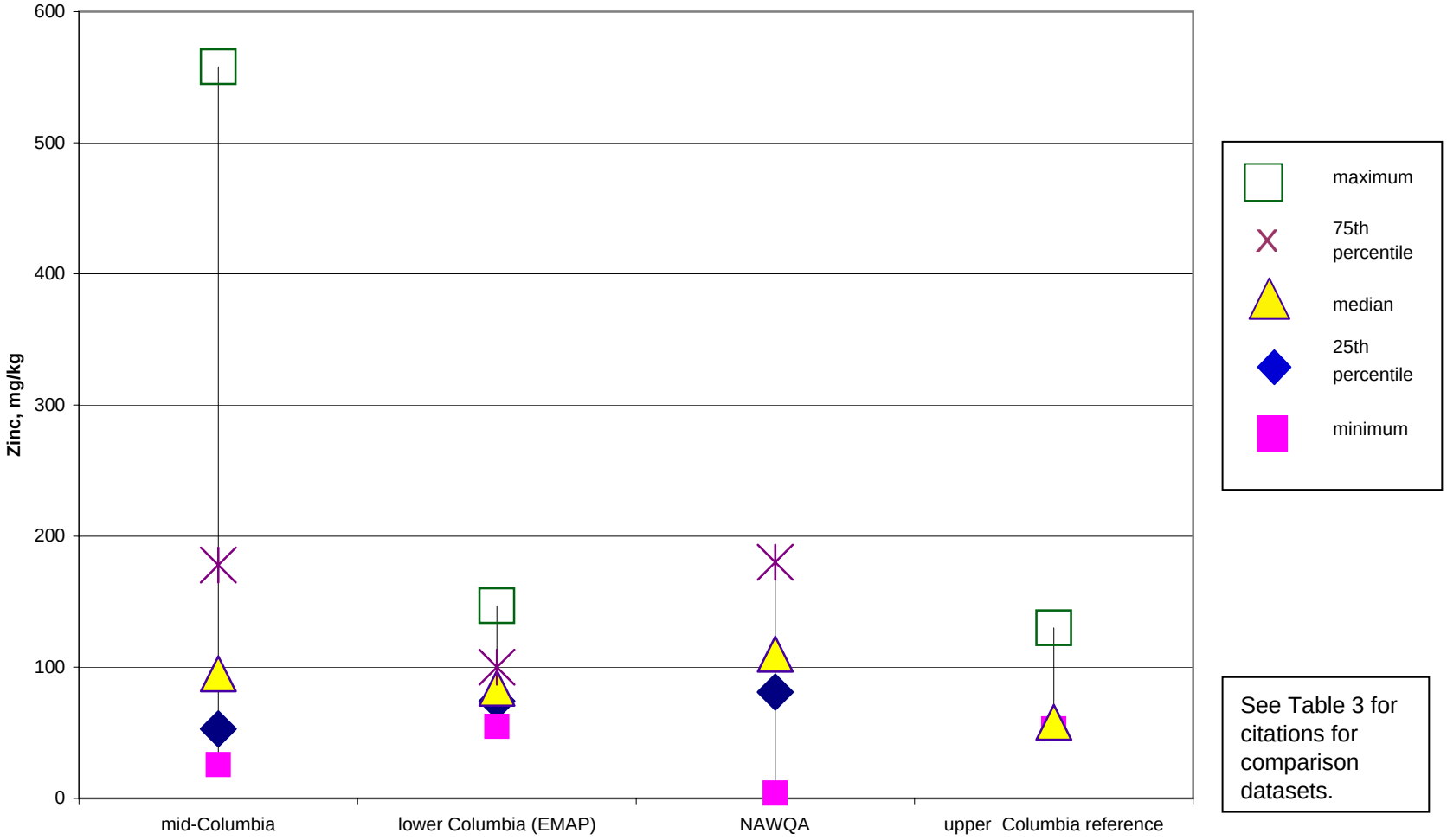


Figure 42. Estimated total DDT (p, p' DDT + p, p' DDE + p, p' DDD) concentrations in mid-Columbia sediments

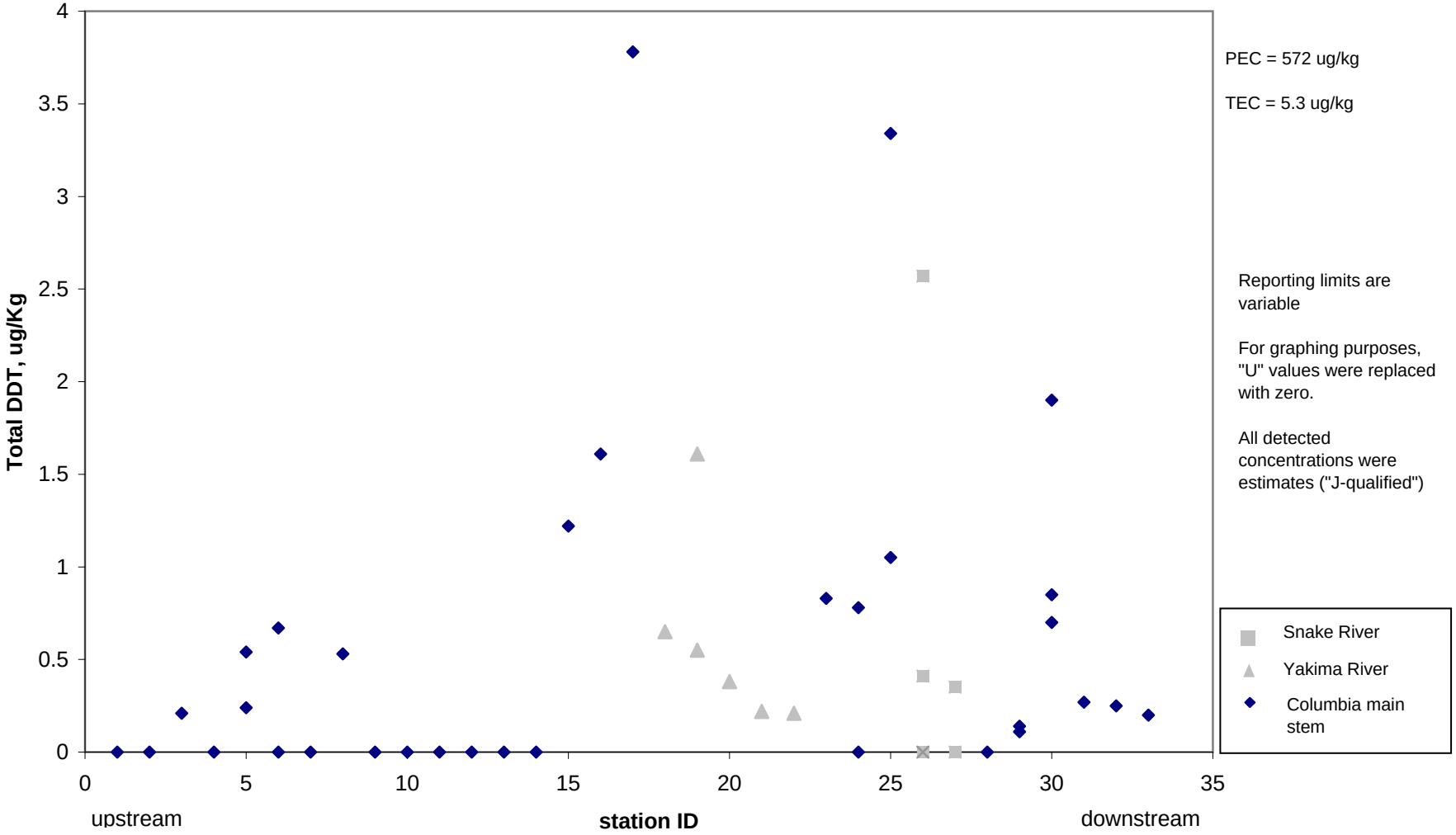


Figure 43. Estimated p, p' DDE concentrations in mid-Columbia sediments

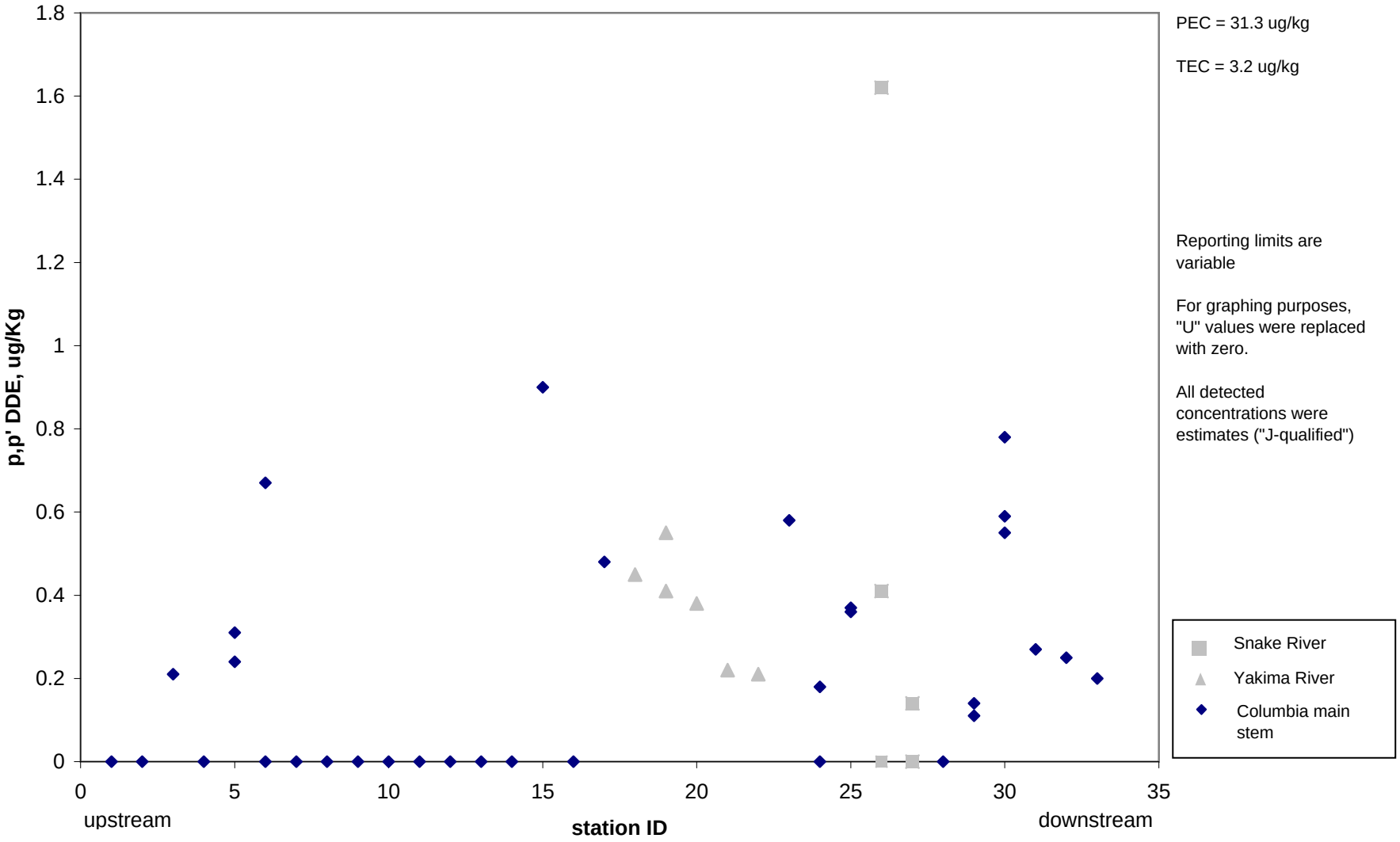


Figure 44. Estimated p, p' DDD concentrations in mid-Columbia sediments

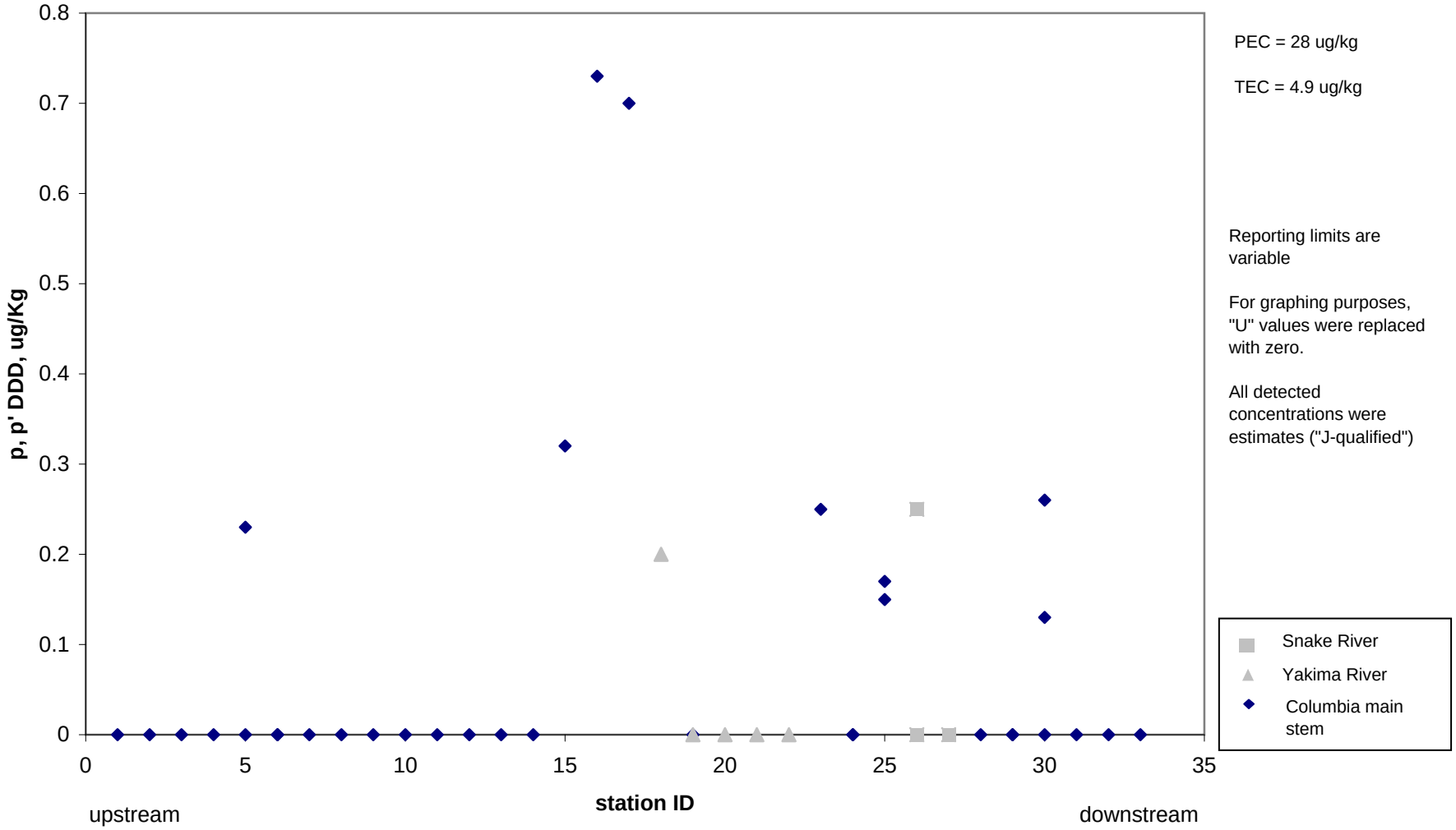


Figure 45. Estimated p,p' DDT concentrations in mid-Columbia sediments

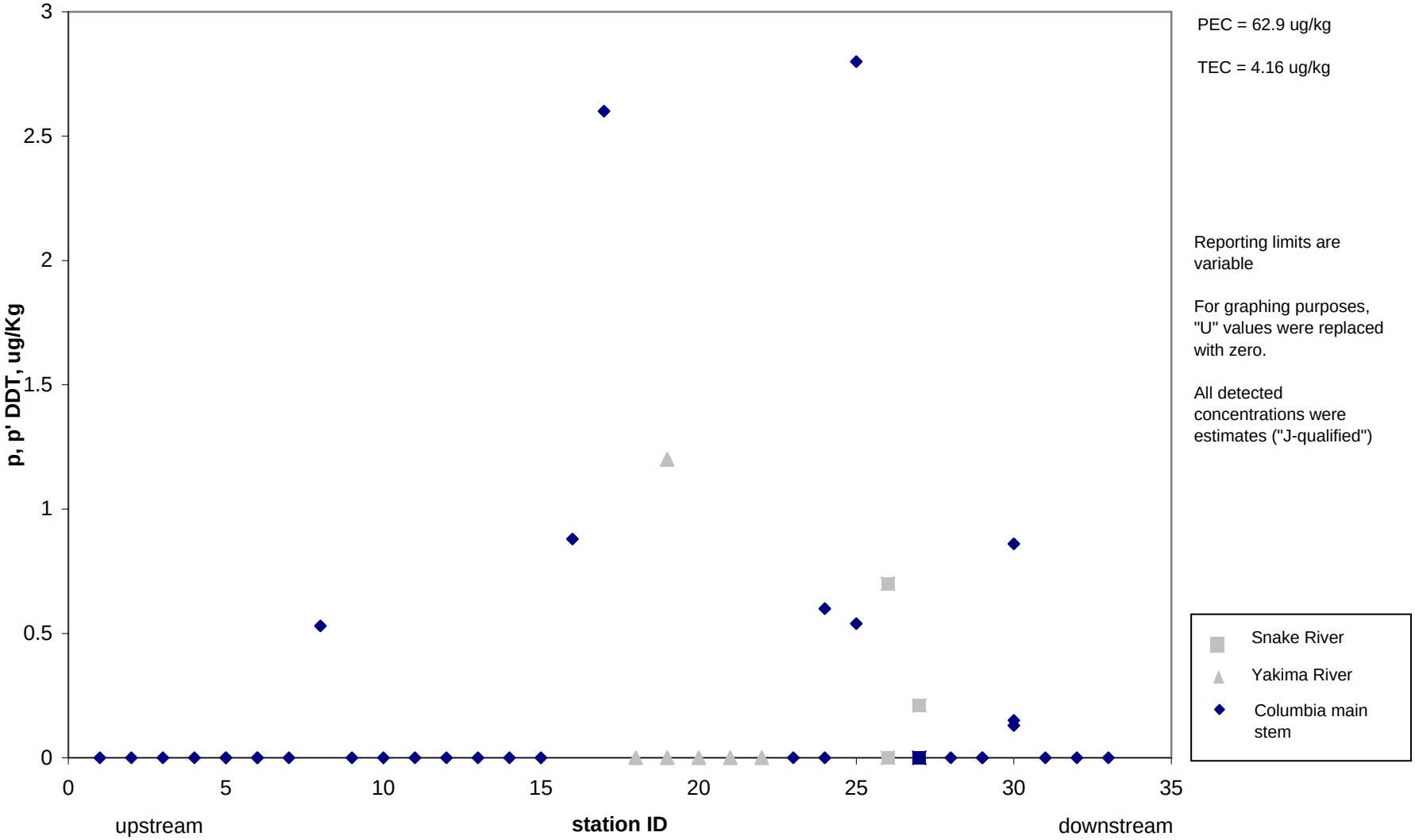


Figure 46. 1,2,3,4,6,7,8,9-OCDD concentration in mid-Columbia sediments

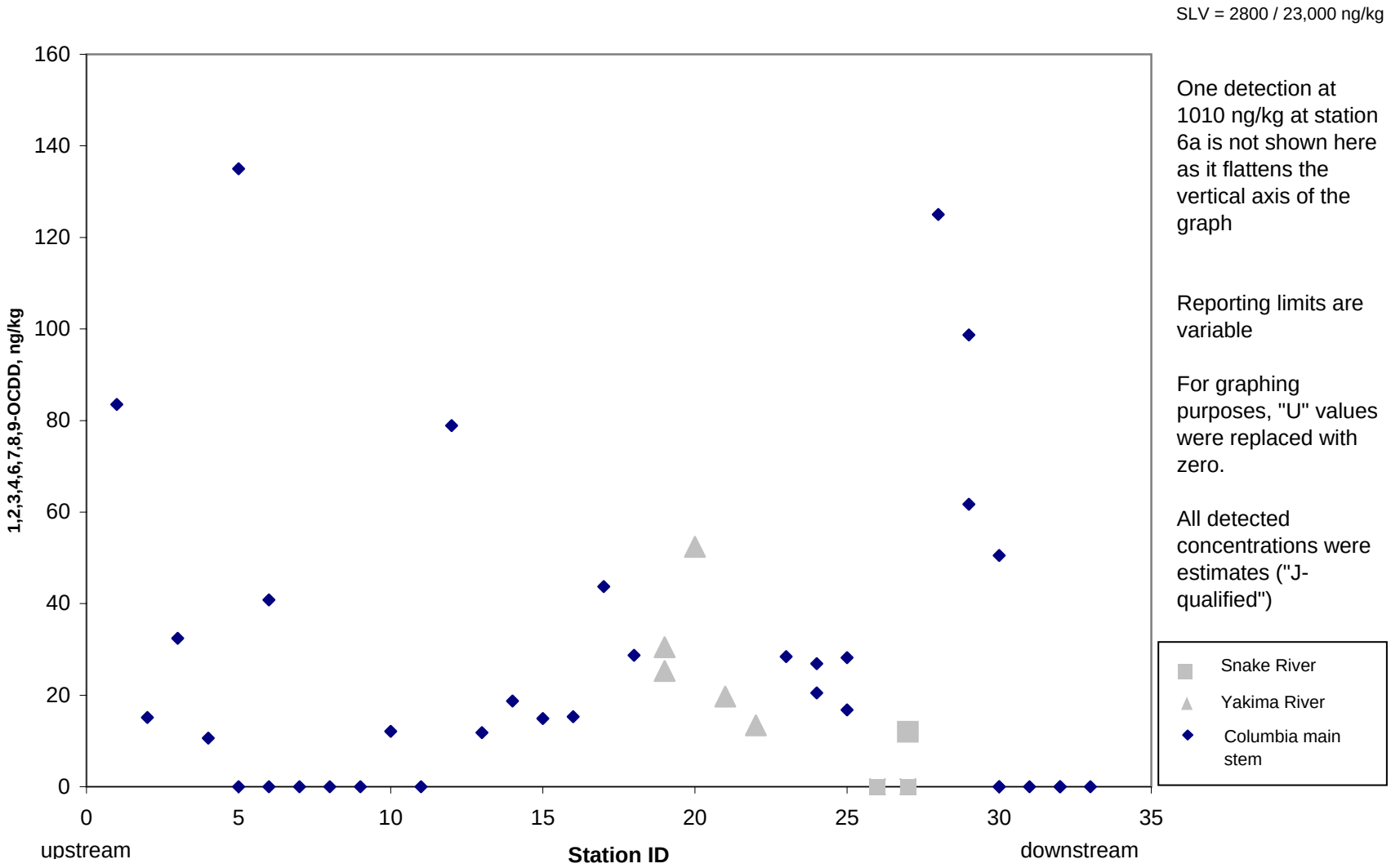


Figure 47. 1,2,3,4,6,7,8-HpCDD concentrations in mid-Columbia sediment

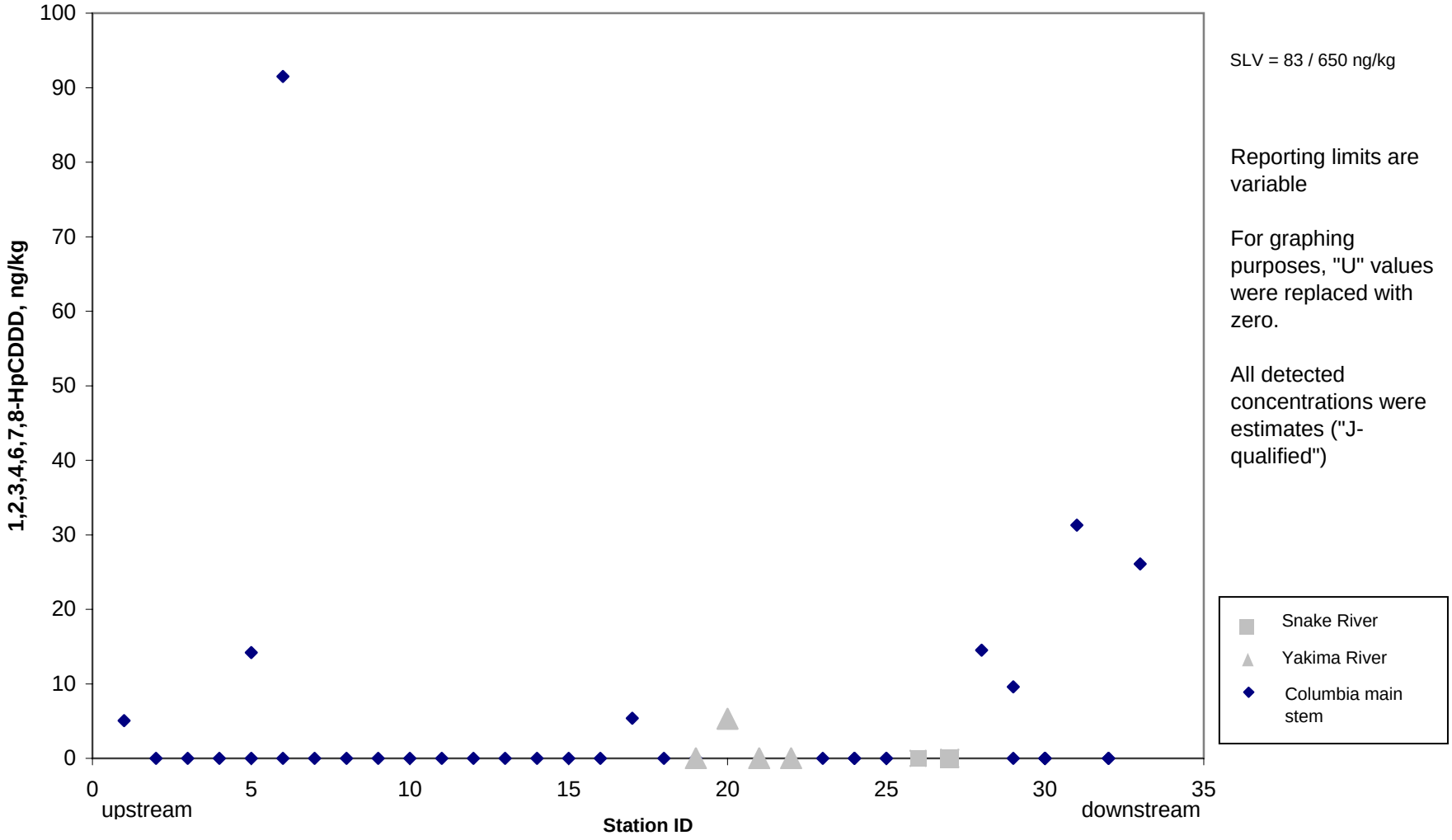


Figure 48. Sum of estimated PBDE congeners in mid-Columbia sediments

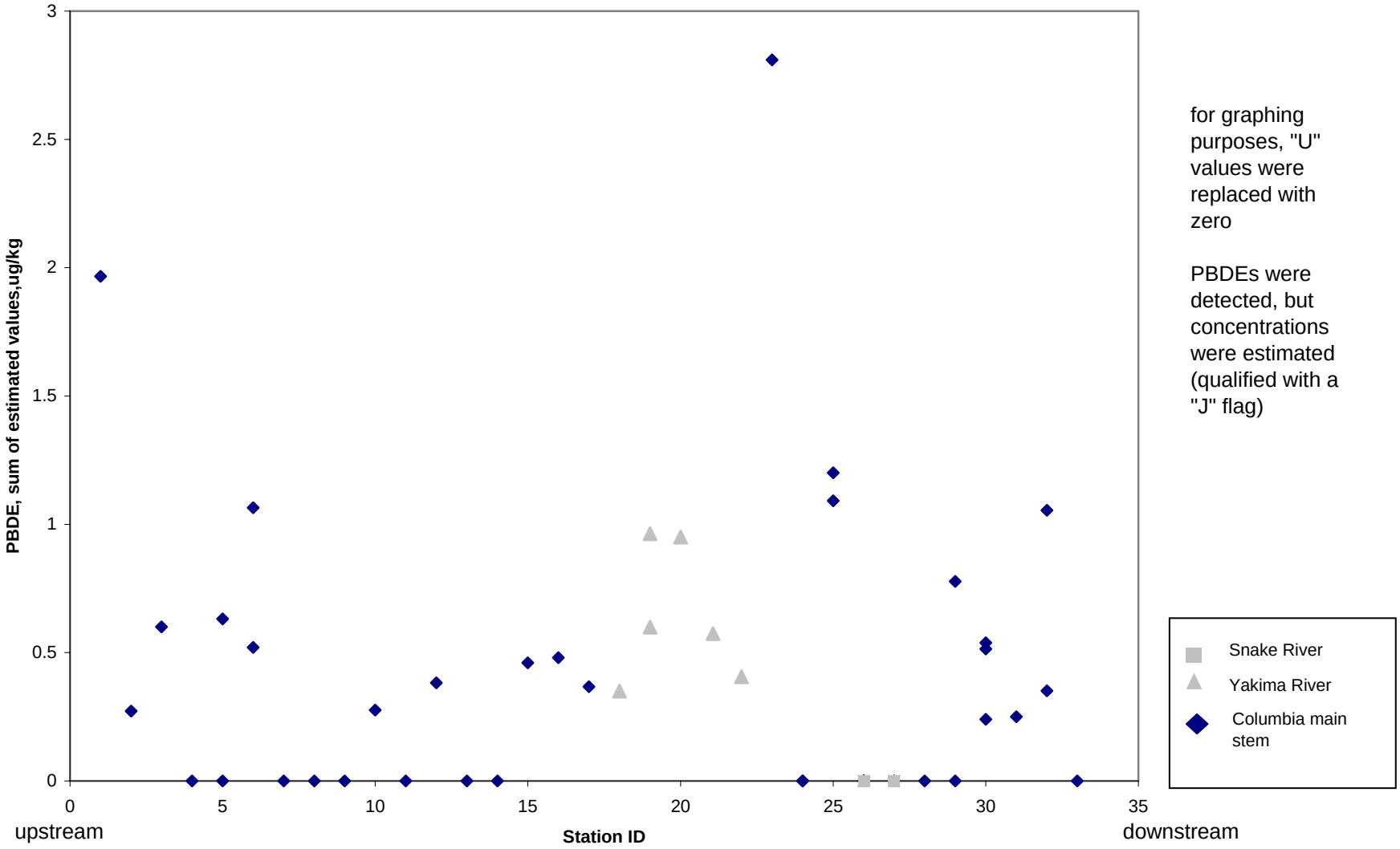


Figure 49. Estimated PBDE congeners, mid-Columbia sediments