

# **Evaluation of Sediment Quality of the Erie Canal between the Niagara River and Rochester, New York**



**New York State Canal Corporation**

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## ABSTRACT

Contaminated sediments within New York State are a legacy from past activities; municipal and industrial discharges from facilities and operations adjacent to waterbodies of the State. The Erie Canal provided a transportation conduit that allowed raw material and finished goods to be transported across the state and on to numerous harbors and seaports within the United States. The Canal also provided a convenient source of water for manufacturing operations and disposal of processing wastes. Many of these wastes have found their way into the sediments of the Canal System and must be identified and managed properly to maintain the integrity of the canal system. This project addresses one portion of the canal between the Niagara River and the Genesee River in Rochester and evaluates the existing contaminants within the sediments and makes some recommendations for further action to deal with the contaminants that were identified.

## CHAPTER 1

### INTRODUCTION

The purpose of this project is to evaluate the general level of contaminants present within the Erie Canal sediments between its confluence with the Niagara River in North Tonawanda, New York and the Genesee River in Rochester, New York. The Canal Corporation has conducted routine sediment sample collection to document sediment quality from 1991 until late 1998 for use in evaluating sediment quality. Studies by the New York State Department of Environmental Conservation (NYSDEC) in the early 1990s identified contaminants in the canal, a definite source for the contamination was not readily identified. The study further recommended that the sources of dioxin and furans in the canal sediments be better defined, a plan or schedule for this investigation was not established due to the intensive effort and cost of this type of study. From 1994 to January of 1998 the Canal Corporation collected routine sediment samples from numerous locations in the western canal system based on requests for sediment data by the NYSDEC. Both shallow and deep depth core samples have been used to show levels of contamination in the canal sediment. This data has been presented to both the NYSDEC and the New York State Department of Health (NYSDOH) to support canal maintenance, capital construction and development activities. The reported data has not precluded operational or development activities based on the contaminant levels that have been presented to both of the regulatory authorities. It was suggested by the NYSDEC that supplemental sediment sampling should continue to further support the development of a database of sediment quality. This data set might be useful within this reach of the canal to support a forensic investigation into contaminant sources.

A program of extensive sediment sampling involves the analysis of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans. These analyses are extremely expensive. With this in mind an alternative source for funding of these analyses was sought through the Great Lakes National Program Office of the United States Environmental Protection Agency (USEPA) in mid-1997. In October of 1997 a grant award was offered to accomplish an evaluation of the general profile of sediment



quality within this section of the Canal. Bad weather during the fall and winter of 1997 forced the delay of sediment sampling to the spring and late summer of 1998. Duplicate cores were collected during sampling activities for all of the deep depth cores. One of the core pairs was sectioned based on visual characteristics; the sediment from each section was homogenized and sent to the analytical laboratory for analysis. The second core of the pair was sectioned into 2 centimeter and 4 centimeter sections and refrigerated for future radionuclide dating.

### **Questions to be Addressed**

As stated earlier, the history of the Canal in this section of the State provided an opportunity for it to become a convenient location for many municipal, commercial and industrial wastewater discharges. In many places the canal is the lowest area of topography within many of the communities of Western New York. Historically, there was little awareness of the ability of contaminants to accumulate in sediments or biota, and the phenomenon of biomagnification was not readily known. Therefore individuals, communities and industries alike routinely discharged contaminants both into the canal and on property surrounding the canal. Some of the key questions to be addressed by this project include the following:

- What are the spatial levels of contaminants currently present in the sediment of this portion of the canal?
- Has there been an increase or a decrease in the levels of contaminants discharged to the canal over time?
- Is it possible to pinpoint a current or historical source of contamination based on the levels of contaminants found in the canal sediments?

## **CHAPTER 2**

### **BACKGROUND**

The New York State Canal Corporation (NYSCC) was formed in 1992 by an act of the New York State Legislature to be the caretaker of New York State's Canal System. One of the Corporation's primary duties is the maintenance of the system including the dredging of sediments and the repair of the embankments that impound the canal system. This project will focus on one of the obstacles that hinder the on-going dredging of canal sediments and the repair of the Erie Canal system embankments: the presence of contaminated sediments that impede or can possibly prevent these activities. The area to be addressed by this project is that portion of the system that originates at the Erie Canal's confluence with the Niagara River and flows eastward through numerous communities until it joins with the Genesee River near Rochester, New York. In order to understand why the sediments are contaminated, one must first understand the hydraulic conditions of the western Erie Canal system and some of its history.

#### **Site History**

The Erie Canal was one of the first of two canal systems constructed by New York State. Construction was initiated on July 4, 1817, and was completed on October 26, 1825 when then Governor DeWitt Clinton opened the Erie Canal system. The original Erie Canal was completed at a cost of \$7,150,000. Dubbed "Clinton's Ditch" or "Clinton's Folly" during construction, once completed its use increased trade between the eastern and western portions of the State. It extended from Albany westward to Buffalo, was 12.2 meters wide and 1.2 meters deep, and could accommodate boats of about 30 tons capacity, towed by horses or mules. It had 83 locks, each of which were 27.4 meters long and 4.6 meters wide. As its use increased, the need to enlarge the capacity of the system became evident.

The first enlargement began in 1836 and was completed in 1862, providing a channel 21.3 meters wide and 2.1 meters deep to handle boats of up to 240-ton capacity.



The cost of this enlargement plus subsequent improvements through 1895 totaled some \$80,000,000. The systems usage continued to grow, to the point where additional capacity was needed to meet demand.

Construction of the current canal system, mostly along new alignment, began in 1905. River and Lake Channels were utilized wherever possible. The new canals were put into operation as sections were completed, and in 1918 the entire new Canal System was in service. The current Erie Canal stretches from Waterford westerly across the State to Tonawanda on the Niagara River. From its confluence with the Hudson River in Waterford, it uses the Mohawk River to Frankfort. Between Frankfort and New London west of Rome, the Canal continues as a man-made land-cut channel. Beyond New London the Canal utilizes Wood Creek, Oneida Lake, the Oneida River, Seneca River, and Clyde River to Lyons. From Lyons to Rochester and on to Lockport, the Erie Canal is an artificial land-cut channel, often located higher than the adjacent countryside, sometimes by as much as 18.3 meters. The last segment from Lockport to Tonawanda consists of a land-cut section and the canalized Tonawanda Creek.

The total length of the Erie Canal is 547 kilometers, consisting of 354 kilometers of canalized rivers and lakes and 193 kilometers of land-cut channels. It has 35 locks (18 in river sections and 17 in land-cut sections), 2 guard locks, 10 movable dams, 2 taintor gate dams, 13 guard gates and 42 canal terminals. The segment that is under consideration by this project consists of 108 kilometers of land-cut channel and 18.5 kilometers of the canalized Tonawanda Creek between the Niagara River and the Genesee River in Rochester. Appendix A, included at the end of this project report provides mapping of the area of the canal system under consideration.

### **Hydraulic Conditions**

For nearly the last ninety years the Canal system has been used as the downstream recipient of wastes from surrounding property owners and adjoining communities. For many of these years the Canal System has received discharges from municipal

wastewater and industrial facilities and treatment plants along its path. Scores of storm water and combined sewer overflows add to the organic and inorganic loading to the canal. Many of these contaminants ultimately settle to the canal bottom due to the relatively low flow velocities in the system. Anaerobic conditions within the sediments decompose some of the constituents while other less degradable compounds are sequestered in the sediment matrix. Additionally, the dumping of snow into the canal by adjacent municipalities has been performed for many years contributing organic and inorganic contaminants in the water and sediments. For purposes of this project the Canal between Buffalo and Rochester will be divided into five (5) reaches, approximately 24 kilometers in length which are discussed below. Each section will discuss some of the physical attributes of the reach as well as any potential contributors to the contamination that have been observed.

#### **Reach Number 1**

From its starting point at the west end, the Erie Canal has draws as much as 90% of its flow from the Niagara River on the Tonawanda summit level. The confluence of the Canal and the Niagara River is 339.2 miles or 546 kilometers from the Federal Dam in Troy, New York and has been labeled as milepoint 339.2 for the purposes of this project. The Niagara River, carrying Lake Erie waters to supply the Erie Canal east to Rochester and to augment the supply of water from Rochester to the Oswego River, supplies the Tonawanda summit level. Flow between Tonawanda and Lockport is supplemented by water from both the Ellicott Creek and Tonawanda Creek as the canal progresses northeasterly. Road and wastewater drainage enters the canal through numerous pipes and structures from Tonawanda all the way to Lockport, and the flow from five (5) small creeks and streams enter the canal system between Tonawanda and Pendleton. During navigation season, historically early May through late November, flow from all of these creeks join with the water from the Niagara River and continue toward the northeast. Shortly after its confluence with Tonawanda Creek the Canal proceeds through a guard gate structure (Number 18) near Pendleton and then into a deep rock cut for the completion of its journey to Lockport. During the non-navigational



season, the Pendleton Guard Gate is lowered, preventing the water from the Niagara River from entering the canal system. When the guard gate is closed the flow of water from both Ellicott and Tonawanda creeks reverses direction and flows to the west into the Niagara River. The entire canal from Pendleton all the way to the Genesee River is drained during the non-navigation season to minimize the potential for freeze/thaw effects on the canal's elevated embankments. During this time frame there is little flow in the bottom of the canal prism; the water that is present originates from drainage of surrounding properties and through storm, combined, and sanitary sewer systems. Numerous swales and drainage ditches provide surface water runoff from nearby commercial and industrial complexes. In some areas where the canal is below the surrounding topography, the dewatered prism acts as a cutoff trench collecting groundwater from surrounding aquifers.

In Lockport, above the double canal lock structure (E34/35), the Canal is located below the surrounding grade by some 6 to 10 meters within a rockcut. Numerous storm sewer and combined sewer overflows enter the canal mixing with the flow from the southwest during the navigation season. Just above the lock structure, a power tunnel (constructed around 1912) conveys water around the Locks through a powerhouse and reenters the canal at an elevation some 15 meters below. Along both sides of the ravine where the two locks are located, the rock is now honey-combed with power tunnels that provided a source of power and a convenient place to discharge wastes for over a century. The power tunnels on the south side of the canal are quite long and join with a tunnel that was constructed for Eighteenmile Creek to pass under the Canal. Numerous industries used the water in the power tunnel and discharged to it, notably including Lockport Electric Light Company (now New York State Gas and Electric), Thompson Milling Company, Trevor Manufacturing Company and the Boston and Lockport Block Company. Two other companies Franklin Mills and Western Block Company received water from the power canal and directly discharged into the Eighteenmile Creek tunnel. During Canal construction a waste weir and a drain were placed in the side and bottom of the canal respectively to allow for draining of the canal into Eighteenmile creek during the non-navigational season. During the navigation season, two of the three waste gates

remain open to supplement the flow in the creek by approximately 1.4 cubic meters per second [personal communication R. Jordan, NYSCC]. The end of this study reach terminates at milepoint 321.1; the total length of this reach is approximately 18.1 miles or 29.1 kilometers.

## **Reach Number 2**

From Lockport, milepoint 321.1, all the way to Middleport the land to the north side of the canal, is at a lower elevation. In this area the only flow that can enter the system is from the surrounding property south of the canal. The hamlets of Orangeport, Gasport, Reynales Basin and the Village of Middleport may contribute small amounts of surface runoff and subsurface flow to the canal. In most instances the surface water from the south side of the canal is collected in parallel ditches that transport the surface water flow to culverts that pass under the canal bed. In this reach there are twenty-one (21) such culverts. To the east of Reynales Basin excess flows from the canal are spilled into the East Branch of Eighteenmile creek. Three waste gates are maintained at this location; during the navigation season approximately 0.3 cubic meters per second of excess canal water is discharged. Between Reynales Basin and Middleport a waste gate structure with two gates is maintained which discharges (at a rate of approximately 0.2 cubic meters per second) excess canal water into Johnson Creek. In the Village of Middleport a structure with two waste gates is maintained that spills approximately 0.3 cubic meters per second of excess flows from the canal into Jeddo Creek. The end of this study reach terminates at milepoint 309.4, for a total length under consideration of 11.7 miles or 18.8 kilometers.

## **Reach Number 3**

From Middleport, milepoint 309.4, to Albion, milepoint 292.9, the land on the north side of the Canal is at a lower elevation. In this area the only flow that can enter the system is from the surrounding property south of the canal. The hamlets of Knowlesville, Eagles Harbor, and the Villages of Medina and Albion can contribute small amounts of surface runoff and subsurface flow to the canal. In most instances the



surface water from the south side of the canal is collected in parallel ditches that transport the surface water flow to culverts that pass under the canal bed. In this reach there are twenty-four (24) such culverts. In the Village of Medina an aqueduct transports the canal over Oak Orchard Creek which is flowing northward. Part of the aqueduct structure includes a series of waste gates that spill approximately 9.6 cubic meters per second of excess canal flows during the navigational season into the creek. To the east of Medina, Fish Creek runs under the canal and continues northward. To the east of Eagle Harbor a waste weir is maintained to spill excess flows from the canal at a rate of approximately 0.5 cubic meters per second into Otter Creek. Just to the west of the Village of Albion, Sandy Creek passes under the Canal. During navigation season, excess water in the canal is diverted through a four- (4) gate and spillway structure into Sandy Creek. During a typical season, approximately 0.1 cubic meter per second is diverted.

Within this reach, approximately 3.2 kilometers east of Middleport on the south side of the canal, FMC operates an agricultural chemicals plant within about a hundred meters of the canal. During canal sampling by this author on April 18, 1995, a 10.2 centimeter diameter PVC line was observed originating from construction activities east of Middleport on the north side of the canal. It is unknown if this line discharged materials to the canal from reported on-site drying beds or if water was being withdrawn from the canal at the former FMC landfill. This study reach terminates at milepoint 292.9, for a total length under consideration of 16.5 miles or 26.6 kilometers.

#### **Reach Number 4**

From Albion, milepoint 292.9, to Brockport, milepoint 279.6, the land on the north side of the Canal is at a lower elevation. In many locations the canal is also higher in elevation of the surrounding land on the south side. Only in areas such as the hamlets of Hindsburg and Hulberton and immediately east of the Village of Albion can surface water flow enter the system from the surrounding property south of the canal. These locations can contribute small amounts of surface runoff and subsurface flow to the canal. In most instances the surface water from the south side of the canal is collected in parallel

ditches that transport the surface water flow to culverts that pass under the canal bed. In this reach there are nineteen (19) of these culverts. In the area of Brockville and in the Village of Brockport, waste gate structures are located for the removal of excess flow from the canal. In the recent past there has been no need to use these structures. In Holley a waste gate is maintained that discharges approximately 0.6 cubic meters per second into the East Branch of Sandy Creek.

Approximately 3.2 kilometers east of Albion on the south side of the canal there is an inactive hazardous waste landfill (McKenna Landfill), that is scheduled to be closed by capping within the next calendar year. There are numerous groundwater monitoring wells on both the south and north side of the canal. At the current time it is unknown what the contaminants of concern are and whether there has been any off-site migration of potential contaminants. The total length of this reach of the canal is 13.3 miles or 21.4 kilometers between milepoint 292.9 and the ending milepoint 279.6.

#### **Reach Number 5**

From Brockport, milepoint 279.6, to South Greece the land on the north side of the Canal is at a lower elevation. In many locations the canal is also higher in elevation than the surrounding topography on the south side. Only in the hamlet of Adams Basin, immediately east of the Village of Brockport, and both east and west of Spencerport can surface water flow enter the system from the surrounding property south of the canal. These locations can contribute small amounts of surface runoff and subsurface flow to the canal. In most instances the surface water from the south side of the canal is collected in parallel ditches that transport the surface water flow to culverts that pass under the canal bed. In this reach there are seventeen (17) such culverts. In Adams Basin a waste gate is maintained to spill excess flows to the Salmon Creek. A flowrate of approximately 0.05 cubic meters per second is maintained during the navigational season. To the east of the Village of Spencerport, a waste weir and gate is maintained to spill excess flows from the canal into Northrup Creek. The New York State Department of Environmental Conservation (NYSDEC) has requested that a flowrate of at least 1.8



cubic meters per second be maintained during the navigational season. Within this reach in South Greece an additional waste weir is located that can be used to spill excess canal flows to Round Pond Creek. This structure has not been used for many years.

From Greece to the Genesee River, milepoint 261.2, the canal is in a deep rock cut, which is below the surrounding grade. Numerous pipes are evident discharging into the canal. It is suspected that the vast majority are storm sewers.

At its junction with the Genesee River, the majority of the flow from the Canal turns to the north and flows toward Lake Ontario. It is likely that very little of the canal water crosses the Genesee River to continue its journey to the east due to the substantially higher flowrate in the river. Therefore, it is believed that the majority of contaminants that could be present in the Canal would follow the course of the Genesee River to Lake Ontario. The end of this study terminates at milepoint 261.2. The total length of this reach under study is 18.4 miles or 29.6 kilometers.

## **CHAPTER 3**

### **MATERIALS AND METHODS**

To evaluate the sediment conditions within the canal prism, a review of all studies, all available reports and sediment data within this portion of the canal was conducted. Generally, there is scant published information and there have been very few studies of sediment quality within this project study area. Unpublished data was also considered in the preparation of this project.

#### **NYSDEC Project Reports**

A four-year study of sediment quality was undertaken by the NYSDEC during 1989 to 1992 within the Canal, focusing around Eighteenmile Creek, and near areas where creeks and streams cross under or are augmented by water from the canal system [2]. The sediment samples collected within the Erie Canal were surficial in nature and generally represented surface sediment quality. The majority of the sampling that was performed as part of this project represents sediment quality observed in discrete grab samples collected within the Eighteenmile Creek watershed and other streams and creeks that cross the Erie Canal. This document states that levels of both dioxin and furan appear to have entered creeks and streams from discharges of canal water. Although the Canal System may be the intermediary recipient of contamination now in the Canal sediments it is not the generator of the contamination. The NYSDEC report did not locate the upstream source or sources of the contamination to the Canal.

**Table Number 3.1**  
**1991 to 1992 NYSDEC Sampling Locations**

<b>Sample Date</b>	<b>Location</b>	<b>Mile Point</b>	<b>Comments</b>
9/91 to 1/92	Route 265	339.0	Ponar Dredge, Surface Grab
9/91 to 1/92	Three Mile Island	335.8	Ponar Dredge, Surface Grab
9/91 to 1/92	Sherwood Avenue	334.5	Ponar Dredge, Surface Grab
9/91 to 1/92	Sawyer Creek	334.4	Ponar Dredge, Surface Grab
9/91 to 1/92	Dunnigan Road	326.9	Ponar Dredge, Surface Grab
9/91 to 1/92	Pendleton Gate	325.3	Surface Core Composite
5/92	Robinson Road	324.4	Ponar Dredge, Surface Grab
5/92	Murphy Road	324.0	Ponar Dredge, Surface Grab
5/92	Hinman Road	323.1	Ponar Dredge, Surface Grab
5/92	Route 93 Bypass	322.8	Ponar Dredge, Surface Grab
5/92	Minard Road	322.4	Ponar Dredge, Surface Grab
9/91 to 1/92	Main Street	321.6	Surface Composite Grab
5/92	Transit Road	321.6	Ponar Dredge, Surface Grab
9/91 to 1/92	Exchange Street	320.7	Ponar Dredge, Surface Grab

Both Olcott Harbor and Eighteenmile Creek, tributaries to Lake Ontario, have been determined to be an Area of Concern (AOC) by the International Joint Commission. Funding to conduct an additional study of the presence of contaminants in both Eighteenmile Creek and Olcott Harbor has been provided to the NYSDEC by the United States Environmental Protection Agency, Great Lakes National Program Office (GLNPO). The results of this study were released in late 1998 and show a sampling station was established downstream of where flow augmentation from the Erie Canal enters Eighteenmile Creek [3]. Although elevated levels of contaminants were encountered during this study, this sampling station is located in an area of both past and present commercial and industrial use and is nearly 300 to 400 meters downstream of the canal. No attempt was made by the NYSDEC to quantify the sediments in the creek upstream of its confluence with the canal; therefore, it is unknown if upstream sources exist that may be contributing to the sediment contaminant load in Eighteenmile Creek. Although this report identifies contamination in the Creek below the point of augmentation by the canal, no sampling was conducted in the Canal to show the



contaminants were originating from that source or the upstream portion of Eighteenmile Creek.

### **Other Past Sampling Activities**

To maintain the canal, approval and authorization from both the New York State Department of Environmental Conservation (NYSDEC) and the United States Army Corps of Engineers (USACOE) must be obtained. The Rivers and Harbors Act of 1899 requires project sponsors to obtain a Section 10 and Section 404 approval from the United States Army Corps of Engineers prior to conducting work either in, above or next to "Waters of the United States of America." The USACOE takes jurisdiction over Section 10, Waters of the United States, based on whether the waterbody currently or has in the past been navigable. Prior to the USACOE issuing this permit, applicants are required to obtain a New York State, Section 401 Water Quality Certification (WQC). The NYSDEC is the responsible agency that issues this certification for activities within or that could impact waterbodies within New York State.

Beginning in the summer of 1994 an investigation of sediment quality between Lockport and the Genesee River in Rochester was conducted to establish a database of contaminant levels within canal sediments. This information was used to justify the continued repair of canal embankment and dredging activities within the system. It was further used to show compliance with the NYSDEC regulatory guidance requirements for obtaining permits. A significant effort was made by the author to continue routine sampling activities between early November of 1994 and as recently as July of 1997. During the non-navigation season when the canal has been dewatered, the bottom sediments can be accessed relatively easily to obtain either surface grab or push core samples. Generally, most samples are obtained by pushing a core tube into the sediment and compositing the recovered material for analysis. Sampling conducted during the navigational season was performed from a vessel with a ponar dredge or push core apparatus. The recovered sediment was homogenized and a composite, representative sample sent to the laboratory for analysis.



**Table Number 3.2**  
**Other Sampling Activities 1994 to 1998**

Sample Date	Location	Mile Point	Reason for Sampling
February 4, 1998	Tonawanda Harbor	338.9	Proposed Harbor Project
July 7, 1997	Ellicott Creek Backwater	335.9	Proposed Project
July 7, 1997	Ellicott Creek Backwater	335.8	Proposed Project
November 28, 1995	Lockport C	324.4	Canal Survey
November 28, 1995	Lockport B	322.2	Canal Survey
November 28, 1995	Lockport A	322.0	Canal Survey
March 22, 1994	7-38.5-7D	321.5	Pre-dredge Sample
April 18, 1995	Lock 35	321.4	Canal Survey
December 1, 1996	Lock 35	321.4	Contractor's Samples
April 18, 1995	Bypass	321.4	Canal Survey
December 1, 1996	Bypass	321.4	Contractor's Samples
November 28, 1995	Exchange Street	320.7	Proposed Construction Project
April 18, 1995	Canal Survey	320.6	Canal Survey
April 18, 1995	Canal Survey	317.7	Canal Survey
November 10, 1994	Gasport GG	314.2	Proposed Construction Project
October 19, 1995	Gasport GG	314.2	Guard Gate Contractor
April 18, 1995	Canal Survey	312.6	Canal Survey
March 21, 1994	7-35-7D	310.2	Pre-dredge Sample
April 18, 1995	Canal Survey	309.5	Canal Survey
November 18, 1996	7-34-7D	308.2	Canal Survey
November 18, 1996	7-34-7D	307.9	Canal Survey
March 21, 1994	7-34-7D	307.5	Pre-dredge Sample
April 18, 1995	Canal Survey	307.4	Canal Survey
November 9, 1994	Medina GG	303.2	Proposed Construction Project
October 19, 1995	Medina GG	303.2	Guard Gate Contractor
August 16, 1995	Canal Survey	303.0	Canal Survey
April 18, 1995	Canal Survey	302.4	Canal Survey
April 19, 1995	Canal Survey	296.9	Canal Survey
April 19, 1995	Canal Survey	292.3	Canal Survey
April 19, 1995	Canal Survey	287.0	Canal Survey
April 19, 1995	Holley GG	284.6	Canal Survey
September 26, 1995	Holley GG	284.6	Guard Gate Contractor
April 19, 1995	Canal Survey	282.5	Canal Survey
November 9, 1994	Brockport GG	280.4	Proposed Construction Project
October 19, 1995	Brockport GG	280.4	Guard Gate Contractor
April 19, 1995	Canal Survey	276.9	Canal Survey
April 19, 1995	Canal Survey	272.1	Canal Survey
April 19, 1995	Canal Survey	267.4	Canal Survey
November 13, 1994	7-12-7B	261.4	Post Dredge Sample
November 13, 1994	7-10-7B	261.1	Post Dredge Sample

## **USEPA Grant Sediment Sampling**

There has been some continued concern by the NYSDEC, that insufficient data existed to properly characterize the canal between the Niagara River and Rochester, New York. This continued concern provided a catalyst for the Canal Corporation to request grant funding from the USEPA Great Lakes National Program Office in September of 1996. As part of the conditions of the grant offering a Quality Assurance Project Plan (QAPP) was prepared in early 1997 and submitted for review to the USEPA. Existing surface sediment and core samples collected between 1994 and 1997 were evaluated to determine if there were gaps in the previously collected data. Sample locations were selected to supplement and complement the existing data and to collect information within back water areas of the canal where existing sediment could provide a time history for evaluation. Both the USEPA and the NYSDEC reviewed the proposed sampling locations, analytical protocols and method of collection for this project. After modifications were made to the plan, it was approved on September 30, 1997 [4]. Due to the time of season and poor weather conditions, sampling could not be started until April 1998.

The proposed study is intended to document, in qualitative terms, the levels of organic chemicals and selected trace metals in the bottom sediments of the Erie Canal, which flows from the Niagara River to the Genesee River and on to Lake Ontario. Surficial sediment and sediment core samples were collected as part of this study to determine the levels of contamination for the parameters of concern. The majority of canal system is maintained with water within its banks for the navigation season, while a large portion of the canal is drained during the non-navigation season. This is performed to eliminate the potential for freeze-thaw effects in the sections that are elevated above the surrounding area, as is the case from Pendleton, New York to Rochester, New York. The rest of the canal system, from the Niagara River to Pendleton contains water on a year round basis.



The first phase of this project took place within the dewatered section of the canal before water was introduced into the canal. Starting in the Lockport, New York area, just above the double lock structure and proceeding eastward samples were collected on April 15 and 16, 1998. A second sampling trip was conducted on April 22, 1998 starting in the Brockport, New York area and proceeding westward. Sample locations where water is maintained in the canal throughout the year were deferred until late summer of 1998 so that analyses from the earlier sampling event could be evaluated on a preliminary basis. There were also some locations within the dewatered area of the canal system that were deferred until boat access to the sample points could be gained due to limited dry-weather topography.

On September 9 and 10, 1998, sampling within the Genesee River area, a location within the rock cut west of the Genesee River and a former boat turning basin location was core sampled from a shallow draft vessel. Starting in the Knowlesville area, samples were obtained on October 6 and 7, 1998 proceeding westerly by use of a shallow draft vessel. On October 6, 1998 samples were collected between Knowlesville and Lockport NY, and on October 7, 1998 samples were collected between Lockport and the Niagara River, again by the use of a shallow draft vessel.

In order to allow for the collection of samples within USEPA and NYSDEC contract laboratory holding time requirements, at about 12 locations a second duplicate core sample was collected for radio-nuclide dating. The cores that were collected for dating were capped and sealed in an upright orientation until they could be sectioned at a later date. During the initial development of the QAPP, it was proposed that sediment cores and a companion surficial grab would be obtained at selected locations, sectioned and dried for radio-nuclide dating. Had the initial core dating showed clear dating horizons, a second core was to be taken at a later time and again sectioned. The collection methodology was changed due to the limited time available for core collection and the relatively long holding time for cores that are being evaluated for dating purposes. Core dating information is evaluated in a later section of this report. At three (3) of the deeper core locations, reasonable dating profiles could be determined. There

was some material left over from the core slices that was still under refrigeration at the laboratory. The limited quantity of sediment could be used for only one analysis. Since the levels of PCB seemed to be significantly elevated, the refrigerated sediment was sent to the analytical laboratory for PCB analysis. It must be noted for the record that the USEPA Method holding times for this sediment had been exceeded, but the results still provide a reasonable chronology of contaminated sediment deposition. Table Number 3.3, following, shows the listing of sample locations and length of core sample collected.

Study area maps, which show the location of the collected samples, are included in Appendix A of this report. A summary of the sediment sampling results are included in Appendix B.

**Table Number 3.3**  
**Sampling Dates and Locations**

Sample Date	Location	Mile Point	Type/Length	Distance from Landmark	Latitude Differential	Longitude Corrected
October 7, 1998	EPA-1	339.4	Composite of 50.2 cm core	Confluence with the Niagara River	43-01-26.60009	78-52-53.88735
October 7, 1998	DUP #9 (EPA-1)	339.4	Blind Duplicate (Composite)	Confluence with the Niagara River	43-01-26.60009	78-52-53.88735
October 7, 1998	EPA-2	335.8	Composite of 20.3 cm core	450 m west of Robinson Road Bridge	43-01-55.46394	78-49-36.53095
October 7, 1998	DUP #8 (EPA-2)	335.8	Blind Duplicate (Composite)	450 m west of Robinson Road Bridge	43-01-55.46394	78-49-36.53095
October 7, 1998	EPA-3	332.9	Upper 26.7 cm of core	1670 m west of Bear Ridge Road Bridge	43-03-21.09159	78-48-22.57795
October 7, 1998	EPA-3	332.9	Lower 45.7 cm of core	1670 m west of Bear Ridge Road Bridge	43-03-21.09159	78-48-22.57795
October 7, 1998	EPA-4	331.7	Composite of 30.5 cm core	320 m west of Campbell Road Bridge	43-04-03.67936	78-46-25.14743
October 7, 1998	EPA-5	328.0	Upper 47.0 cm of core	250 m west of Tonawanda Creek Road Bridge	43-05-01.26117	78-44-04.17086
October 7, 1998	EPA-5	328.0	Lower 47.0 cm of core	250 m west of Tonawanda Creek Road Bridge	43-05-01.26117	78-44-04.17086
October 7, 1998	EPA-6	325.8	Composite of 20.3 cm core	170 m west of Fisk/Feigel Road Bridge	43-06-41.94762	78-44-21.75024
April 15, 1998	EPA-7	322.2	Upper 30.5 cm of core	42 m east of Prospect Street Bridge	43-09-52.90215	78-42-04.39275
April 15, 1998	EPA-7	322.2	Lower 30.5 cm of core	42 m east of Prospect Street Bridge	43-09-52.90215	78-42-04.39275
October 6, 1998	EPA-8	322.1	Upper 24.5 cm of core	230 m east of Prospect Street Bridge	43-09-57.47350	78-41-58.84433
October 6, 1998	EPA-8	322.1	Lower 17.1 cm of core	230 m east of Prospect Street Bridge	43-09-57.47350	78-41-58.84433
April 15, 1998	EPA-9	321.2	Composite of 33.0 cm core	180 m east of Lock E-34	43-10-21.30944	78-41-28.03316
April 15, 1998	EPA-10	319.5	Composite of 55.9 cm core	147 m west of Cold Springs Rd Bridge	43-11-08.54077	78-40-05.24806
October 6, 1998	EPA-11	313.9	Upper 45.7 cm of core	70 m east of Bolton Road Bridge/Gasport Wadewater	43-12-06.45436	78-33-26.30087
October 6, 1998	EPA-11	313.9	Lower 25.4 cm of core	70 m east of Bolton Road Bridge/Gasport Wadewater	43-12-06.45436	78-33-26.30087
October 6, 1998	DUP#7 (EPA-11)	313.9	Blind Duplicate (Lower)	70 m east of Bolton Road Bridge/Gasport Wadewater	43-12-06.45436	78-33-26.30087
April 22, 1998	Middleport Background	309.3	Composite of 12.7 cm core	213 m east of Verman Street Bridge	43-12-50.38549	78-28-21.68480
April 22, 1998	Middleport #1	307.2	Composite of 25.4 cm core	740 m west of Shelby Road Bridge	43-12-50.18074	78-26-21.33157
April 22, 1998	EPA-12	307.1	Upper 33.0 cm of core	730 m west of Shelby Road Bridge	43-12-49.27041	78-26-20.23428
April 22, 1998	EPA-12	307.1	Lower 33.0 cm of core	730 m west of Shelby Road Bridge	43-12-49.27041	78-26-20.23428
April 15, 1998	EPA-13	306.9	Composite of 22.9 cm core	15 m west of Shelby Road Bridge	43-12-58.28390	78-25-52.41810



**Table Number 3.3 (continued)**  
**Sampling Dates and Locations**

Sample Date	Location	Mile Point	Type/Length	Distance from Landmark	Latitude Differential Corrected	Longitude
April 15, 1998	EPA-13A	304.8	Composite of 38.1 cm core	100 m west of Prospect Road Bridge	43-13-31.68507	78-23-35.04054
October 6, 1998	EPA-14	298.9	Upper 20.3 cm of core	165 m west of Allens Road Bridge/Knowlesville Widewater	43-14-47.59231	78-17-12.36280
October 6, 1998	EPA-14	298.9	Lower 25.4 cm of core	165 m west of Allens Road Bridge/Knowlesville Widewater	43-14-47.59231	78-17-12.36280
October 6, 1998	DUP#6 (EPA-14)	298.9	Blind Duplicate (Lower)	165 m west of Allens Road Bridge/Knowlesville Widewater	43-14-47.59231	78-17-12.36280
April 15, 1998	EPA-15	294.9	Composite of 33.0 cm core	680 m east of Gaines Basin Road Bridge	43-15-02.97158	78-13-02.92783
April 15, 1998	DUP#2 (EPA-15)	294.9	Blind Duplicate (Composite)	680 m east of Gaines Basin Road Bridge	43-15-02.97158	78-13-02.92783
April 15, 1998	DUP#1 (EPA-15)	294.9	Blind Duplicate (Composite)	680 m east of Gaines Basin Road Bridge	43-15-02.97158	78-13-02.92783
April 16, 1998	EPA-16	293.5	Composite of 45.7 cm core	30 m east of Ingersoll Street Bridge	43-14-53.83301	78-11-23.67109
April 16, 1998	EPA-17	293.2	Composite of 40.6 cm core	440 m west of Brown Street Bridge	43-14-51.03537	78-11-01.59497
April 16, 1998	EPA-18A	290.7	Composite of 20.3 cm core	33 m west of County Route 11 Bridge	43-14-57.74171	78-08-09.06305
April 16, 1998	EPA-18B	290.7	Composite of 20.3 cm core	2 m east of County Route 11 Bridge	43-14-57.90509	78-08-07.62628
April 16, 1998	EPA-18C	290.7	Composite of 20.3 cm core	20 m east of County Route 11 Bridge	43-14-58.08698	78-08-06.37581
April 16, 1998	EPA-20	286.3	Composite of 55.9 cm core	250 m west of Groth Road Bridge	43-15-02.08446	78-02-56.43072
April 16, 1998	DUP#3 (EPA-20)	286.3	Blind Duplicate (Composite)	250 m west of Groth Road Bridge	43-15-02.08446	78-02-56.43072
April 22, 1998	EPA-21	280.0	Upper 33.0 cm of core	150 m east of Park Avenue Bridge	43-12-51.80622	77-56-01.10886
April 22, 1998	EPA-21	280.0	Lower 33.0 cm of core	150 m east of Park Avenue Bridge	43-12-51.80622	77-56-01.10886
April 22, 1998	EPA-22	272.4	Composite of 15.2 cm core	450 m west of Martha Street Bridge	43-11-44.44666	77-48-33.47739
September 10, 1998	EPA-23	269.5	Upper 39.4 cm of core	180 m west of Manitou Road Bridge/Widewater	43-11-12.90326	77-45-20.74385
September 10, 1998	EPA-23	269.5	Lower 25.4 cm of core	180 m west of Manitou Road Bridge/Widewater	43-11-12.90326	77-45-20.74385
September 10, 1998	EPA-24	261.8	Upper 40.6 cm of core	540 m east of Brooks Avenue Bridge	43-07-38.34003	77-39-11.81062
September 10, 1998	EPA-24	261.8	Lower 30.5 cm of core	540 m east of Brooks Avenue Bridge	43-07-38.34003	77-39-11.81062
September 10, 1998	EPA-24 (Lab Duplicate)	261.8	Lower 30.5 cm of core	540 m east of Brooks Avenue Bridge	43-07-38.34003	77-39-11.81062
September 9, 1998	EPA-25	261.2	Upper 50.8 cm of core	850 m south of Exchange Street Bridge at Rochester Wall	43-08-07.33901	77-37-13.17323
September 9, 1998	EPA-25	261.2	Lower 50.8 cm of core	850 m south of Exchange Street Bridge at Rochester Wall	43-08-07.33901	77-37-13.17323
September 9, 1998	DUP#4 (EPA-25)	261.2	Blind Duplicate (Upper)	850 m south of Exchange Street Bridge at Rochester Wall	43-08-07.33901	77-37-13.17323

## Sediment Analysis Guidance

The removal of sediments from a navigable waterbody, such as the Canal system requires that the US Army Corps of Engineers issue a Section 10 dredge and fill permit which normally is conditioned on the issuance of a 401 Water Quality Certification (WQC) by the NYSDEC. The requirements for a NYS 401 WQC to support a dredging or other sediment removal project within the canal system require that an applicant evaluate sediment quality within the project area against NYS guidance documents. In late November of 1993, the NYSDEC published a guidance document that used water quality standards, information from the Ontario Ministry of the Environment and Energy and the National Oceanic and Atmospheric Administration to establish sediment criteria for use in New York State.[5] The screening criteria was patterned after the Ontario Ministry guideline definitions, establishing both a Lowest Effect Level (LEL) and a Severe Effect Level (SEL). Simultaneously with the development of this guidance, the NYSDEC Division of Water was developing a similar document, which established levels of sediment contamination and related them to a level above which there was a concern [6]. This document classifies sediments within navigable waterways into three categories, Classes "A" through "C". Class "A" sediment is considered innocuous and the NYSDEC allows for the unrestricted reuse of the material once it has been removed from a water environment. Class "C" sediments are determined based on several different approaches such as those contained in the New York State Technical Guidance for Screening Contaminated Sediments [4]. Category "B" sediments are considered to be the area between the "A" and "C" criteria, by default. For the screening of contaminants within the canal system between the Niagara River and the Genesee River, sediments are required to be tested for the parameters listed in Table Number 3.4, following. In addition, sediment samples are tested for Total Organic Carbon (TOC) content and also Total Volatile Solids (TVS) content to allow for the comparison with the chemical constituents.



**Table Number 3.4****NYSDEC Sediment Guidance Levels**

Threshold Values in Parts per Million (PPM), unless otherwise noted

<u>Parameter</u>	<u>Category A</u>	<u>Category B</u>	<u>Category C</u>
Total Mercury	<0.1	0.1 to 4.0	>4.0
Total Cadmium	<0.6	0.6 to 10.0	>10.0
Total Lead	<30.0	30.0 to 100.0	>100.0
Total Copper	<16.0	16.0 to 110.0	>110.0
Total PCB	<0.1	0.1 to 10.0	>10.0
2,3,7,8 TCDD			
toxic equivalents (TEQ)	<4.5 PPT	4.5 to 50 PPT	>50.0 PPT

Sediments are analyzed for total organic carbon (TOC) using USEPA Method 9060. This provides for a Minimum Practical Quantification Limit (MPQL) of 0.1 percent on a dry weight basis. Total volatile solids (TVS) are analyzed using USEPA Method 160 which also yields a MPQL of 0.1 percent. Both of these parameters are sometimes used to “normalize” the contaminant concentrations to a standard percentage of organic carbon or volatile solids. Inorganic compounds are analyzed using USEPA Method 6010 for Total Cadmium, Lead and Copper. This method allows for a MPQL for cadmium of 0.5 PPM, for lead 0.3 PPM and for copper 2.5 PPM. Mercury is evaluated by use of USEPA method 7471 to a MPQL 0.02 PPM.

The level of PCB contamination in the sediments of the canal was performed using USEPA Method 8080 (and more recently Method 8081) on a homolog basis. Both of these methods provide for a MPQL of 0.08 PPM. For purposes of this project a comparison of individual homolog groups or PCBs was not undertaken since the general homolog patterns seen for all samples are consistent. Total PCB is used to determine whether sediment can be removed from the environment and its ultimate fate after removal. At the current time the USEPA does not regulate PCBs on a congener or



homolog basis, evaluation is on a total PCB basis. Once the level of PCB in a soil or sediment reaches 50 PPM its disposal is regulated under the Toxic Substance Control Act (TSCA).

Dioxin/Furan analyses are performed on the sediment samples using USEPA Method 1613A, which can provide a MPQL of 2 PPT depending on the specific congener under consideration. The results of this USEPA method produce results that identify the concentration of the 2,3,7,8-substituted dioxin and furan substituted congeners and the different isomer or homolog groups for these compounds. The following discussion addresses these compounds as follows:

Polychlorinated dibenzo-*p*-dioxins (PCDDs) include 75 individual compounds or congeners of which 7 are thought to have dioxin-like toxicity, similar to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. These are the congeners with chlorine substitutions in the 2,3,7, and 8 positions making the compound coplanar and potentially more bioactive. Polychlorinated dibenzofurans (PCDFs) include 135 individual compounds or congeners of which only 10 are thought to have dioxin-like toxicity; these are also the ones with chlorine substitutions in the 2,3,7, and 8 positions.

PCDD and PCDF compounds are often found in complex mixtures in the environment. To evaluate these compounds for risk assessment purposes a procedure of toxicity equivalency was developed to describe the cumulative toxicity of these complex mixtures. Toxic Equivalency (TEQ) is the method that is used to quantify the 2,3,7,8 substituted congeners by calculating their toxicity in proportion to the toxicity of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. This method was developed by the USEPA and is routinely used by the NYSDEC in their regulatory role of dealing with contaminated sediment issues.

Analytical results for dioxin are reported in terms of parts per trillion (PPT), by use of USEPA Methods 1613A using high resolution mass spectrometry (HRMS) analyses. The toxicity equivalency of sediment is then calculated by multiplying all of

the concentrations in PPT for each of the congeners by their appropriate TEF. Table Number 3.5; below provides the factors that are currently used for these calculations. The sum for the given sample is the total equivalency of the sediment relative to 2,3,7,8-tetrachlorodibenzo-*p*-dioxin.

**Table Number 3.5**  
**Toxic Equivalency Factors [7]**

<b>Dioxin Congener</b>	<b>TEF</b>	<b>Furan Congener</b>	<b>TEF</b>
Mono chlorodibenzodioxins	0	Mono chlorodibenzofurans	0
Di chlorodibenzodioxins	0	Di chlorodibenzofurans	0
Tri chlorodibenzodioxins	0	Tri chlorodibenzofurans	0
2,3,7,8 tetrachlorodibenzodioxins	1.0	2,3,7,8 tetrachlorodibenzofurans	0.1
Other tetrachlorodibenzodioxins	0	Other tetrachlorodibenzofurans	0
2,3,7,8 pentachlorodibenzodioxins	0.5	1,2,3,7,8 pentachlorodibenzofurans	0.05
Other pentachlorodibenzodioxins	0	2,3,4,7,8 pentachlorodibenzofurans	0.5
2,3,7,8 hexachlorodibenzodioxins	0.1	Other pentachlorodibenzofurans	0
Other hexachlorodibenzodioxins	0	2,3,7,8 hexachlorodibenzofurans	0.1
2,3,7,8 heptachlorodibenzodioxins	0.01	Other hexachlorodibenzofurans	0
Other heptachlorodibenzodioxins	0	2,3,7,8 heptachlorodibenzofurans	0.01
Octachlorodibenzodioxins	0.001	Other heptachlorodibenzofurans	0
		Octachlorodibenzofurans	0.001

For this project, TEQ is used to determine the relative levels of Dioxin and Furan concentration in sediments. No attempt is made in this paper to discuss the health or biota impacts associated with the Dioxin/Furan TEQ levels. For consistency in the preparation of this project, analytical results with a level below the congener's detection limit were reported as 1/2 of the detection limit for purposes of the TEQ calculation.

A method of evaluation of both Dioxin and Furan compounds is by comparison of the isomer or homolog groups as a percentage of the total 2,3,7,8-PCDD and PCDF. The data is plotted and compared to homolog profiles for materials that have been evaluated by the USEPA in their inventory of sources of dioxin in the United States[1]. Another method of evaluation used is the comparison of 2,3,7,8 substituted congeners as a percentage of the total 2,3,7,8-PCDD and PCDF [1]. This method of evaluation gives a



reasonable method for determining the source or sources of dioxins and furans to the environment.

At this point it is important to note that whether the contaminant is either a dioxin or a furan, a standardized numbering system identifies the positions of the chlorine atoms around the rings of the molecule. The term dioxin has now become an abbreviation with several different meanings. As discussed above, the term is typically used to describe a family of 210 nearly planar, or flat, aromatic compounds. This group includes 75 PCDD congeners and 135 PCDF congeners. The term congener typically means the molecule has a specific number of chlorine atoms in specific positions around the molecule. The term isomer or homolog refers to a molecule or group of molecules where the same number of chlorine atoms may be present around the molecule, but they may be in different positions. Therefore, different congeners could contain the same number of chlorine atoms in the same proportion by weight but they could possess differing physical or chemical properties because of differences in structure of their molecules. It is believed that the more planar or flat molecules where the chlorine atoms are in the 2,3,7 or 8 positions around the molecule are more toxic. The Toxic Equivalency Factors (TEF) values on Table Number 3.5 are assigned to each congener or homolog based on that belief.

### **Radionuclide Dating Analysis**

The evaluation of the quantity of radioactive isotopes in sediment is a useful tool in determining the rates of sedimentation at a specific location as well as evaluating the general timeframe of contaminated sediment deposition. Cesium-137, (Cs-137) is a particle-associated, radionuclide that first entered natural water systems in measurable amounts in the early 1950s as global fallout from the atmospheric testing of nuclear weapons. This knowledge yields a simple, but useful piece of dating information; any core section with detectable Cs-137 activity contains a significant component of particles deposited since about 1954. Cores that contain a continuous undisturbed record of sediment accumulation can be dated on the basis of their depth profile of Cs-137 activity.

The deepest penetration of measurable Cs-137 activity corresponds to about 1954, while peak activity corresponds to 1963 to 1964, the years of maximum global fallout. In an ideal core, the Cs-137 activity decreases smoothly from the mid 1960s peak toward the surface. In such a core, the top sample or two could contain detectable activity of Beryllium-7, (Be-7).

Be-7 is a cosmic ray produced radionuclide that is supplied continuously from the atmosphere to the earth's surface. Because of its relatively short half-life (53.4 days), detectable activity of Be-7 is confined to upper core sections that contain a significant component of particles deposited within about 6 months to a year of core collection.

Potassium-40, (K-40) is a radioactive element that makes up about 0.01% of naturally occurring potassium. It is used as a compositional indicator. For example, since quartz sands are depleted in potassium relative to clay minerals, coarser sediments tend to have lower levels of K-40 than fine-grained sediments. A fairly constant level of K-40 throughout a core is a good sign, consistent with minimal compositional variability that can complicate interpretation of contaminant data.

As discussed previously, a duplicate core sample was collected at selected sediment coring locations. Table 3.6 provides a listing of the duplicate cores collected, the collection date and their location.



Table Number 3.6  
Duplicate Cores for Radionuclide Testing

Sample Date	Location	Length of Duplicate Core For Dating	Latitude Differential Corrected	Longitude
October 7, 1998	EPA-1	59 Centimeters	43-01-26.60009	78-52-53.88735
October 7, 1998	EPA-3	54 Centimeters	43-03-21.09159	78-48-22.57795
October 7, 1998	EPA-5	112 Centimeters	43-05-01.26117	78-44-04.17086
April 15, 1998	EPA-7	56 Centimeters	43-09-52.90215	78-42-04.39275
October 6, 1998	EPA-8	28 Centimeters	43-09-57.47350	78-41-58.84433
April 15, 1998	EPA-9	30 Centimeters	43-10-21.30944	78-41-28.03316
October 6, 1998	EPA-11	95 Centimeters	43-12-06.45436	78-33-26.30087
April 22, 1998	EPA-12	48 Centimeters	43-12-49.27041	78-26-20.23428
October 6, 1998	EPA-14	42 Centimeters	43-14-47.59231	78-17-12.36280
April 22, 1998	EPA-21	44 Centimeters	43-12-51.80622	77-56-01.10886
September 10, 1998	EPA-23	68 Centimeters	43-11-12.90326	77-45-20.74385
September 10, 1998	EPA-24	100 Centimeters	43-07-38.34003	77-39-11.81062
September 9, 1998	EPA-25	112 Centimeters	43-08-07.33901	77-37-13.17323

The duplicate cores were capped onsite and stored during transportation to a central processing area to be sectioned. The cores were extruded from the core tube and cut into 2-centimeter sections over the upper 8 centimeters of the core using a stainless steel knife. Between slices the sectioning equipment was decontaminated to prevent the transfer of chemical constituents from one section to another. Below the 8-centimeter level the balance of the core was cut into 4-centimeter sections. All core slices were placed into new quart sized zip-lock bags labeled with appropriate markings for future identification and refrigerated.

A sub-sample of the sediment core section to be evaluated was cut from each slice in a wedge shape to better obtain a representative sample from each core slice. The sample was dried under a hood using a heat lamp at the Rensselaer Polytechnic Institute (RPI) geochemistry laboratory. Once dry the samples were ground in a mortar with a

pestle, weighed and transferred to plastic vials for gamma counting.

The sub-samples were analyzed for Be-7, Cs-137 and K-40. Core-top sections that had not "aged" more than a few months were also analyzed for the short-lived radionuclide, Be-7. Radionuclide activities are reported in units of picocurie per kilogram (pCi/kg). One picocurie is equivalent to 2.22 decays per minute.

All dates used for gamma counting are reported as Julian dates. The first two numbers of a Julian date represent the last two numbers of the year, while the last three numbers of the Julian date represent the day of the year consecutively numbered from January 1<sup>st</sup>.

Examples:

98001=January 1, 1998

97365=December 31, 1997

Radionuclide measurements were carried out using a gamma counter with an intrinsic germanium detector. Blank corrections were applied to each sample based on the analysis of empty sample containers. Background corrections were applied to each radionuclide based on the sample count rate at energies just above and just below each peak of interest. Detector efficiency was calibrated using an NBS sediment standard (River sediment NBS 4350B), a liquid NBS standard (NBS 4953-C) that was used to prepare spiked sediments (G-standards), and secondary standards (D-standards) prepared at the Lamont-Doherty Earth Observatory and calibrated to NBS standards.

No major problems were encountered with the gamma counter. Results of analyses of standards and blanks (empty sample vials) are given later in this data package. Data on samples is reported with an error of  $\pm 1$  standard deviations based on counting statistics. Counting errors associated with nuclide peaks, background regions, and blanks are all included in the calculation of the reported standard deviation. One duplicate analysis (a second count of the same sample aliquot) was run for every twenty samples and results are reported later in this data package. A report of the counting that was conducted by RPI is included as Appendix E of this report.



## **CHAPTER 4**

### **DISCUSSION**

#### **Sediment Evaluation**

Each of the analyses, results and field observations will be discussed for each of the five canal sections. The results of the sediment sampling have been evaluated using the NYSDEC criteria shown in Table Number 3.4. It should be noted that all PCB concentrations are evaluated on an Aroclor basis

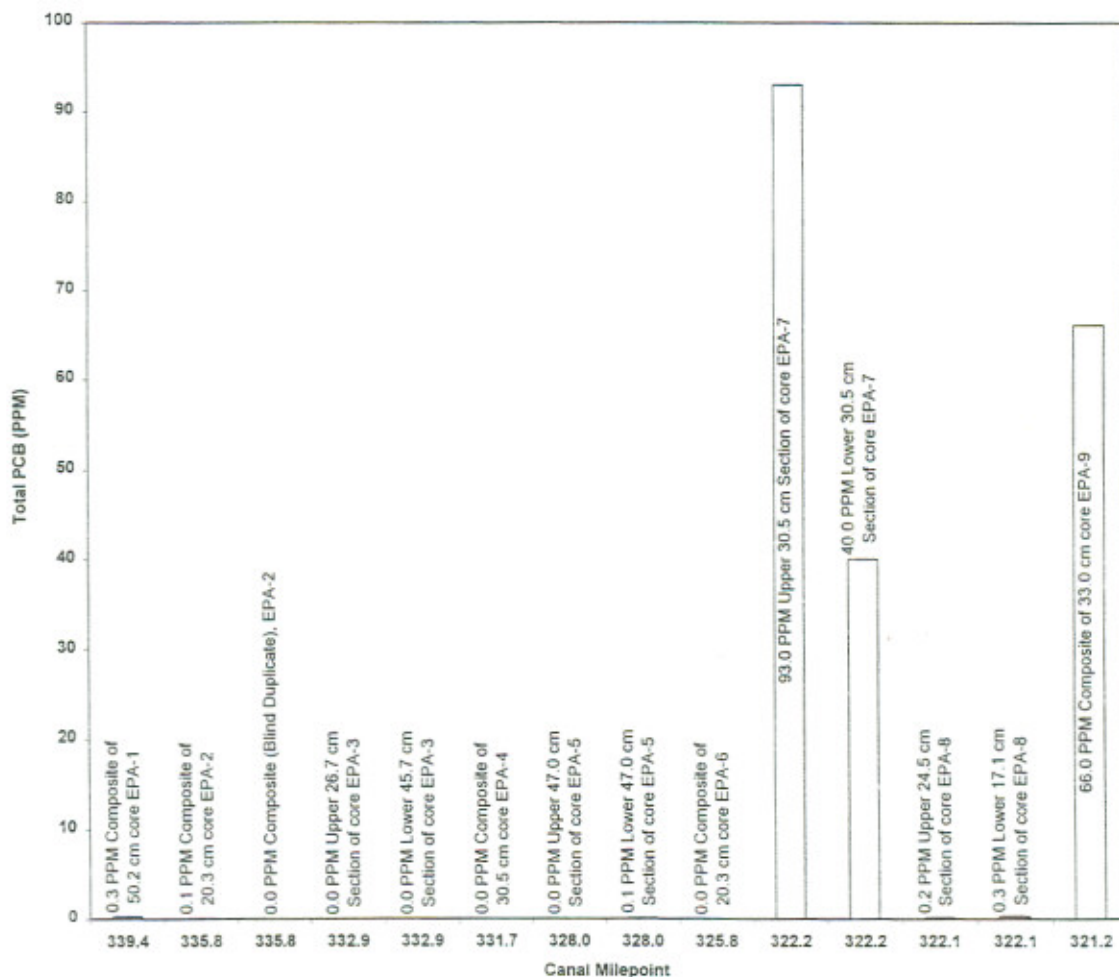
#### **Reach Number 1**

Within this reach nine push cores were collected within a 6.4 kilometer stretch from the confluence of the canal with the Niagara River at milepoint 339.4 to immediately east of the double lock structure in Lockport at milepoint 221.2. At five of the sampling sites the cores were sectioned based on visual observation of the sediments (light brown silts and clay versus black silts and clay). Both the upper and lower sections were individually composited, placed into new, pre-cleaned sample jars with teflon coated lids, packed in ice and submitted to the laboratory.

Total PCB levels in the sediment between the Niagara River and west of the Prospect Street Bridge in Lockport were generally between non-detect and 0.3 PPM as shown below on Figure # 4.1. Immediately west of Lockport, under the Prospect Street Bridge at sampling site EPA-7, a significant level of PCB contamination is present in the core sample collected mid-April prior to the canal being filled for the navigation season. PCB levels in the composited upper 30.5 centimeters of sediment show a concentration of 93 PPM; the level of contamination in a composite of the lower 30.5 centimeters of sediment is 40 PPM. At sampling site EPA-8, which is located approximately 188 meters east of site EPA-7; another core was collected through the water column in early October. In both the upper and lower core sections, PCB concentrations were 0.2 PPM and 0.3 PPM, respectively. Below the double lock structure at sampling site EPA-9, a 33.0

centimeter core was collected and composited. The concentration of PCB within this core, which represents a composite of the upper 33.0 centimeters of sediment, was 66 PPM. The geometry of the canal at this point is quite wide and there is little to no flow velocity during canal operations. Based on observations of this location on the canal during the navigation season, it appears that the increased sediment depth and the elevated total PCB concentrations found at this sampling location are due to the low flow velocities in this area. Based on the above results it appears that a source of the PCB contamination exists in the vicinity of milepoint 322.2.

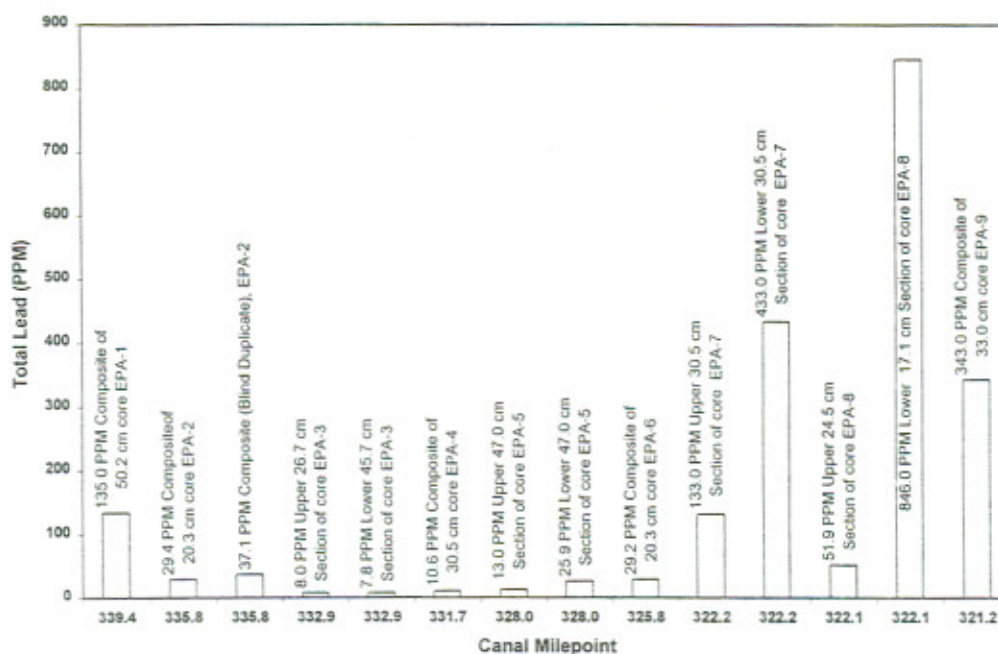
Figure # 4.1  
Total PCB Concentration in Reach # 1





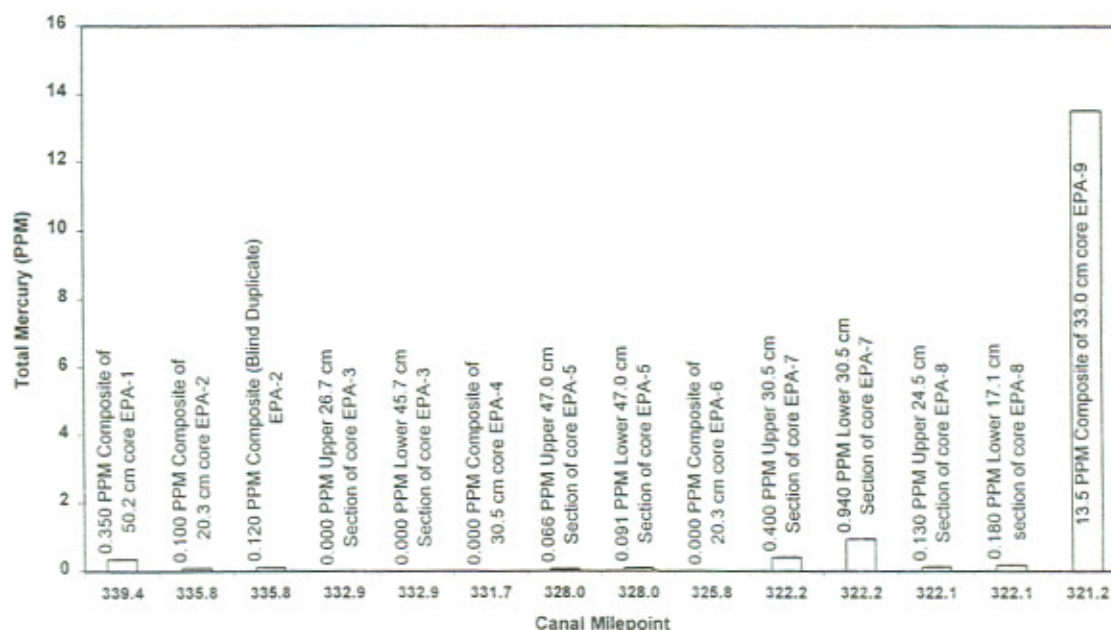
The cores collected and the sections obtained within reach 1 were also analyzed for total lead. What is curious about this group of samples is the elevated levels that are seen in sample EPA-1 which exhibited the concentration of 135.0 PPM. This sample was collected at the confluence of the canal and the Niagara River; it is unknown what the source of this elevated lead level could be since it could represent upstream contaminants in the Niagara River. The core collected at sample site EPA-7 showed a level of 133.0-PPM total lead within the upper section of the core while the lower section was significantly elevated to a level of 433.0 PPM. This phenomenon is also evident at sampling site EPA-8 where the upper 24.5 centimeters of the core showed a lead concentration of 51.9 PPM while in the lower 17.1 centimeters of the core showed a lead concentration of 846.0 PPM. This leads me to believe that the rate of lead contamination within the canal may have subsided over time. At sampling site EPA-9 lead concentration of the composited 33.0 centimeter core was 343.0 PPM. Of note is that sample site EPA-7 is almost underneath the Prospect Street Bridge while the both EPA-8 and EPA-9 is downstream of this bridge. This structure has been closed for numerous years due to its deteriorated condition and most likely contains lead-based paint. Figure # 4.2 below provides a graphical representation of the lead concentration within this reach.

**Figure # 4.2**  
**Lead Concentration in Reach # 1**



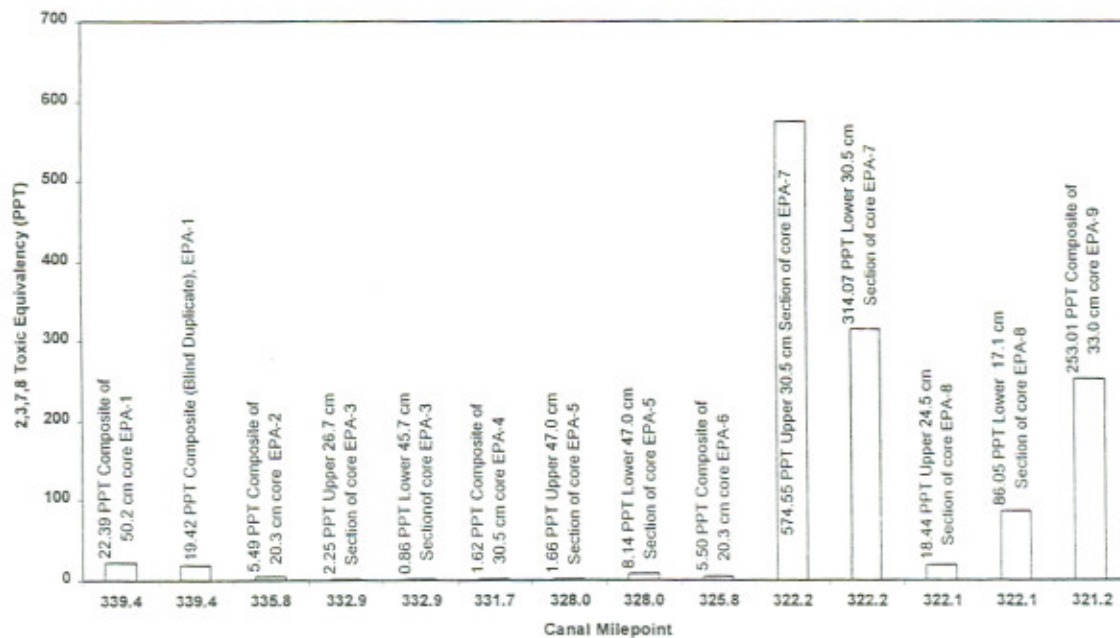
Within this reach only three areas are of interest when one looks at mercury contamination in the sediments; there is an elevated level (0.350 PPM) at sample site EPA-1, most likely attributable to contaminants in the Niagara River. Elevated levels are also detected at sample site EPA-7. The upper section exhibits a level of 0.400 PPM while the lower core section contains 0.940 PPM mercury. The significant difference between upper and lower sections suggests that contaminant levels are decreasing in the more recent sediment deposits. The most surprising mercury contaminant concentration identified was at sampling site EPA-9 where the level of 13.5 PPM was identified within the top 33.0 centimeters of the sediment. It is unclear whether there is a supplemental source of mercury to the system or if the effects of low flow velocity have contributed to this elevated concentration. A third possibility is that the results of this sample may not accurately represent the mercury concentrations in the sediment in this area. Supplemental sampling is suggested to verify the presence of elevated Mercury levels. Figure # 4.3, below show levels of mercury contamination within the sediments plotted on an axis of canal milepoint.

**Figure # 4.3**  
**Mercury Concentration in Reach # 1**



The results of the dioxin/furan analyses evaluated on a TEQ basis are similar to the trend seen in PCB contamination. There is a slight elevation of dioxin TEQs apparent at sample site EPA-1; the level appears to be consistent with the level of this contaminant encountered in numerous other locations along the canal in western New York. A significant TEQ concentration in the upper section at sample site EPA-7 of 574.55 PPT compares with a level of 314.07 PPT within the lower section of this core. Based on the above results, it appears that quite possibly the source of PCB contamination may also be the source of the dioxin/furan contamination in the vicinity of milepoint 322.2, near the Prospect Street Bridge. At sample site EPA-8 the trend reverses itself where the upper core section is at 18.44 PPT while the lower section is 86.05 PPT on TEQ basis. At sample site EPA-9, the levels of Dioxin/Furans on TEQ basis within the sediment composited from a 33.0 centimeter core is 253.01 PPT.

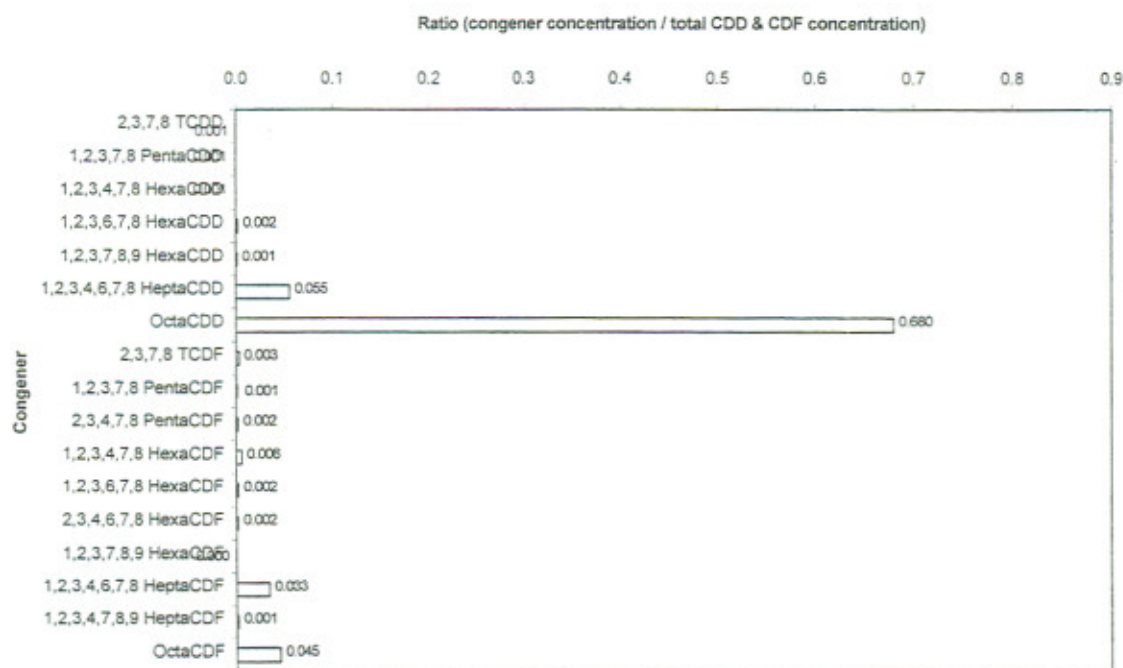
**Figure # 4.4**  
**Dioxin/Furan TEQ in Reach # 1**





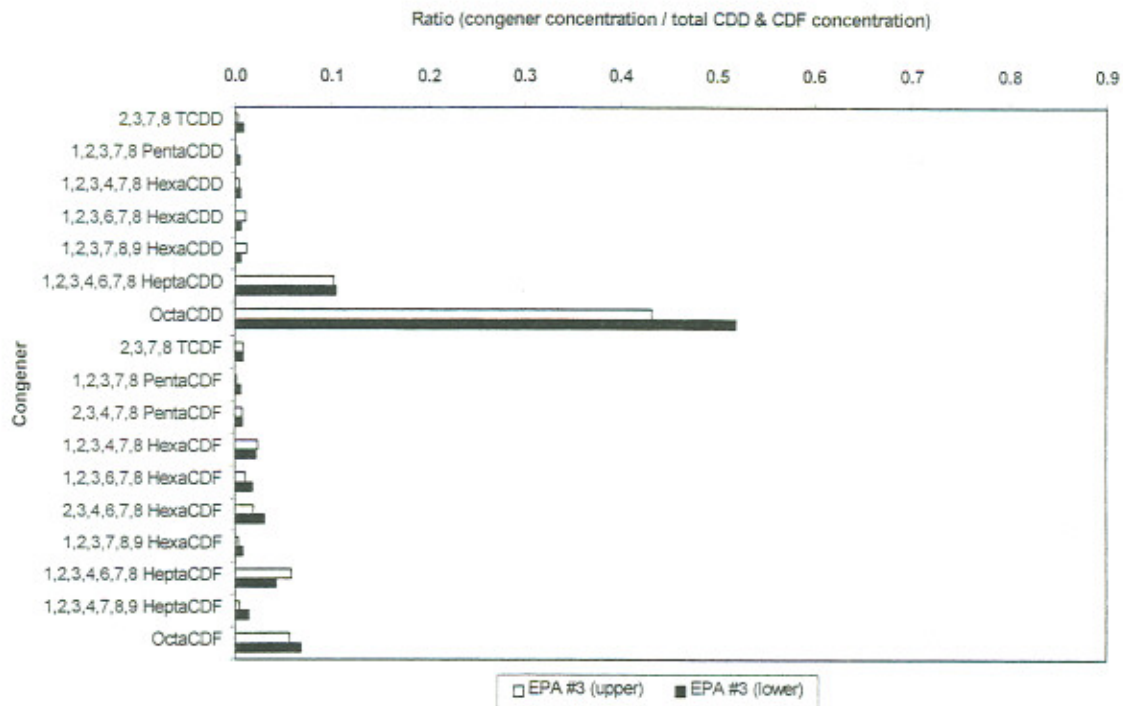
Both the upper and lower core sections within Reach Number 1 exhibit the same trend in congener profile with the exception of sampling site EPA-3. The general congener profile for the sediments within this reach are shown in Figure # 4.5.

**Figure # 4.5**  
**Congener Profile - Reach Number 1**  
(without core EPA-3)



Sample site EPA-3 has a different congener profile in both the upper and lower core sections than any of the other samples from this reach. There are significantly increased levels of 1,2,3,4,6,7,8 Heptachlorodibenzodioxin along with slightly elevated levels of all of the Pentachlorodibenzofurans and Hexachlorodibenzofurans and 1,2,3,4,7,8,9 Heptachlorodibenzofurans. There is about a 20 percent decrease in the percent of Octachlorodibenzodioxin within the sample results. It is currently unknown if this shift in congener pattern might identify a different source or quite possibly an area where biotic or abiotic degradation has caused a decrease in the more highly chlorinated congeners within the upper sediments. These sediments are also closer to the surface of the water column, hereby allowing for photo-degradation from sunlight (photolysis). Figure # 4.6 following, shows the congener patterns observed in core EPA-3.

**Figure # 4.6**  
**Congener Profile Milepoint 332.9 (EPA #3)**



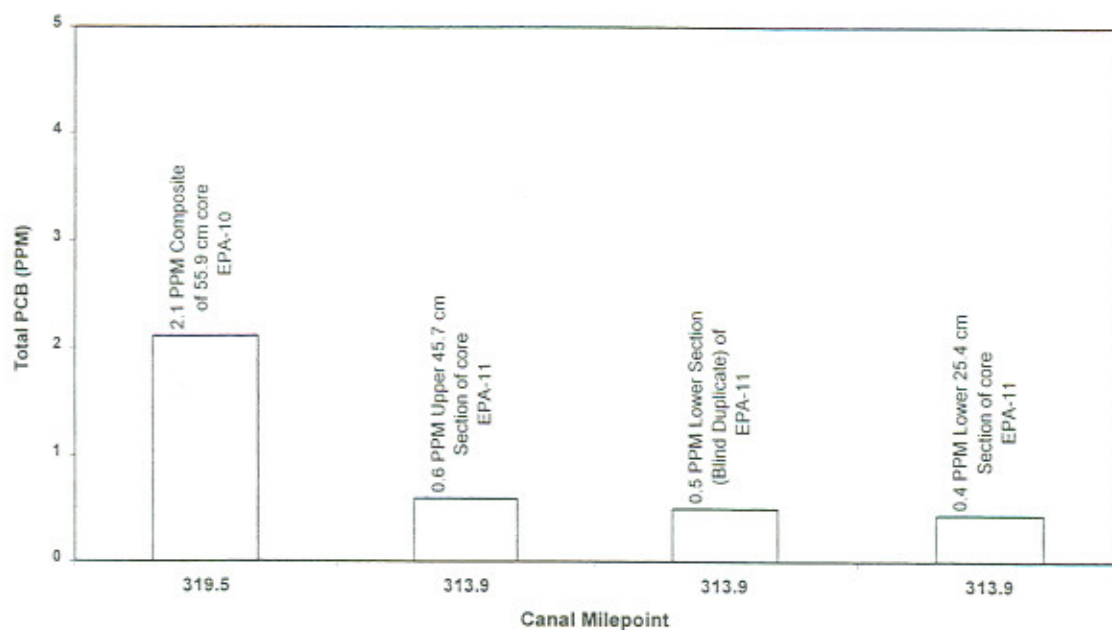
## Reach Number 2

Within this reach only 2 push cores were collected, one was at milepoint 319.5, (EPA-10) upstream (west) of the Cold Springs bridge and a second at milepoint 313.9, (EPA-11) in the Gasport widewater area that is currently a marina. At sampling site EPA-10, a 55.9 centimeter long core was collected, the sediment composited and packaged for shipment to the laboratory. For sampling site EPA-11, the 71.1 centimeter core that was collected was sectioned based on visual observation of the sediments, both the upper and lower sections were individually composited, placed into new sample jars, packed in ice and submitted to the laboratory.

PCB levels in the composite obtained at sampling site EPA-10 were 2.1 PPM and the sample collected at EPA-11 showed surface levels in the range of 0.5 to 0.6 PPM.

The levels of PCBs in the lower section of the core contained PCBs in a concentration of 0.4 PPM as shown on Figure # 4.7, below.

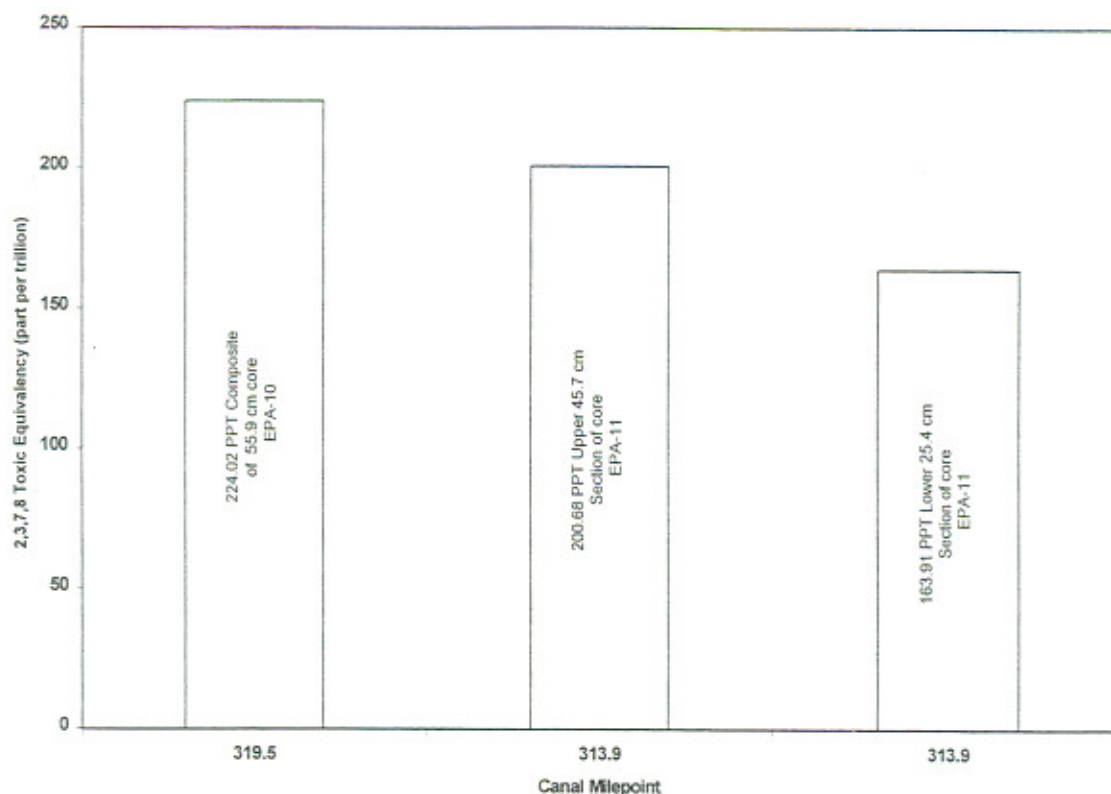
**Figure # 4.7**  
**PCB Concentration in Reach # 2**



Dioxin/furan analyses evaluated on a TEQ basis trend downward as you move from Lockport eastward. The TEQ concentration measured in the composite of the core collected at sampling site EPA-10, 224.02 PPT is less than the TEQ levels encountered in the Lockport area. The upper section obtained at sample site EPA-11 of 220.68 PPT is only slightly elevated above the level of 163.91 PPT found in the lower section of this core. Dioxin/Furan TEQ concentrations are shown below on Figure # 4.8.



Figure # 4.8  
Dioxin/Furan TEQ in Reach # 2



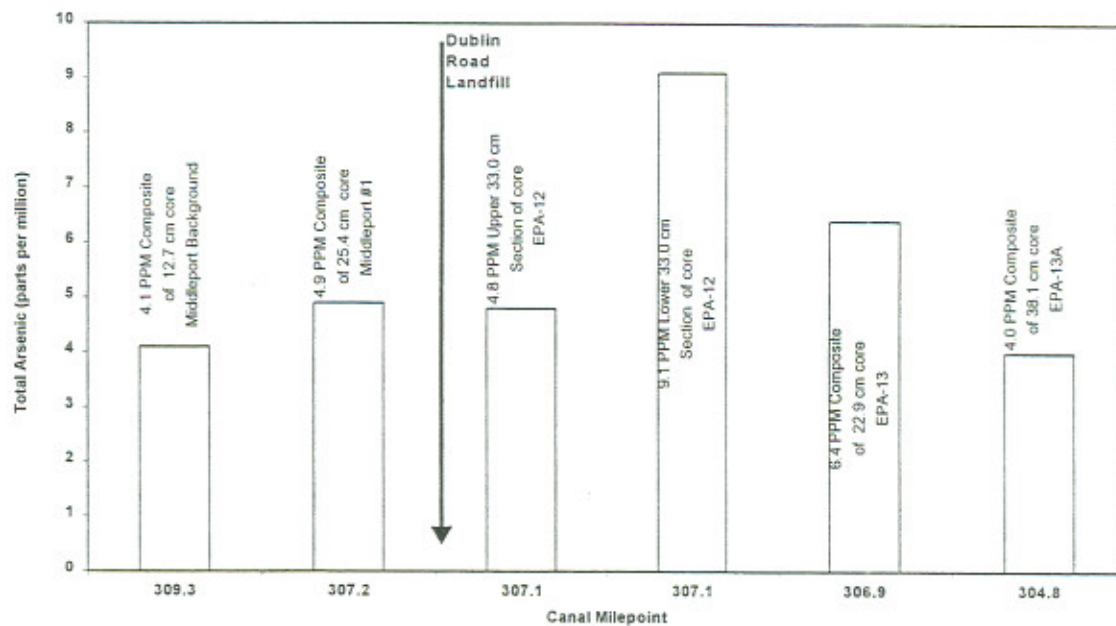
The composite core and both the upper and lower core sections within this reach exhibit the same congener profile. This profile is also quite similar to the profile seen within reach 1.

### Reach Number 3

Within this reach 9 push cores were collected, many were small in length since there is limited sediment within the main channel of the canal. The levels of PCB encountered were 1.0 PPM or lower, many were non-detectable. Adjacent to the canal at milepoint 307.1 in the Middleport area, there is a landfill that has reportedly been used for the disposal of arsenic wastes from pesticide manufacture. Two background core samples were taken west of the landfill area. These samples were collected and

composited, the first one was taken nearly 3 kilometers upstream of the site, and a second about 160 meters upstream. A core sample was taken immediately downstream of the landfill and visually sectioned into an upper 33.0 centimeter section and a lower 33.0 centimeter section. Core samples were collected about 320 meters further downstream and another was taken over 3.2 kilometers downstream of the landfill. The results of the analysis for arsenic is shown on Figure # 4.9, below. Downstream of the landfill, arsenic levels are higher than background concentrations in the deeper, older sediments. The arsenic concentrations within the more recently deposited surficial sediments return to background levels approximately 4.8 kilometers further downstream. Thus with no other inputs, one might speculate that the elevated arsenic found within the deeper sediments originated from the landfill.

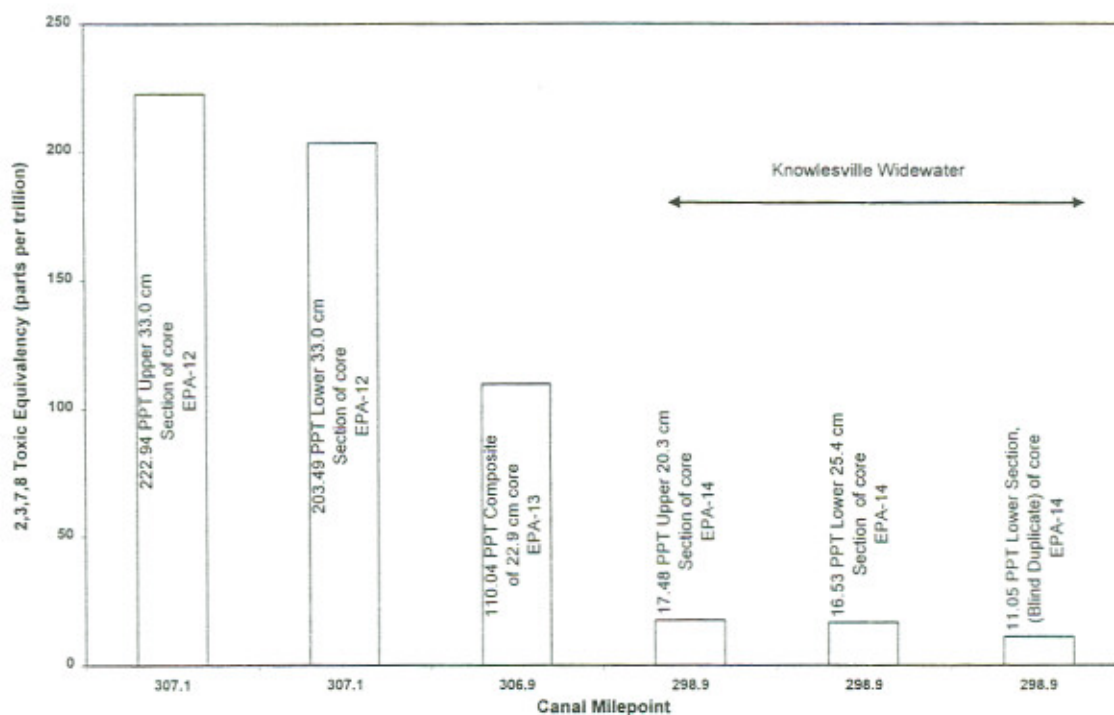
Figure # 4.9  
Arsenic Concentration in Reach # 3



Dioxin/Furan TEQ levels in this reach trend downward as you move easterly. Core samples collected at sample site EPA-12, milepoint 307.1 are generally the same as the levels found in reach number 2. At this location there is little difference in TEQ concentration between the upper and lower sections of the core. A composite from sample site EPA-13, milepoint 306.9 is nearly half of the levels seen at milepoint 307.1. Samples collected at sample site EPA-14, milepoint 298.9 were collected in a very large

widewater area. This location appears to have seen little contaminant impact due to its location. Figure # 4.10, below shows the TEQ concentrations encountered within this reach.

Figure # 4.10  
Dioxin/Furan TEQ in Reach # 3



The composite core and both the upper and lower core sections within the channel and the widewater area of this reach exhibit the same congener profile. This profile is also quite similar to the profile seen within reach number 1.

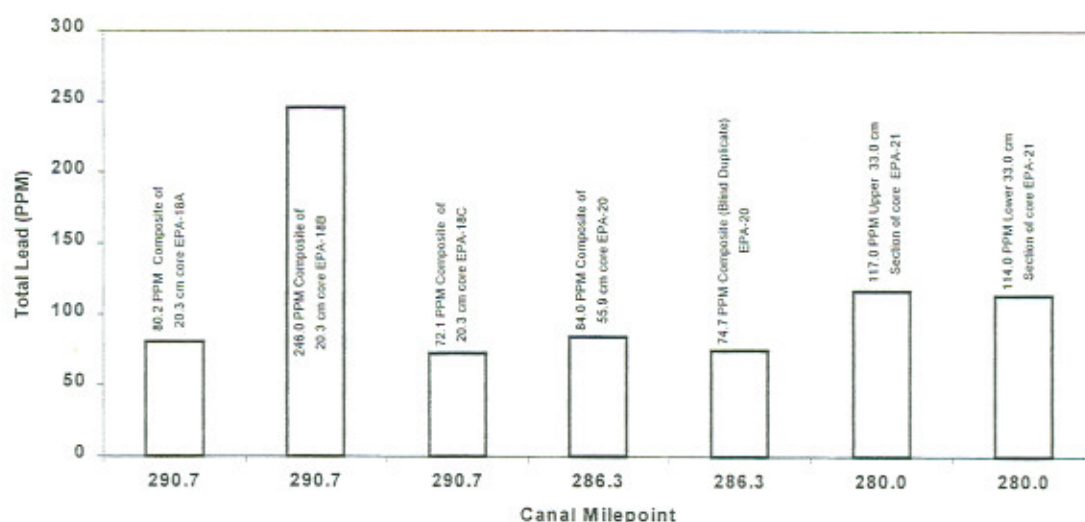
#### Reach Number 4

Within this reach 5 push cores were collected, 3 were taken from the upper 20.3 centimeters of sediment to evaluate the surface sediment quality adjacent to a bridge. The levels of PCB contamination encountered in the sediment were non-detectable within this reach. Sample sites at EPA-18A, milepoint 290.7 represents the conditions 33 meters upstream of the Orleans County Rote 11 Highway bridge, site EPA-18B was collected 2



meters from the downstream side of the bridge span and EPA-18C was collected 20 meters downstream. Many were small in length since there is limited sediment within the main channel of the canal. The elevated levels exhibited at sample sites EPA-20 and EPA-21 can not be accounted for since they are quite some distance from structures crossing the canal. It is hypothesized that the lead level detected may have been caused by the downstream transport of paint flakes. Figure # 4.11 shows the lead concentrations within this reach of the canal.

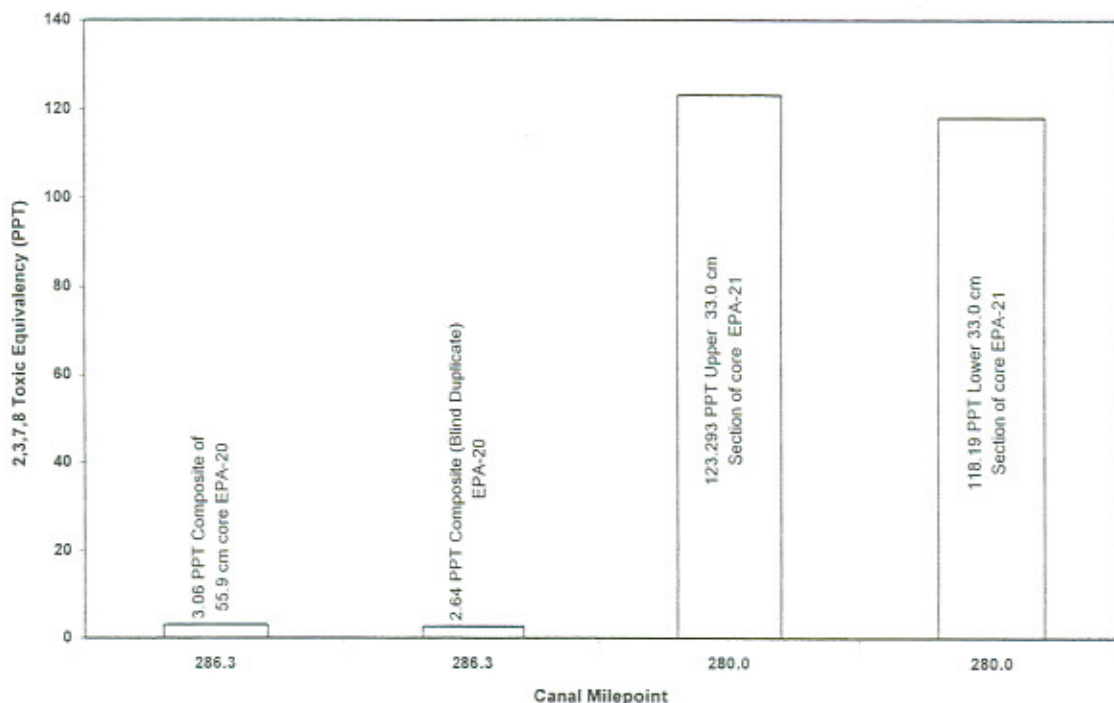
**Figure # 4.11**  
**Lead Concentration in Reach # 4**



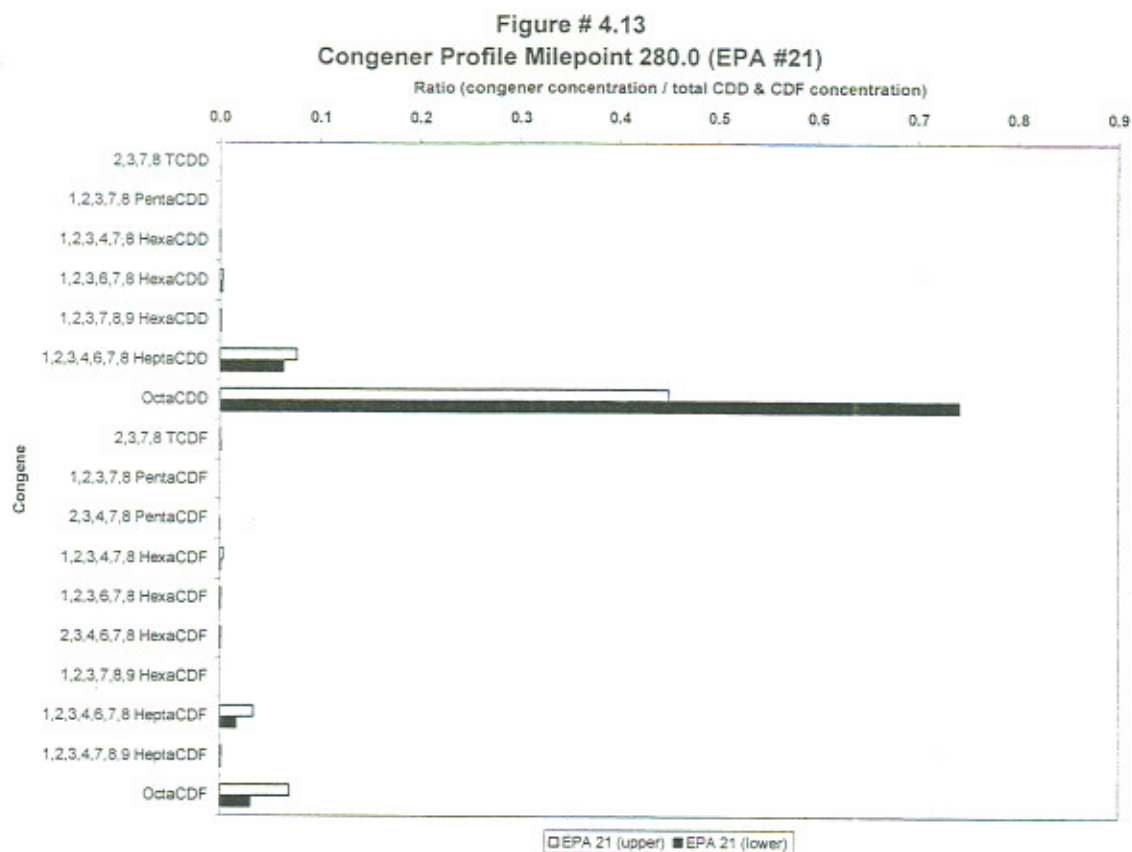
As discussed for reach number 3, the Dioxin/Furan TEQ levels are generally trending downward as one moves easterly. Core samples collected at sample site EPA-20, milepoint 286.3 show a level that is substantially lower than have been observed to the west. The location for this sample site was within an area of the canal of standard cross-section, where there would be little deposition of contaminants over time. Samples collected at sample site EPA-21, milepoint 280.0 were collected in a relatively wide area of the canal, on the outside of a curve. Dioxin/Furan TEQ levels are generally the same as those found in the western end of reach number 3. At this location there is little

difference in TEQ concentration between the upper and lower sections of the core. Figure # 4.12, below shows the TEQ concentrations encountered within this reach.

Figure # 4.12  
Dioxin/Furan TEQ in Reach # 4



The composite core collected at sampling site EPA-20 and the lower core section of the core collected at sampling site EPA-21 exhibit the same congener profile, similar to the profile seen within all of the western canal reaches. In the upper section of sampling site EPA-21 there is a significant reduction in the Octachlorodibenzodioxin with a corresponding increase in the concentrations of 1,2,3,4,6,7,8 Heptachlorodibenzodioxin, 1,2,3,4,6,7,8 Heptachlorodibenzofuran and Octachlorodibenzodioxin. There is no known reason for this shift in congener pattern. Figure # 4.13 following, shows the congener patterns observed both the upper and lower sections of core EPA-21.

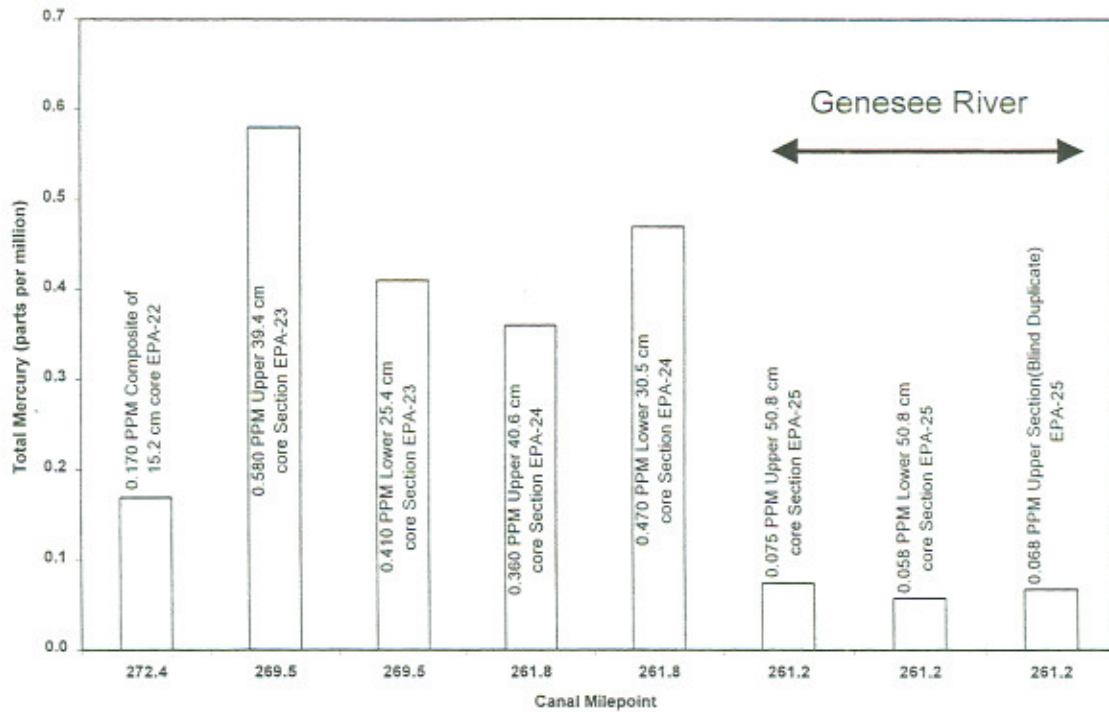


## Reach Number 5

Four push cores were collected within this reach, 3 were sectioned based on characteristics of the sediment while the fourth core was composited over its entire length. The levels of PCB contamination encountered in the sediment within this reach ranged from 1.05 PPM to non-detectable. The concentration of mercury in the sediment shows the dilution effects of the confluence of the canal with the Genesee River in Rochester. The levels of total mercury within the Genesee River downstream of the confluence are nearly an order of magnitude below the levels seen in the canal sediments. Since the flowrate in the canal represents only a small share of the combined flow, the dilution effects can be clearly seen in Figure # 4.14.

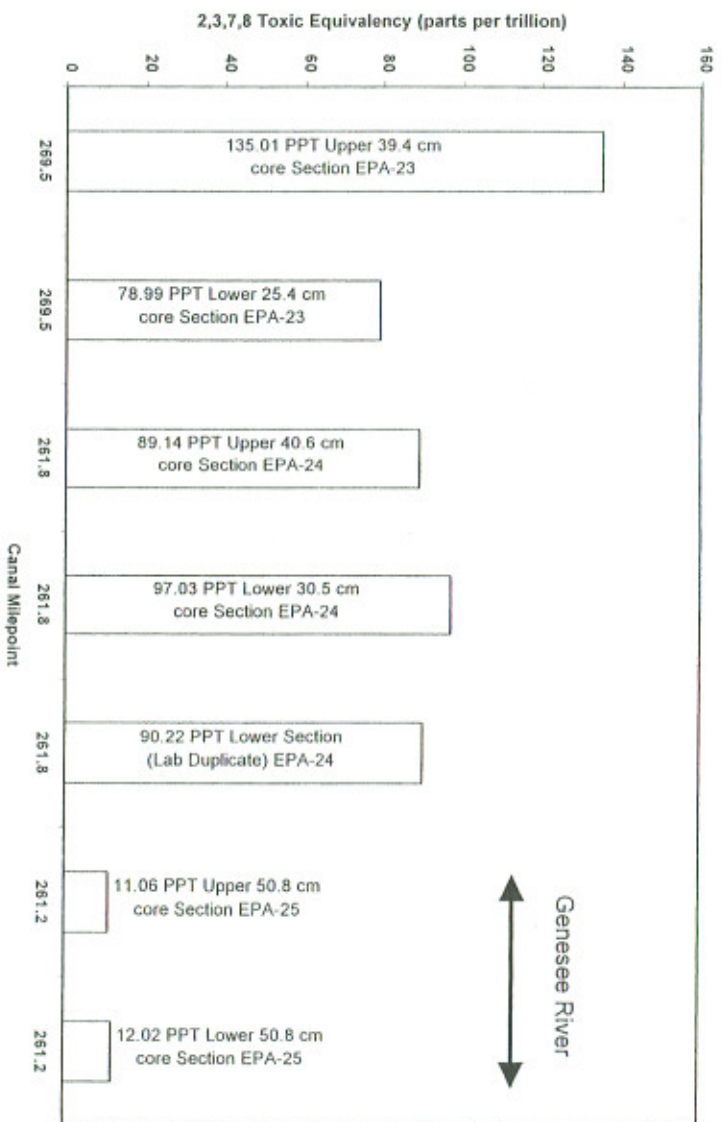


Figure # 4.14  
Mercury Concentration in Reach # 5



The dilution effects on the dioxin/furan TEQ concentrations are also evident by being nearly an order of magnitude less than the levels encountered in the canal sediments upstream of the confluence of the Genesee River. In sediments that were evaluated prior to the confluence the level of dioxin/furan TEQ continues to show the downward trend when moving from west to east along the canal. The levels within the sediment are approximately 1/5 of the TEQ levels found in the Lockport, New York area, with little change in the congener pattern. Figure # 4.15, below shows the dioxin/furan TEQ concentrations within this reach.

Figure # 4.15  
Dioxin/Furan TEQ in Reach # 5



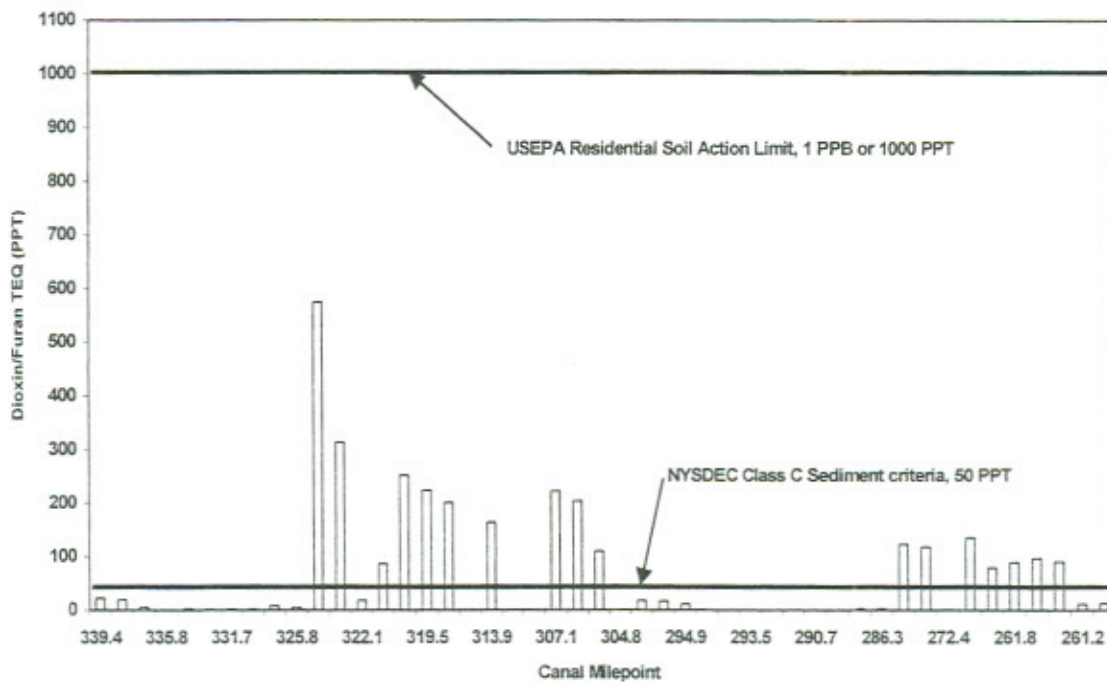
## CHAPTER 5

### RESULTS

#### Dioxin/Furan and PCB Contaminant Sources

Elevated levels of dioxin/furan contamination were encountered within the sediments under the Prospect Street Bridge in Lockport and are detectable in the sediments all the way to the Genesee River in Rochester. In some locations the 2,3,7,8 substituted TEQ levels exceed the NYSDEC Class C Sediment criteria of 50 ppt [6]. In no case does the level of 2,3,7,8 TCDD TEQ found in the sediment exceed the USEPA residential soil action limit of 1 PPB [8] or the NYSDEC Technical and Administrative Guidance Memorandum allowable soil concentration of 6 PPB [9].

Figure # 5.1  
2,3,7,8 Substituted Dioxin/Furan TEQ Levels in Sediments

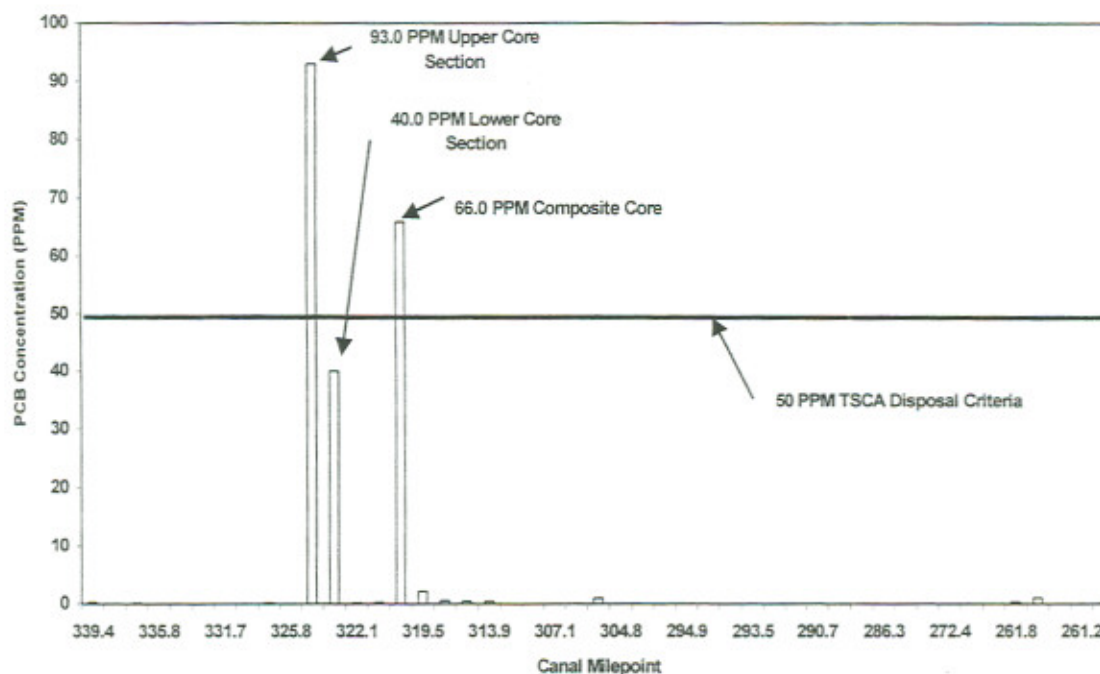


Elevated PCB levels are apparent in the Lockport area originating in the same area as the dioxin/furan contamination but do not seem to be spread as widely to the east.



Two locations showed levels of total PCB that exceeded the TSCA disposal criteria of 50 PPM. These two areas should be further sampled to determine the extent of the contaminated area.

**Figure # 5.2**  
**PCB Concentration in Sediments**



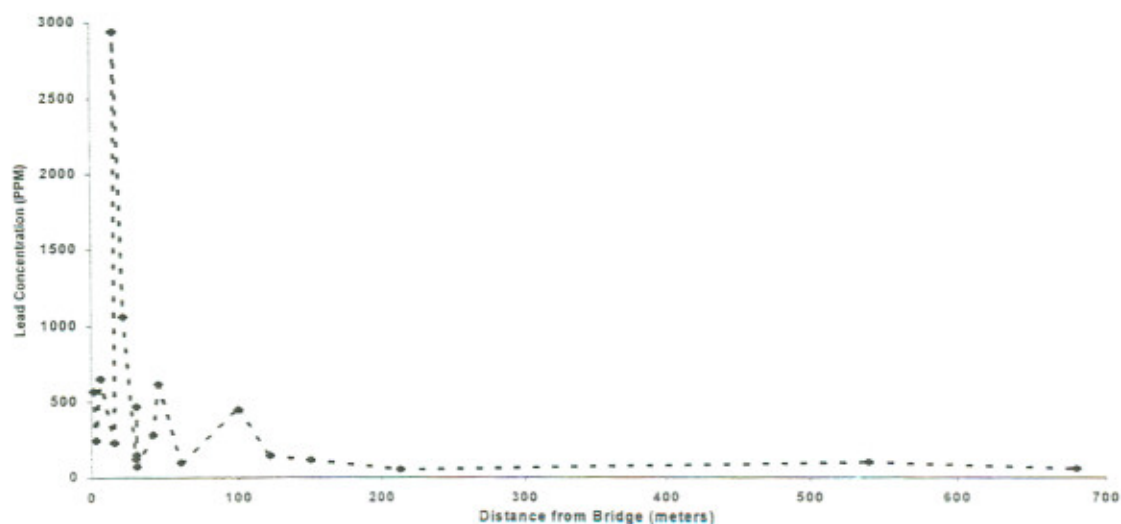
An evaluation of individual dioxin/furan congeners is included in Appendix C of this report while dioxin/furan congener groups or homolog groups are included in Appendix D. The cores show that a distinct Dioxin/Furan pattern prevails throughout nearly all of the sediment samples with some minor exceptions. By evaluating each cores individual congener profile, it appears that the congener profile has a distinct pattern similar to the profile encountered for the discharge of wastewater effluent from a pulp and paper mill [1]. When evaluating the congener or homolog group profile, the sediment shows a distinct similarity to the historical PCDD/PCDF concentrations in technical Pentachlorophenol products [1]. The Buffalo Paperboard Corporation (Repulping Operation), Niagara Materials Company (Phenolics) and Occidental Chemical Corporation (Unknown Operations) operated in the general area of the

suspected discharge [2]. These types of industries could have contributed to the potential sources of both Dioxin/Furan and PCB contamination that originates in this area. The New York State Canal Corporation does not have the regulatory or enforcement capabilities to investigate the area outside the canal prism to determine the potential dischargers of past contamination. In New York State that duty falls to the New York State Department of Environmental Conservation. I recommend that additional investigation within storm sewers and drainage swales from the general upland areas adjacent to the Canal be undertaken by the New York State Department of Environmental Conservation to attempt to track down the past discharger(s).

### Lead Contamination Sources

Distances downstream of structures have been obtained for numerous sediment cores over the past four years. By plotting the distance verses lead concentration, a general trend can be shown for the lead concentration in the canal sediments. Sampling that was conducted as recently as the Fall of 1999 at reconstruction project for the Exchange Street lift bridge showed visible flakes of lead based paint downstream of the bridge structure. Samples collected immediately upstream of the bridge did not exhibit visible paint flakes [Dergosits, unpublished data]. Based on the data, lead concentrations can be predicted from flaking or deteriorated paint as shown on Figure # 5.3.

**Figure # 5.3**  
**Lead Concentration Downstream of Bridges**



Although the amount of data points that are used to prepare the above figure and analysis may be somewhat limited, it is clear that particulate lead has caused an impact on the canal sediments. Supplemental data collection will be continued to better define the trend in sediment contamination.

### **Radionuclide Dating Chronologies**

All sections of cores EPA 7, EPA 8 and EPA 9 were counted. Due to delays in laboratory processing, only the top section of core EPA 8 was counted within 200 days of collection allowing for a reliable Be-7 analysis. The top section did have detectable Be-7, but the Cs-137 profile did not allow for detailed dating. Low levels of Cs-137 were detected in all EPA 8 samples analyzed with the exception of the 12-16 cm section that also had the lowest level of K-40. This suggests a compositional difference of the sediments in this interval.

Based on the Cs-137 profile, core EPA 9 exhibited recent (post 1954) sediment to about 20 cm. in depth. The small increase in Cs-137 levels between the surface and about 8cm suggests that mixing had a significant influence at this site evidenced by the physical geometry of the area and its location just downstream of the Erie Canal Lock 34/35 structure. The calculated sedimentation rate in this area based on the information in the dating profile, suggests that a depositional rate of approximately 0.2 cm/year may be possible in this area.

The core EPA 7 has an excellent Cs-137 profile that permits rather detailed dating. The deepest penetration of detectable Cs-137 (at about 30 cm) would correspond to deposition in about 1954. The well-defined maximum (at about 22-cm) identifies mid 1960s deposition. Both markers yield a net sedimentation rate of 0.6 to 0.7 cm/yr. This core is an excellent candidate for analyses to develop contaminant level chronologies. In an effort to unmistakably identify a 1999 time horizon at this site, an additional core, EPA 7A was collected and the top section analyzed for Be-7 within a few weeks of sampling. The effort was not successful, as Be-7 was not detected.



A screening strategy was developed for the other cores that were collected. The core sections between 0-2 cm and 12-16 cm were first analyzed to determine if Be-7 was present in the upper section and if Cs-137 was present in either the 0-2 cm or 12-16 cm depth. Cores EPA 1, EPA 3, EPA 5, EPA 14, EPA 23, and EPA 25 were eliminated from consideration for further radionuclide analyses based on the fact that Cs-137 was not detected in the 12-16 cm, and sometimes not in the 0-2 cm section.

Cores EPA 11, EPA 12, EPA 21 and EPA 24 all had at least 16 cm of recent (post 1954) deposition based on the detection of Cs-137. All of the sections of core EPA 21 were analyzed and, based on the Cs-137 profile, this core contains sediment deposited from about the mid 1950s (the bottom section still had detectable Cs-137) to date of collection. Analyses of sections from cores collected at sites EPA 7, EPA 8, EPA 9 and EPA 21 were used to develop contaminant level chronologies, which will be discussed in the following section of this report. A copy of the sediment dating report is included in Appendix E.

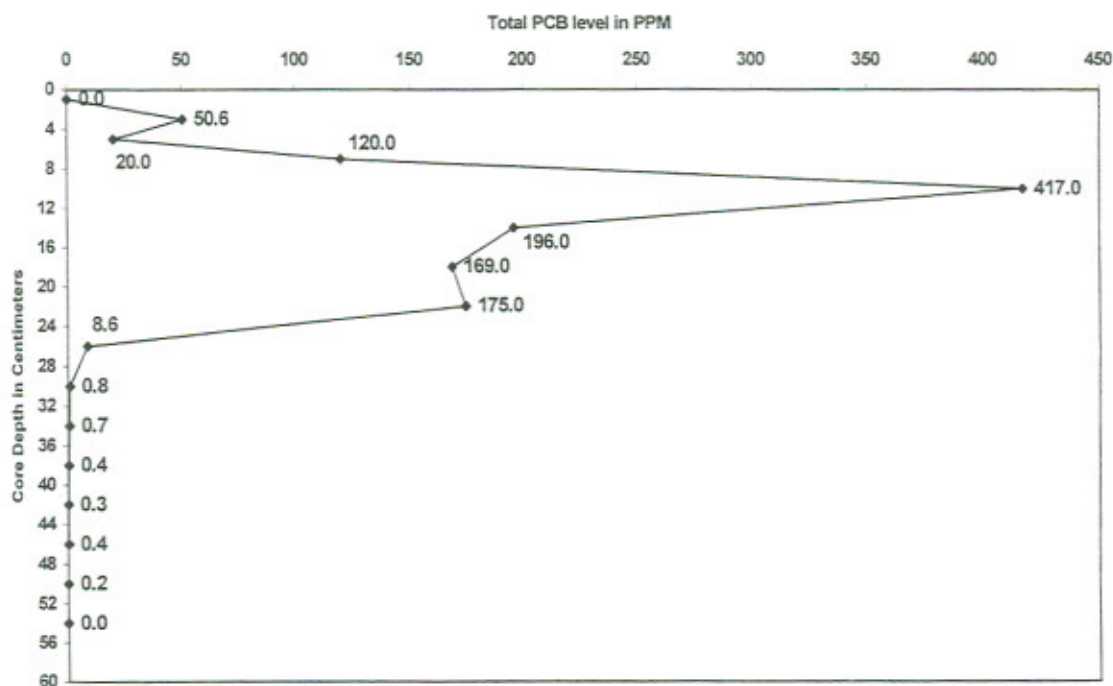
### **PCB Level Contaminant Chronologies**

As discussed above, the cores collected in Reach #1 at sample site EPA 7 and EPA 9, and in Reach #4 at sample site EPA 21 showed reasonable dating profiles that could allow chemical contaminants to be identified based on their initial date of introduction into the bottom sediments. Since the core obtained at site EPA 8 appeared to show evidence of severe mixing, the sections from this core were also analyzed for total PCB concentrations to determine if a significant peak concentration was identifiable in the core. It must be stated at this point, that all of the sediment cores that were collected for radionuclide dating were held longer than the USEPA recommended holding times for PCB analyses. Although the analyses may not meet the holding time requirements, the core slices were refrigerated to preserve them while radionuclide dating was accomplished. The contaminant profile data still provides a reasonable presentation of the PCB discharge events. Since it is now known that these three areas provide

reasonable dating horizons, future sampling activities can be designed and conducted that would comply with all EPA holding time requirements.

A second point that should be mentioned is that due to the limited volume of sediment that is contained in a 2-centimeter slice of a 5.1 centimeter diameter core, only an evaluation for PCB could be conducted at these sample locations. The vertical profile for PCB contamination within the core collected at site EPA 7 is shown below.

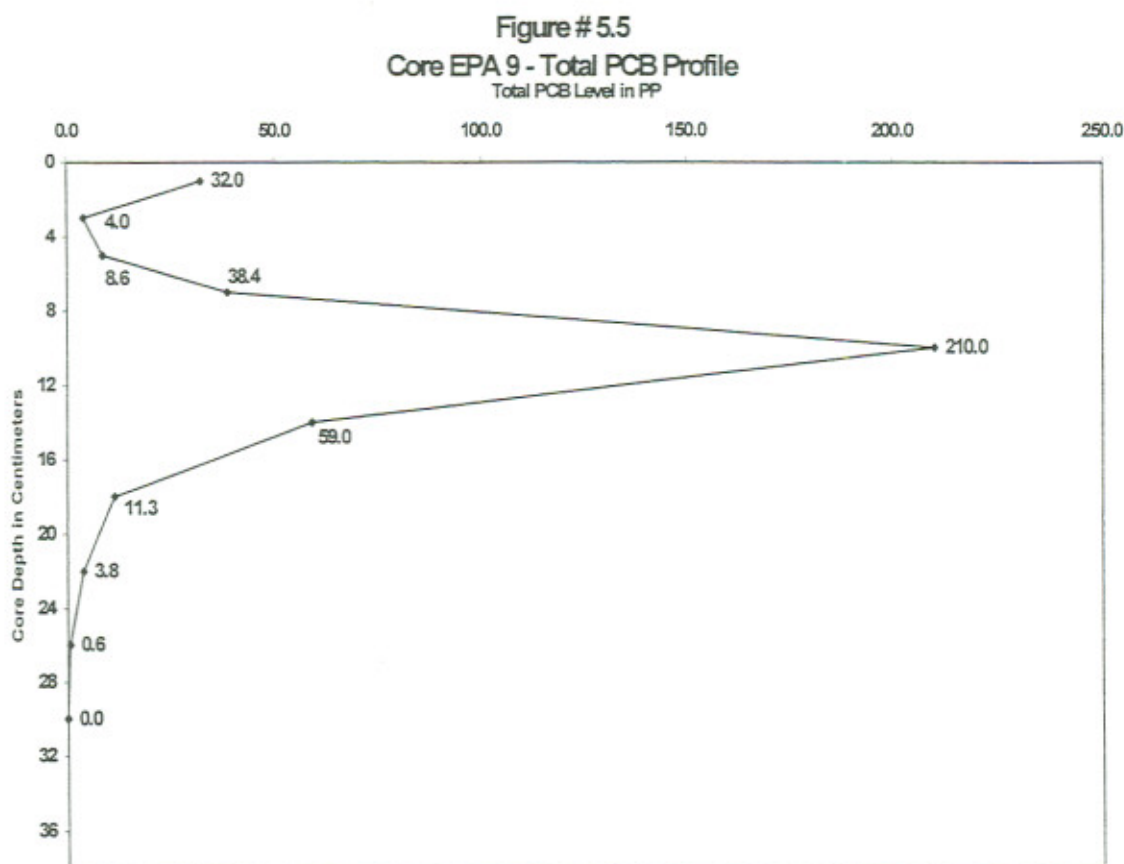
**Figure # 5.4**  
**Core EPA 7 - Total PCB Profile**



The information that is provided by this profile is quite dramatic, the initial detection of PCB that appears significant in the sediment appears in the 24 to 28 centimeter depth. Based on extrapolation this sediment horizon is estimated to have been deposited in approximately 1958. The low level of PCB detection that occurs in the 28 to 52 centimeter range are believed to be remnants of sediment from upper layers of the core, smearing within the core tube while the core is being pushed into the sediment. More significant discharges appear to have occurred in the 1961 to 1979 era with a more

peak discharge apparent in the 8 to 12 cm range, which would correspond to approximately 1982.

At site EPA 9 the peak contaminant levels have been reduced, most likely by mixing of the contaminants as they progressed over the vertical drop of the flight of Locks. Based on the Cs-137 profile in this area the deposition rates at this location are slower than were determined at site EPA 7, about 0.21 cm/year. This peak occurrence of Cs-137 appears in the duplicate sample analyzed in the 6 to 8 centimeter range.



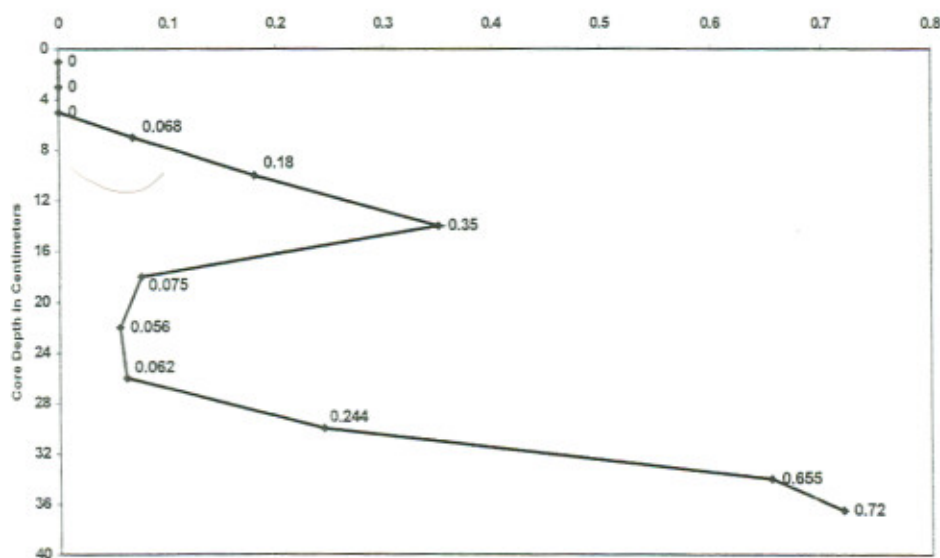
The information provided by this profile does not readily coincide with the information found at site EPA 7. The initial detection of PCB that appears significant in the sediment appears in the 20 to 24 centimeter depth, with a peak concentration appearing in the core section at 8 to 12 centimeter depth. Based on extrapolation of the Cs-137 data, the initial occurrence of PCB would have appeared well before the historical



use of this compound, before the turn of the century. The more significant peak discharge apparent in the 8 to 12 centimeter range would correspond to approximately 1948. Based on the wide difference between core EPA 7 and EPA 9 it is doubtful that the dating information in this core is accurate. It is possible that water diversions through the lock structure or the nearby hydroelectric facility may have increased turbulence in the water column leading to the questionable results in this core. What is interesting is the correlation between the depths of the peak contaminant levels in both core EPA 7 and EPA 9. Both cores show initial introduction of the contaminant in the 20 to 28 centimeter depth range. At core EPA 7 which is upstream, the initial contaminant depth is in the 24 to 28 centimeter range while at core EPA 9 the depth is in the 20 to 24 centimeter range. This would be consistent with the downstream flow of contamination over time. It is also interesting that the sediment depth for the peak contaminant level is consistent, at the 8 to 12 centimeter level in both cores.

At sample site EPA 8 the turbulence caused by vessel propellers in this location might have mixed up the sediments so that a contaminant profile was not identifiable. This core was also subjected to an evaluation of the sediment by core slice for PCB. Generally, this core shows the wide range of PCB contaminant mixing throughout the

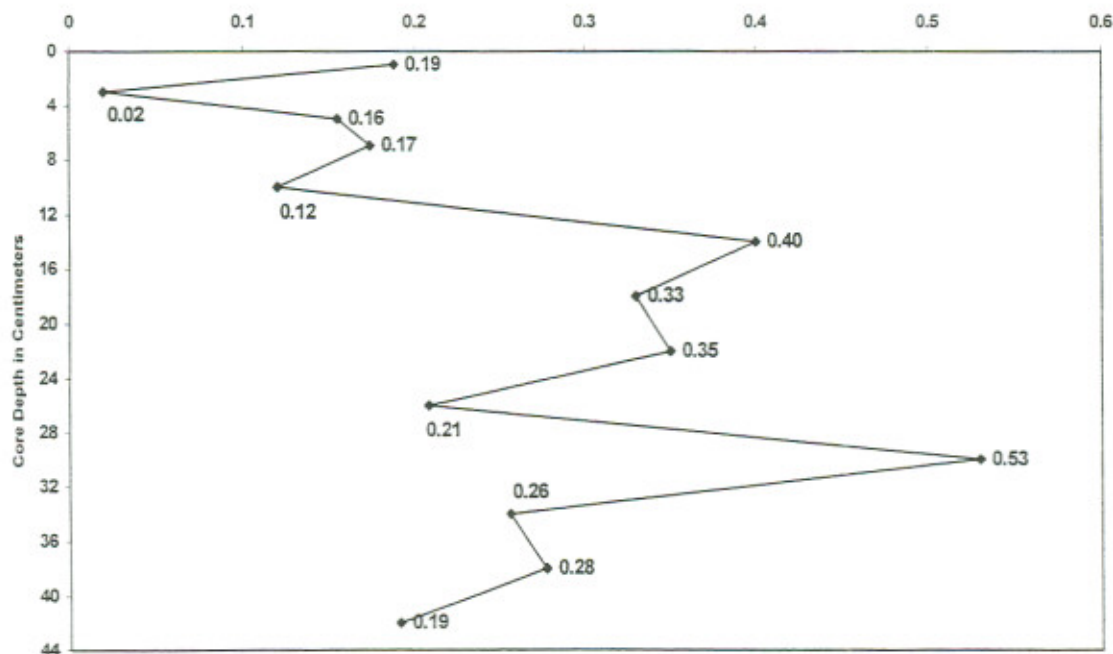
Figure # 5.6  
Core EPA 8 - Total PCB Profile  
Total PCB Level in PPM



vertical core striation. It is interesting how significantly lower the PCB concentrations are at this core sampling location, the highest concentration is well below 1 PPM total PCB.

In Reach #4, the sample core collected at site EPA 21 exhibited a reasonable dating profile. This location was also evaluated for the vertical extent of PCB concentration. Peak occurrence of Cs-137 appears in the sample analyzed in the 24 to 28 centimeter range, based on this Cs-137 profile the deposition rates at this location are about 0.8 cm/year. The wide variation of PCB concentration through the core suggests that a relatively dilute source of PCB was discharging to the sediments over a long time frame. The peak concentration of PCB of 0.53 PPM would approximately equate to 1960, with a secondary peak of 0.40 PPM around 1980.

**Figure # 5.7**  
**Core EPA 21 - Total PCB Profile**  
Total PCB level in ppm

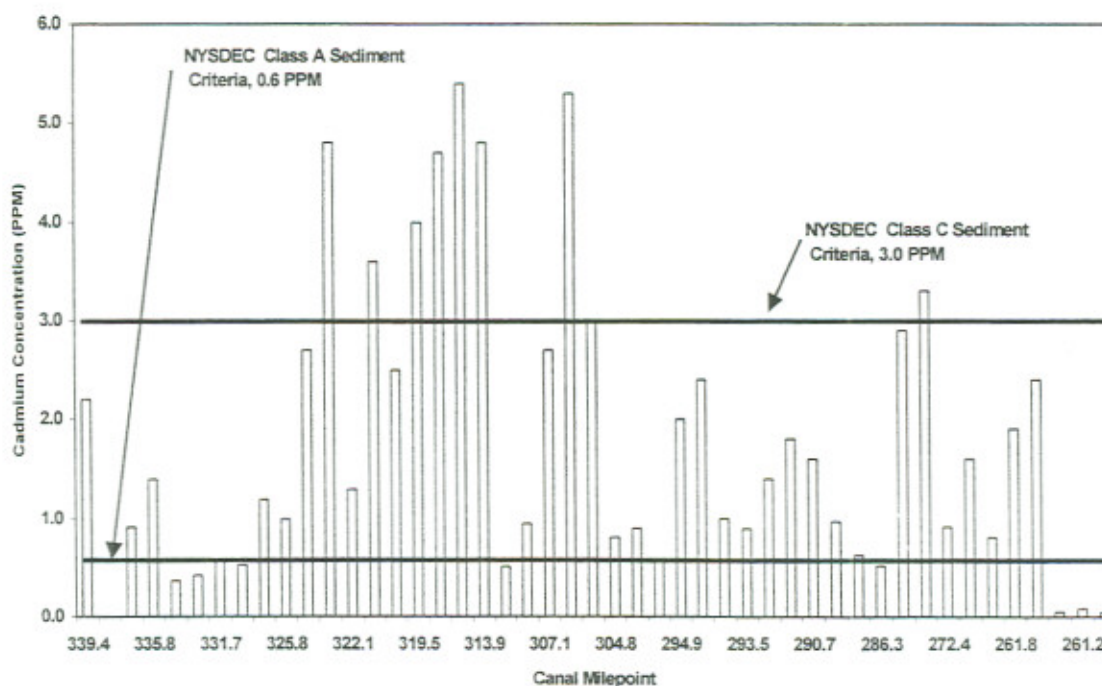


## Other Heavy Metal Contaminants

Samples were collected and analyzed for mercury, cadmium and copper during the study. The results from these analyses were inconclusive and cannot be used to identify a contaminant source.

The levels of cadmium within the canal sediments appear to be elevated above the NYSDEC class C sediment criteria of 3.0 PPM starting within the City of Lockport in the vicinity of core EPA 7 and easterly to the Medina area, core EPA 13. The general trend is that the lower core sections, which represent the older sediments, are higher in cadmium contamination. This would appear to coincide with the potential for a historic discharges in the Lockport area. At core EPA 21 the cadmium level is 2.90 PPM, slightly below the 3.0 PPM threshold in the upper sediments. In the lower core section the cadmium concentration is 3.3 PPM, this suggests that mixing has played a role in the deposition of this contaminant.

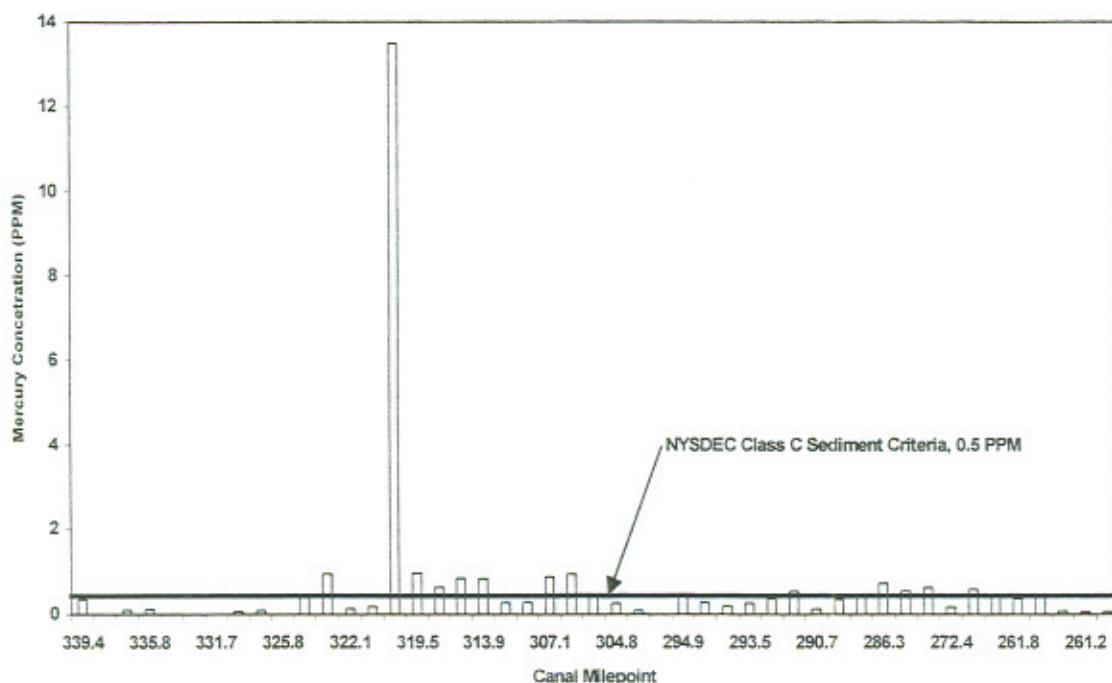
**Figure # 5.8**  
**Cadmium Concentration in Sediment**





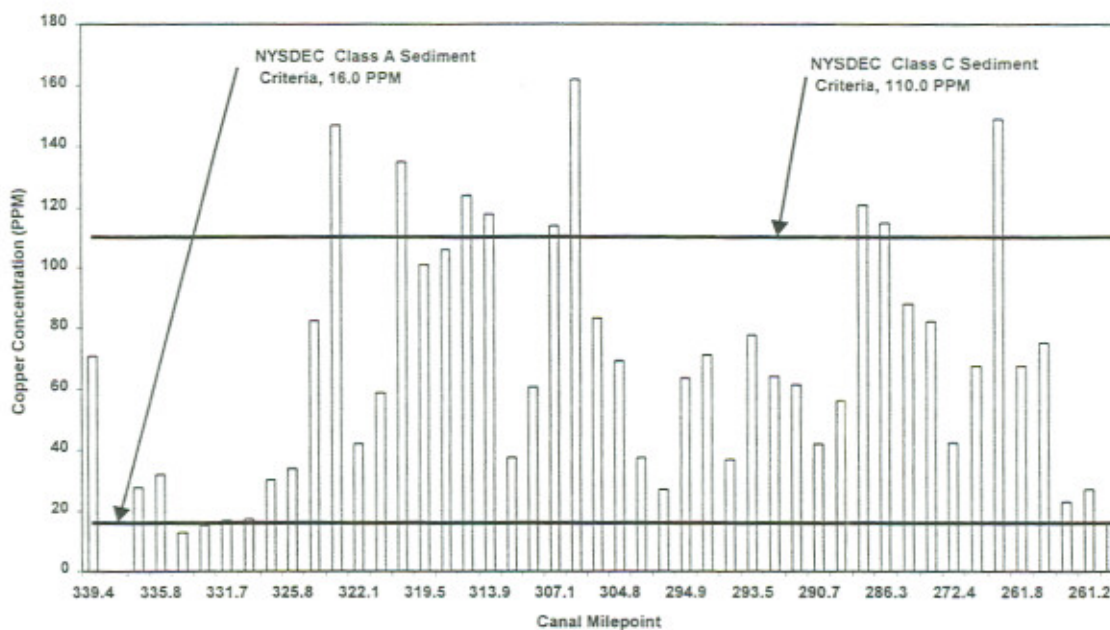
The general trend of mercury contamination within the canal sediment appears to be close to the NYSDEC class C sediment criteria level of 0.5 PPM for most of the canal between Lockport and the Genesee River with one major exception. That exception was found in core EPA 9 which was collected below the flight of locks in Lockport where the mercury concentration was 13.5 PPM. The first elevated levels of mercury was found at core location EPA 7 where the lower older sediments showed mercury at 0.94 PPM while the upper, newer sediments were below the 0.5 PPM threshold.

**Figure # 5.9**  
**Mercury Concentration in Sediments**



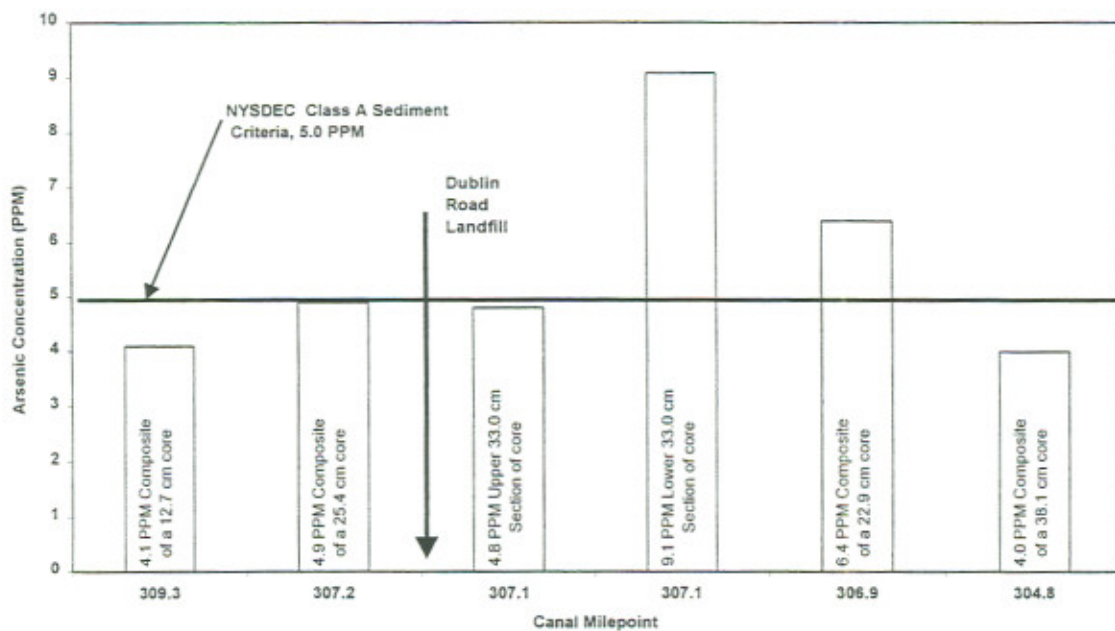
The concentration of copper within the sediments generally showed the same trend as the level of cadmium in the sediments. Lower core sections also showed higher copper concentrations than the upper more recent core sections.

**Figure # 5.10**  
**Copper Concentration in Sediments**



An evaluation of arsenic contamination within the canal sediments seems to point to a historical discharge into the canal prism. The level of arsenic in the deeper sediments Immediately below the former Dublin Road landfill are nearly double the NYSDEC threshold for this contaminant.

**Figure # 5.11**  
**Arsenic Concentration in Sediments**





## CHAPTER 6

### CONCLUSIONS

- There have been discharges of metals; PCBs and dioxin/furan compounds introduced into the canal system that have contaminated some of the sediments within the canal system.
- Two locations showed levels of PCB that exceeded TSCA waste criteria; they should be further sampled to determine the depth and lateral extent of the contamination.
- The core at site EPA 7 shows that the initial discharge of PCB into the canal occurred in approximately 1958, while the peak discharge occurred in the 1980 to 1982 time horizon.
- There is a general trend of decreasing dioxin/furan concentrations as one moves easterly from milepoint 322.2. Sediments located within the Genesee River at milepoint 261.2 showed significantly lower dioxin/furan concentrations due to dilution effects.
- There is a general trend of increased lead concentrations downstream of bridges that cross the canal. Past activities of bridge washing and abrasive blasting prior to painting may be the cause of this contamination. Additional detailed sediment sampling should be conducted before and after bridge maintenance functions to determine if these activities are impacting sediment quality. Subsequent benthic testing of the sediments may be warranted.
- Heavy metal contamination generally starts in the Lockport area and is evident all the way to Medina, New York.
- There appears to be elevated levels of arsenic present in the sediments downstream of the Dublin Road landfill just east of Middleport. Although this landfill was capped within the last five years, off-site migration of arsenic compounds is apparent in the older canal sediments. Supplemental sampling to determine the nature and extent of this contamination and its spread to the canal is warranted. In addition it would be prudent for the New York State Department of Environmental Conservation to reopen the Record of Decision (ROD) for the Dublin Road site to investigate this off-site migration.

## CHAPTER 7

### QUALITY ASSURANCE/QUALITY CONTROL

#### Data Quality Requirements

Field sampling and laboratory analyses were performed in accordance with approved EPA standard procedures unless otherwise noted in Table 7.1. Data Quality Objectives (DQOs) and acceptance criteria for precision and accuracy are also summarized in Table 7.1. The precision and accuracy criteria presented in that table are based upon historical laboratory results and not field results.

Very little existing data were available to evaluate expected concentrations for those analytes quantified during this study. Data resulting from this study will be useful for evaluating distributions of sediment contaminants. Radiodating of some of the sediment cores collected did not show areas where uniform depositional rates occurred; those cores were eliminated from further study. Three cores did show reasonable depositional profiles and depositional rates could be calculated.

Complete data packages have been provided with all sample results for this project. Included with the data packages are chain-of-custody records, data results, case narratives, chromatograms (where appropriate), raw and intermediate results, instrument calibration data, and results of quality control evaluations as determined below:

- Precision: Precision can be defined as the relative uncertainty about a given measurement and is determined by replicate analyses. Due to the difficulty in obtaining true, duplicate sediment core samples, none were collected. However, eight replicate samples were submitted for laboratory analysis. These samples were collected at the same time and

represent a check of laboratory accuracy. Acceptability of sample results was based upon the precision criteria presented in Table 7.1.

- **Accuracy:** Accuracy can be defined as the absolute uncertainty about the true value. The accuracy or abilities of the laboratory to determine the true values or concentrations of proposed analytes has been evaluated previously by the NYSDEC during the laboratory contractor selection and certification process. This process includes the required analysis of NYSDEC prepared Performance Evaluation samples and on-site audits by a team of NYSDEC chemists. Laboratory matrix spike/matrix spike duplicate (MS/MSD) samples were analyzed to evaluate the accuracy of each batch of samples submitted for this project. Dioxins were also evaluated in the MS/MSD on a limited basis due to high cost associated with this analysis and because rigorous QA/QC procedures are associated with the EPA 1613A analysis. The acceptable accuracy in quantifying those analytes to be examined has been summarized in Table 7.1.
- **Blanks:** Due to the type of matrix to be sampled (sediments), no field blanks were prepared for analysis. Method blanks were evaluated as a required component of the NYSDEC Analytical Services Protocol for control labs (NYSDEC ASP Exhibit E).
- **Representativeness:** It is expected the sediment cores collected will be representative of areas of the Erie Canal that have not been dredged for quite some time. They are generally taken from backwater areas and other locations that would be minimally disturbed
- **Comparability:** Standard procedures were followed when sampling and analyzing all parameters of concern. As low detection and reporting limits were employed during this study, resulting data should be compatible with data from other investigations.



- **Completeness:** Completeness can be defined as the percentage of acceptable data necessary to accomplish the study objectives. Due to the high cost of sample analysis and the limited number of samples to be collected, it was important that all QA criteria be strictly adhered to so as to accomplish project objectives. Successful analysis and reporting of at least 75% will define completeness for this aspect of the study. Also any data not meeting minimum QA criteria will be identified.

**Table Number 7.1**  
**Sediment Analytical Methods**

Parameter	Responsible Lab	Standard Method	Precision	Accuracy	Initial Calibration	Ongoing Calibration	Blanks	Minimum Practical Quantification Limit (PPB)
Radioisotope Dating: 7-Beryllium 137 Cesium 210 Lead	RPI	Gamma Spectroscopy	+/- 10%	+/- 5%	Annual	Weekly	Biweekly	MDL=0.1pCi/g
Dioxin/Furan 2,3,7,8 Substituted Congeners	Zenon Labs (Phillips)	EPA-1613A	+/- 40% (Based on EPA-8290)	+/- 40%	When Necessary	Daily	Per Method	0.000002
PCB Aroclors	H2M Labs Scilab	EPA-8081		25-160%	5 pt. curve	Every 10 Samples 1/Batch or 20 (Max)		0.033 to 0.067
Total Organic Carbon	H2M Labs	EPA-9060	+/-20%RPD	+/- 20%	ICV/CCV 15%			0.1%
Total Volatile Solids	H2M Labs	EPA-160		Per Method	N/A			0.01%
---Metals---								
Lead (Pb)	H2M Labs	EPA-6010	+/-20%RPD	+/- 25%	Daily	Every 10 Samples	Every 10 Samples	0.3
Copper (Cu)	H2M Labs	EPA-6010	+/-20%RPD	+/- 25%	Daily	Every 10 Samples	Every 10 Samples	2.5
Cadmium (Cd)	H2M Labs	EPA-6010	+/-20%RPD	+/- 25%	Daily	Every 10 Samples	Every 10 Samples	0.5
Mercury (Hg)	H2M Labs	EPA-7471	+/-20%RPD	+/- 25%	Daily	Every 10 Samples	Every 10 Samples	0.1

## **Sampling Procedures**

All sampling for this study was performed from the NYSCC floating plant using a push core sampler or by accessing the bed of the canal while it was dewatered to obtain a push core. The Principal Investigator was responsible to assure that all sampling is performed in accordance with standard sampling protocols, providing all sediment coring equipment necessary for the successful conduct of the proposed study including: the sediment coring apparatus. The Principal Investigator was responsible for transporting the sediment cores and surficial sediment samples to an on-shore sample processing location.

At the sample processing location the Principal Investigator was responsible for;

- removing all of samples from core tubes, homogenization of samples, placement of sample material in sample containers and packing of samples in coolers,
- Providing all sample processing materials and supplies necessary for the successful processing of samples as proposed herein.
- Providing a chain of custody form for all samples and submitting all samples to the selected laboratories within the proper field holding times.

## **Documentation, Data Reduction and Reporting**

The laboratory results were reported to the NYSCC in accordance with the requirements of ASP, Exhibit B - Category B Deliverables (NYSDEC, 1991). This is a complete document package, which allows for full data validation. Data reduction and evaluation was performed using a Microsoft Excel spreadsheet. Sample concentrations are reported in PPM dry weight, PPB dry weight or PPT dry weight. All field and laboratory QA/QC results have been reported including any and all field blanks, duplicate analyses, matrix spike and matrix spike duplicates analyzed during this study. An evaluation of the precision, accuracy, and completeness based upon replicate and spike analysis has also been included.



## Data Validation

All data were reviewed by the Principal Investigator to determine its validity. Those data not meeting the previously identified criteria for precision, accuracy, and blank values were reanalyzed where possible, or flagged if additional sample material was not available. Data that have been flagged indicate why they did not meet the minimum QA criteria. Laboratory QA sample evaluation included analysis of surrogate spikes to determine the average percent recovery and method blanks, which were, compared to respective batch results. The following statistical equations were utilized to quantify the precision, accuracy and completeness of laboratory data resulting from this project. Results from these statistical calculations have been used to determine whether data quality requirements presented in Table 7.1 were met.

### Precision:

The laboratory precision was evaluated by performing duplicate analyses and comparing results. Matrix spike/matrix spike duplicates (MS/MSD) were utilized for organic parameters. Laboratory duplicate analysis are conducted to evaluate inorganic and conventional parameters. These QC samples were analyzed at a frequency of 1 per batch as required by the NYSDEC ASP Exhibit E.

If calculated from duplicate measurements, relative percent difference is used to measure precision:

$$RPD = \frac{(C_1 - C_2) \times 100\%}{(C_1 + C_2) / 2}$$

Where:  $RPD$  = relative percent difference

$C_1$  = larger of the two observed values

$C_2$  = smaller of the two observed values

If calculated from three or more replicates, the relative standard deviation rather than RPD is used to determine precision:

$$RSD = \left( \frac{s}{\bar{y}} \right) \times 100\%$$

Where:  $RSD$  = relative standard deviation

$s$  = standard deviation

$\bar{y}$  = Mean of replicate analyses

Standard deviation is defined as follows:

$$s = \sqrt{\sum_{i=1}^n \frac{(y_i - \bar{y})^2}{n-1}}$$

Where:  $s$  = standard deviation

$y_i$  = measured value of the  $i$ th replicate

$\bar{y}$  = Mean of replicate measurements

$n$  = number of replicates

### Accuracy:

Accuracy is quantified by determining the percent recovery of "known" surrogate spike material in samples. Matrix spikes, matrix spike duplicates, reference standards and laboratory blank samples may also be used in the assessment of accuracy. These QC samples are analyzed at the frequency specified in the NYSDEC ASP, Exhibit E.

For measurements where matrix spikes are used, the percent recovery is calculated as follows:

$$\%R = 100\% \times \left( \frac{S - U}{C_{sa}} \right)$$

where:  $\%R$  = percent recovery

$S$  = measured concentration in spiked aliquot

$U$  = measured concentration in unspiked aliquot

$C_{sa}$  = actual concentration of spike added

When a standard reference material (SRM) is used:

$$\%R = 100\% \times \left( \frac{C_m}{C_{srm}} \right) 0$$

where:  $\%R$  = percent recovery

$C_m$  = measured concentration of SRM

$C_{srm}$  = actual concentration of SRM



## Completeness

The completeness of analytical results has been calculated to determine if sufficient analytical results are provided to achieve the project objectives. Completeness was calculated using the following equation:

$$\% \text{ Completeness} = \frac{v}{n} \times 100\%$$

where:      $v$      = number of valid samples  
               $n$      = number of valid samples necessary to achieve project objectives

## **Quality Control Evaluation**

Analytical quality control results were evaluated to determine whether the Data Quality Objectives (DQOs) and acceptance criteria for the project were achieved. In general, these objectives and criteria were met.

Using the quality control criteria and methods previously outlined; these evaluations are summarized below. They are based upon the laboratory case narrative summaries. Laboratory calculations of precision and accuracy have been randomly spot checked.

## Metals

All sample holding times as required by the method were met and all preparation blank results were below the required detection limits.

Matrix Spike recoveries were within the 75-125% control limits except for sample EPA 10 (SDG#NYS033) where cadmium, copper and mercury matrix spike recoveries were slightly beyond the control limits (Cadmium 52.2%, Copper 68.6% and Mercury 126%).

The lead ICP serial dilution result for sample Middleport1 was not within the required control limit (10%)

All duplicate analyses were within the 20% Relative Percent Difference (RPD) control limits except for cadmium for sample EPA 10. The cadmium results for that batch are flagged.

#### PCBs

Two surrogate spikes, tetrachloro-m-xylene (TCX) and decachlorobiphenyl (DCB), are applied to each sample. Acceptable percent recoveries are between 50 and 150%. The DCB recoveries in the majority of samples were biased high on one or both columns due to unresolved interfering peaks. TCX recoveries were within the acceptable range with the exception of high results on one column for EPA 7, Lower and EPA 9 due to coeluting interference and low results on both columns for EPA 25 Upper Matrix Spike Duplicate.

Matrix spikes and matrix spike duplicates were run for all batches of samples. The 60 to 150% recovery guidelines was used as the acceptable evaluation guideline for these results. All samples with the exception of Heptachlor for sample EPA 10 were within this range, Heptachlor in the MS analysis was not resolved from a large interference on one of the columns, therefore the result of the other column was reported.

A method blank is also run with each batch of samples. Blank results were evaluated and all found to be acceptable since all analytes were less than the laboratory reporting limits.

#### Dioxin/Furans

The analytical laboratory QA/QC included an internal standard spike as part of each sample and a method blank, also with an internal standard spike added, run with each sample batch. The internal standard spikes consist of 15 carbon-13 and one chlorine-37 labeled isotopes.

For this study, internal standard spikes were added to all sediment samples and method blanks. The acceptable percent recoveries for the spiked congeners is 60 to 150%.

All percent recoveries for the internal standard spikes analyzed for this sediment study were within the acceptable range of 60 to 150% with the exception of the following. Both sample EPA 24 Lower - Octachlorodibenzo-*p*-dioxin at 153% and sample EPA 23 Upper - Octachlorodibenzo-*p*-dioxin at 157% show interference from a high native Octachlorodibenzo-*p*-dioxin response. In the case of samples EPA 7 Upper, EPA 7 Lower, EPA 10 and EPA 13, the reported recoveries were slightly low due to the spiking level being too low relative to native PCDD/F levels to determine spike recoveries.



## CHAPTER 8

### REFERENCES

- [1] USEPA, April 1998, The Inventory of Sources of Dioxin and the United States, United States Environmental Protection Agency, Office of Research and Development, External Review Draft.
- [2] NYSDEC, June 1994, An Investigation of the Dioxin/Furan Concentrations in the Sediments of Eighteenmile Creek and the Erie Canal Near Lockport, New York, New York State Department of Environmental Conservation, Division of Water.
- [3] NYSDEC, October 1998, Eighteenmile Creek/Olcott Harbor Sediment Survey, New York State Department of Environmental Conservation, Division of Water
- [4] Dergosits, J. R., September 20, 1997, Quality Assurance Plan, Contaminated Sediment Evaluation of the Erie Canal North Tonawanda to Spencerport, New York, New York State Canal Corporation, Office of Canal Maintenance and Operations.
- [5] NYSDEC, November 1993, Technical Guidance for Screening Contaminated Sediments, New York State Department of Environmental Conservation, Division of Fish and Wildlife and Division of Marine Resources.
- [6] NYSDEC, October 1994, Interim Guidance - Freshwater Navigational Dredging, New York State Department of Environmental Conservation, Division of Water.
- [7] USEPA, 1989, Interim procedures for estimating risks associated with exposures to mixtures of chlorinated dibenzo-p-dioxins and dibenzofurans (CDDs and CDFs), United States Environmental Protection Agency, Risk Assessment Forum
- [8] Paustenbach, D., Wenning, R., Lau, V., Harrington, N., Rennix, D., Parsons, A., January 3, 1992, Recent Developments on the Hazards posed by 2,3,7,8-Tetrachlorodibenzo-p-Dioxin in Soil: Implications for setting Risk-Based Cleanup Levels at Residential and Industrial Sites, Journal of Toxicology and Environmental Health, 36:103-149.
- [9] NYSDEC, January 24, 1994, TAGM HWR-94-4046, New York State Department of Environmental Conservation, Division of Hazardous Waste Remediation.

- [10] Baudo, R., Giesy, J., Muntau, H., 1990, *Sediments: Chemistry and Toxicity of In-place Pollutants*, Lewis Publishers.
- [11] McGovern E. Carol, Undated, Background Concentrations of 20 elements in soils with special regard for New York State, New York State Department of Environmental Conservation, Wildlife Pathology Unit.
- [12] NYSDEC, Solid Waste Regulations 6NYCRR Part 360-4.4.
- [13] Cleverly, D., Monetti, M., Phillips, L., Cramer, P., Heit, M., McCarthy, S., O'Rourke, K., Stanley, J., Winters, D., August 1996, A Time-Trends Study of the Occurrences and Levels of CDDs, CDFs and Dioxin-like PCBs in Sediment Cores From 11 Geographically Distributed Lakes in the United States Organohalogen Compounds, 28:77-82.
- [14] Czuczwa, Jean M., McVeety, Bruce D., Hites, Ronald, November 2, 1984, Polychlorinated Dibenzo-p-Dioxins and Dibenzofurans in Sediments from Siskiwit Lake, Isle Royale, Science, 226:568-569.
- [15] Bowen, H. J. M., 1979, *Environmental Chemistry of the Elements*, Academic Press.

# Appendix A

## Project Study Area Maps



# Appendix B

## Sediment Data Summaries

Location	Sample Number	Mile Point	TOC %	TVS %	Cadmium (ppm)	Lead (ppm)	Mercury (ppm)	Copper (ppm)	Arsenic (ppm)	PCB (ppm)	TEQ (ppt)
EPA-1	Composite	339.4	3.3	4.4	2.20	135.0	0.350	70.9		0.31	22.392
DUP #9 (EPA-1)	Composite	339.4									19.422
EPA-2	Composite	335.8	2.3	3.0	0.92	29.4	0.100	27.9		0.10	5.495
DUP #8 (EPA-2)	Composite	335.8	2.4	3.0	1.40	37.1	0.120	32.2		N/D at <0.054	
EPA-3	Upper	332.9	1.9	2.9	0.37	8.0	<0.060	12.9		N/D at <0.046	2.255
EPA-3	Lower	332.9	2.6	2.6	0.42	7.8	<0.052	15.3		N/D at <0.044	0.857
EPA-4	Composite	331.7	1.3	2.6	0.57	10.6	<0.058	16.9		N/D at <0.048	1.615
EPA-5	Upper	328.0	2.5	2.9	0.53	13.0	0.066	17.3		N/D at <0.048	1.661
EPA-5	Lower	328.0	2.4	2.6	1.20	25.9	0.091	30.3		0.14	8.138
EPA-6	Composite	325.8	3.2	5.3	1.00	29.2	<0.110	34.1		N/D at <0.076	5.500
EPA-7	Upper	322.2	5.8	3.9	2.70	133.0	0.400	82.5		93.00	574.550
EPA-7	Lower	322.2	5.8	5.8	4.80	433.0	0.940	147.0		40.00	314.070
EPA-8	Upper	322.1	3.0	4.5	1.30	51.9	0.130	42.3		0.16	18.441
EPA-8	Lower	322.1	3.5	3.6	3.60	846.0	0.180	59.0		0.28	86.045
EPA-9	Composite	321.2	5.5	3.9	2.50	343.0	13.500	135.0		66.00	253.010
EPA-10	Composite	319.5	4.5	3.9	4.00	128.0	0.960	101.0		2.11	224.020
EPA-11	Upper	313.9	3.0	5.0	4.70	95.0	0.630	106.0		0.59	200.680
DUP#7 (EPA-11)	Upper	313.9	2.9	5.3	5.40	110.0	0.830	124.0		0.50	
EPA-11	Lower	313.9	2.9	5.0	4.80	120.0	0.820	118.0		0.44	163.905
Middleport Background	Composite	309.3	2.2	3.3	0.51	51.0	0.270	37.8	4.1		
Middleport #1	Composite	307.2	2.5	5.5	0.95	59.9	0.280	60.8	4.9		
EPA-12	Upper	307.1	2.7	3.9	2.70	104.0	0.870	114.0	4.8	0.09	222.943
EPA-12	Lower	307.1	3.2	3.8	5.30	140.0	0.940	162.0	9.1	0.05	203.488
EPA-13	Composite	306.9	2.8	3.3	3.00	85.9	0.440	83.4	6.4	1.00	110.035
EPA-13A	Composite	304.8	3.2		0.81	37.8	0.260	69.4	4.0		
EPA-14	Upper	298.9	0.7	2.1	0.90	34.0	0.088	37.8		N/D at <0.043	17.483
EPA-14	Lower	298.9	1.6	3.6	0.56	17.5	<0.062	27.3		N/D at <0.043	16.527
DUP#6 (EPA-14)	Lower	298.9									11.053
EPA-15	Composite	294.9	1.9		2.00	70.9	0.470	63.9			
DUP#1 (EPA-15)	Composite	294.9	1.8		2.40	58.1	0.280	71.5			
DUP#2 (EPA-15)	Composite	294.9	1.9		1.00	42.9	0.190	37.1			
EPA-16	Composite	293.5	1.2		0.90	122.0	0.260	78.0			
EPA-17	Composite	293.2	2.0		1.40	66.3	0.360	64.4			
EPA-18A	Composite	290.7	2.1		1.80	80.2	0.530	61.7			
EPA-18B	Composite	290.7	1.1		1.60	246.0	0.120	42.3			
EPA-18C	Composite	290.7	4.8		0.97	72.1	0.340	56.5			
EPA-20	Composite	286.3	2.2	2.6	0.63	84.0	0.410	121.0		N/D at <0.045	3.060
DUP#3 (EPA-20)	Composite	286.3	2.2	2.3	0.52	74.7	0.720	115.0		N/D at <0.044	2.637
EPA-21	Upper	280.0	2.6	2.5	2.90	117.0	0.540	88.2		N/D at <0.051	123.293
EPA-21	Lower	280.0	1.7	2.7	3.30	114.0	0.620	82.5		N/D at <0.050	118.185
EPA-22	Composite	272.4	1.1	1.7	0.92	54.5	0.170	42.5			
EPA-23	Upper	269.5	1.7	2.1	1.60	73.8	0.580	67.9		0.09	135.010
EPA-23	Lower	269.5	1.9	1.7	0.81	106.0	0.410	149.0		N/D at <0.040	78.990
EPA-24	Upper	261.8	2.6	2.1	1.90	102.0	0.360	67.9		0.34	89.140
EPA-24	Lower	261.8	3.6	2.4	2.40	100.0	0.470	75.4		1.05	97.030
EPA-24 (Lab Duplicate)	Lower	261.8									90.220
EPA-25	Upper	261.2	1.3	1.9	0.05	16.6	0.075	23.1		at <0.050	11.057
EPA-25	Lower	261.2	1.1	1.9	0.08	20.8	0.058	27.3		0.10	12.023

Location	Sample Number	Mile Point	Total TCDF	Total PCDF	Total HexaCDF	Total HeptaCDF	OctaCDF	Total Furans	Total TCDD	Total PCDD	Total HexaCDD	Total HeptaCDD	OctaCDD	Total Dioxins	Total Dioxins and Furans
EPA-1	Composite	339.4	120.0	120.0	120.0	220.0	200.0	780.0	27.0	13.0	94.0	620.0	2400.0	3154.0	3934.0
DUP #9 (EPA-1)	Composite	339.4	95.0	120.0	110.0	170.0	130.0	625.0	24.0	11.0	56.0	480.0	2100.0	2671.0	3296.0
EPA-2	Composite	335.8	19.0	14.0	31.0	86.0	19.0	169.0	21.0	7.1	20.0	69.0	630.0	747.1	916.1
DUP #8 (EPA-2)	Composite	335.8						0.0						0.0	0.0
EPA-3	Upper	332.9	1.0	3.9	11.0	10.0	6.7	32.6	0.3	1.0	11.0	22.0	51.0	85.3	117.9
EPA-3	Lower	332.9	0.3	0.2	2.7	2.3	2.1	7.6	0.3	0.2	0.6	6.2	16.0	23.2	30.8
EPA-4	Composite	331.7	3.4	3.2	7.0	11.0	9.0	33.6	0.8	0.2	4.8	26.0	260.0	291.8	325.4
EPA-5	Upper	328.0	9.8	4.8	4.6	9.9	11.0	40.1	2.2	0.3	3.5	31.0	150.0	187.0	227.1
EPA-5	Lower	328.0	39.0	23.0	49.0	110.0	52.0	273.0	5.0	3.2	41.0	280.0	1400.0	1729.2	2002.2
EPA-6	Composite	325.8	28.0	22.0	34.0	51.0	43.0	178.0	9.6	4.1	27.0	150.0	650.0	840.7	1018.7
EPA-7	Upper	322.2	980.0	1300.0	3300.0	10000.0	5700.0	21280.0	99.0	28.0	2500.0	19000.0	200000.0	221627.0	242907.0
EPA-7	Lower	322.2	160.0	220.0	3500.0	15000.0	6300.0	25180.0	70.0	9.2	2200.0	14000.0	120000.0	136279.2	161459.2
EPA-8	Upper	322.1	55.0	63.0	150.0	360.0	250.0	878.0	22.0	11.0	68.0	410.0	1800.0	2311.0	3189.0
EPA-8	Lower	322.1	160.0	260.0	760.0	1400.0	1300.0	3880.0	66.0	25.0	150.0	1200.0	7600.0	9041.0	12921.0
EPA-9	Composite	321.2	600.0	790.0	2300.0	6800.0	3400.0	13890.0	55.0	45.0	1300.0	8700.0	57000.0	67100.0	80990.0
EPA-10	Composite	319.5	160.0	240.0	2200.0	9600.0	3500.0	15700.0	34.0	34.0	1200.0	8300.0	84000.0	93568.0	109268.0
EPA-11	Upper	313.9	320.0	380.0	1400.0	3900.0	2400.0	8400.0	71.0	51.0	590.0	6900.0	46000.0	53612.0	62012.0
DUP#7 (EPA-11)	Upper	313.9													
EPA-11	Lower	313.9	130.0	260.0	1800.0	6100.0	3800.0	12090.0	47.0	31.0	720.0	8400.0	58000.0	67198.0	79288.0
Middleport Background	Composite	309.3													
Middleport #1	Composite	307.2													
EPA-12	Upper	307.1	180.0	380.0	1900.0	7000.0	4300.0	13760.0	79.0	19.0	1000.0	9800.0	76000.0	86898.0	100658.0
EPA-12	Lower	307.1	160.0	340.0	2100.0	7000.0	3100.0	12700.0	80.0	15.0	1100.0	9600.0	67000.0	77795.0	90495.0
EPA-13	Composite	306.9	150.0	170.0	960.0	3200.0	2700.0	7180.0	44.0	12.0	240.0	1600.0	16000.0	17896.0	25076.0
EPA-13A	Composite	304.8													
EPA-14	Upper	298.9	22.0	31.0	170.0	530.0	250.0	1003.0	6.1	3.8	86.0	730.0	4000.0	4825.9	5828.9
EPA-14	Lower	298.9	5.1	23.0	180.0	610.0	170.0	988.1	0.4	1.8	100.0	840.0	5300.0	6242.2	7230.3
DUP#6 (EPA-14)	Lower	298.9	2.2	10.0	110.0	400.0	130.0	652.2	0.3	0.8	51.0	620.0	3600.0	4272.1	4924.3
EPA-15	Composite	294.9													
DUP#1 (EPA-15)	Composite	294.9													
DUP#2 (EPA-15)	Composite	294.9													
EPA-16	Composite	293.5													
EPA-17	Composite	293.2													
EPA-18A	Composite	290.7													
EPA-18B	Composite	290.7													
EPA-18C	Composite	290.7													
EPA-20	Composite	286.3	5.8	8.6	16.0	29.0	11.0	70.4	0.5	0.3	12.0	130.0	770.0	912.8	983.2
DUP#3 (EPA-20)	Composite	286.3	7.9	7.2	12.0	23.0	10.0	60.1	0.5	0.6	7.8	73.0	480.0	561.9	622.0
EPA-21	Upper	280.0	200.0	230.0	1300.0	4700.0	2900.0	9330.0	41.0	25.0	780.0	6100.0	26000.0	32946.0	42276.0
EPA-21	Lower	280.0	420.0	220.0	700.0	2200.0	1300.0	4840.0	57.0	34.0	780.0	5400.0	32000.0	38271.0	43111.0
EPA-22	Composite	272.4													
EPA-23	Upper	269.5	170.0	330.0	1400.0	4500.0	1800.0	8200.0	44.0	42.0	710.0	6100.0	30000.0	36896.0	45096.0
EPA-23	Lower	269.5	30.0	140.0	720.0	2600.0	840.0	4330.0	9.8	19.0	430.0	3600.0	17000.0	21058.8	25388.8
EPA-24	Upper	261.8	390.0	240.0	400.0	1700.0	830.0	3560.0	47.0	38.0	360.0	2400.0	9300.0	12145.0	15705.0
EPA-24	Lower	261.8	400.0	230.0	550.0	1800.0	1000.0	3980.0	52.0	50.0	580.0	4000.0	17000.0	21682.0	25662.0
EPA-24 (Lab Duplicate)	Lower	261.8	420.0	260.0	480.0	1600.0	710.0	3470.0	54.0	55.0	530.0	3400.0	14000.0	18039.0	21509.0
EPA-25	Upper	261.2	15.0	13.0	11.0	37.0	27.0	103.0	6.1	1.9	15.0	85.0	500.0	608.0	711.0
EPA-25	Lower	261.2	23.0	19.0	23.0	61.0	33.0	159.0	6.0	3.4	29.0	150.0	840.0	1028.4	1187.4



Location	Sample Number	Mile Point	2,3,7,8 TCDD	1,2,3,7,8 PentaCDD	1,2,3,4,7,8 HexaCDD	1,2,3,6,7,8 HexaCDD	1,2,3,7,8,9 HexaCDD	1,2,3,4,6,7,8 HeptaCDD	OctaCDD
EPA-1	Composite	339.4	3.3	2.4	1.6	11.0	7.1	310.0	2400.0
DUP #9 (EPA-1)	Composite	339.4	2.3	1.8	1.4	8.4	5.7	250.0	2100.0
EPA-2	Composite	335.8	1.0	0.9	0.5	1.9	1.6	33.0	630.0
DUP #8 (EPA-2)	Composite	335.8							
EPA-3	Upper	332.9	0.3 *	0.2	0.5 *	1.3	1.4	12.0	51.0
EPA-3	Lower	332.9	0.3 *	0.2 *	0.2 *	0.2 *	0.2 *	3.2	16.0
EPA-4	Composite	331.7	0.3 *	0.2 *	0.2 *	0.6	0.5	13.0	260.0
EPA-5	Upper	328.0	0.3 *	0.3 *	0.4 *	0.4 *	0.4 *	16.0	150.0
EPA-5	Lower	328.0	1.3	0.8	0.8	3.8	2.2	120.0	1400.0
EPA-6	Composite	325.8	0.3 *	0.7	0.9	2.9	2.9	75.0	650.0
EPA-7	Upper	322.2	3.3 *	2.8 *	7.0 *	150.0	27.0	8600.0	20000.0
EPA-7	Lower	322.2	15.0	9.3	6.5 *	250.0	51.0	6400.0	12000.0
EPA-8	Upper	322.1	1.4	1.7	1.9	6.9	5.3	200.0	1800.0
EPA-8	Lower	322.1	2.7	3.0	3.0	18.0	9.2	620.0	7600.0
EPA-9	Composite	321.2	4.7	5.7	8.2	130.0	19.0	3100.0	57000.0
EPA-10	Composite	319.5	6.5 *	14.0	16.0	150.0	42.0	3800.0	84000.0
EPA-11	Upper	313.9	11.0	7.5	8.8	72.0	29.0	3300.0	46000.0
DUP#7 (EPA-11)	Upper	313.9							
EPA-11	Lower	313.9	4.8	4.3	8.3	120.0	24.0	4000.0	58000.0
Middleport Background	Composite	309.3							
Middleport #1	Composite	307.2							
EPA-12	Upper	307.1	7.6	2.1 *	12.0	120.0	30.0	3400.0	76000.0
EPA-12	Lower	307.1	13.0	4.8	12.0	180.0	38.0	3600.0	67000.0
EPA-13	Composite	306.9	3.4 *	2.6 *	3.7 *	20.0	13.0	680.0	16000.0
EPA-13A	Composite	304.8							
EPA-14	Upper	298.9	0.3 *	0.7	1.4	9.4	3.3	310.0	4000.0
EPA-14	Lower	298.9	0.4 *	0.6	1.0	12.0	2.6	330.0	5300.0
DUP#6 (EPA-14)	Lower	298.9	0.3 *	0.2 *	0.3 *	6.7	1.8	230.0	3600.0
EPA-15	Composite	294.9							
DUP#1 (EPA-15)	Composite	294.9							
DUP#2 (EPA-15)	Composite	294.9							
EPA-16	Composite	293.5							
EPA-17	Composite	293.2							
EPA-18A	Composite	290.7							
EPA-18B	Composite	290.7							
EPA-18C	Composite	290.7							
EPA-20	Composite	286.3	0.2 *	0.2 *	0.2 *	1.2	0.6	51.0	770.0
DUP#3 (EPA-20)	Composite	286.3	0.2 *	0.3	0.2 *	0.8	0.7	32.0	480.0
EPA-21	Upper	280.0	3.0	5.2	14.0	120.0	38.0	3200.0	19000.0
EPA-21	Lower	280.0	6.0	8.1	13.0	98.0	38.0	2700.0	32000.0
EPA-22	Composite	272.4							
EPA-23	Upper	269.5	8.9	8.2	16.0	110.0	44.0	2900.0	30000.0
EPA-23	Lower	269.5	5.1	5.5	9.3	72.0	23.0	1600.0	17000.0
EPA-24	Upper	261.8	8.7	7.3	8.6	46.0	26.0	1100.0	9300.0
EPA-24	Lower	261.8	12.0	10.0	11.0	73.0	37.0	2000.0	17000.0
EPA-24 (Lab Duplicate)	Lower	261.8	13.0	11.0	12.0	70.0	37.0	1600.0	14000.0
EPA-25	Upper	261.2	4.3	1.9	0.7	1.9	1.4	41.0	500.0
EPA-25	Lower	261.2	4.3	1.9	0.9	3.5	2.1	74.0	840.0

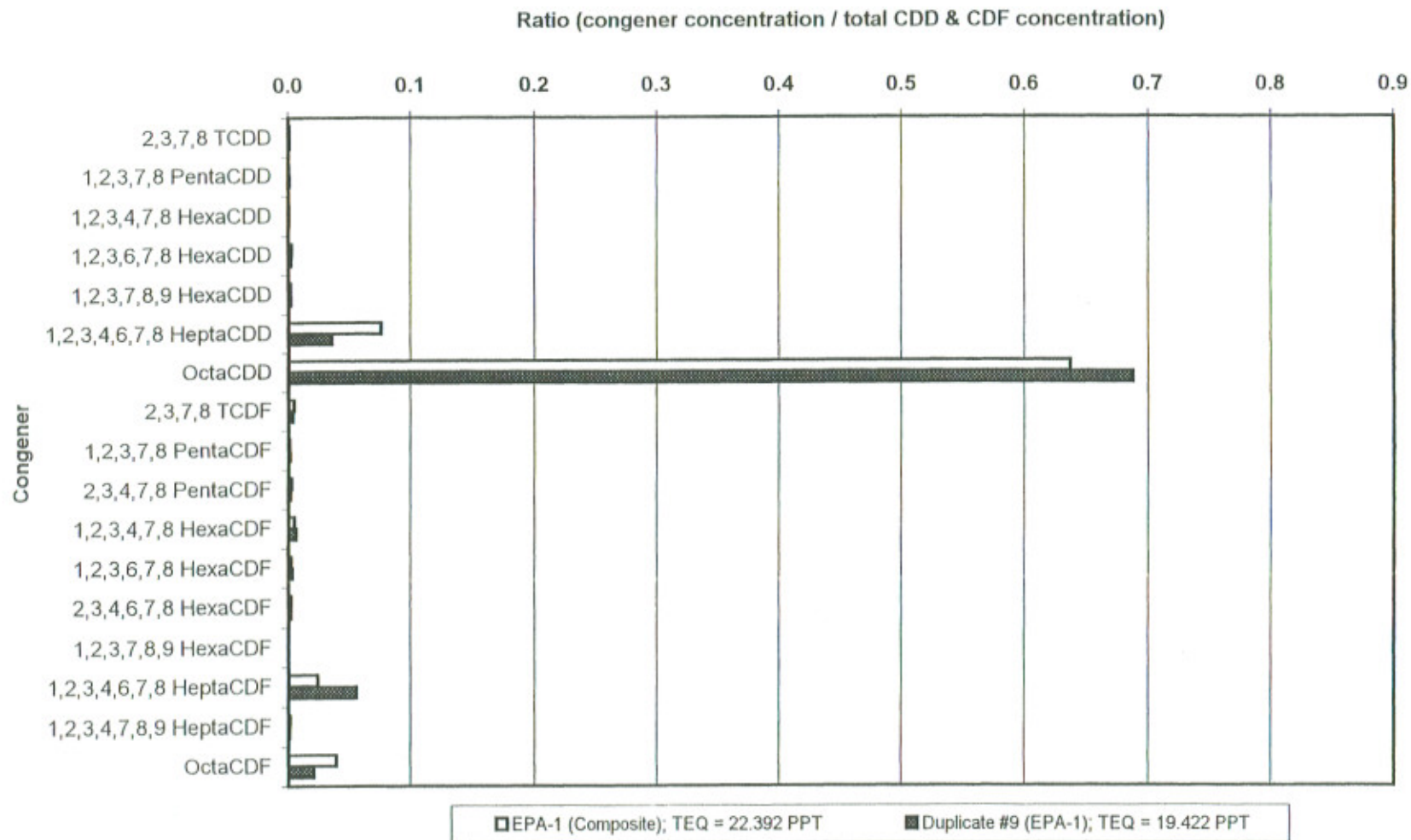
Location	Sample Number	Mile Point	2,3,7,8 TCDF	1,2,3,7,8 PentaCDF	2,3,4,7,8 PentaCDF	1,2,3,4,7,8 HexaCDF	1,2,3,6,7,8 HexaCDF	2,3,4,6,7,8 HexaCDF	1,2,3,7,8,9 HexaCDF	1,2,3,4,6,7,8 HeptaCDF	1,2,3,4,7,8,9 HeptaCDF	OctaCDF
EPA-1	Composite	339.4	20.0	3.5	7.3	15.0 *	8.3	8.6	0.5 *	110.0	5.7	200.0
DUP #9 (EPA-1)	Composite	339.4	14.0	2.4	8.9	15.5 *	7.2	8.0	0.7 *	79.0	4.7	130.0
EPA-2	Composite	335.8	3.4	1.3	1.5	5.5	2.8	1.6	0.2 *	51.0	0.8	19.0
DUP #8 (EPA-2)	Composite	335.8										
EPA-3	Upper	332.9	1.0	0.2 *	0.9	2.8	1.3	2.3	0.4 *	6.9	0.5 *	6.7
EPA-3	Lower	332.9	0.3 *	0.2 *	0.2 *	0.7	0.6	0.9	0.2 *	1.3	0.4 *	2.1
EPA-4	Composite	331.7	0.9	0.1 *	0.5	0.9	0.8	0.8	0.2 *	4.3	0.6	9.0
EPA-5	Upper	328.0	1.7	0.2 *	0.7	0.4 *	0.4 *	0.5 *	0.5 *	4.6	0.6 *	11.0
EPA-5	Lower	328.0	4.7	0.9	2.1	5.9	2.7	2.2	0.3 *	39.0	1.9	52.0
EPA-6	Composite	325.8	4.1	0.9	2.0	4.5	2.2	2.8	0.5 *	24.0	0.6 *	43.0
EPA-7	Upper	322.2	190.0	26.0	170.0	820.0	270.0	160.0	7.5 *	2600.0	270.0	5700.0
EPA-7	Lower	322.2	22.0	8.4	20.0	170.0	67.0	58.0	5.5 *	2900.0	170.0	6300.0
EPA-8	Upper	322.1	8.5	2.7	4.5 *	35.0	11.0	6.9	0.8 *	210.0	5.6	250.0
EPA-8	Lower	322.1	26.0	13.0	25.0	270.0	61.0	15.0	1.4 *	1300.0	24.0	1300.0
EPA-9	Composite	321.2	100.0	18.0	110.0	360.0	130.0	35.0	3.4	1800.0	160.0	3400.0
EPA-10	Composite	319.5	25.0	8.6	30.0	100.0	40.0	37.0	8.0 *	2700.0	79.0	3500.0
EPA-11	Upper	313.9	49.0	17.0	43.0 *	340.0	88.0	38.0	2.5 *	1900.0	45.0	2400.0
DUP#7 (EPA-11)	Upper	313.9										
EPA-11	Lower	313.9	15.0	6.0	7.0 *	65.0 *	41.0	48.0	4.2 *	1800.0	81.0	3800.0
Middleport Background	Composite	309.3										
Middleport #1	Composite	307.2										
EPA-12	Upper	307.1	23.0	9.0 *	23.0	240.0 *	120.0	74.0	0.4 *	2500.0	110.0	4300.0
EPA-12	Lower	307.1	16.0	4.9 *	16.0	120.0 *	63.0	78.0	0.6 *	2200.0	99.0	3100.0
EPA-13	Composite	306.9	27.0	11.0	20.5 *	330.0	84.0	7.0 *	2.8 *	2000.0	37.0	2700.0
EPA-13A	Composite	304.8										
EPA-14	Upper	298.9	3.2	1.1	2.5	23.0	9.8	5.9	0.4 *	250.0	5.2	250.0
EPA-14	Lower	298.9	1.0	0.9	1.3	5.9	7.5	5.1	0.9 *	280.0	4.1	170.0
DUP#6 (EPA-14)	Lower	298.9	0.9	0.2 *	1.2	3.7	4.8	3.3	0.7 *	180.0	3.0	130.0
EPA-15	Composite	294.9										
DUP#1 (EPA-15)	Composite	294.9										
DUP#2 (EPA-15)	Composite	294.9										
EPA-16	Composite	293.5										
EPA-17	Composite	293.2										
EPA-18A	Composite	290.7										
EPA-18B	Composite	290.7										
EPA-18C	Composite	290.7										
EPA-20	Composite	286.3	1.6	0.6	1.0	2.6	1.1	1.2	0.2 *	13.0	0.3 *	11.0
DUP#3 (EPA-20)	Composite	286.3	2.1	0.8	0.9	3.0	1.1	1.0	0.3 *	11.0	0.7	10.0
EPA-21	Upper	280.0	18.0	4.1 *	11.0	140.0	48.0	55.0	1.0 *	1400.0	69.0	2900.0
EPA-21	Lower	280.0	36.0	4.0 *	17.0	55.0 *	38.0	39.0	0.5 *	700.0	39.0	1300.0
EPA-22	Composite	272.4										
EPA-23	Upper	269.5	22.0	6.4	23.0	75.0 *	30.0	28.0	2.3	1600.0	66.0	1800.0
EPA-23	Lower	269.5	9.1	4.4	13.0	42.0 *	24.0	12.0	1.7	1100.0	27.0	840.0
EPA-24	Upper	261.8	45.0	11.0	42.0	90.0 *	32.0	13.0	1.2 *	770.0	23.0	830.0
EPA-24	Lower	261.8	42.0	8.2	25.0	41.5 *	19.0	13.0	0.8 *	510.0	29.0	1000.0
EPA-24 (Lab Duplicate)	Lower	261.8	42.0	7.6	25.0	35.5 *	20.0	13.0	1.8	470.0	30.0	710.0
EPA-25	Upper	261.2	5.7	1.7	6.3	1.6 *	1.4	1.6	0.2 *	18.0	0.9	27.0
EPA-25	Lower	261.2	6.2	1.7	6.2	1.9 *	1.3	1.8	0.2 *	18.0	1.4	33.0

## Appendix C

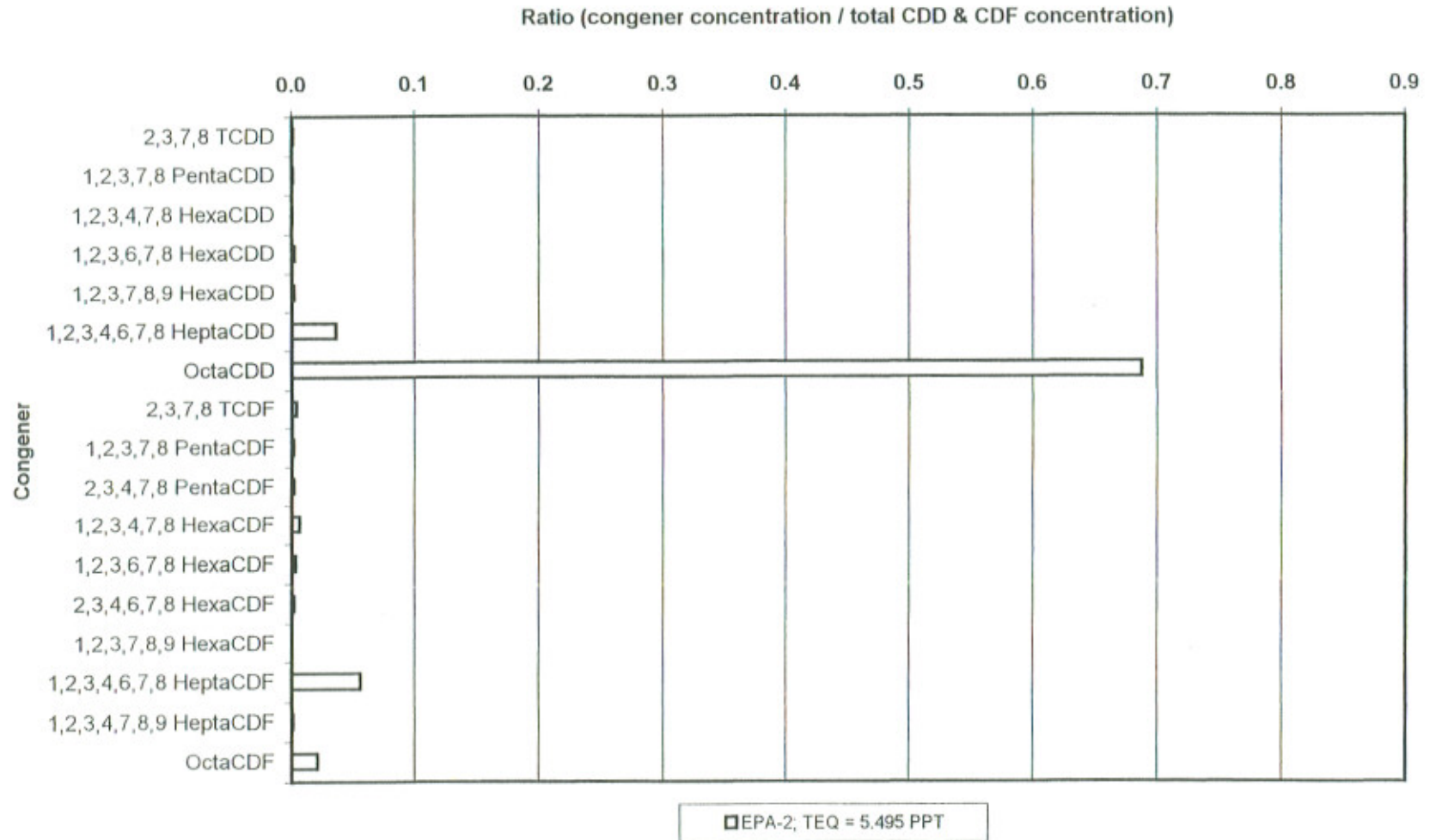
### Congener Group Profiles



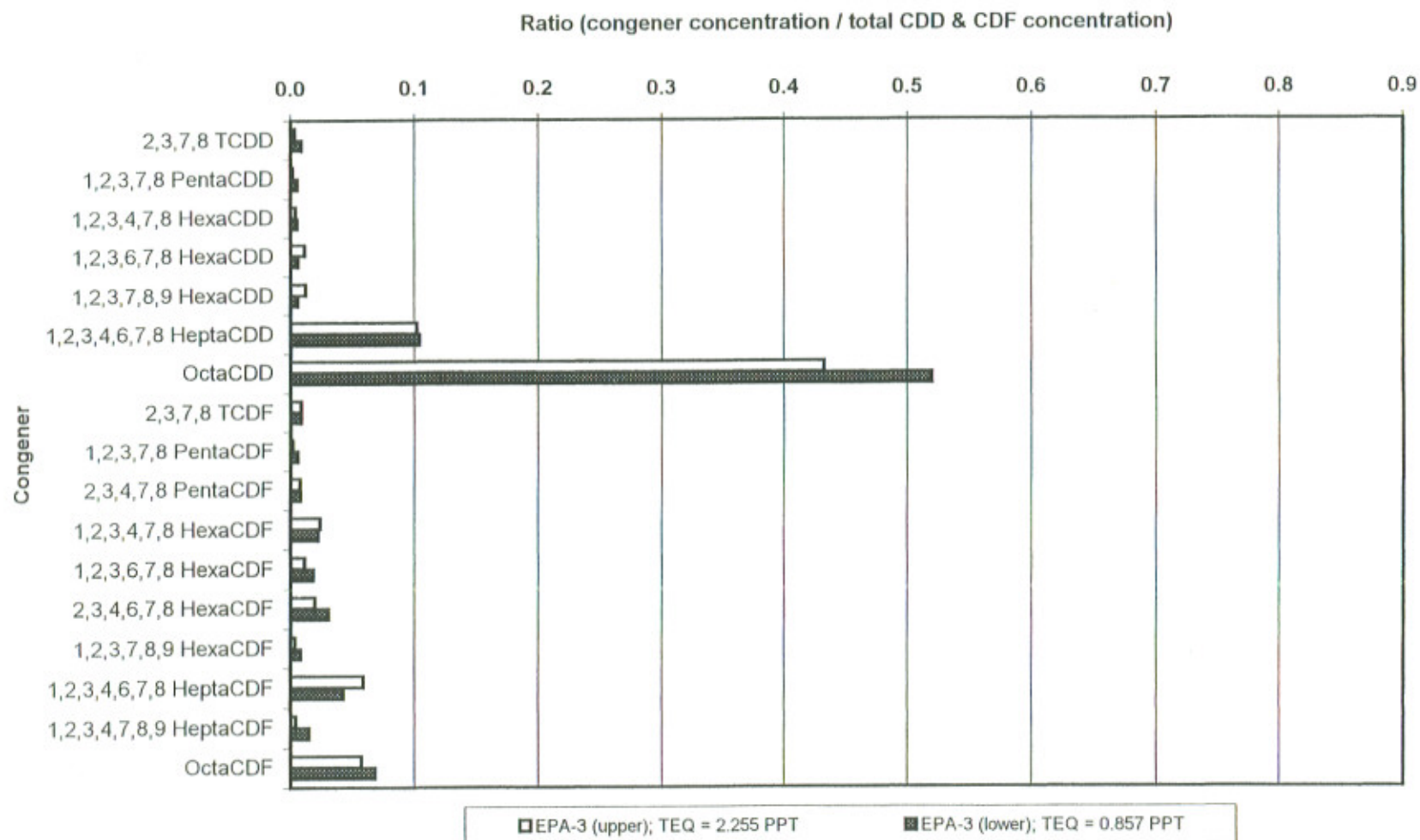
## Congener Profile Milepoint 339.4 (EPA-1)



## Congener Profile Milepoint 335.8 (EPA-2)

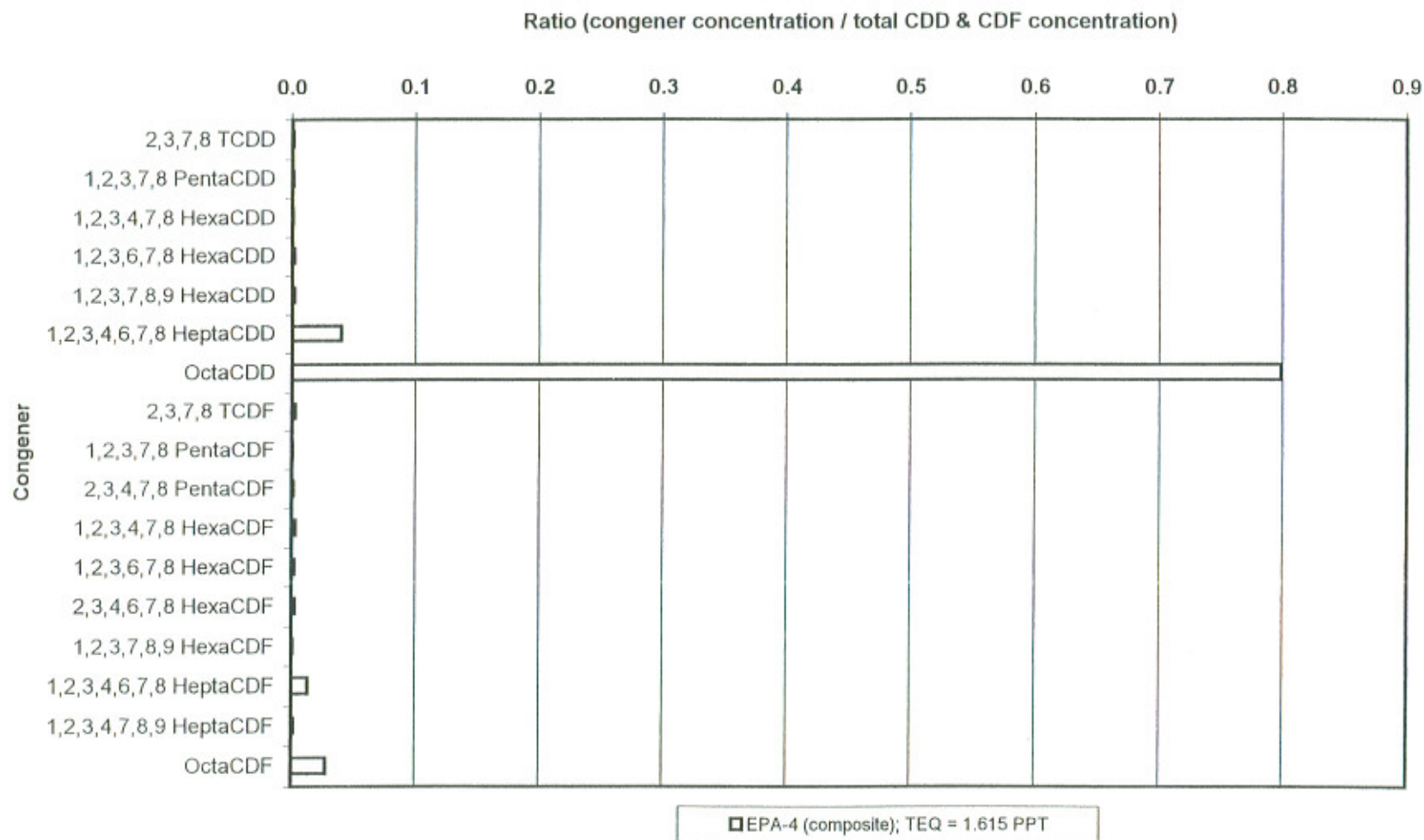


## Congener Profile Milepoint 332.9 (EPA-3)

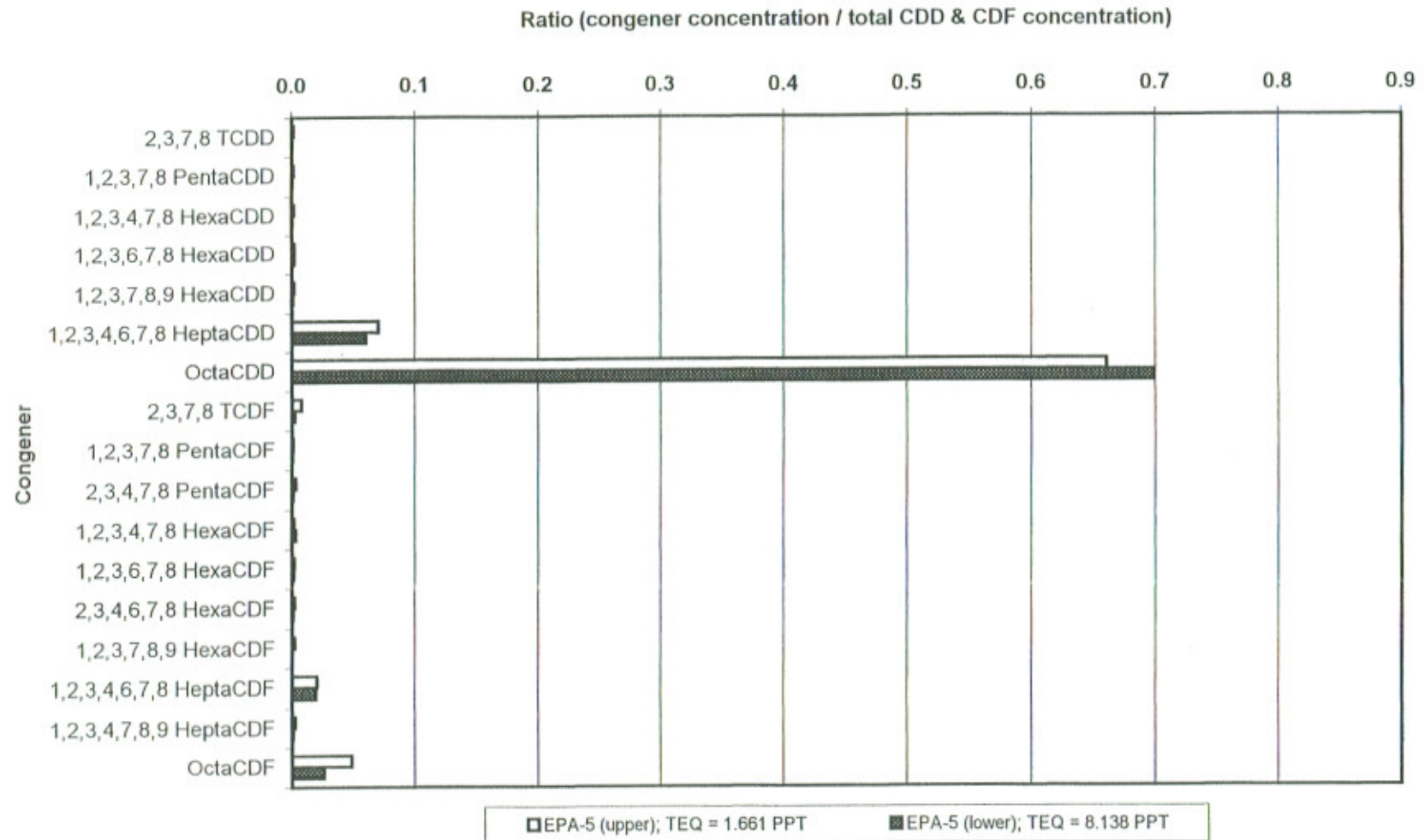




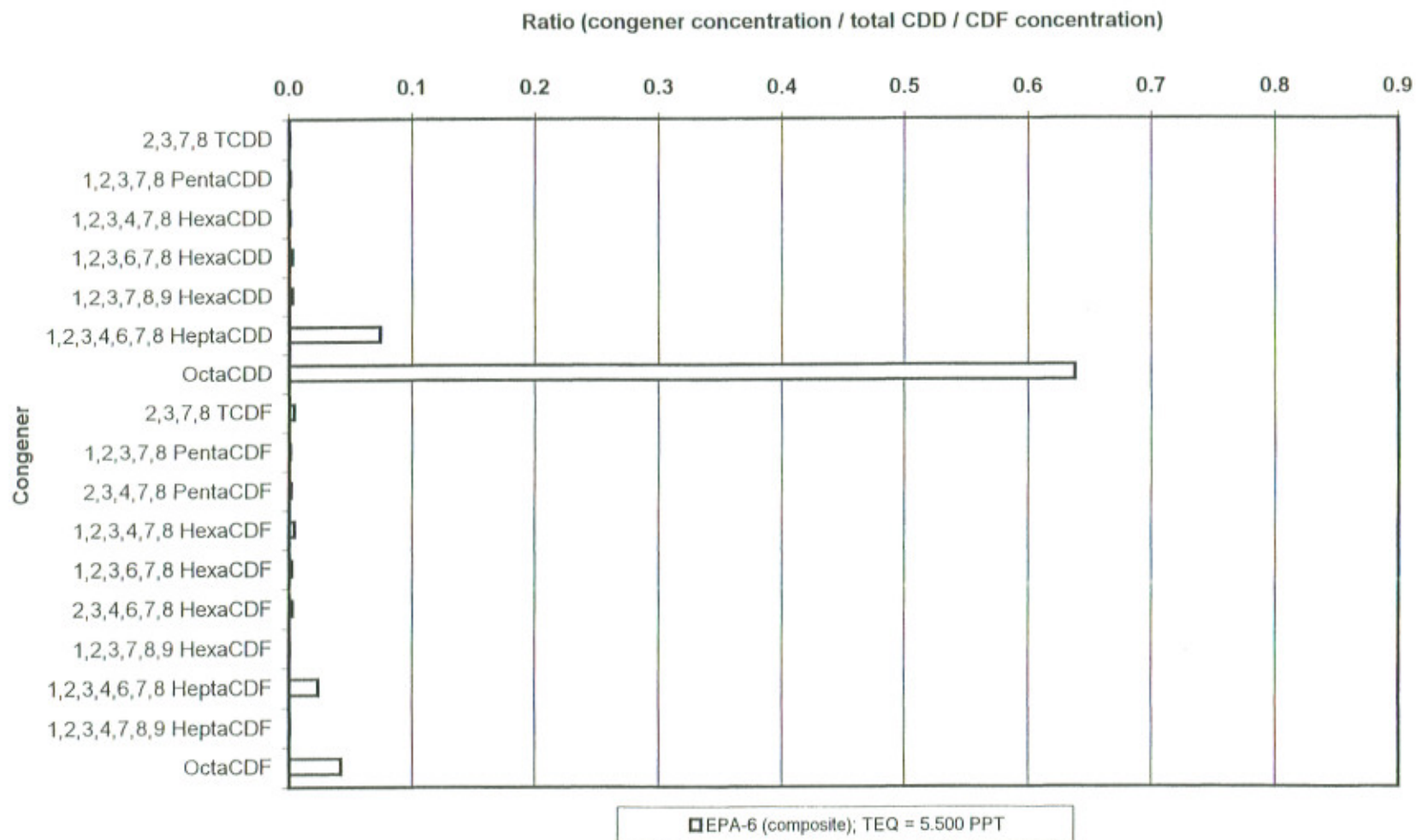
## Congener Profile Milepoint 331.7 (EPA-4)



## Congener Profile Milepoint 328.0 (EPA-5)

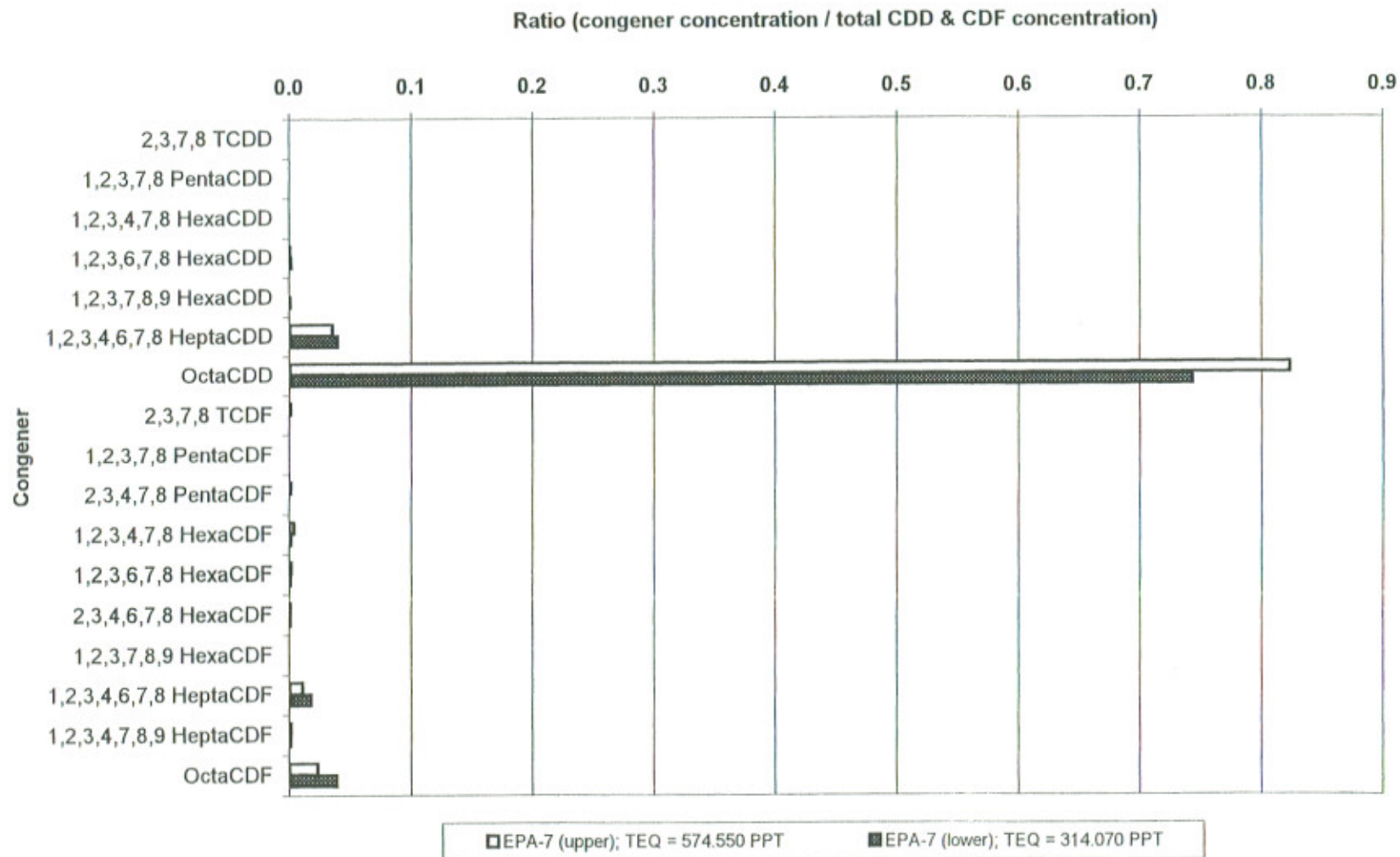


## Congener Profile Milepoint 325.8 (EPA-6)

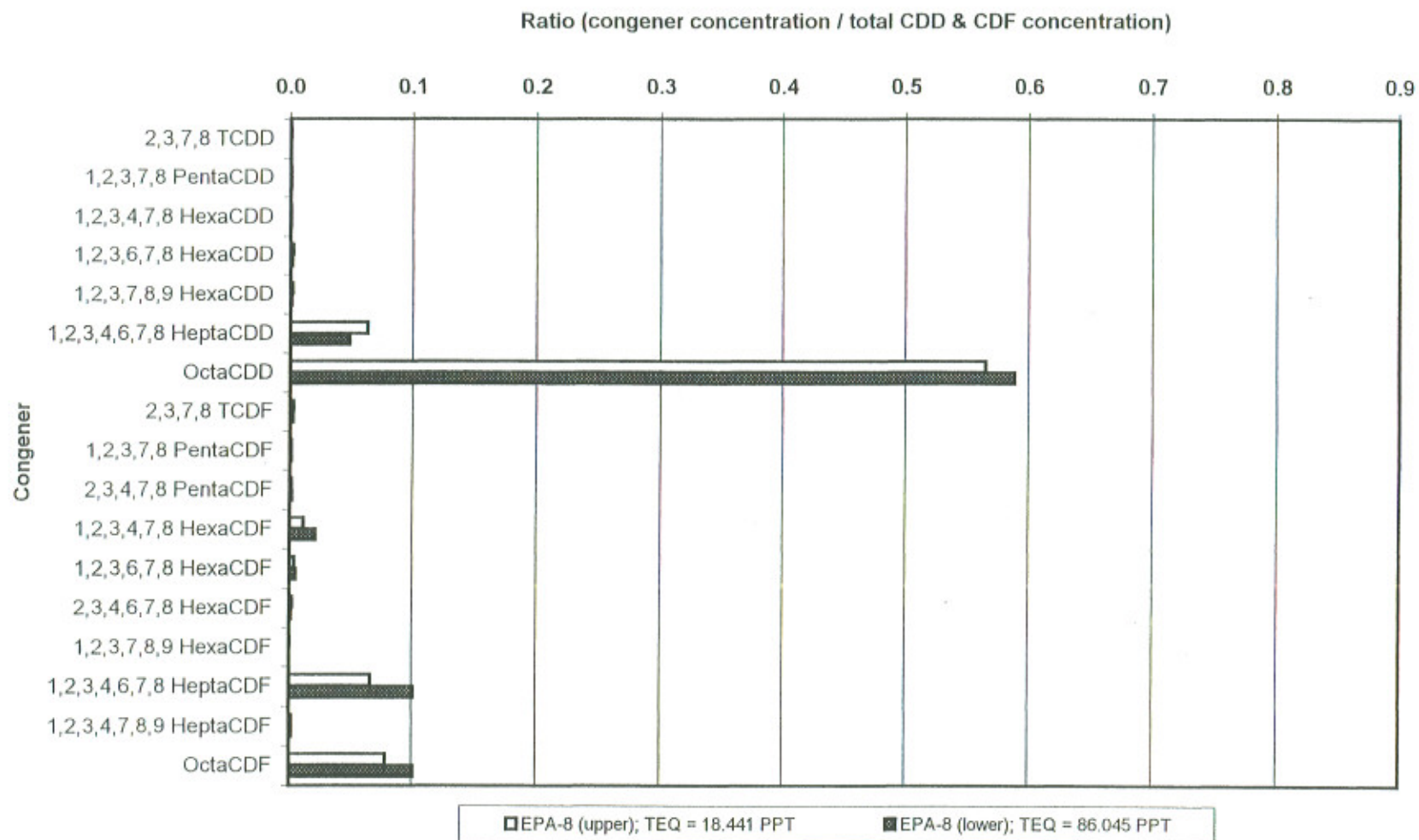




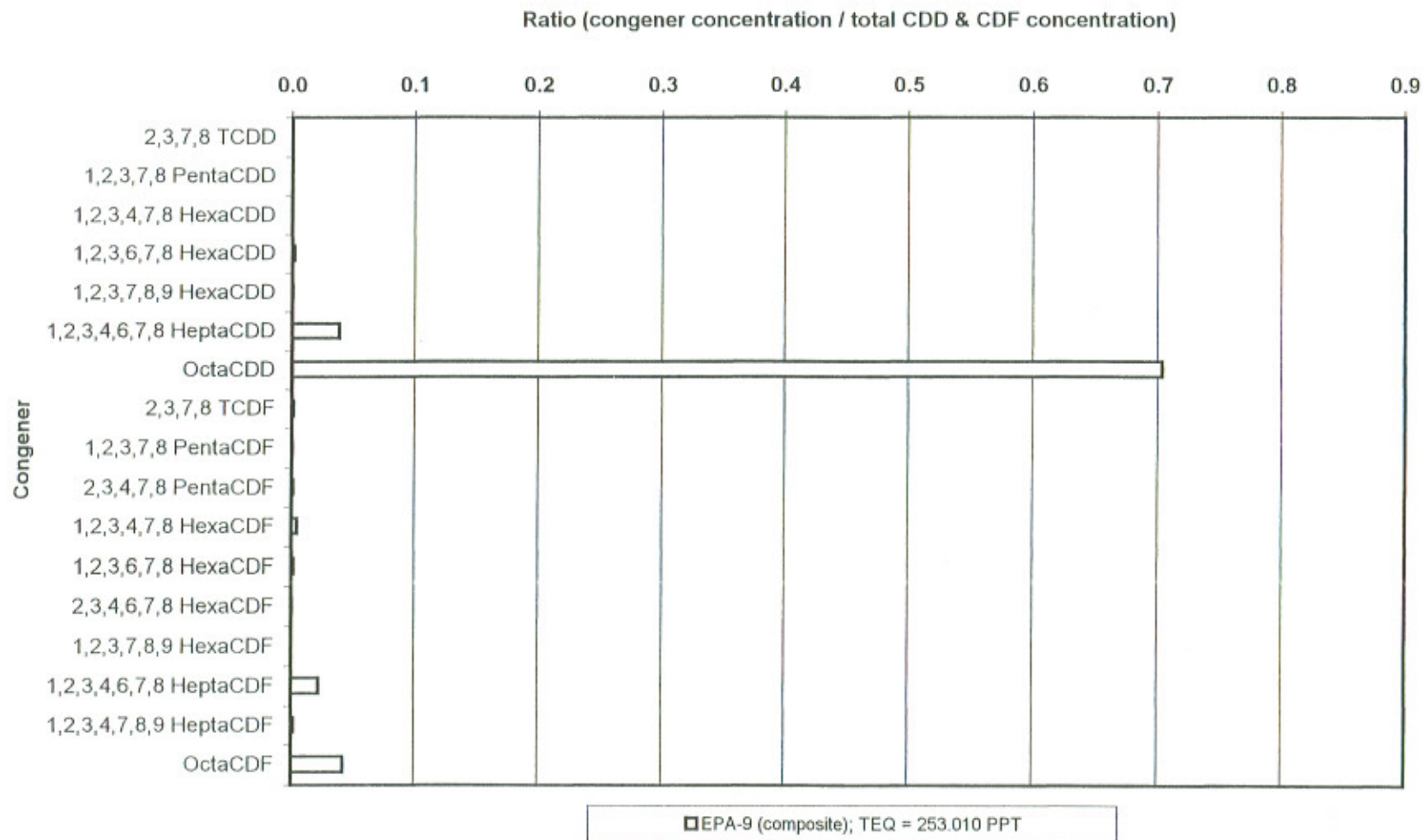
## Congener Profile Milepoint 322.2 (EPA-7)



## Congener Profile Milepoint 322.1 (EPA-8)

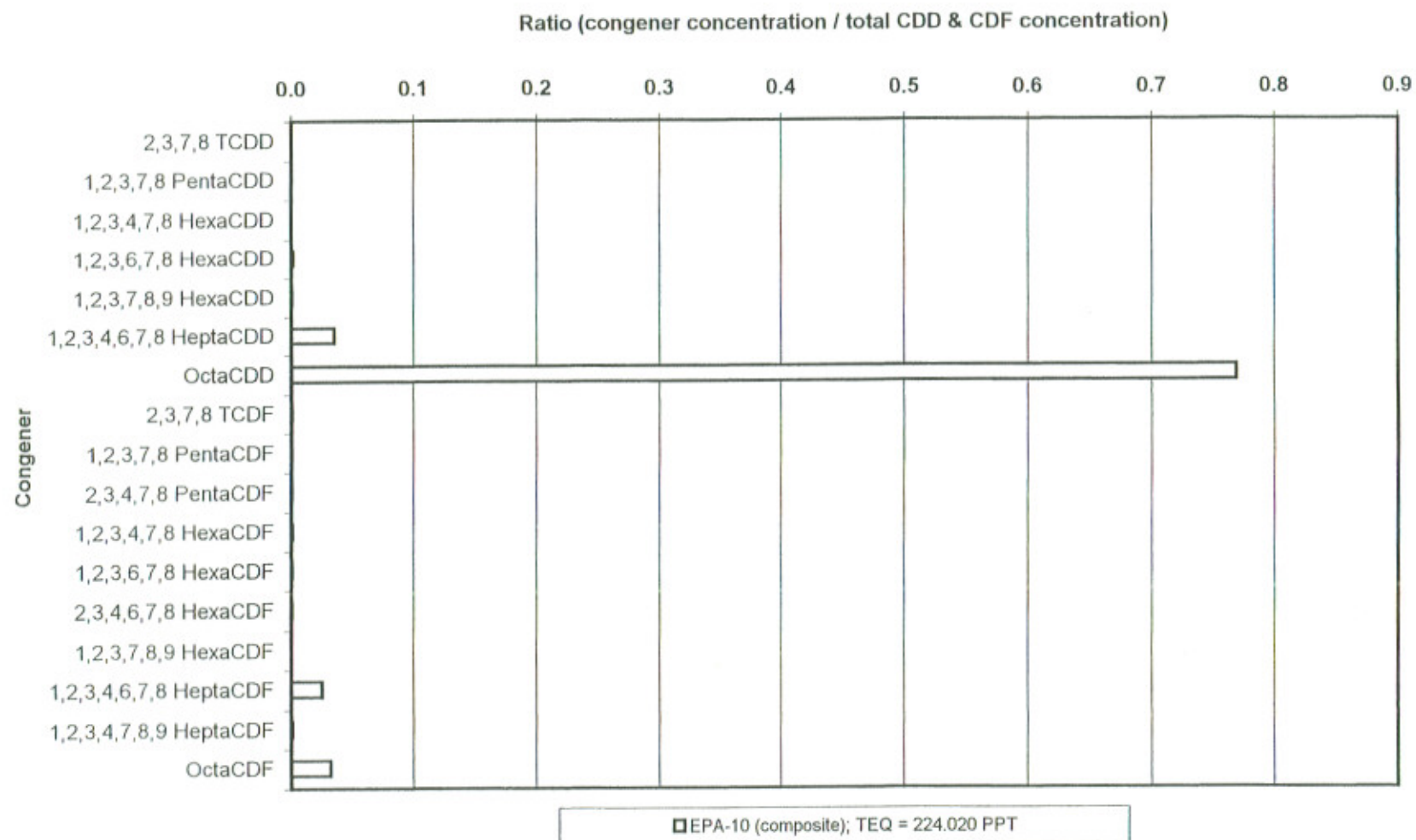


## Congener Profile Milepoint 321.1 (EPA-9)

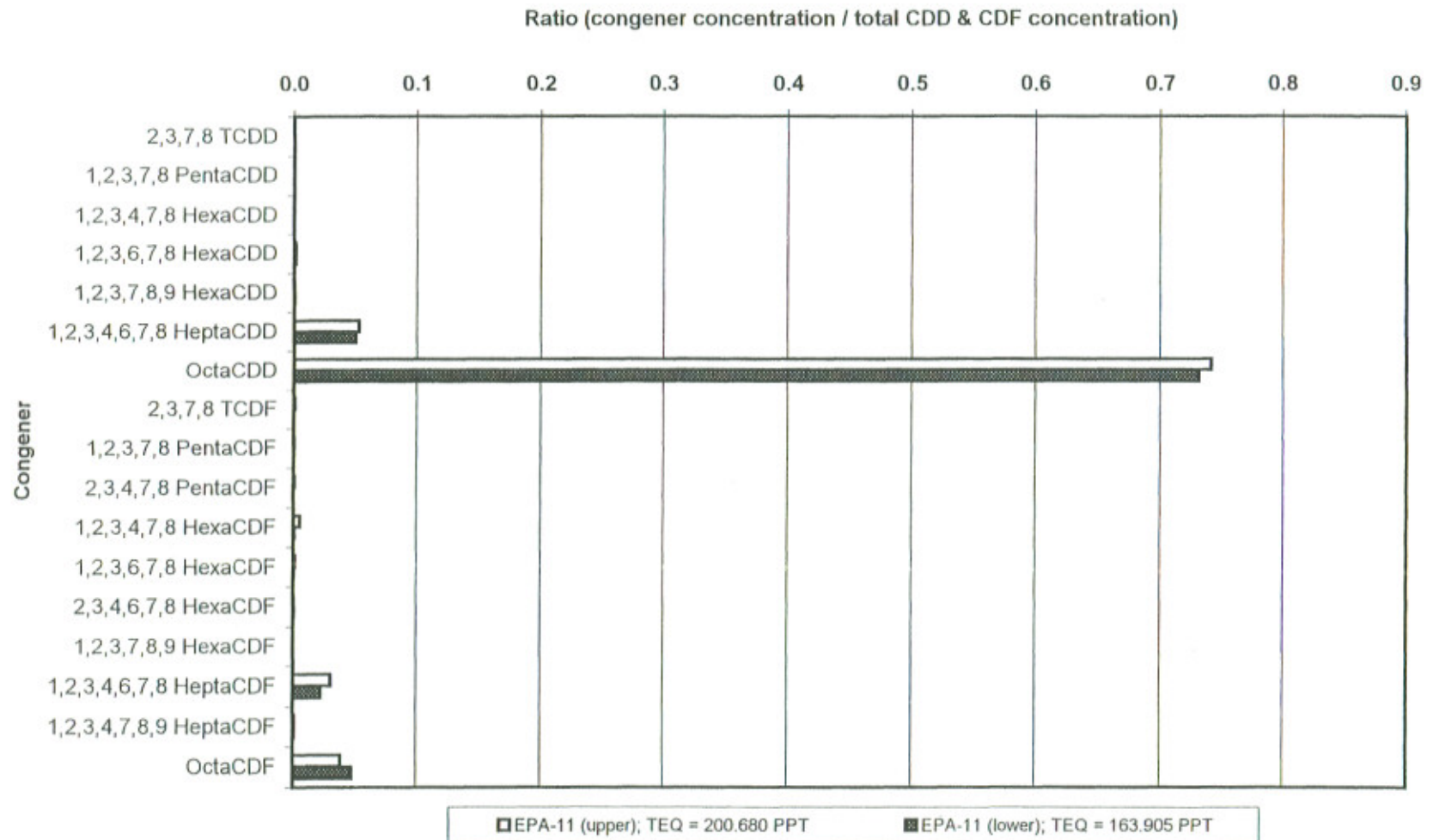




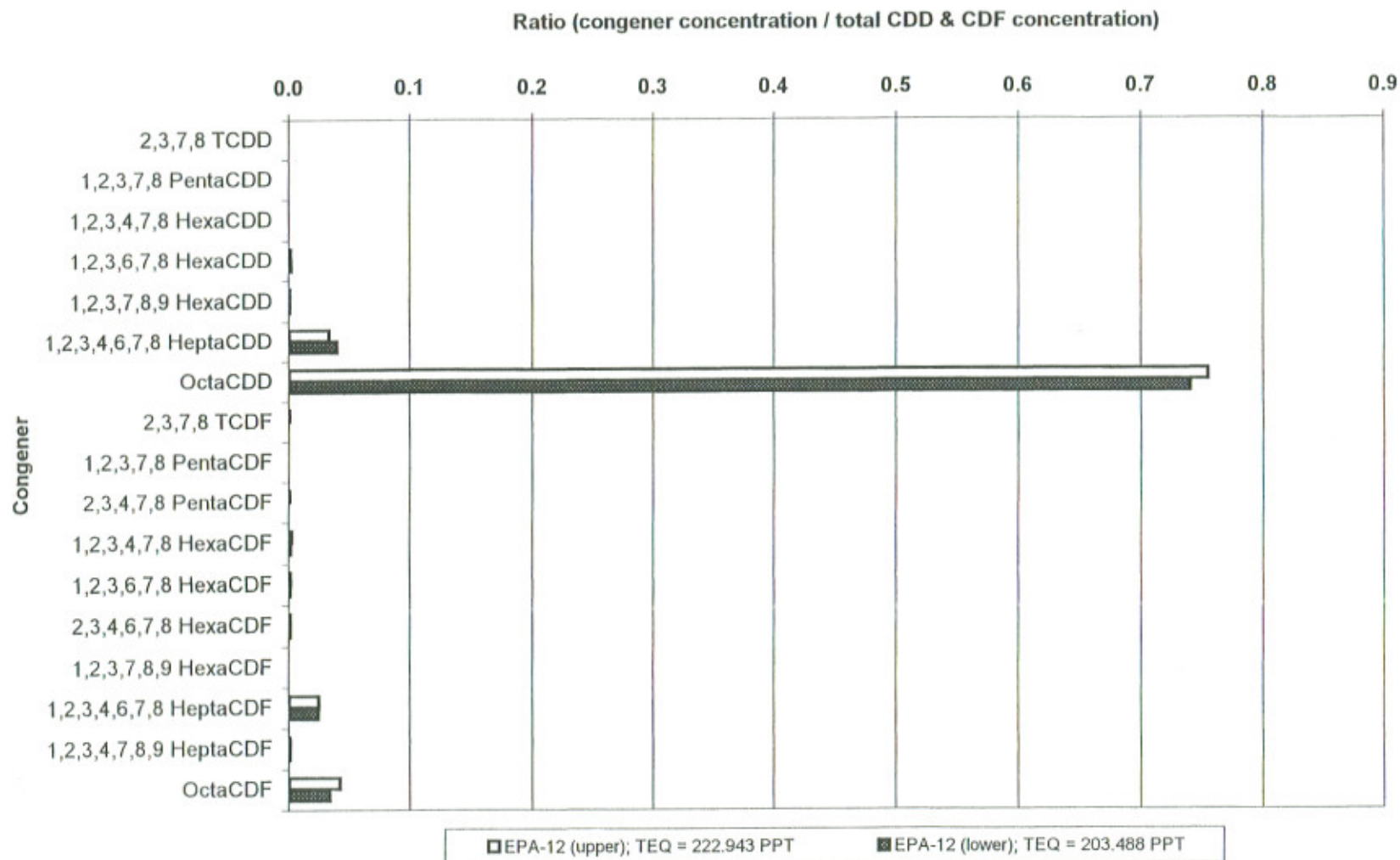
## Congener Profile Milepoint 319.5 (EPA-10)



## Congener Profile Milepoint 309.3 (EPA-11)

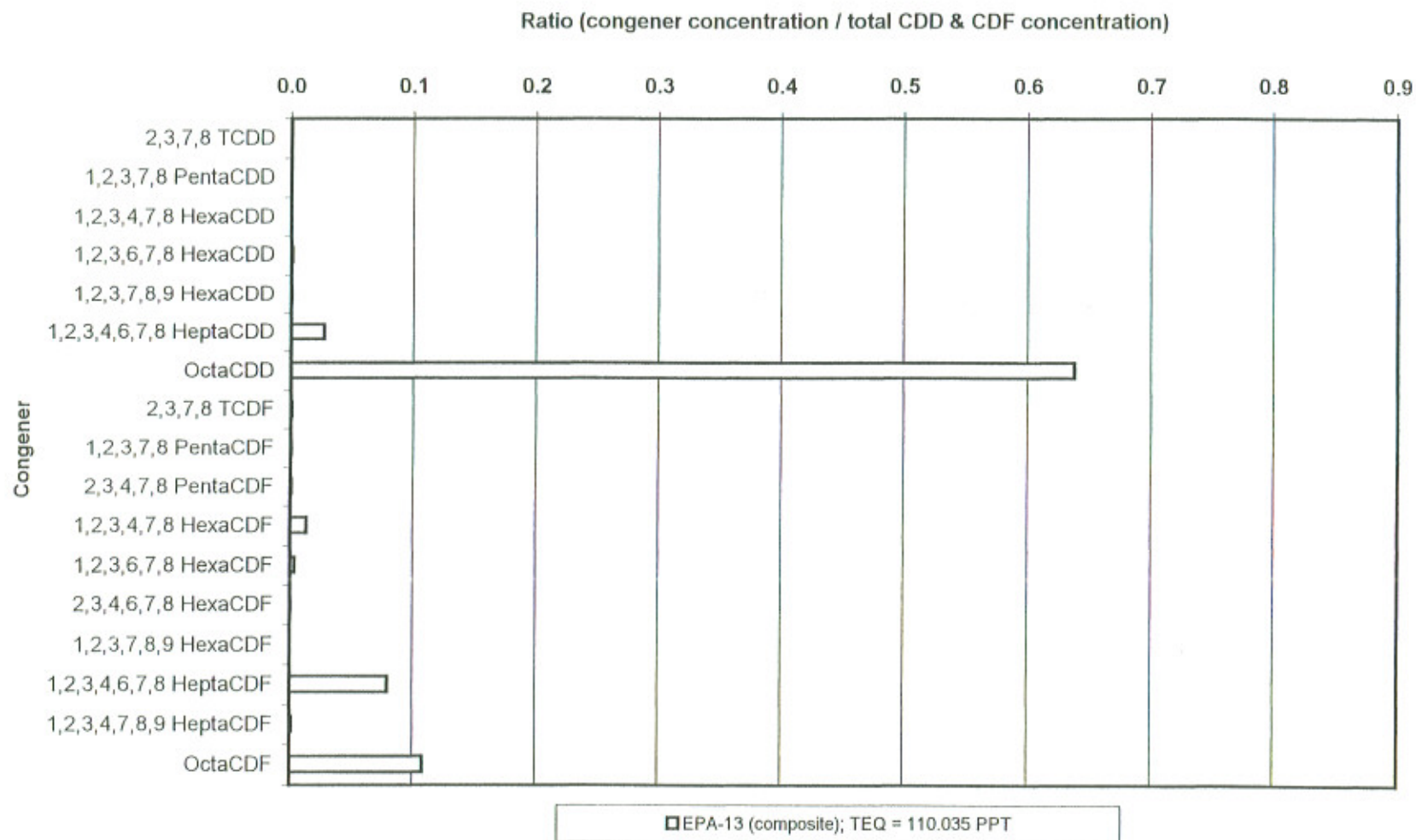


## Congener Profile Milepoint 307.1 (EPA-12)

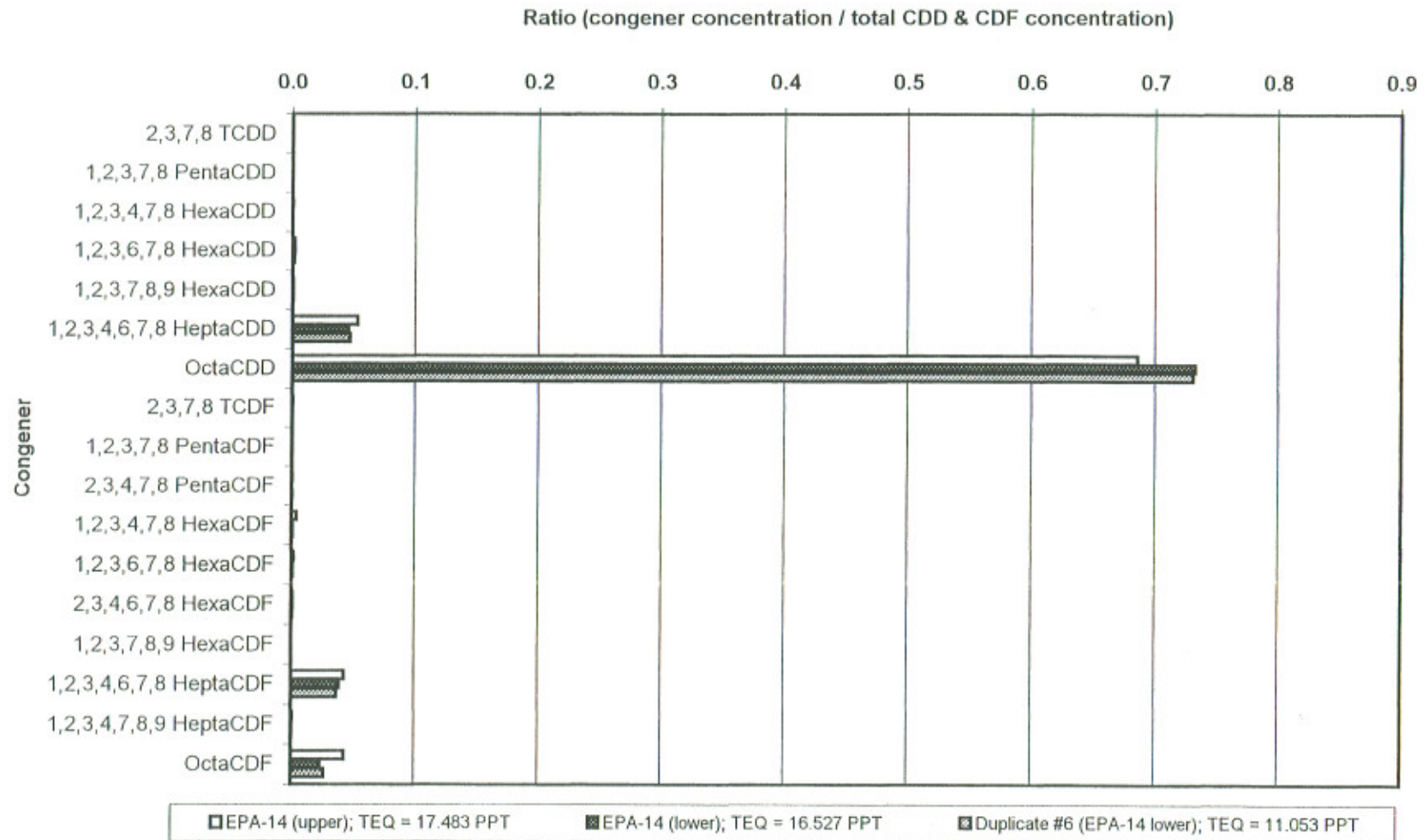




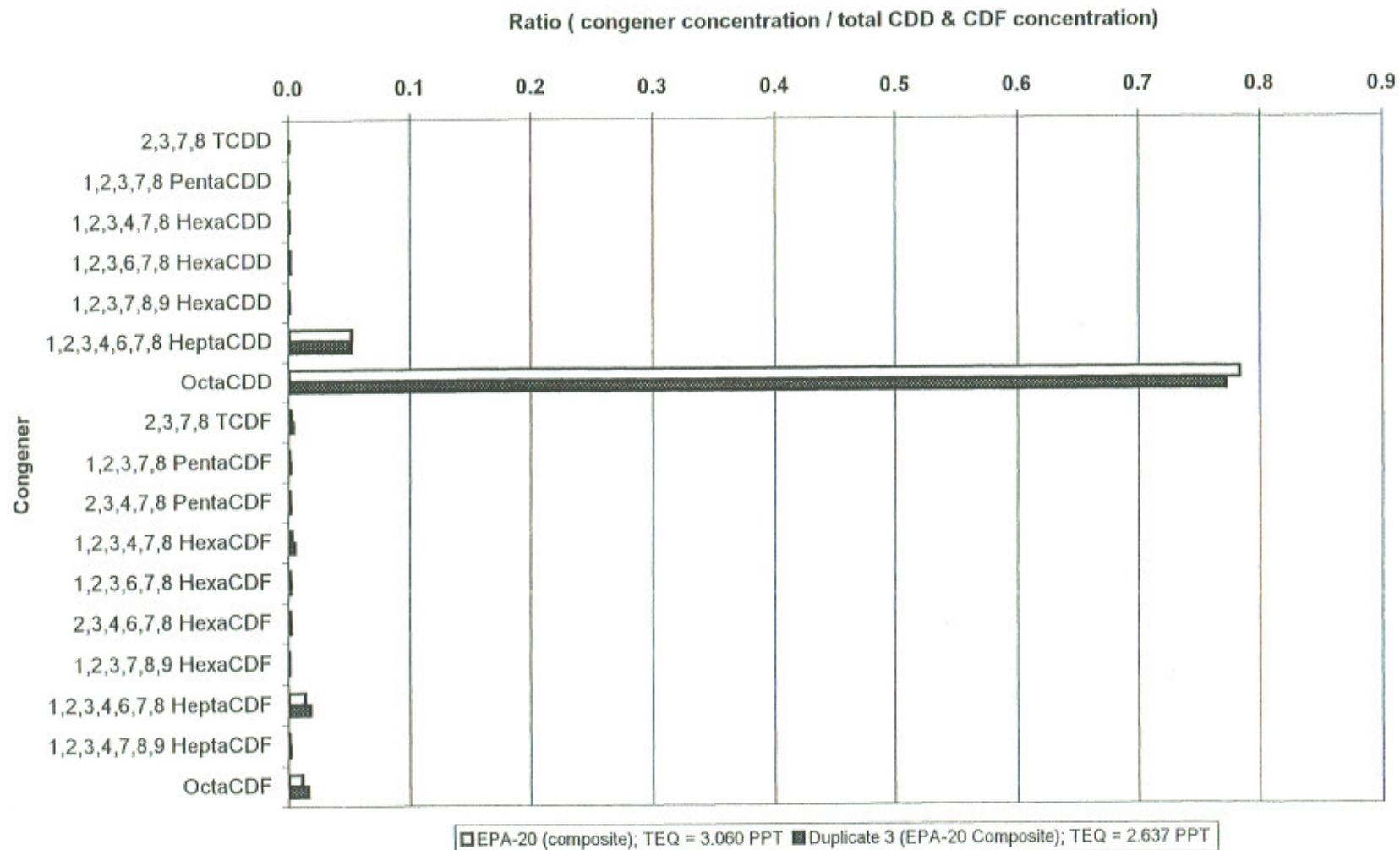
## Congener Profile Milepoint 306.9 (EPA-13)



## Congener Profile Milepoint 298.9 (EPA-14)

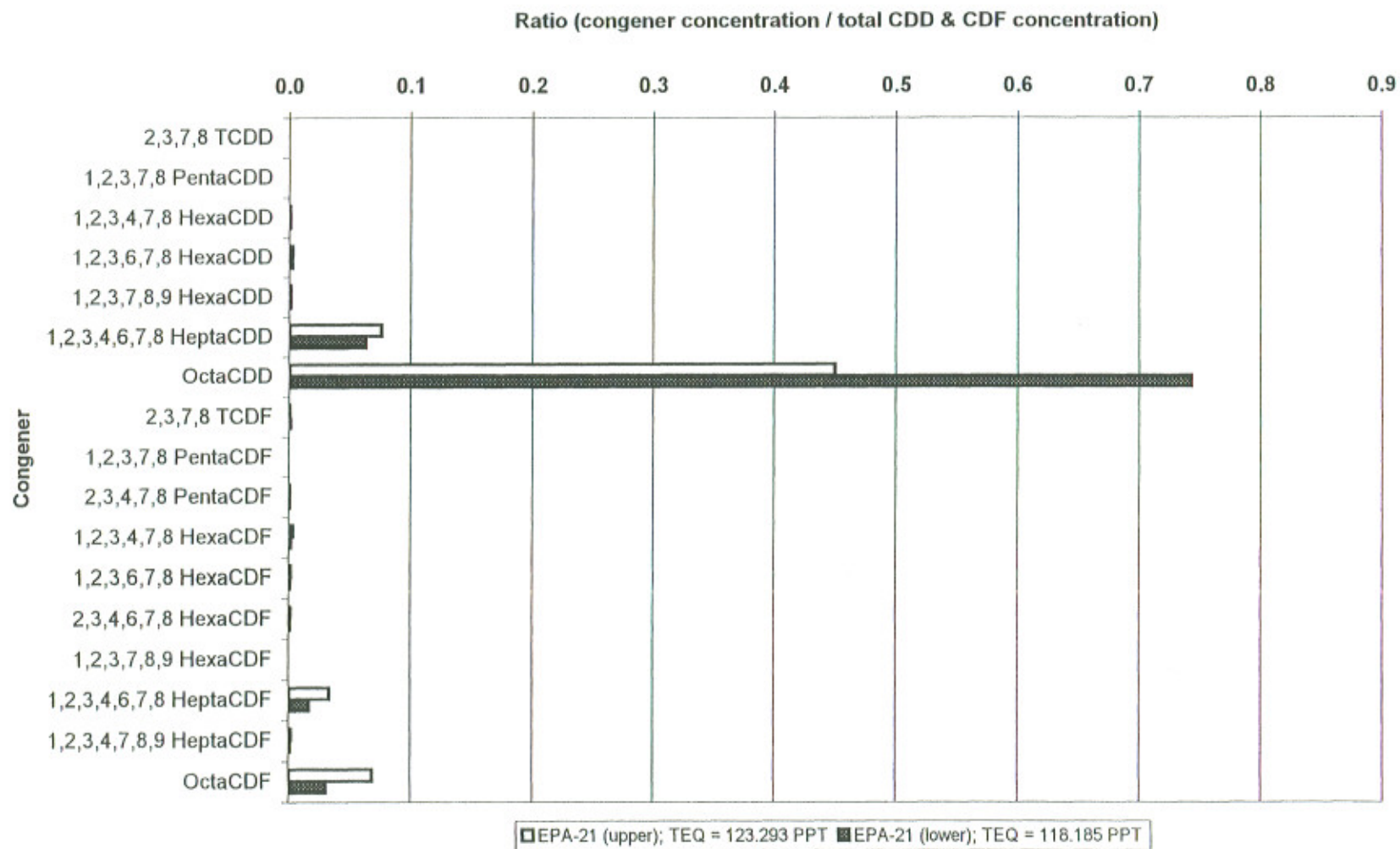


## Congener Profile Milepoint 286.3 (EPA-20)

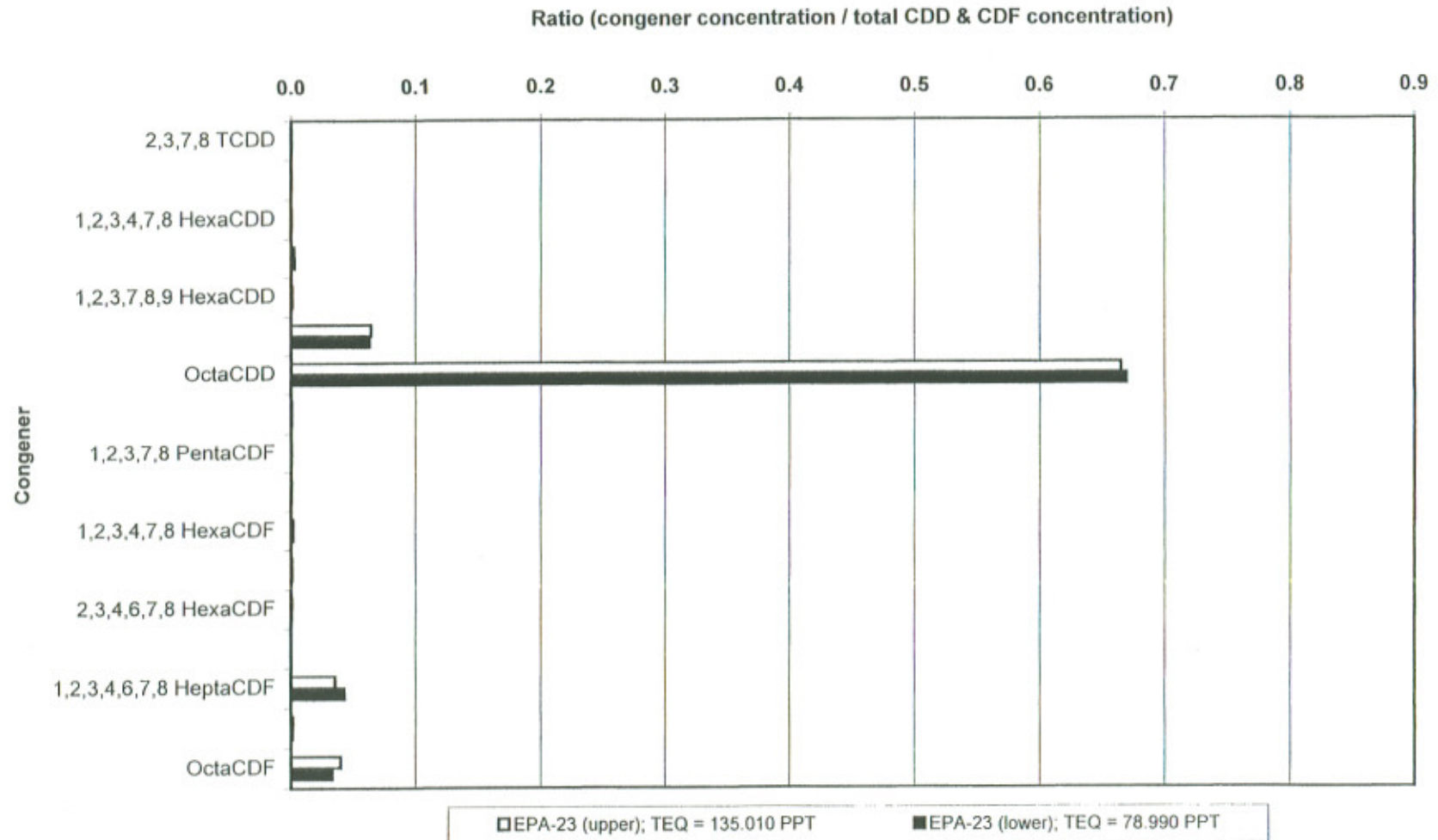




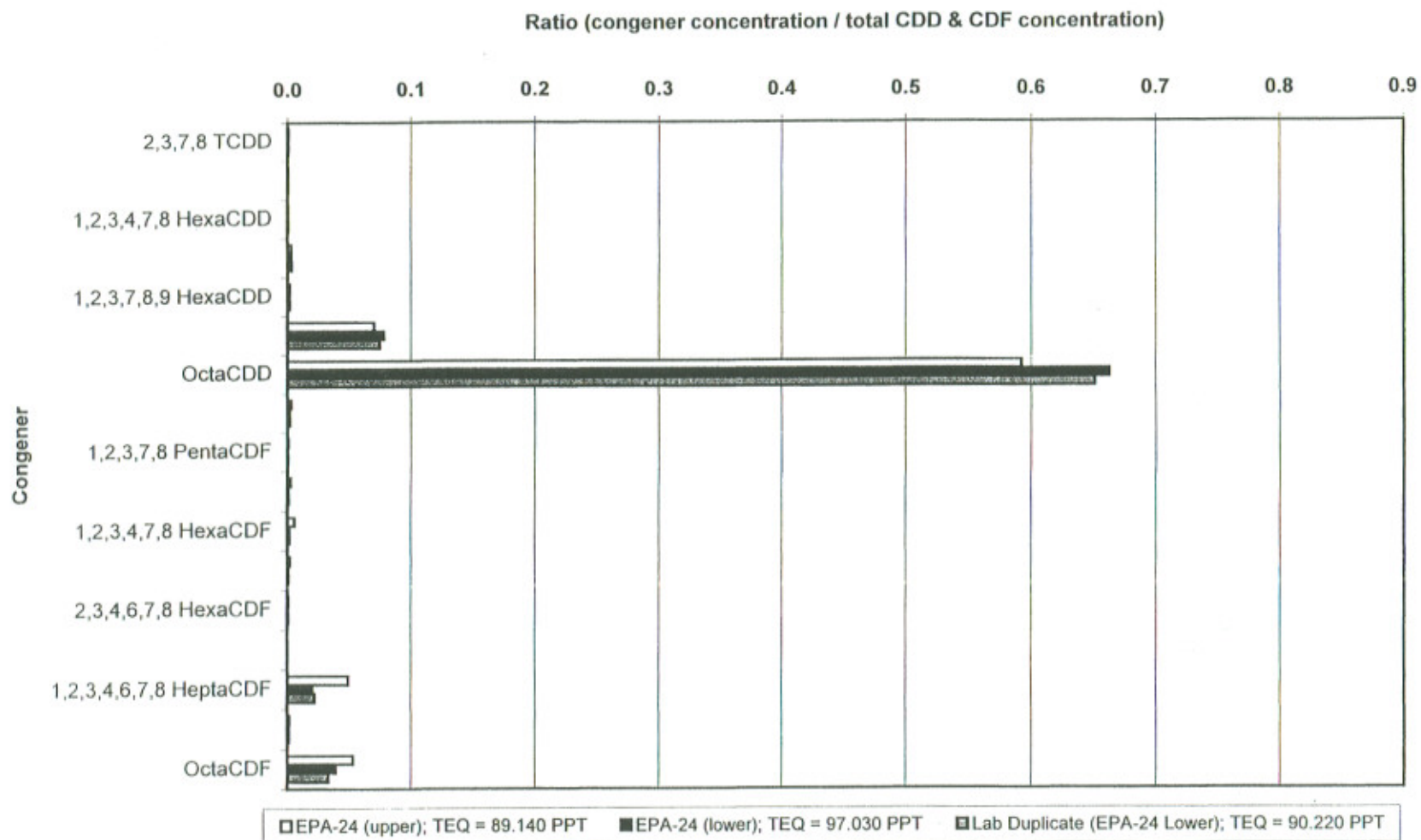
## Congener Profile Milepoint 280.0 (EPA-21)



## Congener Profile Milepoint 269.5 (EPA-23)

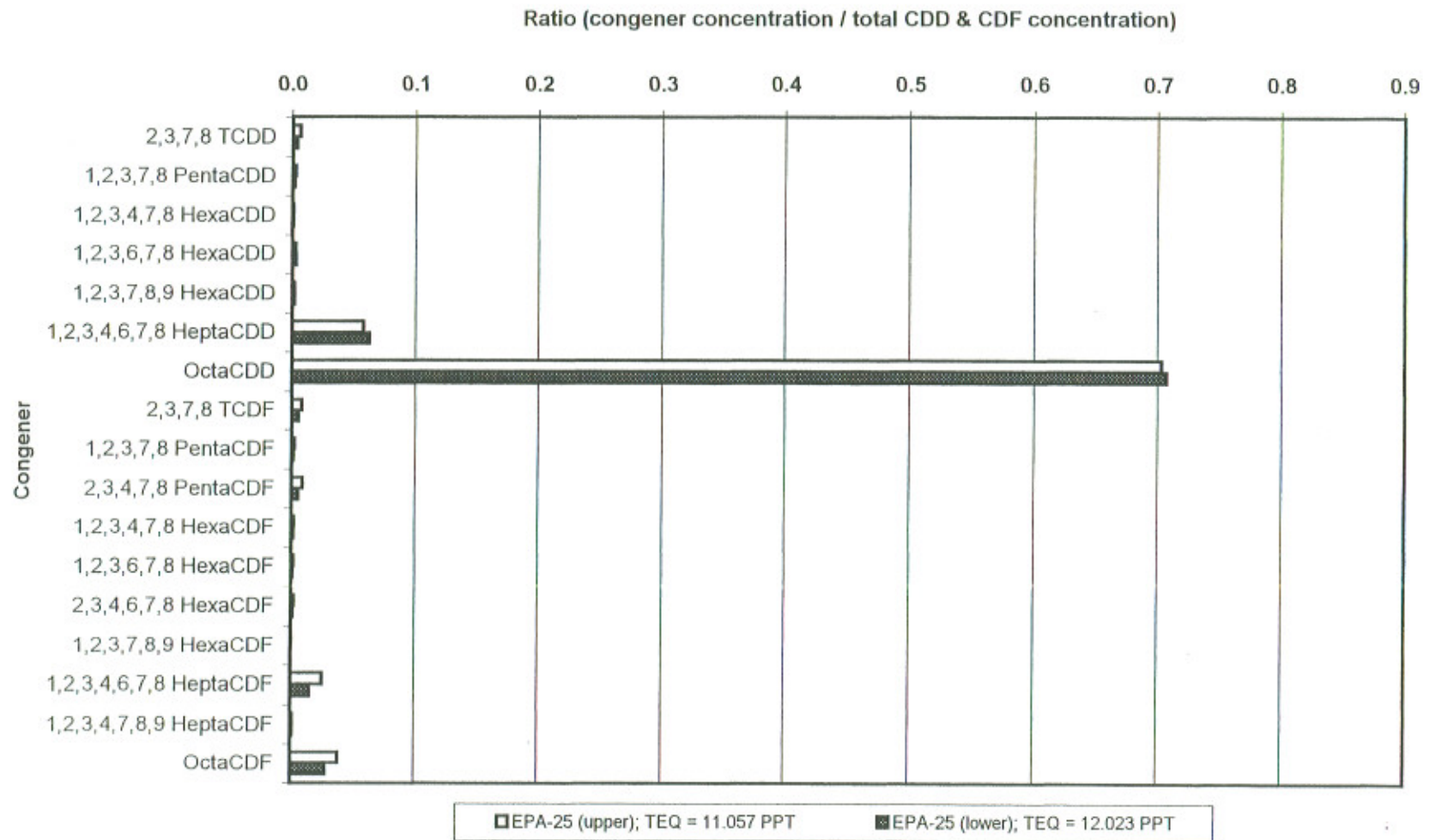


## Congener Profile Milepoint 261.8 (EPA-24)





## Congener Profile Milepoint 261.2 (EPA-25)

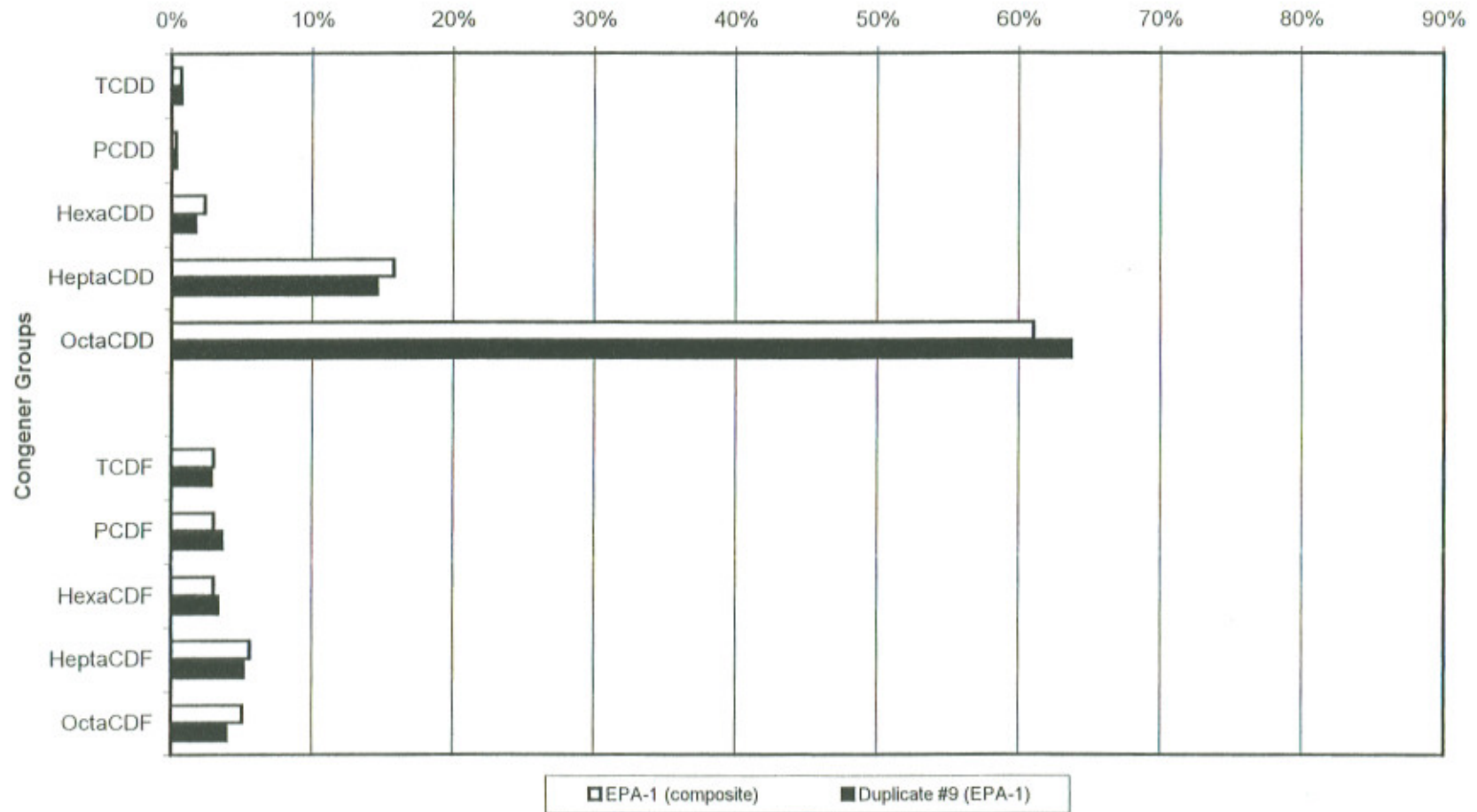


## Appendix D

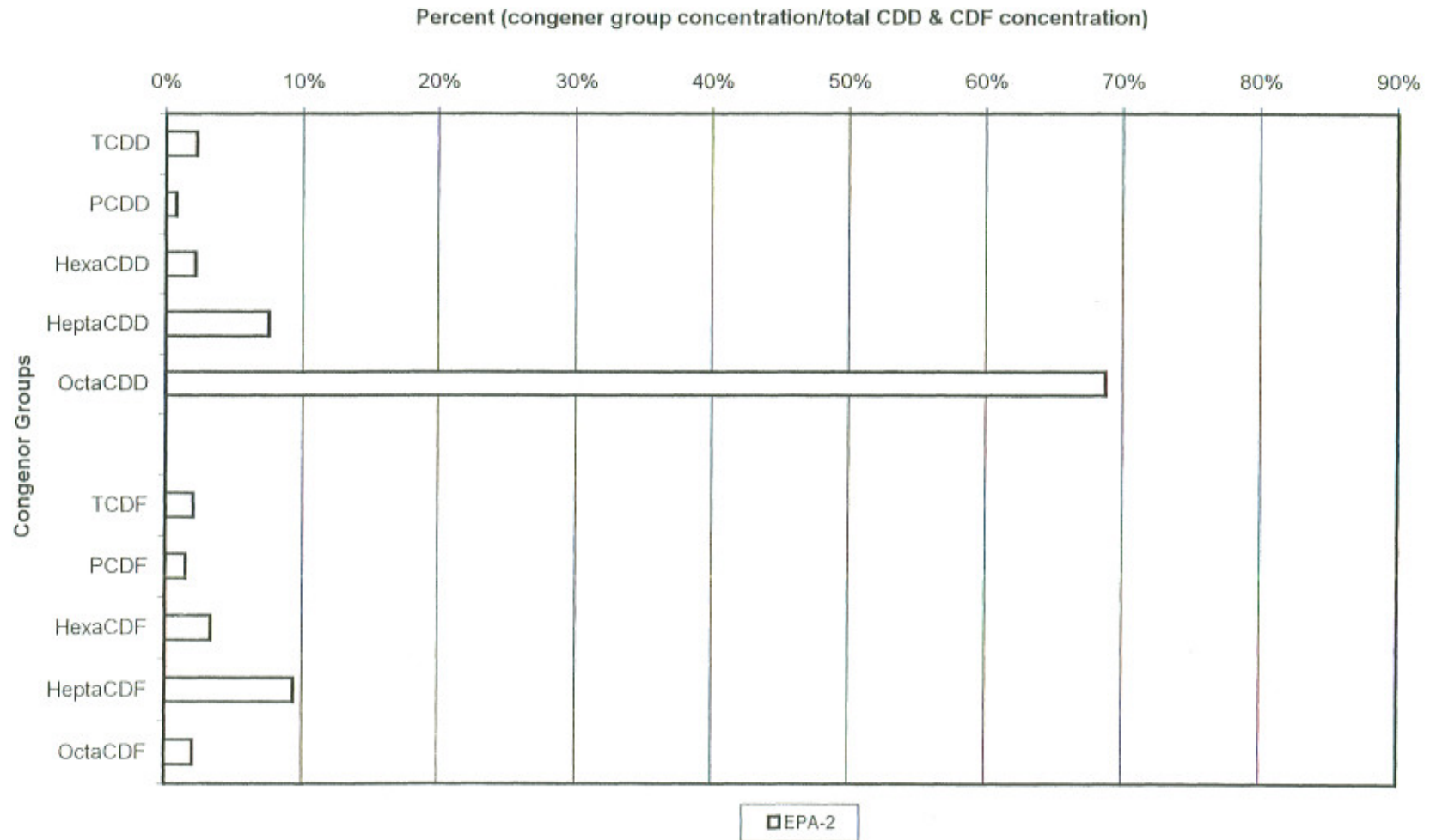
### Homolog Group Profiles

## Site EPA-1 and Blind Duplicate #9

Percent (congener group concentration/total CDD & CDF concentration)



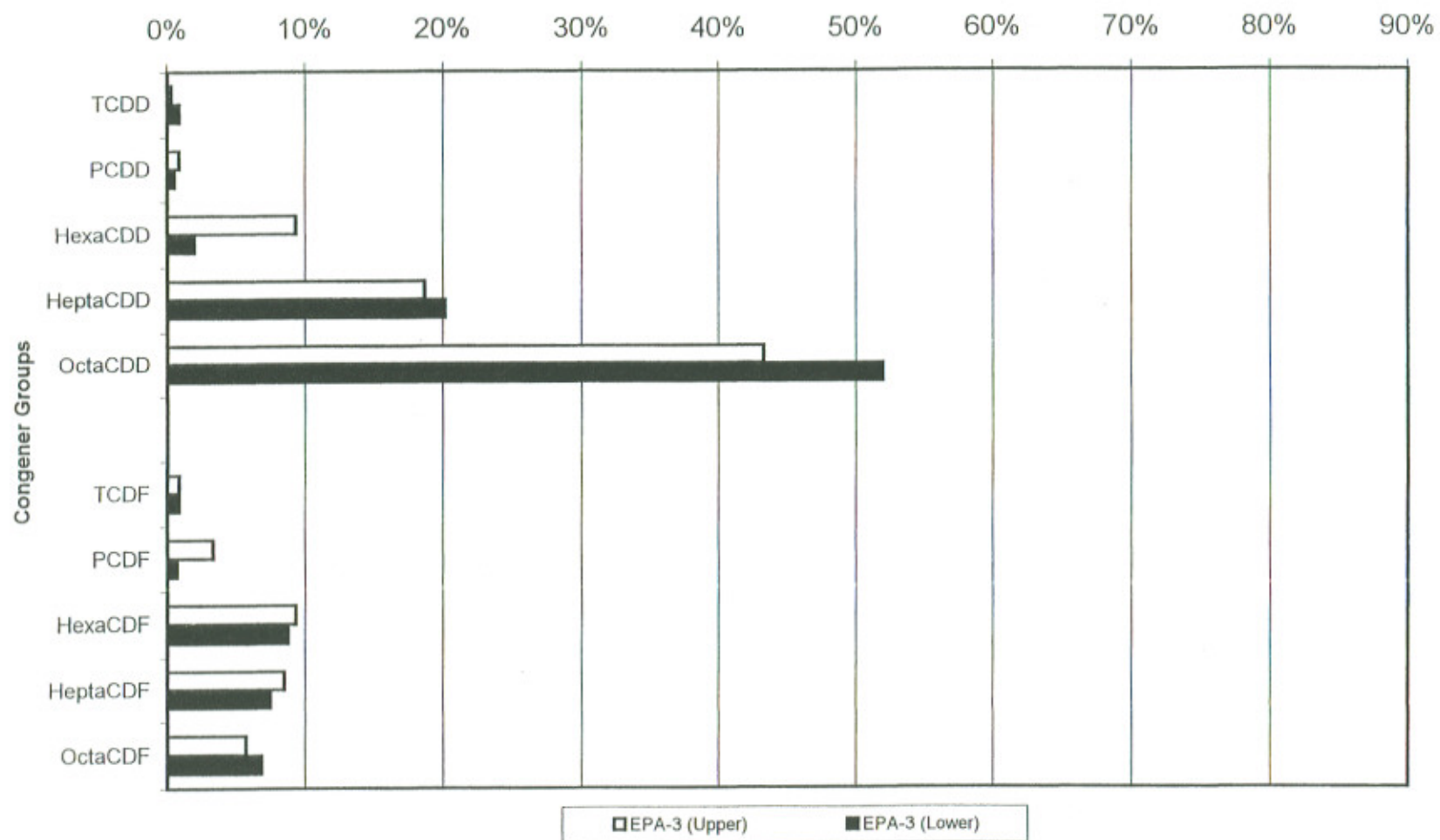
## Site EPA-2 (Composite)



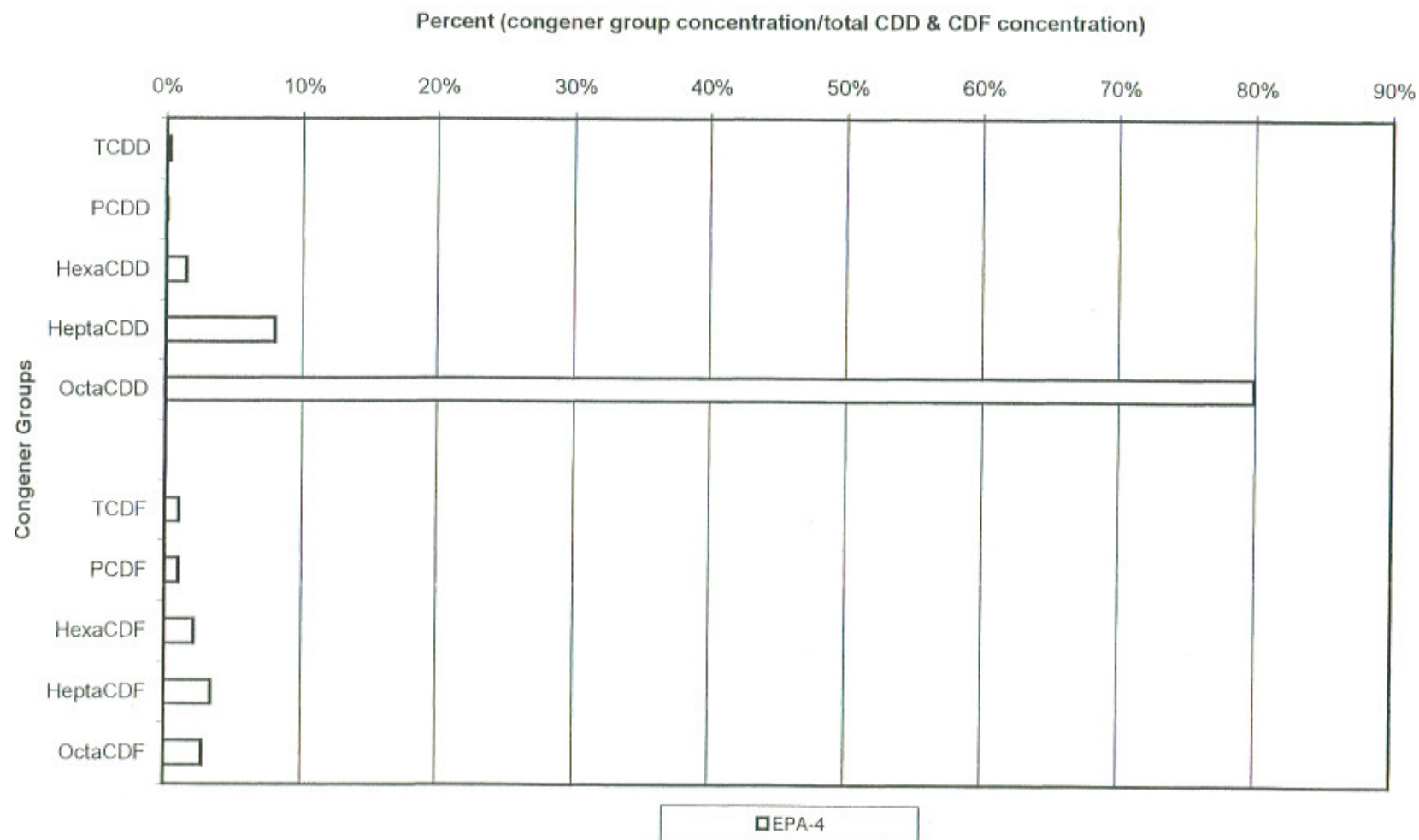


## Site EPA-3 (Upper and Lower Core Sections)

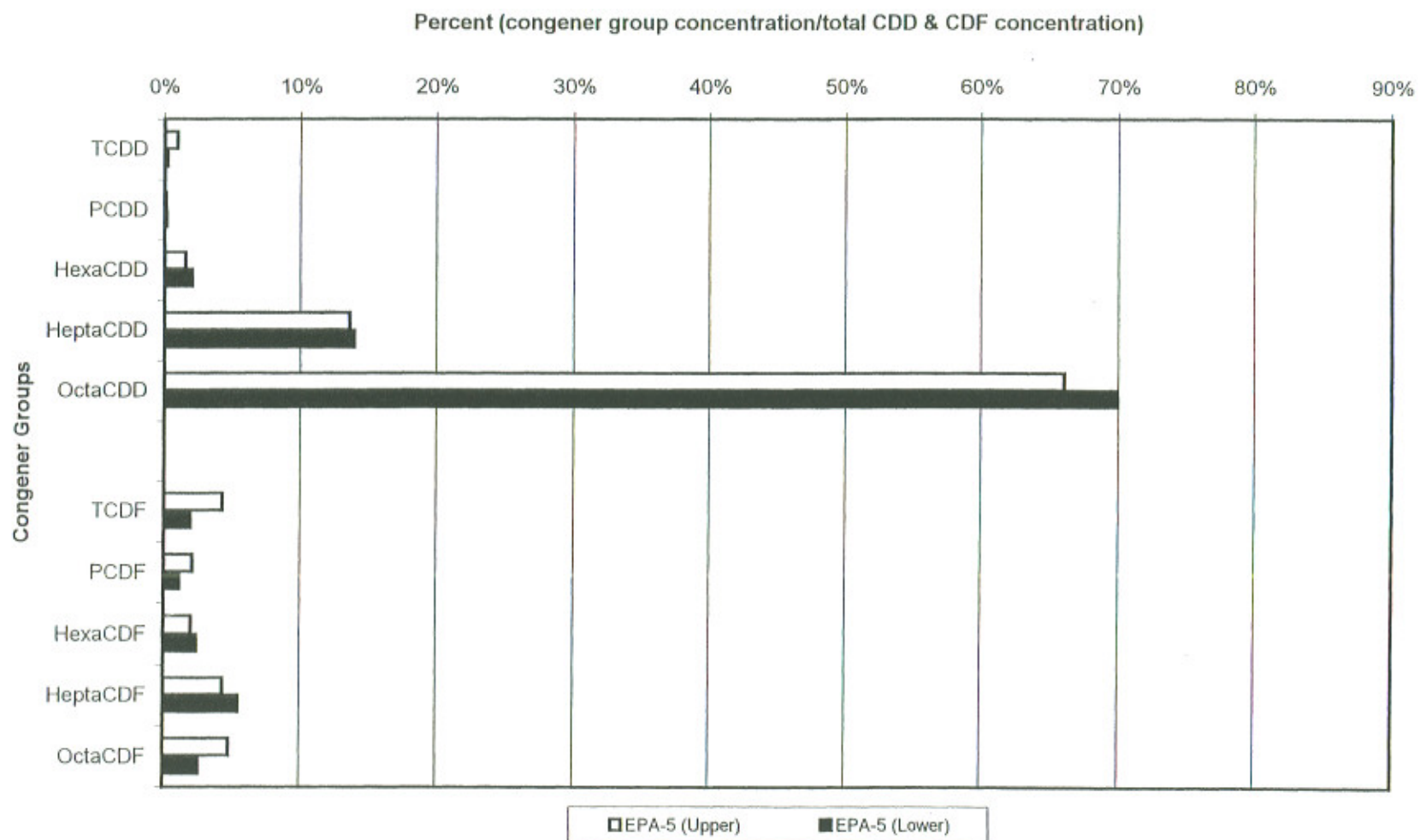
Percent (congener group concentration/total CDD & CDF concentration)



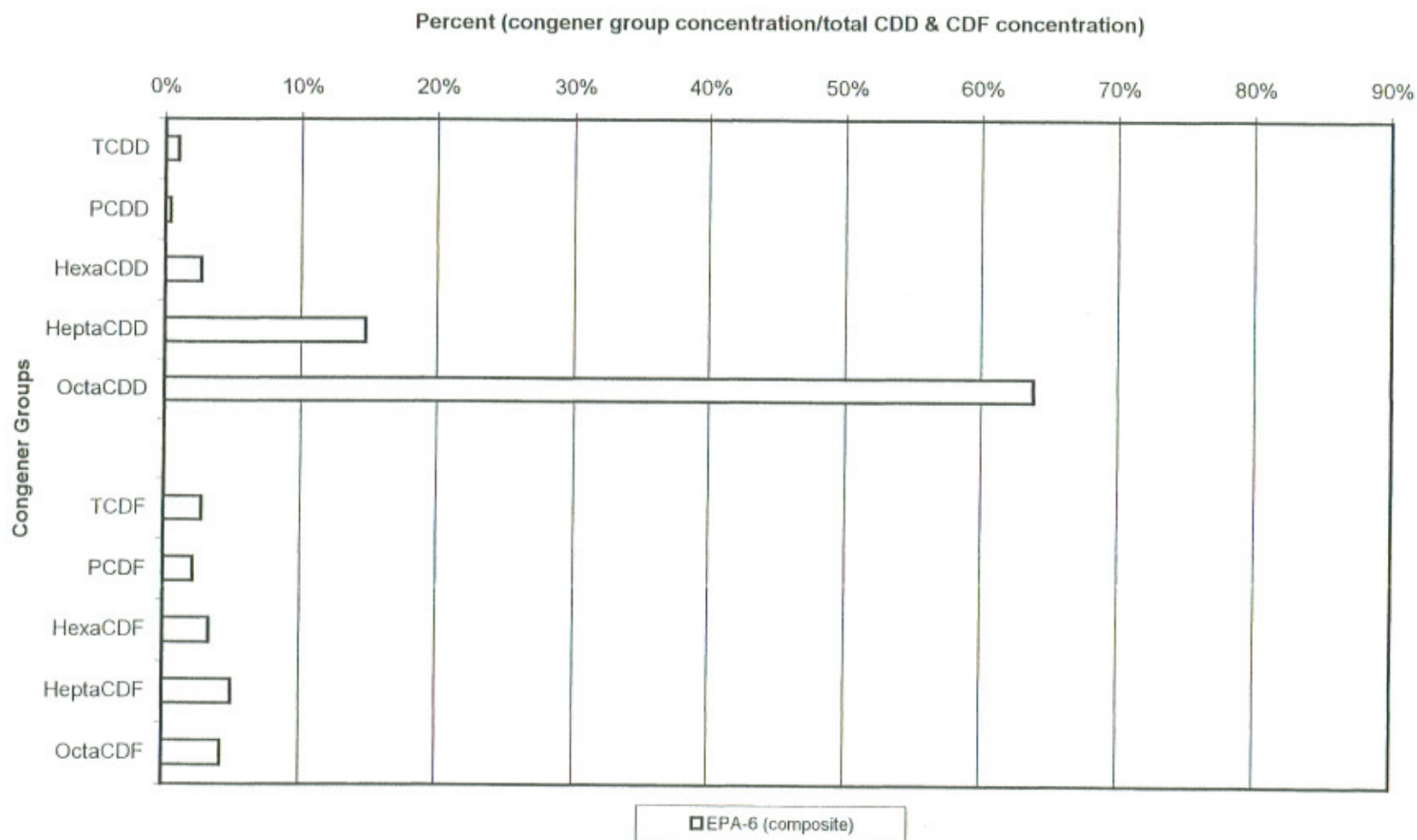
## Site EPA-4 (Composite)



## Site EPA-5 (Upper and Lower Core Sections)

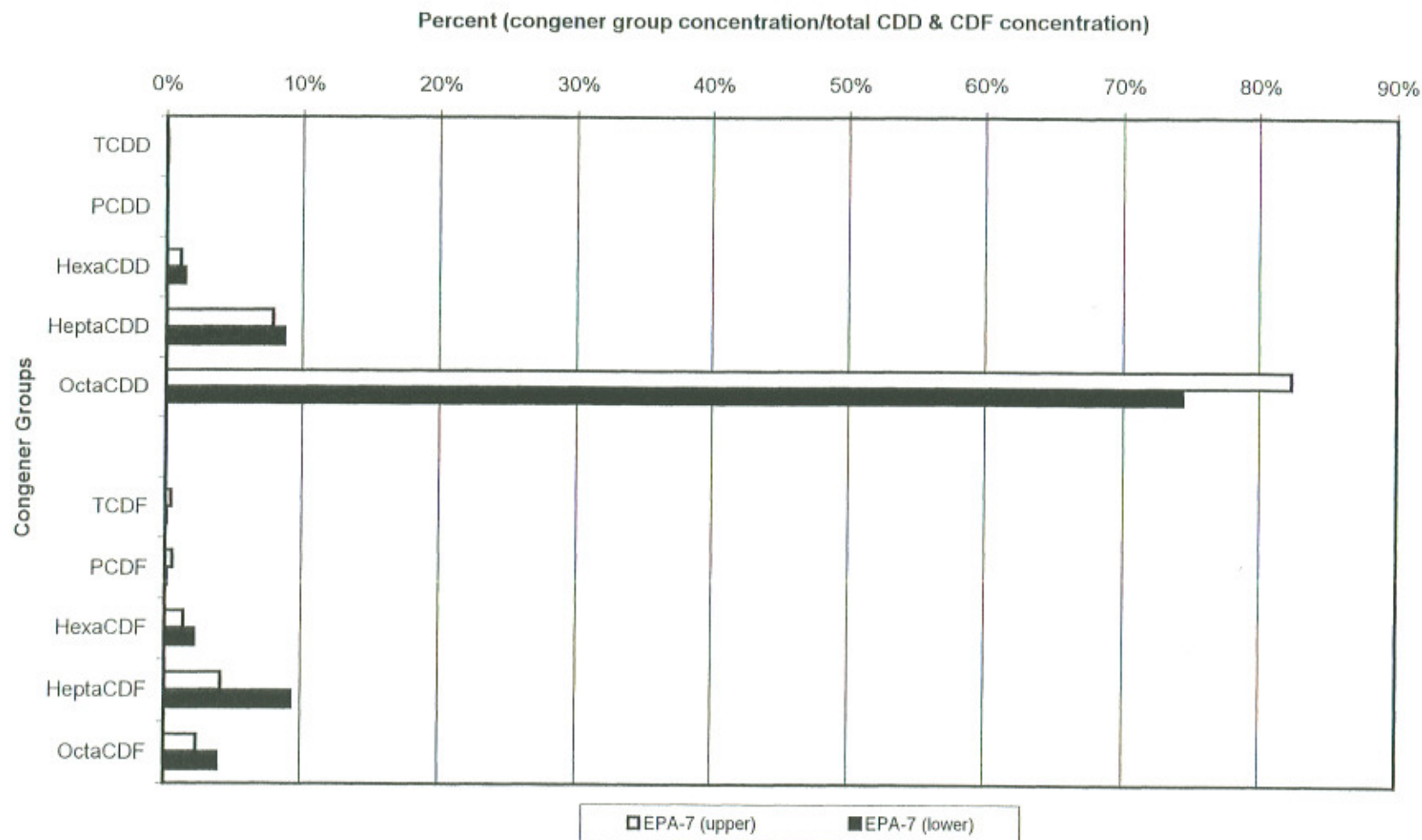


## Site EPA-6 (Composite)

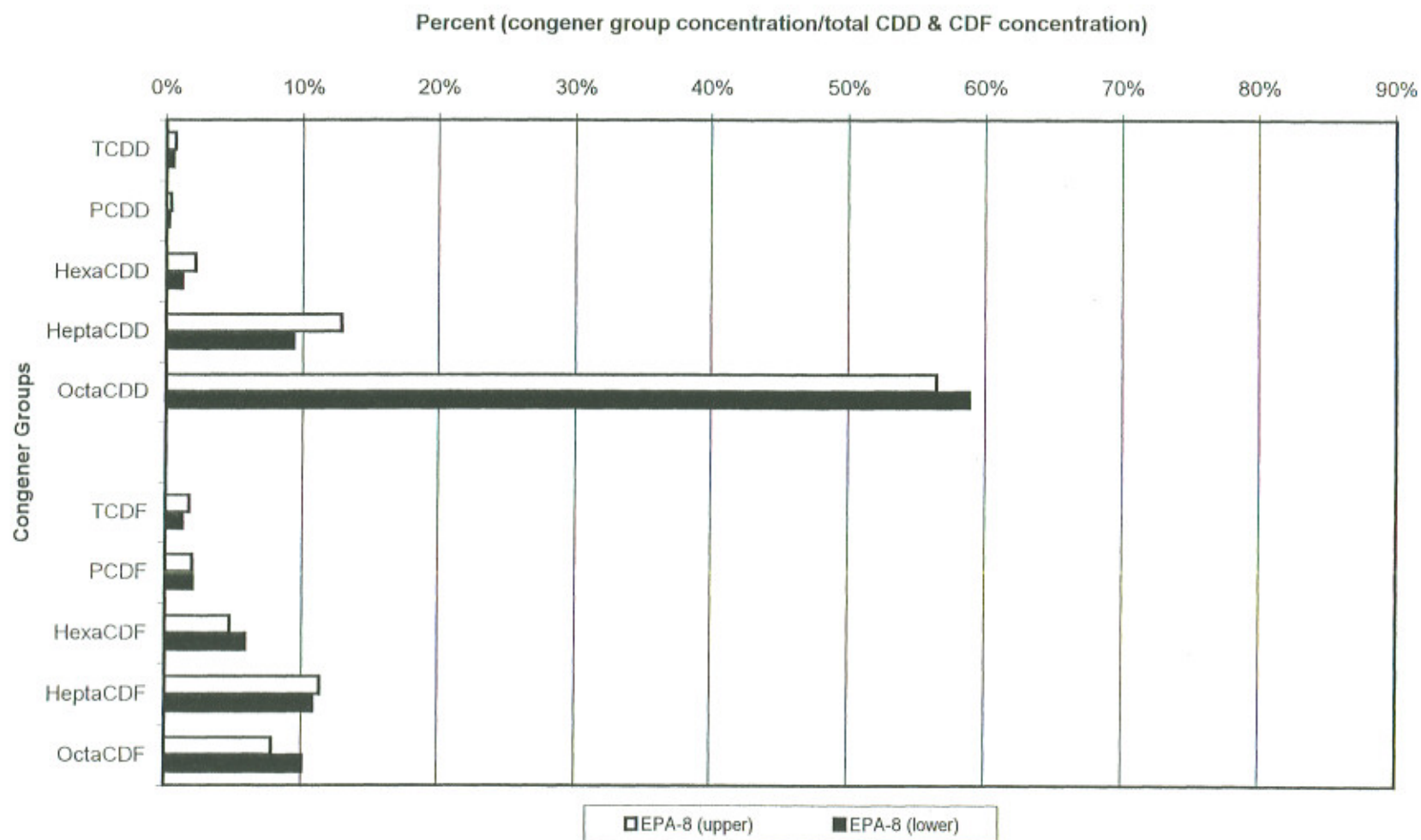




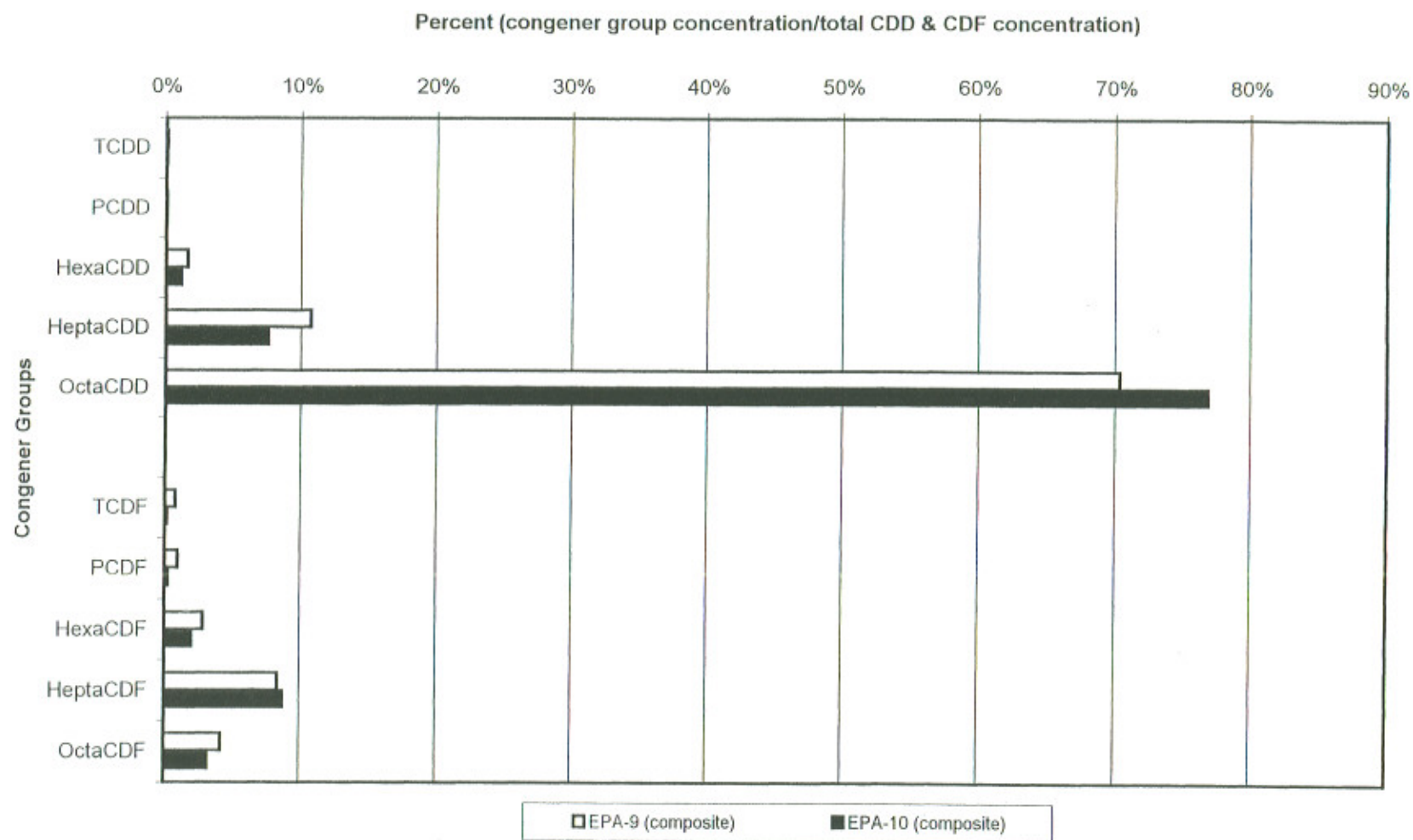
## Site EPA-7 (Upper and Lower Core Sections)



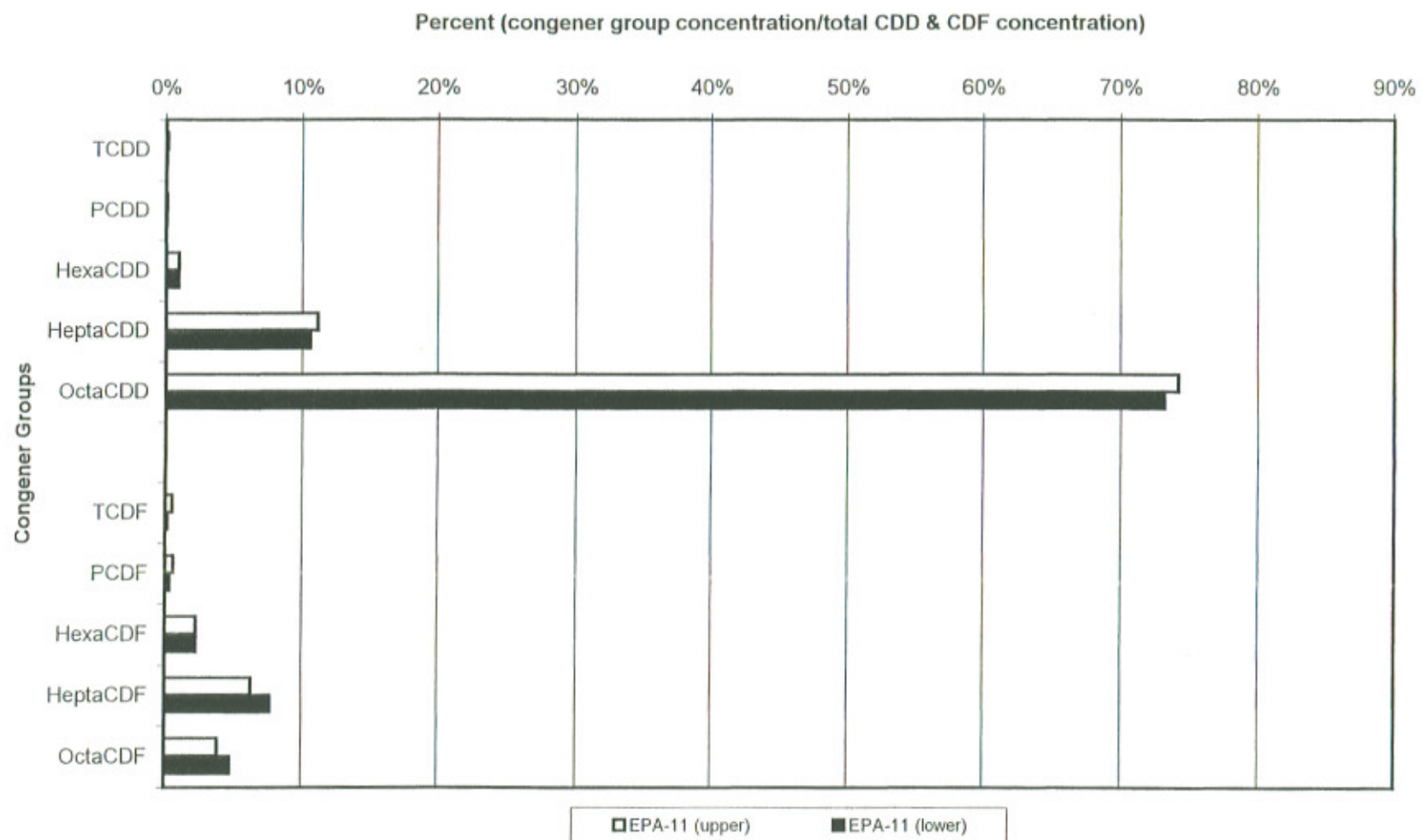
## Site EPA-8 (Upper and Lower Core Sections)



## Site EPA-9 (Composite) and EPA-10 (Composite)

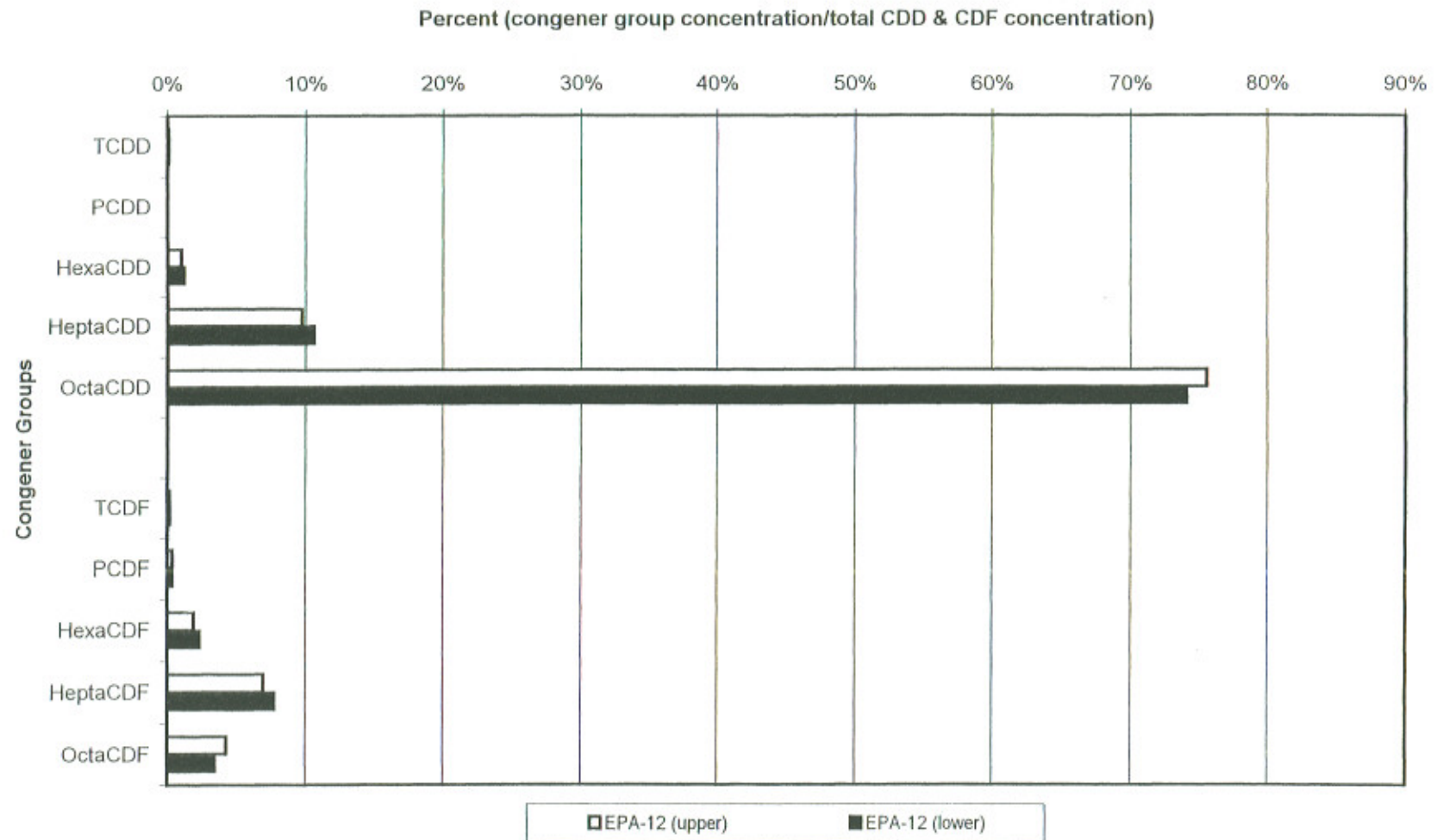


## Site EPA-11 (Upper and Lower Core Sections)

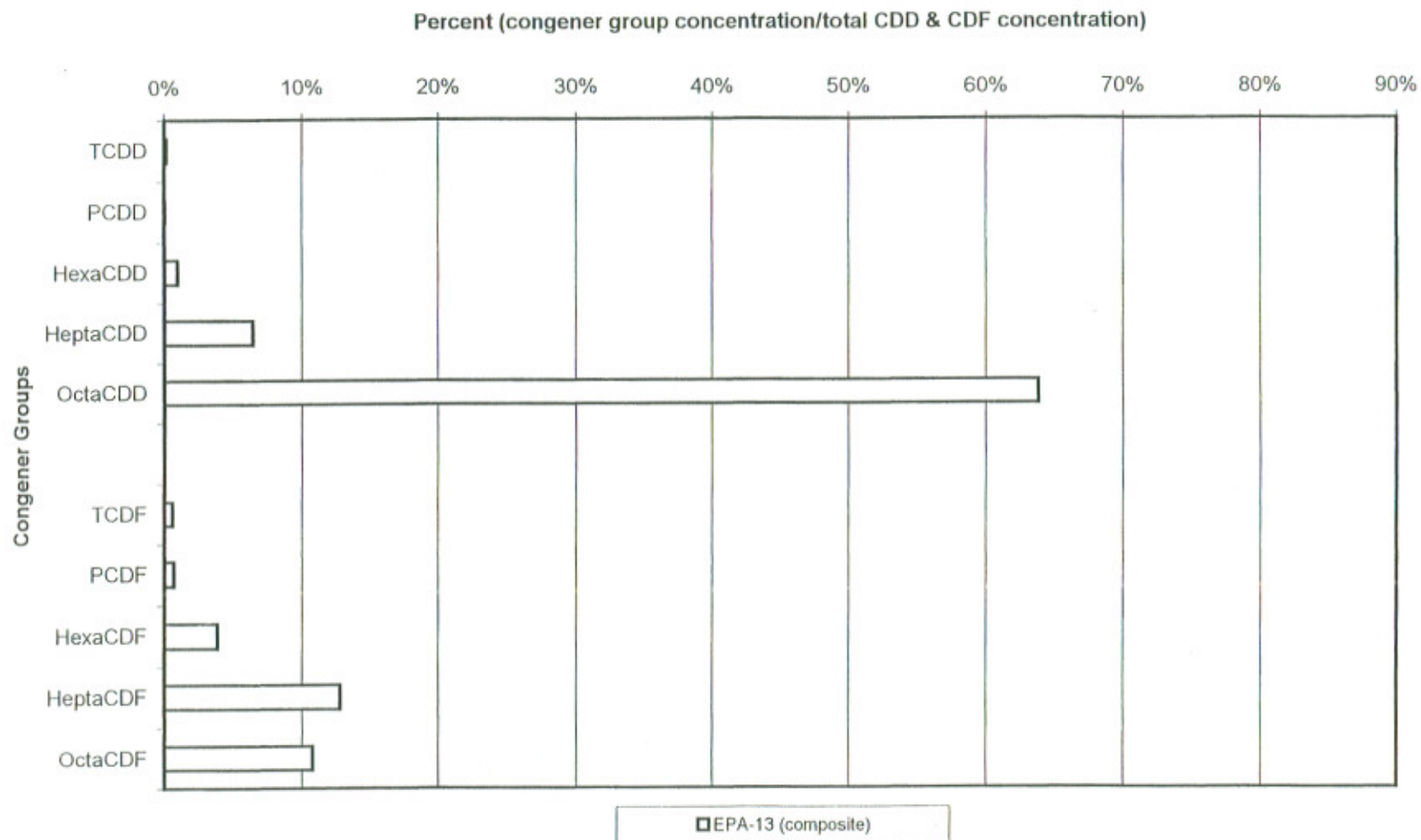




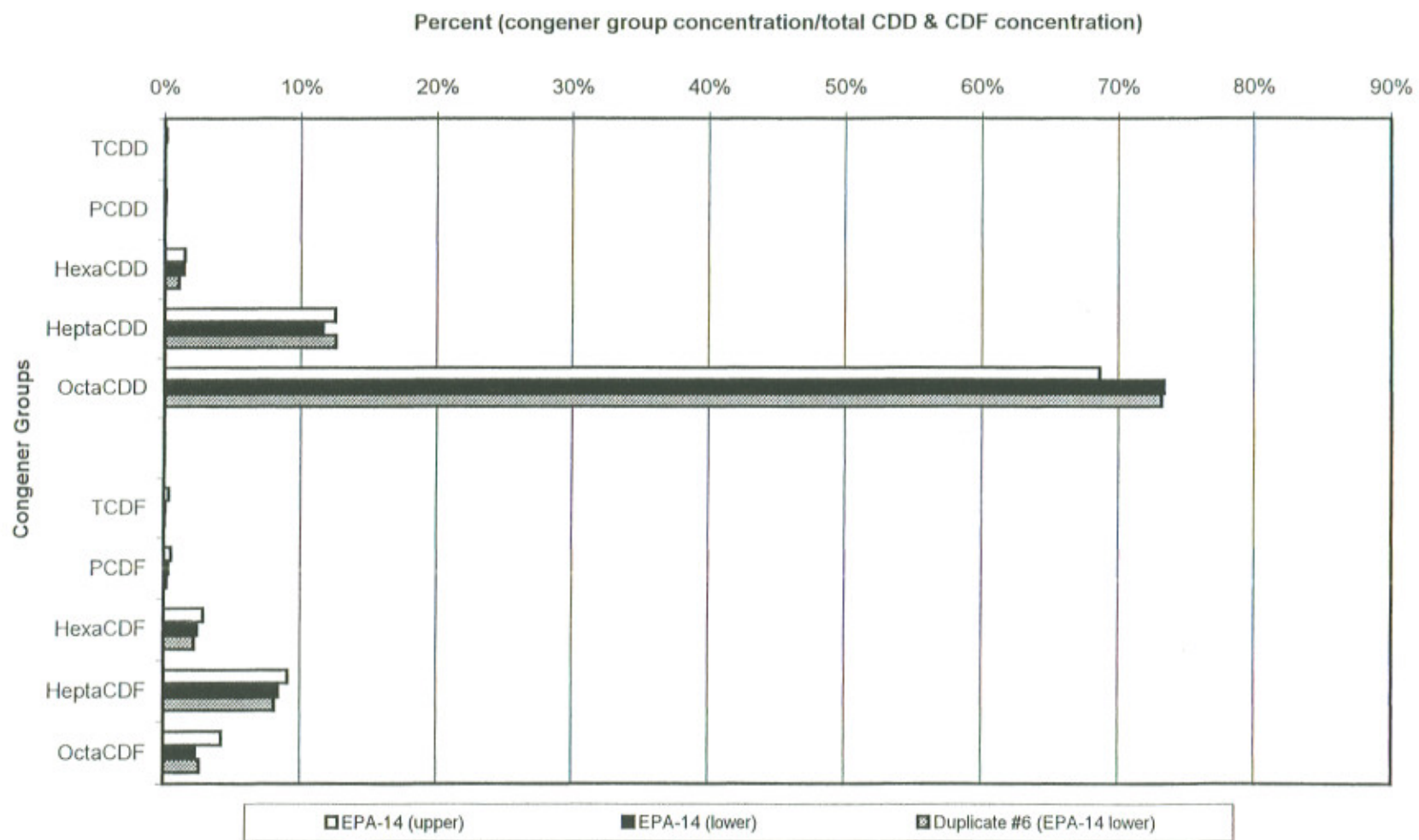
## Site EPA-12 (Upper and Lower Sections of Core)



## Site EPA-13 (composite)

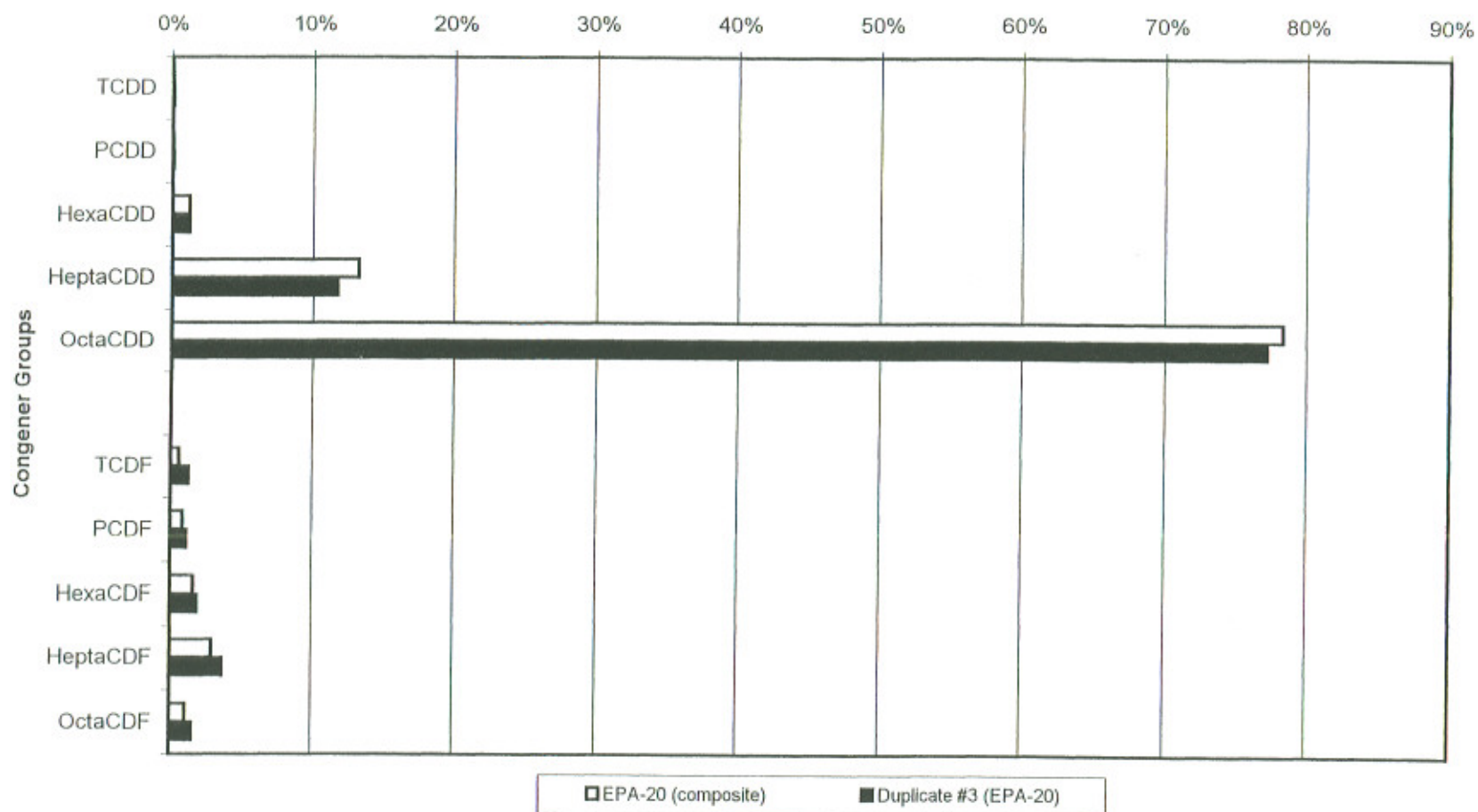


## Site EPA-14 (Upper and Lower Core Sections)



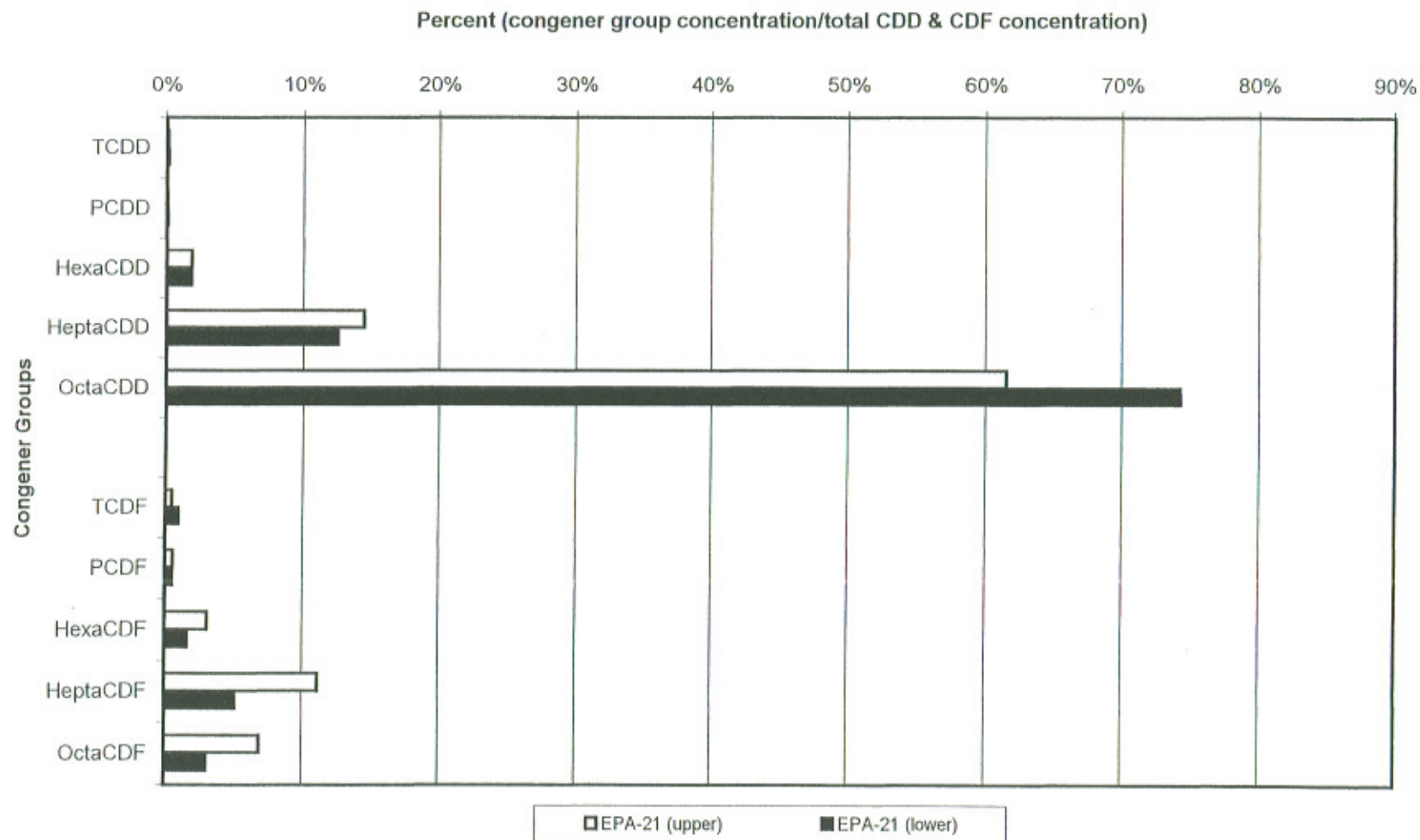
## Site EPA-20 and Blind Duplicate #3

Percent (congener group concentration/total CDD & CDF concentration)

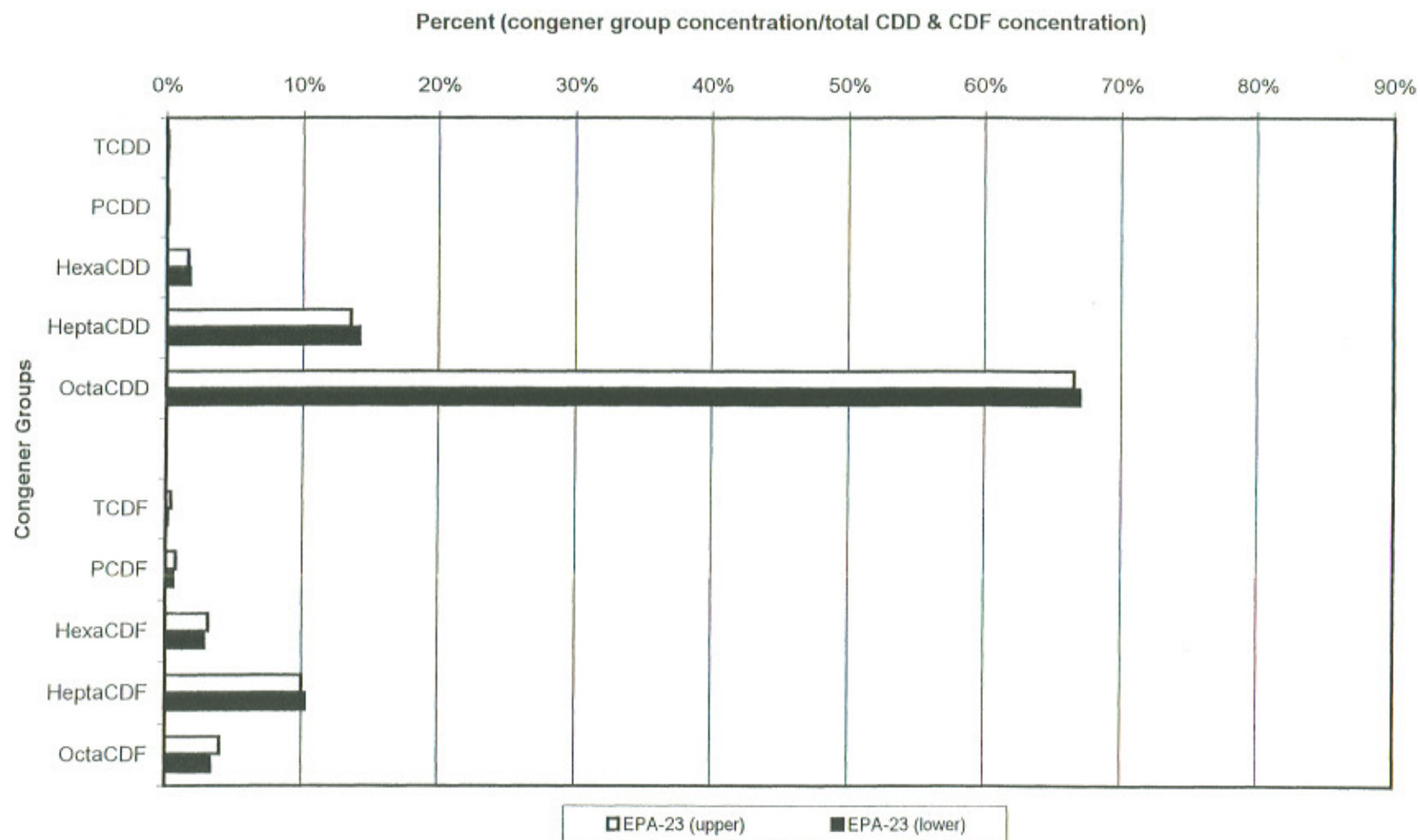




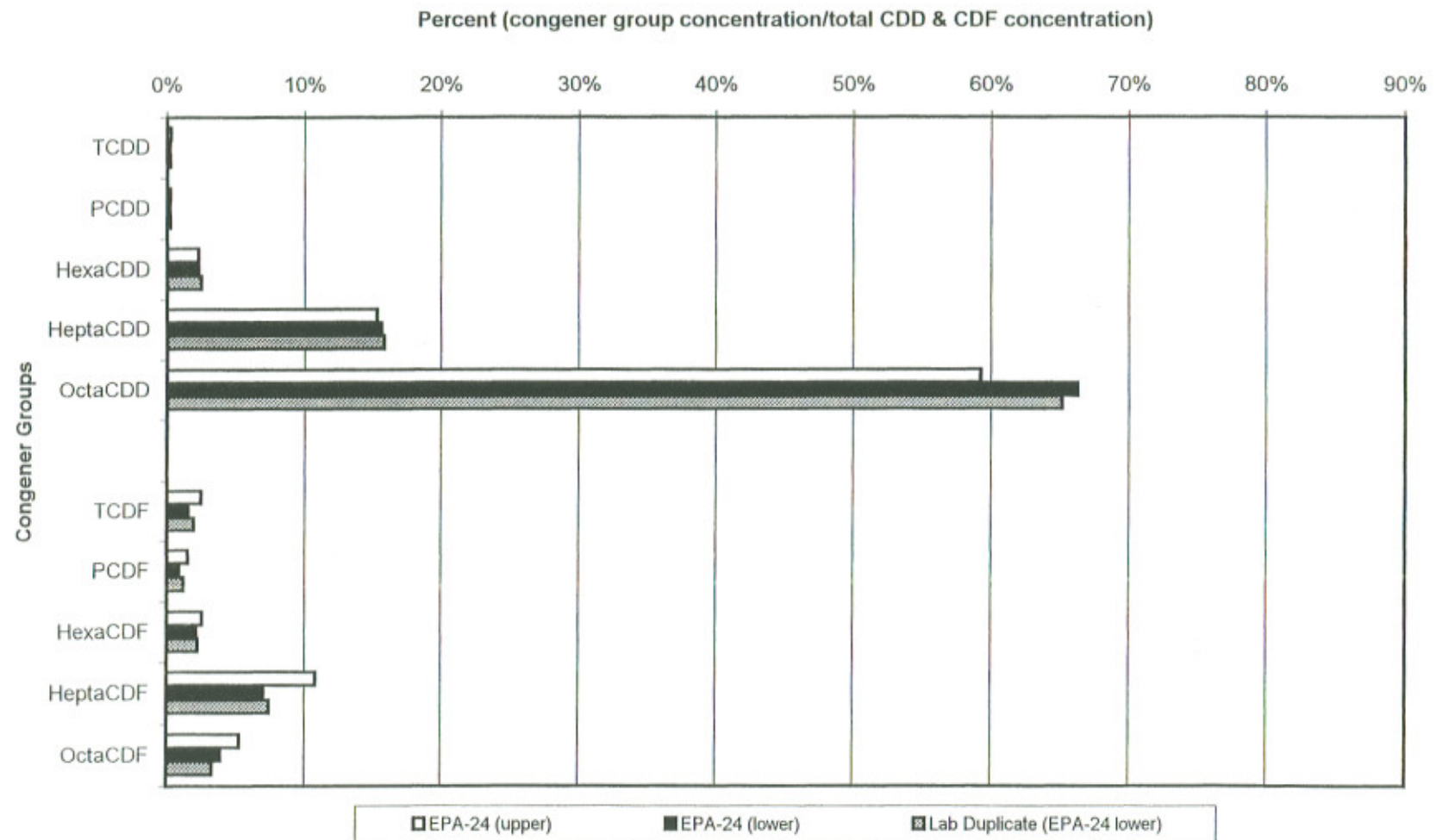
## Site EPA-21 (Upper and Lower Core Sections)



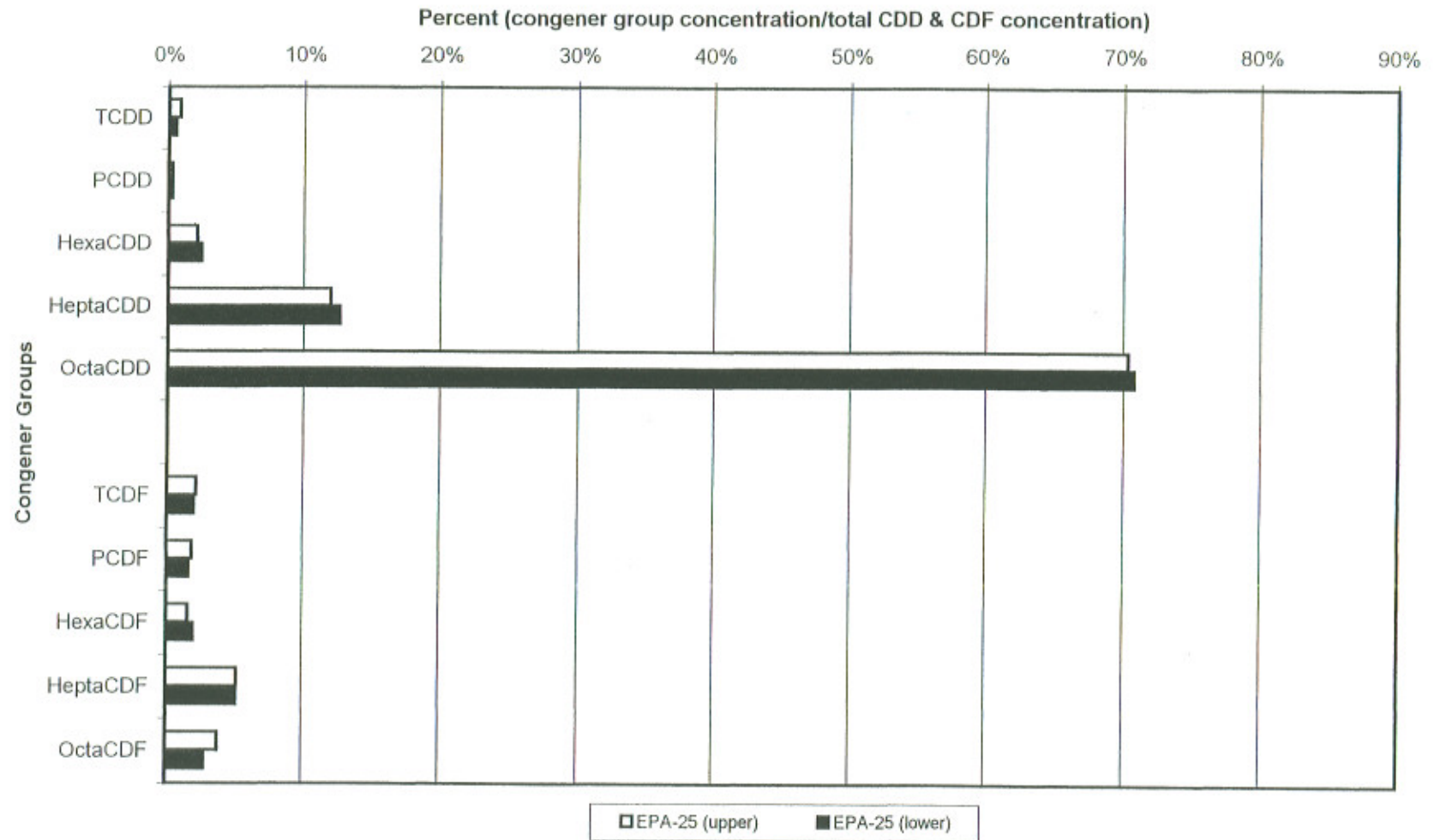
## Site EPA-23 (Upper and Lower Core Sections)



## Site EPA-24 (Upper and Lower Core Sections)



## Site EPA-25 (Upper and Lower Core Sections)





# Appendix E

## Radionuclide Dating of Sediment Cores

RPI Data Package

**Radionuclide Dating of Sediment Cores**

**Under USEPA Grant # GL985364-01-0  
Contaminated Sediment Evaluation – Erie Canal**

Submitted to:

John Dergosits  
Canal Environmental Engineer  
New York State Thruway Authority  
New York State Canal Corporation  
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Submitted by:

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3 AUGUST 1999

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# COVER PAGE

EPA1 0-2cm	EPA8 0-2cm	EPA14 0-2cm
EPA1 12-16cm	EPA8 2-4cm	EPA14 12-16cm
	EPA8 4-6cm	
EPA3 0-2cm	EPA8 6-8cm	EPA21 0-2cm
EPA3 12-16cm	EPA8 8-12cm	EPA21 2-4cm
	EPA8 12-16cm	EPA21 4-6cm
EPA5 0-2cm	EPA8 20-24cm	EPA21 6-8cm
EPA5 12-16cm	EPA8 24-28cm	EPA21 8-12cm
		EPA21 12-16cm
EPA7 0-2cm	EPA9 0-2cm	EPA21 16-20cm
EPA7 2-4cm	EPA9 2-4cm	EPA21 20-24cm
EPA7 4-6cm	EPA9 4-6cm	EPA21 24-28cm
EPA7 6-8cm	EPA9 6-8cm	EPA21 28-32cm
EPA7 8-12cm	EPA9 8-12cm	EPA21 32-36cm
EPA7 12-16cm	EPA9 12-16cm	EPA21 36-40cm
EPA7 16-20cm	EPA9 16-20cm	EPA21 40-44cm
EPA7 20-24cm	EPA9 20-24cm	
EPA7 24-28cm	EPA9 24-28cm	EPA23 0-2cm
EPA7 28-32cm	EPA9 28-30cm	EPA23 12-16cm
EPA7 32-36cm		
EPA7 36-40cm	EPA11 0-2cm	EPA24 0-2cm
	EPA11 2-4cm	EPA24 2-4cm
EPA7A 0-2cm	EPA11 4-6cm	EPA24 4-6cm
	EPA11 6-8cm	EPA24 6-8cm
	EPA11 8-12cm	EPA24 8-12cm
	EPA11 12-16cm	EPA24 12-16cm
	EPA12 0-2cm	EPA25 0-2cm
	EPA12 12-16cm	EPA25 12-16cm

I certify that this data package is complete and accurate. Release of the data contained in this data package has been authorized by the Laboratory Director or the Director's designee, as verified by the following signature:

Signature: Richard F. Bopp Name: Richard F. Bopp  
Date: 8/3/99 Title: Lab Director



## NARRATIVE

### 1. Sample Receipt:

All samples were collected and delivered to Richard Bopp at RPI by John Dergosits of the NYS Thruway Authority.

### 2. Sample Analysis:

Sub-samples of sediment core sections were dried in a hood under a heat lamp. They were ground in a mortar with a pestle and transferred to plastic vials for gamma counting.

The sub-samples were analyzed for  $^{137}\text{Cs}$  and  $^{40}\text{K}$ . Core-top sections that had not "aged" more than a few months were also analyzed for the short-lived radionuclide,  $^7\text{Be}$ . Radionuclide activities are reported in units of picocuries per kilogram (pCi/kg). One picocurie is equivalent to 2.22 decays per minute.

All dates for gamma counting are reported as Julian dates.

Examples:

98001 = January 1, 1998

97365 = December 31, 1997

### 3. Instrument Calibration:

Radionuclide measurements were carried out using a gamma counter with an intrinsic germanium detector. Blank corrections were applied to each sample based on the analysis of empty sample containers. Background corrections were applied to each radionuclide based on the sample count rate at energies just above and just below each peak of interest. Detector efficiency was calibrated using an NBS sediment standard (River sediment NBS 4350B), a liquid NBS standard (NBS 4953-C) that was used to prepare spiked sediments (G-standards), and secondary standards (D-standards) prepared at the Lamont-Doherty Earth Observatory and calibrated to NBS standards.

No major problems were encountered with the gamma counter. Results of analyses of standards and blanks (empty sample vials) are given later in this data package. Data on samples is reported with an error of  $\pm 1$  standard deviations based on counting statistics. Counting errors associated with nuclide peaks, background regions, and blanks are all included in the calculation of the reported standard deviation. One duplicate analysis (a second count of the same sample aliquot) was run for every twenty samples and the results are reported later in this data package.

#### **4. Additional Information**

Gamma counter log books, laboratory notebooks, and liquid nitrogen log sheets are kept at the laboratory and are available on request.

Raw data sheets are kept at the laboratory and are available on request as hard copy or on disk (Excel v 7.0 spreadsheet format).

### EPA 1

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	99	32	305	267	12765.3	966.7
12-16	43	39			11485.9	1187.1

### EPA 3

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	11	27	567	283	11328.8	933.0
12-16	-6	31			14488.7	1245.0

### EPA 5

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	-8	31	466	350	14985.6	1153.6
12-16	45	40			16247.1	1387.3

### EPA 7

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	157	47			20417.5	1579.8
2-4	182	49			19832.3	1573.3
4-6	77	50			19269.4	1656.4
6-8	140	63			18810.6	1836.7
8-12	425	68			13235.2	1474.0
12-16	309	58			13361.2	1377.5
16-20	574	63			15281.2	1351.6
20-24	937	98			16321.0	1728.4
20-24 Dup	904	81			17617.4	1481.1
24-28	311	47			17352.1	1322.1
28-32	40	37			18206.1	1315.5
32-36	5	57			18068.0	1761.1
36-40	-16	53			14779.5	1598.1

### EPA 7A

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	175	54	-200	323	14071.9	1405.2

## EPA 8

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	132	35	1026	432	21169.5	1391.7
2-4	175	47	711	594	20972.0	1594.4
4-6	164	44	2679	4023	22092.3	1586.5
6-8	162	66			20039.0	1978.1
8-12	206	58			21933.2	1874.7
12-16	30	50			16392.6	1499.3
20-24	103	63			22523.9	2046.4
24-28	168	72			23471.6	2180.8

## EPA 9

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	763	57			12548.3	975.7
2-4	846	95			14157.8	1618.8
4-6	932	69			14592.7	1144.6
6-8	951	88			13530.6	1367.8
6-8 Dup	1107	102			14982.4	1553.4
8-12	829	78			10759.0	1192.3
12-16	285	52			9466.7	1100.3
16-20	135	33			12838.8	1040.9
20-24	9	25			11341.6	875.8
24-28	40	26			12854.9	978.8
28-30	-13	38			13354.4	1276.1

## EPA 11

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	209	45	-227	418	21685.4	1569.5
2-4	352	73			23646.7	2091.8
4-6	395	67			21958.5	1840.7
6-8	635	63			20924.3	1523.6
8-12	501	58			20501.1	1492.4
12-16	514	74			19865.0	1804.3
12-16 dup	656	65			18541.0	1458.8

## EPA 12

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	446	56	-3750	3281	19047.3	1490.5
12-16	457	76			22562.3	2000.8



### EPA 14

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	104	30	-182	298	13373.6	1034.3
12-16	-21	34			14605.3	1231.9

### EPA 21

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	214	43			15398.9	1238.1
2-4	185	56			19048.5	1690.3
4-6	263	53			19333.0	1596.7
6-8	324	41			15634.5	1158.4
8-12	736	63			21304.3	1471.3
12-16	1025	105			18831.5	1863.7
12-16 Dup	908	93			20068.7	1856.3
16-20	1120	80			18026.1	1319.6
20-24	1355	95			16831.2	1318.4
24-28	1752	126			18917.8	1621.1
28-32	1298	84			18057.4	1230.3
32-36	989	78			18196.3	1398.1
36-40	670	56			17957.6	1244.3
40-44	353	43			16344.1	1176.7

### EPA 23

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	130	41	8	580	16655.1	1355.0
12-16	-21	38			18220.2	1397.8

### EPA 24

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	262	49	90	616	17848.0	1448.1
2-4	250	46			20629.1	1483.1
4-6	391	61			20504.2	1669.3
6-8	298	47			19635.6	1470.5
8-12	432	62			18720.2	1578.6
12-16	503	67			21369.8	1762.8

### EPA 25

Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
0-2	-23	32	723	502	16547.0	1179.7
12-16	43	55			15702.3	1624.1

## Duplicates

Core	Depth Interval (cm)	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
EPA7	20-24	937	98			16321.0	1728.4
EPA7	20-24 Dup	904	81			17617.4	1481.1
EPA9	6-8	951	88			13530.6	1367.8
EPA9	6-8 Dup	1107	102			14982.4	1553.4
EPA11	12-16	514	74			19865.0	1804.3
EPA11	12-16 Dup	656	65			18541.0	1458.8
EPA21	12-16	1025	105			18831.5	1863.7
EPA21	12-16 Dup	908	93			20068.7	1856.3
ECPN	48-52	640	48			15985.9	1052.3
ECPN	48-52 dup	606	72			15745.3	1467.9

## Blanks

Count date	Cs-137 (pCi/kg)	1 $\sigma$	Be-7 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
97155	-2	27	-559	213	-105.8	414.2
98312	-6	29	-31	185	281.3	525.7
98341	-6	25	272	169	-86.9	454.8
99052	-3	29	-216	180	-174.4	503.8
99123	-41	25	11	164	7.6	455.1
99190	25	32	7	209	-120.4	561.5

## Standards

Standard	Count Date	Cs-137 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
G std	98314	608	74	12696.3	1299.8
G std	99141	568	58	15278.9	1146.2
G std	99156	557	58	14525.5	1119.8
G std	99209	597	65	14666.3	1197.0
Accepted Values:		571	36	14000	2200

Standard	Count Date	Cs-137 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
D-Std	97160	998412	50103	95708.0	8746.6
D-Std	98140	983404	49399	91897.9	9529.8
D-std	98337	941207	47189	77132.7	7324.2
D-Std	99118	1006258	50595	88458.7	10104.1
D std	99131	1006645	50614	87988.3	10182.4
D std	99152	1018169	51228	93709.8	10811.6
Dstd	99154	1014077	50949	87479.7	9652.7
D std	99197	997461	50136	80683.4	9583.4
Accepted Values:		1000000	100000	85000.0	12800.0

Standard	Count Date	Cs-137 (pCi/kg)	1 $\sigma$	K-40 (pCi/kg)	1 $\sigma$
NBS 4350B	98317	775	83	13959.3	1177.9
NBS 4350B	99154	846	77	14245.0	1079.6
Accepted Values:		784	50	14000	2200



## Data Interpretation

Cs-137 is a particle-associated radionuclide that first entered natural water systems in measurable amounts in the early 1950s with global fallout from the atmospheric testing of nuclear weapons. This fact yields a simple, but useful piece of dating information – any core section with detectable Cs-137 activity contains a significant component of particles deposited since about 1954. Cores that contain a continuous undisturbed record of sediment accumulation can be dated on the basis of their depth profile of Cs-137 activity. The deepest penetration of measurable Cs-137 activity corresponds to about 1954, while peak activity corresponds to 1963-4, the years of maximum global fallout. In an ideal core, the Cs-137 activity decreases smoothly from the mid 1960s peak toward the surface. In such a core, the top sample or two could contain detectable activity of Be-7.

Be-7 is a cosmic ray produced radionuclide that is supplied continuously from the atmosphere to the earth's surface. Because of its relatively short half-life (53.4 days), detectable activity of Be-7 is confined to upper core sections that contain a significant component of particles deposited within about 6 months to a year of core collection.

K-40 is a radioactive element that makes up about 0.01% of naturally occurring potassium. It is used as a compositional indicator. For example, since quartz sands are depleted in potassium relative to clay minerals, coarser sediments tend to have lower levels of K-40 than fine-grained sediments. A fairly constant level of K-40 throughout a core is a good sign, consistent with minimal compositional variability that can complicate interpretation of contaminant data.

All sections of cores EPA 7, 8 and 9 were counted. Only in the case of EPA 8 was the top section counted within 200 days of collection allowing reliable Be-7 analysis. The top section did have detectable Be-7, but the Cs-137 profile (see figure) did not allow for detailed dating. Low levels of Cs-137 were detected in all samples analyzed with the exception of the 12-16 cm section that also had the lowest level of K-40 suggesting a compositional difference.

Based on the Cs-137 profile (see figure), EPA 9 had recent (post 1954) sediment to about 20 cm. The small increase in Cs-137 levels between the surface and about 8 cm suggests that mixing had a significant influence at this site.

EPA 7 has an excellent Cs-137 profile that permits rather detailed dating. The deepest penetration of detectable Cs-137 (at about 30 cm) would correspond to deposition in about 1954. The well-defined maximum (at about 22 cm) identifies mid 1960s deposition. Both markers yield a net sedimentation rate of 0.6 to 0.7 cm/yr. This core is an excellent candidate for analyses to develop contaminant level chronologies. In an effort to unambiguously identify a 1999 time horizon at this site, core EPA 7A was collected and the top section was analyzed for Be-7 within a few weeks of sampling. The effort was not successful, as Be-7 was not detected.



A screening strategy was developed for the other cores. We first analyzed the 0-2 cm sections and the 12-16 cm sections. How to proceed was decided based on these results. Cores 1, 3, 5, 14, 23, and 25 were eliminated from consideration for further radionuclide analyses based on fact that Cs-137 was not detected in the 12-16 cm (and sometimes not even in the 0-2 cm) section.

Cores EPA 11, 12, 21, and 24 all had at least 16 cm of recent (post 1954) deposition based on the detection of Cs-137. All of the sections of core EPA 21 were analyzed and, based on the Cs-137 profile (see figure), this core contains sediment deposited from about the mid 1950s (the bottom section still had detectable Cs-137) to the date of collection. Analyses of sections from this core could be used to develop contaminant level chronologies.

Radionuclide analysis of additional sections of cores EPA 11, 12, and 24 is suggested. In each case, it is possible that complete Cs-137 profiles will allow for detailed dating interpretation and ultimately the development of contaminant level chronologies.

