INJURY DETERMINATION REPORT
HUDSON RIVER SURFACE WATER RESOURCES

HUDSON RIVER NATURAL RESOURCE DAMAGE ASSESSMENT

HUDSON RIVER NATURAL RESOURCE TRUSTEES

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF THE INTERIOR

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DECEMBER 2008

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Acronyms and Abbreviations

C.A.R.P.	Contaminant Assessment and Reduction Project
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. 9601 *et seq.* (2008)
CWA	Clean Water Act, 33 U.S.C. 1251 *et seq.* (2008)
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
FWS	U.S. Fish and Wildlife Service
GE	The General Electric Company
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
NYSDEC	New York State Department of Environmental Conservation
PCBs	Polychlorinated Biphenyls
TOPS	Trace Organics Platfor Sampler
TSCA	Toxic Substances Control Act, 15 U.S.C. 2601 *et seq.* (2008)
USGS	U.S. Geological Survey

EXECUTIVE SUMMARY

The Hudson River Natural Resource Trustees include the New York State Department of Environmental Conservation (NYSDEC), the U.S. Department of the Interior (DOI) through the U.S. Fish and Wildlife Service (F&WS) and the National Park Service (NPS), and the U.S. Department of Commerce (DOC) through the National Oceanic and Atmospheric Administration (NOAA). Under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), the Trustees have the authority to assess damages to natural resources resulting from releases of hazardous substances. The Trustees also have the authority to restore or acquire the equivalent of such injured resources.

The Trustees have evaluated potential polychlorinated biphenyl-related (PCB) injuries to the surface water of the Hudson River. The Trustees have undertaken this injury assessment as part of their ongoing natural resource damage assessment (NRDA) of the Hudson River.

This study evaluates the water column of the Hudson River, extending from Hudson Falls to the Battery in New York City, a distance of approximately 200 miles. This portion of the river is an important natural, historical, and cultural resource.

Since the mid-1970s, federal and state agencies and the General Electric Company (GE) have collected over 9,000 water samples from the Hudson River and have tested these samples for PCBs. Approximately 80.5 percent of samples in the consolidated database contained PCBs, often at concentrations an order of magnitude or more above relevant state and federal regulatory criteria. These exceedances have occurred throughout all parts of the river and for every year sampled. Altogether, these exceedances of water quality standards demonstrate that Hudson River's surface water has been and continues to be injured as a consequence of PCB exposure. These injuries are expected to continue into the future. About 19.5 percent of the samples did not contain detectable concentrations of PCBs, likely because the collection and/or analytical methods were not sufficiently sensitive to detect the PCB concentrations present.

This report fulfills the requirements for surface water injury determination, as set forth in the DOI NRDA regulations (43 C.F.R. §§ 11.61 and 11.62). Subsequent reports will address other NRDA requirements, such as pathway determination (43 C.F.R. § 11.63), injury quantification (43 C.F.R. § 11.70 *et seq.*), and damage determination (43 C.F.R. § 11.80 *et seq.*).

INTRODUCTION

Polychlorinated biphenyls, also known as PCBs, have polluted large stretches of the Hudson River since the late 1940s. EPA has estimated that the two General Electric manufacturing facilities located in Fort Edward and Hudson Falls, New York, discharged 1.3 million pounds of PCBs into the river (EPA 1991).

PCBs persist in the environment for many decades, and scientific research indicates they can be harmful to animals and humans. The exact nature of these effects depends on many factors, including the level and duration of exposure, the specific PCBs to which the organism is exposed, and the specific organism. Although acute PCB toxicity is rare, exposure to very high levels of PCBs can result in death to wildlife. For example, high PCB concentrations in the brain have been associated with a high probability of death in a number of bird species (Hoffman *et al.* 1996). In addition, lower concentrations may cause a variety of adverse effects, such as partial or complete reproductive failure, birth defects, impaired growth, behavioral changes, lesions, immune system dysfunction, hormone imbalances, and other adverse effects. These or other adverse effects have been observed in a wide variety of species, including fish, birds, and mink.[1]

Under CERCLA (42 U.S.C. 9601 *et seq.* (2008)), the Trustees for the Hudson River may assess potential damages to natural resources resulting from the release of hazardous substances such as PCBs. This report is part of the ongoing Natural Resource Damage Assessment (NRDA) of the Hudson River. In particular, pursuant to the U.S. Department of the Interior's (DOI's) NRDA regulations (43 C.F.R. § 11.10 *et seq.*), this report examines potential PCB-related injuries to the river's surface water resources through an evaluation of exceedances of water quality standards established for PCBs.

The first section of this report sets forth background information, including:

- A summary of the Trustees' authority (Section 1.1);
- A description of the surface water resources (Section 1.2);
- A definition of injury to surface water resources, pursuant to DOI's NRDA regulations (43 C.F.R. § 11.10 *et seq.*) (Section 1.3);
- A description of PCBs and PCB contamination in the Hudson River (Section 1.4); and
- The water quality guidance criteria and standards used to evaluate whether an injury to surface water resources exists (Section 1.5).

Section 2 presents available data on PCB concentrations in Hudson River water and also discusses related technical water sampling and analysis issues. In Section 3, the Trustees analyze these data with respect to relevant water quality standards and criteria. Section 4 summarizes the report's findings and provides the Trustees' injury determination for the Hudson River's surface water, and Section 5 contains the report's references.

1 Studies of the effects of PCBs on fish include: Stickel *et al.* 1984, Barron *et al.* 2000, Orn *et al.* 1998, Niimi 1996, Dey *et al.* 1993, Wirgin and Garte 1989, and Bowser *et al.* 1990. Studies of the effects of PCBs on birds include: Hoffman *et al.* 1998, Hoffman *et al.* 1995, Van den Berg *et al.* 1992, and Tillitt *et al.* 1993. Studies of the effects of PCBs on mink include: Aulerich and Ringer 1977, Jensen *et al.* 1977, Wren *et al.* 1987, Heaton *et al.* 1995, Restum *et al.* 1998, and Bursian *et al.* 2003.

1.1 The Trustees' Authority

The responsibility for restoring natural resources that have been injured by hazardous substances lies with several governmental agency heads known as Trustees. Trustees include the heads of state agencies, Indian tribes, and Federal government agencies such as the U.S. Department of the Interior and the U.S. Department of Commerce. These entities act as stewards of natural resources and are responsible for holding these resources in trust for the public.

The authority of the Hudson River Trustees is derived from federal law, which authorizes the President and the representatives of any state to act on behalf of the public as Trustees for natural resources, including surface water (Section 107(f)(1) *et seq.* of CERCLA and Section 311(f)(5) of the Federal Water Pollution Control Act, also known as the Clean Water Act (CWA)). Pursuant to CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (40 C.F.R. Part 300), the President has designated the Secretary of Commerce and the Secretary of Interior to act as Trustees for particular natural resources managed or controlled by their agencies (CERCLA § 107(f)(2) and 40 C.F.R. § 300.600). On November 30, 1987, the Governor of New York appointed the Commissioner of Environmental Conservation as the Trustee for state natural resources. The Commissioner's natural resource damage responsibility under federal law complements long-standing authority under state common law and Articles 1 and 3 of the New York State Environmental Conservation Law to conserve, improve, and protect New York's natural resources.

The Trustee entities, including the U.S. Department of Commerce, the U.S. Department of the Interior, and the State of New York, have formed a Natural Resource Trustee Council for the purpose of conducting an assessment of the river's natural resources. Each organization has designated representatives that possess the technical knowledge and authority to perform natural resource damage assessments. For the Hudson River, the designees are the National Oceanic and Atmospheric Administration (NOAA), the U.S. Fish and Wildlife Service (FWS, which represents the concerned DOI agencies and the National Park Service), and the New York State Department of Environmental Conservation (NYSDEC).

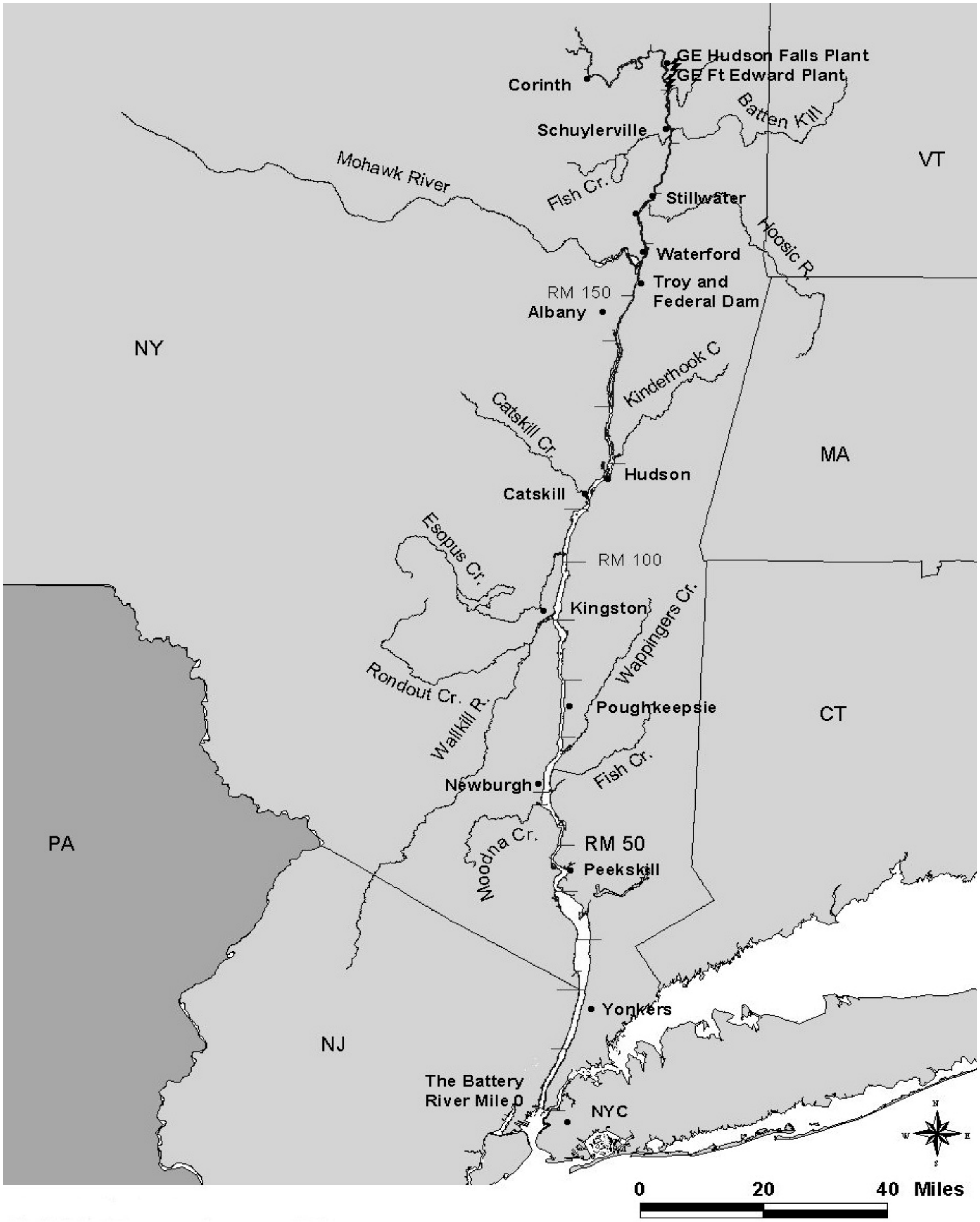
1.2 Description of Surface Water Resources

The surface water resources evaluated in this assessment consist of the Hudson River between Hudson Falls and the Battery in New York City (*i.e.,* all waters below river mile 197).[2] This portion of the river is depicted in Figure 1. The portion of the river that lies upstream of the Albany/Troy metropolitan area is generally referred to as the Upper Hudson. This stretch of river is approximately 40 miles in length. The portion of the river below Albany is referred to as the Lower Hudson and is approximately 160 miles long.

The Hudson River is an important natural, historical, and cultural resource (NRDA Plan 2000). The portion of the river addressed in this report (*i.e.*, that below Hudson Falls) provides habitat for biological resources, including birds, fish, mammals, invertebrates, and plants. The waters and sediments of the river support a diverse ecosystem that includes several species of rare and endangered fish, birds, amphibians, and reptiles. The health of surface water resources iscritical to the survival and health of the biota in the ecosystem. In addition, human uses of the river, such as recreational fishing and navigation, are closely linked to the quality of the surface water.

2 The term "river mile 197" (or RM 197) refers to a location on the Hudson River that is approximately 197 miles north of the Battery (river mile 0). River miles decrease from north to south.

Figure 1. The Hudson River Below Corinth, NY



Note: Horizontal lines indicate 10-river mile (RM) markings, starting at RM 0 in the Battery.

1.3 DEFINITION OF INJURY

Pursuant to CERCLA, DOI has promulgated regulations that define a number of categories of injuries to natural resources (43 C.F.R. § 11.10 *et seq.*). This report addresses one definition of injury that is applicable to the surface water resources of the Hudson River, *i.e.,* the exceedance of water quality criteria.[3,4] Under this definition, surface water is injured when the following requirements are met:

- The concentrations and duration of hazardous substances measured in the surface water are in excess of applicable water quality criteria established by § 304(a)(1) of the Clean Water Act (CWA), or by other federal or state laws or regulations that establish such criteria;
- The surface water met the criteria before the release of the hazardous substance;
- The surface water is a committed use as a habitat for aquatic life, water supply, or recreation (43 C.F.R. §§ 11.62(b)(1)(ii) and (iii)). If surface water is used for more than one of these purposes, the most stringent applicable criterion is to be used; and
- Concentrations of hazardous substances are measured in (a) two water samples from different locations, separated by a straight-line distance of not less than 100 feet, or (b) in two water samples from the same location collected at different times (43 C.F.R. § 11.62(b)(2)(i)).

1.4 POLYCHLORINATED BIPHENYLS (PCBS)

This report evaluates whether polychlorinated biphenyls (PCBs) have injured the surface water of the Hudson River. PCBs are hazardous substances as defined in CERCLA § 101(14), and consist of 209 individual compounds, known as congeners. A congener may have between one and ten chlorine atoms, which may be located at various positions on the PCB molecule. By way of example, a "trichlorobiphenyl" has three chlorine atoms per molecule.

Commercial production of PCBs began in the United States in 1929. For some years, PCBs were widely used as fire preventatives and insulators in the manufacture of transformers and capacitors. Due in part to increasing concerns about the compounds' impacts on human health and the environment, in 1976 Congress passed the Toxic Substances Control Act (TSCA), which required EPA to establish labeling and disposal requirements for PCBs. TSCA also mandated an eventual ban on the manufacture and processing of PCBs. As a result of this legislation, virtually all uses of PCBs and their manufacture have been prohibited in the United States since 1976.

PCBs are classified as a probable human carcinogen by numerous national and international health-protective organizations, such as the EPA, the Agency for Toxic Substances and Disease Registry (an arm of the U.S. Public Health Service) and the World Health Organization. Research has also linked PCB exposure to developmental and other human health problems.[5]

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3 A second definition of injury provides an alternative and independent way to determine whether surface water resources have been injured. Under this definition, surface water is injured if a natural resource, such as biota, has been injured as a consequence of exposure to the surface water, suspended sediments, or bed, bank, or shoreline sediments, all of which are considered part of surface water resources (43 C.F.R. § 11.62 (b)(1)(v)). Although this report does not evaluate injury under this second definition, the Trustees may choose to do so in the future.

4 The term "criteria" as used in the regulations include both promulgated regulatory standards and guidance criteria.

5 Studies linking PCB to developmental and other health problems in humans include: Carpenter 2006, Fitzgerald *et al.* 2008, and Kouznetsova *et al.* 2007.

PCBs can take many decades to break down in the environment. They also build up in animals (bioaccumulate), increasing in concentration as they move up the food chain. This bioaccumulation occurs both via bioconcentration–the absorption and concentration of PCBs in the tissues of organisms from the environment in which it lives–as well as from biomagnification, in which organisms of successively higher trophic levels up the food chain accumulate increasingly higher levels of PCBs as they consume organisms below them. This is of special concern in areas such as the Hudson River, where fish are exposed to PCB contamination and may be consumed by humans and other animals high on the food chain.

Historical Releases of PCBs to the Hudson River

Beginning in 1947 for General Electric's Fort Edward plant, and beginning in 1952 for its Hudson Falls plant, PCB-laden waste waters were discharged directly into the Hudson River. These direct discharges continued until 1977. In addition, the two plants contributed PCBs to the Hudson River watershed and ultimately to the river by disposing of manufacturing wastes in nearby landfills and wastewater collection systems (*e.g.,* sewers and municipal wastewater treatment plants) (EPA 1997). Discharges between 1956 and 1975 have been estimated at about 30 pounds per day or about 11,000 pounds per year (EPA 2000b). Altogether, EPA has estimated that the two General Electric manufacturing facilities located in Fort Edward and Hudson Falls discharged 1.3 million pounds of PCBs into the river (EPA 1991, 1997).

A significant amount of the PCBs discharged before 1973 accumulated in sediments behind the Fort Edward dam, which was located a little over a mile downstream from the Fort Edward facility (EPA 1999). After the deteriorating dam was removed in 1973, subsequent spring floods carried the PCB-contaminated sediments downstream, and many of the PCBs settled in areas of low flow described as "hot spots" for their high concentrations of PCBs (EPA 1999; Brown *et al.* 1985). In 1977, the Thompson Island Pool, a stretch of the Upper Hudson River between river miles 197 and 188.5, was estimated to contain 103,000 pounds of PCBs (Brown *et al.* 1988). The sediments of the entire Upper Hudson River were estimated to contain 341,000 pounds of PCBs (Brown *et al.* 1988).

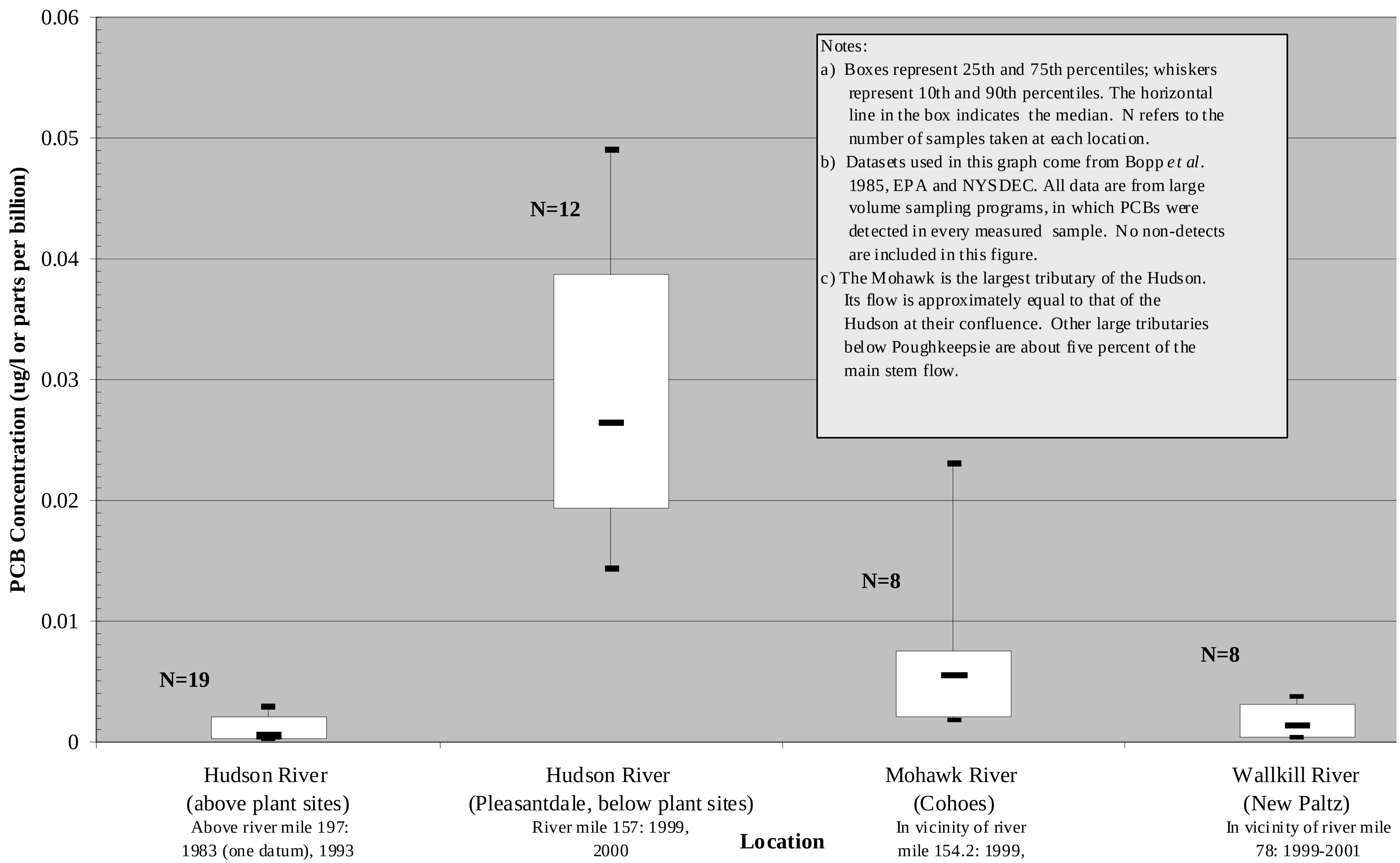
Additional PCBs have entered the Hudson River via the migration of PCB-contaminated oils through bedrock at the Hudson Falls plant site. In 1991, these seeps were augmented by the partial failure of the Allen Mill gate structure near the Hudson Falls plant (EPA 2000b). This failure resulted in a release of PCB-contaminated oils and sediments from the plant that had accumulated within the structure. Although GE's manufacturing facilities were not the only source of PCBs to the Hudson, NYSDEC has previously demonstrated that non-GE sources of PCBs in the Upper Hudson contributed negligible amounts of PCBs to the river prior to 1975,[6] and EPA has indicated that the GE plant sites are the single largest contributor of PCBs to the river.[7]

The Trustees have conducted a preliminary upstream-downstream analysis, comparing PCB concentrations in the water upstream of the GE plant sites with concentrations downstream. Figure 2 shows the results and clearly demonstrates the very significant difference in PCB levels above and below the plants. PCBs in tributaries such as the Mohawk and the Walkill Rivers are at much lower concentrations than in the main stem of the Hudson.

6 Interim Opinion and Order, "In the Matter of Alleged Violations of Sections 17-0501, 17-0511, and 11-0503 of the Environmental Conservation Law of the State of New York by General Electric Company," (February 9, 1976) at 22.

7 In its Phase 3 Report Feasibility Study (page 1-42), EPA states: "In the freshwater Hudson, GE-related contamination represents 80 to 100 percent of the in-place and water-borne contamination. In the Upper Hudson, this percentage is quite close to 100 percent" (EPA 2000c). In the saline portion of the Hudson, GE-related contamination represents a somewhat smaller portion of the in-place and recently deposited PCB inventory (*ibid.*).

Figure 2. Recent Surface Water PCB Concentrations in the Hudson River and in Hudson River Tributaries



Water quality monitoring efforts in the mid-1990s indicated that locations above Rogers Island continued to release PCBs to the river, and more detailed investigations ensued. During the course of this work, it was determined that residual PCBs were entering the river through seeps in the fractured bedrock beneath the Hudson Falls plant site. These seeps combined with other locations are a continuing source of PCB inputs to the Hudson and appear to be contributing approximately 0.2 pounds of PCBs per day (QEA 1999). Other ongoing sources of PCBs to the river include releases from the contaminated remnant deposits, and releases from the bedrock in the vicinity of the Fort Edward plant site former outfall.

PCB inputs from the GE Hudson Falls Plant Site are being addressed under a New York State lead remedial program. Specifically, a Record of Decision (ROD) was executed and released on March 15, 2004. Under this ROD, GE will construct an underground well system to collect the remaining PCBs in the bedrock at the plant site in an effort to prevent future migration to the river.

The continuing source near the previous outfall below the GE Fort Edward Plant Site is being addressed under a New York State lead remedial program and is currently being investigated.

1.5 APPLICABLE WATER QUALITY CRITERIA

A number of PCB water quality guidelines, standards, and criteria are applicable to the Hudson River. This report specifically considers the following criteria:

- National water quality criteria developed by EPA pursuant to § 304(a)(1) et seq. of the Clean Water Act (CWA); and
- State of New York drinking water standards, water quality standards and guidance criteria for the protection of humans and wildlife.

As shown in Table 1, PCB water quality standards and guidance criteria have evolved over the past 25 years. In general, the earlier standards and criteria were intended to protect both humans and aquatic organisms. For example, the earliest PCB water quality criterion (0.001 mg/l, issued by EPA in 1976)[8] was designed to protect both human health and aquatic organisms.

8 A PCB concentration of one microgram per liter (1 µg/l) means that there is one microgram (0.000001 gram) of PCBs per liter of water. Because a liter of water weighs 1000 grams, another way to express the concentration 1 µg/l is as 1 ppb, or one part per billion. EPA's 0.001 µg/l criterion can, therefore, also be written as 0.001 ppb or one part per trillion (1 ppt).

Table 1
Summary of Applicable PCB Water Quality Standards and Guidance Criteria

Standard (applicability)	Threshold (in µG/L, or parts per billion)	Effective Dates[b]	Authorities
Freshwater and Marine Aquatic Life and Consumers Thereof (all surface waters)	0.001 µg/l Guidance Criterion	7/76 - present	41 FR 32947 (August 6, 1976) U.S. Environmental Protection Agency. Quality Criteria for Water (“Red Book”). EPA 440/9-76-023, PB 263 943 July, 1976.
Human Health (all surface water)	0.000079 µg/l Guidance Criterion	11/28/80 - 2/5/93	45 FR 79318 (November 28, 1980) U.S. Environmental Protection Agency. Ambient Water Quality Criteria for Polychlorinated Biphenyls. Office of Water Regulations and Standards. EPA 440/5-80-068. November, 1980.
	0.000044 µg/l[a] Guidance Criterion	2/5/93 - 12/19/98	57 FR 60848 (December 22, 1992) (Effective date 2/5/93) 63 FR 68354 (December 19, 1998)
	0.00017 µg/l Guidance Criterion	12/19/98 - 11/02	U.S. Environmental Protection Agency. National Recommended Water Quality Criteria - Correction. Office of Water. EPA 822-Z-99-001. April, 1999.
	0.000064 µg/l Guidance Criterion	11/02 - present	U.S. Environmental Protection Agency. National Recommended Water Quality Criteria: 2002. Office of Water. EPA-822-R-02-047. November, 2002.
Aquatic Life (freshwater)	0.014 µg/l[a] Criterion Continuous Concentration	11/28/80 - present	45 FR 79318 (November 28, 1980) U.S. Environmental Protection Agency. Ambient Water Quality Criteria for Polychlorinated Biphenyls. Office of Water Regulations and Standards. EPA 440/5-80-068. November, 1980.
Aquatic Life (saltwater)	0.030 µg/l[a] Criterion Continuous Concentration		
Piscivorous Wildlife (Earlier NYS standard: all surface water not Class I Later NYS standard: all surface water)	0.001 µg/l (all freshwater and saltwater not class I) Guidance Criterion	8/8/83 – 8/2/85	NYSDEC Division of Water. Policy and Delegation Memo (83-W-38), Ambient Water Quality Criteria. Dr. Robert Collin. August 8, 1983.
	0.001 µg/l (saltwater) Guidance Criterion	7/24/85 – 3/12/98	NYSDEC Division of Fish and Wildlife. Fact Sheet: Polychlorinated Biphenyls, PCBs. Surface Water Quality Standard Documentation. July 26, 1984. NYSDEC Division of Water. Technical and Operation Guidance Services (85-W-38), Ambient Water Quality Standards and Guidance Values. John Zambrano. July 24, 1985.
	0.001 µg/l Regulatory Standard	8/2/85 - 3/12/98	6 NYCRR § 701, App. 31 (until 8/91); 6 NYCRR § 703.5 (from 8/91 to 3/12/98)
	0.00012 µg/l Regulatory Standard	3/12/98 - present	6 NYCRR § 703.5

Table 1 (continued)
Summary of Applicable PCB Water Quality Standards and Guidance Criteria

Standard (applicability)	Threshold (in µG/L, or parts per billion)	Effective Dates[b]	Authorities
Human–Sources of Drinking Water (Class A, A-S, AA, and AA-S waters)	0.0095 µg/l Guidance Criterion	1/23/84 – 8/2/85	NYSDEC Division of Water. Technical and Operation Guidance Services (84-W-38), Ambient Water Quality Criteria. Dr. Robert Collin. January 23, 1984.
	0.01 µg/l Regulatory Standard	8/2/85 - 3/12/98	6 NYCRR § 701, App. 31 (until 8/91); 6 NYCRR § 703.5 (from 8/91 to 3/12/98)
	0.09 µg/l Regulatory Standard	3/12/98 - present	6 NYCRR § 703.5
Human–Fish Consumption (all surface water)	0.0000006 µg/l Guidance Criterion	11/15/91 – 3/12/98	New York State Human Health Fact Sheet-Ambient Water Quality Value Based on Human Consumption of Fish and Shellfish. Polychlorinated Biphenyls, PCBs. November 15, 1991 and March 31, 1993. NYSDEC Division of Water. Technical and Operation Guidance Services (1.1.1.) Ambient Water Quality Standards and Guidance Values. John Zambrano. November 15, 1991.
	0.000001 µg/l Regulatory Standard	3/12/98 to present	6 NYCRR § 703.5

Notes:

a. This criterion is for application to measurements of individual Aroclors (e.g,. Aroclor 1242) rather than to total PCBs.

b. Generally, the effective period for a guidance criterion begins when the criterion is available. The effective period for a regulatory standard begins when the regulation becomes effective.

As scientific understanding of PCBs grew and the ability to measure them improved, EPA and NYSDEC established PCB standards designed to protect more specific classes of organisms or uses. For example, in 1980 EPA issued additional water quality criteria for PCBs.[9] These standards were intended to protect aquatic life in freshwater (0.014 µg/l) and in saltwater (0.030 µg/l) habitats. In addition, one New York regulatory standard, set forth at 6 NYCRR § 703.5, is designed to protect wildlife that consume fish, while another is intended to protect human consumers of fish. Both standards apply to the entire length of the river. Other state standards are applicable to only freshwater portions, to only saltwater portions, or to areas designated as sources of drinking water supplies. Altogether, as shown in Table 1, there are six current federal and state PCB regulatory standards that are applicable to some or all portions of the Hudson River, each with a specific function and associated protective level.

9 See table for citations.

COMPILATION AND ANALYSIS OF EXISTING DATA

This section describes existing water quality datasets for the Hudson River and sets forth the procedures used to combine the datasets for use in this analysis.

2.1 SURFACE WATER DATA SOURCES

This injury determination relies on PCB surface water concentration data from five sources: the U.S. Geological Survey (USGS), EPA, NYSDEC, the General Electric Company (GE) and Dr. Richard Bopp of Rensselaer Polytechnic Institute. The following paragraphs briefly describe each of these data sets.

USGS

The USGS has collected river discharge (flow) and water quality data at various points along the Upper Hudson River since 1907. In 1975, the USGS initiated regular monitoring of PCBs in the water column at Waterford and then expanded its monitoring program to a total of seven stations, all within the Upper Hudson. The USGS collects samples using a depth-integrating sampler that continuously collects a water sample from a vertical column of water between the river surface and river bed. This method collects a mixture of water that represents the PCB concentration in the entire water column.

The resulting dataset includes 2,618 measurements of PCBs and represents a valuable source of information that can be used to indicate trends in river PCB concentrations for the Hudson River over time. The method detection limit[10] for the USGS sampling was 0.1 µg/l between 1975 and 1984, and 0.01 µg/l from 1984 to 2001.

DR. RICHARD BOPP

Dr. Richard Bopp *et al.* collected 28 samples in the lower river and 11 in the upper river as part of studies to "quantify the modes and rates of PCB transport in the Hudson" (Bopp *et al.* 1985). Forty-five additional samples were taken below the Battery, above the plant sites, and in other reference locations. The samples were collected between 1977 and 1983.

10 The importance of detection limits and the interpretation of data with respect to detection limits are discussed later in the report.

Bopp's work represents the first effort in the Hudson River to filter and extract large volume (10-20 liter) samples. As with the Trace Organics Platform Sampler program discussed below, the large-volume sampling approach allowed much smaller concentrations of PCBs to be detected, relative to other methods in use at the time. For example, dissolved PCBs were measured at concentrations as low as 0.002 µg/l in Dr. Bopp's samples, a value that is much lower than the 0.01 µg/l detection limit reported by USGS.

General Electric

In 1989, General Electric began sampling the water column of the Hudson for PCBs. GE sampled at 124 locations, 120 of which are located in the upper river. As of January 2007, GE had reported a total of 6,738 data points from locations ranging from river mile 70, near Newburgh Bay, to river mile 200.5, above the GE plants.[11] The sampling results generally include measurements of total PCBs, PCB homologue distributions (the sum of PCBs that have the same number of chlorine atoms), and other water quality parameters. The GE data are quantitated based on Aroclor[12] standards, not individual congener standards. Detection limits between 0.000009 µg/l and 0.025 µg/l have been reported in the GE database.

EPA

As part of EPA's Reassessment of the Hudson River PCB Superfund Site, EPA collected a total of 126 surface water samples from 11 river locations in 1993 (EPA 2000a). Of these locations, eight were in the upper river, and three were in the lower river.

EPA collected these water samples using two different techniques, depending on the data's intended use. One approach entailed collecting sequential water samples along transects. EPA used these data as "snapshots" of conditions in the river at a moment in time and used the data in their evaluation of water column PCB levels, congener distributions, and relationships between dissolved and suspended phases of PCBs. EPA also collected flow-averaged composite water samples. These samples represent the average concentration of PCBs in water over a 15-day period and as such provide a slightly longer-term perspective on PCBs in the river. EPA used these latter measurements to investigate the transportation of PCBs within the river. EPA's sampling techniques can detect very low concentrations of PCBs.

NYSDEC

NYSDEC has developed a type of water sampling equipment, termed the Trace Organics Platform Sampler (TOPS, see Litten 2003). This device can concentrate certain kinds of contaminants from very large samples of water. Coupled with laboratory methods that eliminate false positive interferences, this technique is capable of detecting very low concentrations of organochlorines, including PCBs.

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11 GE provided databases and reports obtained from NYSDEC at various times.

12 Aroclor refers to the trade name under which PCBs were sold in North America by the Monsanto Chemical Corporation. A given Aroclor product is defined by the four-digit number that follows the Aroclor name. The last two digits usually indicate the percent by weight of chlorine in the mixture. For example, Aroclor 1260 contains 60 percent chlorine. Each Aroclor contains a mixture of congeners.

The TOPS method entails pumping water through a filter to collect particles and then passes the clarified water through columns holding a synthetic resin that traps dissolved chemicals. The amount of water passing through the filters is carefully monitored. Both the filter and the resins are sent to an analytical laboratory where the contaminants are extracted. The extracts are analyzed using modern PCB analytical techniques, which permit the identification and quantitation of all 209 PCB congeners. The TOPS sampling program has been used elsewhere in New York State, notably in the Contaminant Assessment and Reduction Project (C.A.R.P.) in the New York/New Jersey harbor. Between 1998 and 2001, NYSDEC used the TOPS method to collect a total of 41 samples from one Upper Hudson location and five Lower Hudson locations (Litten 2003).

Table 2 summarizes all the above data sets, which contain a total of 9,568 data points.

Table 2
PCB Water Concentration Data Sources

Data Source	Total Number of Data Points	Period of Record	Sites Sampled	Detection Limit	Number of Non-Detects
USGS	2,618	1975-2001	7 in upper river 6 in lower river	0.1 µg/l (1975 - 1984) 0.01 µg/l (1984 - present)	427
Bopp	45	1977-1981, 1983	11 in upper river 28 in lower river 6 in the harbor and reference areas	0.018 µg/l[a]	0
GE	6,738	1989-2007	120 in upper river 4 in lower river	0.0000092 µg/l - 0.025 µg/l	1,670[b]
EPA	126	1993	8 in upper river 3 in lower river	0.005 µg/l[a]	0
NYSDEC	41	1998-2001	1 in upper river 5 in lower river	0.006 µg/l[a]	0

Notes:

a. The effective detection limit for large-volume sampling programs is determined by the size of the sample taken and thus can vary considerably from sampling event to sampling event. For this reason, the lowest recorded PCB concentration for the dataset is listed instead of a detection limit. All samples within the large-volume sampling datasets detected PCBs (*i.e.*, there were no non-detects).

b. At times, GE used more than one PCB analytical method on its samples. In some cases, one method produced a non-detect while another method produced a detectable concentration. This figure is the total number of samples that were non-detects by any method used.

2.2 Data Compilation

This injury determination considers surface water concentrations of samples taken from the main stem of the Hudson River downstream from the GE plant sites. For purposes of comparison, this report also evaluates samples taken from the Hudson above the GE plants and from tributaries to the Hudson. In cases in which a sampling location was not reported, or was listed as river mile 197 (at the plant sites), the actual location was determined, if possible, by interviewing NYSDEC or USGS personnel, or reviewing relevant documents. Samples for which the locations were unknown were not used.

Each data set was examined to identify all duplicate samples (*i.e.,* those taken at the same time and location). These generally fell into three categories:

1. Laboratory duplicates, in which one sample from the field was analyzed twice, using the same analytical method each time, for quality control purposes;
2. Duplicates, in which one field sample was analyzed using more than one analytical method, to compare the result obtained by one method with that obtained by the other(s);
3. Field replicates, in which more than one sample was collected in the same place and at the same time.

For samples falling into the first category, if the duplicate results were similar enough to one another to meet the sampling program's data quality objectives, data from the first analysis were used and the sample result that was specifically defined as the duplicate was not included. If the duplicate results were so different from each other that they failed to meet the sampling program's data quality objectives, the data from both samples were discarded.

In cases in which a sampling program analyzed a single sample using different methods, as described in (2), above, and differing values were reported, the value reported for the capillary method was used, as this method is the more reliable.

For samples falling into category (3) above, the reported values were averaged.

Some of the samples that EPA collected presented unique issues. In particular, EPA collected some flow-averaged samples in which the volume sampled was proportional to the water flow on the day the sample was taken. EPA took these samples approximately every other day over 15-day periods. EPA composited the samples (*i.e.,* mixed them together) on the sixteenth day. For purposes of this report, a single sampling date in the middle of the period is assigned to the composite sample. Similarly, some of the NYSDEC samples were collected not at a single location but were collected from a moving boat along a stretch of the river. In these cases, the midpoint of the range is selected to approximate the area in which the sample was taken.

Following the preparation of the data sets as described above, all the data were incorporated into a single dataset, which was then sorted by river mile and date. In cases in which more than one sampling program sampled the same location on the same day, the lowest reported value was used.

2.3 Non-Detects

Of the total of 6,127 measurements in the consolidated data set, 1,196, or 19.5 percent, did not detect PCBs. All non-detect values were measured in either the USGS sampling or the GE program. It is likely that the collection and/or analytical methods used in those programs were simply not sufficiently sensitive to detect the PCB concentrations present.

Programs using large-volume sampling methods have helped surmount this problem. Where implemented, the large-volume programs have consistently detected PCBs at concentrations in exceedance of relevant standards: for example, all Hudson River samples collected in the large-volume programs contained PCBs at concentrations exceeding the EPA 0.001 μg/l guidance criterion. Nevertheless, for purposes of the injury determination analysis discussed below, this report assumes that all samples that failed to detect PCBs had a PCB concentration of zero. This approach of using a zero for results reported as non-detect is consistent with the Hudson River NRDA Analytical Quality Assurance Plan (Hudson River Natural Resource Trustees 2005).

INJURY DETERMINATION AND EVALUATION

This section evaluates the available data on PCB concentrations in Hudson River surface water to determine whether surface water injury exists. The dataset is evaluated both as a whole and using the spatial and temporal groups described above.

3.1 DEFINITION OF INJURY

As noted in section 1.3 of this report, pursuant to CERCLA, DOI has promulgated regulations that define several categories of injuries to natural resources (43 C.F.R. § 11.10 *et seq.*). This report addresses one definition of injury that is applicable to the surface water resources of the Hudson River, *i.e.,* the exceedance of water quality regulatory standards or guidance criteria. Under this definition, surface water is injured when the following requirements are met:

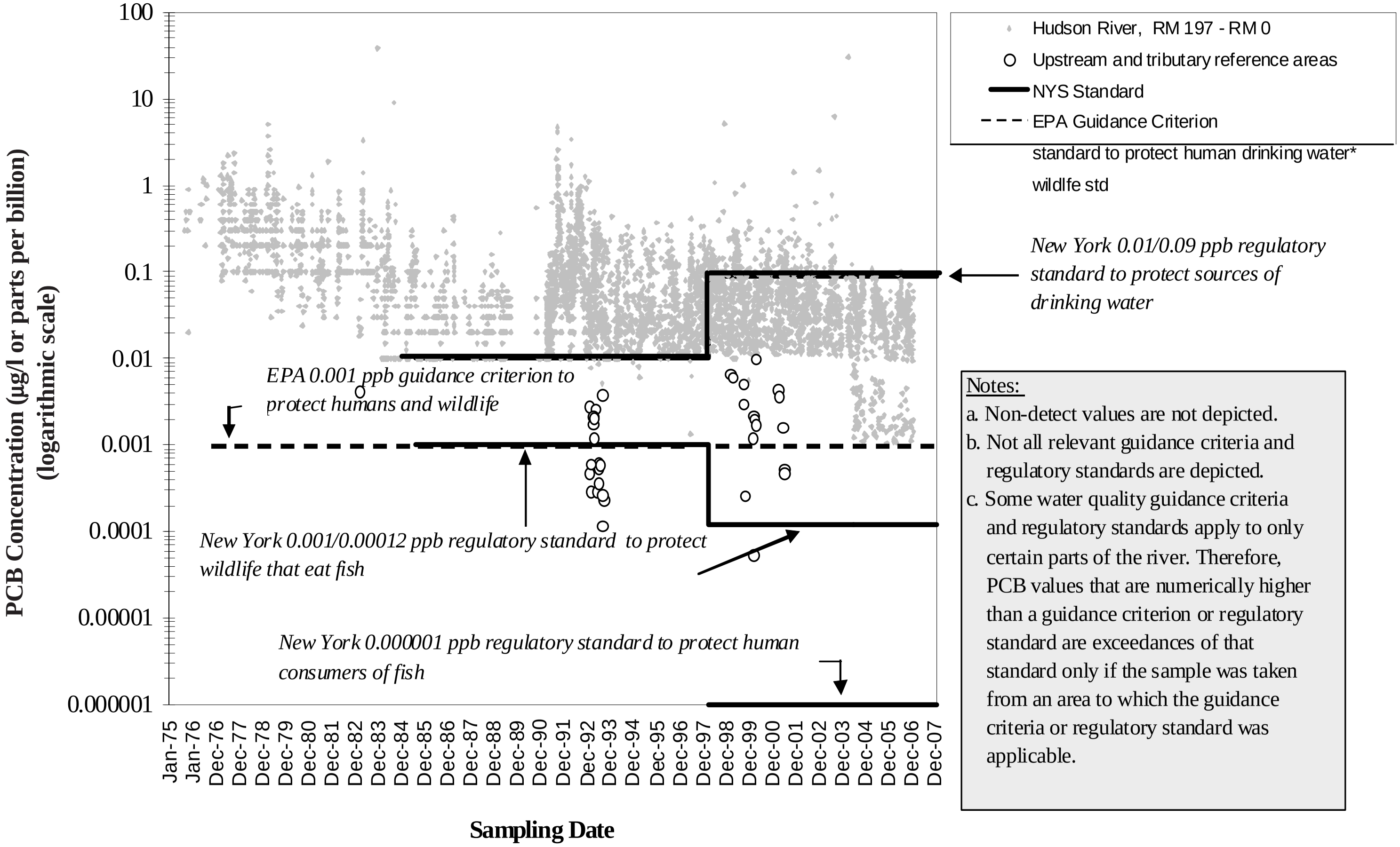
1. The concentrations and duration of hazardous substances measured in the surface water are in excess of applicable water quality regulatory standards or guidance criteria established by § 304(a)(1) *et seq.* of the Clean Water Act (CWA), or by other Federal or State laws or regulations that establish such criteria;
2. The surface water met the regulatory standard or guidance criteria before the release of the hazardous substance;
3. The surface water is a committed use as a habitat for aquatic life, water supply, or recreation (43 C.F.R. §§ 11.62(b)(1)(ii) and (iii)). If surface water is used for more than one of these purposes, the most stringent applicable criterion is to be used; and
4. Concentrations of hazardous substances are measured in (a) two water samples from different locations, separated by a straight-line distance of not less than 100 feet, or (b) in two water samples from the same location collected at different times (43 C.F.R. § 11.62(b)(2)(i)).

These four requirements are addressed below in sections 3.2 through 3.4.

3.2 EXCEEDANCE OF APPLICABLE WATER QUALITY CRITERIA

To evaluate injury, the measured PCB values from all Hudson River sampling programs were compared to each of the guidance criteria and regulatory standards set forth in Table 1. Figure 3 shows all measurements of PCBs in Hudson River surface water (non-detects are not depicted). This figure demonstrates that, of the 4,931 samples that contained PCBs at detectable concentrations, all exhibited PCB concentrations that exceed one or more guidance criteria and regulatory standards. Even the lowest concentrations measured are many orders of magnitude greater than the more stringent standards, such as those for the protection of piscivorous wildlife or for the protection of human consumers of fish. (Standards are depicted as lines that begin chronologically at the point in time when they became effective.)

Figure 3. Hudson River PCB Concentrations, All Locations 1975-2007



Notes:
a. Non-detect values are not depicted.
b. Not all relevant guidance criteria and regulatory standards are depicted.
c. Some water quality guidance criteria and regulatory standards apply to only certain parts of the river. Therefore, PCB values that are numerically higher than a guidance criterion or regulatory standard are exceedances of that standard only if the sample was taken from an area to which the guidance criteria or regulatory standard was applicable.

Table 3 summarizes the exceedances of the various surface water standards and guidance criteria for samples that detected PCBs; it also shows the proportions and percentages of samples that exceed applicable water quality standards and the numbers of non-detects. The Trustees note that even though no PCBs were detected in some samples, it does not follow that the surface water was in compliance: actual PCB concentrations may in fact have exceeded applicable standards. As Table 2 above shows, the detection limits of some sampling programs were higher than many of the applicable water quality standards (listed in Table 1).

Table 3
Summary of Exceedances of Applicable PCB Guidance Criteria or Regulatory Standards[a]

Standard (applicability)	Threshold (in ug/1, or parts per billion)	Effective Dates	Total Number of Samples	Number of Non-Detects	Exceedances[b]	
					Number	Percent[c]
Freshwater and Marine Aquatic Life and Consumers Thereof (all surface waters)	0.001 µg/l Guidance Criterion	7/76 - present	6,107	1,191	4,931	80.7
Human Health (all surface water)	0.000079 µg/l Guidance Criterion	11/28/80 - 2/5/93	984	167	817	83.0
	0.000044 µg/l Guidance Criterion	2/5/93 - 12/19/98	Not calculated[d]	Not calculated[d]	Not calculated[d]	
	0.00017 µg/l Guidance Criterion	12/19/98 - 11/02	1,283	443	840	65.5
	0.000064 µg/l Guidance Criterion	11/02 - present	995	203	791	79.5
Aquatic Life (freshwater)	0.014 µg/l Guidance Criterion	11/28/80 to present	Not calculated[d]	Not calculated[d]	Not calculated[d]	
Aquatic Life (saltwater)[e]	0.030 µg/l Guidance Criterion		Not calculated[d]	Not calculated[d]	Not calculated[d]	
Piscivorous Wildlife (Earlier standard: all surface water not Class I Later standard: all surface water)	0.001 µg/l (all freshwater and saltwater not class I) Guidance Criterion	8/83 to 8/85	233	15	218	93.6
	0.001 µg/l (saltwater) Guidance Criterion	7/85 to 3/98	0	n/a	n/a	n/a
	0.001 µg/l Regulatory Standard	8/2/85 - 3/12/98	2,432	315	2,117	87.0
	0.00012 µg/l Regulatory Standard	3/12/98 - present	2,538	674	1,863	73.4

Table 3 (continued)
Summary of Exceedances of Applicable PCB Guidance Criteria or Regulatory Standards[a]

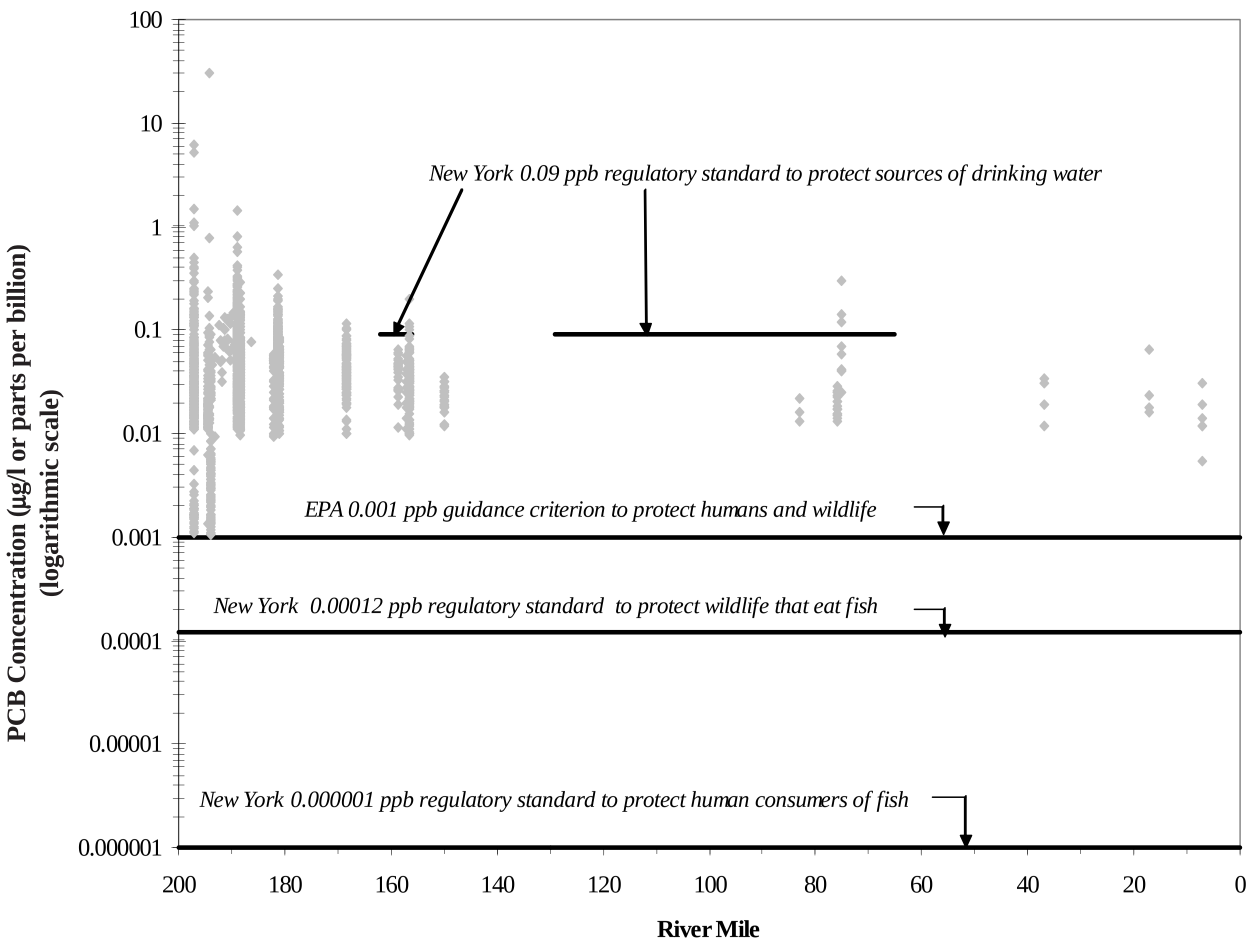
Standard (applicability)	Threshold (in ug/1, or parts per billion)	Effective Dates	Total Number of Samples	Number of Non-Detects	Exceedances[b]	
					Number	Percent[c]
Human–Sources of Drinking Water (Class A, A-S, AA, and AA-S waters)	0.0095 µg/l Guidance Criterion	1/84 - 8/85	69	5	64	92.8
	0.01 µg/l Regulatory Standard	8/2/85 - 3/12/98	384	26	304	79.1
	0.09 µg/l Regulatory Standard	3/12/98 - present	263	54	5	2
Human–Fish Consumption (all surface water)	0.0000006 µg/l Guidance Criterion	11/15/91 - 3/12/98	1,869	288	1,581	84.6
	0.000001 µg/l Regulatory Standard	3/12/98 - present	2,538	674	1,863	73.4

Notes:
a. Exceedances are counted when a PCB concentration exceeds the numeric threshold, *if*: (i) the sample was collected at a part of the river designated as supporting the stated use for which the threshold was developed, and (ii) the sample was collected during the timeframe for which the regulatory standard or guidance criterion was in effect. Measured PCB concentrations in samples taken from other parts of the river or during other timeframes are not considered to be exceedances of the guidance criteria or regulatory standard.
b. This analysis assumes that non-detect samples had a PCB concentration of zero.
c. This is the number of samples with values exceeding a given regulatory standard or guidance criterion expressed as a proportion of the total number of samples taken when it was in force. In cases where a regulatory standard or criterion only applied to a specific river segment, the total number of samples includes only those sampled in the specific segment.
d. The stated guidance criterion is applicable to individual Aroclors rather than total PCBs.
e. For purposes of this analysis, saltwater is considered to be the area between river miles 0 to 65, inclusive.

As both Figure 3 and Table 3 make clear, virtually all Hudson River surface water samples in which PCBs exceeded detection limits had concentrations in excess of the 0.001 µg/l criterion and were orders of magnitude above the more stringent standards. All the applicable standards have been exceeded at least once, and most standards were exceeded numerous times.

Figure 3 also shows available PCB concentration data for samples taken at reference areas (*i.e.,* at sites upstream of the GE plants or in Hudson River tributaries). While some of these samples exceed relevant PCB water quality criteria and standards, especially the most stringent standards, many fall below EPA's 0.001 µg/l criterion. Further, these values are typically one or two orders of magnitude (10 to 100-fold) lower in concentration than virtually allof the main stem Hudson River samples in which PCBs were detected. Figure 4 illustrates spatial variability in Hudson River waters. This figure focuses on the most recent ten-year time period (1997-2007) and graphs PCB concentrations as a function of river mile.

Figure 4. Hudson River PCB Concentrations, All Locations 1997-2007



Notes:
a. Non-detect values are not depicted.
b. Not all relevant guidance criteria and standards are depicted.
c. As indicated in this figure, some guidance criteria and standards are applicable to only certain parts of the river (e.g., the drinking water standard is only applicable to certain water classes, which are located approximately at RM 162 to 156 and RM 129 to 65).

3.3 Condition of the River Prior to Release

The second element of injury is that the surface water met the applicable regulatory standards or guidance criteria prior to the release of the hazardous substance. This condition has also been met. PCBs are man-made chemicals. Therefore, prior to discharge by GE, PCBs would not have been present in the Hudson River to any substantial degree.[13] Recent data (Figure 2) show that median PCB concentrations in the Hudson River upstream of the GE plant sites are 40-fold lower than median concentrations in samples taken near Pleasantdale.[14] Further, NYSDEC has previously demonstrated that non-GE sources of PCBs in the Upper Hudson contributed negligible amounts of PCBs to the river prior to 1975, and EPA has indicated that the GE plant sites are the single largest contributor of PCBs to the Hudson River. Although PCB standards were not put in place until 1976, had the applicable standards been in effect prior to GE's PCB releases, the evidence is compelling that the surface water of the Hudson River would have complied with those standards.

3.4 Committed Use Determination

The third element of injury is that the resource be a committed use as a habitat for aquatic life, water supply, or recreation. According to the DOI regulations, to constitute a committed use, the surface water resources must either be currently used as a habitat for aquatic life, water supply, or recreation, or must be a planned public use for which a financial commitment was established prior to the release of hazardous substances (43 C.F.R. § 11.14(h)). The most stringent criterion or standard applies when surface water has more than one committed use (43 C.F.R. § 11.62(b)(iii)).

The State of New York has established committed uses for all parts of the Hudson River. Table 4 and Figure 5 show the committed uses for each section. In particular, each river segment has a designated best use as well as other designations as determined by New York law. For example, two sections of the Hudson below Hudson Falls are designated as sources of drinking water. All parts of the river are committed uses for fishing, fish propagation and survival, and for primary and/or secondary contact recreation. Furthermore, because the river is currently used as habitat for a variety of plant and animal species, as a drinking water source for several communities, and also is a source of recreation for anglers, boaters, and swimmers, this element of the injury definition is satisfied.

13 The quantitative determination of baseline conditions (*i.e.,* the conditions that would have existed in the Hudson but for GE's PCB releases) is part of the next NRDA phase, injury quantification (43 C.F.R. § 11.72). When historical data is not available, control or reference areas should be used to determine baseline conditions. The Trustees anticipate addressing the issue of baseline services in more detail as NRDA efforts progress.

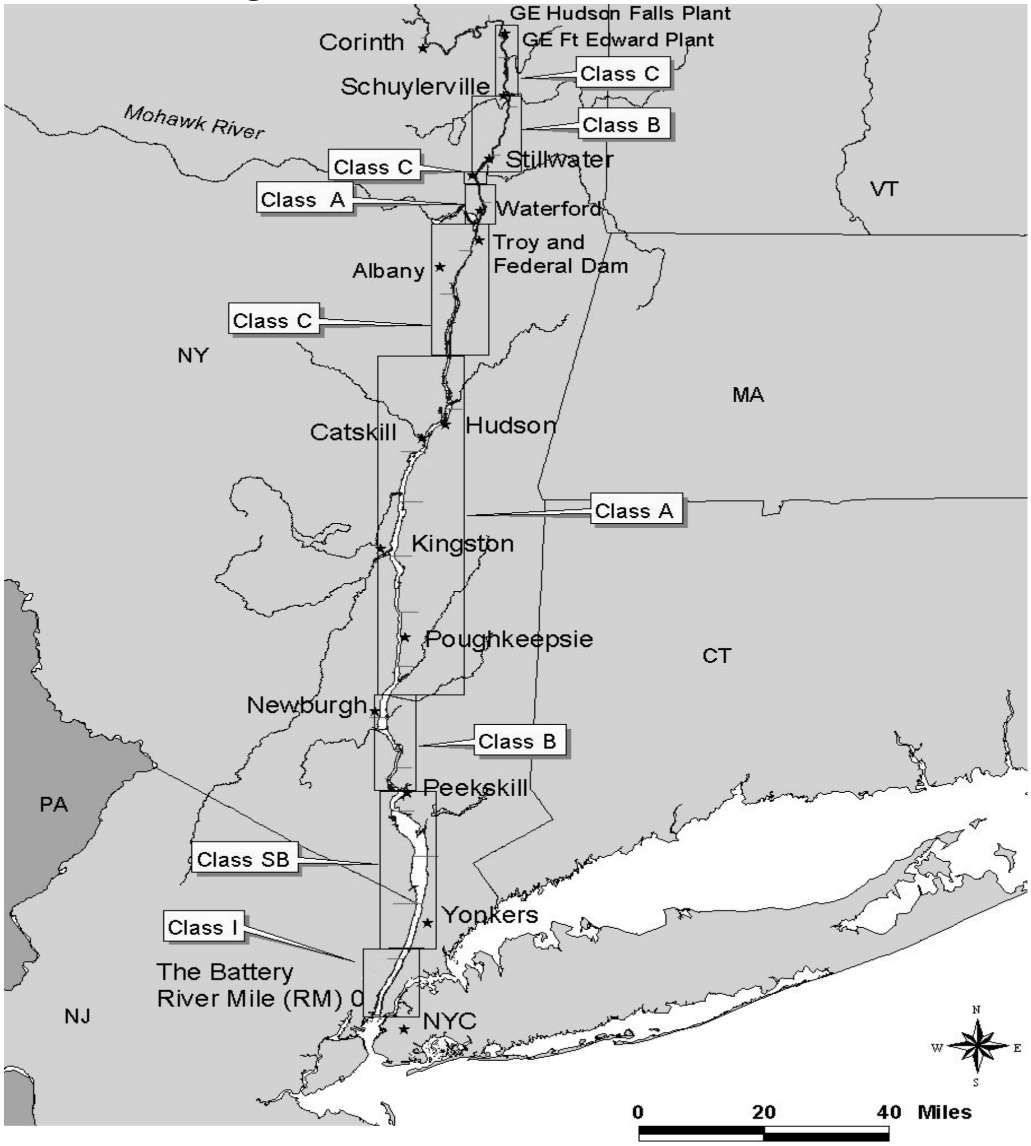
14 Recently obtained data indicates that between 2001 and 2007 GE took an additional 31 samples on the Mohawk at Cohoes. In 28 of these, no PCBs were measured above detection limits, which ranged from 0.004 µg/l to 0.010 µg/l. Only three samples detected PCBs; concentrations in these samples ranged from 0.012 to 0.026 µg/l and averaged 0.017 µg/l. Pleasantdale is located approximately 40 miles down stream from the GE plant sites.

Table 4
Hudson River Committed Uses

River Mile Range	Location Description	New York State Water Quality Class (water type)	Committed Uses[a]
0 to 14.5	Battery to New York County/Bronx County border	Class I (saline surface water)	**Secondary contact recreation** **Fishing** Fish propagation and survival (6 NYCRR § 701.13 *et seq.*)
14.5 to 47	New York County/Bronx County border to Bear Mountain Bridge	Class SB (saline surface water)	**Primary and secondary contact recreation** **Fishing** Fish propagation and survival (6 NYCRR § 701.11 *et seq.*)
47 to 65	Bear Mountain Bridge to Chelsea Station 4	Class B (fresh surface water)	**Primary and secondary contact recreation** **Fishing** Fish propagation and survival (6 NYCRR § 701.7 *et seq.*)
65 to 129.2	Chelsea Station 4 to Houghtaling Island at light 72	Class A (fresh surface water)	**Water supply for drinking, culinary or food processing** **Primary and secondary contact recreation** **Fishing** Fish propagation and survival (6 NYCRR § 701.6 *et seq.*)
129.2 to 156	Houghtaling Island at light 72 to confluence with Mohawk River	Class C (fresh surface water)	**Fishing** Fish propagation and survival Primary and secondary contact recreation (although factors other than water quality may limit the use for these purposes) (6 NYCRR § 701.8 *et seq.*)
156 to 162	Confluence with Mohawk River to Lock 2 Dam	Class A (fresh surface water)	**Water supply for drinking, culinary or food processing** **Primary and secondary contact recreation** **Fishing** Fish propagation and survival (6 NYCRR § 701.6 *et seq.*)
162 to 165	Lock 2 Dam to Lock 3 Dam	Class C (fresh surface water)	**Fishing** Fish propagation and survival Primary and secondary contact recreation (although factors other than water quality may limit the use for these purposes) (6 NYCRR § 701.8 *et seq.*)
165 to 182.2	Lock 3 Dam to confluence with Battenkill	Class B (fresh surface water)	**Primary and secondary contact recreation** **Fishing** Fish propagation and survival (6 NYCRR § 701.7 *et seq.*)
182.2 to 197	Confluence with Battenkill to end of National Priorities List site	Class C (fresh surface water)	**Fishing** Fish propagation and survival Primary and secondary contact recreation (although factors other than water quality may limit the use for these purposes) (6 NYCRR § 701.8 *et seq.*)

Notes:
a. The designated “best use(s)” for each water class are indicated in boldface. Waters of a given class must also be suitable for the other listed purposes.

Figure 5. Hudson River Water Classes



Note: Horizontal lines indicate 10-river mile (RM) markings, starting at RM 0 in the Battery.

3.5 Minimum Water Sampling Requirements

The DOI NRDA regulations state that surface water samples used in assessing injuries meet a specific acceptance criterion: "The acceptance criterion for injury to the surface water resource is the measurement of concentrations of . . . a hazardous substance in two samples from the resource. The samples must be one of the following types: (A) Two water samples from different locations, separated by a straight-line distance of not less than 100 feet; . . . or (D) Two water samples from the same location collected at different times" (43 C.F.R. § 11.62(b)(2)(i)).

The water quality data compiled for the injury determination include numerous stations throughout the Hudson River assessment area. Many of these stations have been sampled repeatedly, during different seasons and over many years: for example, since 1975, USGS has reported results from over 700 water samples at Waterford, NY and over 500 at Fort Edward. The data used to assess injury are therefore sufficient to meet this requirement for establishing injury.

SUMMARY OF DETERMINATION OF INJURY TO HUDSON RIVER SURFACE WATER

The information presented in this report demonstrates that the surface water of the Hudson River from Hudson Falls to the Battery in Manhattan is an injured resource. All elements of this definition have been met. In particular:

- Since the 1970s, when PCB measurements in the Hudson River began, PCB concentrations in all parts of the river below Hudson Falls have routinely exceeded federal and state water quality criteria and standards developed for protection of aquatic life, piscivorous wildlife, and for human consumers of fish;
- Prior to the release of PCBs into the river, the river would have been in compliance with applicable PCB water quality standards had these standards been in place at the time;
- All parts of the Hudson River have at least one committed use as a habitat for aquatic life, water supply, and/or recreation;
- The most recent water quality data and EPA's Record of Decision for the Hudson River (EPA 2002) demonstrates that existing injuries to the surface water of the Hudson River will continue into the future.

This report fulfills the requirements for surface water injury determination, as set forth in the DOI NRDA regulations (43 C.F.R. §§ 11.61 and 11.62). Subsequent reports will address other NRDA requirements, such as pathway determination (43 C.F.R. § 11.63), injury quantification (43 C.F.R. § 11.70 *et seq.*), and damage determination (43 C.F.R. § 11.80 *et seq.*).

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