FIRST FIVE-YEAR REVIEW REPORT FOR

HUDSON RIVER PCBs SUPERFUND SITE

Prepared by

U.S. Environmental Protection Agency

Region 2

New York, NY

------------------------------------ June 1, 2012

Walter E. Mugdan, Director **Date**

Emergency and Remedial Response Division

Hudson River Five-Year Review Report
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List of Acronyms and Abbreviations

ARAR	Applicable or Relevant and Appropriate Requirement
BERA	Baseline Ecological Risk Assessment
BMP	Baseline Monitoring Program
BSAF	Biota-Sediment Accumulation Factor
CAG	Community Advisory Group
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CIC	Community Involvement Coordinator
CTE	Central Tendency Exposed
CU	Certification Unit
DoC	Depth of Contamination
EC_x	Effects Concentration
EPA	U.S. Environmental Protection Agency
EPS	Engineering Performance Standards
FS	Feasibility Study
g	gram
GAC	Granulated Activated Carbon
GCL	Geosynthetic Clay Liner
GE	General Electric
HHRA	Human Health Risk Assessment
IRIS	Integrated Risk Information System
HQ-OSRTI	Headquarters Office of Superfund Remediation and Technology Innovation
kg	kilograms
L	Liters
lbs	pounds
LOAEL	Lowest Observed Adverse Effect Level
m	meter
MCL	Maximum Containment Level
mg	milligrams
µg	microgram
MNA	Monitored Natural Attenuation
MPA	Mass Per Unit Area
ng	nanogram
NOAEL	No Observed Adverse Effect Level
NRD	Natural Resource Damage
NYSCC	New York State Canal Corporation
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOT	New York State Department of Transportation
PCB	Polychlorinated Biphenyl
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion

PWS	Public Water Supply
OU	Operable Unit
QoLPS	Quality of Life Performance Standards
RA	Remedial Action
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RI	Remedial Investigation
RM	River Mile
RME	Reasonable Maximum Exposure
ROD	Record of Decision
RPM	Remedial Project Manager
SEDC	Supplemental Engineering Data Compilation
SOW	Statement of Work
SSAP	Sediment Sampling and Analysis Program
TEF	Toxic Equivalency Factor
TID	Thompson Island Dam
TIP	Thompson Island Pool
TRV	Toxicity Reference Dose
TSCA	Toxic Substances Control Act
WCS	Waste Control Specialists, LLC.
WQ	Water Quality

Executive Summary

The purpose of this five-year review is to determine whether the remedial actions at the Hudson River PCBs Superfund Site, located in eastern New York State from the Village of Hudson Falls to the Battery in New York City (the Site) are protective of public health and the environment and functioning as designed. This five-year review was conducted for the Remnant Deposits and the in-river sediments of the Upper Hudson River. The review was conducted pursuant to Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. §§ 9601 (CERCLA) and 40 CFR 300.430(f)(4)(ii) and undertaken in accordance with the Comprehensive Five-Year Review Guidance, OSWER Directive 9355.7-03B-P (June 2001).

The Environmental Protection Agency (EPA) is addressing the Site in discrete phases or components known as operable units (OUs). The 1984 Record of Decision (ROD) for the first OU (OU1) addresses the Remnant Deposits and in addition called for a treatability study of the Waterford Water Works to determine whether upgrades or alterations of the facilities were needed. The 2002 ROD for the second OU (OU2) selected dredging to address polychlorinated biphenyl (PCB) contaminated in-place sediments of the Upper Hudson River, as well as monitored natural attenuation (MNA) of PCB contamination that remains in the river after dredging. This five-year review is a statutory review and will review the remedial action at the Remnant Deposit sites as well as the remedy currently being implemented for the Upper Hudson River sediments.

The remedy at the formerly exposed Remnant Deposits (OU1) at the Hudson River PCBs Superfund Site currently protects human health and the environment as the in-place containment and cap system prevents human exposure, and the perimeter fencing and signage continue to be maintained. However, in order for the remedy to be protective in the long-term, institutional controls need to be implemented to ensure that future use of the Remnant Deposits does not compromise the integrity of the cap system or result in unsafe exposures.

The remedy selected in the 2002 ROD is currently under construction. Based on data collected and reviewed to date, EPA expects that the remedy at OU2 will be protective of human health and the environment upon completion. In the interim, human exposure pathways that could result in unacceptable risks are being controlled.

EPA anticipates that once the institutional control has been implemented at OU1 and the dredging and MNA remedy have been completed at OU2, the remedies at the Hudson River PCBs Superfund Site will be protective of human health and the environment. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

Five-Year Review Summary Form

SITE IDENTIFICATION		
Site Name: Hudson River PCBs Superfund Site		
EPA ID: NYD980763841		
Region: 2	**State:** NY	**City/County:** Hudson Falls to Battery in NYC
SITE STATUS		
NPL Status: Final		
Multiple OUs? Yes	**Has the Site achieved construction completion?** No	
REVIEW STATUS		
Lead agency: EPA		
Author name (Federal or State Project Manager): Gary Klawinski and Jennifer LaPoma		
Author affiliation: EPA		
Review period: 4/23/2007-4/23/2012		
Date of Site inspection: **OU1:** 4/4/12 **OU2**: These inspections are ongoing as there is a full-time EPA staff onsite		
Type of review: Statutory		
Review number: 1		
Triggering action date: 4/23/2007		
Due date[1]: 4/23/2012		

[1] Legislative leaders and stakeholders requested that EPA extend its targeted date of completion of this five-year review so that stakeholder comments could be fully considered in the development of the document. As a result, EPA targeted May 31, 2012 as the completion date.

Five-Year Review Summary Form (continued)

Issues/Recommendations

OU(s) without Issues/Recommendations Identified in the Five-Year Review:
OU2

Issues and Recommendations Identified in the Five-Year Review:
OU1

OU(s): 01	**Issue Category:** Institutional Controls			
	Issue: The 1984 ROD does not contain any requirement for institutional controls which would restrict residential use of OU1.			
	Recommendation: In order for the remedy to be protective in the long-term, an institutional control should be in place to ensure that future use of the Remnant Deposits does not compromise the integrity of the cap system or result in unsafe exposures.			
Affect Current Protectiveness	**Affect Future Protectiveness**	**Implementing Party**	**Oversight Party**	**Milestone Date**
No	Yes	Property Owner, State and PRP	EPA/State	April 23, 2017

Protectiveness Statement(s)

Operable Unit:	*Protectiveness Determination:*
01	Short-term Protective

Protectiveness Statement:

The remedy at the formerly exposed Remnant Deposits at the Hudson River PCBs Superfund Site currently protects human health and the environment as the in-place containment and cap system prevents human exposure, and as perimeter fencing and signage continue to be maintained. However, in order for the remedy to be protective in the long-term, an institutional control needs be implemented to ensure that future use of the Remnant Deposits does not compromise the integrity of the cap system or result in unsafe exposures.

Operable Unit:	*Protectiveness Determination:*
02	Will be Protective

Protectiveness Statement:

Based on data collected and reviewed to date, EPA expects that the remedy at OU2 will be protective of human health and the environment upon completion. In the interim, human exposure pathways that could result in unacceptable risks are being controlled.

Sitewide Protectiveness Statement

Protectiveness Determination:

Will be Protective

Protectiveness Statement:

EPA anticipates that once the institutional control has been implemented at OU1 and the dredging and MNA remedy have been completed at OU2, the remedies at the Hudson River PCBs Superfund Site will be protective of human health and the environment. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

I. Introduction

This first five-year review for the Hudson River PCBs Superfund Site (the Site), located in eastern New York State from the Village of Hudson Falls to the Battery in New York City, was conducted by Remedial Project Managers (RPM) Gary Klawinski and Jennifer LaPoma, and other EPA staff within EPA Region 2's Emergency and Remedial Response Division and EPA Headquarters' Office of Superfund Remediation and Technology Innovation (HQ-OSRTI). The review was conducted pursuant to Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, 42 U.S.C. §§ 9601-9675 and 40 CFR 300.430(f)(4)(ii) and done in accordance with the Comprehensive Five-Year Review Guidance, OSWER Directive 9355.7-03B-P (June 2001). The purpose of five-year reviews is to ensure that implemented remedies protect public health and the environment and that they function as intended by the Site decision documents. This report will become part of the Site file.

In accordance with Section 1.2.3 of the Five-Year Review Guidance, this first statutory five-year review is triggered by the Remedial Action (RA) start date of April 23, 2007 for the removal of in-place sediments of the Upper Hudson River. The five-year review is required because hazardous substances, pollutants, or contaminants remain at the Site that would not allow for unrestricted use.

EPA is addressing the Site in phases using separate components known as OUs. The 1984 ROD for OU1 addresses the Remnant Deposits and in addition called for a treatability study of the Waterford Water Works to determine whether upgrades or alterations of the facilities were needed. The 2002 ROD for OU2 selected dredging to address PCB-contaminated in-place sediments of the Upper Hudson River, as well as MNA[2] of PCB contamination that remain in the river after dredging. This five-year review is a statutory review and will review the remedial action at the Remnant Deposit sites as well as the remedy currently being implemented for the Upper Hudson River sediments.

In 1999, EPA removed 4,400 tons of contaminated soil from Roger's Island (OU3) under CERCLA's removal action authority. Additionally, Superfund removal actions have been conducted in the floodplains of the Upper Hudson River (OU4). OU4 is currently in the remedial investigation (RI) phase of the Superfund process and addresses contamination in low-lying shoreline areas from areas upstream of Remnant Deposit 1 to Troy New York; this OU will be the subject of a separate ROD. The Rogers Island removal action and the floodplains investigation are not subject to this five-year review.

[2] The term MNA was used in the 2002 ROD. It is substantively equivalent to monitored natural recovery, which is now the more commonly accepted term when applied to riverine systems.

II. Site Chronology

Table 1, attached, summarizes site-related events.

III. Site Background

Site Location

The Site includes a nearly 200 river-mile stretch of the Hudson River in eastern New York State from the Village of Hudson Falls to the Battery in New York City. The Site is divided into the Upper Hudson River (the length of river between Hudson Falls and the Federal Dam at Troy, New York) and the Lower Hudson River (the length of river between Federal Dam at Troy and the Battery). For purposes of the project, EPA further divided the Upper Hudson River area into three main sections known as River Section 1, River Section 2, and River Section 3.

The Site also includes five Remnant Deposits located upriver from River Section 1. The Remnant Deposits are areas of PCB-contaminated sediments that became exposed after the river water level dropped following the removal of the Fort Edward Dam in 1973. Remnant Deposit 1 originally appeared as an island, but due to flooding in 1976 and 1983 most of the exposed sediment associated with this deposit site was scoured. Remnant Deposit 2 is approximately 3.5 acres and is located on the west bank of the Hudson River, in the town of Moreau. Remnant Deposit 3 is approximately 17 acres and is located on the east bank of the Hudson River, in the town of Fort Edward. Remnant Deposit 4 is approximately 24 acres and is located on the west bank of the Hudson River in the town of Moreau. Remnant Deposit 5 is approximately 3.5 acres and is located on the east bank of the Hudson River in the town of Fort Edward.

Figure 1 provides the location of OU1. Figure 2 provides the location of OU2. Rogers Island, the location of the 1999 EPA soil removal action (OU3), is also identified in Figure 2 and is located in the Town of Fort Edward, Washington County, New York. OU4 of the Upper Hudson River are the low-lying shoreline areas between Fort Edward and Troy, NY.

Physical Characteristics

The Upper Hudson River is freshwater and non-tidal. Downstream of Fort Edward, the river is joined by several tributaries, the largest of which are the Mohawk River, Batten Kill, Fish Creek, and the Hoosic River. The flow in the Upper Hudson River is primarily controlled by several reservoirs above Glens Falls, including the Great Sacandaga Lake. The Upper Hudson River has an average depth of less than 8 feet in the shoal areas and approximately 18 feet in the channel, with a maximum depth of more than 45 feet. The New York State Canal Corporation (NYSCC) navigation channel is generally identified as being a minimum of 12 feet deep by design in the project area.

The Champlain Canal is coincident with portions of the Hudson River, extending from Waterford on the Hudson to Whitehall at the southern end of Lake Champlain. Bedrock, cut away to form the Champlain Canal, is exposed in some areas of the river, while lacustrine silts and clays of glacial age are exposed in other areas. Coarser-grained sediments are often observed in the river channel, while finer-grained sediments are more common in shallow water.

Areas adjacent to the Upper Hudson River include forested shoreline wetlands, transitional uplands, and vegetated backwater such as emergent marsh and scrub-shrub wetlands.

Land and Resource Use

In the Upper Hudson River, land use is primarily residential and agricultural with some commercial and industrial activities. Such uses of the river and lands surrounding the river are projected to remain the same. The Site passes through 14 different counties as the river flows to its final discharge point in New York Harbor. Four counties (Albany, Washington, Rensselaer and Saratoga) lie adjacent to the Upper Hudson River. Within these four counties, forest and farmlands surround urban centers and historic villages. In addition to the General Electric (GE) Hudson Falls and Fort Edwards plants, the area is home to other businesses including technology companies, oil service companies, and food companies.

The City of Poughkeepsie, the Dutchess County Water and Wastewater Authority, the Village of Rhinebeck, the Castle Point Medical Center, as well as the Highland and Port Ewen Water Districts obtain at least a portion of their water supplies directly from the Hudson River. The Towns of Waterford and Halfmoon also have intakes for obtaining Hudson River water, although both towns currently obtain their water from the City of Troy via an EPA-constructed water line. The river has been utilized for hydroelectric and thermal power generation, as well as for manufacturing processes, cooling and fire protection. The river is also used for irrigating agricultural lands and watering domestic lawns and gardens.

The river supports a variety of water-based recreational activities including sportfishing, waterfowl hunting, swimming and boating; however, at the current time, there is an “eat none” fish advisory for the entire Upper Hudson River and for “women under 50 years and children under the age of 15 years” for the entire Site.

The Town of Moreau has expressed an interest in creating a potential passive recreational park at Remnant Deposits 2 and 4. EPA will continue to discuss with the Town of Moreau, New York State, and GE the potential use of these sites.

History of Contamination

From approximately 1947 to 1977, GE discharged an estimated 1.3 million pounds of PCBs from its capacitor manufacturing plants at Hudson Falls and Fort Edward into the Hudson River. The two plants are located adjacent to or near the Hudson River in the Village of Hudson Falls and the Town of Fort Edward. PCB oils were discharged directly and indirectly from GE’s two facilities as both non-permitted and permitted discharges. These discharged PCBs were transported through the river and adhered to sediments that settled and accumulated in the impounded pool behind the Fort Edward Dam, as well as other depositional areas farther downstream. In 1973, the Fort Edward Dam was removed due to its deteriorating state which resulted in the remobilization and downstream distribution of PCBs that had accumulated behind the dam. The Remnant Deposits were also exposed due to the lowering of the river water level when the Fort Edward Dam was removed. During subsequent floods, PCB-contaminated sediments from the Fort Edward Dam area were scoured and transported downstream.

Initial Response

New York State Department of Environmental Conservation (NYSDEC) surveyed the Upper Hudson River sediments from 1976-1978 and again in 1984. Areas with average Total PCB[3] concentrations of 50 parts per million (ppm) or greater were identified and are known as the NYSDEC-defined PCB "hot spots." There were 40 NYSDEC-identified hot spots, located between river mile (RM) 194 at Rogers Island and Lock 2 at RM 163. Hot spots 1 through 4 were dredged by New York State for navigational purposes in the 1970s.

NYSDEC brought legal action against GE in 1975, which resulted in a $7 million program for the investigation of PCBs and the development of methods to reduce or remove the threat of PCB contamination. In 1975, the New York State Department of Health (NYSDOH) began to issue health advisories recommending that people limit their consumption of fish from the Hudson River. In 1976, NYSDEC issued a ban on all fishing in the Upper Hudson River from Hudson Falls to the Federal Dam at Troy, due to the potential risk from consuming PCB-contaminated fish. NYSDEC issued a ban on most commercial fishing, including striped bass in the Lower Hudson River. NYSDEC reopened the Upper Hudson River to "catch-and-release sportfishing" in 1995.

In 1974, the New York State Department of Transportation (NYSDOT) dredged approximately 250,000 cubic yards of PCB-contaminated sediment in the vicinity of Rogers Island for navigational purposes. The dredged materials were placed in a disposal area known as Special Area 13, which is located along the west bank of the river just south of Roger's Island. Another approximately 380,000 cubic yards of sediment were dredged from the east and west channels around Roger's Island in 1974 and 1975 and disposed of in the Old Moreau Dredge Spoil Area, located on the west shore of the river opposite the southern end of Rogers Island and north of Special Area 13.

In 1978, NYSDEC removed approximately 14,000 cubic yards of highly-contaminated sediments from Remnant Deposit 3A and placed these sediments in a secure encapsulation site in Moreau, along with approximately 215,000 cubic yards of sediment that had been dredged by

[3] Total PCBs represents the sum of all measured PCB congeners. PCBs are a group of chemicals consisting of 209 individual compounds known as congeners. The congeners can have from one to ten chlorine atoms per molecule, each with its own set of chemical properties.

NYSDOT from the east channel of Rogers Island to clear the navigational channel just below the location of the former Fort Edward Dam. Unstable river banks at two of the Remnant Deposits were reinforced at that time. Three remnant sites were re-vegetated to prevent public contact with the sediments and to minimize erosion and release of PCBs into the environment.

Historical use of Rogers Island for staging and disposal of PCB-contaminated dredge spoils in the late 1970's presented an environmental concern. This concern was prompted by historical reports and information received by the NYSDEC from a citizen alleging that PCB-contaminated soil was being spread on the Island. In October 1998, EPA initiated an evaluation of the extent of PCB-contaminated soils to determine if health concerns existed for the residents of the island. EPA’s sampling results indicated that surface soils on Rogers Island within the floodplain of the Hudson River were contaminated with PCBs and lead. Based on a direct contact human health concern, between June and December of 1999, a total of 4,440 tons of contaminated soil was excavated from nine Rogers Island properties and disposed of off-site (3,530 tons of PCB-contaminated soil were removed during this action) under CERCLA’s removal authority. Backfilling with clean materials and the installation of erosion controls followed the excavation activities.

Basis for Taking Action

In 1984, EPA signed a ROD for the Hudson River which selected a remedial action for OU1 and a treatability study of the Waterford Water Works. The primary concern for OU1 sites was the potential for the public’s direct contact with PCB-contaminated sediments and the potential volatilization of the PCBs. Additionally, without remediation, discharges from these sites through bank scouring during periods of high flow would have continued to be a mechanism in the transfer of PCBs to the Hudson River.

In December 1989, EPA announced its decision to initiate a detailed Reassessment RI/Feasibility Study (FS) of the interim no-action decision for the Upper Hudson River sediments. The Reassessment was divided into three phases. Phase 1 consisted primarily of a review of existing data and was completed in August 1991. Phase 2, which included the collection and analysis of new data as well as modeling studies and human health and ecological risk assessments and peer reviews, began in December 1991 and concluded in November 2000. Phase 3, also known as the FS, formally began in September 1998 and was released concurrently with the Proposed Plan in December 2000.

Through the Reassessment, EPA determined that once introduced into the river, PCBs adhered to sediments with some fraction being carried in the water column. Physical, chemical, and biological release mechanisms allow PCBs in the sediment to be available for redistribution and to be a source of PCB contamination to the water column. The sediments would continue to release contamination to the water column and to biota, through aquatic and benthic food chains, unless they are managed or remediated. Therefore, removal of PCB-contaminated sediments would result in reduced PCB concentrations in fish tissue, thereby accelerating the reduction in potential future human health and ecological risks.

The Human Health Risk Assessment (HHRA) showed that, under the baseline conditions, the cancer risks and the non-cancer health hazards from ingestion of fish from the Upper Hudson River are expected to be above EPA's generally acceptable levels for the 40-year exposure duration beginning in 1999. The total cancer risk for the reasonable maximum exposed (RME) individual assuming an ingestion rate of 51 half-pound meals/year with appropriate adjustments based on age is 1×10^{-3} or 1,000 times higher than the goal for protection and 10 times higher than the highest risk level generally allowed under the federal Superfund law. Non-cancer health hazards for the RME young child, adolescent, and adult, respectively, are 104, 71, and 65 times higher than the level considered as protective of public health (i.e., a Hazard Index = 1). Ingestion of one half-pound fish meal every two months, the average ingestion rate, results in cancer risks to the central tendency exposed (CTE) individual that are within the cancer risk range and for the non-cancer assessment that are above the goal of protection of a Hazard Index of 1. The non-cancer health hazards for the CTE individual, with appropriate modifications for ingestion rates based on bodyweight for the individual age groups, are 7, 8 and 12 times higher for the adult, adolescent and young child, respectively, than the level considered to be protective (i.e., Hazard Index = 1). The cancer risks and non-cancer health hazards from ingestion of fish from the Mid-Hudson River are about half as high as those in the Upper Hudson, due to lower concentrations of PCBs in fish, but are also above levels of concern.

EPA's 2000 Baseline Ecological Risk Assessment (BERA) evaluated a large suite of assessment endpoints across the multiple trophic levels of the Hudson River aquatic environment. The results of the EPA 2000 BERA led to the inclusion of an ecological remedial action objective (RAO) and remedial goal in the ROD. The ecological RAO is to reduce the risks to ecological receptors by reducing the concentration of PCBs in fish; and it was based upon the finding of unacceptable risks to mink and river otter (piscivorous mammals) from the consumption of PCB-contaminated fish in the absence of remediation. The risk-based remedial goal for the ecological exposure pathway is a range from 0.3 to 0.03 milligram/kilogram (mg/kg) PCBs in fish (largemouth bass, whole body), based on the lowest observed adverse effect level (LOAEL) and the no observed adverse effect level (NOAEL) for consumption of fish by the river otter. The ecological remedial goal is considered protective of all the ecological receptors evaluated because it was developed for the river otter, the piscivorous mammal and ecological receptor calculated to be at greatest risk from PCBs at the Site. In addition, a range from 0.7 to 0.07 mg/kg PCBs in spottail shiner (whole fish) was developed based on the LOAEL and NOAEL for the mink, a species known to be sensitive to PCBs.

IV. Remedial Actions

Remedy Selection OU1

On September 25, 1984 EPA issued a ROD for OU1. The major components of the selected remedy consisted of the following:

Remnant Deposits

- In-place capping of the exposed Remnant Deposits (sites 2, 3, 4, and 5), consisting of a soil cover using 18-inches of subsoil placed in 6-inches lifts and a final 6-inches later of topsoil;
- Riprap stabilization system upgraded above the 100-year flood level; and
- Installation of fencing and posting to prevent public access.

Waterford Water Works Treatability Study

- Detailed evaluation of the Waterford Water Works treatment facilities; and
- Sampling and analysis of treatment operations to determine if an upgrade or alterations of the facilities were needed.

River Sediments

- Interim No-Action decision with regard to PCBs in the sediments of the Upper Hudson River.

The 1984 ROD did not call for the implementation of institutional controls.

Remedy Implementation OU1

Remnant Deposits

The NYSDEC prepared preliminary design documents for the construction of the in-place containment remedy at the OU1. Pursuant to an Administrative Order on Consent issued by the EPA on September 27, 1989, GE prepared a construction plan and other related plans for in-place containment of Remnant Deposits 2 through 5. The final cap system, which included GE's refinements to the design, consisted of (in ascending order) a sand/fill bedding layer, a custom designed geosynthetic clay liner (GCL) composite located at the top of the 100-year flood zone, a sand drainage layer, and a topsoil and vegetative cover. The cap system modification also included a gas collection and venting system.

In October 1989, GE began construction activities with the clearing of vegetation and construction of access roads. On July 31, 1990, the United States District Court for the Northern District of New York approved a Consent Decree between the United States and GE in which GE agreed to perform EPA's in-place containment remedy for the Remnant Deposits (OU1) and to perform post-construction monitoring.

It was determined during design meetings with the EPA, NYSDEC, and NYSDOH that areas of the Remnant Deposits with PCB concentrations exceeding 5 ppm should be capped. GE delineated the 5 ppm boundary between June and September 1990. The areas of cover typically extended at least five feet beyond the limits of the 5 ppm boundary.

The sand/fill bedding layer (6 inches) was placed first to provide a uniform surface for the GCL and to bridge soft/unstable subsoil zones. The GCL consisted of two layers of reinforcing geotextile and a low-permeability layer. The geotextile distributes the load of subsequent cap components over the soft foundation soils as a way to minimize the potential for differential cap settlement and/or subsidence. The bottom geotextile acts as a gas collection layer, which conveys the gas to a passive gas venting system. Some methane gas is anticipated to be generated by organic sediment decomposition.

Overlying the GCL is a drainage sand layer (12 inches) which intercepts infiltrating precipitation and conveys it off-site. The topsoil and vegetative cover layers (6 inches) protect the cap system from erosion. The vegetative cover system consists of perennial and annual grasses. The cap surfaces are generally flat sloped (approximately 3.5 percent), thereby minimizing overland flow velocities of storm runoff and further reducing the potential for cap system erosion.

The Remnant Deposit sites' banks were stabilized with riprap along the Hudson River to protect them from erosive forces. The riprap extends at least two feet above the Hudson River's 100-year flood elevation and was sized to withstand the river flow velocities associated with such an event. The cap system, and subsequent maintenance of the caps system, at OU1 limits the exposure of contaminants to ecological receptors.

A perimeter drainage channel system was constructed around each site to divert off-site precipitation runoff, thereby reducing cap erosion potential. Where required (Remnant Deposit sites 2, 3, and 4), stream transfer channels were constructed to convey upland streams over the sites. The stream transfer channels have a high-density polyethylene membrane liner as an additional protection. These channels have riprap linings in place of the topsoil/vegetative cover components. The perimeter drainage and stream transfer channels are designed for the peak flow associated with a 100-year storm event.

The construction of the in-place containment of Remnant Deposit sites 2, 3, 4, and 5 was completed by May 1991. Remedial efforts were not conducted at Remnant Deposit 1 as the majority of the deposit site had already washed downstream and due to the impracticability of capping the island. The 2002 ROD recognized the possibility that a large flow event could release an additional portion of the PCB-contaminated sediment that might remain at Remnant Deposit 1 and, therefore, called for follow-up sampling of this area to determine whether the deposit needs to be remediated. However, on a site visit to the Remnant Deposits with GE, NYSDEC and NYSDOH personnel on April 4, 2012, EPA observed that sediment would not likely be present in an amount sufficient for sample collection.

In accordance with the remediation requirements of the 1990 Consent Decree, GE developed a maintenance plan for post-closure of Remnant Deposits 2, 3, 4, and 5. The maintenance plan calls for a site inspection which documents the components of the site's continuing performance. Inspections are conducted on the site access road, roadway condition, diversion ditches, roadway sideslopes, and culverts and are reported in a biannual report to the EPA. At each Remnant Deposit, site security, vegetative cover, and site drainage are observed and repaired as necessary. The maintenance plan additionally calls for an inspection after a rain event which produces at least 2-1/2 inches of rain in a 24-hour period.

Waterford Water Works

The Waterford Water Works treatability study was included in the 1984 ROD to determine if an upgrade or alterations to the Waterford Water Works facility were needed. Treated drinking water from the Waterford supply system rarely exceeded 0.1 parts per billion (ppb) of PCBs at the time of the 1984 ROD. Based on 35 samples collected by New York State, the concentration of PCBs in Waterford drinking water averaged 0.06 ppb. However, analysis of the river water quality indicated incidents where PCB concentrations had exceeded 1 ppb, the maximum allowable exposure promulgated by the NYSDOH at the time, thus generating the need for a study to be conducted.

NYSDEC, with funding provided by EPA, conducted the treatability study at the Waterford Water Works. The study was released in 1990 and found that PCB concentrations were below analytical detection limits after treatment and met standards applicable to public water supplies.

Remedy Selection OU2

EPA identified its selected remedy for OU2 in a ROD issued on February 1, 2002. The selected remedy includes the dredging of approximately 2.65 million cubic yards of PCB-contaminated sediments from the Upper Hudson River, which was estimated in the ROD to contain 70,000 kg (about 150,000 pounds (lbs)) of Total PCBs (approximately 65 percent of the Total PCB mass present within the Upper Hudson River). The selected remedy also assumes a separate source control action near the GE Hudson Falls plant, which was to be managed by NYSDEC.

The following are the RAOs developed for the remedy:

- Reduce the cancer risks and non-cancer health hazards for people eating fish from the Hudson River by reducing the concentration of PCBs in fish;
- Reduce the risks to ecological receptors by reducing the concentration of PCBs in fish;
- Reduce PCB levels in sediments in order to reduce PCB concentrations in river (surface) water that are above applicable or relevant and appropriate requirements (ARARs);
- Reduce the inventory (mass) of PCBs in sediments that are or may be bioavailable;
- Minimize the long-term downstream transport of PCBs in the river.

The major components of the selected remedy include:

- Removal of sediments based primarily on a mass per unit area (MPA) of 3 grams per square meter (g/m^2) Tri+ PCBs [4] or greater (approximately 1.56 million cubic yards of sediments) from River Section 1;
- Removal of sediments based primarily on an MPA of 10 g/m^2 Tri+ PCBs or greater (approximately 0.58 million cubic yards of sediments) from River Section 2;
- Removal of selected sediments with high concentrations of PCBs and high erosional potential (NYSDEC Hot Spots 36, 37, and the southern portion of 39) (approximately 0.51 million cubic yards) from River Section 3;
- Dredging of the navigation channel, as necessary, to implement the remedy and to avoid hindering canal traffic during implementation. Approximately 341,000 cubic yards of sediments will be removed from the navigation channel (included in volume estimates in the first three components, above);
- Removal of all PCB-contaminated sediments within areas targeted for remediation, with an anticipated residual of approximately 1 mg/kg Tri+ PCBs (prior to backfilling);
- Performance standards for air quality and noise and included in the ROD consistent with state and federal law;
- Other performance standards (including but not necessarily limited to resuspension rates during dredging, production rates during dredging, residuals after dredging) will be developed during design with input from the public and in consultation with the state and federal natural resource trustees. These performance standards will be enforceable, and based on objective environmental and scientific criteria. The standards will promote accountability and ensure that the cleanup meets the human health and environmental protection objectives of the ROD;
- Independent external peer review of the dredging resuspension, PCB residuals, and production rate performance standards and the attendant monitoring program, as well as the report prepared at the end of the first phase of dredging that will evaluate the dredging with respect to these performance standards;
- Performance of the dredging in two phases whereby remedial dredging will occur at a reduced rate during the first year of dredging. This will allow comparison of operations with pre-established performance standards and evaluation of necessary adjustments to dredging operations in the succeeding phase or to the standards. Beginning in Phase 1 and continuing throughout the life of the project, EPA will conduct an extensive monitoring program. The data that EPA gathers, as well as the Agency’s ongoing evaluation of the work with respect to performance standards, will be made available to the public in a timely manner and will be used to evaluate the project to determine whether it is achieving its human health and environmental protection objectives;

[4] Tri+ PCBs represents the sum of PCBs with 3 to 10 chlorine atoms per molecule.

- Backfill of dredged areas with approximately one foot of clean material to isolate residual PCB contamination and to expedite habitat recovery, where appropriate;
- Use of rail and/or barge for transportation of clean backfill materials within the Upper Hudson River area;
- MNA of PCB contamination that remains in the river after dredging;
- Use of environmental dredging techniques to minimize and control resuspension of sediments during dredging;
- Transport of dredged sediments via barge or pipeline to sediment processing/transfer facilities for dewatering and, as needed, stabilization;
- Rail and/or barge transport of dewatered, stabilized sediments to an appropriate licensed off-site landfill(s) for disposal. If a beneficial use of some portion of the dredged material is arranged, then an appropriate transportation method will be determined (rail, truck, or barge);
- Monitoring of fish, water, and sediment to determine when Remediation Goals are reached, and also monitoring the restoration of aquatic vegetation; and
- Implementation (or modification) of appropriate institutional controls such as fish consumption advisories and fishing restrictions by the responsible authorities, until relevant Remediation Goals are met.

Remedy Implementation OU2

In April 2004, EPA issued peer-reviewed Engineering Performance Standards (EPS), which included a Resuspension Standard, a Residuals Standard, and a Productivity Standard. These performance standards were designed to promote accountability and ensure that the cleanup meets the human health and environmental protection objectives set forth in the 2002 ROD. In May 2004, EPA issued Quality of Life Performance Standards (QoLPS), which included standards governing air quality, odor, noise, lighting, and navigation impacts. These standards were developed in consultation with New York State and with public input and are consistent with applicable federal and state laws. Additionally, in January 2005, EPA, working with NYSDEC and NYSDOH, issued a set of Substantive Water Quality (WQ) Requirements governing: (1) in-river release of constituents not subject to the EPS and (2) discharges of treated water from the sediment processing facility to the Champlain Canal. On September 14, 2006, EPA provided GE with requirements relating to the discharges of non-contact storm water from the processing facility to Bond Creek.

In October 2005, GE and EPA executed a Consent Decree with an accompanying statement of work (SOW) requiring GE to perform Phase 1 of the remedial action. Phase 1 was to be implemented initially at less than full-scale and was to include an extensive monitoring program. The Consent Decree provided, among other things, that, after the completion of Phase 1, EPA and GE would each prepare a Phase 1 Evaluation Report that would evaluate the Phase 1 dredging relative to the EPS, and, as appropriate, propose changes to those standards. Following the peer review of the Phase 1 Evaluation Reports, the Consent Decree called for EPA to notify

GE of EPA's decision on any changes to the EPS, QoLPS, SOW, or the scope of Phase 2, after which GE would elect whether to perform Phase 2 under the Consent Decree. The SOW and its attachments (Critical Phase 1 Design Elements, Remedial Action Monitoring Scope, Performance Standards Compliance Plan Scope, Remedial Action Community Health and Safety Plan Scope, Operation, Maintenance and Monitoring Scope, and Certification Unit (CU)/Certification Forms) outlined a number of requirements for the implementation of Phase 1. Data gathered during Phase 1 was expected to enable EPA to determine if adjustments were needed to Phase 2 operations or to the performance standards.

The court approved the Consent Decree on November 2, 2006 (Civil Action No. 1:05 CV-01270, U.S. District Court for the Northern District of New York). In January 2009, GE and EPA agreed to a modification of the Consent Decree which addressed GE's reimbursement of costs incurred by EPA in providing an alternate water supply and water treatment to downstream water suppliers and included a revised scope of the water quality monitoring program for Phase 1.

Pre-Dredging Phase 1 Activities

Between March 2006 and May 2009, GE submitted and EPA approved a Final Design Report for Phase 1 and Remedial Action Work Plans (RAWPs) for the construction of the sediment processing facility, an associated rail yard, the on-river support facilities and for the performance of Phase 1 dredging, processing facility operations, and subsequent habitat replacement/ reconstruction in Phase 1 dredge areas.

On April 23, 2007, construction activities began at the sediment processing facility located on a more than 100-acre site between the Champlain Canal and the main rail line in Fort Edward, New York. Three support facilities, a work support marina in Moreau, general support property in Fort Edward, and a backfill/cap material barge loading area in Moreau were constructed to support the remedial action. Construction of the sediment processing facility was substantially completed by January 2009. On May 11, 2009, a Phase 1 Pre-Dredging Construction Conference was held pursuant to Section 2.3.3.1 of the SOW.

The 2002 ROD states that during the sediment dredging, EPA will increase monitoring at public water systems that use the Hudson River as a drinking water source as a way to evaluate the potential for increased PCB levels in the river resulting from dredging operations. EPA provided funding to the NYSDOH's Bureau of Water Supply Protection to develop and implement monitoring of these public water supplies (PWS) prior to and during dredging.

PSWs included in the monitoring program were Halfmoon Water District, Waterford Water Works, Poughkeepsie City/Town, Rhinebeck Village Water, Port Ewen which all drew water directly from the Hudson River. Stillwater Village utilizes groundwater which is under the direct influence of the Hudson River. Additionally, Green Island, which operates an infiltration gallery in the Hudson River as the system's primary raw water source, was also monitored under the program.

In the spring, summer, and fall (primary dredging months) of 2008, NYSDOH conducted its baseline pre-dredging sampling event with the collection of pre-treatment and treatment samples from all seven PSWs. Water sample results were all below the Maximum Contaminant Level (MCL) (500 parts per trillion (ppt)) for PCBs in drinking water.

Phase 1

Phase 1 dredging was designed with the goal of dredging, dewatering, and disposing of 265,000 cubic yards of sediments from 18 CUs encompassing 90 acres within River Section 1. These areas included the northern portion of Thompson Island Pool (TIP) on the north, south, east and west sides of Rogers Island, as well as the area of river in the vicinity of Griffin Island, between RM 190.4 and RM 189.9. On May 15, 2009, Phase 1 dredging began with the removal of sediments from the river utilizing mechanical dredges with enclosed environmental clamshell buckets. Sediments were then transported by barge to the Fort Edward sediment processing facility. After sediment removal, dredged areas were backfilled or capped in accordance with the EPA-approved design, the requirements of the Residuals Performance Standard, as modified, and, in some cases, by agreement between EPA and GE. At the sediment processing facility, dredged sediments went through a multi-stage dewatering process before being loaded into railcars for off-site transport to a permitted disposal landfill.

Approximately 35 percent of the processed sediments were shipped by the end of the 2009 Phase 1 dredging season. These processed sediments were sent to Waste Control Specialists, LLC (WCS) in Andrews, Texas. In a letter dated May 7, 2010, GE notified EPA that the agreement with WCS had been terminated as WCS was unable to meet GE's contractual requirements during 2009. The remaining processed materials were temporarily stored at the sediment processing facility and subsequently transported by rail to an alternate approved disposal facility in 2010. Remaining Phase 1 processed sediments where shipped to Clean Harbors Grassy Mountain, LLC in Grassy Mountain, Utah, US Ecology Idaho, Inc. in Grand View, Idaho, and Wayne Disposal, Inc. in Bellville, Michigan. Water produced through the dewatering process was treated and discharged into the Champlain Canal in accordance with the applicable Substantive WQ Requirements.

Extensive sampling and monitoring were conducted throughout Phase 1 in accordance with the Phase 1 Performance Standards Compliance Plan Scope and the Remedial Action Monitoring Scope in order to assess achievement of established Phase 1 EPS, QoLPS, and Substantive WQ Requirements. GE addressed exceedances of the standards by performing response actions pursuant to the Performance Standards Compliance Plan Scope.

Phase 1 dredging was completed in 10 of the originally-planned 18 CUs, which encompassed 48 acres, versus the originally planned 90 acres. Dredging and backfilling were completed in the fall of 2009 and resulted in a total of 286,000 cubic yards of sediment being removed from the 10 CUs.

Dredging of the navigation channel, as necessary, to implement the remedy and to avoid hindering canal traffic was performed in the areas within the navigation channel where dredging was necessary to meet the vessel draft requirements to implement the remedy. Approximately 1,500 cubic yards of material were removed from the Champlain Canal between locks 7 and 8 during Phase 1 to allow for safe passage of barges going to the unloading wharf.

In March 2010, both EPA and GE completed individual Final Phase 1 Evaluation Reports. EPA's report detailed the effectiveness of the first phase of dredging, as well as the challenges encountered during the first dredging season. It also laid out EPA's proposed modifications to the EPS for dredging resuspension, residuals, and productivity for the second phase of the project. GE's Phase 1 Evaluation Report concluded that the EPS were not and could not be met in Phase 1 and needed to be modified for Phase 2. GE's report included the Company's proposed modifications to the EPS for Phase 2.

The EPA Phase 1 Evaluation Report indicated that three significant guideposts for success during Phase 1 were achieved. These were:

- Both sediment volume and the PCB mass removed in Phase 1 met or exceeded the amounts initially estimated for the Phase 1 portion of the project. The mass of PCBs removed was equivalent to the planned mass of 20,000 kg for all 18 originally planned Phase 1 CUs, but represented an 80 percent increase in PCB removal over what was expected for the 10 CUs (11,000 kg) dredged in Phase 1.
- There were few shut-downs due to exceedances of the Resuspension Standard, with limited impact on dredging productivity. Fish tissue impacts were limited to within 2 to 3 miles downstream of the TIP, and the data did not indicate any measurable impacts to fish or water quality in the Lower River.
- 75 percent of the adjusted area (which includes structure and shoreline setbacks) was completed and closed in compliance with the Residuals Standard, although it was necessary to cap portions of several CUs out of compliance with the Residuals Standards due to schedule constraints (approximately 25 percent of the adjusted area). The Residuals Standard proved to be an effective tool to identify and manage previously uncharacterized inventory.

These successes were achieved despite complications experienced during the Phase 1 effort, including an inaccurate estimate of the depth of contamination (DoC), extensive wood debris, high river flows, shallow navigation channels, and limitations on dredged sediment transport and processing.

EPA's Phase 1 Evaluation Report determined that problems encountered during Phase 1 were manageable. Although the timely completion of the project continues to be an important consideration, EPA recommended that the Productivity Standard could be modified to allow EPA, at its discretion, to extend the Phase 2 schedule in order to accommodate conditions beyond the control of EPA and GE (such as extreme river flows, force majeure, or the discovery of significant additional inventory to be removed) without impacting the overall benefits of the project. EPA also expressed that the Residuals Standard should be streamlined and simplified and that scow unloading should be refined by making additional equipment available at the wharf for unloading scows. Additionally, EPA recommended that the time in which dredged areas are left open before capping or backfilling would be minimized.

Significant effort was taken to ensure that the remedy was implemented in a protective manner during Phase 1. The establishment and monitoring of the EPS and QoLPS proved to be effective tools in helping to protect the community while meeting the remedial goals of the project. In addition, in order to ensure that the remedy would not have negative impacts on water supplies downstream of the dredging, EPA constructed an alternate water supply line to provide the towns of Waterford and Halfmoon with water from the City of Troy, which does not obtain its water from the Hudson River. EPA also agreed to pay certain of Waterford's and Halfmoon's increased costs of obtaining water from Troy during the dredging project.

NYSDOH continued its monitoring program of PWSs from May through November 2009 to measure PCB concentrations in water samples from the PSWs in the Lower Hudson during Phase 1. The Village of Stillwater was excluded as it had a GAC system. Waterford Water Works and Halfmoon Water District also were excluded from the program as both supplies were obtaining their water from Troy. All samples collected at the four PSWs (Poughkeepsie, Rhinebeck Village Water, Green Island, and Port Ewen) were found to have PCB concentrations below the MCL.

EPA's and GE's Phase 1 Evaluation Reports were made available to the public during the peer review process in 2010 (described in more detail below). The public was invited to make comments on the reports directly to the independent peer review panel (the panel convened twice in a public setting in Saratoga Springs). Prior to EPA making a final determination on the changes to the Phase 2 dredging program, stakeholders were also given the opportunity to meet with senior level EPA managers. Certain stakeholders expressed an interest in increasing the size of the dredge target areas in River Sections 2 and 3, in order to account for the fact that, based on the design sampling, PCB concentrations in non-target areas are higher than EPA anticipated in the ROD. Other stakeholders expressed their support of GE's arguments set forth in its Phase 1 Evaluation Report. EPA evaluated these claims and determined that the remedy selected in the 2002 ROD was still expected to achieve its objectives, and the stakeholder's concerns did not support a modification of the scope of the remedy. Refer to Technical Assessment Question A for further discussion on the matter.

GE conducted habitat replacement/reconstruction in the dredged areas in 2010 and 2011. These activities were completed in July 2011. On August 15, 2011, EPA approved GE's Certification of Completion of Phase 1 Field Activities.

Phase 1 Peer Review

In accordance with Paragraph 14 of the Consent Decree and EPA's Peer Review Handbook (EPA Science Policy Council Handbook: Peer Review, December 2000), a "contractor-run peer review" was conducted to review both EPA's and GE's Phase 1 Evaluation Reports. The independent peer review panel was given a set of four charge questions to address in its review of the documents. The questions were as follows:

- Does the experience in Phase 1 show that each of the Phase 1 EPS can consistently be met individually and simultaneously?
- If not, and if EPA and/or GE has proposed modified EPS, does the experience in Phase 1 and any other evidence before the panel show that it will be practicable to consistently and simultaneously meet the EPS that are being proposed for Phase 2?
- If the experience in Phase 1 and other evidence before the panel does not show that it will be practicable to consistently and simultaneously meet the EPS that are being proposed for Phase 2, can the Phase 1 EPS be modified so that they could consistently be met in Phase 2, and, if so, how?
- If EPA and/or GE have proposed modifications to the monitoring and sampling program for Phase 2, are the proposed modifications adequate and practicable for determining whether the Phase 2 EPS will be met?

The Peer Review Panel was not charged with evaluating whether the remedial action will, or may, achieve the human health and/or environmental objectives of the 2002 ROD or whether Phase 2 should be implemented. Paragraph 14.c of the Consent Decree specified the process for selecting a Peer Review Panel to evaluate the Phase 1 Evaluation Reports and address the charge questions. Based on an agreed-upon selection process, seven panelists were selected in September 2009 based on expertise and the absence of conflicts of interests. Prior to the end of Phase 1 dredging, EPA and GE provided the panel members with a tour of the Site so that they could see the Phase 1 operations first-hand.

On February 17 and 18, 2010, the Phase 1 Peer Review Panel held an Introductory Session to hear presentations from EPA and GE regarding information gained during Phase 1 of the dredging project. On March 8, 2010, EPA and GE submitted their respective Phase 1 Evaluation Reports to the Peer Review Panel. EPA and GE proposed modifications to the EPS based on information gathered and the outcome of the Phase 1 dredging. The public was given the opportunity to review and provide comments to the Peer Review Panel on both the EPA and GE reports, and the Peer Review Panel publicly discussed its views on the reports in early May 2010. The panel members' individual views on the charge questions were compiled into a report that underwent factual review by EPA and GE and was provided to the public for informational purposes in mid-August 2010.

On September 10, 2010, the Peer Review Panel released its "Peer Review of Phase 1 Dredging Final Report," in which the panel members answered the charge questions. The Peer Review

Panel found that the 2004 EPS for Resuspension, Residuals, and Productivity were not met individually or simultaneously during Phase 1 and could not be met in Phase 2 without substantive changes. The Panel concluded that neither the EPA's nor GE's proposed modified EPS would support the successful execution of Phase 2.

Consequently, the Panel developed and recommended the implementation of modified EPS and best management practices. One of the major issues demonstrated in Phase 1 was that the Residuals Standard had a substantial impact on project success and on the interaction with the Resuspension Standard and the Productivity Standard. The Panel expressed that a key obstacle to simultaneously achieving the EPS involved incomplete DoC characterization combined with adherence to the 2004 EPS residual target levels. As a result, the Residuals Standard affected both the Resuspension Standard and Productivity Standard. Repeated dredge passes and prolonged exposure of PCBs in sediments in the CUs resulted in increased PCB resuspension and release. An unexpected increase in inventory, due to incomplete DoC characterization, had the greatest effect on the Productivity Standard in terms of numbers of CUs remediated.

In its report, the Panel proposed that if the DoC is better characterized, and a focus is placed on not leaving the CU sediments exposed for a prolonged period of time, the bulk of PCB inventory can be removed during Phase 2. Therefore, the Panel proposed a revision to the Residuals Standard to accelerate CU closure by establishing an elevation-focused dredge design paradigm, which would reduce resuspension, manage residuals, and improve productivity.

For Phase 2 Year 1, the Panel proposed that the Resuspension Standard and Productivity Standard should be based on metrics consistent with Phase 1. The Panel did not believe, however, that dredging activities should be interrupted if the targets are not achieved during Phase 2 Year 1. The goal of these interim standards was to establish baseline targets during Phase 2 Year 1 and to allow dredging to recommence in 2011, while near-field and far-field data are collected.

Phase 2 Decision

On December 17, 2010, EPA transmitted a letter to GE, pursuant to paragraph 15.b of the Consent Decree, that notified GE of EPA's "decision regarding changes, if any, to the Phase 1 Engineering Performance Standards, the Phase 1 Quality of Life Performance Standards, the [Statement of Work ("SOW")], and the scope of Phase 2 ("Phase 2 Decision")." On December 31, 2010, GE formally notified EPA that it would conduct Phase 2 pursuant to the Consent Decree. On August 15, 2011, the United States Department of Justice filed in the United States District Court a modification to the Consent Decree which revised certain provisions to address EPA's Phase 2 Decision.

The Phase 2 Decision included changes in methodology to improve sampling in order to obtain a better characterization of the DoC. GE would additionally be required to adjust the DoC calculations to account for variability encountered in establishing the DoC. As a result, GE agreed to sample sediment cores that under the previous Sediment Sampling and Analysis Program (SSAP), conducted post-ROD, had a less than a 60 percent recovery rate. In 2010, GE began the Supplemental Engineering Data Compilation (SEDC) Program where a total of 640 core locations were sampled. In 2011, a total of 590 core locations were sampled. A total of 566 core locations are targeted for the 2012 SEDC Program which will cover CUs 71-100. Results from the SEDC Program have been generally consistent with EPA's general understanding of PCB distribution in the river.

Additionally, in the Phase 2 Decision, EPA notified GE that in regard to the Residuals Standard, there would be a maximum of two dredge passes implemented followed by backfill or capping as appropriate. In circumstances when concentrations of PCBs are encountered above 500 ppm Tri+ PCBs after the second dredging pass, EPA will require a third pass. Areas near shore above 50 ppm Total PCBs after the first pass will require a second dredge pass. EPA set limits on capping at 11 percent of the total project area excluding bedrock/clay/shoreline areas. A limit of 3 percent was established within the 11 percent for areas where the concentration of PCBs remains above 6 ppm Tri+ PCBs below the top 6 inches of sediment after dredging. EPA set the Productivity Standard for Phase 2 a minimum of 350,000 cubic yards of sediment to be dredged each year.

For the Resuspension Standard, if at a designated measuring location, the concentration exceeds 500 ppt for 5 days out of any 7, GE may be required to take steps which could include a temporary slowdown of operations or a temporary shutdown of operations. The amount of PCBs allowed to travel downstream should not exceed 2 percent of the total amount of PCBs actually excavated from river bottom as measured at the first designated location downstream of where dredging is taking place. At Waterford, the farthest downstream measuring station, the load should not exceed 1 percent of the amount excavated. If these limits are exceeded for 14 consecutive days, then GE may be required to temporarily slow down operations.

EPA's Phase 2 Decision also incorporated the concept of adaptive management into the cleanup. As the Peer Review Panel recommended, EPA needs to be able to adapt to new information and make or require changes through adaptive management in order to achieve the expected benefits of the project. The approach includes the annual reassessment of the EPS based on each prior year's data, routine reassessment of dredging operations, best management practices, and dredging performance with regard to the EPS. The objectives of the adaptive management approach are to maintain or improve the efficiency of the project, mitigate short-term impacts as needed, help ensure that the remedy is successfully completed consistent with the ROD, and that the targets and objectives set forth in the ROD are met. The adaptive management approach additionally includes other project activities such as habitat reconstruction and the quality of life standards. EPA met with GE in January 2012 to review potential adaptive management changes for the 2012 dredging season.

Phase 2

GE conducted Phase 2 Year 1 from June 6 to November 8, 2011. Dredging was initially scheduled to begin in early May 2011. However, dredging was delayed due to a historic 100-year flood event which caused the flow rate of the river to rise above 50,000 cubic feet per second (cfs). Once flow rates subsided to 12,000 cfs in early June, GE began the dredging season 24 hours a day and 6 days per week. During dredging, up to 3 dredge platforms with 5-cubic yard dredge buckets were on the Upper Hudson River at one time. During the dredging season, there were 19 hopper barges and 17 tugboats operating at one time, which represents a decrease from Phase 1 in-river operations, while continuing to meet the Productivity Standard.

A total of 363,332 cubic yards of sediment, at approximately 1.25 tons per cubic yard, were removed during the Phase 2 Year 1 dredging season, which exceeded the Phase 2 Productivity Standard. A total of 670 barges were unloaded at the processing facility which represented a total of 27,200 kg Total PCB mass removed. Processed sediments were shipped to US Ecology Idaho, Inc. in Grand View, Idaho and Wayne Disposal, Inc. in Bellville, Michigan for disposal.

Phase 2 Year 1 was marked by improved compliance with the EPS and QoLPS. The QoLPS for air quality had a reduction in exceedances at both the processing facility and the dredge corridor. Compliance with the Residuals Standard resulted in approximately 3 percent of counted nodes capped. Counted nodes are areas where dredging has occurred but capping is still required due to high residuals after dredging or areas where inventory still remains. Inventory is characterized as the presence of PCB concentrations of 6 ppm Tri + PCB or greater in sediments at depths below the top 6 inches after two dredging passes.

The dredging was consistently in compliance with the Resuspension Standard throughout Phase 2 Year 1. After Phase 1, EPA questioned whether the Thompson Island automated monitoring station was configured in a way that would allow for collection of representative samples. The collective data set from this station, which analyzed duplicate samples when initial values were over the MCL for Total PCBs in drinking water, indicated that the sample results were inconsistent. Further inspection at this station revealed that the intakes were covered with weeds and/or mud, which could bias the sample results. After discussions between EPA and GE, a new Thompson Island buoy station was deployed above the Thompson Island Dam (TID). Results from the new station were stable, which further supported EPA's concerns about collecting representative samples from the original automated Thompson Island station. Utilizing the lines of evidence from EPA's data review and experiences with the automated station during Phase 1, and the early of part of Phase 2 Year 1, EPA and GE decided to discontinue data collection at the automated station.

The remedial activities conducted to date have had short-term temporary impacts to aquatic and wildlife habitats of the Upper Hudson River, and such impacts are expected to occur for the remainder of the construction period. An important aspect of the remedy requires that, where appropriate, a habitat replacement and reconstruction program should be implemented for submerged aquatic vegetation, wetlands, and unconsolidated river bottom. This program is being implemented to mitigate impacts to those resources in an adaptive management framework. The habitat replacement and reconstruction program is being implemented, as appropriate, in accordance with federal and State requirements. The State, federal natural resource trustees, and the public have been given, and continue to have, opportunities to provide input or feedback regarding the habitat replacement and reconstruction work. While this habitat replacement and reconstruction work began in 2010 (i.e., in the year following the 2009 Phase 1 dredging), much remains to be completed because the project has several additional construction years. A monitoring program is in place for Phase 1 areas and is under development for Phase 2 areas to verify the attainment of the habitat replacement objectives. Results of this monitoring program will be included in future five year reviews.

In 2011, GE conducted a deposition study in River Section 1 based on the 2010 Peer Review recommendations. Surface sediment samples were collected using a transect approach which targeted sediments from 0 to 2 inches in the dredge prisms and areas outside of the dredge prisms. The study concluded that PCB deposition was not having a measureable impact on surface sediment PCB concentrations.

No additional navigational dredging was required to access the dredge prisms or traverse the channel in 2011. As the project moves south, however, there may be locations that will require additional dredging to allow passage of vessels in the channel or to access shallow dredge areas. This will be handled during the review of proposed dredge prisms submitted as part of the applicable annual design work plan.

After the 2011 dredging season, GE proposed equipment modifications at the processing facility which included an expansion of the coarse material staging area, construction of a second gravity thickener, and construction of an additional barge unloading station. EPA agreed to these modifications and, to date, the coarse material staging area and second gravity thickener have been completed. The second unloading station was completed and became operational in May 2012.

On May 10, 2012, EPA approved GE’s proposed plan for the characterization, processing, and disposal of non-Toxic Substances and Control Act (TSCA) sediments actively dredged from the Upper Hudson River as part of the Hudson River PCB Dredge Project. GE has submitted an addendum to the RAWP, specifying TSCA/Non-TSCA identification procedures, segregation and handling protocols, size separation processes, sampling, staging procedures, and reporting formats. EPA anticipates that this plan will become a component of the material processing.

Institutional Controls Implementation

The 2002 ROD included institutional controls in the form of fish consumption advisories and fishing restrictions until the relevant remediation goals are met. In 1975, NYSDOH issued a fish consumption advisory. NYSDOH's 2012-2012 "Health Advice on Eating Sportfish and Game[5]" includes the following specifications:

- Women of childbearing age (under 50 years old) and children (under 15 years old) should not eat fish or crabs from the Hudson River from the Corinth Dam to the New York City Battery.

- Women over 50 years old and men over the age of 15 are advised to not eat any fish from the Route 9 Bridge Dam in Glens Falls to the Troy Dam. From Bakers Falls to the Troy Dam, the NYSDEC catch-and-release regulations apply. Table 2, which is from the NYSDOH's *Hudson River Fish Advisory Outreach Project*, summarizes the advisories relative to women over the age of 50 and men over the age of 15.

These advisories apply to the tributaries and connected water of the Hudson River if there are no dams, falls or barriers to stop the fish from moving upstream.

In 1976, NYSDEC banned all fishing in the Upper Hudson and most commercial fishing in the Lower Hudson. In 1995, NYSDEC reopened the Upper Hudson River to sportfishing on a catch-and-release basis only. NYSDEC requires that all fish caught in the river section between the Federal Dam at Troy and Bakers Falls in the Village of Hudson Falls, New York, must be immediately returned to the water without unnecessary injury to the fish. Since no fish may be possessed here, the use or possession of fish as bait is also prohibited. This regulation applies to all tributaries in this section of the Hudson River up to the first barrier (dam or waterfall) that is impassable to fish. Fines for violation of any of these rules carry a maximum penalty of $250 per violation and are enforced by NYSDEC.

Since the 2002 ROD, NYSDOH has also developed a multi-year initiative *Hudson River Fish Advisory Outreach Project* to inform the public of these advisories. The Project aims to make people aware of the Hudson River fish advisories, help people understand the advisory messages and encourages people to follow the advisories. Pursuant to the Consent Decree, GE has contributed $4 million to Health Research, Inc, of Rensselaer, NY, in order to support the State's implementation of appropriate fish consumption advisories and fishing restrictions.

NYSDOH fish advisory outreach work has been conducted in partnership with other state and local agencies. Some partnerships are commercial fisherman, recreational anglers, boating community representatives, environmental justice advocates, immigrant rights advocates, local health officials, environmental conservation officials, parks and recreations officials, health care provider representatives, community group leaders and food pantry and community food networks.

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[5] Available at: www.health.ny.gov/environmental/outdoors/fish/health_advisories/docs/advisory_booklet.pdf

The Project has awarded a total of about $60,000 each year in mini-grants since 2009 to a number of organizational partners. Cornell Cooperative Extension of Dutchess and Rockland counties are two of the original Project partners. Hudson Basin River Watch, with environmental educator the "River Haggie Outdoors," is the third. These partners conducted activities, such as, directly reach the people who fish the Hudson River, connect with families who may eat the fish, and produce tailored outreach materials for specific audiences.

Additionally, NYSDOH Project staff has worked with municipalities, boat clubs, and private property owners to post signs which relay the advisory details for fish and crabs in English and/or Spanish. NYSDOH has worked with these entities and individuals to voluntarily post signs at over 250 fishing access locations.

In addition to the fish consumption advisories and fishing restrictions, EPA believes that additional institutional controls may be needed in order to protect the subaqueous caps installed by GE during the dredging, and to protect areas in which GE conducted habitat restoration measures until the new plantings become established. Such institutional controls may include restrictions on anchoring and other activities that may damage the caps or the new plantings. EPA will work with GE and the NYSCC on the establishment of such institutional controls as may be appropriate.

The 1984 ROD did not identify institutional controls for the Remnant Deposits (OU1). An institutional control should be implemented that would ensure future use of the remnant properties would be limited to uses and activities that would not compromise the integrity of the cap system and will not result in unsafe exposures to contaminants for those using the park.

V. Five-Year Review Process

Administrative Components

The five-year review team consisted of Gary Klawinski (RPM for OU2) and Jennifer LaPoma (RPM for OU1), Dave King (Project Coordinator and Director of the Hudson River Field Office), Doug Garbarini (New York Remediation Branch Chief), Marian Olsen (Human Health Risk Assessor) and Marc Greenberg (Ecological Risk Assessor, HQ-OSRTI), and Doug Fischer (Site Attorney) of EPA. Additional reviews were performed by EPA Headquarters to ensure national consistency with the Comprehensive Five-Year Review Guidance.

Community Involvement

The EPA Community Involvement Coordinator (CIC) for the Site, Larisa Romanowski, published a notice in The Albany Times Union on March 30, 2012, notifying the community of the initiation of the five-year review process. This notice was also provided to the Community Advisory Group (CAG) to solicit its input. The notice indicated that EPA would be conducting a five-year review of the remedy for the Site to ensure that the implemented remedy remains protective of public health and the environment and is functioning as designed. It was also indicated that once the five-year review is completed, the results will be made available in the Site repositories. The notice included the RPM's and CIC's mailing addresses and telephone numbers in the event the public had any comments or questions.

The notice also solicited comments from the public and questions related to the five-year review process or to the Site. Written correspondence was received from Congresswoman Nan Hayworth, Congressman Maurice Hinchey, NYSCC, NYSDEC, Scenic Hudson, Hudson Riverkeeper, Hudson River Sloop Clearwater, Natural Resources Defense Council, and Dr. Robert Michaels. These correspondences can be found at: www.epa.gov/hudson/ and were considered during the development of the five-year review report.

EPA extended the completion date for the five-year review based upon requests from the public for additional time to submit comments and to allow EPA sufficient time to consider the comments before completing this review. Additionally, the five-year review was discussed at a CAG meeting held after notice that the five-year review would be conducted. This CAG meeting was followed up by a special CAG meeting that focused on the five-year review. EPA also met on March 29, 2012 with GE, at the company's request, to discuss the five-year review; and EPA met on May 9, at their request, with representatives of Scenic Hudson, Hudson Riverkeeper, Hudson River Sloop Clearwater, Natural Resources Defense Council and Congressman Hinchey's office, to discuss the five-year review.

Document Review

The five-year review consisted of a review of relevant documents for OU1 and OU2. Table 5 provides a list of documents that were reviewed. Additional documents reviewed include the EPA Comprehensive Five-Year Review Guidance (June 2001).

Data Review

Water Quality Monitoring

A component of the Resuspension Standard calls for implementation of a routine water quality monitoring program to evaluate compliance with the Safe Water Drinking Act MCL of 500 ppt for Total PCBs. In Phase 1, water column samples collected at the TID Station exceeded the MCL value on three occasions. In Phase 2 Year 1, water concentrations were in compliance at both TID and Waterford.

The Resuspension Standard includes criteria for limiting the load of PCB mass transported into the Lower Hudson, beyond the far field station at Waterford. The mass load is typically represented as either a Tri+ PCB or Total PCB value. Historically, Tri+ PCBs, the heavier fraction of Total PCBs, have been measured in different media in the Hudson River. PCBs in Hudson River fish have almost exclusively contained Tri+ PCB concentrations throughout these sampling events. In Phase 1, Tri + PCBs and Total PCBs were evaluated and reported for the mass load criteria.

Throughout Phase 1, a seasonal net PCB load limit was evaluated for Total PCBs and Tri+ PCBs. These criteria were tracked throughout the dredging season as 7-day running averages of the net daily Total PCBs and Tri+ PCBs load past certain monitoring stations downstream of dredging operations.

The seasonal net load criterion for Total PCBs was 117 kg/year. This criterion was exceeded mid-season at the TID and Lock 5 (Schuylerville) monitoring stations. However, the Waterford Station remained under the annual target until the final weeks of dredging. By the end of the 2009 dredging season, where a much greater mass of PCBs was encountered in the dredged sediment than had been expected, all stations exceeded the 117 kg/year value for Total PCBs. The seasonal net load was 437 kg at TID, 269 kg at Lock 5, and 151 kg at Waterford. Similar conditions were observed for the Tri+ PCB seasonal net load criterion.

After the 2010 peer review, EPA revised the Resuspension Standard load criteria to a cumulative net load Tri+ PCB criterion. Beginning in Phase 2, the TID monitoring station should not exceed 2 percent of the Tri+ PCB mass removed in a dredging season. The Waterford Station should not exceed 1 percent of the Tri+ PCB mass removed in a dredging season. These standards are tracked utilizing a 7-day running average of the net daily Tri+ PCB load at the TID and Waterford Stations.

In 2011, the cumulative net load Tri+ PCB criterion was in compliance with the Phase 2 Resuspension Standard. Past the TID Station, the Tri+ PCB cumulative load was 59 kg or 0.6 percent of the Tri+ PCB mass removed. Past the Waterford Station, the Tri+ PCB cumulative load was 30 kg or 0.3 percent.

QoLPS

In Phase 1, there were 19 exceedances of the QoLPS for air quality out of a total of 796 samples collected at the processing facility (2.4 percent). At the dredge corridor in Phase 1, there were 81 standard exceedances out of a total of 1846 samples (4.4 percent). The QoLPS for air quality in residential areas is 0.11 micrograms per cubic meter ($\mu g/m^3$) and the standard for commercial/industrial areas is 0.26 $\mu g/m^3$. Of the reported exceedances, the maximum Total PCB concentration reported was 4.2 $\mu g/m^3$ with an average exceedance in residential areas of 0.17 $\mu g/m^3$ and an average exceedance in commercial/industrial areas of 0.75 $\mu g/m^3$.

The overall average Total PCB air concentration recorded during Phase 1 for compliance purposes near dredging operations was 0.04 $\mu g/m^3$. For the 166-day dredging season, less than 4 percent of the total number of samples collected to demonstrate compliance exceeded the standard. Phase 2 included a refinement of the QoLPS for air quality and a reduction in the number of air exceedances as compared to Phase 1 was observed.

During Phase 2 dredging and processing facility operations, a monitoring program has been implemented to assess achievement of the Noise, Odor and Light QoLPS. During those operations, monitoring will continue to be conducted by the dredging contractor at the beginning of any operations or use of equipment that is different from that used previously used at the project and could result in increased levels compared to those previously recorded. Similar steps will be taken at the processing facility operations. Additional noise monitoring will be conducted in response to complaints.

In Phase 1, 0.3 percent of noise measurements exceeded the Noise QoLPS. This was based on 103 exceedances out of a total of 37,500 one hour measurements. In Phase 2 Year 1, there were 9 standard exceedances out of a total of 775 measurements at the processing facility. At the dredge corridor, there were 7 standard exceedances out of a total 1072 measurements.

There were no recorded exceedances of the Odor QoLPS during monitoring conducted by GE's Quality of Life Contractor in Phase 1 and Phase 2 Year 1.

Between May 15, 2009 and December 18, 2009, there were three recorded exceedances of the Light QoLPS and three project-related light complaints. There were no recorded light exceedances during the Phase 2 Year 1.

During Phase 1, GE's dredging contractor monitored vessel traffic to limit the impact of dredging activities on nearby residents and on private and commercial vessels that use the Champlain Canal. During Phase 1, four complaints associated with river operations were reported. However, during this period, there were no deviations from navigation requirements and no instances where in-river project activities significantly affected navigation of commercial or recreational vessels within the dredge corridor.

Fish Monitoring

EPA's Phase 1 Evaluation Report, (Appendix I-C Analysis of Resident Fish Annual Monitoring Data), which can be viewed at EPA's www.hudsondredgingdata.com website, reports results from the 2004-2008 Baseline Monitoring Program supplemented by data from NYSDEC's resident fish annual monitoring program (1997-2003), and the 2009 RA monitoring data.

Key findings in the report were:

- There were some increases in fish tissue PCB levels seen in 2009 within the Upper Hudson River when compared to baseline data. The increases in fish tissue PCB levels were predominantly focused to the TIP (i.e., the section of the river where the Phase 1 dredging occurred), with limited evidence of responses downstream;
- There were no statistically significant increases in fish tissue PCBs at the Albany/Troy lower river monitoring station below the Federal Dam at Troy;

- Variability in fish PCB concentrations was often high (*i.e.,* approximately one order of magnitude range of concentrations within each year) within and among stations, and within reach/section;
- On a River Section basis, PCB concentrations in fall collected yearling pumpkinseed were significantly increased in 2009 in the Thompson Island (River Section 1) and Northumberland/Fort Miller (River Section 2) Pools, and forage fish (minnows) PCB concentrations were significantly increased in 2009 only in the TIP. There were only statistically significant decreases shown for the spring-collected resident sport fish (black bass, yellow perch, and bullhead) in 2009 compared to the baseline data;
- On an individual monitoring station basis, tissue PCBs in pumpkinseed were significantly elevated at three out of five monitoring stations in the TIP. Two of these locations were within dredging areas (one each in Rogers Island and Griffin Island river locations), and one was approximately one mile below the dredging near Rodgers Island. In the Northumberland/Fort Miller Pool, the statistical comparisons indicated that the northernmost station within this pool was marginally higher in 2009 than during the baseline period (2004-2008). All other monitoring stations in this pool showed no changes. There were no changes from the baseline levels of PCBs in pumpkinseed collected at any of the five monitoring stations in the Stillwater Pool in 2009 or the Albany/Troy station;
- Overall, the monitoring data indicated that resuspension of PCBs from sediments during dredging affected fish locally, with greatest impact in the immediate vicinity of the dredging activity, but the current data do not support the notion that dredging had an effect on PCB levels in fish more than 2-3 miles downstream of the TIP.

As an appendix to EPA's December 15, 2010 memorandum entitled "EPA Review of GE Technical Submission Based on New GE Model," EPA issued an "Update on Hudson River Fish Monitoring Program: 2010 Post-Phase 1 Data" in which EPA provided an update on the agency's improved understanding of the effect of Phase 1 dredging on PCB concentrations in the fish of the Upper Hudson River by extending the analysis to include the 2010 data for whole body pumpkinseed collected each fall, and the resident adult sport fish species that are collected each spring.

EPA found that there were no appreciable increases in the spring 2010 Upper Hudson River adult sport fish tissue concentrations of PCBs relative to the five-year baseline (2004-2008) period. Additionally, the monitoring data on PCBs in small or yearling whole-body pumpkinseed collected in fall 2010 indicate that the tissue concentrations had already nearly recovered from the apparent dredging impacts that were reported in 2009.

The apparent dredging impacts that were observed in 2009 were either within or immediately below the Phase 1 dredging areas. Given the Phase 1 experience, EPA anticipates that throughout the remainder of the project, any dredging-related, localized body burden increases of PCBs in fish that are observed in the short-term will rapidly return to baseline levels and continue to decline thereafter following remediation. EPA anticipates this to be the case as exposures related to the dredging are expected to be brief. Tissue concentrations of PCBs in fish have been shown to decrease rapidly, within 1-2 years, following exposure events, once the source of PCBs is controlled. Additionally, tissue concentrations of PCBs in fish have been shown to decrease rapidly following spikes related to environmental dredging. EPA will continue to monitor fish in the Hudson River.

Table 3 provides a summary of the mean annual tissue concentrations of Total PCBs (mg/kg wet weight) in Hudson River fish from 2004 through 2011. Table 4 provides a summary of the mean annual lipid-normalized tissue concentrations of Total PCBs (mg/kg lipid) in Hudson River fish from 2004 through 2011.

River Sediment Evaluation

To assess the effectiveness of sediment removal toward meeting the goals of the ROD the original modeling analysis prepared for the ROD estimated both pre-dredge and post dredge surface concentrations based on the data available at the time and utilized those estimates to establish the remedial goal of 0.05 mg/kg PCBs in species-weighted fish fillet (note that this goal was not projected to be achieved during the 70-year modeled forecast period). Since the ROD, the SSAP has provided a much larger and more extensive data set regarding surface sediment concentrations. The SSAP data set indicates that surface concentrations are higher than expected at the time of the ROD. A number of stakeholders therefore asked EPA to consider whether these higher pre-dredge surface concentrations would necessitate additional dredging in order to achieve the goals of the ROD relative to fish body burdens. In order to address this question, EPA evaluated whether the dredging program, as designed, would result in the necessary reduction in surface sediment concentrations to achieve the goals of the remedy regarding fish body burdens.

In general, fish body burdens are expected to track the changes in concentrations of the chemical in the surface sediments; i.e., if residues decrease in the surface sediment, then residues in fish are expected to decline as well. Bioaccumulation relationships are site-specific, and in any given setting, if a 10-fold reduction in fish body burden is targeted, then, at a minimum, a 10-fold reduction must be achieved in the sediments composing the feeding/home range of the fish.

The extensive SSAP surface sediment data set permits the calculation of current surface sediment PCB concentrations. These data provided a robust basis to calculate recent (2002-2007) surface sediment concentrations. Combining these recent data with the remedial design plans then permitted the calculation of a post-remediation mean surface sediment PCB concentration for each river section based on the following premises: 1) little to no increase in mean surface sediment PCB concentrations outside the dredging areas as a result of dredging-related resuspension, and 2) little natural attenuation of surface sediment concentrations during the construction period itself. Application of these premises allows an area-weighted calculation of pre- and post-dredging conditions based on the SSAP data.

By applying both premises, this analysis makes the most direct comparison of the anticipated changes in sediment concentrations due to dredging alone. Evidence collected to date by EPA and GE indicates that premise 1 is supported by the data. Similarly for premise 2, changes that result from natural attenuation would be applicable to both the ROD and SSAP-based estimates but this process has not been adequately approximated, and is therefore (as stated above) assumed to be minimal throughout the remedial action construction period. The direct comparison focuses on the differences in surface sediment concentrations achieved by dredging alone. That is, the pre- and post-dredging estimates based on the SSAP data and the remedial design absent of natural attenuation and resuspension were compared to the HUDTOX model's No Resuspension Scenario from the ROD. This model run represented the most optimistic estimate of the degree of improvement to be achieved under the ROD; however, EPA's best estimate scenario (the 350 nanograms/Liter (ng/L), ~1 percent release from resuspension scenario) was only marginally different.

For the comparison, surface sediment concentrations were estimated both inside and outside the dredging areas using both the model results (i.e., the ROD model analysis) and SSAP results. These results were then combined to generate an area-wide average surface concentration of Tri+ PCBs for each river section. For the model results, the concentration in surface sediment before remediation was taken to be the model-predicted concentration for the year 2005. The post-remediation surface concentration was the model result in the year 2012, the year after completion of the remedy as simulated by the model.

The HUDTOX model used in the ROD separately simulated Tri+ PCB concentrations in cohesive and non-cohesive surface sediments. The original areas were delineated based on the 1992 side-scan sonar survey of River Section 1 and River Section 2. Cohesive and non-cohesive sediment areas in River Section 3 were developed based on various other available results that were not part of the 1992 side-scan sonar work. The SSAP program delineated sediment types based on a more recent side-scan sonar survey of the entire project area conducted by GE, which separated the river bottom into more categories. To create similarly based estimates for both the HUDTOX model results and the SSAP-based analysis, the 1992 side-scan sonar coverage was intersected with GE dredge polygons to calculate concentrations for the cohesive and non-cohesive sediment texture areas inside and outside dredge boundaries. This discussion is provided in Appendix A of this document "Technical Memorandum on Comparison of ROD and SSAP-based Estimates of the Reduction in Surface Sediment."

EPA also received a request from the NYSCC to consider performing additional sampling in the navigational channel adjacent to CU1 to determine if additional sediment qualifies for dredging. EPA is evaluating this request and will have further discussions with NYSCC on the subject.

Site Inspection

Because the dredging program is still in progress, site inspections are routinely performed throughout the year. EPA maintains full time staff at the Site as the Hudson River Field Office is located at 421 Lower Main Street in Hudson Falls, New York.

On April 4, 2012 EPA met with personnel from GE, NYSDEC and NYSDOH inspected the Remnant Deposits (OU1).

VI. Technical Assessment

Question A: Is the remedy functioning as intended by the decision documents?

Remnant Deposits

The remedy is functioning as intended by the 1984 ROD. In-place containment of the formerly exposed Remnant Deposits (sites 2, 3, 4, and 5) consisting of a soil cover, GCL, and a topsoil and vegetative layer has been functioning as intended in preventing the potential for direct public contact with PCB-contaminated sediments and the potential volatilization of the PCBs. The remedy, as designed, placed a cap system over materials with PCB concentrations exceeding 5 ppm. Areas of cover typically extended at least five feet beyond the limits of the 5 ppm boundary.

To date, 36 rounds of semi-annual inspections have been conducted in accordance with the EPA-approved Post-Closure Maintenance Plan for the PCB Remnant Site Remediation Project. Follow-up activities from the semi-annual site inspections have generally included maintenance of the vegetative cover, access roadways, diversion ditches, culverts and site security. EPA's observations made after the 100-year flood event in 2011 indicated no bank scouring or significant damage to the rip-rap. Also, a site inspection following the significant rain event related to Hurricane Irene where 3.67 inches of rain occurred in a 24-hour period revealed the site to be in stable and generally good condition. Additional actions have been taken to repair areas of settlement that may have been related to the decomposition of organic material beneath the cap system on Remnant Deposit 3.

As a result of the ongoing remedial work conducted at GE's Fort Edward and Hudson Falls plants, which is overseen by the NYSDEC, the residual water column concentrations are approximately 2 ppt which is the upstream source control target identified in the ROD.

While the remedy is functioning as intended by the 1984 ROD, it should be noted that the 1984 OU1 ROD did not identify institutional controls. In order for the remedy to be protective in the long-term, an institutional control needs be implemented to ensure that future use of the Remnant Deposits does not compromise the integrity of the cap system or result in unsafe exposures. EPA will consult with the municipalities about any potential plans they may have for utilizing some of the Remnant Deposits prior to establishing such controls. The Town of Moreau has informed EPA that it would like to use Remnant Deposits 2 and 4 for passive park use. Use of the property as a park, and for that matter any future use of the remnant properties, would need to be limited to uses and activities that would not compromise the integrity of the cap system and will not result in unsafe exposures to contaminants for those using the park.

River Sediments

Due to the large size of the site cleanup, remedy operations are on-going. To date, two seasons of dredging have been conducted in the Upper Hudson River in River Section 1. EPA and GE estimate that it may take an additional 5-7 years to complete dredging in the Upper Hudson River. EPA's oversight of construction activities and its review of monitoring data, compliance with ARARs, the Phase 1 evaluation process and other documents cited throughout this five-year review demonstrate that the remedy is being implemented in accordance with the 2002 ROD that called for a combination of dredging and MNA to achieve the RAOs.

Key remedial activities are provided below, along with a summary of how these actions are meeting the intent of the decision documents.

River Section 1 Sediments

As outlined in the 2002 ROD, the project is being conducted in two phases. Phase 1, conducted in 2009, was initially implemented at less than full-scale and included an extensive monitoring program. Utilizing environmental dredging techniques, GE removed approximately 283,000 cubic yards of sediments from River Section 1 in 2009 based upon an MPA of 3 g/m^2 Tri+ PCBs or greater and or surface concentrations exceeding 10 ppm Tri+ PCBs.

Phase 1 Standards

Due primarily to an improper characterization of DoC, approximately 36 percent of the adjusted Phase 1 dredge areas were capped. This was a greater percentage than EPA anticipated based on the Residuals Standard. It was necessary to cap portions of several CUs out of compliance with the Residuals Standard due to schedule constraints. Areas which met the Residuals Standard were backfilled with approximately 1 foot of clean material to isolate residual PCB contamination and to expedite habitat recovery. The effectiveness of the backfill cap material was tested in 2011 during a 100-year storm event. In 2011, post-storm bathymetry demonstrated the stability of Phase 1 caps as little scouring was observed.

The Productivity Standard met or exceeded the initial estimates for Phase 1. The mass of PCBs removed was equivalent to the planned mass of 20,000 kg for all 18 originally planned Phase 1 CUs, but represented an 80 percent increase over what was expected for the 10 CUs (11,000 kg).

There were limited shutdowns due to the exceedances of the Resuspension Standard. Fish tissue impacts were limited to within 2 to 3 miles downstream of the TIP, and the data did not indicate any measurable impacts to fish or water quality in the Lower River. As noted in more detail above, while the Panel did not believe that the Phase 1 EPS were individually or simultaneously met, the Panel concluded that the EPS could be met with substantive changes to the standards and through the development and implementation of best management practices.

QoLPS, developed in the design phase, have been modified for Phase 2.

Phase 2 Standards

Changes to the EPS have proven to be successful in Phase 2 Year 1. The revised Resuspension Standard limits the amount of PCBs permitted to travel downstream to 2 percent of the total Tri+ PCB mass excavated from the river bottom in a dredging season, as measured at the first designated location downstream of where dredging is taking place. The revised Resuspension Standard was in compliance throughout Phase 2 Year 1.

The revised Residuals Standard resulted in approximately 3 percent of counted nodes capped. The revised Productivity Standard exceeded the target with approximately 363,000 cubic yards of sediment dredged in 2011.

The QoLPS, as per the 2002 ROD, have been implemented as intended and continue to be protective of the community's quality of life. The QoLPS have been reviewed and will continue to be reviewed as the remedy progresses to ensure that these standards continue to protect the community's quality of life.

Deposition Study

In GE's 2012 Deposition Study Report, GE concluded that deposition was not having a measurable impact on surface concentrations; EPA concurred with this conclusion. All new data, including the data associated with GE's deposition study, were considered as part of this five-year review because surface sediment concentrations are an important consideration (along with water concentrations) relative to PCB concentrations in fish. In the Technical Memorandum (Appendix B) changes were evaluated in surface sediment PCB concentrations over time in River Section 1 using GE's 2012 Deposition Study and available data. Recent surface sediment data were not available for comparison in River Sections 2 and 3, but are planned to be collected in upcoming years. Available surface sediment data evaluated included:

- Data collected and evaluated for the 2002 ROD;

- Data from the SSAP program (2002 to 2005) that was used to develop the dredge area delineation. SSAP samples were collected from 0 to 2 inches across the majority of River Section 1;
- Deposition study data collected in spring 2011 before the start of Phase 2 dredging. The samples were collected from selected transect throughout River Section 1 from 0 to 2 inches;
- Deposition study data collected in fall 2011 after dredging from non-dredged areas only. These samples were collected from the same transect as the spring 2011 location throughout River Section 1 from 0 to 2 inches.

EPA used these four data sets to assess potential surface sediment concentration changes over time in River Section 1. EPA determined that sediment PCB concentrations from before the ROD was issued are similar in concentration to the samples collected as part of the SSAP. These data sets average approximately 42 and 46 ppm Total PCBs, respectively. The 2011 deposition study surface sediment data average was 6 to 7 ppm, which is notably lower than the average concentration found during both pre-2002 ROD and the SSAP. In order to take a closer look at how concentrations might have changed over time an evaluation was performed on SSAP cores that were located within 20 feet of the deposition study cores. The co-located SSAP cores averaged 19.5 ppm, which further indicates that a decrease in concentration occurred at the co-located sampling locations over time.

Based on this evaluation, deposition is not expected to significantly contribute to increase in surface concentrations, and in fact, the deposition study indicates that surface concentrations in non-dredged area in River Section 1 have notably reduced over time. The cause of this reduction in surface concentrations over time is anticipated to be attributable to natural processes and activities associated with the dredging. Natural processes include effects associated with natural attenuation and recovery as well as those associated with the transport and redistribution from high flow events. Effects associated with dredging include the introduction of clean backfill into the river that may settle in non-dredged areas. It is anticipated that additional surface sediment samples will be collected both inside and outside of dredge areas as part of the continuing deposition study using a transect approach during 2012 in River Section 2; information gathered from this effort will be used to assess whether the findings of the deposition study for River Section 1 carry over to River Section 2.

River Sediment Evaluation

As noted earlier, a number of stakeholders asked EPA to consider whether the higher than expected surface concentrations indicate that additional dredging is necessary for the goals of the ROD to be achieved. For the reasons set forth in this section, EPA concludes that such additional dredging is not necessary to achieve the ROD objectives. However, EPA agrees that additional dredging would achieve RAOs in a shorter time frame thereby reducing the amount of time the ecological community would potentially be exposed to sediments at concentrations above the cleanup goal.

For River Section 1, the model predicted about a 79 percent reduction in surface sediment concentration. Although the absolute concentration in the surface sediment based on the SSAP cores is higher than the estimates used in the model for the ROD, the percent reduction (approximately 87 percent) is not only comparable, but actually better. This means that the remedial design is expected to yield a potentially greater reduction in fish tissue body burdens than anticipated by the ROD. The results for River Section 3 are comparable to those for River Section 1, in that the expected improvement anticipated by the ROD (4.4 percent) is less than that expected from the remedial design based on the SSAP cores (4.9 percent), although it bears mention that the difference here is less striking. Overall, the reduction in Tri+ PCB concentration expected from the remedial design based on the SSAP core data due to dredging alone (18.1 percent) is comparable to that anticipated by the ROD for the entire Upper Hudson (19.8 percent).

The notable difference between the ROD-anticipated reduction based on the HUDTOX modeling conducted at the time of the ROD and that predicted from the remedial design SSAP core data occurs in River Section 2. The reduction anticipated by the ROD modeling (64 percent) is about twice as much of an improvement for River Section 2 as predicted from the remedial design (36 percent). This indicates that it will likely take River Section 2 longer to reach its ultimate remedial goals than the original forecast in the ROD. Given that the difference between the two estimates is slightly less than a factor of 2 and the model forecast curve is approximately equivalent to an exponential rate of decline, the difference is essentially equivalent to an additional half life on the forecast curve. That is, River Section 2 could be expected to reach its expected remedial goals about one half life longer than that forecast in the ROD. The half life for recovery as forecast by HUDTOX for the ROD is 10 years in River Section 2. Thus based on the discussion above, the achievement of the various remedial goals for River Section 2 may lag those anticipated by the ROD by about 10 years. Given the: 1) uncertainties in the model forecasts; 2) long periods already anticipated to achieve the remedial goals in the Upper Hudson; 3) reduction in surface concentrations over time seen in the River Section 1 Surface Sediment Study which will be replicated in River Section 2; and 4) potentially better than previously anticipated (or at least comparable) improvements in River Sections 1 and 3, EPA believes that the design of the dredging and MNA remedy will achieve the RAOs and specific fish tissue remediation goal identified in the ROD and that this potential delay to achieve remedial goals in River Section 2 is not deemed a sufficient reason to modify the remedial design.

Nevertheless, EPA believes that the remedial goals could be achieved more quickly, and with a reduced time and extent of injury to ecological receptors, if additional dredging (beyond the ROD requirements) were to be carried out, particularly in River Section 2.

The trustee agencies and several environmental groups have noted that surface sediment concentrations of PCBs in areas where the ROD does not call for dredging will cause injury to natural resources for a longer period of time than was expected when the ROD was issued. EPA believes the ecological goals of the ROD will be achieved with time following implementation of the remedy. However, in view of the finding that surface concentrations in areas outside the dredge footprint are higher than expected, and will negatively impact trust resources for a longer period, greater injury to natural resources may result. We therefore support efforts by the trustees to address such greater potential injury through the Natural Resource Damage (NRD) assessment and claims process. EPA will continue to cooperate and communicate with federal and State natural resource trustees on the Hudson River remediation. In addition, EPA understands that the NYSCC may assert a claim for damages resulting from the increased costs of navigational dredging due to PCB contamination. Should either the NRD process or a possible claim by NYSCC result in an undertaking to perform any additional dredging beyond that required pursuant to the EPA ROD, EPA will coordinate fully with GE, the trustees and/or the NYSCC to ensure these efforts are integrated as efficiently as possible.

Processing Facility
In accordance with the 2002 ROD, dredged sediments have been transported via barge to the sediment processing facility for dewatering and stabilization. Processed sediments have been and continue to be transported to licensed off-site landfills for disposal.

Fish Advisories and Other Institutional Controls
NYSDOH and NYSDEC have implemented and modified in some instances fish consumption advisories and fishing restrictions. As described in the 2002 ROD, the remedy called for the achievement of the remediation goal of 0.05 mg/kg in fish, as well as the continuation of fishing restrictions and fish consumption advisories until relevant remedial goals are met. At the current time, NYSDOH is conducting outreach activities to inform the public about fish advisories throughout the Site as described in the Institutional Controls section of this document.

Completion of the dredging and MNA components of the remedy is expected to lead to achievement of the RAOs. GE is collecting and analyzing the fish under agreement with EPA. NYSDOH will continue to evaluate the data into the future to determine if and when fish advisories can be modified. Monitoring of fish will continue to document progress towards achievement of the 0.05 mg/kg remediation goal.

GE's Operation, Maintenance, and Monitoring Plan for Phase 1 Caps and Habitat Replacement/Reconstruction (Phase 1 Cap/Habitat OM&M Plan) and Phase 2 Cap/Habitat OM&M Plan each call for a bathymetric survey to be conducted one year following the placement of the cap as a means to evaluate the integrity of the cap. Subsequent bathymetric surveys shall be performed five and ten years after construction of the cap and continued thereafter at 10-year intervals. In addition, if a flood event with a magnitude at or exceeding the design recurrence interval for the cap occurs, the cap shall be inspected through a bathymetric survey and collection of sediment cores as soon as practical after the event. Following the completion of dredging, the routine 10-year interval monitoring events shall be consolidated so that they are performed for 30 yrs (for Phase 1 caps) and in perpetuity (for Phase 2 caps) at intervals of 10 years after installation of the last cap installed by GE in these areas as part of the remedial action.

Question B: Are the exposure assumptions, toxicity data, cleanup levels, and remedial action objectives used at the time of the remedy still valid?

Remnant Deposits

There have been no changes in the physical conditions of Remnant Deposits 2 through 5 that would change the protectiveness of the remedy. The cap system on the Remnant Deposits prevents exposure to the capped sediments, and perimeter fencing prevents access to the sites. Posted signage provides an additional barrier to exposure.

The Remnant Deposits have limited access based on location in addition to perimeter fencing. Maintenance reports indicate limited areas of erosion that have been repaired. The ongoing procedures to inspect and re-establish the fencing where appropriate should continue as a barrier to exposure. In the event access to these areas is provided for a passive park at Remnant Deposit sites 2 and/or 4, further considerations and measures may be needed such as more frequent inspections or additional sampling. As noted above, an institutional control needs be implemented to ensure that future use of the Remnant Deposits does not compromise the integrity of the cap system or result in unsafe exposures.

In 1984, when the Remnant Deposits remedy was selected, guidance on the development of risk assessment was beginning at EPA and as such, a risk assessment was not conducted. The selection of a value of 5 ppm as the basis for determining areas for capping is consistent with a potential recreational use of the property using current risk assessment tools. Currently, 1 ppm is the concentration associated with a residential property assuming exposures to a young child 1 to 6 years of age exposed 350 days/year for six years and an oral Reference Dose for Aroclor 1254 of 0.00002 mg/kg-day. Considering the less frequent exposures of an adolescent trespassing on the property, capping of all PCB concentrations greater than 5 ppm would be consistent with current risk assessment practices.

As noted above, OU4 is currently in the RI phase of the Superfund process and addresses contamination in low-lying shoreline areas from areas upstream of Remnant Deposit 1 to Troy New York. The low-lying areas adjacent to the capped Remnant Deposits will be included in the ecological and human health risk assessment as part of the OU4 RI process.

River Sediments

The RAOs identified in the 2002 ROD are still valid and appropriate for the Site. As indicated earlier, the reduction in fish tissue concentrations that will be brought about by the overall reduction in the mass of PCBs that may become bioavailable is closely related to the concentration of PCBs in surface sediments throughout the Upper Hudson. In the selected remedy, this reduction is achieved through two important processes: 1) sediment removal by dredging and backfilling, and 2) MNA. Both processes are required to achieve the goals of the ROD.

Fish Ingestion

The original risk assessment found the primary pathway for humans to be exposed to PCBs is consumption of fish. The assessment found the greatest risks associated with fish ingestion assuming consumption by young children, adolescents, and adults. In view of this analysis a risk-based remedial goal for protection of human health of 0.05 mg/kg PCBs in fish fillet was developed based on non-cancer hazard indices for the RME adult fish consumption rate of one-half pound per week and the risks associated with this concentration is also within the risk range. The fish ingestion rate was based on ingestion rates for types of fish found in the Hudson River, as reported in the 1991 New York Angler survey and details regarding the analysis to develop the consumption rate are provided in the HHRA. Based on the 1991 New York Angler survey, the rate derived for the RME adult is about one-half pound meal per week. The fish ingestion rates, cancer slope factor, and oral Reference Dose used in the original risk analysis and also the calculation of risk-based remedial goal have not changed since the original risk assessment. However, the Integrated Risk Information System, or IRIS, EPA's consensus database, is currently re-evaluating the non-cancer toxicity value for PCBs and this value will need to be reassessed at the time of the next five-year review.

At the time of the risk assessment, consistent with the 1996 EPA guidance titled "PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures," EPA evaluated the potential risks from exposure to dioxin-like PCBs in fish in addition to the assessment of non-dioxin like PCBs. The analysis found the dioxin-like PCB cancer risks were approximately equivalent to the RME cancer risk calculated without consideration of the dioxin-like congeners. Since the risk assessment was completed in 1999, EPA released the *Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8 Tetrachlorodibenzo-p-dioxin and Dioxin-Like Compounds* in 2010. The document updated the TEFs for dioxin-like PCBs that were used in the original risk assessment and evaluation of the changes in the TEFs do not impact the overall calculated risks for dioxin-like PCBs. In addition, the IRIS database was updated on February 17, 2012 to include an oral Reference Dose for dioxin and this change will be further evaluated over the next five years.

Ecological Risk

The exposure pathways and receptors pertaining to the EPA 2000 BERA at the time of the remedy selected in the 2002 ROD are still valid. Although there has been recent attention placed on freshwater mussels in the Upper Hudson River by some federal and state agencies and community stakeholders, the assessment endpoint for the protection of benthic community structure continues to be relevant and is inclusive of mussels. Furthermore, benthic community monitoring is required under the approved Operation, Maintenance and Monitoring Plan. The Atlantic Sturgeon (*Acipenser oxyrinchus*) was addressed in the BERA at the time of remedy selection. The recent listing of the New York Bight Atlantic Sturgeon Distinct Population Segment as endangered under the Endangered Species Act (effective April 6, 2012) does not change the exposure assumptions or pathways used in the BERA.

The exposure assumptions and toxicity data used in the BERA are still valid. Therefore, the ecological risk-based remedial goal for the protection of the ecological exposure pathway based on fish consumption by the river otter, and the risk range developed for the mink, are valid. However, new information suggests that protectiveness could be achieved toward the upper ends of these risk ranges.

The recent relevant scientific literature (2000-2012) on mink and river otter exposure parameters and PCB toxicity to mink was reviewed. The laboratory-based toxicity reference value (TRV) (LOAEL, 0.3 mg/kg body weight/day; Auerlick and Ringer, 1977) identified for the effects of PCBs to mink and used in the EPA 2000 BERA is within the range of values cited in Brunstrom *et al.* (2001) and Beckett *et al.* (2008). Field studies are less common than laboratory studies, and the recent field-based TRVs for PCBs reported by Bursian *et al.* (2006) were greater than the field-based TRVs used previously, with the LOAEL being an order of magnitude higher than the value used in the EPA 2000 BERA (LOAEL; 0.04 mg/kg body weight/day; Restum *et al*., 1998). Fuchsman *et al.* (2008) reviewed laboratory and field–based studies evaluating reproductive toxicity of PCBs to mink. These authors developed a dose-response curve that described the relationship between daily intake and production of surviving kits. The effects concentrations (EC_x) for various percent survival response levels (EC_{10}, EC_{20} and EC_{50}) were identified. The field-based LOAEL used in the EPA 2000 BERA falls within the range identified by the EC_{10} to EC_{50} concentration range, and the laboratory-based LOAEL previously used by EPA is only slightly higher than the EC_{50} concentration.

The exposure parameters such as body weight, water ingestion rate, food ingestion rate, home range, and dietary composition that were used for the EPA BERA are overall consistent with values cited in the recent literature for mink and otter. However, Dekar *et al.* (2010) used a bioenergetics-based model to develop a food ingestion rate for otter that is estimated to be higher than the average value identified within the EPA BERA. An important note is that the values used in the EPA BERA were from studies where the food ingestion rate was measured (not modeled).

Taken together, this review indicates that the TRVs used in the EPA BERA are still valid as they are generally similar to more recently reported TRVs; albeit the NOAEL and LOAEL values used by EPA in 2000 would be considered to be at the lower, more conservative end of the ranges available for these TRVs. Similarly, the exposure parameters used in the EPA BERA are still valid. Therefore, as stated above, protectiveness of the ecological exposure pathway following completion of the remedy could be achieved toward the upper ends of the remedial goal risk ranges.

Question C: Has any other information come to light that could call into question the protectiveness of the remedy?

No other information has come to light that could call into question the protectiveness of the remedies.

Technical Assessment Summary

According to the data reviewed for this five-year review and ongoing site inspections, the remedy at the Remnant Deposit is functioning as intended by the 1984 ROD.

Based on data collected and reviewed for the first five-year review and the ongoing site inspections, EPA selected a remedy in the 2002 ROD that is protective of human health and the environment. The remedy selected is currently under construction. There have been no changes in regulatory statutes that affect target sediment cleanup levels, and no new pathways for exposure identified, that would call into question the goals of the remedy as set forth in the ROD.

VII. Issues, Recommendations and Follow-Up Actions

The following issue has been identified for OU1:

Issue	Party Responsible	Oversight Party	Milestone	Affects Protectiveness: Current	Affects Protectiveness: Future
The 1984 ROD does not contain any requirement for institutional controls. An institutional control should be implemented which would ensure that future use of the OU1 does not compromise the integrity of the cap system or result in unsafe exposures.	Property Owner, State and PRP	EPA/State	4/23/2017	No	Yes

These follow-up actions were identified during the development of the five-year review:

- NYSCC has requested that EPA consider performing additional sampling adjacent to CU1 to determine if additional sediment qualifies for dredging. EPA will have further discussions with NYSCC regarding this request;
- EPA expects to evaluate surface sediment data collected from River Section 2 as part of EPA's evaluation of the 2012 dredging season. Surface sediment data collected from River Section 3 will be evaluated as part of EPA's evaluation of the 2013 dredging season. EPA will evaluate changes over time in surface sediment concentrations from River Sections 2 and 3 once GE has collected the samples;
- Determine if there are additional or more effective outreach techniques available to communicate fish advisories and fishing restrictions to the public. EPA will work with counterparts at New York State to assess what additional and/or more effective outreach techniques are available;
- As the dredging project moves south, there may be locations that will require additional dredging to allow passage of vessels in the channel or to access shallow dredge areas. EPA will annually review proposed dredge prisms submitted as part of the annual design work plan.

VIII. Protectiveness Statement

The remedy at the formerly exposed Remnant Deposits (OU1) at the Hudson River PCBs Superfund Site currently protects human health and the environment as the in-place containment and cap system prevents human exposure, and the perimeter fencing and signage continue to be maintained. However, in order for the remedy to be protective in the long-term, institutional controls need to be implemented to ensure that future use of the Remnant Deposits does not compromise the integrity of the cap system or result in unsafe exposures.

Based on data collected and reviewed to date, EPA expects that the remedy at OU2 will be protective of human health and the environment upon completion. In the interim, human exposure pathways that could result in unacceptable risks are being controlled.

EPA anticipates that once the institutional control has been implemented at OU1 and the dredging and MNA remedy have been completed at OU2, the remedies at the Hudson River PCBs Superfund Site will be protective of human health and the environment. In the interim, exposure pathways that could result in unacceptable risks are being controlled.

IX. *Next Review*

The next five-year review is expected to be completed by April 23, 2017.

Table 1: Chronology of Major Site Events

Date	Events
1947-1977	GE's Hudson Falls and Fort Edward facilities discharged approximately 1.3 million pounds of PCBs into Hudson River
1973	Fort Edward Dam removed. Five areas of PCB-contaminated sediments, known as the Remnant Deposits are exposed.
1975	NYSDOH begins issuing fish consumption health advisories due to levels of PCBs in fish
1976	NYSDEC bans all fishing in Upper Hudson and bans most commercial fishing in Lower Hudson including striped bass
1976	GE and NYSDEC sign consent order to address direct PCB discharges into the Hudson River from the two facilities
1980	CERCLA enacted
1983	EPA proposes site to the NPL
1984	EPA formally lists site on the NPL
1984	EPA issues ROD for Remnant Deposits, a study of the Waterford Water Works and Upper Hudson river sediments
1989	EPA issued Administrative Order to GE for Remnant Deposit remedy
1989	EPA begins reassessment RI/FS for interim "No Action" decision for Upper Hudson River sediments
1990-1992	In-place containment of Remnant Deposits 2, 3, 4, and 5
1995	NYSDEC replaces fishing ban with catch-and-release fishing restriction
1998-2000	Peer review panels comment on EPA's reassessment RI/FS
1999	EPA excavates 4,400 tons of contaminated soil from Roger's Island
2000	EPA issues FS and Proposed Plan
2002	EPA signs ROD for Hudson River sediments
2004	Final EPS and Final QoLPS
2005	Dredge Area Delineation Report for Phase 1 Dredging
2006	A final judgment on EPA-GE Consent Decree for sediment remedy selected in 2002 ROD approved and entered by the court (Civil Action No. 1:05 CV-01270, U.S. District Court for the Northern District of New York) issues Consent Decree
2006	Final Design Report for Phase 1 Dredging
2007	Phase 1 begins – Sediment processing facility and rail yard constructed
2009	Community Involvement Plan
2009	Phase 1 dredging begins
2010	GE and EPA submit Phase 1 evaluation reports
2010	Peer Review of Phase 1
2010	GE agrees to conduct Phase 2
2011	Phase 2 begins

<u>Table 2</u>: NYSDOH's Hudson River Fish Advisory Outreach Project Advisories[6]

Location (chemical of concern)	Don't Eat	Eat up to One Meal a Month	Eat up to Four Meals a Month
Corinth Dam to Dam at Route 9 Bridge in South Glens Falls (mercury)		Smallmouth bass over 14"	All other fish species
Sherman Island Dam downstream to Feeder Dam at South Glens Falls (PCBs)		Carp	All other fish species
Dam at Route 9 Bridge in South Glens Falls to Bakers Falls (PCBs)	All fish species		
Bakers Falls to Troy Dam	**Catch and release fishing *only* per NYSDEC regulations. Take no fish. Eat no fish.**		
Troy Dam south to bridge at Catskill (PCBs)	All fish species (except those listed at right→)	Alewife, Blueback herring, Rock bass, Yellow perch	
South of bridge at Catskill (PCBs in fish and cadmium, dioxin and PCBs in crabs)	Channel catfish, Gizzard shad, White catfish Crab hepatopancreas and crab cooking liquid	Atlantic needlefish, Bluefish, Brown bullhead, Carp, Goldfish, Largemouth bass, Rainbow smelt, Smallmouth bass, Striped bass, Walleye, White perch	All other fish species Blue crab meat (six crabs per meal)

[6] These advisories are for women over the age of 50 and men over the age of 15. The advisories are updated on a yearly basis and made available on the NYSDOH website:

http://www.health.ny.gov/environmental/outdoors/fish/health_advisories/docs/advisory_booklet.pdf

Table 3: Mean Annual Tissue Concentrations of Total PCBs (mg/kg wet weight) in Hudson River Fish (2004-2011)

Species	Location[8]	2004	2005	2006	2007	2008	2009	2010	2011
Black Bass	**FD**	0.05	0.05	0.04	0.06	0.03	0.01	0.02	0.06
	RS-1	3.22	2.46	2.27	2.49	2.03	0.77	2.72	1.31
	RS-2	3.20	1.96	2.03	2.80	1.30	1.48	1.82	1.58
	RS-3	1.23	1.71	2.12	1.29	0.62	0.67	1.16	0.79
	AT	2.72	1.68	1.75	0.79	1.18	2.10	1.81	1.12
Bullhead	**FD**	0.07	0.08	0.12	0.04	0.04	0.06	0.02	0.06
	RS-1	8.96	3.46	3.91	4.21	1.88	3.85	5.17	2.94
	RS-2	5.86	5.63	4.17	3.40	5.05	4.06	2.79	3.95
	RS-3	2.42	3.70	3.84	3.27	1.54	2.01	1.86	2.35
	AT	ND	2.58	ND	0.58	ND	ND	ND	ND
Yellow Perch	**FD**	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
	RS-1	2.04	0.67	1.70	0.88	0.65	0.73	0.90	1.22
	RS-2	1.68	0.70	1.32	0.58	0.44	0.53	0.74	0.75
	RS-3	1.18	0.39	0.57	0.40	0.30	0.19	0.27	0.39
	AT	0.75	0.66	0.00	0.00	0.07	0.23	0.20	0.42
Pumpkinseed[9]	**FD**	0.40	0.20	0.08	0.06	0.02	0.05	0.04	0.07
	RS-1	9.35	4.65	8.88	3.34	2.08	14.4	3.47	9.99
	RS-2	7.00	5.74	6.24	2.59	3.51	7.84	2.78	9.78
	RS-3	3.69	3.28	2.75	1.57	1.90	3.13	1.49	3.99
	AT	1.05	1.12	0.79	0.59	0.55	0.79	0.40	0.63

Species	Location [8]	2004	2005	2006	2007	2008	2009	2010	2011
Forage Fish	**FD**	0.07	0.06	0.09	0.03	0.01	0.10	0.04	0.05
	RS-1	4.72	8.69	7.67	1.24	1.85	10.57	3.58	12.9
	RS-2	5.50	4.98	6.20	2.59	1.64	6.49	2.80	10.0
	RS-3	3.58	3.36	3.05	1.74	1.78	3.33	2.80	5.26
	AT	2.11	0.56	1.21	0.52	0.56	0.90	0.42	2.11

ND = Not Detected

[7] Tissue samples prepared as follows: black bass, bullhead, and yellow perch - standard fillet (SF); pumpkinseed - whole body individual fish; forage fish - whole body composite

[8] FD = Feeder Dam, upstream reference location;

RS-1 = River Section 1, Thompson Island Pool;

RS-2 = River Section 2, Northumberland/Ft. Miller Pool;

RS-3 = River Section 3, Stillwater Pool;

AT = Albany/Troy, in Lower Hudson River below Federal Dam at Troy

[9] Mean Annual Tissue Concentrations of Total PCBs (mg/kg wet weight) of Pumpkinseed revised on 6/7/12.

Table 4: Mean Annual Lipid-Normalized Tissue Concentrations of Total PCBs (mg/kg lipid) in Hudson River Fish (2004-2011) [7]

Species	Location[8]	2004	2005	2006	2007	2008	2009	2010	2011
Black Bass	**FD**	17.4	13.4	15.1	12.6	15.9	5.55	4.89	31.5
	RS-1	513	609	703	312	389	190	458	473
	RS-2	506	430	419	443	223	512	380	439
	RS-3	211	331	354	220	165	227	315	206
	AT	251	322	263	92.9	118	230	222	151
Bullhead	**FD**	5.38	8.45	11.1	7.95	5.91	7.45	1.9	9.19
	RS-1	688	271	236	218	182	288	334	343
	RS-2	391	499	263	198	229	235	192	294
	RS-3	130	315	148	153	171	162	110	170
	AT	ND	145	ND	35.0	ND	ND	ND	ND
Yellow Perch	**FD**	0.69	2.43	4.16	1.12	1.83	2.90	3.52	ND
	RS-1	254	167	268	129	96.9	114	159	333
	RS-2	228	213	166	108	89.8	94.2	120	206
	RS-3	104	82.2	66.6	57.3	68.1	44.4	54.0	93.2
	AT	56.5	75.3	ND	ND	80.9	29.9	62.4	88.7
Pumpkinseed	**FD**	12.8	8.46	3.10	2.97	0.78	1.92	1.46	2.59
	RS-1	303	174	317	126	79.4	499	121	370
	RS-2	191	141	205	92.1	127	215	76.8	257
	RS-3	125	101	96.4	61.6	72.3	112	50.4	117
	AT	38.3	39.0	37.3	15.8	22.6	26.4	11.5	37.8

Species	Location[8]	2004	2005	2006	2007	2008	2009	2010	2011
Forage Fish	**FD**	1.36	3.13	3.32	1.03	0.18	4.05	1.09	1.56
	RS-1	122	288	192	53.9	50.4	267	125	418
	RS-2	126	107	142	74.9	53.2	128	96.4	413
	RS-3	81.0	75.9	72.6	53.6	69.4	75.0	89.0	109
	AT	33.2	34.2	37.6	26.5	19.6	32.3	17.6	43.8

ND = Not Detected

[7] Tissue samples prepared as follows: black bass, bullhead, and yellow perch - standard fillet (SF); pumpkinseed - whole body individual fish; forage fish - whole body composite

[8] FD = Feeder Dam, upstream reference location;

RS-1 = River Section 1, Thompson Island Pool;

RS-2 = River Section 2, Northumberland/Ft. Miller Pool;

RS-3 = River Section 3, Stillwater Pool;

AT = Albany/Troy, in Lower Hudson River below Federal Dam at Troy

<u>Table 5</u>: List of Project Related Documents Reviewed

Please visit http://www.epa.gov/hudson/plans.html for these project documents.

- Record of Decision, September 1984;
- Record of Decision, February 2002;
- Preliminary Design Report – In-Place Containment of Hudson River PCB Remnant Sites 2, 3, 4, 5, February 1989;
- Technical Memorandum, Soil Boring & Analysis Remnant Deposit Characterization, June 1991;
- Final Remedial Action Report PCB Remnant Deposit Sites 2, 3, 4, and 5, August 1992;
- Post-Closure Maintenance Plan for Fort Edward PCB Remnant Site Remediation Project, August 1992;
- Final Post-Construction Remnant Deposit Monitoring Program, February 2000;
- Baseline Ecological Risk Assessment, November 2000;
- Hudson River Community Involvement Plan, June 2009;
- Post -Closure Inspection Summary for Fort Edward PCB Remnant Site Remediation Project Sites 2, 3, 4, and 5 Reports up to February 2012;
- EPA Oversight Team's Phase 1 Observation Report, March 2010;
- EPAs Phase 1 Evaluation Report (and attachments), March 2010;
- GE's Phase 1 Evaluation Report, March 2010;
- Hudson River Phase 1 Dredging Peer Review Report, September 2010;
- EPA's 15.b Decision Letter to GE (and attachments), December 2010;
- GE's Remedial Action Workplan for Phase 2 Dredging and Facility Operations in 2011, April 2011;
- GE's Remedial Action Community Health and Safety Plan for 2011– Appendix F of the Remedial Action Work Plan is the Phase 2 CHASP for 2011, April 2011;
- GE's Remedial Action Community Health and Safety Plan for 2012 – Appendix F to Remedial Action Workplan for Phase 2 Dredging and Facility Operations in 2012, April 2012;
- EPA Guidance for conducting Five-Year Reviews.

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Ecology and Environment, Inc. (2012), Technical Memorandum: *Hudson River PCBs Superfund Site – Evaluation of Surface Sediment PCB Concentrations within River Section 1*. Prepared for U.S. Army Corp of Engineers on behalf of U.S. Environmental Protection Agency. May 2012.

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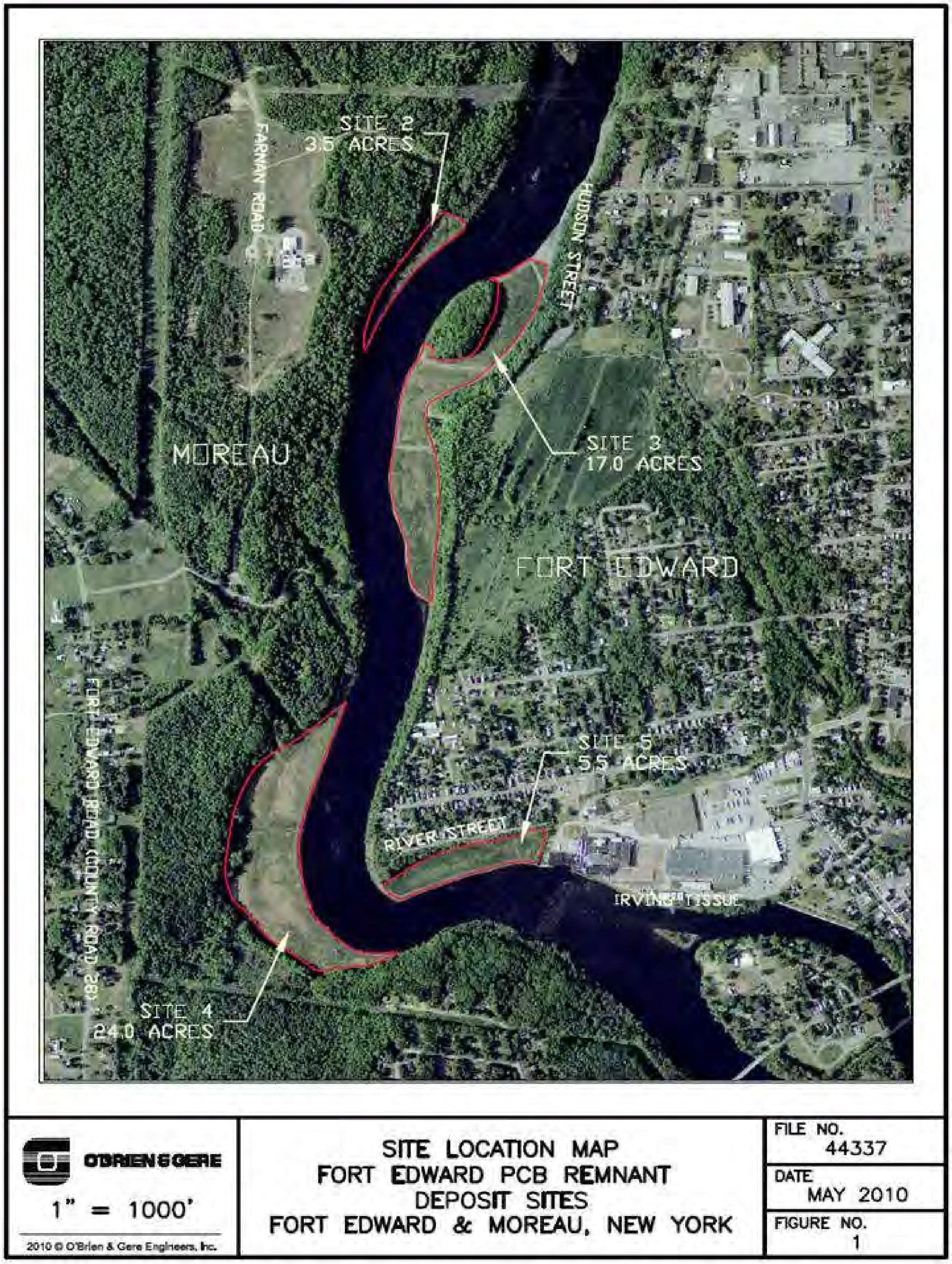
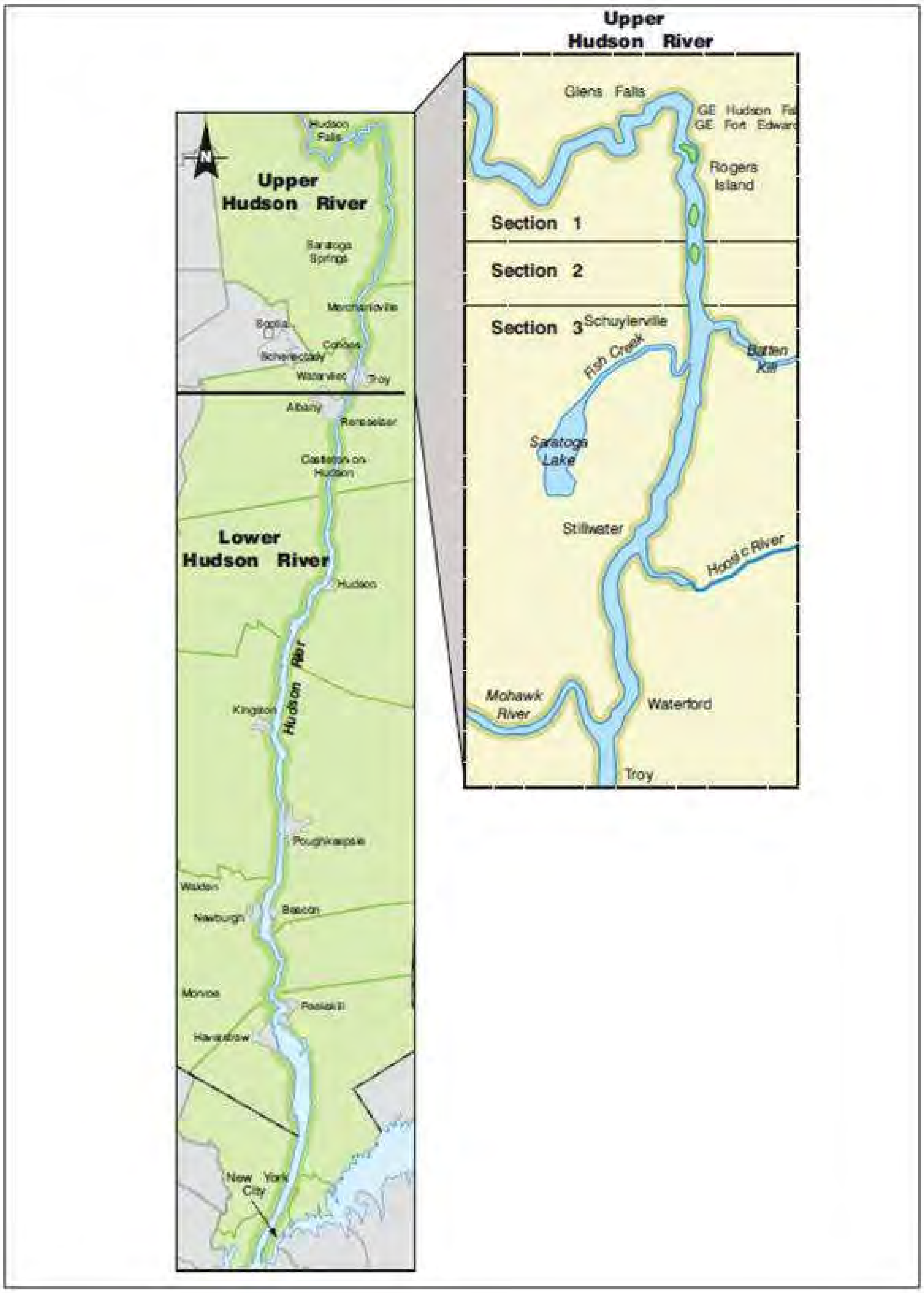
Fuchsman, P. C., T. R. Barber and M. J. Bock. (2008). "Effectiveness of various exposure metrics in defining dose-response relationships for mink (Mustela vison) exposed to polychlorinated biphenyls." Arch Environ. Contam. Toxicol. 54: 130-144.

The Louis Berger Group, Inc. (2012). Technical Memorandum: Text *Describing the Post-Dredging Surface Sediment Concentration Reduction. Prepared for U.S. Environmental Protection Agency. May 22, 2012.*

<u>Figure 1</u>: OU1 Remnant Deposit Site Map



<u>Figure 2</u>: OU2 Hudson River Site Map



Appendix A

Technical Memorandum

Comparison of ROD and SSAP-based Estimates of the Reduction in Surface Sediment

Hudson River PCBs Superfund Site

Date: May 30, 2012

To: Gary Klawinski (USEPA)

From: Ed Garvey and Juliana Atmadja (The Louis Berger Group, Inc.)

Subject: Comparison of ROD and SSAP-based Estimates of the Reduction in Surface Sediment

Concentrations after Dredging

An important component of the Hudson River remedy is the overall reduction in concentrations of PCBs in surface sediments throughout the Upper Hudson. In the selected remedy, this is achieved through two important processes: 1) sediment removal by dredging and backfilling, and 2) monitored natural attenuation. Both processes are required to achieve the goals of the ROD. To assess the effectiveness of sediment removal toward meeting the goals of the ROD, the original modeling analysis prepared for the ROD estimated both pre-dredge and post dredge surface concentrations based on the data available at the time. Since the ROD, the sampling program for the Remedial Design (SSAP) has provided a much larger and more extensive data set regarding surface sediment concentrations. Over the past few years, there have been several discussions and analyses regarding the differences between the concentrations used in the ROD and the ones developed from the SSAP program. Concerns have been raised that the remedial design as currently planned will not yield the level of improvement in surface sediment concentrations of Tri+ PCBs anticipated by the ROD in all river sections. Differences between model and measured concentrations can be important since fish body burdens are ultimately linked to sediment concentrations. A sufficient reduction in surface sediments concentrations must be achieved through dredging and monitored natural attenuation in order to achieve the goals of the remedy regarding fish body burdens. The discussion below summarizes EPA's current understanding of the reduction to be achieved through dredging.

Before beginning further discussion on sediment PCB levels, it is important to note the following. In general, fish body burdens respond in a linear fashion to changes in surface sediment concentration of compounds like PCBs (Burkard, 2009). This is commonly represented through the use of a biota-sediment accumulation factor (BSAF). BSAFs are typically site specific, reflecting local conditions of exposure, organic carbon levels, bio-availability of the contaminants, *etc.* Nonetheless, in any given setting, if a 10-fold in fish body burden is targeted in fish body burden, then a similar 10-fold reduction must be achieved in the sediment to which the fish are exposed. Thus fish body burdens are not driven by absolute sediment concentrations (*e.g.,* 1 ppm PCB in sediment ≡ 1 ppm PCB in fish tissue) but rather they are proportional to sediment concentrations, with local influences incorporated in the BSAF.

The extensive SSAP surface sediment data set permits the calculation of current surface sediment PCB concentrations. These data provide a robust basis to estimate current (2002-2007) surface sediment concentrations. Combining these data with the remedial design plans permits the calculation of a post-remediation mean surface sediment PCB concentration for each river section based on the following premises: 1) little to no increase in mean surface sediment PCB concentrations outside the dredging areas as a result of dredging-related resuspension, and 2) little natural attenuation of surface sediment concentrations during the remediation period itself. Application of these premises allows a simple area-weighted calculation of pre and post-dredging conditions based on the SSAP data.

By applying both premises, this analysis makes the most direct comparison of the changes due to dredging alone. Evidence collected to date by EPA and GE from the recent dredging efforts indicates that premise 1 is true. Additionally, dredging-related resuspension would affect both the model and SSAP estimates. For premise 2, changes that result from natural attenuation would be applicable to both the ROD and SSAP-based estimates. Thus both considerations should be excluded from this comparison which focuses on the differences in surface sediment concentrations achieved by dredging alone. On this basis, the pre and post-dredging estimates based on the SSAP data and the remedial design absent of natural attenuation and resuspension were compared to the HUDTOX "No Resuspension" Scenario.[1] This model run represents the most optimistic estimate of the degree of improvement to be achieved under the ROD; however, EPA's best estimate scenario (the 350 ng/L, ~1 percent release scenario) was only marginally different.

For the comparison, surface sediment concentrations were estimated both inside and outside the dredging areas for both the model and SSAP results. These results were then combined to generate an area-wide average surface concentration of Tri+ PCBs for each river section. For the model results, the concentration in surface sediment before remediation was taken to be the concentration in the year 2005. The post-remediation surface concentration was the model result in the year 2012, the year after completion of the remedy as simulated by the model.

The HUDTOX model separately simulates Tri+ PCB concentrations in cohesive and non-cohesive surface sediments. The original areas were delineated based on the 1992 side-scan sonar survey of RS1 and RS2. Cohesive and noncohesive sediment areas in RS3 were developed based on various studies but did not represent a true mapping of the river bottom. The SSAP program delineated sediment types based on a more recent side-scan sonar survey conducted by GE, which separated the river bottom into more categories. To create similarly based estimates for both the HUDTOX model results and the SSAP-based analysis, the 1992 side-scan sonar coverage was intersected with GE dredge polygons to calculate

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[1] The effect of natural attenuation could be easily isolated in the model results for RS2 and RS3 since the noncohesive areas in these river sections were generally not targeted for remediation. Thus pre-dredge and post-dredge concentrations in the noncohesive areas are essentially the same. However, in RS1, the remedial design targeted both cohesive and noncohesive areas, so that the effects of natural attenuation could not be removed from the comparison for this area. This serves to increase the model estimate of the degree of improvement. As will be shown below, the expected improvement based on the SSAP and remedial design is still better than the model estimate for RS1.

concentrations for the cohesive and noncohesive sediment texture areas inside and outside dredge boundaries.

Table 1 presents the comparison of the percent reduction in the Tri+ PCB surface sediment concentration based on the original model scenario *vs.* the calculation using the SSAP cores and the remedial design. For RS1, the model predicted about a 79 percent reduction in surface sediment concentration. Although the absolute concentration in the surface sediment based on the SSAP cores is higher than the estimates used in the model for the ROD, the percent reduction is at least comparable if not better (approximately 87 percent), meaning that the remedial design is predicted to yield a greater reduction in fish tissue body burdens than anticipated by the ROD. The results for RS3 are comparable to those for RS1, in that the expected improvement anticipated by the ROD (4.4 percent) is less than that expected from the remedial design based on the SSAP cores (4.9 percent). Again the reduction based on the SSAP cores and remedial design is at least comparable to if not better than that anticipated by the ROD. Overall, the reduction in Tri+ PCB concentration expected from the remedial design based on the SSAP core data due to dredging alone (18.1 percent) is comparable to that anticipated by the ROD for the entire Upper Hudson (19.8 percent).

The notable difference between the ROD-anticipated reduction and that predicted from the remedial design occurs in RS2. The reduction anticipated by the ROD (64 percent) is about twice as much of an improvement for RS2 as predicted from the remedial design (36 percent). This indicates that it will take RS2 longer to reach its ultimate remedial goals than the forecast in the ROD. However, because the difference between the two estimates is slightly less than a factor of 2 and the model forecast curve is approximately equivalent to an exponential rate of decline, this difference is essentially equivalent to an additional half life on the forecast curve. That is, RS2 could be expected to reach its expected remedial goals about one half life longer than that forecast in the ROD. The half life for recovery as forecast by HUDTOX for the ROD is about 10 years in RS2. Thus based on the discussion above, achievement of the various remedial goals for RS2 may lag those anticipated by the ROD by about 10 years. Given the uncertainties in the model forecasts, the long periods already anticipated to achieve the remedial goals in the Upper Hudson and the better than anticipated improvements in RS1 and RS3, this delay in RS2 is not deemed a sufficient reason to modify the remedial design at this time.

Reference:

Burkhard, L., 2009. Estimation of Biota Sediment Accumulation Factor (BSAF) from Paired Observation of Chemical Concentrations in Biota and Sediment; EPA/600/R-06/-47 ERASC-013F, Ecological Risk Assessment Support Center, Office of Research and Development; February.

Table 1. Comparison of Area-Weighted Average Surface Concentrations (0-2 inches) for the ROD Model (HUDTOX) Forecast and for the Remedial Design based on SSAP Cores

River Section	Sediment Type	Non-Cohesive Sediment Sub-Type	River Bottom Area (acres)[3]		EPA Model Predicted Average Tri+ PCB Surface Concentrations (0-5 cm) (mg/kg)			SSAP Design Data Remedial Design Area-Weighted Average Tri+ PCB Surface Concentrations[7] (0-2 in) (mg/kg)					Percent Reduction Due to Remediation Alone	
			Inside Dredge Boundaries	Outside Dredge Boundaries	Before Remediation[2]	After Remediation Model Estimate (No Resuspension Scenario)[1,2]	After Remediation Model Estimate Excluding Natural Attenuation during Dredging (No Resuspension Scenario)[1]	Inside Dredge Boundary based on SSAP Cores Before Remediation	Inside Dredge Boundary After Remediation	Outside Dredge Boundary based on SSAP Cores	All Areas Before Remediation - Area Weighted Concentration	All Areas After Remediation - Area Weighted Concentration	EPA Model Prediction	SSAP Design Data Estimate
RS1	Cohesive		103	30	7.0	0.39		18	0.25	4.0	14.8	1.1		
	Non-cohesive		191	204	3.8	1.16		25	0.25	3.9	14.0	2.1		
All Sediment Types (Area Weighted Average)[5]			294	234	**4.6**	**0.96**					**14.2**	**1.9**	**79%[6]**	**87%**
RS2	Cohesive		56	77	5.7	0.66	0.66	20	0.25	7.9	13	4.7		
	Non-cohesive		25	305	0.86	0.33	0.86	29	0.25	8.8	10	8.1		
All Sediment Types (Area-Weighted Average)[4,5]			81	382	**2.26**	0.42	**0.80**				**11**	**7.1**	**64%**	**36%**
RS3	Cohesive Non-cohesive		98	3,262	1.04 0.51	0.25 0.20	0.25 0.51	5.8	0.25	3.2	3.3	3.1		
All Sediment Types (Area-Weighted Average)[4,5]			98	3,262	**0.53**	0.20	**0.51**				**3.3**	**3.1**	**4.4%**	**4.9%**
All River Sections All Sediment Types (Area-Weighted Average)													**19.8%**	**18.1%**

Notes:

1. Model scenario is d004 (no resuspension)
2. Model estimate before remediation is the year 2005 and after remediation is the year 2012. Remediation ends in August 2011.
3. Area inside and outside dredge boundaries are based on GE Hudson dredge polygons intersected with 1992 side scan sonar coverage.
4. Cells in large bold type represent before and after remediation values that are considered most directly comparable between the EPA HUDTOX Model and the SSAP Design-based estimates. The after-remediation values are area-weighted averages exclusive of natural recovery processes for both the model-based estimates and the SSAP Design-based estimates. For example, the value of 0.83 for the Model-based after-remediation estimate for RS2 is an area-weighted average of the post dredge concentration in cohesive sediments (0.74 mg/kg) and the predredge concentration in noncohesive sediments (0.86 mg/kg). The decline in model-based concentrations in noncohesive sediments between before remediation and after remediation conditions is due to natural recovery alone since no dredging in noncohesive sediments was anticipated for RS2.
5. Values in bold are used in the calculation for Percent Reduction due to Remediation Alone. See note 6 for RS1 percent reduction calculation.
6. Percent reduction for RS1 for the model includes both remediation and natural attenuation processes since remediation affected both cohesive and noncohesive sediment areas. As a result, the effect of natural attenuation alone could not be separated from that of remediation in the model output.
7. The SSAP Design-based estimates are based on SSAP data measurements and the expected post-dredging surface concentration of 0.25 ppm Tri+ PCB in dredged areas. Since this calculation is based on data only, it does not include an natural attenuation component. To make a direct comparison possible, the EPA HUDTOX model results were assembled without incorporating a natural attenuation component where possible.

Appendix B

Technical Memorandum

Evaluation of Surface Sediment PCB Concentrations in River Section 1 ecology and environment, inc.

Technical Memo

To: Gary Klawinski, USEPA Region 2

From: Mark Surette, Ecology and Environment, Inc.

CC: David King, Jennifer LaPoma, USEPA Region 2
John Fazzolari, Ecology and Environment, Inc.

Date: 6/1/2012

Re: Hudson River PCBs Superfund Site – Evaluation of Surface Sediment PCB Concentrations within River Section 1

At the request of the United States Environmental Protection Agency (EPA) through the United States Army Corps of Engineers (USACE), Kansas City District, Ecology and Environment, Inc. (E & E) evaluated the results of the data obtained as part of the Baseline Surface Sediment Special Study and the Downstream PCB Deposition Special Study, both were conducted in accordance with the *2011 Remedial Action Monitoring Quality Assurance Project Plan* (2011 RAM QAPP; Anchor QEA, LLC and Environmental Standards, Inc. 2011). The intent of the special studies was to assess what impact, if any, the 2011 dredging operations had upon downstream portions of the Hudson River.

The data for this evaluation were obtained from multiple sources, including sampling events performed prior to and after the 2011 dredging operations. The analytical results from the spring 2011 sampling event, preformed from June 5 to June 8 (prior to dredging operations), were used as approximate baseline surface sediment PCB concentrations. The analytical results from the fall 2011 sampling event, performed from November 4 to November 15 (after dredging operations), were used to provide approximate post-dredging surface sediment PCB concentrations. In addition to assessing the data obtained in 2011, E & E also compared the results of the sampling events to past results of sediment core samples obtained as part of the Sediment Sampling and Analysis Program (SSAP) conducted between 2002 and 2005.

It should be noted that, in the context of the evaluations outlined in this technical memorandum, "surface sediments" are defined as river sediment samples that represent the 0 to 2-inch depth interval, which differs from the historical use of this term at the Hudson River PCBs Superfund Site. In particular, as defined within EPA's Final Decision (Re: Resolution of GE Disputed Issues, 2004), "surface sediments" for the purposes of delineating dredge areas were defined as the 0 to 12-inch depth interval. Since the purpose of the evaluation outlined in this technical memorandum was to compare the changes in surface sediment (as represented by the 0 to 2-inch depth interval) and not to evaluate the data in relation to the criteria outlined in the EPA's 2002 Record of Decision (ROD; EPA 2002), all references to "surface sediments" throughout this memorandum should be understood to mean the 0 to 2-inch depth interval, unless noted otherwise.

Sample Collection Methods

The samples collected as part of the Baseline Surface Sediment Special Study and the Downstream PCB Deposition Special Study were obtained using either an Ekman dredge sampler or a Van Veen sampler. These devices obtain a sample by collecting a thin layer of sediment from a defined surface area. Because of the manner in which the samplers were set up, the samples provide surface sediment PCB concentration data for river sediments within the 0 to 2-inch depth interval. A majority of the locations that were targeted for sampling during the spring 2011 sampling event were also targeted for sampling as part of the fall 2011 sampling event; however, eight locations that were sampled during the spring 2011 sampling event were within areas dredged during the 2011 dredging season. Therefore, these locations were not resampled during the fall 2011 sampling event as had been originally planned, since the data obtained at those locations would not have been useful in supporting the intent of the special studies due to the placement of backfill and/or encapsulation layer material in those areas.

The samples collected as part of the SSAP were obtained either through vibracoring or ponar samplers, using the methods outlined in the *Design Support Sediment Sampling and Analysis Program Quality Assurance Project Plan* (SSAP QAPP; Environmental Standards, Inc., and QEA, LLC 2002). Vibracoring was the preferred sample collection method as it provided sediment PCB concentrations both at the surface and at depth. In locations where vibracoring was not successful in obtaining a sediment core (e.g., in locations where thin layers of sediment were present over bedrock), ponar dredges were used in an attempt to provide a representative sediment sample at that location. Ponar samplers collect sediment in a manner similar to the Ekman dredge and Van Veen samplers.

Data Evaluations

As part of the SSAP, sediment cores were typically sectioned during processing in order to provide a sample that was representative of the 0 to 2-inch depth interval. As mentioned previously, due to the manner in which the Ekman dredge and Van Veen samplers were set up, they also provided surface sediment samples that were representative of the 0 to 2-inch depth interval. While these sampling methods provide equivalent data, there may be variations in the representative samples due to the different sample collection methods. For the purposes of the evaluations described within this memorandum, it is assumed that the two methods provide data that are sufficiently similar to one another.

In total, 90 samples were collected as part of both special studies: 36 samples (including three duplicates) were obtained during the spring 2011 sampling event, and 54 samples (including four duplicates) were obtained during the fall 2011 sampling event. Furthermore, in order to provide a more accurate data comparison, only those SSAP sediment cores that were collected from a location that was within 20 feet of the surface sediment sampling locations targeted as part of the special studies were used in these analyses. Therefore, it should be understood that the results presented in this memorandum regarding the SSAP surface sediment concentration data are from samples that were obtained in close proximity to the sampling locations in the special studies, unless noted otherwise (see attached figures). In total, 67 samples (including five duplicates) obtained as part of the SSAP were colocated within 20 feet of the locations where a surface sediment sample was obtained during either the spring or fall 2011 sampling events. These 67 samples are a subset of the approximately 3,724 samples (including 221 duplicates) obtained as part of the SSAP within River Section 1 that provide surface sediment PCB concentration data (i.e., sediment samples representing the 0 to 2-inch depth interval, including samples collected via vibracoring and ponar dredges).

Evaluation of SSAP and 2011 Special Study Data

The first evaluation performed was to compare the average surface sediment PCB concentration calculated from the sediment core samples obtained as part of the SSAP and the overall results of the 2011 special studies. The focus of this evaluation was to assess the relative change in the surface sediment PCB concentrations throughout River Section 1 as represented by the 2002–2005 SSAP sediment cores results and the 2011 special studies surface grab sample results.

Evaluation of Spring and Fall 2011 Special Study Data

The second evaluation performed was to compare the average surface sediment results that were obtained by the pre-dredging Baseline Surface Sediment Special Study and the post-dredging Downstream PCB Deposition Special Study. The focus of this evaluation was to assess the change in surface sediment PCB concentrations throughout River Section 1 within a single dredging season.

Evaluation of Sediment Type and Sampling Location

Additionally, the data obtained from the various sampling events were further evaluated to determine whether any apparent trends in the surface sediment PCB concentrations were evident based on (1) the surface sediment type at the location where the sample was collected and (2) whether the siting of the sample location was inside or outside the delineated dredge areas, which were developed subsequent to the SSAP. These two trend analyses were compared to trends that were found as part of the evaluation of the data obtained during the SSAP. The focus of these evaluations was to determine whether the surface sediment concentration data behaved in a manner similar to that observed in historical data.

Results and Discussion

Results: Evaluation of SSAP and 2011 Special Study Data

Based on the analytical results for SSAP sediment samples collected within 20 feet of the samples obtained as part of the special studies, the average surface sediment total PCB (TPCB) concentration in River Section 1 was 19.5 milligrams per kilogram (mg/kg), with concentrations ranging from non-detect (ND) to 94.0 mg/kg (see Figure 1 and Table 1). In comparison, based on the combined results of the two special studies conducted in 2011, the average surface sediment TPCB concentration in River Section 1 was 6.5 mg/kg, with concentrations ranging from ND to 94.0 mg/kg. As an additional point of comparison, as stated within the 2002 ROD, "the average concentration in sediments 0 to 25 cm (0 to about 10 inches) in River Section 1 in 1991 was approximately 42 mg/kg [TPCB]" (EPA 2002). Similarly, of all the SSAP samples collected throughout River Section 1 that provide surface sediment PCB concentration data (i.e., sediment core samples that were processed to provide a 0 to 2-inch depth interval or collected using a ponar dredge), including those located greater than 20 feet from the special study sampling locations, the average surface sediment TPCB concentration was 45.6 mg/kg, with concentrations ranging from ND to 1,650 mg/kg.

Figure 1: Average of Surface Sediment PCB Concentrations in River Section 1 Over Time (depth interval varies)

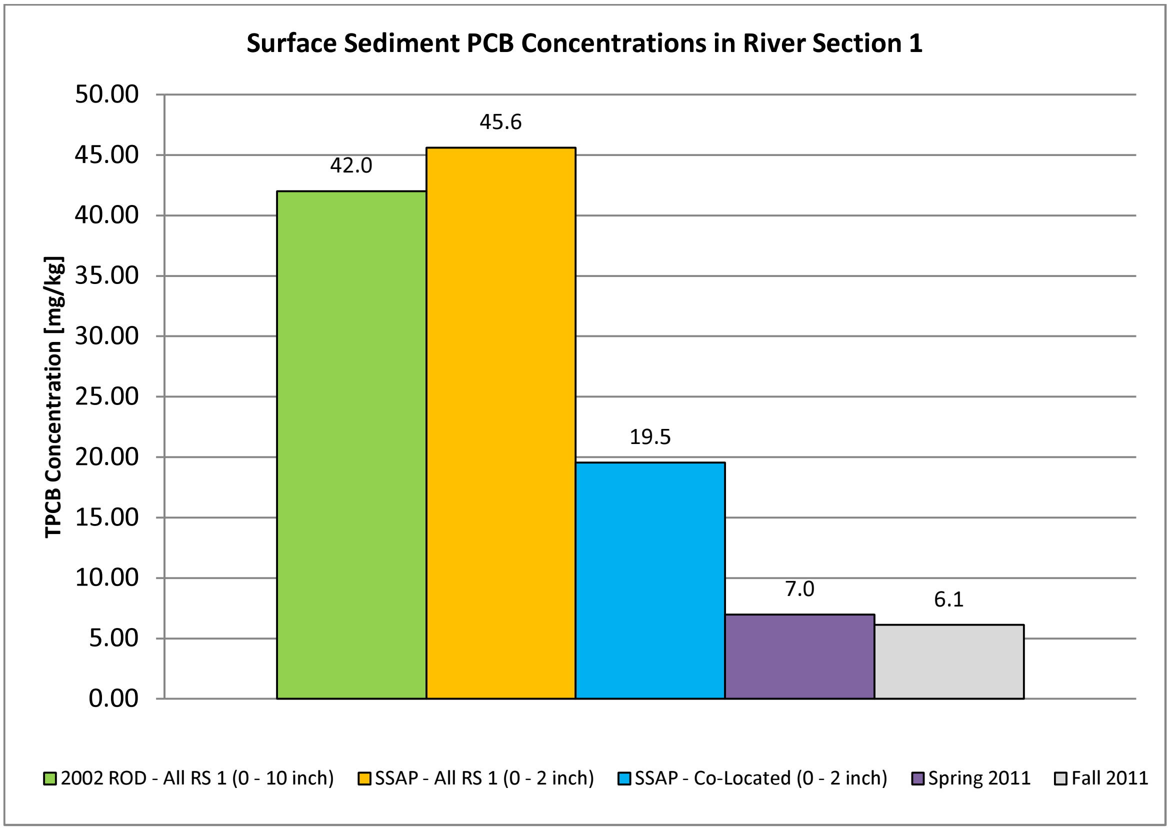

Table 1: Summary of SSAP Surface Sediment Results Colocated with Special Study Samples – River Section 1

Sampling Period	Average TPCB Concentration10 [mg/kg]	Range in TPCB Concentration [mg/kg]
SSAP (2002-2005)	19.5	ND – 94.0
Spring 2011	7.0	ND – 64.5
Fall 2011	6.1	ND – 94.0

Note: non-detect values set to ½ the method detection limit (MDL); duplicate sample results averaged.

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[1] The data was reviewed to identify obvious outliers. Sample DDC-RS1-9089-099 (TPCB concentration of 840.0 mg/kg) was removed from further analyses, as it was determined to be an outlier (the next highest result from the 2011 sampling events was 94.0 mg/kg TPCB). This sample was collected during the fall 2011 sampling event within a portion of CU 49 where two core samples obtained during the SSAP also showed elevated surface sediment TPCB concentrations in the 0 to 2-inch depth interval: RS1-9089-ET047, obtained approximately 1.9 feet away, had a TPCB concentration of 510.0 mg/kg, and RS1-9089-TT216, obtained approximately 1.5 feet away, had a TPCB concentration of 286.0 mg/kg. Those two SSAP results were also removed from further analyses (the next highest colocated SSAP result was 94.0 mg/kg TPCB).

While the data presented in the 2002 ROD provide some insight into the how surface sediment PCB concentrations may have changed in the 11 to 14 year period between when the 1991 data referenced in the 2002 ROD was collected and when the SSAP sediment cores were obtained, a direct comparison of these results is complicated by the differences in core processing methods between the different sampling programs (i.e., 0 to 2-inch depth interval versus a 0 to 10-inch depth interval). However, the data do show that the approximate surface sediment PCB concentrations within River Section 1 remained relatively unchanged during this period.

Results: Evaluation of Spring and Fall 2011 Special Study Data

The average surface sediment PCB concentration obtained from the special studies is notably lower than that obtained as part of the SSAP, whether considering all of the data obtained during the SSAP collected from River Section 1, or just the data obtained from samples collected in close proximity to the special study sampling locations. Based on this evaluation, there has been a decline in the surface sediment PCB concentrations within River Section 1 between the colocated SSAP and spring 2011 sampling events. When considering the activities that have occurred since the collection of the SSAP data, in particular the commencement of Phase 1 dredging operations in 2009, it is expected that levels would have decreased. These activities include:

- The removal of approximately 283,000 cubic yards of contaminated sediments containing approximately 20,020 kilograms (kgs) of PCBs during Phase 1;
- The placement of approximately 155,000 cubic yards of clean backfill material within approximately 31 acres 5of river bottom and the encapsulation of an additional 17.3 acres of river bottom (a total of 48.3 acres of remediated area); and
- A 100-year high-flow event within the Upper Hudson River during the spring of 2011, in which bathymetric changes were evident in some locations.

These activities, when taken as a whole, could have resulted in the reduction in the surface sediment PCB concentrations that were evident between the SSAP and the spring 2011 sampling event. In addition, further activities were completed following the collection of the surface sediment samples during the spring 2011 sampling event but prior to sampling during the fall 2011 event, including:

- The additional removal of approximately 363,000 cubic yards of contaminated sediments containing approximately 27,200 kgs of PCBs during Phase 2 Year 1; and
- The placement of an estimated 104,000 cubic yards of clean backfill material (assumed depth of 1 foot) within approximately 64.5 acres of river bottom and the encapsulation of an additional 10.9 acres of river bottom (a total of 75.4 acres of remediated area).

Based on the two sampling events conducted as part of the 2011 special studies, the average surface sediment TPCB concentration in River Section 1 was 7.0 mg/kg during the spring 2011 sampling event and 6.1 mg/kg during the fall 2011 sampling event (see Table 1). While the results obtained show little, if any, decline in the surface sediment PCB concentrations between these two sampling events, especially when compared to the decline that is apparent when considering the SSAP results, it does indicate that the dredging activities within the 2011 dredging season had little impact upon the surface sediment PCB concentrations in downstream areas.

In addition, when considering the differences between the results, the effects of 100-year high-flow event that occurred in the Upper Hudson River between the collection of the SSAP data and the spring 2011 sampling event must be taken into consideration, as no such event occurred between the spring and fall 2011 sampling events. It is plausible that the introduction of large quantities of clean backfill material placed as part of the 2009 dredging operations prior to the significant hydrodynamic forces associated with the 100-year high-flow event may have resulted in the repositioning of this backfill material throughout River Section 1. Taken together, the 2009 dredging operations and the high-flow event may, at least in part, account for the reduction in the surface sediment PCB concentrations observed between the SSAP and the spring 2011 sampling event and provide some explanation as to why a similar decrease in PCB concentration was not observed between the spring and fall 2011 sampling events.

Furthermore, an assessment to account for the eight locations sampled during the spring 2011 sampling event that were not re-sampled as part of the fall 2011 sampling event was also performed. Sediment cores were collected during the 2011 dredging operations in the areas dredged following placement of the backfill material in order to assess the surface sediment PCB concentrations within the 0 to 2-inch depth interval. These samples were obtained using methods similar to that employed during the SSAP (i.e., vibracoring). A total of 54 sediment cores were collected for this purpose, a majority of which had analytical results of ND. Applying normal data treatments (i.e., substituting ½ the MDLs for NDs, and the averaging of duplicate results), the average surface sediment TPCB concentration in the 0 to 2-inch depth interval for the sediment cores collected in areas dredged during 2011 following backfill placement was 0.3 mg/kg. By substituting this value for the eight locations that were not re-sampled during the fall 2011 sampling event, the overall average surface sediment TPCB concentration for this sampling event was lower at 5.3 mg/kg. While the results of the backfill sampling may not be representative of the exact surface sediment PCB concentrations present at the aforementioned eight locations, the information provides a means to account for the reduction in the overall surface sediment PCB concentrations that will occur following dredging and the placement of backfill material.

Results: Evaluation of Sediment Type and Sampling Location

Beyond the information provided by the "before and after" type assessments discussed above, the data obtained during the 2011 special studies were further evaluated to determine whether or not trends identified during the SSAP were also observed in the data gathered during the 2011 special studies. As discussed in the *Phase 1 Dredge Area Delineation Report* (Phase 1 DAD; QEA, LLC 2005), surface sediment types were initially classified during the SSAP using side scan sonar (SSS). Based on the results of the SSS surveys, the river sediments were mapped into five different sediment types in order to assist in evaluating sediment core data obtained during the SSAP:

- **Type I (clay, silt, fine sands)**: smooth, generally featureless bottom; principally composed of soft aqueous silty sediments.
- **Type II (sands):** smooth to mottled bottom; principally composed of semi-compact to compact sand deposits.
- **Type III (coarse gravel and sand mixtures)**: irregular bottom; principally composed of compact gravel and cobble deposits intermixed with sand.
- **Type IV (mixed sediments)**: smooth and irregular bottom; a varying assemblage of sediments typically associated with Types I, II, and III.
- **Type V (rocky)**: extremely irregular bottom; principally composed of bedrock, cobbles, and/or boulders that are often overlain by a variable thickness of unconsolidated sediments.

As envisioned in the 2002 ROD, the boundaries identified by the SSS surveys were used during the initial dredge area delineation (DAD) process to assist in defining the boundaries of the dredge areas. During the evaluation of the SSAP sediment core data, it was typically observed that higher PCB concentrations were found in Types I, II, and IV sediments (i.e., cohesive sediments), whereas lower PCB concentrations were found in Types III and V (i.e., non-cohesive sediments). It should be noted that during the SSAP, samples were often not collected in areas delineated as Type V due to the sub-bottom bedrock conditions. As shown in Table 2, a similar trend is apparent when evaluating the results of the 2011 special studies. During both sampling events (i.e., the colocated SSAP locations and the corresponding samples collected during the 2011 special studies), no data were obtained in locations delineated as Type V, while the highest average surface sediment PCB concentrations were found in Type II material.

Table 2: Summary of SSAP Surface Sediment Results Colocated with Special Study Samples Compared to Sediment Types – River Section 1

	SSAP (2002-2005)		**Special Studies (2011)**	
Surface Sediment Type	*Average TPCB Concentration [mg/kg]*	*Range in TPCB Concentration [mg/kg]*	*Average TPCB Concentration [mg/kg]*	*Range in TPCB Concentration [mg/kg]*
Type I (Clay/Silt/Fine Sands)	17.6	ND – 86.0	3.4	ND-16.0
Type II (Sands)	29.0	1.5-94.0	13.3	0.45-94.0
Type III (Coarse Gravel/Sands)	0.5	N/A	3.1	2.1-5.1
Type IV (Mixed/Transitional)	15.2	ND-59.0	4.3	ND-18.0
Type V (Rocky)	NA	NA	NA	NA

Notes:

Only one sample was obtained within Type 3 material during the SSAP period that was collected withir feet of the samples obtained as part of the 2011 special studies.

Non-detect values were set to ½ the method detection limit (MDL); duplicate sample results were averaged.

In addition, the results of the 2011 special studies were evaluated to determine whether the siting of a sampling location "inside" as opposed to "outside" a dredge area had any bearing on the surface sediment PCB concentrations. The results show elevated surface sediment PCB concentrations for those sampling locations sited within areas currently slated for dredging when compared to the sample locations sited in areas not targeted for dredging (see Table 3). This trend is evident in both the spring and fall 2011 sampling events. Overall, this trend is expected, as the results of the SSAP, which helped to define the initial dredge areas, showed that elevated PCB concentrations were present in areas where deposition of sediments was known to occur and contributed, in part, to the identification of those areas for remediation. It should be noted that 44 of the 90 samples (49%) obtained during the 2011 special studies were located "outside" of the currently delineated dredge areas, while 46 samples (51%) were located "inside" the dredge areas. Similarly, 29 of the 67 colocated samples (43%) obtained during the SSAP were located "outside" the currently delineated dredge areas, while 38 samples (57%) were located "inside". In comparison, 1,075 of the 3,724 samples (29%) obtained during the SSAP throughout River Section 1 (including those located greater than 20 feet from the special study sampling locations) were located "outside" the currently delineated dredge areas, while 2,649 samples (71%) were located "inside".

Table 3: Summary of Special Study Surface Sediment Results Based on Sample Location – River Section 1

	Location "Inside" Dredge Areas		**Location "Outside" Dredge Area**	
	Spring 2011	*Fall 2011*	*Spring 2011*	*Fall 2011*
Average TPCB Concentration [mg/kg]	8.7	10.0	4.3	2.6

Note:
Non-detect values were set to ½ the method detection limit (MDL); duplicate sample results were averaged.

Taken together, these two analyses show that the trends observed in the data obtained during the 2011 special studies are similar to the trends observed in the SSAP data, mainly: surface sediment PCB concentrations found in samples from cohesive sediments and areas targeted for dredging are higher than in samples from non-cohesive sediments and areas not targeted for dredging. These same trends were evident during the sampling efforts conducted in support of the 2002 ROD, which supports the concept that the dredging locations initially identified during the 2002 ROD and further delineated during the SSAP continue to be the areas where elevated surface sediment PCB concentrations are observed.

Summary

The data collected from various sediment sampling programs conducted at the Hudson River PCBs Superfund Site support the following findings regarding changes in PCB surface sediment concentrations in River Section 1:

1. Overall, average PCB concentrations in surface sediment remained relatively unchanged between the collection of sediment samples evaluated to select the remedy outlined in the 2002 ROD and the collection of sediment cores during the SSAP that defined the dredge areas.

2. In contrast, the decrease in PCB concentrations in surface sediment between the performance of the SSAP and the 2011 special studies is evident. It is likely that the combination of events that occurred in the Upper Hudson River between the SSAP and the special studies (i.e., active remediation, introduction of large quantities of clean backfill, and a historic high-flow), along with natural recovery, caused the observed decrease.

3. When comparing the results of the two sampling events conducted during the 2011 special studies, the data show a slight decrease in the surface sediment PCB concentration, particularly when locations that were remediated are evaluated in light of the backfill surface sediment core data. However, the degree of change is much less than that observed when the 2011 special studies data are compared to the SSAP data, which may indicate that the 100-year high-flow event that occurred prior to the 2011 sampling event may have played a more significant role in reducing the surface sediment PCB concentrations than the 2011 dredging activities. Regardless, the results show little, if any, impact associated with redeposition during 2011.

4. The data from the 2011 special studies follow the historical trends observed during sampling events conducted in development of the 2002 ROD and subsequently confirmed during the SSAP, principally that higher surface sediment PCB concentrations are found in cohesive sediments than in non-cohesive sediments. Also, as would be expected, higher PCB concentrations were also found in surface sediment samples collected "inside" the currently delineated dredge areas than in samples collected "outside" the dredge areas.

The results of the 2011 special studies in River Section 1 will be supplemented by the collection and analysis of surface sediment samples in River Sections 2. This expanded sampling effort will be conducted as part of the 2012 dredging season.

References

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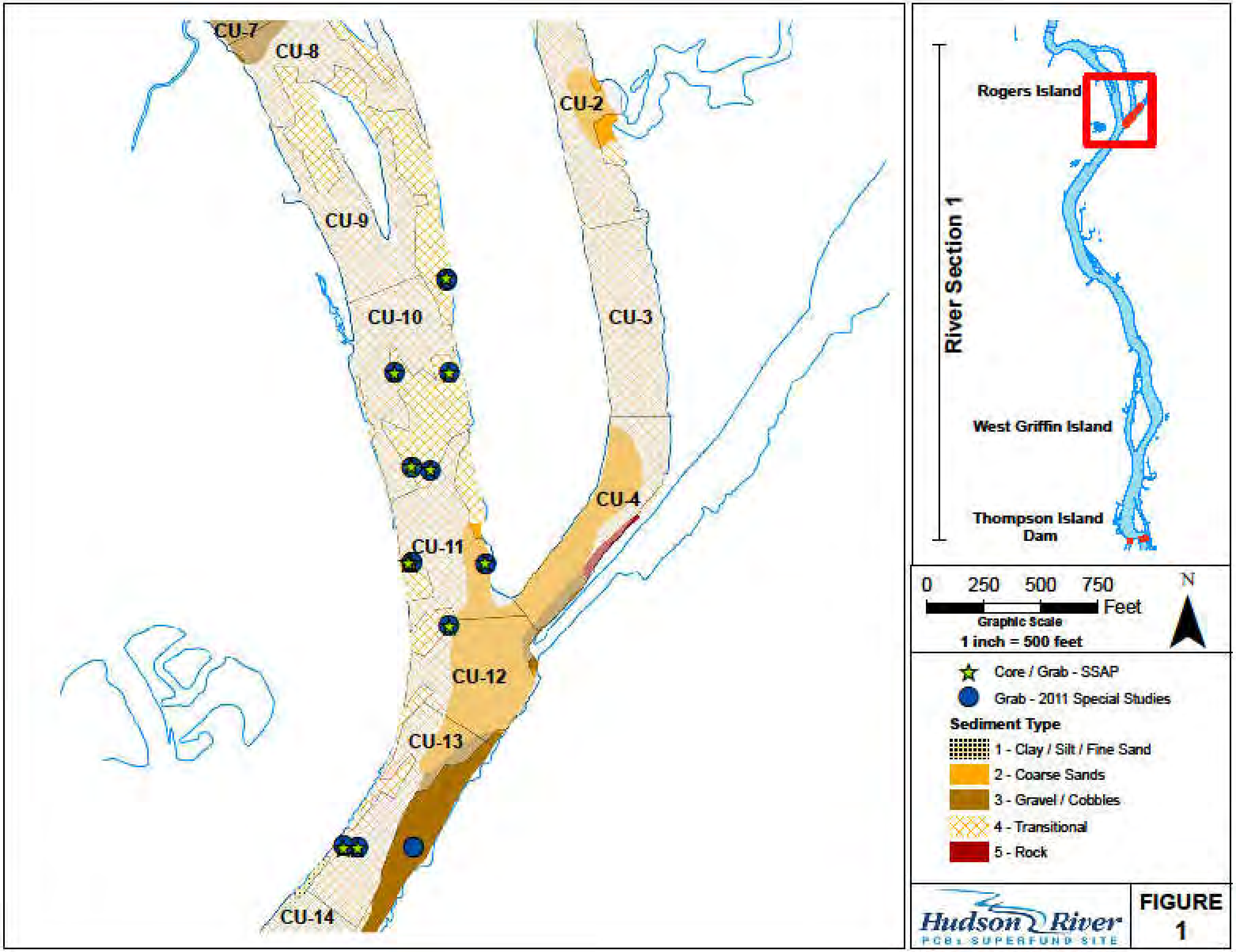
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Rogers Island
River Section 1
West Griffin Island
Thompson Island Dam
0 250 500 750
Feet
Graphic Scale
1 inch = 500 feet
N
Core / Grab - SSAP
Grab - 2011 Special Studies
Sediment Type
1 - Clay / Silt / Fine Sand
2 - Coarse Sands
3 - Gravel / Cobbles
4 - Transitional
5 - Rock
Hudson River
PCBs SUPERFUND SITE
FIGURE
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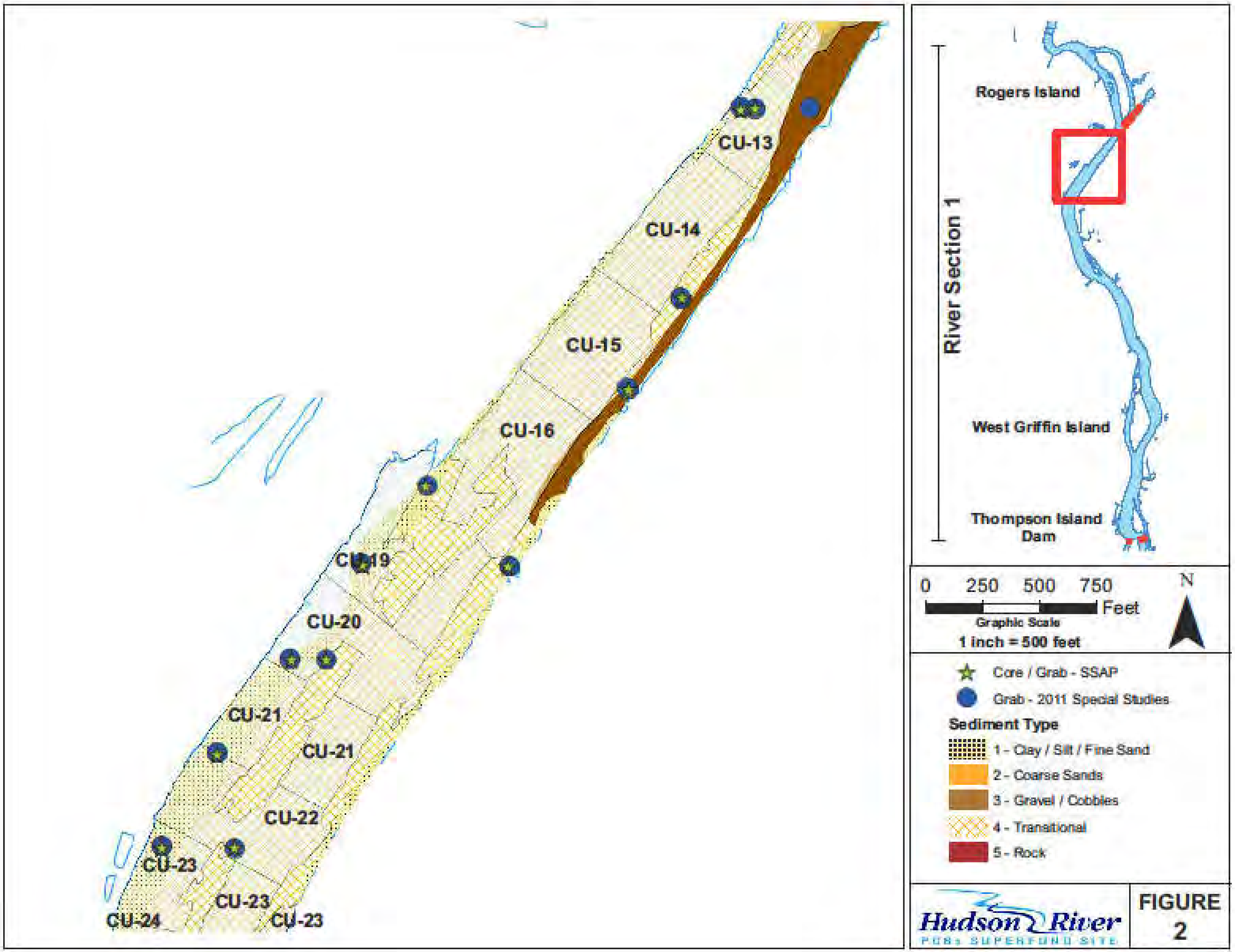
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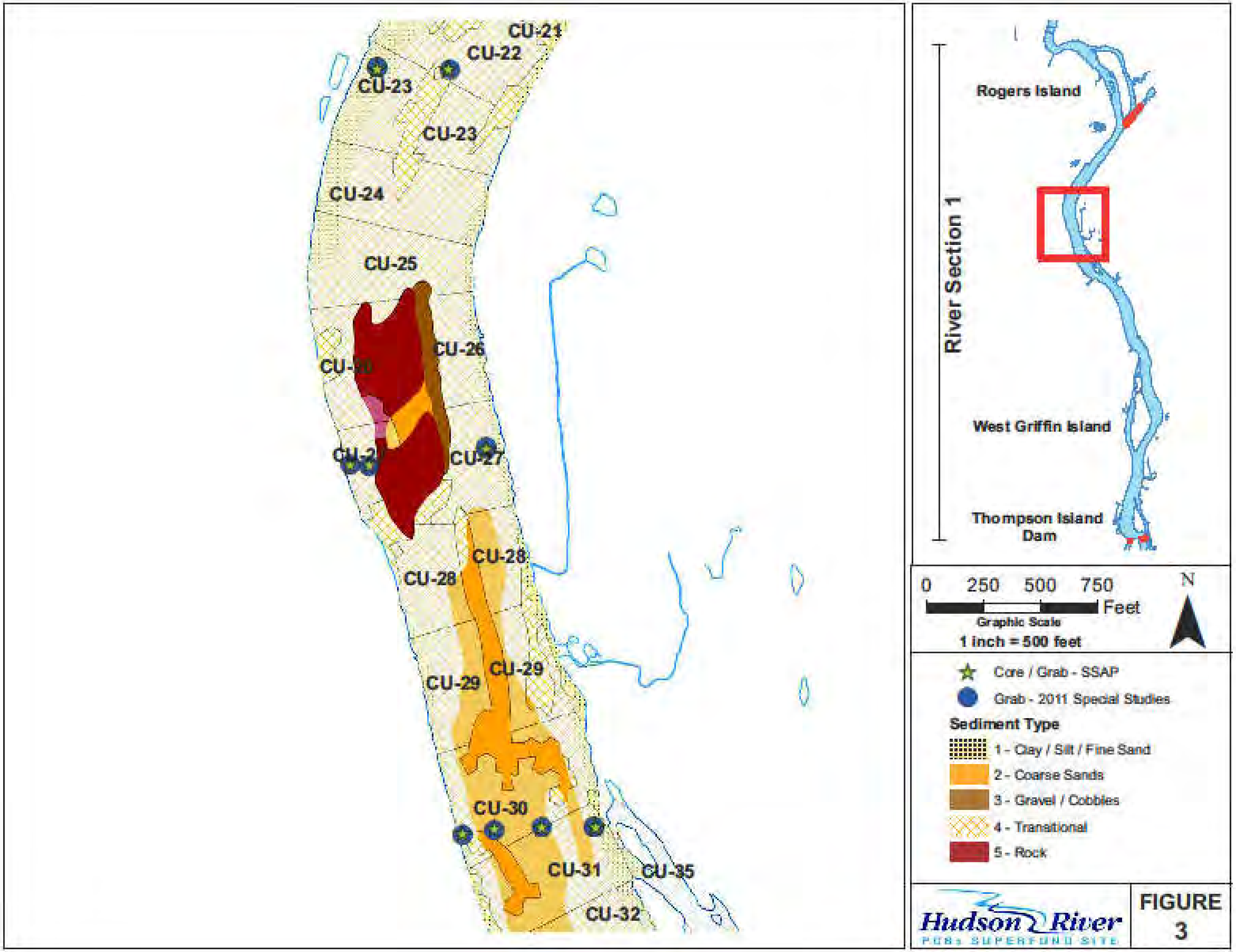
0 250 500 750 Feet
Graphic Scale
1 inch = 500 feet
N
Core / Grab - SSAP
Grab - 2011 Special Studies
Sediment Type
1 - Clay / Silt / Fine Sand
2 - Coarse Sands
3 - Gravel / Cobbles
4 - Transitional
5 - Rock
Hudson River
PCBs SUPERFUND SITE
FIGURE 2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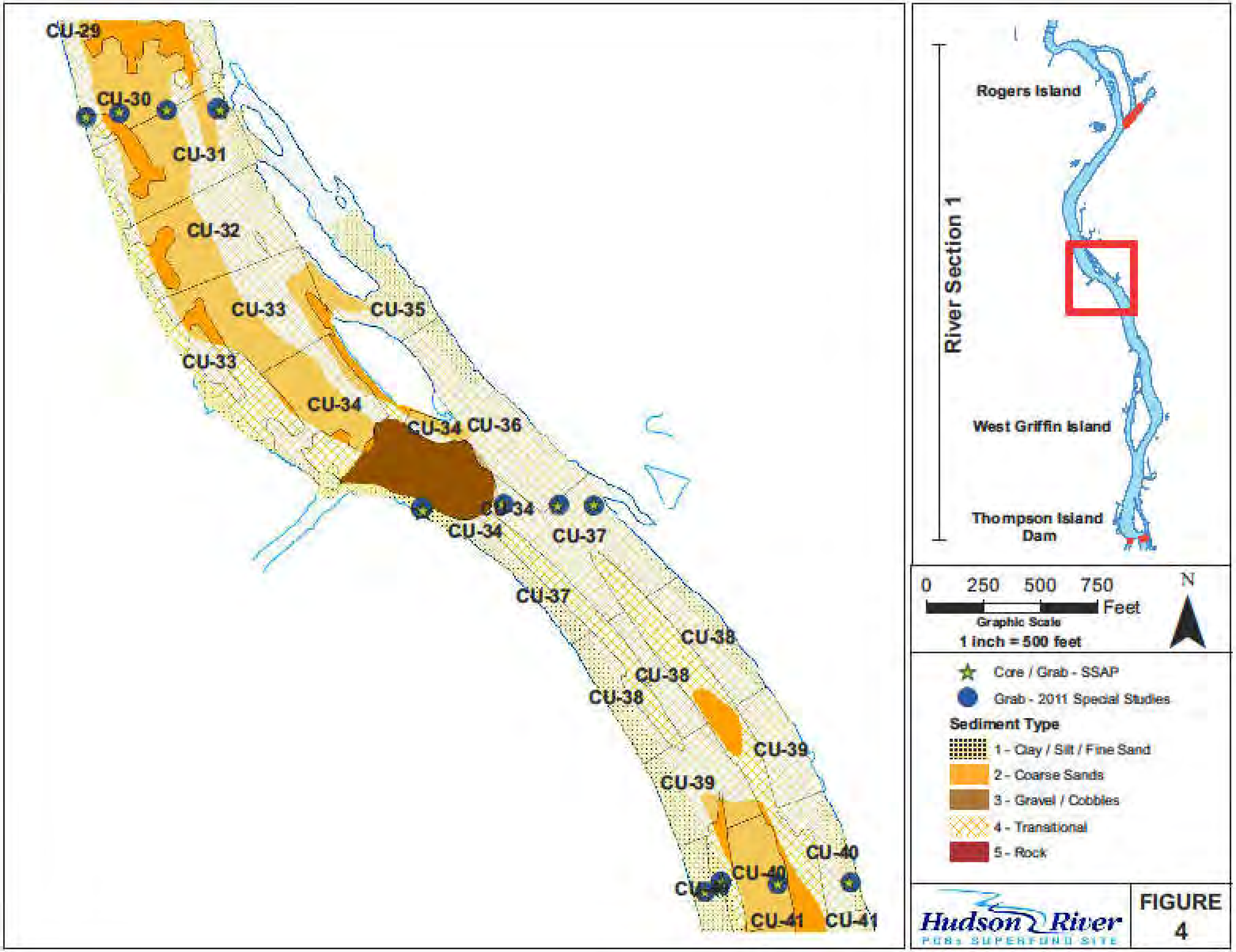
CU-31
CU-35
CU-32
Rogers Island
River Section 1
West Griffin Island
Thompson Island Dam
0 250 500 750 Feet
Graphic Scale
1 inch = 500 feet
N
Core / Grab - SSAP
Grab - 2011 Special Studies
Sediment Type
1 - Clay / Silt / Fine Sand
2 - Coarse Sands
3 - Gravel / Cobbles
4 - Transitional
5 - Rock
Hudson River
PCBs SUPERFUND SITE
FIGURE 3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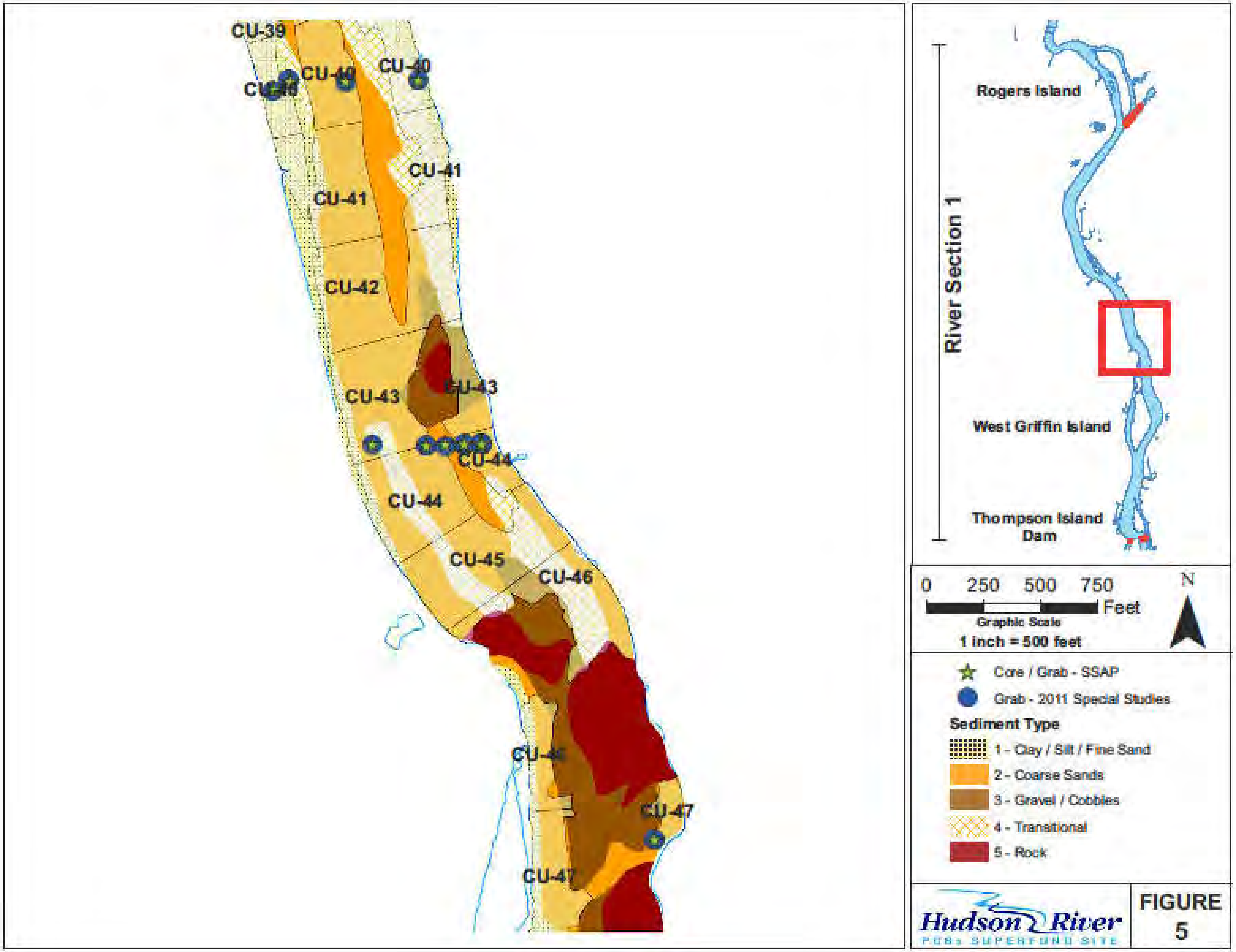
CU-41
Rogers Island
River Section 1
West Griffin Island
Thompson Island Dam
0 250 500 750 Feet
Graphic Scale
1 inch = 500 feet
N
Core / Grab - SSAP
Grab - 2011 Special Studies
Sediment Type
1 - Clay / Silt / Fine Sand
2 - Coarse Sands
3 - Gravel / Cobbles
4 - Transitional
5 - Rock
Hudson River
PCBs SUPERFUND SITE
FIGURE
4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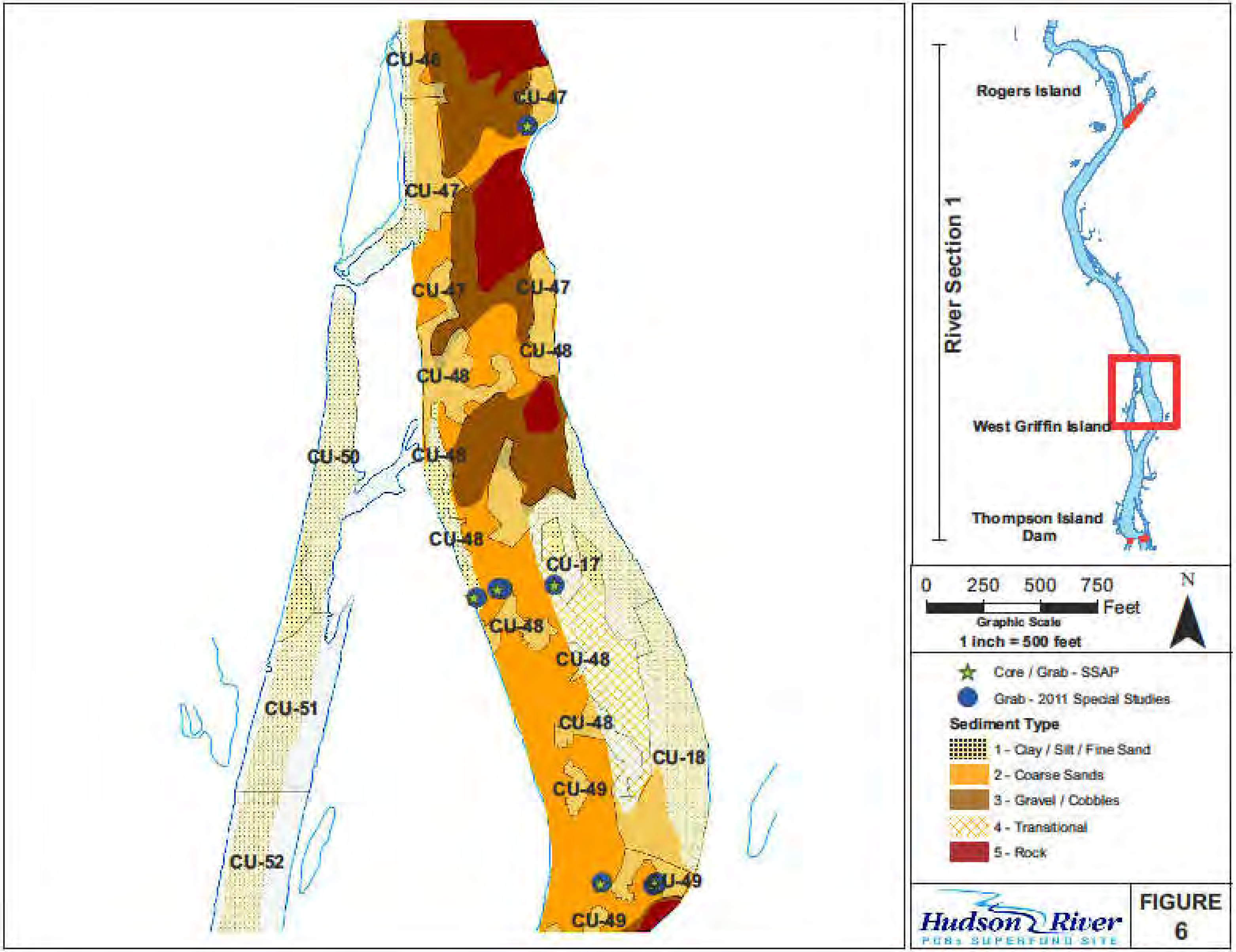
CU-47
Rogers Island
River Section 1
West Griffin Island
Thompson Island Dam
0 250 500 750 Feet
Graphic Scale
1 inch = 500 feet
N
Core / Grab - SSAP
Grab - 2011 Special Studies
Sediment Type
1 - Clay / Silt / Fine Sand
2 - Coarse Sands
3 - Gravel / Cobbles
4 - Transitional
5 - Rock
Hudson River
PCBs SUPERFUND SITE
FIGURE 5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CU-51
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CU-18
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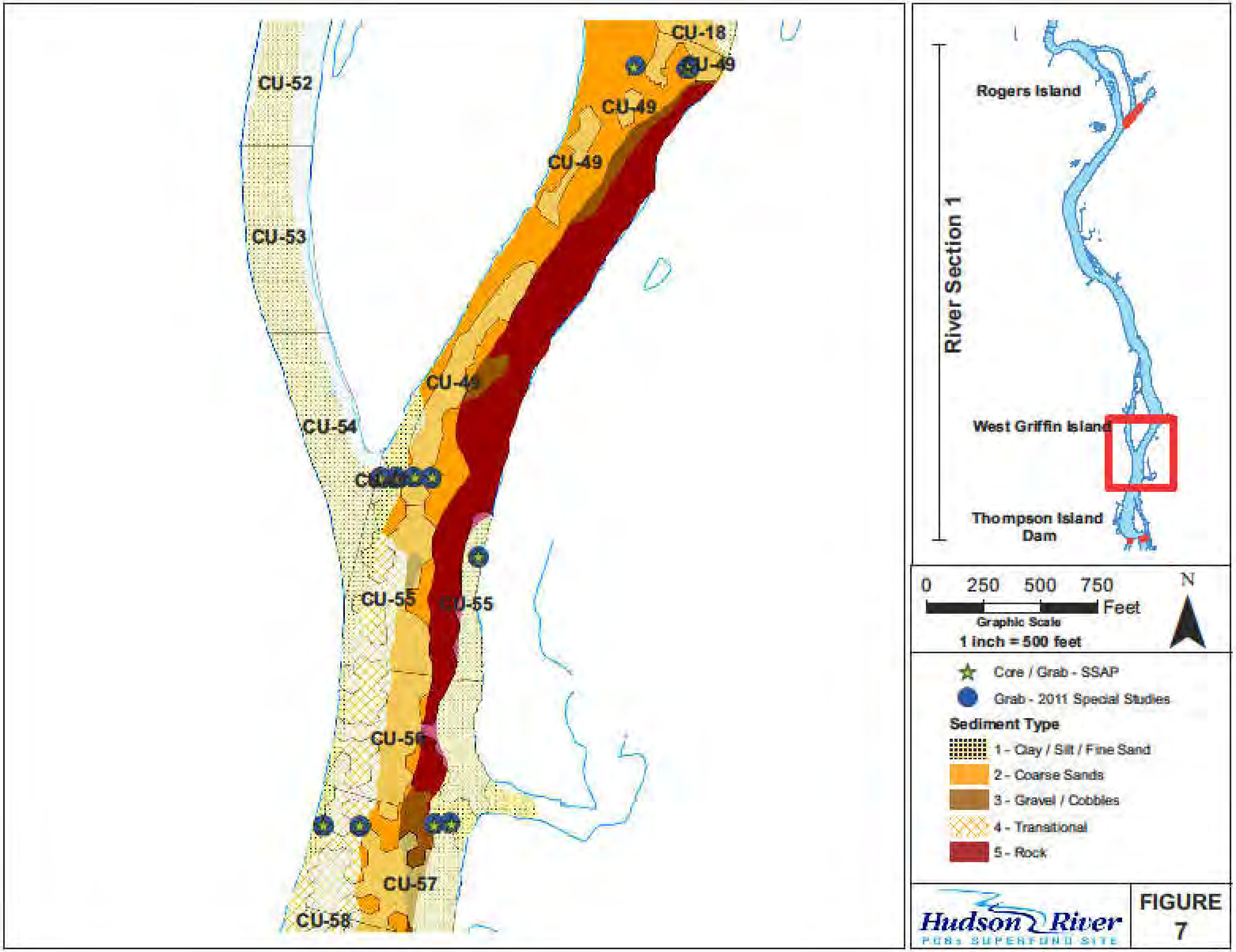
CU-49
Rogers Island
River Section 1
West Griffin Island
Thompson Island Dam
0 250 500 750 Feet
Graphic Scale
1 inch = 500 feet
N
Core / Grab - SSAP
Grab - 2011 Special Studies
Sediment Type
1 - Clay / Silt / Fine Sand
2 - Coarse Sands
3 - Gravel / Cobbles
4 - Transitional
5 - Rock
Hudson River
PCBs SUPERFUND SITE
FIGURE
6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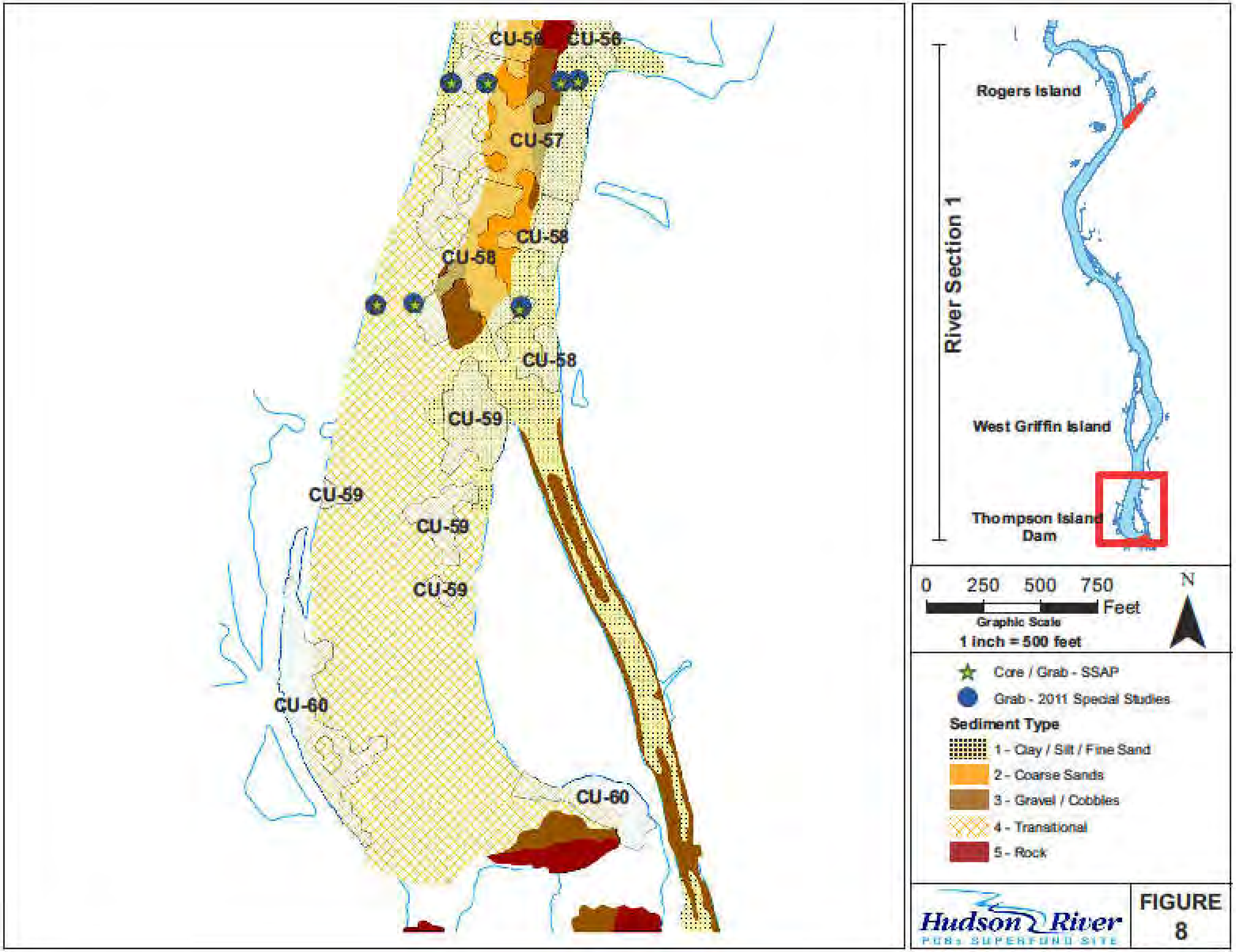
Rogers Island
River Section 1
West Griffin Island
Thompson Island Dam
0 250 500 750 Feet
Graphic Scale
1 inch = 500 feet
N
Core / Grab - SSAP
Grab - 2011 Special Studies
Sediment Type
1 - Clay / Silt / Fine Sand
2 - Coarse Sands
3 - Gravel / Cobbles
4 - Transitional
5 - Rock
Hudson River
PCBs SUPERFUND SITE
FIGURE 7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Rogers Island
River Section 1
West Griffin Island
Thompson Island Dam
0 250 500 750
Feet
Graphic Scale
1 inch = 500 feet
N
Core / Grab - SSAP
Grab - 2011 Special Studies
Sediment Type
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3 - Gravel / Cobbles
4 - Transitional
5 - Rock
Hudson River
PCBs SUPERFUND SITE
FIGURE 8