Hudson River PCBs Site
New York

Record of Decision

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LIST OF ACRONYMS AND ABBREVIATIONS

AOC - Administrative Order on Consent
ARAR - Applicable or Relevant and Appropriate Requirement
AWQC - Ambient Water Quality Criterion

BMR - Baseline Modeling Report

CCC - Criteria Continuous Concentration
CDI - Chronic Daily Intake
CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act
CFR - Code of Federal Regulations
cfs - cubic feet per second
CIP - Community Interaction Program
COPC - Chemicals of Potential Concern
CSF - Cancer Slope Factor
CSM - Conceptual Site Model
CT - Central Tendency
CWA - Clean Water Act
CZMA - Coastal Zone Management Act

DEIR - Data Evaluation and Interpretation Report
DOI - Department of Interior
DOT - Department of Transportation

ECL - Environmental Conservation Law (New York)
EE/CA - Engineering Evaluation/Cost Analysis
EO - Executive Order
EPA - Environmental Protection Agency
EPC - Exposure Point Concentration
ERA - Ecological Risk Assessment
ESA - Endangered Species Act

FEMA - Federal Emergency Management Agency
FISHRAND - Mechanistic Time-Varying Biouptake Model
FR - Federal Register
FS - Feasibility Study
FWQC - Federal Water Quality Criteria

g/m^2 - Grams per square meter
GE - General Electric Company

HHRA - Human Health Risk Assessment
HI - Hazard Index
HQ - Hazard Quotient
HROC - Hudson River PCB Oversight Committee
HUDTOX - Upper Hudson River Toxic Chemical Model

IRIS - Integrated Risk Information System kg - Kilogram

LOAEL - Lowest Observed Adverse Effect Level

MCL - Maximum Contaminant Level
MCLG - Maximum Contaminant Level Goal
μg/kg - Micrograms per Kilogram (Parts Per Billion)
mg/kg - Milligrams Per Kilogram (Parts Per Million)
MNA - Monitored Natural Attenuation
MPA - Mass per Unit Area

NAAQS - National Ambient Air Quality Standards
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NEPA - National Environmental Policy Act
ng/L - Nanograms per Liter (Parts Per Trillion)
NHPA - National Historic Preservation Act
NiMo - Niagara Mohawk Power Company
NOAA - National Oceanic and Atmospheric Administration
NOAEL - No Observed Adverse Effect Level
NPL - National Priorities List
NRC - National Research Council
NRRB - National Remedy Review Board
NTCRA - Non-Time Critical Removal Action
NYCRR - New York Code of Rules and Regulations
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
NYSDOS - New York State Department of State
NYSDOT - New York State Department of Transportation
NYSPDES - New York State Pollutant Discharge Elimination System

O&M - Operation and Maintenance

PCB - Polychlorinated Biphenyl
ppm - part(s) per million (mg/kg or mg/L)
PRG - Preliminary Remediation Goal

RAO - Remedial Action Objective
RBMR - Revised Baseline Modeling Report
RCRA - Resource Conservation and Recovery Act
RfD - Reference Dose
RI - Remedial Investigation
RI/FS - Remedial Investigation/Feasibility Study
RM - River Mile
RME - Reasonable Maximum Exposure
ROD - Record of Decision

SARA - Superfund Amendments and Reauthorization Act of 1986
SPDES - State Pollutant Discharge Elimination System
STC - Scientific and Technical Committee

TBC - To-be-considered (criteria)
TCDD - 2,3,7,8-tetrachlorodibenzo-p-dioxin
TEF - Toxicity Equivalency Factor
TEQ - (Dioxin-like) Toxic Equivalent
TI - Thompson Island
TID - Thompson Island Dam
TIP - Thompson Island Pool
Tri+ PCB - the sum of PCB congeners with three or more chlorine atoms
TQ - Toxicity Quotient
TRV - Toxicity Reference Value
TSCA - Toxic Substances Control Act

UCLM - Upper Confidence Limit on the Mean
USACE-NYD - United States Army Corp of Engineers - New York District
USC - United States Code
USGS - United States Geological Survey
USEPA - United States Environmental Protection Agency
USFWS - United States Fish and Wildlife Service

WHO - World Health Organization

PART 1: THE DECLARATION

Site Name and Location

The Hudson River PCBs Site ("Site") (United States Environmental Protection Agency (EPA) Identification Number NYD980763841) 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 Hudson River has been designated an American Heritage River because of its important role in American history and culture. This federal Superfund Record of Decision (ROD) addresses the risks to people and ecological receptors associated with polychlorinated biphenyls (PCBs) in the in-place sediments of the Upper Hudson River.

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 this 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, which are areas of PCB-contaminated sediment that became exposed after the river water level dropped following removal of the Fort Edward Dam in 1973.

This ROD selects a remedial action for sediments in the Upper Hudson River portion (approximately the upper 40 miles) of the Site. This remedial action will result in reduced risks to humans and ecological receptors living in and near the Upper Hudson and Lower Hudson River.

The Upper Hudson River region includes certain areas that have been and may continue to be sources of PCB contamination to the river, including General Electric Company's (GE's) Hudson Falls plant and Fort Edward plant, and Remnant Deposits 1-5. These source areas have been and/or are planned to be addressed by response actions by EPA, the New York State Department of Environmental Conservation (NYSDEC), and GE. Remedial actions for these areas are not the focus of this decision document, although successful completion (*i.e.*, reduction of PCB input into the river) of the expected source area work near the GE Hudson Falls plant is important to the full realization of the benefits of the remedial action called for in this ROD.

Statement of Basis and Purpose

This is the second ROD issued with respect to this Site. In the first ROD, issued by EPA on September 25, 1984, EPA selected a remedy which included: in-place containment of the Remnant Deposits; evaluation of downstream domestic water quality at Waterford, New York; and interim "No Action" as to the PCB-contaminated river sediment. The 1984 ROD indicated that both the No Action decision for the river sediments and the containment remedy for the Remnant Deposits might be reexamined by EPA in the future. The containment remedy for the Remnant Deposits was performed by GE under a 1990 Consent Decree with EPA. In addition, in

1990, NYSDEC completed the evaluation of downstream domestic water quality at Waterford, New York, which concluded that PCB concentrations were below analytical detection limits after treatment and met standards applicable to public water supplies.

In December 1989, EPA announced its decision to initiate a detailed Reassessment Remedial Investigation/Feasibility Study (RI/FS) of the September 1984 decision concerning the PCB-contaminated Hudson River sediments. The Reassessment is culminating in this decision document, which presents the remedial action selected by EPA for the PCB-contaminated sediments in the Upper Hudson River. EPA selected this remedial action in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and, to the extent practicable, with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (in accordance with CERCLA Section 121(a)). The decisions herein are based on the Administrative Record for this Site. Occasional reference is made to specific documents in the Administrative Record where the information is too voluminous to provide here. The Hudson River PCBs website (www.epa.gov/hudson) is also a source of information.

The United States Environmental Protection Agency is the lead agency for this project. The State of New York, by the Department of Environmental Conservation, which is the support agency for this project, concurs with EPA's decision for this project. The United States Department of Interior (Fish and Wildlife Service) and the United States Department of Commerce (National Oceanic and Atmospheric Administration), which are federal trustees of natural resources, and the New York State Attorney General also support an active environmental dredging remedy.

Assessment of Site

The response action selected in this ROD is necessary to protect the public health, welfare, or the environment from an imminent and substantial endangerment from actual or threatened releases of hazardous substances into the environment.

Description of Selected Remedy

The selected remedy includes the dredging of approximately 2.65 million cubic yards of PCB-contaminated sediments from the Upper Hudson River, which is estimated to contain 70,000 kg (about 150,000 lbs) of total PCBs (approximately 65% of the total PCB mass present within the Upper Hudson River). The selected remedy assumes a separate source control action near the GE Hudson Falls plant. The major components of the selected remedy include:

- Removal of sediments based primarily on a mass per unit area (MPA) of 3 g/m^2 Tri+ PCBs 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 are included in this ROD consistent with state and federal law;
- Other performance standards (including but not necessarily limited to resuspension rates during dredging, production rates during dredging, and residuals after dredging) will be developed during the 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 EPA gathers, as well as the Agency's ongoing evaluation of the work with respect to the 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;
- 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;
- Monitored Natural Attenuation (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.

The targeting of *Hot Spots* 36, 37 and the southern portion of 39, is based on currently available data showing that those areas have high PCB concentrations, and potential for loss to the water column or uptake by biota. Additional sampling will be conducted during remedial design to determine whether other areas in River Section 3 have these characteristics and therefore need to be remediated as part of the selected remedy.

Remedial dredging will be conducted in two phases. The first phase will be the first construction season of remedial dredging. The dredging during that year will be implemented initially at less than full scale operation. It will include an extensive monitoring program of all operations. An independent external peer review of the dredging resuspension, PCB residuals, and production rate performance standards will be conducted during design. Monitoring data will be compared to performance standards identified in this ROD or developed during the remedial design with input from the public and in consultation with the State and federal natural resource trustees. The second phase will be the remainder of the dredging operation, which will be conducted at full-scale. During the full-scale remedial dredging, EPA will continue to monitor, evaluate performance data and make necessary adjustments.

EPA has identified performance standards that address air and noise emissions from the dredging operations and the sediment processing/transfer facilities. Performance standards for other issues will be developed during the first part of the design phase, as described below.

As to air emissions, operations and facilities will comply with the ARARs listed in Table 14-3 which deal with such emissions (*e.g.*, the National Primary and Secondary Ambient Air Quality Standards).

Regarding noise emissions, operations at the sediment processing/transfer facilities will comply with the relevant noise abatement criteria (NAC) of the Federal Highway Administration set forth at 23 CFR Part 772 (see Table 312685-1 of the Responsiveness Summary). Although it is EPA's expectation that the facilities will be located in an industrial or commercial area, the determination of which NAC will apply will depend on where the sediment processing/transfer facilities are sited. The dredging will comply with the New York State Department of Transportation construction noise impact guideline for temporary construction noise, which defines "impact" as occurring at levels exceeding $L_{eq}(1) = 80$ dBA.

The performance standards referred to above regarding noise are being adopted preliminarily. During the remedial design phase, EPA will invite public input regarding these standards before finalizing the noise standards. Once implementation of the dredging begins, if the air or noise performance standards are exceeded, EPA will implement engineering controls or other mitigation measures, as appropriate, in order to address such exceedances.

In addition, during the remedial design phase, EPA will develop other performance standards with input from the public and in consultation with the State and federal natural resource trustees. These standards will address (but may not be limited to) dredging resuspension, production rates, PCB residuals after dredging (or dredging with backfill, as appropriate), PCB air emissions, and community impacts (*e.g.*, odor). The dredging equipment and methods of operation will be selected based on their expected ability to meet the performance standards.

The information and experience gained during the first phase of dredging will be used to evaluate and determine compliance with the performance standards. Further, the data gathered will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging or if performance standards need to be reevaluated. EPA will make the data, as well as its final report evaluating the work with respect to the performance standards, available to the public.

As noted previously, a separate source control action near the GE Hudson Falls plant is to be implemented by GE, under an administrative order issued by NYSDEC, in order to address the continuing discharge of PCBs from that facility. In the event that source control at Hudson Falls is not successfully implemented pursuant to New York State law, EPA has authorized the performance of an Engineering Evaluation/Cost Analysis to evaluate options for a Non-Time Critical Removal Action at Hudson Falls pursuant to CERCLA in order to ensure that the PCB load to the river near the GE Hudson Falls plant is significantly reduced. Regarding the former outfall to the Hudson River (Outfall 004) from GE's Fort Edward plant site, NYSDEC issued a Record of Decision in January 2000 which calls for the excavation of PCB-contaminated soil and sediment in this area of the Upper Hudson River shoreline in order to eliminate this source of PCBs to the river. EPA's analyses assume significant reductions in loading to the river from these sources once the State's plans for remediation are implemented.

EPA considered the recommendations of the National Research Council (NRC) report (*A Risk-Management Strategy for PCB-Contaminated Sediments*, March 2001) in the finalization of the selected remedy for the Hudson River PCBs Site. EPA agrees with the NRC recommendation that there should be no presumption of a preferred or default risk-management option that is applicable to all PCB-contaminated sediment sites. This selected remedy includes a combination of remedial activities that are tailored to the conditions at the Site, including removal of contaminated sediment using environmental dredging techniques, institutional controls, and MNA of PCB contamination in the river until acceptable PCB concentrations in fish are attained.

Statistory Determinations

The selected remedy meets the requirements for remedial actions set forth in Section 121 of CERCLA, 42 U.S.C. § 9621. It is protective of human health and the environment, complies with Federal and State applicable or relevant and appropriate requirements (ARARs) (unless a statutory waiver is justified), is cost effective, and utilizes permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable.

The selected remedy will comply with the location-specific and action-specific ARARs identified, as well as four of the seven chemical-specific ARARs. However, EPA is waiving the remaining three chemical-specific ARARs – the 1 ng/L total PCB federal Ambient Water Quality Criterion; the 0.12 ng/L total PCB New York State standard for protection of wildlife, and the 0.001 ng/L total PCB New York State standard for protection of human consumers of fish – due to technical impracticability. These three standards are not expected to be met because of PCB contamination entering the Upper Hudson River from above Rogers Island (even after source control at Hudson Falls and Fort Edward).

While the remedy will result in a long-term reduction in the mobility and volume of PCBs in the river, it does not satisfy the statutory preference for treatment as a principal element of the remedy. EPA has determined that given the volume of material to be removed, treatment of the material prior to off-site disposal (other than the stabilization of the sediments for handling purposes) would not be cost-effective. During the remedial design or implementation, EPA will determine whether beneficial use (*i.e.*, the manufacture of commercial products) is appropriate for some portion of the dredged material.

Because the remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, the five-year review requirement applies to this action. EPA will monitor PCB concentrations in the water and fish after completion of the remedy and make these data available to the public.

Public Participation

EPA has provided numerous opportunities for public participation and comment in the process leading up to this ROD. This included a 127 day public comment period and 11 public meetings on the Proposed Plan. EPA has received more than 70,000 comments, which have been considered in reaching this decision. Following issuance of this ROD, EPA will continue its community involvement program and will provide members of the public and elected officials opportunity for early and meaningful input during the remedial design and implementation of the cleanup. The post-ROD community interaction program will build on the existing, extensive public process used for the Reassessment RI/FS. EPA will hold a series of public meetings to discuss and take comment on a proposed post-ROD outreach program before it is finalized. This enhanced community involvement program will include opportunities for public comment on, for example, the proposed location(s) and design of sediment processing/transfer facilities;

work hours; noise control and traffic control; other ways to minimize or mitigate possible adverse local impacts (if any); the development of dredging performance standards; and data gathered during the first year of dredging with respect to performance standards. The program will remain active throughout the subsequent construction and post-construction monitoring phases of the project.

ROD Data Certification Checklist

The following information is included in the Decision Summary section of this ROD. Additional information can be found in the Administrative Record for this Site.

- Remediation Goals for PCB concentrations in fish (Section 9.1)
- Surface water and land use assumptions used in the baseline risk assessments and ROD (Sections 7 and 8.1)
- Risks due to PCBs under baseline conditions (Section 8)
- Risks due to PCBs under the various remedial alternatives (Section 11)
- Long- and short-term effects associated with the various remedial alternatives (Sections 11.3 and 11.5)
- Estimated capital, operation and maintenance and total present-worth costs; and the time to implement each of the various remedial alternatives (Sections 10.1, 11.7 and 13.2)
- Findings of the Reassessment reports which support the selected remedy (Sections 6, 8 and 13.4)
- How the selected remedy addresses sediments that constitute principal threats (Section 12)
- Key factors that led to selecting the remedy (*i.e.*, best balance of trade-offs with respect to the balancing and modifying criteria) (Sections 11, 13.4 and 14)

-------------------------	**Recommending Signature**	**-----------------------------------**
Date		**Jane M. Kenny** **Regional Administrator**
--------------------------	**Authorizing Signature**	**------------------------------------**
Date		**Christine Todd Whitman** **Administrator**

PART 2: THE DECISION SUMMARY

1. SITE NAME, LOCATION AND BRIEF DESCRIPTION

1.1 Site Name and Location

The Hudson River PCBs Site (the "Site") includes a nearly 200 river-mile stretch of the Hudson River in eastern New York State. This federal Superfund Record of Decision (ROD) addresses the risks to people and ecological receptors associated with polychlorinated biphenyls (PCBs) in the in-place sediments of the Upper Hudson River. The United States Environmental Protection Agency (EPA) identification number for the Site is NYD980763841.

The Site encompasses approximately the lower two thirds of the generally southerly flowing Hudson River, from the Village of Hudson Falls (Washington County) in the north to the Battery in New York City (New York County) in the south (Figure 1-1). The Site has traditionally been divided into Upper Hudson River and Lower Hudson River segments based on physical and chemical characteristics such as river hydrology and PCB inventory. Reference is also made to a Mid-Hudson River segment (Troy to just south of Poughkeepsie) in a number of Site reports (and this decision document) to promote a more concise discussion of Site risks and modeling efforts.

The Site also includes five Remnant Deposits, which are areas of PCB-contaminated sediment upstream of the location of the former Fort Edward Dam that became exposed after the water level dropped following removal of the dam in 1973.

The Upper Hudson River portion of the Site extends from the Fenimore Bridge in Hudson Falls (River Mile [RM] 197.3) to the Federal Dam at Troy (RM 153.9), a distance of just over 43 river miles. The Lower Hudson River extends from the Federal Dam to the southern tip of Manhattan at the Battery in New York City (RM 153.9 to RM 0). The Mid-Hudson River, which is primarily a subset of the Lower Hudson River, extends from the Federal Dam at Troy (RM 153.9) to just south of Poughkeepsie (River Mile 63).

To facilitate effective project management and address Site complexities, the Upper Hudson River has been further divided into three major sections: River Sections 1, 2 and 3 (see Figure 1-2). Upstream of River Section 1 is a river segment between the Fenimore Bridge and the former Fort Edward Dam (RM 194.8), a distance of about 2.5 river miles. The Upper Hudson River includes certain areas that have been and may continue to be sources of PCB contamination to the river, including General Electric Company's (GE's) Hudson Falls plant and Fort Edward plant, and Remnant Deposits 1-5. These source areas have been, are being, and/or are planned to be addressed by response actions selected by EPA or the New York State Department of Environmental Conservation (NYSDEC). Remedial actions for these areas are not the focus of this decision document although, as discussed later in this Decision Summary, successful completion of the expected source control work near the GE Hudson Falls plant (*i.e.*, reduction of PCB loading to the river) is important to the full realization of the benefits of the remedial action called for in this ROD.

River Sections 1, 2 and 3 extend from the location of the former Fort Edward Dam to the Federal Dam at Troy and are the focus of this decision document. River Section 1 consists of the Thompson Island (TI) Pool. This river section extends about 6.3 miles from the former Fort Edward Dam (RM 194.8) to the TI Dam at RM 188.5. The area between the former Fort Edward Dam and the northern end of Rogers Island, a distance of about 0.2 miles, contains minimal PCB contamination and was not considered for remediation under this decision document. River Section 2 extends from the TI Dam to the Northumberland Dam near Schuylerville (RM 183.4), an extent of 5.1 river miles. River Section 3 extends from below the Northumberland Dam to the Federal Dam at Troy (RM 153.9), an extent of 29.5 river miles.

This ROD addresses active remediation of the in-place sediments in the Upper Hudson River. The Lower Hudson River is not being identified for active remediation in this ROD. Nevertheless, the reduced PCB load over the Federal Dam projected by the selected remedy will ultimately result in reduced concentrations of PCBs in fish, sediment and water. This in turn will result in reduced risks to humans and ecological receptors living in and near the Lower Hudson River from PCB contamination originating in the Upper Hudson River.

Within River Sections 1, 2 and 3 of the Upper Hudson River, Site delineation activities have been undertaken. Field investigatory activities by NYSDEC have identified depositional *hot spot* areas (where average total PCB concentrations in sediment of 50 parts per million or greater are known to exist) and other areas with fine-grained sediment, which characteristically has higher PCB concentrations. In addition, modeling has been utilized to provide an integrated picture of sediment concentrations throughout the three river sections.

Floodplain soils have been documented to contain PCBs. However, the purpose of the Reassessment RI/FS was to determine the appropriate course of action for the contaminated sediment in the Upper Hudson River. An investigation of the floodplains and other areas external to the river (*i.e.*, historical dredge spoil disposal areas along the Upper Hudson River) was not included in the scope of the Reassessment RI/FS and is not addressed in this ROD. In the Upper Hudson River area, limited data also show low PCB uptake in forage crops, non-detect PCB levels in cow milk, and minimal risks via ingestion of foods other than Hudson River fish. Concerns related to possible exposure of residents and ecological receptors to PCB contamination in the floodplains will be further evaluated concurrent with the design phase of this project in coordination with New York State.

1.2 Brief Description

The predominant sources of PCB contamination to the Upper Hudson River were two capacitor manufacturing plants owned and operated by GE. The plants are located adjacent to or near the Hudson River in the Village of Hudson Falls and the Town of Fort Edward. Over a 30-

year period, the plants discharged (including direct pipeline discharge) a substantial amount of PCBs into the river. At the GE Hudson Falls plant, leakage of non-aqueous phase PCB-bearing oils through bedrock to the river continues to be a source of PCB contamination. Regarding the former outfall to the Hudson River (Outfall 004) from the GE Fort Edward plant, NYSDEC issued a Record of Decision in January 2000 that calls for the excavation of PCB-contaminated soil and sediment in this area of the Upper Hudson River shoreline in order to eliminate this source of PCBs to the river. EPA's analysis assumes a significantly reduced PCB loading to the river from these sources once the State's plans for remediation are implemented.

PCBs, the chemicals of concern addressed in this decision document, have been classified by EPA as probable human carcinogens. They are also linked to other serious non-cancer adverse health effects based on observations in animals and emerging evidence in humans.

Once discharged from the GE plants, the PCBs adhered to river sediment and accumulated downstream as they settled in impounded pools and other depositional areas. Historic fish and sediment data indicated PCBs were accumulating downstream of the old Fort Edward Dam as well as accumulating behind the dam. The removal of the dam in 1973 resulted in a remobilization and downstream distribution of PCBs that had accumulated behind the dam. Historically, the highest PCB sediment concentrations have been detected in the cohesive sediments (fine grained sands, silts and clays) within the Upper Hudson River. River scouring/erosion and other mechanisms have mobilized PCB-contaminated sediments from the extensive cohesive deposits, redepositing them farther downstream all the way to the Battery (*i.e.*, New York Harbor). The preponderance of data indicate that burial of contaminated sediment by cleaner materials is not universally or uniformly occurring. Data also indicate that contaminated sediments in River Sections 1, 2 and 3 continue to serve as the major source of PCBs to the water column and the fish within the Upper Hudson River.

1.3 Lead Agency/Funding Information

The United States Environmental Protection Agency is the lead agency for this project. The State of New York, by the Department of Environmental Conservation, which is the support agency for this project, concurs with EPA's decision for this project. The United States Department of Interior (Fish and Wildlife Service) and the United States Department of Commerce (National Oceanic and Atmospheric Administration), which are federal trustees of natural resources, and the New York State Attorney General also support an active environmental dredging remedy.

The remedial action selected by this document is expected to be funded by GE, or by EPA (using Superfund monies) and the State of New York.

2. SITE HISTORY AND ENFORCEMENT ACTIVITIES

2.1 Site History

During an approximate 30-year period ending in 1977, GE used PCBs in its capacitor manufacturing operations at its Hudson Falls and Fort Edward, New York facilities. PCB oils were discharged both directly and indirectly from these plants into the Hudson River. This included both non-permitted and permitted discharges. Even after GE received a permit in 1975, permit exceedances occurred. Estimates of the total quantity of PCBs discharged directly from the two plants into the river from the 1940s to 1977 are as high as 1,330,000 pounds (about 605,000 kg).

Many of the PCBs discharged to the river adhered to sediments and accumulated with the sediments as they settled in the impounded pool behind the Fort Edward Dam, as well as other depositional areas farther downstream. Because of its deteriorating condition, the Fort Edward Dam was removed in 1973. Five areas of PCB-contaminated sediments were exposed due to the lowering of the river water level when the Fort Edward Dam was removed. These five areas are known as the Remnant Deposits. During subsequent floods, PCB-contaminated sediments from the Fort Edward Dam area were scoured and transported downstream.

2.2 Actions to Date

The sediments of the Upper Hudson River were surveyed by NYSDEC in 1976-1978 and 1984. Areas with average total PCB 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-defined *hot spots*, located between 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.

Legal action brought against GE by NYSDEC in 1975 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 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 risks from consuming PCB-contaminated fish. A ban on most commercial fishing, including commercial fishing of striped bass, was issued for the Lower Hudson River. NYSDEC replaced the ban against fishing in the Upper Hudson River with catch-and-release fishing restrictions in 1995. NYSDOH continues to recommend that people eat none of the fish from the Upper Hudson River, that children under the age of 15 and women of child-bearing age eat none of the fish from the river for the entire 200 mile length of the Superfund site, and that the general population eat none of most species of fish caught between the Federal Dam at Troy and Catskill. The commercial striped bass fishery, as well as commercial fishing for eight other species in the Lower Hudson River, is still closed. The striped bass fishery has been closed for approximately 25 years.

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 Rogers Island. Another approximately 380,000 cubic yards of sediment were dredged from the east and west channels 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 1977, the manufacture and sale of PCBs within the United States were generally prohibited under provisions of the Toxic Substances Control Act (TSCA). Although commercial uses of PCBs ceased in 1977, GE's Fort Edward and Hudson Falls plants continue to contaminate the Hudson River with PCBs, due primarily to releases of PCBs via bedrock fractures from the GE Hudson Falls plant.

About 14,000 cubic yards of highly-contaminated sediments were removed by NYSDEC from Remnant Deposit 3A in 1978 and were placed in a secure encapsulation site in Moreau, along with some 215,000 cubic yards of sediment that had been dredged by NYSDOT from the east channel of Rogers Island to clear the navigation channel just below the location of the former Fort Edward Dam. Unstable river banks of 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.

No navigational dredging has occurred in the Upper Hudson River since 1979, except for removal of coarse sediments that periodically accumulate at the mouth of the Hoosic River, a tributary that empties into the Hudson River at RM 167.5 near Schaghticoke. In addition, GE conducted remedial dredging in the area upstream of the Baker's Falls dam, adjacent to the GE Hudson Falls plant in 1997 and 1998.

The Site was proposed for inclusion on the National Priorities List (NPL) in September 1983 and formally listed in September 1984.

In 1984, EPA completed a Feasibility Study (FS) and issued a ROD for the Site. EPA recognized that PCB contamination in the Upper Hudson River sediments was a problem, but selected an interim No Action remedy for the contaminated sediments because, in the Agency's view, the reliability and effectiveness of remedial technologies available at that time were uncertain and there were downward trends of PCBs in fish, sediment, and water at the time. (More recent data show that this downward trend has not continued.) The 1984 ROD did not address the PCB-contaminated oil leaking through bedrock in the vicinity of the GE Hudson Falls plant, which was not known to EPA at the time. The 1984 ROD contained the following components:

- An interim No Action decision with regard to PCBs in the sediments of the Upper Hudson River;

- In-place capping, containment and monitoring of exposed Remnant Deposits (in the area of RM 195 to 196) from the former impoundment behind the Fort Edward Dam, stabilization of the associated river banks and revegetation of the areas; and

- A detailed evaluation of the Waterford Water Works treatment facilities, including sampling and analysis of treatment operations to see if an upgrade or alterations of the facilities were needed.

GE, under a 1990 Consent Decree with EPA, conducted the in-place capping of Remnant Deposits 2 through 5, that are located along the river banks from RM195 to RM 196. The in-place capping of these Remnant Deposits included grading, placement of a two-foot layer of soil and a manufactured geosynthetic clay liner, followed by revegetation to minimize erosion. This prevented direct contact with and potential volatilization of PCBs. The river banks were stabilized with rock to prevent scouring. Cap construction and the erection of gates to limit access were completed in 1991. Remnant Deposit 1 was not remediated, as discussed in Section 6.2.2.2.

NYSDEC, with funding provided by EPA, conducted a 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.

In December 1989, EPA announced its decision to initiate a detailed Reassessment RI/FS of the interim No Action decision for the Upper Hudson River sediments. This was prompted by the five-year review required by CERCLA, technical advances in sediment dredging and treatment/destruction technologies, as well as a request by NYSDEC for a re-examination of the 1984 decision. The Reassessment RI/FS was divided into three phases. Phase 1, consisting primarily of a review of existing data, 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 with release of the FS Scope of Work. The FS was released concurrently with the Proposed Plan in December 2000.

As EPA was beginning Phase 2 of the Reassessment RI/FS in September 1991, GE detected an increase in PCB concentrations at the Upper Hudson River water sampling stations being monitored as part of the construction monitoring program associated with the Remnant Deposits capping. GE ultimately attributed the higher levels to the collapse of a wooden gate structure within the abandoned Allen Mill located adjacent to the river bank near the GE Hudson Falls plant. As reported by GE, the gate structure had diverted water from a tunnel that had been cut into bedrock, thereby preventing oil-phase PCBs originating at the GE Hudson Falls plant, that had migrated to the tunnel via subsurface bedrock fractures, from flowing into the river. From 1993 to 1995, GE removed approximately 45 tons of PCBs from the tunnel under NYSDEC jurisdiction. In 1994, GE documented the presence of PCB-contaminated oils in bedrock seeps at Bakers Falls adjacent to its Hudson Falls plant. GE has instituted a number of mitigation efforts that have resulted in a decline, but not cessation, of PCBs entering the river through the seeps.

In 1998, EPA conducted an evaluation of whether an early response action to address contaminated sediments in the Thompson Island Pool would be warranted prior to completion of the Reassessment RI/FS. This evaluation was prompted by findings of the Low Resolution Sediment Coring Report, in which EPA determined that there were statistically significant losses of PCBs from the sediment to the water column. EPA decided in December 1998 that no feasible and appropriate interim action was available, and EPA would complete the Reassessment RI/FS as planned.

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 soils were 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 were excavated from nine Rogers Island properties and disposed of off-site (3,530 tons of PCB-contaminated soil were removed during this action). Backfilling with clean materials and the installation of erosion controls followed the excavation activities.

The GE Fort Edward plant Outfall 004 has also been a source of PCBs to the river. In January 2000, NYSDEC signed a Record of Decision that called for removal of PCB-contaminated soils and sediments near Outfall 004. NYSDEC is currently undertaking the Remedial Design of that remedy.

2.3 Enforcement Activities

EPA notified GE of the remedy selected in the 1984 ROD and offered the company the opportunity to implement the selected remedy with respect to the Remnant Deposits and the Waterford drinking water supply evaluation. GE declined EPA's offer. NYSDEC, with funding provided by EPA, conducted the evaluation at the Waterford Water Works. In addition, NYSDEC prepared a design for the in-place containment of the Remnant Deposits. This design was completed in 1988.

In March 1989, GE offered to assume responsibility for the implementation of the in-place containment remedy for the Remnant Deposits. EPA issued a September 27, 1989 Administrative Order on Consent to GE which required the company to prepare a remedial design report for the construction of access roads to the Remnant Deposits and to submit a design for the in-place containment of the Remnant Deposits incorporating the NYSDEC-prepared design, plus any EPA-approved refinements to that design. EPA also issued a September 27, 1989 Administrative Order to GE requiring the company to construct and maintain the access roads to the Remnant Deposits. GE constructed the in-place containment of the Remnant Deposits under a 1990 Consent Decree with EPA. EPA will evaluate the need for further remedial action for the Remnant Deposits after completion of a 5-year review of the Remnant Deposit containment remedy, performed pursuant to CERCLA §121(c). See further discussion of the Remnant Deposits in Section 6.2.2.2 below.

The GE manufacturing plants in Hudson Falls and Fort Edward are listed under the New York State Inactive Hazardous Waste Disposal Sites Remedial program. GE currently is conducting remedial activities near the GE Hudson Falls and Fort Edward plants pursuant to Orders on Consent with NYSDEC. GE has thus far declined to implement the January 2000 NYSDEC Record of Decision for the Fort Edward plant Outfall 004. The NYSDEC is conducting the remedial design for that ROD.

3. COMMUNITY/PUBLIC PARTICIPATION

3.1 Public Participation

Community/public participation activities to support selection of the remedy were conducted in accordance with CERCLA § 117 and the NCP Section 300.430(f)(3). The Hudson River PCBs Reassessment RI/FS was unique from a community/public participation standpoint. The Site, whose boundaries encompass rural, suburban and metropolitan areas in 14 different counties in the State of New York, as well as portions of New Jersey, draws a large and diverse population for recreational, commercial, industrial, and cultural reasons. The Site generated enormous public interest based on this diversity, the Site history and its geographic extent.

To provide the maximum opportunity for all interested parties to participate in the project, EPA employed both customary and expanded approaches. First, EPA provided for extensive community/public participation and kept citizens, government officials, environmental groups, and private interest groups aware of and updated on each step of the Reassessment RI/FS process through personal communications, the distribution of fact sheets and press releases, and numerous public meetings. Also, a Technical Assistance Grant, which provides funding for activities to help the community located along the Hudson River understand the technical details of the Reassessment RI/FS and participate in the decision-making process, was issued to the environmental group, Scenic Hudson, Inc. In addition, EPA established a Community Interaction Program (CIP), a description of which follows.

EPA established and maintained 16 Information Repositories, located in public buildings from Glens Falls to New York City, and placed copies of the Reassessment RI/FS reports into these repositories. Many of the reports are also available on the internet at EPA's website for the Site (www.epa.gov/hudson). EPA held more than 75 public meetings during the course of the

Reassessment RI/FS. EPA also responded to public comment on the Reassessment RI/FS reports and has placed these Responsiveness Summaries in the Information Repositories. In addition, peer reviews were held in which panels of independent experts reviewed and commented on EPA's Reassessment RI/FS reports. The public was invited to attend the peer review meetings and to provide comment. Responses to peer review comments were also developed. In addition, the Administrative Record file, including the Reassessment RI/FS reports, the Responsiveness Summaries, the Feasibility Study and the Proposed Plan, was made available to the public. These documents were made available at the Crandall Public Library in Glens Falls, the Adriance Memorial Library in Poughkeepsie and the EPA Superfund Records Center in New York City.

The Proposed Plan was released for public comment on December 12, 2000. Due to several requests by the public, the comment period, originally intended to conclude on February 16, 2001, was extended to April 17, 2001. During the comment period, a total of 11 public meetings were held to provide the public with information on the preferred remedy and receive public comments. There were approximately 5,000 people who attended the public meetings. Meetings were held in Saratoga Springs (December 2000), Poughkeepsie (December 2000, January 2001), New York City (January 2001), Albany (February 2001), Hudson Falls (February 2001), Haverstraw (February 2001), Newburgh (April 2001), Troy (April 2001), Queensbury (April 2001), and Saddle Brook, New Jersey (March 2001). EPA also held a number of meetings with public officials concerning the Proposed Plan.

3.2 Community Interaction Program

The CIP, entirely unique to the Reassessment RI/FS, is based on the community relations plan, and consisted of a three-tiered committee structure starting with four community-level liaison groups (Agricultural, Citizen, Environmental and Governmental). The CIP began in early 1991. This program provided expanded and systematic opportunities for all interested parties to participate in the project. The Steering Committee, the Hudson River PCB Oversight Committee (HROC), and the Scientific & Technical Committee (STC) also were established. All Reassessment RI/FS reports were sent to these groups for review and were made available to other members of the public interested in the Site. Comments received during the meetings and from written submissions were considered in the deliberative process that led to the Proposed Plan.

The Steering Committee, HROC and STC included representatives from the Liaison Groups, NYSDEC, NYSDOH, EPA (including the Project Managers, Community Relations Coordinator, and Deputy Director of Region 2's Superfund Division), GE, and researchers and scientists familiar with the Site, PCBs, modeling, toxicology and other relevant disciplines. EPA considers the STC to constitute peer input but not peer review. (See Section 5.0 below for a discussion of peer review conducted for the Site). More detailed information on the CIP can be found in the Community Relations Plan for the Hudson River PCBs Reassessment RI/FS. EPA's implementation of the CIP is consistent with the NRC recommendation that all affected parties and communities should be involved early and actively in the process.

As is discussed in Section 13.3, during design and implementation of the remedy EPA will limit, to the maximum extent practicable, adverse impacts to local communities. Through the community interaction program, EPA will further discuss with the public and State and local governmental bodies the potential for adverse impacts; where negative impacts might occur, EPA will seek to mitigate them during design and remedial implementation.

4. SCOPE AND ROLE OF RESPONSE ACTION

The primary objective of this response action is to address the risks to human health and the environment due to PCBs in the in-place sediments of the Upper Hudson River. PCB concentrations remain elevated in the Hudson River in the sediments, in the water column and in the fish. PCB concentrations (averages) associated with the Site in all three media generally decrease with distance down river. Removal of the PCB-contaminated sediments will result in reduced PCB concentrations in fish tissue, thereby accelerating the reduction in potential future human health and ecological risks. In addition, by addressing the sediments, the remediation will control a source of PCBs to the water column, which contributes to fish tissue concentrations and transports PCBs downstream.

The Reassessment RI/FS focused primarily on the approximately 40 river miles from the northern end of Rogers Island to the Federal Dam at Troy. While the Superfund Site covers both the Upper and the Lower Hudson River, the Reassessment FS evaluates options to address the PCB-contaminated sediments of the Upper Hudson River only, as this portion contains all of the historical PCB *hot spots*. The Upper Hudson River was also the focus of the 1984 ROD.

The selected remedy recognizes that source control measures are already in place near the GE Hudson Falls plant and assumes reasonable further reductions in PCBs entering the river through bedrock at Bakers Falls near the GE Hudson Falls plant, as a result of the implementation of additional source control measures by GE under NYSDEC authorities. Successful completion of the source control near the GE Hudson Falls plant is important to the full realization of the benefits from the remedial action called for in this ROD. In addition, NYSDEC issued a Record of Decision in January 2000, which calls for source control measures for the Fort Edward plant Outfall 004 in order to eliminate this source of PCBs to the river.

5. PEER REVIEW

To ensure the credibility of the scientific work conducted during the Reassessment RI, EPA utilized both forms of peer involvement: peer input and peer review. Peer input was conducted through internal Agency reviews, reviews by other agencies, and STC reviews of Reassessment RI reports. Peer review was conducted in accordance with EPA guidance, as outlined in the *Peer Review Handbook* (dated December 1998, updated December 2000). The peer review was conducted by independent experts who were unaffiliated with EPA, NYSDEC or GE, and was undertaken on the major scientific works that form the basis for this decision.

Five separate peer review panels were convened. The review process consisted of individual review by each of the six or seven panel members, followed by a panel discussion which was open to the public. Public comments were accepted during this process. The Reassessment RI reports reviewed were the October 1996 Preliminary Model Calibration Report, the geochemistry reports (the February 1997 Data Evaluation and Interpretation Report and the July 1998 Low Resolution Sediment Coring Report), the August 1999 Human Health Risk Assessment, the August 1999 Ecological Risk Assessment and the January 2000 Revised Baseline Modeling Report. Each peer review panel was asked to address specific questions, together called the "charge," regarding the report being reviewed and controversial issues that were identified by EPA and the public prior to and during the peer review meeting. In addition, the panels were invited to address any other issues that were not specifically identified in the charge. The public was invited to submit proposed charge questions and to attend and make comments at each of the five peer review meetings.

The peer reviewers generally agreed with the findings and conclusions of the reports, although they also requested revisions (including extensive revisions to the Ecological Risk Assessment). EPA issued Responses to Peer Review Comments for each of the peer reviews.

The following summarizes some of the major findings of each of the panels:

- Modeling Approach - The reviewers recommended changes to the sediment transport algorithms and the use of a mechanistic bioaccumulation model.

- Geochemistry reports - The reviewers agreed that the river is a dynamic system and that sequestration of PCBs through burial is not widespread. They agreed that there was a loss of PCB inventory from the sediments of the Thompson Island Pool, although they believed that it was important to express the percentage of loss as a range rather than as a single number so that the uncertainty in the estimate was more apparent. They recommended that multivariate statistical analyses be conducted.

- Revised Baseline Modeling Report - The reviewers agreed that the model calibration fit the data, but that the uncertainties in the model forecasts should be acknowledged.

- Human Health Risk Assessment - The reviewers agreed that there is an unacceptable human health risk in the Upper Hudson River from consumption of fish. They recommended that EPA address fetal and infant exposure and provide further discussion on uncertainties. EPA issued a Revised Human Health Risk Assessment, which incorporates all changes made to address the peer review comments.

- Ecological Risk Assessment - The reviewers heavily criticized the report, especially with respect to the lack of site-specific field studies. EPA issued a Revised Ecological Risk Assessment, which incorporates all changes made to address the peer review comments. (Subsequent to the issuance of the Revised Ecological Risk Assessment, NYSDEC released data from recent collections of Upper Hudson River mink and otter that were found to have PCB body burdens at levels where harmful effects would be expected, which is consistent with the conclusions of the Revised Ecological Risk Assessment.)

In the FS, EPA considered the results of the peer review in evaluating remedial alternatives. EPA utilized peer involvement on the evaluation of alternatives and the identification of the preferred alternative through review by the Agency's National Remedy Review Board (NRRB). The NRRB's recommendations and EPA Region 2's responses are set forth in Agency memoranda that were issued in December 2000 and January 2001, respectively.

EPA will establish an additional independent external peer review panel of scientific experts to review the dredging resuspension, PCB residuals and production rate performance standards and the attendant monitoring program, as well as the report prepared after the first phase of dredging that will evaluate the dredging with respect to these performance standards.

6. SITE CHARACTERISTICS

6.1 Conceptual Site Model

The conceptual site model for the Hudson River PCBs Site describes the source to receptor succession in simple terms and identifies the major contamination sources, contaminant release mechanisms, secondary sources, and pathways and receptors of concern (see Figure 6-1). The design of field investigations and human and ecological risk assessments reflect the basic components of the conceptual site model.

In the conceptual site model, PCBs are released from two GE capacitor plants located adjacent to the Upper Hudson River in the towns of Hudson Falls and Fort Edward. The major release mechanism is the direct discharge of PCB oils into the river. Five Remnant Deposits (sediments) also exist, along with other lesser sources of PCBs up-river and down river that contribute to the overall PCB load in the Hudson River.

Once introduced into the river, the PCBs adhere 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 be a source of PCB contamination to the water column. The sediments will continue to release contamination to the water column and biota, through aquatic and benthic food chains, as well as other not easily modeled processes such as boat scour, ice rafting, and bioturbation, unless they are managed or remediated in some manner.

Because the river is a dynamic system with variable energy regimes, the PCB-laden sediments are not sequestered or stable. Some PCB-contaminated sediment is buried by deposition of cleaner sediments at times, but in other places and at other times the sediments are redistributed. This redistribution may be local or more regional depending on the energy of flow events and/or physical type or size of the sediment particles. The redistributed sediments release contamination to the water column and high flow events (*e.g.*, floods) further increase the bioavailability of contaminants to organisms in the water column. Scouring during high flow events is also considered an important release mechanism.

The conceptual site model shows that the fish ingestion pathway is a completed exposure route for the Site. Receptors include humans (anglers and their families), piscivorous (fish eating) fish, piscivorous birds (including threatened and endangered species) and mammals. Additional information on the human and ecological receptor populations is provided in the risk section (Section 8) of this document.

6.2 Results of the Reassessment Remedial Investigation

This section presents a summary of the Reassessment RI. Detailed discussions of the RI findings are found in the December 2000 Reassessment FS and associated documents.

6.2.1 Site Overview

The Hudson is a large river with both fresh and estuarine waters that has been contaminated with PCBs for more than 50 years. The Upper Hudson River portion considered for sediment remediation includes variations in hydrology and river bed geology, which create a complex environmental setting with varying levels of PCB contamination.

6.2.1.1 Hydrology

The Upper Hudson River is entirely freshwater and non-tidal. The annual mean flow of the Hudson River at Fort Edward is approximately 4,800 cubic feet per second (cfs). Downstream of Fort Edward, the river is joined by several tributaries, the largest of which are the Batten Kill, Fish Creek, and the Hoosic River. The combined total of the tributaries significantly increases the flow of the Upper Hudson by the time it reaches Waterford, where the mean annual flow of the river is approximately 8,400 cfs. According to the U.S. Geological Survey (USGS), at its confluence with the Mohawk River (RM 156), the river flow reaches an annual average of 12,300 cfs.

The flow in the Upper Hudson River is primarily controlled by several reservoirs above Glens Falls, including the Great Sacandaga Lake. It is expected that minimum average daily flow at Fort Edward will be maintained in the range of 1,500 cfs to 4,000 cfs, depending on conditions at the Great Sacandaga Lake. In addition, there are eight dams with locks in the portion of the Upper Hudson River that was considered in the Reassessment RI/FS. The locks and dams form a series of pools in the river. The flow in the Upper Hudson River is controlled by these dams, and to a lesser degree, by wetlands and backwaters in the vicinity of the river, which act as a buffer for high and low flow conditions.

The mean gradient of the river between Fort Edward and the Federal Dam at Troy is about three feet per mile. The gradient within each pool is much smaller than the mean gradient, with major elevation drops between the pools at the dams. The width of the Upper Hudson above Lock 4 in Stillwater is approximately 400 feet. The Upper Hudson 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 in a section (western branch) below the TI Dam. The total surface area of the Upper Hudson is approximately 3,900 acres.

The Champlain Canal is coincident with portions of the Hudson River, extending from Waterford (RM 158) on the Hudson to Whitehall at the southern end of Lake Champlain. The Champlain Canal is 60 miles long, including 37 miles of channel in and along the Hudson River from Waterford to Fort Edward, and 23 miles of land-cut sections. The canal diverges from the river at Fort Edward just below Lock 7 and proceeds in a northeasterly direction to Lake Champlain. Land cut areas exist at Stillwater, Northumberland, and Fort Miller. The portion of the river from Waterford to the Federal Dam is considered part of the Erie Canal.

6.2.1.2 River Bed Geology

Sediments of the Upper Hudson have been extensively investigated during Phase 2 of the Reassessment RI/FS, including a geophysical investigation consisting of side-scan sonar, bathymetric soundings, and sub-bottom profiling. Plates 6-1 through 6-7 provide sediment texture classification maps for the Upper Hudson (RM 194.8 to 153.9) including areas with cohesive sediments and PCB *hot spot* areas.

Evaluation of sonar images and other data suggest that sediment distribution patterns are locally complex (*i.e.*, nonhomogeneous areas of deposition and scour exist along with variability of sediment grain size).

Bedrock, cut away to form the Champlain Canal, is exposed in some areas, while lacustrine silts and clays of glacial age are exposed in other areas. Coarser-grained sediments are often observed in the channel while finer sediments are more common in shallow water. Wood chips from prior pulp and paper industry dumping upstream of the former Fort Edward Dam are present in surface sediments in many locations. Sediment mounds created by historic disposal of dredged spoils in the river are still found at some locations. PCB *hot spots* previously defined by the NYSDEC are generally coincident with areas of fine-grained sediments, including silts and clays, where suspended matter with a high affinity for PCBs is most likely to settle. Channel maintenance dredging has removed substantial portions of *Hot Spots* 1 through 4, located in the channels around Rogers Island, although deposition of PCBs from upstream since that time has most likely recontaminated some areas.

Sediment texture classifications were also reported in the 1984 NYSDEC sediment survey of the Thompson Island Pool. These classifications, based on an average of grab and core samples, indicated a composition of about 37 percent gravel, 26 percent fine sands, 11 percent fine sand with wood chips, 9.4 percent clay, 5.4 percent coarse sand, and the remainder consisting of other types (including combinations of the listed types, such as “gravel with wood chips” and “fine sand and gravel”).

6.2.1.3 Wetlands and Floodplains

Both federal and State freshwater wetlands exist throughout the Upper Hudson region. Wetlands along the Upper Hudson River are identified on U.S. Fish and Wildlife Services National Wetland Inventory maps and NYSDEC wetland maps. The 100-year floodplains of the Upper Hudson and tributaries are shown on Flood Insurance Rate Maps prepared by the Federal Emergency Management Agency (FEMA). The width of the 100-year floodplain extends up to 5,000 feet in the vicinity of the Upper Hudson River. Areas adjacent to the Upper Hudson River include forested shoreline wetlands, transitional uplands, and vegetated backwaters such as emergent marsh and scrub-shrub wetlands.

6.2.1.4 Archaeological, Historic, and Cultural Resources

The Upper Hudson River has been an important source of energy, natural resources, and transportation to the region from prehistoric time to the present. During the thousands of years following the final northerly retreat of the Wisconsin Glacier approximately 14,000 years ago, the river and its drainages gradually transformed the landscape, providing a rich habitat and supporting a substantial prehistoric population.

The Hudson Valley has figured prominently in the historical and cultural development of the United States. The valley was home to Native Americans from the mid-1400s to approximately 1600. Following Henry Hudson’s exploration up the Hudson River in 1609, looking for a quick passage to China for the Dutch East India Company, the area was heavily settled by the Dutch. From the 17th through 19th centuries, this region was gradually settled by European immigrants who cleared more of the land, established towns, and built a variety of industries along the river. Efforts to maximize the industrial use of the river led to the construction of locks, dams, gates, channels, and related structures.

During the French and Indian War and the American Revolution, the Hudson River often proved to be of vital logistical importance and was the site of numerous military engagements. The Revolutionary War Battle of Saratoga fought along the Hudson River in 1777 was won by the Americans and led to the French alliance and eventual victory and independence. The foundry at West Point supplied cannons and munitions to the Union forces during the Civil War.

The 60-mile (96.5-km) Champlain Canal was completed in 1825. This canal linked the Upper Hudson River at Troy, New York with the southern end of Lake Champlain at Whitehall, New York. During the heyday of the Champlain Canal, between 1825 and the early 20th century, thousands of canal boats passed between Lake Champlain and the Hudson River, transporting raw materials and finished products.

In 1998, the Hudson River was federally designated an American Heritage River because of its important role in American history and culture. This designation rendered it eligible for technical assistance in achieving natural resource and environmental protection, economic revitalization, and historic and cultural preservation.

EPA has prepared a Phase 1A Cultural Resources Assessment in order to initiate substantive compliance with Section 106 of the National Historic Preservation Act with respect to the selected remedy. EPA's assessment is included as an appendix to the Responsiveness Summary. EPA has identified a number of previously surveyed cultural resources that are either listed on the National Register of Historic Places, or have been determined to be National Register eligible, and that are located within 2,000 feet of the banks of the Upper Hudson River. EPA has also identified cultural resources within this area that have been previously identified but not yet evaluated for their eligibility on the National Register. In addition, there is a potential for additional cultural resources (both historic architectural resources and archaeological sites) to be located either in the immediate vicinity of the remediation areas, or buried within the river sediments. These potential additional resources have not yet been identified, surveyed or evaluated.

6.2.2 Summary of Sampling Results

For the Reassessment RI/FS, EPA used data collected during its own sampling investigations, as well as data collected by many other agencies, institutions, and GE. The investigations include sediment surveys, river flow and water quality investigations, fish and biota sampling, and air monitoring.

6.2.2.1 Nature of Contamination

The contaminants studied in the Reassessment RI/FS are, by definition, polychlorinated biphenyls. PCBs consist of a group of 209 distinct chemical compounds, known as congeners, that contain one to ten chlorine atoms attached to a biphenyl molecule, with the generic formula of $C_{12}H_{(10-x)}Cl_x$, where x is an integer from one to ten. Homologue groups are identified based on the number of chlorine atoms present. For example, monochlorobiphenyls contain one chlorine atom, dichlorobiphenyls contain two chlorine atoms, and trichlorobiphenyls contain three chlorine atoms. Some PCB congeners are structurally and mechanistically similar to dioxin (sometimes called dioxin-like PCBs).

Commercially manufactured PCBs consisted of complex mixtures of congeners, known under various trade names. The PCBs utilized by GE were manufactured by Monsanto Corporation, the company that manufactured 95 percent of the PCBs sold in the US. These PCBs were marketed under the general trade name "Aroclors." About 140 to 150 different congeners have been identified in the various commercial Aroclors, with about 60 to 90 different congeners present in each individual Aroclor.

Detailed information on the analysis of PCBs, measurement of PCBs and chemical, physical, biological and toxicological properties of PCBs may be found in the FS and other Reassessment reports. Aroclor quantitation methods have changed over time. These changes have implications for the interpretation of historical trends in the data and the development of statistical relationships. Further, the 1984 NYSDEC PCB data are reported on a concentration basis as ppm (parts per million or milligram per kilogram [mg/kg] or microgram per gram [μg/g]) in sediment on a dry-weight basis. For mass estimation, these concentrations must be converted by multiplying by the sediment density. Summing mass in the vertical dimension (*i.e.*, at depth) yields mass per unit area (MPA) (See Figure 10-1). Mass units are additive (unlike concentration) and appropriate for spatial statistical analysis, such as kriging or polygonal declustering. MPA units are utilized in the Reassessment RI/FS to develop and screen appropriate technologies and alternatives. MPA was identified as the most useful measure for this task due to the high variability of PCB sediment concentrations.

When PCBs are released into the environment, various processes can alter the pattern of PCBs from the original Aroclors. Analytical techniques vary and have improved over time. Congener-specific analyses were conducted for the Reassessment RI/FS, but most of the older data were reported by groups of, or total, Aroclors. Therefore, a translation method was developed for the Reassessment RI/FS to allow use of historic and recent data sets on a common basis. The parameter common to all data sets is known as Tri+ PCBs and represents the sum of PCBs with 3 to 10 chlorine atoms per molecule.

6.2.2.2 Sources

Upstream Baseline - Niagara-Mohawk Power Corporation Queensbury Site

Sources of PCBs upstream of the Fenimore Bridge include atmospheric deposition and the Niagara-Mohawk Power Corporation ("NiMo") site at Queensbury (located at about RM 209). These sources are considered anthropogenic (man-made) and serve as a baseline for purposes of the FS. Since specific information on the PCB load resulting from atmospheric deposition or other potential sources is not available, the discussion on the upstream baseline is focused on the NiMo Queensbury site.

Remedial activities were conducted at the NiMo Queensbury site, including the river, under the direction of the NYSDEC. Subsequently, PCB contamination in fish in the vicinity of the site was reduced. Some PCB contamination remains in the river near the site and PCBs are found in fish collected near the site. Even though the current contribution of the NiMo site to the PCB load at Hudson Falls has not been quantified, its effect is minimal, particularly in comparison to the source conditions between Hudson Falls and Rogers Island. The concentration from all sources above Hudson Falls is in the range of 1 to 2 nanograms per liter (ng/L) total PCBs in the water column as it flows into the Site. NYSDEC is evaluating possible further remediation at the NiMo site that may reduce the baseline upstream PCB input into the Hudson River PCBs Superfund Site.

Sources of PCBs in the Upper Hudson River

Rogers Island (RM 194.6) forms the northern boundary of the Thompson Island Pool and defines the upstream end of the PCB fate and transport modeling grid (see Section 6.2.3 for model description). Monitoring at Rogers Island is used to assess PCB loads originating above the Thompson Island Pool and entering the model (*i.e.*, the upstream boundary load). The region above Rogers Island that contributes PCBs to the model's upstream boundary load can be divided into two domains: 1) sources of PCBs entering the river north of the Fenimore Bridge in Hudson Falls (RM 197.3) and 2) sources of PCBs entering the river between Hudson Falls and Rogers Island.

There are four potentially important PCB sources to the Upper Hudson River between Hudson Falls and Rogers Island, each at various stages of remediation. The four potentially important sources are the GE Hudson Falls plant, the GE Fort Edward plant, Remnant Deposit 1, and Remnant Deposits 2 through 5. The grouping of the Remnant Deposits is based on differences in the degree of remediation completed.

GE Hudson Falls Plant

This source represents one of the two original discharge locations for PCB contamination from GE. The facility is no longer in operation and the only activity on-site is related to its remediation. Since the cessation of manufacturing discharges, extensive evidence has been found to show that this facility continues to leak PCBs into the Hudson River. The largest documented leakage event occurred during 1991 to 1993, apparently initiated by a partial failure of the gate structure within the abandoned Allen Mill structure near Bakers Falls in 1991. Total PCB loads originating from this structure were quite large during this period (*e.g.*, 260 kg or 570 lbs in September 1991) but have since been greatly reduced. Remedial work conducted by GE under NYSDEC jurisdiction reduced loads by more than 90 percent by 1996 (relative to early 1990s), although the load appears to have increased somewhat in the 1998–99 time frame.

Based on a review of recent water column data (1998 to 2000), it is estimated that leakage from the GE Hudson Falls plant contributes the vast majority of the roughly 3 to 8 kg (about 6 to 18 lbs) of total PCBs per month that travel past Rogers Island under current conditions. Congener patterns in PCB loads at Rogers Island predominantly resemble unweathered Aroclor

1242, consistent with the observed leakage of non-aqueous phase PCB-bearing oils from the bedrock beneath the GE facilities.

In March 2001, under a Consent Order with the NYSDEC, GE proposed additional source controls at the Hudson Falls plant. NYSDEC and EPA are evaluating GE's proposal. It is assumed in models used for the Reassessment RI/FS that, as a result of this additional source control action, the upstream Tri+ PCB load at Fort Edward (Rogers Island) will be reduced from its average current value of 0.16 kg/day (equivalent to an average concentration of 13 ng/L) to an average of 0.0256 kg/day (equivalent to an average concentration of 2 ng/L). If successful, these added reductions of the input from the GE Hudson Falls plant are likely to have a substantial impact on the overall attainable PCB concentrations in all media (air, water, sediment, and fish) in the Upper Hudson after sediment remediation, much more so than the effect of any reductions upstream of Hudson Falls.

GE Fort Edward Plant

The GE Fort Edward plant is located slightly farther from the Hudson River than the GE Hudson Falls facility. PCB contamination exists under the GE Fort Edward plant which is underlain by a layer of silt and clay, as opposed to the fractured bedrock at the GE Hudson Falls facility. Thus, while historical discharges from the GE Fort Edward plant were undoubtedly large, since the elimination of PCB usage and upgrading of the wastewater treatment plant, discharges and leakages to the river have been reduced. It is believed that the majority of post-1977 contamination originating from this source is probably associated with bank erosion of contaminated soils and sediments around the former discharge pipe. These materials are being addressed under a January 2000 NYSDEC Record of Decision. It is presumed that implementation of the remedy selected in the NYSDEC Record of Decision will reduce the PCB loads into the river at this location.

Remnant Deposit 1

Remnant Deposit 1 is the only one of the five Remnant Deposits not addressed by the remedial efforts conducted by GE from 1989 to 1991, as most of Remnant Deposit 1 had already washed downstream, and because it was not practical to cap the island. As such, the sediments of this deposit have been available for subsequent resuspension and transport downstream. It is most likely that this occurs during high flow events when river velocities are sufficient to resuspend large quantities of sediment. Diffusive exchange can also occur during lower flow conditions. While these processes undoubtedly occur to some extent, evidence suggests that these processes are not now major contributors to the annual load at Rogers Island. This is based on the knowledge that this source would yield a somewhat weathered congener pattern, which is not evident in the weekly monitoring data at Rogers Island. Thus, similar to the source area associated with the GE Fort Edward plant, this area may have been important historically, but it is unlikely to contribute a significant portion of the PCB load at Rogers Island under the normal range of flow conditions. However, given the fact that this area remains uncontrolled, the possibility remains that a large flow event such as a 100-year flood may release an additional portion of the PCBs remaining in Remnant Deposit 1. EPA will conduct further sampling to determine whether Remnant Deposit 1 needs to be remediated.

Remnant Deposits 2 through 5

Prior to their remediation, data on water column loads of PCBs, as well as the deposition of sediment in the river, all pointed to the transport of PCB-contaminated materials from the Remnant Deposits downstream. However, since the completion of the engineered caps, which raised the elevation at Remnant Deposits 2 through 5 to above the 100-year flood level in 1991, movement of these materials has been greatly limited. PCB contamination that originates from these deposits would have to reach the river via groundwater; however, available data are insufficient to evaluate the extent to which PCBs may be introduced by groundwater through the Remnant Deposits, given that the water column PCB load is dominated by PCBs from the GE Hudson Falls and Fort Edward plants. EPA's analysis of congener patterns of the 1997 to 1999 Rogers Island water column samples and the partition coefficient data do not suggest significant transport of PCBs to the river from these Remnant Deposits. The Rogers Island pattern of PCBs clearly matches that of the measured leakages from the Hudson Falls plant, both of which are consistent with a release of unweathered PCBs. Remedial efforts at Remnant Deposits 2 through 5 apparently have alleviated a formerly important source.

EPA will conduct a 5-year review for the Remnant Deposit remedy pursuant to CERCLA Section 121(c). EPA may not be able to fully evaluate the need for additional remediation at Remnant Deposits 2 through 5 until source control activities are completed near the GE Hudson Falls and Fort Edward plants, since the continuing release of PCBs to the River from these facilities makes it difficult to isolate the PCB load contributed by Remnant Deposits 2 through 5.

Summary of PCB Sources between Rogers Island and Hudson Falls

Of the four potential sources in the portion of the Hudson River between Hudson Falls and Rogers Island, the source from the GE Hudson Falls plant is best documented as an important contributor to the PCB loads measured in the water column at Rogers Island. The monitoring data at Rogers Island clearly define the source as one originating from "fresh" unweathered Aroclors, thus eliminating the Remnant Deposits as potential sources. PCB loads originating above Hudson Falls have also been reduced recently and are unlikely to contribute more than a few percent of the annual load at Rogers Island. For perspective, the sediment in the Thompson Island Pool downstream of Rogers Island contributes between three and four times as much PCBs to the river as do all the sources upstream of Rogers Island.

6.2.2.3 Contaminated Media

Sediment

Areas of elevated concentrations of PCBs in sediment, *i.e.*, *hot spot*s, are found in depositional areas throughout the Upper Hudson (River Sections 1, 2, and 3). The *hot spots* contain PCB concentration of 50 ppm or more. *Hot spots* are graphically presented on the plates accompanying Section 6.2.1.2 - River Bed Geology (Plates 6-1 through 6-7) of this document. River Section 1 (Thompson Island Pool) contains 20 of the 40 *hot spots* identified by NYSDEC in 1977 and 1984. The sediments exhibit a high degree of heterogeneity with respect to the distribution of PCBs. Historically, the highest concentrations of PCBs in sediments have been observed within the cohesive sediments of River Section 1, and generally lower PCB concentrations are found within the non-cohesive sediments. The maximum concentration measured in River Section 1 was approximately 2000 mg/kg total PCBs, in a slice of a sediment core. 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 total PCBs. It is estimated that there are approximately 45,200 kg (about 100,000 lbs) of total PCB mass in the sediments in River Section 1.

River Section 2 (TI Dam to Northumberland Dam near Lock 5) contains 15 of the 40 NYSDEC-defined *hot spot*s. The average concentration of total PCBs in sediment 0 to 25 cm (0 to about 10 inches) in River Section 2 in 1991 was approximately 26 mg/kg. The maximum concentration of PCBs in the Hudson, 4000 mg/kg total PCBs, was found in this river section in 1991 in *Hot Spot* 28 within a thin slice of a sediment core. It is estimated that there are approximately 28,200 kg (about 62,000 lbs) of total PCB mass in the sediments in River Section 2.

River Section 3 (Northumberland Dam to Federal Dam at Troy) contains five of the 40 NYSDEC-defined *hot spot*s. The average concentration in sediment 0 to 25 cm (0 to about 10 inches) in River Section 3 in 1991 was approximately 9 mg/kg total PCBs. Certain areas in River Section 3, *i.e.*, NYSDEC *Hot Spots* 36, 37, and the southern portion of *Hot Spot* 39, have extensive PCB inventory and show signs of potential loss of this PCB inventory. For example, a comparison of 1977 and 1994 sediment data showed that over two thirds of the PCB inventory was lost from *Hot Spot* 37. It is estimated that there are approximately 34,000 kg (about 75,000 lbs) of total PCB mass in the sediments in River Section 3.

Transport of PCBs in Upper Hudson River Sediments

The original sources of the vast majority of PCB contamination in the Upper Hudson River were the discharges from the GE plants in Fort Edward and Hudson Falls, New York. Over the past 50 years, these PCBs have adhered to the sediments (sands, silts and clays), and these sediments now serve as a continuing source of contamination for the water column and biota. These sediments migrate downstream by both suspended-load and bed-load transport. Bed-load transport represents particles that roll or bounce along the river bottom without being brought into resuspension. Since these particles are not transported into the water column, they have no effect on the suspended sediment concentration. However, the effects of bed-load transport are important in the changes in the thickness of the sediment bed and increase the rate of PCB desorption from the transported sediments into the water column.

The processes that determine the fate of PCBs in the Upper Hudson River may be divided into two categories, *i.e.* transport, and transfer and reaction. Transport is the physical movement of PCBs caused by the net advective movement of water, mixing, and resuspension/deposition of solids to which PCBs are adsorbed. It is dependent on the flow and dispersion characteristics in the water column and the settling velocity and resuspension rate of the solid particles. Transfer and reaction include movement of PCBs among air, water, and solid phases of the system, and biological (or biochemical) transformation or degradation (*i.e.*, break down) of the PCBs. The processes involved in transfer and reaction include volatilization, adsorption, dechlorination (*i.e.*, change of PCBs to less chlorinated congeners), bioturbation, biotransport and biodegradation. PCBs are present in the Upper Hudson River in three phases that interact with each other: freely dissolved, sorbed to particulate matter or solids, and complexed with dissolved (or colloidal) organic matter.

These complex sediment and water exchange processes govern the mechanisms that in turn contribute to bioaccumulation of PCBs in the fish via both benthic and pelagic food webs. These highly variable and complex processes include sediment resuspension and settling, biological mixing (bioturbation), sediment bed-load transport, anthropogenic disturbances such as boat and barge traffic, flood events, ice-rafting, and other such related processes. The net result of these processes is that, in general, the distribution of PCBs in the sediments of the Upper Hudson River is very heterogeneous. This heterogeneity is apparent from examination of the 1977 and 1984 NYSDEC data (including the *hot spot* delineation); the 1994 EPA data; and the 1991, 1998 and 1999 GE data.

PCB loss or gain from the sediment can take many forms. Scour, diffusion, groundwater advection (a process by which contaminants are transported by the movement of groundwater), and biological activity can all potentially remove PCBs from a given location. Biological activity in the form of anaerobic microbial dechlorination can also serve to decrease PCB concentrations in the sediments. Sediment PCB inventories can be increased chiefly by deposition, either with sediment contaminated by newly released PCBs or with redeposited sediments from other contaminated locations.

Long-Term Sequestration of PCBs

Long-term sediment sequestration of PCBs is clearly not assured, as demonstrated by several findings of the Phase 2 investigation. These include:

- The statistically significant loss of the sediment PCB inventory from highly-contaminated sediments in the Thompson Island Pool between 1984 and 1994. Samples collected by

GE in 1998 also show sediment PCB inventory loss in comparison to 1984 data. Loss of the sediment PCB inventory in this case indicates that these highly-contaminated materials are migrating within certain areas making them available to the water column and available for deposition at other locations.

- The continued loading of PCBs from the sediments of the Upper Hudson to the water column despite the controls placed on releases from the GE Hudson Falls plant.

- Sixty percent of the sediment cores showing the highest concentration of PCBs in the top nine inches of sediment (indicating the contaminated material is not deeply buried and is available for redistribution) .

- The scouring of PCB-contaminated sediments from the Upper Hudson resulting from the Hoosic River spring flow in 1993.

- The apparent loss of the sediment inventory in *Hot Spot* 28 based on a comparison of GE and EPA data.

- The occurrence of high PCB concentrations in surface sediment of *Hot Spot* 28.

- The occurrence of high PCB concentrations in the surface sediments of *Hot Spot* 14 as documented by GE in 1999.

PCB Transport from the Upper Hudson to the Lower Hudson

PCBs are transported from the Upper Hudson River to the Lower Hudson (*i.e.*, south of the Federal Dam at Troy). The mass of PCBs transported over the Federal Dam to the Lower Hudson declined from about 3,000 to 4,000 kg/year Tri+ PCBs (6,610 to 8,820 lbs/year) in the late 1970s to about 150 to 500 kg/year Tri+ PCBs (331 to 1,100 lbs/year) by the late 1980s or early 1990s. The most recent estimate of Tri+ PCBs, based on 1998 GE data from a monitoring station at Schuylerville, is 214 kg/year Tri+ PCBs (472 lbs/year); the estimated (modeled) average for the 1990s is about 290 kg/yr Tri+ PCBs (639 lbs/year) over Federal Dam, with a modeled daily average Tri+ PCB water column concentration of 30 ng/L. Total PCB concentrations are 1.45 times the Tri+ PCB concentrations in the water column passing the Federal Dam.

PCBs in Lower Hudson River Sediments

An evaluation of PCB concentrations in sediments below Federal Dam is limited by the lack of a detailed study of this region. An assessment of the Lower Hudson region performed in the 1980s indicated that sediments in New York Harbor had a total PCB concentration of 0.8 mg/kg in the 1970s and 0.5 to 0.7 mg/kg in the 1980s. Sampling data from the 1993 ecological investigation showed a sharp drop in PCB concentrations in sediment below RM 150, with PCB concentrations ranging from less than 0.1 mg/kg to about 1.5 mg/kg (with a fairly high degree of scatter) at nine stations between RM 144 and RM 24.

Water Column

The dominant current sources of PCBs to the water column of the Upper Hudson River may be separated into two groups: PCB-contaminated sediments on the river bottom; and PCB-contaminated oil from bedrock seeps from the GE Hudson Falls plant.

U.S. Geological Survey monitoring of PCBs in the water of the Upper Hudson River began in 1977. GE, in accordance with a Consent Decree with EPA, began monitoring of the Upper Hudson River in 1991. In River Section 1, PCB concentrations in the water column indicate that the sediments of the Thompson Island Pool are the major source of PCBs to the water column of the Upper Hudson during low flow conditions, which are important as they coincide with the period of greatest biological activity and uptake by ecological receptors.

During the summer of 1998 (June through September), the average PCB concentration in the water column at the Thompson Island Dam-West station was 134 ng/L total PCBs. Concentrations from January 1996 through March 2000 averaged 90 ng/L total PCBs. Five observations in excess of 300 ng/L total PCBs were noted during the winter of 1999-2000. As water flows over the six mile stretch of the Thompson Island Pool, the PCB concentration (and mass load) increases 3 to 4 times.

Fish and Other Biota

PCB concentrations in fish are a result of the fish's exposure to PCBs in water and surface sediment, through an aquatic food chain and/or a benthic food chain, respectively. NYSDEC continues to collect and analyze fish tissue data from locations in the Upper Hudson River. Converted to a Tri+ PCB [(1)] basis, the concentrations in River Section 1 (Thompson Island Pool) in 1999 averaged about 21 mg/kg (wet weight in fish fillet) in largemouth bass and 13 mg/kg in brown bullhead. Recent maximum PCB concentrations measured were 114 mg/kg in largemouth bass and 31 mg/kg in brown bullhead. The overall maximum PCB concentration in 1999 in the Thompson Island Pool was 288 ppm in white sucker fillet. Fish PCB concentrations are provided in mg/kg wet weight in fish fillet unless otherwise noted.

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[1] For purpose of model analysis and consistency, PCB levels in fish have been converted to a Tri+ basis. It should be noted, however, that total PCBs present in fish closely relate to Tri+ PCB concentrations. It was found that the Tri+ PCB concentration ranged from 98 to 100 percent of the total PCB concentration in fish collected as part of the Phase 2 sampling. Thus, in reality the terms Tri+ PCBs and total PCBs may be used interchangeably herein when measuring, comparing, or projecting fish tissue PCB concentrations. Therefore, the generic term "PCBs" will be used in dealing with fish tissue concentrations from this point forward. The ratio between Tri+ PCBs and total PCBs in the water column and sediment does not approach unity and therefore the terms cannot be used interchangeably for water and sediment.

Fish in River Section 2 (*Hot Spot* 28 and the Fort Miller Pool just below the Thompson Island Dam) were first sampled in 1999. These data reflect elevated PCB concentrations, consistent with other fish data for the Upper Hudson River.

PCB concentrations in fish collected in River Section 3 (Stillwater) in 1999 averaged about 6 mg/kg in largemouth bass and 6 mg/kg in brown bullhead. Recent maximum PCB concentrations measured were 23 mg/kg in largemouth bass and 15 mg/kg in brown bullhead. The recent overall 1998 maximum was 483 ppm PCB in carp fillet. For comparison purposes, EPA has determined that 0.05 mg/kg is an acceptable PCB concentration for Hudson River fish (See Section 9.1).

Because PCBs tend to accumulate in fatty tissues, it is also useful to examine PCB concentrations in fish on a lipid (fat) basis for an analysis of trends. The lipid-based concentrations for brown bullhead and largemouth bass in 1998 were generally similar to those observed from 1995 to 1997 in both River Section 1 and River Section 3, with little evidence of a consistent decline. Time trends of lipid-based concentrations for pumpkinseed in River Section 3 for the Stillwater reach (RM 168.1) show that PCB concentrations in the fish appear to have been nearly stable in recent years. Figures 6-2 and 6-3 provide the lipid-based concentrations in fish for the Thompson Island Pool (RM189, River Section 1) and Stillwater (River Section 3). There are insufficient PCB data for fish in River Section 2 for a time trend analysis.

EPA's analysis of all the data indicates that the PCB concentrations in fish generally decrease with distance downstream of the Thompson Island Pool.

Data recently released by NYSDEC found elevated levels of PCBs in biota. Snapping turtles had greater than 3000 mg/kg PCBs[(2)] in fat and nearly 4 mg/kg PCBs in muscle. Short-tailed shrews had a mean of 7 mg/kg PCBs and a maximum of 38 mg/kg PCBs. Mink and otter that live near the river showed elevated PCB levels. The average PCB level in river otter within 10 kilometers of the Upper Hudson River was 172 mg/kg PCBs (lipid based, liver) and the average level for mink within one kilometer of the river was 33 mg/kg PCBs (lipid based, liver).

Air

PCBs can enter the air via volatilization from PCB-contaminated water and soil although volatilization of PCBs is generally considered to be limited. Air monitoring at the Site in 1991, associated with the capping of the Remnant Deposits, measured PCB concentrations above the detection limit in only 13 of 985 samples. The maximum concentration detected was 0.13 $\mu g/m^3$ of Aroclor 1242. PCBs were detected only when high PCB concentrations released from near the GE Hudson Falls plant were also detected in the water column.

[2] PCBs expressed as the sum of Aroclors analyzed by the NYSDEC.

Air exposure was not expected to present a significant risk to human health, based on the Phase 1 Report, and therefore additional air monitoring was not conducted as part of the Reassessment RI/FS. The Human Health Risk Assessment calculated risk values for exposure to PCBs from inhalation of volatilized PCBs and found that inhalation does not present a significant risk.

6.2.3 Geochemistry and Modeling Conclusions

In the Reassessment RI/FS, EPA evaluated PCB contamination at the Site using a number of tools. These tools include geochemical analyses of the water and sediment, analyses of the biological monitoring data, and synthesis of the data by the application of a set of complex mathematical (computer) models.

PCB physical/chemical transport and fate and PCB bioaccumulation models were applied to predict future levels of Tri+ PCBs in the Upper Hudson River sediment, water and fish. The Upper Hudson River Toxic Chemical Model (HUDTOX) simulated transport and fate in the water column and sediments for 40 miles of the Upper Hudson. HUDTOX was calibrated to a 21-year historical data set, validated utilizing observed data from 1998, and run for a 70-year forecast period from 1998 through 2067. The Farley model (An Integrated Model of Organic Chemical Fate and Bioaccumulation in the Hudson River Estuary) was used to calculate Lower Hudson River sediment and water concentrations. The modeling efforts provided EPA with valuable insights regarding the factors that control transport and fate of PCBs in the Upper Hudson River. The modeled responses are sensitive to changes in hydrology, solids loadings and sediment particle mixing depth and initial conditions.

A mechanistic time-varying model known as FISHRAND was used to predict future fish Tri+ PCB body burdens, which were subsequently used in the Human Health and Ecological Risk Assessments and FS. FISHRAND model predictions were provided for six fish species: brown bullhead, largemouth bass, white perch, yellow perch, pumpkinseed, and spottail shiner. These species were selected to get a representative trophic and spatial distribution of bottom feeders, species at the top of the food chain, and semi-piscivorous species. Model estimates of total PCB concentrations in each species were based on all PCB congeners with three or more chlorine atoms.

Both the HUDTOX and FISHRAND models were calibrated using the extensive database for the Upper Hudson River PCBs Reassessment RI/FS (EPA, 2000, Release 5.0). The database contains approximately 750,000 measurements for sediments, fish and aquatic biota, surface water flow and surface water quality from EPA, NYSDEC, USGS, NOAA and GE. Almost 350,000 of these records contain data acquired by EPA as part of the Phase 2 Reassessment RI/FS sampling effort. The remaining records contain data from a large number of historical and ongoing monitoring efforts in the Hudson River.

Key findings of the geochemistry studies and modeling included:

- Sediment deposition is occurring, on average, in most of the Upper Hudson River, but not at rates or with a consistency sufficient for sequestration of PCB-contaminated sediments.

- PCB concentrations in water are driven by PCBs stored in sediments.

- Over the long term, the concentrations of PCBs entering the river upstream of Rogers Island will limit the reductions of PCB levels in fish tissues.

- Occurrence of a 100-year peak flow does not appear likely to cause massive mobilization of PCB-contaminated sediments.

- Concentrations of PCBs in both the sediment and water column represent important sources of exposure to biota over the long term.

6.2.4 Reassessment RI Conclusions

The following summarize the key conclusions of the Reassessment RI.

- PCBs were released from the two GE capacitor manufacturing plants in Hudson Falls and Fort Edward into the Hudson River. Once in the river, the PCBs generally adhered to sediments or were carried in the water column.

- PCBs in the fine-grained sediments (and, to a lesser extent, the coarse-grained sediments) are a continuing source of contamination to the water column and biota, through aquatic and benthic food chains and through processes that have been empirically measured but are not easily modeled. Because the river is a dynamic system, the PCB-contaminated sediments are not stable. Some PCB-contaminated sediment may be buried by deposition of cleaner sediments at some times, but in other places and at other times, they may be redistributed by scouring. Data show that the burial that is occurring of PCB-contaminated sediment by cleaner sediment in the Thompson Island Pool is not sufficient to mitigate exposure to biota.

- Sixty percent of the low resolution sediment cores show the highest concentrations of PCBs in the top nine inches of sediment.

- As of 1994, there had been a statistically significant loss of PCB inventory from highly contaminated sediments in the Thompson Island Pool and a net loss of PCB inventory from *hot spot* sediments between the Thompson Island Dam and the Federal Dam at Troy.

- High flow events (*e.g.*, floods) may increase the bioavailability of PCBs to organisms in the water column. Water column sampling from a high flow event in January 1998 showed elevated PCB concentrations.

- PCBs in sediments will not be "naturally remediated" via dechlorination. The extent of dechlorination is limited, resulting in less than a ten percent loss of PCB mass.

- The area of the Site upstream of the Thompson Island Dam represents the primary source of PCBs to fish within the freshwater Hudson. This includes the GE Hudson Falls and Fort Edward plants, the Remnant Deposits and, most importantly, the sediments of the Thompson Island Pool.

- PCB concentrations in fish, the primary pathway of concern, are still well above acceptable risk-based and advisory levels, particularly in the Upper Hudson.

- Alleviating the upstream source is important to the long-term recovery of the river. GE has submitted a proposal to the NYSDEC (under its existing Consent Order with the NYSDEC) to address PCB sources in bedrock that are still releasing to the river from GE's Hudson Falls plant. NYSDEC and EPA are evaluating this source control proposal submitted by GE.

- PCBs are transported from the Upper Hudson River to the Lower Hudson River (*i.e.*, south of the Federal Dam at Troy). The mass of PCBs transported over the Federal Dam to the Lower Hudson declined from about 3,000 to 4,000 kg/year Tri+ PCBs (6,600 to 8,800 lbs/year) in the late 1970s to about 150 to 500 kg/year Tri+ PCBs (330 to 1,100 lbs/year) by the late 1980s to early 1990s. Based on data reported by GE from a monitoring station at Schuylerville, 214 kg Tri+ PCBs (471 lbs) of PCBs were transported over the Federal Dam at Troy in 1998.

- Trends of PCB concentrations in the Upper Hudson in water column and fish tissue show a leveling off with little, if any, reduction occurring in the last decade when the effects of the Allen Mill event are excluded.

In summary, the PCB-contaminated sediments of the Thompson Island Pool release PCBs to the water column and contaminate the water column and fish. Burial of contaminated sediment by cleaner material is not occurring universally and stability of the sediment deposits is not assured.

7. CURRENT AND POTENTIAL FUTURE LAND AND WATER USES

As one of America's great rivers, the Hudson has played and will continue to play a major role in the history, culture, and economy of the area. The Hudson has been designated an American Heritage River because of its important role in American history and culture. Current and reasonably-anticipated future land use and surface water use are described below. One new water allocation request is noted below (Section 7.2).

7.1 Current and Reasonably Anticipated Future Land Use

Current land use includes a variety of residential, commercial and industrial activities. Use of the river and lands surrounding the river are projected to remain the same. At this time, no changes in future land use are known, nor are any new uses expected.

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 more highly contaminated portions (areas of proposed active remediation in River Sections 1, 2 and 3) of the Upper Hudson River between Troy (Federal Dam) and Hudson Falls. Within these four counties, forests and farmlands surround urban centers and historic villages. There are apple orchards and dairy farms, parks, nature preserves and gardens. In addition to the GE Hudson Falls and Fort Edward plants, the area is home to technology companies, oil service companies and food companies.

Saratoga and Washington Counties have experienced population growth between 1990 and 1999 of 10.2 percent and 1.4 percent, respectively, while Rensselaer and Albany Counties have experienced population declines of 1.9 percent and 0.3 percent, respectively. Total population of these four counties, according to July 1999 estimates by the US Department of Commerce Bureau of the Census, is just under 700,000. Warren County, in which the City of Glens Falls is located, has a population of just over 60,000 and is just to the northwest of the Hudson River PCBs Site.

7.2 Surface Water Uses

Current surface water uses include the following:

• *Public water supplies*: The cities of Waterford and 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. In addition, a water intake near Chelsea, which is south of Poughkeepsie, may be used to supplement New York City's water supply during periods of drought. Waterford is the only municipal water supply intake in the Upper Hudson River. The treatability study at Waterford Water Works, which was completed in 1990 pursuant to the 1984 Record of Decision, indicated that the treated water met standards applicable to public water supplies at that time. The Town of Halfmoon is developing the facilities to use the Upper Hudson River as a source of public water supply.

• *Industrial and commercial purposes*: Hudson River water is used extensively for hydroelectric and thermal power generation, as well as for manufacturing processes, cooling and fire protection. Industrial use is typically located near urban centers such as Albany and Troy and includes brake lining, paper products, clothing and garden equipment manufacturing facilities, as well as paper mills. A commercial striped bass fishery in the Lower Hudson River remains closed due to the contamination. Other commercial fishery closures are also in place.

The river serves as a transportation corridor within the region. The Champlain Canal was a major transportation route in the past. Commercial traffic has declined on the canal over the last 30 years, but may experience some growth, such as the recent increase in tour boats, in the future through revitalization programs such as the American Heritage River initiative.

Due to the PCB contamination, navigational dredging within the Upper Hudson has been severely limited in the past 25 years. As a result, commercial navigational uses have been reduced and recreational navigational uses impeded. The New York State Canal Corporation has cited the cost to dispose of PCB-contaminated sediment as a critical aspect to the resumption of the dredging program necessary to keep the canal functional. In addition, private dredging outside the navigational channel for such uses as marinas has been limited as well.

• *Residential/Domestic:* Hudson River water is used for watering domestic lawns and gardens. The use of Hudson River water for domestic drinking supplies is described above (Public water supplies).

• *Agricultural:* Hudson River water is used for irrigating agricultural lands. There are no records of water withdrawal for agricultural uses, however, as permits are not required for irrigation withdrawals. Portions of the agricultural land adjacent to the Site lie within New York State Agricultural Districts and include parcels considered to be prime farmland. In addition to apples, crops include corn and hay used for forage, and small quantities of cash crops such as oats and wheat.

• *Recreation:* The Hudson River supports a variety of water-based recreational activities including sport fishing, waterfowl hunting, swimming and boating. Boating (both power and non-power) is available on the river and on the Erie and Champlain Canals; marinas and docks can be found along the waterway. Schaghticoke Canal Park sits at Lock 4 of the Champlain Canal, Schuylerville has a large waterside town park, and other town parks lie along the river, including two in Fort Edward. A marina and hotel complex have been proposed for the southern end of Rogers Island. Area festivals include various county fairs such as those in Washington and Rensselaer Counties. Tourism is popular and important to the local economy throughout the Hudson River Valley.

In 1975, the NYSDOH began to issue health advisories recommending that people limit consumption of fish from the Hudson River. In 1976, NYSDEC issued a ban on fishing in the Upper Hudson River from Hudson Falls to the Federal Dam at Troy, due to the potential risks from consumption of PCB-contaminated fish, and a ban on commercial fishing of striped bass and other species which migrate into the Lower Hudson. NYSDEC replaced the ban against fishing in the Upper Hudson River with a catch-and-release fishing program in 1995. NYSDOH continues to recommend that people eat none of the fish from the Upper Hudson River, that children under the age of 15 and women of child-bearing age eat none of the fish from the river for the entire 200 mile length of the Superfund site, and that the general population eat none of most species of fish caught between the Federal Dam at Troy and Catskill.

• *Ecological Resources:* The Hudson River supports 206 species of fish as well as 143 species of resident and migrating birds. Sixty-four (64) species are listed as Threatened, Endangered, Rare or of Special Concern by federal and New York State authorities. There are 39 areas of significant habitat identified in the Lower Hudson River.

The Hudson River provides diverse habitats for all trophic levels of the river's ecosystem. Plants, plankton, aquatic invertebrates, fish, amphibians, reptiles, birds and mammals use the Hudson River for feeding, reproduction and shelter. In addition to the aquatic communities associated with the river, animals living in wetlands, floodplains and upland communities are also dependent on the river.

Both federal and state freshwater wetlands exist throughout the Upper Hudson region. Tidal wetlands are found in the Lower Hudson River. Also present in the Lower Hudson are New York State Department of State (NYSDOS) significant coastal habitats, United States Fish and Wildlife Service (USFWS) significant habitats, and marshes identified by the United States Army Corps of Engineers (USACE). The 100-year floodplain extends up to 5,000 feet wide at places in the Upper Hudson.

8. SUMMARY OF SITE RISKS

Baseline human health and ecological risk assessments were conducted to evaluate the potential for current and future impacts of site-related contaminants on receptors visiting, utilizing or inhabiting the Hudson River. In the Revised Human Health Risk Assessment (HHRA), cancer risks and non-cancer health hazards were evaluated both for the Upper Hudson River and the Mid-Hudson River. In the Revised Ecological Risk Assessment (ERA), ecological risks were evaluated for both the Upper and Lower Hudson. Under baseline conditions, the human health and ecological risks are unacceptable. The HHRA and ERA support the selected remedy.

8.1 Human Health Risk Assessment

The site-specific HHRA evaluated both cancer risks and non-cancer health hazards from exposure to PCBs in the Hudson River, as documented in the Revised HHRA. The Revised HHRA combines into a single report the August 1999 HHRA for the Upper Hudson River and its March 2000 Responsiveness Summary, the December 1999 HHRA for the Mid-Hudson River and its August 2000 Responsiveness Summary, and the November 2000 Response to Peer Review Comments (on the August 1999 HHRA).

This discussion emphasizes cancer risks and non-cancer health hazards due to PCBs in the Upper Hudson that exceed EPA's goals for protection, which are a one-in-one million excess cancer risk and a non-cancer hazard index (HI) of 1. Cancer risks and non-cancer hazard indices in the Mid-Hudson were calculated to be about one-half those of the Upper Hudson, due to lower concentrations of PCBs in Mid-Hudson fish, sediment and surface water. The cancer risk and non-cancer hazard indices in the Upper Hudson and Mid-Hudson are above EPA's levels of concern for fish consumption.

Consistent with Superfund policy and guidance, the HHRA is a baseline risk assessment and therefore assumes no actions (remediation) to control or mitigate hazardous substance releases and no institutional controls, such as the fish consumption advisories and fishing restrictions that are currently in place, which are intended to control exposure to hazardous substances. Cancer risks and non-cancer hazard indices were calculated based on an estimate of the reasonable maximum exposure (RME) expected to occur under current and future conditions at the Site. The RME is defined as the highest exposure that is reasonably expected to occur at a site. EPA also estimated cancer risks and non-cancer hazard indices based on central tendency (CT), or average, exposures at the Site. The following discussion summarizes the HHRA with respect to the basic steps of the Superfund HHRA process: 1) Data Collection and Analysis, 2) Exposure Assessment, 3) Toxicity Assessment and 4) Risk Characterization.

8.1.1 Data Collection and Analysis

The HHRA utilizes documents relating to the nature and extent of PCB contamination at the Site developed as part of the Reassessment RI/FS (*e.g.*, February 1997 Data Evaluation and Interpretation Report, July 1998 Low Resolution Sediment Coring Report, Database for the Hudson River PCBs Reassessment RI/FS [Release 5.0, October 2000], January 2000 Revised Baseline Modeling Report (RBMR), November 2000 Revised Baseline Ecological Risk Assessment and associated responsiveness summaries). These Reassessment RI/FS documents provided both current and projected future concentrations of PCBs in air, fish, sediments and river water. To calculate cancer risks and non-cancer hazard indices, the information on concentrations in these media (air, water, sediment, fish) are then combined with other information on exposure (see Section 8.1.2) and toxicity (see Section 8.1.3).

- <u>Chemicals of Concern</u>: PCBs, including dioxin-like PCBs, are the chemicals of concern for the Site. Fish at the Site have been collected by the NYSDEC for more than 25 years. Fish samples have been analyzed for PCBs, total DDT, total chlordane, total endrin, total endosulfan, dieldrin, aldrin, mirex, total heptachlor, total hexachlorobenzene, toxaphene, methoxychlor, individual polycyclic aromatic hydrocarbons, cadmium, mercury, dioxins, and dibenzofurans. PCBs (Total and dioxin-like) were identified as the chemicals of concern based on previous analytical results, the toxicity values for the chemicals, and the site definition (*i.e.*, the Site was placed on the Superfund NPL as a result of PCB contamination in the river).

The exposure point concentration (EPC) is the concentration of PCBs in a given environmental medium at the point of human contact. Estimates of the EPC represent the concentration term used in the exposure assessment component of the quantitative risk evaluation. EPCs for PCBs are provided for fish, sediment, drinking/river water, and air. EPCs are also provided for dioxin-like PCBs for fish. The EPCs for PCBs in each of these media are based upon modeled projections of future concentrations in each medium for the RME and CT individuals. These modeled projections are based upon a large monitoring record.

- Fish EPCs: EPCs in fish are based on wet-weight PCB concentrations in fish fillets for brown bullhead, largemouth bass, and yellow perch generated by EPA's peer-reviewed bioaccumulation model, FISHRAND. The fillet represents the portion of the fish most commonly consumed. The fish EPCs were derived by weighting the model output by reported angler preference for species consumption (*i.e.*, weighting the modeled PCB concentrations in fish to reflect the species caught and consumed by anglers) and by averaging over location within the study area. The fish EPCs range from 2.0 mg/kg PCBs wet-weight (for the adult exposed for 22 years under the RME cancer scenario) to 3.3 mg/kg (for the young child exposed for six years under CT non-cancer scenario), due to averaging times for different individuals' exposures for the Upper Hudson (see Tables 8-1 to 8-2).

- Fish EPCs for Dioxin-Like PCBs: EPCs in fish for dioxin-like PCBs were based on FISHRAND output for dioxin-like PCB congeners and the toxic equivalencies (TEQs) of those congeners (see Table 8-3). The TEQs were developed using the 1998 World Health Organization/International Programme for Chemical Safety Toxic Equivalency Factors. Calculated cancer risks associated with dioxin-like PCBs in fish were found to be comparable to the cancer risks from non-dioxin-like PCBs and therefore are not discussed further.

- Sediment EPCs: EPCs in surficial sediment (0 to 4 cm) in the Upper Hudson were modeled using HUDTOX, EPA's peer-reviewed PCBs fate and transport model for the Upper Hudson, assuming baseline conditions of a constant upstream boundary condition of 13 ng/L Tri+ PCBs in river water. Sediment EPCs were derived from the HUDTOX results by weighting for the respective areal extent of cohesive and non-cohesive sediment. The sediment EPCs for the Upper Hudson range from 3.8 ppm (3.8 mg/kg) Tri+ PCBs for the adult RME to 7.2 ppm (7.2 mg/kg) Tri+ PCBs for the adolescent and child CT (see Table 8-4).

- River/Drinking Water EPCs: Surface water from the Hudson River is used for drinking water. EPCs in Upper Hudson river water were derived from concentrations of PCBs in the water column modeled by HUDTOX. The river water EPCs range from 0.034 ppb (3.4E-05 mg/L) total PCB for the adult RME to 0.048 ppb (4.8E-05 mg/L) total PCB for the adolescent and child CT (see Table 8-5). Cancer risks and non-cancer hazard indices due to PCBs in river water were not at levels of concern (at or below EPA's goals for protection) and therefore are not discussed further in this ROD.

- Air EPCs: EPCs in air were derived for the Upper Hudson (see Table 8-6). Cancer risks and non-cancer hazard indices due to PCBs in air are at or below EPA's goals for protection and therefore are not discussed further in this ROD. (see HHRA and also Responsiveness Summary).

8.1.2 Exposure Assessment

The exposure assessment evaluates exposure pathways by which people are or can be exposed to the contaminants of concern in different media (*e.g.*, soil, water, fish). Factors relating to the exposure assessment include, but are not limited to, the concentrations that people are or can be exposed to and the potential frequency and duration of exposure.

- Conceptual Site Model. Table 8-7 provides the rationale for inclusion or exclusion of exposure pathways. Exposure through fish ingestion and recreational exposure through dermal contact and ingestion of sediments are the pathways of greatest concern. Exposures from floodplain soil, non-fish biota (*i.e.*, turtles, ducks, etc.), homegrown crops including vegetables, beef and dairy products were evaluated qualitatively but not quantitatively. These pathways are not discussed further based on the discussion presented in the HHRA, which indicated they are unlikely to be significant pathways for PCB exposure.

- Exposed Populations. Adults (over 18 years old), adolescents (aged 7 to 18 years old) and young children (aged 1 to 6 years old) are or can be exposed to PCBs in the Hudson River due to fish consumption and recreational activities (swimming and wading). Sensitive populations that were qualitatively evaluated include highly exposed (*e.g.*, subsistence) anglers and their families as well as infants of mothers who ingest fish that are exposed *in utero* and/or through consumption of breast milk. With respect to subsistence or highly exposed angler populations in New York State, review of the limited literature suggests that these populations are likely to be adequately represented in the HHRA. With respect to infants (less than one year old), exposure to PCBs *in utero* and via ingestion of breast milk are known exposure routes that may pose risks to fetal development and the infant. Several ongoing studies are evaluating whether there is a relationship between fetal/infant PCB exposure and developmental effects. Standard EPA default factors were used for angler body weight (*e.g.*, 15 kgs for a young child and 70 kgs for an adult).

- Fish Ingestion Rate. Based on the 1991 New York Angler survey of fish consumption by licensed anglers, the RME fish ingestion rate was determined to be 31.9 grams per day, or about 51 half-pound meals per year for adults and the CT (average) fish ingestion rate was determined to be 4.0 grams/day, or about six half-pound meals per year. Fish ingestion rates for adolescents and young children were reduced based on the ratio of adolescent or child body weight to that of an adult. Fish ingestion rates for young children and adolescents are generally consistent with the limited information provided in EPA's 1997 Exposure Factors Handbook.

- Exposure Duration. Population mobility data from the U. S. Census Bureau for the five counties surrounding the Upper Hudson River (Albany, Rensselaer, Saratoga, Warren, and Washington) and fishing duration data from the 1991 New York Angler survey were combined to determine the length of time an angler fishes in the Upper Hudson River (*i.e.*, exposure duration). For cancer risks the exposure duration for fish ingestion was 40 years for the RME exposure estimate (sum of 22, 12, and 6 years for adult, adolescent, and young children exposures, respectively) and 12 years for the CT (average) exposure estimate (sum of 6, 3, and 3 years for adult, adolescent and young child exposures, respectively).

  For non-cancer health hazards, three exposure durations for fish ingestion under the RME exposure estimate were used: 7 years (the chronic exposure period) for the adult, 7 years for the adolescent and 6 years for the young child (aged 1 to 6). These non-cancer exposure durations were selected because they are exposure periods for chronic non-cancer health effects that yield a high-end average daily dose (*i.e.*, the dose an RME individual would receive), based on the decline in PCB concentration with time forecast by EPA's peer-reviewed models. The exposure duration for the CT (average) exposure estimate was set at 12 years, which is the sum of 6 years for the adult and 3 years each for the adolescent and the young child.

- PCB Cooking Loss. PCB losses during cooking were assumed to be 0% (no loss) for the RME estimate and 20% for the CT (average) exposure estimate, based on studies reported in the scientific literature. Potential PCB loss mechanisms include removing skin and fat, draining cooking fluids from the fish and grilling to allow oil to drip away from the fish.

- Recreational Exposure Assumptions. For direct exposure to river water and sediment, there are no site data available to quantify the frequency of exposure. The RME exposure estimates for adults and young children (aged 1 to 6 years old) were assumed to be one day a week (assuming an adult would accompany a young child to the river) for the 13 weeks of summer (13 days/year), and the CT (average) exposure estimates were assumed to be one day every other week for the 13 weeks of summer (7 days/year). Adolescents (aged 7 to 18 years old) were assumed to have about three times more frequent exposure, with an RME estimate of 39 days/year and a CT (average) exposure estimate of 20 days/year. In addition, an avid recreator scenario was evaluated for which the RME exposure estimate for adults, adolescents and young children was assumed to be four times a week for 6 months of the year (104 days/year), and the CT (average) exposure estimate was assumed to be approximately twice a week for 6 months of the year (52 days/year).

- Monte Carlo Probabilistic Analysis. Monte Carlo simulation is a form of probabilistic analysis. In addition to the point estimate analyses, a Monte Carlo analysis was performed to provide a range of estimates of the cancer risks and non-cancer health hazards associated with the fish ingestion pathway. The Monte Carlo analysis helps to evaluate variability in exposure parameters (*e.g.*, differences within a population's fish ingestion rates, number of years anglers are exposed, body weight, etc.) and uncertainty (*i.e.*, lack of complete knowledge about specific variables).

8.1.3 Toxicity

The toxicity assessment determines the types of adverse health effects associated with PCB exposures and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response). Potential health effects for PCBs include the risk of developing cancer over a lifetime. Other non-cancer health effects, such as changes in the normal functions of organs within the body (*e.g.*, changes in the effectiveness of the immune system), are also associated with PCB exposure. Some of the 209 PCB congeners are considered to be structurally and mechanistically similar to dioxin and exert dioxin-like effects.

- Sources of Toxicity Information. The HHRA used the current consensus toxicity values for PCBs from EPA's Integrated Risk Information System (IRIS) in evaluating the cancer risk and non-cancer health effects of PCBs. IRIS provides the primary database of chemical-specific toxicity information used in Superfund risk assessments. More recent toxicity data are provided in Appendix D of the HHRA. These data do not change EPA's use of IRIS values. For the dioxin-like PCBs, the HHRA used toxicity information for dioxin (2,3,7,8-TCDD) provided in EPA's 1997 Health Effects Assessment Summary Tables.

- Cancer. EPA has determined that PCBs cause cancer in animals and probably cause cancer in humans (B2 classification or likely to cause cancer in humans). EPA's cancer slope factors (CSFs) for PCBs represent plausible upper bound estimates, which means that EPA is reasonably confident that the actual cancer risks will not exceed the estimated risks calculated using the CSFs.

  For fish ingestion, the pathway determined to be of greatest concern, CSFs of 2 $(mg/kg\text{-}day)^{-1}$ and 1 $(mg/kg\text{-}day)^{-1}$ were used for the RME and CT (average) exposure, respectively. For dermal and inhalation exposures, a CSF of 2 $(mg/kg\text{-}day)^{-1}$ was used with a dermal absorption fraction of 14%, consistent with the IRIS chemical file. For inhalation, a CSF of 0.4 $(mg/kg\text{-}day)^{-1}$ was used. For the dioxin-like PCBs, the CSF for 2,3,7,8-TCDD of 150,000 $(mg/kg\text{-}day)^{-1}$ was used. Table 8-8 summarizes the cancer toxicity values used in the HHRA.

- Non-Cancer Health Effects. Serious non-cancer health effects have been observed in animals exposed to PCBs. Studies of Rhesus monkeys exposed through ingestion of PCBs (*i.e.*, Aroclors 1016 and 1254) indicate a reduced ability to fight infection and reduced birth weight in offspring exposed *in utero*. Studies of non-cancer health effects, including effects observed in children of mothers who consume PCB-contaminated fish, are being evaluated by EPA as part of the Agency's IRIS process.

  The toxicity assessment is an evaluation of the chronic (7 years or more) adverse health effects from exposure to PCBs. The chronic Reference Dose (RfD) represents an estimate (with uncertainty spanning perhaps an order of magnitude or greater) of a daily exposure level for the human population, including sensitive populations (*e.g.*, children), that is likely to be without an appreciable risk of deleterious effects during a lifetime. Chemical exposures exceeding the RfD do not predict specific disease. For the fish ingestion pathway, the oral RfD for Aroclor 1254 of 2 x 10^{-5} mg/kg-day was used for the RME and CT (average) exposures, because the congener analysis of fish samples most closely resembled Aroclor 1254. For the sediment and water ingestion pathways, the oral RfD for Aroclor 1016 of 7 x 10^{-5} mg/kg-day was used because analyses of sediment and water samples most closely resemble Aroclor 1016. For the dermal contact pathway, dermal RfDs were extrapolated from the oral RfD for Aroclor 1016. Table 8-9 summarizes the non-cancer toxicity values used in the HHRA.

8.1.4 Risk Characterization

This final step in the HHRA combines the exposure and toxicity information to provide a quantitative assessment of site risks. Exposures are evaluated based on the potential risk for developing cancer and the potential for non-cancer health hazards.

Cancer Risks

Cancer risk is expressed as a probability. For example, a 10^{-4} cancer risk means a "one in 10,000 excess cancer risk," or an increased risk of an individual developing cancer of one in 10,000 as a result of exposure to site contaminants under the conditions used in the Exposure Assessment. Under the federal Superfund program, EPA's goal for protection is an excess cancer risk of 10^{-6} or less for the RME individual. Acceptable exposures are an individual lifetime excess cancer risk at or below the range of 10^{-4} to 10^{-6} (corresponding to a one in 10,000 to a one in 1,000,000 excess cancer risk).

Excess lifetime cancer risk is calculated from the following equation:

$$\text{Risk} = \text{CDI} \times \text{CSF}$$

where: Risk = a unitless probability (*e.g.*, 1 x 10^{-3} of an individual developing cancer)

CDI = Chronic Daily Intake averaged over 70 years (mg/kg-day)
CSF = Cancer Slope Factor, expressed as $(\text{mg/kg-day})^{-1}$

At this Site, cancer risks to the RME individual associated with ingestion of fish are above EPA's generally acceptable levels, as shown below (see also Table 8-10). In addition, cancer risks to the average (CT) individual associated with ingestion of fish are above EPA's goal for protection (see also Table 8-11). Cancer risks from exposure to dioxin-like PCBs (*i.e.*, approximately 1×10^{-3}) were comparable to the cancer risks from the non-dioxin-like PCBs presented below for fish ingestion.

Point Estimate Cancer Risk Summary – Upper Hudson River

Pathway	CT (Average) Cancer Risk	RME Cancer Risk
Ingestion of Fish		
Adult	1×10^{-5} (1 in 100,000)	6×10^{-4} (6 in 10,000)
Adolescent	7×10^{-6} (7 in 1,000,000)	4×10^{-4} (4 in 10,000)
Young Child	1×10^{-5} (1 in 100,000)	4×10^{-4} (4 in 10,000)
Total	3×10^{-5} (3 in 100,000)	1×10^{-3} (1 in 1,000)
Exposure to Sediment*		
Baseline Recreator	2×10^{-7} (2 in 10,000,000)	2×10^{-6} (2 in 1,000,000)
Avid Recreator	1×10^{-6} (1 in 1,000,000)	9×10^{-6} (9 in 1,000,000)

**Total risk for young child (aged 1-6), adolescent (aged 7-18), and adult (over 18).*

In addition to these point estimate calculations, EPA calculated cancer risks for ingestion of fish in the Upper Hudson River using a Monte Carlo analysis. The Monte Carlo analysis, which was composed of 72 combinations of input parameters for 10,000 simulated anglers (for a total of 720,000 computer simulations), showed that EPA's RME point estimates were generally within the high-end ($\geq 90^{th}$ percentile) for cancer risks. For the cancer risk assessment, the point estimate RME value for fish ingestion (1×10^{-3}) falls approximately at the 95^{th} percentile from the Monte Carlo base case analysis. The point estimate CT (average) value (3×10^{-5}) and the Monte Carlo base case 50^{th} percentile value (6×10^{-5}) are similar. The results of the Monte Carlo analysis support the point estimate calculations.

Non-Cancer Health Hazards

The potential for non-cancer health effects is evaluated by comparing an exposure level over a specified time period (*e.g.*, 7 years) with an RfD derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a Hazard Quotient (HQ). An HQ less than 1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic non-carcinogenic effects from that chemical are unlikely. An HI represents the sum of the individual exposure levels for different chemicals and different media (*e.g.*, soil, fish) compared to their corresponding RfDs (*i.e.*, HI is the sum of HQs for an individual). The key concept of a non-cancer HI is that a threshold level (measured as an HI of 1) exists below which non-cancer health effects are not expected to occur. Under the federal Superfund program, EPA's goal for protection for non-cancer health hazards is an HI less than 1 for the RME individual.

The HQ is calculated as follows:

$$\text{Non-cancer HQ} = \text{CDI}/\text{RfD}$$

where: CDI = Chronic daily intake (mg/kg-day)
RfD = Reference dose (mg/kg-day)

CDI and RfD are expressed in the same units and represent the same exposure period (*i.e.*, chronic).

At this Site, non-cancer hazard indices to the RME individual associated with ingestion of PCBs in fish are above EPA's generally acceptable levels, as shown below (see also Table 8-12). In addition, non-cancer hazard indices to the average (CT) individual are above EPA's generally acceptable levels (see also Table 8-13). Non-cancer hazard indices for dioxin-like PCBs were not evaluated quantitatively due to EPA's ongoing evaluation of dioxin toxicity.

Point Estimate Non-Cancer Health Hazard Summary - Upper Hudson River		
Pathway	**CT (Average) Non-Cancer HI**	**RME Non-Cancer HI**
Ingestion of Fish		
Adult	7	65
Adolescent	8	71
Young Child	12	104

In addition to the point estimate calculations, EPA calculated non-cancer hazard indices for ingestion of fish in the Upper Hudson River using a Monte Carlo analysis. The analysis, which was composed of 72 combinations of input parameters for 10,000 simulated anglers (*i.e.*, 720,000 computer simulations), showed that EPA's RME point estimates were generally within the high-end ($\geq 90^{th}$ percentile) for non-cancer HI. For non-cancer HIs, the point estimate RME value for fish ingestion (104 for young children) falls between the 95^{th} and 99^{th} percentiles of the Monte Carlo base case. The point estimate CT HI (12 for young child) is approximately equal to the 50^{th} percentile for the Monte Carlo base case HI of 11. The results of the Monte Carlo analysis support the point estimate calculations.

Uncertainty

The process of evaluating human health cancer risks and non-cancer hazard indices involves multiple steps. Inherent in each step of the process are uncertainties that ultimately affect the final cancer risks and non-cancer hazard indices. Uncertainties may exist in numerous areas. Important sources of uncertainty in the HHRA are as follows:

- PCB Bioaccumulation Modeling Uncertainty. The use of a bioaccumulation model to generate future concentrations of PCBs in fish introduces uncertainty in the fish EPCs used in the HHRA calculations. EPA minimized this unavoidable source of uncertainty to the extent possible by developing a bioaccumulation model specifically for the Upper Hudson (FISHRAND), calibrating the model to the extensive database for the Upper Hudson and submitting the model to external peer review. Based on the model calibration (*i.e.*, the ability of the fish bioaccumulation model to capture the historical observed lipid-normalized PCB measurements in fish) and the feedback received during the peer review, the model uncertainty is not sufficient to change the overall conclusion of the HHRA that cancer risks and non-cancer hazard indices due to ingestion of fish are above acceptable levels. Furthermore, the sensitivity/uncertainty analysis conducted for the Monte Carlo analysis showed that this overall conclusion remains the same despite changes in the fish EPCs due to variations in the fish species caught (different species tend to have different characteristic PCB uptake) and variations in fishing location (the concentration tends to decline substantially between the upper and lower reaches of the Upper Hudson River).

- Fish Ingestion Rate. Uncertainty is associated with the fish ingestion rate. This uncertainty is unavoidable because the fish consumption advisories that are in place do not represent baseline conditions, so the surveys of anglers in the Upper Hudson River could not be used to quantify fish consumption in the absence of remediation and institutional controls. EPA minimized this source of uncertainty by using fish consumption data for freshwater bodies in New York State without specific consumption advisories taken from a 1991 New York Angler survey published in a 1992 Cornell University report by Dr. Connelly and colleagues. In addition, the sensitivity/uncertainty analysis conducted for the Monte Carlo analysis showed that, despite the use of different fish ingestion rates based on Maine, Michigan, and Lake Ontario angler surveys published in the scientific literature, the overall conclusion of the HHRA--that cancer risks and non-cancer hazard indices due to ingestion of fish are above levels of concern--remains the same. Lastly, the HHRA peer reviewers specifically evaluated the fish ingestion rate for the RME adult used in the HHRA calculations (31.9 grams/day or approximately one-half pound fish meal per week) and found it to be reasonable and consistent with the NYSDOH level of 32.0 grams/day (current general advisory by NYSDOH for years 2000-2001).

- PCB Toxicity. Toxicity values are inherently uncertain. EPA describes the uncertainty in the cancer toxicity values as extending in both directions (*i.e.*, contributing to possible underestimation or overestimation of cancer slope factors). However, the CSFs were developed to represent plausible upper bound estimates, which means that EPA is reasonably confident that the actual cancer risk will not exceed the estimated risk calculated using the CSF. The CSFs used in the HHRA were externally peer reviewed and supported by the panel of expert scientists (separately from the Hudson River peer review) and are the most current values recommended by EPA in IRIS.

Non-cancer toxicity values are also uncertain. The current oral RfDs for Aroclor 1016 and 1254, which were used in the HHRA, have uncertainty factors of 100 and 300, respectively. The RfD for Aroclor 1016 was externally peer-reviewed and supported by the panel of scientists. The RfD for Aroclor 1254 was developed using the same methodology as Aroclor 1016 and was internally peer-reviewed. Since these RfDs were developed, a number of recent national and international studies have reported possible associations between developmental and neurotoxic effects in children from prenatal or postnatal exposures to PCBs. In light of these new studies, the current RfDs are currently being evaluated as part of the IRIS process. It would be inappropriate to prejudge the results of the IRIS evaluation at this time.

- PCB Body Burden. The fact that any previous exposures (either background or past consumption of PCB-contaminated fish) may still be reflected in an individual's body burden today is an additional source of uncertainty and may result in an underestimate of non-cancer hazard indices and cancer risks.

8.2 Ecological Risk Assessment

The site-specific ERA evaluated the likelihood of current and future adverse ecological effects as a result of exposure to PCBs, as documented in the Revised ERA. The Revised ERA synthesizes into a single report the August 1999 Ecological Risk Assessment, the December 1999 Ecological Risk Assessment for Future Risks in the Lower Hudson River, their respective Responsiveness Summaries issued in March 2000 and August 2000, and the November 2000 Response to Peer Review Comments (on the August 1999 Ecological Risk Assessment).

The Hudson River has a variety of ecosystems. The Upper Hudson River is non-tidal, consists of a series of pools separated by dams and is entirely freshwater. In contrast, the Lower Hudson River is tidal, does not have dams and is freshwater in the vicinity of the Federal Dam, becoming brackish and increasingly more saline toward the Battery. Both the Upper and Lower Hudson River have deep water environments as well as shallow nearshore areas with aquatic vegetation. The Lower Hudson area has areas designated as significant habitats, which are unique, unusual or necessary for the propagation of key species. These include freshwater and brackish shallows, mudflats, marshes, swamp forests, deepwater areas and creeks.

Plants and animals in all portions of the Hudson River are natural resources and need to be protected. Habitats of the Hudson River support threatened or endangered fish, reptiles, birds, and mammals, in addition to rare, threatened and endangered plants. The bald eagle, the Karner blue butterfly and the Indiana bat are three species identified by the U.S. Fish and Wildlife Service as under their jurisdiction which could be affected by the Hudson River PCB cleanup. The shortnose sturgeon has been identified by the National Marine Fisheries Service as a federally-listed endangered species that is found in the Lower Hudson River south of the Federal Dam at Troy. The need for additional survey activities regarding these species will be addressed during the remedial design. Table 8-14 provides the listing of New York State Rare and Listed Species and Habitats occurring in the vicinity of the Hudson River. All threatened, endangered and special concern species listed in the table have been sighted in and along the Lower Hudson River, and some of them (*e.g.*, bald eagle and short-eared owl) are also found in the Upper Hudson River Valley.

This discussion emphasizes ecological risks due to PCBs in the Upper Hudson that exceed EPA's goals for protection. Ecological risks in the Lower Hudson from PCBs are generally lower than those of the Upper Hudson, due to the lower concentrations of site-related PCBs in the Lower Hudson. Nevertheless, ecological risks in the Lower Hudson are also above EPA's levels of concern.

Consistent with Superfund policy and guidance, the ERA is a baseline risk assessment and therefore assumes no actions (remediation) to control or mitigate hazardous substance releases. The following discussion summarizes the ERA with respect to the four basic steps of the Superfund ERA process: 1) Problem Formulation, 2) Exposure Assessment, 3) Effects Assessment, and 4) Risk Characterization.

8.2.1 Problem Formulation

Problem Formulation establishes the goals, breadth, and focus of the ecological risk assessment. Through Problem Formulation, the questions and issues that will be addressed are defined based on identifiable complete or potentially complete exposure pathways and ecological effects and a conceptual model is developed that illustrates the relationships among sources, pathways, and receptors.

The chemicals of concern at the Site are PCBs, including dioxin-like PCBs. Fish at the Site have been collected by the NYSDEC for more than 25 years. Fish samples have been analyzed for PCBs, total DDT, total chlordane, total endrin, total endosulfan, dieldrin, aldrin, mirex, total heptachlor, total hexachlorobenzene, toxaphene, methoxychlor, individual polycyclic aromatic hydrocarbons, cadmium, mercury, dioxins, and dibenzofurans. PCBs (total and dioxin-like) were identified as the chemicals of concern based on previous analytical results, the toxicity values for the chemicals, and the site definition (*i.e.*, the Site was placed on the Superfund NPL as a result of PCB contamination in the river).

Animals and plants living in or near the river, such as invertebrates, fish, amphibians, and water-dependent reptiles, birds, and mammals, are or can be exposed to PCBs directly and/or indirectly through the food chain. Ecological exposure to PCBs is primarily an issue of bioaccumulation through the food chain rather than direct toxicity, because PCBs bioaccumulate in the environment by bioconcentrating (being absorbed from water and accumulated in tissue to levels greater than those found in surrounding water) and biomagnifying (increasing in tissue concentrations as they go up the food chain through two or more trophic levels). As a result, the ecological risk assessment emphasizes indirect exposure at various levels of the food chain to address PCB-related risks at higher trophic levels. The ecological conceptual model is provided in Figure 8-1.

The assessment endpoints are benthic community structure, which is a food source for local fish and wildlife, sustainability (survival, growth, and reproduction) of local forage fish populations, local piscivorous fish populations and local omnivorous fish populations, and protection (survival and reproduction) of insectivorous bird and mammal populations, waterfowl populations, piscivorous bird and mammal populations and omnivorous mammal populations (see Table 8-15). The bald eagle, a federally-listed and New York State-listed threatened species, was evaluated under the assessment endpoint for piscivorous birds. Measurement endpoints were defined for each assessment endpoint.

Receptors were selected to be representative of various feeding preferences, predatory levels and habitats (aquatic, wetland, shoreline). Receptors of concern include the benthic macroinvertebrate community and seven species of fish, as represented by the pumpkinseed (Lepomis gibbosus), spottail shiner (Notropis hudsonius), brown bullhead (Ictalurus, now Ameiurus nebulosus), white perch (Morone americana), yellow perch (Perca flavescens), largemouth bass (Micropterus salmoides) and striped bass (Morone saxatilis). Five bird receptors were selected: the tree swallow (Tachycineta bicolor), mallard (Anas platyrhychos), belted kingfisher (Ceryle alcyon), great blue heron (Ardea herodias) and bald eagle (Haliaeetus leucocephalus). Four mammal receptors were selected: the little brown bat (Myotis lucifugus), raccoon (Procyon lotor), mink (Mustela vison) and river otter (Lutra canadensis).

8.2.2 Exposure Assessment

The exposure assessment includes a quantitative evaluation of contaminant release, migration, and fate; characterization of exposure parameters; and measurement or estimation of exposure point concentrations. Complete exposure pathways and exposure parameters (*e.g.*, body weight, prey ingestion rate, home range) used to calculate the concentrations or dietary doses to which the receptors of concern may be exposed were obtained from EPA references, the scientific literature and directly from researchers.

The ERA utilizes documents on the nature and extent of PCB contamination at the Site developed as part of the Reassessment RI/FS (*e.g.*, February 1997 Data Evaluation and Interpretation Report, July 1998 Low Resolution Sediment Coring Report, Database for the Hudson River PCBs Reassessment RI/FS [Release 5.0, October 2000], January 2000 Revised Baseline Modeling Report and associated responsiveness summaries). These Reassessment RI/FS documents provided both current and future (*i.e.*, forecast) concentrations of PCBs in fish, sediments and river water. A food chain model was then used to estimate receptor exposure.

- PCBs in Fish: PCB concentrations in fish (pumpkinseed, spottail shiner, brown bullhead, largemouth bass, yellow perch and white perch) were based on measured wet-weight PCB concentrations in the sampling database and modeled concentrations generated by EPA's peer-reviewed bioaccumulation model, FISHRAND, for the period 1993 to 2018. Concentrations of PCBs in striped bass were estimated from the FISHRAND results for largemouth bass by applying a ratio of striped bass to largemouth bass body burdens as measured in the fish sampling database. Average concentrations of PCBs measured in fish in 1998 (converted to Tri+ PCBs) range from 41.25 mg/kg for carp in the Stillwater reach of the Upper Hudson (RM 168-178) to 1.16 mg/kg for yellow perch below the Federal Dam at Troy (RM 142-153.2) (see Table 8-16).

- PCBs in Birds: The U.S. Fish and Wildlife Service has analyzed PCB concentrations in tree swallow eggs and nestlings collected in 1994 and 1995 and is currently analyzing samples from tree swallows, great blue herons, bald eagles, and bald eagle prey collected by the U.S. Fish and Wildlife Service and New York State Department of Environmental Conservation in 1997-1999 (see Table 8-17). Tree swallow egg total PCB concentration averages in 1994 range from 42.1 mg/kg at location SA13 to 6.28 mg/kg at Lock 9. Scientific papers published in peer reviewed journals summarized the two years of study. Tree swallow egg total PCB concentrations averaged between the two years of sample collection range from 29.5 mg/kg at location SA13 to 5.904 mg/kg at Locks 8 and 9 of the Champlain Canal. Nestling PCB concentrations averaged between 1994 and 1995 range from 62.2 mg/kg at location REMN to 0.721 mg/kg at Locks 8 and 9 of the Champlain Canal. Average concentrations of total PCBs in nestlings in 1994 range from 55.8 mg/kg at location SA13 to 0.377 mg/kg at Lock 9. Bald eagle eggs collected from the Lower Hudson River in 1998 and 1999 contain between 62 mg/kg and 20 mg/kg PCBs. Plasma collected from Lower Hudson River bald eagles from 1997 through 1999 contained PCB concentrations ranging from 14.2 mg/kg to 0.214 mg/kg.

- PCBs in Sediment: PCB concentrations in surface sediment (0 to 5 cm) were based on 1993 measured concentrations and modeled concentrations generated by EPA's peer-reviewed PCB fate and transport model, HUDTOX, for the period 1993 to 2018. The 95% upper confidence limit on the mean (UCLM) Tri+ PCB concentrations measured in sediment in 1993 range from 54.17 mg/kg at Stillwater in the Upper Hudson (RM 168) to just above 1 mg/kg at RM 122.4 in the Lower Hudson (see Table 8-18).

- PCBs in River Water: PCB concentrations in river water were based on measured concentrations in the Reassessment database as well as modeled concentrations generated by HUDTOX. The 95% UCLM Tri+ PCB concentrations measured in the Upper Hudson water column were 2.33E-04 mg/L in Thompson Island Pool (RM 189), 4.15E-4 mg/L at Stillwater (RM 168) and 1.96E-4 mg/L at the Federal Dam (RM 154). The 95% UCLM Tri+ PCB concentrations measured in Lower Hudson water were 7.70E-4 mg/L at the upper end of the Lower Hudson (RM 137.2-143.5) and just under 9.5E-5 mg/L at the lower end of the Lower River. Table 8-19 presents the average and 95% UCLM concentrations of Tri+ PCBs in the Upper and Lower Hudson river water.

- PCBs in Benthic Invertebrates: PCB concentrations in benthic invertebrates were based on 1993 measured concentrations. The 95% UCLM Tri+ PCB concentrations measured in benthic invertebrates in 1993 range from about 46 mg/kg at Stillwater in the Upper Hudson (RM 168) to just less than 1 mg/kg in portions of the Lower Hudson (see Table 8-20).

Subsequent to the release of the ERA, in April 2001 NYSDEC announced preliminary findings of studies of wild mink, river otter and shrew in the Upper Hudson River Valley. NYSDEC stated that these studies raise concerns about the health of wildlife resulting from the PCB contamination in the river. The studies show elevated levels of PCBs in mink and otter that live near the river, with an average PCB level in river otter within 10 kilometers of the Upper Hudson River of 172 mg/kg on a lipid based PCB concentration in the liver and an average level for mink within one kilometer of the river of 33 mg/kg on a lipid based PCB concentration in the liver. The results for mink are comparable to those of NYSDEC's last Hudson River mink survey, which was conducted in 1982-1984. NYSDEC reported that the PCB levels also are similar to concentrations found in fish in the Hudson River, which have not dropped significantly since the mid-1980s. Based on scientific research of mink and European otters, NYSDEC determined that the PCB levels found in Upper Hudson River mink and otter may cause adverse health effects and reproductive problems in these animals.

8.2.3 Effects Assessment

PCBs have been shown to cause lethal and sub-lethal reproductive, developmental, immunological and biochemical effects. The risk assessment limited its focus to adverse impacts on survival, growth and reproduction. The ecological effects assessment includes literature reviews, field studies and toxicity tests that correlate concentrations of PCBs to effects on ecological receptors. Toxic equivalency factors, based on the toxicity of dioxin, have been developed for the dioxin-like PCB congeners.

Toxicity reference values (TRVs) were used to estimate the potential for ecological risk at the Site as a result of exposure to PCBs (see Revised ERA tables 4.25a-b, 4.26a-b, and 4.27a-b) for fish, birds, and mammals, respectively. TRVs were selected based on Lowest Observed Adverse Effects Levels (LOAELs) and/or No Observed Adverse Effects Levels (NOAELs) from laboratory and/or field based studies reported in the scientific literature. LOAELs are the "lowest" values at which adverse effects have been observed, and NOAELs are the highest dose or body burden at which an adverse effect was not observed. These TRVs reflect the effects of PCBs and dioxin-like PCB congeners on the survival, growth, and reproduction of fish and wildlife species in the Hudson River. Reproductive effects (*e.g.*, egg maturation, egg hatchability and survival of juveniles) were generally the most sensitive endpoints for animals exposed to PCBs.

8.2.4 Risk Characterization

This final step in the ERA combines the exposure and toxicity information to provide a quantitative assessment of site risks to ecological receptors at various trophic levels. Risks were estimated by comparing the results of the Exposure Assessment (measured or modeled concentrations of PCB in receptors of concern) to the TRVs developed in the Effects Assessment. The ratio of these two numbers is called a Toxicity Quotient (TQ). TQs equal to or greater than 1 are typically considered to indicate potential risk to ecological receptors.

The risk characterization indicates that receptors in close contact to the Upper and Lower Hudson River are above EPA's level of concern as a result of exposure to PCBs. For example, as shown below and in Tables 8-21, 8-22, 8-23, and 8-24, TQs for the river otter and mink in River Section 1 (RM 189) are significantly above one, on both a NOAEL and a LOAEL basis, for the entire forecast period (*i.e.*, beginning in 1993 and ending in 2018). The TQs for the river otter in River Section 3 (RMs 168 and 154) and in the Lower Hudson River (RMs 152, 113, 90, and 50) are all greater than one for the entire forecast period.

Toxicity Quotients (TQs) for Dietary Dose
Upper Hudson River - Thompson Island Pool (RM 189)

Receptor & Year	Tri+ PCBs		Dioxin-like PCBs	
	NOAEL	LOAEL	NOAEL	LOAEL
River Otter				
1993	1329	133	3003	107
2018	246	25	554	20
Mink				
1993	257	26	737	26
2018	65	6.5	171	6.1

In addition to the point estimate calculations, EPA calculated toxicity quotients for representative ecological receptors in a probabilistic dose response analysis. The probabilistic dose response analysis for the river otter showed, for example, in 2015 female otters at RM 189 have a greater than 80 percent probability of experiencing a substantial (greater than 80 percent) decrease in fecundity. At RM 154, female otters have a 30 percent probability of experiencing at least a 50 percent reduction in fecundity. The probabilistic dose response analysis showed similar, but somewhat less severe, effects for the mink. For example, in 2015, female mink at RM 189 have a greater than 95 percent probability of experiencing a substantial (greater than 50 percent) reduction in fecundity.

The major findings of the ERA are:

- Birds and mammals that eat PCB-contaminated fish from the Hudson River, such as the bald eagle, belted kingfisher, great blue heron, mink and river otter are at risk at the population level. PCBs may adversely affect the survival, growth, and reproduction of these species. Piscivorous mammals, represented by the river otter, are at the greatest risk due to their feeding patterns.

- Fragile populations of threatened and endangered species, represented by the bald eagle, are particularly susceptible to adverse effects from PCB exposure.

- Piscivorous fish (*e.g.*, largemouth bass and striped bass) and omnivorous fish (*e.g.*, brown bullhead and shortnose sturgeon) in the Hudson River may be adversely affected (*i.e.*, reduced survival, growth and/or reproduction) from exposure to PCBs.

- Omnivorous animals, such as the raccoon, that derive a large portion of their food from the Hudson River may be adversely affected (*i.e.*, reduced survival, growth, and/or reproduction) from exposure to PCBs.

- Birds and mammals that feed on insects with an aquatic stage spent in the Hudson River, such as the tree swallow and little brown bat, may be adversely affected (*i.e.*, reduced survival, growth and/or reproduction), particularly insectivorous mammals living in the Thompson Island Pool area.

- The risks to fish and wildlife are greatest in the Upper Hudson River (in particular the Thompson Island Pool) and decrease in relation to PCB concentrations down river. Based on modeled future PCB concentrations, piscivorous species are expected to be at considerable risk through 2018 (the entire forecast period).

- PCB concentrations in water and sediments in the Upper and Lower Hudson River generally exceed standards and criteria and guidelines established to be protective of the environment.

- Forage fish, such as the pumpkinseed and spottail shiner, are unlikely to be affected outside of the Thompson Island Pool.

- Waterfowl, excluding piscivorous birds, feeding on animals and plants in the Hudson River are unlikely to be adversely affected (*i.e.*, reduced survival, growth and/or reproduction) from exposure to PCBs.

Uncertainty

The process of evaluating ecological risks involves multiple steps. Inherent in each step are uncertainties that ultimately affect the final calculated risks. Important sources of uncertainty in the ERA are as follows:

- PCB Bioaccumulation Modeling Uncertainty: The use of a bioaccumulation model to generate future concentrations of PCBs in fish introduces uncertainty. As noted for the HHRA, EPA took steps to minimize this unavoidable source of uncertainty to the extent possible. Model uncertainty is not sufficient to change the overall conclusion that birds and mammals that eat fish from the Hudson River are at risk above levels of concern.

- Exposure Uncertainty: Uncertainty in the exposure assessment is present due to a lack of complete knowledge regarding exposure, such as the ingestion rates of contaminated prey by receptor species. This source of uncertainty was reduced by applying the most local diet information available (*e.g.*, data for NYS populations where Hudson River data were not available), using median values and contacting researchers directly to determine appropriate exposure parameters.

- Toxicological Uncertainty: There is uncertainty associated with the selection of the TRVs. To minimize this uncertainty, EPA reviewed and summarized hundreds of studies of the effects of PCBs on animals, including a wide variety of laboratory and field based studies that examined a variety of test species, doses, exposures, instruments and analytical methods prior to selection of the final TRVs. In addition, EPA quantitatively examined the uncertainty associated with interspecies variability in sensitivity to PCBs by developing alternative TRVs for some Hudson River receptor species. Uncertainty associated with the toxicity of dioxin-like PCBs was reduced by developing TRVs based on the toxicity of individual PCB congeners rather than on the toxicity of 2,3,7,8,-TCDD (dioxin).

Despite the uncertainty, the sensitivity and uncertainty analyses conducted in the ERA showed that, even at the 5th percentile, TQs for bald eagle egg, kingfisher egg, mink and river otter do not fall below 1 for any location or year, except for mink at RM 154 in 2015. Therefore, ecological risk remains above levels of concern under the federal Superfund program.

Basis for Action

The excess cancer risk and non-cancer health hazards associated with human ingestion of fish, as well as the ecological risks associated with ingestion of fish by birds, fish and mammals, are above acceptable levels under baseline conditions. The response action selected in this ROD is necessary to protect the public health or welfare and the environment from actual releases of hazardous substances into the environment.

9. REMEDIAL ACTION OBJECTIVES

Consistent with the NCP and RI/FS Guidance, EPA developed remedial action objectives (RAOs) for protection of human health and the environment. RAOs specify the contaminants and media of concern, exposure routes and potential receptors, and an acceptable concentration limit or range for each contaminant for each of the various media, exposure routes and receptors. RAOs were then used to establish specific preliminary remediation goals (PRGs) for the Site. PRGs were established after review of both the preliminary chemical-specific ARARs and risk-based concentrations and serve to focus the development of alternatives or remedial technologies that can achieve the remedial goals.

9.1 Remedial Action Objectives

RAOs address the protection of human health and protection of the environment. The following five RAOs have been established for the Hudson River PCBs site.

- ***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.***

  The risk-based PRG for the protection of human health is 0.05 mg/kg PCBs in fish fillet based on non-cancer hazard indices for the RME adult fish consumption rate of one half-pound meal per week (this level is protective of cancer risks as well). Other target concentrations are 0.2 mg/kg PCBs in fish fillet, which is protective at a fish consumption rate of one half-pound meal per month and 0.4 mg/kg PCBs in fish fillet, which is protective of the CT or average angler, who consumes one half-pound meal every two months. Attaining such levels might facilitate the relaxation of the fish consumption advisories and fishing restrictions *(e.g.,* the "eat none" advisory for the Upper Hudson could be relaxed as conditions improve).
- ***Reduce the risks to ecological receptors by reducing the concentration of PCBs in fish.***

  The risk-based PRG for the ecological exposure pathway is a range from 0.3 to 0.03 mg/kg PCBs in fish (largemouth bass, whole body), based on the LOAEL and the NOAEL for consumption of fish by the river otter. The ecological PRG is considered protective of all the ecological receptors evaluated because it was developed for the river otter, the piscivorous mammal 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 NOAEL and LOAEL for the mink, which is a species known to be sensitive to PCBs. Other species, such as the bald eagle, were considered but are at less risk than the river otter.

- ***Reduce PCB levels in sediments in order to reduce PCB concentrations in river (surface) water that are above surface water ARARs.***

  The ARARs for surface water are: 0.5 μg/L [500 ng/L] total PCBs, the federal maximum contaminant level (MCL) for drinking water; 0.09 μg/L [90 ng/L] total PCBs, the New York State standard for protection of human health and drinking water sources; 1 ng/L total PCBs, the federal Ambient Water Quality Criterion; 0.12 ng/L total PCBs, the New York State standard for protection of wildlife; 0.001 ng/L total PCBs, the New York State water quality standard for the protection of the health of human consumers of fish; 0.014 μg/L [14 ng/L] total PCBs, the criteria continuous concentration (CCC) Federal Water

Quality Criterion (FWQC) for freshwater; and 0.03 μg/L [30 ng/L] total PCBs, the CCC FWQC for saltwater.

- ***Reduce the inventory (mass) of PCBs in sediments that are or may be bioavailable.***

  PCBs in sediments may become bioavailable by various mechanisms (*e.g.*, groundwater advection, pore water diffusion, scour, benthic food chains, etc.). Reducing the inventory of PCBs in sediments that are susceptible to such mechanisms will ultimately reduce PCB levels in fish and the associated risks to human health and the environment.

- ***Minimize the long-term downstream transport of PCBs in the river.***

  PCBs that are transported downstream in the water column are available to biota, contributing to the risks from the Site. Downstream transport also moves PCBs from highly contaminated areas to lesser contaminated or clean areas, and from the Upper Hudson River to the Lower Hudson River.

There are no federal or New York State cleanup standards for PCBs in sediment. Although there is no specific PRG for sediment, the concentrations in biota are driven by exposure to PCBs in both the water and sediment through the aquatic and benthic food chains, respectively. In addition, current and future concentrations of PCBs in the water column entering the Upper Hudson River are expected to limit the ability of remedial actions to achieve the site-specific PRGs for PCBs in species-weighted fish, as described above.

EPA has adopted the PRGs identified above as the final Remediation Goals for the Site.

9.2 Applicable or Relevant and Appropriate Requirements (ARARs)

Under the description of ARARs set forth in the NCP and CERCLA, many federal and state environmental requirements must be considered. ARARs and "To-Be-Considered" requirements (TBCs) fall into three broad categories, based on the manner in which they are applied at a site. These include chemical-specific, location-specific and action-specific requirements. These categories are described as follows:

Chemical-specific: These are health- or risk-based numerical values or methodologies that establish concentration or discharge limits, or a basis for calculating such limits, for particular contaminants. Chemical-specific ARARs for total PCBs in the water column are:

- 0.5 ug/L [500 ng/L] (federal MCL);
- 0.09 ug/L [90 ng/L] (NYS standard for protection of human health and drinking water sources);
- 0.03 µg/L [30 ng/L] criteria continuous concentration (CCC) Federal Water Quality Criterion (FWQC) for saltwater;
- 0.014 µg/L [14 ng/L] CCC FWQC for freshwater;
- 1 ng/L (federal Ambient Water Quality Criterion);
- 0.12 ng/L (NYS standard for protection of wildlife); and
- 0.001 ng/L (NYS standard for protection of human consumers of fish).

If more than one such requirement applies to a contaminant, compliance with the more stringent ARAR is required. No ARARs were identified for the cleanup of contaminated river sediments.

Location-specific: These are restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations such as wetlands, floodplains and habitats of endangered species. Examples of man-made features potentially affected include historic districts and archaeological sites. Remedial action alternatives may be restricted or precluded depending on the location or characteristics of a site and the requirements that apply to it.

Action-specific: Action-specific requirements set controls or restrictions on particular kinds of activities related to the management of hazardous substances, pollutants, or contaminants, and are primarily used to assess the feasibility of remedial technologies and alternatives. Examples of action-specific ARARs include Resource Conservation and Recovery Act (RCRA) monitoring requirements and TSCA disposal requirements.

Chemical-specific, location-specific, and action-specific ARARs and TBCs are all considered in the development and evaluation of remedial alternatives. ARARs and TBCs that may be applicable to various remedial alternatives at this Site were identified in the FS. TBCs are non-promulgated criteria, advisories, guidance, and proposed standards issued by federal or state governments. TBCs are not potential ARARs because they are neither promulgated nor enforceable, although it may be necessary to consult TBCs to interpret ARARs, or to determine preliminary remediation goals when ARARs do not exist for particular contaminants, or are not sufficiently protective. Compliance with TBCs is not mandatory, as it is for ARARs, though ARARs may be waived in certain circumstances.

According to CERCLA Section 121(d)(4), an ARAR may be waived by EPA, provided protection of human health and the environment is still achieved, under the following six specific conditions:

- The selected remedial action is only part of a total remedial action that will attain such ARAR when completed;
- Compliance with such ARAR will result in greater risk to human health and the environment than alternative options;
- Compliance with such ARAR is technically impracticable from an engineering perspective;
- The selected remedial action will attain a standard of performance that is equivalent to that required under the given ARAR, through use of another method or approach;
- The requirement is a state requirement that has been inconsistently applied in similar circumstances at other remedial actions within the state; or
- For Superfund-financed remedial actions only, attainment of the ARAR would not provide a balance between the need for protection of public health and welfare and the environment at the facility under consideration, and the availability of money from the Fund to respond to other sites that pose a threat, taking into account the relative immediacy of such threats.

Compliance with or waiver of ARARs at this Site is discussed in Sections 11.2 and 14.2 below.

9.3 Effect of Other PCB Sources on Attaining Remediation Goals

Current and future concentrations of PCBs in the water column entering the Upper Hudson River are expected to limit the ability of remedial actions to achieve the stringent Remediation Goals for fish and some of the ARARs for the water column that have been identified for the Site. The upstream (north of Rogers Island) Tri+ PCB load, currently an average of about 13 ng/L, is expected to be reduced by further source control work near the GE Hudson Falls plant to be conducted by GE under NYSDEC authorities. For purposes of its mathematical modeling during the Reassessment RI/FS, EPA has assumed that such source control will lower the upstream load to an average of 2 ng/L Tri+ PCB beginning January 1, 2005. Whether that level will be attained, and whether an even greater reduction is possible -- thus making achievement of the PRGs easier -- is not yet clear.

Both the current and projected future combined upstream PCB load (Rogers Island below Hudson Falls but upstream of the *hot spots*), although low, exceeds the New York State standard for protection of human consumers of fish (0.001 ng/L total PCBs), the New York State standard for protection of wildlife (0.12 ng/L total PCBs), and the federal Ambient Water Quality Criterion (AWQC) (1 ng/L total PCBs). However, it does not exceed the New York State standard for protection of human health and drinking water sources (0.09 µg/L total PCBs), the federal MCL (0.5 µg/L total PCBs) for potable drinking water supplies, the 0.03 µg/L (30 ng/L) CCC FWQC for saltwater, and the 0.014 µg/L (14 ng/L) CCC FWQC for freshwater.

Over the long term, concentrations of PCBs in the surface sediments and the water column will trend toward equilibrium. As long as a non-zero PCB load exists in the upstream water column, sediment concentrations in the Upper Hudson will also be non-zero, even if the contaminated sediments were to be fully remediated. The upstream boundary load will result in non-zero PCB concentrations in fish (see Section 13.4). EPA has determined, however, that the selected remedy will significantly reduce the risks to human health and the environment at the Site.

10. DESCRIPTION OF ALTERNATIVES

Following development of the RAOs, EPA conducted a rigorous screening and evaluation process in accordance with CERCLA and the NCP. First, potentially applicable remedial technologies or process options for addressing PCB-contaminated sediments in the Upper Hudson were identified and screened (evaluated) based on effectiveness and technical implementability at the Site. Retained technologies were then evaluated in a second screening based on effectiveness, implementability and cost. After the second screening, the following four technologies were retained for consideration in the analysis of remedial alternatives : 1) no action, evaluation of which is required by the NCP; 2) MNA; 3) capping followed by MNA; and 4) removal/dredging (*i.e.*, environmental dredging) followed by MNA.

Process options for treatment and disposal that were retained include near-river treatment, off-site disposal, and beneficial use of dredged materials. During the screening analysis, EPA determined that it would not be administratively feasible to dispose of dredged sediments in a locally-sited landfill. As a result, EPA eliminated near-river disposal of dredged sediments from further consideration. Treatment technologies, such as thermal desorption, were determined to be technically feasible but were not retained because of their high cost, and a locally-sited thermal treatment facility was not expected to be administratively feasible.

After the technology screening, EPA developed and screened remedial alternatives. A specified “cleanup value” for PCBs in sediment was not developed for purposes of evaluating remedial alternatives. Because consumption of fish is the major pathway of concern, EPA developed remedial goals based on PCB concentrations in fish (see Section 9). Therefore, EPA evaluated remedial alternatives based on their ability to reduce PCB concentrations in fish. PCB concentrations in fish are controlled by PCB concentrations in both the sediment and the water column and, therefore, sediment cleanup is considered the means to the goal of protecting human health and the environment.

For the active technologies (capping and removal), areas of sediment targeted for remediation were selected based on the potential for those areas to contribute PCBs to the water column and fish through the food chain. The delineation of the target areas considered a number of factors, primarily the inventory of PCBs in the sediment, but also surface sediment concentrations, sediment texture, bathymetry and depth at which the PCB contamination is found. Areas where 12 inches or greater of relatively clean surface sediment exist were eliminated from consideration. Target areas for remediation were defined as approximately 50,000 square feet (a little over an acre) or greater, due to practical limitations on the number of separate remediation zones that could be accommodated for a project of this size. In addition, rocky areas, as defined by side-scan sonar, were excluded from consideration due to the difficulty of remediating rocky areas. Moreover, rock outcrop areas generally do not contain much sediment.

Due to the high variability of PCB concentrations in sediment, mass per unit area (MPA), rather than concentration, was identified as the most useful measure of the potential contribution of an area to PCB concentrations in water and fish. MPA measurements (*i.e.*, grams of PCBs per square meter) indicate the total mass of PCBs within the sediment. An example MPA calculation is provided in Figure 10-1. MPA was plotted against areas of cohesive and non-cohesive sediment for the Thompson Island Pool (and against PCB mass remediated) to determine breakpoints where a small change in MPA would mean a large increase in sediment area or mass to be remediated. This provides an evaluation of the efficiency of remediation by comparing the mass of PCBs remediated to the amount of the sediment surface that would require remediation. Breakpoints were found at approximately 3 g/m^2 Tri+ PCBs and 10 g/m^2 Tri+ PCBs.

The preliminary evaluation of alternatives included MNA (no sediment remediation) with additional source control in the vicinity of the GE Hudson Falls plant, and remediation of sediment with 10 g/m^2 Tri+ PCBs, 3 g/m^2 Tri+ PCBs, and 0 g/m^2 (full section) Tri+ PCBs in River Sections 1 and 2. In River Section 3, only 10 g/m^2 Tri+ PCBs and 3 g/m^2 Tri+ PCBs were considered. The 0 g/m^2scenario was not considered for River Section 3 because it would have required remediation of an unreasonably large area (over 2,800 acres).

EPA used its peer-reviewed models, HUDTOX and FISHRAND, to evaluate the extent to which remediation of different breakpoint target levels in sediment reduced the PCB concentrations in fish. The model results showed that remediation of sediment in River Section 1, the Thompson Island Pool, had the greatest benefit with respect to reducing PCB concentrations in fish. Remediation of sediment in River Section 2 also showed substantial reductions. However, the model results did not show substantial reductions in PCB concentrations in fish from remediation of sediment in River Section 3. EPA determined that the models were likely insensitive to sediment remediation in River Section 3, due to the spatial scale of the model in that river section.

Because the models are not sensitive to remediation in River Section 3, EPA also considered the historical data for River Section 3, which show increased PCB concentrations in the water column resulting from tributary high flow events that caused scour in the main part of the Hudson. EPA identified certain select areas in River Section 3 for remediation, specifically NYSDEC *Hot Spots* 36, 37, and the southern portion of *Hot Spot* 39, based on PCB inventory and signs of potential loss of PCB inventory. For example, a comparison of 1977 and 1994 sediment data showed that over two thirds of the PCB inventory was lost from *Hot Spot* 37. EPA recognized that additional sampling would need to be conducted during remedial design to determine whether other areas in River Section 3 have high PCB concentrations and the potential for loss to the water column or uptake by biota.

EPA performed preliminary modeling, engineering modeling and refined engineering modeling of more than 50 different capping or removal alternatives, including model runs that tested the sensitivity to different assumptions for the upstream boundary condition. Details regarding these modeling results are provided in the FS. For this document, the terms "dredging" or "removal" mean environmental dredging.

Based on its review of all the model results and in consideration of the geochemical analyses and historical data for the Site, EPA selected five remedial alternatives for detailed analysis: No Action, MNA, CAP-3/10/Select, REM-3/10/Select and REM-0/0/3. This limited number of alternatives covers a range of viable approaches to remedial action and includes a no-action alternative, which is required by the NCP. Pertinent information regarding each of the five alternatives is summarized below (see also Table 10-1).

10.1 Description of Remedy Components

Each of the five alternatives is presented with its respective cost and time frame to construct. The cost figures include both capital costs associated with performing the remedial work and the costs associated with any long-term operation and maintenance (O&M) of the alternative. The present-worth costs are calculated using a discount rate of seven percent and a 30-year time interval for O&M. In this document, present-worth costs are rounded to the nearest ten million dollars (with the exception of Alternatives 1 and 2).

The construction time frames represent the estimated time required for mobilization, operation and demobilization of the remedial work, but do not include the time required for long-term monitoring or O&M.

Further, the time frames do not include the time required to design the remedy or procure contracts for design and construction, or the time period that might be associated with any negotiation with the potentially responsible party for the performance of the remedy.

Alternative 1: No Action (no Upstream Source Control)

Estimated Capital Costs: $0
Operation and Maintenance Costs: $140,000 (present-worth)
Present-Worth Cost: $140,000
Construction Time: 0 Years

The No Action alternative consists of refraining from the active application of any remediation technology to sediments in all three sections of the Upper Hudson River. The No Action alternative also does not assume any source control action near the GE Hudson Falls plant, any administrative actions (including institutional controls, such as fish consumption advisories and fishing restrictions, which are considered to be limited action under the NCP), and any monitoring. A review of Site conditions would be conducted at five-year intervals, as required by CERCLA. The estimated monitoring cost per event is approximately $77,000. Over a 30-year period, six such events would be completed.

Alternative 2: Monitored Natural Attenuation (MNA) with Upstream Source Control

Capital Cost: $417,000
Operation and Maintenance Costs: $38,000,000 (present-worth)
Present-Worth Cost: $39,000,000
Construction Time: 0 Years

The Monitored Natural Attenuation (MNA) alternative relies on naturally occurring attenuation processes to reduce the concentration of PCBs in the Upper Hudson River sediments and assumes a separate source control action near the GE Hudson Falls plant. Natural attenuation processes may include biodegradation, biotransformation, bioturbation, diffusion, dilution, adsorption, volatilization, chemical reaction or destruction, resuspension, downstream transport, and burial by cleaner material. Long-term monitoring would be conducted in sediments, in the water column, and in fish to confirm that contaminant reduction is occurring and that the reduction is achieving Remedial Action Objectives.

Monitoring will include measurements of PCB concentrations in river water, dated sediment cores, PCB inventory in sediment, sediment physical properties (geophysics), and bioaccumulation in resident fish. Reductions in PCB concentrations and the PCB inventory could be documented by historical trends or PCB concentration distributions that show a reduction in the total mass of PCBs in sediments, water and/or biota, or by the presence of degradation products in sediments. The monitoring data would also be used as input parameters in the mathematical models to evaluate progress of the natural attenuation processes against the original predictions.

Institutional controls would be implemented as long-term control measures as part of the MNA alternative, including continuation of fish consumption advisories and fishing restrictions, which are currently in place.

The present-worth cost does not include any capital cost nor any O&M costs associated with source control actions (proposed by GE) at the Hudson Falls plant. The capital cost associated with MNA includes the costs of developing and running the mathematical models; this cost is included with alternatives 3, 4 and 5 as well because they contain MNA as a necessary component. A review of Site conditions would be conducted at five-year intervals, as required by CERCLA.

Alternative 3: CAP 3/10/Select - Capping, with Removal to Accommodate Cap, followed by MNA, with Upstream Source Control

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Capital Cost: $344,000,000
Operation and Maintenance Costs: $24,000,000
(present-worth)
Present-Worth Cost: $370,000,000
Construction Time: 6 Years
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This alternative includes remediation by capping (after removal of more than 1.73 million cubic yards of sediment in areas that either cannot be capped (navigation channels) or require sediment removal to allow for placement of the cap) of sediments based primarily on an MPA of 3 g/m^2 Tri+ PCBs or greater in River Section 1, sediments based primarily on an MPA of 10 g/m^2 Tri+ PCBs or greater in River Section 2 and selected sediments with high concentrations of PCBs and potential for scour in River Section 3 (NYSDEC *Hot Spots* 36, 37 and the southern portion of 39).

This alternative includes sediment removal in the navigation channel, as necessary, to allow for implementation of the remediation and allow normal boat traffic during remediation. The total area of sediments to be remediated is 493 acres, of which approximately 207 acres would be capped. The estimated volume of sediments to be removed is 1.73 million cubic yards. It would take approximately 3 years to design and 6 years (assuming a phased implementation approach for CAP-3/10/Select; see Section 11.5 below) to implement this remedy. This alternative assumes a separate source control action near the GE Hudson Falls plant and also relies on naturally occurring attenuation processes to reduce the concentration of the remaining PCBs in the Upper Hudson River sediments after the construction is completed. A review of Site conditions would be conducted at five-year intervals, as required by CERCLA.

Capping involves placement of an engineered cap consisting of low permeability material on top of the PCB-contaminated sediment. A layer of fill is placed on top of the cap. The low permeability material limits scour or other flow-related erosion, prevents or retards the movement of contaminated pore water into the water column and minimizes exposure of benthic organisms to the PCB-contaminated sediments. The likely process option for containment is the use of a manufactured product consisting of a composite of gravel particles encapsulated with bentonite (AquaBloktm or a similar material).

The cap (containment layer) would be designed to have a high probability of withstanding damage from ice scour and navigational incidents, as well as erosion due to normal or storm-induced flows, without exposing the high concentrations of PCBs that currently exist in the surface sediments at some locations.

A 6-inch benthic substrate layer would be placed on top of the containment layer to prevent bioturbation of the cap material and to serve as a clean habitat for the benthic organisms to repopulate. This material would also serve as a sacrificial layer in the event of erosion or damage, possibly allowing repairs to be conducted before further damage occurs. Placement of 18 inches (1.5 feet) of capping material over the existing surface, especially in shallower areas, could affect the hydraulics of the river, as well as actually move the shoreline toward the channel by as much as 25 to 50 feet in some areas. Therefore, in order to prevent changing the configuration of the river, 1.5 feet of sediment would be removed prior to the placement of the cap in shallow areas. Sediment removal would be accomplished with similar equipment described for the removal alternatives below.

Production rates and sediment processing facilities would be similar to other removal alternatives, but with appropriate quantity changes. In shallower areas with less than three feet of water, an appropriate dredge type (*e.g.*, shallow hydraulic dredge mounted on a pontoon) would be used.

After construction is completed, this alternative relies on institutional controls, such as the fish consumption advisories and fishing restrictions, and perhaps restrictions on activities that could compromise the integrity of the cap, and MNA in areas not remediated until the Remedial Action Objectives are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that thicknesses of the cap and backfill were maintained and that the river was responding with reduced contamination levels over the long run, and to assess the effectiveness of the cap with natural attenuation processes toward achieving the Remedial Action Objectives.

If any portion of the cap became eroded, it would require replacement. As with Alternative 2, the present-worth cost does not include any capital cost or O&M costs associated with source control actions near the GE Hudson Falls plant. If some of the dredged sediment could be given a beneficial use, substantial cost savings could be realized through reduced transportation and disposal fees.

Alternative 4: REM-3/10/Select - Removal followed by MNA, with Upstream Source Control

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Capital Cost: $448,000,000
Operation and Maintenance Costs: $13,000,000
(present-worth)
Present-Worth Cost: $460,000,000
Construction Time: 6 Years
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This alternative includes remediation by removal of sediments based primarily on an MPA of 3 g/m^2 Tri+ PCBs or greater in River Section 1, removal of sediments based primarily on an MPA of 10 g/m^2 Tri+ PCBs or greater in River Section 2 and removal of selected sediments with high concentrations of PCBs and potential for scour in River Section 3 (NYSDEC *Hot Spots* 36, 37, and the southern portion of 39). This alternative also includes sediment removal in the navigation channel as necessary to allow for implementation of the remedy. The total area of sediments targeted for removal is approximately 493 acres. The estimated volume of sediments to be removed is 2.65 million cubic yards, which is estimated to contain 70,000 kg (about 150,000 lbs) of total PCBs. It would take approximately 3 years to design and 6 years to implement this remedy (assuming a phased implementation approach for REM-3/10/Select) .

This alternative assumes a separate source control action near the GE Hudson Falls plant. After construction is completed, this alternative relies on institutional controls, such as the fish consumption advisories and fishing restrictions (although perhaps in a modified form), and MNA until the RAOs are achieved. A review of Site conditions would be conducted at five-year intervals (after remediation), as required by CERCLA.

Subsequent to removal, approximately one foot of backfill will be placed where appropriate over the dredged areas, which would cover residual PCBs thereby reducing the available PCB concentration at the surface and providing an appropriate substrate for biota. In addition, the backfill will help stabilize bank areas after dredging and minimize hydraulic changes to the river. During remedial design, the appropriateness of eliminating the placement of clean backfill in certain targeted areas will be assessed (*e.g.*, nearshore fish habitat areas that have become silted-in over time may be better mitigated by not adding clean backfill and leaving a deeper water habitat). EPA will remain flexible regarding the most appropriate means for restoring dredged areas and will provide the State, other natural resource trustees and the public opportunity to provide input on this issue. The source(s) of the backfill will be determined during the remedial design and construction.

As with Alternatives 2 and 3, the present-worth cost does not include the capital cost or O&M costs associated with source control actions (proposed by GE) at Hudson Falls. The costs are based on the utilization of mechanical environmental dredging techniques and equipment (costs for hydraulic environmental dredging were in the same range -- although slightly higher). The remedy does not specify the type(s) of environmental dredges to be used, so that there is flexibility in remedial design. In addition, if some of the dredged sediment could be given a beneficial use, substantial cost savings could be realized through reduced transportation and disposal fees.

Long-term monitoring would be conducted in sediments, in the water column, and in fish to confirm that contaminant reduction is occurring and that the reduction is achieving Remedial Action Objectives. The monitoring data would also be used as input parameters in the mathematical models to evaluate progress of the natural attenuation processes against the original predictions.

Alternative 5: REM-0/0/3 - Removal followed by MNA, with Upstream Source Control

Capital Cost: $556,000,000
Operation and Maintenance Costs: $13,000,000 (present-worth)
Present-Worth Cost: $570,000,000
Construction Time: 8 Years

This alternative includes Full Section remediation by removal in River Sections 1 and 2 and removal of sediments based primarily on an MPA of 3 g/m^2 Tri+ PCBs or greater in River Section 3. This alternative also includes sediment removal in the navigation channel, as necessary, to allow for the implementation of the remedy. The total area of sediments targeted for removal is approximately 964 acres. The volume of sediments to be removed is estimated to be 3.82 million cubic yards which is estimated to contain more than 84,000 kg (about 185,000 lbs) of total PCBs. It would take approximately 3 years to design and 8 years (assuming a phased implementation approach for REM-0/0/3) to implement this remedy. This alternative assumes a separate source control action near the GE Hudson Falls plant.

Subsequent to removal, approximately one foot of backfill will be placed where appropriate over the dredged areas, which would cover residual PCBs thereby reducing the available PCB concentration at the surface and providing an appropriate substrate for biota. In addition, the backfill will help stabilize bank areas after dredging and minimize hydraulic changes to the river. During remedial design, the appropriateness of eliminating the placement of clean backfill in certain targeted areas will be assessed (*e.g.*, nearshore fish habitat areas that have become silted-in over time may be better mitigated by not adding clean backfill and leaving a deeper water habitat). EPA will remain flexible regarding the most appropriate means for restoring dredged areas and will provide the State, other natural resource trustees and the public opportunity to provide input on this issue. The source(s) of the backfill will be determined during the remedial design and construction.

After construction is completed, this alternative relies on institutional controls, such as the fish consumption advisories and fishing restrictions (although perhaps in a modified form), and MNA in areas not remediated until the Remedial Action Objectives are achieved. A review of site conditions would be conducted at five-year intervals, as required by CERCLA. As with Alternatives 2 through 4, the present-worth cost does not include any capital cost or O&M costs associated with source control actions near the GE Hudson Falls plant. The remedy does not specify the type(s) of environmental dredges to be used, so that there is flexibility in remedial design. In addition, if some of the dredged sediment could be given a beneficial use, significant cost savings could be realized through reduced transportation and disposal fees.

Long-term monitoring would be conducted in sediments, in the water column, and in fish to confirm that contaminant reduction is occurring and that the reduction is achieving Remedial Action Objectives. The monitoring data would also be used as input parameters in the mathematical models to evaluate progress of the natural attenuation processes against the original predictions.

10.2 Key/Common Elements

The following discussion applies to all three active alternatives: CAP-3/10/Select, REM-3/10/Select, and REM-0/0/3.

Phasing

Remedial dredging will be conducted in two phases. The first phase will be the first construction season of remedial dredging. The dredging during that year will be implemented initially at less than full scale operation. It will include an extensive monitoring program of all operations. Monitoring data will be compared to performance standards identified in this ROD or developed during the remedial design, with input from the public and in consultation with the State and federal natural resource trustees. Performance standards shall address (but may not be limited to) resuspension rates during dredging, production rates, residuals after dredging or dredging with backfill as appropriate, and community impacts (*e.g.*, noise, air quality, odor, navigation). The information and experience gained during the first phase of dredging will be used to evaluate and determine compliance with the performance standards. Further, the data gathered will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging, or if performance standards need to be reevaluated. EPA will make the data, as well as its final report evaluating the work with respect to the performance standards, available to the public.

Institutional Controls

Institutional controls (fish consumption advisories and fishing restrictions) will be utilized with the MNA, Capping and Removal alternatives. Institutional controls are considered to be limited action alternatives, and therefore are not included under the No Action alternative.

Source Control

For purposes of EPA's model comparisons of remedial alternatives, source control at the GE Hudson Falls plant was projected to decrease the current concentration of PCBs in the water - column of approximately 13 ng/L Tri+ PCB to 2 ng/L Tri+ PCB, by January 1, 2005. Greater reductions in the upstream loading, through even more effective source control measures near the GE Hudson Falls plant, would serve to further enhance the effectiveness of the remedy.

Monitored Natural Attenuation

MNA refers to reliance on natural biological, physical, and chemical processes within a monitored site cleanup approach. Natural attenuation processes for the Hudson River PCBs site may include biodegradation, biotransformation, bioturbation, diffusion, dilution, adsorption, volatilization, chemical reaction or destruction, resuspension, downstream transport, and burial by clean sediment. The relative importance of each of these mechanisms in reducing PCB concentrations in Hudson River fish is not easily estimated based on available data. Some or all of these processes may be occurring at any given time and location within the river. During the design phase, a monitoring program will be developed to measure the net effects of the natural attenuation processes until the remediation goals are reached.

The following discussion applies to all three active alternatives: CAP-3/10/Select, REM-3/10/Select, and REM-0/0/3.

Cleanup Values

Because consumption of fish is the major pathway of concern and PCB concentrations in fish are controlled by PCB concentrations in both sediment and water, a specified "cleanup value" for sediment was not selected as a goal. Instead, sediment cleanup is considered the means to the goal of protecting human health and the environment. Areas of sediment targeted for remediation were selected based on the potential for those areas to contribute PCBs to the water column and fish through the food chain. The delineation of the target areas considered a number of factors, primarily the inventory of PCBs in the sediment, but also surface sediment concentrations, sediment texture, bathymetry and depth at which the PCB contamination is found. (Areas where 12 inches or greater of clean overburden exist were eliminated.) Target areas for remediation were defined as approximately 50,000 square feet (a little over an acre) because of practical limitations on the number of separate remediation zones that could be accommodated for a project of this size. In addition, areas considered to be rocky, as defined by side-scan sonar, were excluded.

Sediment Concentrations

Sediments that may significantly contribute to the PCB levels in fish, both now and in the future, are considered principal threats. The determination of the significance of the sediment contribution to fish is based primarily on model projections, in conjunction with geochemical analyses. The model projections indicate that the significance of the sediment contribution varies by river section; therefore, the sediment levels that are considered principal threats will correspondingly vary by river section. The PCB-contaminated sediment concentrations considered to be principal threats, as represented by mass per unit area measurements, are 3 g/m^2 Tri+ PCBs in River Section 1 and 10 g/m^2 Tri+ PCBs in River Section 2.

Due to the high variability of PCB concentrations in sediment, mass per unit area (MPA), rather than concentration, was identified as the most useful measure of the potential contribution of an area to PCBs in surface water and fish. MPA measurements *(i.e.*, grams of PCBs per square meter) indicate the total mass of PCBs within the sediment. An example MPA calculation is provided in Figure 10-1. MPA was plotted against areas of cohesive and non-cohesive sediment for the Thompson Island Pool (and against PCB mass remediated) to determine breakpoints where a small change in MPA would mean a large increase in sediment area or mass to be remediated. This provides an evaluation of the efficiency of remediation by comparing the mass of PCBs remediated to the amount of the sediment surface that would require remediation. Breakpoints were found at approximately 3 g/m^2 Tri+ PCBs and 10 g/m^2 Tri+ PCBs. Therefore, the screening of alternatives evaluated MNA (no sediment remediation) plus source control, 10 g/m^2 Tri+ PCBs , 3 g/m^2 Tri+ PCBs, and 0 g/m^2 (full section) Tri+ PCBs for River Sections 1 and 2.

In River Section 3, the 0 g/m^2 scenario was excluded because it would have required remediation of an unreasonably large area (over 2,800 acres). Similarly, a cleanup level such as 1 mg/kg (as sometimes used at other sites) would have targeted unreasonably large areas in Section 3.

The target levels are defined as: 0 g/m^2 - Full Section Remediation, 3 g/m^2 Tri+ PCBs - Expanded Hot Spot Remediation, and 10 g/m^2 Tri+ PCBs - Hot Spot Remediation. Modeling was conducted to evaluate the impact of remediation for combinations of the target levels for each river section on fish tissue PCB levels. It was found that remediation in River Section 1, the Thompson Island Pool, had the greatest benefit with respect to lowering PCB levels in fish and surface water. River Section 2 also showed significant benefits in this regard. The model did not show substantial fish tissue benefits from remediation in River Section 3. However, the data show increased PCB concentrations in the water column in this reach resulting from tributary high flow events that caused scour in the main part of the Hudson. Therefore, certain areas in River Section 3, specifically NYSDEC *hot spots* 36, 37, and the southern portion of 39, were selected for remediation based on PCB inventory and signs of potential loss of PCB inventory. For example, a comparison of 1977 and 1994 sediment data showed that over two thirds of the PCB inventory was lost from *Hot Spot* 37. The 5-year review will be tailored to examine any potential erosion from hot spots not targeted for remediation under this remedy.

Treatment

Treatment technologies, such as thermal desorption, are technically feasible; however, the associated costs would be substantially greater than off-site landfill disposal. Moreover, a locally-sited thermal treatment facility would not be expected to be administratively feasible.

Sediment Processing/Transfer Facilities

It is expected that either one or two sediment processing/transfer facilities will be established to handle materials from the environmental dredging process. The locations of these facilities will be selected by EPA in consultation with New York State during the remedial design phase of the remedy, after consideration of community input, engineering issues (such as those associated with the type of dredging selected), real property issues, noise, air impacts and other appropriate factors. Although it is projected that these facilities will be land-based, water-based facilities will also be evaluated.

Mechanically dredged sediment will arrive at the facilities via barge and will be decanted to remove excess water. The dredged material will then be stabilized with Portland cement, or an equivalent stabilizing agent, cured, and loaded onto rail and/or barge for transport to disposal facilities. If hydraulic dredging is used, the sediment will arrive at the northern sediment processing/transfer facility via pipeline. The hydraulically dredged material will then be mechanically dewatered and loaded onto rail and/or barge for transport to disposal facilities.

The water that is separated will undergo treatment to remove fine sediment particles and dissolved PCBs. Ultimately, the water will be discharged back into the Hudson River in compliance with substantive New York State Pollutant Discharge Elimination System requirements, which are ARARs for this Site.

Transportation

Dredged materials will be transported from the dredging site to the sediment processing/transfer facilities by barge or in-river pipeline. Transportation from the sediment processing/transfer facilities to disposal facilities will be by rail (or possibly barge). Transportation of material for backfill and capping will also be by rail or barge. Community input will be taken regarding the methods utilized for the transport of materials if a beneficial use scenario becomes available.

Disposal

During the screening analysis, it was determined that if a remedy that included dredging were to be selected, it would not be administratively feasible to dispose of that material in a locally-sited landfill. Therefore, only off-site disposal options (at an existing licensed TSCA or solid waste landfill outside of the Hudson Valley) were carried through into the Detailed Analysis in the Reassessment FS. Although off-site landfilling is projected, a beneficial use scenario (for non-TSCA dredged materials) will be evaluated during the design phase. Value engineering to reduce waste volumes (that will also reduce costs) will be explored and, if appropriate, finalized during the remedial design.

Testing will be conducted during construction to evaluate dredged material for other hazardous wastes or constituents to determine the applicability of, and compliance with, federal and State RCRA regulations. This information will be utilized in the determination of acceptable off-site disposal facilities.

Monitoring

Short- and long-term (*i.e.*, pre-, during, and post-construction) monitoring programs will be developed to ensure compliance with performance standards and to ensure protection of human health and the environment. The types and frequency of pre-construction monitoring will be developed during remedial design. Plans for monitoring during and after construction will be developed during the remedial design and modified during and after construction as appropriate. This is consistent with the NRC Report recommendation that long-term monitoring evaluate the effectiveness of the approach as well as ensure protection of public health and the environment.

10.3 Expected Outcomes of Each Alternative

The time to reach target PCB concentrations in fish was a primary factor in comparing remedial alternatives. As more fully described in Section 11.1 - Overall Protection of Human

Health and the Environment, the time to reach target levels (*e.g.*, 0.2 and 0.4 mg/kg) favors the active remediation alternatives. In fact, in River Sections 1 and 2, the No Action alternative does not meet the Remediation Goal of 0.05 ppm in fish, the 0.2 ppm or the 0.4 ppm targets within the model time frame (by 2067). A reduction in risk is realized for each of the four remaining alternatives in the following ascending (lesser to more improvement) order: MNA, CAP-3/10/Select, REM-3/10/Select, and REM-0/0/3. In River Section 3, all of the active remediation alternatives meet the concentration of 0.05 mg/kg within 42 years, MNA reaches it in 48 years and the No Action alternative does not meet the Remediation Goal within the modeling time frame.

In addition, comparisons of the model outputs to data trends suggest that the model may be overly optimistic with regard to the rate of PCB decline in fish predicted for the No Action and Monitored Natural Attenuation (assuming source control) alternatives which would suggest an even stronger preference for active remediation alternatives.

Fish consumption advisories and fishing restrictions would be continued by the appropriate State authorities as part of the No Action and MNA alternatives. For the active remediation alternatives, upon reaching specified target concentrations in fish, consumption advisories could be relaxed from the current “eat none” recommendation for the Upper Hudson River.

As a part of the active remediation alternatives, navigational dredging is necessary in order to implement environmental dredging, so as to allow movement of the dredging and support vessels, as well as to allow for use of the river by recreational and commercial vessels during remediation.

11. COMPARATIVE ANALYSIS OF ALTERNATIVES

In selecting a remedy for a site, EPA considers the factors set forth in CERCLA § 121, 42 U.S.C. § 9621, by conducting a detailed analysis of the viable remedial alternatives pursuant to the NCP, 40 CFR § 300.430(e)(9), EPA’s *Guidance for Conducting Remedial Investigations and Feasibility Studies*, OSWER Directive 9355.3-01, and EPA’s *A Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents*, OSWER 9200.1-23.P. The detailed analysis consists of an assessment of the individual alternatives against each of nine evaluation criteria (two threshold, five primary balancing and two modifying criteria) and a comparative analysis focusing upon the relative performance of each alternative against those criteria. Table 11-1 provides the Remedial Alternatives Comparative Analysis Summary.

The comparison of the effectiveness of alternatives is based on the results of modeling each remedial alternative as well as data projections. Comparisons of the model outputs to data trends suggest that the model may be overly optimistic with regard to the rate of PCB decline in fish predicted for the No Action (no source control) and MNA (assuming source control) alternatives (*i.e.*, the fish tissue PCB data do not show the same type of declines as predicted by the model). As discussed in the Feasibility Study, this occurs because, among other things, the model predictions are averaged over larger spatial scales than the foraging range of many resident fish species and there is uncertainty surrounding the PCB concentration in surface sediment and sediment mixing depths used in the model. Under the modeled remedial alternatives, this over-optimism is minimized to some degree wherever PCBs are removed or capped, because projected rates of decline are replaced by specified concentrations in the remediated areas. Consequently, the benefits of remediation are likely underestimated by comparisons of the active remediation alternatives to the No Action and MNA alternatives.

In order to bound this uncertainty in the No Action and MNA alternatives, an estimated upper bound was also calculated. Assuming that the over-optimism in the model projections stems in part from the model predictions being averaged over larger spatial scales than the foraging range of many resident fish species and the uncertainty surrounding the PCB concentration in surface sediment calculated by the model, an alternative method was used to calculate surface sediment values based on certain fish data. PCB concentrations in brown bullhead, which are affected primarily by concentrations of PCBs in surface sediment, were used to back-calculate concentrations of PCBs in surface sediment that would produce the decline seen in the data. The newly-calculated concentrations of PCBs in surface sediment were then used in the model as an upper bound estimate instead of the model-calculated surface sediment values. Therefore, both the upper bound estimates and the model-calculated values for No Action and MNA were used as points of comparison in the evaluation of effectiveness of the capping and removal alternatives.

Threshold Criteria *- The first two Superfund criteria are known as "threshold criteria" because they are the minimum requirements that each response measure must meet in order to be eligible for selection as a remedy.*

11.1 Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether an alternative eliminates, reduces, or controls threats to public health and the environment through institutional controls, engineering controls, or treatment.

EPA evaluated the overall protectiveness of the No Action and MNA alternatives using the model results and the upper bound results based on recent fish data, as discussed in Section 10.3. The overall protectiveness of the CAP-3/10/Select alternative was evaluated based on modeling of a five-year implementation schedule and zero PCB loss due to resuspension. The risks calculated for the CAP-3/10/Select alternative assume an equilibration period of two years rather than one year to approximate the additional year for phased implementation, such that risks were calculated with a start year of 2010. The overall protectiveness of the selected alternative, REM-3/10/Select, is based on modeling of a six-year implementation schedule, 0.13% PCB loss due to resuspension, and a one-year equilibration period, such that risks were calculated with a start year of 2010. The overall protectiveness of the REM-0/0/3 alternative is based on a seven-year implementation schedule, zero PCB loss due to resuspension and a one-year equilibration period, such that risks were calculated with a start year of 2011.[3] The modeling of all alternatives except No Action assumes additional source control measures near the GE Hudson Falls plant (*i.e.*, reduction of the upstream contribution from the current average of 0.16 kg/day to an average of 0.0256 kg/day on January 1, 2005).

Overall Protection of Human Health

EPA evaluated overall protection of human health in three ways. The first is the relative reduction in cancer risks and non-cancer hazard indices associated with the five remedial alternatives. The second is the time that it would take under each of the alternatives to reach the remediation goal and other targets of PCB concentrations in species-weighted fish fillet. The third is the PCB load transported over the Federal Dam into the Lower Hudson, which also is a measure of the overall protection of the environment. Transport of PCBs over the Federal Dam is discussed for both human health and the environment together at the end of this section.

Relative Reductions in Cancer Risk and Non-Cancer Hazard Indices

Relative reductions in cancer risks and non-cancer hazard indices were calculated to provide an estimate of risk reductions under the various remedial alternatives. The formula used to calculate the percentages of risk reduction is:

$$1 - \frac{\text{Alternative-Specific Risk}}{\text{No Action Risk or MNA Risk}} \times 100$$

Cancer Risks

As shown in the table below, substantial reductions in the RME adult cancer risk are achieved by all active remediation alternatives compared to the No Action and MNA alternatives. The

[3] EPA did not run the models assuming PCB loss due to resuspension or phased implementation for the CAP-3/10/Select and REM-0/0/3 alternatives, based on the model runs of the REM-3/10/Select alternative which predict little or no difference for PCB concentrations in fish assuming different PCB loss due to resuspension (zero, 0.13 % or 2.5%) and a 5 or 6 year implementation schedule.

MNA alternative achieves a 51% to 24% reduction in risk compared to the No Action alternative (modeled and upper bound, respectively). The CAP-3/10/Select alternative achieves a 73% to 83% reduction compared to No Action and a 45% to 78% reduction compared to MNA. The REM-3/10/Select alternative achieves a 76% to 85% reduction compared to No Action and a 50% to 80% reduction compared to MNA. The REM-0/0/3 alternative achieves a 82% to 89% reduction compared to No Action and a 63% to 85% reduction compared to MNA.

Cancer Risks - RME Adult
Upper Hudson River[1]

Alternative	Cancer Risk
No Action[2]	4.1E-04 to 6.6E-04
MNA[2]	2.0E-04 to 5.0E-04
CAP-3/10/Select	1.1E-04
REM-3/10/Select	9.9E-05
REM-0/0/3	7.5E-05

1 Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%; River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

2 Higher value is upper bound.

Non-Cancer Health Hazards

As shown in the table below, substantial reductions in the RME adult non-cancer hazard indices are achieved by all active remediation alternatives compared to the No Action and MNA alternatives. The MNA alternative achieves a 30% to 16% reduction compared to the No Action alternative (modeled and upper bound, respectively). The CAP-3/10/Select alternative achieves a 68% to 77% reduction compared to No Action and a 55% to 73% reduction compared to MNA. The REM-3/10/Select alternative achieves a 71% to 79% reduction compared to No Action and a 58% to 75% reduction compared to MNA. The REM-0/0/3 alternative achieves a 80% to 86% reduction compared to No Action and a 72% to 83% reduction compared to MNA.

Non-Cancer Hazard Indices - RME Adult
Upper Hudson River[1]

Alternative	Non-Cancer Hazard Index
No Action[2]	27 to 38
MNA[2]	19 to 32
CAP-3/10/Select	8.6
REM-3/10/Select	7.9
REM-0/0/3	5.3

1 Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%; River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

2 Higher value is upper bound.

Time to Reach Human Health Risk-Based PCB Concentrations in Fish

The Remediation Goal for the protection of human health is 0.05 mg/kg PCBs in species-weighted fish fillet. In addition, EPA considered target concentrations of 0.2 mg/kg and 0.4 mg/kg PCBs in species-weighted fish fillet. Meeting these target concentrations might facilitate the relaxation of fish consumption advisories from the current “eat none” recommendation in the Upper Hudson River to one of limited fish ingestion. The table below summarizes the years in which these concentrations are projected to be met for various remedial alternatives. It shows that significant benefits are achieved by implementation of one of the active remedies compared to the No Action and MNA alternatives.

For the Upper Hudson River as a whole (length-weighted average), none of the alternatives meets the Remediation Goal of 0.05 mg/kg PCBs in species-weighted fish fillet within the modeled time frame (*i.e.*, by 2067). The continuing upstream source of PCBs must be virtually eliminated in order to meet the Remediation Goal within the modeled time frame (see Section 9.3). All of the alternatives except No Action assume additional upstream source control measures and meet the 0.05 mg/kg Remediation Goal in River Section 3 within the modeled time frame, although in different years (in 2059 for MNA, in 2051 for CAP-3/10/Select and REM-3/10/Select, and in 2050 for REM-0/0/3).

The alternatives differ greatly in how close they each come to meeting the Remediation Goal for the Upper Hudson River as a whole (length-weighted average) within the modeled time period. The No Action alternative reduces PCB concentrations to approximately 0.5 to 0.9 mg/kg (upper bound), which is up to 18 times greater than the Remediation Goal. The MNA alternative reduces PCB concentrations to approximately 0.1 to 0.5 mg/kg (upper bound), which is up to 10 times greater than the Remediation Goal. The CAP-3/10/Select, REM-3/10/Select and REM-0/0/3 alternatives reduce PCB concentrations to approximately 0.1 mg/kg, which is 2 times the Remediation Goal (see Table 11-2).

The three active remediation alternatives significantly reduce the time necessary to reach the 0.2 mg/kg target concentration of PCBs in species-weighted fish fillet compared to the No Action and MNA alternatives. The No Action alternative would not meet the 0.2 mg/kg target by 2067 in the Upper Hudson as a whole (length-weighted average). The MNA alternative meets the 0.2 mg/kg target in the Upper Hudson as a whole (length-weighted average) in 2035 or would not meet it by 2067 (upper bound). In contrast, the CAP-3/10/Select and REM-3/10/Select alternatives meet the 0.2 mg/kg target for the Upper Hudson as a whole (length-weighted average) in 2024 and the REM-0/0/3 alternatives meets the 0.2 mg/kg target in 2018. There are also differences among the alternatives for the time to meet the 0.2 mg/kg target in certain river sections. For example, in River Section 2, the No Action alternative would not meet the 0.2 mg/kg target and the MNA alternative would meet it in 2062 or would not meet it by 2067 (upper bound). However, the CAP-3/10/Select and REM-3/10/Select alternatives would meet the 0.2 mg/kg target in River Section 2 in 2044 and the REM-0/0/3 alternative would meet it in 2034.

The three active remediation alternatives also significantly reduce the time necessary to reach the 0.4 mg/kg target concentration of PCBs in species-weighted fish fillet compared to the No Action and MNA alternatives. The No Action alternative would not meet the 0.4 mg/kg target by 2067 for the Upper Hudson as a whole (length-weighted average). The MNA alternative would meet the 0.4 mg/kg target in 2024 or would not meet it by 2067 (upper bound). The CAP-3/10/Select and REM-3/10/Select alternatives would meet the 0.4 mg/kg target in 2013 and 2012, respectively, and the REM-0/0/3 alternative would meet the 0.4 mg/kg target in 2010.

There also are differences among the alternatives for the time to meet the 0.4 mg/kg target in certain river sections. For example, in River Section 1, the No Action alternative would not meet the 0.4 mg/kg target and the MNA alternative would meet it in 2039 or would not meet it by 2067 (upper bound). However, the CAP-3/10/Select alternative would meet the 0.4 mg/kg target in River Section 1 in 2026, the REM-3/10/Select alternative would meet it in 2025, and the REM-0/0/3 alternative would meet it in 2013.

Year to Reach Human Health Risk-based PCB Concentrations in Species-weighted Fish Fillet Upper Hudson River[1]

Alternative	Remediation Goal (0.05 mg/kg)	0.2 mg/kg	0.4 mg/kg
No Action[2]	> 2067	> 2067	> 2067
MNA[3]	> 2067	2035 to > 2067	2024 to > 2067
CAP-3/10/Select	> 2067	2024	2013
REM-3/10/Select	> 2067	2024	2012
REM-0/0/3	> 2067	2018	2010

1 Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%; River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

2 "> 2067" means that the level will not be achieved within the model forecast period (*i.e.*, by 2067).

3 Higher value is upper bound.

Overall Protection of the Environment

EPA evaluated overall protection of the environment in three ways. The first is the relative reduction in toxicity quotients for the river otter and the mink associated with the five remedial alternatives, using the approach outlined above for reduction in risk to human health. The second is the time that it would take under each of the alternatives to reach the Remediation Goal for protection of ecological receptors, which is a range of PCB concentrations in largemouth bass based on the river otter, and a target range of PCB concentrations in spottail shiner based on the mink. The third is the transport of PCBs over the Federal Dam into the Lower Hudson, which also is a measure of the overall protection of human health. Each of these is discussed below.

Toxicity Quotients

As shown in the table below, substantial reductions in the toxicity quotients for the river otter are achieved by all active remediation alternatives, compared to the No Action and MNA alternatives. The implementation of active remediation alternatives results in a 74% to 83% reduction in river otter toxicity quotients compared to the No Action alternative and a 69% to 87% reduction compared to the upper bound estimate for the No Action alternative.

For the mink, the implementation of the active remediation alternatives results in a 76% to 82% reduction in toxicity quotients compared to the No Action alternative and an 82% to 86% reduction compared to the upper bound estimate for the No Action alternative.

Toxicity Quotients for River Otter and Mink (Tri+ dietary dose)
Upper Hudson River[1]

Alternative	TQ River Otter		TQ Mink	
	LOAEL	NOAEL	LOAEL	NOAEL
No Action[2]	6.9 to 9.4	69 to 94	1.0 to1.3	9.9 to13
MNA[2]	3.3 to 5.9	33 to 59	0.4 to 0.7	4.1 to 7.5
CAP-3/10/Select	1.8	18	0.2	2.4
REM-3/10/Select	1.7	17	0.2	2.3
REM-0/0/3	1.2	12	0.2	1.8

1 Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%; River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

2 Higher value is upper bound.

Time to Reach Ecological Risk-Based Concentrations in Fish

The Remediation Goal for the protection of ecological receptors is a range from 0.3 mg/kg to 0.03 mg/kg PCBs in largemouth bass (whole body), based on the LOAEL and NOAEL for the river otter. In addition, EPA considered a target concentration of 0.7 mg/kg to 0.07 mg/kg PCBs in spottail shiner (whole body), based on the LOAEL and NOAEL for the mink. As shown in Table 11-3 and summarized in the table below, the Remediation Goal is met up to approximately 30 to 40 years earlier for active remediation alternatives than for the No Action and MNA alternatives. The target range based on the mink is met up to approximately 60 years earlier for active remediation alternatives than for the No Action and MNA alternatives.

Year to Reach Ecological Risk-based PCB Concentrations in Whole Body Fish Upper Hudson River[1]

Alternative	Remediation Goal (0.3 to 0.03 mg/kg PCBs in largemouth bass)	Target Range for Mink 0.7 to 0.07 mg/kg spottail shiner
No Action[2,3]	> 2067	2013 to > 2067
MNA[2,3]	2044 to > 2067	2010 to > 2067
CAP-3/10/Select	2035	2006
REM-3/10/Select	2033	2006
REM-0/0/3	2025	2006

1 Upper Hudson River average is weighted by river section length. River Section 1: 6.3 miles = 15.4%; River Section 2: 5.1 miles = 12.5%; and River Section 3: 29.5 miles = 72.1%.

2 Higher value is upper bound.

3 "> 2067" means that the level will not be achieved within the model forecast period (*i.e.*, by 2067).

<u>Transport of PCBs over the Federal Dam</u>

Reduction of the PCB load transported over the Federal Dam and into the Lower Hudson under the various remedial alternatives is a measure of the overall protection of human health and the environment. Reduced PCB loading from the Upper Hudson into the Lower Hudson will ultimately reduce the concentrations of PCBs in sediment, water and fish, and thereby reduce risk to humans and ecological receptors in the Lower Hudson.

As shown in Table 11-4 and summarized on the table below, substantial reductions in the load of PCBs over the Federal Dam are achieved by all active remediation alternatives compared to the No Action and MNA alternatives. Implementation of the CAP-3/10/Select alternative results in a 26% reduction in the cumulative total PCB load to the Lower Hudson from 2011 (the year following the completion of dredging) to 2020, compared to MNA. The REM-3/10/Select alternative results in a 38% reduction in the total PCB load, compared to MNA. The REM-0/0/3 alternative results in a 42% reduction in total PCB load compared to MNA. These percent reductions under the active alternatives may be underestimates due to the potential over-optimism of the model. All of the active alternatives assume source control upstream. Comparisons of the active remedies to the No Action alternative would exhibit even greater reductions, because the No Action alternative does not assume source control.

Cumulative Total PCB load over Federal Dam, 2011-2020

No Action	942 kgs (2070 lbs)
MNA	526 kgs (1160 lbs)
CAP-3/10/Select	390 kgs (860 lbs)
REM-3/10/Select	327 kgs (720 lbs)
REM-0/0/3	305 kgs (670 lbs)

Summary

Cancer risks, non-cancer hazard indices, and ecological toxicity quotients show a consistent pattern of risk reduction for the five remedial alternatives evaluated in detail. The risks, hazard indices and toxicity quotients are highest for the No Action and Monitored Natural Attenuation alternatives and are substantially reduced for the active alternatives. The time to reach risk-based concentrations in fish developed for protection of human health and ecological receptors as well as the reduction in PCB load over the Federal Dam into the Lower Hudson also show the same overall pattern among the five remedial alternatives. The No Action alternative is not protective and the MNA alternative is not sufficiently protective of human health and the environment. The selected remedy, REM-3/10/Select, provides greater overall protectiveness to human health and the environment than the CAP-3/10/Select and slightly less overall protectiveness than the REM-0/0/3 alternative.

11.2 Compliance with Applicable or Relevant and Appropriate Requirements (ARARs)

Section 121 (d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4).

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for invoking a waiver.

The chemical-specific ARARs for total PCBs in the river water are: 0.5 µg/L (500 ng/L) - federal Safe Drinking Water Act MCL; 0.09 µg/L (90 ng/L) - NYS standard for protection of human health and drinking water sources; 0.03 µg/L (30 ng/L) CCC FWQC for saltwater; 0.014 µg/L (14 ng/L) CCC FWQC for freshwater; 1 ng/L - federal Ambient Water Quality Criterion;

0.12 ng/L - NYS standard for protection of wildlife; and 0.001 ng/L - NYS standard for protection of human consumers of fish.

The first four chemical-specific ARARs for surface water listed above would be met by all five remedial alternatives, while the remaining three chemical-specific ARARs for surface water are not expected to be met by any of the five alternatives for the 70-year forecast period. Due to upstream sources of PCBs, EPA has determined that it is technically impracticable to meet the 1 ng/L total PCB federal Ambient Water Quality Criterion, the 0.12 ng/L total PCB NYS standard for protection of wildlife, and the 0.001 ng/L total PCB NYS standard for protection of human consumers of fish. Although these three ARARs will be waived due to technical impracticability, the selected alternative will still be protective. Evaluation of the projected PCB concentrations in the water column by river section shows that the source control action near the GE Hudson Falls plant affects the difference (separation) between the rate of decline for the No Action and MNA alternatives. The benefits of active remediation of the sediments are readily apparent in the differences between the rate of decline for the MNA alternative and those for the active remediation alternatives. As expected, the water quality is best for the REM-0/0/3 alternative and substantially improved for the CAP-3/10/Select and REM-3/10/Select alternatives compared to MNA. The relative benefits of active remediation are greatest for the first 20 years after remediation begins (from 2006 to 2025). However, even at the end of the forecast period (in 2067), the PCB concentrations in the water column associated with the No Action alternative are substantially higher (approximately 30 ng/L Tri+ PCBs at Thompson Island Dam and Schuylerville and 10 ng/L Tri+ PCBs at Federal Dam) than for the other four alternatives (approximately 5 ng/L Tri+ PCBs at Thompson Island Dam and Schuylerville and 1.7 ng/L Tri+ PCBs at Federal Dam).

Because there is no active remediation associated with the sediments for the No Action and MNA alternatives, action-specific and location-specific ARARs do not apply to those alternatives. The three active remedial alternatives would comply with action-specific ARARs (*e.g.*, Clean Water Act Section 404; Toxic Substances Control Act; Section 10 of the Rivers and Harbors Act; New York State ECL Article 17, Titles 3 and 8 and Article 27, Titles 3, 7 and 9) and location-specific ARARs (*e.g.*, Endangered Species Act; Fish and Wildlife Coordination Act; Coastal Zone Management Act; National Historic Preservation Act; and New York State Freshwater Wetlands Act). During remedial design, mitigation measures will be evaluated in order to reduce impacts on floodplains, wetlands, and submerged aquatic vegetation communities, as necessary, to ensure compliance with Executive Orders 11990 and 11988.

Since the Lower Hudson (south of the Federal Dam at Troy) is located within a coastal zone management area, and since the active remedial alternatives might affect a coastal use or resource, the federal Coastal Zone Management Act requires that the remedy be undertaken in a manner consistent, to the maximum extent practicable, with New York State's coastal zone management policies. It is expected that the requirement would be satisfied by each of the active remedial alternatives.

Primary Balancing Criteria *- The next five Superfund criteria, 3 through 7, are known as "primary balancing criteria." These five criteria are factors with which tradeoffs between response measures are assessed so that the best option will be chosen, given site-specific data and conditions.*

11.3 Long-Term Effectiveness and Permanence

Long-term Effectiveness and Permanence considers the ability of an alternative to maintain protection of human health and the environment over time.

Reduction of Residual Risk

The No Action and MNA alternatives result in a continuation of the degraded condition of the sediments and surface water quality of the Upper Hudson River, especially in the Thompson Island Pool, for at least several decades, regardless of any reduced PCB concentrations in the upstream water quality. The No Action alternative removes no PCBs from the river and effects no active reduction in PCB levels in fish. The MNA alternative does assume upstream source control and therefore shows reduced risks when compared to the No Action alternative.

For the CAP-3/10/Select alternative, residual risk is reduced through the capping of 207 acres of PCB-contaminated sediments and removal of 1.73 million cubic yards of sediments. The total area remediated (capped plus removed) via this alternative encompasses 493 acres, and the total quantity of total PCBs remediated is approximately 70,000 kg (150,000 lbs). The reduction in cancer risks through fish consumption ranges from 73% to 83% compared to the No Action alternative and from 45% to 78% compared to the MNA alternative. The reduction in non-cancer hazard indices ranges from 68% to 77% compared to the No Action alternative and from 55% to 73% compared to the MNA alternative.

For the REM-3/10/Select alternative, residual risk is reduced through the removal of 2.65 million cubic yards of sediments containing approximately 70,000 kg (150,000 lbs) of total PCBs over an area of 493 acres. The reduction in cancer risks through fish consumption ranges from 76% to 85% compared to the No Action alternative and from 50% to 80% compared to the MNA alternative. The reduction in non-cancer hazard indices ranges from 71% to 79% compared to the No Action alternative and from 58% to 75% compared to the MNA alternative.

For the REM-0/0/3 alternative, residual risk is reduced through the removal of 3.82 million cubic yards of sediments containing more than 84,000 kg (185,000 lbs) of total PCBs over an area of 964 acres. The reduction in cancer risks through fish consumption ranges from 82% to

89% compared to the No Action alternative and from 63% to 85% compared to the MNA alternative. The reduction in non-cancer hazard indices ranges from 80% to 86% compared to the No Action alternative and from 72% to 83% compared to the MNA alternative.

Adequacy of Controls

The No Action and MNA alternatives do not provide for active engineering controls on the river sediments. The MNA alternative does assume source control near the GE Hudson Falls plant and institutional controls. NYSDOH's 1996 study of anglers in the Upper and Lower Hudson found that, despite a ban on fish consumption in the Upper Hudson and highly restrictive advisories in the Lower Hudson, about 18% of the Upper Hudson respondents had fish in their possession when interviewed and 11% had more than one fish. Most of the fish were largemouth bass, smallmouth bass, and bluegill, species that are often eaten. In the Mid-Hudson region, about 8% actually had fish in their possession when interviewed. Therefore, the existing institutional controls, which rely heavily on voluntary compliance, do not adequately eliminate exposure to PCBs due to consumption of contaminated fish. In addition, institutional controls are inadequate for protection of the environment (*e.g.*, the birds, mammals and fish that consume fish). Given the survey data, it is unlikely that sole reliance on these types of controls would be reliable in the long term to ensure human health and ecological protection.

The CAP-3/10/Select alternative provides for select removal of some PCB-contaminated sediments in target areas and placement of an engineered cap over the remaining target areas. Like the MNA alternative, this alternative also provides for institutional controls, such as the fish consumption advisories and fishing restrictions (although perhaps in a modified form), and other Site use restrictions in capped areas (*e.g.*, prohibition of sediment disturbance activities in waterfront improvements by private residences or commercial/industrial establishments along the shoreline). Although institutional controls would still be required for the two removal alternatives, the risk to consumers of fish would be greatly reduced by these alternatives.

The REM-3/10/Select and REM-0/0/3 alternatives provide for removal of PCB-contaminated sediments in targeted areas. These two alternatives also provide for institutional controls, such as the fish consumption advisories and fishing restrictions (although perhaps in a modified form), but they are unlikely to require additional Site use restrictions after removal activities are completed.

All alternatives will require some degree of monitoring. Monitoring programs will be developed, as appropriate, for all phases of the project.

Reliability of Controls

The No Action alternative is the least reliable. Although the MNA alternative is better than the No Action alternative, the institutional controls associated with the MNA alternative do not protect ecological receptors, and human risk reduction under that alternative relies on knowledge and observance of the fish consumption advisories and fishing restrictions to a greater degree than under the two removal alternatives, which reduce the risk to consumers of fish to a far greater extent than MNA.

For the active remedies and MNA, fish consumption advisories and fishing restrictions will continue to provide some measure of protection of human health until PCB concentrations in fish are reduced to the point where the fish consumption advisories and fishing restrictions can be relaxed or lifted. Among the active alternatives, sediment capping, sediment removal (dredging and excavation), habitat replacement/backfilling and off-site disposal/treatment of removed sediments are all established technologies.

The CAP-3/10/Select alternative relies upon proper design, placement and maintenance of the cap in perpetuity for its effectiveness, continued performance and reliability. A cap integrity monitoring and maintenance program should provide reasonable reliability, although there are inherent challenges in monitoring and maintaining a cap in the Upper Hudson riverine environment. The CAP-3/10/Select alternative is less reliable than the removal alternatives due to the potential for damage to the cap, thereby exposing PCBs. In addition, the CAP- 3/10/Select alternative is vulnerable to a catastrophic flow event, such as might be seen during a 500-year flood or a dam failure.

In general, the REM-3/10/Select and REM-0/0/3 alternatives are the most reliable, as there is little or no long-term additional maintenance associated with the remedial work. Of the removal alternatives, REM-0/0/3 is the most reliable, as it permanently removes the greatest amount of sediment (leaving the least amount of PCBs in the river) and achieves the greatest reduction of the potential scour-driven resuspension of PCB-contaminated sediments south of the confluence with the Hoosic River.

Summary

Based on the above analysis of reduction in residual risk and adequacy and reliability of controls, the three active remedial alternatives are far superior to the No Action and MNA alternatives due to the much greater differences in risk reduction and mass of PCBs removed from the river. The three action alternatives are similar to each other in terms of risk reduction with REM-0/0/3 being the most effective; however, the REM-3/10/Select and REM-0/0/3 alternatives rank higher than the CAP-3/10/Select alternative due to the quantities of PCBs removed from the river and the permanence of such removal versus the long-term operation and maintenance required by capping PCB-contaminated sediments. EPA's analysis of residual risk for each alternative is consistent with the NRC report recommendation to consider options to reduce risk and to consider residual risks associated with material left behind.

11.4 Reduction in Toxicity, Mobility, or Volume Through Treatment

Reduction in Toxicity, Mobility, or Volume of Contaminants through Treatment evaluates an alternative's use of treatment to reduce the harmful effects of principal contaminants, their ability to move in the environment and the amount of contamination present.

The No Action and MNA alternatives do not involve any containment or removal of contaminants from the Upper Hudson River sediments. Because the MNA alternative assumes a separate source control action near the GE Hudson Falls plant, the Tri+ PCB load to the water column upstream of the Thompson Island Pool is projected by EPA modeling to be reduced from 0.16 kg/day to 0.0256 kg/day by January 1, 2005. The No Action and MNA alternatives rely on natural attenuation processes such as burial by cleaner sediments, biodegradation, bioturbation and dilution to reduce concentrations of PCBs in sediments and surface water.

Biodegradation processes have been found to partially convert some of the more highly-chlorinated PCB congeners to less-chlorinated congeners and thereby slightly reduce their toxicity. At the same time, individual fish and other biota will preferentially bioaccumulate the more toxic PCB congeners. Nevertheless, concentrations of PCBs in fish populations will respond slowly over time to slow natural decreases in concentrations in sediments and surface water.

For the CAP-3/10/Select alternative, the mobility of the PCBs in capped areas (approximately 207 acres) would be reduced because these PCBs are sequestered under the cap. However, capping does not satisfy the CERCLA statutory preference for treatment. In addition, there is no reduction in the toxicity or volume of the PCBs under the cap. Under this alternative, the mass of PCBs and the volume of contaminated sediments within the Upper Hudson River are permanently reduced because approximately 1.73 million cubic yards of sediment would be removed. A total of approximately 70,000 kg (about 150,000 lbs) of total PCBs would be removed or isolated from the ecosystem by this alternative. Because the CAP-3/10/Select alternative also assumes source control near the GE Hudson Falls plant, the Tri+ PCB load to the water column is projected by EPA modeling to be reduced from 0.16 kg/day to 0.0256 kg/day by January 1, 2005. In addition, after construction of the remedy is completed, natural attenuation processes would provide additional reductions in PCB concentrations in the remaining sediments and surface water.

For the REM-3/10/Select and REM-0/0/3 alternatives, the mass of PCBs and volume of contaminated sediments in the Upper Hudson River are permanently reduced because sediment volumes from 2.65 to 3.82 million cubic yards, respectively, containing a mass of total PCBs from approximately 70,000 kg (about 150,000 lbs) to an estimated mass of greater than 84,000 kg (about 185,000 lbs), respectively, are removed from the ecosystem. Because these removal alternatives also assume source control near the GE Hudson Falls plant, the Tri+ PCB load to the water column is projected by EPA modeling to be reduced from 0.16 kg/day to 0.0256 kg/day by January 1, 2005. Also, as stated for the CAP-3/10/Select alternative, after construction of the remedy is completed, natural attenuation processes would provide additional reductions in PCB concentrations in the remaining sediments and surface water.

While the active remedial alternatives would permanently remove large volumes of PCBs from the river (thereby reducing their mobility), they do not satisfy the statutory preference for treatment as a principal element of the remedy. Given the volume of material to be removed, treatment of the dredged material prior to off-site disposal would not be cost-effective, other than the stabilization of the sediments for handling purposes. During remedial design, EPA will consider whether there are any new treatment options for the dredged sediment. During the remedial design or implementation, EPA also will determine whether beneficial use (*i.e.*, the manufacture of commercial products) is appropriate for some portion of the dredged material.

11.5 Short-Term Effectiveness

Short-term Effectiveness considers the length of time needed to implement an alternative and the risks the alternative poses to workers, residents and the environment during implementation.

Length of Time Needed to Implement the Remedy

The implementation times for the active alternatives are 6 years for CAP-3/10/Select and REM-3/10/Select and 8 years for REM-0/0/3. This represents the estimated time required for mobilization, operation and demobilization of the remedial work, but does not include the time required for long-term monitoring or O&M. The No Action and MNA alternatives do not involve any active remediation.

For the active remediation alternatives, remedial dredging will be conducted in two phases. The first phase will be the first construction season of remedial dredging. The dredging during that year will be implemented initially at less than full scale operation. It will include an extensive monitoring program of all operations. These monitoring data will be compared to performance standards identified in this ROD or developed during the remedial design. Performance standards will address (but might not be limited to) resuspension rates during dredging, production rates, residuals after dredging and community impacts (*e.g.*, noise, air, odor and navigation). EPA will consider the New York State regulations that specify Champlain Canal navigational channel dimensions in developing the navigation performance standard. An independent external peer review of the dredging resuspension, PCB residuals and production rate performance standards will be conducted during design. The information and experience gained during the first phase of dredging will be used to demonstrate compliance with the performance standards. Further, the data gathered will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging, or if performance standards need to be reevaluated. EPA will make the data, as well as any evaluation of the success or failure of the work in meeting the performance standards, available to the public. See the discussion in Section 13.3 of the Decision Summary regarding community participation during the remedial design and construction periods.

Protection of the Community During Remedial Actions

No construction activities are associated with the remediation of sediments for the No Action and MNA alternatives, so neither alternative increases or decreases the potential for direct contact with or ingestion and inhalation of PCBs from the surface water and sediments.

A community involvement process will be incorporated into this project. EPA will provide opportunities for the public to have involvement and meaningful input throughout project design and construction, including input into the siting and design aspects of sediment processing/transfer facilities.

A Community Health and Safety Plan will be developed by EPA with New York State input during remedial design. The intent of the Community Health and Safety Plan is to protect the community, including persons in residences and businesses, from potential exposures as a direct result of investigative and remedial work activities. The Community Health and Safety Plan will provide for community notification of ongoing health and safety issues, monitoring of contaminants and protection of the community from physical and other hazards. The plan will include a section that outlines the actions to be followed should monitoring of contaminants show contaminant levels above action levels.

Access to sediment processing/transfer facilities and process and treatment areas under the active remediation alternatives will be restricted to authorized personnel. Controlling access to the dredging locations and sediment processing/transfer facilities along with monitoring and engineering controls developed during the design phase will minimize potential short-term risks to the community. The design will also provide for appropriate control of air emissions, noise and light through the use of appropriate equipment that meets all applicable standards. Compliance with these design provisions will be monitored during construction, operation and demobilization. Vehicular traffic will increase due to workers and supply deliveries at the sediment processing and transfer facilities. The potential for traffic accidents might increase marginally as additional vehicles are on the road. These effects are likely to be minimal, in part because the transportation of sediments for disposal and the transportation, within the Upper Hudson River area, of material for backfill and capping is expected to be accomplished by rail and/or barge. 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).

For the active remediation alternatives, work in the river will also be designed with provisions for control of air emissions, noise and light. Work areas outside the channels will be isolated (access-restricted), with an adequate buffer zone so that pleasure craft and commercial shipping can safely avoid such areas. Environmental dredging in the channels will be conducted at times and in ways to minimize disruption to river traffic. Provisions will be made in the routing of barges to avoid impacts to recreational and commercial use of the river. Finally, targeted dredging will be sequenced and directed to ensure minimal impacts to navigation within the river. To help ensure that navigation is not impeded, EPA will consult with the New York State Canal Corporation during remedial design and construction phases on issues related to canal usage, navigational dredging, and other remedy-related activities within the navigational channel. Discrete areas of the river will be subject to dredging and related activities only over short periods of time; once an area is dredged, dredging equipment will move to another area, thereby lessening locational impacts.

Air impacts at dredging sites, on barges and at land based facilities are expected to be minimal. Action levels will be established, monitoring conducted and appropriate engineering control measures employed to ensure that any air releases do not exceed acceptable levels. A community notification system, which will be established during the remedial design, will keep the residents informed regarding the data from EPA's air monitoring program.

EPA believes that implementation of REM-3/10/Select, the selected remedy, will have little if any adverse impact on local businesses or recreational opportunities. Indeed, as discussed in the Responsiveness Summary, the Agency believes that the remedy will have substantial positive economic impacts on local communities and will facilitate enhanced recreational activities in and along the river. To the extent that any adverse local impacts do occur, EPA expects that they will be short-term and manageable. Moreover, EPA believes that any such impacts will be far outweighed by the long-term benefits of the remediation on human health and the environment.

In summary, the active remedial alternatives would not pose significant risk to the nearby communities.

Protection of Workers During Remedial Actions

For the No Action alternative, occupational risks to persons performing the sampling activities (for the 5-year reviews) will be unchanged from current levels. There is some minimal increase in occupational risk associated with the MNA alternative due to the greater degree of sampling involved in the river.

For the three active remediation alternatives (CAP-3/10/Select, REM-3/10/Select and REM-0/0/3), potential occupational risks to Site workers from direct contact, ingestion and inhalation of PCBs from the surface water and sediments, as well as routine physical hazards associated with construction work and working on water, are higher than for the No Action and MNA alternatives. For these alternatives, as well as the No Action and MNA alternatives, personnel will follow a site-specific health and safety plan and OSHA health and safety procedures and wear the necessary personal protective equipment; thus, no unacceptable risks would be posed to workers during the implementation of the remedies.

Vehicles used for the transportation of hazardous waste will be designed and operated in conformance with DOT regulations. EPA will provide the community and local government the opportunity to have input on plans related to the off-site transportation of hazardous wastes. This approach is consistent with the NRC recommendation to involve the local communities in risk management decisions.

Potential Adverse Environmental Impacts During Construction

No construction activities associated with the river sediments are conducted for the No Action and MNA alternatives. Neither continuation of the existing limited sampling activities for the No Action alternative nor the increased monitoring program for the MNA alternative is anticipated to have any adverse effect on the environment, beyond that already caused by the PCB contamination of the sediments in the Upper Hudson River. For the three active remediation alternatives (CAP-3/10/Select, REM-3/10/Select and REM-0/0/3), the release of PCBs from the contaminated sediments into the surface water during construction (dredging and cap placement), will be controlled by operational practices (*e.g.*, control of sediment removal rates, use of environmental dredges and use of sediment barriers). Although precautions to minimize resuspension will be taken, it is likely that there will be a localized temporary increase in suspended PCB concentrations in the water column and possibly in fish PCB body burdens. Analysis of yearly sediment resuspension rates, as well as resuspension quantities during yearly high flow events, shows the expected resuspension due to dredging to be well within the variability that normally occurs on a yearly basis. The performance standards and attendant monitoring program, that are developed and peer reviewed during design, will ensure that dredging operations are performed in the most efficacious manner, consistent with the environmental and public health goals of the project.

Remedial activities may also result in short-term temporary impacts to aquatic and wildlife habitat of the Upper Hudson. Where appropriate, habitat replacement/backfilling measures will be implemented to mitigate these impacts. A monitoring program will be established to verify the attainment of the habitat replacement objectives. Although the degree of impact will be directly related to the area remediated and volume dredged, these differences among the alternatives are not considered to be significant due to their temporary nature and the mitigation measures which will be utilized. In addition, because of existing erosion of the river bed, the presence of invasive species and other adverse impacts to wetlands along the Hudson River, remediation can result in collateral benefits in the course of mitigation, including removal of nuisance species, reintroduction of native species, aeration of compacted and anaerobic soils and other enhancements of wetland habitats.

EPA has consulted with the natural resource trustees (NOAA, DOI and NYSDEC), and they support an environmental dredging remedy since the long-term benefits outweigh the short-term impacts. Short-term impacts are for a limited time scale, will be greatest in the area of active remediation and will dissipate in a downstream direction.

For the CAP-3/10/Select alternative, there is the additional potential transient impact from the temporary exposure of deeper, potentially highly contaminated sediments during the interval between excavation and cap placement. This impact would be minimized by placement of the cap as soon as practicable after the removal operations are complete, assumed to be no more than 30 days. Therefore, regarding this issue, there is not a significant difference in transient impact between the CAP-3/10/Select, REM-3/10/Select and REM-0/0/3 alternatives.

The magnitude of the short-term impacts discussed above varies with the overall scope of the alternative, in terms of volume of material excavated and area remediated. The implementation times for the active alternatives are 6 years for CAP-3/10/Select and REM-3/10/Select, and 8 years for REM-0/0/3.

Time Until Protection is Achieved

The projected time required to reach remedial goals and PCB target levels in fish for each of the remedial alternatives is discussed in Section 11.1 (Overall Protection of Human Health and the Environment).

11.6 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and *materials, administrative feasibility and coordination with other governmental entities are also considered.*

Technical Feasibility

Both the No Action and MNA alternatives are technically feasible as no active measures would be taken for the PCB-contaminated sediments. Source controls are expected to be implemented at and near the GE Hudson Falls plant site under an existing Consent Order between NYSDEC and GE.

Technical feasibility for the active remediation alternatives is discussed below in terms of the main components of the alternatives. Additional information is provided in the FS.

- Sediment Processing/Transfer Facilities - Alternatives CAP-3/10/Select, REM-3/10/Select and REM-0/0/3 require sediment processing/transfer facilities. At these facilities, the transfer, dewatering and stabilization of dredged material would be conducted. Each of these activities is considered a readily implementable, commonly engineered activity. Design of sediment processing/transfer facilities will include requirements for the control of light, noise, air emissions, and water discharges.

EPA has not determined the location of the sediment processing/transfer facilities. A process which includes a community/public involvement component will be developed to evaluate and select sites. Preliminary criteria were utilized to establish a list of preliminary candidate sites to allow for the preparation of a cost estimate. In preparing the cost estimate in the Feasibility Study, EPA assumed two technically feasible locations, a northern facility adjacent to the Hudson River near the Thompson Island Pool and a southern facility near Albany. These transfer facilities are to be temporary and will be removed after completion of the active remedial activities.

Removal - Alternatives CAP-3/10/Select, REM-3/10/Select and REM-0/0/3 require the dredging of contaminated sediments. Dredging of sediments is a readily implementable engineering activity. Environmental dredges will be used to minimize the resuspension and downstream transport of PCBs from the dredging activities. The type of dredging equipment (mechanical and/or hydraulic) will be selected during the remedial design, using the most appropriate equipment for the specific conditions in the river. The use of silt screens or other barriers (*e.g.*, coffer dams, sheet piling), as appropriate, could further assist in limiting downstream migration of PCBs and may be used as well.

Remedial dredging will be conducted in two phases. The first phase will be the first construction season of remedial dredging. The dredging during that year will be implemented initially at less than full scale operation. It will include an extensive monitoring program of all operations. These monitoring data will be compared to performance standards identified in this ROD or developed in consultation with the State, other natural resource trustees, and the public, during the remedial design. Performance standards will address (but may not be limited to) resuspension rates during dredging, production rates, residuals after dredging, and community impacts (*e.g.*, noise, air, odor and navigation). 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. The information and experience gained during the first phase of dredging will be used to evaluate and determine compliance with the performance standards. Further, the data gathered will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging or if performance standards need to be reevaluated. EPA will make the data, as well as any evaluation of the work with respect to the performance standards, available to the public. See the discussion in Section 13.3 of the Decision Summary regarding community participation during the remedial design and construction periods.

Capping - Alternative CAP-3/10/Select requires capping of sediments. The placement of capping materials is a readily implementable engineering activity. This alternative will require long-term monitoring of the cap, and may require boating restrictions to be placed on certain sections of the river. Sand, gravel and/or fine materials may be utilized for capping. The type (*e.g.*, texture/size and sorting) of cap material will be determined on a location specific basis. In addition, an evaluation of the $AquaBlok_{tm}$ system is currently in progress at several remedial sites (*e.g.*, Ottawa River, Ohio; Fort Richardson, AK). The implementability and long-term performance of the $AquaBlok_{tm}$ system have not yet been established, but it is expected that considerable performance data will become available in the near future. However, the principal component of this system is bentonite, which is considered a very stable, low-permeability barrier. Bentonite has been used in multimedia and clay capping systems for many years and has demonstrated effectiveness for the long-term encapsulation of contaminants.

Backfilling - Alternatives REM-3/10/Select and REM-0/0/3 require backfilling where appropriate. The placement of backfill is a readily implementable engineering activity. Sand, gravel and fine materials may be utilized for backfill. Backfill materials will be transported within the Upper Hudson River area by rail and/or barge. The source of backfill material will be determined during the design phase.

Transportation and Disposal - Dredged materials may be transported in-river to sediment processing/transfer facilities using barges or pipelines. These are considered readily implementable engineering activities. Transportation via pipeline is limited to certain distances as a result of pumping limitations. Consequently, in some areas of the river, pipelines may not be implementable.

Off-site transportation of dredged materials to disposal facilities will be by rail and/or barge. These forms of transportation are routine engineering activities that have been employed at many Superfund sites and are technically implementable. EPA will comply with rules for transporting both hazardous and non-hazardous wastes. The location, layout and process integration of rail line and spur connections will be determined in conjunction with the siting process of the sediment processing/transfer facilities (during the design phase). The preliminary screening of rail viability indicated that current rail capacity may require more than one rail connection.

Off-site disposal is a common activity at Superfund sites. The number and location of off-site (outside the Hudson River Valley) disposal facilities will be based on a combination of contaminant concentration, dredged material volume, transportation and cost considerations. A beneficial use analysis will also be performed during the design phase.

REM-3/10/Select is more implementable from a technical feasibility perspective than REM-0/0/3 due to the smaller volume of material to be dredged and handled, as well as the accessibility of the areas to be dredged. Both removal alternatives are more technically implementable than the CAP 3/10/Select alternative due to the combination of capping and dredging issues associated with the capping alternative.

An ex-situ treatment alternative, thermal desorption, was determined to be technically feasible but was eliminated from further consideration during the screening analysis for two reasons: 1) the associated costs of such treatment technologies are significantly greater than off-site landfill disposal; and, 2) a locally-sited thermal treatment facility would not be expected to be administratively feasible.

Administrative Feasibility

Local Landfill - A locally-sited landfill for sediments dredged from the Upper Hudson River was eliminated from consideration during the screening of technologies and alternatives. This was based on the likely administrative infeasibility of siting a local landfill, given the long-standing opposition of local communities to disposal of PCB-contaminated sediments within the Hudson River Valley, as well as the need for a permitting process (should the landfill not be "on-site"). In recognition of the concerns of the local community, permitted facilities outside the Hudson River Valley will be utilized for disposal.

Both No Action and MNA require no active measures; therefore, they are the most implementable from an administrative feasibility perspective. The active remedial measures are somewhat more difficult to implement from an administrative feasibility perspective due to the need for siting the sediment processing/transfer facilities and addressing the associated real property issues, and the need to make arrangements to utilize the river with minimal interruption of boat traffic.

For the active remediation alternatives (CAP-3/10/Select, REM-3/10/Select, and REM-0/0/3), the transfer facilities, constructed on land adjacent to the river, or in-river, are considered "on-site" for the purposes of the permit exemption under CERCLA Section 121(e), although any such facilities will comply with the substantive requirements of any otherwise necessary Federal or State permits. Operations under these alternatives will have to be performed in conformance with the substantive requirements of regulatory programs implemented by the U.S. Army Corps of Engineers under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. In addition, discharges during remediation will conform to substantive NYS regulations related to maintenance of Hudson River water quality. Habitat replacement/backfilling will be implemented as appropriate in accordance with federal and State requirements. The State, federal natural resource trustees and the public will be given the opportunity to provide input regarding the habitat replacement/backfill plan.

In addition, it is expected that contract documents for any of the active remediation alternatives will contain substantial controls on construction activity, including controls on the types of dredging and capping equipment to be used, specifics on the speed of operations, constraints on barge filling practices and controls on temporary storage of contaminated dredge spoils. Construction activities will also be coordinated with the New York State Canal Corporation, which operates the locks on the Upper Hudson River from May through November and controls navigation in the Champlain Canal. Finally, requirements of any other regulatory programs will be incorporated as necessary on the basis of design information developed during subsequent phases of the project.

Following the issuance of this ROD, EPA will involve the community in the selection process of possible locations for the sediment processing/transfer facilities before selecting the final location(s). EPA also will provide the public with opportunities to provide input regarding design aspects of the remedy and performance standards, so that community concerns and suggestions regarding, for example, potential noise, light, odor and traffic impacts can be considered by EPA during the design phase.

Availability of Services and Materials

For the No Action and MNA alternatives, all needed services and materials are available. For the CAP-3/10/Select, REM-3/10/Select and REM-0/0/3 alternatives, because commercial operations on the Champlain Canal system have largely ceased, equipment such as barges and tugs may no longer be available in the project vicinity. However, it is expected that the construction contractors will obtain the needed equipment for a project of the scale envisioned under these alternatives. Backfill materials (*e.g.*, sand and gravel) are readily available from commercial sources.

11.7 Cost

Cost includes estimated capital and annual operation and maintenance costs, as well as present worth cost. Present worth cost is the total cost of an alternative over time in terms of today's dollar value. Cost estimates are expected to be accurate within a range of +50 to -30 percent. (This is a standard assumption in accordance with EPA guidance.)

The discussions of the alternatives below do not include any costs for source control measures that will be taken near the GE Hudson Falls plant. Table 11-5 provides a comparison of present worth costs by alternative with additional information on the area remediated and the mass of contamination removed.

Net Present Worth

The net present worth (year 2000 dollars) of the remedial alternatives ranges from $140,000 for No Action to $570,000,000 for REM-0/0/3. The net present worth of REM/3/10/Select is $460,000,000, which is $110,000,000 less than REM-0/0/3. For the active remedial alternatives (CAP-3/10/Select, REM-3/10/Select and REM-0/0/3), these costs are based on the use of mechanical dredging techniques to remove PCB-contaminated sediments from the Upper Hudson River and the disposal of all dredged materials at licensed TSCA and non-TSCA landfills located outside of the Hudson River Valley. For the option where the non-TSCA material is utilized for beneficial uses, the net present worth of the active remedial alternatives ranges from $338,000,000 for CAP-3/10/Select to $496,000,000 for REM-0/0/3. There is no significant difference in the net present worth costs for the option where hydraulic dredging techniques are utilized to remove PCB-contaminated sediments.

Capital Cost

The No Action alternative has no capital cost. The MNA alternative has a present worth capital cost of $417,000 for further refining the mathematical model for the Upper Hudson River. The present worth of the capital costs for the active remedial alternatives ranges from $344,000,000 for CAP-3/10/Select to $556,000,000 for REM-0/0/3. The present worth of the capital costs for REM-3/10/Select is $448,000,000, some $108,000,000 less than the present worth of the capital costs for REM-0/0/3. For these active remediation alternatives, the present worth of the capital costs includes the disposal of the stabilized dredged materials at licensed TSCA and non-TSCA landfills (located outside the Hudson Valley) and assumes the use of mechanical environmental dredging techniques to remove PCB-contaminated sediments from the river.

For the option where the non-TSCA material is utilized for beneficial uses, present worth of the capital costs for the active remedial alternatives ranges from $314,000,000 for CAP-3/10/Select to $483,000,000 for REM-0/0/3. The present worth of the capital costs of REM-3/10/Select under the beneficial use option is $399,000,000. These beneficial use option costs are also based on the use of mechanical environmental dredging techniques. There is no significant difference in the present worth of capital costs for the option where hydraulic dredging techniques are utilized to remove PCB-contaminated sediments.

O & M Cost

Due to the varying frequency of different elements of the monitoring program, as well as the five-year reviews required by the NCP, O&M costs will vary on an annual basis. The present worth of the O&M cost for the No Action alternative is $140,000 and for the MNA alternative is $38,000,000. The present worth of the O&M costs for CAP-3/10/Select is $24,000,000, for REM-3/10/Select is $13,000,000 and for REM-0/0/3 is $13,000,000. There is no significant difference in the present worth of the O&M costs for the option in which hydraulic dredging techniques are utilized to remove PCB-contaminated sediments.

***Modifying Criteria** - The final two evaluation criteria, 8 and 9, are called "modifying criteria" because new information or comments from the state or the community on the Proposed Plan may modify the preferred response measure or cause another response measure to be considered.*

11.8 State Acceptance

State Acceptance indicates whether based on its review of the RI/FS reports and the Proposed Plan, the state supports, opposes, and /or has identified any reservations with the selected response measure.

The New York State Department of Environmental Conservation, which is the support agency for this project, concurs with EPA's decision for this Site.

11.9 Community Acceptance

Community Acceptance considers whether the local community agrees with EPA's analyses and preferred alternative. Comments received on the Proposed Plan are an important indicator of community acceptance.

There are numerous stakeholders involved with the Site with varying positions on active remediation of the Upper Hudson River. EPA received tens of thousands of comments on the Proposed Plan, some in support of dredging the Hudson and some in opposition to dredging. For example, a number of organizations including environmental groups from the Mid- and Lower Hudson region are in favor of remediation. This includes the environmental group Scenic Hudson, Inc., which was awarded a Technical Assistance Grant for the Site. Groups in favor of an active remedy argue that there would be continued unacceptable human health risks if no remediation is conducted, continued economic loss of commercial fisheries, continued angler consumption of contaminated fish despite advisories and insignificant breakdown of PCBs through dechlorination processes. They further point to the fact that PCB-contaminated sediments are not being universally buried and that the peer review findings support EPA's technical analyses and conclusions.

Many residents of communities immediately adjacent to the areas where dredging would have its greatest construction impacts oppose active remediation, preferring to leave the contamination in place. Among other things, these groups cite concern over the remedy being ecologically devastating, that there is ongoing natural cleanup through dechlorination and burial, that EPA's PCB load estimates are flawed, that the models and data do not support materially accelerated reductions of PCBs in fish from dredging (as compared to results under MNA or No Action) and that EPA's conclusions about the toxicity of PCBs are overstated.

During the comment period on the Proposed Plan, Upper Hudson communities raised concerns about the location and design features of needed dredge material sediment processing/transfer facilities. As discussed below, EPA is not siting these facilities as part of this Record of Decision. Rather, during the remedial design, EPA will provide opportunities for the public to have involvement and meaningful input into the siting and design of such facilities.

The Agricultural, Citizen and Governmental Liaison Groups are generally against active remediation, while most members of the Environmental Liaison Group are in favor of it. Many municipalities have formally endorsed EPA's remedy proposal, while many other municipalities have opposed it.

EPA's responses to the significant public comments received in response to the Feasibility Study and Proposed Plan are contained in the attached Responsiveness Summary.

12. PRINCIPAL THREAT WASTES

Sediments which may contribute to the PCB levels in fish, both now and in the future, are considered principal threat wastes at the Site. The determination of the significance of the sediment contribution to fish is based primarily on model projections, in conjunction with geochemical analyses. The model projections indicate that the significance of the sediment contribution varies by river section; therefore, the sediment levels that are considered principal threats will correspondingly vary by river section. Due to the high variability of PCB sediment concentrations, MPA, rather than concentration, was identified as the most useful measure of the potential contribution of an area to PCBs in surface water and fish. An evaluation of the efficiency of potential remedies was conducted by comparing the mass of Tri+ PCBs remediated to the sediment surface area that would require remediation. The PCB contaminated sediment concentrations considered to be principal threats, as represented by mass per unit area measurements, are 3 g/m^2 Tri+ PCBs in River Section 1 and 10 g/m^2 Tri+ PCBs in River Section 2.

Alternative REM-3/10/Select includes removal of sediments based primarily on an MPA of 3 g/m^2 Tri+ PCBs or greater in River Section 1, removal of sediments based primarily on an MPA of 10 g/m^2 Tri+ PCBs or greater in River Section 2, and removal of selected sediments with high concentrations of PCBs in River Section 3 (NYSDEC *Hot Spots* 36, 37, and the southern portion of 39).

13. SELECTED REMEDY

13.1 The Selected Remedy

The selected remedy is the alternative REM-3/10/Select. This remedy includes the targeted environmental dredging of approximately 2.65 million cubic yards of PCB-contaminated sediment from the Upper Hudson River, which is estimated to contain 70,000 kg (about 150,000 lbs) of total PCBs (approximately 65% of the total PCB mass present in the Upper Hudson River). Table 13-1, *Areas of Sediments, Volumes of Sediments, and Mass of PCBs Remediated,* provides environmental dredging information by River Section. Plates 13.1 through 13.7 provide the removal areas (locations) and depths, as estimated during the Reassessment FS.

In combination with the additional source control action near the GE Hudson Falls plant, the REM-3/10/Select remedy includes the following components:

- Removal of sediments based primarily on a mass per unit area (MPA) of 3 g/m^2 Tri+ PCBs 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 are included in this ROD consistent with state and federal law;
- Other performance standards (including but not necessarily limited to resuspension rates during dredging, production rates during dredging, and residuals after dredging) will be developed during the 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 EPA gathers, as well as the Agency's ongoing evaluation of the work with respect to the 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;
- 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);

- 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;
- Monitored Natural Attenuation (MNA) of PCB contamination that remains in the river after dredging;
- 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.

The targeting of *Hot Spots* 36, 37 and southern portion of 39, is based on currently available data showing that those areas have high PCB concentrations, and potential for loss to the water column or uptake by biota. Additional sampling will be conducted during remedial design to determine whether other areas, such as previously identified *hot spots*, in River Section 3 have these characteristics and therefore need to be remediated as part of the selected remedy.

Remedial dredging will be conducted in two phases. The first phase will be the first construction season of remedial dredging. The dredging during that year will be implemented initially at less than full scale operation. It will include an extensive monitoring program of all operations. An independent external peer review of the dredging resuspension, PCB residuals, and production rate performance standards will be conducted during design. Monitoring data will be compared to performance standards identified in this ROD or developed during the remedial design with input from the public and in consultation with the State and federal natural resource trustees. The second phase will be the remainder of the dredging operation, which will be conducted at full-scale. During the full-scale remedial dredging, EPA will continue to monitor, evaluate performance data and make necessary adjustments.

EPA has identified performance standards that address air and noise emissions from the dredging operations and the sediment processing/transfer facilities. Performance standards for other issues will be developed during design, as described below.

As to air emissions, operations and facilities will comply with the ARARs listed in Table 14-3 which deal with such emissions (*e.g.*, the National Primary and Secondary Ambient Air Quality Standards).

Regarding noise emissions, operations at the sediment processing/transfer facilities will comply with the relevant noise abatement criteria (NAC) of the Federal Highway Administration set forth at 23 CFR Part 772 (see Table 312685-1 of the Responsiveness Summary). Although it is EPA's expectation that the facilities will be located in an industrial or commercial area, the determination of which NAC will apply will depend on where the sediment processing/transfer facilities are sited. The dredging will comply with the New York State Department of Transportation construction noise impact guideline for temporary construction noise, which defines "impact" as occurring at levels exceeding $L_{eq}(1) = 80$ dBA.

The performance standards referred to above regarding noise are being adopted preliminarily. During the remedial design phase, EPA will invite public input regarding these standards before finalizing the noise standards. Once implementation of the dredging begins, if the air or noise performance standards are exceeded, EPA will implement engineering controls or other mitigation measures, as appropriate, in order to address such exceedances.

In addition, during the remedial design phase, EPA will develop other performance standards with input from the public and in consultation with the State and federal natural resource trustees. These standards will address (but may not be limited to) dredging resuspension, production rates, PCB residuals after dredging (or dredging with backfill, as appropriate), PCB air emissions, and community impacts (*e.g.*, odor). The dredging equipment and methods of operation will be selected based on their expected ability to meet the performance standards.

The information and experience gained during the first phase of dredging will be used to evaluate and determine compliance with the performance standards. Further, the data gathered will enable EPA to determine if adjustments are needed to operations in the succeeding phase of dredging, or if performance standards need to be reevaluated. EPA will make the data, as well as its final report evaluating the work with respect to the performance standards, available to the public.

EPA has carefully considered the issues raised by some members of the public pertaining to potential adverse local impacts of a dredging remedy, and these issues are discussed in detail in the Responsiveness Summary. During the remedial design and remedial action, as part of the public involvement program, EPA will work with local communities to identify, minimize, and mitigate adverse local impacts (if any) to the maximum extent practicable.

A separate source control action near GE's Hudson Falls plant is to be implemented by GE, under an administrative order issued by NYSDEC, to address the continuing discharge of PCBs from that facility. Regarding the former outfall to the Hudson River (Outfall 004) from GE's Fort Edward plant site, NYSDEC issued a Record of Decision in January 2000 that calls for the excavation of PCB-contaminated soil and sediment in this area of the Upper Hudson shoreline in order to stop these PCBs from entering the river. EPA's analysis assumes significant reductions in loading to the river from these sources once the State's plans for remediation are implemented.

EPA carefully considered the recommendations of the National Research Council report (A Risk Management Strategy for PCB-Contaminated Sediments, March 2001) in the finalization of the selected remedy for the Hudson River PCBs Site. EPA agrees with the NRC recommendation that there should be no presumption of a preferred or default risk-management option that is applicable to all PCB-contaminated sediment sites. EPA's selected remedy for the Site includes a combination of remedial activities that were tailored to the conditions at the Site, including removal of contaminated sediment using environmental dredging techniques, institutional controls, and monitored natural attenuation of residual PCB contamination until acceptable PCB concentrations in fish are attained.

If major changes are made to the selected remedy as a result of the remedial design or remedial construction processes, such changes will be documented, as appropriate, in the form of a memorandum in the administrative record, an Explanation of Significant Differences (ESD), or a ROD Amendment.

13.2 Summary of the Estimated Costs of the Selected Remedy

The total estimated present-worth cost of the selected remedy is $460 million. A breakdown of the costs is presented in Table 13-2 and is based on the best available information. This is an engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost (based on year 2000 dollars). Changes in the cost elements are likely to occur as a result of new information and data collected during the remedial design. Major changes may be documented in a memorandum in the administrative record, an ESD, or a ROD amendment.

13.3 Issues to be Addressed During the Remedial Design Phase of the Selected Remedy

Following issuance of this ROD, EPA will implement a community involvement program that will provide members of the public and elected officials the opportunity for early and meaningful input during the decision-making phases of the remedial design. The post-ROD community interaction program will build on the existing, extensive public process used for the Reassessment RI/FS. EPA will hold a series of public meetings to discuss and take comment on a proposed post-ROD outreach program before it is finalized. This enhanced community involvement program will include opportunities for public comment on, for example, the proposed location(s) and design of sediment processing/transfer facilities; work hours; noise control and traffic control; other ways to minimize or mitigate possible adverse local impacts (if any); the development of dredging performance standards; and data gathered during the first year of dredging with respect to performance standards. This enhanced community involvement program will remain active throughout the subsequent construction and post-construction monitoring phases of the project. It is anticipated that the post-ROD community involvement program will have two major elements: frequent and regular interaction with communities through meetings focused on specific issues of concern and a notable EPA presence in the upriver community (*i.e.*, a field office which will be established during the remedial design phase and be staffed on a full-time basis during the remedial construction period). These measures will enable EPA to fully involve the public and local communities during the remedial design.

One of the first major issues to be addressed during the remedial design will be the siting of sediment processing/transfer facilities. Siting of the sediment processing/transfer facilities is critical to the implementation of the remedy. This is also one of the most sensitive issues to the communities in the Upper Hudson. The process to select the location(s) of sediment processing/transfer facilities will include:

- public notification of potential facility locations that satisfy necessary engineering criteria;

- public meetings and a public comment period on the proposed locations; and,

- issuance of a document notifying the public about EPA's final decision on the facility location(s) and explaining the reasons for the decision.

Potential adverse impacts to properties near the sediment processing/transfer facilities will be minimized through careful siting and design of the facilities. EPA intends to locate the facilities in industrial or commercial areas. (As noted earlier, although it is projected that the facilities will be land-based, water-based facilities will also be evaluated.) After completion of active remedial activities, the parcels will be restored in a manner that takes into account the anticipated future land use of the parcels, such as redevelopment for commercial or recreational use.

If a sediment processing/transfer facility for the selected remedy is to be located south of the Federal Dam, coastal zone consistency will need to be evaluated for that facility (see Section 11.2). Wetlands, floodplains, endangered species and historical and cultural resource assessments will be conducted for the sediment processing/transfer facilities as well. In addition, EPA will consult with appropriate federal and State agencies in determining whether any especially sensitive or unique habitats exist in the Upper Hudson River that may warrant special consideration as the remedy is designed.

Sampling and monitoring programs will be developed and implemented during the design, construction and post-construction phases to establish sediment cut lines, verify environmental dredging accuracy and completeness, determine releases during dredging and to measure the net effect of upstream source control as well as natural attenuation processes (Section 10.2). These monitoring programs will include sampling of biota, water and sediment such that both short-and long-term impacts to the Upper and Lower Hudson River environs, as a result of the remedial actions undertaken, can be determined and evaluated. EPA will increase monitoring of water supply intakes during each project construction phase to identify and address possible impacts on water supplies drawn for drinking water. The locations, frequency and other aspects of monitoring of the water supplies in the Upper and Lower Hudson will be developed with public input and in consultation with New York State during remedial design.

Other details that will need to be addressed in the remedial design are the type of dredges to be used (mechanical and/or hydraulic), areas to be backfilled, specific processes and equipment for backfilling, dewatering or materials stabilization and ultimate disposal locations. Preliminary reviews of successful environmental dredging projects indicate that both mechanical and hydraulic dredges should be considered at this Site. The use of computerized systems to control and monitor sediment removal, and contaminated sediment resuspension controls such as dredge shrouds, silt curtains, air curtains, sheet piling, and oil booms, will also be reviewed. The Reassessment FS provides additional information on various dredge types considered, their technical implementability, and costs. The remedial design will also evaluate the sediment handling, processing and transportation, and backfilling processes. EPA will consider whether there are any new treatment options or beneficial uses for the dredged sediment and any value engineering methods (*e.g.*, waste volume or toxicity reductions) that would improve the cost-effectiveness of the remedy. The $460 million net present-worth cost estimate of the selected remedy is based on the assumption that no such treatment methods, beneficial uses or value engineering methods are employed.

During the remedial design, EPA, in consultation with the State (NYSDEC), federal natural resource trustees and the public, will establish performance standards for implementation of the remedy. Performance standards shall include (but may not be limited to): resuspension during dredging, production rates, residuals after dredging and community impacts (*e.g.*, noise, air odor, lights and navigation). The dredging equipment and methods of operation will be selected based on their expected ability to meet the performance standards.

The design will call for remedial dredging to be conducted in two phases. In the first phase, the first season of remedial dredging will be implemented initially at less than full-scale, during which extensive monitoring of operations will be performed. These data will be compared to the performance standards established for the project. The information and experience gained during this phase will be used to evaluate and determine compliance with the performance standards and to make any necessary adjustments to operations in the succeeding phase. The second phase will be the remainder of the dredging operation, which will be conducted at full-scale. During the full-scale remedial dredging, EPA will continue to monitor, evaluate performance data and make necessary adjustments.

The design for the project will plan for a construction period of six years (which includes one year at less than full-scale and five years at full-scale operation). EPA expects to complete the remedial design and mobilization that would be necessary for dredging to begin during the 2005 construction season.

Based on available wetland mapping, the dredging operations will occur in locations contiguous to approximately 129 acres of wetlands, although no wetlands are currently expected to be dredged or backfilled. In addition, an estimated 177 acres of submerged aquatic vegetation will be dredged and an additional 46 acres of submerged aquatic vegetation are located contiguous to areas to be dredged. Wetlands and submerged aquatic vegetation in and contiguous to the remediation areas and the sediment processing/transfer facilities will be field delineated during remedial design. A Statement of Findings that supports the determination to include wetland areas in the areas to be remediated is provided in Appendix A. In order to ensure compliance with Executive Order 11990, Protection of Wetlands, Section 404 of the Clean Water Act, and New York wetland-related ARARs (See Section 9.2 and 14.2), following the delineation of areas to be dredged and identification of sediment processing/transfer facility location(s) during the remedial design, EPA will determine appropriate measures to avoid, minimize or mitigate impacts to wetlands. EPA also will consider measures to control or minimize potential migration of PCBs into wetlands if high-flow events occur during remediation. EPA will develop such appropriate measures in consultation with NYSDEC and the federal natural resource trustees.

It is likely that the sediment processing/transfer facilities required for the remedy will need to be located in the floodplain, given the need for the facilities to have direct access to the river. EPA will develop measures to either avoid or minimize potential impacts that the sediment processing/transfer facilities may have on the floodplain after locations are determined during remedial design, in accordance with Executive Order 11988, Floodplain Management. A Statement of Findings that indicates why it is necessary to conduct these remediation-associated activities in the floodplain is provided in Appendix A. EPA also will employ measures to control resuspension and downstream migration of PCBs during remediation, including sediment barriers (*e.g.,* silt curtains) and operational controls, in order to minimize potential impacts to the floodplains from resuspended PCBs.

The Lower Hudson is located within a coastal zone management area. Since the active remedial alternatives might affect a coastal use or resource, the federal Coastal Zone Management Act (CZMA) requires that the selected remedy be undertaken in a manner consistent, to the maximum extent practicable, with New York State's coastal zone management policies. EPA has concluded that the targeted environmental dredging of the PCB contaminated sediments in the Upper Hudson River is consistent with the New York State CZMA policies. A coastal zone consistency analysis regarding the sediment transfer/processing facilities will be prepared and submitted to New York State after the locations of such facilities are determined but before the remedial design is finalized.

EPA will conduct additional identification and evaluation efforts during remedial design to determine the extent of potential effects to National Register listed or eligible resources. Once EPA has completed the identification and evaluation efforts, it will then determine if and to what extent National Register listed or eligible resources will be adversely affected by the selected remedy, and will identify appropriate methods to mitigate those effects.

Because contamination will remain on-site above health-based levels even after the remedy is implemented, five-year reviews in accordance with CERCLA (Section 121) are required.

13.4 Rationale for Selection of the Selected Remedy

The selection of a remedy is accomplished through the evaluation of the nine criteria as specified in the NCP. A remedy selected for a site will be protective of human health and the environment, comply with ARARs (or justify a waiver) and offer the best balance of tradeoffs with respect to the balancing and modifying criteria in the NCP.

Through the analyses conducted for the Reassessment RI/FS, EPA has determined that there is an unacceptable risk to human health and the environment from the consumption of fish from the Hudson River. It has also been determined that the unacceptable risk will continue for many decades without active remediation of the PCB-contaminated sediments and control of the upstream sources. Accordingly, the No Action alternative is not protective of human health and the environment and therefore could not be selected for the Site.

The MNA alternative, which does not include any active remediation of the sediments but does account for future upstream source control, will reduce risks from consumption of fish, but it is predicted to take at least twenty years longer than the selected remedy to reach target levels in fish tissue in River Sections 1 and 2. Comparisons of the model output to recent data trends suggest that the model may be overly optimistic with regard to the rate of PCB decline in fish predicted for the MNA alternative (as well as for No Action). Consequently, the models may overstate the benefits of those approaches and underestimate the relative benefits of active remediation.

All of the three active remediation alternatives, REM- 3/10/Select, CAP-3/10/Select, and REM-0/0/3, would be protective of human health and the environment as they permanently remove large volumes of PCBs from the river, which will result in significant reductions in risk from consumption of fish from the Hudson. REM-0/0/3 would provide the greatest degree of protectiveness, because it removes the largest volume of PCB-contaminated sediment and addresses the largest area. However, the predicted difference in fish tissue concentrations between REM-0/0/3 and REM-3/10/Select, and correspondingly, the difference in risk, is small.

Therefore, the lesser cost associated with REM-3/10/Select makes REM-3/10/Select more cost effective.

The modeling projects that the target concentration of 0.4 mg/kg PCB in fish fillet (wet weight), which is protective of the average adult who consumes one fish meal from the Upper Hudson every two months, will be attained within 5 years of completion of dredging (before or by 2013) for the three active remediation alternatives. The target of 0.2 mg/kg PCB, protective of an adult who consumes one fish meal from the Upper Hudson per month, is projected to be attained within 16 years of completion of dredging for the three active remediation alternatives. It is projected to take at least 10 additional years for MNA to reach the 0.2 mg/kg and 0.4 mg/kg PCB target levels, as compared to the active remediation alternatives, but this time frame would be decades longer based on the upper bound estimate of MNA. The Remediation Goal of 0.05 mg/kg PCB for human consumption of fish, which is protective of an adult who consumes one fish meal from the Upper Hudson per week, will not be attained by any of the alternatives within the modeling time frame in the Upper Hudson River as a whole (length-weighted average). However, in River Section 3, the model projections show that the selected remedy will meet the 0.05 mg/kg PCB Remediation Goal, within 43 years after completion of the active remediation. As a result, the Remediation Goal of 0.05 mg/kg also is expected to be attained in the majority of the Lower Hudson River, due to the lower initial concentration of Site-related PCBs in the Lower Hudson compared to the Upper Hudson.

Due to the continuing Tri+ PCB load of 0.0256 kg/d assumed after implementation of the source control action in the vicinity of the GE Hudson Falls plant, the PCB concentration in fish averaged over the Upper Hudson is projected by EPA's models to be reduced to a range of 0.09 to 0.14 mg/kg by the selected remedy within the 70-year modeled time period, which is slightly above the Remediation Goal of 0.05 mg/kg. If GE's proposed source control is able to reduce the Tri+ load to zero, then the selected remedy is predicted to reach the Remediation Goal of 0.05 mg/kg PCBs in fish tissue by 2039 in River Section 1, by 2041 in River Section 2, and by 2025 in River Section 3. The CAP-3/10/Select and REM-0/0/3 alternatives are expected to reach the Remediation Goal in similar time frames. Under MNA with an upstream load of zero Tri+ PCBs, the model predicts it would take until 2063 in River Section 1, 2061 in River Section 2, and 2032 in River Section 3. This emphasizes the impact of reducing the upstream PCB load to the greatest extent possible, as well as the need for remediation of the sediments.

The active remedial alternatives would permanently remove large volumes (and therefore reduce mobility) of PCBs from the river, although they do not satisfy the statutory preference for treatment as a principal element of the remedy. Given the volume of material to be removed, treatment of the dredged material prior to off-site disposal, other than the stabilization of the sediments for handling purposes, would not be cost-effective. During remedial design, EPA will consider whether there are any new treatment options for the dredged sediment and whether there are value engineering recommendations (*e.g.*, waste volume or toxicity reductions) that could improve the cost-effectiveness of the remedy. During the remedial design or implementation, EPA will determine whether beneficial use (*i.e.*, the manufacture of commercial products) is appropriate for some portion of the dredged material.

MNA, CAP-3/10/Select, REM-3/10/Select and REM-0/0/3 rely on institutional controls (fish consumption advisories and fishing restrictions) to protect human health until target PCB concentrations in fish are achieved. The MNA alternative relies more heavily on institutional controls than the active remedial alternatives because of the significantly longer times needed to meet target concentrations under MNA. Institutional controls do not protect ecological receptors, and human health risk reduction relies on knowledge of and voluntary compliance with the consumption advisories and fishing restrictions. Consequently, the active remedial alternatives are substantially more protective of people who do not follow the fish consumption advisories, because of the residual risk in consuming fish and the shorter time required to reach fish PCB target levels under those alternatives.

The selected remedy is also protective of the environment, because the selected remedy will reduce PCB concentrations in fish averaged over the entire Upper Hudson, and in the Lower Hudson, to levels that are at or within the range of 0.3 to 0.03 mg/kg in whole largemouth bass (equivalent to 0.12 to 0.012 mg/kg in fish fillet), which is the Remediation Goal for ecological exposure. The selected remedy is therefore protective of the piscivorous or semi-piscivorous birds such as the belted kingfisher, great blue heron and bald eagle, and the piscivorous or semi-piscivorous mammals, such as the river otter and mink, which are the ecological receptors at greatest risk at the Site. By removing PCBs from the Upper Hudson River, the selected remedy also is protective of piscivorous fish, such as the largemouth bass and striped bass, omnivorous fish, such as the brown bullhead, insectivorous birds, such as the tree swallow, insectivorous mammals, such as the little brown bat, and omnivorous mammals, such as the raccoon, which also are at risk at the Site.

Overall reductions in ecological risk achieved by the selected remedy are large, especially in comparison with the No Action and MNA alternatives. The selected remedy is protective of the piscivorous birds and mammals which are the ecological receptors at greatest risk at the Site.

The selected remedy, REM-3/10/Select, is more cost-effective than the REM-0/0/3 alternative. The selected remedy is $110 million less expensive than REM-0/0/3, without substantially greater reductions in ecological and human health risks. In addition, the capping alternative that was considered (CAP-3/10/Select) would not be as permanent or reliable as the selected remedy and would raise significant long-term maintenance concerns.

The selected remedy will comply with the location-specific and action-specific ARARs identified, as well as four of the seven chemical-specific ARARs for the site. However, although the selected remedy will approach some of these numbers, three of the chemical-specific ARARs are not expected to be met because the PCB contamination entering the Upper Hudson River from above Rogers Island (even after source control near the GE Hudson Falls plant) will likely exceed those ARARs. Therefore, technical impracticability ARAR waivers are required for three chemical-specific ARARs (1 ng/L total PCBs federal Ambient Water Quality Criterion; 0.12 ng/L total PCBs New York State standard for protection of wildlife; and, 0.001 ng/L total PCBs New York State standard for protection of human consumers of fish). Even the most aggressive removal alternative, REM-0/0/3, would require these same waivers.

Implementation of the selected remedy will greatly reduce the mass of PCBs in the sediments and lower the average PCB concentration in surface sediments, which in turn will reduce PCB levels in the water column and fish and other biota, thereby reducing the level of risk to human and ecological receptors. Reduced amounts of PCBs in the water column and reduced surface sediment concentrations will also reduce the long-term transport of PCBs from each river section to the next and from the Upper Hudson River to the Lower Hudson River. For example, there is expected to be a 38 percent reduction of the PCB load that is transported into the Lower Hudson River in the 10 years following remediation as compared to MNA alone (with upstream source control).

The selected remedy is technically and administratively feasible and is implementable. All of the necessary personnel, equipment and services required are expected to be readily available or reasonably arranged.

In summary, the REM-3/10/Select alternative was chosen based on the need for active remediation in order to protect human health and the environment. The REM-3/10/Select alternative fulfills the statutory requirement for permanent remedies, to the maximum extent practicable, whereas capping does not, and the REM-3/10/Select alternative is more cost-effective than the REM-0/0/3 alternative.

14. STATUTORY DETERMINATIONS

EPA and the State of New York believe that the selected remedy complies with the CERCLA and NCP provisions dealing with remedy selection. This includes selection of remedies that are protective of human health and the environment, comply with applicable or relevant and appropriate requirements (or justify a waiver from such requirements), are cost effective and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity or mobility of hazardous substances as a principal element. The following sections discuss how the selected remedy meets these statutory requirements.

14.1 Protection of Human Health and the Environment

The selected remedy is protective of human health and the environment. Risk is reduced through removal of PCB-contaminated sediment, followed by backfilling and MNA. Risk from human consumption of fish in River Sections 1, 2, and 3, as well as in the Lower Hudson River, is significantly reduced. The modeling projects that one of the targets of this remedy, a fish PCB concentration of 0.4 mg/kg, which is protective of the average adult who consumes one fish meal from the Upper Hudson every two months, will be attained within the entire upper Hudson River within 20 years of active remediation. The modeling also projects that the target PCB fish concentration of 0.2 mg/kg, protective of an adult who consumes one fish meal from the Upper Hudson per month, is expected to be attained in River Section 2 within 32 years of active remediation. These time periods are significantly shorter than the time periods projected for attaining the 0.4 mg/kg and 0.2 mg/kg targets in these sections of the river under either the No Action alternative or the MNA alternative. Moreover, as discussed earlier, the actual time differentials may be greater that those calculated by EPA's models. The selected remedy achieves a 76% to 85% reduction in the RME cancer risk and a 71% to 79% reduction in the RME non-cancer hazard index compared to No Action. The selected remedy achieves a 50% to 80% reduction in the RME cancer risk and a 58% to 75% reduction in the RME non-cancer hazard index compared to the MNA alternative.

As stated above, according to EPA's model projections for the Upper Hudson River, the selected remedy will meet the Remediation Goal for human consumption of fish, 0.05 mg/kg, in River Section 3 within 43 years after completion of the active remediation. Therefore, the Remediation Goal of 0.05 mg/kg, or one fish meal per week for an adult, also is expected to be attained in the majority of the Lower Hudson River within this time frame, due to the lower initial concentration of Site-related PCBs in the Lower Hudson compared to the Upper Hudson. Because of the continuing Tri+ PCB load of 2 ng/L assumed after implementation of the source control action in the vicinity of the GE Hudson Falls plant, the PCB concentration in fish averaged over the Upper Hudson is expected to be reduced to a range of 0.09 to 0.14 mg/kg, within the 70-year modeled time period, which is slightly above the Remediation Goal of 0.05 mg/kg. However, the protectiveness of the selected remedy is further enhanced through continuation of institutional controls, such as the fish consumption advisories and fishing restrictions.

If GE's proposed source control is able to reduce the upstream Tri+ load to zero, then the selected remedy is predicted to reach the Remediation Goal of 0.05 mg/kg PCBs in fish tissue by 2039 in River Section 1, by 2041 in River Section 2, and by 2025 in River Section 3.

The selected remedy is also protective of the environment. The selected remedy will reduce PCB concentrations in fish averaged over the entire Upper Hudson, and in the Lower Hudson, to levels that are at or within the range of 0.3 to 0.03 mg/kg in whole fish, which is the Remediation

Goal for ecological exposure. The selected remedy is therefore protective of the piscivorous or semi-piscivorous birds such as the belted kingfisher, great blue heron and bald eagle, and the piscivorous or semi-piscivorous mammals, such as the river otter and mink, which are the ecological receptors at greatest risk at the Site. By removing PCBs from the Upper Hudson River, the selected remedy also is protective of piscivorous fish, such as the largemouth bass and striped bass, omnivorous fish, such as the brown bullhead, insectivorous birds, such as the tree swallow, insectivorous mammals, such as the little brown bat, and omnivorous mammals, such as the raccoon, which also are at risk at the Site.

By greatly reducing the mass of PCBs in the sediments and lowering the average concentrations of PCBs in surface sediments, the selected remedy will also reduce the long-term transport of PCBs from each River Section to the next and from the Upper Hudson River to the Lower Hudson River.

14.2 Compliance with ARARs

The selected remedy will comply with the location-specific and action-specific ARARs identified, as well as four of the seven chemical-specific ARARs for the Site. However, although the selected remedy will approach some of these numbers, three of the chemical-specific ARARs are not expected to be met because the PCB contamination entering the Upper Hudson River from above Rogers Island (even after source control near the GE Hudson Falls plant) will likely exceed those ARARs. Therefore, because of technical impracticability, three chemical-specific ARARs pertaining to water column concentrations (1 ng/L total PCBs federal Ambient Water Quality Criterion; 0.12 ng/L total PCBs New York State standard for protection of wildlife; and, 0.001 ng/L total PCBs New York State standard for protection of human consumers of fish) are hereby waived (CERCLA Section 121(d)(4)(c) and 40 CFR 300.430(f)(1)(ii)(C)(3)). Even the most aggressive removal alternative, REM-0/0/3, would require these same waivers. Even with the technical impracticability waivers, the selected remedy is protective of human health and the environment.

The ARARs for the selected remedy are provided in Tables 14-1 through 14-3. The TBCs are provided in Tables 14-4 and 14-5.

14.3 Cost-Effectiveness

The cost of the selected remedy, REM-3/10/Select, is proportional to its overall effectiveness. The selected remedy's overall effectiveness is determined based on a consideration of its long-term effectiveness and permanence (Section 11.3, above), reduction in toxicity, mobility or volume through treatment (Section 11.4, above); and short-term effectiveness (Section 11.5, above).

The selected remedy is significantly more protective of human health and the environment in the long-term than the No Action and MNA alternatives. Although the MNA ($39 Million) and No Action ($0.14 Million) alternatives are considerably less expensive than the selected remedy, those alternatives are not sufficiently protective of human health and the environment. No Action and MNA would result in a continuation of unacceptably elevated fish PCB concentrations at the Site, and the continued degradation of the sediments and surface water quality of the Upper Hudson River, especially in River Section 1, for at least several decades longer than any of the active remedial alternatives. While the CAP-3/10/Select alternative is approximately $90 million less expensive than the selected remedy and provides a degree of risk reduction that is similar to the risk reduction under the selected remedy, CAP-3/10/Select is less permanent and reliable than the selected remedy. CAP-3/10/Select does not effectively eliminate long-term risks for target areas that are capped because of long-term effectiveness and maintenance concerns associated with the cap, and it would also require certain Site use restrictions in the capped areas.

The selected remedy is more cost-effective than the REM-0/0/3 alternative. REM-3/10/Select is $110 million less expensive than REM-0/0/3, without substantial differences in the amount of ecological or human health risk reduction.

In summary, the selected remedy is cost-effective.

14.4 Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Practicable

EPA has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the Site. Of those alternatives that are protective of human health and the environment and comply with ARARs (or provide a basis for invoking an ARAR waiver), EPA has determined that the selected remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and the bias against off-site disposal without treatment and considering State and community acceptance.

Implementation of the selected remedy will greatly reduce the mass of PCBs in the sediments and lower the average PCB concentration in surface sediments, which in turn will reduce PCB levels in the water column and fish and other biota, thereby reducing the level of risk to humans and ecological receptors. These permanent reductions will also reduce the long-term transport of PCBs from each river section to the next and from the Upper Hudson River to the Lower Hudson River. For example, as noted above, EPA projects that there will be at least a 38 percent reduction of the PCB load that is transported into the Lower Hudson River in the 10 years following the implementation of the selected remedy as compared to MNA alone (with upstream source control).

14.5 Preference for Treatment as a Principal Element

The selected remedy results in the targeted removal of 2.65 million cubic yards of contaminated sediments containing approximately 70,000 kg (about 150,000 lbs) of total PCBs (approximately 65% of the total PCB mass present within the Upper Hudson River) from the river environment. This results in a long-term reduction in the mobility and volume of PCBs in the river, even though treatment is not a principal element of the remedy. As explained above (Section 14.3), EPA has determined that given the volume of material to be removed, treatment of the material prior to off-site disposal (other than the stabilization of the sediments for handling purposes) would not be cost-effective. During remedial design, EPA will consider whether there are any new treatment options for the dredged sediment and whether there are value engineering recommendations (*e.g.*, waste volume or toxicity reductions) that could improve the cost-effectiveness of the remedy. During the remedial design or implementation, EPA will determine whether beneficial use (*i.e.*, the manufacture of commercial products) is appropriate for some portion of the dredged material.

14.6 Five-Year Review Requirements

Because the selected remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action. The five-year review will evaluate the results from monitoring programs established as part of this remedy to ensure that the remedy remains protective of human health and the environment.

The protectiveness of the selected alternative will be further enhanced through continuation of institutional controls, including the continuation of fish consumption advisories and fishing restrictions, as needed, until such time as the Remediation Goals are achieved.

15. DOCUMENTATION OF SIGNIFICANT CHANGES FROM PREFERRED ALTERNATIVE OF PROPOSED PLAN

The Proposed Plan for the Hudson River PCBs Site was released in December 2000. The Proposed Plan identified Alternative 4: REM-3/10/Select (active removal of sediments with backfilling followed by MNA in River Sections 1, 2, and 3) as the preferred alternative for remediating the contaminated sediments. EPA reviewed all written (including electronic formats such as e-mail) and oral comments during the public comment period. EPA has determined that no significant changes to the remedy, as originally identified in the Proposed Plan, are necessary or appropriate. At the same time, EPA notes the following items that were not included in the

Proposed Plan (these items are not significant changes for purposes of Section 117(b) of CERCLA):

- A community involvement program will provide members of the public and elected officials the opportunity for early and meaningful input during the remedial design. This enhanced community involvement program will remain active throughout the subsequent construction and post-construction monitoring phases of the project.

- The remedial dredging will be conducted in two phases. In the first phase, the first construction season of remedial dredging will be implemented initially at less than full-scale, during which extensive monitoring of operations will be performed. The second phase will be the remainder of the dredging operation, which will be conducted at full-scale and is expected to last five years;

- Performance standards will be established for the project. These will be used to evaluate the first season of dredging and provide information to make any necessary adjustments to the operations of the succeeding phase. During the full-scale remedial dredging, EPA will continue to evaluate performance data and make necessary adjustments;

- Backfill material will be transported within the Upper Hudson River area by rail and/or barge. By movement of this material as well as dredged sediment in this manner, impacts on local traffic will be minimized. Throughout design, further steps to avoid/mitigate traffic impacts and other potentially adverse impacts on the quality of life will be explored.

In the Proposed Plan, EPA indicated that the preferred remedy would be performed in conjunction with a separate Non-Time Critical Removal Action to address the ongoing release of PCBs to the river from the vicinity of the GE Hudson Falls plant. Source control at Hudson Falls is currently being addressed by GE under New York State order pursuant to State law. In the event that source control at Hudson Falls is not successfully implemented pursuant to State law, EPA has authorized the performance of an Engineering Evaluation/Cost Analysis to evaluate options for a Non-Time Critical Removal Action at Hudson Falls pursuant to CERCLA in order to ensure that the PCB load to the river is significantly reduced.

PART 3: RESPONSIVENESS SUMMARY

The Responsiveness Summary is provided as a separate attachment to this Record of Decision.

Appendix A
Record of Decision
Hudson River PCBs Superfund Site
Statement of Findings: Floodplains and Wetlands

Need to Affect Floodplains and Wetlands

The selected remedy (REM 3/10/Select - Removal followed by MNA, assuming Upstream Source Control) entails excavation of PCB-contaminated sediments, which have been determined to pose a threat to human health and ecological receptors, within a 40-mile reach of the Upper Hudson River. Implementation of the selected remedy will greatly reduce the levels of PCB contamination in Hudson River sediments and the separate source control action will substantially reduce the potential for recontamination of remediated areas. EPA has determined that there is no practicable alternative that is sufficiently protective of human health and the environment and would not result in excavation of these sediments. Because certain submerged aquatic vegetation (SAV) communities along the Upper Hudson are contaminated by PCBs, they have been included in the areas targeted for dredging. In addition, certain wetlands adjacent to PCB-contaminated SAV communities may be affected by the dredging operations.

In addition to the selected remedy, the following four remedial alternatives were considered in the December 2000 Feasibility Study:

- No Action (no Upstream Source Control);
- Monitored Natural Attenuation (MNA) with Upstream Source Control;
- CAP-3/10/Select - Capping, with Removal to Accommodate Cap, followed by MNA, with Upstream Source Control; and
- REM-0/0/3 - Removal followed by MNA with Upstream Source Control.

The No Action alternative and the MNA alternative do not entail excavation of contaminated sediments. The former does not include any physical remedial measures, and the latter relies on natural attenuation and a separate source control action only. Under both alternatives, contamination currently in the Upper Hudson River sediments would remain in place and remain a potential source for contamination of Hudson River floodplain sediments and floodplain, wetland, and SAV ecological communities. The No Action alternative would not be protective of human health and the Hudson River environment. Although the MNA alternative assumes a separate source control action, it would not mitigate the ongoing adverse effect the contaminated sediments are having on the floodplain, wetlands and SAV communities.

Implementation of the CAP-3/10/Select and REM-0/0/3 alternatives would entail excavation of Upper Hudson River sediments, resulting in temporary disturbance to the floodplain, wetlands and SAV communities. Approximately 1.73 million and 3.82 million cubic yards of PCB-contaminated sediment would be excavated under the CAP-3/10/Select and REM-0/0/3 alternatives, respectively. The CAP-3/10/Select also would entail the capping of 207 acres of contaminated sediments. Like the selected remedy, the CAP-3/10/Select and REM-0/0/3 alternatives, by removing PCB-contaminated sediments from the Upper Hudson River, would be protective of human health and the environment, including the floodplain, wetlands and SAV communities.

Effects of Proposed Action on Floodplains and Wetlands

A principal benefit of EPA's selected remedy will be removal of a considerable sediment-bound contaminant mass from the river. PCB-contaminated sediments removed from the Upper Hudson River no longer will function as a source of contamination of Hudson River floodplains, wetlands and SAV communities. As removal work proceeds, the mass of PCBs available to be transported during flood events into the floodplains and wetlands bordering the river will diminish. In this context, the selected remedy will have a substantial positive impact, especially during flood events when the potential for sediment resuspension is greatest. Further, removal of PCB-contaminated sediments will greatly reduce the risk to ecological receptors resident in the Hudson River floodplain, wetlands and SAV communities.

Excavation of sediments may result in temporary, localized disturbance to the floodplain, wetlands and SAV communities. Approximately 2.65 million cubic yards of PCB-contaminated sediment will be excavated. The selected remedy calls for 0.8 million cubic yards of fill to be placed in the river as a follow-up activity to dredging operations. Thus, EPA will remove considerably more material from the river bottom than it will place as fill. In addition, backfilling will not affect the active storage capacity of the Upper Hudson because it is a series of impounded pools controlled by dams. For both these reasons, it is not expected that backfilling will exacerbate conditions during flood events. No permanent impact (positive or negative) to the capacity of the floodplain to carry flood flows will result from implementation of the selected remedy.

Based on available wetland mapping, the dredging operations will occur in locations contiguous to approximately 129 acres of wetlands, although no wetlands are currently expected to be dredged or backfilled. In addition, an estimated 177 acres of submerged aquatic vegetation will be dredged and an additional 46 acres of submerged aquatic vegetation are located contiguous to areas to be dredged. Wetlands and SAV communities in and contiguous to the remediation areas and the sediment processing/transfer facilities will be field delineated during remedial design.

Dredging and backfilling will result in changes to the sediment supply and channel morphology, which in turn may lead to river bed and bank erosion and sedimentation. To minimize river bank instability that could adversely affect floodplains, wetlands and SAV, the selected remedy calls for shoreline stabilization measures, where appropriate. In addition, the selected remedy will employ engineering and operational controls to reduce resuspension of sediments during dredging and backfilling. These measures will reduce impacts on SAV communities due to reduced light penetration through the water column. In any event, impacts to SAV communities are expected to be temporary and localized.

Construction of sediment processing/transfer facility(ies) called for in the selected remedy may require the placement of fill in the floodplain. The discharge of water from the facility(ies) will comply with all substantive state and federal requirements.

The selected remedy will comply with applicable or relevant and appropriate substantive requirements relating to floodplains and wetlands, including Executive Order 11988: Floodplain Management; Executive Order 11990: Protection of Wetlands, 40 CFR Part 6, Appendix A; and the New York State Freshwater Wetlands Act.

Measures to Mitigate Potential Harm to the Floodplains and Wetlands

The following mitigation measures will be undertaken to reduce impacts on floodplains, wetlands and SAV communities:

- EPA will employ measures to control resuspension and downstream migration of PCBs during remediation, including sediment barriers (*e.g.*, silt curtains) and operational controls, in order to minimize potential impacts to floodplains, wetlands and SAV communities;
- A habitat replacement program will be implemented in an adaptive management framework to replace SAV communities, wetlands, and river bank habitat;
- A shoreline stabilization program will be implemented;
- Wetlands adjacent to the remediation area and at the sediment processing/transfer facility location(s) will be field delineated during remedial design;
- During remedial design, EPA will consider in detail the need to minimize encroachments or impacts to wetlands in the vicinity of the sediment processing/transfer facility(ies); and
- If it is determined that the selected remedy requires unavoidable impacts to wetlands, EPA will implement compensatory wetland mitigation, as appropriate, in consultation with USACE, the federal trustees, and NYSDEC.

Appendix B

GEORGE E. PATAKI
GOVERNOR

ERIN M. CROTTY
COMMISSIONER

STATE OF NEW YORK
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
ALBANY, NEW YORK 12233-1010

DEC 21 2001

Via Facsimile & Overnight Mail
Honorable Jane M. Kenny
Regional Administrator
United States Environmental Protection Agency, Region II
290 Broadway, 26th Floor
New York, New York 10007-1866

Dear Regional Administrator Kenny,

The New York State Departments of Environmental Conservation (DEC) and Health (DOH), collectively referred to as the State, have reviewed the December 20, 2001 "Environmental Protection Agency (EPA) Superfund Record of Decision, Hudson River PCBs Site, Hudson Falls to New York City, New York." EPA has provided this opportunity for the State to review the Record of Decision before it is executed by EPA consistent with federal Superfund regulations.

I want to thank you for incorporating the State's concerns into the selected remedy which demonstrates that EPA shares the State's views on the cleanup of the Upper Hudson River. This decision is a major step towards the revitalization of the Hudson River so that future generations can enjoy the full potential of the Hudson River as an economic, recreational, and natural resource. This decision not only achieves a cleaner, healthier Hudson River but also balances the public health and ecological needs to clean-up the polychlorinated biphenyls (PCB) contamination with the concerns expressed by the many stakeholders, including the local communities. As we move forward to the remedial design, remedial construction and remedial post-construction phases, the State will remain vigilant in its efforts to work with EPA and other interested parties to implement this remedy.

This decision reaffirms what the findings of EPA and State scientific and technical studies have clearly shown: the removal of PCBs in the Upper Hudson is the most appropriate and effective way to mitigate the unacceptable risks those contaminants pose to public health and the environment. The State recognizes that the PCB contaminated sediments in the Upper Hudson River are significant ongoing sources of PCB to the Hudson River. The selected remedy described in the Record of Decision will likely achieve significant reductions in the quantity of PCBs associated with the contamination in the Upper Hudson River. These significant PCB sources to the Hudson River will be abated, which should enable the State to reduce the current fishing restrictions and consumption advisories.

EPA received thousands of public comments on its December 2000 "Superfund Proposed Plan - Hudson River PCBs Superfund Site." In addition, the State provided comments and recommendations to EPA during development of the Record of Decision via an August 1, 2001 letter from Governor Pataki and my August 13, 2001, August 20, 2001 and October 24, 2001 letters consistent with the State's Support Agency role. The final Record of Decision demonstrates that EPA has given thorough and thoughtful consideration to the concerns of the public and the State in its deliberations. As a result, the Record of Decision includes some significant enhancements (discussed below) compared to the Proposed Plan that should allow the selected remedy to be implemented in a manner that balances public concerns with the need to mitigate the public health and environmental risks resulting from the PCB contamination in the Upper Hudson River.

Community Involvement Program

The Record of Decision calls for the development and implementation of an enhanced community involvement program that will provide opportunities for meaningful public involvement throughout the remedial design, remedial construction, and remedial post-construction phases. This program will include the development of performance standards; the siting and design of sediment processing/transfer facilities; the design and implementation of measures to mitigate any potential adverse impacts of the remedial work on the public, the environment, and local communities; and the evaluation of performance monitoring data during remedy implementation. We are encouraged that the State, local communities, and other stakeholders will be able to participate in this important process. The community involvement program will help EPA to identify and mitigate any potential adverse community impacts resulting from remedy implementation.

Land Based Facilities for Remedy Implementation

Once any necessary land-based facilities are no longer needed, the Record of Decision calls for restoration of the parcels in a manner that takes into account the anticipated future land use of the parcels, such as redevelopment for commercial or recreational use. In addition, the Record of Decision requires that EPA evaluate the use of on-water solids treatment facilities.

Community Health and Safety Plan

The Record of Decision provides for a comprehensive Community Health and Safety Plan (Plan) which will be developed during the remedial design phase with input from the public. This plan will be designed to protect the community during remedial construction. In addition, EPA will increase monitoring of water supply intakes during each project construction phase to identify and address possible impacts on water supplies drawn for drinking water. The locations, frequency and other aspects of monitoring of the water supplies in the Upper and Lower Hudson River will be developed with public and State input during the remedial design phase. This Plan will also ensure that the public is adequately informed of any health and safety issues throughout the remedial process.

Honorable Jane M. Kenny
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December 21, 2001

Floodplain Issues

The Record of Decision states that EPA will evaluate the residential and ecological impacts of PCBs in the floodplain concurrent with the remedial design phase to determine if further investigation and/or remediation may be appropriate. The State believes that this is an important element in understanding the magnitude of risks to people who reside along the Upper Hudson River and to the floodplain environment.

Performance Standards

The Record of Decision calls for the development, during the remedial design phase, of performance standards for remedy implementation. The community involvement program will provide opportunities for public participation in this process. The State believes it is essential that the performance standards be designed to protect the public and the environment during remedial construction and to attain the remedial goals for this remedy.

Phased Remedy Implementation Approach

The Record of Decision describes a phased approach to remedy implementation that includes development of peer reviewed performance standards during the remedial design phase, development and implementation of an extensive monitoring program of all operations during the initial and succeeding phases of remedy implementation, and a peer reviewed comparison of the monitoring results to the performance standards. The community involvement program discussed above will provide opportunities for public participation in many aspects of this phased approach. Phased remedy implementation as described in the Record of Decision is a reasonable approach that balances public concerns with the need to achieve the remedial goals and mitigate the public health and environmental risks posed by the PCB contamination in the Upper Hudson River.

Mitigation of Potential Impacts on Navigation

The Record of Decision provides for the development of a navigation performance standard during the remedial design phase, in consultation with the public and the State. EPA will consider the State's regulations which specify Champlain Canal navigational channel dimensions in developing this navigation performance standard, which the State believes will likely be an integral component of the standard. Dredging will be sequenced and directed to ensure minimal impacts to navigation within the Hudson River. EPA will consult with the New York State Canal Corporation during the remedial design and construction phases on issues related to canal usage, navigational dredging, and other remedy related activities within the navigational channel.

The State of New York finds the selected remedy to be protective of human health and the environment, and the selected remedy will reduce public health and environmental risk. Implementation of the selected remedy will also provide positive changes to the ecology of the Hudson River and will provide long-term benefits to the communities along its banks. The Record of Decision provides for meaningful community involvement during remedy design and implementation. The Record of Decision also provides for the development and implementation of measures to mitigate any adverse impacts to local communities related to the selected remedy.

Accordingly, the State of New York hereby concurs with the Environmental Protection Agency's Superfund Record of Decision, Hudson River PCBs Site, Hudson Falls to New York City, New York dated December 20, 2001.

Very truly yours,

Erin M. Crotty