St. Lawrence Environment Natural Resource Damage Assessment Plan

Preliminary Draft
Report

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ACRONYMS

AET	apparent effects threshold
ALCOA	Aluminum Company of America
AM	Assessment Manager
AOC	Area of Concern
AWQC	ambient water quality criteria
BF	bioaccumulation factors
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
COC	chain-of-custody
CWA	Clean Water Act (Federal Water Pollution Control Act)
DEC	Department of Environmental Conservation
DOI	U.S. Department of Interior
DOL	Department of Law
DQO	data quality objective
EC	Environment Canada
EROD	ethoxyresorufin-O-deethylase
FDA	U.S. Food and Drug Administration
FPSA	Former Potliner Storage Area
FTL	Field Team Leader
GC/ECD	gas chromatography with electron capture detection
GC/MS	gas chromatography with mass spectrophotometry
GIS	geographic information system
GLWQG	Great Lakes Water Quality Guidance
GM	General Motors Powertrain
HPGL	hypothalamic-pituitary-liver
HPI	hypothalamus-pituitary-interrenal
IJC	International Joint Commission
LEL	lowest effects level
LOAEL	lowest observable adverse effect

MACT	Maximum Achievable Control Technology
MDL	method detection limit
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NRDA	natural resource damage assessment
NTCRA	Non-Time Critical Removal Action
NTR	National Toxics Rule
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYDOH	New York State Department of Health
OME	Ontario Ministry of the Environment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzo-p-furan
PCE	perchloroethylene
PI	Principal Investigator
PM	Project Manager
PRP	potentially responsible party
QA/QC	quality assurance/quality control
QAPjP	Quality Assurance Project Plan
RACT	Reasonably Available Control Technology
RCRA	Resource Conservation and Recovery Act
RI/FS	Remedial Investigation and Feasibility Study
RMC	Reynolds Metal Company
ROD	Record of Decision
RPD	relative percent difference
RSI	River and Sediment Investigation
SDWA	Safe Drinking Water Act
SLETC	St. Lawrence Environment Trustee Council
SOP	Standard Operating Procedure
SPDES	State Pollution Discharge Elimination System

SRMs	standard reference materials
SRMT	St. Regis Mohawk Tribe
SRS	Supplemental Remedial Studies
TCDD	tetrachlorodibenzo-p-dioxin
TE	toxic equivalent
TEC	toxic equivalent concentration
TEF	toxic equivalency factor
TSA	Technical System Audit
TSCA	Toxic Substances Control Act
UAO	Unilateral Administrative Order
U.S. EPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compounds
WDNR	Wisconsin Department of Natural Resources

EXECUTIVE SUMMARY

The St. Regis Mohawk Tribe, the U.S. Department of the Interior, the National Oceanic and Atmospheric Administration, and the State of New York Department of Environmental Conservation and Department of Law (collectively called the St. Lawrence Environment Trustee Council) are in the process of assessing damages to natural resources that have resulted from releases of hazardous substances to the St. Lawrence River, the Grasse River, the Raquette River, the general area of Massena, New York, and the Mohawk Territory of Akwesasne, including, without limitation, all land, water, sediments, air, flora, and fauna in the St. Lawrence Environment Assessment Area (also referred to as the Massena-Akwesasne Assessment Area).

This assessment plan is a work plan for the natural resource damage assessment (NRDA) for the St. Lawrence Environment Assessment Area and is designed to be in accordance with natural resource damage assessment regulations promulgated by the U.S. Department of the Interior at 43 CFR Part 11. This NRDA focuses on injury and related damages caused by releases of hazardous substances from the Aluminum Company of America, Reynolds Metals Company, and General Motors Powertrain, formerly the General Motors Central Foundry Division (collectively, "the companies"). Releases of hazardous substances have occurred and continue to occur from various sources at and near the assessment area and include polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzo-p-furans, polycyclic aromatic hydrocarbons, trace metals (including aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, and zinc), cyanides, hydrofluoric acid and other fluoride compounds, volatile organic compounds, phenols, and styrene. A review of available data indicates that natural resources, including surface waters, sediments, groundwaters, soils, air, aquatic biota, terrestrial biota, and vegetation, have been injured as a result of releases of hazardous substances.

This assessment plan has been prepared prior to completion of remedial measures at the assessment area. The trustees recognize that a phased approach toward implementation of this assessment plan, together with appropriate remedial and restorative efforts, may lead to a finding that portions of this plan need not be implemented or fully implemented. The goal of the St. Lawrence Environment Trustee Council is to promote restoration of area ecosystems to their full function and to compensate the public, through restoration, for past, present, and future losses. This assessment plan has been developed in large part through a 1991 cooperative funding agreement with the companies. The St. Lawrence Environment Trustee Council is involved in discussions with the companies toward further cooperation in restoring the St. Lawrence environment.

CHAPTER 1
INTRODUCTION

The St. Regis Mohawk Tribe (SRMT), the U.S. Department of the Interior (DOI), the National Oceanic and Atmospheric Administration (NOAA), and the New York State (NYS) Department of Environmental Conservation (DEC) and Department of Law (DOL) are in the process of assessing damages to natural resources that have resulted from releases of hazardous substances to the St. Lawrence River, the Grasse River, the Raquette River, the general area of Massena, New York, and the Mohawk Territory of Akwesasne, including, without limitation, all land, water, sediments, air, flora, and fauna in this St. Lawrence Environment Assessment Area (also referred to as the Massena-Akwesasne Assessment Area). The Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) [§ 107 (f), 42 U.S.C. § 9607, as amended] and the Clean Water Act (Federal Water Pollution Control Act, or CWA) [33 U.S.C. § 1321] provide authority to the SRMT, the DOI, NOAA, and NYS (collectively called the St. Lawrence Environment Trustee Council, SLETC) to seek such damages. This assessment plan is guided by the natural resource damage assessment (NRDA) regulations promulgated by the DOI at 43 CFR Part 11. This assessment plan was prepared by the SLETC and Stratus Consulting Inc.

1.1 BACKGROUND

1.1.1 The Natural Resource Damage Assessment Process

CERCLA provides that parties that have released hazardous substances into the environment shall be liable for damages for injury to, destruction of, or loss of natural resources caused by the releases. While injuries to human health are not directly included in the NRDA injury identification process, human health and human natural resource use considerations are included in evaluating injury and quantifying related damage to natural resources. Certain state and federal agencies which have been designated as Trustees and affected Indian tribes are empowered to obtain compensation from potentially responsible parties (PRPs) for damages to the natural resources. Trustees must use recovered funds to restore, replace, rehabilitate, or acquire the equivalent of the injured natural resources. In lieu of receiving funds for damages to natural resources, the trustees may allow the PRPs to directly implement restoration activities. This NRDA focuses on injury and related damages caused by the release of hazardous substances from the Aluminum Company of America (ALCOA), Reynolds Metals Company (RMC), and General Motors Powertrain (GM, formerly the General Motors Central Foundry Division). ALCOA purchased RMC in 1999. However, for the purposes of this assessment plan, we have maintained a distinction between the ALCOA and RMC facilities.

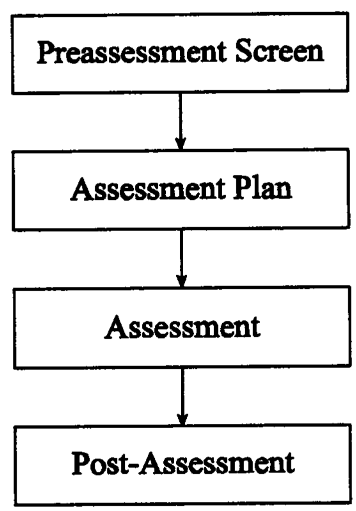
Important terms used in this assessment plan include:

Injury A measurable adverse change, either long or short term, in the chemical or physical quality or the viability of a natural resource resulting from the release of a hazardous substance [43 CFR § 11.14 (v)].

Service The physical and biological functions performed by the resource, including human uses of those functions [43 CFR § 11.14 (nn)]. Services may include wildlife habitat, recreation, erosion control, and ceremonial and medicine uses.

Damages The amount of money sought by the natural resource trustees as compensation for injury, destruction, and loss of natural resources [43 CFR § 11.14 (1)]. The SLETC may also accept restoration activities in lieu of direct monetary compensation.

Figure 1-1
Natural Resource Damage Assessment/Restoration Process



The process described in the NRDA regulations involves four major components (Figure 1-1). The first is the development of a **preassessment screen,** which determines whether a discharge or release of hazardous substances warrants an NRDA. The **assessment planning** process represents the second phase. The assessment plan is a work plan for the NRDA and ensures that the assessment proceeds in a cost-effective manner. Trustees are required to provide an opportunity for public review of, and comment on, the assessment plan. The third component involves conducting the **assessment,** which includes performing scientific studies to determine whether injury has occurred, quantifying the injuries and reduction of services provided by the natural resource, and calculating monetary compensation for injuries. One option that the trustees are considering is to work cooperatively with the companies in implementing this assessment plan. The fourth component consists of the **post-assessment.** A report of assessment containing the results of the assessment work is prepared and made available to the public. The PRPs are then presented with required restoration activities and/or the amount of money sought by the natural resource trustees as compensation for injury, destruction, and loss of natural resources, and a restoration plan is developed and implemented.

1.1.2 The Preassessment Screen

In May 1991, a preassessment screen was prepared by the SLETC. In this first phase of the NRDA process, the SLETC made the determination to proceed with an assessment, concluding — based on a rapid review of readily available data [43 CFR § 11.23 (b)] — that there is a reasonable probability of making a successful claim for damages to aquatic, terrestrial, air, sediments, and other resources within the trusteeships of the SRMT, DOI, NOAA, and New York State Department of Environmental Conservation (NYSDEC) [43 CFR § 11.23 (b)]. Based on readily available information, the PRPs were identified as ALCOA, RMC, and GM. In the preassessment screen, the trustees made the following determinations:

1. Releases of hazardous substances have occurred [43 CFR § 11.23 (e)(1)].

   - Numerous investigators, including the SRMT, NYSDEC, GM, RMC, ALCOA, Environment Canada (EC), U.S. Environmental Protection Agency (U.S. EPA), U.S. Fish and Wildlife Service (USFWS), and many university researchers, have demonstrated that multiple releases of polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzo-p-furans (PCDFs), polycyclic aromatic hydrocarbons (PAHs), trace elements (aluminum,[1] arsenic, barium, cadmium, copper, lead), fluorides,[2] cyanide, phenol, and styrene have occurred and continue to occur from various sources at and near the assessment area. These are hazardous substances as that term is defined by Section 101(14) of CERCLA and are listed as toxic pollutants pursuant to 33 U.S.C. § 1317 (a) and 40 CFR § 401.15.

2. Natural resources for which trustees can assert trusteeship have been, or are likely to have been, adversely affected by the releases of hazardous substances [43 CFR § 11.23 (e)(2)].

   - Natural resources for which the SRMT, DOI, NOAA, and NYS are trustees and that are likely to have been adversely affected by releases of hazardous substances include, but are not limited to, surface water; sediments; groundwater; soils; aquatic biota, including fish, amphibians, reptiles, invertebrates, and aquatic vegetation; terrestrial biota, including endangered species, migratory birds, and wildlife; vegetation; and air.

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1. Aluminum phosphide and aluminum sulfate are designated as hazardous substances under Section 102(a) of CERCLA 40 CFR 302.4.

2. Fluorine, hydrogen fluoride, and sodium fluoride have been named as hazardous substances by the U.S. EPA and have been found at 130 of the sites on its National Priorities List (NPL). All three compounds are designated as hazardous substances defined by Section 101 (14) of CERCLA and are listed as toxic pollutants pursuant to 33 U.S.C. § 1317 (a) and 40 CFR § 401.15. In addition, Section 111 (d)(1) of the Clean Air Act requires states to establish emission standards for existing sources such as primary aluminum reduction plants, which include the RMC and ALCOA facilities.

3. The quantities and concentrations of the released substances are sufficient to potentially cause injury to those natural resources [43 CFR § 11.23 (e)(3)].

    ▸ Numerous investigations in the assessment area have documented the presence of hazardous substances, including PCBs, fluorides, PAHs, phenols, cyanide, aluminum, and styrene at concentrations sufficient to potentially injure natural resources in the assessment area.

4. Data sufficient to pursue an assessment are readily available or obtainable at reasonable cost [43 CFR § 11.23 (e)(4)].

    ▸ Studies conducted in the assessment area by the SRMT, NYSDEC, GM, RMC, ALCOA, EC, U.S. EPA, USFWS, and many university researchers are available and will be used to the extent practicable in the NRDA. The assessment will build on this information to identify and evaluate potential injuries, determine exposure pathways, quantify resulting damages to the public, and develop a plan to restore injured natural resources. Additional assessment costs are likely to be reasonable, as defined by DOI regulations [43 CFR § 11.14 (ee)].

5. Response actions carried out or planned will not sufficiently remedy the injury to natural resources without further action [43 CFR § 11.23 (e)(5)].

    ▸ Although the U.S. EPA has carried out and planned future, additional response actions in the assessment area, these actions will not be sufficient to remedy the injury to natural resources without further action on the part of the trustees. Injuries to the assessment area include past, present, and future residual losses. Remediation at the site, intended to reduce ongoing releases of hazardous substances, will not make the public whole for these past, present, and future losses.

Based on these findings, the trustees determined that all federal regulatory prerequisites for conducting an NRDA had been met, and that conducting an NRDA is appropriate.

1.1.3 Importance of Restoration

The goal of the SLETC is to promote restoration of area ecosystems to their full function and to compensate the public, through restoration, for past, present, and future losses. Restoration is important to the Mohawks of Akwesasne, whose trusteeship includes the entire St. Lawrence Environment and whose territory is located downstream, downwind, and downgradient from GM, RMC, and ALCOA sites. Many social, cultural, and spiritual values, beliefs, and philosophies of the Mohawk people are tied to their relationship with the natural world. Remediation and restoration efforts are not only important for restoring the local environment but also critical to ensuring the long-term survival of the Mohawk economy as well as cultural values, beliefs, and practices.

1.2 PURPOSE OF THE ASSESSMENT PLAN

The assessment plan is a description of the methods to be used to determine the nature, extent, and degree of injury to natural resources in the assessment area and to measure the damages resulting from the injury. The purpose of the assessment plan is to ensure that the assessment is performed in a planned and systematic manner and that the methodologies selected for use in the assessment can be conducted at a reasonable cost [43 CFR § 11.30 (b)]. The assessment plan addresses SLETC's overall assessment approaches and emphasizes the utilization of existing data. If determined to be necessary, the trustees may modify the assessment plan [43 CFR § 11.32 (e)].

1.3 ORGANIZATION OF THE ASSESSMENT PLAN

This assessment plan is organized as follows. Chapter 2 presents background information on the site, including the location and description of the assessment area, natural resources affected by hazardous substances, the history and description of hazardous substances released, and remedial activities at the sites. Chapter 3 describes the authority of the trustees to proceed with the assessment. Chapter 4 identifies coordination efforts with the Remedial Investigation and Feasibility Study (RI/FS) process and with other agencies, and also discusses previous actions taken by the trustees as part of the NRDA process. Chapter 5 contains documentation of the St. Lawrence Environment Trustee Council's decision to proceed with a Type B assessment. Chapter 6 provides confirmation that natural resources have been exposed to hazardous substances released from the site, and Chapter 7 discusses a preliminary estimate of recovery periods. Chapters 8 and 9 provide an overview of approaches to be employed by the trustees in the injury and damage assessment process, respectively. Chapter 10 contains a quality assurance project plan for the NRDA, and Chapter 11 provides references for literature cited in the assessment plan. Appendix A provides a copy of the Preassessment Screen Determination for the St. Lawrence Environment in the vicinity of Massena, New York prepared by the Trustees for Natural Resources in May 1991.

1.4 PUBLIC REVIEW AND COMMENT

The DOI regulations provide that an assessment plan will be made available for a period of 30 days for review and comment by PRPs; other natural resource trustees; other affected federal, state, or tribal agencies; and any interested members of the public. The SLETC has extended this review and comment period to 60 days in order to encourage public involvement in this important matter. The SLETC believes that public comments may provide the trustees with new information and ideas that may be incorporated into the assessment plan. For this reason, a public meeting will be scheduled in the vicinity of the St. Lawrence environment to encourage comment and discussion. Comments may be submitted in writing to:

Barbara David
Environment Division
St. Regis Mohawk Tribe
412 State Route 37
Hogansburg, NY 13655

Comments must be received within 60 days from the date the notice of availability is published in the Federal Register, New York's Environmental Notice Bulletin, and newspapers in the vicinity of the St. Lawrence Environment Assessment Area. In the final assessment plan, the trustees will respond to comments.

CHAPTER 2
ASSESSMENT AREA BACKGROUND

In this chapter, background information on the St. Lawrence Environmental Assessment Area is provided. This chapter is organized into the following sections:

- Section 2.1 provides a description of the assessment area, including an overview of the St. Lawrence Environmental Assessment Area, the St. Lawrence River watershed, Akwesasne, the Town and Village of Massena, and the climate and geology.

- Section 2.2 provides summary information on the natural resources in the St. Lawrence Environmental Assessment Area that are potentially affected by releases of hazardous substances from the PRPs.

- Section 2.3 provides background information on releases of hazardous substances from PRP facilities and identifies historical remedial activities.

- Section 2.4 summarizes remedial activities in the St. Lawrence Environmental Assessment Area conducted or planned pursuant to consent orders with the U.S. EPA as part of Records of Decision (RODs) or Unilateral Administrative Orders (UAOs).

2.1 THE ASSESSMENT AREA

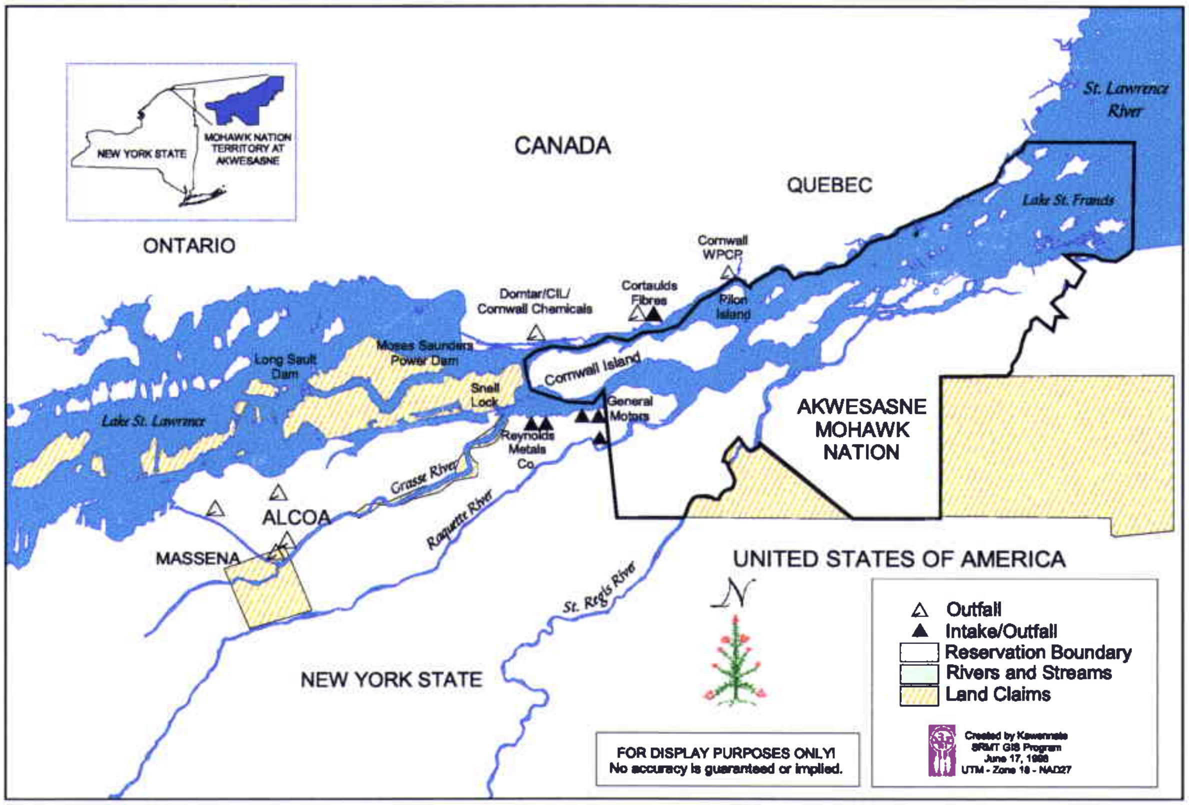
2.1.1 Assessment Area Location

The St. Lawrence Environment Assessment Area, in northern New York State, is the area that has been affected by releases of hazardous substances from the GM, RMC, and ALCOA Massena facilities. The assessment area comprises the vicinity of the St. Lawrence River, the Grasse River, and the Raquette River near Massena, New York, the general area of Massena, New York, and the Mohawk Territory of Akwesasne.

The assessment area includes, but may not be limited to, the following general subareas (see Figure 2-1):

- the St. Lawrence River from Snell Lock to Lake St. Francis, including all areas of Akwesasne and all sediments, surface water, groundwater, bordering wetlands, and contiguous upland areas

Figure 2-1
Map of the Massena/Akwesasne Assessment Area



Prepared by St. Regis Mohawk Tribe Environment Division.

- the Raquette River in the vicinity of and downstream from RMC and GM to the St. Lawrence River, including all sediments, surface water, groundwater, bordering wetlands, and contiguous upland areas

- the Massena Power Canal and the Grasse River in the vicinity of and downstream from ALCOA to the St. Lawrence River, including all sediments, surface water, groundwater, bordering wetlands, and contiguous upland areas

- the boundaries of all listed active and inactive hazardous waste sites

- other locations in the vicinity of the St. Lawrence, Raquette, and Grasse rivers or their tributaries where GM, RMC, and ALCOA have released and/or continue to release or dispose of wastes

- tributary streams passing through GM, RMC, and ALCOA active and inactive hazardous waste sites.

2.1.2 The St. Lawrence River Watershed

The St. Lawrence River is the outlet of Lake Ontario, draining the Great Lakes watershed and linking it to the Atlantic Ocean. The Great Lakes-St. Lawrence River system is the earth's largest freshwater reservoir, containing some 20% of the planet's freshwater. The St. Lawrence River itself is 1,900 miles long (Quemerais et al., 1996). Draining more than 502,000 square miles, it is among the world's largest rivers. With an average flow in the Massena area of 245,000 cubic feet per second (cfs), it has a recorded maximum flow of 352,000 cfs and minimum flow of 139,000 cfs. Over 114 miles of the St. Lawrence River are within New York State. The fluvial section of the river, extending from Lake Ontario to Lac Saint-Pierre, is made up of rapids, lakes, and archipelagos. Approximately 70% of Lake Ontario water entering Lake St. Francis flows along the south shore of Cornwall Island (the largest island in Akwesasne Territory) and divides into two channels at St. Regis Island (Kaiser et al., 1990). Outside the assessment area, most of the St. Lawrence River is a fast flowing, deep river (current velocity of 1.6-5 ft/s), with little deposition of suspended particulate matter (Kaiser et al., 1990). As a result, both dissolved and particulate adsorbed contaminants are quickly flushed through these locations with little opportunity for desorption and bioaccumulation. In contrast, Lake St. Francis, the riverine lake in the eastern portion of the assessment area (see Figure 2-1), is a large, shallow basin with bathymetric and current conditions conducive to particle settling and contaminant transfer (Kaiser et al., 1990).

The St. Lawrence and its tributaries are home to many plant and animal species and to a variety of human cultures (St. Lawrence Center, 1993). Because of its size and enormous complexity, the St. Lawrence River plays a determining role in the environmental life of the North American continent (Bouchard and Millet, 1993). The diverse aquatic, wetland, open, forested, and island environments offer food and shelter to a variety of plant and animal species, many of which are unique or rare. Several bird sanctuaries that protect important migratory birds and a variety of wetland species are located downstream in Akwesasne Territory and in Quebec (Bouchard and Millet, 1993).

Cultural and historical elements such as architecture, archaeology, ethnography, and natural resource use are closely tied to the St. Lawrence River and are protected by a variety of U.S., tribal, First Nations, and Canadian laws (St. Lawrence Center, 1993). Cultural heritage includes not only material goods but also nonmaterial, intangible elements that are expressed in language, ceremonial practices, traditional ecological knowledge, place names, art, song, dance, legends, oral traditions, and ongoing traditional cultural practices surrounding hunting, fishing, and gathering (Mander, 1991; Cornelius, 1992; Canter, 1996). For the Mohawks of Akwesasne, cultural practices are not confined to the current boundaries of the territory but include all areas in the aboriginal territory of the Mohawks that have been or continue to be used by Mohawk people.

The assessment area also includes many exceptional, rare, and culturally important landscapes. Thousands of known archaeological sites are found along the banks of the St. Lawrence River, many of which have provided important information about the lifestyles of Mohawk people and Euro-Quebecers who have lived in the area (St. Lawrence Center, 1993). Some of the oldest known settlements of Iroquois people have been found on islands in Akwesasne Territory and date back to the Archaic period, more than 9,000 years ago.

The Great Lakes-St. Lawrence River system is an international route linking the Atlantic Ocean to areas as far inland as Lake Superior. The St. Lawrence River plays a critical role in the economy of Canada and the United States and is considered one of the most important commercial shipping arteries in the world. In 1988, 19,000 vessels traveled this route carrying 111 million tonnes of cargo. Between 1987 and 1989, commercial traffic through the St. Lawrence Seaway alone represented an average of 3,000 vessels and 40 million tonnes of cargo per year (Bouchard and Millet, 1993).

The Raquette and Grasse rivers are tributaries of the St. Lawrence River. The Raquette River, with a watershed of 1,257 square miles, flows northeasterly through Massena at an average flow of 1,306 cfs. The river is approximately 72 miles long. The outlying areas surrounding the river are mainly farmland and forests. Along the mouth of the river, cedar, aspen, silver maple, and willow are prevalent. Marshland areas contribute to a diversified habitat and fauna.

The Grasse River, with a watershed that covers 608 square miles, flows through the Village of Massena and northeasterly to the St. Lawrence River. It has an estimated long-term average flow of 1,150 cfs and is approximately 68 miles long.

Major sources of contaminants to the St. Lawrence River include industrial and municipal activities along the river and its watershed. In particular, major point sources of PCBs (particularly the GM and the RMC facilities) have been identified in the vicinity of Massena, New York, on the south shore of the river, as well as the ALCOA facilities on the Grasse River, a St. Lawrence River tributary draining the Massena area. Vanier et al. (1996) reported that from the mid-1970s to the mid-1980s, the most contaminated sediments in the international section of the St. Lawrence River were found between the outlets of the Grasse and Raquette rivers. They also noted that the highest PCB concentrations in fish have also been observed there. They concluded that contamination levels in this part of Lake St. Francis are believed to be the highest in the St. Lawrence River system. Toxic organic contaminants also enter St. Lawrence River water by desorption and solubilization from particulates and sediments and from airborne deposition.

2.1.3 Akwesasne

Overview

The St. Lawrence River has been part of the homeland of Kahniakehaka (Mohawk) people for millennia. Known to the Mohawk people as "Kaniatarowanenneh," this river, its tributaries, and the surrounding area have been a rich source of fish, wildlife, grasses, trees, medicinal plants, water, farmland, and other important resources that have allowed Akwesasne to grow and thrive as a territory. The river has long served as a means of transportation for trade with other Native Nations. Traditions established thousands of years before European settlers arrived in the region enabled Mohawk people to develop a unique relationship with the other living beings found in ecosystems along the St. Lawrence River and its tributaries. Many social, cultural, and spiritual values, beliefs, and philosophies of the Mohawk people are tied to their relationship with the natural world.

The Mohawks call this region Akwesasne, meaning land where the partridge drums. This word originally referred to the sound of the rapids in the St. Lawrence River and reflects the importance of the water, fish, game, and other resources of the region. The name Akwesasne itself, like many other words in the Mohawk language, carries meaning for the Mohawks regarding their connection to this important region.

Akwesasne includes the land and waters where the Mohawk people have raised their families, fished and hunted, and buried their dead for thousands of years. In non-Indian terms, Akwesasne is a culturally and historically significant place for the Mohawk people. This significance transcends mere historical importance and possesses a spiritual dimension of great magnitude. The cultural, spiritual, social, political, and ecological ties to the natural world are the elements that distinguish Mohawks as unique, culturally distinct people. Cultural activities, language, and ceremonies surrounding fishing, hunting, trapping, gathering, and farming have always kept Mohawk people in daily contact with all parts of the natural world. For Mohawks, a healthy natural world is required for the physical, mental, and spiritual health of Mohawk individuals and their communities, as well as the larger Mohawk Nation and the Haudenosaunee Confederacy (Akwesasne Task Force on the Environment, 1997).

The contamination of the ecosystem by local industries is believed to have had profound effects on Mohawk culture. The importance of many species, such as turtles, waterfowl, and fur-bearing mammals, goes all the way back to creation. The turtle, a species heavily contaminated with PCBs, symbolically represents the very foundation of the earth. In addition, turtles are used in many ceremonies and are used for medicine. Natural resources such as turtles, which are considered to have little value in U.S. and world market economies, are highly esteemed and valued by the Mohawk people because of their profound cultural importance (Akwesasne Task Force on the Environment, 1997).

For the Mohawks of Akwesasne, pollution problems are believed to have resulted in lost relationships with the natural world, something that can only be likened to mourning. The loss of place, relationships, and balance can be culturally devastating. Many Mohawks in Akwesasne feel that the impacted plant and animal species and the overall balance in the natural world must be restored to ensure the long-term survival of Mohawk people (Akwesasne Task Force on the Environment, 1997).

Akwesasne Geography

Akwesasne is located on the banks of the St. Lawrence River at the confluence of the Raquette and St. Regis rivers. It is situated approximately 75 miles northeast of Lake Ontario and 60 miles southwest of Montreal. Akwesasne lies within the Saint Lawrence Valley and is characterized by gently rolling to hilly topography with some large areas of swamp on the eastern extremities of the mainland portion. The Adirondack Mountains are 30 miles to the south and the Laurentians 90 miles to the north. Akwesasne's closest neighbors include the city of Massena, to the west; the city of Cornwall, Ontario, to the north; and Huntington, Quebec, to the east. The current boundaries of Akwesasne include approximately 29,000 acres of undisputed land.

A land claim, currently before a Federal District Court, covers an additional 13,682 acres of Akwesasne Mohawk territory (see Figure 2-1). This includes 2,040 acres on Barnhart and Long Sault islands; 2,204 acres in the Hogansburg triangle; 8,483 acres in Fort Covington, New York; 640 acres in Massena, which includes a part of the ALCOA property; and 315 acres of grasslands along the Grasse River (Tarbell, 1990). Additional land claims include many of the islands that make up the region known as the Thousand Islands and land in present-day Canada. A larger, 9 million acre claim for Mohawk Aboriginal Territory encompasses land from the Nation River in Canada, including the St. Lawrence River to the Mohawk River, near present-day Albany, New York (Tarbell, 1990). Traditionally, Akwesasne territorial waters run from Wolfe Island in the Thousand Islands to Beauharnois, Quebec.

Akwesasne (as used herein, and unless otherwise noted) is made up of more than 30 islands and includes the region's largest fresh water marshes. Soils throughout the reservation are composed predominantly of glacial till and clay deposits. The low-lying areas of Akwesasne contain mainly willow brush, native swamp, foliage grasses, and a mixture of deciduous soft woods. Upland areas support northeastern mixed hardwood forests of maple, beech, oak, and elm, along with white pine and white spruce. Hay crops, pasture, and family vegetable gardens occupy the remaining cultivated lands.

Akwesasne Demographics

Akwesasne has a total population of approximately 14,000 Mohawks, with more than 9,000 living in the territory at any given time. Over 30% of the Akwesasne population is absent from the community, with individuals and their families living where jobs can be found. Many Mohawks have moved back to Akwesasne because of poor socioeconomic conditions in many major cities, including layoffs in the construction industry. The Mohawk Council of Akwesasne's Environment Department estimates the population growth rate at 2% per year. It is believed that the population will continue to grow at a steady rate in the near future.

According to data collected by the Mohawk Council of Akwesasne, approximately 30% of the total population speak Mohawk as a first language. Although English is the most common language for the majority of the population, many elders speak only Mohawk. The Mohawk language is taught in the school system from kindergarten to high school. Several area universities and adult education programs in the community offer courses in the Mohawk language. Despite efforts to teach Mohawk, there continues to be great concern within the community regarding the loss of the language since much of the language is tied to activities that involve natural resource use. When Mohawks can no longer engage in activities such as fishing, trapping, or gardening, many fear that the language associated with these activities will be lost (Akwesasne Task Force on the Environment, 1997).

Results from work done by the Mohawk Council of Akwesasne indicate that almost every Akwesasne family has at some time been involved with subsistence fishing in the St. Lawrence, Raquette, St. Regis, or Grasse rivers. Fish have always been a healthy protein source for many families. Certain fishermen were very skilled and, at times, were relied on to supply fish for the entire community. The number of these fishermen declined from over 100 in 1930 to 11 in 1990, and went back up to 40 in 1996.

Like fishing, agriculture has also been critical to Mohawk people and their culture for millennia. Akwesasne residents have long been known for their ability to grow food for their community. Because most Mohawk families have always had vegetable gardens, almost every Mohawk can be considered a farmer or tiller of soil. The number of commercial farms that supply such products as milk, cheese, meat, and vegetables to external non-Native markets declined from 129 in the 1930s to 19 in 1990 to 7 in 1996.

According to the Mohawk Council of Akwesasne, unemployment is very high in Akwesasne, averaging about 45%. Only 2,000 jobs are available in the community for an estimated 8,600 employable individuals. Currently, over 100 businesses are found within the territory of Akwesasne. Many are very new, with 70% of businesses under 5 years of age. Over 30% of the businesses are service oriented, 30% are retail, 10% are government related, 6% are manufacturing, 6% are volunteer organizations, 3% are media, and 2% are tourism.

2.1.4 Town and Village of Massena

Overview

Massena is located in the northeastern section of St. Lawrence County, approximately 200 feet above sea level on the St. Lawrence Marine Plain. The region is predominantly agricultural and forest land with low, gently rolling hills at its periphery. The Grasse River flows northeasterly through the village of Massena. The Grasse and Raquette rivers empty into the St. Lawrence River just outside of the village. The St. Lawrence River borders Massena on the north, and the Mohawk Nation Territory of Akwesasne bounds this area to the east.

Massena Land Use

The northeastern section of St. Lawrence County is a relatively rural area. Agriculture (mainly dairy farming), forests, and wetlands govern the existing land use in the area. Other uses include outdoor recreation and woodlots, energy facilities, and transportation systems. The natural resources and waters encompassing the town and village of Massena support various recreational uses. Fishing, boating, hiking, and camping are all popular activities. The New York State Office of Parks, Recreation and Historic Preservation operates the Robert Moses State Park located in the town of Massena. The park encompasses approximately 2,267 acres and attracts a large number of tourists to its campgrounds, beach, marina, boat launch, and scenic vistas overlooking the St. Lawrence River and Lake St. Francis.

The St. Lawrence Seaway borders Massena on the north. Along the seaway, Eisenhower Lock attracts ships in transit from over 50 nations, and visitor facilities there attract an estimated 150,000 people a year. East of Eisenhower Lock is Snell Lock.

Other land uses in this area are industrial. GM and RMC are adjacent to one another. These plants are bounded by the St. Lawrence River on the north, the Raquette River on the south, and Akwesasne on the east. Approximately 6 miles upstream on the Grasse River, west of GM and RMC, ALCOA maintains an industrial facility.

2.1.5 Assessment Area Climate

The assessment area is situated on the 45th parallel of latitude and has a fairly moderate climate. The average frost-free period is 140 days per year, and the average annual mean temperature for Massena is 43.4°F. The annual mean minimum temperature is 33.1°F. Summer daytime temperatures range from 70 to 80°F. Periods of higher temperatures however, are not uncommon.

The prevailing average wind direction is WSW; however, another common wind direction is ENE. Average annual windspeed is 7.8 mph. The ENE winds tend to be strongest, at 10 mph. Winds also tend to be strong (10 mph) when they are generated from the WNW direction.

Precipitation in the assessment area is relatively uniform throughout the year. Monthly rainfall averages from 2 to 3.5 inches, and the total annual rainfall is about 33 inches. Mean seasonal snowfall in Massena is approximately 62 to 70 inches per year, commencing in November and lasting through March. Maximum average snowfall occurs in December, January, February, and March, with corresponding values of 19.5 inches, 14.9 inches, 17.9 inches, and 10.3 inches, respectively.

2.1.6 Assessment Area Geology

The assessment area lies within the Oriented Till Ridges subsection of the St. Lawrence Lowland physiographic providence. The vicinity around Massena is characterized by northeast-southwest trending low, elongated till ridges. Geologically, the area is typified by unconsolidated Pleistocene deposits overlying Paleozoic carbonate bedrock. The Pleistocene deposits are characterized by approximately 100 feet of sediments consisting of glacial till and lacustrine clays.

The Malone drift comprises the lower and middle till units in the assessment area. The lower till is characterized by a dense mixture of clay, silt, sand, and gravel, and the middle till consists of a denser layer of clay, silt, sand, and gravel. The upper till (the Fort Covington Drift), which includes reworked older till, is a dense composite of clay, silt, sand, gravel, and boulders. The Fort Covington drift is the material that makes up the distinctive elongated hills found in the assessment area. The drift may even be covered by younger lacustrine clays and sediments in the low-lying areas. Marine sediments from a shallow sea that occupied the area are also found. The bedrock underlying the unconsolidated materials comprises the Ordovician Beekmantown Group. This is characterized by massive dark-gray dolomite, including beds of limestone, sandstone, and shale. At Massena, the unit is approximately 500 feet thick, with bedding planes dipping approximately 0 to 5 degrees to the north-northwest. Joints and isolated faults in the bedrock trend northeast-southwest.

2.2 NATURAL RESOURCES IN THE ST. LAWRENCE ENVIRONMENT ASSESSMENT AREA

2.2.1 Overview

The assessment plan focuses on trust resources that are under the authority of one or more of the trustees for natural resources. Natural resources that will be addressed include but may not be limited to the following (The Trustees for Natural Resources, 1991):

- fish (both native and introduced)
- migratory and other birds
- threatened and endangered species of plants, birds, animals, and invertebrates
- mammals, including marine mammals
- invertebrates
- amphibians/reptiles
- vegetation
- edible/ceremonial/medicinal/other culturally important species for the Mohawks of Akwesasne
- groundwater
- surface water
- sediments
- soils
- air.

Table 2-1 summarizes some species of special concern to the SLETC.

2.2.2 Fisheries

Within the St. Lawrence Environment Assessment Area are major recreational, commercial, and tribal subsistence fisheries (St. Lawrence RAP Team, 1990). One of the largest fisheries in New York State is located within the 114 mile international portion of the St. Lawrence River. It supports several major warmwater species, including largemouth and smallmouth bass (*Micropterus salmoides, M. dolomieui*), muskellunge (*Esox masquinongy*), walleye (*Stizostedion vitreum v.*) and yellow perch (*Perca flavescens*) and coldwater species including northern pike *(Esox lucius)*. Other important fishery resources include American eel (*Anguilla rostrata*), brown bullhead (*Ictalurus nebulosus*), and lake sturgeon (*Acipenser fulvescens*). Canadian commercial harvests in the Cornwall section of the river are highest for brown bullhead, white sucker *(Catastomas commersoni)*, black crappie *(Pomoxis nigromaculatus)*, pumpkinseed *(Lepomis*

Table 2-1
Representative Species and Species of Concern

Mammals	Fish	Birds	Reptiles	Amphibians	Invertebrates	Plants
Mink[a, b]	Lake sturgeon[a, c]	All eagles[a, d] Bald eagle[a, c] Golden eagle[a, e]	All turtles[a] Blanding's turtle[a, c]	All frogs[a, b]	Mussels[a]	Medicinal plants and trees[a]
Muskrat[a, b]	Mooneye[a, c]	Common tern[a, c]		Blue spotted salamander[a, e]	Quahog clam[a]	Wetlands plants[a]
Otter[a, b]	Black redhorse[a, c]	All swallows[a, d]		Spotted salamander[a, e]	Common northern welk[a]	Tobacco[a]
Beaver[a, b]	Pugnose shiner[a, f]	All waterfowl[a, b]		Mudpuppy[a, g]	Yellow lampmussel[e]	Garden crops[a]
Fisher[a, b]	Blackchin shiner[a, e]	All snipe[a, d]				
Ermine[a, b]	Pike[a]	All sandpiper[a, d] Upland sandpiper[a, e]				
Weasel[a, b]	Perch[a]	All owls[a, d]				
Porcupine[a]	Muskellunge[a]	All hawks[a, d] Red shouldered hawk[a, c] Cooper's hawk [a, e]				
Striped skunk[a, d]	White sucker[a]	Sharp-shinned Hawk[a,e]				
Bobcat[a, d]	Pickerel[a]	American kestrel[a]				
Raccoon[a, b]	Catfish[a]	Osprey[a, c]				
Moose[a, b]	Bullhead[a]	Common loon[a, e]				
White tailed deer[a, b]	Gar[a]	All herons[a] Great blue herons[a, c, g]				
Cotton tail rabbit[a, b]	Sunfish [a] Longear sunfish [c]	Sparrow[a] Henslow's sparrow[a, c] Vesper sparrow[a,c] Grasshopper sparrow[a, e]				
Snowshoe hare[a,b]	Bluegill[a]	Ruffed grouse[a,b]				
Red squirrel[a]	Trout[a]	Hermit thrush[a, d]				

Table 2-1 (cont.)
Representative Species and Species of Concern

Mammals	Fish	Birds	Reptiles	Amphibians	Invertebrates	Plants
Fox[a, b]	Walleye[a]	Sedge wren[a, e]				
Small footed bat[a, e]	Eels[a, h]	Black tern[a, e]				
Beluga[a, i]	Carp[a]	Common nighthawk[a, e]				
	Atlantic salmon[a]	Black capped chickadee[a, d]				
		Loggerhead shrike[a, f]				
		Least bittern[a, e] American bittern[a, e]				
		Northern harrier,[a, c]				
		Wild turkey[a, b]				
		Eastern bluebird[a, e]				
		American robin[a, d]				
		Belted kingfisher[a, d]				
		Pied-billed Grebe[a,c]				

a. These species are of special significance and importance to the Mohawks of Akwesasne.
b. These species are considered "wild game" as defined by New York Environmental Conservation Law.
c. These species are classified as "threatened" by Federal Law or the New York Environmental Conservation Law and are fully protected.
d. These species are "protected wild birds" as defined by New York Environmental Conservation Law.
e. These species are of special concern as defined by New York Environmental Conservation Law. Documented evidence exists relating to their continued welfare in New York State.
f. These species are classified as "endangered species" as defined in federal law or New York Environmental Conservation Law and are fully protected.
g. These species are considered Indicator species by federal, state, or tribal environmental agencies.
h. These species are important in the diet of an endangered, threatened, or protected species or a species of concern.
i. These species is protected under the Marine Mammal Protection Act.

gibbosus), and American eel (St. Lawrence RAP Team, 1990). Overall, the species most heavily harvested from the St. Lawrence River include yellow perch, rock bass, and smallmouth bass; (St. Lawrence RAP Team, 1990).

Major fisheries found in the Raquette River include gamefish and panfish such as smallmouth bass, northern pike, walleye, yellow perch, brown bullhead, rock bass, and muskellunge. The fisheries present in the Grasse River are similar to the St. Lawrence River and include yellow perch, white perch *(Morone americana)*, rock bass, northern pike, smallmouth bass, and walleye.

2.2.3 Migratory and Other Birds

A number of migratory birds use the St. Lawrence Environment Assessment Area for breeding, feeding, and/or as a migratory stopover. Estimated waterfowl populations between 1974 and 1978 in the Lake St. Francis area include a spring population of 3,700 geese [snow goose *(Chen caerulescens)* and Canada goose (*Branta canadensis*)]; 8,000 dabbling ducks [black duck (*Anas rubripes*), mallard (*A. platyrhynchos*), northern pintail *(A. acuta)*, northern shoveler *(A. clypeata)*, gadwall (*A. strepera*), American widgeon *(A. americana)*, green-winged teal *(A. crecca)*, blue winged teal *(A. discors)*, and wood duck (*Aix sponsa*)]; and 57,000 diving ducks [scaups *(Aythya affinis)*, common goldeneye *(Aquila chrysaetos)*, and mergansers (*Mergus merganser*)]. Fall populations include 1,100 geese, 3,000 dabbling ducks, and 64,000 diving ducks (Bouchard and Millet, 1993). In Quebec, almost all harvesting of snow geese and 65% of duck harvesting occurs along the St. Lawrence River (Bouchard and Millet, 1993). Great blue herons (*Ardea herodias*) and black-crowned night herons (*Nycticorax nycticorax*) nest in colonies known as heronries located downstream in Akwesasne and Quebec (Bouchard and Millet, 1993; Boily et al., 1994; Champoux et al., 1995). They return year after year to these sites to nest in tall trees in wooded areas, mostly on islands, that are near food sources and devoid of humans and land predators.

Birds identified as priority species in the St. Lawrence River Action Plan include species found in the St. Lawrence Environment Assessment Area, such as the bald eagle *(Haliaeetus leucocephalus)*, peregrine falcon *(Falco peregrinus)*, horned grebe *(Podiceps auritus)*, least bittern *(Ixobrychus exilis)*, red-headed woodpecker *(Melanerpes erythrocephalus)*, and loggerhead shrike *(Lanius ludovicianus migrans)* (Bouchard and Millet, 1993). In addition, many species of waterfowl, birds of prey, and songbirds are species of great cultural, economic, and subsistence importance to Mohawk people.

2.2.4 Mammals

A wide variety of mammalian species are found in the assessment area, including muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), porcupine (*Erethizon dorsatum*), snowshoe hare (*Lepus americanus*), cotton-tail rabbits (*Sylvilagus floridanus*), otter (*Lutra canadensis*), fisher

(*Martes pennanti*), striped skunk (*Mephitis mephitis*), ermine (*Mustela erminea*), weasel (*Mustela frenata*), beaver (*Castor canadensis*), white tailed deer (*Odocoileus virginianus*), red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), and coyote (*Canis latrans*). Fur-bearing mammals, deer, porcupine, skunk, and many other mammals are species of great cultural, economic, and subsistence importance to Mohawk people.

Beluga whales (*Delphinapterus leucas*) found in the Gulf of St. Lawrence are experiencing reproductive problems, cancer, and compromised immune systems, possibly related to PCBs and other contaminants (Béland, 1988, 1996; Béland et al., 1990, 1991, 1993; Muir et al., 1990; Martineau et al., 1988, 1994; De Guise et al., 1995a). They are known to eat American eels, which accumulate large concentrations of persistent toxicants such as PCBs. They have been identified as a priority species for the St. Lawrence River Action Plan. In 1988, 2,052 whale watching excursions out of Quebec involving 77,805 passengers on ocean excursions and 32,000 land-based visitors. It is estimated that 125 jobs are linked directly to whale watching. In 1988, overall revenue was $8 million for ocean excursions and $0.2 million for land based visits (Bouchard and Millet, 1993).

2.2.5 Amphibians/Reptiles

Many amphibians and reptiles are found in the assessment area, including a variety of frogs, salamanders, mudpuppies, toads, turtles, and snakes. All species of turtles and several other amphibians and reptiles are species of great cultural, economic, and subsistence importance to Mohawk people.

In addition, the pickerel frog (*Rana palustris*) and five reptiles: the brown snake (*Storeia dekayi*), northern water snake (*Nerodia sipedon*), map turtle (*Graptemys geographica*), spiny softshell turtle (*Trionyx spiniferus*), and Blanding's turtle (*Emydoidea blandingii*), all of which have been identified as a priority species in the St. Lawrence River Action Plan, are believed to be in the area.

2.2.6 Wetlands and Vegetation

Although a specific inventory of the terrestrial ecology in the assessment area has not been done, general information relative to the northern section of St. Lawrence County is available. Cover types within the vicinity include landscaped areas, commercial wood lots, farmland, abandoned farmland, forested tracts, and wetland areas. Generally, forests in the St. Lawrence County area include maple-beech-birch-hemlock, along with black cherry, ash, red maple, basswood, aspen-birch, and spruce-fir.

Numerous New York State and federally regulated freshwater wetlands are located in St. Lawrence County (outside of the Adirondack Park). In 1987, 1,183 were listed in the county, with a total acreage of approximately 109,000 acres. An extensive stretch of regulated wetland is located near the RMC and GM plants. It is approximately 170 acres and is one of the three largest wetlands in the Town of Massena. Extensive wetlands also exist within Akwesasne. Many species of plants, birds, animals, and trees are found in wetland areas that are of special significance to Mohawk people. Trees typically found in this type of wetland include red maple, American elm, and ash. Specifically the Black Ash tree is the only species used by Mohawk Basketmakers. Cover types consist of emergent marsh, deciduous wetland, coniferous wetland, and wetland/open water. Wildlife observed in these areas include ruffed grouse, woodcock, many species of frog, white-tailed deer, raccoon, muskrat, and beaver.

The St. Lawrence Action Plan outlines a number of priority species, including 9 trees, 14 shrubs, and 223 herbaceous plants. Of these species, 62 are considered rare species and 10 are designated rare throughout Canada. Many are especially vulnerable because of pollutant threats.

2.2.7 Rare, Threatened, and Endangered Species/Species of Special Concern

Overwintering bald eagles, a federally listed threatened species [87 Stat. 84, as amended; 6 USC 1531 et seq.], have been reported in the vicinity of GM, ALCOA, and RMC. No information has been collected to determine their level of exposure to local contaminants of concern. Other species that are potentially in the area include the red-shouldered hawk, common tern, northern harrier, and osprey, which are listed as threatened species in New York State (6 NYCRR 182.5b); and the common loon, least bittern, and the yellow lampmussel, which are listed as species of special concern in New York State (6 NYCRR 182.5c).

Lake sturgeon are also found in the area and are a threatened species in New York State (6 NYCRR 182.5b) and a species of great cultural importance to Mohawk people. The Blanding's turtle is listed as a threatened species in New York State (6 NYCRR 182.5b) and has been identified in the general vicinity (Harper, 1996). The blue-spotted and spotted salamander are listed as species of special concern (6 NYCRR 182.5c) and potentially in the area.

Several rare plants have been reported in the general area, including one that is classified as endangered in New York State [lesser fringed gentian (*Gentianopsis procer*)], two classified as threatened [wiry panic grass (*Panicum flexile*) and white camas (*Zigadenus elegans* ssp. Glaucus)], and two classified as rare [marsh horsetail (*Equisetum palustre*) and meadow horsetail (*Equisetum pratense*)] (Harper, 1996).

2.2.8 Groundwater

Groundwater resources are present in the St. Lawrence Environment Assessment Area and are used for drinking water supply, industrial, or commercial applications.

2.2.9 Surface Water

Several major rivers are located in the assessment area including the St. Lawrence River, Grasse River, Raquette River, Robinson Creek, and Turtle Creek. Other surface water resources include tributaries, wetlands, lagoons, and marshes.

2.2.10 Sediment

Sediments as defined in the DOI regulations are a component of surface water resources [43 CFR § 11.14 (pp)]. However, for the purposes of this assessment plan, sediments are addressed separately. Sediments are found in the assessment area in locations where surface water resources are found. Hence sediment resources are located in the St. Lawrence River, Grasse River, Raquette River, Robinson Creek, and Turtle Creek and in tributaries, wetlands, lagoons, and marshes.

2.2.11 Soil

Soils resources are present in the St. Lawrence Environment Assessment Area and include terrestrial areas on the PRP properties, in Akwesasne, in bank soils on the St. Lawrence River, Grasse River, Raquette River, Robinson Creek, and Turtle Creek, and other terrestrial locations in the assessment area.

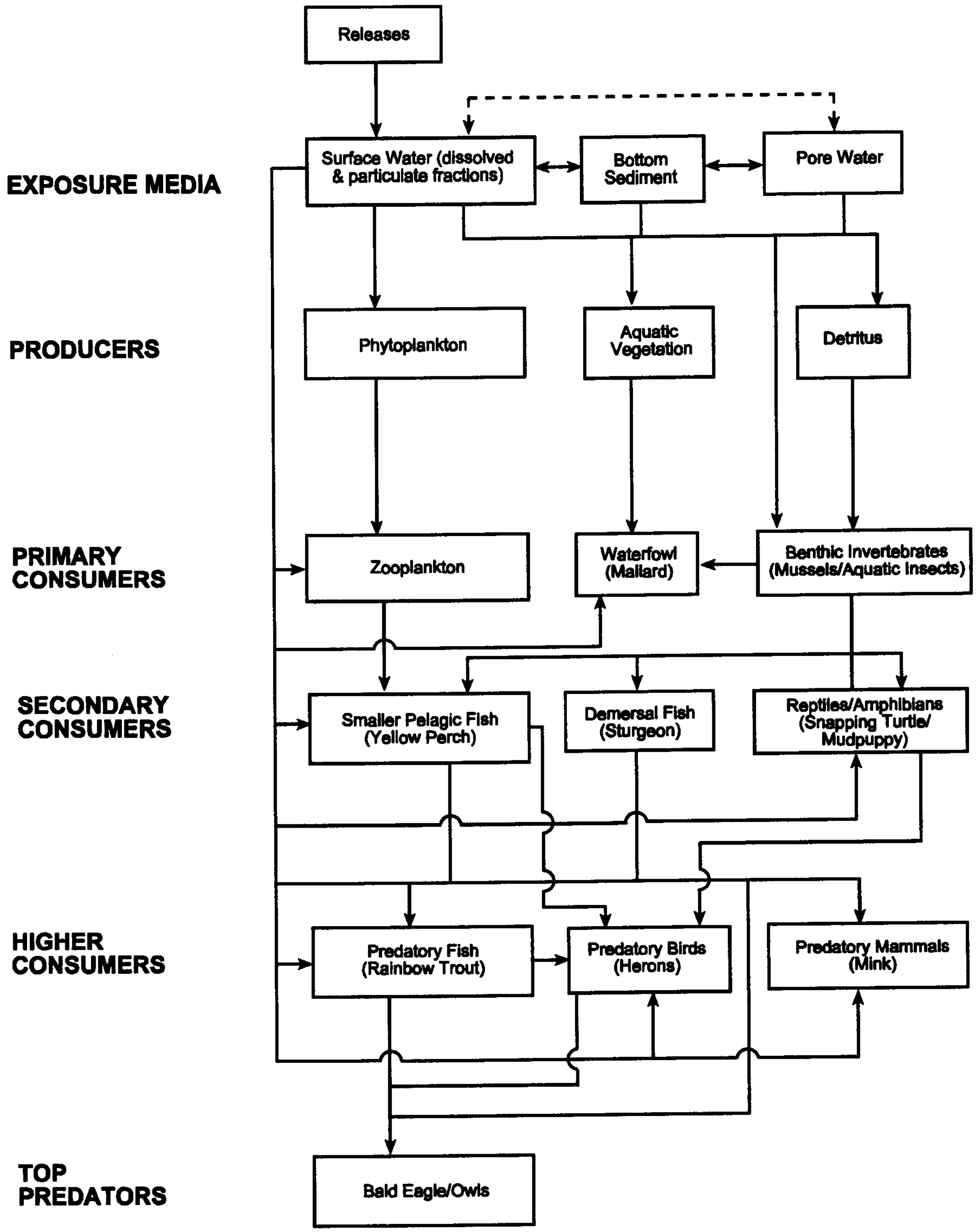
2.2.12 Air

Release of hazardous substances into the air can injure air resources in the St. Lawrence Environment Assessment Area. As described in Section 2.1.5, the average prevailing wind direction is WSW, hence releases of hazardous substances into the air from the PRP facilities will travel downwind toward the Akwesasne territory.

2.2.13 Habitats/Food Webs

Very few studies have been conducted to examine the habitats and food webs in the assessment area (Ram, 1990). A representative food web for an aquatic system that may be found in the area is included in Figure 2-2.

Figure 2-2
Representative Exposure Pathways and Species for an Aquatic Ecosystem



2.3 BACKGROUND INFORMATION ON RELEASES OF HAZARDOUS SUBSTANCES FROM PRP FACILITIES

The St. Lawrence, Grasse, and Raquette rivers and associated air, water, sediment, fish, and wildlife in the vicinity of Massena and the Mohawk Nation Territory of Akwesasne have been contaminated with hazardous substances, including PCBs, PAHs, trace metals (including aluminum, arsenic, barium, cadmium, chromium, copper, iron, lead, and zinc), cyanides, hydrofluoric acid and other fluoride compounds, polychlorinated dibenzo-p-dioxins (PCDD), polychlorinated dibenzo-p-furans (PCDF), volatile organic compounds (VOC), phenols, and styrene (U.S. EPA, 1990; The Trustees for Natural Resources, 1991; NYSDEC, 1991b, 1992b; Benedict, 1994).

This section provides background information on releases of these hazardous substances from PRP facilities. In addition, remedial activities before the PRPs entered into consent orders with the U.S. EPA (i.e., before 1985) are also described. Remedial activities after the PRPs entered into consent orders with the U.S. EPA (e.g., as part of RODs or UAO) are discussed in Section 2.4. All information in this section has been taken from secondary sources, including RODs, yearly summaries, RI/FS reports, and Remedial Action Plans developed by NYSDEC, the St. Lawrence RAP Team, and the U.S. EPA.

2.3.1 Overview of Facilities that Have Released Hazardous Substances

The PRPs in the St. Lawrence Environment Assessment Area are GM, RMC, and ALCOA. GM is an aluminum casting facility located on the St. Lawrence River just west of the Akwesasne Mohawk nation. The RMC facility is an aluminum production plant and is located directly upstream from the GM site. The ALCOA facility is also an aluminum production plant and is located off Route 37 in the town of Massena approximately 6 miles upstream from the GM facility (see Figure 2-1 for a map of the assessment area and the locations of the PRP facilities). A summary of known releases of hazardous substances by facility is provided in Table 2-2.

Facilities in the area that are also located on the south shore of the St. Lawrence River are the Moses-Saunders Power Dam, located upstream of Akwesasne; and the Mineral Processing Company, located adjacent to GM. Facilities located on the north shore in Cornwall Ontario (Canada) include Domtar Inc., ICI Forest Products (formerly CIL), Cornwall Chemicals, Courtaulds Fibres (closed in 1992), Courtaulds Films (closed in 1989), Stanchem and the Cornwall Water Pollution Control Plant (see Figure 2-1).

Table 2-2
Known Releases of Hazardous Substances by ALCOA, RMC, and GM in the St. Lawrence Environment Assessment Area

Substance	ALCOA	RMC	GM
Cyanide	X	X	—
Fluoride Compounds	X[a]	X[b]	—
PAHs	X[a]	X[b]	X[c]
PCBs	X	X	X
PCDDs	X[d]	X[b]	X[d]
PCDFs	X[d]	X[b]	X[d]
Phenols	X[a]	X	X[c]
Styrene	—	—	X[e]
Trace Metals[f]	X	X	X
Volatile Organic Compounds (VOCs)	X[a]	—	X[c]

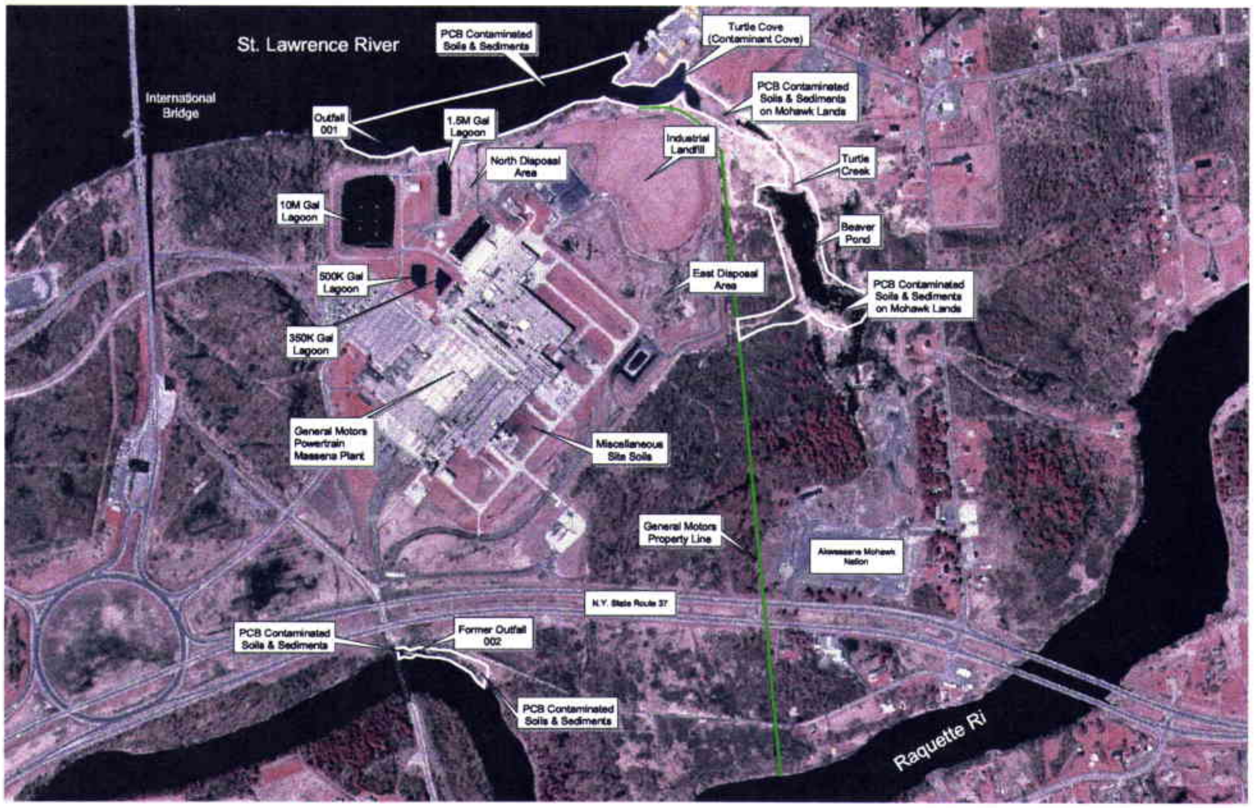
Source: NYSDEC, 1991b, unless otherwise noted.
a. NYSDEC, 1992b.
b. NYSDEC, 1992c.
c. U.S. EPA, 1990.
d. Believed to be present as contaminants in PCB fluids; PCDD/PCDF are formed during PCB manufacture or when PCB containing fluids are used in high temperature applications (The Trustees for Natural Resources. 1991).
e. Benedict, 1994.
f. Trace metals measured above background concentrations at various locations on, or near, these facilities, and in various environmental media (e.g., soils, groundwater) include aluminum, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, vanadium, and zinc. Not all of these trace metals were measured at each facility. See NYSDEC 1991b, NYSDEC 1992b, NYSDEC 1992c, U.S. EPA 1990, and The Trustees for Natural Resources, 1991 for additional information.

2.3.2 General Motors Powertrain

Site Description

GM, located on Rooseveltown Road in St. Lawrence County in Massena, is an aluminum casting facility that encompasses approximately 270 acres of industrial and undeveloped land (Figure 2-3). The property is bordered on the north by the St. Lawrence River, on the east by Akwesasne, on the south by the Raquette River, and on the west by property belonging to Conrail and the RMC. Land use in the area consists of mixed residential and industrial areas. The nearest residence is located in Akwesasne, approximately 300 feet from the GM facility fence line and Industrial Landfill.

Figure 2-3
GM Superfund Site in Massena, New York



Created By Kawennate
SRMT GIS Program - January 2000

Site History

GM (New York State Site Code 645007, U.S. EPA ID# NYD091972554) has operated the plant since 1959. From 1959 to 1980, PCBs were a component in hydraulic fluid that was used in diecasting machines. It is estimated that these machines leaked approximately 100,000 gallons of hydraulic fluid per year because of high operation pressures (up to 2,500 psi). In the early 1960s, a hydraulic fluid reclamation system was installed to catch the leaking hydraulic fluid in drains. Wastewater from the reclamation system and stormwater then entered the facility's wastewater treatment system.

In the early 1960s, wastewater containing PCB-laden oil passed through a 1.5 million gallon (mgal) lagoon and then into the St. Lawrence River. The lagoon was periodically drained and the sludge was landfilled on site. In 1968-1969, a Gunite™-lined interceptor lagoon was added adjacent to the 1.5 mgal lagoon. This interceptor lagoon has since been buried and is considered to be part of the North Disposal Area. From 1972 until 1976, a physical/chemical treatment and hydraulic fluid recovery system was installed at the plant. Wastewater was then sent to a 350,000 gal lagoon for settling and the treated water was then pumped to the 500,000 gal lagoon and a 10 mgal lagoon for reuse as plant process water. Periodically, water was discharged to the St. Lawrence River from the 1.5 mgal lagoon through SPDES Outfall 001. At times, the system failed to meet SPDES permit discharge limits. Although the 1.5 mgal lagoon was not used for settling after 1976, water still passed through this lagoon, which contained PCB sludges, before being discharged to the St. Lawrence River. In 1980, the 350,000 gal lagoon was taken out of service and an activated sludge treatment system was installed. In 1985, additional carbon absorption and chemical coagulation treatments were installed and the 1.5 mgal lagoon was hydraulically separated from the wastewater system. PCB-laden sludges from the 1.5 mgal lagoon and the wastewater system were periodically landfilled in on-site disposal pits in the North Disposal Area, the East Disposal Area, and the Industrial Landfill (Figure 2-3). GM no longer uses the diecasting process at the facility and instead uses the lost foam process to make engine blocks.

As a result of GM's past waste disposal practices, the GM facility was placed on the Superfund National Priorities List (NPL) on September 21, 1984. In 1985, GM entered into a Consent Order with the U.S. EPA under the authority of the Toxic Substances Control Act (TSCA). In addition to payment of penalties for failure to comply with TSCA, GM agreed to close an abandoned pumphouse. In 1985, GM also agreed to fence its property to prevent children from entering its landfill. On April 16, 1985, the U.S. EPA and GM negotiated a Consent Order (Index No. II CERCLA-50201) requiring GM to perform a Remedial Investigation/Feasibility Study (RI/FS) to investigate the type and extent of contamination. A two-phased RI was completed and approved by the U.S. EPA on June 9, 1989. A final FS was issued by GM in November 1989. Records of Decision (RODs) were issued on December 17, 1990, and on March 31, 1992.

Based on sampling and analyses conducted to date, the RODs identified four major contaminants at the G.M. site — PCBs, PAHs, phenols, and volatile organic compounds (VOCs). Other contaminants of concern (COCs) include PCDDs, PCDFs, styrene, and the metals aluminum, chromium, copper, iron, lead, nickel, mercury, and zinc (U.S. EPA, 1990; NYSDEC 1991b; Benedict, 1994).

St. Lawrence River

Outfalls to the St. Lawrence River have caused sediment contamination. Originally, the GM facility had three separate outfalls. Outfall 001 is the main discharge for process water. Before 1977, process wastewaters and noncontact cooling waters were diverted from Outfall 002 to 001. After 1977, Outfall 002 received only stormwater. Outfalls 002 and 003 are joined and discharge river water pump leakage from the main pump house and stormwater to the St. Lawrence River. Past wastewater discharges of PCBs into surface water have resulted in contamination of St. Lawrence River sediments. Currently, water from all lagoons undergoes treatment and carbon filtration before discharge to the St. Lawrence River.

The majority of contaminated river sediments are within the St. Lawrence River system, with an estimated 29,100 cubic yards of contaminated sediments with PCB concentrations greater than 1 mg/kg in the St. Lawrence River and contaminant cove area (CDM, 1994). The maximum concentration of PCBs detected in the St. Lawrence River sediments was 8,800 mg/kg, just off the GM Outfall (CDM, 1994). PAHs were also detected in St. Lawrence River sediments adjacent to the GM facility at concentrations up to 8 mg/kg.

Raquette River

In 1970, PCB-contaminated soil was excavated during plant expansion and deposited on the north bank of the Raquette River just east of the Tavern Road Bridge, resulting in sediment contamination in this river system. In addition, GM discharged surface water runoff to the Raquette River until 1989 under a State Pollution Discharge Elimination System (SPDES) permit. The area affected includes an estimated 4,000 cubic yards of soil and sediments with PCB concentrations greater than 1 mg/kg on the northern bank of the Raquette River and in the river near the former GM Outfall (CDM, 1994). The highest concentration of PCBs detected in the Raquette River sediments was 4,000 mg/kg just off the GM Outfall (CDM, 1994). NYSDEC detected total PCB concentrations as high as 36 mg/kg in sediments in the river (U.S. EPA, 1990).

Akwesasne

In 1975, a berm surrounding the East Disposal Area (see East Disposal section below) was breached, resulting in water and sludge flowing east to Mohawk Nation lands and to Turtle Creek. Visible spill material was removed from Mohawk Nation lands and placed on GM property. Additional leaching and runoff from the Industrial Landfill have resulted in contamination of Mohawk Nation lands, wetlands, and water, in addition to St. Lawrence River sediments and area food chains. Groundwater flow in the area generally reflects surface topography, and groundwater flows toward the St. Lawrence River and northeast to Turtle Creek. This creek and the adjacent wetlands are discharge areas for shallow groundwater flow. It is estimated that approximately 15,300 cubic yards of soil contaminated with PCBs at concentrations above 1 mg/kg are found on Mohawk Nation lands (CDM, 1994). The highest PCB concentrations detected during the RI/FS were measured in Turtle Creek sediments at 48 mg/kg (CDM, 1994). In addition, NYSDEC detected total PCB sediment concentrations of 3,101 mg/kg in Turtle Creek, with at least four additional samples above 100 mg/kg PCBs (U.S. EPA, 1990).

East Disposal Area

From 1973 to 1975, GM removed PCB-contaminated sludge from their lagoons and transferred it to a sludge settling basin in the East Disposal Area. PCB contaminated sludges were originally pumped to a bermed disposal area east of the plant. Most of the PCBs found in the East Disposal Area are within the original sludge disposal basin, with an area of approximately 3 acres. In the summer of 1975, the berm was breached and water and sludge flowed east to Mohawk Nation lands. As a result, an area of PCB-contaminated soil occurs to the east of the original disposal area. Two smaller, less contaminated areas have also been identified to the southwest of the original disposal area, south of the Industrial Landfill. In 1977, the East Disposal Area was filled with construction debris and soil.

It is estimated that this area consists of approximately 27,300 cubic yards of excavatable soil, debris, and sludge with PCB concentrations greater than 10 mg/kg (CDM, 1994). The maximum PCB concentration detected in this area was 79,600 mg/kg (CDM, 1994). The maximum concentration of phenols detected was 11,000 mg/kg (CDM, 1994).

Industrial Landfill

The 12 acre Industrial Landfill received foundry sand, soil, and concrete excavated during plant construction. In addition, it received diecasting machines, solid industrial waste, and PCB contaminated sludge, lubricants, caustic waste, degreasers, and aluminum dross. The landfill is approximately 35 feet above natural ground level and is 300 feet from the nearest residence. It is estimated that the Industrial Landfill contains approximately 424,000 cubic yards of contaminated material with PCB concentrations greater than 10 mg/kg (CDM, 1994). The maximum PCB concentration detected in the landfill was 18,000 mg/kg (CDM, 2000). The maximum phenol concentration detected was 51 mg/kg (CDM, 1994).

North Disposal Area

In December 1971, approximately 800,000 gallons of PCB-contaminated sludge were removed from two Industrial Lagoons and deposited into pits adjacent to the lagoons in the North Disposal Area. These pits were backfilled in 1973 with tree stumps, construction debris, and soil. The North Disposal Area is 7.2 acres and consists of approximately 30,400 cubic yards of soil, debris, and sludge with PCB concentrations greater than 10 mg/kg (CDM, 1994). This area includes a buried interceptor lagoon adjacent to the 1.5 mgal lagoon. The highest PCB concentration detected in this area was 31,000 mg/kg (CDM, 1994).

Groundwater in the area has PCBs levels up to 4.1 μg/L. The highest concentration of phenols detected in this area was 7,300 mg/L. Fifteen different VOCs were detected in the subsurface soil, with maximum concentrations of perchloroethylene (PCE) at 800 μg/L and vinyl chloride at 158 μg/L. The adjacent pumphouse also contained approximately 13,000 gallons of PCB liquids in a wet well. It was abandoned in 1976 and closed under a Consent Order in 1985.

Industrial Lagoons

The interceptor lagoon used from 1968 to 1976 was covered in September 1976 with construction debris and soil. Sludges from all the lagoons are contaminated to some degree with PCBs.

RI/FS reports (e.g., Hughes Environmental Systems and BBLES, 1993) document maximum measured PCB concentrations in lagoon sediments of 77,200 mg/kg in the 1.5 mgal lagoon;

1,620 mg/kg in the 350,000 gal lagoon; 383 mg/kg in the 500,000 gal lagoon; and 300 mg/kg in the 10 mgal lagoon. The maximum phenol concentration detected was 60,000 mg/kg in the 350,000 gal lagoon (Hughes Environmental Systems and BBLES, 1993). VOCs and metals were also detected at elevated levels, with the maximum concentrations generally found in the 350,000 gal lagoon. Since 1980, wastewater treatment sludges have been shipped off site to permitted hazardous waste disposal facilities.

Other Areas on GM Property

Miscellaneous areas on the facility were contaminated with PCBs during sludge handling and routine plant operations. Approximately 8,300 cubic yards of soil in various areas on the GM property are contaminated with PCBs at concentrations greater than 10 mg/kg (CDM, 1994).

2.3.3 Reynolds Metal Company

Site Description

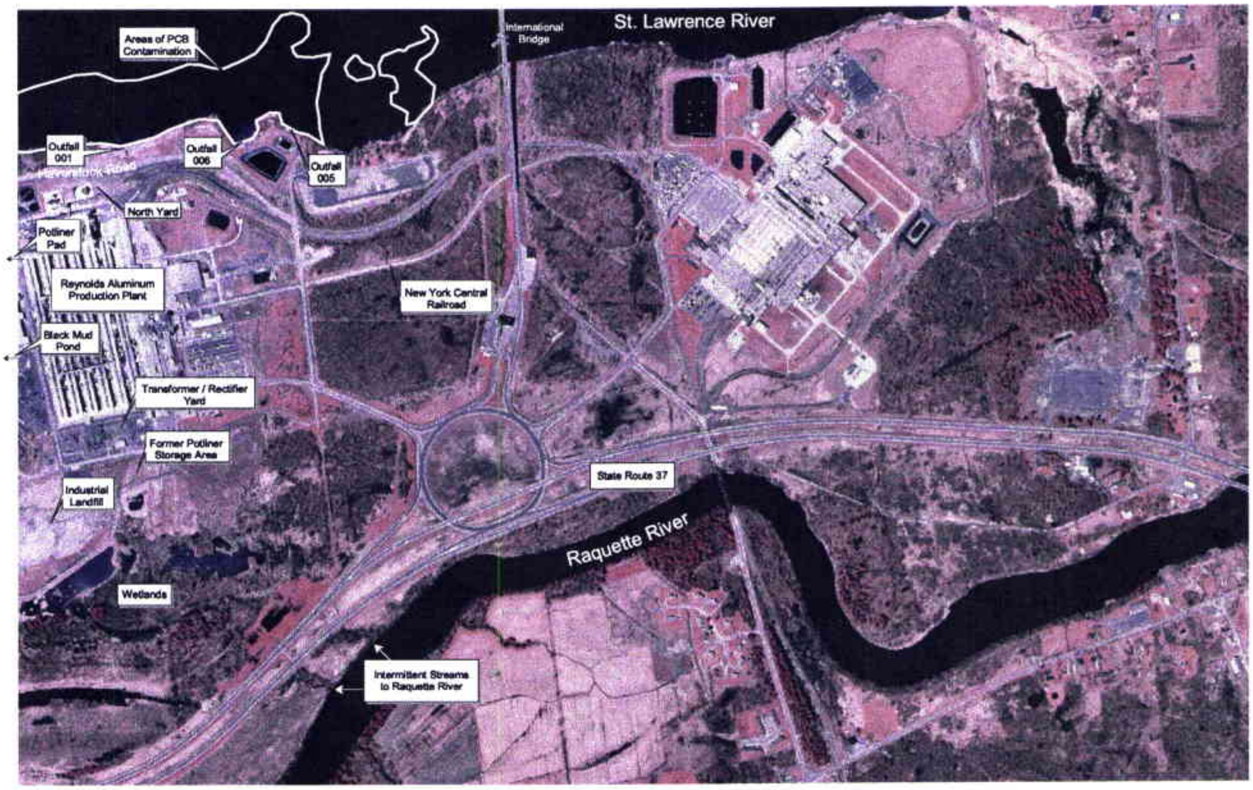
The RMC St. Lawrence Plant (New York State Site Code 645009) is located on the shores of the St. Lawrence River, off Route 37 in the town of Massena. The RMC property is bounded on the north by the Grasse and St. Lawrence rivers, on the east by Conrail (formerly New York Central Railroad), on the south by the Raquette River, and on the west by Haverstock Road (South Grasse River Road) (Figure 2-4). The RMC property occupies approximately 1,600 acres.

Site History

The RMC St. Lawrence Plant was constructed in 1958 for the production of aluminum from alumina (aluminum oxide). The facility occupies about 7%, or 112 acres, of the total property owned by RMC. The main components of the plant are the reduction plant, structures, and facilities encompassing about 20.5 acres; the solid waste landfill covering 11.5 acres; and the Black Mud Pond occupying approximately 6 acres (Figure 2-4).

Major areas of concern (AOCs) at the facility include the Black Mud Pond, the Industrial Landfill, the former Potliner Storage Area, the Wetlands, the North Yard, the Potliner Pad, miscellaneous areas including the Rectifier Yard and adjacent drainage ditch, and an area north of Haverstock Road. The Black Mud Pond was used for the disposal of spent potliners after they were digested to extract cryolite. It also received a bleed stream from the fume control system. The waste was pumped to the lagoon as a slurry. There is no permitted discharge from the lagoon. The landfill is currently used for the disposal of general mill wastes and sludges (some of which are contaminated by PCBs), and was formerly used for the disposal of potliners. The potliners have been re-excavated and were run through the cryolite recovery system. The base of the landfill extends into a regulated wetland. A leachate collection system has been installed but is only partially effective. Asbestos waste has also been found in the landfill. The disposal or storage of potliner waste at the Potliner Pad, Black Mud Pond, the Industrial Landfill, and the former

Figure 2-4
The RMC Superfund Site



Potliner Storage Area were major sources of fluoride contamination at the RMC facility. Other sources of fluoride contamination include wastewater spills, discharges from the cryolite recovery systems, and air emissions. A fluid containing high levels of PCBs was formerly used in the heat transfer system of the plant area. Leaks and spills are known to have occurred, and high levels of PCBs have been found in the soil near the plant in the northern area of the facility and in down-gradient drainage pathways. The heat transfer medium pumphouse is also contaminated with PCBs.

A September 8, 1987, Consent Order between RMC and NYSDEC required RMC to perform an RI/FS. The RI/FS was completed in 1991 and a ROD was issued in January 1992. In March 1993, NYSDEC issued a Consent Order requiring the implementation of remedial design and remedial actions. Remedial activities began in October 1993 and are ongoing (see Section 2.4.3). The 1993 Consent Order divided the RMC remediation into six priority sites:

- the Black Mud Pond
- the Industrial Landfill and former Potliner Storage Area
- the North Yard Area
- the Potliner Storage Pad
- the Wetlands
- miscellaneous areas.

Each site is described in detail below.

Black Mud Pond

The contents of Black Mud Pond contain varying concentrations of cyanide, fluoride, PCBs, magnesium, sulfate, trace metals (aluminum, arsenic, barium, copper, iron, lead, nickel, manganese, and zinc), and PAHs. With the exception of PAHs and some trace metals, these contaminants have also been detected in groundwater near the pond. Because of the low permeabilities of the subsurface soils, groundwater contamination is believed to be confined to a limited area near the pond. However, shallow contaminated groundwater may be discharging to surface water drainage pathways to the south and east of the pond. Contaminants can also be transported from the pond through the air.

Industrial Landfill and Former Potliner Storage Area

The Industrial Landfill and the Former Potliner Storage Area (FPSA) have been characterized as one contaminant source area because of their proximity, the similarity of contaminants, and the receptor zone of contaminants migrating from the area. The contamination detected in the waste, groundwater, leachate, and surface water is indicative of potliner-related material, and is characterized by elevated concentrations of aluminum, cyanide, fluoride, sodium, sulfate, and PAHs. Concentrations of PCBs are also detected in both areas. Before the construction of the runoff collection system, surface water runoff was discharged directly to a portion of the wetlands south of the landfill area. Contaminated groundwater from the FPSA was uncontrolled and also discharged to the wetlands. A leachate collection underdrain on the landfill intercepts the flow of some, but not all, contaminated groundwater from the landfill to the wetlands. Water level and water quality data indicate that contaminated groundwater is constrained to lateral movement through the fill to the wetlands and that downward migration is not occurring.

North Yard

PCBs, PCDFs, and PCDDs are distributed in North Yard surficial soils. PCBs are present in North Yard catch basins that collect water from subsurface French drains. The heat transfer medium system was the source of PCB, PCDF, and PCDD contamination. North Yard groundwater contamination is characterized by local areas of elevated concentrations of arsenic, cyanide, and fluoride. North Yard utility trenches act as preferential pathways for groundwater flow.

Potliner Pad

Groundwater contamination detected in the vicinity of the Potliner Pad is indicative of potliner-related materials and is characterized by elevated levels of cyanide, fluoride, sodium, sulfate, and trace metals (arsenic, beryllium, iron, manganese, and vanadium). Surface water and sediment contaminants include those mentioned above as well as the trace metals aluminum and cobalt, and PCBs. The source of the potliner-related contamination was spent potliner that was temporarily stored on the Potliner Pad and other processes in the area. Spent potliner is no longer stored in this area.

Wetlands

Wetlands surface water and sediment samples contain elevated concentrations of cyanide, fluoride, phenols, sulfate, sodium, trace metals (aluminum, arsenic, iron, and vanadium) and PCBs. The Landfill/FPSA is the major source of contamination to the wetlands. The drainage ways leading from the Rectifier Yard may be additional sources of PCB contamination to the wetlands. Two intermittent streams that flow to the Raquette River are a potential pathway of contaminant migration.

Miscellaneous Areas

Soil samples taken from within the Rectifier Yard confirm the presence of PCBs. Sediments samples taken from within the drainage pathway receiving a portion of the stormwater runoff collected within the Rectifier Yard contain PCBs. The drainage flows to the wetlands. Other contaminated areas include the Haverstock Road area and the Rectifier Yard Ditch.

2.3.4 ALCOA

Site Description

The ALCOA facility is an active aluminum production plant located on 3,500 acres in the town of Massena. The facility is bordered on the north by the St. Lawrence River, on the east by property belonging to Conrail (formerly New York Central Railroad), on the southwest by the Massena Power Canal, and on the southeast by the Grasse River. The plant is located off Route 37 near downtown Massena. The Mohawk Nation Territory of Akwesasne is downstream of the facility, approximately seven miles to the east (see Figure 2-1). The Grasse River flows are partially controlled by dams upstream of the ALCOA site. The Grasse River in this area is approximately 400 feet wide and up to 30 feet deep in portions of the river. In general, the Grasse River in this area is characterized by slow currents and a top layer of soft, silty sediment that overlies a second sediment layer with coarser characteristics.

Land use in the area surrounding ALCOA consists of mixed residential and industrial uses. A residential area is located along Dennison Cross Road, which generally parallels the northeastern boundary of the facility. Residential and commercial land use is found in Massena, which has about 15,000 people, located southwest of the ALCOA facility. Agriculture is the principal land use in areas surrounding the town of Massena. The Grasse River is used recreationally for fishing, canoeing, tubing, power boating, water skiing, swimming, and camping. Two groups, the Mohawk population and recreational fishermen, fish near ALCOA. Access to the Grasse River is unlimited in several areas. Grasslands along the Grasse River and a square mile that includes the ALCOA property are part of the Mohawk land claim.

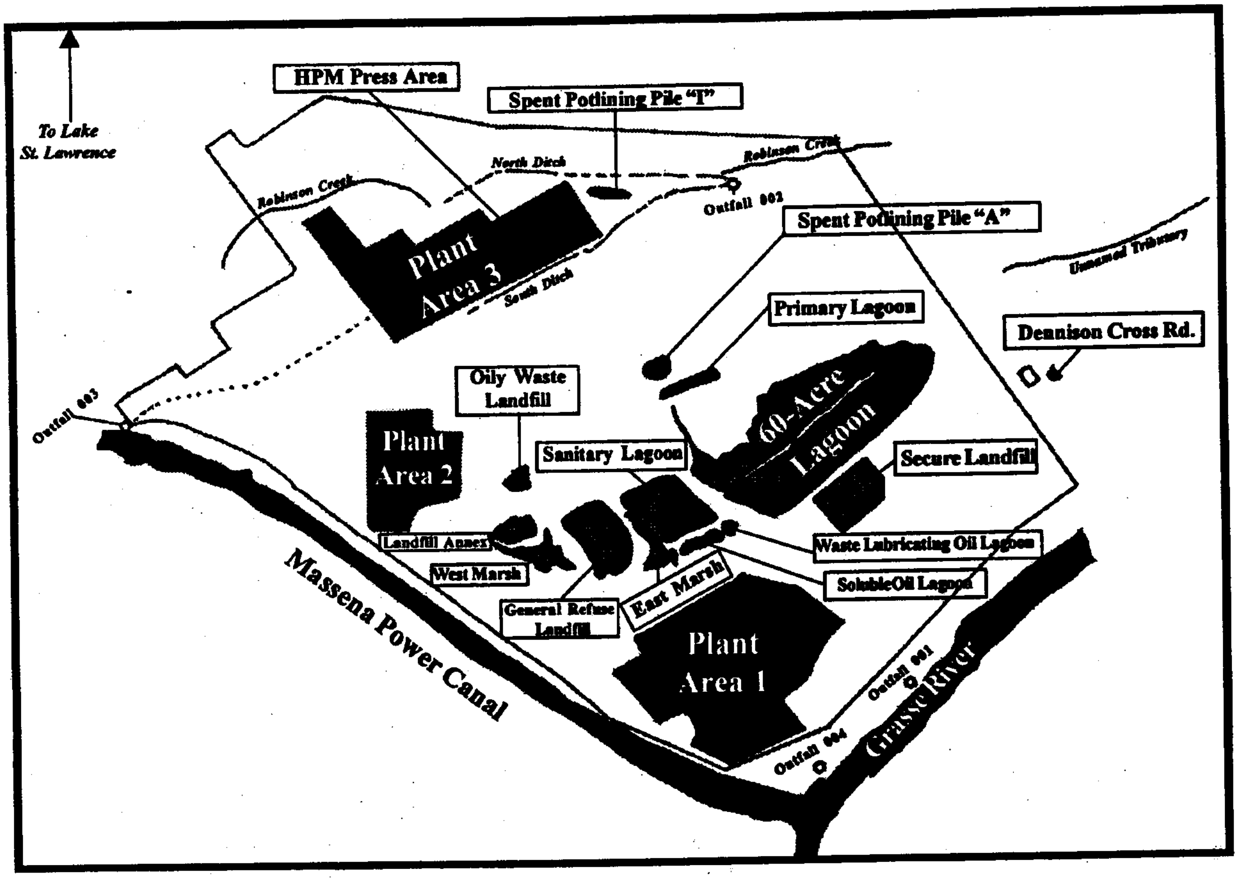
Site History

The ALCOA Massena Operation is an aluminum production and fabricating facility that has been in continuous operation since 1903, producing aluminum from alumina. The production plant includes three areas — the fabricating area (Area 1), the ingot-extrusion area (Area 2), and the smelting plant (Area 3) — and there are 11 disposal areas (Figure 2-5). As a result of production activities and years of continuous operations and expansion, various types of industrial waste were generated, disposed of, and spread throughout the facility including fluoride and PCBs. The disposal of potlining waste at the Spent Potlining Piles I and A were major sources of fluoride contamination at the ALCOA facility. Leachate from these former waste disposal areas has contributed to localized contamination of groundwater and surface waters at the facility. Other sources of fluoride contamination include the Primary Lagoon and Dredge Spoils area, the 60 Acre Lagoon, and air emissions. From the late 1950s through the early 1970s, PCBs were a component of hydraulic fluids and electrical equipment. As a result of production activities and past disposal practices, PCBs and other hazardous wastes were generated and disposed of at the facility. At least 18 contaminated areas on the facility property are being investigated and remediated.

Contamination on facility property and in upland areas is being investigated and remediated by ALCOA under the authority of several Consent Orders with NYSDEC. The facility is on the NYSDEC Registry of Class 2 Inactive Hazardous Waste Sites. Effective January 16, 1985, ALCOA and NYSDEC entered into a Consent Order whereby ALCOA agreed to develop and implement an inactive hazardous waste disposal site remedial program subject to the approval of NYSDEC.

Contamination in the river system surrounding the facility is being investigated by ALCOA in accordance with a 1989 UAO issued by the U.S. EPA. The area adjacent to the ALCOA facility (approximately six miles of the Grasse River) being investigated includes that portion of the Grasse River, any tributaries of that river, and any wetlands between the confluence of the Grasse and St. Lawrence rivers and a point one mile west and upriver from ALCOA's western most outfall (Figure 2-6). Contaminants have entered the ALCOA study area primarily via ALCOA's outfalls.

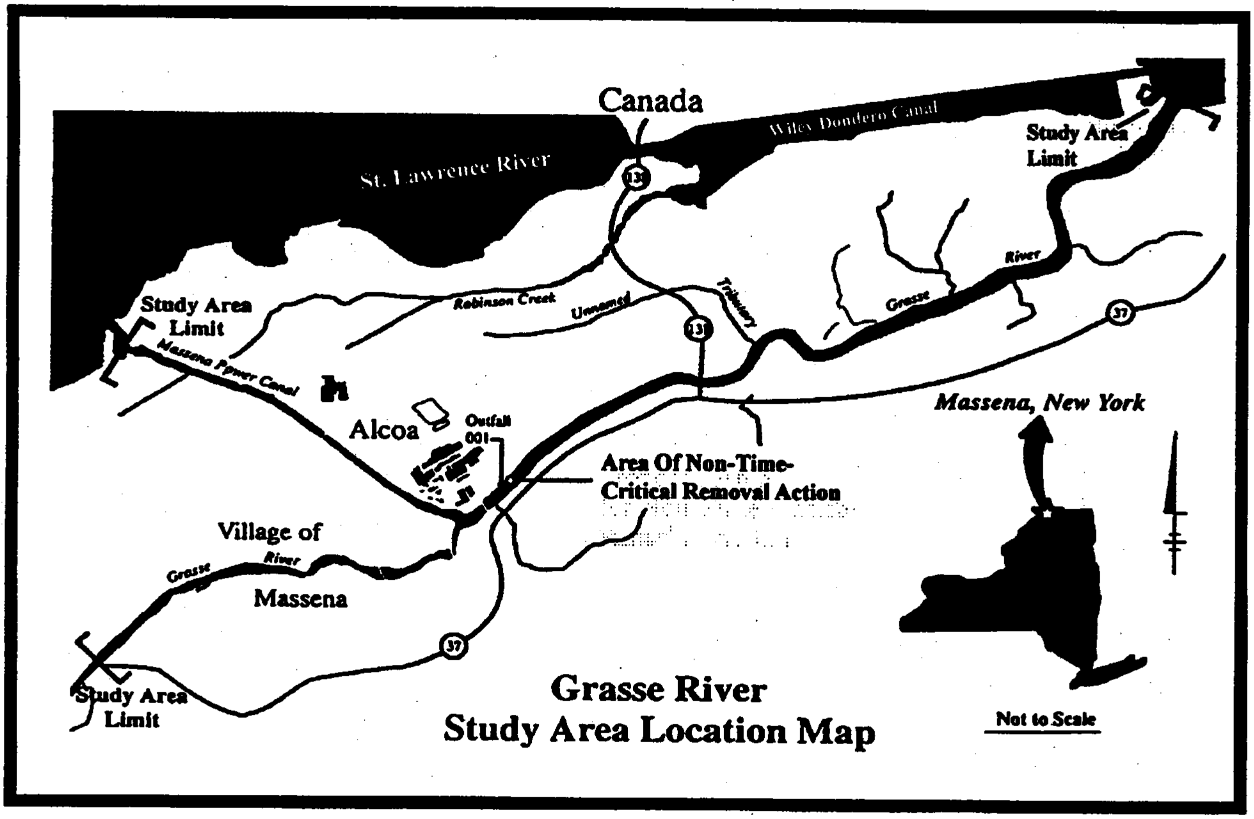
Figure 2-5
The ALCOA Superfund Site



Source: NYSDEC, 1992b.

In addition to the areas on the facility that are being cleaned up under NYSDEC authorities, process and sanitary wastewater from the ALCOA facility is discharged to the Grasse River through four outfalls. Outfall 001 is the facility's primary surface water discharge point. ALCOA currently discharges approximately 5 mgal/day through Outfall 001; flows from this outfall were higher before ALCOA implemented water reduction measures at the facility. Contaminants historically present in the effluent of Outfall 001 included PCBs, cyanide, and fluoride. Several lagoons and landfills on the facility were the sources of these constituents. Through the SPDES process, ALCOA has reduced the concentration of PCBs and other contaminants discharged from Outfall 001.

Figure 2-6
ALCOA Study Area



Source: U.S. EPA Region 2, 1994.

In the mid-1980s, ALCOA and NYSDEC signed a series of Consent Orders, pursuant to which ALCOA agreed to investigate and remediate contamination at the ALCOA facility. However, the Orders did not include an investigation of contamination on the river system surrounding the facility. In March 1991 and January 1992, NYSDEC issued RODs that outlined selected remedies for the ALCOA facility, excluding the river system.

The first ROD issued in March 1991 identified the following eight areas of concern:

- Active Potliner Disposal Site (NYS Site Code 645001)
- Inactive Potliner Disposal Site (NYS Site Code 645003)
- Dennison Road (NYS Site Code 645004)
- Primary Lagoon and Dredge Spoils Area (NYS Site Code 645005; Unit 1)
- Soluble Oil Lagoon (NYS Site Code 645005; Unit 3)

- Oily Waste Landfill (NYS Site Code 645016)
- West Marsh (NYS Site Code 645017)
- Unnamed Tributary (NYS Site Code 645019)

The second ROD issued in January 1992 identified an additional six areas of concern:

- General Refuse Landfill (NYS Site Code 645002)
- 60 Acre Lagoon (NYS Site Code 645005; Unit 2)
- Waste Lubricating Oil Lagoon (NYS Site Code 645005; Unit 4)
- Sanitary Lagoon (NYS Site Code 645005; Unit 5)
- East Marsh (NYS Site Code 645020)
- Landfill Annex (NYS Site Code 645026)

Background information on the 14 areas of concern identified in the RODs is presented below.

Active Potliners Disposal Site (NYS Site Code 645001)

The ALCOA Active Potliners Disposal Site is a disposal area for used potliner waste. This site was active between 1976 and 1983 and was capped by ALCOA with undisclosed material in 1984. Typical potlining waste contains up to 2,000 mg/L cyanide; the resulting leachate contains elevated concentrations of cyanide, fluoride, ammonia, and heavy metals. ALCOA did not have a permit to operate this site as a disposal area. The nearest residence is approximately 3,500 feet away. The site is not lined and has no leachate collection system. The Grasse River is about 5,000 feet away and is downgradient.

General Refuse Landfill (NYS Site Code 645002)

The ALCOA General Refuse Landfill is a 22 acre landfill that was in use between 1955 and 1990. Sample data indicate the presence of hazardous wastes in this landfill including PCBs and solvents. Although the landfill site was active up to 1990, it did not have a Part 360 permit. ALCOA and NYDEC entered into a Consent Order in 1985, which permitted the operation to continue in accordance with Part 360 technical requirements for solid waste management facilities until December 1, 1990. Leachate from the General Refuse Landfill discharges to the East Marsh and may also flow into the West Marsh as well. Groundwater samples collected in the vicinity of the General Refuse Landfill contained elevated concentrations of VOCs, PAHs, PCBs, and trace metals.

Inactive Potliner Disposal Site (NYS Site Code 645003)

The ALCOA Inactive Potliner Disposal Site is an inactive potliner landfill located near the smelting plant near Route 131. The site was used from 1951 to 1976. Typical potlining waste contains up to 2,000 mg/L cyanide; the resulting leachate from these wastes contains elevated concentrations of cyanide, fluoride, ammonia and heavy metals. The site was capped by ALCOA with clay between 1977 and 1983 and a leachate collection system was installed around the toe of the site. This leachate system collects between 50,000 and 100,000 gallons of leachate per year; however, it is only partially effective in preventing contaminant migration. The site is approximately 100 feet from Robinson Creek. A caustic solution containing ferric cyanide is leaching from the site.

Dennison Road Site (NYS Site Code 645004)

The ALCOA Dennison Road Site is a 0.75 acre inactive landfill site located in a ravine formed by river dredge material. The area was used for the disposal of drums of oily sludges, solvents, degreasers, and the still bottoms from these degreasers between 1969 and 1979. The area is about 600 feet long and 25 feet deep. The site is located about 2,500 feet from the nearest residence and about 1,500 feet from the Grasse River. Groundwater contamination has resulted, and test soil borings and surface samples confirm PCB, VOC, and fluoride contamination.

Wastewater and Waste Oil Lagoon Site (NYS Site Code 645005)

The ALCOA Wastewater and Waste Oil Lagoon Site is composed of five lagoons: Primary Lagoon and Dredge Spoils Area, 60 Acre Lagoon, Soluble Oil Lagoon, Waste Lubricating Oil Lagoon, and Sanitary Waste Lagoon. Primary contaminants are PCBs, PAHs, cyanides, fluorides, and phenols.

Primary Lagoon and Dredge Spoils Area, and 60 Acre Lagoon. The Primary Lagoon serves as an initial settling basin for a wastewater stream associated with the potliner air emissions scrubbing system. The lagoon was excavated in 1972 and was active until 1994. The Primary Lagoon is unlined. The effluent from this lagoon discharges to the 60 Acre Lagoon (actual size is 83 acres), which served as a settling pond. Storm sewer and process cooling waters also enter the 60 Acre Lagoon. In 1977, the Primary Lagoon was dredged and the sludge placed in the Dredge Spoils Area. Elevated PCBs concentrations were measured in the Dredge Spoils Area, and elevated concentrations of PAHs, cyanide, fluoride and trace metals were measured in both the Primary Lagoon sludge and the Dredge Spoils Area sludge. Elevated concentrations of PAHs, PCBs, cyanide, and fluoride have been measured in sludge collected from the 60 Acre Lagoon. Elevated concentrations of VOCs, PAHs, PCBs, phenols, fluoride, cyanide, and trace metals have also been measured in groundwater samples collected at the site.

Soluble Oil Lagoon. The Soluble Oil Lagoon is 3 acres and was a holding pond for waste oil and soluble oils generated on site. It was also used for the disposal of solvents and both caustic and acidic solutions from etching operations. The lagoon is not lined and was active between 1959 and 1986. Elevated concentrations of PCBs, PAHs, VOCs, and trace metals have been measured in the lagoon sludge, and elevated concentrations of phenol, fluoride, cyanide, and assorted organic chemicals, including PCBs, have been measured in groundwater samples.

Waste Lubricating Oil Lagoon. The Waste Lubricating Oil Lagoon is approximately 1.2 acres. It operated from 1969 to 1980 and served as a temporary storage basin for various waste oils generated in manufacturing areas of the plant and skimmed from the Soluble Oil Lagoon. It received approximately 100,000 gallons of waste oil per year. Water containing floating oil and sludge was transferred to the Soluble Oil Lagoon in 1980. The remaining oil and sludge were mixed with local soils and cement dust and solidified. Stabilizing material was brought in and graded, and the area was capped with clay and top soil in 1982. The Waste Lubricating Oil Lagoon contains 19,000 cubic yards of solidified material contaminated with greater than 600 mg/kg PCBs, and elevated levels of solvents and phenols. Groundwater samples collected near the Waste Lubricating Oil Lagoon and the Soluble Oil Lagoon contain elevated concentrations of PAHs, PCBs, phenols, fluoride, cyanide and trace metals.

Sanitary Lagoon. The Sanitary Lagoon is 18 acres and serves as a treatment pond for sanitary waste and stormwater runoff. It was built between 1960 and 1962, and was a primary settling basin from 1962 through 1995. It is currently used only for emergency overflows from the wastewater pumping stations. The lagoon holds approximately 34,000 cubic yards of sludge containing up to 560 mg/kg PCBs on a dry weight basis, fluoride, and low levels of volatiles and PAHs. Groundwater flows to the west to discharge into the East Marsh. Elevated concentrations of PAHs, PCBs, phenols, fluoride, cyanide, and trace metals have been measured in groundwater samples.

Oily Waste Landfill (NYS Site Code 645016)

The ALCOA Oily Waste Landfill is approximately 1 acre and consists of two pits. Approximately 1,400 cubic yards of heavy lubricating oil sludges were disposed of at this site between 1979 and 1984. Chlorinated and nonchlorinated solvents and PCBs have been found in the waste. These pits were closed between 1982 and 1984, when free liquids were removed and residual waste was solidified in place.

West Marsh (NYS Site Code 645017)

The West Marsh is approximately 3 acres and drains into the Grasse River via ALCOA Outfall 001. PCB concentrations up to 29,000 mg/kg have been measured in the marsh sediments.

Unnamed Tributary (NYS Site Code 645019)

The Unnamed Tributary receives runoff water and untreated anode-bake scrubber water from the smelting area via ALCOA Outfall 002. This tributary is approximately 1.5 miles long and discharges into the Grasse River. PCB concentrations of more than 18,000 mg/kg have been measured in the stream sediments near the outfall; PAH concentrations have been measured up to 16,420 mg/kg.

East Marsh (NYS Site Code 645020)

The East Marsh is approximately 4 acres and is adjacent to the General Refuse Landfill and the Soluble Oil Lagoon. The march contains approximately 17,500 cubic yards of PCB-contaminated sediment. The marsh used to receive significant surface water discharge from the West Marsh and the landfill, and also groundwater seepage from the landfill and the lagoon. Elevated concentrations of PCBs, PAHs, VOCs, cyanide, fluoride, and trace metals have been measured in surface water or groundwater collected from the site.

Annex Site (NYS Site Code 645026)

The ALCOA Annex Site is a 5 acre inactive landfill annex that was in use in the 1940s and the mid-1970s. This landfill is located near the General Refuse Landfill. Sample data indicate the presence of hazardous wastes in this landfill, including PCBs and solvents. Leachate from the Annex Site discharges into the West Marsh. Groundwater samples collected near the Annex Site contained elevated concentrations of VOCs, PAHs, fluorides, and trace metals.

Grasse River and Power Canal

In addition to the hazardous waste sites located on the plant property, ALCOA discharged contaminants to the Grasse River and Power Canal through eight outfalls:

- Outfall 001: This outfall is located 2,200 feet below the Power Canal on the Grasse River. It serves as the main discharge point for storm water and treated water. Volume discharged is 13 mgal/day annualized.

- Outfall 002: This outfall discharges to the Unnamed Tributary. It discharges nonprocessed storm water runoff from Area 3 and emergency process overflows. Volume discharged is 0.12 mgal/day annualized.

- Outfall 003: This outfall discharges to the Power Canal. It discharges stormwater from Area 3. Volume discharged is 0.23 mgal/day annualized.

- Outfall 004: This outfall discharges approximately 2,000 feet upstream from Outfall 001. It discharges stormwater from Area 1. Most of this water is treated through an activated carbon treatment plant before discharge. Volume discharged is 0.11 mgal/day annualized. In early 2000, it is anticipated that all storm-related bypasses of water at Outfall 004 will be eliminated by diverting flows before treatment into a storage basin.

- Outfalls 005: Outfall 005 discharges directly into the Grasse River near Dennison Cross Road. In early 2000, it is anticipated that water currently discharged through Outfall 005 will be routed through an expanded activated carbon treatment plant at the Outfall 004 location (ALCOA, 1999b).

- Outfalls 006: This outfall discharges internally to other permitted outfalls.
- Outfall 007: This outfall discharges to the Grasse River from areas in the southwestern portion of the facility.
- Outfall 008: This outfall discharges to Robinson Creek. It discharges stormwater from the northeast portion of the facility.

As a result of discharges through these outfalls, sediments in the Massena Power Canal and the Grasse River are contaminated with hazardous substances, including PCBs, aluminum, and fluoride.

2.3.5 Other Sources of Contaminants

St. Lawrence Seaway

The St. Lawrence River contains many obstacles and navigation can be difficult. From 1978 to 1988, the Canadian Coast Guard recorded 307 cases of accidental spills of pollutants (mostly petroleum products) from vessels on the St. Lawrence River. Ninety-six percent of the 307 spills occurred in ports: 114 spills occurred during ballast removal, 95 during refueling, 40 while emptying oil tankers, and 58 due to other causes. In addition, 15 maritime accidents resulted in oil spills, with only two of them, one near Matane and the other near Saint-Romauld, Quebec, being considered major spills. None of the accidental spills occurred near the St. Lawrence Environment Assessment Area (Bouchard and Millet, 1993).

St. Lawrence-FDR Power Project

The St. Lawrence-FDR Power Project, the U.S. portion of the Moses-Saunders Power Dam, is located approximately four miles upstream from the GM site. It has historically used PCBs and spills have been recorded. Use, storage, and spills of PCB-contaminated oils are believed to have been limited to the switchyard. Existing information documenting past and present use of PCBs, including quantities and concentrations used, as well as documentation on past transformer spills and past PCB sampling and clean-up efforts are currently being compiled as part of the New York Power Authority's (NYPA's) relicensing efforts. In 1998, NYPA and their contractors compiled SPDES discharge monitoring data for Outfalls 001 and 002 (station drainage), Outfalls 007A and 018 (stormwater drainage from the switch yard), and Outfalls 047 and 050 (power transformer banks and generating unit). In addition, NYPA or their contractors have taken samples to determine if PCBs are present in the soil within and around the switchyard, in the sediments in the vicinity of the stormwater outfalls, and in the stormwater from the outfalls. The results of the sampling are currently being finalized by the NYPA.

Mineral Processing Company

The Mineral Processing Company, in the town of Massena, processed aluminum dross in the 1970s. The 2 acre site is located adjacent to GMC, with Route 37 to the south and the Mohawk Nation to the east. In addition to processing aluminum dross, the company also cut up old machinery for sale as scrap, and as a result, hydraulic fluid containing PCBs was spilled in and around the facility. NYSDEC confirmed the presence of PCBs at levels requiring remedial cleanup, and the site was listed as a Class 2 site in the New York State Registry of Inactive Hazardous Waste Disposal Sites (NYSDEC, 1996).

Waste Stream Site

This Waste Stream Site is located north of Route 11 in Potsdam, New York. The site consists of a 25 acre scrap yard and a solid waste transfer station. Historically, the site received scrap, which was crushed and cut up for resale. Some of the materials contained PCBs. Equipment from GM, for example, was found to be contaminated with PCBs at levels exceeding 6,000 mg/kg. PCB contamination has also been found beneath the tin press at levels exceeding 360 mg/kg. Operation of this facility resulted in the release of PCB contaminated oily waste into the environment. The tin press has been remediated. However, PCB oily waste remains in sediments found in an on-site stream. The site is approximately 3,500 feet from the Raquette River. PCBs may also be located at unknown residual levels at the site. A preliminary site assessment is under way to identify remaining levels of contamination and pathways for contaminant migration (NYSDEC, 1997b).

Cornwall Industries

Before 1960, industrial facilities in Canada did little to control waste discharges. Also, raw sewage was discharged from the city of Cornwall directly in the St. Lawrence River until 1968. According to the St. Lawrence RAP Team (1990), the sources that have discharged waste water directly into the St. Lawrence River in the Cornwall, Ontario, area include:

- Domtar Fine Papers (Domtar)
- ICI (formerly CIL)
- Cornwall Chemicals
- Stanchem
- Courtaulds Fibres (closed in 1992) and Courtaulds Films (closed in 1989)
- Cornwall Water Pollution Control Plant.

A pulp and paper mill that has existed in Cornwall at the Domtar location since 1881 discharged large quantities of untreated wastewater until the mid-1960s. Domtar currently discharges approximately 130,000 m^3/day of industrial wastewater. Most of the effluent undergoes primary treatment and a clarifier removes suspended solids, which are landfilled. A low suspended solids stream bypasses the clarifier and joins the main effluent stream before being discharged into the St. Lawrence River. Domtar's effluent is typical for kraft pulp mills and has been found to have significant concentrations of resin and fatty acids, phenols, aluminum, and chloroform. Other compounds that have more elevated concentrations in the final effluent than in the intake include volatiles such as benzene, dibromochloromethane, ethylbenzene, and 1,1,1-trichloroethane; PAHs such as acenaphthalene, anthracene, fluoranthene, naphthalene, and phenanthrene; and cadmium, chromium, copper, lead, zinc, chloride, sulfate, nitrate, sodium, potassium, total phosphorus, total Kjeldahl nitrogen, and ammonia. Concentrations of cadmium found in the effluent ranged from 0.8 to 1.3 μg/L, which exceeded Ontario's Industrial Effluent Objectives. Limited sampling of effluent in 1987 revealed no detectable dioxins or furans, but some of these compounds have been found in the clarifier sludge. Domtar's pulp and paper mill is also a source of atmospheric particulate matter that is composed primarily of sodium sulfate. Emission rates have been measured to be about 60 kg/hr. Particulates deposit fairly quickly within 200 m of the stack and, according to the Remedial Action Plan, are not likely to affect the river.

The chlor-alkali plant at ICI started operation in 1935. It is believed to have lost approximately 150 kg of mercury per year to the environment until the 1970s. Effluents from ICI and Cornwall Chemicals are combined before discharge, which averages about 4,000 m^3/day, and the effluent is discharged directly to the St. Lawrence River through the Domtar diffuser. ICI converts salt into sodium hydroxide and chlorine using the mercury cell process. All liquid effluent is treated to remove mercury, and the discharge meets Canadian Chlor-Alkali Regulations of less than 0.0025 kg mercury per tonne of chlorine produced, although concentrations of mercury ranged from 2.9 to 7.3 μg/L in effluent. Organic parameters are low but with detectable levels of tetra- and pentachlorodibenzofurans and bis(2-ethylhexyl)phthalate. ICI also discharges mercury to the atmosphere. Monitoring has shown that 90% of the mercury emitted to the atmosphere will fall out within 0.5 miles of the plant property line and become bound up by organic matter in soil. Only small amounts would be expected to fall out directly on the St. Lawrence River because the plant is more than 0.5 miles from the nearest shoreline.

Cornwall Chemicals manufactures sodium hydrosulfide, hydrochloric acid, carbon tetrachloride, and carbon disulfide from chlorine and sodium hydroxide. Effluent from this industry contains significant quantities of carbon tetrachloride and chloroform. Effluent concentrations of 25 other halogenated volatiles, including methylene chloride, trichloroethylene, vinyl chloride, toluene, xylenes, acrolein, acrylonitrile, carbon disulfide, octachlorodibenzo-p-dioxin, octachlorodibenzofuran, fluoranthene, benzyl butyl phthalate, and di-n-octyl phthalate, exceeded intake water concentrations. Concentrations of mercury (2 to 3.7 μg/L) and zinc (0.14 to 2.93 mg/L) also exceeded Ontario Industrial Effluent Objectives.

Stanchem operates a packaging plant that produces small quantities of chemicals for laboratory or industrial use. As part of their process, Stanchem washes containers that are returned to them for refilling. Effluent has exceeded the Ontario Industrial Effluent Objectives, containing elevated concentrations of cadmium (0.017 to 0.029 mg/L), copper (2.0 mg/L), lead (1.2 to 2.2 mg/L), mercury (0.003 to 0.0054 mg/L), and oil and grease. Effluent also contains several organic contaminants, including PAHs, bis(2-ethylhexyl)phthalate, di-n-butylphthalate, bromodichloromethane, chloroform, chloromethane, dibromochloromethane, tetrachloroethene, hexachloroethane, hexachlorobenzene, and PCBs.

Courtaulds Fibres (closed in November 1992) made rayon at the same site since 1925. Courtaulds Films (formerly BCL Canada Ltd., closed in 1989) operated since 1955, producing cellophane. Before 1978, wastewater from these two companies was discharged into a natural bay of the St. Lawrence River, resulting in high acid and zinc concentrations in the waters, as well as high mercury and zinc levels in the sediment. Before its closure, Courtaulds Fibres was one of the largest volumetric sources of lead, the second largest discharger of mercury, and the primary source of zinc in the Cornwall area, with concentrations up to 45 times the Ontario Industrial Effluent Objectives of 1.0 mg/L. The highest concentrations of cadmium, arsenic, chromium, and nickel were found in sediments near or downstream of Courtaulds Fibres. Effluent contained relatively low levels of organic compounds, with detectable levels of octachlorodibenzo-p-dioxin, pentachlorophenol, di-n-octyl phthalate, benzo[b]fluoranthene, and 1,1,1,-trichloroethane found only at very low concentrations. Annual loadings of contaminants for the Courtaulds catchment area were calculated in 1980 to be as follows: 0.57 g chlorinated benzenes, 0.8 g pesticides, 3.7 g total PCBs, 13 g PAHs, and 48 g heavy metals.

The Cornwall Water Pollution Control Plant is a primary treatment plant that discharges approximately 50,000 m^3/day. Industries that discharge wastewater to the municipal sewer include BASF Canada (closed in 1990), which manufactured polyester sheer draperies; Richelieu Knitting Mills; and Champlain Industries, which produce animal feed grade whey. Both the City of Cornwall sanitary landfill and the Domtar waste disposal site have leachate collection systems that discharge to the municipal sewer system. Annual loadings of contaminants from the City of Cornwall were calculated in 1980 to be as follows: 49 g chlorinated benzenes, 171 g pesticides, 461 g total PCBs, 1,027 g PAHs, and 3,650 g heavy metals.

These industries, including the Water Pollution Control Plant, are all located on the north shore of the St. Lawrence River in Canada (see Figure 2-1).

2.4 REMEDIAL ACTIVITIES IN THE ASSESSMENT AREA

In the previous section, background information on releases of hazardous substances from PRP facilities and past historical remedial activities were identified. In this section, remedial activities conducted or planned after the PRPs entered into consent orders with the U.S. EPA as part of RODs or UAOs are discussed. All information found in this section has been taken from secondary sources, including RODs, yearly summaries, and Remedial Action Plans developed by the St. Lawrence RAP Team, the NYSDEC, or the U.S. EPA.

2.4.1 Overview

The U.S. EPA is overseeing remediation at the GM facility and has organized remedial work under two Administrative Orders. Under the authority of Consent Orders issued by NYSDEC, both ALCOA and RMC are responsible for investigating and remediating hazardous waste contamination found on facility property and in upland areas. In addition, contamination in the river systems surrounding both the ALCOA and the RMC facilities is being investigated in accordance with Administrative Orders issued by the U.S. EPA. These Administrative Orders require the respective companies to develop and implement measures to remediate hazardous waste contamination of aquatic sediments in the St. Lawrence, Raquette, and Grasse rivers adjacent to and downstream of the respective industrial sites.

2.4.2 General Motors Powertrain

Summary

To meet clean-up goals, the OU-1 ROD, stipulated a combination of excavation, treatment, or containment remedies for the GM site as follows:

- dredge/excavate contaminated sediments and soils in the St. Lawrence and Raquette rivers, Turtle Creek, and associated riverbanks and wetlands (the St. Lawrence River system)
- excavate contaminated sludges, soil, and debris in the North Disposal Area, in and around the four Industrial Lagoons, and in other areas on GM property
- excavate contaminated soil on Akwesasne
- treat dredged/excavated material by either biological treatment (or other innovative treatment technology which has been demonstrated to achieve site treatment goals) or thermal destruction, to be determined by the U.S. EPA following treatability testing.
- dispose of treated dredged/excavated materials on site.
- recover and treat contaminated groundwater downgradient from the site with discharge of treated groundwater to the St. Lawrence River

- establish interim surface runoff control to prevent migration of contamination from the East Disposal Area.

Similarly, the OU-2 ROD, also stipulated a combination of excavation, treatment, or containment remedies for the remaining areas of the GM site as follows:

- excavate sludge, visibly oily soils, and soil containing PCBs at concentrations at or greater than 500 mg/kg from the East Disposal Area at the site

- consolidate and contain in place less contaminated soils (i.e., soils containing PCBs at concentrations greater than 10 mg/kg and less than 500 mg/kg) in the East Disposal Area

- control groundwater migration from the East Disposal Area by installing a composite cap and a slurry wall

- treat excavated material from the East Disposal Area by either biological treatment (or another innovative treatment technology that has been demonstrated to achieve site treatment goals) or thermal destruction (treatment residuals will be disposed of on site)

- recontour, regrade, and contain contaminated material in the Industrial Landfill

- control groundwater migration from the Industrial Landfill by installing a composite cap and a slurry wall.

Before remediation, a wetlands assessment, floodplains assessment, cultural resource survey, and statement of consistency with the New York Coastal Zone Management Program were completed.

Since PCBs are present in higher concentrations and in more samples than the other contaminants, and are found in several areas on the property, PCBs were selected as the primary contaminant of concern at the site. Hence, remedy or cleanup goals were selected primarily based on PCB concentrations. Cleanup levels — levels of contaminant of concern that must be met in the river system and in the soil and groundwater once remediation is completed — for the General Motors-Massena (Operable Unit 1) site (consisting of contaminated sediments in the St. Lawrence River, Grasse River and Raquette River, contaminated groundwater and soils on the GM and the St. Regis Mohawk property, and contaminated material in the industrial lagoons and the North Disposal Area) were as follows (U.S. EPA, 1990):

- 1 mg/kg PCB in sediment in the St. Lawrence and Raquette rivers
- 0.1 mg/kg PCB in sediment in Turtle Creek
- 10 mg/kg PCB and 50 mg/kg total phenols in soil sludge on GM property
- 1 mg/kg PCB in soil on the St. Regis Mohawk Reservation

- 0.1 μg/L PCB, 1 μg/L total phenols in groundwater
- 100 μg/L 1,2-(trans)-dichloroethylene (1,2 DCE), 5 μg/L trichloroethylene (TCE), and 2 μg/L vinyl chloride (i.e., VOCs) in groundwater.

Based on the ROD issued for the General Motors-Massena (Operable Unit 2) site (consisting of the East Disposal Area and the Industrial Landfill area), the cleanup levels for 1,2 DCE and TCE in groundwater were reduced to 5 μg/L (U.S. EPA, 1992).

A summary of remedial activities at the GM site is provided in Table 2-3.

St. Lawrence River

The OU-1 ROD requires dredging and excavation of sediments and soils with PCB concentrations above 1 mg/kg for PCB contaminated soils and sediments in the St. Lawrence River and associated riverbanks and wetlands. In the spring of 1995, GM placed a steel sheetpile wall between the sediment removal area and the main river channel. The wall formed a barrier that prevented resuspended sediments from leaving the dredging area and moving downstream. Boulders, debris, and aquatic weeds were excavated. The mechanical removal work was followed by dredging and pumping of sediments through a floating pipeline to a collection point on shore. The sediments were screened to remove large debris. Excess water was removed from the sediments, treated to eliminate any contaminants, and then discharged back into the river. The dewatered sediments were pressed into forms (cakes) and placed in a lined stockpile area.

After the dredging was completed, the river bottom was divided into sections, or "grids," and samples of remaining sediments were collected to ensure that the dredging program had met the U.S. EPA's cleanup of 1 mg/kg. An analysis of the samples indicated that PCB concentrations in all areas except one averaged less than 3 mg/kg. The area adjacent to the GM plant Outfall 001, however, continued to show elevated PCB levels. Despite repeated dredging attempts, final sampling results showed an average of 25 mg/kg in this area. With the exception of one sample at a PCB concentration of 6,000 mg/kg, all other samples had PCB concentrations below 100 mg/kg. All dredging activities were complete by early November 1995.

To isolate the remaining PCBs from the St. Lawrence environment, GM installed a sediment cap in the vicinity of the outfall. The sediment cap consisted of three layers, each a minimum of 6 inches thick. The bottom layer, called the filter layer, contains sand blended with activated carbon to absorb any PCBs that may migrate upward toward the river water. The middle layer, called the barrier layer, contains small gravel-sized stone and isolates the filter layer from the top layer. The top layer, called the armor layer, contains larger stone and prevent waves and river current from eroding the cover. The large stones will also act as habitat for fish. GM has prepared a long-term monitoring and maintenance plan, which includes regular inspections of the cap and repair, if necessary.

Table 2-3
Timetable for GM Remedial Activities

1983	GM is fined $507,000 by the U.S. EPA, which charged GM with 21 counts of illegal dumping and storage of PCB laden waste under the Toxic Substances Control Act (TSCA).
1985	GM pays U.S. EPA a penalty of $395,000 to settle the 1983 case.
4/1985	U.S. EPA and GM enter into a Consent Order for a Remedial Investigation/Feasibility Study (RI/FS).
Summer 1985	GM fences off Industrial Landfill.
Fall 1985	GM completes installation of carbon adsorption for some stormwater discharges.
5/1986	GM submits a draft Remedial Investigation Report to the U.S. EPA.
Summer 1987/1988	GM implements interim remedial measures, including closing, grading, and temporary capping the Industrial Landfill.
5/1988	GM submits a Phase II Remedial Investigation Report to the U.S. EPA.
2/1989	NYSDEC issues draft State Pollution Discharge and Elimination System (SPDES) permit modifications to GM requiring nondetectable levels of PCBs using Method 608 with a detection limit of 0.065 μg/L.
11/1989	GM submits a draft Feasibility Study Report to the U.S. EPA.
12/1990	The U.S. EPA issues a ROD for a first operable unit that includes sediment, soil, and sludge excavation and treatment, as well as groundwater recovery and treatment.
3/1992	The U.S. EPA issues a ROD for a second operable unit that includes a mix of treatment and containment of contaminated soil.
3/1992	The U.S. EPA issues a Unilateral Administrative Order (UAO) compelling implementation of the first operable unit remedial actions.
8/1992	The U.S. EPA issues a UAO compelling implementation of the second operable unit remedial actions.
8/1993	GM performs additional sampling for design and implementation of a remediation plan.
1994	Contaminated sediment removal project is postponed because of a silt curtain problem.
Spring-11/1995	Using a steel sheet pile wall, over 18,000 cubic yards of contaminated materials are removed from the St. Lawrence River. A sediment cover is placed near GM Outfall 001 where contaminated materials remain.
6/1995	The U.S. EPA issues a Post-Decision Proposed Plan calling for on-site treatment using thermal extraction for materials with PCBs above 500 mg/kg and on-site containment of materials with PCB concentrations less than 500 mg/kg. This plan was withdrawn in August, 1998.
1996-1997	No final decision is reached concerning the U.S. EPA Post-Decision Proposed Plan.
1/1998	Monitoring study shows that portions of the sediment cap that was placed near GM Outfall 001 to cover contaminated materials is deficient. The sediment cap is repaired.
3/1999	EPA issues a ROD amendment calling for off-site disposal of contaminated St. Lawrence and Raquette River sediments rather than thermal treatment. Material with PCB concentrations equal to or exceeding 10 mg/kg will be disposed of off-site at a hazardous waste landfill.
8/1999	EPA issues an amendment to the UAO for operable unit one requiring GM to perform the remedial design and remedial action as specified in the ROD amendment of March 1999.
1999	In 1999, GM conducted geotechnical (seismic) data collection, and additional sampling of the landfill. GM also installed additional groundwater wells, removed previously dredged sediments from the St. Lawrence River (that were stored on site in storage cells), and performed a TSCA cleanup of the Active Lagoons.

Sources: NYSDEC, 1995; U.S. EPA, 1998b; CDM, 1998.

A visual inspection of the sediment cap conducted between June 5 and June 30, 1997, revealed that the sediment cap stone cover (the armor layer) was deficient in shallow areas parallel to shore (BBLES, 1998). The sediment cap in deeper areas (between 4 and 10 feet) was in good condition. No observations were made of the sediment cap in waters deeper than 10 feet. The deficient sediment cap stone cover layer was observed in water depths ranging from 1.5 to 4 feet of water and covered an area of approximately 1,000 square feet. This area was repaired in October 1997 by back-filling the deficient areas with approximately 50 tons of stone (3 to 5 inches in diameter) (BBLES, 1998).

Raquette River

The OU-1 ROD requires dredging and excavation of sediments and soils with PCB concentrations greater than 1 mg/kg for PCB contaminated soils and sediments in the St. Lawrence River and associated riverbanks and wetlands. In August 1998, GM released a Pre-Final Design Report for Remediation of the Raquette River outlining the proposed (1) work plan for removing PCB contaminated materials from the Raquette River, (2) cleanup verification methods, and (3) installation of a final cover system over excavated areas (CDM, 1998).

Akwesasne

The OU-1 ROD requires the dredging and excavation of sediments and soils with PCB concentrations greater than 0.1 mg/kg from PCB contaminated areas in Turtle Creek and from associated riverbanks and wetlands and excavation of PCB-contaminated soil on Mohawk Nation Territory adjacent to the GM facility with PCB concentrations greater than 1 mg/kg.

North Disposal Area, Industrial Lagoons, and Other Areas on GM Property

The OU-1 ROD requires that contaminated sludges, soil, and debris with PCB concentrations greater than 10 mg/kg be excavated from the North Disposal Area, the four Industrial Lagoons, and from other areas on GM's property.

East Disposal Area

The OU-2 ROD requires the excavation of materials containing PCBs at concentrations at or greater than 500 mg/kg from the East Disposal Area. An estimated 59,000 cubic yards of material will be excavated and treated. Because of past disposal practices, this volume may include nonoily soil with PCB concentrations less than 500 mg/kg that cannot be segregated. Nonoily soil with PCB concentrations greater than 10 mg/kg and less than 500 mg/kg in the East Disposal Area will be consolidated, regraded, and contained under a composite cover. Approximately 115,000 cubic yards of material will be contained in the East Disposal Area along with treated soils backfilled in the East Disposal Area and bulk debris.

During remediation, surface water runoff will be collected, treated if necessary, and discharged to the St. Lawrence River in compliance with SPDES requirements to minimize offsite migration of contaminants via runoff. Bulk items that are not amendable to treatment will be separated, stockpiled, and disposed in a facility that meets all TSCA requirements. The U.S. EPA has the option of electing not to excavate parts of the East Disposal Area if debris, boulders, cobble, or other bulk items make excavation technically impractical. Treated soils will be backfilled in the East Disposal Area, used to grade the remainder of the untreated material in the East Disposal Area, and covered with a composite cap. The East Disposal Area will be permanently maintained. Groundwater and air will be monitored to ensure that PCBs and other contaminants are not migrating from the East Disposal Area. Monitoring will continue as long as contaminants are present in the East Disposal Area. The contaminant area will be fenced and marked consistent with TSCA regulations.

Control of groundwater migration from the East Disposal Area with a slurry wall will be contingent upon results of additional data collection. The U.S. EPA will consider alternatives to the slurry wall system if data demonstrate that the cost of the slurry wall system is significantly higher than any proposed alternative. A proposed alternative must, at a minimum, meet the objectives of the groundwater extraction system selected as part of the OU-1 ROD and be as protective as the slurry wall system. The water from pumping wells and any surface water runoff will be treated, as necessary, in a wastewater treatment system with a combination of air stripping to remove VOCs and carbon adsorption to remove PCBs. Treated water will be discharged to the St. Lawrence River in compliance with state SPDES requirements. During and after remediation, groundwater and surface water will be monitored.

Industrial Landfill

The OU-2 ROD requires that the estimated 424,000 cubic yards of contaminated material in the Industrial Landfill be contained with a composite cover. The ROD requires that the Industrial Landfill be regraded and the slope be adjusted to comply with federal and state requirements. After topsoil removal, the following materials must be added to the Industrial Landfill: 1 foot of clay, one layer of flexible membrane liner, one layer of drainage material, one layer of geotextile, 18 inches of rooting zone soil, and 6 inches of topsoil. Revegetation of the cover will also be required. The cover will be maintained. Groundwater and air will be monitored to ensure that PCBs and other contaminants are not migrating from the Industrial Landfill. Monitoring will continue as long as contaminants are present in the Industrial Landfill. The OU-2 ROD requires that the containment area be fenced and marked consistent with TSCA regulations.

The ROD also requires that any PCB sludge, oily PCB-contaminated soil, or nonoily soil hotspots containing greater than 500 mg/kg PCBs that are exposed during landfill regrading and slope adjustment be treated in a manner similar to comparable material excavated from the East Disposal Area. During remediation, surface area runoff will be collected, treated if necessary, and discharged to the St. Lawrence River in compliance with SPDES requirements to minimize off-site migration of contaminants via runoff. The U.S. EPA believes that a slurry wall would significantly reduce the volume of contaminated groundwater that will be extracted from the site. The U.S. EPA estimates that, without a slurry wall, the volume of contaminated groundwater that will need to be collected downgradient of the Industrial Landfill is 2 million gallons per year. By comparison, the U.S. EPA estimates that the volume of contaminated groundwater that would be collected within the slurry wall (assuming no recharge from beneath the slurry wall or from the St. Lawrence River) is 150,000 gallons per year.

Groundwater

Groundwater flow generally reflects surface topography, and on the GM site flows north toward the St. Lawrence River and northeast to Turtle Creek. This creek and the adjacent wetlands are discharge areas for shallow groundwater flow. There is also some limited shallow groundwater flow south toward the Raquette River. The OU-1 ROD requires the recovery and treatment of groundwater downgradient from the GM site, with discharge of treated groundwater to the St. Lawrence River.

Disposal of PCB-Containing Material

The U.S. EPA's first ROD (OU-1) included a requirement for on-site treatment for all soils, sediments, and sludges with PCB concentrations greater than 10 mg/kg using biological treatment or thermal destruction. In June 1995, the U.S. EPA issued a Post-Decision Proposed Plan that called for on-site treatment using extraction for materials with PCBs greater than 500 mg/kg and on-site containment of materials with lower PCB concentrations.

A 1998 Revised Post-Decision Proposed Plan withdraws the 1995 Post-Decision Proposed Plan and calls for off-site disposal, rather than treatment, of materials contaminated with PCBs greater than 10 mg/kg. The 1998 proposal deals only with a focused portion of the OU-1 ROD and includes materials that were excavated or dredged from the St. Lawrence and those contaminated materials that will be excavated or dredged from the Raquette River. Any materials that are excavated during the installation of a groundwater cutoff wall will also be disposed of off site as per the Revised Post-Decision Proposed Plan. Materials contaminated with PCBs less than 10 mg/kg will be contained in an as-yet-to-be identified area on site under a vegetative cap.

Future Monitoring

Because the remedy will result in hazardous substances above health-based levels remaining on site in the Industrial Landfill and the East Disposal Area, a review will be conducted within at least five years. GM has also prepared a long-term monitoring and maintenance plan on the river sediment cap, which includes regular inspections of the sediment cap and repair, if necessary.

2.4.3 Reynolds Metals Corporation

Summary

In January 1992, NYSDEC issued a ROD on the Reynolds site. Based on sampling and analyses conducted to date, the ROD identified numerous contaminants at the RMC site. These contaminants included PCBs, PAHs, PCDDs, PCDFs, phenols, cyanide, fluoride, sulfate, and trace metals (aluminum, arsenic, barium, beryllium, cobalt, copper, iron, lead, nickel, manganese, vanadium, and zinc) (NYSDEC, 1992c). Of these contaminants, clean-up goals were derived for PCBs, PCDDs, and several PAHs (benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, fluoranthene, and pyrene) based on concentrations in soil. These clean goals were established for soils designated for excavation assuming an organic carbon content of 1% and were designed to be protective of groundwater quality. The NYSDEC is the lead agency for oversight of this cleanup. The soil clean-up goals were:

- 10 mg/kg PCB in areas within groundwater and surface water management areas (areas within the influence of groundwater pumping wells, groundwater drains, groundwater monitoring wells, or surface water runoff management areas under SPDES permits)
- 1 mg/kg PCB in areas outside of groundwater and surface water management areas
- 0.1 mg/kg or 1.0 mg/kg PCB in wetlands (depending on analytical and construction constraints to reduce PCB concentrations to 0.1 mg/kg)
- 0.33 mg/kg for the PAHs benzo(b)fluoranthene, benzo(k)fluoranthene, and chrysene
- 19 mg/kg for the PAH fluoranthene
- 6.5 mg/kg for the PAH pyrene
- 0.0005 mg/kg for PCDDs and specifically for 2,3,7,8-TCDD.

For the Potliner Pad and Wetlands, an additional clean-up goal was determined using a leachate extraction procedure on soils or sediment. The pH of the extraction fluid will be adjusted for background overburden groundwater pH conditions and analyzed for cyanide, fluoride, and sulfate. The clean-up goal is that concentrations of these compounds in these areas will be below NYS effluent standards (6 NYCRR Part 703.6).

In addition to contamination throughout the facility, RMS also discharged contaminants to the St. Lawrence River through four outfalls (Figure 2-4). As a result of this discharge, contamination is also found in the river system surrounding Reynold's property. In September 1989, the U.S. EPA issued a UAO requiring that Reynolds investigate and clean up contamination of the river system surrounding its facility.

Construction for on-site (i.e., land-based) remedial activities began in October 1993 and are completed, with the exception of the landfill cap, which will be installed following the completion of remedial actions in the river. Remediation projects have been divided into six priority areas:

- the Black Mud Pond
- the Industrial Landfill and Former Potliner Storage Area
- the North Yard Area
- the Potliner Storage Pad
- the Wetlands
- miscellaneous areas.

In addition to land based remediation, remedial options for the contaminated sediments in the St. Lawrence River are being developed. Sediments having less than 50 mg/kg PCB will be placed in the landfill. Remediation in each of these areas is described in more detail below.

A summary of remedial activities at the RMC site is provided in Table 2-4.

Black Mud Pond

The ROD requires that all wastes within the Black Mud Pond and contaminated soils beneath the pond will be dewatered and capped in place. A dewatering system to remove water from the pond was installed in the summer of 1995. This system has been effective at dewatering the Black Mud Pond primarily due to the elimination of locally available recharge. The Black Mud Pond was used for the disposal of potlining waste contaminated with cyanide. These materials also had PCB concentrations of 50 mg/kg or less. A hazardous waste closure cap was installed over the Black Mud Pond in August 1996 to eliminate infiltration of precipitation and aid in lowering groundwater elevation. The cap was integrated with surface water controls (i.e., grading, vegetation) to minimize surface water runoff entering the area, direct surface water away from Black Mud Pond, and control erosion. As of February 2000, approximately 1.7 million gallons of leachate has been extracted and treated according to established procedures. Double-walled piping was installed to allow pumping directly from the horizontal drain risers to the Black Mud Pond dewatering sump.

Following capping, groundwater levels will be measured monthly to monitor the effectiveness of the cap. If monitoring data indicate that the water table has not been lowered below the contaminated soil and waste as a result of capping, the installation and operation of perimeter groundwater collection and treatment will be required. Monitoring has revealed that the leachate contaminant levels are being reduced according to design. A long-term groundwater monitoring program will be implemented to monitor both the vertical migration and the horizontal migration of contaminants and to ensure leaching is not occurring. A completion report was released in July 1997.

Table 2-4
Timetable for RMC Remedial Activities

9/1987	NYSDEC enters into a Consent Order with RMC to develop and implement a facility-wide remedial program.
1988	Interim remedial measures include removal of contaminated sediments and capping north yard drainage ditch (Outfall 004). Other highly contaminated areas are capped and fenced.
7/1988	RMC adds carbon adsorption treatment to one of its outfalls.
1989	Interim remedial measures include completion of contaminated sediment removal, and capping and ditch relocation for Outfall 004. Outfall 002 is diverted to a treated system that includes carbon adsorption.
2/1989	NYSDEC issues draft SPDES permit modifications to RMC requiring nondetectable levels of PCBs using Method 608 with a detection limit of 0.065 μg/L.
9/1989	U.S. EPA issues separate UAOs to ALCOA and RMC, which require investigation and remediation of contaminated sediments in the AOC.
7/1990	Remedial Investigation Report is completed.
1990	Approximately 2,875 cubic yards of contaminated material is excavated from the 002 Outfall ditch and disposed of off site.
2/1991	Construction is completed to permanently divert Outfall 004 to an activated carbon treatment system. Also, a shallow groundwater collection system installation is completed. North Yard treatment system is installed.
8/1991	Feasibility Study Report is completed.
1/1992	NYSDEC issues a ROD for remedial action at the RMC facility. The remedy includes removal and/or treatment of contaminated soils and sediments; upgrade of groundwater, surface water; and leachate collection and treatment systems.
3/1992	RMC agrees to a Consent Order that includes nondetectable levels of PCB in discharges, bioaccumulation monitoring, and continued site remediation. This settles the 2/89 SPDES permit action (see above).
3/1993	NYSDEC issues a Consent Order requiring implementation of remedial design and remedial actions. Construction begins on 10/93 and is expected to be completed in 1998.
11/1993	U.S. EPA issues a ROD for the RMC study area, including remedial action for St. Lawrence River contaminated sediment.
1994	Land based remediation continues.
1995	Memorandum of Understanding is negotiated with NYSDEC for air emissions, which includes building hoods, modernizing cells, installing air pollution equipment, and using best management practices. RMC has installed a new fume control center that includes both dry and wet scrubbers to control air emissions from the plant. Tests to demonstrate compliance are scheduled to be completed by October 2001.
12/19/97	Reynolds pays $19,000 in fines under an enforcement action for a violation of TSCA when stripping oil and oily waste water contaminated with PCBs are shipped off site labeled as nonhazardous waste.
1995 to present	Contaminated sediment removal project is postponed. Land based remediation continues on schedule.

Table 2-4 (cont.)
Timetable for RMC Remedial Activities

1998	A Proposed Plan was issued in July, 1998 specifying that waste contaminated with PCBs greater than 50 ppm will be shipped off site. Waste contaminated with PCBs less than 50 ppm will be placed in an on-site landfill. This was formalized in a ROD issued by EPA in September 1998.
Fall 1999	RMC is purchased by ALCOA.
2/2000	RMC issues a final work plan for dredging PCB contaminated sediments from contaminated areas in the St. Lawrence River and associated river bank.
Sources: NYSDEC, 1995; U.S. EPA, 1997a, 1998b; Bechtel Environmental, 2000.	

Landfill/Former Potliner Storage Area

The ROD requires that a new and upgraded groundwater and leachate recovery system be installed around the Landfill/FPSA. The previous runoff collection system was inadequate to intercept all of the surface water runoff and groundwater discharges from the Landfill/FPSA. The new groundwater and leachate recovery system will collect and treat all contaminated water. Collected water will be treated at the North Yard GAC System. In addition, a hazardous waste closure cap will be installed over the Landfill/FPSA to contain the waste in place and significantly reduce infiltration of precipitation and subsequent leachate generation. This cap will be integrated with surface water controls to minimize surface water runoff entering the area and to minimize erosion. The landfill was used for the disposal and consolidation of PCB-contaminated materials with concentrations of 50 ppm or less that were excavated during the remediation of other areas of the Reynolds facility. A comprehensive operation and maintenance plan must be developed to monitor the landfill conditions and peripheral conditions to ensure that off-site migration does not occur.

Interim remedial water management improvements include a short geomembrane wall embedded in the clay berm/access road between the landfill and wetlands to increase the storage capacity of surface water runoff from the landfill. This area currently stores runoff for subsequent treatment, and the proposed improvement will increase the storage capacity, and hence minimize the potential for overflow from this area in the event of a severe rain.

The closure cap design for the landfill was approved by NYSDEC on December 1996. The landfill will be capped after river remediation spoils are disposed of in the landfill. The river remediation is proposed to be completed by December 2001, with the landfill cap construction to be finalized by December 2002.

North Yard

The ROD requires that all soils in the North Yard contaminated with 25 mg/kg PCBs or greater be excavated. Soils having greater than 50 mg/kg PCB were taken offsite for disposal; lesser contaminated soils were moved to the landfill. Remaining areas with PCB contamination greater than 10 mg/kg will be graded and capped to provide adequate drainage and reduce infiltration and migration of contaminants.

Interim remedial measures were implemented in the North Yard to minimize release to the environment before remediation. These measures (pre-1991; pre-ROD) included covering and paving, fencing, and rerouting storm drainage and french drain flow to the North Yard GAC system. Soils with greater than 10 mg/kg PCBs were excavated and clean fill was placed in the hole. The area was then capped and paved. As part of the selected remedy for this site, the ROD requires that the existing surface water and shallow groundwater collection system be modified and enhanced and/or a new surface water and shallow groundwater collection and treatment system be installed. The ROD also requires long-term monitoring of surface and groundwater.

Work was completed on restoring full service to the pitch storage system in October 1996. The piping to the storage tanks had been disturbed during remediation. The completion report was approved by NYSDEC in November 1998.

Potliner Pad

The ROD requires that all contaminated soils and sediments from the Potliner Pad and adjacent drainage ditches be excavated. Soils were excavated to remove most of the soil containing chemicals indicative of potliner material in July 1997. The ditch was lined with a geomembrane and crushed stone. Remaining excavated areas were backfilled with clean soil and paved with reinforced concrete. The total volume of soil excavated was 17,711 cubic yards. A total of 17,539 cubic yards of contaminated soil was moved to the on-site landfill, and 172 cubic yards was hauled off site. The clean-up goals for PAHs and PCBs were achieved. Test results in one location indicated a cyanide level slightly higher than the NYS effluent standard. Remediation included construction for surface water control and for groundwater flow reduction and isolation.

All remedial design and remedial actions are complete. Long-term monitoring and maintenance will continue.

Wetlands

The ROD requires that the currently identified impacted area of the wetlands be dewatered and that contaminated soils in the impacted area and the adjacent drainageways be excavated. The excavated material was placed in the onsite landfill for management under the planned landfill cap and leachate collection system. The wetland was satisfactorily replaced by wetland of a similar function after excavation of the contaminated soils. In addition, Reynolds has agreed to create an additional 6 acres of open water wetland habitat to be located west of the site adjacent to the current wetland.

To mitigate the impact on the wetlands, the remediated portions will be restored to wetlands of similar functions. Approximately 2 acres of open water at the south toe of the landfill was converted to uplands. These 2 acres will be replaced with wetlands created on RMC property adjacent to the wetlands as discussed above. This area will be an open water habitat surrounded by emergent vegetation, scrub shrubs, and saplings. The completion report was approved in January 1998.

Miscellaneous Areas (Rectifier Yard)

The ROD requires that all contaminated soils and sediments exceeding clean-up goals established for the Miscellaneous Areas be excavated. Soils and sediments in the Rectifier Yard with PCB levels greater than 1 mg/kg were excavated in May 1995. Soils were also excavated to meet clean-up goals for various PAH compounds (benzo[b]fluoranthene, benzo[k]fluoranthene, and chrysene at 0.33 mg/kg; fluoranthene at 19 mg/kg; pyrene at 6.5 mg/kg). In all, 2,524 cubic yards of material were removed from the remediated area; 2,484 cubic yards with PCB levels between 1 and 25 mg/kg and 15 cubic yards with PCB levels between 25 and 50 mg/kg were placed in the on-site landfill, and 25 cubic yards with PCB levels greater than 50 mg/kg were hauled off site to a licensed disposal facility. The New York Power Authority's substation, though not operated by RMC, was carefully sampled and shown to be unaffected by PCBs. This substation is located immediately adjacent to the west side of that portion of the Rectifier Yard that was remediated. In addition, a concrete containment structure was built around the oil tanks in the Rectifier Yard to contain any leaks or spills. Surface water will be monitored to determine the adequacy of the remediation. Remediation is considered complete and completion reports have been approved.

Air

RMC has installed a new fume control center that includes both dry and wet scrubbers to control air emissions from the plant. From 1959 to 1968, it is estimated that the RMC plant emitted at least 139 kg of fluoride per hour, and from 1968 to 1973, about 51 kg per hour were released into the atmosphere. Tests to demonstrate compliance are scheduled to be completed by October 2001. This control center is designed to meet the new Maximum Achievable Control Technology (MACT) air emission standards set by the U.S. EPA (U.S. EPA, 1997a, 40 CFR § 63 Subpart LL). MACT standards were promulgated in October 1997. Foundation work for the new fume system started in October 1997 and construction of the flume control system was completed in June 1999. The first phase of modernization of the RMC facility was started in June 1995 and included the installation of improved anode enclosures on each of the 504 pots on the three plant production lines. These new anodes are designed to improve the collection of fumes.

St. Lawrence River

In August 1991, Reynolds completed an additional river study, which outlined the nature and extent of contamination in the Reynolds Study Area. PCBs were found to be the primary contaminant in sediments in these areas. Other contaminants that were detected included PAHs, dibenzofurans, fluoride, aluminum, and cyanide. RMC estimates that approximately 77,600 cubic yards of sediment in the St. Lawrence River at the RMC facility have PCB concentrations greater than 1 mg/kg or PAH concentrations above 10 mg/kg.

In 1993, RMC submitted an Analysis of Alternatives Report to the U.S. EPA. After review and comment, the U.S. EPA selected a cleanup plan for the RMC Study Area that called for the dredging of contaminated sediments with PCB concentrations greater than 1 mg/kg from the Study Area. Sediments with PCBs concentrations greater than 25 mg/kg were to be treated to reduce the concentrations to 10 mg/kg or less. In September 1993, the U.S. EPA issued a Decision Document calling for this remedy. RMC began design of the selected remedy in 1994 and collected additional sediment and surface water samples to delineate the extent of the contaminated area and the volume of materials to be dredged. In April 1995, RMC submitted a request for re-evaluation of the disposal method for contaminated sediments. In 1998, the U.S. EPA changed the 1993 Decision Document to allow disposal of all dredged sediments with PCB concentrations greater than 50 mg/kg off site at a secure landfill rather than be treated on site. Sediments with PCB concentrations less than or equal to 50 mg/kg would be consolidated in the Industrial Landfill on RMC's property.

2.4.4 Aluminum Company of America

Summary

ALCOA agreed by Consent Order to remediate 14 hazardous waste sites on its 3,500 acre site. In March 1991, January 1992, May 1994, and subsequent amendments, NYSDEC RODs outlined selected remedies for the ALCOA facility, excluding the river system. Remedies included a combination of excavation and treatment of areas highly contaminated with PCBs and other contaminants, and consolidation and containment of other areas on the facility. ALCOA has constructed a two-cell, secure landfill on its facility that complies with TSCA and Resource Conservation and Recovery Act (RCRA) requirements. It is used for the disposal of various hazardous wastes resulting from ALCOA remediation projects.

Based on sampling and analyses conducted to date, the RODs identified numerous contaminants at the RMC site. These contaminants included PCBs, PAHs phenols, cyanide, fluoride, trace metals (unspecified), and VOCs (NYSDEC, 1991c, 1992b). Other contaminants at the ALCOA site include the trace metals aluminum, arsenic, copper, and zinc, and PCDDs and PCDFs (NYSDEC, 1991b). Of these contaminants, clean-up goals were derived for PCBs and numerous organic compounds (1,1,1-trichloroethane, benzene, tetrachloroethene, trichloroethene, toluene, total xylene, phenanthrene, pyrene) based on concentrations in soil (Table 2-5). These clean-up goals were established for soils designated for excavation and were designed to be protective of groundwater and surface water quality. These clean-up goals were also determined for areas within or outside a groundwater management unit (areas within the influence of groundwater pumping wells, groundwater drains, groundwater monitoring wells). For the Primary Lagoon and Dredge Spoil Area, and the Spent Potlining Pile A, an additional clean-up goal was determined using a leachate extraction procedure on soils beneath any excavated material. The pH of the extraction fluid will be adjusted for background overburden groundwater pH conditions and analyzed for cyanide, fluoride, and sulfate. The clean-up goal is that concentrations of these compounds will be below NYS effluent standards (6 NYCRR Part 703.6). The NYSDEC revised the cleanup goals for ALCOA for PAHs only, based on the revised 1994 TAGM (see Table 2-5; updated soil cleanup objectives to protect groundwater).

A U.S. EPA Administrative Order (Index No. II CERCLA-90229, Grasse River Order) was issued to ALCOA on September 28, 1989, and amended on May 24, 1995, requiring ALCOA to investigate and clean up contamination in a designated study area, including portions of the Grasse River, its tributaries, and wetlands. The river cleanup process for the ALCOA study area is ongoing under U.S. EPA oversight. The ALCOA study area encompasses approximately 8.5 miles of the Grasse River from Massena (downstream of the Route 37 bridge) to the confluence with the St. Lawrence River. The area also includes Robinson Creek (which discharges to the St. Lawrence River) and the Massena Power Canal, which connects the Massena Intake Dam to the former Massena Power Dam at the Grasse River/Power Canal confluence. The remediation activities to date has involved the following major activities.

River and Sediment Investigations. In 1991, ALCOA conducted a River and Sediment Investigation (RSI) to characterize the nature, extent, and volume of contamination in the ALCOA Study Area. It evaluated a broad range of potential chemicals of concern and concluded that PCBs were the major chemical of interest in the lower Grasse River.

Non-Time Critical Removal Activities. Between June 1995 and October 1995, approximately 2,600 cubic yards of PCB contaminated sediment and 400 cubic yards of PCB contaminated mixed debris and boulders was removed and dewatered as part of a hot spot removal action in the vicinity of Outfall 001. It was claimed by ALCOA that some sediments could not be removed from the river because of rocky terrain.

Supplemental Remedial Studies. Between 1995 and 1998, ALCOA conducted a Supplemental Remedial Studies (SRS) Program with the goal of obtaining site-specific information relating to PCB sources to the Grasse River, the fate and transport of PCBs (including uptake by fish), the extent to which natural attenuation may be occurring, and the effects of the NTCRA.

Table 2-5
Soil Clean-up Goals for Sites Designated for Excavation

Compound	Areas outside Groundwater Management Areas[a] (mg/kg)	Areas within Groundwater Management Areas (mg/kg)	Updated Soil Cleanup Objectives to Protect Groundwater[c] (mg/kg)
1,1,1-Trichloroethane	0.76	7.6	0.76
Benzene	0.04	0.4	0.06
Tetrachloroethene	0.02	0.2	1.4
Trichloroethene	0.13	1.3	0.7
Toluene	0.15	1.5	1.5
Total xylene	0.12	1.2	1.2
Phenanthrene	2.2	2.2	220
Pyrene	6.6	6.6	665
Other PAHs	0.3	0.3	—[d]
PCBs[b]	1.0	10	10

a. Groundwater management areas are areas within the influence of groundwater pumping wells, groundwater drains, groundwater monitoring wells.
b. In biologically sensitive areas such as surface water bodies and wetlands, the PCB soil clean-up goal is 0.1 mg/kg. However, the soil clean-up goal of 1.0 mg/kg can be used depending on analytical and construction constraints to reduce PCB concentrations to 0.1 mg/kg.
c. The NYSDEC Division Technical and Administrative Guidance Memorandum (TAGM) identifies soil clean-up objectives, and clean-up levels to protect groundwater for contaminated soils that are in the unsaturated zone above the water table (NYSDEC, 1994). These soil cleanup objectives may be inappropriate for soils that are near, or in, the saturated zone.
d. The TAGM identifies soil cleanup objectives for individual PAHs but not for PAHs as a group.

Sources: NYSDEC 1991c, 1992b, 1994.

Analysis of Alternative Remedial Activities. A draft Analysis of Alternatives report was issued by ALCOA in December 1996. In this report, ALCOA provided an analysis of alternative remedial activities to meet the clean-up goals in the ALCOA study area as specified in the ROD for this site. A final Analysis of Alternatives report was issued by ALCOA in December 1999 (ALCOA, 1999a). ALCOA has concluded that PCB contamination in the Grasse River sediments is widespread, that no clear hot-spots or areas of extremely elevated PCB concentrations exist, and that the river sediment has a low potential for resuspension and bioturbation. Hence, burial and natural attenuation of hazardous substances may be the preferred remedial option (ALCOA, 1999b; 1999c). The U.S. EPA has not selected a cleanup alternative for the ALCOA study area and will outline its selection in a Decision Document. The chosen remedy will then be designed and implemented.

In-River Particle Broadcasting Treatability Study. One remedial activity suggested by ALCOA is to apply a thin layer cap to the sediment in the Grasse River by adding approximately 6 inches of clean fill consisting of 50% sand and 50% top soil. An In-River Particle Broadcasting Treatability Study Work Plan was released by ALCOA in August 1999 (ALCOA, 1999c) describing a pilot study to test the effectiveness of different particle broadcasting methods on the bottom and steeply sloped sides of a small section of the Grasse River. To date, no work has been approved for the particle broadcasting study.

ALCOA has analyzed numerous sediment, water, and fish samples from the Study Area. The results of the analysis associated with the RIS and SRS programs are summarized in ALCOA's Comprehensive Characterization of the Lower Grasse River report released in August 1999 (ALCOA, 1999b).

A summary of remedial activities at the ALCOA site is provided in Table 2-6.

Information on remediation activities at the 14 areas of concern identified in the RODs is presented below.

Active Potliner Disposal Site "A" (NYS Site Code 645001)

As specified in the ROD, all waste and contaminated soil at Pile A were excavated and placed in an on-site dedicated cell within the on-site secure landfill. A groundwater recovery system was installed and is currently operational. The site was backfilled and covered with clean fill after confirmatory sampling determined that the clean-up goals had been achieved. This work was completed in 1995.

General Refuse Landfill (NYS Site Code 645002)

The ROD required that a hazardous waste cap be upgraded, and a groundwater diversion trench and a leachate collection system be installed, at the General Refuse Landfill site. Following

Table 2-6
Timetable for ALCOA Remedial Activities

1/1985	NYSDEC enters into a Consent Order with ALCOA to investigate and remediate hazardous and industrial waste areas at the facility.
8/1987	ALCOA completes a Remedial Investigation Report (Volumes I and II).
2/1989	NYSDEC issues draft SPDES permit modifications to ALCOA requiring nondetectable levels of PCBs using Method 608 with a detection limit of 0.065 μg/L.
9/1989	U.S. EPA issues separate UAOs to ALCOA and RMC, which require investigation and remediation of contaminated sediments in the AOC.
Fall 1989	Leachate collection system is installed at the general refuse landfill as an interim remedial measure to intercept contaminant migration to the East Marsh.
Fall 1990	Contaminated sediment is excavated and shipped off site from the West Marsh (8,000 cubic yards) and the first 400 feet of the Unnamed Tributary stream bed (1,500 cubic yards).
10/1990	A revised Consent Order is issued to guide the remaining Remedial Investigations, design, and implementation.
11/1990	An FS is finalized for nine ALCOA plant site areas.
12/1990	General Refuse Landfill ceases to receive waste; interim cap is installed.
2/1991	ALCOA completes an FS for remaining plant sites.
3/1991	NYSDEC issues a ROD to document specified remedial alternatives for eight of the ALCOA sites. The remedy includes a combination of contaminant removal, treatment, and containment.
6/1991	ALCOA adds carbon adsorption to one outfall.
7/1991	ALCOA is required to pay $7.5 million in criminal fines and civil penalties to New York State: $3.75 million for SPDES permit wastewater discharge violations and a $3.75 million criminal fine for illegal storage, shipping, and disposal of hazardous waste.
8/1991	ALCOA enters into a Consent Order with NYSDEC that outlines actions to reduce PCB discharges. This settles the 2/89 SPDES permit action (see above).
12/1991	Installation of a dry scrubber (to replace a wet system) for air pollution control and other water reduction actions reduce wastewater discharges from the ALCOA facility from 12 to 6 million gallons per day.
1/1992	NYSDEC issues a second ROD for the remaining six sites on the ALCOA property. The remedy includes leachate collection, groundwater treatment, and removal and treatment of soils and sediments.
3/1992	ALCOA installs carbon treatment on a second outfall.
6/25/92	ALCOA pays a $2,250 fine for violation of TSCA when two capacitors are found on site that were supposed to have been disposed of off site.
1995	Contaminated sediment hotspots removed from the Grasse River includes 3,500 cubic yards of contaminated materials as part of a Non-Time Critical Removal Action (NTCRA).
1996-1999	ALCOA conducts supplemental remedial studies to support Grasse River analysis of alternatives.
8/1999	Report summarizing data collected as part of river and sediment studies conducted in 1991-1994, supplemental remedial studies conducted in 1995-1998, and the NTCRA in 1995 for the Grasse River released. In-River Particle Broadcasting Treatability Study (PBTS) Work Plan to evaluate feasibility of burying contaminated sediments in the Raquette River with clean sediment submitted to agencies for approval.
12/1999	Revised Analysis of Alternatives Report released in Dec, 1999

Sources: NYSDEC, 1995; ALCOA, 1999b, 1999c.

completion of the remedial design, a diversion trench and a leachate collection system were constructed and capping of the landfill was completed in 1994.

Inactive Potliners Disposal Site "I" (NYS Site Code 645003)

As specified in the ROD, an RI/FS was completed and the contamination at the site was contained through the construction of a perimeter slurry wall, a hazardous waste cap, and installation of a deeper leachate collection system. This work was completed in 1993. A groundwater recovery system was installed and is currently in operation.

Dennison Road Site (NYS Site Code 645004)

In 1979, oil and water were pumped from the ravine of the Dennison Road Site and taken by truck to the waste lubricating oil lagoon. The remaining waste in the ravine was covered with soil, and the area was regraded and subsequently covered with vegetation. Groundwater monitoring wells have been installed in the area. An RI/FS was completed in 1990. As specified in the ROD, wastes and soils were excavated, treated (if necessary), and disposed of on site in a secure landfill. The remedial design was completed in early 1994 and the remedial work was completed in 1995. Groundwater contamination is being monitored. Residents have been supplied with a permanent municipal water supply to replace the temporary carbon filters used to treat their groundwater supplies.

By August 1995, over 62,000 cubic yards of contaminated soil from this site were placed in the ALCOA secure landfill. As part of this work, 6,959 drums were identified and 6,037 were overpacked, characterized, and shredded. The other 922 drums were empty and sent to the secure landfill. This site was remediated and backfilled in November 1995.

Primary Lagoon and Dredge Spoils Area (NYS Site Code 645005; Unit 1)

As specified in the ROD, dredge spoils, lagoon sludge, and underlying soil has been excavated and dewatered, solidified and capped in place. Solidified materials containing greater than 50 mg/kg PCB were removed and placed in the secure landfill. This work was completed in 1996.

60 Acre Lagoon (NYS Site Code 645005; Unit 2)

Because of the nature and volume of the contaminated sludge present at this site, the ROD provided ALCOA with the opportunity to pursue in-situ treatment technologies such as bioremediation. The in-situ process must reduce the PCB concentration in the sludge to 50 mg/kg or less or permanently immobilize it. If in-situ processes are unsuccessful, the material must be excavated and treated before disposal in a secure on-site vault. While technological options are being evaluated, ALCOA developed and implemented a plan beginning in 1992 which was designed to eliminate or discourage the use of the lagoon by waterfowl. A surface water discharge monitoring and control program was completed in 1999 which was designed to meet all applicable discharge limits. The 60 Acre Lagoon site, which actually encompasses 83 acres, needs to be addressed. To date, designs have not been finalized and construction is scheduled for completion in 2000. This is to include removal of all sludge. Sludge containing PCB concentrations greater than 50 mg/kg are to be disposed of in the secure landfill; the remainder is to be left in place and capped.

Soluble Oil Lagoon (NYS Site Code 645005; Unit 3)

The ROD required that all wastewater be decanted and treated to satisfy facility discharge requirements. All sludge and underlying soils will be excavated and treated via the solvent extraction process to concentrate the waste oil. The concentrated waste oil will be incinerated off site and the treated material placed in an onsite secure vault. An RI/FS has been completed. Remedial designs for the Soluble Oil Lagoon have not yet been finalized. The Soluble Oil Lagoon was in a former wetland.

Waste Lubricating Oil Lagoon Site (NYS Site Code 645005; Unit 4)

The ROD required that all solidified waste and visibly contaminate soil be excavated followed by confirmatory sampling to determine if cleanup goals had been met. An RI/FS was completed and remedial designs have been developed. The Waste Lubricating Oil Lagoon was excavated in 1996 and 1997 and the waste was placed in the ALCOA Secure Landfill. The Waste Lubricating Oil Lagoon was in a former wetland.

Sanitary Lagoon (NYS Site Code 645005; Unit 5)

Because of the nature of the contaminated sludge present at this site, the ROD provided ALCOA with the opportunity to pursue in-situ treatment technologies such as bioremediation. If unsuccessful, the material must be excavated and treated before disposal in a secure on-site vault. An RI/FS was completed in 1992 and remedial designs have been developed. The Sanitary Lagoon was excavated in 1996 and 1997 and the waste was placed in the ALCOA Secure Landfill. The Sanitary Lagoon was in a former wetland that must be replaced.

Oily Waste Landfill (NYS Site Code 645016)

The Oily Waste Landfill consists of two pits that were used for disposal and solidification of lubricating oils and sludges. The ROD required that all wastes and visibly waste contaminated soils be excavated and disposed of in accordance with the cleanup goals. At this site, all liquids were removed, wastes were solidified, and the pits were capped by ALCOA. In addition, the waste and underlying soils have been excavated and landfilled in the secure landfill and the site capped with a geo-synthetic clay liner and closed in 1995. The remedial design was completed in 1994.

West Marsh (NYS Site Code 645017)

The ROD required installation of a drainage system along the existing marsh channel, and for contaminated areas to be backfilled and capped to create an upland region. The acres of lost wetland will be replaced. Under an Interim Remedial Measure, 8,000 cubic yards were excavated for off-site disposal. The remaining waste marsh sediments were removed and placed in the adjacent landfill annex, backfilled, and capped in 1993. This site has been de-listed following completion of the remediation. Replacement of the wetland is yet to be accomplished.

Unnamed Tributary (NYS Site Code 645019)

The ROD required that areas of PCB contaminated sediment and soil above 1 mg/kg be excavated and disposed of onsite in a secure vault. The original grade of the tributary will be re-established using clean fill and rip-rap to control for erosion. Biological monitoring will be conducted for 5 years to determine the effectiveness of the cleanup. An Interim Remedial Measure conducted in 1990 removed 1,500 cubic yards of PCB contaminated sediments from the first 400 feet of the tributary. Under the RI/FS and ROD, a remedy was selected. Remediation was completed in 1998 and was composed of two parts. The first part involved the excavation of a 1.5 mile outfall pipe. Contaminated materials within the pipe, as well as any contaminated soils adjacent to the pipe, were removed. A new pipe was placed inside the old one and grouted in place. The second part involved the removal of approximately 7,600 linear feet of sediments from the tributary. Excavation was to a native clay layer, with a clean-up goal of 1.0 mg/kg PCB. Presently, a 5-year biomonitoring program is underway.

This tributary is not within the secure industrial complex and is accessible to the public.

East Marsh (NYS Site Code 645020)

As specified in the ROD, contaminated marsh sediments and soils have been excavated and placed in the secure landfill. Remedial design was completed in 1994. The marsh is no longer being used as discharge outlets for water from the West Marsh, the General Refuse Landfill, and the Soluble Oil Lagoon. The excavated wetland has not been replaced.

Landfill Annex Site (NYS Site Code 645026)

For the Landfill Annex, the ROD required excavation of and off-site disposal of all visible drums located along the southern periphery of the site as well as all unearthed drums and visibly stained soil in the vicinity of the drums. Following excavation, the area was backfilled and capped. The ROD also required construction of a slurry wall around the entire perimeter of the site to direct groundwater flow away from the area and stop the migration of leachate into the West Marsh and construction of a leachate collection system inside the slurry wall. In 1994, the waste in the 5 acre landfill annex was contained in place through the construction of a perimeter slurry wall, a hazardous waste cap, and a leachate collection system.

Other Sites

Unpaved plant roads (NYS Site Code 645005, Unit 6) are currently undergoing an RI. It is anticipated that remediation will be completed by December 2000. Remediation was completed in 1997 for Storage Tank 51 (NYS Site Code 645023). The remediation involved excavation and removal of contaminated material to the secure landfill. A ROD for the West Fill Area (NYS Site Code 645025) is nearing completion and is expected to be issued in the year 2000. The proposed remediation will be that contaminated areas are to be excavated. A feasibility study has been completed for the HPM Press Area (NYS Site Code 645024). A ROD was issued in March 1998 for this area. Waste was excavated and placed in the Secure Landfill in 1998.

Air

The ALCOA plant, which has operated since 1903, has historically released fluoride as well as other particulates. It was estimated that 31 kg of gaseous fluorides were emitted per hour with total fluoride emissions of 742 kg per 24-hour period of gaseous fluorides. An additional 2,163 kg of total particulates were released each day. In December 1991, ALCOA installed a dry scrubber (to replace a wet system) for air pollution control. In 1998, a NYSDEC Air Enforcement Consent Order required that Reasonably Available Control Technology (RACT) for NOx be installed on four large boilers, used as auxiliary for providing steam to the ALCOA facility, which are a major source of NOx. NYSDEC alleged that ALCOA was not in compliance with 6 NYCRR Part 227-2.3(a), which required them, by March 15, 1994, to undertake any one of the following four procedures to remain in compliance: (1) submit a plan to bring the facility into compliance for emissions of NOx; (2) submit a schedule and receive a permit to limit the operation of the facility so that it is not a major source of NOx (a so-called cap); (3) submit a schedule for the expiration of the certificate to operate each combustion source subject to the regulations; or (4) cease operation [6 NYCRR §227-2.3(a)]. ALCOA submitted a plan to limit the emissions from the facility in such a way as to comply with RACT and submitted a permit modification application; that permit modification was not issued.

The Consent Order states that ALCOA shall proceed with construction and operation at the boiler house of the "Selected NOx Control Technologies" specified in the "Engineering Evaluation of Low NOx Retrofit for Aluminum Company of America, Massena, NY" dated December 1, 1997. Construction was completed within 43 weeks after the effective date of the order. Additionally, ALCOA submitted to the NYSDEC a stack test protocol within 30 weeks of the effective date of the order. From the end of the forty-third week after the effective date of the order, ALCOA has complied with the emission limits set forth in 6NYCRR Part 227.2.4(b) for gas/oil.

2.4.5 Other Remediation Activity in the St. Lawrence Environment Assessment Area

Mineral Processing Company

In May 1995, GM entered into an Order of Consent with NYSDEC, agreeing to remove and contain PCB-contaminated waste found at the Mineral Processing Company site. The PCB contamination originated from GM equipment and was a result of spilled hydraulic fluid containing PCBs. A focused RI was conducted to evaluate affected soils and groundwater impacted at this site and confirmed that PCB levels up to 500 mg/kg were found in the dismantling bins inside the main building. PCB levels up to 150 mg/kg were found in the soils of the equipment storage area outside the building, and PCB levels up to 50 mg/kg were found in miscellaneous soils around the site. The groundwater beneath the site was found to be contaminated with VOCs and semi-VOCs (NYSDEC, 1996).

As part of the remediation, all materials above 10 mg/kg were put into containers and taken off site for disposal. All soils below 10 mg/kg of PCBs were capped with a 12 inch protective cover. The building was decontaminated, dismantled, and taken off site for disposal. A concrete pad was decontaminated, but allowed to remain in place and covered with a 12 inch cap. Three monitoring wells were installed to study the groundwater.

Following remediation, the site was reclassified as a Class 4 site in the New York State Registry of Inactive Hazardous Waste Disposal Sites. A Class 4 site is defined as a site that has been properly closed and requires continued management. The low level PCB-contaminated soils beneath the protective cap and the site's groundwater will be monitored to ensure the site is properly closed and maintained to protect human health and the environment.

CHAPTER 3
AUTHORITY

3.1 INTRODUCTION

The cornerstone of the trustees' authority is their sovereign public trust responsibility and fiduciary obligation to the natural resources in the St. Lawrence Environment Assessment Area. Natural resources for which the trustees have an obligation, and which have been or are likely to have been adversely affected by the releases of hazardous substances, include surface water, sediments, groundwater, soils, air, and biological resources, including aquatic biota, terrestrial biota, and wildlife.

Under Section 107 (f) of CERCLA, the four trustees, individually and together, are authorized to recover damages for injury to, destruction of, and loss of natural resources resulting from a release of hazardous substances from a facility. Under the National Contingency Plan (NCP), "where there are multiple trustees, because of coexisting or contiguous natural resources or concurrent jurisdictions, they should coordinate and cooperate in carrying out" their trustee responsibilities [40 CFR § 300.615]. The SRMT, the DOI, NOAA, and NYSDEC are heeding this regulatory suggestion in working cooperatively under a Memorandum of Understanding to prepare this plan as part of a comprehensive NRDA of the St. Lawrence Environment Assessment Area pursuant to CERCLA and consistent with the NCP. Under the NRDA regulations, assessment plans must "include a statement of the authority for asserting trusteeship or co-trusteeship for those natural resources within the Assessment Plan" [43 CFR § 11.31 (a) (2)]. A general description of the natural resource authority asserted by these trustees is given below. These descriptions are not meant to be an exhaustive and all inclusive listing of their authority over trustee natural resources. In addition, each trustee may have co-trustee authority over natural resources listed within the trusteeship of another trustee.

3.2 ST. REGIS MOHAWK TRIBE

A thriving population of indigenous people has lived within the St. Lawrence Environment Assessment Area, and have maintained sustainable and positive relationships with the natural resources appertaining to the area, for several thousand years. Since time immemorial, the St. Lawrence River has been known as Kaniatarowanenneh, which means the majestic and magnificent river, by the Mohawk people of Akwesasne. Mohawk knowledge, understanding, and sacred respect for the water, fish, waterfowl, fur-bearing animals, and other natural resources have sustained the community. Mohawk diplomacy, navigational skills and strategic position in straddling the St. Lawrence, Raquette, St. Regis, Salmon, and Grasse rivers made them a powerful force during the development of the fur trade and the establishment of the U.S. and Canadian Governments.

Mohawk rights and interests in the use and enjoyment of natural resources upon and appertaining to their land were supported throughout the treaty era during the 18th and 19th centuries. Indeed, Mohawk use and enjoyment of riparian rights was so dominant toward the end of the 18th century that a treaty executed with the Six Nations of the Iroquois Confederacy at Canandaigua, New York, in 1794 sought and obtained a concession of power from the Confederacy regarding the local water near Indian land. The Canandaigua Treaty secured to the people of the United States "the free use of the harbors and rivers adjoining and within their [the Six Nations] respective tracts of land, for the passing and securing of vessels and boats and liberty to land their cargos where necessary for their safety" [Federal Treaty with the Six Nations, 1794 (Article V)]. This Mohawk promise to not stop, tax, or impose duty or tariff on U.S. ships along the St. Lawrence River represents a clear acknowledgment of Mohawk rights and use of the resource. Mohawk off-reservation treaty rights to harvest local natural resources were reaffirmed in the 1796 Treaty with the Seven Nations, in which certain Mohawk land rights in the Grasse River basin were memorialized.

For generations, the Mohawks of Akwesasne have depended on their rights to hunt, fish, trap, and gather within and near the St. Lawrence Environment Assessment Area for their nourishment, health, and economic livelihood. CERCLA identifies Indian tribes as public trustees of natural resources in defining natural resource liability under the statute. The statutory description of tribal standing reaffirms the definition of natural resources set forth at §9601(16) to include claims for "natural resources belonging to, managed by, controlled by, or appertaining to such tribe, or held in trust for the benefit of such tribe, or belonging to a member of such tribe as such resources are subject to a trust restriction on alienation . . ." [42 U.S.C. § 9607 (f)(1)]. In addition, the description of the "permitted release" defense that may be available to liable parties in some cases [42 U.S.C. § 9601 (10); 9607 (f) (i) (j)] is significantly modified in natural resource liability cases where a tribe is involved. In this instance, any permit that is offered as a shield to liability is subjected to substantive scrutiny and can only serve as a defense if "the issuance of that permit or license was not inconsistent with the fiduciary duty of the United States with respect to such Indian Tribe." The President is required under CERCLA to designate in the NCP [40 CFR Part 300] the officials who are authorized to act on behalf of the public as trustees for natural resources under CERCLA and the CWA. Under the NCP, tribal chairmen (or heads of their governing bodies) of Indian tribes, or a person designated by the tribal officials, act on behalf of the Indian tribes as trustees for natural resources under tribal trusteeship [40 CFR § 300.610].

3.3 U.S. DEPARTMENT OF THE INTERIOR

For the United States, Executive Order 12580 and the NCP [40 CFR Part 300] have designated the federal officials who are authorized to act on behalf of the public as trustees for natural resources under CERCLA and the CWA. Under the NCP, the Secretary of the Interior is designated to act as a trustee for natural resources "belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the DOI," as well as the supporting ecosystems for those natural resources [40 CFR §§ 300.600(a), (b), (b)(2)]. Based on the authority designated to the Secretary of the Interior, DOI derives trusteeship authority over natural resources in the assessment area from its statutorily prescribed programs, including, but not limited to:

- the Migratory Bird Treaty Act of 1918 [16 U.S.C. §§ 703-712] — migratory birds and their supporting ecosystems
- the Bald and Golden Eagle Protection Act of 1940 [16 U.S.C. §§ 668-668d]
- the Anadromous Fish Conservation Act of 1965 [16 U.S.C. §§ 757a-757g]
- the Estuary Protection Act of 1968 [16 U.S.C. §§ 1221-1226]
- the Marine Mammal Protection Act of 1972 [16 U.S.C. §§ 1361-1407]
- the Endangered Species Act of 1973 [16 U.S.C. §§ 1531-1544] — including endangered, threatened, or candidate species and their supporting ecosystems
- the Emergency Wetlands Resources Act of 1986 [16 U.S.C. §§ 3901-3932]
- the Great Lakes Coastal Barrier Act of 1988 [16 U.S.C. §§ 3501-3510]
- the Great Lakes Fish and Wildlife Restoration Act of 1990 [16 U.S.C. § 941]
- the Great Lakes Fish and Wildlife Tissue Bank Act of 1992 [16 U.S.C. §§ 943-943c].

3.4 NOAA

Based on the authority delegated to the Secretary of the Interior and NOAA acting on behalf of the Secretary of Commerce, NOAA derives trusteeship and/or co-trusteeship authority over natural resources in the assessment area under numerous statutes, regulations, and statutorily prescribed programs. These statutes, regulations, and programs include, but are not limited to, the following: Subpart G of the NCP, as amended, 40 CFR Sections 300.500(b)(1) and (2); CERCLA [104(b)(2),107(f)(1) and (2), 122(j)]; SARA; OPA; CWA; and Executive Order 12580.

3.5 NEW YORK STATE

On November 30, 1987, New York State Governor Cuomo appointed the Commissioner of Environmental Conservation as trustee for natural resources under section 107 of CERCLA and Section 311 of the CWA. As trustee, the commissioner is charged to assess damages to natural resources resulting from releases of hazardous substances and to use recovered funds to restore, replace, or acquire the equivalent of the injured resource. Natural resources include land, fish, wildlife, biota, air, and ground and surface waters owned, managed, controlled by, or appertaining to the State of New York. The commissioner's natural resource damage responsibility under federal law complements long-standing authority under state common law and Articles 1 and 3 of the New York State Environmental Conservation Law to conserve, improve, and protect New York's natural resources.

CHAPTER 4
COORDINATION

The U.S. EPA has a specific, affirmative obligation under federal law "to seek to coordinate" with the trustees the assessments, investigations, and planning of remedial investigations and actions that it directs [42 U.S.C. § 9604 (b)(2)]. The U.S. EPA also has an obligation to notify the trustees and encourage their participation in any settlement negotiations with the companies [42 U.S.C. § 9622 (j)(1)].

In addition, the unilateral orders which the U.S. EPA entered against ALCOA and RMC specifically direct the companies to produce "a plan for data-gathering that will assist natural resource trustees in their assessment of injury to, destruction of, or loss of any natural resources resulting from a release of hazardous substances." See *In re Alcoa*, No. II CERCLA-90229 ¶39(E); *In re Reynolds Metals Co.*, No. II CERCLA-90230 ¶26(E).

The trustees acknowledge that some of the data gathered by the companies are useful in this assessment process, and further acknowledge their commitment to the companies to provide for full incorporation and integration, without duplication, of all data that are useful in the implementation of this assessment plan.

Upon publication of this assessment plan, the trustees anticipate a coordination effort by the U.S. EPA consistent with its statutory obligation and the terms of the outstanding unilateral orders, and further acknowledge trustee expectations regarding participation in settlement discussions in the future.

CHAPTER 5
DECISION TO PERFORM TYPE B ASSESSMENT

This chapter documents the trustees' decision to perform a Type B assessment. Trustees can select a Type A or a Type B NRDA [43 CFR § 11.33]. Type A procedures are "simplified procedures that require minimal field observation" [43 CFR § 11.33(a)]. A Type A model has been developed for Great Lakes environments (NRDAM/GLE) [43 CFR § 11.33(a)]. Under 43 CFR § 11.34, an authorized official may use a Type A assessment only if six factors are found in existence at a particular site. Several of these factors do not apply to the assessment area, including those defined in § 11.34(d) (i.e., wind speed) and § 11.34(f) (i.e., subsurface currents), making a Type A inappropriate. A Type B assessment provides alternative methodologies for conducting NRDAs and consist of three phases: injury determination, injury quantification, and damage determination [43 CFR § 11.60(b)].

Releases of hazardous substances in the assessment area are likely to have occurred for over 30 years. Hazardous substances have been transmitted through the food chain, affecting many different trophic levels. Consequently, the releases cannot be considered of a short duration, minor, or resulting from a single event, and therefore are not readily amenable to simplified models. Further, the spatial and temporal extent and heterogeneity of exposure conditions and potentially affected resources are not suitable for application of simplifying assumptions and averaged data and conditions inherent in Type A procedures. For example, the NRDAM/GLE is designed for application to discrete spills of oil/hazardous substances "up to a few days in duration" [Vol. 1, Sec. 1.2, publication incorporated by reference at 43 CFR § 11.18(a)(5)] rather than long-term, chronic exposures; biological injuries are based on acute toxicity of substances, rather than chronic toxic effects; transport submodels are not designed to be applied to complex, heterogeneous habitats and transport parameters; and only surface water exposure pathways are considered [see publication incorporated by reference at 43 CFR § 11.18(a)(5)]. Therefore, simplified Type A assessment methodologies would be inappropriate for this NRDA.

The trustees have determined (1) that the Type A NRDAM/GLE is not appropriately applied to the long-term, spatially, and temporally complex nature of releases and exposures to hazardous substances characteristic of the assessment area; (2) that substantial site-specific data already exist to support the assessment; and (3) that additional site-specific data can be collected at reasonable cost. As a result, the trustees have concluded that the use of Type B procedures is justified.

CHAPTER 6
CONFIRMATION OF EXPOSURE

A natural resource has been "exposed" to a hazardous substance if "all or part of a natural resource is, or has been, in physical contact with . . . a hazardous substance, or with media containing the . . . hazardous substance" [43 CFR § 11.14(q)]. The assessment plan should confirm that:

> . . . *at least one* of the natural resources identified as potentially injured in the preassessment screen has in fact been exposed to the . . . hazardous substance [43 CFR § 11.34(a)(1)] (emphasis added).

The regulations state that "whenever possible, exposure shall be confirmed using existing data" from previous studies of the assessment area [43 CFR § 11.34(b)(1)].

The following sections provide confirmation of exposure, based on a review of the available data, for a number of the potentially injured resources within the assessment area. Exposure to hazardous substances has been confirmed for the following natural resources:

- surface water resources (including surface water and sediments)
- groundwater
- soil
- biological resources, including aquatic and terrestrial flora and fauna
- air.

Information on concentrations of hazardous substances in natural resources in the assessment area was obtained primarily from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998), from federal and state agency reports (e.g., NYSDEC, 1992c; U.S. EPA, 1990), and from reports prepared by PRP consultants (e.g., ALCOA, 1999b; BBLES, 2000; CDM, 2000). The St. Lawrence Environment Trustee Council Environmental Database contains information on PCB contaminant levels from 1975 to 1991. This database is under revision by the SLETC to include other contaminants of concern for the assessment area and more recent data. Since the database is under revision, some site-relevant information may be missing from the following analysis. However, sufficient site-relevant information was available to confirm that natural resources in the assessment area have been and continue to be exposed to hazardous substances.

6.1 Surface Water

Surface waters in the assessment area have been exposed to multiple hazardous substances, including PCBs, fluoride, PAHs, phenols, cyanide, and aluminum.

6.1.1 PCBs

PCB concentrations are elevated in surface waters in the assessment area. Because some studies had relatively high analytical detection limits (e.g., 65 ng/L), surface water PCB concentrations may be reported as below detection but still be at concentrations elevated above background levels. As a result, reported measurements of PCBs at concentrations below detection levels may underestimate the magnitude of environmental exposure to PCBs.

St. Lawrence River

Surface waters in the St. Lawrence River have been exposed to elevated concentrations of PCBs. Maximum PCB concentrations adjacent to and downstream of the Massena facilities have consistently been elevated compared to concentrations measured at upstream potential background locations (Table 6-1); PCB concentrations have been measured in both the north and south channels of the St. Lawrence River. However, the maximum concentration of PCBs measured in the north channel (70 ng/L; Sylvestre, 1989, as cited in Dreier et al., 1997) is much lower than the maximum concentration measured in the south channel (12,285 ng/L; NYSDEC, 1989).

The highest concentrations of PCBs in St. Lawrence surface waters are located along the southern shore of the river, typically below facility outfalls and in Contaminant Cove and Dead Clam Cove (Table 6-1; see Figure 2-1 for a map of the assessment area). Elevated concentrations of PCBs have been measured at the mouth of the Grasse and Raquette rivers, near Dead Clam and Contaminant coves, and along the St. Lawrence River adjacent to and downstream of the RMC and GM facilities, with maximum PCB concentrations ranging from 13 to 12,285 ng/L (Table 6-1). PCB concentrations have also been measured farther downstream of the Massena facilities. In Lake St. Francis, near Yellow Island, PCBs have been detected at concentrations up to 16 ng/L (detection limit 1.2 ng/L; Anderson and Biberhofer, 1991, as cited in Dreier et al., 1997).

Upstream potential background concentrations of PCBs in the St. Lawrence River have typically been below method detection limits (Table 6-1). Between 1977 and 1979, PCBs were not detected in the St. Lawrence River immediately upstream of the Massena area (Chan, 1980; Kauss et al., 1988). However, PCB concentrations up to 4.2 ng/L were measured in the St. Lawrence River between Lake Ontario and Massena in 1988 (Anderson and Biberhofer, 1991, as cited in Dreier et al., 1997). Surface water PCB data from Lake Ontario suggest that potential upstream

Table 6-1
Maximum PCB Concentrations in Surface Water in the Assessment Area

Location	Year	Detection Limit (ng/L)	Maximum PCB Concentration (ng/L)[a]	Reference
Upstream Potential Background Areas: St. Lawrence River				
Upstream of Hogansburg Dam	1977	NA	ND	Chan, 1980
Cornwall Island	1977	NA	ND	Chan, 1980
Cornwall upstream of Domtar Facility	1979	1	ND	Kauss et al., 1988
Lake Ontario to Massena, NY	1988	1.2	4.2	Anderson and Biberhofer, 1991[b]
Assessment Area: St. Lawrence River (North Channel)				
North Channel near Cortaulds Facility	1988	10	70	Sylvestre, 1989[b]
Middle of North Channel	1991	1	19	Kadlec, 1991
Cortaulds Outfall A1	1991	1	20	Kadlec, 1991
Assessment Area: St. Lawrence River (South Channel)				
West Edge of Reynolds Property	1991	1	125	Kadlec, 1991
RMC Outfall 001	1988	NA	991	Hagler Bailly Services, 1998
	1989	5	411	NYSDEC, 1989
	1991	1	99	Kadlec, 1991
RMC Outfall 002	1988	5	492	NYSDEC, 1989
RMC Outfall 003	1988	5	132	NYSDEC, 1989
South of Cornwall Island across from GM Facility	1988	10	>100	Sylvestre, 1989[b]
GM Outfall B	1991	1	141	Kadlec, 1991
Dead Clam Cove	1987	NA	571	Hagler Bailly Services, 1998
	1989	5	340	NYSDEC, 1989
Contaminant Cove	1989	5	12,285	NYSDEC, 1989
	1991	1	2,727	Kadlec, 1991
Akwesasne Property, near the Tribal Water Intake	1991	1	13	Kadlec, 1991
Akwesasne Property, Turtle Creek	1988	5	88	NYSDEC, 1989
Lake St. Francis near Yellow Island	1988	1.2	16	Anderson and Biberhofer, 1991[b]

Table 6-1 (cont.)
Maximum PCB Concentrations in Surface Water in the Assessment Area

Location	Year	Detection Limit (ng/L)	Maximum PCB Concentration (ng/L)[a]	Reference
Upstream Potential Background Areas: Grasse River				
Upstream of Massena Dam	1991	1	4.2	Kadlec, 1991
	1992	65	ND	Ecology and Environment, 1992a
	1995	NA	34	ALCOA, 1999b
Assessment Area: Grasse River				
Massena Power Canal	1991	1	11	Kadlec, 1991
	1990	NA	367[c]	Engineering-Science, 1991a
ALCOA Outfall 001	1991	1	126	Kadlec, 1991
Downstream of ALCOA Outfall 001	1995	NA	2,878	ALCOA, 1999b
Near mouth of Unnamed Tributary	1991	NA	500	Ecology and Environment, 1992b
3.3 miles upstream from mouth	1997	NA	266	ALCOA, 1999b
1.9 miles upstream from mouth	1997	NA	195	ALCOA, 1999b
Mouth of Grasse River	1977	NA	180	Chan, 1980
	1991	1	229	Kadlec, 1991
Upstream Potential Background Areas: Raquette River				
Upstream of Raquette River Tributaries	1991	1	3.4	Kadlec, 1991
Assessment Area: Raquette River				
Downstream of GM Outfall east of Route 128 Bridge	1988	1.2	19	Anderson and Biberhofer, 1991[b]
Mouth of Raquette River	1988	1.2	15	Anderson and Biberhofer, 1991[b]

a. Maximum PCB values are derived from total PCB concentrations as reported in original source document; total PCB concentrations may have been determined from total aroclor or total congener concentrations data.
b. As cited in Dreier et al., 1997.
c. Maximum PCB concentration based on mean PCB concentrations as reported in source document.
NA denotes information not available.
ND denotes not detected (i.e., concentration is below the method detection limit).

PCB concentrations in the St. Lawrence River are approximately 1 ng/L (Neilson and Stevens, 1987, as cited in Dreier et al., 1997).

Grasse River

Surface waters in the Grasse River have been exposed to elevated concentrations of PCBs. Maximum PCB concentrations measured in the Grasse River and the Massena Power Canal range from below detection in upstream potential background locations to 2,878 ng/L at locations downstream of the ALCOA facility (Table 6-1). Maximum concentrations in upstream potential background locations ranged from below detection (detection limit 65 ng/L; Ecology and Environment, 1992b) to 34 ng/L (ALCOA, 1999b). ALCOA measured the same location in the Grasse River upstream of the Massena Dam seven times between 1995 and 1997; the mean PCB concentration was 9.5 ng/L, but five out of the seven samples had PCB concentrations between 1.8 and 4.9 ng/L (ALCOA, 1999b). These lower PCB concentrations are similar to the maximum PCB value of 4.2 ng/L (detection limit 1.0 ng/L) measured by Kadlec (1991) at this location (Table 6-1). In contrast, maximum PCB concentrations at locations downstream of the ALCOA facility were consistently elevated, ranging from 126 ng/L to 2,878 ng/L.

Raquette River

Surface waters in the Raquette River have been exposed to elevated concentrations of PCBs. Maximum PCB concentrations measured in the Raquette River range from 3.4 ng/L in an upstream potential background location to 19 ng/L at locations downstream of the GM Outfall east of the Route 128 bridge (Table 6-1). The upstream potential background location is upstream of two intermittent tributaries that drain into the Raquette River from the wetland on the RMC property (referred to as the Raquette River tributaries and the RMC Wetland; see Figure 2-3). PCB concentrations up to 3,700 ng/L have been measured in this wetland, as described below (Woodward-Clyde, 1990b).

Other Locations

Other surface water resources in the assessment area have been exposed to elevated PCB concentrations. These areas include the East and West marshes at ALCOA (see Figure 2-5), the RMC Wetland (see Figure 2-4), and Turtle Creek on the Akwesasne property (see Figure 2-3). PCBs have been detected in all three of these wetlands, with measured PCB concentrations up to 1,400 ng/L in the West Marsh at ALCOA and 3,700 ng/L in the RMC Wetland (Engineering-Science, 1989; Woodward-Clyde, 1990b). PCBs were not detected in control wetlands (detection limit 65 ng/L; Woodward-Clyde, 1990b).

Summary — PCB Exposure

In summary, elevated PCB concentrations have been measured in surface waters of the St. Lawrence River adjacent to and several miles downstream of the RMC and GM facilities, in the Grasse River downstream of ALCOA, in the Massena Power Canal, in Turtle Creek, in the wetlands and tributaries on the ALCOA and RMC property, and in the Raquette River downstream of the RMC facility and the GM Outfall east of the Route 128 bridge. These PCB concentrations are higher than concentrations measured in potential background locations and confirm that surface waters have been exposed to PCBs.

6.1.2 Fluoride

Dissolved fluoride concentrations in uncontaminated major rivers typically range from 10 to 20 μg/L (Carpenter, 1969, as cited in Rose and Marier, 1977). Fluoride concentrations measured upstream of the Massena facilities in the St. Lawrence, Grasse, Raquette, and St. Regis rivers ranged from 70 μg/L (Raquette River) to 140 μg/L (above the Massena Dam; Kadlec, 1991). These concentrations are higher than those typically found in uncontaminated surface waters and may indicate aerial deposition of fluoride from the ALCOA and RMC facilities. As a result, locations immediately upstream of the ALCOA and RMC facilities may be inappropriate for determining baseline conditions.

Surface waters in the assessment area have been exposed to elevated concentrations of fluoride. Information on fluoride concentrations in surface water in the assessment area is limited mainly to RI/FS studies performed at and near the ALCOA and RMC facilities. However, the available data indicate that fluoride concentrations are elevated relative to upstream potential background concentrations. For example, total fluoride concentrations have been measured in the RMC Wetland (12,000-96,000 μg/L); at several sites on the ALCOA property (see Figure 2-5 for a map of the ALCOA site), including the Massena Power Canal (3,000 μg/L), the 60 Acre Lagoon (7,000 μg/L), the Spent Potlining Pile (28,000 μg/L), and the Unnamed Tributary (4,000 μg/L); and the Grasse River (36,000 μg/L) (Engineering-Science, 1989; Woodward-Clyde, 1990a). Fluoride concentrations in surface water of the Grasse River are generally most elevated above upstream potential background concentrations in the immediate vicinity of the ALCOA and RMC facilities, and decrease in waters downstream of the ALCOA and RMC facilities. However, fluoride concentrations in the Grasse River downstream of ALCOA (680-1,300 μg/L; Ecology and Environment, 1992a) still exceed potential background concentrations by several orders of magnitude.

6.1.3 PAHs

Information on PAH concentrations in surface waters from the assessment area is limited. Most of the data are from RI/FS and RAP studies and focus on specific individual PAH compounds. The concentration data are typically summarized in these reports as the sum of the individual PAH compounds measured (i.e., total PAH concentration). Hence, the PAH data may represent a conservative measurement of the actual total amount of PAHs in the environment. For the purposes of evaluating whether natural resources have been exposed to PAHs, total PAH concentrations are reported unless otherwise noted.[1]

Relative to upstream potential background concentrations, PAH concentrations are elevated in surface waters in the assessment area. PAH concentrations in potential background locations of 1 to 5 ng/L have been measured upstream and in the vicinity of the Domtar facility in St. Lawrence River surface water (Anderson and Biberhofer, 1991, as cited in Dreier et al., 1997). Elevated PAH concentrations have been measured in the Grasse River in the immediate vicinity and downstream of the ALCOA facility (15,000 ng/L), in the north and south channels of the St. Lawrence River (5-30 ng/L), and the southwest end of Lake St. Francis (30 ng/L; Anderson and Biberhofer, 1991, as cited in Dreier et al., 1997). These elevated PAH concentrations above concentrations measured at potential background locations confirm that surface waters in the assessment area have been exposed to PAHs.

6.1.4 Phenols

Information on concentrations of phenols in surface waters in the assessment area is limited to water quality surveys performed in 1979 and 1985. Potential background concentrations of phenols were measured in the St. Lawrence River in the 1979 survey only; phenol concentrations upstream of the Moses-Saunders Dam were below the method detection limit of 1 μg/L (Kauss et al., 1988).

Elevated concentrations of phenols have been measured at some locations in the assessment area. In the north channel of the St. Lawrence River, elevated phenol concentrations were measured downstream of the Domtar facility (4 μg/L), near the Cortaulds facility (5 μg/L), downstream along the north channel to the mouth of the Raisin River (1.2 μg/L) (Kauss et al., 1988), and near the source of the Cortaulds effluent (24 μg/L; St. Lawrence RAP Team, 1990). In the south channel of the St. Lawrence River, elevated phenol concentrations were measured near the mouth of the Grasse River (1.2 μg/L), in the vicinity of GM (2 μg/L), and downstream to the mouth of the St. Regis River (1 μg/L; Kauss et al., 1988). However, phenol concentrations in surface water

1. For subsequent evaluation of injuries to natural resources resulting from exposure to PAHs (i.e., during the assessment stage of the NRDA process, see Figure 1-1), individual PAH compounds will be examined.

along the south channel generally ranged from nondetectable (detection limit 0.05 μg/L) to 1 μg/L (Kauss et al., 1988).

6.1.5 Cyanide

Elevated cyanide concentrations have been measured in surface waters from the RMC property in the RMC Wetland (30 to 1,300 μg/L), the Massena Power Canal (16 μg/L), Robinson Creek (33 μg/L), the Dennison Cross Road Drainage on the ALCOA property (26 μg/L), the Grasse River near ALCOA (22 μg/L), and an Unnamed Tributary to the Grasse River near ALCOA (30 μg/L) (Engineering-Science, 1989; Woodward-Clyde, 1990a; Ecology and Environment, 1992a).

Potential background concentrations of cyanide measured in the St. Lawrence River at upstream locations have consistently been below detection limits (detection limits generally 10 μg/L; Kauss et al., 1988).

6.1.6 Aluminum

Aluminum concentrations in the vicinity and downstream of PRP facilities are generally elevated relative to upstream potential background concentrations. Aluminum concentrations in surface water samples collected between 1986 and 1989 ranged from less than 200 μg/L in the Massena Power Canal to 400 μg/L downstream of the ALCOA Outfalls on the Grasse River (Engineering-Science, 1989). Maximum aluminum concentrations in surface water samples collected in 1991 were 478 μg/L immediately downstream of the ALCOA Outfall 001 and 836 μg/L near the mouth of the Grasse River (detection limit 200 μg/L; Ecology and Environment, 1992a). Aluminum concentrations in the St. Lawrence River in areas adjacent to the RMC and GM facilities and near the mouth of the Grasse River have been measured up to 280 μg/L (Chan, 1980; Kauss et al., 1988).

Other areas where aluminum concentrations are elevated in surface waters in the assessment area include the RMC Wetland (19,000 μg/L); several locations on the ALCOA property, including the East Marsh and West Marsh (7,800 μg/L and 9,380 μg/L, respectively), Robinson Creek (836 μg/L), and the Unnamed Tributary (2,440 μg/L); and the north channel of the St. Lawrence River in the vicinity of Cortaulds and the Cornwall Water Pollution Control Plant (1,400 μg/L) (Kauss et al., 1988; Engineering-Science, 1991b; Ecology and Environment, 1992a).

Potential upstream background aluminum concentrations measured in the late 1970s in the St. Lawrence River were generally less than 100 μg/L (Kauss et al., 1988). In the early 1990s, concentrations of aluminum in the Grasse River upstream of the Massena Dam ranged from below detection (detection limit 200 μg/L) to 272 μg/L (Ecology and Environment, 1992a). However, since surface water immediately upstream of the ALCOA and RMC facilities could be contaminated with aluminum from aerial deposition, these upstream locations may be inappropriate for determining baseline conditions.

6.1.7 Summary — Surface Water Exposure

In summary, surface waters in the assessment area have been and continue to be exposed to elevated concentrations of hazardous substances, including PCBs, fluoride, PAHs, phenols, cyanide, and aluminum (Table 6-2).

Table 6-2
Summary of Confirmed Surface Water Exposure within the Assessment Area

Assessment Area Location	Hazardous Substances					
	PCBs	Fluoride	PAHs	Phenols	Cyanide	Aluminum
Akwesasne Property	X	X	X	X		X
St. Lawrence River	X	X	X	X		X
Grasse River	X	X	X	X	X	X
Raquette River	X					
ALCOA Facility	X	X	X		X	X
GM Facility	X			X		
RMC Facility	X	X			X	X

Areas left blank (i.e., not identified by an X) indicate that insufficient information is available to determine if a specific location has been exposed to a specific hazardous substance.

6.2 SEDIMENTS

Sediments are defined in the DOI regulations as a component of the surface water resource [43 CFR § 11.14 (pp)]. However, for the purposes of this assessment plan, sediments are addressed separately from surface water for several reasons: (1) there is a large amount of data specific to sediments, (2) sediments can be a principal and ongoing exposure pathway to other natural resources, and (3) restoration actions may focus on sediments.

Sediments in the assessment area have been exposed to multiple hazardous substances, including PCBs, fluoride, PAHs, phenols, cyanide, aluminum and dibenzofurans.

6.2.1 PCBs

St. Lawrence River

Sediments in the St. Lawrence River have been exposed to elevated concentrations of PCBs. PCB concentrations adjacent to and downstream of the Massena and Cornwall facilities have consistently been higher than concentrations measured at upstream potential background locations (Table 6-3); PCB concentrations have been measured in sediments from both the north and south channels of the St. Lawrence River. While PCB concentrations are elevated in sediments in the north channel, the maximum concentration measured (2.67 mg/kg; Kauss et al., 1988) is much lower than the maximum concentration of 8,800 mg/kg measured in sediments near the GM Outfall (CDM, 1994). In the south channel, maximum PCB concentrations were 3,454 mg/kg near RMC Outfall 001, 66 mg/kg in contaminant cove, 4,630 mg/kg near Turtle Creek, and 2.0 mg/kg near the mouth of the Raquette River (Table 6-3). The highest levels of PCB concentrations are typically found in sediments near facility outfalls. Farther downstream in the south channel in the vicinity of Yellow Island, PCB concentrations of 1.11 mg/kg have been measured in sediment (Anderson and Biberhofer, 1991, as cited in Dreier et al., 1997).

Upstream potential background PCB concentrations in sediments in the St. Lawrence River range from <0.10 to 0.3 mg/kg (Table 6-3). In a recent study, maximum PCB concentrations measured in sediment samples collected upstream of the Domtar facility on the north channel were 0.03 mg/kg (detection limit 0.0017 mg/kg) (Richard and Pick, 1995).

Grasse River

Sediments in the Grasse River and the Massena Power Canal have been exposed to elevated concentrations of PCBs. Since 1979 PCB concentrations have been measured in sediments from the Massena Power Canal and downstream of the Massena Dam to the mouth of the Grasse River (Table 6-3). Maximum PCB concentrations range from 1.98 mg/kg at the mouth of the Grasse River (Kauss et al., 1998) to 11,000 mg/kg downstream of ALCOA Outfall 001 (ALCOA, 1999b). PCBs have also been measured in sediments from the Unnamed Tributary on the ALCOA property at concentrations up to 3.5 mg/kg (Engineering-Science, 1989). Recent data confirm that sediments continue to have elevated PCB concentrations along the length of the river (ALCOA, 1999b).

Upstream potential background PCB concentrations in sediments in the Grasse River (collected upstream of the Massena Dam) range from below detection to 1.8 mg/kg (Table 6-3). In the 1992 RI/FS study for ALCOA, upstream potential background PCB concentrations in the Grasse River sediments above the Massena Dam were below detection limits (<0.08 mg/kg) (Ecology and Environment, 1992a).

Table 6-3
Maximum PCB Concentrations in Sediments in the Assessment Area

Location	Year	Detection Limit (mg/kg)	Maximum PCB Concentration (mg/kg, dry weight)[a, b]	Reference
Upstream Potential Background Areas: St. Lawrence River				
Upstream Stations (exact locations not provided)	1979	NA	0.15	Kauss et al., 1988
Upstream Moses-Saunders Dam	1981	NA	0.08	Merriman, 1987
	1988	NA	0.3	Hagler Bailly Services, 1998
Wiley-Dondero Canal	NA	0.1	<0.10 to 0.20	Gunn, 1989
Upstream of the Domtar Facility	1994	0.0017	0.03	Richard and Pick, 1995
Assessment Area: St. Lawrence River (North Channel)				
Vicinity of the Cortaulds Facility	1979	NA	2.67	Kauss et al., 1988
Downstream of the Domtar Facility	1981	NA	0.85	Merriman, 1987
Downstream of the Cortaulds Facility	1985	NA	1.01	Anderson and Biberhofer, 1991[c]
North of Cornwall Island	NA	NA	1.76	Hagler Bailly Services, 1998
	1991	0.0005	0.98	Vanier et al., 1996
Assessment Area: St. Lawrence River (South Channel)				
Near Mouth of Grasse River	1985	NA	16.7	Hagler Bailly Services, 1998
Near Reynolds Outfall 001	1988	NA	3,454	Hagler Bailly Services, 1998
Near RMC Facility, Upstream of Contaminant Cove	1985	NA	3	Anderson and Biberhofer, 1991[c]
Near GM Outfall	NA	NA	8,800	CDM, 1994
Contaminant Cove	1985	NA	13.8	Anderson and Biberhofer, 1991[c]
	1987	NA	66	Hagler Bailly Services, 1998
	1991	0.0005	11	Vanier et al., 1996
	1994	NA	4.9	Richard et al., 1997
Near Turtle Creek	1985	NA	4,630	Hagler Bailly Services, 1998
Near Mouth of Raquette River	1981	NA	2	Merriman, 1987
Downstream of Mouth of Raquette River	1991	0.0005	1.83	Vanier et al., 1996

Table 6-3 (cont.)
Maximum PCB Concentrations in Sediments in the Assessment Area

Location	Year	Detection Limit (mg/kg)	Maximum PCB Concentration (mg/kg, dry weight)[a, b]	Reference
Assessment Area: St. Lawrence River (South Channel) (cont.)				
Upstream of Mouth of St. Regis River	1991	0.0005	1.22	Vanier et al., 1996
East of Yellow Island	1985	NA	1.11	Anderson and Biberhofer, 1991[c]
	1991	0.0005	0.99	Vanier et al., 1996
	1994	NA	0.74	Richard et al., 1997
South of Yellow Island	1991	0.0005	0.88	Vanier et al., 1996
	1994	0.0017	1.01	Richard and Pick, 1995
North of Chatelain Island	1994	0.0009	0.59	Richard and Pick, 1995
Upstream Potential Background Areas: Grasse River				
Upstream of Massena Dam	1987	NA	1.8	Engineering-Science, 1987
	1992	0.08	ND	Ecology and Environment, 1992a
Assessment Area: Grasse River				
Massena Power Canal	1992	0.08	5.88	Ecology and Environment, 1992a
Downstream of ALCOA 001 Outfall	1979	NA	49	Kauss et al., 1988
	1992	0.08	2,200	Ecology and Environment, 1992a
	1993	NA	11,000	ALCOA, 1999b
	1997	NA	2,408	ALCOA, 1999b
3.8 miles upstream from mouth	1997	NA	596	ALCOA, 1999b
Downstream of KOA Campground	1992	0.08	170	Ecology and Environment, 1992a
Downstream of Haverstock Rd.	1997	NA	81	ALCOA, 1999b
Mouth of Grasse River	1979	NA	1.98	Kauss et al., 1988
	1991	NA	7.5	Ecology and Environment, 1992a
	1981	NA	8.74	Merriman, 1987
Upstream Potential Background Areas: Raquette River				
Upstream of Raquette River Tributaries	1990	0.09-0.15	ND	Woodward-Clyde, 1991

Table 6-3 (cont.)
Maximum PCB Concentrations in Sediments in the Assessment Area

Location	Year	Detection Limit (mg/kg)	Maximum PCB Concentration (mg/kg, dry weight)[a, b]	Reference
Assessment Area: Raquette River				
Near GM Outfall	NA	NA	4,000	CDM, 1994
Mouth of Raquette River	1985	NA	2.84	Anderson and Biberhofer, 1991[c]
	1991	0.0005	1.29	Vanier et al., 1996

a. Maximum PCB values are derived from total PCB concentrations as reported in original source document; total PCB concentrations may have been determined from total aroclor or total congener concentrations data.
b. Sediment PCB concentration data from samples typically less than 24 inches in depth.
c. As cited in Dreier et al., 1997.
NA denotes information not available.
ND denotes not detected (i.e., concentration is below the method detection limit).

Raquette River

Sediments in the Raquette River have been exposed to elevated concentrations of PCBs. Maximum PCB concentrations range from 2.84 mg/kg at the mouth of the Raquette River to 4,000 mg/kg near the GM Outfall (Table 6-3). Sediment samples taken from 17 locations in the Raquette River in 1990 in the vicinity of and upstream of the Raquette River tributaries contained PCBs at concentrations below method detection limits (0.09-0.15 mg/kg) (Woodward-Clyde, 1991). Hence PCB concentrations in the Raquette River downstream of and adjacent to the GM facility have been exposed to elevated concentrations of PCBs.

Summary — PCB Exposure

In summary, sediments in the assessment area contain PCBs at concentrations above background concentrations. PCBs have been measured in sediments of the north and south channels of the St. Lawrence River and in sediments in the Grasse River and Raquette River in the vicinity of and downstream of the ALCOA, RMC, and GM facilities.

6.2.2 Fluoride

Fluoride concentrations have been measured in sediments in the assessment area at concentrations above those in potential background locations. Near the ALCOA facility, fluoride concentrations have been measured in Robinson Creek (790 mg/kg), the Unnamed Tributary (920 mg/kg), the Massena Power Canal (730 mg/kg), and the 60 Acre Lagoon (2,100 mg/kg) (Engineering-Science, 1987; Engineering-Science, 1989). Near the RMC facility, fluoride concentrations between 293 and 123,800 mg/kg have been measured in sediments collected from the St. Lawrence River (Woodward-Clyde, 1992). Sediment fluoride concentrations up to 54,000 mg/kg have been measured in the RMC Wetland (Woodward-Clyde, 1990a). There are no available data for fluoride concentrations in sediments in the downstream reaches of the Grasse, Raquette, or St. Regis rivers.

It is difficult to identify potential background locations near the assessment area because local areas upstream of the ALCOA and RMC facilities may receive aerial depositions of fluoride. For example, 515 mg/kg fluoride was measured in St. Lawrence River sediments collected near the southwest side of Cornwall Island, a location identified as a reference area for the St. Lawrence by Woodward-Clyde (1992). However, it may be inappropriate to consider this location as a reference site because it is in an area that potentially could receive aerial fluoride deposition from the ALCOA and RMC facilities. In another example, concentrations of fluoride in sediment collected from the Raquette River, upstream of the Raquette River tributaries, were slightly higher than those in samples collected downstream of the tributaries (325 mg/kg and 300 mg/kg, respectively) (Woodward-Clyde, 1992). Woodward-Clyde again described this location as a reference site for the Raquette River (Woodward-Clyde, 1992); however, as with the St. Lawrence site, this upstream area of the Raquette River could receive aerial fluoride deposition from the ALCOA and RMC facilities. Even if these fluoride concentrations determined in reference areas as identified by Woodward-Clyde (1992) are representative of background concentrations, fluoride concentrations in sediment in the assessment area are elevated above background, confirming that fluoride exposure has occurred in the assessment area.

6.2.3 PAHs

PAH concentrations have been measured in sediments in the assessment area above those in potential background locations. Concentrations of PAHs in St. Lawrence River sediments are greatest in the south channel in the vicinity of the Grasse River, and near the RMC facility (Woodward-Clyde, 1992). The elevated sediment PAH concentrations extend downstream in the south channel, with elevated levels detected around several of the islands and at the entrance to Lake St. Francis (Sloterdijk, Date unknown).

PAHs have been measured at concentrations between 3.85 and 3,200 mg/kg in sediments collected from the St. Lawrence River near the RMC facility (Woodward-Clyde, 1992; Wood et al., 1997). In areas of the Grasse River downstream of the Massena Power Canal, PAH concentrations up to 5,130 mg/kg have been measured in sediments near the ALCOA Outfall 004. Sediment PAH concentrations continue to exceed potential background concentrations farther downstream in the Grasse River with concentrations up to 39.9 mg/kg (Engineering-Science, 1987). PAH concentrations have also been measured in sediments near or within the ALCOA facility, including Robinson Creek (17,080 mg/kg), the Unnamed Tributary (10,620 mg/kg), the 60 Acre Lagoon (7,495 mg/kg), and the Drainage Area (1,430 mg/kg) (Engineering-Science, 1987, 1989).

Upstream potential background concentrations of PAHs in sediments from the St. Lawrence River up to 0.2 mg/kg have been reported on the southwest end of Cornwall Island (Woodward-Clyde, 1992). Concentrations of PAHs in sediments from the Grasse River upstream of the Massena Power Canal up to 2.68 mg/kg have been reported (Engineering-Science, 1987). As discussed in Section 6.2.2, it may be inappropriate to consider these locations as reference sites because they could receive aerial PAH deposition from the ALCOA and RMC facilities. However, even if these PAH concentrations are representative of background concentrations, PAH concentrations in sediment in the assessment area are elevated above background, confirming that PAH exposure has occurred in the assessment area.

6.2.4 Cyanide

Available data for cyanide concentrations in the sediments of the assessment area are limited to RI/FS studies. Cyanide has been measured in sediments at concentrations up to 20.5 mg/kg in St. Lawrence River sediment collected near the RMC facility (Woodward-Clyde, 1992), up to 91 mg/kg in nonvegetated sediments collected from the RMC Wetland (Woodward-Clyde, 1990a), and up to 0.419 mg/kg in sediments collected in the vicinity of the Raquette River tributaries (Woodward-Clyde, 1992). Cyanide has also been measured in sediments in the vicinity of the ALCOA facility, with concentrations up to 31 mg/kg in the 60 Acre Lagoon and up to 25.1 mg/kg in the Unnamed Tributary (Engineering-Science, 1989).

Upstream potential background concentrations for cyanide in sediments in the St. Lawrence River (upstream of the assessment area) and the Raquette River (upstream of the Raquette River tributaries) were below method detection limits (generally 0.1 mg/kg) (Woodward-Clyde, 1992). There were no available upstream potential background data for the Grasse River.

6.2.5 Aluminum

Aluminum has been measured in sediments in the assessment area above potential background locations. Aluminum has been measured in sediments in the St. Lawrence River near the RMC facility at concentrations up to 159,000 mg/kg (Woodward-Clyde, 1992). Aluminum has also been measured up to 19,200 mg/kg in sediments collected from the Raquette River, downstream of the Raquette River tributaries (Woodward-Clyde, 1992). Aluminum has also been measured in sediments near or on the ALCOA property up to 27,400 mg/kg in the Massena Power Canal, up to 32,100 mg/kg in the Grasse River downstream of the ALCOA Outfall 001, and up to 30,900 mg/kg in the Unnamed Tributary (Engineering-Science, 1989).

Upstream concentrations of aluminum in sediments ranged from 10,600 mg/kg in the St. Lawrence River (southwest of Cornwall Island) (Woodward-Clyde, 1992) to 1,620 mg/kg in the Grasse River above Massena Dam (Ecology and Environment, 1992a) and to 14,900 mg/kg upstream of the Raquette River tributaries (Woodward-Clyde, 1992). These locations were designated as reference sites for RI/FS studies performed for the ALCOA and RMC facilities. However, it may be inappropriate to consider these locations as reference sites because of the potential for these upstream areas to receive aerial aluminum deposition from the ALCOA and RMC facilities. However, even if these aluminum concentrations are representative of background concentrations, aluminum concentrations in sediment in the assessment area are elevated above background confirming that aluminum exposure has occurred in the assessment area.

6.2.6 Dibenzofurans

Total dibenzofurans have been measured in the sediments of the St. Lawrence River at concentrations above background concentrations. Total dibenzofurans were documented in sediments in the vicinity of Outfalls 001, 002 and 003 and Former Outfalls 002 and 004. Detectable concentrations ranged from 2.7 ng/g to 440 ng/g. The sample with the highest concentration was in the proximity of Outfall 001. Dibenzofurans were not detected in the background sample (Woodward Clyde 1991).

6.2.7 Summary — Sediment Exposure

In summary, sediments in the assessment area have been and continue to be exposed to elevated concentrations of hazardous substances, including PCBs, fluoride, PAHs, cyanide, and aluminum (Table 6-4).

6.3 GROUNDWATER

Available groundwater data are limited to RI/FS studies performed at the Massena facilities in the 1980s, and residential well monitoring performed on the Akwesasne property in the 1990s. Most of these studies did not provide data for off-site potential background concentrations. As an alternative, when concentration data were not available to determined potential background levels, concentrations of hazardous substances in groundwater were compared to NYS water quality standards or criteria. This comparison was based on the premise that most uncontaminated groundwater resources would not have concentrations of hazardous substances greater than the

Table 6-4
Summary of Confirmed Sediment Exposure within the Assessment Area

Assessment Area Location	Hazardous Substances				
	PCBs	**Fluoride**	**PAHs**	**Cyanide**	**Aluminum**
Akwesasne Property	X	X	X	X	X
St. Lawrence River	X	X	X	X	X
Grasse River	X		X		X
Raquette River	X	X		X	X
ALCOA Facility	X	X	X	X	X
GM Facility	X				
RMC Facility	X	X	X	X	X

Areas left blank (i.e., not identified by an X) indicate that insufficient information is available to determine if a specific location has been exposed to a specific hazardous substance.

standard or criterion level. Hence, for this analysis of exposure, exceedences of standards or criteria is indicative of exposure above background levels.

6.3.1 PCBs

PCBs have been measured in groundwater samples collected from the ALCOA, RMC, and GM facilities, as well as in residential wells on the Akwesasne Property (Table 6-5).

PCB concentrations measured in groundwater samples collected from the ALCOA property have exceeded the NYS standard of 0.09 μg/L for the protection of groundwater as a source of drinking water (6 NYCRR Parts 700-706), typically in areas where surface contamination is extensive. Maximum concentrations of PCBs ranged from 0.095 μg/L near Dennison Road to 92 μg/L in the vicinity of the 60 Acre Lagoon (Table 6-5).

PCB have also been measured in groundwater samples collected from a number of monitoring wells in the western area of the RMC property and on the GM property. Maximum PCB concentrations detected in groundwater samples from monitoring wells on the RMC property in the vicinity of the Black Mud Pond (0.25 μg/L), the Landfill (13.3 μg/L), and the Potliner Pad Area (0.10 μg/L) exceeded the NYS standard for PCBs (Woodward-Clyde, 1990b). In addition, PCB concentrations in groundwater collected from reference wells were all below the method

Table 6-5
Maximum PCB Concentrations in Groundwater in the Assessment Area

Location of Monitoring Well	Year	Detection Limit (μg/L)	Maximum PCB Concentration (μg/L)[a]	Reference
Assessment Area: Akwesasne Property				
Residential Well East of St. Regis River	1993-1995	0.001	0.017	NYSDOH, 1995
Assessment Area: GM Property				
Near the 1.5 mgal Lagoon	1981	NA	140	Dames and Moore, 1982[b]
	1982	NA	270	Dames and Moore, 1982[b]
Landfill Adjacent to the Akwesasne Property	1981	NA	5.9	Dames and Moore, 1982[b]
	1982	NA	41	Dames and Moore, 1982[b]
Near the 1.5 mgal Lagoon	1990	0.5	790	Premo, 1990
Assessment Area: ALCOA Property				
Near 60 Acre Lagoon	1987	NA	92	Engineering-Science, 1987
Near Oily Waste Landfill	1987	NA	2.3	Engineering-Science, 1987
Near Soluble Oil Lagoon	1987	NA	3.9	Engineering-Science, 1987
Near Dennison Road	1989	0.065	0.95	Engineering-Science, 1991a
Assessment Area: RMC Property				
Near the Landfill	1990	NA	13.3	Woodward-Clyde, 1990b
Near Black Mud Pond	1990	NA	0.25	Woodward-Clyde, 1990b
Near the Potliner Pad Area	1990	NA	0.1	Woodward-Clyde, 1990b

a. Maximum PCB values are derived from total PCB concentrations as reported in original source document; total PCB concentrations may have been determined from total aroclor or total congener concentrations data.
b. As cited in Bobrow et al., 1983.
NA denotes information not available.

detection limits (detection limit not provided; Woodward-Clyde, 1990b), indicating that groundwater resources at the RMC have been exposed to PCBs. On the GM property, maximum concentrations of PCBs in groundwater in the early 1980s were 41 μg/L near the industrial landfill (adjacent to the Akwesasne property) and 270 μg/L near the 1.5 mgal lagoon on the GM property (Table 6-5; Dames and Moore, 1982, as cited in Bobrow et al., 1983). More recent studies of groundwater indicate that PCB concentrations continue to be elevated on the GM properties. In groundwater samples taken on the GM property in 1990, PCB concentrations ranged from nondetectable to 790 μg/L near the 1.5 mgal lagoon (detection limit, 0.5 μg/L for Aroclor 1248; Premo, 1990).

PCB concentrations have also been measured in groundwater from residential wells located on the Akwesasne property east of the St. Regis River. The maximum PCB concentration (0.017 μg/L) was below the NYSDEC standards of 0.09 μg/L for the protection of groundwater as a source of drinking water (Table 6-5). Currently, there is no readily available information on PCB concentrations in groundwater collected from residential wells closer to the PRP properties.

6.3.2 Fluoride

On the ALCOA property, fluoride concentrations measured in groundwater monitoring wells near the 60 Acre Lagoon (11-30 mg/L), south of the 60 Acre Lagoon (17-20 mg/L), near the Dennison Cross-Road (2.2-22 mg/L), and near the Primary Lagoon (41-51 mg/L) exceeded the Class GA Water Quality Standard of 1.5 mg/L (6 NYCRR Part 703.5; Engineering-Science, 1987).

Fluoride concentrations in groundwater samples collected throughout the RMC property also exceeded the 1.5 mg/L standard with concentrations of 18 mg/L near the Black Mud Pond, 220 mg/L near the Landfill, 56.3 mg/L near the North Yard, and 374 mg/L near the Potliner Pad Area (Woodward-Clyde, 1990b). Concentrations of fluoride in groundwater samples from reference wells located on the west side of the RMC property were all below method detection limits (detection limit not provided) (Woodward-Clyde, 1990b).

No information was available to evaluate fluoride concentrations in groundwater samples from the GM property.

6.3.3 PAHs

PAHs have been measured in groundwater from monitoring wells on the ALCOA property at concentrations exceeding the NYSDEC water quality standard of 50 μg/L. Concentrations of PAHs from wells in the immediate vicinity of the 60 Acre Lagoon were greater than 2,000 μg/L. Maximum PAH concentrations in wells in the general area of the Soluble Oil Lagoon and the Spent Potlining Pile A were 550 μg/L and 129,000 μg/L, respectively (Engineering-Science, 1987, 1990b). No information was available to evaluate PAH concentrations in groundwater from the GM and RMC properties.

6.3.4 Phenols

Phenols have been measured in groundwater from monitoring wells on the ALCOA property at concentrations exceeding the NYS groundwater quality standard of 1 μg/L total phenolics (Engineering-Science, 1987). Concentrations of phenol in groundwater up to 3,560 μg/L have been measured in samples of groundwater from monitoring wells located near the Waste Lubricating Oil Lagoon (Engineering-Science, 1987).

Phenol concentrations in groundwater samples from the RMC facility have exceeded the NYS groundwater quality standard of 1 μg/L throughout the facility, including the Black Mud Pond (50 μg/L), the Landfill (66 μg/L), the North Yard (5.4 μg/L), and the Potliner Pad Area (190 μg/L; Woodward-Clyde, 1990b). Phenol concentrations were also elevated above potential background concentrations (identified as nondetectable; detection limit not provided) from reference locations (Woodward-Clyde, 1990b).

No information was available to evaluate phenol concentrations in groundwater from the GM property.

6.3.5 Cyanide

Concentrations of cyanide exceeding the NYS water quality standard of 0.2 mg/L have been measured in groundwater from monitoring wells on the ALCOA property (Engineering-Science, 1987); cyanide concentrations in wells near a Spent Potlining Pile and the Primary Lagoon ranged from 5.2 mg/L to 13 mg/L. Cyanide concentrations from wells between the Primary Lagoon and the 60 Acre Lagoon ranged from 6.4 to 24 mg/L (Engineering-Science, 1987).

Concentrations of cyanide in groundwater samples taken throughout the RMC property have exceeded the NYS water quality standard of 0.2 mg/L. Total cyanide in groundwater was measured at concentrations above the water quality standard in areas such as the Black Mud Pond (2.5 mg/L), the Landfill (22 mg/L), the North Yard (3.9 mg/L), and the Potlining Pad Area (53 mg/L; Woodward-Clyde, 1990b).

No information was available to evaluate cyanide concentrations in groundwater from the GM property.

6.3.6 Aluminum

Elevated aluminum concentrations have been measured in groundwater samples collected close to the 60 Acre Lagoon (8,800 μg/L), south of the 60 Acre Lagoon (6,600 μg/L), and near the Soluble Oil Lagoon (4,100 μg/L; Engineering-Science, 1987). These aluminum concentrations exceed the potential background concentration of approximately 100 μg/L (Engineering-Science, 1987).

Concentrations of aluminum in groundwater samples have been measured on the RMC property; maximum concentrations have been measured in groundwater collected from near the Black Mud Pond (230,000 μg/L), the Landfill (96,600 μg/L), the North Yard (26,600 μg/L), and the Potliner Pad Area (327,000 μg/L) (Woodward-Clyde, 1990b). Aluminum concentrations in groundwater samples from a number of monitoring wells on the RMC property exceeded the potential background concentration by several orders of magnitude.

No information was available to evaluate aluminum concentrations in groundwater from the GM property.

6.3.7 Summary — Groundwater Exposure

Groundwater contamination on the ALCOA property is extensive throughout the shallow aquifer and is believed to be migrating in several directions: east from the central and southern ridges toward the marshy areas of the property, with the potential of discharging into the Grasse River via Outfall 001, and north and east from the 60 Acre Lagoon, with the potential of discharging into the Unnamed Tributary or Robinson Creek (Engineering-Science, 1987). Groundwater on the GM property is believed to be migrating north and east toward the Akwesasne property (Bobrow et al., 1983).

Groundwater contamination on the RMC property is also extensive, and is believed to be migrating in several directions: north from the Black Mud Pond area, with a potential of discharging to the St. Lawrence River, and south from the Black Mud Pond area, with a potential of discharging to the RMC Wetland, the Raquette River tributaries, and eventually the Raquette River (Woodward-Clyde, 1990b).

The limited groundwater data available indicate that groundwater in the assessment area has been exposed to hazardous substances, including PCBs, fluoride, PAHs, phenols, cyanide, and aluminum (Table 6-6).

6.4 SOILS

Available soil data are limited mainly to RI/FS studies performed on the ALCOA, RMC, and GM properties. Of the sampling locations used in these studies, most are concentrated in areas known to have contamination either because of known historical use as landfill areas or because of spills. Therefore, based on the available data, it is difficult to assess exposure to the surrounding soils that may be exposed to PCBs and other hazardous substances by runoff and/or aerial deposition.

Table 6-6
Summary of Confirmed Groundwater Exposure within the Assessment Area

Assessment Area Location	Hazardous Substances					
	PCBs	Fluoride	PAHs	Phenols	Cyanide	Aluminum
Akwesasne Property	X					
ALCOA Facility	X	X	X	X	X	X
GM Facility	X					
RMC Facility	X	X		X	X	X

Areas left blank (i.e., not identified by an X) indicate that insufficient information is available to determine if a specific location has been exposed to a specific hazardous substance.

6.4.1 PCBs

PCBs have been measured in soils collected from the ALCOA, GM, and RMC facilities as well as from Akwesasne (Table 6-7).

On the ALCOA property, maximum PCB concentrations ranged from 1.98 mg/kg in soils collected from the Primary Lagoon Sludge Area to 253 mg/kg in soils collected from the Waste Lubricating Oil Lagoon (Table 6-7). These concentrations are much greater than PCB concentrations measured as nondetectable (detection limits not provided) from potential background locations (Engineering-Science, 1989).

PCB concentrations were measured in soils on RMC property up to 690 mg/kg near the RMC Wetland and up to 1,400 mg/kg in the North Yard (Table 6-7). Concentrations of total PCBs in soils from the reference areas on the RMC property ranged from nondetectable (detection limit not provided) to 0.24 mg/kg (Woodward-Clyde, 1990b).

The greatest concentrations of PCBs in soils from the assessment area have been reported in the GM landfill, with measured PCB concentrations up to 18,000 mg/kg (CDM, 2000). Soil PCB concentrations measured in fill located along the Raquette River were up to 400 mg/kg (RMT, 1989).

Recent studies (1993-1995) reported PCB concentrations in the soils on Akwesasne property. The greatest concentrations were found in soils bordering the GM property (0.259-0.886 mg/kg), along the Raquette River (0.615-0.659 mg/kg), near Raquette Point (0.215 mg/kg), east of the St. Regis River (0.464 mg/kg), and on Cornwall Island (0.316 mg/kg) (NYSDOH, 1995). These concentrations do not exceed Tribal Standards of 1 mg/kg.

Table 6-7
Maximum PCB Concentrations in Soils in the Assessment Area

Location	Year	Detection Limit	Maximum PCB Concentration (mg/kg dry weight)[a]	Reference
Assessment Area: RMC				
North Yard	1990	NA	1,400	Hagler Bailly Services, 1998
Wetland	1988	NA	690	Woodward-Clyde, 1990b
Assessment Area: ALCOA				
Dennison Road Disposal Area	1987	NA	12.7	Engineering-Science, 1989
Oily Waste Landfill	1987	NA	4.9	Engineering-Science, 1989
Waste Lubrication Oil Lagoon	1987	NA	253	Engineering-Science, 1989
Primary Lagoon Sludge Area	1990	NA	1.98	Hagler Bailly Services, 1998
Assessment Area: GM				
Fill along the Raquette River	1988	NA	400	RMT, 1989
GM Facility	1993	NA	4,000	CDM, 1998
Landfill	1999	0.33	18,000	CDM, 2000
Assessment Area: Akwesasne				
Adjacent to GM Landfill	1993-1995	0.002	0.866	NYSDOH, 1995
Along the Raquette River	1993-1995	0.002	0.659	
Near Raquette Point	1993-1995	0.002	0.215	
East of the St. Regis River	1993-1995	0.002	0.464	
Cornwall Island	1993-1995	0.002	0.316	

a. Maximum PCB values are derived from total PCB concentrations as reported in original source document; total PCB concentrations may have been determined from total aroclor or total congener concentrations data.
NA denotes information not available.
ND denotes not detected (i.e., concentration is below the method detection limit).

6.4.2 Other Hazardous Substances

Additional hazardous substances have been measured at concentrations that exceed potential background levels in soil borings from the Landfill Area on the RMC property. Such hazardous substances include fluoride (8,500 mg/kg; 36 mg/kg background), phenols (16 mg/kg; 1.3 mg/kg background), and cyanide (300 mg/kg; nondetectable for background, detection limit not provided) (Woodward-Clyde, 1990b).

Elevated concentrations of polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-p-furans (PCDFs) have been measured in soils collected from the North Yard Area of the RMC facility. Maximum concentrations that have been measured include 9.92 μg PCDD/L and 9.35 μg PCDF/L (NYSDEC, 1992b).

6.4.3 Summary — Soil Exposure

The limited soil data available indicate that soils in the assessment area have been and continue to be exposed to PCBs (Table 6-8). PCB concentrations in soil have been measured at the ALCOA, RMC, and GM facilities, on the Akwesasne property, and along the banks of the Raquette and St. Regis rivers. In addition, concentrations of fluoride, phenols, PCDD, PCDF, and cyanide on RMC property have exceeded background concentrations (Table 6-8).

Table 6-8
Summary of Confirmed Soil Exposure within the Assessment Area

Assessment Area Location	Hazardous Substances					
	PCBs	Fluoride	Phenols	Cyanide	PCDD	PCDF
Akwesasne Property	X					
Along the St. Lawrence River	X					
Along the Raquette River	X					
ALCOA Facility	X					
GM Facility	X					
RMC Facility	X	X	X	X	X	X

Areas left blank (i.e., not identified by an X) indicate that insufficient information is available to determine if a specific location has been exposed to a specific hazardous substance.

6.5 AQUATIC BIOTA

Several investigations have shown that fish, amphibians and aquatic reptiles, and aquatic invertebrates in the assessment area have been exposed to multiple hazardous substances, including PCBs, PAHs, and fluoride. Unless otherwise noted, all tissue concentration data for aquatic biota are presented in this section as mg/kg wet weight.

6.5.1 Fish

PCBs

St. Lawrence River. Elevated PCB concentrations in fish from the assessment area have been documented since the late 1970s (Table 6-9). PCBs have been detected in the tissues of numerous fish species, including alewife, American eel, brook trout, brown bullhead, carp, channel catfish, chinook salmon, golden shiner, northern pike, pike (unspecified species), pumpkinseed, rock bass, smallmouth bass, spottail shiner, walleye, white sucker, and yellow perch.

In the St. Lawrence River, PCB concentrations are generally higher in fish collected from the south channel in the vicinity of and downstream of the RMC and GM facilities than in the north channel; maximum PCB concentrations ranged from 1.08 to 81.5 mg/kg in fish in the south channel and from 1.81 to 28 mg/kg in fish in the north channel (Table 6-9). In general, these PCB concentrations in fish tissues are greater than concentrations from upstream potential background areas. For example, maximum concentrations of PCBs in spottail shiner ranged from 6.8 to 64.9 mg/kg in the south channel, well above upstream potential background concentrations of less than 0.04 mg/kg for this species. Concentrations of PCBs in fish tissues collected in fish from potential background areas are not available for all fish species. Of the fish species collected from potential background areas for the St. Lawrence River, maximum PCB concentrations ranged from below detection (detection limit not provided or 0.05 mg/kg) to 0.32 mg/kg for brown bullhead, northern pike, smallmouth bass, spottail shiner, and yellow perch. For carp, the maximum PCB concentration was 3.54 mg/kg, higher than concentrations in most fish species in the upstream potential background areas examined (Table 6-9).

Grasse River. PCBs have been measured in fish from the Grasse River; PCB concentrations are generally higher in fish collected near and downstream of the ALCOA facility. PCB concentrations in fish or fish tissue ranged from 0.12 to 52.1 mg/kg in the assessment area of the Grasse River. In upstream potential background areas, concentrations ranged from below detection (detection limit 0.04 mg/kg) to 1.4 mg/kg (Table 6-9). For spottail shiners, maximum PCB concentrations ranged from below detection (detection limit 0.04 mg/kg) in upstream potential background areas (Ecology and Environment, 1992a) to 43 mg/kg in fish collected between the ALCOA facility and Route 131 (ALCOA, 1999b). For brown bullheads, maximum PCB concentrations ranged from 0.99 mg/kg in upstream potential background areas (Ecology and Environment, 1992a) to 35 mg/kg in fish collected above Haverstock Road (ALCOA, 1999b).

Raquette and St. Regis rivers. Limited information is available on PCB concentrations in fish from the Raquette River and the St. Regis River. In the Raquette River, average whole body PCB

Table 6-9
Maximum PCB Concentrations in Fish in the Assessment Area

Location	Year	Species	Detection Limit (mg/kg)	Maximum PCB Concentrations in Fillet (mg/kg, wet weight)[a]	Reference
Upstream Potential Background Areas: St. Lawrence River					
Near Morrisburg	1988-1989	Spottail shiner	NA	ND[b]	St. Lawrence RAP Team, 1990
Near MacDonnell Island	1979, 1987-1989	Spottail shiner	NA	0.04[b]	St. Lawrence RAP Team, 1990
Above Moses-Saunders Dam	1988	Carp Brown bullhead Northern pike Smallmouth bass Yellow perch	0.05	3.54 0.18 0.18 0.26 ND	Sloan and Jock, 1990
Assessment Area: St. Lawrence River (North Channel)					
North of Cornwall Island	1978	White sucker Pike Channel catfish Yellow perch Walleye	NA	4.65 2.51 2.50 2.45 1.81	St. Lawrence RAP Team, 1990
	1988	Carp Pumpkinseed Brown bullhead	0.05	28 8.08 2.14	Sloan and Jock, 1990
Assessment Area: St. Lawrence River (South Channel)					
Near the RMC Facility	1989	Spottail shiner	0.023	16.6[b]	St. Lawrence RAP Team, 1990
South of Cornwall Island	1978	Channel catfish White sucker Brown bullhead Pike Walleye	NA	44.7 9.32 5.94 4.13 2.64	St. Lawrence RAP Team, 1990
West of Raquette Point	1988	Carp Smallmouth bass Northern pike	0.05	4.62 4.42 3.02	Sloan and Jock, 1990
Near GM	1989	Spottail shiner	NA	38[b]	BBLES, 1998
	1992	Spottail shiner	NA	64.9[b]	NYSDEC, 1997[d]
	1999	Spottail shiner	NA	6.8[b]	BBLES, 2000
Near St. Regis Village	1988	American eel Yellow perch	0.05	46.5 1.08	Sloan and Jock, 1990

Table 6-9 (cont.)
Maximum PCB Concentrations in Fish in the Assessment Area

Location	Year	Species	Detection Limit (mg/kg)	Maximum PCB Concentrations in Fillet (mg/kg, wet weight)[a]	Reference
Assessment Area: St. Lawrence River (South Channel) (cont.)					
Mouth of Turtle Creek	1988	Brown bullhead Yellow perch Northern pike	0.05	81.5 12.3 5.12	Sloan and Jock, 1990
Upstream Potential Background Areas: Grasse River					
Above Massena Dam	1988	Brown bullhead Rock bass Smallmouth bass	0.05	0.15 0.11 ND	Sloan and Jock, 1990
	1992	Brown bullhead Smallmouth bass Rock bass Spottail shiner	0.04	0.99[b] ND[b] ND[b] ND[b]	Ecology and Environment, 1992a
	1995	Brown bullhead	NA	0.17	ALCOA, 1999b
	1996	Smallmouth bass	NA	1.4	ALCOA, 1999b
Assessment Areas: Grasse River					
Massena Power Canal	1989	Alewife	NA	5.7[a]	Engineering-Science, 1991a
	1991	Brown bullhead Smallmouth bass	NA NA	0.12[a] 1.9[a]	Ecology and Environment, 1992a
Grasse River	1986	Chinook salmon	NA	3.17	NYSDEC, 1986[e]
	1979-1994	Spottail shiner	NA	9.07	Ontario Ministry of the Environment (unpub. data)
Below Power Canal	1991	Pumpkinseed Smallmouth bass	NA	8.17[c] 8.63[c]	Skinner, 1992
Below Massena Power Dam	1989	Spottail shiner	0.023	9.07[b]	St. Lawrence RAP Team, 1990
At ALCOA Discharge	1988	Brown bullhead Smallmouth bass Yellow perch	0.05	9.21 7.72 2.57	Sloan and Jock, 1990
	1992	Brown bullhead Smallmouth bass Rock bass Spottail shiner	0.04	13.6[b] 6.5[b] 1.7[b] 14.7[b]	Ecology and Environment, 1992a

Table 6-9 (cont.)
Maximum PCB Concentrations in Fish in the Assessment Area

Location	Year	Species	Detection Limit (mg/kg)	Maximum PCB Concentrations in Fillet (mg/kg, wet weight)[a]	Reference
Assessment Areas: Grasse River (cont.)					
Between ALCOA Plant & Rt. 131	1995	Spottail shiner Smallmouth bass	NA	43[b] 37.5	ALCOA, 1999b
	1998	Brown bullhead	NA	23.7	ALCOA, 1999b
Downstream of Dennison Rd.	1991	Yellow perch Pumpkinseed Brown bullhead	NA	26.2[b,c] 21.1[b,c] 25.0[b,c]	Skinner, 1992
Downstream of Rt. 131	1991	Brown bullhead Golden shiner Yellow perch Northern pike	NA	39.2[b,c] 26.5[b,c] 52.1[b,c] 12.7[b,c]	Skinner, 1992
	1993	Brown bullhead Smallmouth bass	NA	24 67	ALCOA, 1999b
	1995	Spottail shiner	NA	20.5[b]	ALCOA, 1999b
Above Haverstock Rd.	1991	Smallmouth bass Yellow perch Smallmouth bass Golden shiner	NA	11.2[c] 25.4[b,c] 8.71[c] 15.9[b,c]	Skinner, 1992
	1993	Smallmouth bass Brown bullhead	NA	25 35	ALCOA, 1999b
Near Mouth of Grasse River	1992	Brown bullhead Smallmouth bass Rock bass Spottail shiners	0.04	21.9[b] 4[b] 2.8[b] 25.1[b]	Ecology and Environment, 1992a
Mouth of Grasse River	1988	Brown bullhead Pumpkinseed Yellow perch	0.05	10.7 7.06 2.99	Sloan and Jock, 1990
	1991	Spottail shiner	NA	12.4[b,c]	Ecology and Environment, 1992a
	1992	Smallmouth bass	NA	8.71[b,c]	Ecology and Environment, 1992a
	1996	Spottail shiner	NA	11.4[b]	ALCOA, 1999b
Assessment Area: Raquette River					
Raquette River	1988	Spottail shiner	0.023	1.84[b]	St. Lawrence RAP Team, 1990

Table 6-9 (cont.)
Maximum PCB Concentrations in Fish in the Assessment Area

Location	Year	Species	Detection Limit (mg/kg)	Maximum PCB Concentrations in Fillet (mg/kg, wet weight)[a]	Reference
Upstream Potential Background Area: St. Regis River					
Above Hogansburg Dam	1988	Carp Yellow perch Smallmouth bass Brown bullhead	0.05	2.9 0.44 0.26 ND	Sloan and Jock, 1990
Assessment Area: St. Regis River					
Below Hogansburg Dam	1988	Channel catfish American eel Brook trout Smallmouth bass	0.05	10.1 7.87 2.98 1.22	Sloan and Jock, 1990

a. Maximum PCB values are derived from total PCB concentrations as reported in original source document; total PCB concentrations may have been determined from total aroclor or total congener concentrations data.
b. PCB concentrations based on whole body, not fillet.
c. Maximum PCB concentration based on mean PCB concentrations as reported in original source document.
d. As cited in BBLES, 1998.
e. As cited in Engineering-Science, 1987.
NA denotes information not available.
ND denotes not detected (i.e., concentration is below the method detection limit).

concentrations up to 1.84 mg/kg have been measured in spottail shiner (Sloan and Jock, 1990). In the St. Regis River, maximum PCB concentrations in fish ranged from 1.22 to 10.1 mg/kg, generally higher than those measured in fish collected from upstream potential background areas (0.26 to 2.9 mg/kg) on the St. Regis River (Table 6-9).

Overall, long-lived, bottom-feeding, or high lipid content fish such as American eel, brown bullhead, channel catfish, and carp have the highest tissue concentrations of PCBs in the assessment area. Based on the available data, fish collected from downstream reaches of the St. Lawrence, Grasse, Raquette, and St. Regis rivers (i.e., the assessment area) have been exposed to elevated concentrations of PCBs.

Fluoride

Fluoride has been measured in fish tissue from fish collected from the St. Lawrence River in the assessment area. Fluoride concentrations ranged from 1.06 to 12.1 mg/kg in white sucker fillets and from 2.08 to 34.8 mg/kg in yellow perch fillets (Woodward-Clyde, 1992). There are no available data for potential background concentrations of fluoride in fish tissue.

6.5.2 Amphibians and Aquatic Reptiles

PCBs

PCBs have been measured in amphibians and reptiles collected from the St. Lawrence River, the Grasse River, the Raquette River, and the St. Regis River, and on Akwesasne property (Table 6-10). In the assessment area, maximum PCB concentrations ranged from 2.4 mg/kg to greater than 2,000 mg/kg in tissue collected from amphibians and from 0.4 mg/kg to 3,000 mg/kg in tissue collected from reptiles. PCB concentrations were measured in fat, liver, muscle, and eggs/gonad tissue from amphibians and reptiles. In general, the highest PCB concentrations were measured in fat (Table 6-10). Maximum concentrations of PCB measured in fat collected from amphibians were greater than 2,000 mg/kg (Stone, 1988). Maximum concentrations of PCB measured in fat from reptiles ranged from 7 mg/kg in the map turtle (NYSDEC, 1992a) to 3,000 mg/kg in the snapping turtle (Ransom and Lickers, 1988).

Since PCB concentrations were not detected (detection limit, 0.04 mg/kg) in frogs collected from the Grasse River above the Massena Dam (the only potential background location where data has been collected), the presence of PCBs in amphibian and reptile tissue in the assessment area above detection limits indicates that these organisms have been exposed to PCBs.

Other Hazardous Substances

Elevated concentrations of PCDDs and PCDFs were measured in fat and liver samples in a snapping turtle collected from the Massena Area (exact location not provided) in 1985 (Ryan et al., 1986). Concentrations were generally higher in fat samples than in liver samples. In fat samples, PCDD concentrations up to 0.37 μg/kg and PCDF concentrations up to 3.02 μg/kg were measured; in liver samples, PCDD concentrations up to 0.07 μg/kg and PCDF concentrations up to 0.48 μg/kg were measured (Ryan et al., 1986).

Limited data are available on potential background concentrations of PCDDs and PCDFs for aquatic reptiles in the assessment area. PCDDs and PCDFs have been measured in two snapping turtles at upstream locations in the St. Lawrence near the outlet of Lake Ontario. Maximum concentrations of PCDDs were 0.47 μg/kg in fat and 0.11 μg/kg in liver and maximum concentrations of PCDFs were 0.15 μg/kg in fat and 0.03 μg/kg in liver (Ryan et al., 1986). These concentrations at upstream locations in the St. Lawrence are similar to PCDD concentrations, but lower than PCDF concentrations, measured in aquatic reptiles collected in the Massena area.

Table 6-10
PCB Concentrations in Amphibians and Reptiles in the Assessment Area

Location	Year	Species	Detection Limit (mg/kg)	Tissue	Maximum PCB Concentration (mg/kg, wet weight)[a]	Reference
Amphibians						
Grasse River, above Massena Dam (potential background location)	1992	Frog	0.04	Muscle	ND	Ecology and Environment, 1992a
Grasse River, near ALCOA	1992	Frog	0.04	Muscle	2.4	Ecology and Environment, 1992a
Akwesasne, Contaminant Cove near Mouth of Turtle Creek	1988	Bullfrog Green frog	NA	Muscle Muscle	7.2 3.9	NYSDEC, 1992a
Akwesasne Property (location not provided)	1987	Frog	NA	Fat	>2,000	Stone, 1988
	1992-1993	Mudpuppy	NA	Gonad	314.7	Gendron et al., 1997
Reptiles						
St. Lawrence River (location not provided)	1987	Snapping turtle	NA	NA	3,000	Ransom and Lickers, 1988
Grasse River, approximately 100 m upstream from mouth	1988	Snapping turtle	NA	Fat Liver Muscle	821 95 1.6	NYSDEC, 1992a
Raquette River, downstream of Twin Bridges	1988	Map turtle	NA	Fat Liver Muscle	7 19 0.4	NYSDEC, 1992a
	1988	Snapping turtle	NA	Fat	21.6	Hagler Bailly Services, 1998
Raquette River, near Raquette Point	NA	Map turtle	NA	Fat	186.4[b]	Hagler Bailly Services, 1998
Raquette River (location not provided)	1990	Snapping turtle	NA	Eggs	11	Bonin et al., 1995
Akwesasne, next to GM Landfill	1985	Snapping turtle	NA	Fat	835	Ransom and Lickers, 1988
Akwesasne, Contaminant Cove near Mouth of Turtle Creek	1988	Snapping turtle	NA	Fat Liver Muscle	1,347 62 2.7	NYSDEC, 1992a

Table 6-10 (cont.)
PCB Concentrations in Amphibians and Reptiles in the Assessment Area

Location	Year	Species	Detection Limit (mg/kg)	Tissue	Maximum PCB Concentration (mg/kg, wet weight)[a]	Reference
Reptiles (cont.)						
Akwesasne (location not provided)	1990	Snapping turtle	NA	Eggs	5.1	Bonin et al., 1995
St. Regis River (location not provided)	1990	Snapping turtle	NA	Eggs	0.9	Bonin et al., 1995

a. Maximum PCB values are derived from total PCB concentrations as reported in original source document; total PCB concentrations may have been determined from total aroclor or total congener concentrations data.
b. Maximum PCB concentration based on mean PCB concentrations as reported in original source document.
NA denotes information not available.
ND denotes not detected (i.e., concentration is below the method detection limit).

6.5.3 Invertebrates

PCBs and PAHs

PCB concentrations in freshwater mussels in the assessment area were evaluated following a series of caging studies performed by the Ontario Ministry of the Environment in 1988. The studies focused on the bioaccumulation of PCBs in caged mussels over a three-week period at various locations in the St. Lawrence, Grasse, and Raquette rivers (St. Lawrence RAP Team, 1990). PCB tissue concentrations were highest in caged mussels placed in areas of the south channel of the St. Lawrence River, downstream of the Reynolds Outfall (0.34 mg/kg), downstream of the GM Outfall (0.44 mg/kg), and in the Grasse River (0.70 mg/kg) (St. Lawrence RAP Team, 1990). PCB concentrations in all of the mussels from the cage sites in the north channel (e.g., downstream of Cortaulds) were below method detection limits (detection limit not provided). Concentrations of PAHs in caged mussels followed a similar pattern, with the highest concentrations measured in mussels downstream of the Reynolds Outfall (2.68 mg/kg) and in the Grasse River (0.41 mg/kg).

ALCOA also conducted caging studies with freshwater mussels in June and September 1998, looking at PCB bioaccumulation over a 30-day period at various locations in the Grasse River (ALCOA, 1999b). The maximum PCB tissue concentration measured was 0.74 mg/kg (dry weight) in the June 1998 study and 0.19 mg/kg (dry weight) in the September study. PCB concentrations in caged mussels in upstream locations in the Grasse River were all below the detection limit of 0.12 mg/kg (dry weight).

Studies have also been conducted to measure PCB concentrations in crayfish from the Grasse River. PCB concentrations in crayfish from the upstream reaches of the Grasse River (above Massena Dam) were below method detection limits (0.04 mg/kg), whereas downstream of the dam, near the ALCOA facility, PCB concentrations up to 4.8 mg/kg were measured in crayfish (Ecology and Environment, 1992a).

Bioaccumulation studies with the invertebrate *Chironomus tentans* evaluated the bioavailability of PAHs and PCBs from sediment collected near the outfalls of the ALCOA, RMC, and GM facilities (Wood et al., 1997). Test organisms were exposed to either 100% sediment or dilutions of sediment with a control sediment collected from the upper reaches of the Hudson River in New York. Bioaccumulation of PAHs and PCBs was observed in *C. tentans* exposed to most of the sediments tested, indicating that these organisms are exposed to PAHs and PCBs from the sediment (Table 6-11). Bioaccumulation factors based on wet tissue weights and dry sediment weights ranged from 0.04 to 0.28 for PAHs and 0.22 to 1.42 for PCBs (Table 6-11). These data indicate that PAH and PCBs in assessment area sediments are bioavailable to benthic invertebrates and therefore confirm exposure to benthic organisms that reside in areas in which sediments are contaminated. Limited bioaccumulation data were generated for sediment collected near the RMC Outfall since both 100% RMC sediment and 3% RMC sediment (diluted with control sediment) was acutely lethal to *C. tentans* over the 12 day exposure test.

6.5.4 Summary — Aquatic Biota Exposure

In summary, existing data demonstrate that fish, amphibians and aquatic reptiles, and aquatic invertebrates in the assessment area have been and continue to be exposed to hazardous substances, including PCBs, fluoride, and PAHs (Table 6-12).

6.6 TERRESTRIAL BIOTA

The available data indicate that terrestrial invertebrates, birds, and mammals have been exposed to hazardous substances, including PCBs and fluoride. Unless otherwise noted, all tissue concentrations in terrestrial biota are presented as mg/kg wet weight.

Table 6-11
Concentrations of PAHs and PCBs in Sediment Collected near ALCOA, RMC, and GM Outfalls and in *Chironomus tentans* Larvae after a 12-Day Exposure Test

Sediment Source and Percent Concentration Used for Exposure Test	PAHs			PCBs		
	Sediment Concentration (mg/kg, dry weight)	Larvae Concentration (mg/kg, wet weight)	BF[a]	Sediment Concentration (mg/kg, dry weight)	Larvae Concentration (mg/kg, wet weight)	BF
100% ALCOA	78	16	0.21	16	7.9	0.49
	78	8.4	0.11	16	7.4	0.46
66% ALCOA	47	11	0.23	11	3.2	0.29
	47	7.5	0.16	11	2.4	0.22
33% ALCOA	18	5.0	0.28	5.4	3.2	0.59
	18	4.5	0.25	5.4	3.1	0.57
100% RMC	3,200	ND[b]	ND	700	ND[b]	ND
3% RMC[c]	75	6.7	0.09	22	12	0.55
	75	2.8	0.04	22	6.5	0.30
100% GM	1.4	0.2	0.14	24	13	0.54
66% GM	ND	ND	ND	11	3.1	0.28
33% GM	ND	ND	ND	3.6	5.1	1.42
Control Sediment[d]	0.2	0.1	0.5	0.1	0.04	0.4
	0.2	0.1	0.5	ND	ND	ND
	0.2	0.2	1.0	ND	ND	ND

a. Biota and sediment bioaccumulation factors (BF) based on wet weight tissue and dry weight sediment.
b. No tissue concentration because sediment was lethal to all exposed organisms.
c. 3% RMC sediment resulted in 71-75% mortality in exposed *C. tentans.*
d. Control sediment collected from the upper reaches of the Hudson River in New York.
ND = Not determined.

Source: Wood et al., 1997.

Table 6-12
Summary of Confirmed Aquatic Biota Exposure to PCBs within the Assessment Area

Assessment Area Location	Aquatic Biota			
	Fish	Amphibians	Reptiles	Aquatic Invertebrates
Akwesasne Property (Turtle Creek)	X	X	X	
St. Lawrence River	X		X	X
Grasse River	X	X	X	X
Raquette River	X		X	X
St. Regis River	X		X	
Massena Power Canal	X			
GM Property		X	X	

Areas left blank (i.e., not identified by an X) indicate that insufficient information is available to determine if a specific location in the assessment area has been exposed to PCBs.

6.6.1 Invertebrates

PCBs

PCB concentrations have been measured in terrestrial invertebrates near Contaminant Cove. Concentrations up to 54 mg/kg were measured in earthworms and up to 9.7 mg/kg in insects (Bush, 1992). There are no available data for potential background concentrations of PCBs for earthworms and insects in the assessment area.

Fluoride

Terrestrial invertebrates have also been exposed to fluoride; fluoride concentrations in honeybees and bumblebees ranged from 29 to 406 mg/kg on Cornwall Island (Rice, 1983). There are no available data for potential background concentrations of fluoride in bees in the assessment area.

6.6.2 Birds

PCBs

PCB have been detected in birds in the assessment area (Table 6-13). PCBs have been measured in eggs, fat, liver, muscle, and skin tissue from numerous bird species, including common merganser, gadwall, mallard, and red-winged blackbird. Maximum PCB concentrations ranged from below detection (detection limit not provided) to 614 mg/kg; as with aquatic biota, PCB

Table 6-13
PCB Concentrations in Birds in the Assessment Area

Location	Year	Species	Detection Limit (mg/kg)	Tissue	Maximum PCB Concentration (mg/kg, wet weight)[a]	Reference
Assessment Area: St. Lawrence River						
Near the RMC Facility	1987	NA (hatchling ducks)	NA	Fat	150	NYSDEC, 1992a
	1988	Gadwall Common merganser	0.1	Fat	6.6 47	NYSDEC, 1992a
Dead Clam Cove, near the RMC Facility	1988	Common merganser	0.1	Fat	24	NYSDEC, 1992a
Near Massena-Cornwall Bridge	1988	Common merganser	NA	Skin Liver	10.5 1.6	Hagler Bailly Services, 1998
	1988	Common merganser	0.1	Fat	36	NYSDEC, 1992a
Near the GM Facility	1988	Common merganser	NA	Skin	98.9	Hagler Bailly Services, 1998
	1988	Gadwall Common merganser	0.1	Fat	15 55	NYSDEC, 1992a
Akwesasne, Contaminant Cove near Mouth of Turtle Creek	1988	Mallard	0.1	Fat Liver Muscle Skin	614 8 5.8 69	NYSDEC, 1992a
Contaminant Cove	1991	Tree swallow Red-winged blackbird	<0.1	Eggs	4 19	Bishop et al., 1995a
Raquette Point	1987	Canada goose	0.1	Fat Skin	7.8 7.7	NYSDEC, 1992a
	1987	Mallard	0.1	Fat	6.6	Stone, 1988
	1988	Common merganser	0.1	Fat	166	NYSDEC, 1992a
	1988	Common merganser	NA	Skin	320.8	Hagler Bailly Services, 1998
	1989	Mallard	0.1	Fat	5.6	NYSDEC, 1992a

Table 6-13 (cont.)
PCB Concentrations in Birds in the Assessment Area

Location	Year	Species	Detection Limit (mg/kg)	Tissue	Maximum PCB Concentration (mg/kg, wet weight)[a]	Reference
Assessment Area: Raquette River						
Near mouth of Raquette River	1988	Mallard	0.1	Fat	4.6	NYSDEC, 1992a
	1988	Mallard	NA	Skin Liver	1.72 1.37	Hagler Bailly Services, 1998
Akwesasne Property near Raquette River	1988	Ruffed grouse	NA	Liver	1.61	Hagler Bailly Services, 1998
Raquette River, downstream of Twin Bridges	1987	Wood duck	NA	Fat Skin Muscle	1.9 1.02 ND	Hagler Bailly Services, 1998

a. Maximum PCB values are derived from total PCB concentrations as reported in original source document; total PCB concentrations may have been determined from total aroclor or total congener concentrations data.
NA denotes information not available.
ND denotes not detected (i.e., concentration is below the method detection limit).

concentrations are highest in fat collected from the birds. Maximum PCB concentrations measured in fat ranged from 1.9 mg/kg in wood ducks to 614 mg/kg in mallards (Table 6-13). Tree swallow eggs and red-winged blackbird eggs collected at Akwesasne in 1991 contained PCBs up to 4 mg/kg and 19 mg/kg, respectively (Bishop et al., 1995a).

There are no available data for potential background concentrations of PCBs in birds in the assessment area. However, concentrations exceeded the FDA tolerance level of 3 mg/kg in poultry (determined on a fat basis) at a number of locations for a number of species (Table 6-13). Hence, it is determined that these birds have been exposed to PCBs in the assessment area.

6.6.3 Mammals

PCBs

Elevated PCB concentrations have been measured in mammals in the assessment area. Sampling by the St. Regis Mohawk Tribe in the 1980s found elevated concentrations (up to 11,000 mg/kg) of PCBs in the fat of a shrew sampled near the landfill on the GM property (Stone, 1988). This concentration greatly exceeds the FDA limit for human consumption of beef and poultry

(3 mg/kg, determined on a fat basis). Although shrews are not consumed by humans, this elevated concentration suggests that this and other ground-dwelling mammals inhabiting the border area between the GM facility and the Akwesasne property may accumulate significant concentrations of PCBs. In addition, these elevated PCB concentrations indicate that shrews and potentially other ground-dwelling mammals have been exposed to PCBs in the assessment area.

PCB concentrations in mammals from the assessment area were also measured during a NYSDEC wildlife study conducted in 1988. PCB concentrations of 0.7 mg/kg were measured in the liver of a muskrat sampled from Turtle Creek near the GM facility, and concentrations of 0.8 mg/kg were measured in the fat of two muskrats sampled from the Akwesasne property near Raquette Point and along the St. Regis River (NYSDEC, 1992a).

Fluoride

Fluoride concentrations have been measured (or the effects of fluoride exposure have been observed) in mammals in the assessment area. Fluorosis, a debilitating bone disease (see Chapter 8), has been observed in captive animals (cattle) on Cornwall Island (Krook and Maylin, 1979) and on a farm 2 km southeast of the RMC facility (Crissman et al., 1980).

Fluoride concentrations were measured in femurs of meadow voles (*Microtus pennsylvanicus*) and short-tailed shrews (*Blarina brevicada*) collected from the assessment area near the RMC and ALCOA facilities (Miles, 1983). Femur fluoride concentrations ranged from 1,310 to 5,599 mg/kg in meadow voles and from 5,284 to 8,678 mg/kg in short-tailed shrews (Miles, 1983). There are no available data for potential background concentrations of fluoride for mammals in the assessment area.

6.6.4 Summary — Terrestrial Biota Exposure

In summary, terrestrial biota have been and continue to be exposed to hazardous substances, including PCBs (Table 6-14) and fluoride.

Birds and mammals from a variety of areas downstream of the ALCOA, RMC, and GM facilities and on the Akwesasne property have PCB concentrations greater than the FDA tolerance level for human consumption of beef and poultry (3 mg/kg). Since uncontaminated birds and mammals would be expected to have concentrations of hazardous substances much less than the FDA tolerance level, exceedences of these tolerance levels were considered indicative of exposure above background levels for this assessment of exposure. Hence, birds and mammals have been exposed to PCBs in the assessment area. Insects sampled on the Akwesasne property also indicate exposure to PCBs and fluoride.

Table 6-14
Summary of Confirmed Terrestrial Biota Exposure to PCBs within the Assessment Area

Assessment Area Location	Terrestrial Biota		
	Birds	**Mammals**	**Insects**
Akwesasne Property	X	X	X
Along St. Lawrence River	X	X	
Along Raquette River	X		
Along St. Regis River		X	

Areas left blank (i.e., not identified by an X) indicate that insufficient information is available to determine if a specific location in the assessment area has been exposed to PCBs.

6.7 VEGETATION

Aquatic and terrestrial vegetation in the assessment area have been exposed to hazardous substances, including PCBs and fluoride.

6.7.1 Aquatic Vegetation

PCBs

PCBs have been measured in macrophytes along both the north and south channels of the St. Lawrence River between Cornwall Island and Lake St. Francis. Maximum mean PCB concentrations were 0.49 mg/kg (dry weight) in whole plant samples collected along the south channel of the St. Lawrence River in the vicinity of the RMC and GM facilities (Richard et al., 1997). Mean PCB concentrations in macrophytes collected from the north channel ranged from 0.05 to 0.11 mg/kg (dry weight), whereas mean PCB concentrations in macrophytes collected from the south channel ranged from 0.11 to 0.49 mg/kg (dry weight) (Richard et al., 1997).

PCB concentrations have also been measured in live leaves of cattails from a number of sites on the ALCOA property, including the 60 Acre Lagoon (0.043 mg/kg, wet weight), the Sanitary Lagoon (0.098 mg/kg, wet weight), the East Marsh (0.04 mg/kg, wet weight), and the South Pond (0.025 mg/kg, wet weight; Engineering-Science, 1991b).

Elevated PCB concentrations measured in macrophytes in the assessment area were greater than concentrations in macrophytes in the north channel of the St. Lawrence River (Richard et al., 1997), indicating that macrophytes have been exposed to PCBs.

Fluoride

Concentrations of fluoride in macrophytes collected from the ALCOA property during a 1991 RI/FS study suggest that aquatic vegetation have been exposed to fluoride (Engineering-Science, 1991b). In this study, fluoride concentrations were measured in cattails from areas on the ALCOA property at the Spent Potlining Pile I (6.07 mg/kg), the Spent Potlining Pile A (3.13 mg/kg), the South Drainage Ditch (4.47 mg/kg), and the South Pond (2.51 mg/kg) (Engineering-Science, 1991b). Cattail samples from the wetland reference area contained fluoride concentrations up to 5.83 mg/kg (Engineering-Science, 1991b). However, it is inappropriate to consider the wetland area as a reference site since it is located just north of the ALCOA facility and may be subject to aerial deposition of fluoride from the ALCOA facility releases.

6.7.2 Terrestrial Vegetation

PCBs

Available data suggest that terrestrial plants on the Akwesasne property have been exposed to aerial sources of PCBs. Concentrations up to 1.4 mg/kg have been measured on the heads of goldenrods, and concentrations up to 1.7 mg/kg have been measured in grass clippings adjacent to the GM property (Stone, 1988). Terrestrial plants accumulate PCBs in their roots and leaves, which are their points of entry. However, PCBs do not appreciably move from the roots to the leaves of the plant (Buckley, 1982). Hence, PCBs found on the leaves and other extremities of the plant most likely derive from deposition of aerial particulates and vapor.

Fluoride

Vegetation assessments of fluoride exposure have been ongoing in the Cornwall region in the assessment area since 1969. Fluoride concentrations in vegetation from the Cornwall area have been elevated above potential background concentrations (2 mg/kg) since the 1970s. Concentrations of fluoride ranging from 451 mg/kg (1972) to 1,171 mg/kg (1975) have been measured in maple foliage samples from the southwest side of Cornwall Island (Rice, 1983; Emerson, 1987).

NYSDEC has monitored monthly concentrations and seasonal mean concentrations of fluoride in plants from the assessment area since 1989 (Table 6-15). Concentrations of fluoride measured in vegetation near the ALCOA facility have consistently been sufficiently elevated to violate NYSDEC growing-season standards since the earliest available data. Since fluoride concentrations in uncontaminated terrestrial vegetation would not be expected to exceed standard or criterion levels, for this analysis of exposure, exceedences of standards or criteria is deemed indicative of exposure above background levels. Fluoride concentrations in vegetation from the RMC and the Akwesasne properties (Cornwall Island) have also violated NYSDEC standards,

Table 6-15
Maximum and Seasonal Mean Concentrations of Fluoride in Vegetation Sampled near the ALCOA and RMC Facilities and on the Akwesasne Property (Cornwall Island), 1989-1996

Year	Maximum (mg/kg), Dry Weight	Seasonal Mean (mg/kg), Dry Weight	Violations of NYSDEC Fluoride Standards[a]
ALCOA Sites			
1989	119	60	30 and 60 day, and growing season standards
1990	280	119	30 and 60 day, and growing season standards
1991	262	171	30 and 60 day, and growing season standards
1992	479	150	30 and 60 day, and growing season standards
1993	166	120	30 and 60 day, and growing season standards
1994	137	54	30 and 60 day, and growing season standards
1995	155	131	30 and 60 day, and growing season standards
1996	290	194	30 and 60 day, and growing season standards
RMC Sites			
1989	242	88	30 and 60 day, and growing season standards
1990	231	74	30 and 60 day, and growing season standards
1991	58	36	No violation
1992	32	23	No violation
1993	92	54	30 and 60 day, and growing season standards
1994	121	59	30 and 60 day, and growing season standards
1995	31	30	No violation
1996	27	21	No violation
Akwesasne Property (Cornwall Island)			
1989	NA	NA	NA
1990	NA	NA	NA
1991	100	72	30 and 60 day, and growing season standards
1992	103	59	30 and 60 day, and growing season standards
1993	76	38	30 and 60 day standard
1994	94	NA	30 and 60 day standards
1995	146	51	30 and 60 day, and growing season standards
1996	45	32	No violation

NA = Not available.
a. Standards are based on total fluoride concentrations in part per million measured on a dry weight basis in or on forage for consumption by grazing ruminants. Average fluoride concentrations shall be less than the following: 40 ppm for the entire growing season (not to exceed 6 consecutive months), 60 ppm for any 60 day period, and 80 ppm for any 30 day period.

Source: NYSDEC, 1997a.

but have generally been much lower than the vegetation concentrations on the ALCOA property. Fluoride levels in vegetation from the ALCOA and Akwesasne properties (i.e., Cornwall Island) continue to be elevated, with violations as recently as 1996.

Elevated concentrations of fluoride have also been detected in shrubs and tree foliage near the ALCOA and RMC facilities. In 1977, fluoride concentrations in dogwood near the RMC facility were 315 mg/kg, and concentrations in bitternut hickory foliage were up to 705 mg/kg (Rice, 1983). Near the ALCOA facility, dogwood concentrations were 143 mg/kg and bitternut hickory foliage concentrations were 650 mg/kg (Rice, 1983). More recent studies have measured elevated concentrations of fluoride in vegetation sampled from areas downwind of the ALCOA (119 mg/kg) and RMC (74 mg/kg) facilities (NYSDEC, 1990a).

Elevated fluoride concentrations have been measured (on a dry weight basis) on unwashed foliage downwind of the ALCOA and RMC facilities in grasses (113 mg/kg); forbs and shrubs (389 mg/kg); red, silver, and sugar maples (251 mg/kg); basswood, cottonwood, quaking aspen, elm, and ash (367 mg/kg); and bitternut hickory foliage (705 mg/kg) (Miles, 1983). Wild grape had fluoride concentrations up to 196 mg/kg (dry weight) within one mile northeast of the RMC facility and 119 mg/kg (dry weight) within two miles of the ALCOA facility (Miles, 1983). Fluoride concentrations of 265 mg/kg (dry weight) were measured in Manitoba maple leaves within two miles of the RMC facility (Miles, 1983). These fluoride concentrations in unwashed plant foliage were 200 times greater than concentrations measured in reference plants (Miles, 1983).

6.7.3 Summary — Vegetation Exposure

In summary, aquatic and terrestrial vegetation have been and continue to be exposed to hazardous substances, including PCBs and fluoride (Table 6-16). PCBs and fluoride have been measured in terrestrial and aquatic vegetation from a number of sites within the assessment area, including the ALCOA property, the RMC property, the Akwesasne property (namely Cornwall Island), and the north and south channel of the St. Lawrence River.

6.8 AIR

Available data suggest that air resources of the assessment area have been exposed to multiple hazardous substances, including PCBs, fluoride, and styrene.

6.8.1 PCBs

Data on PCB concentrations in the air of the assessment area are limited to studies performed in the late 1980s and the early 1990s. In 1990, NYSDEC (1990a) detected PCB concentrations of

Table 6-16
Summary of Confirmed Vegetation Exposure to PCBs and Fluoride within the Assessment Area

	Aquatic Vegetation		Terrestrial Vegetation	
Assessment Area Location	**PCBs**	**Fluoride**	**PCBs**	**Fluoride**
Akwesasne Property			X	X
ALCOA Facility	X	X		X
RMC Facility				X
St. Lawrence River	X			

Areas left blank (i.e., not identified by an X) indicate that insufficient information is available to determine if a specific location in the assessment area has been exposed to a specific hazardous substance.

72 ng/m^3 in air near Contaminant Cove. NYSDEC (1990a) also analyzed air samples near the RMC facility and detected PCB concentrations of 269 ng/m^3. In a year-long monitoring study in 1993, PCB concentrations in the air were monitored at five sites and a control area on the Akwesasne property. The highest concentrations (20 ng/m^3) were measured along the south shore of the St. Lawrence River near the landfill at the GM facility (Bush et al., 1995, Chiarenzelli et al., 2000).

PCB concentrations measured in snow samples collected from the Akwesasne property in the early 1990s ranged from 8.8 to 432.2 ng/L; the average sample contained 193.9 ng/L (Gilligan, 1992). House dust sampled at the same time contained concentrations of PCBs up to 265.4 ng/L (Gilligan, 1992). There are no available data for potential background concentrations of PCBs in air for the assessment area.

6.8.2 Fluoride

Measurable concentrations of fluoride in the air of the assessment area are common because of releases of hydrogen fluoride gas from the ALCOA and RMC facilities. In 1989, concentrations of hydrogen fluoride in the air downwind of the RMC facility were measured up to 3.5 ppb (2.86 μg/m^3)[2] (NYSDEC, 1990a). A year later, a more comprehensive air sampling study measured hydrogen fluoride concentrations in the air near the RMC facility up to 5.2 ppb (4.25 μg/m^3) (NYSDEC, 1990a).

2. Fluoride concentrations converted from ppb to μg/m^3 according to the following equation: μg/m^3 = (ppb) × (molecular weight of hydrogen fluoride (20.006)) / 24.45 (U.S. EPA, 2000).

Elevated hydrogen fluoride concentrations in the air were measured between 1976 and 1987 on the Akwesasne property (Cornwall Island) above the permissible Ontario Ministry of the Environment 30-day guideline of 0.32 $\mu g/m^3$ (Table 6-17). Since fluoride concentrations in uncontaminated air would not be expected to exceed standard or criterion levels, for this analysis of exposure, exceedences of standards or criteria are deemed indicative of exposure above background levels.

Table 6-17
Exceedences of Ontario Ministry of the Environment Ambient Air Quality Standards for Fluoride (measured as Hydrogen Fluoride, HF) on Cornwall Island

Year	Ontario Ambient Air Quality Standard ($\mu g/m^3$ HF)	% Time Exceeded		Reference
		Station A	Station B	
1976	0.32	64	26	Bumbaco and Shelton, 1976
1977	0.32	31	30	Bumbaco and Shelton, 1978
1978	0.32	45	23	Bumbaco and Shelton, 1979
1979	0.32	58	48	Bumbaco and Shelton, 1980
1980	0.32	25	76	Bumbaco and Shelton, 1981
1981	0.32	67.5	92.9	DeBellefeuille, 1985
1982	0.32	0	0	DeBellefeuille, 1985
1983	0.32	49.4	22.1	DeBellefeuille, 1985
1984	0.32	1.3	9.1	DeBellefeuille, 1985
1985	0.34	NA	0	DeBellefeuille, 1985
1986	0.34	NA	8.5	DeBellefeuille and Desjardins, 1986
1987	0.34	NA	51	Environment Canada, 1988

NA = Not available.

6.8.3 Styrene

Elevated concentrations of styrene has been measured in the air on Akwesasne immediately east (and downwind) of the GM facility. Styrene concentrations in the air ranged from 0.9 to 13.3 ppb (3.83 to 56.7 $\mu g/m^3$)[3] in samples collected on Akwesasne in September 1994 (Benedict, 1994).

3. Styrene concentrations converted from ppb to $\mu g/m^3$ according to the following equation: $\mu g/m^3$ = (ppb) × (molecular weight of styrene (104.16)) / 24.45 (U.S. EPA, 2000).

Styrene concentrations measured in the air at Akwesasne in 1998 ranged from below detection (detection limit not provided) to 12 ppb (51.1 $\mu g/m^3$) (Barkley, 1998).

These concentrations are elevated relative to rural background areas (0.28 to 0.34 $\mu g/m^3$) and typical urban areas (0.29 to 3.8 $\mu g/m^3$) (ATSDR, 1995). In addition, evidence of elevated styrene concentrations in the air is provided by complaints from residents of Raquette Point on the Akwesasne property of strong styrene odors (Benedict, 1994). The detectable odor threshold for styrene is 0.05 ppb (0.21 $\mu g/m^3$) (Benedict, 1994).

6.8.4 Summary — Air Exposure

In summary, air has been exposed to hazardous substances, including PCBs, fluoride, and styrene (Table 6-18). PCBs have been measured in the air surrounding the Akwesasne property and in areas downwind of the RMC and GM facilities. In addition, aerial sources of PCBs are believed to be the cause of elevated concentrations measured in vegetation from the Akwesasne property.

Table 6-18
Summary of Confirmed Air Exposure to PCBs, Fluoride, and Styrene within the Assessment Area

Assessment Area Location	Hazardous Substances		
	PCBs	**Fluoride**	**Styrene**
Akwesasne Property	X	X	X
ALCOA Facility		X	
RMC Property	X	X	
St. Lawrence River			

Areas left blank (i.e., not identified by an X) indicate that insufficient information is available to determine if a specific location in the assessment area has been exposed to a specific hazardous substance.

Fluoride has been measured in the air of the assessment area, in particular in air downwind of the ALCOA and RMC facilities, and on the Akwesasne property (Cornwall Island). Styrene has been measured in the air on the Akwesasne property, downwind of the GM facility.

6.9 SUMMARY AND CONCLUSIONS

As shown in Table 6-19, multiple natural resources have been exposed to hazardous substances in the assessment area. These hazardous substances include PCBs, PCDDs, PCDFs, fluoride, PAHs, phenols, cyanide, aluminum, and styrene. Most of the available exposure data are from RI/FS studies conducted at the ALCOA, RMC, and GM facilities during the late 1980s and early 1990s. Moreover, the absence of confirmation of exposure for specific areas or resources in the assessment area does not imply that these areas or resources were not exposed to hazardous substances. Rather, insufficient information is currently available to determine if exposure has occurred. Based on confirmed contamination and exposure pathways for other areas or resources in the assessment area, it is highly likely that exposure to hazardous substances has occurred in areas or resources currently identified as no confirmed exposure. For example, aquatic biota near the ALCOA and RMC facilities have likely been exposed to hazardous substances (see Table 6-19).

Table 6-19
Summary of Confirmed Exposure of Natural Resources to Hazardous Substances within the Assessment Area Based on Available Data

Area	Surface Water	Sediment	Ground-water	Soil	Aquatic Biota	Terrestrial Biota	Vegetation	Air
Akwesasne Property	X	X	X	X	X	X	X	X
St. Lawrence River	X	X			X	X	X	
Grasse River	X	X			X			
Raquette River	X	X		X	X	X		
St. Regis River					X	X		
ALCOA Facility	X	X	X	X			X	X
GM Facility	X	X	X	X	X			
RMC Facility	X	X	X	X			X	X

Areas left blank (i.e., not identified by an X) indicate that insufficient information is available to determine if a specific natural resource in the assessment area has been exposed to hazardous substances at a specific location. Based on confirmed contamination and exposure pathways for other areas or resources in the assessment area, it is highly likely that exposure to hazardous substances has occurred in these areas or resources currently identified as no confirmed exposure.

The available data confirm that concentrations of hazardous substances in the assessment area exceed potential background concentrations or relevant regulatory standards and criteria. Exposure of abiotic and biotic natural resources within the assessment area has been reported since the 1970s and continues into the present.

CHAPTER 7
RECOVERY PERIOD

This chapter provides a preliminary determination of the recovery period for the exposed natural resources of the assessment area [43 CFR § 11.31 (a)(2)]. This preliminary determination can "serve as a means of evaluating whether the approach used for assessing the damage is likely to be cost-effective . . ." [43 CFR § 11.31 (a)(2)]. This preliminary determination is based on existing literature and data.

A recovery period is defined as "either the longest length of time required to return the services of the injured resource to their baseline condition, or a lesser period of time selected by the authorized official and documented in the Assessment Plan" [43 CFR § 11.14 (gg)]. Services are defined as "the physical and biological functions performed by the resource including the human uses of those functions. These services are the result of the physical, chemical, or biological quality of the resource" [43 CFR § 11.14 (nn)]. The following factors may be considered in estimating recovery times:

- ecological succession patterns in the area
- growth or reproductive patterns, life cycles, and ecological requirements of biological species involved, including their reaction or tolerance to the . . . hazardous substance involved
- bioaccumulation and extent of . . . hazardous substances in the food chain
- chemical, physical, and biological removal rates of the . . . hazardous substance from the media involved . . .[43 CFR § 11.73 (c)(2)].

As shown in Sections 6.1 and 6.2 of Chapter 6, surface water and sediments of the St. Lawrence, Grasse, and Raquette rivers have been and continue to be exposed to PCBs and other hazardous substances. Natural resources will remain injured as long as environmental media such as soils, sediments, air, groundwater, and surface water remain contaminated and continue to operate as exposure pathways (see Chapter 8). As such, this preliminary determination of recovery period for the assessment area focuses on natural processes related to the loss of PCBs from environmental media.

PCBs are highly persistent compounds and degrade very slowly (Eisler, 1986; Erickson, 1997). However, PCBs can be degraded by microbial communities under both aerobic (i.e., in the presence of oxygen) and anaerobic (i.e., with no oxygen present) conditions. Aerobic microbial degradation acts primarily on selected lower chlorinated PCB congeners, ultimately producing carbon dioxide, water, and chloride ions (Erickson, 1997). Anaerobic microbial degradation involves dechlorination, where chlorine atoms are preferentially removed from the higher chlorinated congeners and lower chlorinated PCB congeners are produced (Brown et al., 1987; Abramowicz et al., 1993). Anaerobic dechlorination does not reduce the amount of PCBs present, but reduces the number of chlorine atoms on the PCB molecules.

Both aerobic degradation and anaerobic dechlorination have been documented in sediments from PCB-contaminated aquatic systems (e.g., Brown and Wagner, 1990; Flanagan and May, 1993), including in sediments from the Grasse River (Minkley et al., 1999a, 1999b). The ability of microbial communities to dechlorinate different congeners is site-specific, with different river systems showing different patterns of dechlorination, presumably related at least in part to differences in microbial communities present. Other factors that affect the rate and end products of dechlorination include the PCB concentration and the PCB congeners present (Brown et al., 1987; Rhee et al, 1993a; Sokol et al., 1994).

The total PCB sediment concentration is a primary factor regulating PCB dechlorination, with dechlorination rates increasing with increasing sediment PCB concentration (Abramowicz et al., 1993). An apparent threshold concentration may exist below which dechlorination does not occur. For example, in PCB contaminated reaches of the Hudson River — a PCB contaminated Superfund site in New York — a threshold sediment concentration of 30 mg/kg was estimated for dechlorination of PCBs (U.S. EPA, 1997b). Sokol et al. (1998) also observed a similar threshold concentrations for PCB dechlorination in sediment collected from the St. Lawrence River near the RMC facility; no dechlorination occurred at concentrations below a threshold of between 35 and 45 mg/kg. However, a recent evaluation of dechlorination studies conducted as part of the U.S. EPA's reassessment of the Hudson River PCB Superfund site concluded that a threshold concentration for dechlorination is not supported by the available data (Eastern Research Group, 1999). While dechlorination is predictable at higher PCB concentrations, there is uncertainty regarding if, and to what extent, dechlorination occurs at lower concentrations (Eastern Research Group, 1999). For example, both field and laboratory studies suggest that some limited dechlorination may be occurring at PCB concentrations less than 10 ppm in Grass River sediments (Minkley et al., 1999b).

Rhee et al. (1993b) observed that dechlorination did not occur at elevated PCB concentrations (e.g., as elevated as 1,000 or 1,500 mg/kg) indicating that dechlorination may be inhibited at extremely elevated PCB concentrations as well. Dechlorination has been observed in the laboratory in sediments collected near the ALCOA, RMC, and GM facilities (Sokol et al., 1994). However, the extent of dechlorination was highly variable, ranging from 2 to 45% of the average number of chlorine atoms per original biphenyl molecule.

As summarized in Sokol et al. (1998), natural remediation via anaerobic dechlorination appears to be limited because:

- chlorine removal decreases as sediment PCB concentration decreases
- chlorine removal is limited by the position and pattern of chlorine substitution on the biphenyl molecule
- chlorine removal only occurs above a threshold concentration of approximately 30 mg/kg.

For example, in the Hudson River it has been determined that dechlorination reduced the original PCB concentrations (on a mass basis) present in the river by less than 10% (U.S. EPA, 1997b). For the Hudson River, U.S. EPA (1997b) concluded that the remaining PCBs would not be further naturally "remediated" via dechlorination.

Other natural processes related to the loss of PCBs include volatilization and desorption into the water column (from the sediment) and migration downstream. However, both of these processes are slow relative to the mass of PCBs in the sediment.

As an alternative to natural sedimentation or dredging, ALCOA has proposed addressing the contaminated sediment in the Grasse River by applying a thin layer cap as one remediation alternative (ALCOA, 1999c). However, natural processes other than degradation that reduce the risk of exposure to hazardous substances (e.g., sedimentation and natural burial of contaminated sediments) are not considered by the St. Lawrence Environmental Trustees as examples of natural recovery. While the risk of exposure of natural resources may be minimized as a result of these processes, the hazardous substances may still pose a threat to the ecosystem in the future since the parent substance will not be degraded into nontoxic forms.

For the purposes of this assessment plan, the natural recovery time is the length of time required to return the services of the injured resources to their baseline condition [43 CFR § 11.14 (gg)]. In the Akwesasne area, the baseline condition is the reduction of these hazardous compounds to baseline levels (i.e., those before PCB releases). For example, 4,000 cubic yards of PCB contaminated soils and sediments (greater than 1 mg/kg) were placed on the northern bank of the Raquette River and in the river near the former GM Outfall. While natural processes may, over time, bury this contaminated soil and sediment with clean deposits to depths where disturbances by organisms or physical processes (e.g., severe storm events) are unlikely, this process would only reduce or minimize the risk of exposure to these hazardous substances, not eliminate them.

Based on continued bioaccumulation of PCBs in aquatic biota, the slow natural degradation rates of PCBs, and estimates of relatively long recovery periods for other PCB contaminated sites, the conclusion of the preliminary determination of the recovery period is that it is unlikely that natural recovery will occur within tens or even hundreds of years.

CHAPTER 8
INJURY ASSESSMENT APPROACHES

8.1 INTRODUCTION

Chapter 6 provided data confirming that natural resources in the assessment area have been exposed to multiple and continuing releases of hazardous substances, including PCBs, PAHs, fluorides, cyanides, phenols, aluminum, and styrene. It is likely that natural resources, including surface water, sediments, groundwater, soils, air, aquatic and terrestrial biota, and vegetation, have been and will continue to be injured as a result of this exposure. To determine the nature and extent of these injuries, the trustees will conduct an injury assessment. The purpose of the injury assessment is to determine whether natural resources have been injured [43 CFR § 11.61], to identify the environmental pathways through which injured resources have been exposed to hazardous substances [43 CFR § 11.63], and to quantify the degree and extent (spatial and temporal) of injury [43 CFR § 11.71].

DOI regulations define "injury" as a:

> . . . measurable adverse change, either long- or short-term, in the chemical or physical quality or the viability of a natural resource resulting either directly or indirectly from exposure to a . . . release of a hazardous substance, or exposure to a product of reactions resulting from the . . . release of a hazardous substance. As used in this part, injury encompasses the phrases "injury," "destruction," or "loss" [43 CFR § 11.14(v)].

This chapter provides an overview of known and suspected injuries to natural resources and describes approaches that will be used by the trustees to assess injuries in the assessment area. It is emphasized that the trustees will use existing literature and data, where available and appropriate, to determine and quantify injuries. Where these data are insufficient, additional studies may be performed.

8.2 INJURY ASSESSMENT PROCESS

The injury assessment will involve two basic steps:

1. ***Injury determination.*** The trustees will determine whether an injury to one or more natural resources has occurred as a result of releases of hazardous substances [43 CFR § 11.62].

2. ***Injury quantification.*** The injuries determined by the trustees will be quantified in terms of changes from "baseline conditions"[1] [43 CFR § 11.71(b)(2)]. Quantification will address both the spatial and temporal extent of injury, as well as evaluation of the degree of injury.

To ensure that existing data are incorporated into the assessment, the trustees have developed a phased injury assessment approach. This approach, summarized in Figure 8-1, includes the following phases:

1. ***Phase I: Data Compilation and Critical Review.*** Existing historical and current site-specific baseline and assessment area data will be compiled into electronic databases for critical evaluation. The evaluation will consist of analyzing existing data with respect to determination of sources of hazardous substance releases, exposure pathways, exposure to natural resources, and determination and quantification of injury. Existing data or information relevant to restoration planning also will be evaluated. Additional literature/document review will be conducted, as appropriate, to develop injury thresholds against which environmental exposure data may be compared, or to address any identified data gaps. Based on the results of Phase I, the trustees may conduct additional assessment studies (Phase II).

2. ***Phase II: Injury Assessment Studies.*** If data gaps are identified following Phase I, site-specific field and/or laboratory studies may be implemented to complete injury determination and quantification. Implementation of site-specific studies may also be required to facilitate restoration planning.

3. ***Phase III: Injury Determination and Quantification.*** Injury determination and quantification approaches for each natural resource are described in the following sections of this chapter.

4. ***Phase IV: Damage Determination and Restoration Planning.*** Damage determination and restoration planning approaches are described in Chapter 9.

The following sections of this chapter provide relevant injury definitions, injury determination approaches, pathway evaluation, and injury quantification approaches for each natural resource that had been potentially injured as a result of exposure to hazardous substances. Each section also reiterates that supplemental injury assessment studies (Phase II; Figure 8-1) may be implemented based on the results of the injury evaluation analysis (Phase I; Figure 8-1).

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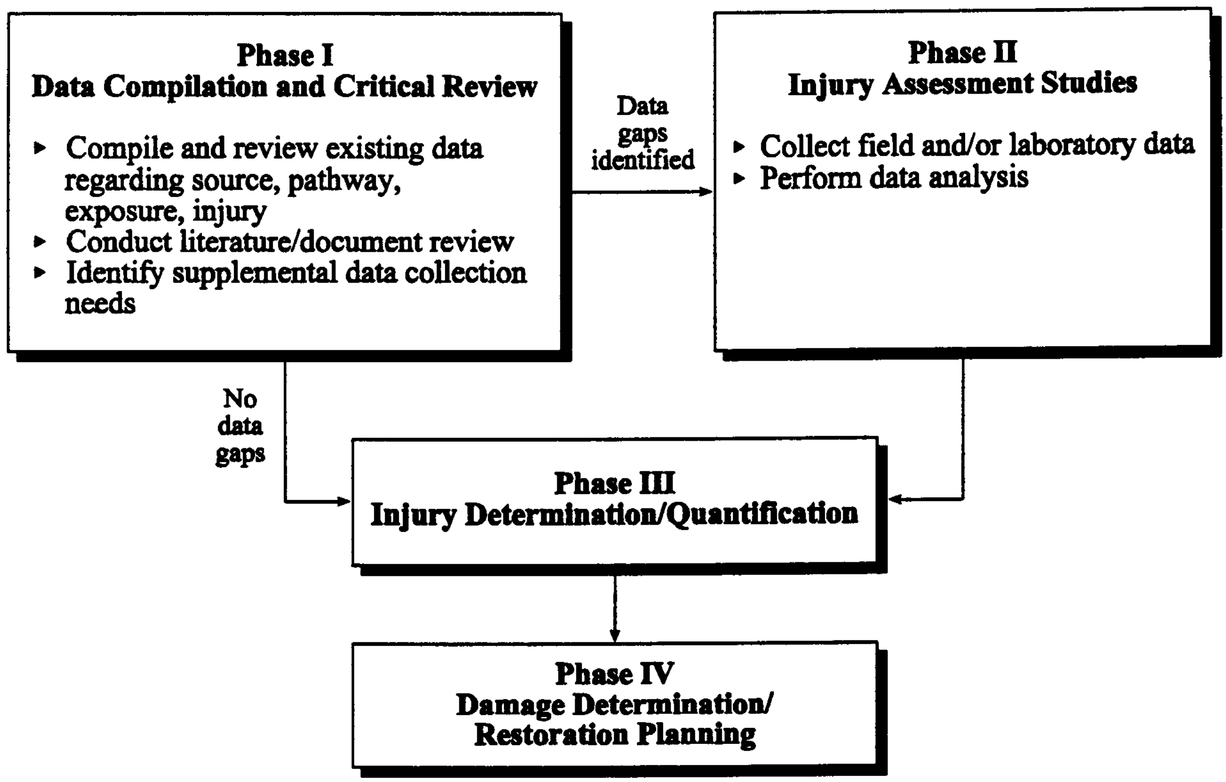
1. Baseline conditions are the conditions that "would have existed at the assessment area had the . . . release of the hazardous substance . . . not occurred" [43 CFR § 11.14(e)] and are the conditions to which injured natural resources should be restored [43 CFR § 11.14(ll)].

Figure 8-1
Phased Injury Assessment Approach to Be Implemented by the Trustees



8.3 SURFACE WATER RESOURCES

As previously discussed in Sections 6.1 and 6.2, surface water resources are defined in the DOI regulations as including both surface water and sediments suspended in water or lying on the bank, bed, or shoreline [43 CFR § 11.14(pp)]. However, because of their distinct characteristics, surface water resources and sediment resources are discussed separately in this assessment plan.

8.3.1 Injury Definitions

Based on initial review of existing data, definitions of injury relevant to evaluation of injuries to surface water resources include the following:

▸ Concentrations and duration of substances in excess of drinking water standards as established by Sections 1411-1416 of the Safe Drinking Water Act (SDWA), or by other federal or state laws or regulations that establish such standards for drinking water, in surface water that was potable before the release [43 CFR § 11.62(b)(1)(i)].

- Concentrations and duration of substances in excess of water quality criteria established by Section 1401(1)(D) of SDWA, or by other federal or state laws or regulations that establish such criteria for public water supplies, in surface water that before the discharge or release met the criteria and is a committed use as a public water supply [43 CFR § 11.62(b)(1)(ii)].

- Concentrations and duration of substances in excess of applicable water quality criteria established by Section 304(a)(1) of the CWA, or by other federal or state laws or regulations that establish such criteria, in surface water that before the release met the criteria and is a committed use as habitat for aquatic life, water supply, or recreation [43 CFR § 11.62(b)(1)(iii)].

- Concentrations and duration of substances sufficient to have caused injury to ground water, air, geologic, or biological resources, when exposed to surface water; suspended sediments; or bed, bank, or shoreline sediments [43 CFR § 11.62(b)(1)(v)].

- Concentrations of hazardous substances that exceed baseline concentrations and, as a result, cause loss of services to the Akwesasne Mohawks provided by surface water resources (including Mohawk existence values) [43 CFR § 11.14(e)].

Table 8-1 lists specific regulatory criteria and concentration thresholds that may be used to evaluate injury to surface waters as defined in 43 CFR § 11.62 (b)(1)(iii) and (v). For example, established criteria include levels of PCB concentrations intended to protect aquatic life, wild and domestic animals, and humans. Pursuant to Section 304(a) of the Clean Water Act, the U.S. EPA has established ambient water quality criteria (AWQC) for the protection of aquatic life. For PCBs, the AWQC is 14 ng/L for chronic exposures (U.S. EPA, 1999). The National Toxics Rule (NTR), which was promulgated by the U.S. EPA pursuant to the CWA, established numeric criteria for 92 priority pollutants for states and jurisdictions that had not adopted sufficient criteria necessary to comply with the CWA [57 FR 60848 et seq.; 40 CFR § 131.36]. The NTR adopted the U.S. EPA chronic AWQC for PCBs of 14 ng/L. A more restrictive criterion for PCBs was established in the Great Lakes Water Quality Guidance (GLWQG) promulgated by the U.S. EPA in 1995 under 40 CFR § 132 (revised March 12, 1997 [62 FR 11723-11731]). The revised GLWQG recommends a surface water PCB criterion of 0.12 ng/L for the protection of wildlife. New York State has established a PCB standard of 90 ng/L for the protection of human health from a drinking water source, 0.12 ng/L for the protection of wildlife, and 0.001 ng/L for the protection of human health from fish consumption (NYSDEC, 1998a).

Table 8-1
Relevant Regulatory Standards and Criteria and Relationship to Injury Definitions

Relevant Standards or Criteria		Injury Definitions: Concentrations in Excess of Water Quality Criteria or Standards	Injury Definitions: Concentrations in Excess of Drinking Water Standards
Safe Drinking Water Act	Maximum Contaminant Level (MCL)[a]		✓
	Maximum Contaminant Level Goal (MCLG)[b]		✓
	Secondary Maximum Contaminant Level (SMCL)[c]		✓
Tribal Standard (protection of drinking water)			✓
Tribal Standard (protection of aquatic life)		✓	
NYS Standard (protection of drinking water)			✓
NYS Standard (protection of wildlife)		✓	
U.S. EPA Ambient Water Quality Criteria (protection of aquatic life)		✓	
National Toxics Rule (protection of aquatic life)		✓	
Great Lakes Water Quality Guidance (protection of wild and domestic animals)		✓	
Great Lakes Water Quality Guidance (protection of human health from cancer)		✓	

a. MCL: A federally enforceable maximum permissible level of a water contaminant that is delivered to any user of a public water system.
b. MCLG: Concentration of a drinking water contaminant that is protective of adverse human health effects.
c. SMCL: Federal guidelines regrading taste, odor, color, and certain nonaesthetic effects of drinking water.

The U.S. EPA also recommends a surface water PCB concentration of 0.17 ng/L for the protection of human health from cancer resulting from consumption of contaminated organisms (U.S. EPA, 1999). This criterion is more restrictive in the GLWQG; the GLWQG recommends a surface water PCB criterion of 0.0067 ng/L for the protection of human health from cancer resulting from consumption of contaminated organisms from the Great Lakes environment (40 CFR § 132; revised March 12, 1997 [62 FR 11723-11731]).

Standards or criteria have been established for many of the hazardous substances of concern in the assessment area. For example, threshold concentrations for aluminum, fluoride, the PAH benzo(a)pyrene, PCBs, and phenols have been determined from U.S. EPA, SDWA, Tribal, and NYS regulatory standards or criteria for the protection of drinking water or for the protection of

Table 8-2
Examples of Applicable Surface Water Criteria and Standards for the Assessment Area (concentrations in μg/L)

Injury Definitions		Threshold Concentrations				
		PCBs	Aluminum	Benzo(a)pyrene	Fluoride	Phenols
Concentrations of hazardous substances in surface water in excess of Safe Drinking Water Act standards or relevant state drinking water standards.						
Safe Drinking Water Act	MCL[a]	0.5	—	0.2		1[d]
	MCLG[b]	0	—	0	4,000	0[d]
	SMCL[c]	—	200	—	2,000	—
Tribal Drinking Water Standard		0.001	—	—	—	
NYS Drinking Water Standard		0.09	—	0.002	1,500	1[e]
Concentrations of hazardous substances in excess of Ambient Water Quality Criteria or relevant state standards for the protection of aquatic life.						
NYS Standard		0.00012[f]	100	—	derived[g]	—
U.S. EPA Ambient Water Quality Criteria		0.014	87	—	—	2,560

a. MCL: A federally enforceable maximum permissible level of a water contaminant that is delivered to any user of a public water system.
b. MCLG: Concentration of a drinking water contaminant that is protective of adverse human health effects.
c. SMCL: Federal guidelines regrading taste, odor, color, and certain nonaesthetic effects of drinking water.
d. Measured as pentachlorophenol.
e. Measured as total phenols; standard based on aesthetic considerations.
f. PCB standard for protection of wildlife.
g. Concentration is derived based on the following equation: (0.02)exp ({0.907 [ln (ppm hardness)] + 7.394}).

aquatic life and wildlife (Table 8-2). These and other relevant threshold concentrations may be used to evaluate injury to surface waters from exposure to hazardous substances in the assessment area.

8.3.2 Injury Determination Approaches

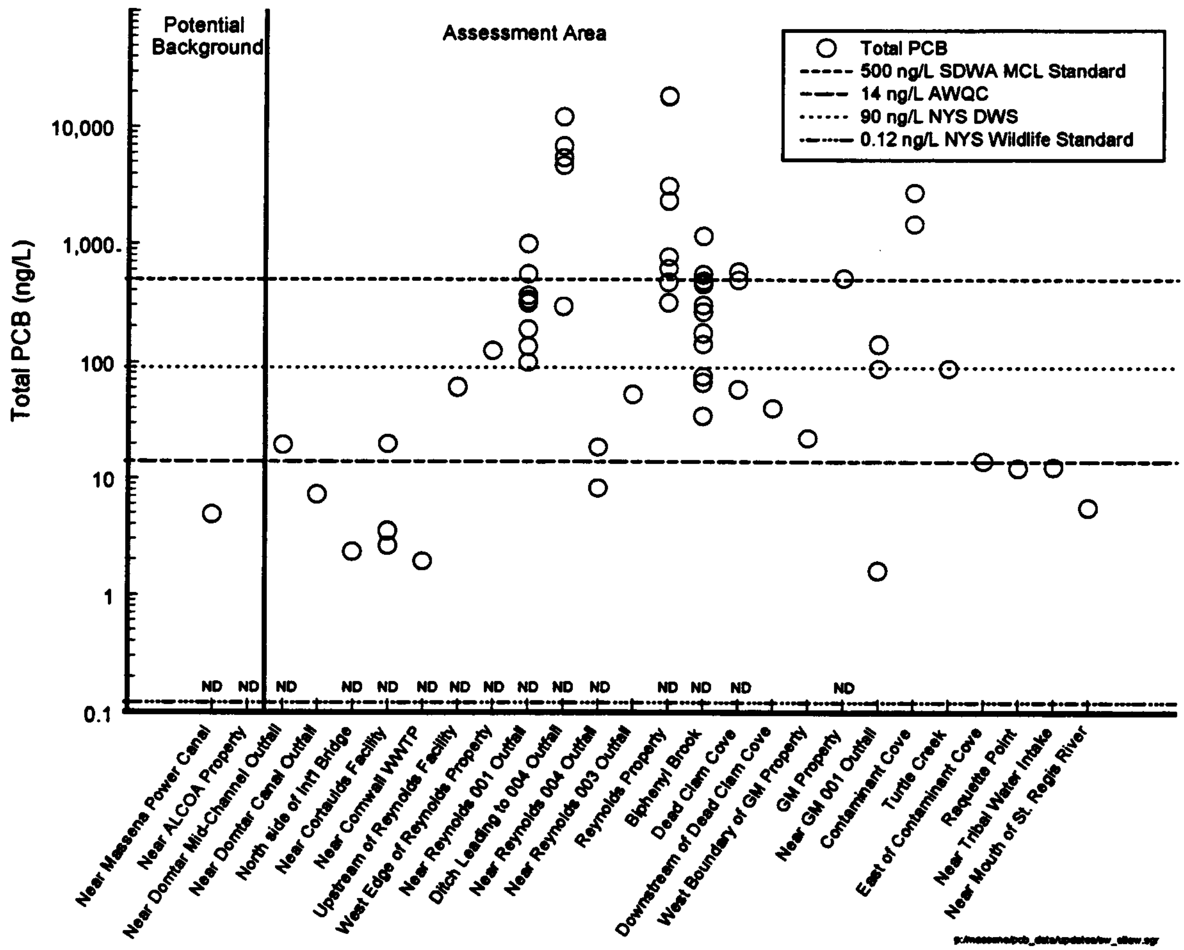
Each of the injury definitions identified in Section 8.3.1 consists of several components. Table 8-3 summarizes the components of each definition and the conceptual approach that may be taken in assessing each component. The injury determination to be undertaken for surface water resources will focus on a comprehensive analysis of existing data using the evaluation approach presented in Table 8-3.

Table 8-3
Components of Relevant Surface Water Injury Definitions

Injury Definition	Definition Components	Evaluation Approach
Water Quality Exceedences [43 CFR § 11.62(b)(1)(iii)]	Surface waters are a committed use as aquatic life habitat, water supply, or recreation.	Determine whether assessment area water bodies have committed uses.
	Concentrations and duration of hazardous substances are in excess of applicable water quality criteria.	Perform temporal and spatial comparisons of surface water concentrations to state, federal, and tribal water quality criteria/standards.
	Criteria were not exceeded before release.	Compare baseline conditions to state, federal, and tribal water quality criteria.
Drinking Water Standards Exceedences [43 CFR § 11.62 (b)(1)(i)]	Concentrations and duration of hazardous substances are in excess of applicable drinking water standards.	Perform temporal and spatial comparisons of surface water concentrations to state, federal, and tribal standards.
	Water was potable before release.	Compare baseline conditions to drinking water standards.
Biological Resources Injured when Exposed to Surface Water/Sediments [43 CFR § 11.62(b)(1)(v)]	Biological resources are injured when exposed to surface water/sediments.	Determine whether natural resources have been injured as a result of exposure to surface water/sediments.
Baseline Exceedence [43 CFR § 11.14(e)]	Surface water resources are injured when concentrations of hazardous substances exceed baseline.	Determine whether concentrations exceed baseline.
	Baseline exceedences cause loss of services to the Akwesasne Mohawks (including Mohawk existence values)	Determine whether surface water services have been lost as a result of exceedences.

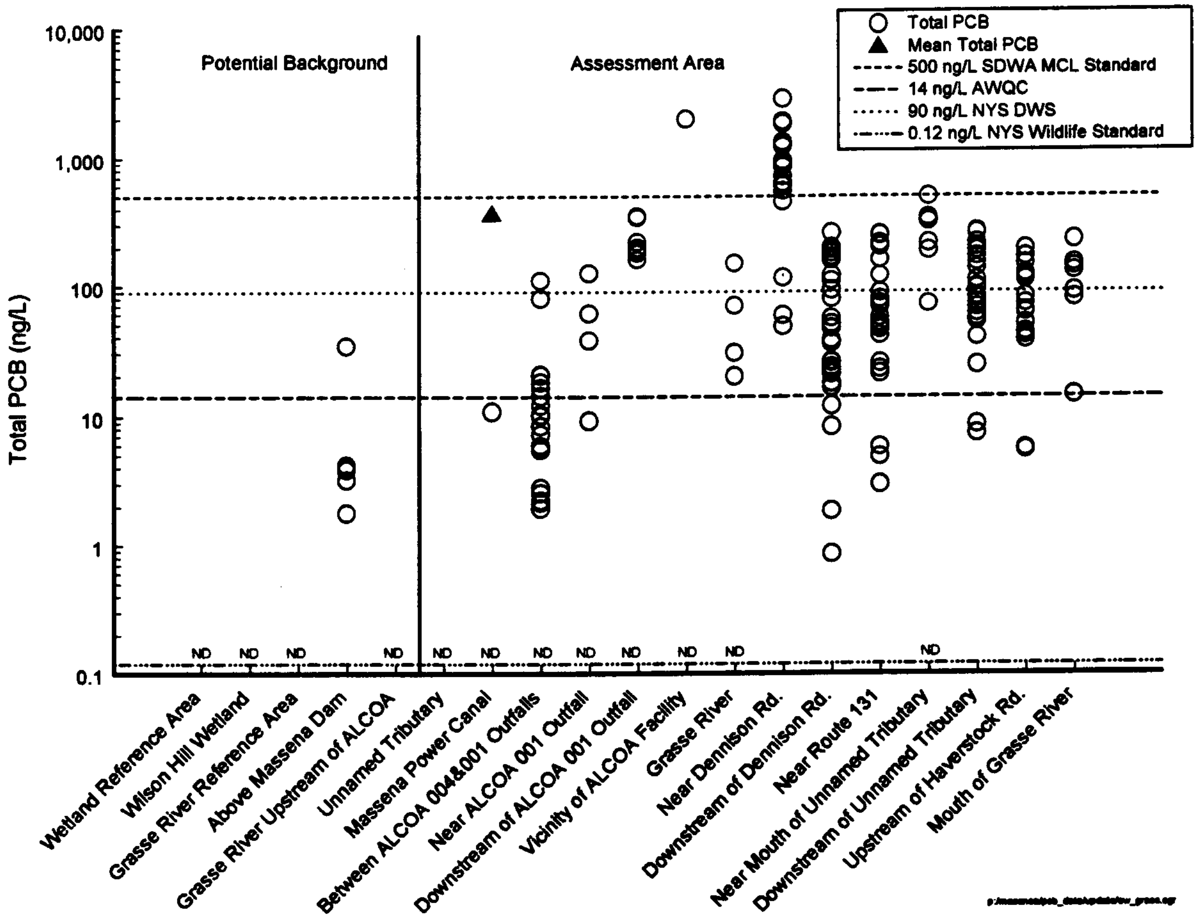
An initial review of available data suggests that surface water resources are injured according to the injury definitions presented in Table 8-3. For example, Figure 8-2 presents surface water PCB concentration data relative to PCB injury threshold concentrations. These threshold criteria include the SDWA Maximum Contaminant Level standard for PCBs in drinking water (500 ng/L), the NYS standard for PCBs in drinking water (90 ng/L), the U.S. EPA AWQC for the protection of aquatic life (14 ng/L), and the NYS standard for the protection of wildlife (0.12 ng/L) (see Table 8-2). As shown in Figure 8-2, surface water criteria/standards, particularly those greater than the U.S. EPA AWQC of 14 ng/L, are exceeded in the following areas: the St. Lawrence River in the vicinity of PRP facilities (Figure 8-2a), the Grasse River downstream of the Massena Dam (Figure 8-2b), and the Raquette River downstream of the Raquette River tributaries (Figure 8-2c).

Figure 8-2a
Total PCB Concentrations (ng/L) in Surface Water from the Assessment Area of the St. Lawrence River, 1989-1991



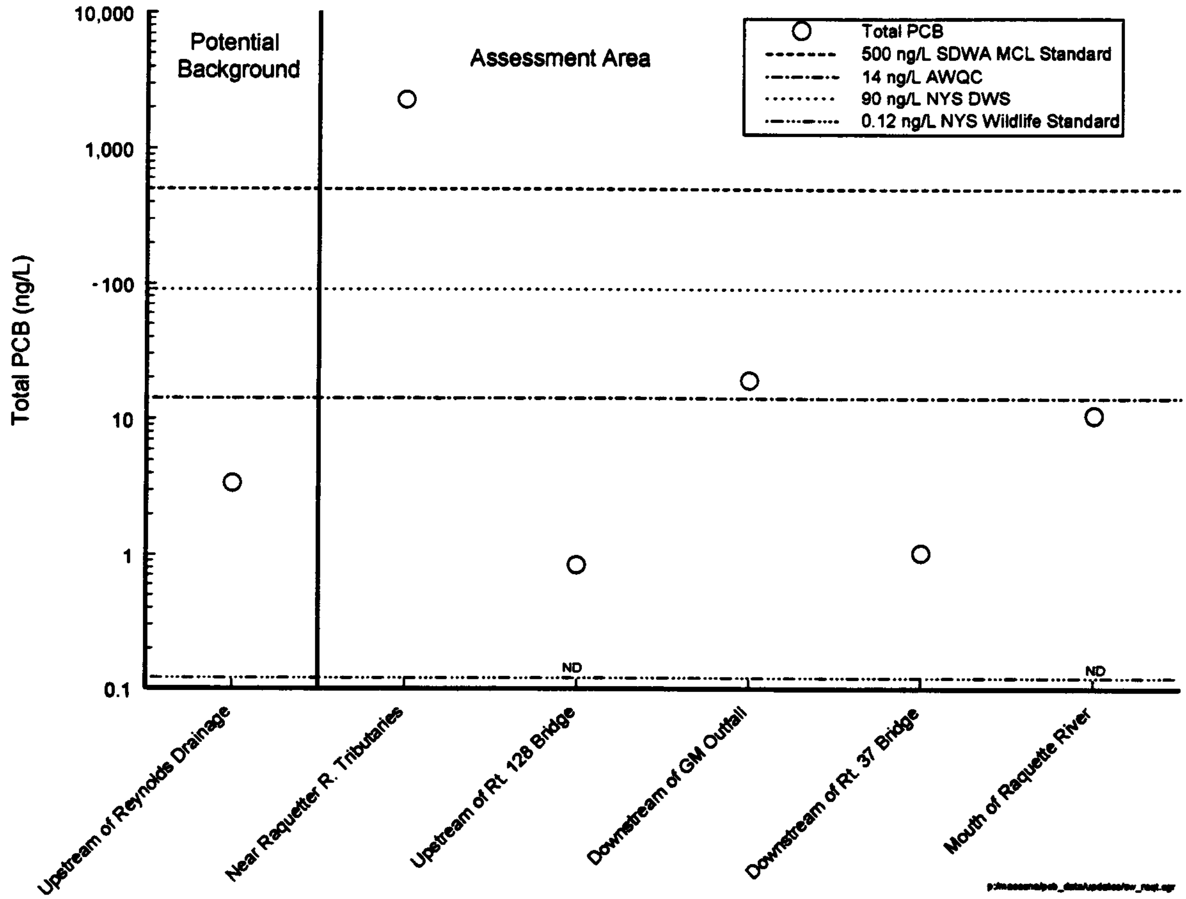
Total PCB values were derived from either the total Aroclor value (sum of all Aroclor's measured) or the total congener concentration as reported in the original source document. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Figure 8-2b
Total and Mean Total PCB Concentrations (ng/L) in Surface Water from the Assessment Area of the Grasse River, 1979-1997



Total PCB values were derived from either the total Aroclor value (sum of all Aroclor's measured) or the total congener concentration as reported in the original source document. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998) and ALCOA (1999b). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Figure 8-2c
Total PCB Concentrations (ng/L) in Surface Water of the Assessment Area from the Raquette River, 1990-1991



Total PCB values were derived from either the total Aroclor value (sum of all Aroclor's measured) or the total congener concentration as reported in the original source document. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

As discussed in Chapter 6, the detection limit in numerous studies evaluating PCB concentrations in surface waters in the assessment area was often 65 ng/L, a concentration substantially higher than relevant injury criteria. Therefore, a PCB concentration identified as not detected may be as high as 65 ng/L. Regardless, the available data clearly demonstrate a pattern of exceedences of applicable threshold criteria in surface waters within the assessment area.

Preliminary evaluation of available data has also identified apparent exceedences of applicable standards or criteria for aluminum, the PAH benzo(a)pyrene, fluoride, and phenols within the assessment area. For example, total fluoride concentrations have been measured in surface water at concentrations well above the calculated 1,730 μg/L threshold criterion (assuming surface water hardness of 80 mg/L) established by NYS for the protection of aquatic life; fluoride concentrations in excess of the NYS standard have been documented in the RMC Wetland (12,000-96,000 μg/L), the Massena Power Canal (3,000 μg/L), the 60 Acre Lagoon Marsh (7,000 μg/L), the Grasse River near ALCOA (36,000 μg/L), and the Unnamed Tributary to the Grasse River near ALCOA (4,000 μg/L).

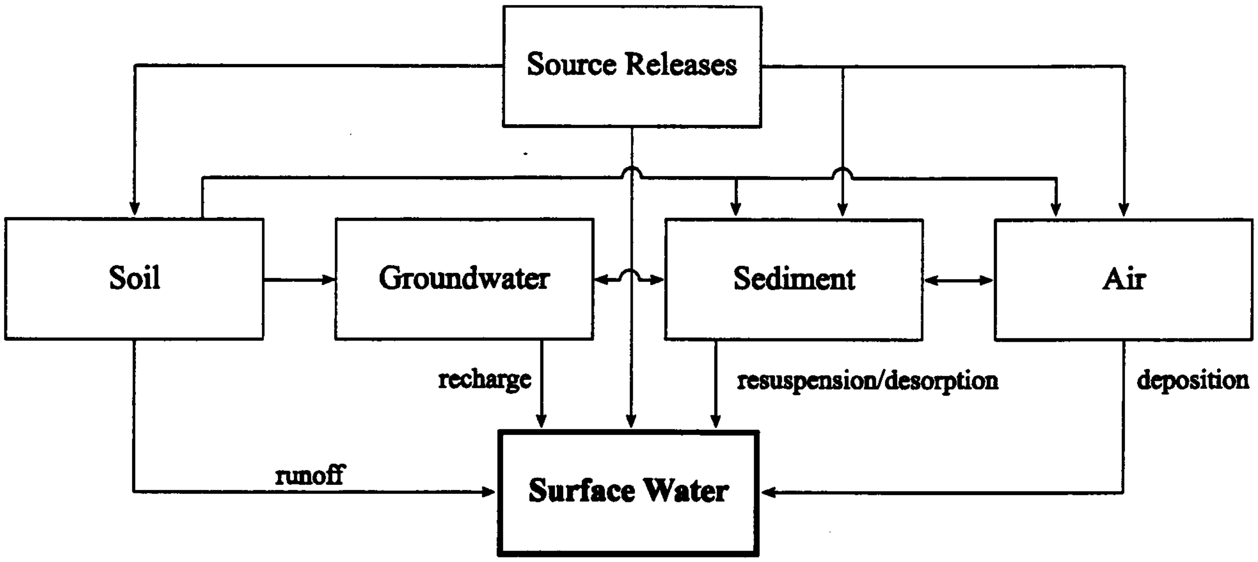
In addition to exceedences of federal, state, or tribal standards or criteria, preliminary evaluation of available surface water data suggests potential exceedences of baseline for hazardous substances of concern in the assessment area. Baseline exceedences will be evaluated as they relate to Akwesasne Mohawk values and existence values. Akwesasne Mohawk values include the direct use of plants and animals for food, medicine, or rituals, and cultural/spiritual requirements for a nonpolluted environment. Existence values relate to the values placed by the general public (and the tribe) on healthy, nonpolluted environments. Further data analysis may be performed as part of the assessment process to fully evaluate surface water injuries.

8.3.3 Pathway Evaluation

Pathways from discharge sources to surface water resources in the assessment area include direct discharges of hazardous substances to surface water, soil runoff, groundwater transport, surface water/sediment transport, and aerial transport (Figure 8-3). For example, PCBs have been directly discharged into surface waters of the assessment area from GM, RMC, and ALCOA facilities via stormwater and industrial outfalls (Chapter 2). Pathways to surface water resources can also include indirect discharges in wastewater. For example, wet-scrubbing systems for control of atmospheric emissions may contribute to fluorides in wastewaters that are discharged to surface waters. Resuspension of contaminated sediments can also expose surface water resources to PCBs and other hazardous substances. High sediment concentrations of PCBs in the Grasse River serve as a potential pathway to the surface waters of the Grasse and St. Lawrence rivers.

Existing stormwater/industrial outfall, sediment, soil, air, and groundwater contaminant data will be used to evaluate pathways of hazardous substances to surface water resources. Pathway determination will include evaluating concentrations of hazardous substances in pathway

Figure 8-3
Representative Surface Water Exposure Pathways



resources to determine if complete pathways exist from points of release and exposed natural resources. For example, Figure 8-4 demonstrates evidence of a completed pathway between sediments and surface water in the Grasse River, upstream and downstream of PCB releases by ALCOA. PCB concentrations in both surface water and sediments are low upstream of releases and increase substantially downstream of releases. Further data analysis may be performed as part of the assessment process to fully evaluate pathways to surface water resources.

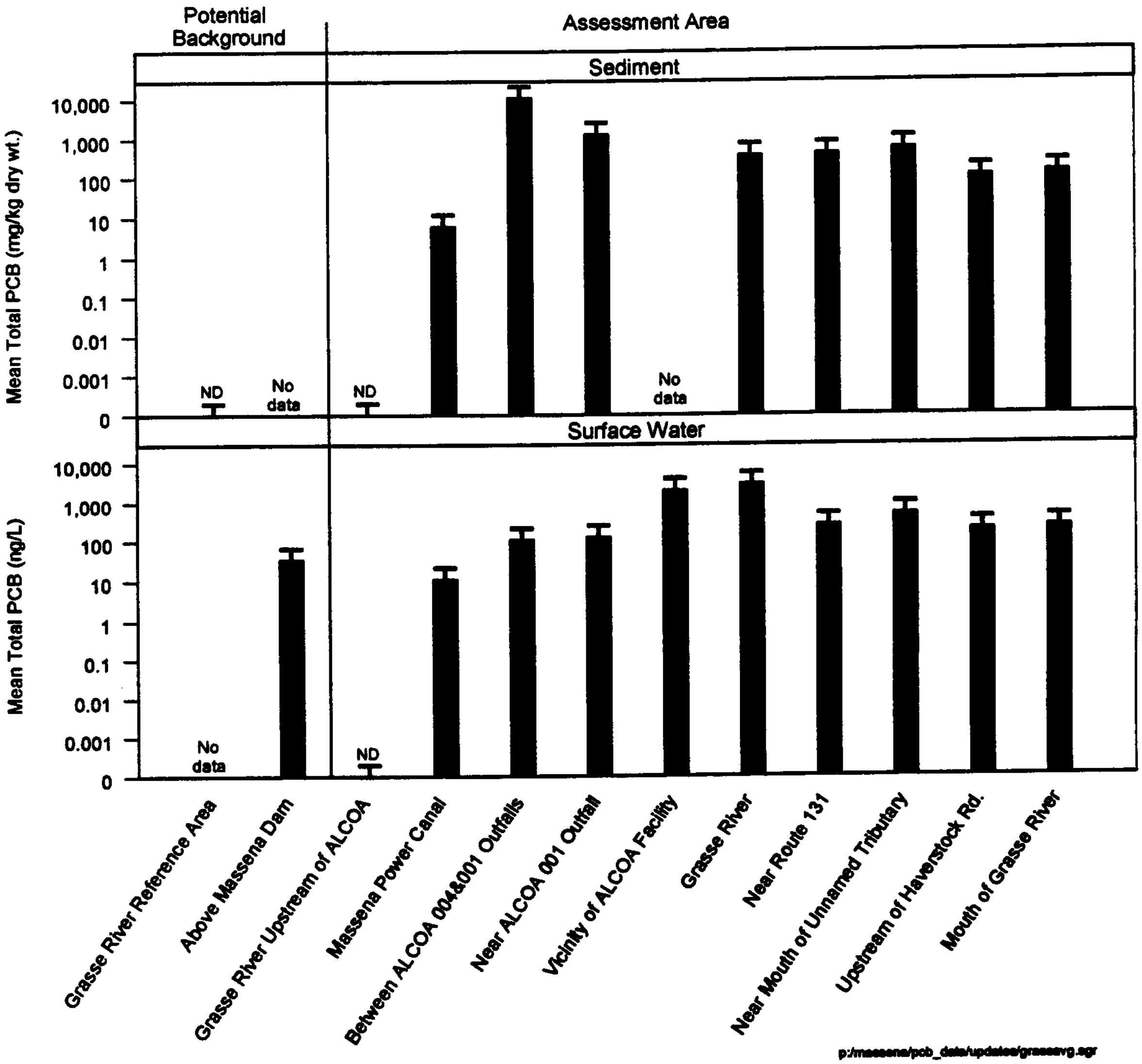
8.3.4 Injury Quantification Approaches

Quantification of injuries to surface water resources will include evaluation of:

- the spatial extent of injuries throughout the assessment area
- the temporal extent of injuries throughout the assessment area.

Geographic information system (GIS) platforms will be used to facilitate spatial quantification using the database prepared in the Phase I assessment. Existing data (Table 6-1) indicate that surface water concentrations of PCBs in the vicinity of ALCOA, RMC, and GM have exceeded surface water injury thresholds (Table 8-2). As shown in Figure 8-5a, preliminary evaluation of available surface water PCB data shows that exceedences of relevant surface water injury thresholds have occurred in the St. Lawrence, Grasse, and Raquette rivers, adjacent to or

Figure 8-4
Mean Total PCB Concentrations in Sediment (mg/kg, dry weight) and Surface Water (ng/L) from the Assessment Area of the Grasse River, 1975-1997



Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998) and ALCOA (1999b). ND denotes not detected; the concentration was below the detection limit as reported in the original source document. Error bars denote one standard deviation of the mean estimate.

downstream of ALCOA, GM, and RMC facilities. Concentrations are greatest (>500 ng/L) proximate to the ALCOA (Figure 8-5b), GM, and RMC (Figure 8-5c) facilities.

The spatial extent of hazardous substance released from PRP facilities into surface water resources will be analyzed based on the location and degree of exceedence of applicable criteria and standards. For example, as shown in Figures 8-5a, reaches of the Massena Power Canal proximate to ALCOA, the entire Grasse River downstream of the ALCOA facility, reaches of the Raquette River near GM, and reaches of the St. Lawrence River downstream of ALCOA, GM, and RMC may be potentially injured based on exceedences of the AWQC standard for the protection of aquatic life (14 ng/L) and exceedences of the SDWA Maximum Contaminant Level (500 ng/L). Figure 8-5a also shows that PCB concentrations in surface water decrease with increasing distances downstream of PRP facilities in the St. Lawrence and Raquette rivers, but still exceed the NYS standard for the protection of wildlife (0.12 ng/L) within the territory of Akwesasne.

8.3.5 Additional Studies

Available data indicate that surface waters are injured based on injury definitions presented in Table 8-3. Based on the results of Phase I injury evaluation (see Figure 8-1), additional studies may be undertaken to supplement existing data on concentrations of hazardous substances in surface waters, and pathways to exposed surface water resources in the assessment area. Any additional studies will be described in addenda to the assessment plan.

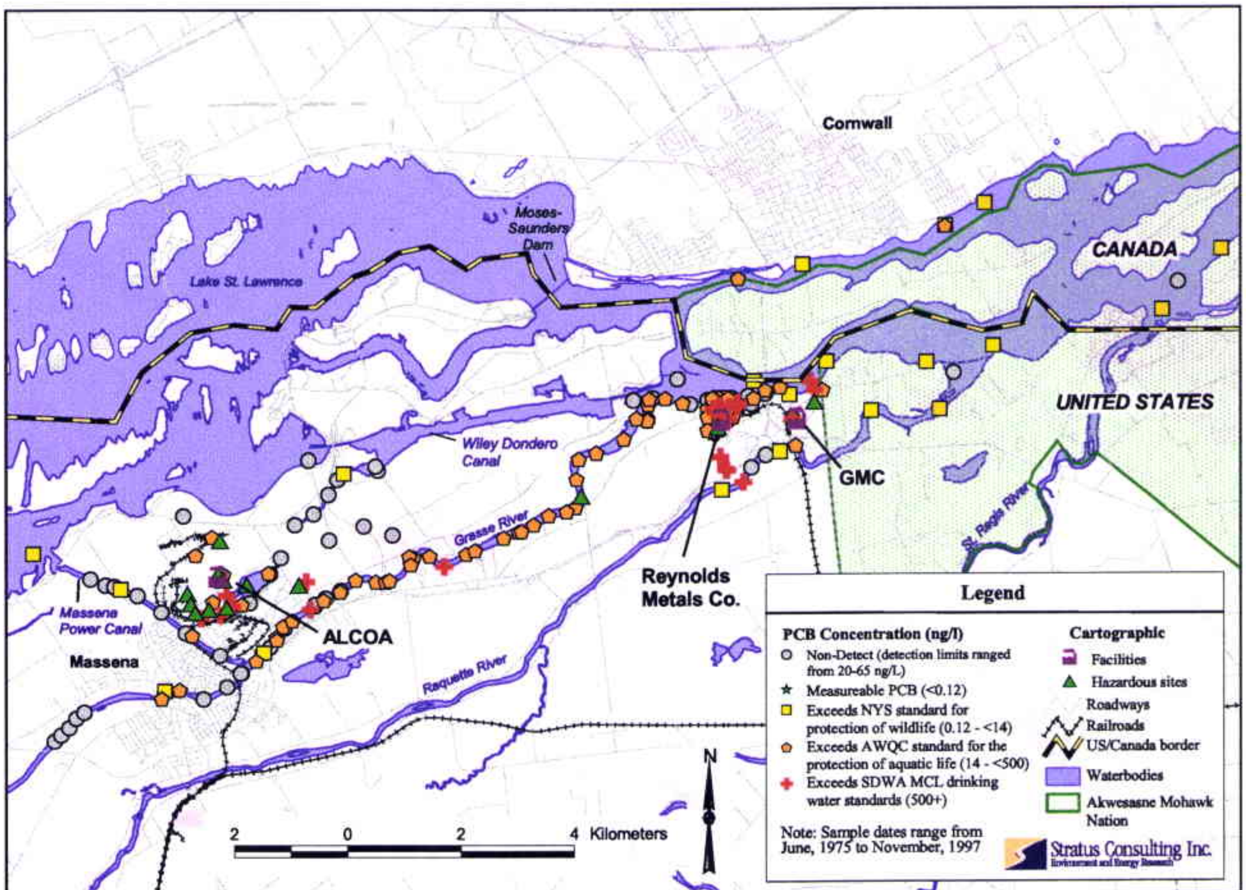
8.4 SEDIMENTS

8.4.1 Injury Definitions

Based on initial review of existing data, injuries to sediments that may be evaluated by the trustees include the following:

- Concentrations of hazardous substances sufficient to cause the sediments to exhibit characteristics identified under or listed pursuant to the Solid Waste Disposal Act [43 CFR § 11.62(b)(iv)].
- Concentrations of hazardous substances sufficient to cause injury to biological or surface water resources that are exposed to sediments [43 CFR §11.62(b)(1)(v); 11.62(e)(11)].
- Concentrations of hazardous substances in excess of relevant state or tribal sediment standards [43 CFR § 11.62(b)(iii)].

Figure 8-5a
Locations within the Assessment Areas Where Surface Water Samples Exceed Relevant New York State or Federal Water Quality Standards for Total PCBs

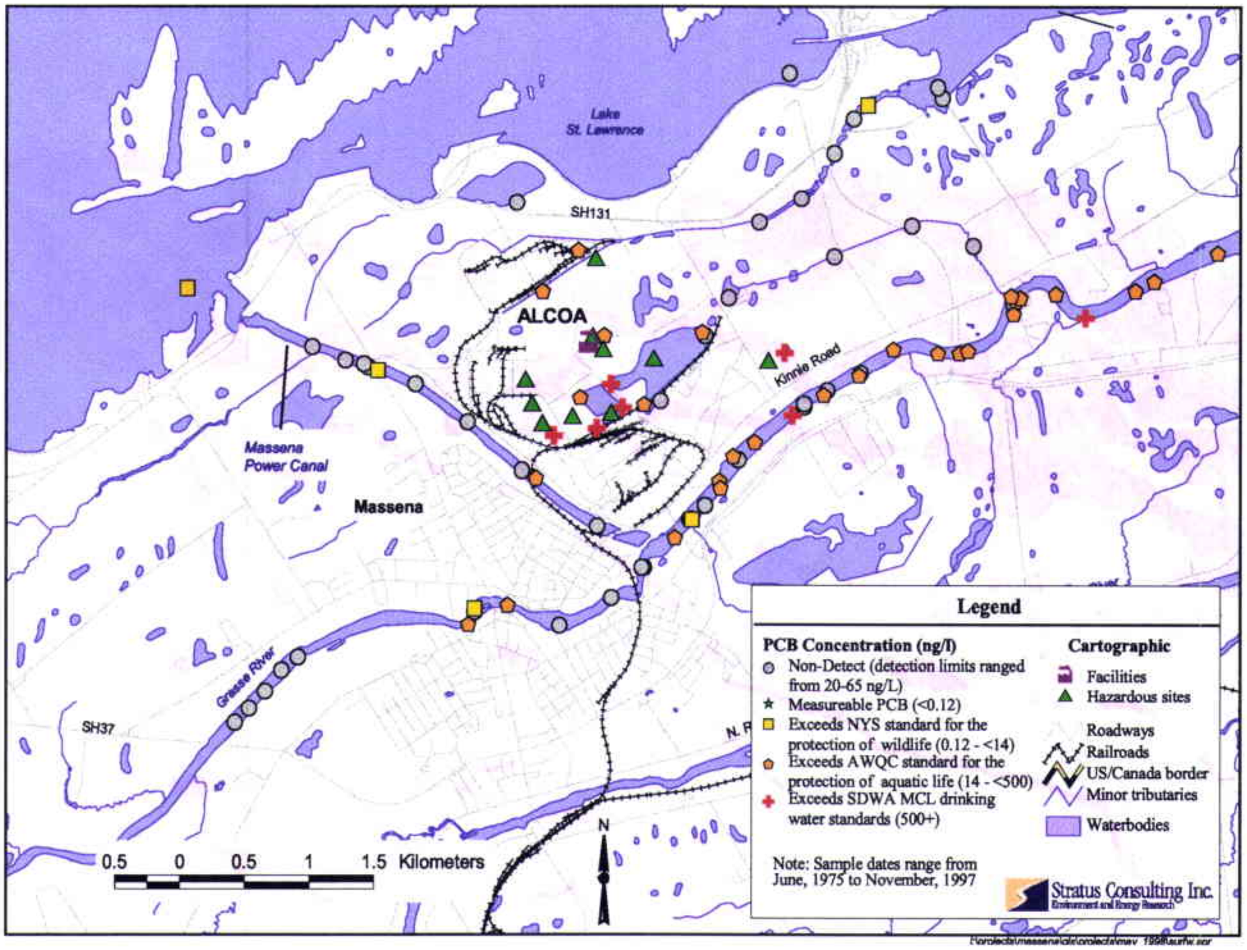


Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998) and ALCOA (1999b).

- Concentrations of hazardous substances that exceed baseline concentrations [43 CFR § 11.14(e)] and, as a result, cause loss of services to the Akwesasne Mohawks provided by sediment resources (including Mohawk existence values).

- Concentrations of hazardous substances in excess of sediment threshold concentrations (e.g., Environment Canada, 1992; Long et al., 1995; Ingersoll et al., 1996; Jones et al., 1997; Smith et al., 1996; NYSDEC, 1998b; Macdonald et al., 2000).

Figure 8-5b
Locations within the Assessment Area near ALCOA Where Surface Water Samples Exceed Relevant New York State or Federal Water Quality Standards for Total PCBs

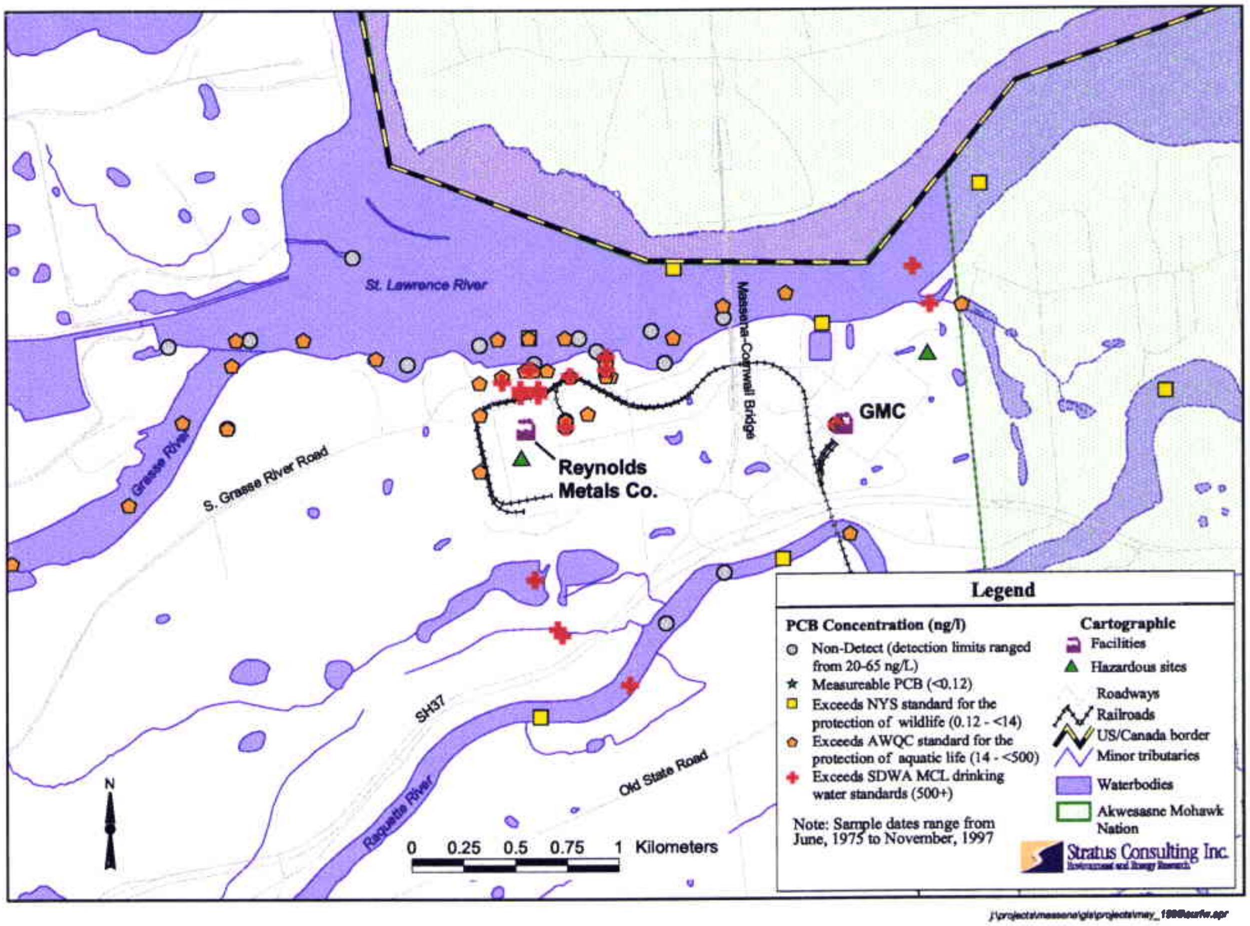


Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998) and ALCOA (1999b).

8.4.2 Injury Determination Approaches

The trustees anticipate using an evaluation approach for assessing injury to sediments similar to the approach described for surface water. Exceedences of relevant federal, state, or tribal standards will be evaluated, as will exceedences of baseline related to Akwesasne Mohawk use and existence values. Injuries to other resources caused by exposure to contaminated sediments will also be determined. For example, the Wisconsin Department of Natural Resources (WDNR, 1993) evaluated several models for estimating the PCB concentrations in surficial sediments that

Figure 8-5c
Locations within the Assessment Area near RMC and GM Where Surface Water Samples Exceed Relevant New York State or Federal Water Quality Standards for Total PCBs



Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998).

are likely to cause injury to surface water and biota. These sediment models were based on several protection endpoints, including surface water regulatory criteria, fish tissue PCB accumulation, and protection of benthic invertebrates. Table 8-4 summarizes the results of this evaluation; the threshold sediment concentrations presented range from 0.0002 to 3.409 mg/kg, depending on the protection endpoint and the type of model used. Many of the threshold concentrations are substantially less than 1.0 mg/kg.

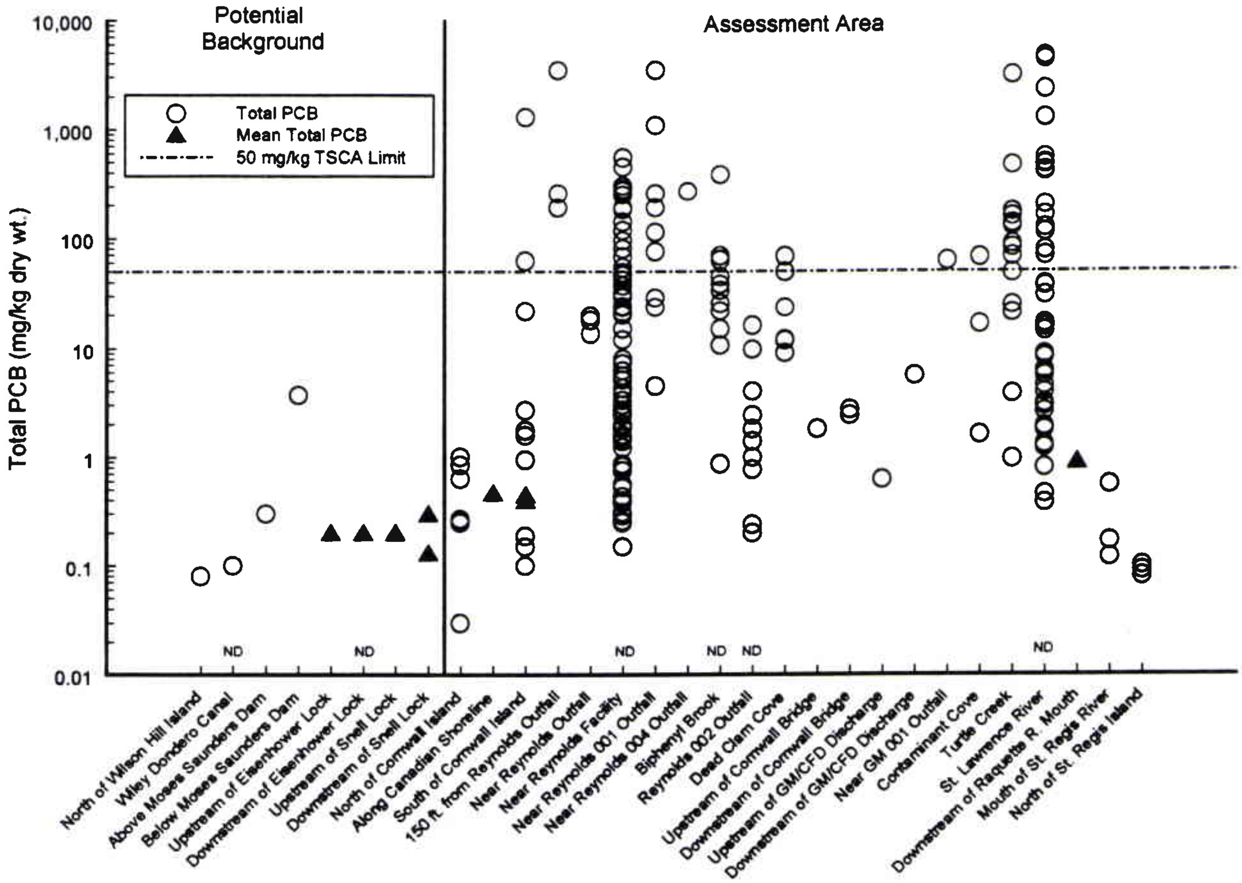
An initial review of existing data performed using this injury determination approach suggests that sediments throughout much of the assessment area may be injured. As shown in Figure 8-6, sediment samples taken in the vicinity and downstream of ALCOA, RMC, and GM facilities have PCB concentrations exceeding injury thresholds. For example, Figure 8-6 shows that many downstream sediment samples collected at various depths (majority of samples were collected from less than 61 cm in depth) in the St. Lawrence (Figure 8-6a) and Grasse (Figure 8-6b) rivers exceeded the 50 mg/kg threshold for hazardous chemical disposal under the TSCA [40 CFR § 761.60(a)(5)]. With the exception of one sample, PCB concentrations in sediments collected from the Raquette River did not exceed the 50 mg/kg threshold for hazardous chemical disposal under the TSCA (Figure 8-6c). However, injury to other resources likely occurs at sediment concentrations well below the TSCA limit of 50 mg/kg (see Table 8-4). Further data analysis may be performed as part of the assessment process to evaluate sediment injuries fully.

8.4.3 Pathway Evaluation

The physical and chemical properties of a hazardous substance will influence how it accumulates in sediment. For example, once released into the environment, the relatively low water solubility of PCBs dominates their environmental fate and transport. In the environment, PCBs are strongly adsorbed onto soils, sediments, and particulates; the highest environmental concentrations typically are measured in aquatic sediments containing microparticulates and high organic or clay content (Eisler, 1986). In aquatic systems, sediments are a primary transport mechanism and sink for PCBs (Thomann and Connolly, 1984; Ram and Gillett, 1993). Consequently, important pathways to injured sediments include the settling of PCBs from contaminated surface water and contaminant soil, the resuspension of contaminated sediments, and input from contaminated groundwater sources (Figure 8-7). Another important pathway is direct disposal of contaminated sediment on river banks or in river sediments. For example, contaminated GM site soil was disposed of on the banks of the north bank of the Raquette River (see Chapter 2).

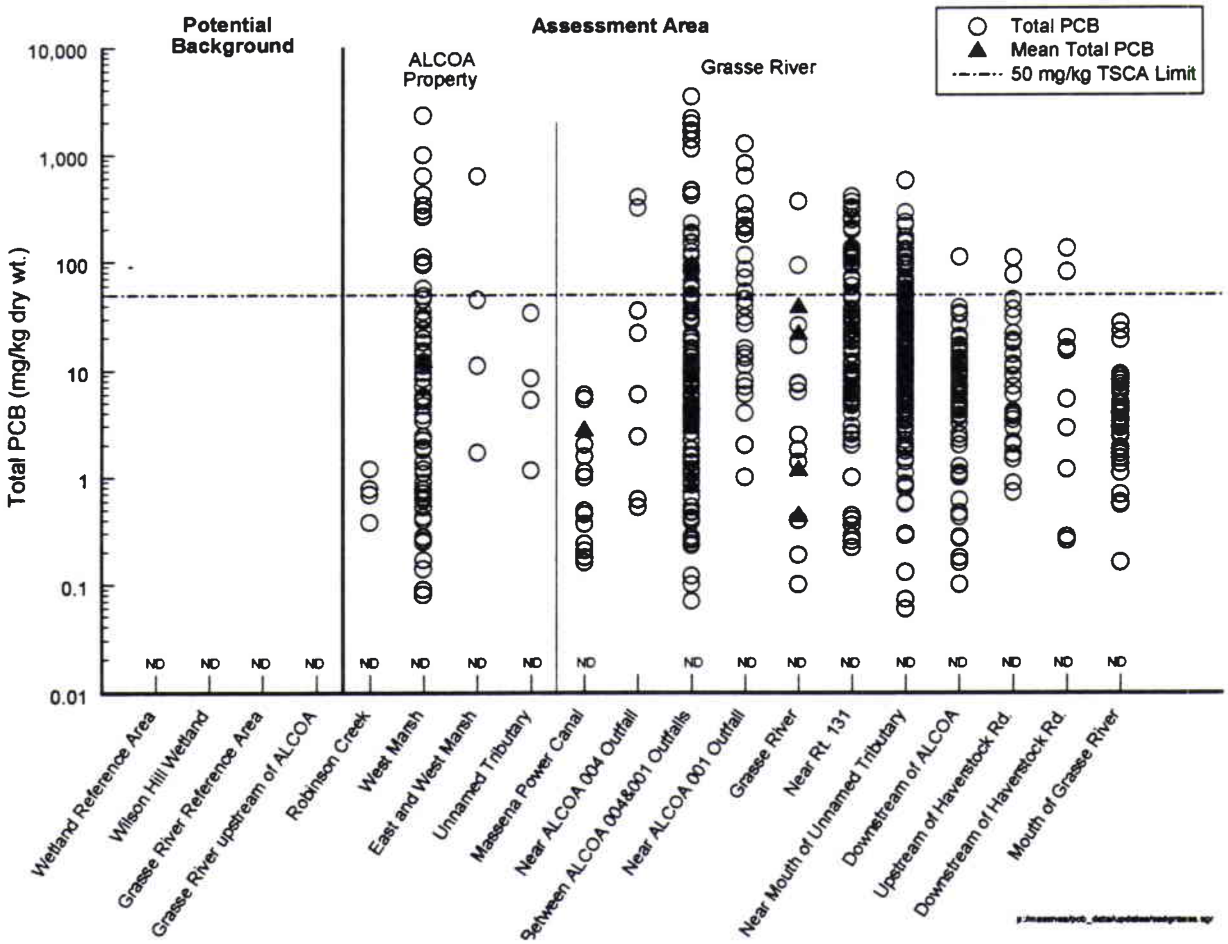
Data on sediment concentrations and distributions, coupled with physical transport data and models, may be used to evaluate sediment transport pathways of hazardous substances. For example, Vanier et al. (1996) suggest that local point sources of PCBs (e.g., Contaminant Cove), river hydrology, physicochemical processes, and microbial dechlorination of PCBs are important factors in explaining the fate of PCBs in the St. Lawrence River sediments. Existing stormwater/industrial outfall, surface water, soil, and groundwater contaminant data will be used to evaluate pathways of hazardous substances to sediment resources. Pathway determination will include evaluating concentrations of hazardous substances in pathway resources to determine if complete pathways exist from points of release and exposed natural resources. Further data analysis may be performed as part of the assessment process to fully evaluate pathways to sediment resources.

Figure 8-6a
Total and Mean Total PCB Concentrations (mg/kg, dry weight) in Sediments from the Assessment Area of the St. Lawrence River, 1975-1990



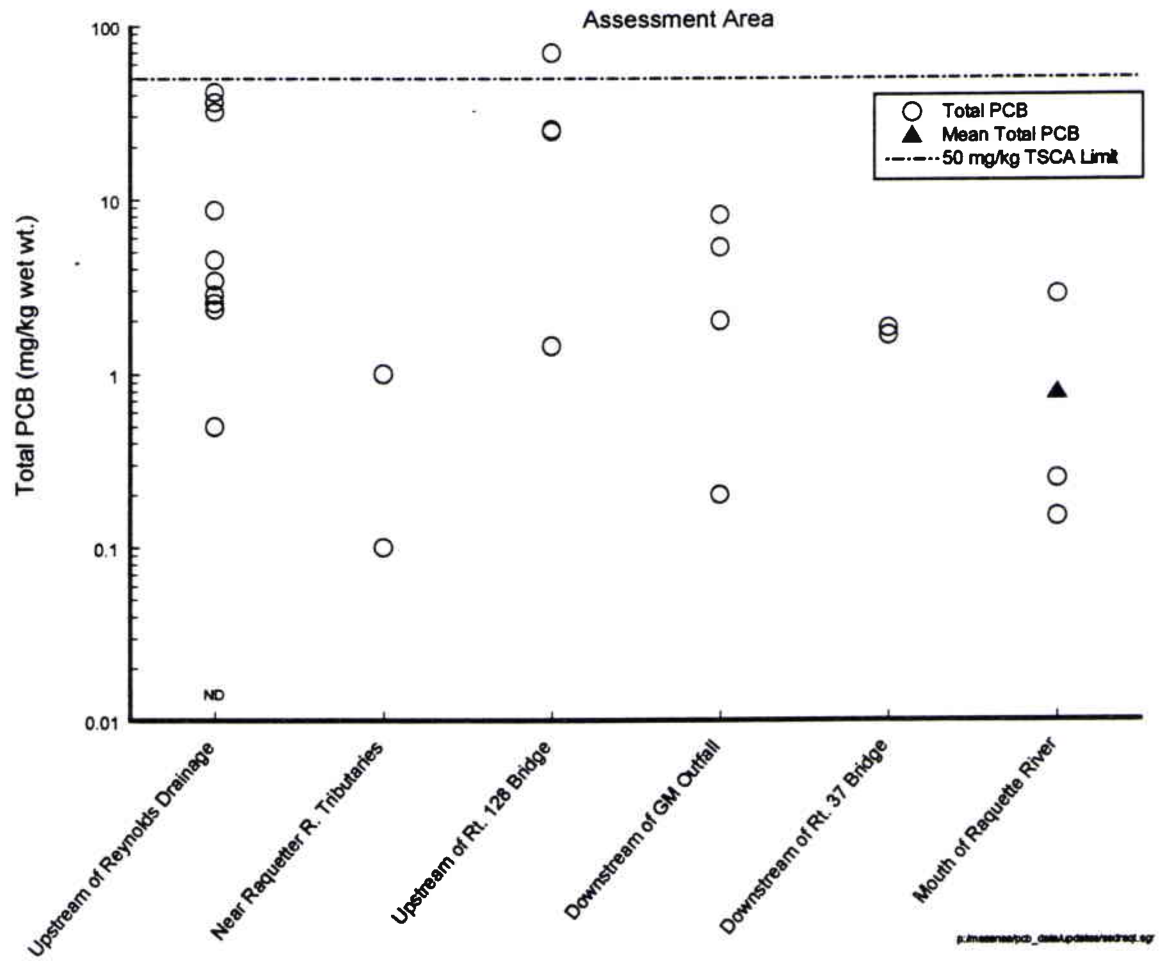
Total PCB values are a combination of summed Aroclor values and values reported as "Total PCB" by the source documents. Mean Total PCB values are values that were reported as means of Total PCB values by the source documents. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Figure 8-6b
Total and Mean Total PCB Concentrations (mg/kg, dry weight) in Sediments from the Assessment Area of the Grasse River, 1975-1997



Total PCB values are a combination of summed Aroclor values and values reported as "Total PCB" by the source documents. Mean Total PCB values are values that were reported as means of Total PCB values by the source documents. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998) and ALCOA (1999b). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Figure 8-6c
Total and Mean Total PCB Concentrations (mg/kg, dry weight) in Sediments from the Assessment Area of the Raquette River, 1975-1991



Total PCB values are a combination of summed Aroclor values and values reported as "Total PCB" by the source documents. Mean Total PCB values are values that were reported as means of Total PCB values by the source documents. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Table 8-4
Summary of Potential Sediment PCB Injury Thresholds Associated with Injuries to Other Natural Resources[a]

Injury Endpoint	Type of Model	Threshold Sediment PCB Concentration (mg/kg)
Causes surface water concentrations to exceed 0.49 ng/L (NR 105 human cancer criterion — warm water fisheries)	Equilibrium partitioning	0.004-0.020
Causes surface water concentrations to exceed 3.0 ng/L (NR 105 wild and domestic animal criterion)	Equilibrium partitioning	0.022-0.123
Causes PCB concentrations in edible fish fillets to exceed 2 mg/kg FDA tolerance level for protection of human health	Accumulation relative to sediments	0.200-1.000
	Thermodynamic equilibrium	0.188-1.038
	Bioconcentration	0.616-3.409
	Food chain multiplier	0.035-0.104
Causes whole fish PCB concentrations to exceed 0.100 mg/kg IJC objective for protection of piscivorous birds and mammals	Accumulation relative to sediments	0.010-0.050
	Thermodynamic equilibrium	0.0045-0.026
	Bioconcentration	0.015-0.082
	Food chain multiplier	0.0009-0.0026
Causes PCB concentrations in whole fish to exceed 0.023 mg/kg GLWQG for protection of piscivorous wildlife	Accumulation relative to sediments	0.002-0.012
	Thermodynamic equilibrium	0.001-0.006
	Bioconcentration	0.004-0.020
	Food chain multiplier	0.0002-0.0006
Causes surface water PCB concentrations to exceed 14 ng/L U.S. EPA chronic AWQC for protection of aquatic life	Equilibrium partitioning	0.070-0.554
Exceeds lowest effect level (LEL) for protecting 95% of benthic invertebrate species from Aroclor 1248 — Ontario Ministry of the Environment	Organic carbon- and aroclor-dependent	0.030-0.240
Exceeds apparent effects threshold (AET) for protecting marine invertebrates — State of Washington sediment standards	Organic carbon-dependent; based on lab bioassays	0.120-0.960
Exceeds AET for protecting marine invertebrates — NOAA	Data from equilibrium partitioning models and spiked-sediment toxicity tests	0.370
Exceeds minimal effect threshold (MET) for protecting benthic organisms from total PCBs	Organic carbon-dependent interim criteria for St. Lawrence River sediment	0.2[b]
Exceeds probable effects level (PEL) for protecting *Hyalella azteca* and *Chironomus riparius* from total PCBs	Based on laboratory toxicity tests with *H. azteca* and *C. riparius* and field-collected sediments	0.24[c]

Table 8-4 (cont.)
Summary of Potential Sediment PCB Injury Thresholds Associated with Injuries to Other Natural Resources[a]

Injury Endpoint	Type of Model	Threshold Sediment PCB Concentration (mg/kg)
Exceeds PEL for protecting aquatic organisms from total PCBs	Based on laboratory toxicity tests and field assessments of benthic community structure	0.277[d]
Exceeds effects range-median (ER-M) for protecting aquatic organisms from total PCBs	Based on laboratory toxicity testing, modeling and field studies	0.18[e]
Exceeds concentration protective of piscivorous wildlife based on PCBs bioaccumulation.	Organic carbon-dependent; based on equilibrium partitioning model	1.4[f]
Exceeds mid-range effect concentration for protection of sediment dwelling organisms from total PCBs	Consensus approach based on integrating existing sediment effects concentrations	0.4[g]

a. Source WDNR, 1993, unless otherwise denoted.
b. Environment Canada, 1992.
c. Ingersoll et al., 1996.
d. Smith et al., 1996.
e. Long et al., 1995.
f. NYSDEC, 1998a.
g. MacDonald et al., 2000.

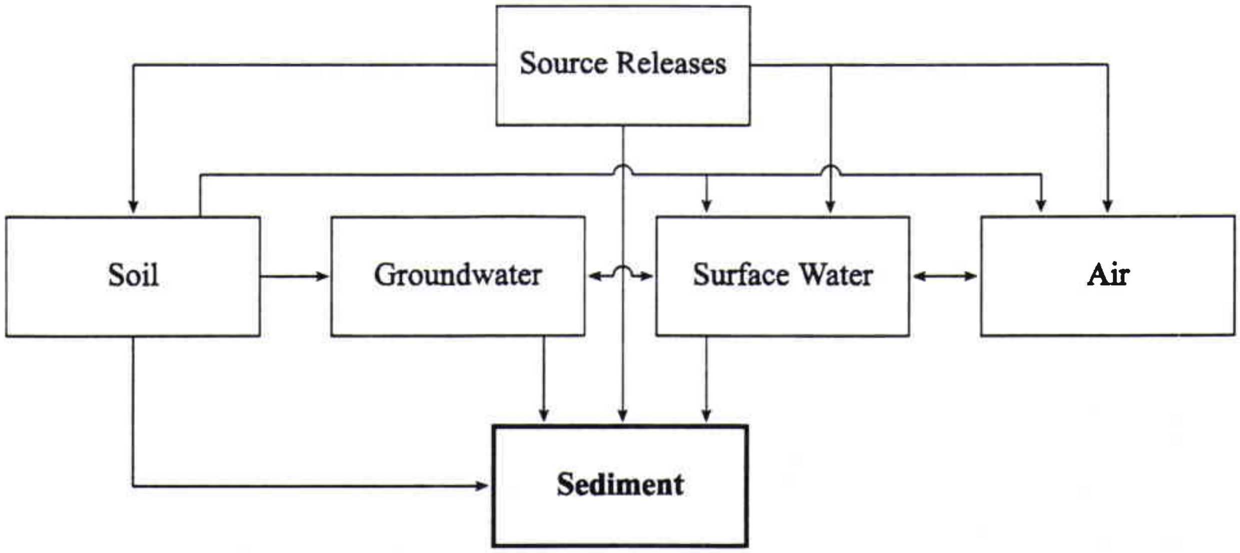
8.4.4 Injury Quantification Approaches

Quantification of injuries to sediment resources will include an evaluation of:

- the spatial extent of injuries throughout the assessment area
- the temporal extent of injuries throughout the assessment area.

GIS platforms will be used to facilitate spatial quantification using the database prepared in the Phase I assessment. Existing data indicate that concentrations of PCBs in sediment near the ALCOA, RMC, and GM facilities have exceeded sediment injury thresholds (Table 8-4) for at least 15 years (see Table 6-3). As shown in Figure 8-8a preliminary evaluation of available sediment PCB data shows that exceedences of relevant sediment injury thresholds have occurred in the St. Lawrence, Grasse, and Raquette rivers, adjacent to or downstream of the ALCOA, GM, and RMC facilities. Similar to surface water PCB concentrations, sediment PCB concentrations are highest (greater than 50 mg/kg, dry weight) in the Grasse River, near and downstream of ALCOA (Figure 8-8b), and in the St. Lawrence River proximate to the GM and RMC facilities

Figure 8-7
Representative Sediment Exposure Pathways



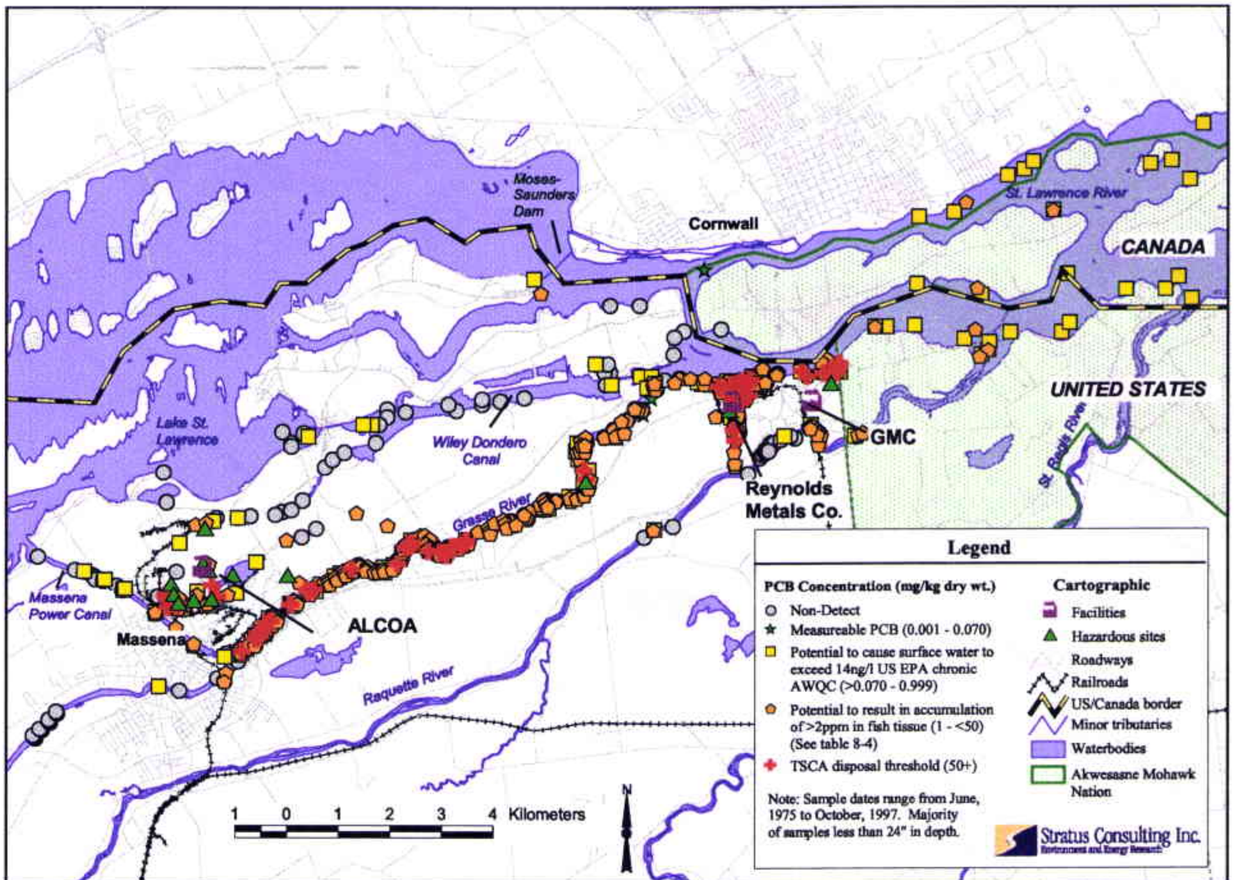
(Figure 8-8c). In addition, sediment PCB concentrations projected to be sufficiently elevated to result in predicted PCB accumulation in fish tissue in excess of the FDA tolerance limit of 2 mg/kg (see Table 8-4) are present in the lower reaches of the Grasse River (Figure 8-8b) and in the Raquette River downstream of GM Outfall 002 (Figure 8-8c).

The spatial extent of hazardous substance in sediment resources will be analyzed based on the location and degree of exceedence of applicable criteria and standards. For example, reaches of the Massena Power Canal proximate to ALCOA, reaches of the Grasse River downstream of ALCOA, and reaches of the St. Lawrence River downstream of ALCOA, GM, and RMC facilities may be potentially injured because of exceedences of sediment injury threshold concentrations that injure other natural resources (e.g., surface water, biota) and because of exceedences of the TSCA hazardous waste disposal threshold (50 mg/kg) (Figure 8-8a). Figure 8-8a also shows that concentrations of PCBs decrease with increasing distances downstream of PRP facilities in the St. Lawrence and Raquette rivers, but still exceed potential sediment injury thresholds (greater than 1 mg/kg) within the territory of Akwesasne.

8.4.5 Additional Studies

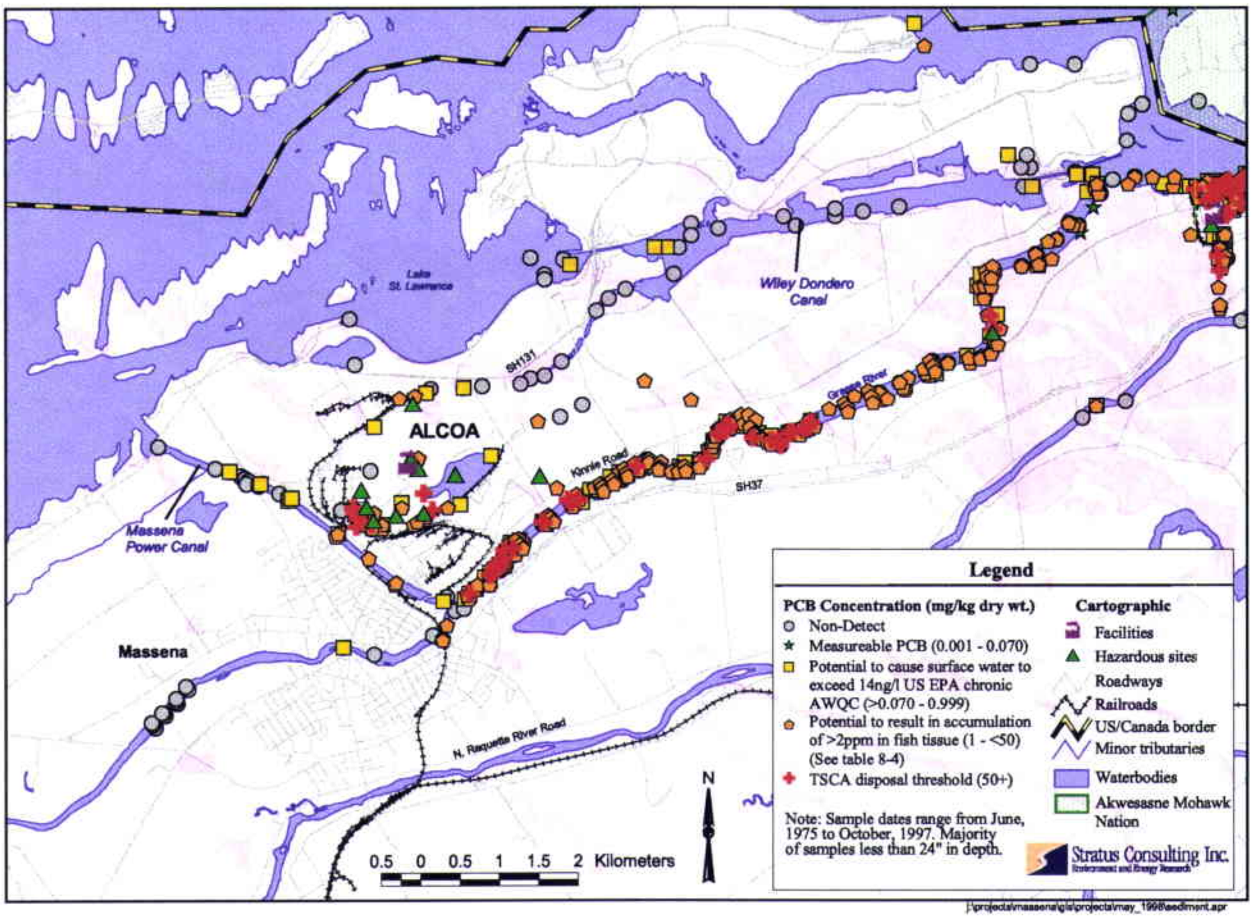
Available data indicate that sediments are injured based on injury definitions presented in Section 8.4.1 and as summarized in Table 8-4. Based on the results of Phase I injury evaluation (see Figure 8-1), additional studies may be undertaken to supplement existing data on

Figure 8-8a
Locations within the Assessment Area Where Sediment Concentrations of Total PCBs Exceed the TSCA Hazardous Waste Disposal Threshold or Potentially Injure Other Natural Resources



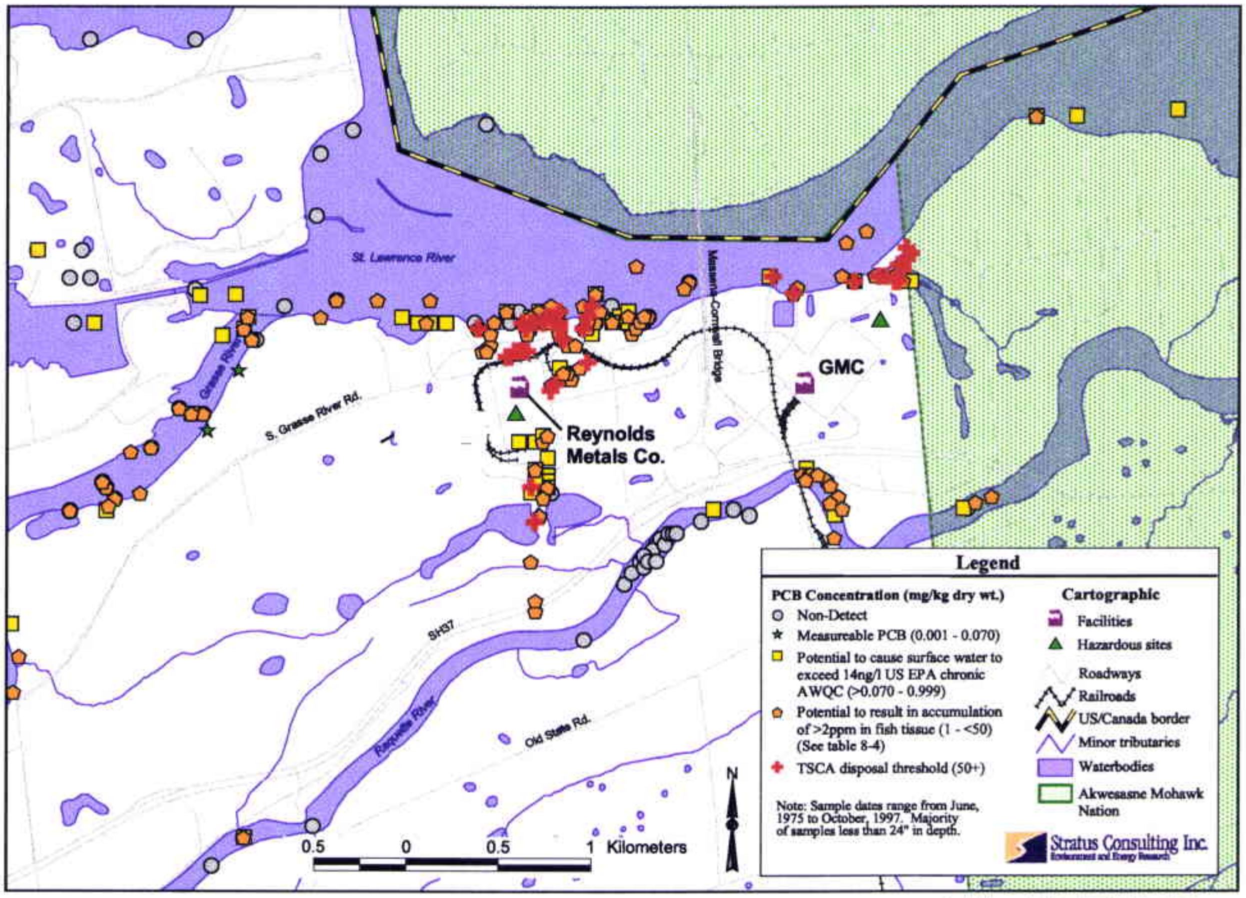
Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998) and ALCOA (1999b).

Figure 8-8b
Locations within the Assessment Area near ALCOA Where Sediment Concentrations of Total PCBs Exceed the TSCA Hazardous Waste Disposal Threshold or Potentially Injure Other Natural Resources



Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998) and ALCOA (1999b).

Figure 8-8c
Locations within the Assessment Area near RMC and GM Where Sediment Concentrations of Total PCBs Exceed the TSCA Hazardous Waste Disposal Threshold or Potentially Injure Other Natural Resources



Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998) and ALCOA (1999b).

concentrations of hazardous substances in sediments, and pathways to exposed sediments in the assessment area. In addition, injury to sediments may be examined by evaluating impacts to sediment-dwelling invertebrates. Any additional studies will be described in addenda to the assessment plan.

8.5 GROUNDWATER RESOURCES

8.5.1 Injury Definitions

Based on initial review of existing data, injuries to groundwater resources that may be evaluated by the trustees include the following:

- Exceedences of drinking water standards, established by sections 1411-1416 of the SDWA, or by other federal or state laws or regulations that establish such standards for drinking water, in groundwater that was potable before release [43 CFR § 11.62(c)(i)].
- Exceedences of AWQC established by section 304(a)(1) of the CWA, or by other federal or state laws or regulations that establish such criteria for domestic water supplies, in groundwater that before the release met the criteria and is a committed use as a domestic water supply [43 CFR § 11.62(c)(iii)].
- Concentrations of hazardous substances in groundwater sufficient to have caused injury to surface water, air, geologic, or biological resources, when exposed to groundwater [43 CFR § 11.62(c)(iv)].
- Concentrations of hazardous substances that exceed baseline concentrations [43 CFR § 11.14(e)] and, as a result, cause loss of services to the Akwesasne Mohawks provided by groundwater resources (including Mohawk existence values).

8.5.2 Injury Determination Approaches

Based on the injury definitions described in Section 8.5.1, the trustees anticipate assessing groundwater injuries using an approach similar to that described for surface water and sediment resources. The evaluation will include identifying committed uses and potability of groundwater resources, concentrations and duration of hazardous substances in groundwater, exceedences of state or federal drinking water standards, and exceedences of baseline. Examples of applicable standards for the assessment area are provided in Table 8-2.

A preliminary review of the available groundwater data (primarily from RI/FS data collected at GM, RMC, and ALCOA) suggests that groundwater resources have been injured. For example, PCB concentrations in groundwater wells adjacent to Akwesasne property have been measured up to 41,000 ng/L (Dames and Moore, 1982 as cited in Bobrow et al., 1983; see Table 6-5), far in excess of the SDWA MCL of 500 ng/L and the NYS standard of 90 ng/L for PCBs in groundwater. Mean concentrations of PCBs in groundwater monitoring wells on ALCOA (Figure 8-9a) and RMC (Figure 8-9b) properties also routinely exceed relevant federal SDWA and NYS groundwater standards. In addition, the NYS objective for soil cleanup of subsurface soils to protect groundwater quality is 10 mg/kg total PCBs in soil at an organic carbon content of 5% (NYSDEC, 1994). As discussed in Section 6.4, PCBs have been measured in soils collected from the assessment area well in excess of 10 mg/kg. Hence, the potability of groundwater exposed to these PCB contaminated soils is most likely compromised.

Additional assessment activities will focus on acquiring site-specific and recent groundwater contaminant data. The evaluation will include:

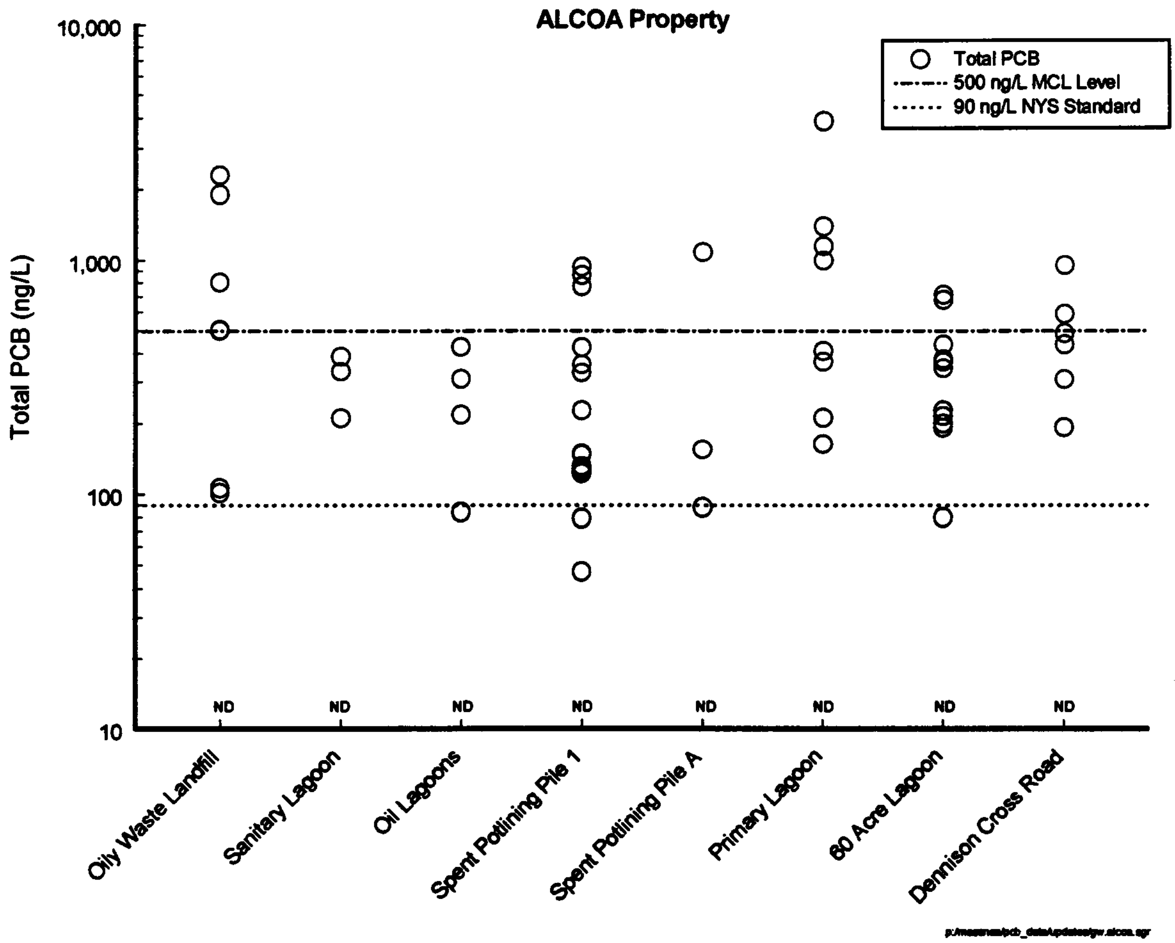
- delineating the aquifers
- identifying the location of all existing wells
- determining committed uses of groundwater sources
- evaluating the need for additional groundwater contaminant data.

Appropriate groundwater background contaminant data also will be evaluated to determine a baseline. Potential background aquifers will be selected based on the following criteria:

- similar geology to that of impacted areas
- similar groundwater flow patterns and systems to those of impacted areas
- location of wells away from obvious sources of hazardous substances and associated plumes
- consideration of groundwater type and other geochemical indicators that may distinguish uncontaminated from contaminated groundwater.

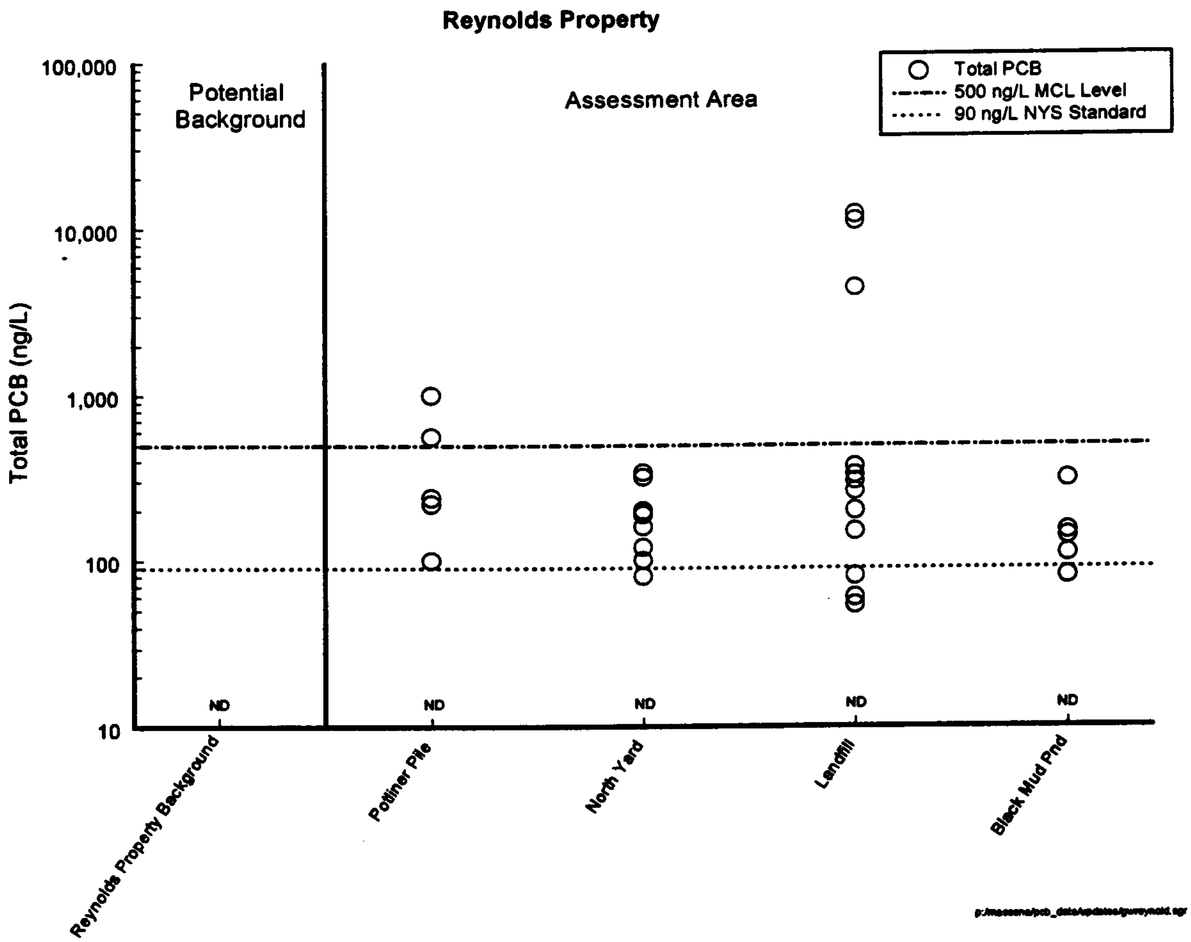
This information will be necessary to evaluate the spatial extent of injuries, delineate vertical and horizontal distribution and movements of contaminant plumes, and determine if groundwater is a significant pathway of exposure to other abiotic and biotic resources. Groundwater is also a potential pathway of exposure to other resources on Akwesasne property. Further data analysis may be performed as part of the assessment process to fully evaluate groundwater injuries.

Figure 8-9a
Total PCB Concentrations (ng/L) in Groundwater from the Assessment Area of the ALCOA Property, 1978-1990



Total PCB values are a combination of summed Aroclor values and values reported as "Total PCB" by the source documents. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Figure 8-9b
Total PCB Concentrations (ng/L) in Groundwater from the Assessment Area near the RMC Property, 1990-1991

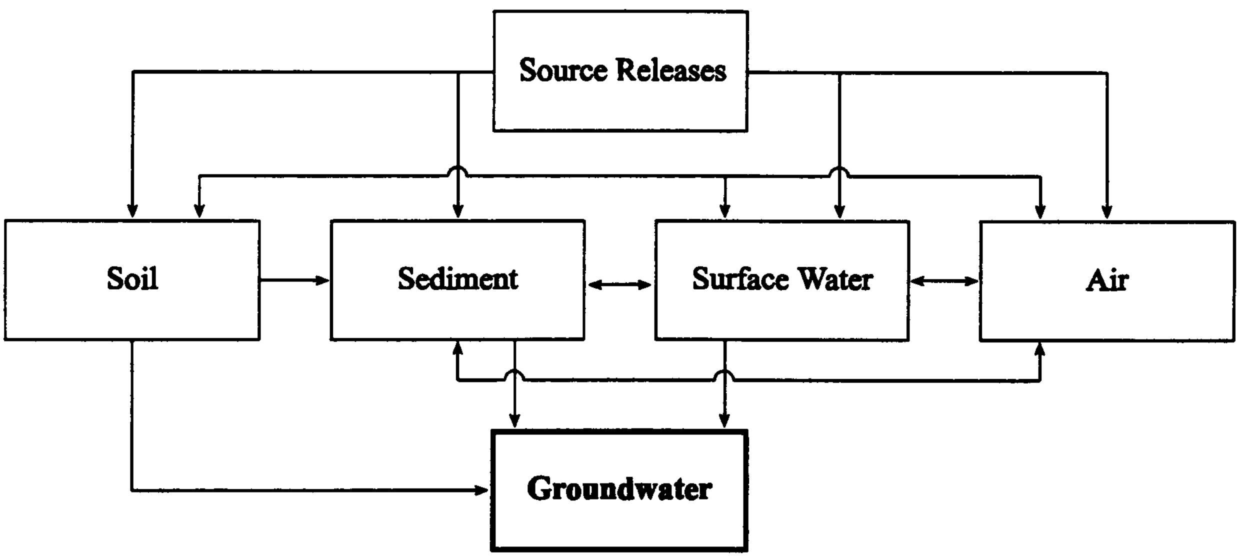


Total PCB values are a combination of summed Aroclor values and values reported as "Total PCB" by the source documents. Data derived from the St. Lawrence Environment Trustee Council environmental Database (Hagler Bailly Services, 1998). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

8.5.3 Pathway Evaluation

The mobility of hazardous substances in aquifers is a complex function of hydrodynamic and biogeochemical processes and conditions, including recharge locations, infiltration rate, hydraulic gradient, groundwater velocity and flow patterns, discharge locations, permeability, solubility, precipitation, adsorption, desorption, oxidation/reduction, and other reactions. Within the assessment area, contaminated soils are a primary pathway of contaminant exposure to groundwater (Figure 8-10). For example, hydrophobic substances such as PCBs strongly adsorb onto soils, sediments, and particulates (Eisler, 1986). PCBs remain immobile in groundwater when leached with water or landfill leachate, hence the strong correlation between soil PCB concentrations and groundwater PCB concentrations at the three facilities (Bobrow et al., 1983). However, PCBs and potentially other hydrophobic substances (e.g., PAHs) can become "intensely mobile" when leached with organic solvents (Bobrow et al., 1983). Organic solvents (e.g., phenols) are present in a number of landfill areas at all three facilities, and have been measured in groundwater samples from ALCOA and GM monitoring wells (Bobrow et al., 1983; Engineering-Science, 1987).

Figure 8-10
Representative Groundwater Exposure Pathways



Groundwater discharge from the assessment area is a potential pathway for the transportation of hazardous substances to the St. Lawrence, Grasse, and Raquette rivers and associated tributaries and wetlands (Engineering-Science, 1989; PRC Environmental Management, 1989).

Existing stormwater/industrial outfall, surface water, sediment, and soil contaminant data will be utilized to evaluate pathways of hazardous substances to groundwater resources. Pathway determination will include evaluating concentrations of hazardous substances in pathway resources to determine if complete pathways exist from points of release and exposed natural resources. Further data analysis may be performed as part of the assessment process to fully evaluate pathways to groundwater resources. If necessary, additional studies may be undertaken to supplement existing data on pathways to exposed groundwater resources in the assessment area.

8.5.4 Injury Quantification Approaches

Quantification of injuries to groundwater resources may include evaluation of:

- the areal extent of injured groundwater within the assessment area (e.g., square meters or kilometers)
- the volumetric extent of injured groundwater (e.g., cubic meters of groundwater)
- the temporal extent of injuries throughout the assessment area, including the yield (or flux) of injured groundwater (e.g., m^3/yr).

GIS platforms will be used to facilitate spatial and areal quantification using the database prepared in the Phase I assessment. Existing data indicate that exceedences of groundwater quality criteria in the assessment area have occurred since the earliest studies on the GM property, in 1981. Monitoring wells have since been installed at the ALCOA, GM, and RMC facilities to measure groundwater in specific areas of concern. Preliminary evaluation of the extent of the potential injuries to groundwater indicates that elevated concentrations of hazardous substances such as PCBs, fluoride, PAHs, cyanide, and heavy metals have been measured at a number of monitoring wells at the ALCOA, RMC, and GM facilities (Table 6-5). However, the areal and volumetric extent of the contamination (e.g., magnitude and flow direction of the plumes) has not been delineated thoroughly.

8.5.5 Additional Studies

Available data indicate that groundwater are injured based on injury definitions presented in Section 8.5.1. Based on the results of Phase I injury evaluation (see Figure 8-1), and as noted previously in Section 8.5.2, additional studies may be undertaken to supplement existing data on concentrations of hazardous substances in groundwater, and on pathways to groundwater resources in the assessment area. Any additional studies will be described in addenda to the assessment plan.

8.6 SOIL

8.6.1 Injury Definitions

Based on initial review of existing data, injuries to soil resources that may be evaluated by the trustees include the following:

- Concentrations of hazardous substances in excess of appropriate tribal standards.
- Concentrations sufficient to injure other resources, including terrestrial organisms and vegetation (e.g., toxicity), groundwater, and wildlife [43 CFR 11.62(e)].
- Concentrations of hazardous substances that exceed baseline concentrations [43 CFR § 11.14(e)] and, as a result, cause loss of services to the Akwesasne Mohawks provided by soil resources (including Mohawk existence values).

8.6.2 Injury Determination Approaches

The injury determination to be undertaken for soil resources will focus on a comprehensive analysis of existing data using the evaluation approach presented in Table 8-5. A review of available data suggests that soils on the GM, RMC, ALCOA, and Akwesasne properties may be injured. For example, elevated concentrations of PCBs have been measured in soil samples from all three PRP facilities, and on Akwesasne property (see Table 6-7). Figure 8-11 shows that soil concentrations of PCBs at ALCOA (Figure 8-11a), GM (Figure 8-11b), and RMC (Figure 8-11c) have exceeded the St. Regis Mohawk tribal standard of 1 mg/kg and the NYS soil cleanup objective of 1 mg/kg PCB for surficial soils (10 mg/kg PCB for subsurface soils) (NYSDEC, 1994).

Soil PCB concentrations may also be sufficient to injure terrestrial organisms. Using representative soil, surface water, and sediment PCB concentration data obtained from samples from GM, RMC, and Akwesasne sites, Ram and Gillett (1993) developed a predictive model for estimating bioaccumulation in aquatic and terrestrial organisms. When estimating bioaccumulation in terrestrial organisms, soil concentrations were represented by a lognormal distribution with a mean of 0.15 mg/kg (±1.7 mg/kg). This estimate for the mean PCB concentration in soil was based on measured PCB concentrations in the assessment area (excluding the most highly contaminated areas from disposal areas) and is less than the NYS surficial soil clean-up criterion of 1 mg/kg (NYSDEC, 1994) and less than the preliminary remediation goal of 0.371 mg/kg for protection of wildlife for use in risk assessments and decision making at CERCLA sites (Efroymson et al., 1997c). However, the Ram and Gillett (1993) model — which incorporated both surface water and sediment PCB concentrations as well as soil PCB concentrations — predicted that PCB concentrations in the assessment area would

Table 8-5
Components of Relevant Soil Injury Definitions

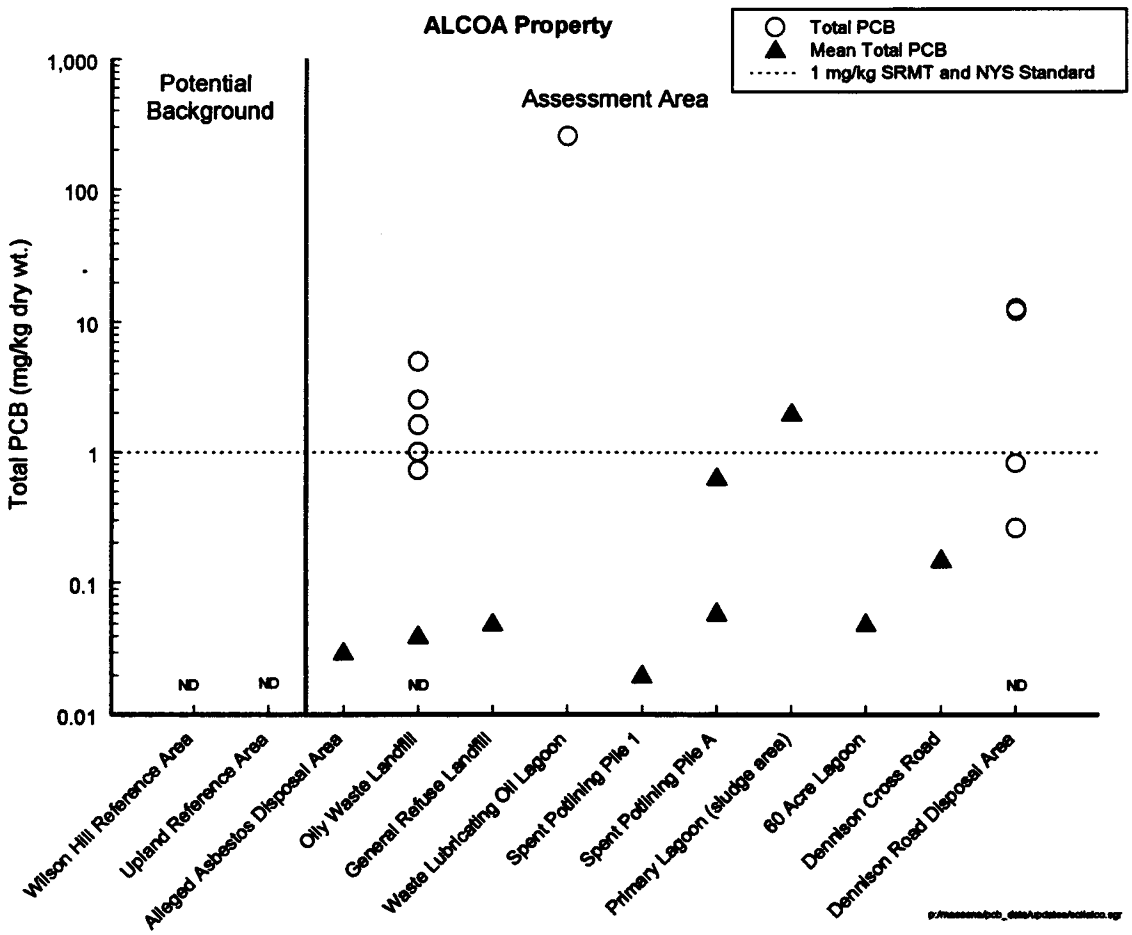
Injury Definition	Definition Components	Evaluation Approach
Soil Standard Exceedences [43 CFR § 11.62(e)]	Concentrations and duration of hazardous substances are in excess of applicable tribal soil standards.	Perform temporal and spatial comparisons of soil concentrations to tribal soil standards.
Biological Resources are Injured when Exposed to Soil [43 CFR § 11.62(e)]	Biological resources are injured when exposed to soil.	Compare soil concentrations to literature-derived toxicity thresholds. If necessary, conduct site-specific laboratory toxicity tests with soils (e.g., plant, microbial, and earthworm toxicity tests).
Baseline Exceedence [43 CFR § 11.14(e)]	Soil resources are injured when concentrations of hazardous substances exceed baseline.	Determine whether concentrations exceed baseline.
	Baseline exceedences cause loss of services.	Determine whether soil services have been lost as a result of exceedences.

cause bioaccumulation of PCBs in some terrestrial organisms (especially insectivorous and omnivorous mammals) via trophic transfer. For example, the model predicted that the star-nosed mole would obtain 87% of its PCB residue (total PCB residue 50-60 mg/kg) over a 2 year exposure period by consuming PCB contaminated oligochaetes during the winter.

Additional data and pathway analysis will be conducted to determine if soil PCBs represent a significant pathway to surface and groundwater resources, and are sufficient to cause injury (either by exceedences of tribal standards, exceedences of baseline, or bioaccumulation in terrestrial biota).

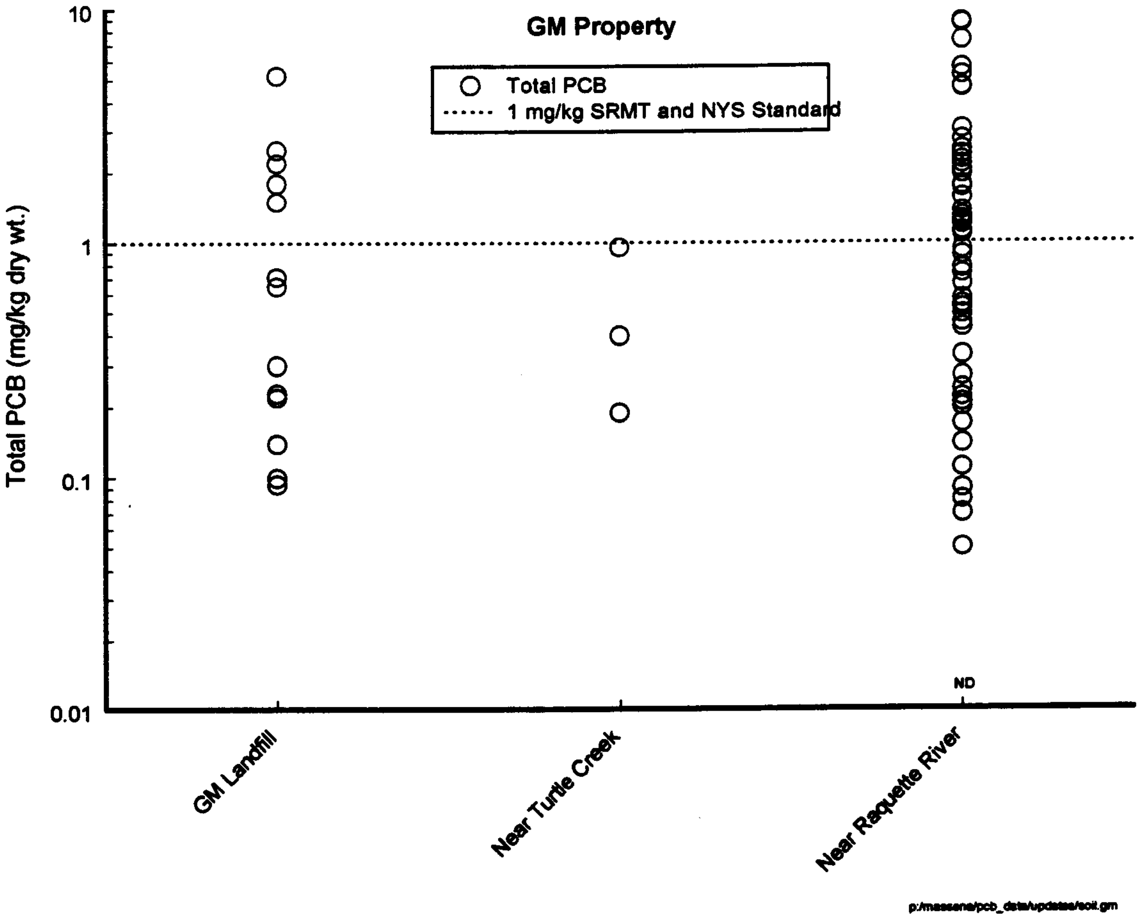
Other hazardous substances found in the assessment area, such as cyanide, fluorides, and PAHs, may be present in soils at concentrations sufficient to elicit phytotoxic responses. Table 8-6 shows concentrations of PCBs, aluminum, fluorides, PAHs, and phenols that can cause toxicologic responses in terrestrial plants and soil dwelling organisms (e.g., bacterial microfauna). Available data will be reviewed and compared to toxicological benchmarks and site-specific ecological information (e.g., plant and animal species presence/absence, species diversity) to assess if concentrations of these substances have caused biological injuries to terrestrial organisms. Further data analysis will be performed as part of the assessment process to fully evaluate soil injuries.

Figure 8-11a
Total and Mean Total PCB Concentrations (mg/kg, dry weight) in Soil from the Assessment Area near the ALCOA Property, 1987-1990



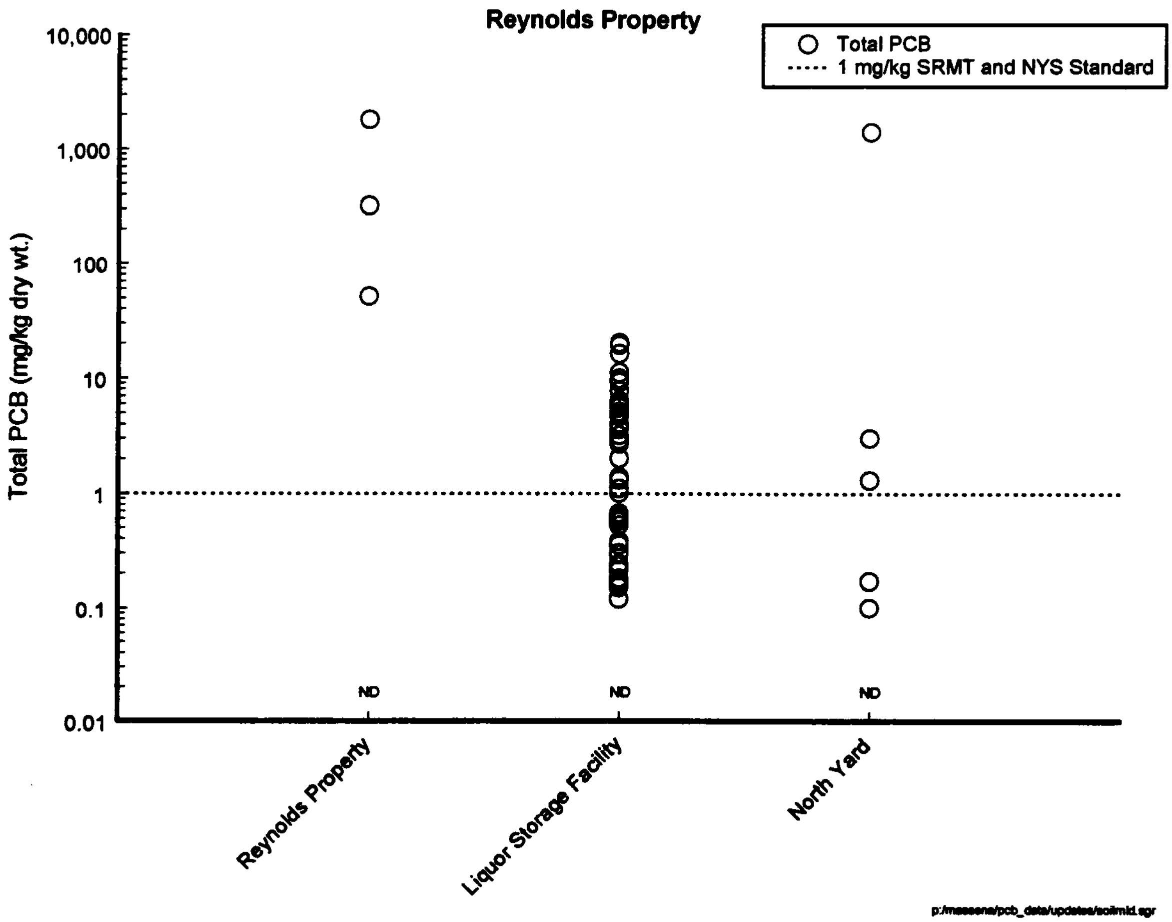
Total PCB values are a combination of summed Aroclor values and values reported as "Total PCB" by the source documents. Mean Total PCB values are values that were reported as means of Total PCB values by the source documents. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Figure 8-11b
Total and Mean Total PCB Concentrations (mg/kg, dry weight) in Soil from the Assessment Area near the GM Property, 1986



Total PCB values are a combination of summed Aroclor values and values reported as "Total PCB" by the source documents. Mean total PCB values are values that were reported as means of total PCB values by the source documents. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Figure 8-11c
Total and Mean total PCB Concentrations (mg/kg, dry weight) in Soil from the Assessment Area of the RMC Property, 1988-1990



Total PCB values are a combination of summed Aroclor values and values reported as "Total PCB" by the source documents. Mean Total PCB values are values that were reported as means of Total PCB values by the source documents. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Table 8-6
Toxicological Benchmarks: Concentrations of Potential Soil Contaminants that May Injure Terrestrial Plants, Soil Dwelling Organisms, and Wildlife

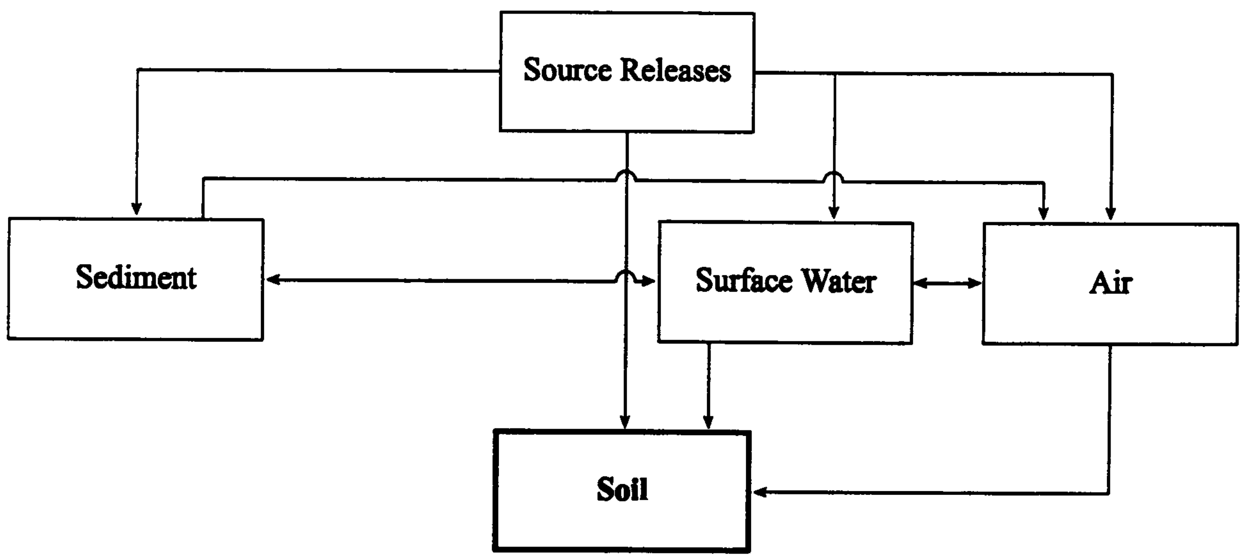
Hazardous Substance	Toxicological Threshold	Toxicological Effect	Reference
Terrestrial Plants			
Aluminum	50 mg/kg (soil) 0.3 mg/L (soil solution)	Interferes with root cell division, nutrient uptake, and enzyme activities, and decreases root respiration.	Efroymson et al., 1997a
Fluoride[a]	200 mg/kg (soil) 5 mg/L (soil solution)	Reduces growth.	
PCBs (as Aroclor 1254)	40 mg/kg (soil)	Reduces growth and water use	
Phenol	70 mg/kg (soil) 10 mg/L (soil solution)	Reduces growth	
Styrene	300 mg/kg (soil) 10 mg/L (soil solution)	Reduces growth	
Soil Dwelling Organisms			
Aluminum	600 mg/kg (microorganism)	Reduces microbial arylsulfatase and alkaline phosphatase activities.	Efroymson et al., 1997b
Benzo(a)pyrene	100 mg/kg (in food)[b]	Reduces growth in litter layer-dwelling soil invertebrates.	
Fluoride[a]	30 mg/kg (microorganism)	Reduces microbial mineralization of nitrogen and potassium.	
Phenols	100 mg/kg (microorganism) 30 mg/kg (earthworm)	Reduces microbial mineralization of carbon and nitrogen. Reduces survival in earthworms.	
Wildlife			
PCBs	0.371 mg/kg[c]	Based on unspecified effects in short-tailed shrew	Efroymson et al., 1997c
General Soil Quality Guideline for Protection of Environment			
Benzo(a)pyrene	0.1 mg/kg (interim criteria)	Not provided in source document. Protective of environmental receptors assuming agricultural land use.	CCME, 1997
Phenol	20 mg/kg (soil)	Not provided in source document. Protective of environmental receptors assuming agricultural land use.	
Fluoride	200 mg/kg	Not provided in source document. Protective of environmental receptors assuming agricultural land use.	CCME, 1991

a. Identified in source document as fluorine (a synonym for fluoride).
b. No screening benchmark determined by Efroymson et al., 1997b. Information provided in source document for reference and support material only.
c. Preliminary remediation goal for protection of wildlife for use in risk assessments and decision making at CERCLA sites.

8.6.3 Pathway Evaluation

Soils at GM, RMC, and ALCOA facilities have been contaminated with hazardous substances following the disposal or release of hydraulic fluids, spent potliners, and other industrial wastes (see Chapter 2). Figure 8-12 shows potential pathways to soil. Soils are exposed to hazardous substances via aerial deposition (e.g., fluorides, volatilization of PCBs) and/or surface runoff from landfill and disposal sites.

Figure 8-12
Representative Soil Exposure Pathways



Existing stormwater/industrial outfall, surface water, sediment, and air contaminant data will be used to evaluate pathways of hazardous substances to soil resources. Pathway determination will include evaluating concentrations of hazardous substances in pathway resources to determine if complete pathways exist from points of release and exposed natural resources. Further data analysis will be performed as part of the assessment process to fully evaluate pathways to soil resources.

8.6.4 Injury Quantification Approaches

Quantification of injuries to soil will include evaluation of:

- the spatial extent of injuries throughout the assessment area
- the temporal extent of injuries throughout the assessment area.

As described for surface water and sediments, GIS platforms will be used to facilitate spatial quantification using the database prepared in the Phase I assessment (Figure 8-1). For example, based on the available data, the spatial extent of soil PCB contamination appears to be localized within the vicinity of disposal areas such as the GM Landfill, various locations on the ALCOA property, and the RMC Wetland (Figures 8-11a, b, and c; see also Table 6-7). PCBs have also been measured above background levels in fill along the Raquette River near GM and on the Akwesasne property (see Table 6-7).

Also, as appropriate, the volume of soils injured and the degree of service loss will be quantified. Further data analysis will be performed to quantify injuries to soils.

8.6.5 Additional Studies

Available data indicate that soils may be injured based on injury definitions presented in Table 8-5. Based on the results of Phase I injury evaluation (see Figure 8-1), additional studies may be undertaken to supplement existing data on concentrations of hazardous substances in soils, and pathways to exposed soil resources in the assessment area. Any additional studies will be described in addenda to the assessment plan.

8.7 AIR

8.7.1 Injury Definitions

Based on initial review of existing data, injuries to air that may be evaluated by the trustees include the following:

- Concentrations of emissions in excess of standards for hazardous air pollutants established by Section 112 of the Clean Air Act, 42 U.S.C. 7412, or by other federal or state air standards established for the protection of public welfare or natural resources [43 CFR § 11.62(d)(1)].
- Concentrations and duration of emissions sufficient to have caused injury . . . to surface water, groundwater, geologic, or biological resources when exposed to the emissions [43 CFR § 11.62(d)(2)].
- Concentrations of hazardous substances that exceed baseline concentrations [43 CFR § 11.14(e)] and, as a result, cause loss of services to the Akwesasne Mohawks provided by air resources (including Mohawk existence values).

8.7.2 Injury Determination Approaches

Available data indicate that concentrations of fluoride, styrene, and PCBs are elevated in the air of the assessment area (Section 6.8). Injury assessment will involve determining if these concentrations constitute injury as defined in Section 8.7.1; the injury determination approach is presented in Table 8-7. Examples of applicable air criteria and standards are presented in Table 8-8.

Table 8-7
Components of Relevant Air Injury Definitions

Injury Definition	Definition Components	Evaluation Approach
Air Standard Exceedences [43 CFR § 11.62(d)(1)]	Concentrations and duration of hazardous substances are in excess of applicable tribal or state air standards.	Perform temporal and spatial comparisons of air concentrations to tribal and state air standards.
Other Resources Are Injured when Exposed to Air [43 CFR § 11.62(d)(2)]	Concentrations and duration of hazardous substances are sufficient to injure surface water.	Perform temporal and spatial comparisons of air concentrations to surface water concentrations of hazardous substances.
	Concentrations and duration of hazardous substances are sufficient to injure soil.	Perform temporal and spatial comparisons of air concentrations to soil concentrations of hazardous substances.
	Biological resources are injured when exposed to air.	Determine whether concentrations are sufficient to cause bioaccumulation and toxicity to biological resources.
Baseline Exceedence [43 CFR § 11.14(e)]	Air resources are injured when concentrations of hazardous substances exceed baseline.	Determine whether concentrations exceed baseline.
	Baseline exceedences cause loss of services.	Determine whether air services have been lost as a result of exceedences.

A preliminary review of available data indicates that air resources may be injured as a result of elevated concentrations of hydrogen fluoride. For example, hydrogen fluoride has been measured in air samples in the RMC parking lot and on nearby roadways downwind of the RMC plume at concentrations up to 3.5 ppb (2.86 $\mu g/m^3$) (Mo, 1989). Exceedences of the Ontario Ministry of the Environment's Ambient Air Quality Standards for hydrogen fluoride have routinely occurred on the southwestern portion of Cornwall Island; as shown in Table 6-17, hydrogen fluoride concentrations in air routinely exceeded the 30-day maximum concentration of 0.32 $\mu g/m^3$ between 1976 and 1987 (Bumbaco and Shelton, 1976; Bumbaco and Shelton, 1978; Bumbaco and Shelton, 1979; Bumbaco and Shelton, 1980; Bumbaco and Shelton, 1981; DeBellefeuille, 1985; DeBellefeuille and Desjardins, 1986; Environment Canada, 1988).

Table 8-8
Examples of Applicable Air Criteria and Standards for the Assessment Area (concentrations in $\mu g/m^3$)

Injury Definitions	Threshold Concentrations		
	PCBs	Fluoride	Styrene
Tribal Air Standards	0.005	—	—
NYS Standard — 12 hour average	—	3.7	—
NYS Standard — 24 hour average	—	2.85	—
NYS Standard — 7 day average	—	1.65	—
NYS Standard — 1 month average	—	0.8	—
NYS Short Term Guidance Concentration	—	—	51,000
NYS Annual Guidance Concentration	—	—	510
Ontario Ministry of the Environment — 24 h average	—	0.86[a]	—
Ontario Ministry of the Environment — 30 d average	—	0.34[a]	—

a. Expressed as gaseous hydrogen fluoride.

Currently, the trustees lack sufficient information on the form of fluorides or PAHs released from the ALCOA and RMC stacks (e.g., hydrogen fluoride, sodium fluoride, fluoride bound to PAHs). Speciation studies may be conducted by the trustees to evaluate the form and concentrations of these fluoride and PAH compound releases from the stacks. Since no validated method exists to unambiguously measure hydrogen fluoride and various fluoride compounds, speciation methodology will need to be carefully researched and several methods may be used to provide a reasonable measurement of fluoride compounds.

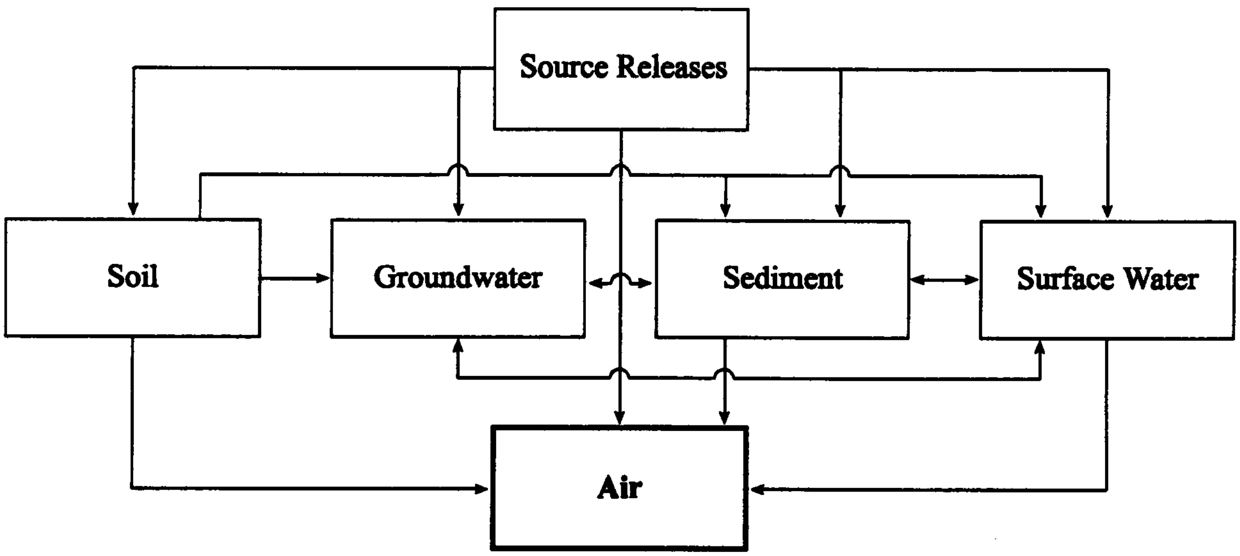
Potential injuries to air caused by styrene and PCBs may also be investigated. Styrene concentrations in air immediately east and downwind of the GM facility and on Akwesasne property have been measured up to 8.0 $\mu g/m^3$ (Benedict, 1994). These concentrations are below the NYSDEC Annual Guideline Concentration of 510 $\mu g/m^3$ (NYSDEC, 1991a). However, elevated styrene concentrations in air greater than baseline concentrations may cause losses of human services. Similarly, exceedences of baseline for volatilized PCBs may be evaluated. Further data analysis may be performed as part of the assessment process to fully evaluate air injuries.

8.7.3 Pathway Evaluation

The primary source of hazardous substances, including fluorides and PAHs, to the air resource is stack emissions from PRP facilities. Insufficient chemical speciation data are available to determine the various forms of fluoride released from ALCOA or RMC stacks. However, the plume from the RMC stack contains numerous compounds. In a report by Mo (1988), the plume is described as a haze that had a characteristic odor. Stack emissions of fluorides (e.g., hydrogen fluoride, sodium fluoride, fluoride bound to PAHs) from RMC and ALCOA facilities are the main pathway of releases of these hazardous substances to the air.

PCB volatilization from contaminated soils, sediments, and surface water represents potential pathways to air (Figure 8-13). For example, an odor associated with the Contaminant Cove site near GM appears to be associated with volatilized PCBs (Mo, 1988).

Figure 8-13
Representative Air Exposure Pathways



Stack emission, surface water, and soil contaminant data will be used to evaluate pathways of hazardous substances to air resources. Pathway determination will include evaluating concentrations of hazardous substances in pathway resources to determine if complete pathways exist from points of release and exposed natural resources. Further data analysis may be performed as part of the assessment process to fully evaluate pathways to air resources.

8.7.4 Injury Quantification Approaches

Quantification of injuries to air resources may include evaluation of:

- the spatial extent of injuries throughout the assessment area
- the temporal extent of injuries throughout the assessment area.

As described for other resources, GIS platforms may be used to facilitate spatial quantification using the database prepared in the Phase I assessment. Results of sampling conducted over several growing seasons to monitor the concentration of fluorides in the air and fluoride deposition on vegetation show that the spatial extent of potential injuries include Cornwall Island, Akwesasne property, and property in the immediate vicinity of ALCOA and RMC (Sections 6.7.2. and 6.8.2). Hydrogen fluoride has been measured up to 5.2 ppb (4.25 $\mu g/m^3$) (NYSDEC, 1990a) downwind of the ALCOA and RMC facilities, and on Cornwall Island it has frequently exceeded the Ontario Ministry of the Environment 30-day guideline of 0.32 $\mu g/m^3$ (see Table 6-17). In addition, atmospheric deposition of aerial fluoride compounds has resulted in fluoride concentrations in terrestrial vegetation in excess of the NYSDEC growing season standards. Further data analysis may be performed to quantify injuries to air.

8.7.5 Additional Studies

Available data indicate that air resources may be injured based on injury definitions presented in Table 8-7. Based on the results of Phase I injury evaluation (see Figure 8-1), and as noted in Section 8.7.2, additional studies may be undertaken to supplement existing data on concentrations of hazardous substances in soils, and pathways to exposed soil resources in the assessment area. Any additional studies will be described in addenda to the assessment plan.

8.8 AQUATIC BIOTA

8.8.1 Injury Definitions

Based on initial review of existing data, injuries to aquatic biota resources that may be evaluated by the trustees include the following:

- Concentrations of a hazardous substance sufficient to exceed action or tolerance levels established under section 402 of the Food, Drug and Cosmetic Act, 21 U.S.C. 342, in edible portions of organisms [43 CFR § 11.62(f)(1)(ii)].

- Concentrations of a hazardous substance sufficient to exceed levels for which an appropriate governmental health agency has issued directives to limit or ban consumption of such organism [43 CFR § 11.62(f)(1)(iii)].

- Concentrations of a hazardous substance sufficient to cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations [43 CFR § 11.62(f)(1)(i)].

- Concentrations of hazardous substances that exceed baseline concentrations [43 CFR § 11.14(e)] and, as a result, cause loss of services to the Akwesasne Mohawks provided by biological resources (including Mohawk existence values).

An injury to biological resources can also be demonstrated, per the DOI regulations, if an adverse biological response meets the following acceptance criteria [43 CFR § 11.62 (f)(2)(i-iv)]:

- The biological response is often the result of exposure to . . . [the] hazardous substances.
- Exposure to . . . [the] hazardous substances is known to cause this biological response in free-ranging organisms.
- Exposure to . . . [the] hazardous substances is known to cause this biological response in controlled experiments.
- The biological response measurement is practical to perform and produces scientifically valid results.

8.8.2 Injury Determination Approaches

The injury definitions in Section 8.8.1 contain several components. Table 8-9 summarizes the components of each definition and the approaches that may be used by the trustees in assessing each component. The injuries will be evaluated for various aquatic biota resources, including aquatic invertebrates, fish, amphibians, reptiles, and mammals. Approaches for evaluating consumption advisories, exceedences of FDA tolerances, exceedences of baseline, and biological injuries to aquatic biota are described below.

Injuries to aquatic biological resources will be evaluated according to the proposed injury assessment approach (see Figure 8-1), including a focused review of available data, comparison to injury thresholds, and an evaluation of the spatial and temporal extent of injuries throughout the assessment area.

Consumption Advisories and Exceedences of FDA Tolerances

Available data show that fish and aquatic reptiles (e.g., turtles) have accumulated PCB concentrations that exceed tribal, state, and federal standards or tolerance levels for consumption of those species.

Fish. PCB concentrations in fish collected from the assessment area since the late 1970s have been sufficiently elevated to trigger issuance of fish consumption advisories by the New York State Department of Health (NYSDOH) and the Canada Department of Health and Welfare

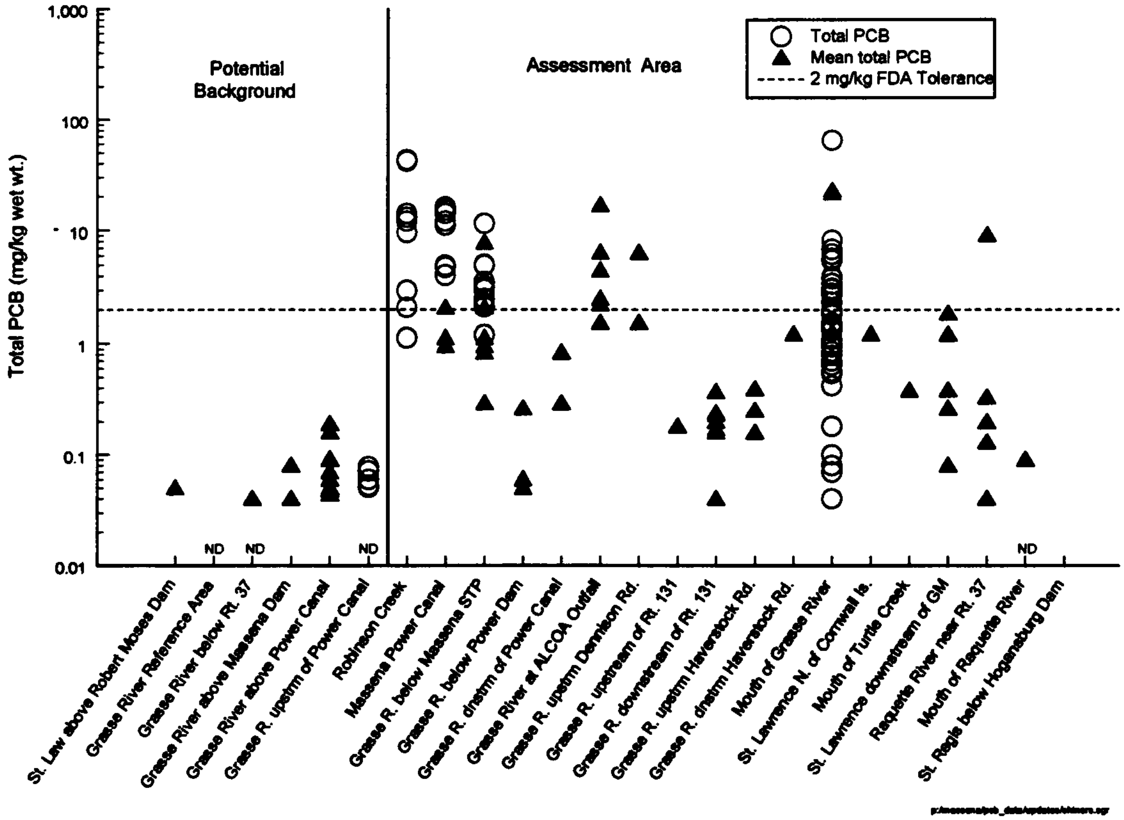
Table 8-9
Components of Relevant Biological Resources Injury Definitions

Injury Definition	Definition Components	Evaluation Approach
Food, Drug, and Cosmetic Act Exceedences [43 CFR § 11.62 (f)(1)(ii)]	Tissue concentrations of a hazardous substance in edible portions of organisms exceed applicable standards.	Compare organism tissue concentrations to applicable Food and Drug Administration (FDA) tolerances.
Consumption Advisory Exceedences [43 CFR § 11.62 (f)(1)(iii)]	Tissue concentrations of a hazardous substance exceed levels for which a state has issued directives to limit or ban consumption.	Compile fish, reptile, and bird consumption advisories and relate to hazardous substances.
Baseline Exceedence [43 CFR § 11.14(e)]	Aquatic biota resources are injured when concentrations of hazardous substances exceed baseline.	Determine whether exceedences of baseline affect Akwesasne Mohawk values or existence values.
Adverse Changes in Viability [43 CFR § 11.62 (f)(1)(i)]	The biological resource or its offspring has undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations.	Determine whether the measured biological response satisfies the criteria for indicating an adverse change in viability.

(Kauss et al., 1988). For example, PCB concentrations in bullhead (fillets) and spottail shiner (whole fish) are provided in Figures 8-14 and 8-15 for various locations within the assessment area; total and mean PCB concentrations in these fish were often above the 2 mg/kg FDA tolerance limit. Area commercial carp and eel fisheries were closed in the late 1970s and early 1980s because of elevated PCB and mercury contamination (Kauss et al., 1988). Fish consumption advisories (see Table 9-2) are still in effect for the Massena Power Canal, the Grasse River, Contaminant Cove, and the St. Lawrence River (NYSDOH, 1999). There is a complete ban on all fish consumption in the Grasse River from the mouth of the river to the Massena Canal, and in the St. Lawrence River at Contaminant Cove (NYSDOH, 1999). There is also a ban on eating American eel, channel catfish, and lake trout larger than 25 inches, and carp, chinook salmon, and brown trout larger than 20 inches in the St. Lawrence River. Since 1986, the St. Regis Mohawk Tribe has promulgated a ban on consumption of all fish species for women of childbearing age, infants, and children under the age of 15 (Ransom, 1986).

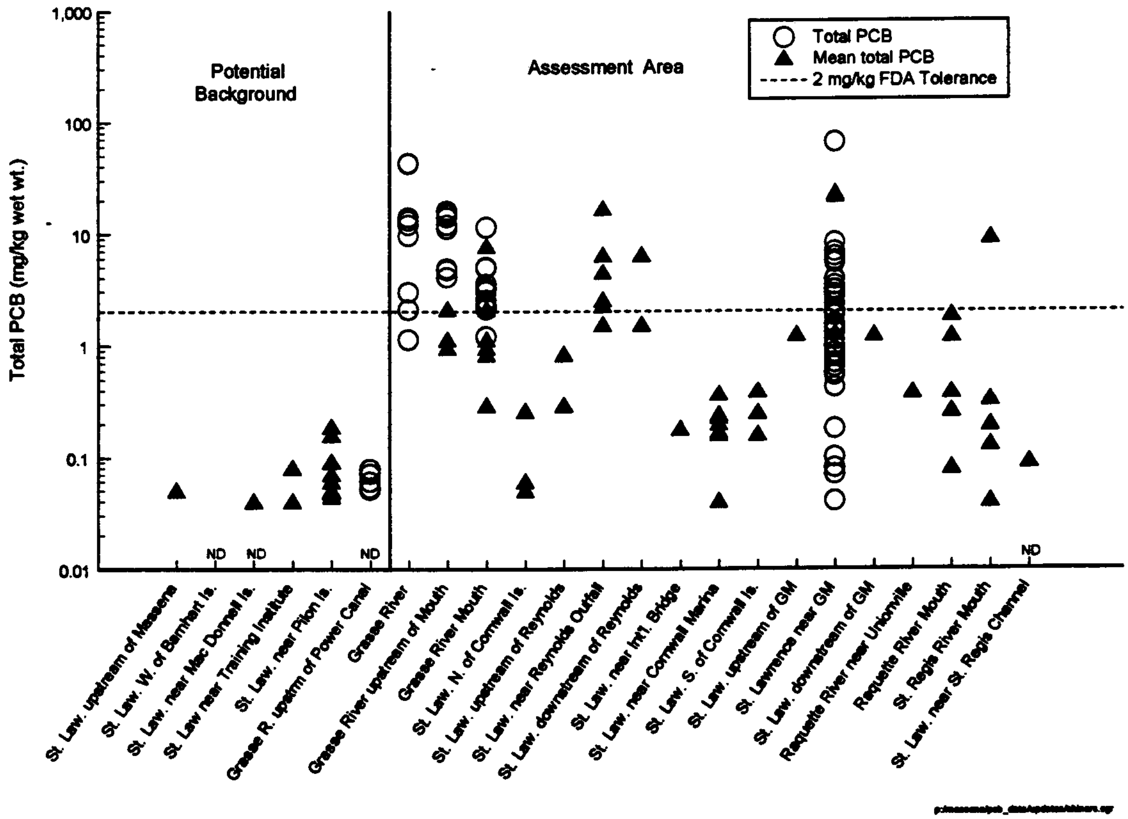
Aquatic Reptiles. Based on PCB contamination, the NYSDOH has enacted consumption advisories for snapping turtles (*Chelydra serpentiana serpentina*) (NYSDOH, 1999). The advisory stipulates that all fat, liver, and eggs should be trimmed away or disposed of before eating.

Figure 8-14
Total and Mean Total PCB Concentrations (mg/kg, wet weight) in Brown Bullhead Fillets Collected from Upstream Potential Background and the Assessment Area of the St. Lawrence, Grasse, Raquette, and St. Regis Rivers (1976-1997)



Total PCB values were derived from either the total Aroclor value (sum of all Aroclor's measured) or the total congener concentration as reported in the original source document. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998) and ALCOA (1999b). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

Figure 8-15
Total and Mean Total PCB Concentrations (mg/kg, wet weight) in Young-of-the-Year Spottail Shiners (whole body) Collected from Upstream Potential Background and the Assessment Area of the St. Lawrence, Grasse, Raquette, and St. Regis Rivers (1976-1997)



Total PCB values were derived from either the total Aroclor value (sum of all Aroclor's measured) or the total congener concentration as reported in the original source document. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998); ALCOA (1999b); BBL (1998, 2000); NYDEC (1997); and OME (1997). ND denotes not detected; the concentration was below the detection limit as reported in the original source document.

As described in Table 8-9, the trustees' evaluation of injuries to fish and aquatic reptiles will include determining which species exceed FDA tolerance levels, consumption advisory levels, and baseline levels. Fish and reptile consumption advisories in the assessment area will be tabulated and related to hazardous substances (primarily PCBs, see Table 9-2). For example, Table 6-9 and Figures 8-14 and 8-15 show specific locations and concentrations of PCBs in fish collected from the assessment area and from potential background areas. As previously discussed, many fish inhabiting the assessment area exceed the FDA tolerance level for PCBs.

Biological Injuries

Biological injuries include those injuries that adversely affect the viability of aquatic and terrestrial biota [43 CFR § 11.62 (f)(1)(i)]. Biological injuries to aquatic biota may be assessed in aquatic invertebrates, fish, reptiles, amphibians, and mammals. The injury assessment approach will be to determine if exposure, as assessed by surface water and sediment concentrations or by body burden concentrations, is sufficient to cause biological injuries. The following injury categories may be assessed by the trustees: death, disease, cancer, physiological malfunctions (including reproduction), developmental effects (reduced growth), and physical deformities. Injury will be assessed in the organisms presented below by category of injury.

Category of Injury: Death

Invertebrates. Concentrations of hazardous substances in the assessment area may be sufficient to cause death in exposed aquatic invertebrates. For example, field studies assessing the health of the benthic invertebrate community in sediment collected from the St. Lawrence River (adjacent to the RMC property) and the Raquette River (south of the RMC property) indicate that the benthic invertebrate community composition (density and diversity) has been impaired as a result of exposure to hazardous substances (Woodward-Clyde, 1992; 1995). Invertebrate abundance and taxa richness were reduced in areas with elevated PAHs (Woodward-Clyde, 1992) and possibly other contaminants. Reduced taxa richness, more pollution-tolerant organisms, fewer *Ephemeroptera* and *Tricoptera* species, and shifts to pollution-tolerant *Chironomidae* species were observed at two sampling locations (described as SL-3 and SL-7 in Woodward-Clyde, 1995) that had elevated sediment PCBs (and possibly PAHs and metals).

The most severe impact to benthos was observed in samples collected 50 feet offshore of RMC Outfall 001 (described as SL-3 in Woodward-Clyde, 1992). At this location, the abundance of annelida, insecta, and crustacea was dramatically reduced compared to reference locations (Table 8-10). In addition, mollusca abundance was reduced at this location compared to upstream locations on the south shore of the St. Lawrence River (Woodward-Clyde, 1992). A similar reduction in the abundance of insecta was observed in the Raquette River (Table 8-10).

Table 8-10
Abundance and Taxa Richness of Dominant Macroinvertebrate Classes in the Raquette and St. Lawrence Rivers

Location	Abundance (number of individuals/m^2)				Taxa Richness (total taxa collected)
	Phylum Annelida	Subphylum Crustacea	Superclass Insecta	Phylum Mollusca	
Reference Raquette River (RR-1)[a]	6,173	—	2,408	6,539	30
Raquette River (RR-2)[b]	2,393	—	44	2,870	20
Reference St. Lawrence River (SL-1)[c]	2,190	449	4,351	4,115	41
Upstream St. Lawrence River (SL-2)[d]	1,380	7,217	4,060	11,622	30
Outfall 001 (SL-3)[e]	261	29	15	3,493	6

a. 1.7 miles upstream of RMC facility along the north shore of the Raquette River.
b. Along the north shore and 20 feet downstream from the confluence of the Raquette River and a small ditch draining the RMC wetlands.
c. St. Lawrence River downstream of Pollys Gut along west shore (west and south of Cornwall Island). Note: this area potentially receives fluorides from ALCOA atmospheric releases.
d. South shore of St. Lawrence River immediately upstream of RMC facility and RMC Outfall 001.
e. South shore of St. Lawrence River 50 feet offshore of RMC Outfall 001.

Source: Woodward-Clyde, 1992.

Sediment collected from near RMC facilities on the St. Lawrence River was acutely lethal to the aquatic insect *Chironomus tentans* in laboratory-based sediment toxicity evaluations (Wood et al., 1997). In fact, sediment from RMC diluted with control sediment to 3% resulted in 71 to 75% mortality to *C. tentans*. This sediment sample (100%) had elevated concentrations of PAH (3,200 mg/kg dry weight) and PCBs (700 mg/kg dry weight) (Wood et al., 1997).

Amphibians. Elevated PCB concentrations can cause in death in amphibians. For example, larval survival of the green frog (*Rana clamitans*) and the leopard frog (*Rana pipiens*) was significantly reduced in laboratory studies when test organisms were exposed for 5 to 6 days to 50 μg/L PCB (Rosenshield et al., 1999). However, no lethality was observed in test organisms exposed to 5 μg/L PCB. Hence, PCB concentrations greater than 5 but less than 50 μg/L are likely associated with mortality. Concentrations of PCB in surface waters in the assessment area may be sufficient to cause death in exposed amphibians because maximum PCB concentrations have been measured up to 12.3 μg/L in Contaminant Cove (NYSDEC, 1989).

Fish. PCBs and PAHs are known to cause death in the early life stages of fish. In general, the early life stages of fish are most susceptible to the lethal effects of these contaminants (McKim, 1995). Developmental deformities and early life stage mortalities have been reported in fish exposed to PCBs. Eggs of fish are extremely sensitive to the toxicity of dioxin-like PCB congeners (Walker and Peterson, 1992). Parts per billion concentrations of individual PCBs (e.g., PCB congener 126) in eggs of lake trout can induce overt lethality or sublethal effects, including delayed time to hatch, hemorrhaging and yolk-sac edema, and craniofacial deformities (Walker and Peterson, 1992).

Sensitivity of salmonids and potentially other species of fish to PCBs may be enhanced by a nutritional deficiency in the eggs of vitamin B1 (thiamine). An egg vitamin B1 deficiency has been described in several species of salmonids in the Great Lakes region, including chinook salmon (*Oncorhynchus tshawytscha*), brown trout (*Salmo trutta*), and lake trout (*Salvelinus namaycush*) (Fisher et al., 1996; Brown et al., 1998). Recent studies conducted with trout (*Salmo trutta*) suggest that the toxicity of PCBs may be enhanced in fish eggs containing low vitamin B1 concentrations (Ackerman et al., 1998; Wright et al., 1998).

Phase I injury evaluation may include determining whether or not concentrations of PCBs and other hazardous substances in tissues of assessment area fish or in surface water resources are sufficient to produce mortality in the early life stages of fish. An example approach used to assess impacts of PCBs and related compounds (e.g., chlorinated dioxins and dibenzofurans) was described by Cook et al. (1997). The approach involves use of toxic equivalency factors (TEFs), which rank the toxicity of PCB congeners relative to 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD). Concentrations of specific PCB congeners are measured or estimated in fish eggs and an individual TEF value derived for each PCB is calculated. The individual TEF values are then summed to derive a toxic equivalency concentration (TEC, also referred to as TEQ). The resulting TEC is compared to literature-derived toxicity thresholds.

An example of how this approach may be used in Phase I assessment is described below in a hypothetical illustration. Hypothetical egg PCB congener data are converted to respective toxic equivalents (TEs), as shown in Table 8-11. The TEs are summed to derive a TEC. TEC_{egg} for a mixture of "n" congeners equals the sum of each congener's TEC_{egg} (pg TCDD TE/g wet wt. egg), which is the product of the concentration of the congener in the eggs, C_{egg} (pg congener/ g wet wt. egg), and the TEF (pg TCDD TE/pg congener):

$$TEC_{egg} = \sum_{i=1}^{n} [(C_{egg})_i \cdot (TEF)_i]. \qquad (8\text{-}1)$$

Note that several (noncoplanar) PCB congeners have TEF values that are reported as less than a specific value. In these instances, the toxicity of a PCB congener was not observed at the maximum concentration tested in rainbow trout early life stage toxicity studies (Zabel et al., 1995). For purposes of risk analysis, "less than" TEF values are typically treated as zero (see Table 8-11).

The TEC_{egg} value is then compared to the literature-derived lowest observable adverse effect (LOAEL) threshold for early life stage mortality as follows:

$$TEC_{egg}\text{ (observed)/LOAEL} = \text{Hazard Quotient}. \quad (8\text{-}2)$$

A hazard quotient value of less than 1.0 indicates a relatively low potential risk of PCB-induced early life stage mortality; whereas a hazard quotient value of greater than 1.0 indicates a potential risk of PCB-induced early life stage mortality. In our hypothetical example (Table 8-11), there is a potential risk of PCB-induced early life stage mortality (e.g, hazard quotient factor = 1.42).

Table 8-11
Example TEF Approach to Be Used to Assess Relative Risk to Early Life Stages of Fish from Exposure to PCBs

Type of PCB Congener	Measured PCB Congener Concentration in Rainbow Trout Eggs (pg/g wet wt.)	TEF[a] (pg congener/pg TCDD equivalent)	TE_{egg}[b]
28+31	220000	<0.000009	0
52	180000	<0.000007	0
77	36260	0.00018	6.53
81	2660	0.00062	1.65
105	540000	<0.000002	0
118	980000	<0.000006	0
126	7000	0.0049	34.30
153	1220000	0	0
169	180	0.00003	0.0054
170+190	240000	<0.000004	0
TEC_{egg}			42.5
LOAEL (mortality)[a]			30
Relative Risk			1.42

a. Cook et al., 1997.
b. TEF values that are reported in the literature as a "less than" value are assumed to be zero.

Injuries resulting in death of aquatic biota will be evaluated according to the proposed phased injury assessment approach as described earlier (see Figure 8-1). The trustees may conduct site-specific sediment bioavailability and toxicity studies downstream of source release areas to evaluate the hazardous substances that contribute to the mortality observed in sediment dwelling aquatic invertebrates, the concentrations of hazardous substances that are sufficient to cause death or sublethal effects, and the spatial extent of biological injuries. The trustees may also conduct site-specific toxicity studies in the assessment area to evaluate if hazardous substances are sufficiently elevated to cause death, or sublethal effects, in amphibians.

As described above, the TEF approach, coupled with available literature-derived toxicity thresholds, may be used in the Phase I assessment to assess relative risk of early life stage mortality in assessment area fish.

Category of Injury: Disease

Fish. The hazardous substances of concern in the assessment area can cause a variety of sublethal impairments in fish, including immune modulation, biochemical changes, endocrine disruption, tumor formation, histopathological lesions, and other tissue deformities. Collectively, these effects can adversely affect fish health. For example, immune modulation — either enhancement of immune function or suppression of immune function, can have deleterious consequences to an organism. Immune enhancement can result in heightened allergenic responses or autoimmune disease (Krzystyniak et al., 1995). Conversely, immune suppression can result in increased susceptibility of fish to disease, parasitism, or cancer (Khan and Thulin, 1991; Zelikoff, 1994; Anderson and Zeeman, 1995). PCBs and heavy metals can enhance or suppress immune function in fish, depending on species, endpoint measured, dose, and route and duration of exposure (Zelikoff, 1994; Rice and Schlenk, 1995). PAHs also are known immune suppressants in fish (Weeks et al., 1992; Zelikoff, 1994). Injuries resulting in disease in aquatic biota will be evaluated according to the proposed phase injury assessment approach (see Figure 8-1).

Category of Injury: Cancer

Fish. PCBs and PAHs are associated with neoplasia (tumor formation) in fish (Bailey et al., 1987; Moore and Meyers, 1994; Baumann and Harshbarger, 1995; Schrank et al., 1997). Studies of liver tumor incidences in brown bullhead (*Ictalurus nebulosus*) inhabiting the Black and Cuyahoga rivers in Ohio have been important case studies for understanding the etiology of neoplasia in fish (Baumann et al., 1991; Smith et al., 1994). Baumann and Harshbarger (1995) demonstrated that as concentrations of PAH decreased in Black River sediments, incidences of liver cancer in brown bullhead decreased significantly. Neoplasia serves as an important bioindicator of pollution stress in fish (Hinton et al., 1992) and can be used to monitor the efficacy of remediation/restoration activities in contaminated aquatic environments (Anderson et al., 1997). Injuries resulting in cancer in aquatic biota will be evaluated according to the proposed phase injury assessment approach (see Figure 8-1).

Aquatic mammals. Immunosuppressed marine mammals, including whales, dolphins, and harbor seals that contain high body burdens of PCBs, may be subject to increased rates of infectious disease and cancers (Repetto and Baliga, 1996). Therefore, injuries to Beluga whales may be evaluated by the trustees. Because of the migratory habits of aquatic mammals, it is anticipated that the initial scope of the Phase I evaluation will be limited to determining the potential contribution of migratory assessment area fish (e.g., eels) to bioaccumulation of PCBs and other organochlorine compounds in St. Lawrence River whale populations.

Category of Injury: Physiological Malfunctions

Fish. Exposure of fish to PCBs and PAHs can cause measurable biochemical changes in the liver and other organs of fish. These compounds can induce the synthesis of cytochrome P4501A (CYP1A), a protein involved in the metabolism of planar aromatic hydrocarbons (Stegeman and Hahn, 1994). For example, in situ caged fish studies in the assessment area have been conducted to evaluate the effects of PCB bioaccumulation on liver enzyme functions in fish. PCB exposure was shown to cause a 3.5-fold increase in ethoxyresorufin-O-deethylase (EROD) activity (a measure of CYP1A induction) in the livers of black bullhead (Moon et al., 1996; Otto and Moon, 1996). Induction or suppression of the cytochrome P450 activity in fish can have deleterious consequences to fish health. For example, induction of this enzyme system is linked to tumorigenesis via metabolic activation of PAHs to procarcinogens (Stegeman and Hahn, 1994).

Induction of the CYP1A enzyme system is also linked to endocrine disruption in fish. For example, laboratory studies have shown that induction of this enzyme may result in modulation of estrogen responsiveness in fish. High induction leads to inhibition of estrogen-induced egg yolk (vitellogenesis) synthesis by the liver; low induction may lead to potentiation of egg yolk synthesis (Anderson et al., 1996a, 1996b). Either effect may adversely affect reproduction in fish. In addition, potentiation of estrogen responsiveness may also enhance tumorigenesis in fish (Teh and Hinton, 1998). Conversely, suppression of the CYP1A enzyme system can also represent an adverse response to contaminant stress, resulting in bioaccumulation of contaminants in tissues. Unlike black bullhead described above, rainbow trout exposed under the same conditions showed no EROD induction (Moon et al., 1996; Otto and Moon, 1996). Ultimately, this lack of ability to detoxify and excrete a contaminant could affect the organism's survival as well as the suitability of fish for consumption by humans (Moon et al., 1996) and wildlife.

Another adverse endocrine effect in fish, potentially attributable to hazardous substances found in the assessment area, involves suppression of the hypothalamus-pituitary-interrenal (HPI) axis in fish. For example, yellow perch (*Perca flavescens*) captured downstream from the assessment area on the St. Lawrence River (near Paix Islands) and exposed to PAHs, PCBs, and mercury were unable to respond normally to acute stress (Hontela et al., 1992).

Monosson (1999) reviewed numerous laboratory and field studies on the reproductive toxicity of PCBs in exposed fish. Reproductive effects associated with PCB exposure were defined as changes to the hypothalamic-pituitary-gonadal-liver (HPGL) axis and included altered sex steroid hormones (e.g., reduced estradiol and testosterone concentrations) and retinoid concentrations (e.g., vitamin A), reduced pituitary gonadotropin, reduced gonadal growth, reduced egg deposition, and reduced vitellogenin production (NOAA, 1999).

Aquatic reptiles and amphibians. PCBs may also cause biological injuries to snapping turtles, frogs, and mudpuppies. From field studies in Lake Ontario, Bishop et al. (1991) showed a statistical association between PCB concentrations in eggs of snapping turtles and poor development of eggs. PCBs were the most strongly associated chemicals, although other chemicals may have contributed to the observed toxicity. Larval mortality of 63% to 98% was observed in the northern leopard frog larvae exposed to sediment from the St. Lawrence River containing 600 ppm PCBs; mortality was between 11 and 15% in control sediments (Savage and Quimby, 1999). In addition to lethal effects, larval frogs exposed to elevated PCBs in St. Lawrence River sediment also had excessive weight gain and advanced metamorphoses, suggesting alterations in the hormones prolactin and thyroxine (Savage and Quimby, 1999). In a laboratory study with green frogs and leopard frogs, Rosenshield (1999) observed reduced growth in tadpoles, reduced swimming speed, and an increased incidence of edema in frogs exposed to PCB 126 via the water column; adverse effects were typically observed in frogs exposed to 50 μg/L PCB, although the lowest observable effect level was 5 μg/L PCB.

As previously discussed for fish, PCB exposure can induce liver P4501A (CYP1A) induction in freshwater turtles and frogs. Yawetz et al. (1997) observed P4501A induction in hepatic microsomes in three species of freshwater turtles exposed to Aroclor 1254. Similarly, Huang et al. (1998) observed indication of P450-associated monooxygenases in the northern leopard frog intraperitoneally exposed to PCB 126.

Within the assessment area, adverse endocrine reproductive effects have been observed in mudpuppies (*Necturus maculosus*, an aquatic salamander) contaminated with PCBs. As described for fish above, impairments of the HPI axis of mudpuppy have been observed in populations collected on Akwesasne property (Gendron et al., 1997).

Aquatic mammals. Chemical contaminants in the St. Lawrence River ecosystem have been associated with histopathological lesions and tumors in Beluga whales (*Delphinapterus leucas*). Organochlorine contaminants, including PCBs and carcinogenic PAHs, are suspected causative agents (Béland et al., 1993; De Guise et al., 1994, 1995a, 1995b).

Injuries resulting in physiological malfunctions in aquatic biota will be evaluated according to the proposed phase injury assessment approach (see Figure 8-1).

Category of Injury: Developmental Effects (reduced growth)

Monosson (1999) also reviewed numerous laboratory and field studies on the developmental toxicity of PCBs in exposed fish. Developmental effects associated with PCB exposure were those primarily on embryo and larval growth and survival, and included decreased fry survival, reduced fry weight and length (i.e., reduced growth), decreased hatch rate, and increased numbers of abnormal embryos (NOAA, 1999).

Injuries resulting in developmental effects, including reduced growth in aquatic biota will be evaluated according to the proposed phase injury assessment approach (see Figure 8-1).

Category of Injury: Physical Deformities

Fish. The hazardous substances of concern in the assessment area may also cause a variety of histopathological lesions and other tissue deformities. Investigations conducted in other contaminated aquatic environments have revealed lesions in gill, liver, spleen, kidney, and gonads of fish (Hinton et al., 1992; Adams et al., 1996; Schrank et al., 1997; Teh et al., 1997).

Amphibians. Increased frequencies of skeletal deformities (e.g., deformed limb structures) were detected in adult mudpuppies collected on Akwesasne property; these deformities were statistically correlated with the degree of PCB contamination in the gonads of female mudpuppies (Gendron, 1994).

Injuries resulting in physical deformities in aquatic biota will be evaluated according to the proposed phase injury assessment approach (see Figure 8-1).

Summary

Relevant aquatic biological injuries to be evaluated by the trustees are presented in Table 8-12.

Biological injuries identified in various aquatic species will be tabulated and related to hazardous substances based on a review of the toxicological literature, results of additional Phase I and Phase II assessment studies, and concentrations of hazardous substances in exposure media and in the organisms.

8.8.3 Pathway Evaluation

As per DOI regulations, pathway may be determined by demonstrating the presence of hazardous substances in sufficient concentrations in the pathway resource or by using a model that demonstrates that the conditions existed . . . such that the route served as a pathway [43 CFR § 11.63(a)(2)].

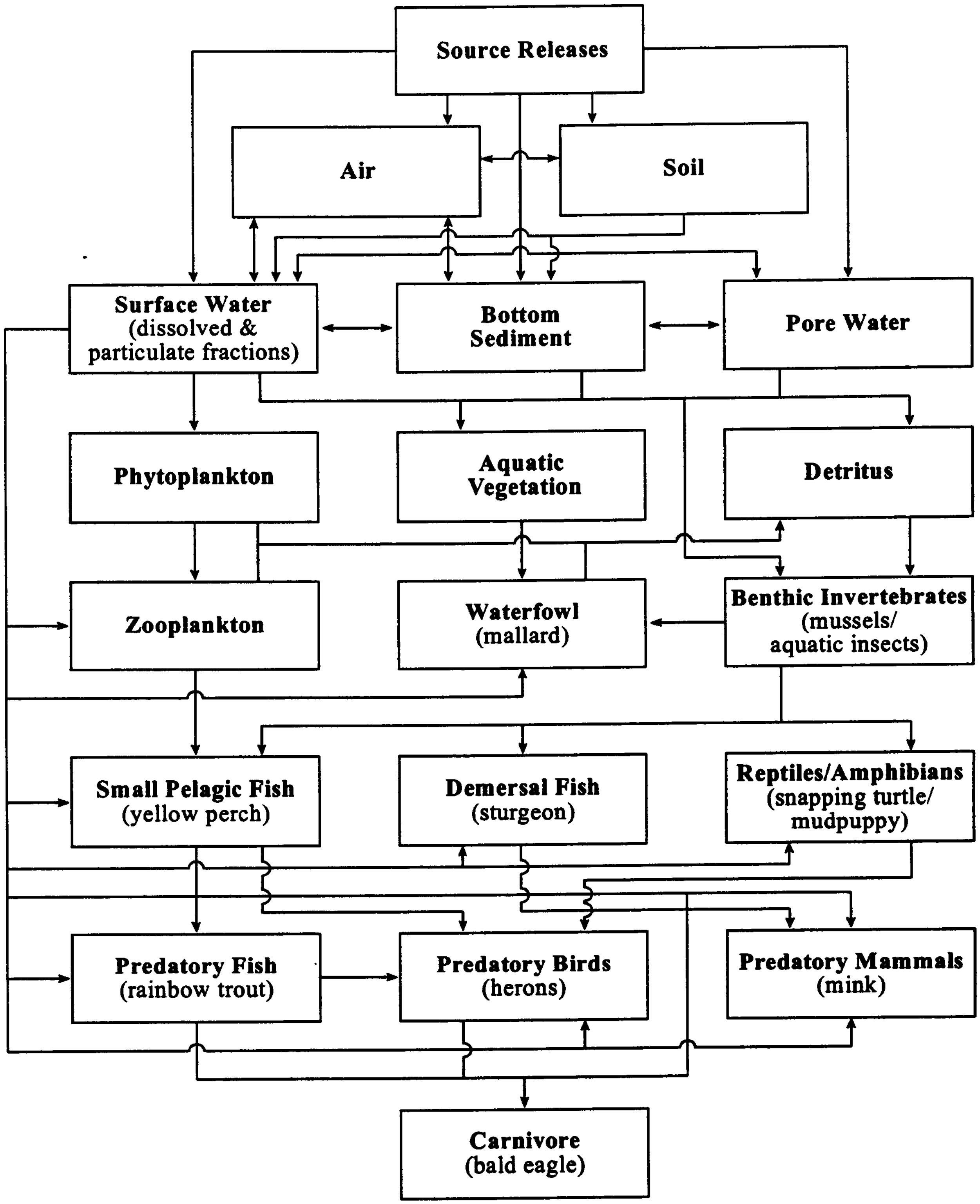
Table 8-12
Relevant Aquatic Biological Injury Categories by Resource

	Resource				
Injury Category	**Aquatic Invertebrates**	**Fish**	**Amphibians**	**Aquatic Reptiles**	**Aquatic Mammals**
Death	✔	✔ (early life stages)	✔		
Disease		✔			✔
Cancer		✔			✔
Physiological Malfunctions (including reproduction)	✔	✔	✔	✔	✔
Physical Deformities	✔	✔	✔	✔	✔

Exposure pathways to aquatic biological resources in the assessment area include direct exposure through physical contact with hazardous substances in surface water and sediments as well as indirect exposure through food chain processes (Figure 8-16). Food chain processes represent a significant pathway of exposure to aquatic vertebrates (Ram and Gillett, 1993). For example, fish accumulate PCBs and other hazardous substances through physical contact with contaminated surface water and sediments and by the consumption of contaminated food (e.g., zooplankton, benthic invertebrates, other fish).

Existing data on hazardous substance concentrations in surface water, sediments, and biota will be used to evaluate exposure pathways to aquatic biota. For example, Kadlec (1994) showed that PCBs in the water column may be an important pathway of exposure to fish of the assessment area. In addition, Kadlec (1994) showed that the PCB congener pattern found in fish was similar to the pattern found in surrounding surface water. Ram and Gillett (1993) developed an aquatic/terrestrial foodweb model for PCBs in the assessment area that included estimated distributions of surface water and sediment concentrations and predicted concentrations in aquatic biota via bioconcentration and food chain transfer. Using site-specific surface water and sediment PCB data from the assessment area, they were able to predict resultant PCB residues in aquatic biota and demonstrate that concentrations of PCBs in surface water and sediments of the assessment area are sufficient to cause the observed accumulation of PCBs in aquatic biota. Gobas et al. (1993, 1995, 1999) also has developed trophic transfer models that predict PCB concentrations in fish and invertebrates in Lake Ontario. These and other site-relevant models may be used to evaluate exposure pathways to aquatic biota in the assessment area.

Figure 8-16
Representative Aquatic Exposure Pathways and Species



Pathway determination will include evaluating concentrations of hazardous substances in pathway resources to determine if complete pathways exist from points of release and exposed natural resources. Further data analysis may be performed as part of the assessment process to fully evaluate pathways to biological resources.

8.8.4 Injury Quantification Approaches

Quantification of injuries to aquatic biota resources may include evaluation of:

- the spatial extent of injuries throughout the assessment area
- the temporal extent of injuries throughout the assessment area.

GIS platforms will be used to facilitate spatial quantification using the database prepared in the Phase I assessment. For example, preliminary evaluation of the spatial extent of injury indicates that PCB concentrations in fish collected from the St. Lawrence River, the Grasse River, and the Massena Power Canal (adjacent to and downstream of PRP facilities) are elevated above background concentrations (Figures 8-14 and 8-15). Existing data also show that elevated concentrations of PCBs in aquatic biota have resulted in consumption advisories for sport fish in the Lake Ontario/St. Lawrence area since 1976 (NYSDEC, 1976). Existing biological data also suggest that fish, aquatic reptiles, amphibians, and aquatic mammals are potentially injured by releases of hazardous substances in the assessment area. Injuries will be quantified by assessing the degree of injury (e.g., biological, temporal, spatial extent) when compared to baseline.

8.8.5 Additional Studies

Available data indicate that aquatic biota are injured based on injury definitions presented in Table 8-9. Biological effects resulting from exposure to hazardous substances, including PCBs and PAHs, have been measured in invertebrates, aquatic reptiles and amphibians, fish, and aquatic mammals. Exposure to sediments in the assessment area may result in benthic invertebrate lethality (Wood et al., 1997) or altered benthic community composition (Woodward-Clyde, 1992; 1995). The biological effects of PCBs on aquatic reptiles and amphibians include lethality (Savage and Quimby, 1999), reproductive impairment (Bishop et al., 1991), biochemical alterations (Gendron et al., 1997; Savage and Quimby, 1999), and skeletal deformities (Gendron et al., 1997). The biological effects of PCBs and/or PAHs on fisheries resources include lethality (Walker and Peterson, 1992), impaired embryo development (Walker and Peterson, 1992), immune modulation (Weeks et al., 1992; Zelikoff, 1994; Rice and Schlenk, 1995), reproductive effects (Walker and Peterson, 1992; NOAA, 1999), interactions between nutrient status and reproductive effects (Ackerman et al., 1998; Wright et al., 1998), reduced growth (NOAA, 1999), histopathological effects (Schrank et al., 1997; Teh et al., 1997), biochemical alterations (Moon et al., 1996), and carcinogenic effects (Bailey et al., 1987; Moore and Meyers, 1994; Baumann and Harshbarger, 1995; Schrank et al., 1997). Exposure to PCBs and PAHs in the St. Lawrence

River ecosystem has been associated with histopathological lesions and carcinogenic effects in aquatic mammals (Béland et al., 1993; De Guise et al., 1994, 1995a).

Based on the results of the Phase I injury evaluation (see Figure 8-1), additional studies may be conducted, as determined by the trustees, to supplement existing data on the biological effects associated with exposure to hazardous substances in the St. Lawrence Assessment Area.

8.9 TERRESTRIAL BIOTA RESOURCES

8.9.1 Injury Definitions

Based on initial review of existing data, injuries to terrestrial biota resources that may be evaluated by the trustees include those previously listed in Section 8.8.1.

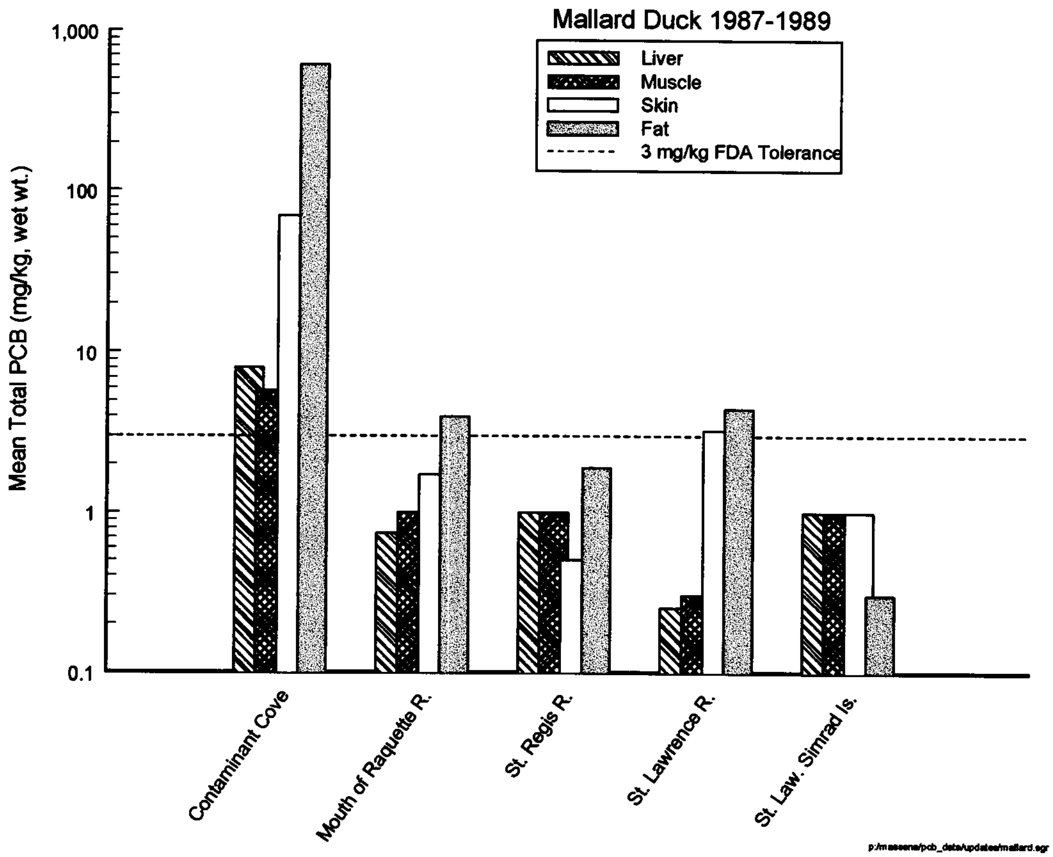
8.9.2 Injury Determination Approaches

Following the same injury assessment approach described in Section 8.8, injury to insects, birds, and terrestrial mammals by the hazardous substances of concern may be assessed as described below. Injuries to terrestrial biological resources will be evaluated according to the proposed injury assessment approach (see Figure 8-1), including a focused review of available data, comparison to injury thresholds, and an evaluation of the spatial and temporal extent of injuries throughout the assessment area.

Consumption Advisories, Exceedences of FDA Tolerances, and Exceedences of Baseline

Available data show that birds have accumulated PCB concentrations that exceed tribal, state, and federal standards or tolerance levels for consumption of those species. As previously presented in Table 6-13, PCB concentrations in the fat of birds collected from the assessment area in the late 1980s have been sufficiently elevated to exceed the 3 mg/kg (in fat) FDA tolerance level. For example, PCB concentrations in liver, muscle, skin and fat of mallard duck are presented in Figure 8-17; mean total PCB levels exceed the FDA tolerance level of 3 mg/kg in fat in ducks collected from Contaminant Cove, at the mouth of the Raquette River, and in the St. Lawrence River. PCB concentrations in the fat of birds collected from the assessment area have also been sufficiently elevated to trigger bird consumption advisories by the NYDOH. For example, since 1991, NYS health advisories for sportfish and game have stipulated that no common mergansers should be eaten (NYSDOH, 1999). In addition, other waterfowl should be skinned and all fat removed before cooking, and consumption should be limited to no more than two meals per month (NYSDOH, 1999).

Figure 8-17
Mean Total PCB Concentrations (mg/kg, wet weight) in Tissues of Mallard Ducks Collected in the Assessment Area at Contaminant Cove and Areas Downstream along the St. Lawrence, Raquette, and St. Regis Rivers (1987-1989)



"Mean total PCB" concentrations are values that were reported as means of total PCB concentrations in original source document. Data derived from the St. Lawrence Environment Trustee Council Environmental Database (Hagler Bailly Services, 1998).

As described in Table 8-9, evaluation of injuries to birds and mammals by the trustees will include determining which species exceed FDA tolerance levels, consumption advisory levels, and baseline levels. Bird consumption advisories present in the assessment area will be tabulated and related to hazardous substances (primarily PCBs).

Biological Injuries

Insects

A review of limited site-specific data in the assessment area indicates that fluoride exposure may result in injury to insects. Rice (1983) measured elevated fluoride concentrations in honeybees and bumblebees ranging from 29 to 406 mg/kg on Cornwall Island. Fluoride concentrations between 100 and 200 ppm dry weight in honeybees are sufficient to cause fluoride toxicity (Lillie, 1970, as cited in Rose and Marier, 1977; Bromenshenk, 1978, as cited in Rice, 1983). In addition, Cornwall Island residents reported noticeable reductions in bee and grasshopper populations between 1969 and 1983 (Miles, 1983) potentially resulting from fluoride exposure. Laboratory studies have measured increased fluoride concentrations in honeybees (*Apis mellifera*) as a result of exposure to gaseous and particulate fluorides (Mayer et al., 1988). Dreher (1965, as cited in Mayer et al., 1988) observed acute lethality (LD_{50}) at fluoride concentrations of 10 μg/bee, and Lillie (1970, as cited in Rose and Marier, 1977) concluded after a review of the literature that fluoride concentrations of 4-5 μg/bee (130-170 ppm dry weight) were sufficient to be lethal. In addition, Aikens et al. (1970, as cited in Mayer et al., 1988) observed reduced lifespan in caged worker bees continuously exposed to 4-5 ppb gaseous fluoride.

Elevated concentrations of hydrogen fluoride (up to 5.2 ppb) in the air measured downwind of the RMC (NYSDEC, 1990a) have been associated with chromosomal damage in fruitflies. Chromosomal damage has been observed in fruitflies exposed to 1.3 and 2.6 ppm airborne hydrofluoric acid over a six-week period (Gerdes et al., 1971, as cited in Rose and Marier, 1977).

Birds

PCBs. The concentration of total PCBs in eggs of tree swallows collected between 1991 and 1994 from Akwesasne property was 11.1 mg/kg, although no significant difference in hatchling or fledgling success was observed (Bishop et al., 1995b). Laboratory studies have shown that concentrations of PCBs in bird eggs in the range of 5-10 mg/kg may be associated with embryotoxicity (Peakall et al., 1972; Britton and Huston, 1973; Wiemeyer et al., 1984; Brunstrom and Reutergardh, 1986; Kubiak et al., 1989; Yamashita et al., 1993). Embryo mortality, edema, and deformities syndrome in colonial fish-eating birds such as herring gulls, common terns, Forster's terns, and double-crested cormorants have been related to organochlorine (e.g., PCB) contamination in the Great Lakes (Gilbertson et al., 1991; Giesy et al., 1994), although other organochlorines (e.g., DDE) may play a significant role in the observed toxic effects (Custer et al., 1999). The concentration of PCBs measured in common mergansers (e.g., 0.6-8.5 mg/kg wet weight in muscle) of the assessment area (Skinner, 1992) suggests that egg concentrations in birds may approach embryotoxic levels for some sensitive species.

As described for fish (Section 8.7.2), exposure of birds to PCBs and related compounds can cause sublethal alterations in CYP1A enzyme activity and other biochemical processes. For example, retinyl palmitate (vitamin A) concentrations are negatively correlated with PCB (i.e., congeners

105 and 118) concentrations in eggs of great blue herons (*Ardea herodias*) collected from Dickerson Island in Lake St. Francis (Boily et al., 1994). Recently hatched tree swallows (*Tachycineta bicolor*) collected on Akwesasne show induced EROD activity and depressed liver retinyl palmitate concentrations (Bishop et al., 1995b).

Fluoride. No site-specific data on the effects of fluoride exposure on birds are available from the assessment area. However, laboratory and field studies have documented adverse effects of fluoride exposure on birds. For example, eastern screech-owls (*Otus asio*) fed a 200 mg/kg fluoride-contaminated diet had reduced fertility (reduced number of eggs per hatch) and reduced hatching success (reduced number of young per clutch) (Pattee et al., 1988). In addition, the dietary exposure of 200 mg/kg fluoride may have had potential teratogenic effects (Hoffman et al., 1985, as cited in Pattee et al., 1988). This dietary fluoride concentration fed to the eastern screech owls is typical of fluoride levels in invertebrates and small mammals inhabiting fluoride-contaminated environments (Pattee et al., 1988). Other studies have observed elevated bone fluoride concentrations in black-crowned night herons (*Nycticorax nycticorax*) exposed to fluoride (Henny and Burke, 1990) and lower nesting densities of house martins (*Delichon urbica*) exposed to fluoride (Newman, 1977, as cited in Pattee et al., 1988).

Mammals

PCBs. Mink (*Mustela vison*) and river otter (*Lutra canadensis*), both species of special significance to the Akwesasne, are potentially injured by releases of PCBs in the assessment area. For both species, fish are a significant source of food; hence, trophic transfer of PCBs is probable (Ram and Gillett, 1993). Laboratory investigations have shown that mink are extremely sensitive to the toxic effects of PCBs (Aulerich et al., 1987; Addison et al., 1991; Wren, 1991; Eisler, 1996). Adverse effects in mink exposed to PCBs include lethality, reduced growth, impaired reproduction, weight loss, and histopathological lesions (Eisler, 1996). The trustees may evaluate potential mink and otter habitat in the assessment area and perform an analysis (similar to that described in Section 8.8.2) to determine whether PCB exposure in the assessment area will likely cause adverse impacts to mink and otter reproduction and survival.

Fluoride. Based on limited data in the assessment area, mammals (especially herbivores) appear to have been injured by fluoride exposure. For example, captive animals on Cornwall Island have been impacted by fluoride exposure since the 1960s (Emerson, 1988). Krook and Maylin (1979) observed chronic fluorosis in cattle on Cornwall Island even though the fluoride concentration in the foliage was less than the 40 mg/kg growing standard. Effects of fluoride exposure on Cornwall Island cattle include osteosclerosis, osteonecrosis, failure of modeling of bone, brown discoloration of teeth, mottling on permanent teeth (chalk-like spots, patches, or striations), teeth attrition (uneven and excessive wear), bulging of the gingiva (due to excessive mobility of teeth and recession of the alveolar bone), and delayed eruption of permanent teeth (Krook and Maylin, 1979). In extreme cases, mastication was painful and cattle would not eat. Chronic fluoride poisoning of cattle was also suspected on a New York State farm 2 km southeast of the RMC facility, where fluorosis caused such severe lameness that the cattle could not move and they were sold for slaughter (Crissman et al., 1980). Although the results with captive animals are not easily transferred to wild free-ranging mammals, the exposure pathway and biological effects in cattle suggest that other herbivorous mammals on Cornwall Island have also been affected by fluoride.

Elevated fluoride concentrations have been measured in femurs of meadow voles (*Microtus pennsylvanicus*) and short-tailed shrews (*Blarina brevicada*) collected from the assessment area near the RMC and ALCOA facilities (Miles, 1983). Femur fluoride values (mg/kg dry fat-free weight) ranged from 1,310 to 5,599 mg/kg in meadow voles (mean 3,775 mg/kg) and from 5,284 to 8,678 mg/kg in short-tailed shrews (mean 6,557 mg/kg) (Miles, 1983). These elevated fluoride concentrations in the voles and shrews are consistent with observed clinical symptoms of fluorosis (including increased tooth wear and tooth lesions) observed in wood mice, moles, and field voles. Walton (1987) observed excessive tooth wear and loss of tooth enamel associated with fluoride exposure in incisor teeth in wood mice (*Aprodemus sylvaticus*), moles (*Talpa europaea*), and field voles (*Microtus agrestis*) near an aluminum reduction plant. Severe tooth damage was seen only in animals close to the aluminum reduction plant (200-300 m), and increased tooth wear was associated with increased bone fluoride concentration (skeletal fluoride concentrations ranged from 2,500 to 15,000 mg/kg dry weight compared with 168 mg/kg dry weight in an uncontaminated reference location). Clinical symptoms, apart from mild tooth lesions, did not appear to occur until bone fluoride exceeded 2400 mg/kg dry weight (Walton, 1987).

A risk assessment based on site-specific fluoride data in various media predicted that white-tailed deer (*Odocoileus virginianus*) residing on Cornwall Island were potentially injured from exposure to fluoride. The predicted daily intake of fluoride ranged from 2 to 324 μg/deer/day, with 12% of the deer population exceeding the daily intake threshold for fluorosis of 55 μg/deer/day (Kent et al., 1995).

Other studies have documented injury to mammals as a result of fluoride exposure. Lameness induced by fluoride has been observed in wild deer (Kay et al., 1976, as cited in Rose and Marier, 1977). In a predator-prey situation, even a minor loss of mobility induced by fluorosis can lead to rapid elimination of the individuals affected (Kay et al., 1976, as cited in Rose and Marier, 1977). In fact, fluoride exposure in the common hare (*Lepus europaeus* Pall.) near an industrial zone may be related to the greater percentage of older hares trapped near the contaminated zone than in the control zone (Paukert, 1988).

Injuries to terrestrial biota resources will be evaluated according to the proposed injury assessment approach (see Figure 8-1).

Summary. Relevant terrestrial biological injuries to be evaluated by the trustees are presented Table 8-13.

Table 8-13
Relevant Terrestrial Biological Injury Categories by Resource

Injury Category	Resource		
	Insects	**Birds**	**Mammals**
Death	✔	✔	
Disease			
Cancer			
Physiological Malfunctions (including reproduction)	✔	✔	✔
Physical Deformities	✔	✔	✔

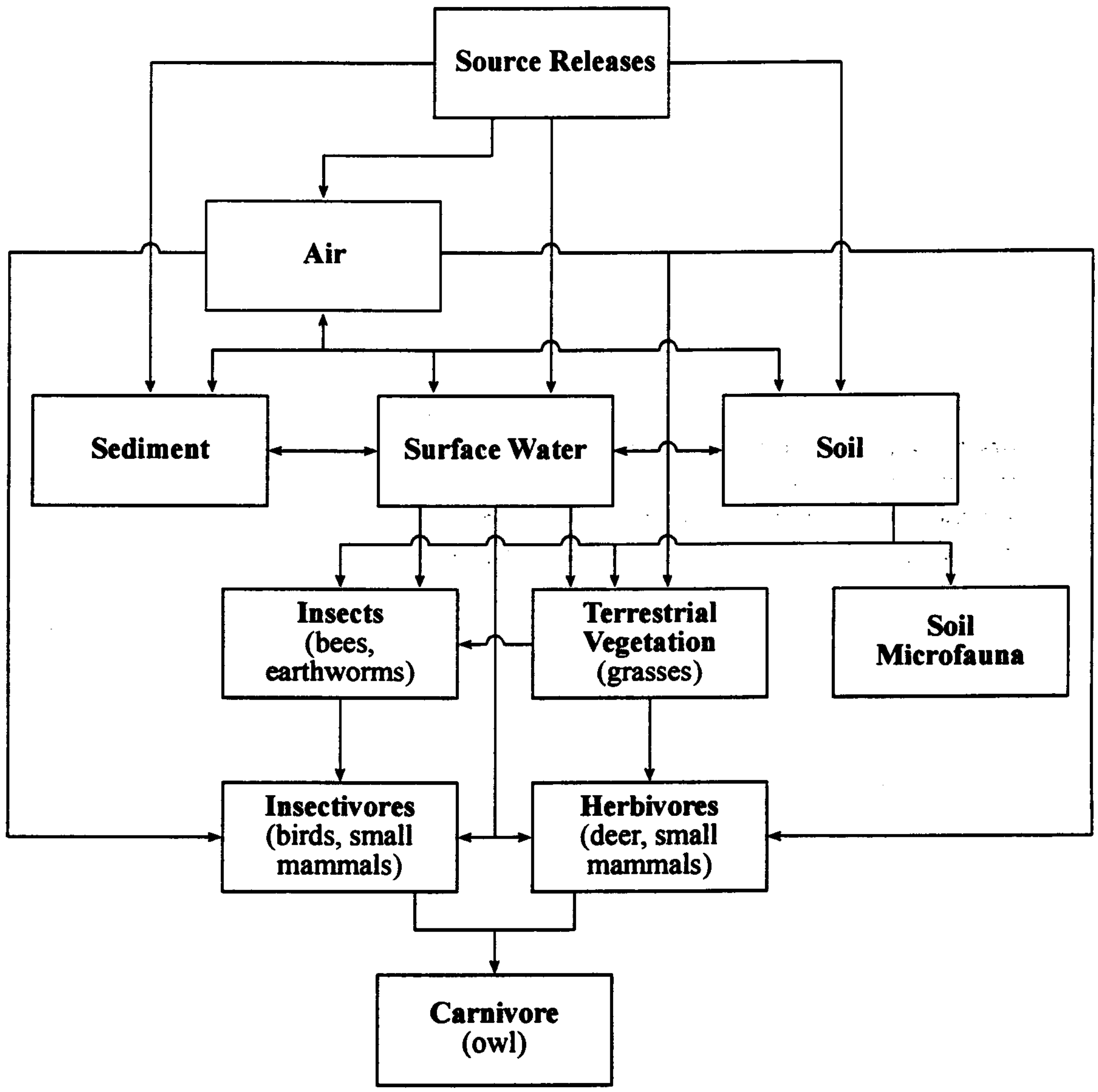
Biological injuries identified in various terrestrial organisms will be tabulated and related to hazardous substances based on a review of the toxicological literature, results of additional Phase I and Phase II assessment studies, and concentrations of hazardous substances in exposure media and in the organisms, and risk analysis.

8.9.3 Pathway Evaluation

As per DOI regulations, pathway may be determined by demonstrating the presence of hazardous substances in sufficient concentrations in the pathway resource or by using a model that demonstrates that the conditions existed . . . such that the route served as a pathway [43 CFR § 11.63(a)(2)]. Exposure pathways to biological resources in the assessment area include direct exposure through physical contact with hazardous substances in surface water, air, soil, and sediments as well as indirect exposure through food chain processes (Figure 8-18). For example, PCB residue data from surface water, sediments, soils, and biota can be used to determine if pathways of exposure exist for birds and mammals of the assessment area. As described previously, using site-specific surface water, sediment, and soil PCB data, Ram and Gillett (1993) predicted resultant PCB residues in several birds and mammals of the assessment area and demonstrated that concentrations of PCBs in surface water, sediments, and soils are sufficient to cause the observed accumulation of PCBs in terrestrial biota. In addition, Ram and Gillett (1993) also determined that if mink were to consume 50 to 100% of their diet within the assessment area, more than 20% would develop lethal body burden concentrations and the majority would suffer reproductive impairment.

Pathways of fluoride exposure to birds and terrestrial mammals will be evaluated. For example, ingestion of earthworms that contain fluoride-contaminated soil in their gut appears to be a pathway of fluoride exposure in mammals (e.g., moles and shrews) and birds (Walton, 1987). The

Figure 8-18
Representative Terrestrial Exposure Pathways and Species



fluoride concentration in the earthworms is predominately associated with the gut contents (Walton, 1987) and is bioavailable under acidic conditions (e.g., pH < 2.0) typically found in vertebrate stomachs (Walton, 1987).

Pathway determination will include evaluating concentrations of hazardous substances in pathway resources to determine if complete pathways exist from points of release and exposed natural resources. As described in Section 8.8.3, further data analysis will be performed as part of the assessment process to fully evaluate pathways to terrestrial biological resources.

8.9.4 Injury Quantification Approaches

Quantification of injuries to terrestrial biota resources may include evaluation of:

- the spatial extent of injuries throughout the assessment area
- the temporal extent of injuries throughout the assessment area.

GIS platforms will be used to facilitate spatial quantification using the database prepared in the Phase I assessment. For example, existing data since the late 1980s indicate that elevated concentrations of PCBs in several bird species in the assessment area have exceeded consumption advisory levels. In addition, some species may suffer adverse biological injuries from PCB and fluoride exposure. Preliminary evaluation of the spatial extent of potential biological injuries to birds includes several locations on Akwesasne, Cornwall Island, and islands in Lake St. Francis. Injuries will be quantified by assessing the degree of injury (e.g., biological, temporal, spatial extent) when compared to baseline. Further data analysis may be performed to quantify injuries to birds, mink, and other terrestrial species.

8.9.5 Additional Studies

Available data suggest that terrestrial biota are injured based on the injury definitions presented in Section 8.9.2 and Table 8-9. Biological effects resulting from exposure to hazardous substances, including PCBs and fluorides, have been measured in insects, birds, and mammals. An assessment of the biological effects of fluoride on insects includes lethality (Lillie, 1970, as cited in Rose, 1977; Aikens et al., 1970, as cited in Mayer et al., 1988), fluoride toxicity (Bromenshenk, 1978, as cited in Rice, 1983), and chromosomal damage (Gerdes et al., 1971, as cited in Rose and Marier, 1977). The biological effects of PCBs on birds include embryotoxicity (Peakall et al., 1972; Wiemeyer et al., 1984; Kubiak et al., 1989; Yamashita et al., 1993), embryo mortality, edema, deformities (Gilbertson et al., 1991; Giesy et al., 1994), and biochemical alterations (Boily et al., 1994). Fluoride ingestion in birds via dietary pathways may result in reproductive impairment (Pattee et al., 1988), teratogenic effects (Hoffman et al., 1985, as cited in Pattee et al., 1988), or reproductive effects (Newman, 1977, as cited in Pattee et al., 1988). The biological effects of PCBs on mammals (especially mink and river otter) include lethality, reduced growth, impaired reproduction, weight loss, and histopathological lesions (Eisler, 1996). The biological effects of fluoride on mammals include osteosclerosis, osteonecrosis, failure of modeling of bone, brown discoloration of teeth, mottling on permanent teeth, teeth attrition, bulging of the gingiva, delayed eruption of permanent teeth (Krook and Maylin, 1979), and lameness (Kay et al., 1976, as cited in Rose and Marier, 1977).

Based on the results of Phase I, additional studies may be undertaken to supplement existing data on concentrations of hazardous substances in terrestrial biota, pathways to exposed terrestrial biota, and potential biological injuries in terrestrial biota of the assessment area. Any additional studies will be described in addenda to the assessment plan.

8.10 VEGETATION RESOURCES

8.10.1 Injury Definitions

Based on initial review of existing data, injuries to terrestrial biota resources that may be evaluated by the trustees include:

- Concentrations of a hazardous substance sufficient to cause the biological resource or its offspring to have undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations [43 CFR § 11.62(f)(1)(i)].
- Concentrations of a hazardous substance sufficient to exceed levels for which an appropriate state health agency has issued directives to limit or ban consumption of such organism [43 CFR § 11.62(f)(1)(iii)].
- Concentrations of hazardous substances that exceed baseline concentrations [43 CFR § 11.14(e)] and, as a result, cause loss of services to the Akwesasne Mohawks provided by vegetation resources (especially Mohawk existence values and the medicinal uses of plants).

8.10.2 Injury Determination Approaches

The injury definitions in Section 8.10.1 contain several components. Table 8-14 summarizes the components of each definition and the approaches that may be used by the trustees in assessing each component. Injury to aquatic macrophytes, lichens, grasses, forbs, scrubs, and trees by the hazardous substances of concern may be assessed as described below. Injuries to vegetation

Table 8-14
Components of Relevant Vegetation Injury Definitions

Injury Definition	Definition Components	Evaluation Approach
Exceed Relevant Standards or Criteria for Hazardous Substances [43 CFR § 11.62(f)(1)(iii)]	Tissue concentrations of a hazardous substance in plant exceed applicable standards.	Compare plant tissue fluoride concentrations to applicable NYS criterion.
Adverse Changes in Viability [43 CFR § 11.62 (f)(1)(i)]	The biological resource or its offspring has undergone at least one of the following adverse changes in viability: death, disease, behavioral abnormalities, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), or physical deformations.	Determine whether the measured biological response in plants satisfies the criteria for indicating an adverse change in viability.
Biological Resources Are Injured when Exposed to Soil [43 CFR § 11.62(e)]	Biological resources are injured when exposed to soil (e.g., phytotoxicity).	Compare soil concentrations to literature-derived toxicity thresholds. If necessary, conduct site-specific laboratory toxicity tests with soils (e.g., plant/ microbial toxicity tests).
Baseline Exceedence [43 CFR § 11.14(e)]	Aquatic biota resources are injured when concentrations of hazardous substances exceed baseline.	Determine whether exceedences of baseline affect Akwesasne Mohawk values or existence values, particularly those related to the medicinal use of plants.

resources will be evaluated according to the proposed injury assessment approach (see Figure 8-1), including a focused review of available data, comparison to injury thresholds, and an evaluation of the spatial and temporal extent of injuries throughout the assessment area.

Aquatic Vegetation

Recent investigations within the assessment area have shown that floating (*Nuphar variegatum*) and submerged (*Myriophyllum spicatum*) aquatic vegetation within the proximity of PCB-contaminated sediments can bioaccumulate PCBs to a significant extent (37 to 585 ng/g dry weight total PCBs). The plants bioaccumulated from 0.3 to 10 times more PCBs than found in adjacent sediments (Richard et al., 1997). Therefore, the high biomass of aquatic plants within the St. Lawrence River and Lake St. Francis ecosystems represents an important reserve of PCBs that could be transferred to herbivorous (plant eating) animals (Richard et al., 1997).

PCBs may also adversely affect the growth of aquatic plants. Rates of clonal growth and leaf production are reduced in American wildcelery (*Vallisneria americana*) exposed to PCBs (Aroclor 1254:1260) of approximately 0.5 to 30 ng/g dry weight in the plant tissue (Lovett-Doust et al., 1994, as cited in Richard et al., 1997). Biological injuries to aquatic plants may be evaluated by the trustees. In addition, the role of aquatic plants as a pathway of exposure to other species may be investigated.

Wetland Vegetation

Wetland vegetation loss on the RMC property has been documented in areas such as Dead Clam Cove, where vegetation no longer exists in the immediate vicinity and surrounding areas of RMC 002 Outfall (Stone, 1988). The loss of wetland plant species in the RMC Wetland has also been attributed to hazardous substances and other toxicants being released from the RMC, including airborne fluoride, cyanide, and arsenic (Woodward-Clyde, 1990a). The "area of damage" in the RMC Wetland was estimated to be 2 acres in 1989; the area of less severe yet still significant damage was not estimated (Woodward-Clyde, 1990a). Habitat loss and biological injuries to wetland vegetation may be assessed by the trustees. Injuries to wetland resources will be evaluated according to the proposed injury assessment approach (see Figure 8-1).

Terrestrial Vegetation

Terrestrial vegetation in the assessment area has been injured as a result of fluoride exposure. Phytotoxicological investigations have been conducted by the Ontario Ministry of the Environment (OME) on Cornwall Island during the growing season from 1976 to at least 1986. Visible injury typical of fluoride exposure (i.e., plant growth inhibition, tip and marginal foliar necrosis, chlorosis, wilting and death of leaves (Miles, 1983, Rice, 1983) was observed in wild grape and gladiolus on Cornwall Island for each growing season between 1977 and 1982 (Rice, 1983). Visible damage to white pine, wild cherry, and Manitoba maple was also reported on St. Regis tribal lands and on Cornwall Island (Miles, 1983; Rice, 1983). Emerson (1987) noted that in the 1984 OME assessment of Cornwall Island, average fluoride injury occurred in approximately 10% in that year's needles of several red pines. In addition, Cornwall Island residents reported dead or dying eastern white pines nearest — and downwind of — the RMC plant (Miles, 1983).

Results from the OME phototoxicity evaluations indicate that fluoride concentrations are elevated in vegetation on Cornwall Island in areas closest to the RMC facility. In addition, these elevated fluoride concentrations were correlated with fluoride-like injuries to vegetation (wild grape; trembling aspen; red, silver, and Manitoba maple). Fluoride injury to trembling aspen, red pine, and red maple was confirmed with histological and pathological examination (Emerson, 1987).

Exceedences of fluoride exposure on vegetation has occurred in the assessment area. For example, in 1990, seasonal mean fluoride concentrations were 119 ppm and 74 ppm in foliage grasses in the immediate vicinity and downwind of the RMC and ALCOA facilities, respectively

(NYSDEC, 1990a). Both of these concentrations exceeded the NYS rules and regulations of 40 ppm for fluoride concentrations in foliage over the growing season. Foliage in other sampling locations farther downwind of the ALCOA and RMC facilities had between 5 and 28 ppm foliage fluoride concentrations. Although these concentrations are below the NYS guidelines, they do exceed the OME's "upper limit of normal" guideline for fluoride in rural foliage of 15 ppm (Emerson, 1987). In fact, maximum monthly (30 days) fluoride concentrations over the growing season were 280 ppm and 231 ppm at the same RMC and ALCOA facilities, well above the 30-day NYS rules and regulations of 80 ppm for fluoride concentrations in foliage (NYSDEC, 1990a).

Other studies have observed injury associated with fluoride exposure. Elevated fluoride concentrations can result in impaired fruit quality and reduced fruit yield (U.S. EPA, 1980, as cited in Miles, 1983), and possibly reduced reproduction and resistance (Miles, 1983). In some plants, mutagenic effects have been observed. Exposure of 0.019 ppm sodium fluoride and hydrogen fluoride to seedling roots of barley (*Hordium vulgare*) resulted in chromosomal bridges, fragments, and gaps during mitosis of root tip cells (Bale and Hart, 1973, as cited in Rose and Marier, 1977). In addition, some lichen species are sensitive to fluoride exposure. Fructicose (shrubby) and foliose (leaf-like) lichens were more sensitive than crustose (crust-like) lichens to airborne fluoride exposure from an aluminum works in Holyhead, North Wales (Perkins and Millar, 1987). Lichen flora were almost eliminated within 1 km of the aluminum works, and the area was recolonized with a pollution-tolerant lichen species. Injuries to terrestrial vegetation resources will be evaluated according to the proposed injury assessment approach (see Figure 8-1).

Summary

Biological injuries identified in aquatic and terrestrial vegetation will be tabulated and related to hazardous substances based on a review of the toxicological literature, results of additional assessment studies (Section 8.10.5), and concentrations of hazardous substances in exposure media and in vegetation. As described in Table 8-13, evaluation of injuries to vegetation by the trustees also may include determining which species exceed NYS growing season standards (e.g., Table 6-15), and baseline levels for hazardous substances. Further data analysis may be performed as part of the assessment process to fully evaluate vegetation injuries.

Phase I injury assessment also may include a service reduction analysis approach. For example, GIS platforms (Section 8.10.4) will be used to assess fluoride concentrations in vegetative communities on Cornwall Island. Based on injury thresholds compiled in Phase I and, potentially, Phase II assessments (Section 8.10.5), the spatial extent and degree of service reductions may be assessed. Service reductions may include lost ecological services (e.g., habitat for herbivorous mammals) or lost human use services (e.g., Akwesasne Mohawk use of ceremonial plants).

8.10.3 Pathway Evaluation

As per DOI regulations, pathway may be determined by demonstrating the presence of hazardous substances in sufficient concentrations in the pathway resource or by using a model that demonstrates that the conditions existed . . . such that the route served as a pathway [43 CFR § 11.63(a)(2)]. Aquatic plants are exposed to hazardous substances via contaminated surface water and sediments (Figure 8-16). For example, Richard et al. (1997) showed a significant positive relationship between degree of sediment PCB contamination and PCB levels in aquatic macrophytes. Through hierarchical cluster analysis of PCB congener patterns, Richard et al. (1997) also showed that macrophytes accumulate congeners similar to those found in surrounding sediments and are enriched in tetrachlorobiphenyl congeners relative to sediments. As discussed in Section 8.9.3, terrestrial vegetation may be exposed to PCBs via aerial transport as well as contaminated soils (Figure 8-18). PCB congener concentrations in soils, surface water, sediments, air, and vegetation may be evaluated to determine pathways of exposure to vegetation.

Atmospheric transport of gaseous and particulate fluoride is the primary pathway of fluoride to vegetation. In general, as the distance downwind (i.e., east) of RMC and ALCOA increases, fluoride concentrations in the vegetation typically decrease (Miles, 1983; Rice, 1983). Particulate and gaseous fluoride absorbed onto or into plants provides a pathway to foraging animals. Fluoride found naturally in soils or added to soils as fertilizer is not believed to be a significant pathway of fluoride to vegetation (U.S. EPA, 1980, as cited in Miles, 1983).

Existing stormwater/industrial outfall, stack emission, surface water, sediment, soil, air, and groundwater contaminant data will be used to evaluate pathways of hazardous substances to vegetation resources. Pathway determination will include evaluating concentrations of hazardous substances in pathway resources to determine if complete pathways exist from points of release and exposed natural resources. Further data analysis may be performed as part of the assessment process to fully evaluate pathways to vegetation resources.

8.10.4 Injury Quantification Approaches

Quantification of injuries to vegetation may include evaluation of:

- the spatial extent of injuries throughout the assessment area
- the temporal extent of injuries throughout the assessment area.

As described for surface water and sediment resources, GIS platforms will be used to facilitate spatial quantification using the database prepared in the Phase I assessment. Recent data (1995) show that PCB concentrations in macrophytes from the assessment area are elevated along the south channel of the St. Lawrence River from Contaminant Cove all the way downstream to the entrance of Lake St. Francis (Section 6.7.1). Concentrations in macrophytes from the south channel range from 186 μg/kg to 488 μg/kg (Richard et al., 1997). Concentrations in macrophytes from the north channel of the St. Lawrence are elevated, but are much lower than concentrations in the south channel (generally 50-100 μg/kg) (Richard et al., 1997).

Elevated concentrations of PCBs and fluoride in terrestrial vegetation are well documented, with exceedences of fluoride growing season standards occurring since the late 1980s (Table 6-15). The spatial extent of fluoride contamination within the exposure area includes areas downwind from ALCOA and the RMC facilities, including Cornwall Island. PCBs as high as 1.7 mg/kg have been measured in vegetation samples on and near Akwesasne property. Further data analysis and assessment of service reductions (as described in Section 8.10.2) may be performed to quantify injuries to aquatic and terrestrial vegetation.

8.10.5 Additional Studies

Available data indicate that vegetation are injured based on injury definitions presented in Table 8-13. Biological effects resulting from exposure to hazardous substances, including PCBs and fluorides, have been measured in aquatic vegetation, wetland vegetation, and terrestrial vegetation. The biological effects of PCBs in aquatic vegetation include reduced growth (Lovett-Doust et al., 1994, as cited in Richard et al., 1997). Biological effects resulting from elevated concentrations of airborne fluoride, cyanide, and arsenic on wetland vegetation include loss of plant species (Woodward-Clyde, 1990a). The biological effects of fluoride on terrestrial vegetation include plant growth inhibition, tip and marginal foliar necrosis, chlorosis, wilting, and death of leaves (Miles, 1983; Rice, 1983); impaired fruit quality and reduced fruit yield (U.S. EPA, 1980, as cited in Miles, 1983); and mutagenic effects (Bale and Hart, 1973, as cited in Rose and Marier, 1977).

Based on the results of Phase I, additional studies may be undertaken to supplement existing data on concentrations of hazardous substances in vegetation, and pathways to exposed aquatic and terrestrial vegetation in the assessment area. Any additional studies will be described in addenda to the assessment plan.

8.11 ASSESSMENT OF RESIDUAL INJURY

The overall injury quantification process will also include an evaluation of how any selected remedies or response actions in the assessment area will affect natural resources. This evaluation may include determination of how much injury will continue to occur after completion of the remedy/response actions, as well as consideration of any additional injuries that have resulted from response actions [43 CFR § 11.15 (a)(1)]. For example, applying a thin layer cap of clean fill over contaminated sediments has been proposed as a possible remedial alternative for the Grasse River (ALCOA, 1999c). The trustees' injury determination may consider both ongoing post-response injuries caused by any residual contamination following capping, as well as any collateral natural resource injuries caused by the capping process itself (e.g., smothering effects of capping on the benthic community).

The trustees' assessment of residual injuries (including collateral injuries resulting from response actions) will be initiated following selection of remedial alternatives and may be based on evaluation of existing data (e.g., information contained in RI/FS reports) or on additional studies, if necessary.

8.12 OBTAINING AND SHARING DATA

The potentially responsible parties will be given the opportunity, as deemed appropriate by the trustees, to obtain validated data from studies conducted under this plan. Data requests should be made in writing to the trustees. Data will be provided when it is available.

The PRPs will also be given the opportunity, as deemed appropriate by the trustees, to split samples or obtain duplicate samples while sampling is being conducted under this plan. Notice of the intent to request split or duplicate samples should be made in writing to the trustees.

CHAPTER 9
RESTORATION PLANNING AND COMPENSABLE VALUE DETERMINATION

9.1 INTRODUCTION

This chapter provides an overview of the restoration and economic valuation approaches to be used. These approaches are explained in the context of the DOI regulations promulgated under CERCLA (43 CFR Part 11, as amended).

The court in *Ohio v. Interior* recognized a statutory preference for using restoration costs as the measure of natural resource damages (59 FR 14281). The court used the term restoration costs to encompass the costs of restoring, rehabilitating, replacing, and/or acquiring the equivalent of the injured natural resources. The court also stated that the reliably calculated lost values of injured natural resources may be assessed as damages. These values are attributable to the public loss of services provided by the injured natural resources between the time of the release and the time the resources are fully returned to their baseline conditions [43 CFR § 11.83(c)(1)]. These lost services are referred to as interim lost use and their associated values as compensable values.

Baseline refers to the conditions of the injured natural resources that would have existed absent the release of hazardous substances [43 CFR § 11.14(e)]. Restoration actions are undertaken to return injured natural resources to their baseline conditions. Actions that achieve baseline conditions at an earlier date will restore the ability of natural resources to provide services sooner than if baseline conditions were achieved at a later date. In this way, the restoration actions that achieve baseline at the earlier date reduce total interim lost use. Therefore, restoration actions and interim lost use are jointly determined.

This chapter is organized as follows. Sections 9.2 and 9.3 discuss approaches to restoration planning and compensable value determination. This discussion will guide the trustees in developing a Restoration and Compensation Determination Plan (43 CFR §11.81). The Restoration and Compensation Determination Plan is intended to provide sufficient information to enable the trustees to select the appropriate restoration alternatives to be used to determine restoration costs and compensable values. Sections 9.4 and 9.5 briefly discuss two topics related to the Restoration and Compensation Determination Plan: 1) the preliminary estimate of damages and 2) double counting, uncertainty, and time.

At present, the existing information regarding possible restoration alternatives is not sufficient to develop the Restoration and Compensation Determination Plan. Therefore, the Restoration and Compensation Determination Plan will be developed at a later date [43 CFR § 11.81(d)(1)].

9.2 RESTORATION PLANNING

9.2.1 Development of Restoration Alternatives

The trustees will identify a range of possible restoration alternatives [43 CFR § 11.82(a)]. This range must include a natural recovery alternative with minimal management actions. Other alternatives with more intensive actions that more quickly return the injured natural resources to their baseline conditions may also be included. At least some range of possible alternatives will incorporate Mohawk community needs and goals in the restoration planning.

9.2.2 Evaluation and Selection of Restoration Projects

When selecting the appropriate restoration alternative to be used to determine restoration costs and compensable values, the trustees will evaluate each proposed alternative using all relevant considerations, including the following factors [43 CFR § 11.82(d)]:

- technical feasibility
- the relationship between the expected restoration costs and expected restoration benefits
- cost-effectiveness
- the results of any actual or planned response actions
- the potential for additional natural resource injury resulting from the proposed alternative
- the natural recovery time period
- the ability of the natural resources to recover with or without alternative actions
- the potential effects of the proposed alternative on human health and safety, as well as cultural and social institutions
- consistency with relevant federal, state, and Mohawk policies

- compliance with applicable federal, state, and Mohawk laws
- compliance with community values and norms.

9.2.3 Costing of Restoration Projects

The application of a strict cost/benefit test to each proposed alternative is not required under DOI regulations and is therefore not envisioned by the trustees. The trustees will, however, consider the likely costs and benefits of proposed alternatives in light of the other relevant considerations. A detailed economic study of the proposed alternatives is not contemplated.

The trustees will consider all potential restoration costs when evaluating proposed alternatives. Though this is not an exhaustive list, these costs typically include many of the following components:

- planning costs
  - restoration plan development
  - public review, public meetings, response to comments, and community relations
  - human health and safety, and QA plans
  - chemical, physical, and biological surveys
  - feasibility and pilot studies
  - NEPA (National Environmental Policy Act) compliance, and other regulatory compliance requirements, including Mohawk requirements
- implementation costs
  - physical, chemical, and biological contaminant removal, treatment, or containment
  - habitat creation and enhancement
  - fish, wildlife, and plant restocking and protection
  - land and water rights acquisition
  - contributions to existing mitigation banking programs or regional response plans
  - trustee oversight of actions undertaken by responsible parties
  - community relations
  - contracting costs
- program evaluation and monitoring costs
  - monitoring progress of restoration actions
  - evaluating restoration results

- follow-up studies or actions, as required
- ongoing management.

9.3 COMPENSABLE VALUE DETERMINATION

9.3.1 Conceptual Background

In addition to restoration costs, trustees may seek compensation for the loss of natural resource services between the time of the release and the time when the resources are returned to baseline conditions (i.e., interim lost use). These compensable values represent "the value of lost public use of the services provided by the injured resources, plus lost nonuse values such as existence and bequest values" [43 CFR § 11.83(c)(1)].[1] The terms use and nonuse values are defined below.

- ***Use value*** refers to the value of the resources to the public attributable to the direct (or active) use of the resources provided by the natural resources [43 CFR § 11.83 (c)(1)(i)]. These values generally refer to direct or in situ consumption or utilization of a resource, such as recreational, commercial, cultural, ceremonial, medicinal, nutritional, and subsistence use.

- ***Nonuse value*** is defined as the difference between compensable value and use value [43 CFR § 11.83 (c)(1)(ii)]. These values, also referred to as passive use values, include all values not based on the in situ consumption or utilization of the resource (e.g., the indirect values individuals place on a resource from simply knowing that it exists, or will continue to exist, in a given condition).

Cultural values are a key component of this case. Such values are obtained from the traditional activities and beliefs of the Mohawk Community of Akwesasne and the Haudenosaunee (Iroquois) Confederacy. Cultural values may be categorized as use or nonuse values, depending on their particular characteristics.

The goal of this NRDA is to determine appropriate actions to restore injured natural resources and service flow losses to the conditions that would have existed absent the release of hazardous materials (i.e., baseline conditions). In addition, the trustees may seek recoveries for the interim losses of natural resource services from the time of the release to the time baseline conditions have completely recovered.

1. The court ordered DOI to revise the CERCLA damage assessment regulations to allow for the recovery of all reliably calculated lost values of injured natural resources, including both lost use values and lost nonuse values [*State of Ohio V. United States Department of the Interior,* 880 F.2d 432 (D.C. Cir. 1989)].

In addition, the trustees may seek the recovery of certain other losses. These include without limitation the cost to restore injured natural resources to their baseline conditions; costs and other losses suffered as a result of site remediation activities; forgone fees not collected by a federal or state agency, or tribal government, because of the injury; and the reasonable costs of assessment.

9.3.2 Natural Resource Service Categories and Economic Assessment Methods

Natural resource services refer to the functions performed by a natural resource for the benefit of the public or another natural resource, including ecological services such as nesting habitat and human services such as hunting. The determination of compensable values is based on a reduction in these services. Examples of natural resources and their associated services that could be affected by a release are shown in Table 9-1.

Table 9-1
Categories of Injured Natural Resources and Lost Services

Examples of Injured Natural Resources[a]	Examples of Lost Services[b]
Various natural resources	Archaeological and cultural services, including traditional hunting and fishing, ceremonial, medicinal, and nonuse services
Habitats (e.g., wetlands, forested uplands, grasslands, riverine systems, coastal systems, sediments, coral reefs)	Services provided to other natural resources such as clean water, sediments, soils, and food and resultant loss of Tribal medicinal, ceremonial, and cultural services
Fish, wildlife, invertebrates, and plants	Endangered species, nonuse, recreational, educational, commercial, medicinal, ceremonial, nutritional, and subsistence services
Parks, wildlife refuges, and other public lands	Habitat, recreational, educational, preservation, cultural, nonuse, medicinal, and ceremonial services
Beaches, rivers, surface water bodies, and wetlands	Commercial use (e.g., municipal/industrial/ agricultural water supply, marine transport, economic development); recreational use (e.g., swimming, fishing, hunting, wildlife viewing); subsistence use; flood control/ erosion prevention; and nonuse
Groundwater	Municipal, commercial, industrial, and agricultural uses — discharge of clean groundwater to surface water bodies — nonuse, ceremonial, medicinal, and cultural services

a. The categories listed in this table are not mutually exclusive (i.e., a release may result in an injury to multiple resource categories, as well as a range of lost services).
b. The services provided by a natural resource can accrue to humans and to other natural resources, and need not be consumptive.

The specific categories of services that are expected to be addressed in this case are discussed in Sections 9.3.3 through 9.3.10. These sections indicate basic linkages between an injury to a natural resource and a reduction in associated services. The specific economic methods that will be used to assess these losses are contingent on further progress in injury determination activities so that the determination of compensable values will be consistent with the injury determination. Based on the natural resource services that are potentially affected in this case, however, at least three groups of economic methods may be useful in the determination of compensable values. These groups are discussed below.

- ***Market-based techniques.*** Compensable values may be estimated by examining markets for natural resources where such markets exist. Examples include estimating a loss in fees collected by federal or state agencies, or tribal governments, for the use of recreational resources, and estimating a reduction in the value of commercial fishing harvests (i.e., economic rent). Market-based techniques could be used to assess damages related to commercial fishing, subsistence fishing, agriculture, or other resource services still to be identified.

- ***Revealed preference techniques.*** Where established markets for natural resource services do not exist, compensable values may be estimated by examining behavior in related markets. For example, the value of a recreational site may be estimated by analyzing the travel costs incurred by individuals visiting the site (i.e., the travel cost method). Other revealed preference techniques that can be applied in NRDAs include random utility models and property valuation models. Revealed preference techniques could be used in this case to assess impacts on recreational services, ecological services, agriculture, cultural services, and other natural resource services.

- ***Stated preference techniques.*** In the absence of established markets, compensable values may also be estimated by using stated preference techniques about an individual's willingness to pay for services or by determining levels of compensatory restoration that have comparable value to the lost human use services (value-to-value restoration scaling). In cases where there are no behavioral data available to characterize the demand for natural resources, the trustees may use these techniques to determine compensable values for diminished cultural services, subsistence fishing, or other natural resource services.

The following criteria will be used to select appropriate economic assessment methodologies for the determination of compensable values [43 CFR § 11.83(a)(3)].

- Selected methods shall be feasible and reliable for the particular incident and type of damage to be measured.

- Selected methods shall be performed at a reasonable cost [43 CFR § 11.14(ee)].

- Selected methods shall avoid double counting, or allow double counting to be estimated and eliminated in the final damage calculation.

- Selected methods shall be cost-effective [43 CFR § 11.14(j)].

Regardless of the particular economic assessment methods selected, the determination of compensable values will follow the following general steps:

- identify linkages between the natural resource injury and the resulting diminishment in services

- characterize the nature and extent of the diminishment in natural resource services

- estimate the value of the diminishment in natural resource services.

When estimating compensable values, a number of data sources may be used, including historical use records, forecasts of future use, market data, survey data, and related scientific and economic literature. These data sources, and other details involved in the determination of compensable values, will be developed later when sufficient information becomes available regarding possible restoration alternatives.

9.3.3 Cultural Services

The resources of the St. Lawrence, Grasse, and Raquette rivers in the Massena-Akwesasne assessment area have been used historically by the community of Akwesasne for cultural and ceremonial purposes. Important traditional uses of the natural resources of the area have been altered by the presence of contamination. PCBs, fluorides, and PAHs found in plants and animals may be limiting the use of these species for ceremonial and medicinal purposes by the Mohawks of Akwesasne. Hundreds of tree and other plant species, for example, have been used for food and medicinal purposes in the area. A few examples include whitepine, snakeroot, white lily, sweetflag, goldthread, sweetgrass, wildgrape, popular, wild cherry, white cedar, tamarack, blackwillow, hemlock, silver maple, dogwood, and staghorn sumac. Further service losses associated with the contamination of ceremonially and traditionally used flora and fauna are also possible, including mental anguish and depression resulting from the disassociation of Mohawk people from the river and the natural world.

In addition, contamination or the threat of contamination may be tarnishing the cultural, intrinsic, aesthetic, and historical values of Akwesasne and the St. Lawrence River region (The Trustees for Natural Resources, 1991). This is because of the close relationship between the Mohawk people and the river as a source of transportation, recreation, fishing, hunting, trapping, gathering, contemplation, and ceremonial and educational uses.

The objective of the compensable value assessment for cultural services is to quantify, where possible, the human use losses and the corresponding compensable value for these services. Diminished services may include intrinsic, spiritual, medicinal, ceremonial, and historical uses of natural resources.

9.3.4 Subsistence Fishing, Hunting, Trapping, and Gathering Services

The St. Regis Mohawk Tribe historically has used fish, waterfowl, and various mammalian and other species from the St. Lawrence River as a significant part of their diet. This source of protein has been limited since high levels of contamination have been found in many of the species. Contamination or the threat of contamination of fish, wildlife, and plants in the area is believed to have led to behavioral changes in subsistence resource use. In 1986, the St. Regis Mohawk Tribe issued a fish consumption advisory with the recommendation that pregnant women, women of childbearing age, and children under age 15 eat no fish, and that all other Mohawks should not eat more than one meal (one-half pound) per week of fish from any body of water in or around Akwesasne (The Trustees for Natural Resources, 1991).

The objective of the compensable value assessment for subsistence fishing, hunting, trapping, and gathering services is to quantify, where possible, the human use losses and the corresponding compensable value for these services. Diminished services may be indicated by impacts to fish, wildlife, and plants, and related consumption advisories.

9.3.5 Commercial Fishing Services

Significant restrictions on commercial fisheries have existed on the St. Lawrence River in the vicinity of the GM, ALCOA, and RMC facilities. A commercial eel fishery has been restricted since 1976. Commercial eel fishing was banned in Lake Ontario in 1982 because of high tissue burdens of PCBs and other contaminants. The ban has been extended to include the St. Lawrence River in the vicinity of the three facilities (The Trustees for Natural Resources, 1991).

The objective of the compensable value assessment for commercial fishing services is to quantify, where possible, the human use losses and the corresponding compensable value for these services. Diminished services may be indicated by the commercial fishing restrictions and subsequent ban of commercial eel fishing due to PCB contamination.

9.3.6 Recreational Services

Fishing

Service losses for recreational fishing can be associated with a change in the quantity, quality, or location of fishery stocks, as well as with fish consumption advisories. Evidence of such losses can be seen in the St. Lawrence, Grasse, and Raquette rivers, and in the Massena area, where recreational fisheries have been affected by elevated concentrations of PCBs in the tissues of fish. PCBs in at least 16 species of fish collected from the St. Lawrence and Grasse rivers near the three sites have exceeded concentrations where reproductive inhibition or failure has been reported in the toxicological literature (The Trustees for Natural Resources, 1991).

Because of the levels of PCB contamination found in certain fish from the St. Lawrence River Basin, NYSDEC, the New York Department of Health (NYDOH), the St. Regis Mohawk Tribe, and the Mohawk Council of Akwesasne have issued health advisories since 1977 against the consumption of fish harvested from certain parts of the St. Lawrence Basin (The Trustees for Natural Resources, 1991). The 1999-2000 advisories are shown in Table 9-2.

Elevated levels of PCBs in the vicinity, and the presence of fish consumption advisories, could affect recreational fishing in several ways. Studies have consistently suggested that angler participation, the number of recreational fishing trips, the species and size of fish targeted, the consumption behavior of anglers, and fish preparation methods are affected by fish consumption advisories (e.g., Connelly et al., 1992; Siemer and Brown, 1994; Connelly et al., 1996). Such behavioral responses can result in losses to the public. Anglers who do not change their behavior in response to contamination and fish consumption advisories may also be affected because the quality of their fishing experience is reduced by the knowledge that the area is contaminated.

Contamination and fish consumption advisories may also result in a reduction in economic activity associated with recreational fishing in the vicinity of the sites. For example, health advisories and public awareness of contamination in the area have resulted in the discontinuation of several professional fishing guide services and fish camps operated by the St. Regis Mohawk Tribe (The Trustees for Natural Resources, 1991). Further impacts on the economy of the area are possible given the potential for significant behavioral change by anglers in response to the advisories.

The objective of the compensable value assessment for recreational fishing services is to quantify, where possible, the human use losses and the corresponding compensable value for these services. Diminished services may be indicated by impacts to recreational fisheries, and by the fish consumption advisories.

Table 9-2
Fish Consumption Advisories: St. Lawrence, Grasse, and Raquette Rivers, 1999-2000

Water Body (county)	Species	Recommendations	Chemicals of Concern
Grasse River, mouth to Massena Power Canal (St. Lawrence)	All species	Eat none	PCBs
Massena Power Canal (St. Lawrence)	Smallmouth bass	Eat no more than one meal per month	PCBs
	All species	Women of childbearing age, infants and children under age 15 should not eat any fish from these waters	General Advisory
St. Lawrence River (whole river)	American eel, channel catfish, lake trout larger than 25 inches, carp, chinook salmon, and brown trout over 20 inches.	Eat none	PCBs, mirex, dioxin
	White perch, white sucker, rainbow trout, smaller lake and brown trout, and coho salmon greater than 25 inches.	Eat no more than one meal per month	PCBs, mirex, dioxin
	All species	Women of childbearing age, infants and children under age 15 should not eat any fish from these waters	General Advisory
Bay at St. Lawrence River/Franklin County Line (also known as Contaminant Cove or Turtle Cove)	All species	Eat none	PCBs

Source: NYSDOH, 1999.

Hunting and Trapping

Hunting and trapping of wildlife for food and fur is a part of the traditional lifestyle practiced by some residents of the St. Lawrence region, including Canadians and the Mohawks of Akwesasne. These activities also provide recreation and a source of income for many others in New York State. Game birds in the area include ruffed grouse, wild turkey, gray partridge, ring-necked pheasant, American woodcock, sora rails, Virginia rails, and 19 species of waterfowl. Furbearers taken by trapping include coyote, beaver, river otter, bobcat, fisher, striped skunk, mink, muskrat, raccoon, red and gray foxes, and weasels. Other game mammals include white-tailed deer, varying hare, cottontail rabbit, and gray squirrel. Snapping turtles and several species of frogs are also harvested by some individuals.

Within the general area affected by PCB contamination, wildlife are susceptible to contaminants that move through the aquatic environment into the food chain, or that are absorbed directly through the skin and mucous membranes. High levels of contamination have been found in the tissues of snails, tadpoles, frogs, waterfowl, muskrats, beaver, and turtles in the area. Although specific standards for PCB concentrations in wildlife species for protecting human health are lacking, the U.S. Food and Drug Administration (FDA) has set a tolerance for poultry (3.0 ppm, lipid basis) and finfish (2.0 ppm, edible portion; wet weight basis) [21 CFR § 109.30 (a)]. A tolerance level limits the extent of allowable contamination of a food (e.g., poultry or fish) that is intended for introduction into, or have been shipped in, interstate commerce (Adams et al., 1993). These tolerance levels were issued as temporary concentrations because of the unavoidable nature of PCB contamination in food and are effective until such time that these contaminants can be eliminated at the earliest practicable time [21 CFR § 109.30 (a)]. A comparison of these tolerance levels to wildlife sampled in the area indicates that several of the waterfowl species exceeded the poultry tolerance level, and some turtles, frogs, and muskrats exceeded the tolerance level for finfish (see Chapter 8).

Contamination, or the threat of contamination, of wildlife in the area could lead to behavioral changes in hunting and trapping similar to those mentioned for recreational fishing. Hunters and trappers could change their participation rates, the number or location of trips, or the types of species targeted. The quality of the recreational experience could also be affected by the knowledge that the area is contaminated. Potential changes in hunting and trapping behavior could also lead to economic impacts such as a reduction of income from fur sales or a reduction in commercial hunting services.

The objective of the compensable value assessment for recreational hunting and trapping services is to quantify, where possible, the human use losses and the corresponding compensable value for these services.

Nonconsumptive Services

Wildlife viewing, hiking, and picnicking are examples of nonconsumptive services that may be affected by contamination in the vicinity of the facilities. Activities such as swimming and boating may also be affected since surface water quality standards for PCBs have been exceeded in the Grasse, Raquette, and St. Lawrence rivers. These activities are popular at the Robert Moses State Park, located in the Town of Massena: tourists are attracted to its campgrounds, beach, marina, boat launch, and scenic vistas.

The objective of the compensable value assessment for recreational nonconsumptive services is to quantify, where possible, the human use losses and the corresponding compensable value for these services.

9.3.7 Ecological and Endangered Species Services

Ecological services refer to the provision of habitat, food, and other needs of biological resources, including threatened and endangered (T&E) species. In the affected area, a mosaic of forests, wetlands, water bodies, and tributary streams provides habitat for breeding, juvenile rearing, and forage by wildlife, including migratory and resident birds, mammals, reptiles, amphibians, fish, and individuals of various T&E species such as the bald eagle. The ability of these habitats to provide such services most likely has been impaired because of high concentrations of PCBs and other contaminants found in sediments, water bodies, and terrestrial habitats (The Trustees for Natural Resources, 1991).

PCBs are known for their persistence and ability to bioaccumulate and biomagnify in the food chain. As they bioaccumulate, PCBs can elicit various biologic and toxic effects in terrestrial and aquatic organisms. Other contaminants of concern associated with the assessment area (PCDDs, PCDFs, and PAHs) can elicit a variety of toxic effects, and carcinogenic and mutagenic responses (The Trustees for Natural Resources, 1991). The bioaccumulation of contaminants has direct impacts on biological resources that humans value for recreational, commercial, and intrinsic purposes.

The objective of the compensable value assessment for ecological and endangered species services is to quantify, where possible, the ecological and human use losses and the corresponding compensable value for these services. Diminished services may be indicated by the contamination of sediments, water bodies, and terrestrial ecosystems, and by impacts to T&E species and other species of concern (see Section 2.2.7 of Chapter 2 for a compilation of T&E species and species of special concern in the assessment area).

9.3.8 Groundwater Services

Groundwater resources beneath the GM, ALCOA, and RMC facilities, as well as in aquifers used by residents in Massena and the Mohawks of Akwesasne, have been found to contain PCBs and other contaminants of concern at concentrations above human health standards (The Trustees for Natural Resources, 1991). Historically, the residents of Akwesasne have depended primarily on groundwater wells for their drinking water and have used the St. Lawrence River as a reliable secondary source. Starting in January 1982, the Environmental Department of the St. Regis Mohawk Health Services advised the residents living in the Raquette Point section of Akwesasne not to drink water from their wells or from the St. Lawrence, Raquette, or Grasse rivers because PCB traces were found in test well samples and in river samples. From 1982 until the installation of a public water supply line, 46 households and one school on Raquette Point were using bottled water. Currently, all residents in the Raquette Point area are on the public water supply line, whose intake is located one mile south of the GM facility. Because of the perceived threat of contamination of the St. Lawrence River, it is believed that many Akwesasne residents continue to purchase and use bottled water. Some also travel to the Adirondacks to obtain spring water.

The objective of the compensable value assessment for groundwater services is to quantify, where possible, the human use losses and the corresponding compensable value for these services. Diminished services may include the precluded use of groundwater supplies and use of substitute water sources at additional cost.

9.3.9 Agricultural Services

Given the proximity of farmland to the sites, injury to crops and livestock operations from contaminants is possible. The St. Regis Indian Reservation lands on Cornwall Island and their lands north of the Raquette River to the St. Lawrence River contain cultivated vegetation that may be injured by fluorides emitted from the ALCOA and RMC facilities. The contaminated vegetation may in turn cause fluorosis (brittle bones) in cattle. In addition, the cultivated vegetation in the area, which includes fruits, vegetables, and native plants, may also be affected by PCBs that volatilize and accumulate on the vegetation. This could result in further injury to biological resources as the PCBs and other contaminants move through the food chain (see Chapter 8).

The objective of the compensable value assessment for agricultural services is to quantify, where possible, the human use losses and the corresponding compensable value for these services.

9.3.10 Geologic Resource Services

With the exception of Ogdensburg Limestone, there are no known geologic resources of economic importance in the area which could be considered as candidates for damage assessment. Ogdensburg Limestone, which underlies the entire area, is used primarily as an aggregate in concrete and asphalt and for general engineering application in fills and drains. Very fine Ogdensburg Limestone is also used as an agricultural lime. Clay from the St. Lawrence River sediment is also used by Mohawks in pottery that is made for both utilitarian (i.e., food storage) and artistic purposes. It is conceivable that portions of the Ogdensburg Limestone could be contaminated by effluent from various waste sites.

The objective of the compensable value assessment for geologic resource services is to quantify, where possible, the human use losses and the corresponding compensable value for these services.

9.4 PRELIMINARY ESTIMATE OF DAMAGES

At the time that this assessment plan was made available for public review and comment, sufficient data to complete a preliminary estimate of damages were not available. Thus, the preliminary estimate of damages will be completed later, as provided in 43 CFR § 11.38 (e).

9.5 DOUBLE COUNTING, UNCERTAINTY, AND ADJUSTMENTS FOR TIME

Steps will be taken to avoid double counting damages. Measures taken, and anticipated to be taken, to return injured resources to their baseline conditions will be accounted for in the determination of compensable values. Additionally, a number of economic assessment methods may be used to determine compensable values. Therefore, where possible, potential overlap in the estimation of compensable values between different methods will be identified. Values identified as being counted more than once will be subtracted in the final damage calculation.

Known sources of uncertainty in the determination of compensable values will be identified. Where reasonable alternative assumptions may apply, the sensitivity of the damage estimate to those assumptions will be evaluated. Where possible, a range of probability estimates will be derived so that the expected value can be determined as the damage estimate.

Finally, compensable value estimates will be adjusted for time. An appropriate discount rate will be used to compound past values, and to discount future values, to the present time.

Chapter 10
Quality Assurance Project Plan

10.1 Introduction

This Quality Assurance Project Plan (QAPjP) has been developed to support studies that may be performed as part of the Massena-Akwesasne NRDA. Under the NRDA regulations [43 CFR § 11.31], the QAPjP is required to develop procedures to ensure data quality and reliability. This QAPjP is intended to provide quality assurance/quality control (QA/QC) procedures, guidance, and targets for use in future studies conducted for the NRDA. It is not intended to provide a rigid set of predetermined steps with which all studies must conform or against which data quality is measured, nor is it intended that existing data available for use in the NRDA must adhere to each of the elements presented in this QAPjP. Ultimately, the quality and useability of data are based on methods employed in conducting studies, the expertise of study investigators, and the intended uses of the data. The QAPjP has been designed to be consistent with the NCP and U.S. EPA's Guidelines and Specifications for Preparing Quality Assurance Project Plans (U.S. EPA, 1998a).

The elements outlined in this plan are designed to:

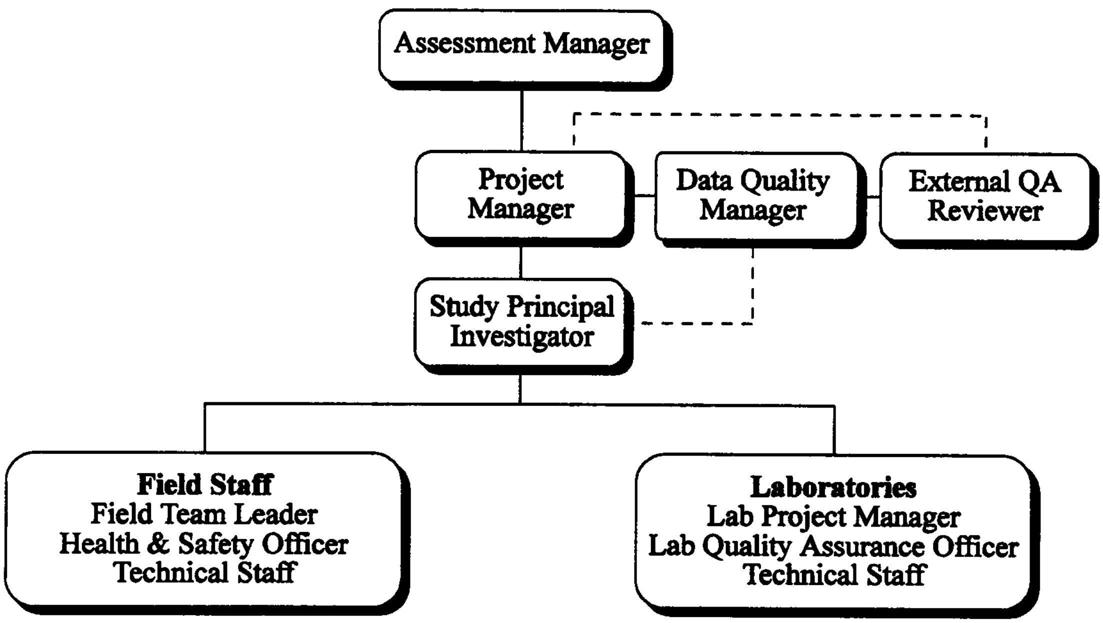
- provide procedures and criteria for maintaining and documenting custody and traceability of environmental samples
- provide procedures and outline QA/QC practices for the sampling, collection, and transporting of samples
- outline data quality objectives (DQOs) and data quality indicators
- provide a consistent and documented set of QA/QC procedures for the preparation and analysis of samples
- help to ensure that data are sufficiently complete, comparable, representative, unbiased, and precise so as to be suitable for their intended uses.

Before the implementation of NRDA studies, Standard Operating Procedures (SOPs) providing descriptions of procedures typically will be developed. These SOPs will be appended to this QAPjP, as developed, to provide an ongoing record of methods and procedures employed in the assessment. SOPs will be developed and updated as methods and procedures are reviewed and accepted for use.

10.2 PROJECT ORGANIZATION AND RESPONSIBILITY

Definition of project organization, roles, and responsibilities helps ensure that individuals are aware of specific areas of responsibility that contribute to data quality. However, fixed organizational roles and responsibilities are not necessary and may vary by study or task. An example of project quality assurance organization, including positions with responsibility for supervising or implementing quality assurance activities, is shown in Figure 10-1. Key positions and lines of communication and coordination are indicated. Descriptions of specific quality assurance responsibilities of key project staff are included below. Only the project positions related directly to QA/QC are described; other positions may be described in associated project plans. Specific individuals and laboratories selected to work on this investigation will be summarized and appended to this QAPjP or included in study-specific SOPs when they are established.

Figure 10-1
Project Organization



10.2.1 Assessment Manager and Project Manager

The Assessment Manager (AM) is responsible for all technical, financial, and administrative aspects of the project. The Project Manager (PM) supports the AM and is responsible for producing quality data and work products for this project within allotted schedules and budgets. Duties include executing all phases of the project and efficiently applying the full resources of the project team in accordance with the project plans. Specific QA-related duties of the AM and the PM can include:

- coordinating the development of a project scope, project plans, and data quality objectives
- ensuring that written instructions in the form of SOPs and/or associated project plans are available for activities that affect data quality
- monitoring investigative tasks for their compliance with plans, written procedures, and QC criteria
- monitoring the performance of subcontractors in regard to technical performance and specifications, administrative requirements, and budgetary controls
- participating in performance and/or systems audits and monitoring the implementation of corrective actions
- reviewing, evaluating, and interpreting data collected as part of this investigation
- supervising the preparation of project documents, deliverables, and reports
- verifying that all key conclusions, recommendations, and project documents are subjected to independent technical review, as scheduled in the project plans.

10.2.2 Data Quality Manager

A Data Quality Manager can be assigned to be responsible for overall implementation of the QAPjP. Duties include conducting activities to ensure compliance with the QAPjP, reviewing final QA reports, preparing and submitting QA project reports to the AM and PM, providing technical QA assistance, conducting and approving corrective actions, training field staff in QA procedures, and conducting audits, as necessary. Specific tasks may include:

- assisting the project team with the development of data quality objectives
- managing the preparation of and reviewing data validation reports
- submitting QA reports and corrective actions to the PM
- ensuring that data quality, data validation, and QA information are complete and are reported in the required deliverable format
- communicating and documenting corrective actions

- maintaining a copy of the QAPjP
- supervising laboratory audits and surveillance
- ensuring that written instructions in the SOPs and associated project plans are available for activities that affect data quality
- monitoring investigative tasks for their compliance with plans, written procedures, and QC criteria
- monitoring the performance of subcontractors in regard to technical performance and specifications, administrative requirements, and budgetary controls
- reviewing, evaluating, and interpreting data collected as part of this investigation.

10.2.3 External QA Reviewer

External QA Reviewers can review QA documentation and procedures, perform data validation, and perform field and laboratory audits if needed.

10.2.4 Principal Investigator

Study-specific Principal Investigators (PIs) ensure that QA guidance and requirements are followed. The PI or the designee will note significant deviations from the QAPjP for the study. Significant deviations will be recorded and promptly reported to the PM and Data Quality Manager. In addition, the PI typically is responsible for reviewing and interpreting study data and preparing reports.

10.2.5 Field Team Leader

The Field Team Leader (FTL) supervises day-to-day field investigations, including sample collection, field observations, and field measurements. The FTL generally is responsible for all field QA procedures defined in the QAPjP, and in associated project plans and SOPs. Specific responsibilities may include:

- implementing the field investigation in accordance with project plans
- supervising field staff and subcontractors to monitor that appropriate sampling, testing, measurement, and recordkeeping procedures are followed

- ensuring the proper use of SOPs associated with data collection and equipment operation
- monitoring the collection, transport, handling, and custody of all field samples, including field QA/QC samples
- coordinating the transfer of field data, including field sampling records, chain-of-custody records, and field logbooks
- informing the PI and Data Quality Manager when problems occur, and communicating and documenting any corrective actions that are taken.

10.2.6 Laboratory Project Manager

A Laboratory Project Manager can be responsible for monitoring and documenting the quality of laboratory work. Duties may include:

- ensuring that the staff and resources produce quality results in a timely manner are committed to the project
- ensuring that the staff are adequately trained in the procedures that they are using so that they are capable of producing high quality results and detecting situations that are not within the QA limits of the project
- ensuring that the stated analytical methods and laboratory procedures are followed, and the laboratory's compliance is documented
- maintaining a laboratory QA manual and documenting that its procedures are followed
- ensuring that laboratory reports are complete and reported in the required deliverable format
- communicating, managing, and documenting all corrective actions initiated at the laboratory
- notifying the Data Quality Manager, within one working day of discovery at the laboratory, of any situations that will potentially result in qualification of analytical data.

10.2.7 Technical Staff

Project technical staff represent a variety of technical disciplines and expertise. Technical staff should have adequate education, training, and specific experience to perform individual tasks, as assigned. They are required to read and understand any documents describing the technical procedures and plans that they are responsible for implementing.

10.3 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

10.3.1 Overview

The overall QA objectives are to help ensure that the data collected are of known and acceptable quality for their intended uses. QA objectives are qualitative and quantitative statements that aid in specifying the overall quality of data required to support various data uses. These objectives often are expressed in terms of accuracy, precision, completeness, comparability, representativeness, and sensitivity. Laboratories involved with the analysis of samples collected in support of this NRDA will make use of various QC samples such as standard reference materials (SRMs), matrix spikes, and replicates to assess adherence to the QA objectives discussed in the following sections and in specific laboratory QA/QC plans. Field and laboratory QC targets for chemical analyses, frequency, applicable matrices, and acceptance criteria are listed in Table 10-1.

Table 10-1
Laboratory and Field Quality Control Sample Targets for Chemical Analyses

QC Element	Target Frequency	Applicable Matrices	Target Acceptance Criteria
Method Blank	1 in 20 samples	S, SW, T	Method dependent
Laboratory Duplicate	1 in 20 samples	S, SW, T	Method dependent
Matrix Spike	1 in 20 samples	S, SW, T	Method dependent
Standard Reference Material	1 in 20 samples	S, SW, T	Method dependent
Equipment Blank	1 in 20 samples	SW	Study dependent
Field Duplicate	1 in 20 samples	S, SW, T	Study dependent
Surrogates	All samples for organics analysis	S, SW, T	Method dependent
Laboratory Control Sample	1 in 20 samples	S, SW, T	Method dependent

S = sediment; SW = surface water; T = tissue.

Because numeric QC criteria are specific to a study, method, or laboratory, criteria are not included in this QAPjP. When appropriate, criteria can be established when study and method procedures are approved; such criteria will be appended to this QAPjP or included in study-specific SOPs. Criteria will be determined based on factors that may include:

- specific analytical methods and accepted industry standards of practice
- matrix-specific control limits for acceptable sample recovery, accuracy, or precision
- historical laboratory performance of selected analytical methods
- intended uses of the data.

Where statistically generated or accepted industry standards of practice are not available, QC criteria may be defined by the Data Quality Manager working with the Laboratory QA Officer and PIs.

10.3.2 Quality Control Metrics

Accuracy

Accuracy is a quantitative measure of how close a measured value lies to the actual or "known" value. Sampling accuracy is partially evaluated by analyzing field QC samples such as field blanks, trip blanks, and rinsates (or equipment blanks). In these cases, the "true" concentration is assumed to be not detectable, and any detected analytes may indicate a positive bias in associated environmental sample data.

Laboratory accuracy is assessed using sample (matrix) spikes and other QC samples. For example, a sample (or blank) may be spiked with an inorganic compound of known concentration and the average percent recovery (%R) calculated as a measurement of accuracy. A second procedure is to analyze a standard (e.g., SRMs or other certified reference materials) and calculate the %R for that known standard. As an additional, independent check on laboratory accuracy, blind SRMs submitted as field samples may be used.

Accuracy criteria are established statistically from historical performance data, and often are based on confidence intervals set about the mean. Where historical data are not adequate for statistical calculations, criteria may be set by the Laboratory Project Manager, Data Quality Manager, and PIs. Accuracy criteria will be appended to this QAPjP or included in study-specific SOPs, when established. Accuracy may be assessed during the data validation or data quality assessment stage of these investigations.

Precision

Precision is a measure of the reproducibility of analytical results under a given set of conditions. The overall precision of a set of measurements is determined by both sampling and laboratory variables. Reproducibility is affected by sample collection procedures, matrix variations, the extraction procedure, and the analytical method.

Field precision typically is evaluated using sample replicates, which are usually duplicate or triplicate samples. Sample replicates may be generated by homogenizing the sample, splitting the sample into several containers, and initiating a blind submittal to the laboratory with unique sample numbers. For a duplicate sample, precision of the measurement process (sampling and analysis) is expressed as:

$$\text{Relative Percent Difference (RPD)} = \frac{(\text{Duplicate Sample Result} - \text{Sample Result})}{(\text{Duplicate Sample Result} + \text{Sample Result})} \times 200.$$

For a triplicate analysis, precision of the sampling and analysis process is expressed as:

$$\text{Percent Relative Standard Deviation (\%RSD)} = \frac{\sigma_{n-1}}{\text{Mean}} \times 100,$$

where σ_{n-1} is the standard deviation of the three measurements.

Laboratory precision typically is evaluated using laboratory duplicates, matrix spike duplicates, or laboratory control sample or SRM duplicate sample analysis. Duplicates prepared in the laboratory are generated before sample digestion. Laboratory precision is also expressed as the RPD between a sample and its duplicate, or as the %RSD for three values.

Precision criteria are established statistically from historical performance data, and are usually based on the upper confidence interval set at two standard deviations above the mean. Where historical data are not adequate for statistical calculations, criteria may be set by the Laboratory Project Manager, Data Quality Manager, and PIs. Precision criteria will be appended to this QAPjP or included in study-specific SOPs, when established.

Completeness

Completeness is defined as the percentage of measurement data that remain valid after discarding any invalid data during the field or laboratory QC review process. A completeness check may be performed following a data validation process. Analytical completeness goals may vary depending on study type, methods, and intended uses of the data.

Analytical data completeness will be calculated by analyte. The percent of valid data is 100 times the number of sample results not qualified as unusable (R), divided by the total number of samples analyzed. Data qualified as estimated (J) because of minor QC deviations (e.g., laboratory duplicate RPD exceeded) will be considered valid.

Comparability

Comparability is a qualitative parameter expressing the confidence with which one dataset can be compared to another. Comparability is facilitated by use of consistent sampling procedures, standardized analytical methods, and consistent reporting limits and units. Data comparability is evaluated using professional judgment.

Representativeness

Representativeness expresses the degree to which data accurately and precisely represent a defined or particular characteristic of a population, parameter variations at a sampling point, a processed condition, or an environmental condition. Representativeness is a qualitative parameter that is dependent on the proper design of the sampling program and proper laboratory protocol. Sampling designs for this investigation will be intended to provide data representative of sampled conditions. During development of sampling plans and SOPs, consideration will be given to existing analytical data, environmental setting, and potential industrial sources. Representativeness will be satisfied by ensuring that the sampling plan is followed.

Sensitivity

Detection limit targets for each analyte and matrix will be appended to this QAPjP or included in study-specific SOPs as they are established.

10.4 SAMPLING PROCEDURES

10.4.1 Sample Collection

Samples are collected and handled in accordance with the procedures contained in SOPs or associated project plans. These documents typically describe sample collection, handling, and documentation procedures to be used during field activities. SOPs and work plans/protocols may cover the following topics, as appropriate:

- procedures for selecting sample locations and frequency of collection
- sample site selection, positioning, and navigation procedures
- sampling equipment operation, decontamination, and maintenance
- sample collection and processing, which includes sample collection order and homogenization procedures, sample containers, and volume required
- field QC sample and frequency criteria
- sample documentation, including chain-of-custody (COC) and field documentation forms and procedures
- sample packaging, tracking, storage, and shipment procedures.

10.4.2 Sample Containers, Preservation, and Holding Times

Containers will be prepared using EPA-specified or other professionally accepted cleaning procedures. Analysis statements for containers prepared by third-party vendors will be included in the project file. Since the investigations involved with this NRDA may involve samples not amenable to typical environmental sample containers (such as whole body tissue samples), multiple types of containers may be required. Sample containers may include aluminum foil and watertight plastic bags for tissue samples and whole body samples.

When appropriate, sample coolers will contain refrigerant in sufficient quantity to maintain samples at the required temperatures until receipt at the laboratories.

10.4.3 Sample Identification and Labeling Procedures

Before transportation, samples should be properly identified with labels, tags, or markings. Identification and labeling typically includes, but need not be limited to, the following information:

- project identification
- place of collection
- sample identification
- analysis request
- preservative
- date and time of collection
- name of sampler (initials)
- number of containers associated with the sample.

10.4.4 Field Sampling Forms

Field sampling forms should be described in the appropriate SOP or associated project plans. Forms typically must be completed in the field at the same time as the sample label. As with the sample label, much of the information can be preprinted, but date, time, sampler's initials, and other specific field observations should be completed at the time of sampling.

10.4.5 Sample Storage and Tracking

In the field, samples may be stored temporarily in coolers with wet or dry ice (as appropriate). Security should be maintained and documentation of proper storage should be provided in the project field notebook. Samples stored temporarily in coolers should be transported to a storage facility as soon as logistically possible. When possible, samples will be shipped directly to the appropriate laboratories from the field.

Before analysis, samples will be stored under appropriate conditions at the storage facility or laboratory (refrigerator or freezer). Security should be maintained at all times. A log book or inventory record typically is maintained for each sample storage facility refrigerator or freezer. The log books or inventory records are used to document sample movement in and out of the facility. In general, samples will be placed into a freezer and information regarding sample identification, matrix, and study will be recorded. Additional information in the record for each sample may include the date of the initial storage, subsequent removal/return events with associated dates, and initials of the person(s) handling the samples. Additional information may also include study name and special comments. If required, unused samples or extra samples will be archived in a secure location under appropriate holding conditions to ensure that sample integrity is maintained.

Documentation should allow for unambiguous tracking of the samples from the time of collection until shipment to the laboratory. The tracking system should include a record of all sample movement and provide identification and verification (initials) of the individuals responsible for the movement.

10.5 SAMPLE CUSTODY

COC procedures are adopted for samples throughout the field collection, handling, storage, and shipment process. Each sample will be assigned a unique identification label and have a separate entry on a COC record. A COC record should accompany every sample and every shipment to document sample possession from the time of collection through final disposal.

10.5.1 Definition of Custody

A sample is defined as being in a person's custody if one of the following conditions applies:

- The sample is in the person's actual possession or view.
- The sample was in the person's possession and then was locked in a secure area with restricted access.
- The person placed it in a container and sealed the container with a custody seal in such a way that it cannot be opened without breaking the seal.

10.5.2 Procedures

The following information typically will be included on COC forms:

- place of collection
- laboratory name and address
- sample receipt information (total number of containers, whether COC seals are intact, whether sample containers are intact, and whether the samples are cold when received)
- signature block with sufficient room for "relinquished by" and "received by" signatures for at least three groups (field sampler, intermediate handler, and laboratory)
- sample information (field sample identifier, date, time, matrix, laboratory sample identifier, and number of containers for that sample identifier)
- name of the sampler
- airbill number of overnight carrier (if applicable)
- disposal information (to track sample from "cradle to grave")
- block for special instructions
- analysis request information.

The sample identification, date and time of collection, and request for analysis on the sample label should correspond to the entries on the COC form and in associated field log books or sampling forms.

The Data Quality Manager or designated representative is responsible for reviewing the completed COC forms. Any inconsistencies, inaccuracies, or incompleteness in the forms must be brought to the attention of the field staff completing the form. If the problem is significant, corrective action should be taken and documented. Depending on the problem, this may involve informing the laboratory that a sample ID or analysis request needs to be changed, or notifying the FTL that retraining of field staff in COC procedures is indicated. The corrective action and its outcome should be documented.

10.6 ANALYTICAL PROCEDURES

Several methods or procedures may be used to measure analytes in different environmental media. For example, PCBs may be measured by quantification of Aroclors using Method 8081, quantification of total PCBs using Method 8081, or quantification of PCB congeners and coplanars using gas chromatography with electron capture detection (GC/ECD) and/or gas chromatography with mass spectrophotometry (GC/MS). Coplanar PCB congeners may be analyzed and reported with the PCB congener analysis. Preconcentration steps (e.g., carbon column cleanup) may be required to obtain adequate detection limits for these compounds. General QC considerations and targets for analyses are described below, along with considerations for biological testing.

Laboratory method detection limit (MDL) studies should be conducted for each matrix per analytical method, according to specifications described in 40 CFR Part 136 or other comparable professionally accepted standards. The MDL is a statistically derived, empirical value that may vary.

Laboratory QC samples, which include a method blank, replicate (matrix spike or duplicate) analyses, laboratory control sample, and SRM, will be performed at a target frequency of 1 per 20 samples per matrix per analytical batch. Method blanks should be free of contamination of target analytes at concentrations greater than or equal to the MDL, or associated sample concentrations should be greater than 10 times the method blank values. The matrix spike/matrix spike duplicate and laboratory control sample analyses should meet the specific accuracy and precision goals for each matrix and analytical method.

10.7 CALIBRATION PROCEDURES AND FREQUENCY

This section provides information on general calibration guidelines for laboratory and field methods.

10.7.1 Laboratory Equipment

All equipment and instruments used for laboratory analyses will be operated and maintained according to the manufacturer's recommendations, as well as by criteria defined in the laboratory's SOPs. Operation, maintenance, and calibration should be performed by personnel properly trained in these procedures. Documentation of all routine and special maintenance and calibration should be recorded in appropriate log books and reference files.

Calibration curve requirements for all analytes and surrogate compounds should be met before sample analysis. Calibration verification standards, which should include the analytes that are expected to be in the samples and the surrogate compounds, should be analyzed at a specified frequency and should be within a percent difference or percent drift criterion.

10.7.2 Field Equipment

All equipment and instruments used to collect field measurements will be operated, maintained, and calibrated according to the manufacturer's recommendations, as well as by criteria defined in individual SOPs. Operation, calibration, and maintenance should be performed by personnel properly trained in these procedures. Documentation of all routine and special maintenance and calibration should be recorded in appropriate log books or reference files. Field instruments that may be used include thermometers/temperature probes, scales, pH meters, dissolved oxygen meters, and global positioning system units.

10.8 DATA VALIDATION AND REPORTING

10.8.1 General Approach

Data generated by the laboratory and during field measurements may undergo data review and validation by an External QA Reviewer. Laboratory data may be evaluated for compliance with data quality objectives, with functional guidelines for data validation, and with procedural requirements contained in this QAPjP.

10.8.2 Data Reporting

Laboratories should provide sufficient information to allow for independent validation of the sample identity and integrity, the laboratory measurement system, the resulting quantitative and qualitative raw data, and all information relating to standards and sample preparation.

10.8.3 Data Review and Validation of Chemistry Data

Data review is an internal laboratory process in which data are reviewed and evaluated by a laboratory supervisory or QA personnel. Data validation is an independent review process conducted by personnel not associated with data collection and generation activities. External and independent data validation may be performed for selected sample sets as determined by the PM and Data Quality Manager. Each data package chosen for review will be assessed to determine whether the required documentation is of known and documented quality. This includes evaluating whether:

- field COC or project catalog records are present, complete, signed, and dated
- the laboratory data report contains required deliverables to document procedures.

Two levels of data validation may be performed: full or cursory validation. Initial data packages received for each sample matrix may receive full validation. This consists of a review of the entire data package for compliance with documentation and quality control criteria for the following:

- analytical holding times
- data package completeness
- preparation and calibration blank contamination
- initial and continuing calibration verifications
- internal standards
- instrument tuning standards
- analytical accuracy (matrix spike recoveries and laboratory control sample recoveries)
- analytical precision (comparison of replicate sample results)
- reported detection limits and compound quantitation
- review of raw data and other aspects of instrument performance
- review of preparation and analysis bench sheets and run logs.

Cursory validation may be performed on a subset of the data packages at the discretion of the PM and Data Quality Manager. Cursory review includes the comparison of laboratory summarized QC and instrument performance standard results to the required control limits, including:

- analytical holding times
- data package completeness
- preparation and calibration blank contamination
- analytical accuracy (matrix spike recoveries and laboratory control sample recoveries)
- analytical precision (comparison of replicate sample results).

The full or cursory validation will follow documented QC and review procedures as outlined in the guidelines for data validation (U.S. EPA, 1998a) and documented in validation and method SOPs. Various qualifiers, comments, or narratives may be applied to data during the validation process. These qualifier codes may be assigned to individual data points to explain deviations from quality control criteria and will not replace qualifiers or footnotes provided by the laboratory. Data validation reports summarizing findings will be submitted to the Data Quality Manager for review and approval.

Laboratory data will be evaluated for compliance with data quality objectives. Data useability, from an analytical standpoint, may be evaluated during the data evaluation. The data users (the PI, PM, AM) will determine the ultimate useability of the data.

10.9 PERFORMANCE AND SYSTEM AUDITS

A Data Quality Manager or designee will be responsible for coordinating and implementing any QA audits that may be performed. Checklists may be prepared that reflect the system or components being audited, with references to source of questions or items on the checklist. Records of all audits and corrective actions should be maintained in the project files.

10.9.1 Technical System Audits

Technical System Audits (TSAs) are qualitative evaluations of components of field and laboratory measurement systems, including QC procedures, technical personnel, and QA management. TSAs determine if the measurement systems are being used appropriately. TSAs are normally performed before or shortly after measurement systems are operational, and during the program on a regularly scheduled basis. TSAs involve a comparison of the activities described in the study plan and SOPs with those actually scheduled or performed. Coordination and implementation of any TSAs will be the responsibility of the Data Quality Manager or designee.

Analytical Data Generation (laboratory audit)

Laboratory audits may be performed to determine whether the laboratory is generating data according to all processes and procedures documented in the associated project plans, QAPjP, SOPs, and analytical methods. Laboratory audits can be performed by an External QA Reviewer, a Data Quality Manager, or their designee.

Field Audits

Field audits may be performed to determine whether field operations and sample collection are being performed according to processes and procedures documented in the study plan, QAPjP, and SOPs.

10.9.2 Performance Evaluation Audits

Performance evaluation audits are quantitative evaluations of the measurement systems of a program. Performance evaluation audits involve testing measurement systems with samples of known composition or behavior to evaluate precision and accuracy, typically through the analysis of standard reference materials. These may be conducted before selecting an analytical laboratory.

10.10 PREVENTATIVE MAINTENANCE PROCEDURES AND SCHEDULES

Preventative maintenance typically is implemented on a scheduled basis to minimize equipment failure and poor performance. In addition to the scheduled calibration procedures described above, the following procedures may be followed.

- Thoroughly clean field equipment before returning to the office. The equipment generally should be stored clean and dry.
- Replaceable components such as pH electrodes and dissolved oxygen membranes should be inspected after and before each use, and replaced as needed to maintain acceptable performance.
- Equipment that is malfunctioning or out of calibration will be removed from operation until repaired or recalibrated.

10.11 PROCEDURES USED TO ASSESS DATA USEABILITY

Data useability ultimately is a function of study methods, investigator expertise and competence, and intended uses. QA/QC procedures are designed to help ensure data useability but, in themselves, neither assure data useability nor — if not implemented — indicate that data are not useable or valid. Data validity and useability will ultimately be determined by the PI, PM, and AM using their best professional judgment. Independent data validation, consultations with Data Quality Managers, and review of project-wide databases for data compatibility and consistency can be used to support useability evaluations. The useability and validity of existing and historical data, which were not collected pursuant to the QAPjP presented in this assessment plan, will be determined by the AM, PM, PIs, and trustee technical staff using their best professional judgment.

10.12 CORRECTIVE ACTIONS

10.12.1 Definition

Corrective actions consist of the procedures and processes necessary to correct and/or document situations where data quality and/or QA procedures fall outside of acceptance criteria or targets. [These criteria/targets may be numeric goals such as those discussed in Section 10.3, or procedural requirements such as those presented throughout the QAPjP and other project documents (e.g., SOPs)].

The goal of corrective action is to identify as early as possible a data quality problem and to eliminate or limit its impact on data quality. The corrective action information typically is provided to a Data Quality Manager for use in data assessment and long-term quality management. Corrective action typically involves the following steps:

1. discovering any nonconformance or deviations from data quality objectives or the plan
2. identifying the party with authority to correct the problem
3. planning and scheduling an appropriate corrective action
4. confirming that the corrective action produced the desired result
5. documenting the corrective action.

10.12.2 Discovery of Nonconformance

The initial responsibility of identifying nonconformance with procedures and QC criteria lies with the field personnel and bench-level analysts. Performance and system audits are also designed to detect these problems. However, anyone who identifies a problem or potential problem should initiate the corrective action process by, at the least, notifying a PI or Data Quality Manager of his or her concern.

Deviations from QAPjP or SOP procedures are sometimes required and appropriate because of field or sample conditions. Such deviations should be noted in field or laboratory logbooks and their effect on data quality evaluated by a PI and Data Quality Manager. Occasionally, procedural changes are made during an investigation because method improvements are identified and implemented. Even though these procedural improvements are not initiated because of nonconformance, they are procedural deviations and typically should be documented.

10.12.3 Planning, Scheduling, and Implementing Corrective Action

Appropriate corrective actions for routine problems depend on the situation and may range from documentation of the problem to resampling and reanalysis to the development of new methods. When the corrective action is within the scope of these potential actions, the bench-level analyst or the field staff can identify the appropriate corrective action and implement it. Otherwise, the corrective action should be identified and selected by the PM, the FTL, the Laboratory Manager, or the Data Quality Manager.

10.12.4 Confirmation of the Result

While a corrective action is being implemented, additional work dependent on the nonconforming data should not be performed. When the corrective action is complete, the situation should be evaluated to determine if the problem was corrected. If not, new corrective actions should be taken until no further action is warranted, either because the problem is now corrected or because no successful corrective action has been found.

10.12.5 Documentation and Reporting

Corrective action documentation may consist of the following reports or forms:

- corrective action forms initiated by project staff that will be collected, evaluated, and filed by the Data Quality Manager
- corrective action log maintained by the Data Quality Manager to track the types of nonconformance problems encountered and to track successful completion of corrective actions
- corrective action plans, if needed, to address major nonconformance issues
- performance and systems audit reports, if such audits are performed
- corrective action narratives included as part of data reports from independent laboratories
- corrective action forms initiated by laboratory staff and summarized in the report narrative.

10.12.6 Laboratory-Specific Corrective Action

The need for corrective action in the analytical laboratory may come from several sources: equipment malfunction, failure of internal QA/QC checks, method blank contamination, or failure of performance or system audits; and/or noncompliance with QA requirements.

When measurement equipment or analytical methods fail QA/QC checks, the problem should immediately be brought to the attention of the appropriate laboratory supervisor in accordance with the laboratory's SOP or Quality Assurance Manual. If failure is due to equipment malfunction, the equipment should be repaired, the precision and accuracy should be reassessed, and the analysis rerun.

All incidents of QA failure and the corrective action tasks should be documented, and reports should be placed in the appropriate project file. Corrective action should also be taken promptly for deficiencies noted during spot checks of raw data. As soon as sufficient time has elapsed for a corrective action to be implemented, evidence of correction of deficiencies should be presented to a Data Quality Manager or PI.

Laboratory corrective actions may include, but are not limited to:

- reanalyzing the samples, if holding time criteria permits and sample volume is available
- resampling and analyzing
- evaluating and amending sampling analytical procedures
- accepting data and acknowledging the level of uncertainty.

CHAPTER 11
REFERENCES

Abramowicz, D.A., M.J. Brennan, H.M.V. Dorf, and E.L. Gallagher. 1993. Factors influencing the rate of polychlorinated biphenyl dechlorination in Hudson River sediments. *Environmental Science and Technology* 27:1125-1131.

Adams, M.A., M. Bolger, C.D. Carrington, C.E. Coker, G.M. Cramwer, M.J. DiNovi, and S. Dolan. 1993. Guidance Document for Cadmium in Shellfish. Center for Food Safety and Applied Nutrition, United States Food and Drug Administration. Washington, DC. January. <http:/vm.cfsan.fda.gov/~frf/guid-cd.html> Accessed August 11, 1999.

Adams, S.M., K.D. Ham, M.S. Greeley, R.F. LeHew, D.E. Hinton, and C.F. Saylor. 1996. Downstream gradients in bioindicator responses: Point source contaminant effects on fish health. *Canadian Journal of Fisheries and Aquatic Sciences* 53:2177-2187.

Addison, E.M., G.A. Fox, and M. Gilbertson. 1991. Proceedings of the Expert Consultation Meeting on Mink and Otter. International Joint Commission, United States and Canada.

Akerman, G., U. Tjarnlund, E. Noaksson, and L. Balk. 1998. Studies with oxythiamine to mimic reproduction disorders among fish early life stages. *Marine Environmental Research* 46(1-5):493-497.

Akwesasne Task Force on the Environment. 1997. Superfund clean-up at Akwesasne: A case study in environmental injustice. *International Journal of Contemporary Sociology* 34:267-290.

ALCOA. 1999a. Analysis of Alternatives Report. Grasse River Study Area, Massena, New York. Prepared by ALCOA Inc., Massena, NY. December 29.

ALCOA. 1999b. Comprehensive Characterization of the Lower Grasse River. Prepared by ALCOA for the Grasse River Study Area, Massena, NY. Includes Volume I (main report), Volume II (Appendixes A through F) and the Grasse River Project GIS database.

ALCOA. 1999c. In-River Particle Broadcasting Treatability Study Work Plan. Prepared by ALCOA for the Grasse River Study Area, Massena, NY.

Anderson, D.P. and M.G. Zeeman. 1995. Immunotoxicology in fish. In *Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment.* Gary M. Rand (ed.), Taylor & Francis, Washington, DC, pp. 371-402.

Anderson, M.J., M.R. Miller, and D.E. Hinton. 1996a. *In vitro* modulation of 17ß-estradiol-induced vitellogenin synthesis: Effects of cytochrome P4501A1 inducing compounds on rainbow trout (*Oncorhynchus mykiss*) liver cells. *Aquatic Toxicology* 34(4):327-350.

Anderson, M.J., H. Olsen, F. Matsumura, and D.E. Hinton. 1996b. *In vivo* modulation of 17ß-estradiol-induced vitellogenin synthesis and estrogen receptor in rainbow trout (*Oncorhynchus mykiss*) liver cells by ß-Naphthoflavone. *Toxicology and Applied Pharmacology* 137:210-218.

Anderson, M.J., M.G. Barron, S.A. Diamond, J. Lipton, and J.T. Zelikoff. 1997. Biomarker selection for restoration monitoring of fishery resources. In *Environmental Toxicology and Risk Assessment: Modeling and Risk Assessment (Sixth Volume), ASTM STP 1317.* F.J. Dwyer, T.R. Doane, and M.L. Hinman (eds.), American Society for Testing and Materials, Philadelphia, PA, pp. 333-359.

ATSDR. 1995. Styrene Fact Sheet. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry, available from ATSDR Information Center, Atlanta, GA.

Aulerich, R.J., S.J. Bursian, M.G. Evans, J.R. Hochstein, K.A. Koudele, B.A. Olson, and A.C. Napolitano. 1987. Toxicity of 3,4,5,3',4',5'-hexachlorobiphenyl to mink. *Archives of Environmental Contamination and Toxicology* 16:53-60.

Bailey, G., D. Selivonchick, and J. Hendricks. 1987. Initiation, promotion, and inhibition of carcinogenesis in rainbow trout. *Environmental Health Perspective* 71:147-153.

Barkley, J. 1998. Final Report, Styrene Sampling on the St. Regis Mohawk Reservation to Determine Impacts Caused by General Motors. Available from the St. Regis Mohawk Tribe, Hogansburg, NY.

Baumann, P.C. and J.C. Harshbarger. 1995. Decline in liver neoplasms in wild brown bullhead catfish after coking plant closes and environmental PAHs plummet. *Environmental Health Perspectives* 103:168-170.

Baumann, P.C., M.J. Mac, S.B. Smith, and J.C. Harshbarger. 1991. Tumor frequencies in walleye (*Stizostedion vitreum*) and brown bullhead (*Ictalurus nebulosus*) and sediment contaminants in tributaries of the Laurentian Great Lakes. *Canadian Journal of Fisheries and Aquatic Sciences* 48:1804-1809.

BBLES. 1998. St. Lawrence River Monitoring and Maintenance Annual Report. Prepared for General Motors Powertrain, Massena, NY, by BBL Environmental Services, Inc., Syracuse, NY. January.

BBLES. 2000. St. Lawrence River Monitoring and Maintenance Annual Report. Prepared for General Motors Powertrain, Massena, NY, by BBL Environmental Services, Inc., Syracuse, NY. January.

Bechtel Environmental. 2000. Final Dredging Program Work Plan for the River Remediation Project at the Reynolds Metals Company St. Lawrence Reduction Plant, Massena, NY. Revision 2. Prepared by Bechtel Associates Professional Corporation, NY for Bechtel Environmental, Inc., Oak Ridge, TN. February.

Béland, P. 1988. Witness for the prosecution — scientific studies on beached belugas are strengthening the case against chemical pollutants. *Nature Canada* Fall:29-36.

Béland, P. 1996. The beluga whales of the St. Lawrence River. *Scientific American* 274(May):74-80.

Béland, P., A. Faucher, and P. Corbeil. 1990. Observations on the birth of a beluga whale (*Delphinapterus leucas*) in the St. Lawrence Estuary, Quebec, Canada. *Canadian Journal of Zoology* 68:1327-1329.

Béland, P., S. DeGuise, C. Girard, A. Lagacé, D. Martineau, R. Michaud, D. Muir, R. Norstrom, and E. Pelletier. 1991. Toxic compounds and health and reproductive effects in St. Lawrence beluga whales. Presented at Cause-Effect Linkages II Conference, Traverse City, MI. September 27-28.

Béland, P., S. DeGuise, C. Girard, A. Lagace, D. Martineau, R. Michaud, D.C.G. Muir, R.J. Norstrom, E. Pelletier, S. Ray, and L.R. Shugart. 1993. Toxic compounds and health and reproductive effects in St. Lawrence beluga whales. *Journal of Great Lakes Research* 19:766-775.

Benedict, L. 1994. Clean Air Program Styrene Report. St. Regis Mohawk Tribe Environment Division.

Bishop, C.A., M.D. Koster, A.A. Chek, D.J.T. Hussell, and K. Jock. 1995a. Chlorinated hydrocarbons and mercury in sediments, red-winged blackbirds (*Agelaius phoeniceus*) and tree swallows (*Tachycineta bicolor*) from wetlands in the Great Lakes-St. Lawrence River basin. *Environmental Toxicology and Chemistry* 14:491-501.

Bishop, C.A., S. Trudeau, S.W. Kennedy, J.J. Stegeman, and R.J. Norstrom. 1995b. Biochemical Indicators of Contaminant Exposure in Passerines, Colonial Waterbirds and Snapping Turtles of the Great Lakes — St. Lawrence River Basin. Presented at the Eighth International Symposium Pollutant Responses in Marine Organisms, April 3-6, Pacific Grove, CA.

Bishop, C.A., R.J. Brooks, J.H. Carey, P. Ng, R.J. Norstrom, and D.R. Lean. 1991. The case for a cause-effect linkage between environmental contamination and development in eggs of the common snapping turtle (*Chelydra S. serpentina*) from Ontario, Canada. *Journal of Toxicology and Environmental Health* 33(4):521-47.

Bobrow, P., B. Brown, M. Denham, G. Harris, J. Racette, and S. Rock. 1983. An Evaluation of Possible Groundwater by PCBs in the Vicinity of Raquette Point, New York. Submitted to St. Regis Mohawk Health Services, Akwesasne-Hogansburg, NY, by Environmental Studies Program, St. Lawrence University, Canton, NY. January.

Boily, M.H., L. Champoux, D.H. Bourbonnais, J.L. DesGranges, J. Rodrigue, and P.A. Spear. 1994. B-carotene and retinoids in eggs of great blue herons (*Ardea herodias*) in relation to St. Lawrence River contamination. *Ecotoxicology* 3:271-286.

Bonin, J., J.-L. DesGranges, C.A. Bishop, J. Rodrigue, A. Gendron, and J.E. Elliott. 1995. Comparative study of contaminants in the mudpuppy (Amphibia) and the common snapping turtle (Reptilia), St. Lawrence River, Canada. *Archives of Environmental Contamination and Toxicology* 28:184-194.

Bouchard, H. and P. Millet. 1993. The St. Lawrence River: Diversified Environments, St. Lawrence Update. Series No. 97. Environment Canada, St. Lawrence, Quebec.

Britton, W.M. and T.M. Huston. 1973. Influence of polychlorinated biphenyls in the laying hen. *Poultry Science* 32:1620-1624.

Brown, J.F. and R.E. Wagner. 1990. PCB movement, dechlorination, and detoxication in the Acushnet estuary. *Environmental Toxicology and Chemistry* 9:1215-1233.

Brown, J.F., R.E. Wagner, H. Feng, D.L. Bedard, M.J. Brennan, J.C. Carnahan, and R.J. May. 1987. Environmental dechlorination of PCBs. *Environmental Toxicology and Chemistry* 6:579-593.

Brown, S.B., D.C. Honeyfield, and L. Vandenbyllarrdt. 1998. Thiamine Analysis in Fish Tissues. In *Early Life Stage Mortality Syndrome in Fishes of the Great Lakes and Baltic Sea*. American Fisheries Society Symposium 21. G. McDonald, J.D. Fitzsimons, and D.C. Honeyfield (eds.). American Fisheries Society, Bethesda, MD, pp. 73-81.

Brunstrom, B. and L. Reutergardh. 1986. Differences in sensitivity of some avian species to the embryotoxicity of a PCB, 3,3'4,4'-tetrachlorobiphenyl, injected into the eggs. *Environmental. Pollution* (Series A) 42:37-45.

Buckley, E.H. 1982. Accumulation of airborne polychlorinated biphenyls in foliage. *Science* 216:520-522.

Bumbaco, M.J. and J.H. Shelton. 1976. Ambient Air Levels of Fluorides at Cornwall Island, Ontario (April 15-October 15, 1976). Prepared by Surveillance Division, Air Pollution Control Directorate. December.

Bumbaco, M.J. and J.H. Shelton. 1978. Ambient Air Levels of Fluorides at Cornwall Island, Ontario (April 15-October 15, 1977). Prepared by Surveillance Division, Air Pollution Control Directorate. January.

Bumbaco, M.J. and J.H. Shelton. 1979. Ambient Air Levels of Fluorides at Cornwall Island, Ontario (April 15-October 15, 1978). Prepared by Surveillance Division, Air Pollution Control Directorate. May.

Bumbaco, M.J. and J.H. Shelton. 1980. Ambient Air Levels of Fluorides at Cornwall Island, Ontario (October, 1978-October 1979). Prepared by Surveillance Division, Air Pollution Control Directorate. May.

Bumbaco, M.J. and J.H. Shelton. 1981. Ambient Air Levels of Fluorides at Cornwall Island, Ontario (October, 1979-October 1980). Prepared by Surveillance Division, Air Pollution Control Directorate. December.

Bush, B. 1992. Analytical Results. New York State Department of Health, Wadsworth Laboratories.

Bush, B., R.M. Smith, P.W. O'Keefe, and E. Fitzgerald. 1995. Occurrence of 99 PCB Congeners in Air at 6 Sites in the Mohawk National Land (Akwesasne) near a St. Lawrence River Power Dam. *Abstract from Sharing Knowledge, Linking Sciences: An International Conference on the St. Lawrence Ecosystem. May 10-12, Cornwall, Ontario.*

Canter, L.W. 1996. Prediction and assessment of impacts on the cultural (historical and archaeological) environment. In *Environmental Impact Assessment*. L.W. Canter (ed.). McGraw-Hill, New York.

CCME. 1991. Interim Canadian Environmental Quality Criteria for Contaminated Sites. Canadian Council of Ministers of the Environment. Prepared by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites CCME EPC-CS34. Winnipeg, Manitoba, Canada. September.

CCME. 1997. Recommended Canadian Soil Quality Guidelines. Canadian Council of Ministers of the Environment. Winnipeg, Manitoba, Canada. March.

CDM. 1994. Preliminary Design Report for the Industrial Landfill, East Disposal Area/Containment Area and Site-Wide Groundwater Controls. Prepared for General Motors Corporation by Camp Dresser and McKee, Cambridge, MA. June 21.

CDM. 1998. Pre-Final Design Report for Remediation of Raquette River. Prepared for General Motors Powertrain, by Camp Dresser and McKee, Cambridge, MA. August 31.

CDM. 2000. Industrial Landfill/GWCT Sampling and Analysis Report. Prepared for General Motors Corporation, Massena, NY, by Camp Dresser and McKee, Cambridge, MA.

Champoux, L., J.L. DesGranges, J. Rodrigue, S. Trudeau, M. Boily, A. Hontela, and P.A. Spear. 1995. St. Lawrence River ecosystem monitoring: The great blue heron and black-crowned night heron colony of Dickerson Island, Lake St. Francis, Quebec. Proceeding of *Sharing Knowledge, Linking Sciences: An International Conference on the St. Lawrence Ecosystem, Selected Presentations and Papers. Volume 1. May 10, 11, and 12, Cornwall, Ontario, Canada.*

Chan, C.H. 1980. St. Lawrence River Water Quality Surveys, 1977. Scientific Series No. 113. Environment Canada Inland Waters Directorate, Burlington, Ontario.

Chiarenzelli, J., B. Bush, A. Casey, E. Barnard, B. Smith, P. O'Keefe, E. Gilligan, and G. Johnson. 2000. Defining the sources of airborne polychlorinated biphenyls: evidence for the influence of microbially dechlorinated congeners from river sediment? *Can. J. Fish. Aquat. Sci.* 57 (Suppl 1): 86-94

Connelly, N.A., B.A. Knuth, and C.A. Bisogni. 1992. Effects of the Health Advisory and Advisory Changes on Fishing Habits and Fish Consumption in New York Sport Fisheries. Report for New York Sea Grant Institute Project No. R/FHD-2-PD. Department of Natural Resources, New York State College of Agricultural and Life Sciences.

Connelly, N.A., B.A. Knuth, and T.L. Brown. 1996. Sportfish consumption patterns of Lake Ontario anglers and the relationship to health advisories. *North American Journal of Fisheries Management* 16:90-101.

Cook, P.M., E.W. Zabel, and R.E. Peterson. 1997. The TCDD toxicity equivalence approach for characterizing risks for early life stage mortality in trout. Chapter 2 in *Chemically-Induced Alterations in the Functional Development and Reproduction of Fishes*. R. Rolland, M. Gilbertson and R. Peterson (eds.). SETAC Press, Pensacola, FL.

Cornelius, C.A. 1992. A Culture Based Curriculum Framework. A dissertation submitted to the Cornell University Education Department, Ithaca, NY.

Crissman, J.W., G.A. Maylin, and L. Krook. 1980. New York State and U.S. federal fluoride pollution standards do not protect cattle health. *Cornell Veterinarian* 70:183-192.

Custer, T.W., C.M. Custer, R.K. Hines, S. Gutreuter, K.L. Stromburg, P.D. Allen, and M.J. Melancon. 1999. Organochlorine contaminants and reproductive success of double-crested cormorants from Green Bay, Wisconsin, USA. *Environmental Toxicology and Chemistry* 18:1209-1217.

DeBellefeuille, M. 1985. Ambient Air Levels of Fluoride at Cornwall Island, Ontario — April 16, 1985-October 15, 1985. Prepared by Ottawa District Office, Environment Canada. November.

DeBellefeuille, M. and R. Desjardins. 1986. Ambient Air Levels of Fluoride at Cornwall Island, Ontario — April 15, 1986-October 14, 1986. Prepared by Ottawa District Office, Environment Canada. November.

De Guise, S., A. Lagace, and P. Béland. 1994. Tumors in St. Lawrence beluga whales (*Delphinapterus leucas*). *Veterinary Pathology* 31(4):444-449.

De Guise, S., D. Martineau, P. Béland, and M. Fournier. 1995a. Possible mechanisms of action of environmental contaminants on St. Lawrence beluga whales (*Delphinapterus leucas*). *Environmental Health Perspectives* 4:73-77.

De Guise, S., A. Lagace, P. Béland, C. Girard, and R. Higgins. 1995b. Non-neoplastic lesions in beluga whales (*Delphinapterus leucas*) and other marine mammals from the St. Lawrence Estuary. *Journal of Comparative Pathology* 112(3):257-271.

Dreier, S.I., J. Anderson, J. Biberhofer, M. Eckersley, R. Helliar, M.B.C. Hickey, L. Richman, and F. Stride and the St. Lawrence River (Cornwall) Remedial Action Plan Public Advisory Committee. 1997. Great Lakes, Great River: Remedial Action Plan for St. Lawrence River (Cornwall) Area of Concern Stage 2 Report: The Recommended Plan. November.

Eastern Research Group. 1999. Report on the Peer Review of the Data Evaluation and Interpretation Report and Low Resolution Sediment Coring Report for the Hudson River PCBs Superfund Site. Prepared for the U.S. Environmental Protection Agency, Region 2, New York, by Eastern Research Group, Inc. June 3.

Ecology and Environment. 1992a. Grasse River — River and Sediment Investigation. Prepared by Ecology and the Environment, Inc. for Aluminum Company of America, Massena, NY. February.

Ecology and Environment. 1992b. Grasse River RSI — PCDD/PCDF Results. Prepared by Ecology and the Environment, Inc. for Aluminum Company of America, Massena, NY. March.

Efroymson, R.A., M.E. Will, and G.W. Suter II. 1997b. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. ES/ER/TM-126/R2. Prepared by Lockheed Martin Energy Systems, Inc., for the U.S. Department of Energy. November.

Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones. 1997c. Preliminary Remediation Goals for Ecological Endpoints. ES/ER/TM-162/R2. Prepared by the U.S. Department of Energy by Lockheed Martin Energy Systems, Inc. Oak Ridge National Laboratory.

Efroymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten. 1997a. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. ES/ER/TM-85/R3. Prepared by Lockheed Martin Energy Systems, Inc., for the U.S. Department of Energy. November.

Eisler, R. 1986. Polychlorinated Biphenyl Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. U.S. Fish Wildl. Serv. Biol. Rep. 85(1.7), Contaminant Hazard Reviews Report no. 7. U.S. Department of the Interior, Washington, DC. April.

Eisler, R. 1996. Planar PCB Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review. National Biological Service Biological Report 31. U.S. Department of the Interior, Washington, DC. August.

Emerson, R.N. 1987. Phytotoxicology Investigations in the Cornwall Area of Ontario in the Vicinity of the Reynolds Metals Company (RMC), and the Aluminum Company of America (ALCOA), Massena, New York — 1985. ARB-008-87-Phyto. Prepared by the Phytotoxicology Section, Air Resources Branch, Ontario Ministry of the Environment. August.

Emerson, R.N. 1988. Phytotoxicology Investigations in the Cornwall Area of Ontario in the Vicinity of the Reynolds Metals Company (RMC), and the Aluminum Company of America (ALCOA), Massena, New York — 1986. ARB-142-87-Phyto. Prepared by the Phytotoxicology Section, Air Resources Branch, Ontario Ministry of the Environment.

Engineering-Science. 1987. Waste Site Investigation ALCOA Massena Operations, Volume I — Investigative Report. Engineering Science Inc. Submitted by Aluminum Company of America to the New York State Department of Environmental Conservation, Albany. August.

Engineering-Science. 1989. Waste Site Investigation ALCOA Massena Operations, Volume IV — Supplemental Report. Engineering Science Inc. Submitted by Aluminum Company of America to the New York State Department of Environmental Conservation, Albany. March.

Engineering-Science. 1991a. Waste Site Investigation ALCOA Massena Operations, Volume XI — Feasibility Study Report II, New or Revised Appendix Material. Engineering Science Inc. Prepared for the New York State Department of Environmental Conservation, Albany, by Aluminum Company of America, Massena, NY. June.

Engineering-Science. 1991b. Waste Site Investigation ALCOA Massena Operations, Volume XII — Final Comprehensive Biota Sampling Program Report. Engineering Science Inc.

Submitted by Aluminum Company of America to the New York State Department of Environmental Conservation, Albany. March.

Environment Canada. 1988. Ambient Air Levels of Fluoride at Cornwall Island, Ontario — April 16, 1987 — October 13, 1987. Prepared by Ottawa District Office, Environment Canada. August.

Environment Canada. 1992. Interim Criteria for Quality Assessment of St. Lawrence River Sediment. St. Lawrence Action Plan. July.

Erickson, M.D. 1997. *Analytical Chemistry of PCBs*. Lewis Publishers, New York, 667 pp.

ERM. 1993. Summary Report North Disposal Area — Soil Borings. Prepared for Hughes Environmental Systems, Inc. General Motors, Massena, NY by ERM — Northeast Albany, NY. November.

Fisher, J.P., J.D. Fitzsimons, G.F. Combs Jr., and J.M. Spitsbergen. 1996. Naturally occurring thiamine deficiency causing reproductive failure in Finger Lakes Atlantic salmon and Great Lakes lake trout. *Transactions of the American Fisheries Society* 125:167-178.

Flanagan, W.P. and R.J. May. 1993. Metabolite detection as evidence for naturally occurring aerobic PCB biodegradation in Hudson River sediments. *Environmental Science and Technology* 27:2207-2212.

Gendron, A. 1994. Multi-Level Detection of Toxic Stress in the Mudpuppy (*Necturus maculosus*) an Aquatic Salamander. Report submitted to Environment Canada.

Gendron, A.D., C.A. Bishop, R. Fortin, and A. Hontela. 1997. In vivo testing of the functional integrity of the corticosterone-producing axis in mudpuppy (Amphibia) exposed to chlorinated hydrocarbons in the wild. *Environmental Toxicology and Chemistry* 16(8):1694-1706.

Giesy, J.P., J.P. Ludwig, and D.E. Tillet. 1994. Deformities in birds of the Great Lakes region: Assigning causality. *Environmental Science and Technology* 28(3):128-135.

Gilbertson, M., T. Kubiak, J. Ludwig, and G. Fox. 1991. Great Lakes embryo mortality, edema, and deformities syndrome (GLEMEDS) in colonial fish-eating birds: Similarity to chick-edema disease. *Journal of Toxicology and Environmental Health* 33(4):455-520.

Gilligan, E. 1992. Results of Environmental Sampling at Raquette Point and Cornwall Island, Akwesasne. Report prepared by Syracuse University, Department of Civil and Environmental Engineering, Syracuse, NY.

Gobas, F.A.P.C. 1993. A model for predicting the bioaccumulation of hydrophobic organic chemicals in aquatic food-webs: Application to Lake Ontario. *Ecological Modelling* 69:1-17.

Gobas, F.A.P.C., M.N. Z'Graggen, and Z. Zhang. 1995. Time response of the Lake Ontario ecosystem to virtual elimination of PCBs. *Environmental Science and Technology* 29:2038-2046.

Gobas, F.A.P.C., J.B. Wilcockson, R.W. Russell, and G.D. Haffner. 1999. Mechanism of biomagnification in fish under laboratory and field conditions. *Environmental Science and Technology* 33:133-141.

Gunn, L.D. 1989. Letter re: Permit Application #6-4058-00004/00001-0. Addressed to S.C. Hung, St. Lawrence Seaway Development Corporation, Massena, New York, from the New York State Dept. of Environmental Conservation, Watertown. September 25.

Gunther, G. 1982. New York State Department of Health PCB and Heavy Metal Special Study, Akwesasne-Mohawk (St. Regis) Reservation, Bombay, Franklin County, NY.

Hagler Bailly Services. 1998. St. Lawrence Environment NRDA Data Compilation Report. Prepared for the St. Lawrence Environment Trustee Council by Hagler Bailly Services, Boulder, CO. August.

Harper, L.H. 1996. Results of Field Surveys for Rare, Threatened and Endangered Species and Significance of Natural Communities at the St. Lawrence-FDR Power Project, Phase Two Report.

Henny, C.J. and P.M. Burke. 1990. Fluoride accumulation and bone strength in wild black-crowned night-herons. *Archives of Environmental Contamination and Toxicology* 19:132-137.

Hinton, D.E., P.C. Baumann, G.R. Gardner, W.E. Hawkins, J.D. Hendricks, R.A. Murchelano, and M.S. Okihiro. 1992. Histopathologic biomarkers. In *Biomarkers: Biochemical, Physiological, and Histological Markers of Anthropogenic Stress*. R.J. Huggett, R.A. Kimerle, P.M. Mehrle, Jr., and H.L. Bergman (eds.). Lewis Publishers, Boca Raton, FL, pp. 155-210.

Hontela, A., J.B. Rasmussen, C. Audet, and G. Chevalier. 1992. Impaired cortisol stress response in fish from environments polluted by PAHs, PCBs, and mercury. *Archives of Environmental Contamination and Toxicology* 22:278-283.

Huang, Y.-W., M.J. Melancon, R.E. Jung, and W.H. Karasov. 1998. Induction of cytochrome P450-associated monooxygenases in northern leopard frog, *Rana pipiens,* by 3,3',3,3',4-pentachlorobiphenyl. *Environmental Toxicology and Chemistry* 17:1564-1569.

Hughes Environmental Systems and BBLES. 1993. Comprehensive Sampling and Analysis Plan. Sampling and Analysis Plan. Volume I. Prepared for General Motors Powertrain, Massena, NY, by Hughes Environmental Systems, Inc., and BBL Environmental Services, Inc.

Ingersoll, C.G., P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, D.R. Mount, and R.G. Fox. 1996. Calculation and evaluation of sediment effect concentrations for the amphipod *Hyalella azteca* and the midge *Chironomus riparius*. *Journal of Great Lakes Research* 22(3):602-623.

Jones, D.S., G.W. Suter, and R.N. Hull. 1997. Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Sediment-Associated Biota: 1997 Revision. ES/ER/TM-95/R4. Prepared for the Department of Energy. November.

Kadlec, M.J. 1991. St. Regis Mohawk Tribe — Ambient Water Quality Assessment. Environment Division, Clean Water Program. Available from the St. Regis Mohawk Tribe, Hogansburg, NY.

Kadlec, M.J. 1994. Bioconcentration of Congener Specific Polychlorinated Biphenyl (PCB) in Rainbow Trout (*Oncorhynchus mykiss*) Exposed to the Water Column of the St. Lawrence River. Thesis. State University of New York, Albany.

Kaiser, K.L.E., B.G. Oliver, M.N. Charlston, K.D. Nicol and M.E. Comba. 1990. Polychlorinated biphenyls in St. Lawrence River sediments. *The Science of the Total Environment* 97/98:495-506.

Kauss, P.B., Y.S. Hamdy, and B.S. Hamma. 1988. St. Lawrence River Environmental Investigations — Volume I, Background: Assessment of Water, Sediment and Biota in the Cornwall, Ontario and Massena, New York Section of the St. Lawrence River, 1979-1982. Prepared by Water Resources Branch, Ontario Ministry of the Environment, Toronto, Ontario and B.H. Environmental Consultant, Bramalea, Ontario. February.

Kent, R.A., U.A. Schneider, and A.V. Pawlisz. 1995. Impacts of Inorganic Fluorides on Terrestrial Ecosystems: An Ecological Risk Assessment Case Study. 16th Annual Meeting and 2nd SETAC World Congress. Society of Environmental Toxicology and Chemistry, Vancouver, BC.

Khan, R.A. and J. Thulin. 1991. Influence of pollution on parasites of aquatic animals. *Advances in Parasitology* 30:201-237.

Krook, L. and G.A. Maylin. 1979. Industrial fluoride pollution: Chronic fluoride poisoning in Cornwall Island cattle. *Cornell Veterinarian* 69(Supplement 8):1-70.

Krzystyniak, K., H. Tryphonas, and M. Fournier. 1995. Approaches to the evaluation of chemical-induced immunotoxicity. *Environmental Health Perspectives Supplements: Great Lakes and Human Health* 103(9):17-22.

Kubiak, T.J., H.J. Harris, L.M. Smith, T.R. Schwartz, D.L. Stalling, J.A. Trick, L. Sileo, D.E. Docherty, and T.C. Erdman. 1989. Microcontaminants and reproductive impairment of the Forster's tern on Green Bay, Lake Michigan — 1983. *Archives of Environmental Contamination and Toxicology* 18:706-727.

Long, E.R., D.D. MacDonald, S.L. Smith, and F.D. Calder. 1995. Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environmental Management* 19:81-97.

MacDonald D.D., L.M. Dipinto, J. Field, C.G. Ingersoll, E.R. Long, and R.C. Swartz. 2000. Development and Evaluation of Consensus-Based Sediment Effect Concentrations for polychlorinated biphenyls. *Environmental Toxicology and Chemistry* 19:1403-1413.

Mander, J. 1991. *In the Absence of the Sacred.* Sierra Club Books, San Francisco, CA.

Martineau, D., A. Lagacé, P. Béland, R. Higgins, D. Armstrong, and L.R. Shugart. 1988. Pathology of stranded beluga whales (*Delphinapterus leucas*) from the St. Lawrence Estuary, Québec, Canada. *Journal of Comparative Pathology* 98:287-311.

Martineau, D., S. De-Guise, M. Fournier, L. Shugart, C. Girard, A. Lagacé, and P. Béland. 1994. Pathology and toxicology of beluga whales from the St. Lawrence Estuary, Quebec, Canada: Past, present and future. *Science of the Total Environment* 154(2-3):201-215.

Mayer, D.F., J.D. Lungden, and L.H. Weintstein. 1988. Evaluation of fluoride levels and effects on honey bees (*Apis mellifera* L.) (Hymenoptera: Apidae). *Fluoride: Journal of The International Society for Fluoride Research* 21(3):113-120.

McKim, J.M. 1995. Early life stage toxicity tests. Appendix B in *Fundamentals of Aquatic Toxicology. Effects, Environmental Fate, and Risk Assessment.* G.M. Rand (ed.). Taylor and Francis Publishers, Washington, DC, pp. 974-1011.

Merriman, J.C. 1987. Trace Organic Contaminants in Sediment of the International Section of the St. Lawrence River, 1981. Technical Bulletin No. 148. Prepared by Environment Canada, Water Quality Branch, Burlington, Ontario.

Miles, J.A. 1983. The Distribution and Concentration of Fluorides in Native Vegetation and Small Mammal Species in the Vicinity of the St. Regis Indian Reserve — 1977. Thesis. University of Montana.

Minkley, E.G., Jr., M.S. Blough, M.M. D'Andrea, L.E. Dansey, and J.T. Hauck. 1999a. Evaluation of PCB Biodegradation in Grasse River Sediments Volume I: 1995/96 Studies. Final Report. Carnegie Mellon Research Institute Biotechnology Group. July.

Minkley, E.G., Jr., M.S. Blough, M.M. D'Andrea, and J.T. Hauck. 1999b. Evaluation of PCB Biodegradation in Grasse River Sediments Volume II: 1997/98 Studies. Interim Final Report. Carnegie Mellon Research Institute Biotechnology Group. August.

Mo, S.H. 1988. Interim Report: Massena Ambient Air Survey, November 15-18, 1988. Air Study #229. Bureau of Toxic Air Sampling, New York State Dept. of Environmental Conservation, Albany.

Mo, S.H. 1989. Interim Report: Massena Ambient Air Survey, August 22-25, 1989. Air Study #229. Bureau of Toxic Air Sampling, New York State Dept. of Environmental Conservation, Albany.

Moon, T.W., D.M.E. Otto, D.M. Arquette, and J.K. Buttner. 1996. Detection of contaminant exposure in fish by activation of detoxication enzymes. *Great Lakes Research Review* 2(2):36-40.

Moore, M.J. and M.S. Meyers. 1994. Pathobiology of chemical-associated neoplasia in fish. In *Aquatic Toxicology*. D. Malins and G.K. Ostrander (eds.). Lewis Publishers, Boca Raton, FL, pp. 327-386.

Muir, D.C.G., C.A. Ford, R.E.A. Stewart, T.G. Smith, R.F. Addison, M.E. Zinck, and P. Béland. 1990. Organochlorine contaminants in belugas, *Delphinapterus leucas*, from Canadian waters. In *Advances in Research on the Beluga Whale, Delphinapterus* leucas. T.G. Smith, D.J. St. Aubin, and J.R. Geraci (eds.). *Canadian Bulletin of Fisheries and Aquatic Science* 224:165-190.

NOAA. 1999. Reproductive, Developmental and Immunotoxic Effects of PCBs in Fish: A Summary of Laboratory and Field Studies. Prepared by Emily Monosson for National Oceanic Atmospheric Administration, March.

NYSDEC. 1976. Press release re: Order prohibiting the possession of fish caught in Lake Ontario and its tributaries. Tuesday, September 14. A.A. Berle, Commissioner, New York State Department of Environmental Conservation, Albany.

NYSDEC. 1989. St. Lawrence River Data. Memorandum to Ken Jock, Bill Daigle and John Privitera from Ward Stone dated August 8, 1988. New York State Department of Environmental Conservation, Albany.

NYSDEC. 1990a. Interim Report: Massena Ambient Air Survey, September 16-19, 1990. Air Study #229. Bureau of Toxic Air Sampling, New York State Department of Environmental Conservation, Albany.

NYSDEC. 1990b. Natural Resource Damages Preassessment Screen for the St. Lawrence, Grasse and Raquette River and Environs. Prepared by the New York State Department of Environmental Conservation, Albany.

NYSDEC. 1991a. Air Guide 1: Guidelines for the control of toxic ambient air contaminants. New York State Department of Environmental Conservation. Prepared by the Division of Air Resources.

NYSDEC. 1991b. St. Lawrence River at Massena Remedial Action Plan Stage II. New York State Department of Environmental Conservation. August.

NYSDEC. 1991c. Record of Decision for the Aluminum Company of America, Massena Operations, Massena, NY. March.

NYSDEC. 1992a. Chemical Contaminants in Wildlife from Akwesasne and the Vicinity of the General Motors Corporation/Central Foundry Division Massena, New York Plant. Technical Report 92-4 (BEP), Division of Fish and Wildlife. October.

NYSDEC. 1992b. Record of Decision for the Aluminum Company of America — Massena Operations, Massena, New York. Prepared by New York State Dept. of Environmental Conservation, Div. of Hazardous Waste Remediation — Region 6, Watertown. January.

NYSDEC. 1992c. Record of Decision for Reynolds Metals Company, St. Lawrence Reduction Plant, Massena, New York. NYSDEC Site No: 6-45-009. Prepared by New York State Department of Environmental Conservation, Division of Hazardous Waste Remediation — Region 6, Watertown. January.

NYSDEC. 1994. Revised division technical and administrative guidance memorandum (TAGM) on determination of soil cleanup objectives and cleanup levels. HWR-94-4046. Prepared by the New York State Department of Environmental Conservation, Albany.

NYSDEC. 1995. St. Lawrence River at Massena, New York Remedial Action Plan 1995 Update. Prepared by the New York State Department of Environmental Conservation, Albany. April.

NYSDEC. 1996. Proposed Remedial Action Plan, Mineral Processing Inc., Massena, St. Lawrence County, NY Site No. 6-45-018. Prepared by the New York State Department of Environmental Conservation, Albany. February 26.

NYSDEC. 1997a. 1996 Fluoride Sampling Results — Massena. Memorandum to T. Morgan prepared by D. Hershey, New York State Department of Environmental Conservation. July 14.

NYSDEC. 1997b. Summary Sheet prepared by New York State Department of Environmental Conservation on Waste Stream, Inc., Potsdam, New York, site.

NYSDEC. 1998a. Final Express Terms for Amendments to Title 6 Chapter X Parts 700-706. Water quality standard TOGS 1.1.1, New York State Department of Environmental Conservation, Albany. June.

NYSDEC. 1998b. Technical Guidance for Screening Contaminated Sediments. New York State Department of Environmental Conservation, Albany. March.

NYSDOH. 1995. Environmental Sampling at Akwesasne: Summary Report (Draft). New York State Department of Health. Prepared for and in cooperation with St. Regis Mohawk Tribe, First Environment Research Projects. September 1993, July 1994, September 1995.

NYSDOH. 1999. Health Advisory, Chemicals in Game and Sportfish: 1999-2000. New York State Department of Health. Available at <http:/www.health.state.ny.us/nysdoh/environ/fish.htm>

Otto, D.M.E. and T.W. Moon. 1996. Phase I and II enzymes and antioxidant responses in different tissues of brown bullheads from relatively polluted and non-polluted systems. *Archives of Environmental Contamination and Toxicology* 31(1):141-147.

Pattee, O.H., S.N. Wiemeyer, and D.M. Swineford. 1988. Effects of dietary fluoride on reproduction in eastern screech-owls. *Archives of Environmental Contamination and Toxicology* 17:213-218.

Patterson, D. 1993. Updated Green Bay Mass Balance Modeling Results with Reduction in Organic Matter Settling Rates. State of Wisconsin Memorandum to MariAnn Sumi, Lee Liebenstein, and Jo Mercurio from the Wisconsin Department of Natural Resources, December 1.

Paukert, J. 1988. Fluorine in the urine of the common hare (*Lepus europaeus* Pall.) and in the precipitation fallen in the regions influenced by smoke emissions. *Ekologia (CSSR)* 7(3):299-309.

Peakall, D.B., J.L. Lincer, and S.E. Bloom. 1972. Embryonic mortality and chromosomal alterations caused by Aroclor 1254 in ring doves. *Environmental Health Perspective* 1(April):103-104.

Perkins, D.F. and R.O. Millar. 1987. Effects of airborne fluoride emissions near an aluminum works in Wales: Part 1 — corticolous lichens growing on broadleaved trees. *Environmental Pollution* 47:63-78.

PRC Environmental Management. 1989. Base Line Risk Assessment, General Motors Corporation — Central Foundry Division (Part 1). PRC Environmental Management Inc., Massena, NY. September 11.

Premo, D. 1990. GM #645007. Letter to GM Foundry Project Coordinator, Massena, NY, St. Lawrence County.

Quemerais, B., K.R. Lum, and C. Lemieux. 1996. Concentrations and transport of trace metals in the St. Lawrence River. *Aquatic Sciences* 58(1):53-68.

Ram, R.G. and J.W. Gillett. 1993. An aquatic/terrestrial foodweb model for polychlorinated biphenyls (PCBs). In *Environmental Toxicology and Risk Assessment*, W.G. Landis, J.S. Hughes, and M.A. Lewis (eds.). American Society for Testing and Materials, Philadelphia, PA, pp. 192-212.

Ram, R.N. 1990. An Exposure Assessment Model for Polychlorinated Biphenyls in Foodwebs. A dissertation presented to Cornell University, Ithaca, NY.

Ransom, J. 1986. St. Regis Mohawk Tribe Issues Ban on Local Fish Consumption. Available from the St. Regis Mohawk Tribe, Hogansburg, NY.

Ransom, J. and H. Lickers. 1988. Akwesasne environment: Appraisals of toxic contamination at the St. Regis Mohawk Reservation. *Northeast Indian Quarterly* V:22-26.

Repetto, R. and S.S. Baliga. 1996. *Pesticides and the Immune System: The Public Health Risks.* World Resources Institute, Washington, DC.

Rhee, G.-Y., R.C. Sokol, C.M. Bethoney, and B. Bush. 1993a. Dechlorination of polychlorinated biphenyls by Hudson River sediment organisms: Specificity to the chlorination pattern of congeners. *Environmental Science and Technology* 27:1190-1192.

Rhee, G.-Y., B. Bush, C.M. Bethoney, A. DeNucci, H.-O. Oh, and R.C. Sokol. 1993b. Reductive dechlorination of Aroclor 1242 in anaerobic sediments: Pattern, rate and concentration dependence. *Environmental Toxicology and Chemistry* 12:1025-1032.

Rice, C.D. and D. Schlenk. 1995. Immune function and cytochrome P4501A activity after acute exposure to 3,3',4,4',5-pentachlorobiphenol (PCB 126) in channel catfish. *Journal of Aquatic Animal Health* 7:195-204.

Rice, P. 1983. Report of Peter Rice Concerning Fluoride Pollution of Cornwall Island, Ontario, by Emissions from Reynolds Metals Company and ALCOA Aluminum Smelters in New York. October.

Richard, M.R. and F.R. Pick. 1995. PCB contamination of sediments and two species of macrophytes from the St. Lawrence River. In *Sharing Knowledge, Linking Sciences: An International Conference on the St. Lawrence Ecosystem, May 10, 11, and 12. Cornwall, Ontario.* R. Needham and E.N. Novakowski (eds.). University of Ottawa, Ottawa, Canada, pp. 259-271.

Richard, M.R., M.E. Fox, and F.R. Pick. 1997. PCB concentrations and congener composition in macrophytes and sediments in the St. Lawrence River near Cornwall, Ontario. *Journal of Great Lakes Research* 23(3):297-306.

RMT. 1989. GMC-CFD Massena Facility, Phase II Remedial Investigation. Addendum Report for Remedial Investigation Feasibility Study. Madison, WI.

Rose, D. and J.R. Marier. 1977. Environmental Fluoride, 1977. NRCC No. 16081. Prepared by National Research Council of Canada, Ottawa, Ontario.

Rosenshield, M.L., M.B. Jofré, and W.H. Karasov. 1999. Effects of polychlorinated biphenyl 126 on green frog (*Rana clamitans*) and leopard frog (*Rana pipiens*) hatching success, development, and metamorphosis. *Environmental Toxicology and Chemistry* 18:2478-2486.

Ryan, J.J., B. P.-Y. Lau, J.A. Hardy, W.B. Stone, P. O'Keefe, and J.F. Gierthy. 1986. 2,3,7,8-Tetrachlorodibenzo-p-dioxin and related dioxins and furans in snapping turtle (*Chelydra serpentina*) tissues from the upper St. Lawrence River. *Chemosphere* 15:537-548.

Savage, W. and F.W. Quimby. 1999. Effects of polychlorinated biphenyl-contaminated sediment on larval amphibian growth and development. Poster presented at the Hazardous Waste Research Council Conference, St. Louis, MO. May.

Schrank, C.S., S.M. Cormier, and V.S. Blazer. 1997. Contaminate exposure, biochemical, and histopathological biomarkers in white suckers from contaminated and reference sites in the Sheboygan River, Wisconsin. *Journal of Great Lakes Research* 23(2):119-130.

Siemer, W.F. and T.L. Brown. 1994. Motivations and satisfactions of Lake Ontario boating salmonid anglers. *Journal of Great Lakes Research* 20(2):457-470.

Skinner, L.C. 1992. Memorandum regarding Grasse River to Al Schiavone, Gerry LeTendre, Bob Lange, Bill Daigle, Jim Reagan, Don Hesler, Darryl Sweredoski, Frank Bifera, and Peter Mack.

Sloan, R.J. and K. Jock. 1990. Chemical Contaminants in Fish from the St. Lawrence River Drainage on Lands of the Mohawk Nation at Akwesasne and Near the General Motors Corporation/Central Foundry Division, Massena, New York Plant. Technical Report 90-1 (BEP). Prepared by Division of Fish and Wildlife, New York State Department of Environmental Conservation, Albany.

Sloterdijk, H. Date unknown. Contribution by Massena (PCB, PAH) and Cornwall (Hg) to the Contamination of Lake St. Francis: Some Historical Evidence from the 1980's. Centre Saint-Laurent. Environment Canada, Montreal.

Smith, S.B., M.A. Blouin, and M.J. Mac. 1994. Ecological comparisons of Lake Erie tributaries with elevated incidence of fish tumors. *Journal of Great Lakes Research* 20(4):701-716.

Smith, S.L., D.D. MacDonald, K.A. Keenleyside, C.G. Ingersoll, and L.J. Field. 1996. A preliminary evaluation of sediment quality assessment values for freshwater ecosystems. *Journal of Great Lakes Research* 22:624-638.

Sokol, R.C., C.M. Bethoney, and G.-Y. Rhee. 1998. Effect of Aroclor 1248 concentration on the rate and extent of polychlorinated biphenyl dechlorination. *Environmental Toxicology and Chemistry* 17:1922-1926.

Sokol, R.C., O.-S. Kwon, C.M. Bethoney, and G.-Y. Rhee. 1994. Reductive dechlorination of polychlorinated biphenyls in St. Lawrence River sediments and variations in dechlorination characteristics. *Environmental Science and Technology* 28:2054-2064.

Stegeman, J.J. and M.E. Hahn. 1994. Biochemistry and molecular biology of monooxygenases: current perspectives on forms, functions, and regulation of cytochrome P450 in aquatic species. In *Aquatic Toxicology.* D.C. Malins and G.K. Ostrander (eds.). CRC Press, Boca Raton, FL, pp. 87-206.

St. Lawrence Center. 1993. St. Lawrence Update, The River at a Glance. St. Lawrence Action Plan. Environment Canada. St. Lawrence Centre Montréal, Quebec.

St. Lawrence RAP Team. 1990. The St. Lawrence River Area of Concern — Remedial Action Plan for the Cornwall-Lake St. Francis Area, Stage 1 Report: Environmental Conditions and Problems Definitions.

Stone, W. 1988. Akwesasne environment: The contaminated turtle. *Northeast Indian Quarterly* V(3):26-29.

Tarbell, H. 1990. Mohawk land rights: Towards rebuilding a nation. *Current* 5(7):10-11.

Teh, S.J. and D.E. Hinton. 1998. Gender-specific growth and hepatic neoplasia in medaka (*Oryzias latipes*). *Aquatic Toxicology* 41(1-2):141-159.

Teh, S.J., S. M. Adams, and D.E. Hinton. 1997. Histopathologic biomarkers in feral freshwater fish populations exposed to different types of contaminant stress. *Aquatic Toxicology* 37:51-70.

The Trustees for Natural Resources. 1991. Preassessment Screen Determination for the St. Lawrence Environment in the Vicinity of Massena, New York. Prepared by the St. Regis Mohawk Tribe, the National Oceanic and Atmospheric Administration, the State of New York Department of Environmental Conservation, and the U.S. Department of the Interior. May 14.

Thomann, R.V. and J.P. Connolly. 1984. Model of PCB in the Lake Michigan lake trout food chain. *Environmental Science and Technology* 18:65-71.

U.S. EPA. 1983. Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans. EPA-600/4-83-004. U.S. Environmental Protection Agency, Washington, DC.

U.S. EPA. 1990. Record of Decision: General Motors — Central Foundry Division Site, Massena, NY. U.S. Environmental Protection Agency, Region II, New York.

U.S. EPA. 1992. Record of Decision for the General Motors-Massena (Operable Unit 2 Site). Region 2. U.S. Environmental Protection Agency.

U.S. EPA. 1994. Superfund Program Update for the ALCOA Study Area. Region 2. U.S. Environmental Protection Agency.

U.S. EPA. 1997a. Superfund Post-Decision Proposed Plan, Reynolds Metals Company Study Area. Region 2. U.S. Environmental Protection Agency.

U.S. EPA. 1997b. Phase 2 Report — Review Copy. Further Site Characterization and Analysis. Volume 2C — Data Evaluation and Interpretation Report. Hudson River PCBs Reassessment RI/FS. U.S. Environmental Protection Agency, Washington, DC. February.

U.S. EPA. 1998a. EPA Guidance for Quality Assurance Project Plans — EPA QA/G-5. EPA/600/R-98/018. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC. February.

U.S. EPA. 1998b. Superfund Post-Decision Proposed Plan, Reynolds Metals Superfund Site, Massena, St. Lawrence County, NY. July. Region 2. U.S. Environmental Protection Agency.

U. S. EPA. 1999. National Recommended Water Quality Criteria — Correction. EPA 822-Z-99-001. U.S. Environmental Protection Agency, Office of Water. April.

U.S. EPA 2000. Fact Sheet on Hydrogen Fluoride (and Related Compounds). EPA 7664-39-3. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. <www.epa.gov/ttn/uatw/hlthef/hydrogen.html> Accessed March 7, 2000.

USFWS and University of Wyoming. 1987. Type B — Technical Document: Injury to Fish and Wildlife Species. Prepared by the U.S. Fish and Wildlife Service and the University of Wyoming for the U.S. Department of the Interior, Washington, DC.

Vanier, C., M. Sylvestre, and C. Planas. 1996. Persistence and fate of PCBs in sediments of the Saint Lawrence River. *The Science of the Total Environment* 192:229-244.

Walker, M.K. and R.E. Peterson. 1992. Toxicity of polychlorinated dibenzo-p-dioxins, dibenzofurans, and biphenyls during early development in fish. In *Chemically-Induced Alterations in Sexual and Functional Development: The Human/Wildlife Connection.* Princeton Scientific Publishing, Princeton, NJ, pp. 195-202.

Walton, K.C. 1987. Extraction of fluoride from soil with water, and with hydrochloric acid solutions simulating predator gastric juices. *The Science of the Total Environment* 65:247-256.

WDNR. 1993. Development of Sediment Quality Objective Concentrations for PCBs in Deposit A, Little Lake Butte des Morts. Prepared by the Wisconsin Department of Natural Resources Sediment Management and Remedial Techniques Team, February.

Weeks, F.A., D.P. Anderson, A.P. DuFour, A. Fairbrother, A.J. Goven, G.P. Lahvis, and G. Peters. 1992. Immunological biomarkers to assess environmental stress. In *Biomarkers: Biochemical, Physiological, and Histological Markers of Anthropogenic Stress*. R.J. Huggett, R.A. Kimerle, P.M. Mehrle, Jr., and H.L. Bergman (eds.). Lewis Publishers, Boca Raton, FL, pp. 211-234.

Wiemeyer, S.N., T.G. Lamont, C.M. Bunck, C.R. Sindelar, F.J. Gramlich, J.D. Fraser, and M.A. Byrd. 1984. Organochlorine pesticide, polychlorobiphenyl, and mercury residues in bald eagle eggs 1969-1979 and their relationships to shell thinning and reproduction. *Archives of Environmental Contamination and Toxicology* 13:529-549.

Wood, L.W., P. O'Keefe, and B. Rush. 1997. Similarity analysis of PAH and PCB bioaccumulation patterns in sediment-exposed *Chironomus tentans* larvae. *Environmental Toxicology and Chemistry* 16:283-292.

Woodward-Clyde. 1990a. Final Remedial Investigation Report, St. Lawrence Reduction Plant, Vol. 1. Prepared for Reynolds Metals Company, Massena, NY, by Woodward-Clyde Consultants. March 30.

Woodward-Clyde. 1990b. Revised Final Remedial Investigation Report, St. Lawrence Reduction Plant, Volume I. Submitted on behalf of Reynolds Metals Company, to New York State Department of Environmental Conservation, Watertown, NY, by Woodward-Clyde Consultants. July 2.

Woodward-Clyde. 1991. Revised Additional River Sampling Report — St. Lawrence Reduction Plant. Prepared by Woodward-Clyde Consultants. Submitted by Reynolds Metals Company to U.S. Environmental Protection Agency, New York, NY. August 14.

Woodward-Clyde. 1992. St. Lawrence River and Raquette River Technical Data Summary Report — Reynolds Metals Company, Massena, New York. Prepared by Woodward-Clyde Consultants. Submitted by Reynolds Metal Company to U.S. Environmental Protection Agency — Region 2, New York, NY. February.

Woodward-Clyde. 1995. Baseline Ecological Monitoring Report. Reynolds Metals Co., Massena, New York. Project No. 89C2515H-1. Prepared for Reynolds Metals Co. by Woodward-Clyde Consultants. April.

Wren, C.D. 1991. Cause-effect linkages between chemicals and populations of mink (*Mustela vison*) and otter (*Lutra canadensis*) in the Great Lakes basin. *Journal of Toxicology and Environmental Health* 33(4):549-585.

Wright, P.H., D.E. Tillitt, J. Zajicek, M. Anderson, J. Fitzsimons, M. Holey, and D. Honeyfield. 1998. Dioxin toxicity to lake trout embryos with low thiamine levels. Abstract presented at the Society of Environmental Toxicology and Chemistry Annual Meeting, Charlotte, NC.

Yamashita, N., S. Tanabe, J.P. Ludwig, H. Kurita, M.E. Ludwig, and R. Tatsukawa. 1993. Embryonic abnormalities and organochlorine contamination in double-crested cormorants (*Phalacrocorax auritus*) and Caspian terns (*Hydroprogne caspia*) from the upper Great Lakes in 1988. *Environmental Pollution* 79:163-173.

Yawetz, A., M. Benedek-Segal, and B. Woodin. 1997. Cytochrome P4501A immunoassay in freshwater turtles and exposure to PCBs and environmental pollutants. *Environmental Toxicology and Chemistry* 16:1802-1806.

Zabel, E.W., P.M. Cook, and R.E. Peterson. 1995. Toxic equivalency factors of polychlorinated dibenzo-*p*-dioxin, dibenzofuran and biphenyl congeners based on early life stage mortality in rainbow trout (*Oncorhynchus mykiss*). *Aquatic Toxicology* 31:315-328.

Zelikoff, J.T. 1994. Fish immunotoxicology. In *Immunotoxicology and Immunopharmacology*. Second Edition. J.H. Dean, M.I. Luster, A.E. Munson, and I. Kimber (eds.). Raven Press, NY, pp. 71-95.

Appendix
Preassessment Screen Determination for the St. Lawrence Environment in the Vicinity of Massena, New York

PREASSESSMENT SCREEN DETERMINATION

FOR

THE ST. LAWRENCE ENVIRONMENT

IN THE VICINITY OF

MASSENA, NEW YORK

MAY 14, 1991

prepared by

<u>THE TRUSTEES FOR NATURAL RESOURCES:</u>

THE ST. REGIS MOHAWK TRIBE

THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

THE STATE OF NEW YORK, DEPARTMENT OF ENVIRONMENTAL CONSERVATION

THE U.S. DEPARTMENT OF THE INTERIOR

PREASSESSMENT SCREEN DETERMINATION

for

The St. Lawrence Environment in the Vicinity of Massena, New York

I. INTRODUCTION

This determination concerns potential claims for damages to natural resources authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) § 107(f), 42 U.S.C. §9607(f), as amended. This determination recognizes that there is a reasonable probability that a claim for damages to aquatic, terrestrial, air, and other resources within the trusteeships of the U.S. Department of Interior, the National Oceanic and Atmospheric Administration (NOAA), the State of New York, and the St. Regis Mohawk Tribe exists in this case on the basis of a review of relevant information gathered as of this date. Although this preassessment screen determination conforms to the Federal Natural Resource Damage Assessment Regulations found at 43 C.F.R. Part 11, Subpart B (1988), the trustees specifically reserve the decision of whether and to what extent those procedures should be utilized to assess damages in this case.

II. AUTHORITIES AND DELEGATIONS

This determination was prepared under the authority of Section 107(f) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, 42 U.S.C. §9607 (f), and other applicable Federal, State and Tribal laws, regulations and directives which serve to designate Federal, State, and Tribal natural resource trustees and which authorize the recovery of natural resource damages.

III. IDENTIFICATION OF NATURAL RESOURCES POTENTIALLY AT RISK

A. Hazardous Substances Released

The following substances are the particular pollutants released or suspected to have been released into the geographic areas of concern in this case:

- Polychlorinated biphenyls (PCBs).
- Polychlorinated dibenzo-p-dioxins (PCDDs)
- Polychlorinated dibenzo-p-furans (PCDFs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Trace elements (aluminum, arsenic, barium, cadmium, copper, lead)
- Fluorides.

With the exception of fluorides, these are hazardous substances as that term is defined by Section 101(14) of CERCLA and are listed as toxic pollutants pursuant to 33 U.S.C. § 1317 (a) and 40 C.F.R. § 401.15. Fluoride is not designated as a hazardous substance, but Section 111(d)(1) of the Clean Air Act requires States to establish emission standards for certain existing sources. Existing primary aluminum reduction plants, which includes two of the three aluminum industrial facilities mentioned below, are categorized as sources under this designation.

B. Areas of Exposure

The following areas, collectively known as the St. Lawrence Environment, are those which have been presently identified and into which significant quantities of PCBs and possibly PCDDs, PCDFs, PAHs, trace elements, and fluorides have been released, as discussed below. The U.S. Department of Interior, NOAA, the State of New York, and the St. Regis Mohawk Tribe believe that natural resources within their trust have been injured.

1. The St. Lawrence River. This area includes the surface waters, sediments, submerged lands and associated wetlands of the St. Lawrence River and tributaries from the mouth of the Grasse River downstream to the base of Lake St. Francis. High concentrations of PCBs, PAHs, and trace elements are found in the sediments adjacent to outfalls from two industrial aluminum facilities that discharge into the St. Lawrence River [i.e., the General Motors Corporation - Central Foundry Division (GM Foundry) aluminum casting plant and the Reynolds Metals, Inc. (Reynolds Metals) aluminum reduction plant]. Both companies have state pollutant discharge elimination system (SPDES) permits issued by the State of New York under the National Pollutant Discharge Elimination System to discharge waters via these outfalls. It should be noted that the Reynolds Metals SPDES permit did not allow Reynolds Metals to discharge any PCBs.

2. The Grasse River. This area includes the surface water, sediments, submerged lands, and associated wetlands of the Grasse River from the Massena Power Canal downstream approximately 10 km to its confluence with the St. Lawrence River. High concentrations of PCBs, PAHs, and aluminum are found in this reach, particularly in sediments downstream of outfalls from a third aluminum facility in the local area, an aluminum reduction plant owned and operated by the Aluminum Company of America (ALCOA).

3. The Raquette River. This area includes the surface waters, sediments, submerged lands, and associated wetlands of the Raquette River from the Reynolds Metals site downstream for approximately six and one-half km to its confluence with the St. Lawrence River. Elevated concentrations of PCBs, PAHs, and several trace elements are found in the sediments of this reach of the river, particularly downstream of an inactive outfall from the GM Foundry.

4. The general area of Massena, New York, offers an atmosphere supporting a mosaic of forests, wetlands, water bodies, tributary streams, and farmlands that provides a habitat for breeding, juvenile rearing and forage by wildlife, including migratory and game birds, mammals, reptiles, amphibians, as well as fish, and a myriad of other forms of plant and animal life. High concentrations of PCBs have been observed in several species of migratory and resident birds, mammals, reptiles, amphibians, and fish. PCBs have been detected in vegetation, and evidence of fluoride poisoning has been observed in several plant species.

5. St. Regis Mohawk Tribe areas of concern. The areas of concern to the St. Regis Mohawk Tribe include all land, water, and air within the St. Regis Mohawk Reservation and the historical areas of *Akwesasne*, the traditional lands, water, and air of the Mohawk people. This area further includes a stream known as Turtle Creek adjacent to the GM Foundry site and portions of the Raquette and St. Lawrence Rivers that are on or adjacent to the Reservation or within traditional hunting or fishing territory protected by treaty rights and Federal and Tribal law. This area also includes wetlands and terrestrial habitats of

Akwesasne that support aquatic and terrestrial life. The natural resources of *Akwesasne* are of special concern because they hold great spiritual, cultural, aesthetic, intrinsic, historical, recreational, and economic values.

6. Groundwater resources. This area includes potentially impacted aquifers defined as those geologic units in which saturated conditions exist beneath the GM Foundry, ALCOA, and Reynolds Metals sites and in the surrounding areas beneath Massena, New York and the St. Regis Mohawk Reservation. High concentrations of PCBs have been found in the groundwater beneath the GM Foundry site. PCBs have also been observed in groundwater beneath the ALCOA and Reynolds Metals facilities, although additional investigation is necessary to determine the extent of contamination beneath these two sites.

7. Geologic resources. This area includes potentially impacted mineral resources within New York's northernmost physiographic province, called the St. Lawrence Lowlands. Mineral resources actively mined in the Massena, New York area include six sand and gravel mines and one topsoil mine. Essentially no data have been gathered, and there is no available information to date, on the impacts to these mining operations or other geological resources in the Massena/St. Lawrence River area.

C. Probable Pathways

The following are the likely pathways of transport for PCBs, PCDDs, PCDFs, PAHs, trace elements, and/or fluorides to the above described areas of exposure:

1. Industrial wastewater discharge through two SPDES-permitted outfalls, surface water runoff, and groundwater discharge at the GM Foundry property. PCBs were used at the GM Foundry as a component of hydraulic fluids in die-casting machinery. These machines generated 2,000 psi of pressure and caused leakage of hydraulic fluid. Until 1989, PCBs from the die-casting operations were discharged via one outfall to the St. Lawrence River and one outfall to the Raquette River. Since January 1989, the discharge to the Raquette River outfall has been rerouted to the St. Lawrence River outfall. The contaminants of concern in contaminated soils, fill and sludges on the site have also entered the Raquette and St. Lawrence Rivers as either a constituent of nonpoint runoff from various industrial areas or of the noncontact water that is reported to have been carried to the Raquette River via the formerly permitted outfall. Contaminated groundwater beneath the site flows to the north and northeast toward the St. Lawrence River and the unnamed tributary stream on the St. Regis Mohawk Reservation. These pathways have likely been active from 1959 to the present.

2. Industrial wastewater discharge through four outfalls, surface water runoff, and groundwater discharge from the ALCOA site, which is located approximately 15 km from the GM Foundry along the Grasse River. None of the available information gathered adequately describes the use of PCBs on the facility. However, PCB contaminated effluents and surface runoff are collected by ALCOA's wastewater system and discharged to the Grasse River through the four outfalls [note: ALCOA has five identified outfalls, but one of these (006) commingles with another (001) prior to discharge into the Grasse River]. Nonpoint surface runoff and contaminated groundwater may also discharge directly to the Grasse River through three of the outfalls while the fourth discharges to a power canal which runs along the western site border which ultimately discharges into the Grasse River. These pathways are presently active. It is not known how long PCBs and other contaminants of concern have been discharged from the ALCOA site.

3. Industrial discharge through four outfalls, surface water runoff, and groundwater discharge from the Reynolds Metals site, which is located approximately 1.5 km upstream of the GM Foundry, on the St. Lawrence River. Fluids contaminated with PCBs were used in the heat transfer system at the Reynolds Metals facility. Most contaminated wastewater and surface runoff generated by plant operations are collected by the wastewater system at the site and discharged to the St. Lawrence River through the four outfalls. Nonpoint surface runoff and contaminated groundwater may also discharge to the St. Lawrence River and the Raquette River. Contaminated groundwater and runoff also discharge to a marshy area known as the "West Marsh" which drains to the Raquette River. These pathways have likely been active from 1958 to the present.

4. Discharge of gaseous and particulate fluorides through stack releases at the ALCOA and Reynolds Metals facilities and subsequent deposition on and adsorption to vegetation. The quantities transported and duration of transport are unknown at this time, pending further investigation.

5. Desiccation and subsequent airborne transport of PCB-contaminated soils and sediments, as well as the volatilization of PCBs; adsorption to particulate matter; and subsequent airborne transport. The quantities transported and duration of transport are unknown at this time, pending further investigation.

D. Suspected Sources of Toxic Pollutants

1. Polychlorinated biphenyls comprise a class of 209 chlorinated aromatic hydrocarbon compounds. PCBs are characterized by extreme stability, low solubility in water, and long-term persistence in the environment. PCB-containing fluids have a wide variety of industrial applications, including use in electrical, heat transfer, and hydraulic systems. Environmental concerns stopped the manufacture of PCBs in 1977; however, they continue to be present in many industrial applications.

PCBs were used at the GM Foundry, ALCOA, and Reynolds Metals sites in the aluminum production and casting process. At the GM Foundry, these substances were used from 1959 until 1973. At Reynolds Metals, it is suspected that PCBs were used soon after the plant began operations in 1958 to about 1973 or later. At ALCOA, which began operations in 1903, PCBs may have been used as early as 1929, when they were first manufactured.

During these time periods, production wastewaters contaminated with PCBs were discharged through the outfalls of the three facilities into the St. Lawrence, Raquette, and Grasse Rivers. Although PCBs are no longer manufactured, the discharge of low level PCB contaminated effluents through the facilities' outfalls is still occurring.

At the GM Foundry site, approximately 26,400 liters of PCB-contaminated hydraulic fluid that has leaked from the die-casting equipment flows into the facility's wastewater system each year. In the early 1960s, hydraulic fluid was recovered by a reclamation process and subsequently discharged to a lagoon, which emptied into the St. Lawrence River. In 1976, a closed loop wastewater treatment system was installed, although wastewater was intermittently discharged to the lagoon and river. In 1985, the discharge lagoon was hydraulically isolated from the wastewater system. Currently, approximately 950,000 liters per day of treated wastewater are discharged into the St. Lawrence River through a SPDES permit. This permit was issued in 1980 and allows a maximum PCB concentration of 2 μg/l.

At the Reynolds Metals site, fluids containing high concentrations of PCBs were formerly used in the heat transfer system of the plant area. Leaks and spills are known to have occurred, and high levels of PCBs in the soils have been detected near the plant area. Although PCBs are present in effluents and drainageways at the Reynolds Metals facility, no PCB discharges are authorized by the company's SPDES permit.

For the ALCOA site, none of the available information gathered adequately describes the use of PCBs on the facility. However, environmental investigations found PCBs in seven active and inactive areas on the site. These areas contribute leachate and effluent contaminated with PCBs to the Grasse River. In 1985, ALCOA was issued a SPDES permit allowing a maximum PCB concentration of 10 µg/l in their discharge to the Grasse River. In 1987, the permit was modified to allow a maximum concentration of 2 µg/l PCBs.

The magnitude of existing PCB contamination downstream of the three sites cannot be attributed solely to permitted discharges. Mass balance and sediment loading calculations indicate that GM Foundry and ALCOA discharged PCBs far in excess of that allowed in their current SPDES permits. (Such calculations were not conducted for the Reynolds Metals site.) The mass of PCBs in the St. Lawrence River adjacent to the GM Foundry site was estimated at 6,100 kg, which is three orders of magnitude greater than the permitted discharge (<4.5 kg). For the Grasse River adjacent to the ALCOA site, the estimated PCB mass of 76 kg is more than 3 times as great as the mass allowed under their permit (<22.7 kg).

2. PCDDs and PCDFs are classes of refractory, lipophilic, and highly toxic compounds (acutely toxic responses have been observed in the parts-per-trillion range) chemically similar to PCBs. These substances exhibit the same stability and long-term persistence in the environment as do PCBs. None of the available information gathered discussed the possible presence of PCDDs and PCDFs on the three sites, but these substances are found as contaminants in PCB fluids and are formed during manufacture or when the fluids are used in high temperature applications. It is believed that some PCDDs and PCDFs are formed during the incomplete combustion of a wide variety of compounds, including PCBs.

3. Polycyclic aromatic hydrocarbons (PAHs) comprise a large class of organic compounds that contain two or more fused aromatic rings. PAHs are produced largely by incomplete combustion of organic compounds. While none of the available information gathered adequately describes the specific uses of PAHs on the three facilities, the available information does indicate the presence of PAHs at all three facilities. Waste effluents from aluminum operations, in general, provide a direct route of entry for PAHs to aquatic ecosystems. PAHs have low solubilities in water and moderate persistence in the environment. PAHs are moderately toxic, causing acute toxicity to aquatic organisms generally between 250 and 5,000 µg/l.

4. Trace elements are naturally present in the environment at low concentrations but levels are often increased due to industrial activities. None of the information gathered adequately describes the use of trace elements at the three sites, but they are often impurities in hydrocarbons and chemicals used in industrial applications. Some of the elements, such as cadmium, mercury, and copper, can be toxic to aquatic organisms at relatively low concentrations (generally between 1 and 500 µg/l).

5. Fluoride is an inorganic substance that can be released into the air as a gas or as particulates, or dissolved in fluids and discharged as effluent. This substance is commonly used in the aluminum production process and data indicate that fluorides have likely been

released from the three aluminum facilities via air stacks and outfalls. Fluoride at fairly low concentrations (<500 µg/l) is known to elicit avoidance responses in migrating anadromous salmonids.

PCDDs, PCDFs, PAHs, trace elements, and fluorides have not been fully characterized in environmental media downstream from the GM Foundry, ALCOA, and Reynolds Metals sites. Several PAHs, aluminum, arsenic, barium, cadmium, copper, and lead were found at elevated concentrations in sediments immediately downstream of the GM Foundry, but only 8 of 39 sediment samples collected were analyzed for these substances. PCDDs and PCDFs were not detected, but even fewer samples were analyzed for these substances. Of those that were, matrix interferences caused highly variable detection limits. Environmental investigations at the ALCOA and Reynolds Metals sites have concentrated primarily on the distribution of PCBs in downstream sediments and not on other contaminants that may be associated with aluminum reduction activities.

IV. PREASSESSMENT SCREEN DETERMINATION CRITERIA

A. Satisfaction of Criteria of 43 C.F.R. §11.23(e)

1. Releases of hazardous substances have occurred.

The release of PCBs has been documented from the GM Foundry, Reynolds Metals and ALCOA sites. Exceptionally high concentrations of PCBs are found in the sediments immediately downstream of the GM Foundry and Reynolds Metals outfalls on the St. Lawrence, downstream of the ALCOA outfall on the Grasse River, and downstream of the GM Foundry outfall on the Raquette River. First-order estimates of loading to the sediments indicate that over 6,000 kg of PCBs have been discharged from the sites to the St. Lawrence, Grasse and Raquette Rivers.

Data on the concentrations of PCBs in spottail shiners also implicates all three sites as major sources of PCBs to the St. Lawrence and Grasse Rivers. Young-of-the-year shiners, which have a very limited home range close to the shoreline, were analyzed for PCBs. The highest concentrations were observed in shiners collected closest to the outfalls. This finding indicates a substantial discharge of PCBs from the three sites to the St. Lawrence and Grasse Rivers.

Limited sampling has found PCBs in terrestrial vegetation. These results provide evidence for the aerial release and deposition of PCBs. High concentrations of PCBs observed in several species of migratory and resident birds, mammals, reptiles, amphibians, and fish also provides evidence of accumulation in higher order organisms.

The release of PAHs, PCDDs, PCDFs, trace elements, and fluorides may have been and may be occurring to various degrees but has yet to be characterized at all three sites. Elevated concentrations of several PAHs and trace elements have been found in sediments downstream of the GM Foundry outfall on the St. Lawrence River and downstream of the ALCOA outfall on the Grasse River.

2. Natural resources for which U.S. Department of Interior, NOAA, the State of New York, and the St. Regis Mohawk Tribe may assert trusteeship under CERCLA have been or are likely to have been adversely affected by the discharge or release.

The areas of exposure discussed above include natural resources that are within the trusteeship of the St. Regis Mohawk Tribe, State of New York, U.S. Department of the

Interior, and NOAA. Other natural resources within the trusteeship of one or more trustees may also have been injured by the contaminants of concern. These other resources also may require investigation. The resources adversely affected are within the above trusteeships. The riverine, wetland, and adjacent terrestrial habitats serve as breeding grounds, nursery areas, and foraging areas for species managed, or that could be managed in the future, under a number of Acts.

Recreational, commercial, and tribal fisheries such as those for American eel, brown bullhead, smallmouth bass, yellow perch, and walleye have been impacted by elevated concentrations of PCBs in the tissues of fish. PCBs in at least 16 species of fish collected from the St. Lawrence and Grasse Rivers in the vicinity of the three sites have exceeded concentrations where reproductive inhibition or failure has been reported in the toxicological literature.

Individuals of various endangered species, including but not limited to the bald eagle, and waterfowl and other migratory birds may have been and/or may be adversely impacted by PCBs, PAHs, PCDDs, PCDFs, and heavy metals released into the area of exposure.

Groundwater resources used for drinking water supply, industrial, or commercial applications have been found to contain PCBs and other contaminants of concern at concentrations above human health standards. Groundwater resources in the area fall under the authority of the State of New York and the St. Regis Mohawk Tribe.

PCBs and other contaminants of concern found in vegetation samples may be limiting the use of plant species used for ceremonial and medicinal purposes by the St. Regis Mohawk Tribe. The contaminants may also be tainting these plants, which have special spiritual and cultural significance. In addition, the contaminants may be tarnishing the cultural, intrinsic, recreational, aesthetic and historic values of *Akwesasne* and the St. Lawrence region.

3. The quantity and concentration of released hazardous substances is sufficient to potentially cause injury, as used in the Federal damage assessment regulations.

PCBs are known for their persistence and ability to bioaccumulate and biomagnify in the food chain. In light of these characteristics, the primary hazard of PCBs is their chronic effect, not their acute effect. For example, an average bioconcentration factor for PCBs in fish is estimated at approximately 50,000 (i.e., concentration in fish tissue can reach 50,000 times the concentration in water). Concentrations of PCBs in tissues of aquatic organisms are generally greater than or equal to concentrations in sediment.

Injury to U.S. Department of Interior, NOAA, State of New York, and St. Regis Mohawk trust resources have been caused potentially by the toxicity of PCBs, PCDDs, PCDFs, PAHs, trace elements, and fluorides. Sublethal toxic effects on aquatic organisms have been reported in toxicological literature at PCB levels in tissue of less than 1 mg/kg and as low as 0.1 mg/kg. On the basis of surveys in the proximity of the three sites, there are at least 16 species of fish whose members carry tissue levels of PCBs in excess of 1 mg/kg.

The levels of PCBs in the edible flesh of certain species of fish caught recreationally or commercially in the areas of exposure are potentially sufficient to cause injury to trust resources because the value of such fish as a food source for humans has been reduced. Under the NRDA regulation found in 43 CFR at § 11.62(f)(1)ii), an injury to biological resources occurs if action or tolerance levels established under section 402 of the Food, Drug and Cosmetic Act, 21 U.S.C. 342 in edible portions of organisms are exceeded, and § 11.62(f)(1)(iii), the concentration of a hazardous substance is sufficient to establish injury if it exceeds levels for which a state health agency has issued directives to limit or ban consumption. Because the levels of PCB contamination found in certain recreational fish from the St. Lawrence Basin exceeded the FDA action level of 2 parts per million the New York State Department of Environmental Conservation (NYDEC) and the New York State Department of Health (NYDOH) have issued health advisories since 1977 against the consumption of fish harvested from certain parts of the St. Lawrence Basin. In 1986, the St. Regis Mohawk Tribe issued a fish consumption advisory with the recommendation that pregnant women, women of childbearing age, children under age 15, and all other Mohawks should eat no more than one meal (one-half pound) per week of fish from any body of water in or around *Akwesasne*. As a result of elevated levels of PCBs and other toxic contaminants in fish from the St. Lawrence and Grasse Rivers, NYDEC and NYDOH have recently expanded these restrictive health advisories to include fish harvested from portions of these rivers near Massena. Health advisories and public awareness of contamination in the study area have resulted in the discontinuation of several professional fishing guide services and fish camps operated by the St. Regis Mohawk Tribe.

No commercial fisheries currently exist on the St. Lawrence River in the vicinity of the aluminum facilities. A commercial eel fishery has been restricted since 1976. The commercial eel fishery was banned in Lake Ontario in 1982 because of high tissue burdens of PCBs and other contaminants. The ban has been extended to include the St. Lawrence River in the vicinity of the three aluminum sites.

The levels of PCBs in groundwater aquifers used for drinking or irrigation in the areas of exposure are potentially sufficient to cause injury to trust resources because the value of such groundwater for humans has been reduced. Under the NRDA regulation found at 43 CFR §11.62(c)(i), an injury to a groundwater resource has resulted from the discharge of hazardous substances if the concentrations of substances are in excess of drinking water standards, established by §§ 1411-1416 of the Safe Drinking Water Act or by other Federal or State laws or regulations that establish such standards for drinking water in groundwater that was potable before the discharge or release. Concentrations of PCBs in the groundwater beneath GM Foundry, ALCOA and Reynolds Metals as well as in aquifers used by the St. Regis Mohawk Tribe have exceeded 0.1 μg/l (ie.100 pptr). Title 6 of the New York State Official Compilation of Codes, Rules and Regulations, Part 703 pertaining to protection of human health establishes 0.1 μg/l PCBs in the groundwater as the maximum allowable concentration. The St. Regis Tribal Council Resolution No. 89-19 establishes a groundwater cleanup standard of 0.01 μg/l (ie. 10 pptr) for PCBs.Since January 1982, the St. Regis Mohawk Health Services Department has advised tribal residents of Raquette Point not to drink water from their groundwater wells. Currently, 20 households and 1 school receive bottled water.

PCBs transported from the site to terrestrial resources and habitats can elicit various biological and toxic effects in terrestrial organisms, as well. For example, 50 percent of mink that were fed diets containing PCBs at 6.7 and 8.6 mg /kg died within 6 months. Mallard ducks that have been fed PCBs have suffered higher mortality rates from a viral disease than ducks whose diet did not include PCBs.

PCDDs and PCDFs can elicit a wide variety of effects in laboratory animals, including carcinogenic and mutagenic responses. Reproductive effects, kidney and liver damage, edema, and immunosuppression have all been documented. Of the different dioxin and dibenzofuran isomers, 2,3,7,8-tetrachlorodibenzo-p-dioxin and 2,3,7,8-tetrachlorodibenzofuran are the most toxic.

PAHs can elicit a variety of toxic effects to aquatic and terrestrial organisms. Bottom-dwelling fish inhabiting areas where sediments are contaminated with PAHs have shown a high incidence of oral, dermal, and hepatic neoplasms. Benzo(a)pyrene, which was found in sediments of the St. Lawrence River off of the GM Foundry outfall, is a particular concern for terrestrial wildlife. This PAH has been shown to produce tumors in mice, rats, hamsters, guinea pigs, rabbits, ducks, and monkeys.

Trace elements can have a wide range of effects on aquatic systems and terrestrial wildlife. Juvenile salmonids are particularly sensitive to copper, cadmium, and zinc, with toxic effects evident in the low parts per billion range.

Airborne fluorides that are transported to aquatic and terrestrial habitats can be toxic to a variety of mammal, fish, and vegetation species. Cattle and other grazing animals can contract fluorosis (brittle bones and teeth) and other health problems after ingesting feed containing low levels of fluoride. Salmonids are known to avoid fish passage facilities that contain low levels of fluorides ($<500\ \mu g/l$) discharged from aluminium plants. Damage to vegetation on Cornwall Island due to fluorides has been reported. In evergreens, severe fluoride damage results in defoliation and dieback.

The effects of PCDDs, PCDFs, PAHs, trace elements, and fluorides on trust aquatic and terrestrial resources associated with the St. Lawrence, Grasses and Raquette Rivers has not been thoroughly investigated.

4. Data sufficient to pursue an assessment are readily available or likely to be obtained at reasonable cost.

Available data to date clearly meet the requirements for injury in the Federal regulations (i.e., state and tribe issued warning for consumption of recreational fish; state bans on commercial fisheries; loss of use of groundwater resources). Other data strongly suggest that injury to other resources can be documented; however, additional data are needed to define and quantify injuries and determine damages. The anticipated increment of extra benefits derived from obtaining these data in terms of the precision and accuracy of the injury determination and quantification and the determination of damages clearly exceeds the cost of obtaining this data. The cost of this data acquisition together with the other anticipated costs of the damage assessment is expected to be substantially less than the anticipated damage amount determined in the Injury, Quantification, and Damage Determination phases of the damage assessment.

5. Response actions carried out or planned do not sufficiently remedy the injury to natural resources without further action.

No final remedies have been implemented with respect to the affected or potentially affected natural resources that fall under the trust of U.S. Department of Interior, NOAA, the State of New York, or the St. Regis Mohawk Tribe. Interim measures have been implemented or are underway at all three industrial facilities' sites. These measures involve reducing or eliminating pathways and sources of contaminants to the surrounding environs. Final remedies are being developed or should soon be selected for the various inactive hazardous waste sites for which General Motors, ALCOA, and Reynolds Metals are responsible, respectively. The U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation are the lead enforcement agencies each directing remedial programs for different hazardous waste sites which together include portions of the St. Lawrence, Grasse and Raquette Rivers and various areas on and near each of the three industrial plant sites.

B. Information reviewed.

The sources reviewed or consulted for this Preassessment Screen Determination are listed in the attached Appendix.

V. NO POTENTIAL DAMAGES ARE EXCLUDED FROM LIABILITY

A. There are no damages currently identified in this case that resulted from releases specifically identified as an irreversible and irretrievable commitment of natural resources in an environmental impact statement or other comparable environmental analysis.

B. The releases of hazardous substances in this case have continued without interruption from their commencement through the present time and have not occurred wholly before December 11, 1980, the date of the enactment of CERCLA.

C. There are no damages currently identified in this case that have resulted from the application of a pesticide product registered under the Federal Insecticide, Fungicide and Rodenticide Act, 7 U.S.C. §§135 - 135k.

D. There are no damages currently identified in this case that resulted from a federally permitted release, as defined by Section 101(10) of CERCLA.

E. There are no damages currently identified in this case that resulted from the release or threatened release of recycled oil from a service station dealer described in section 107(a)(3) or (4).

VI. PREASSESSMENT SCREEN DETERMINATION

Based upon the facts, data, expert opinion, and analyses cited in the foregoing sections, The U.S. Department of Interior, the National Oceanic and Atmospheric Administration, the State of New York, and the St. Regis Mohawk Tribe, hereby determine that a natural resource damage assessment in this case can and should be performed.

DATE OF DETERMINATION: May 14, 1991

The St. Regis Mohawk Tribe
The National Oceanic and Atmospheric Administration
The State of New York, Department of Environmental Conservation
The U.S. Department of the Interior

REFERENCES

Cole, D.B. 1989. Akwesasne's preliminary natural resource damage assessment prepared for the General Motors - Central Foundry (GM) superfund site. Prepared for the St. Regis Mohawk Environmental Division (SRMED). September 22, 1989.

National Oceanic Atmospheric Administration. 1989. Preliminary natural resource survey, GM Foundry, Massena, New York, NYD091972554. Site ID: A6. May 11, 1989.

New York State Department of Environmental Conservation. 1990. Natural Resource Damages Preassessment Screen for the St. Lawrence, Grasse and Raquette Rivers and environs, Massena, New York. Prepared by the New York State Department of Environmental Conservation with contributions from the New York State Department of Law, Albany, New York, September 1990.

United States Department of the Interior. 1989. Preliminary natural resource survey, GM Foundry, Massena, New York. May 24, 1989.