St. Lawrence River Environment Natural Resource Damage Assessment: Restoration and Compensation Determination Plan and Environmental Assessment

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prepared by:

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EXECUTIVE SUMMARY

For decades, three industrial facilities in Massena, New York have released hazardous substances to the St. Lawrence River environment. The facilities include Alcoa West, Alcoa East (the former Reynolds Metals Corporation), and the General Motors Central Foundry (together, the Facilities). Production wastes and associated contaminants (including, but not limited to, PCBs, PAHs, fluoride, and metals) from these Facilities were disposed of through outfalls into rivers and streams, in on-site disposal sites, and via aerial emissions. These contaminants were then transported throughout the environment via hydrological, aerial, and biological pathways, exposing and causing corresponding injury to natural resources. Some remediation of this contamination has occurred under the direction of the U.S. Environmental Protection Agency and the New York State Department of Environmental Conservation; additional remedial actions are still under review.

Under Federal law, Federal and State agencies and Indian Tribes are authorized to act as trustees of natural resources on behalf of the public. In this role, Trustees assess and recover damages resulting from injuries to natural resources due to hazardous substance releases (e.g., PCBs, PAHs, fluoride, and metals), and use these recovered damages to plan and implement actions to restore, replace, rehabilitate, and/or acquire the equivalent of injured natural resources and the services these resources provide (42 U.S.C. Section 9601 et seq., CERCLA; 43 C.F.R. §11.80(b)).

A Trustee Council has been formed to assess injuries and determine damages to the natural resources of the St. Lawrence Environment, and develop a plan for restoration of these injured natural resources. The Trustee Council consists of the U.S. Fish and Wildlife Service (on behalf of the U.S. Department of the Interior (DOI)), the New York State Department of Environmental Conservation (on behalf of the State of New York), the National Oceanic and Atmospheric Administration (on behalf of the U.S. Department of Commerce), and the St. Regis Mohawk Tribe Environment Division (on behalf of the St. Regis Mohawk Tribe) (together, the Trustees).

The Trustees have identified Alcoa, Incorporated (Alcoa), Reynolds Metals Company (RMC) and General Motors Corporation (GM) (together, the Companies) as the parties potentially responsible for releases of hazardous substances from the Facilities and for the corresponding natural resource injuries and damages, and invited the Companies to conduct the assessment for the site cooperatively. The Companies have been actively involved in the damage assessment and restoration planning process since an agreement for cooperative assessment efforts was signed by the Companies and Trustees in 2000 and executed in 2001 (Trustees and Companies 2000). The Trustees subsequently worked cooperatively with Alcoa and GM, due to the merger between Alcoa and RMC.

When GM entered into bankruptcy in 2009, the Trustees filed a bankruptcy claim for natural resource liability and continued separate negotiations with Alcoa. On June 17, 2011, the courts approved the Consent Decree and settlement agreement resolving the GM bankruptcy claim brought by the Trustees. The GM Consent Decree includes shares of GM stock, the value of which will be determined upon liquidation and will be used for restoration. The Consent Decree with Alcoa is comprised of a cash payment of approximately $16.7 million for ecological and cultural restoration projects and past costs, implementation of five recreational fishing access projects, and purchase and legal transfer to NYSDEC of approximately 465 acres of property (the "Coles Creek" and "Wilson Hill" properties).

As part of this natural resource damage assessment and restoration (NRDAR), the Trustees have drafted for public review this Restoration and Compensation Determination Plan (RCDP). The purpose of an RCDP is to, "list a reasonable number of possible alternatives for (i) the restoration or rehabilitation of the injured natural resources to a condition where they can provide the level of services available at baseline, or (ii) the replacement and/or acquisition of equivalent natural resources capable of providing such services" (43 C.F.R. §11.81 (a)). Therefore, this RCDP: 1) describes natural resource injuries and associated losses in resource services due to the presence of elevated levels of Facility-related contaminants in the St. Lawrence environment (i.e., contaminants from both Alcoa and GM facilities), and 2) outlines proposed restoration projects, including the scale of each project estimated to provide resource benefits sufficient to compensate for losses, specifically focusing on the Trustees' priorities and proposed plans with respect to the use of the cash payment, in conjunction with the benefits that will result from the transfer of the Coles Creek and Wilson Hill properties to NYSDEC, which are assumed to provide partial compensation for the natural resource injuries and service reductions described in Chapters 3 and 4.

This assessment focuses on the aquatic habitat of the St. Lawrence River and associated tributaries (i.e., Grasse, Raquette, and St. Regis Rivers, Massena Power Canal, Unnamed Tributary, Robinson Creek, and Turtle Cove/Creek) within U.S. waters from the Wiley Dondero Canal and Moses Saunders Dam downstream to the international border with Canada, as well as habitat on Facility property (both aquatic and terrestrial), and Akwesasne[1] (together, assessment area). Natural resources (i.e., surface water, sediment, and biota) in these areas have been exposed to hazardous substances at levels sufficient to cause injury based on the DOI NRDA regulations (43 C.F.R. §11). These injuries have resulted in a reduction of ecological, recreational, and cultural services.

Within the assessment area, natural resource exposure to contaminants of concern has been documented at least since the 1970s and is expected to continue into the future. Injury to ecological resources has likely occurred since that time, but damages based on ecological injuries are calculated beginning in 1981 (in accordance with the promulgation

[1] The current territory of the St. Regis Mohawk Tribe.

of CERCLA and the divisibility of injuries), continuing at least through 2106, at which point the uncertainty of recovery and the effects of discounting minimize damages.[2] Injury and corresponding recreational fishing losses are assessed from 1984 (the first year a fish consumption advisory (FCA) was put into place), through both 2030 and 2050 (based on the uncertainty of when the FCAs will be removed). Cultural losses are measured from 1955, the year in which Akwesasne residents began to notice changes in their natural environment, and continue indefinitely.

Ecological Losses and Preferred Restoration

Facility-related contamination is sufficient to cause a loss in the baseline ecological services (i.e., level of services but for contamination) provided by assessment area resources such as sediment (macroinvertebrates), fish, amphibians, reptiles, birds, and mammals. Service losses, based on adverse effects such as reductions in growth, reproduction, and survival are estimated using site-specific and literature-based studies. Exposure and effects information is sufficient to quantify losses to sediment, fish, birds, and some semi-aquatic mammals. Quantified losses are then scaled to reflect the range in severity and magnitude of these effects at different contaminant concentrations for each resource. In addition, remedial activities have resulted in quantifiable impacts to assessment area resources. Habitat equivalency analysis (HEA) is used to quantify the present value of losses from 1981 through the reasonable expected recovery of the resource (2106), and to scale restoration (Exhibit ES-1). Data on exposure and effects of Facility-related contaminants on other resources (e.g., amphibians, reptiles) are sufficient to indicate injury but are insufficient for quantification. Therefore, likely losses incurred by these other resources are evaluated qualitatively and are addressed in the context of restoration.

EXHIBIT ES-1 QUANTIFIED ECOLOGICAL LOSSES (DISCOUNT SERVICE-ACRE-YEARS; DSAYS)

RESOURCE	LOST DSAYS (1981-2106)
Sediment (Macroinvertebrates)	32,352
Fish	31,047
Birds	34,023
Mammals	12,115
Remedial-Induced Injury	181
Total	**109,718**
Notes: Lost DSAYs in present value 2010.	

[2] The statute was passed December 11, 1980. For purposes of settlement, the Trustees begin assessing damages in the first full month after the statue was passed (i.e., January 1, 1981).

The Trustees propose as compensation for ecological service losses a suite of restoration projects that they expect will together provide additional (i.e., above and beyond baseline) ecological services of appropriate type and quality. The preferred types of restoration were selected from a larger list compiled from proposals received from Trustee agencies, the Companies, other government agencies, academics, non-governmental organizations, and the general public, and were evaluated based on site-specific and regulatory criteria (43 C.F.R. §11.82 (d)). Each alternative was also assessed for compliance with relevant and applicable laws (e.g., the National Environmental Policy Act; NEPA). Preferred alternatives include:

- Wetland Enhancement/Restoration,
- Streambank enhancement/restoration,
- Upland enhancement/restoration,
- Avian enhancement/restoration,
- Fisheries enhancement/restoration,
- Amphibian and reptile enhancement/restoration,
- Mammal enhancement/restoration, and
- Land conservation.

A suite of specific projects within these categories were then identified, evaluated, and scaled so as to sufficiently compensate for ecological losses. Projects providing approximately 91,742 DSAYs of ecological benefits are identified, at a cost of approximately $8.31 million (the cash settlement for ecological damages with Alcoa, including acquisition of the Coles Creek and Wilson Hill properties). ALCOA will purchase the Coles Creek and Wilson Hill properties on behalf of the trustees at a total cost of approximately $1.03 million (to be deducted from the $8.31 million). These properties will be deeded to the State of New York to become part of the Coles Creek State Park and Wilson Hill Wildlife Management Area, respectively. The Trustees were also awarded $9,500,000 in an Allowed Unsecure Claim to resolve the GM bankruptcy (CD 2011). The total value of the settlement is still undetermined. Potential projects providing the remaining ecological compensation are discussed in Section 5.5 but will be identified once funds from the GM settlement become available. Proposed potential and preferred projects were selected based on information available at the time of settlement. Substitutions may be necessary based on project infeasibilities.

Recreational Fishing Losses and Preferred Restoration

PCB contamination has resulted in fish consumption advisories (FCAs) on the St. Lawrence River, Bay at St. Lawrence (Franklin County line), Grasse River, and Massena Power Canal. These FCAs have adversely affected recreational fishing, reducing the number of fishing trips taken to this river system.

This recreational fishing analysis applies a service-to-service equivalency approach to establish the scale of restoration required to make the public whole for past and expected future recreational fishing losses. Specifically, the Trustees used a site-specific random utility maximization (RUM) model, which utilizes data on angler site choices to determine how anglers trade off site quality attributes (e.g., catch rates, access conditions, presence of fish consumption advisories) with travel costs (43 C.F.R. §11.83 (c)(2)(iv)). The RUM model is applied to determine the losses in recreational fishing opportunities due to the presence of FCAs, as well as to evaluate the recreational fishing benefits provided by specific restoration projects.

Lost trips are estimated between 1984 (when the first advisory was put into place) and the date when consumption advisories are expected to be removed (based on modeled future contaminant concentrations in fish). However, it is unclear when contaminant levels will decline to levels sufficient to warrant the elimination of advisories in the assessment area. As a result, lost trips are calculated assuming two different advisory removal dates, 2030 and 2050. Using a standard discount rate of three percent, the Trustees estimate 221,075 present value trips were lost between 1981 and 2030, and 250,740 present value trips were lost between 1981 and 2050. These lost trips were valued at approximately $1,300,000.

As described in the Alcoa Consent Decree, as compensation for lost recreational fishing trips Alcoa will undertake, at the direction of the Trustees, a suite of five restoration projects that together will provide sufficient, additional (i.e., above and beyond baseline) recreational fishing opportunities of appropriate type and quality. The preferred project alternatives were selected from a larger list of projects compiled from proposals received from Trustee agencies, the Companies, and the public, were evaluated based on site-specific and regulatory criteria (43 C.F.R. §11.82 (d)). Each alternative was also assessed for compliance with relevant and applicable laws (e.g., NEPA). Preferred alternatives include: 1) new shore fishing access, and 2) new boat fishing access.

The Trustees are currently in the process of reviewing designs for the five specific restoration projects for implementation that provide adequate compensation for recreational fishing losses (i.e., using the same RUM model as described above). This particular set of projects provides new or improved access to all three major rivers in the Massena area (St. Lawrence, Grasse, and Raquette), and supports a mix of shore- and boat-based fishing opportunities. Furthermore, several of the sites are located at informal angler access points, thereby increasing the likelihood that the new/improved sites would receive substantial use. These projects are:

- Springs Park Boat Launch,
- Lower Grasse River Boat Launch (intersection of Massena Point Road and Route 131),
- Lower Raquette River Boat Launch (off of Route 37 east of Massena Center),
- Upper Grasse River Boat Launch (on the upper Grasse River adjacent to the Madrid water treatment facility), and

- Middle Grasse River Boat Launch (south of Route 131).

Further details regarding these projects are provided in the Consent Decree.

Cultural Losses and Preferred Restoration

SRMT's proposed approach to cultural restoration is rooted in the community's experience and understanding of cultural harm. Although the people of Akwesasne have experienced the harms caused by environmental contamination in many different ways, the overall effect on Tribal members has been both a disruption of the traditional practices that allow for the continuation of a Mohawk way of life, and a forcible rapid acculturation to non-indigenous ways of interacting with the environment and each other. The Mohawk perspective on redress for these harms centers on promoting: 1) the restoration of natural resource-based cultural activities that were adversely affected by the release of hazardous contaminants, 2) the enhancement of connections between Mohawk people and the natural environment, and 3) knowledge transfers between generations of Mohawks, so that existing indigenous knowledge can be preserved and enlivened.

Akwesasne's approach to cultural restoration seeks to promote the restoration of land-based cultural practices and traditional economic activities within the community. For example, Akwesasne will establish and directly support long-term master-apprentice relationships in the four areas of traditional cultural practice that were harmed by the release of hazardous contaminants, and promote and support the regeneration of practices associated with traditions in these areas:

1. Water, fishing, and use of the river;
2. Horticulture, farming, and basket-making;
3. Medicine plants and healing; and
4. Hunting and trapping.

Mentoring and personal relationships promoting experiential learning over a sustained period of interaction on the land is the basis of Indigenous learning-teaching models. All of the existing knowledge-holders in the affected areas have been identified and as many as possible will be recruited to serve as teachers of skills, practices and language. These "masters" will be equipped as necessary with tools, supplies and support and connected with an appropriate number of "apprentices" drawn from an established pool of younger Akwesasne individuals who have expressed interest and demonstrated commitment to learning cultural practices under this teaching model.

The plan will also support the enhancement of existing programs and institutions that demonstrate an ability to promote intergenerational cultural knowledge transfer in the identified areas of harm. This will be accomplished through the one-time institutional funding of proposals for the enhancement or expansion of existing programs.

The St. Regis Mohawk Tribe will receive $8,387,898 to implement cultural restoration projects.

CHAPTER 1 | INTRODUCTION

1.1 PURPOSE OF RCDP

The purpose of a Restoration and Compensation Determination Plan (RCDP) is to inform the public as to the type and scale of preferred restoration alternatives that are expected to compensate for injuries to natural resources due to hazardous substance releases (43 C.F.R. §11.81). In this case, hazardous substances including polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), fluoride, and metals have been released into the environment of the St. Lawrence River watershed from three facilities in and near Massena, New York. Natural resources (e.g., surface water, sediments, invertebrates, fish, amphibians, reptiles, birds, and mammals) have been exposed to and adversely affected by these contaminants, resulting in a loss in ecological, recreational fishing, and cultural resource services.

1.2 ORGANIZATION OF THIS CHAPTER

This chapter provides the following:

- Trustee authority for this RCDP,
- An overview of the St. Lawrence Environment (e.g., ecology),
- A brief history of the three Massena-area facilities and their contaminant releases,
- Coordination with the potentially responsible parties,
- Relationship to remedial activities,
- Public participation,
- Geographic and temporal scope of the assessment, and
- An outline of the remainder of this RCDP.

1.3 TRUSTEE AUTHORITY

This RCDP has been prepared by the Trustees of the St. Lawrence River Environment. Under Federal law, the Trustees are authorized to act on behalf of the public to assess and recover natural resource damages, and to plan and implement actions to restore, replace, or rehabilitate natural resources injured or lost as a result of the release of a hazardous substance, or to acquire the equivalent resources or the services they provide (42 U.S.C. §9601 *et seq*. (CERCLA); 43 C.F.R. §11). The Trustees for this site include:

- The New York State Department of Environmental Conservation (NYSDEC) on behalf of the State of New York,

- The National Oceanic and Atmospheric Administration (NOAA) on behalf of the United States Department of Commerce,
- The St. Regis Mohawk Tribe Environment Division on behalf of the St. Regis Mohawk Tribe (SRMT), and
- The United States Fish and Wildlife Service (FWS) on behalf of the United States Department of the Interior (DOI).

1.4 OVERVIEW OF ST. LAWRENCE ENVIRONMENT

The St. Lawrence River watershed includes the St. Lawrence River and the tributaries that drain into the river from both the U.S. and Canadian sides of the international border. The St. Lawrence River flows approximately 530 miles from Lake Ontario into the St. Lawrence Estuary and the Gulf of St. Lawrence before heading out to the Atlantic Ocean (ACOE 2006). However, the St. Lawrence Seaway, completed in 1958 to provide power as well as navigation and commerce opportunities on the river, involves a series of dams, flood control structures, and locks. These structures control water levels in the river by regulating flow.

Tributaries to the St. Lawrence River in the vicinity of the assessment area include the Grasse, Raquette, and St. Regis Rivers, as well as Turtle Creek, which flow into the St. Lawrence downstream of the Moses Saunders Dam near the towns of Massena, Raquette Point, and St. Regis. Tributaries in the vicinity of Massena but upstream of the Moses Saunders Dam include: Robinson Creek, which discharges into the Wiley-Dondero Canal (downstream of the Eisenhower Lock and just upstream of Massena), Coles Creek and Brandy Brook (both upstream of Eisenhower Lock).

The St. Lawrence River ecosystem between Lake Ontario and the Beauharnois Dam in Montreal (approximately 50 miles downstream from Massena) consists of multiple habitat types, including open water, embayments, freshwater marshes, submerged aquatic vegetation, and islands. These habitats support numerous natural resources such as benthic (i.e., bottom-dwelling) organisms, fish, reptiles, amphibians, birds, and mammals, including dozens of state- and Federally-protected species. A general description of these resources is provided below, including examples of threatened, endangered, and of special concern species. St. Lawrence River habitats and tributaries have been designated Significant Coastal Fish and Wildlife Habitat including but not limited to the Grasse River, Brandy Brook, Coles Creek, Wilson Hill Wildlife Management Area, Wilson Hill Island, Lake St. Lawrence Tern Colonies, and St. Lawrence River Shoreline Bays.

In addition, the St. Lawrence Estuary, approximately 350 miles downstream of Massena, supports numerous habitats and species including the threatened St. Lawrence beluga whales and several other marine mammals (whales, dolphins, seals). A portion of this area has been designated as the Saguenay St. Lawrence Marine Park and a larger area has been proposed as the St. Lawrence Estuary Marine Protected Area.

Mussels

Several species of native freshwater mussels are present in tributaries to the St. Lawrence River. These mussel species include the eastern elliptio (*Elliptio complanata*) and the eastern lamp mussel (*Lampsilis radiata*). In the past, these species were also found in the main stem of the St. Lawrence, but invasive species such as the zebra and quagga mussels have negatively impacted (i.e., reduced) their populations (Riccardi et al. 1996). Specifically, nineteen species of mussels have been identified in the Grasse River and St. Regis River drainages (MED 2008, Erickson 2003, Erickson and Garvey 1997). These include four New York State Species of Greatest Conservation Need: the black sandshell (*Ligumia recta),* elktoe (*Alasmidonta marginata),* pocketbook (*Lampsilis ovata*), and the yellow lampmussel (*Lampsilis cariosa*) (NYSDEC 2011b). Three mussel species are considered of special concern in North America (Metcalfe-Smith et al. 1998), a designation given to a species or subspecies that may become endangered or threatened by a relatively minor habitat disturbance.

Fish

The St. Lawrence watershed supports a diverse fishery. Prominent species include largemouth (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*), muskellunge (*Esox masquinongy*), walleye (*Sander vitreus*), brown bullhead (*Ameiurus nebulosus*), and yellow perch (*Perca flavescens*). The American eel (*Anguilla rostrata*) migrates up the St. Lawrence River from the Sargasso Sea and uses the four rivers in the vicinity of the Site as elver and adult habitat. St. Lawrence River watershed fish species listed by the State of New York as endangered, threatened or of special concern include the lake whitefish (*Coregonus clupeaformis*), lake sturgeon (*Acipenser fulvescens*), eastern sand darter (*Ammocrypta pellucida*), and longear sunfish (*Lepomis megalotis*) (Environment Canada 2002). Lake sturgeon, a long-lived migratory species, currently utilizes the St. Lawrence, Grasse, Raquette and St. Regis Rivers for spawning, juvenile and/or adult habitat. Eel populations are in significant decline and are proposed for Federal protection status (USFWS 2011). In addition, Chinook (*Oncorhynchus tshawytscha*) and Coho salmon (*Oncorhynchus kisutch*) are present in the St. Lawrence system from a stocked Lake Ontario population, but Atlantic salmon, which once utilized the St. Lawrence and its tributaries, have not been found in decades.

Turtles

Of the approximately 20 species of turtles in New York State, at least seven species are expected to occur in the St. Lawrence River watershed. Common species include the map turtle (*Graptemys geographica*), painted turtle (*Chrysemys picta picta*), and snapping turtle (*Chelydra serpentina serpentina*); state-listed[3] species include the state-threatened Blandings turtle (*Emydoidea blandingii*), and the wood turtle *(Clemmys insculpta*), a state species of special concern (NYSDEC 2011a, 2011h). These species are found in a variety

[3] "Listed" means designated as threatened, endangered, of special concern, or other protective status.

of habitats that occur in the St. Lawrence watershed, including slow moving, shallow water; lakes; marshes; and vegetated areas with sandy bottoms (NYSDEC 2011e).

Salamanders

A number of salamander species may be found in the assessment area. These include the mudpuppy (*Necturus maculosus*), considered to be the only exclusively aquatic amphibian in the St. Lawrence River basin, and two state species of special concern, the Jefferson salamander *(Ambystoma jeffersonianum*) and the blue-spotted salamander (*Ambystoma laterale*) (NYSDEC 2011a, 2011e).

Frogs

A number of frog and toad species documented in New York State are expected to occur in the St. Lawrence watershed near Massena. These include the American toad (*Bufo americanus*), bullfrog *(Rana catesbeiana*), green frog (*R. clamitans*), northern leopard frog (*R. pipiens*), gray tree frog (*Hyla versicolor*), spring peeper (*Hyla crucifer crucifer*), wood frog (*R.sylvatica sylvatica*), and pickerel frog (*R.palustris*). No Federal- or state-listed species of frogs are known to occur in the assessment area. Some species (e.g., green frog) spend much of their life cycle in close contact with sediments and moist soils, whereas other species (e.g., wood frog) tend to live and spawn in upland ponds or riparian floodplains (NYSDEC 2011e, Environment Canada 2004).

Birds

Both resident and migratory birds utilize the habitat of the St. Lawrence River watershed for breeding, feeding, and roosting. These include waterfowl, waterbirds, raptors and songbirds. The lower St. Lawrence River is identified as an Important Bird Area by the National Audubon Society. This area supports large numbers of breeding common terns and a large and globally-significant bank swallow colony at Sparrowhawk Point, north of Ogdensburg (Audubon 2009).

Species in the assessment area that are listed as endangered, threatened or of special concern by the State of New York include the black tern (*Chlidonias niger)*, common tern (*Sterna hirundo)*, wood thrush (*Hylocichla mustelina*), vesper sparrow (*Pooecetes gramineus*), short-eared owl (*Asio flammeus*), northern harrier (*Circus cyaneus*), pied-billed grebe (*Podilymbus podiceps*), bald eagle (*Haliaeetus leucocephalus*) and least bittern (*Ixobrychus exilis*). The St. Lawrence River has also been identified as a bald eagle wintering area since at least 1975, and is currently the second largest known in New York State, supporting an average of 20 to 30 eagles annually (NYSDEC 2011c).

Mammals

Over 40 species of mammals have been recorded in the St. Lawrence assessment area. Utilizing aquatic, floodplain, and terrestrial habitats, these species rely on the area's natural resources for all life history characteristics. For example, mink (*Neovison vison*) feed in the river and the floodplain, and rely on floodplain and upland areas for breeding and denning. Short-tailed shrews (*Blarina brevicauda*) prey on earthworms in the floodplain, and deer *(Odocoileus virginianus)* access the river for water while spending the rest of their time in the upland areas.

Wetlands

Numerous New York State and Federally-regulated freshwater wetlands are located within the St. Lawrence River watershed. These areas support numerous species of plants and animals. For example, the Snye Marsh complex is a large wetland in the northeastern part of Akwesasne that extends from the St. Lawrence River to approximately 12 miles inland from the Quebec portion of the community well into upstate New York. Snye Marsh was formed by a complex interaction between ice dams and St. Lawrence River flows. The calm and shallow warm waters of Snye Marsh are home to 127 species of birds (including 13 species of waterfowl), amphibians, reptiles, turtles, and small mammals, and are an important spawning area for over 45 species of fish (SRMT Environment Division 2003).

Another distinctive wetland area is the Lac Saint Francois marsh, a National Wildlife area along the St. Lawrence River, which was designated to be a significant wetland of international importance by the RAMSAR Convention on Wetlands in 1987. The area is known as RAMSAR site number 361 and is one of the largest remaining areas of shoreline marsh on the St. Lawrence River that has not been directly modified. Sharing the border with the U.S., the area includes a shallow freshwater lake, rivers, streams, ponds, and flooded woodland, with mature forest on elevated land. The vegetation of the area includes 40 rare species in Quebec and Canada. The area also supports a rich fauna, including mammals, reptiles and amphibians, over 75 species of fish, and breeding and staging waterbirds, which include several species of ducks (Ramsar 2009).

In addition, the Pointe Mouillee wetland, part of the larger wetland complex of Bainsville Bay Marsh, has been classified as an Ontario Provincially Significant Wetland and is one of only three remaining coastal wetlands in the reach of the St. Lawrence River within Ontario. The Pointe Mouillee wetland contains habitats such as mixed forest swamps and marshes where many fish species and waterfowl thrive, including a sturgeon spawning area and black tern habitat. This wetland lies within the Cornwall Area of Concern (AOC) which is adjacent to the Massena AOC in New York (RRCA 2008).

The lower St. Lawrence River and Estuary, located downstream from the assessment area, provide habitat and resources for both resident and migratory marine mammal species. Beluga whale (*Delphinapterus leucas*) and harbor seal (*Phoca vitulina*) are resident in the lower St. Lawrence River and estuary. St. Lawrence beluga move seasonally within the river and estuary, but have been found on the eastern U.S. coast. In summer they range in the vicinity of the Saguenay River, their winter range is not well-established. Migratory species include blue whale, fin whale, humpback whale, long-finned pilot whale, killer whale, minke whale, and North Atlantic right whale.

1.5 Site History

There are three major facilities that have released hazardous substances to the St. Lawrence Environment: Alcoa West, Alcoa East (formerly Reynolds Metals Corporation; RMC), and the General Motors Corporation (GM) Central Foundry (together Facilities; Exhibit 1-1). These facilities are located within the Massena AOC (EPA 2011).

This section provides a brief history of each of these facilities, describing manufacturing processes, past releases of hazardous substances, Federal and state remedial investigations, and subsequent remedial activities. Additional detail is provided in Appendix A, and is available from other publicly available documents (e.g., EPA 2008, 1993, 1992).

1.5.1 ALCOA (ALCOA WEST)

The Alcoa West facility commenced production of aluminum from alumina in 1903.[4] Consisting of three main sections - a fabricating area, an ingot extrusion area, and a smelting plant - the facility utilized the baked anode method to produce aluminum. Production wastes contained hazardous substances including PCBs, PAHs, cyanide, fluoride, aluminum and other metals, phenols, volatile organic compounds (VOCs), and ammonia. Disposal of these wastes (and associated hazardous substances) included discharges to the Grasse River, Unnamed Tributary, Power Canal, and Robinson Creek through several outfalls, and dispersal to on-site and off-site locations through atmospheric transport and deposition. In addition, 11 disposal areas received waste associated with facility operations and at least 18 contaminated areas on facility property have been investigated and remediated. NYSDEC has regulatory authority for the investigation and remediation of contamination on facility property, including upland areas, on-site marshes, lagoons, landfills, disposal sites, and the Unnamed Tributary. The United States Environmental Protection Agency (EPA) has regulatory authority for investigation and remediation of contamination in the Grasse River, Power Canal, and Robinson Creek. Although EPA has not selected a remedy for the Alcoa West site, some remediation has been implemented in the Grasse River as part of pilot studies or through removal actions.

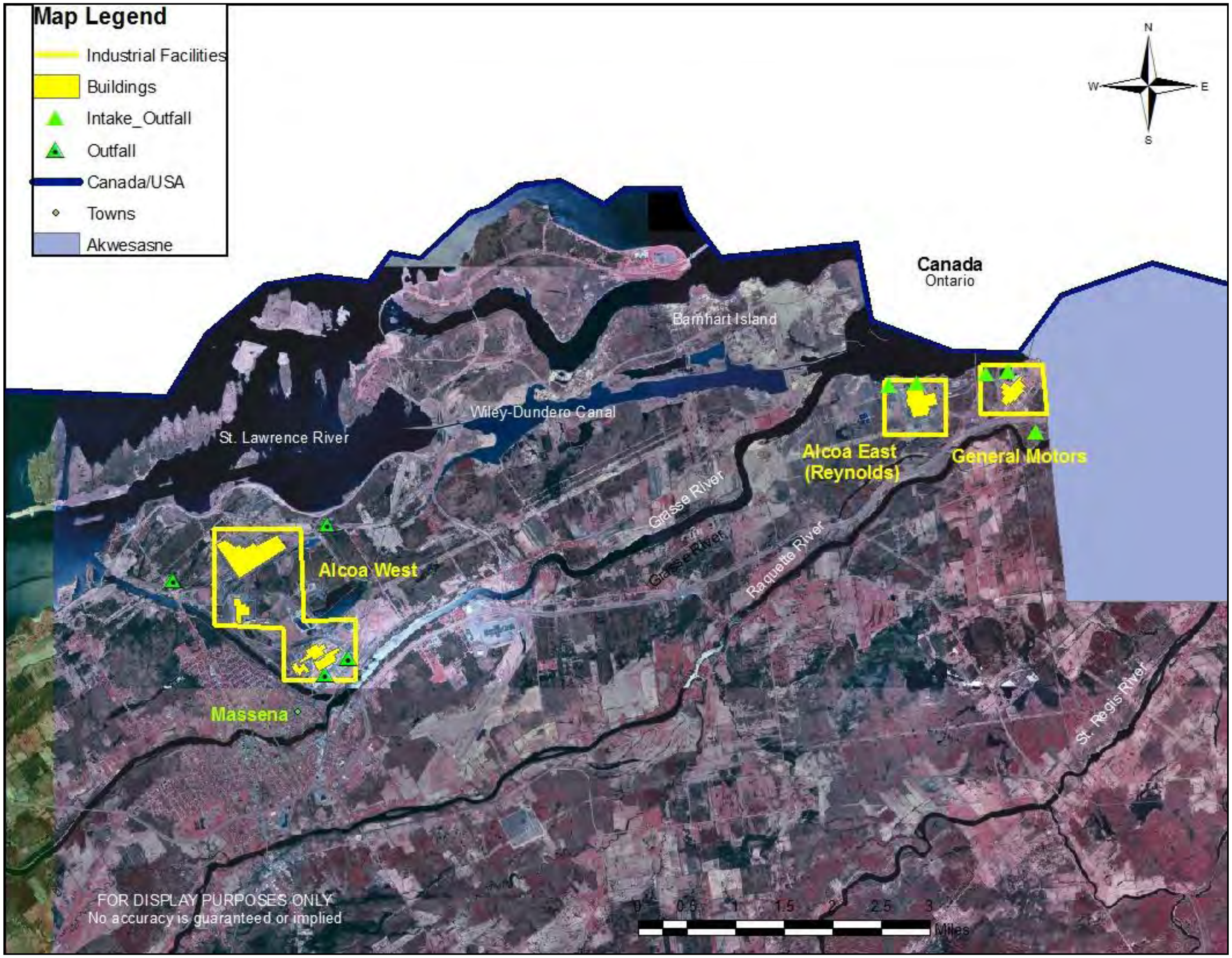
1.5.2 GM

Operations at the General Motors Central Foundry began in 1959 with the manufacture of aluminum cylinder heads and other parts for automobile engines. From 1959 to 1974, the plant used PCBs as a component of the hydraulic fluids in its die casting process, after which time production methods were switched to the lost styrene method (EPA 2008b). The industrial wastes resulting from production contained hazardous substances including PCBs, PAHs, dioxins and furans, styrene, phenols, VOCs, and aluminum and other metals. These wastes (and associated hazardous substances) were placed in the East and North Disposal Area, Industrial Landfill, Industrial Lagoons, and other areas on the GM

[4] Alumina is any one of a variety of aluminum oxide compounds.

property. Wastes were also discharged through various outfalls into the St. Lawrence and Raquette Rivers, and through drainage-ways, groundwater, and runoff into Turtle Cove/Creek and its associated wetlands. EPA has regulatory authority for investigation and remediation of contamination on facility property, including upland areas, landfills, and other disposal areas, and beyond facility boundaries including the St Lawrence River, Raquette River, Turtle Cove/Creek, and Akwesasne Tribal lands. Records of Decision (RODs) were issued in 1990 and 1992.

EXHIBIT 1-1 MAJOR INDUSTRIAL FACILITIES THAT RELEASED HAZARDOUS SUBSTANCES TO THE ST. LAWRENCE RIVER ENVIRONMENT



Remediation of the Raquette River, St. Lawrence River and Turtle Cove was conducted between 1995 and 2008. Other remediation covered by the RODs is not yet complete. For example, on-site cleanup and remediation of groundwater and remaining portions of Turtle Cove/Creek parcels is on-going or has not yet been implemented.

1.5.3 RMC (ALCOA EAST)

Constructed in 1958, the Reynolds Metals Corporation plant (now Alcoa East) produced aluminum from alumina. To-date, the facility has produced aluminum using the Soderberg method; Alcoa intends to convert its production process to the pre-baked anode method following plant modernization (McShea 2009). The facility includes the original aluminum reduction plant, various landfills and other disposal areas, wetlands, and Black Mud Pond. Production wastes contained hazardous substances including PCBs, PAHs, cyanide, fluoride, aluminum, and other metals, dioxins and furans, and sulfate. Disposition of these wastes (and associated hazardous substances) included discharges through various outfalls into the St. Lawrence River, drainage-ways to on-site wetlands, disposal on-site, and dispersal to on-site and off-site locations through atmospheric transport and deposition. NYSDEC has the regulatory authority for the investigation and remediation of contamination on facility property including upland areas, on-site marshes, landfills, disposal sites, and Black Mud Pond. EPA has the regulatory authority for investigation and remediation of contamination in the St Lawrence River, issuing a ROD in 1993. Remediation was implemented between 1995 and 2009.

1.6 COORDINATION WITH RESPONSIBLE PARTY

Under CERCLA, the parties responsible for releases of hazardous substances may be invited to participate in a cooperative natural resource damage assessment and restoration (43 C.F.R. §11.32(a)(2)). Although the final authority regarding determinations of injury and restoration rests solely with the Trustees, cooperative assessments can be beneficial to the public by reducing duplication of effort, expediting the assessment, and implementing restoration earlier than might otherwise be the case.

For the St. Lawrence River Environment, the Trustees have identified Alcoa, Incorporated (Alcoa), RMC, and GM (together, the Companies) as the parties responsible for releases of hazardous substances and corresponding natural resource damages, and have invited the Companies to conduct a cooperative assessment for the site. The involvement of RMC and GM in the cooperative assessment ended due to a merger with Alcoa and bankruptcy, respectively. The Companies' active involvement in the damage assessment and restoration planning process includes the following:

- Providing funding and assistance for assessment activities,
- Providing data and developing a database of contaminant concentration data,
- Participating in the development of injury assessments of ecological and human use services,

- Identifying parcels for potential land conservation, and
- Participating in the evaluation of ecological, recreational fishing and cultural restoration projects.

1.7 RELATIONSHIP TO REMEDIAL ACTIVITIES

NRDAR is a process that occurs *in addition* to the remedial process conducted by regulatory agencies like the EPA. These two processes have different goals. Remedial action objectives are risk-based, and are developed to protect human health and the environment from further unacceptable harm. Remedies are selected based on nine evaluation criteria that are used in a comparative analysis of remedial alternatives and may result in contamination remaining in the environment above levels that existed prior to their release. The goal of NRDAR is the restoration of resources to their baseline condition (i.e., what their condition would be absent the release of a hazardous substance). Losses resulting from natural resource exposure to released hazardous substances are estimated over time until the resource is restored (i.e., interim losses). These losses can therefore extend beyond the date of remedy completion due to contaminants being left in the environment at levels injurious to natural resources.

There are components of NRDAR and remedy however, that overlap. For example, remedial decisions can include consideration of NRDAR restoration objectives. Work to remedy a site may partially or completely restore injured natural resources, and NRDAR estimates take this into account. In addition, remedial actions may cause "collateral injury" to habitat, and quantification and restoration of this remedy-induced injury is also evaluated within NRDAR.

For the St. Lawrence Environment NRDAR, the Trustees have interacted with EPA as EPA evaluated the degree and extent of contamination, conducted human health and ecological risk assessments, and evaluated, selected, designed, and implemented remedies. This coordination provided an understanding of the remedial process and helped the Trustees evaluate how each of EPA's decisions affects estimates of natural resource damages. The Trustees also worked with EPA to integrate remediation and restoration and coordinate remedial activities with some of the Trustees' restoration priorities.

1.8 PUBLIC PARTICIPATION

Public participation and review is an integral part of the restoration planning process, and is specifically mentioned in the DOI NRDAR regulations (e.g., 43 C.F.R. §11.81(d)(2)). To facilitate public involvement in the ecological and recreational restoration planning process, the Trustees published a press release in September 2006, inviting the public to share ideas and suggestions for projects expected to improve the habitat or adversely affected species and/or enhance opportunities for recreational fishing. Over 20 project proposals were received and screened by the Trustees. The projects that were successful in passing the Trustees' screening were considered in the development of this document.

In addition, SRMT conducted community outreach, developed educational materials, and solicited comments, suggestions, and proposals from Tribal members. For example, between 2004 and 2009, the SRMT NRD Program created a Community Advisory Committee to ensure research was proceeding in an appropriate manner, conducted an Oral History Project through interviews with community members to fill data gaps, held public community outreach and government meetings, made public radio announcements, produced and mailed out a Cultural Impacts DVD to the public, conducted a Traditional Activities Survey of current traditional activity practitioners, and solicited cultural restoration ideas and suggestions from the community and surrounding areas.

Public participation has been an essential part of this process. To continue the Trustees' dedication to public involvement, this draft RCDP is available for public review and comment for a period of 30 days. Comments must be submitted in writing to:

Barbara Tarbell
Lead Administrator, St. Lawrence Environment Trustee Council
St. Regis Mohawk Tribe Environment Division
412 State Route 37
Akwesasne, NY 13655

Copies of this document are available online at:

- NYSDEC website (insert)
- NOAA: http://www.darrp.noaa.gov/northeast/lawrence/admin.html
- SRMT website: http://www.srmt-nsn.gov
- USFWS website: http://www.fws.gov/northeast/nyfo/ec/nrda.htm

And in hard copy by request from:

Barbara Tarbell
Lead Administrator, St. Lawrence Environment Trustee Council
St. Regis Mohawk Tribe Environment Division
412 State Route 37
Akwesasne, NY 13655

1.9 GEOGRAPHIC SCOPE

The assessment area is based on the geographic scope within which trust resources have been directly or indirectly affected by the releases of hazardous substances from the Facilities (43 C.F.R. §11.14 (c)). For the St. Lawrence Environment, this area includes U.S. waters of the St. Lawrence River from the Moses Saunders Dam, Long Sault Dam, and upstream of the Wiley-Dondero Canal downstream to the mouth of the St. Regis River, a suite of tributaries to the St. Lawrence River, aquatic and terrestrial areas on-site at the Facilities, and Akwesasne. Subsections of riverine habitat are depicted in Exhibits 1-2 and 1-3 and are described below:

- Moses Saunders to Polly's Gut (Moses Saunders dam downstream along the western edge of Cornwall Island through Polly's Gut in U.S. waters),
- GM Remediation Area,
- Around GM (St. Lawrence River immediately adjacent to the GM Remediation Area in U.S. waters, including the Ship Channel),
- RMC Remediation Area,
- Around RMC (St. Lawrence River immediately adjacent to the RMC Remediation Area in U.S. waters, including the Ship Channel),
- Grasse River (confluence with the Power Canal downstream to the St. Lawrence River),
- Raquette River (Route 37 Bridge downstream to the St. Lawrence River),
- St. Regis River (dam at Hogansburg downstream to St. Lawrence River),
- Turtle Cove / Creek,
- Unnamed Tributary,
- Robinson Creek, and
- Downstream of Robinson Creek (Wiley Dondero Canal).

EXHIBIT 1-2 MAP OF THE ASSESSMENT AREA NEAR THE FACILITIES

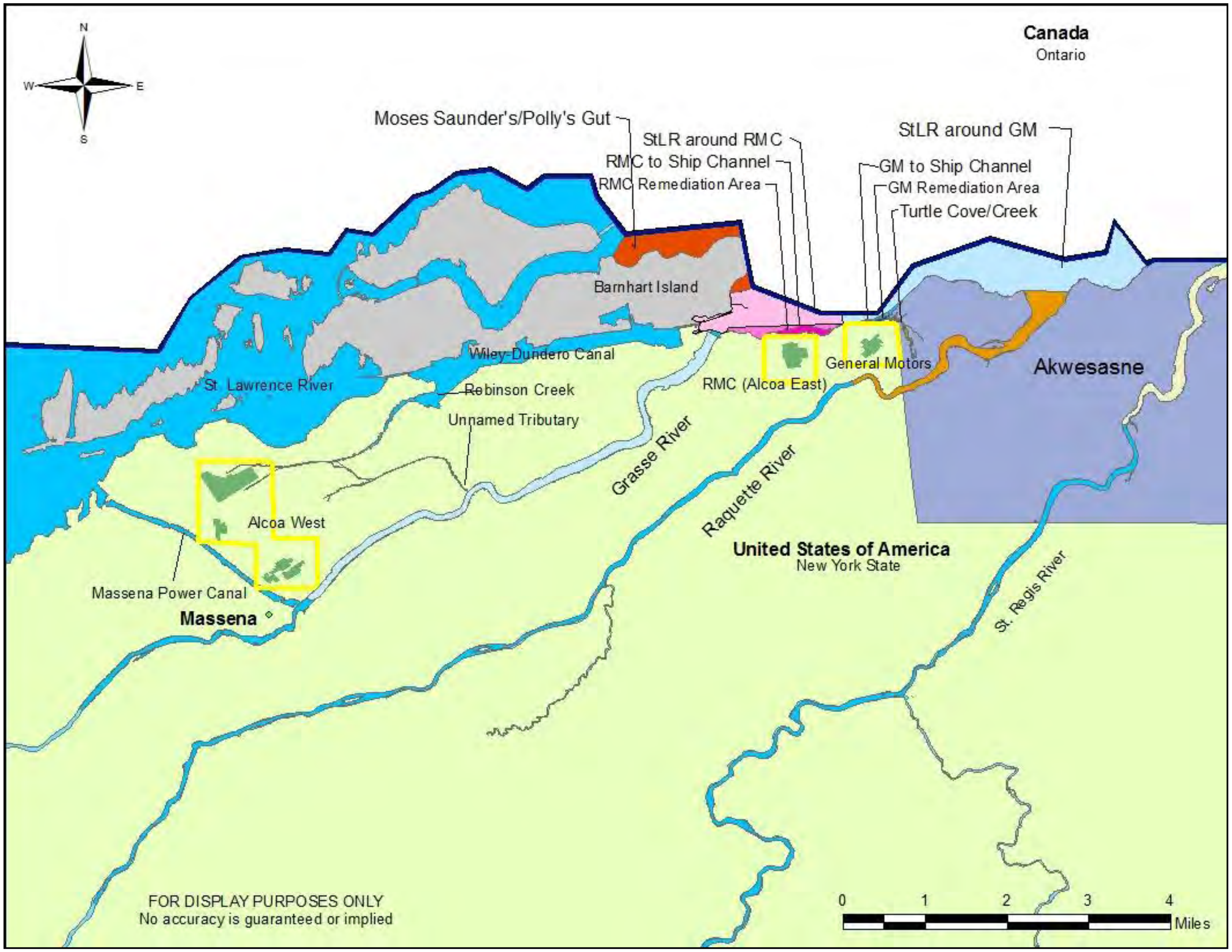
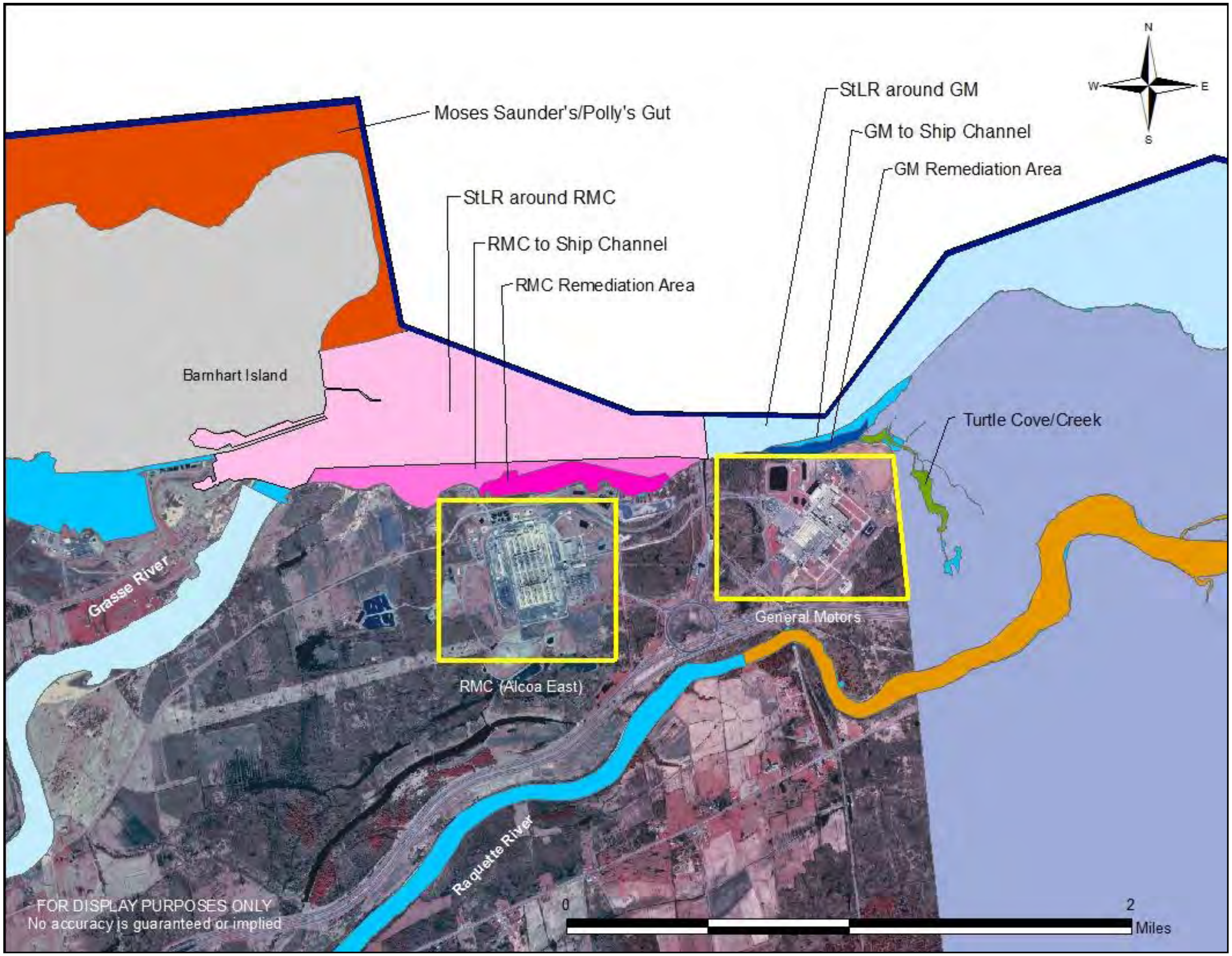


EXHIBIT 1-3 MAP OF RMC AND GM REMEDIATION AREAS



1.10 TEMPORAL SCOPE

The temporal scope of this assessment is based on determination of both injury to natural resources and corresponding damages. Injury has occurred when there is:

> *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 (43 C.F.R. §11.14 (v)).*

Within the assessment area, natural resource exposure to Facility-related hazardous substances has been documented at least since the 1970s and is expected to continue into the future.[5] Injury to ecological resources has likely occurred since that time, but damages based on ecological injuries are calculated beginning in 1981 (in accordance with the promulgation of CERCLA), continuing at least through 2106, at which point the resources are predicted to recover.[6] Injury and corresponding damages with regard to recreational fishing losses are assessed from 1984 (the first year a fish consumption advisory (FCA) was put into place), through both 2030 and 2050 (based on the uncertainty of when the FCAs will be removed).[7] Cultural losses are measured from 1955, the year in which Akwesasne residents began to notice changes in their natural environment, and continue indefinitely. Recovery scenarios may change with the implementation of additional remedial activities in the assessment area or with long-term environmental recycling of contaminants remaining after remedy implementation (e.g., through resuspension of contaminated sediments).

1.11 ORGANIZATION OF THE RCDP

The remainder of this document is organized as follows:

- Chapter 2 describes the natural resources and contaminants of concern in the assessment area.
- Chapter 3 provides evidence for injury to natural resources exposed to contamination in the assessment area.
- Chapter 4 describes quantitatively and qualitatively the likely ecological losses to resources within the St. Lawrence Environment.

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[5] Exposure may have occurred since the early 20th century, as Alcoa began producing aluminum at Massena in 1903, RMC in 1958, and GM in 1959 (EPA 2008a, 2008b, MAHA 2008).

[6] The statute was passed December 11, 1980. For purposes of settlement, the Trustees begin assessing damages in the first full month after the statue was passed (i.e., January 1, 1981).

[7] It is unclear when contaminant levels will decline to levels sufficient to warrant the elimination of advisories in the Assessment Area. As a result, lost trips are calculated assuming two different advisory removal dates, 2030 and 2050.

- Chapter 5 provides an overview of the Trustees' proposed plan for restoration of ecological services as compensation for ecological losses, including compliance with the National Environmental Policy Act and other applicable laws.
- Chapter 6 documents the recreational fishing losses modeled for the assessment area due to FCAs.
- Chapter 7 provides an overview of the Trustees' proposed plan for provision of additional and improved fishing access as compensation for recreational fishing losses, including compliance with the National Environmental Policy Act and other applicable laws.
- Chapter 8 describes the cultural losses experienced by SRMT due to contamination of the St. Lawrence Environment.
- Chapter 9 provides an overview of the projects proposed by SRMT to assist the Tribal community in restoring some of the cultural opportunities and knowledge that has been lost due to contamination, including compliance with the National Environmental Policy Act (NEPA) and other applicable laws.

CHAPTER 2 | NATURAL RESOURCES AND CONTAMINANTS OF CONCERN

The St. Lawrence Environment is a complex ecosystem composed of a suite of inter-dependent natural resources. Each of these resources, including surface water, sediment, and the organisms that utilize the riverine and associated wetland and upland habitats (e.g., fish, birds, reptiles, amphibians, and mammals), is a trust resource. Over the years, these resources have been exposed to contaminants released from the Companies' facilities, and have suffered adverse effects. The following sections describe the natural resources within the assessment area and identify the contaminants of concern (COCs).

2.1 NATURAL RESOURCES

Natural resources are defined in the DOI regulations as:

> *Land, fish, wildlife, biota, air, water, ground water, drinking water supplies, and other such resources belonging to, managed by, held in trust by, appertaining to, or otherwise controlled by the United States (including the resources of the fishery conservation zone established by the Magnuson Fishery Conservation and Management Act of 1976), any State or local government, any foreign government, any Indian Tribe, or, if such resources are subject to a trust restriction on alienation, any member of an Indian Tribe. These natural resources have been categorized into the following five groups: Surface water resources, ground water resources, air resources, geologic resources, and biological resources (43 C.F.R. § 11.14 (z)).*

This RCDP focuses on surface water resources (i.e., surface water and sediment) and biological resources (e.g., macroinvertebrates, fish, amphibians and reptiles, mammals, and birds) within the assessment area. Data regarding contamination of soil and groundwater was limited, but indicated that injury to these resources was unlikely, and therefore the Trustees determined that no further assessment of soil or groundwater was necessary (Appendices B and C).

2.1.1 SURFACE WATER RESOURCES

Surface water resources are defined as:

> *The waters of the United States, including the sediments suspended in water or lying on the bank, bed, or shoreline and sediments in or transported through coastal and marine areas (43 C.F.R. § 11.14(pp)).*

Surface waters are exposed to contaminants from Company facilities discharged directly to the St. Lawrence River or its tributaries, transmitted through the movement of contaminated surface water or groundwater, and through the remobilization and release of contaminants from the sediment (e.g., via dredging, natural scouring, porewater exchange, or bioturbation). Sediments exposed to contaminants include the bed and bank sediments of the St. Lawrence, Grasse, and Raquette Rivers; Unnamed Tributary; Power Canal; Robinson Creek; and Turtle Cove/Creek.

2.1.2 BIOLOGICAL RESOURCES

Biological resources are defined as:

> *Those natural resources referred to in § 101(16) of CERCLA as fish and wildlife and other biota. Fish and wildlife include marine and freshwater aquatic and terrestrial species; game, nongame, and commercial species; and threatened, endangered, and State sensitive species. Other biota encompass shellfish, terrestrial and aquatic plants, and other living organisms not otherwise listed in this definition (43 C.F.R. § 11.14(f)).*

The biological resources potentially exposed to contamination in the assessment area include aquatic macroinvertebrates, reptiles, amphibians, fish, birds and mammals that forage in or along aquatic and/or terrestrial habitat, and marine mammals. These resources have the potential to be exposed to contamination through direct contact with contaminated water and sediment, and/or through consumption of contaminated media or prey. Examples of species recorded within the St. Lawrence Environment, including threatened, endangered, or of special concern species, are presented above in Section 1.4.

2.2 CONTAMINANTS OF CONCERN

The contaminants of concern (COCs) in the assessment area are those hazardous substances (as defined by Section 101(14) of CERCLA) to which trust resources have been exposed as a result of releases to the assessment area. These contaminants include both organic (e.g., petroleum derivatives, synthetic carbon-based chemicals) and inorganic (e.g., metals) contaminants.

This RCDP focuses on contaminants that are Facility-related, pervasive and persistent in the environment, and for which both exposure (i.e., media concentration) and effect (i.e., toxicity) data are readily available. These include PCBs, PAHs, aluminum, cyanide, fluoride, polychlorinated dibenzo-dioxins (PCDDs), and polychlorinated dibenzo-furans (PCDFs). Each of these contaminants is discussed in more detail below.

Other contaminants, including cadmium, lead, and mercury, were also reviewed. The Trustees determined that these contaminants either were not Facility-related or were unlikely to have adversely impacted trust resources. Therefore, these contaminants were not investigated further (Appendix D).

2.2.1 POLYCHLORINATED BIPHENYLS (PCBS)

PCBs are a class of compounds that consists of 209 chlorinated hydrocarbon chemicals (individually known as PCB congeners). Primarily manufactured in mixtures that contained different concentrations of individual PCB congeners, the most common and well-known mixtures were produced by the Monsanto Company under the trade name Aroclor. PCBs were manufactured from the 1930s until their production was banned in the United States by EPA in 1979, which required companies to phase out use of PCBs by 1985, except in cases where they were totally enclosed (EPA 1979). PCBs were used primarily as insulating materials for electrical transformers and capacitors because of their chemical stability at high temperatures, but they were also used in such diverse products as paints and carbon copy paper.

PCBs are relatively mobile in the environment in that they can be volatilized and transported in the atmosphere, resulting in their presence in animal tissues and environmental media around the world. The chemical structure of PCBs also allows these compounds to accumulate in the fatty tissues of organisms and bioaccumulate and biomagnify through food webs (Eisler 2000).

In organisms, PCBs can cause a range of adverse health effects, including liver and dermal toxicity, teratogenic and other reproductive effects, and immunological and neurological effects. Responses depend on the species and the particular congener mixture to which that species is exposed, and can therefore vary from subtle (e.g., induction of hepatic microsomal enzymes) to severe (e.g., impaired reproduction and death). In addition, PCB concentrations are likely to be greater at higher trophic levels due to bioconcentration and biomagnifications.

2.2.2 POLYCYCLIC AROMATIC HYDROCARBONS (PAHS)

Polycyclic aromatic hydrocarbons are organic compounds that are primarily produced from the incomplete burning of organic matter but also occur in petroleum products (Kuzia and Black 1985). Concentrated in the refining process, PAHs are prevalent at higher concentrations in refined petroleum products as compared to crude oil (Connell and Miller 1981). These compounds can be mobilized atmospherically or aquatically (usually through runoff from land or when oil is spilled).

In the environment, PAHs are stable and persistent. Some compounds adsorb to particles that settle into the sediments (Eisler 2000). Others also partition into biological organisms, and can accumulate in fatty tissues. As a result, they can bioconcentrate in an individual organism as well as biomagnify through food webs, depending on specific organisms' abilities to metabolize and excrete PAHs. For example, most fishes can readily metabolize PAHs, so tissue concentrations in fish are not typically elevated (Eisler 2000, EPA 2000).

Several PAHs, including benzo(a)anthracene, benzo(a)pyrene, chrysene, and dibenzo(a,h)anthracene, are some of the most potent carcinogens known to exist (Eisler 2000, ATSDR 1995). Although the occurrence of cancer in aquatic organisms has not been definitively linked to PAHs, these compounds have been implicated in causing a variety of developmental anomalies and tumors in fish and aquatic mammals. PAHs also cause a variety of other toxicological responses in aquatic organisms, birds, and mammals, including inhibited survival, growth, and reproduction (Eisler 2000).

2.2.3 ALUMINUM

Aluminum, a naturally occurring elemental metal, is the most abundant metal in the earth's surface (ATSDR 1999). Highly reactive, aluminum almost never exists in its pure elemental form, instead combining with elements such as oxygen, silicon, and fluorine. Aluminum is unique in that it is very strong, lightweight, and non-corrosive (Lenntech 2008). In addition, aluminum is easily combined with other metals, such as copper, zinc, and magnesium, to form alloys. Given these unique properties, aluminum is widely used throughout the world, most notably in airplane construction, soda cans, foil, and in a variety of structural components.

In its most common form, aluminum oxide, aluminum is not considered harmful to humans, plants, or animals at low concentrations (Lenntech 2008). However, at elevated concentrations aluminum has the potential to cause toxic effects, particularly when present in acidic water.

In acidic waters, aluminum oxide combines with hydrogen ions to form aluminum ions (Al^{3+}) and water molecules. High concentrations of aluminum ions may affect gill osmoregulation in fish, result in thinner shells and reduced chick weight in birds, lead to reduced weight and activity levels in mammals, and limit nutrient uptake in plants. Despite the potential effects of aluminum on birds and mammals, aluminum is not thought to biomagnify within the food chain (ATSDR 1999).

2.2.4 CYANIDE

Cyanide refers to a collection of compounds involving the cyanide anion (CN^-). These compounds are both naturally occurring and man-made. Most naturally occurring cyanide exists as cyanogenic glycosides, produced in certain plants as a metabolic product (e.g., almonds, corn, and apple seeds). The majority of man-made cyanide is hydrogen cyanide, which is used in the production of organic cyanides. Cyanide compounds are used for a variety of purposes. For example, sodium cyanide is used during mining processes to isolate metals of interest. Organic cyanides are used in a variety of industrial processes as resins, plastics, solvents, elastomers, and lubricants. Hydrogen cyanide is used to fumigate areas and as an insecticide (Eisler 2000).

Cyanide compounds are relatively volatile, typically in the form of hydrogen cyanide gas (Eisler 2000). Thus, cyanide does not persist in most soils and surface waters. Cyanide that is not volatilized is metabolized by microorganisms or is used to form complex metallic compounds in soil. Further, cyanide has a relative short half-life in the atmosphere of one to five years (ATSDR 2006).

High concentrations of free cyanide (hydrogen cyanide or the cyanide anion) are lethal to most living organisms. Free cyanide affects the respiratory system of animals resulting in convulsions, unconsciousness, and rapid death (ATSDR 2006). At sub-lethal exposures, cyanide is detoxified quickly by plants and animals and does not bioaccumulate within organisms (Eisler 2000). Many living organisms are unaffected by exposure to sub-lethal doses of cyanide. However, chronic exposure to sub-lethal amounts of cyanide may also result in adverse effects such as reduced swimming performance in fish, reduced chick weight and respiratory problems in birds, and respiratory irritation and disease in mammals.

2.2.5 FLUORIDE

Fluorides are inorganic compounds involving fluorine (e.g., hydrogen fluoride, sodium fluoride, and calcium fluoride). Fluorides occur naturally due to the weathering of rocks and volcanic eruptions. Anthropogenic fluorides stem from coal combustion, various industrial processes, and the fluoridation of drinking water. Among other applications, fluorides are used in the production of gasoline alkylates and chlorofluorocarbons, for cleaning and etching glass, and in steel manufacture (IPCS 2002).

Given the widespread use of fluorides, fluoride compounds are found at low concentrations in air, soil, and water. In air, fluorides exist as hydrogen fluoride gas or as particulates. Fluorides have been shown to bioaccumulate in aquatic and terrestrial organisms either through direct uptake by plants and fish, or through secondary ingestion. However, fluorides are not thought to biomagnify within aquatic and terrestrial food chains (IPCS 2002).

In aquatic systems, fluorides may affect the movement of fish sensitive to changes in water chemistry. Specifically, trout and salmon may become lethargic and engage in erratic movements following exposure to high concentrations of fluorides. Fluorides can also limit microbial activity in soil and decrease terrestrial plant growth. In mammals, exposure to high concentrations of fluoride may lead to emaciation, stiffness of joints, and abnormalities in teeth (i.e., fluorosis) and bones (e.g., bones may become enlarged and brittle; IPCS 2002).

2.2.6 POLYCHLORINATED DIBENZO-P-DIOXINS (PCDDS) AND POLYCHLORINATED DIBENZOFURANS (PCDFS)

Dioxins are a group of synthetic organic chemicals that contain 210 structurally-related individual chlorinated dibenzo-p-dioxins and chlorinated dibenzofurans. Although chemically related, these compounds vary in their physical and chemical properties as well as toxicity. PCDDs and PCDFs have never been intentionally produced, except in small quantities for research; they are unintentionally produced as byproducts of incineration and combustion processes, chlorine bleaching in pulp and paper mills, and as impurities in some chlorinated organic chemicals. They are distributed widely in the environment because of their persistence (EPA 1999).

Dioxin and furan exposure is associated with a wide array of adverse health effects. For example, in fish, PCDDs and PCDFs can cause mortality, growth abnormalities and inhibition, immune suppression, blue-sac disease, and loss of scales (Sijm and Opperhuizen 1996). The PCDDs and PCDFs are similar in physical structure to PCBs and elicit similar responses in birds – reproductive impairment, edema, thyroid function impairment, and deformities (Hoffman et al. 1996).

2.2.7 TOXICITY OF MIXTURES

The toxicological implications of natural resource exposure to multiple contaminants in the assessment area are uncertain. Interactions between contaminants in abiotic media depend on environmental parameters such as pH, alkalinity, and organic carbon, and therefore bioavailability and resultant exposures can change over time and geographic area. In organisms, the toxicity of contaminant mixtures can also be affected by parameters such as species, life stage, and nutritional status. The specific contaminants within the mixture also affect the mixture's overall effect on an organism, as different contaminants have different modes of toxicity.

Site-specific toxicological information for all contaminants of concern is considered when available. Toxicity tests using surface water or sediment from the assessment area provide information regarding the toxicity of the suite of contaminants that implicitly accounts for all relevant environmental parameters, but such information is less readily available for the assessment area than more commonly measured chemical data. Therefore, this evaluation focuses on chemical data, and assumes that the toxicity of contaminants is additive.

CHAPTER 3 | NATURE AND EXTENT OF CONTAMINATION AND INJURY DETERMINATION

The St. Lawrence River and its tributaries together support a watershed that has experienced many decades of ecological impacts due to contamination. This chapter demonstrates injury, based on the DOI regulations, to trust resources exposed to Facility-related contamination from and in the St. Lawrence Environment.

Determination of injury to natural resources within the assessment area consists of documentation that there is: 1) a viable pathway for the released hazardous substance from the point of release to a point at which natural resources are exposed to the released substance, and 2) that injury of site-related resources has occurred as defined in 43 C.F.R. § 11.62. The Trustees evaluated injury to sediment, fish, birds, amphibians and reptiles, and mammals using site-specific data on contaminant concentrations and toxicity, and information from the peer-reviewed literature that documents adverse effects at specific contaminant levels.

3.1 PATHWAY

Site-specific pathway studies, as well as existing information in numerous peer-reviewed journals and reports, indicate multiple pathways of contamination from the GM, Alcoa, and RMC facilities to trust resources. These include, but are not limited to:

GM (EPA 2005,1992)

- At GM, as part of routine operations beginning in the early 1960s, wastewater containing PCB-laden oil passed through the 1.5 million-gallon lagoon and then was discharged into the St. Lawrence River.
- In 1970, PCB contaminated soil excavated during plant expansion was placed on the north bank of the Raquette River.
- During operations, PCB-laden sludge from the 1.5 million-gallon lagoon and from the wastewater treatment plant (constructed in 1976) was periodically removed to the North and East Disposal Areas (both unlined) and to the Industrial Landfill. In 1975, a berm surrounding the East Disposal Area was breached. Water and sludge flowed east to Akwesasne. Surface soil runoff and subsurface flow discharged contaminants to Turtle Creek.
- PCB-contaminated wastewater discharged to the St. Lawrence River through an outfall pipe and as surface water runoff.

- Discharges through an outfall pipe and surface water runoff from contaminated bank soil entered the Raquette River.
- Analysis of fish in Turtle Cove revealed high levels of PCB contamination. As a result, a fish consumption advisory (FCA) has been issued by the New York State Department of Health.

RMC (EPA 2006,1993)

- Wastes from the plant's potliner recovery system, which contained alumina, fluoride, cyanide, and PCBs, were disposed of in Black Mud Pond. These contaminants have been detected in groundwater near the pond. Shallow contaminated groundwater and these associated contaminants may be discharging to surface water pathways to the south and east of the pond.
- The plant's Solid Waste Landfill and former Potliner Storage Area are characterized as a contaminant source area, based on their proximity to aquatic habitat and the similarity of contaminants migrating from the area to those detected in natural resources. The contamination detected in facility waste, groundwater, leachate and surface water is characterized by elevated concentrations of cyanides, fluorides, aluminum, PAHs, and PCBs.
- Groundwater from the Solid Waste Landfill and former Potliner Storage Area drains to wetland RR-6, south of the Landfill area.
- PCBs and PCDFs/PCDDs are distributed in North Yard surficial soils. North Yard groundwater contamination is characterized by local areas of elevated concentrations of aluminum, arsenic, cyanide, PCBs, and fluoride.
- RMC also discharged contaminants to the St. Lawrence River through four outfalls (Outfalls 001, 002, 003, and 004). Discharges include water from the facility's wastewater treatment system, contact cooling water and storm water runoff, sanitary treatment plant, and intermittent runoff.

ALCOA (EPA 2008,2008C; ALCOA 2001)

- Storm water and treated water were discharged to the Grasse River, Power Canal, Unnamed Tributary, and Robinson Creek through eight outfalls. These discharges contained hazardous substances including PCBs, aluminum, and fluoride.
- On-site disposal areas, including the Annex Site, Waste Lubricating Lagoon, Soluble Oil Lagoon, and General Refuse Landfill, received production wastes contaminated with hazardous substances including PCBs, PAHs, metals, fluoride, and cyanide. Leachate from these areas contaminated both surface water runoff and groundwater.
- Past releases and storm water runoff from the site have contaminated sediments in drainage ditches, wetlands, the Massena Power Canal, the Unnamed Tributary, Robinson Creek and the Grasse River. Analysis of fish in the Grasse River and Power Canal revealed high levels of PCB contamination. As a result, a fish

consumption advisory (FCA) has been issued by the New York State Department of Health.

CONTAMINANT FATE AND TRANSPORT

As noted in Chapter 2, the COCs move throughout the environment and accumulate in sediment and biota. Although contaminants may be absorbed dermally (or via the gills in fish) from direct contact with contaminated water or sediment, they are more likely to be accumulated by organisms through consumption of contaminated water, sediment, or prey. The chemical properties of these contaminants can then cause them to bioaccumulate and bioconcentrate in exposed organisms.

3.2 INJURY TO SEDIMENT RESOURCES

Injury to sediment is defined as a component of injury to surface water resources, and has occurred when:

> *Concentrations and duration of substances [are] 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 C.F.R. § 11.62(b)(1)(v)).*

To demonstrate the potential for injury to sediment and benthic macroinvertebrates in the assessment area, site-specific toxicity information is reviewed and contaminant concentrations are compared to sediment quality guidelines (SQGs).

3.2.1 SITE-SPECIFIC TOXICITY

Site-specific toxicity studies describe the adverse effects of COCs, including PCBs, PAHs, fluoride, and aluminum, on benthic macroinvertebrates within the assessment area. In 1993, Metcalfe-Smith et al. (1996) collected sediment from seven sites at varying distances from the RMC outfall. These sediments contained high concentrations of primarily PAHs and PCBs. The mayfly *Hexagenia limbata* was exposed to these sediments in 21-day bioassays. Both mortality and growth were recorded and compared to controls. *H. limbata* experienced 100 percent mortality at sampling locations with high COC concentrations, and a combination of increased mortality and decrease in weight (in the surviving organisms) at other stations with lower (but still elevated relative to controls) COC concentrations (Exhibit 3-1).

EXHIBIT 3-1 RESULTS OF TOXICITY TESTS EXPOSING *H. LIMBATA* TO SEDIMENT FROM NEAR THE RMC OUTFALL [1]

SITE	PCBS (PPM DW)	PAHS (PPM DW)	INCREASE IN MORTALITY[2]	DECREASE IN WEIGHT[2]
B-9	1.85	15.02	15%	NS
C-5	1.92	14.08	5%	NS
C-9	1.96	16.83	10%	NS
B-14	10.9	51.31	12.5%	NS
B-4	11.3	140.75	2.5%	48%
B-3	12.0	1,504.27	0%	53%
B-2	101.0	2,502.74	100%	NA
B2-E	114.0	1,493.29	100%	NA

Notes:
[1] Other COCs were also detected in sediment, such as fluoride, cyanide, and metals.
[2] Control-adjusted.
DW = dry weight.
NS = Not statistically significantly different from control.
NA = Not applicable. No organisms survived and therefore could not be measured for charges in weight.
Source: Metcalfe-Smith et al. (1996).

In another study, the freshwater midge, *Chironomus tentans,* was exposed for 12 days to sediment collected near the outfalls of Alcoa, GM, and RMC that was known to contain high concentrations of PCBs and PAHs. Although the original purpose of the study was to assess bioaccumulation patterns of PCBs and PAHs, the toxicity of these contaminants was sufficient to cause substantial mortality to the test organisms (O'Keefe 2002, Wood et al. 1997). Therefore, sediments were diluted using uncontaminated sediment.[8] The survival and biomass (i.e., weight) of remaining organisms was significantly reduced after exposure to sediments from all three Facilities. Results are summarized in Exhibit 3-2.

[8] Control sediment was from the upper reach of the Hudson River.

EXHIBIT 3-2 TOXICTY OF GM, ALCOA, AND RMC SEDIMENT TO *C. TENTANS*

LOCATION	PERCENT FACILITY SEDIMENT	PCBS (PPM DW)	PAHS (PPM DW)	INCREASE IN MORTALITY [1]	DECREASE IN BIOMASS [1]
GMC	100%	24	1.4	44%	28%
	66%	11	NR	33%	15%
	33%	3.6	NR	27%	17%
Alcoa	100%	78	16	23%	0%
	66%	47	11	15%	13%
	33%	18	5.4	7%	20%
RMC	100%	3,200	700	100%	NA
	66%	NR	NR	100%	NA
	33%	NR	NR	100%	NA
	3%	75	22	65%	37%

Notes:
[1] Control-adjusted.
NR = Not reported.
NA = Not applicable; no organisms survived and therefore could not be measured for changes in biomass.
Sources: O'Keefe (2002), Wood et al. (1997).

3.2.2 COMPARISON OF ASSESSMENT AREA SEDIMENT PCB AND PAH CONCENTRATIONS TO SEDIMENT QUALITY GUIDELINES

Data on PCB and PAH concentrations in sediment have been recorded within the assessment area since the mid-1980s, and were compiled in the St. Lawrence Cooperative NRD Database (Exponent 2006, NOAA 2006). Additional data were provided by Alcoa (2010). Relevant data were queried from the database and Alcoa (2010) are summarized in Exhibit 3-3. The potential for injury to sediment due to other COCs (e.g., aluminum) is presented in Appendix D.

Although no promulgated criteria for contaminant concentrations in sediment exist, published SQGs calculate thresholds below which adverse (i.e., toxic) effects to sediment-dwelling organisms are unlikely to occur (e.g., threshold effects concentration; TEC), and above which adverse effects are expected to occur (e.g., probable effects concentration; PEC; MacDonald et al. 2000). These SQGs are based on a database of co-located sediment concentration and toxicity data, and document adverse effects such as reduction in growth (i.e., reduction in biomass), reproductive impairment, and increased mortality to organisms similar to those found in the assessment area (MacDonald et al. 2000). Assessment area sediment PCB and PAH concentrations are compared to corresponding TECs and PECs. Exceedances of these thresholds indicate injury to sediment resources in all sections of the assessment area (Exhibits 3-3 and 3-4).

EXHIBIT 3-3 AVERAGE SURFACE SEDIMENT PCB CONCENTRATIONS AND EXCEEDENCES OF THE TEC (0.06 PPM) AND PEC (0.68 PPM)

ASSESSMENT AREA SUB-SECTION	YEARS OF DATA	NUMBER OF SAMPLES	AVERAGE PCB CONCENTRATION (PPM DW)	PERCENT SAMPLES ABOVE TEC[1]	PERCENT SAMPLES ABOVE PEC[1]
Grasse River	1988-2007	2,507	21.5	85%	71%
Raquette River	1989-2004	64	20.1	73%	28%
Power Canal	1990-1991	22	1.0	64%	32%
Unnamed Tributary	1991-1998	130	12.1	98%	60%
Robinson Creek	1991-1998	14	2.0	50%	14%
RMC Remediation Area	1985-2002	500	22.0	98%	72%
RMC To Ship Channel	1988-1996	18	1.6	100%	39%
St. Lawrence River Around RMC	1989-1990	6	0.6	100%	33%
GM Remediation Area	1985-2003	37	619.4	100%	89%
St. Lawrence Around GM	1985-2004	22	0.7	86%	14%
GM To Ship Channel	1993	6	0.6	100%	50%
Turtle Cove/Creek	1985-2004	39	116.3	82%	59%

Notes:

[1] TEC is the Threshold Effects Concentration, PEC is the Probable Effects Concentration (MacDonald et al. 2000).

[2] Surface sediment is defined as 0-20 centimeters.

Source of contaminant data: Alcoa (2010), Exponent (2006), NOAA (2006).

EXHIBIT 3-4 AVERAGE SURFACE SEDIMENT PAH CONCENTRATIONS AND EXCEEDENCES OF THE TEC (1.61 PPM) AND PEC (22.8 PPM)

ASSESSMENT AREA SUB-SECTION	YEARS OF DATA	NUMBER OF SAMPLES	AVERAGE PAH CONCENTRATION (PPM DW)	PERCENT SAMPLES ABOVE TEC[1]	PERCENT SAMPLES ABOVE PEC[1]
Grasse River	1990-1991	73	52.8	88%	34%
Power Canal	1991	10	2.93	50%	0%
Robinson Creek	1991	14	1.86	36%	0%
RMC Remediation Area	1990-2005	285	92.4	84%	28%
RMC to Ship Channel	1990-1993	9	10.4	100%	11%
SLR around RMC	1990	5	12.12	100%	0%
GMC Remediation Area	1985	4	18.75	100%	50%
Unnamed Tributary	1991-1998	52	1.2	17%	2%

Notes:

[1] TEC is the Threshold Effects Concentration; PEC is the Probable Effects Concentration (MacDonald et al. 2000).

[2] Surface sediment is defined as 0-20 centimeters.

Source of contaminant data: Exponent (2006), NOAA (2006).

3.2.3 COMPARISON OF ASSESSMENT AREA SEDIMENT FLUORIDE CONCENTRATIONS TO ADVERSE EFFECTS THRESHOLDS FOR MACROINVERTEBRATES

Metcalfe-Smith et al. (2003, 1996) tested the toxicity of site-specific fluoride on the growth and survival of three benthic invertebrate species, including *Hyalella azteca*, *Chironomous tentans*, and *Hexagenia limbata*. Results indicated that *H. azteca* is the most sensitive of the three species and has an IC25 (inhibiting concentration causing 25 percent impairment) for growth at 290 ppm fluoride in sediment (dw). The average sediment fluoride concentrations in most sub-sections of the assessment area were elevated above the IC25 for *H. azteca* growth (Exhibit 3-5). Metcalfe-Smith et al. (2003, 2001) also reported that *H. limbata* avoided fluoride-contaminated sediments from the RMC study area; these mayflies did not burrow into sediments containing 891 to 1,680 ppm fluoride.

EXHIBIT 3-5 SEDIMENT FLUORIDE CONCENTRATIONS IN THE ASSESSMENT AREA [1]

ASSESSMENT AREA SUB-SECTION	YEARS OF DATA	NUMBER OF SAMPLES	AVERAGE FLUORIDE CONCENTRATION (PPM DW) [2]
Grasse River	1991	127	**377**
Grasse River Background [3]	1991	14	122
Power Canal	1991	17	**328**
Unnamed Tributary	1991	4	**475**
Robinson Creek	1991-1998	28	**448**
RMC Remediation Area	1991-1993	10	**11,669**
RMC to Ship Channel	1991-1993	2	150
Raquette River Background	1991	2	**313**
Moses Saunders to Polly's Gut	1991	1	**515**
Downstream of Robinson Creek	1991	1	**395**

Note:

[1] Source: Exponent (2006), NOAA (2006).

[2] Bolded, shaded values exceed the IC25 for *H. azteca* growth (290 ppm).

[3] Grasse River Background section is included here for fluoride because the "background" designation of that area is for contaminants discharges through aquatic and terrestrial pathways. Exposure of natural resources to fluoride, which was discharged as an aerial contaminant, can occur in upstream areas not affected by outfalls, runoff, etc.

3.2.4 CONCLUSION

Site-specific toxicity studies and measured concentrations of COCs in exceedence of sediment quality guidelines indicate that injury to sediment and sediment-dwelling organisms has occurred.

3.3 INJURY TO BIOLOGICAL RESOURCES

Injury to biological resources has resulted from the release of a hazardous substance if the concentration of that substance is 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 C.F.R. § 11.62(f)(1)(i)).*
>
> or
>
> *Exceed levels for which an appropriate State health agency has issued directives to limit or ban consumption of such organism (43 C.F.R. § 11.62 11(f)(iii)).*

3.3.1 FISH

To demonstrate injury to fish within the assessment area due to COCs, site-specific toxicity information is reviewed and contaminant concentrations in fish tissue are compared to literature-based adverse effects thresholds. The analysis is summarized in this section and specific details are presented in Appendix G. In addition, the presence of a FCA constitutes a biological injury to the fishery resources of the assessment area.

Site-Specific Toxicity

A site-specific toxicity study was performed to evaluate the effects of COCs, including PCBs and PAHs on fish within the assessment area. Fathead minnows (*Pimephales promelas*) were exposed to sediment collected from seven sites at varying distances from the RMC outfall (Metcalfe-Smith et al. 1996). Minnows experienced avoidance, weight-loss, reductions in growth, and increases in mortality at COC concentrations greater than controls (Exhibit 3-6).

EXHIBIT 3-6 RESULTS OF TOXICITY TESTS EXPOSING *P. PROMELAS* TO SEDIMENT FROM NEAR THE RMC OUTFALL[1]

SITE	PCBS (PPM DW)	PAHS (PPM DW)	INCREASE IN MORTALITY[2]	DECREASE IN WEIGHT[2]
B-9	1.85	15.02	0%	NS
C-5	1.92	14.08	0%	NS
C-9	1.96	16.83	0%	NS
B-14	10.9	51.31	2.5%	NS
B-4	11.3	140.75	5%	13%
B-3	12.0	1504.27	0%	13%
B-2	101.0	2502.74	12.5%	21%
B2-E	114.0	1493.29	27.5%	25%

Notes:
[1] Other COCs were also detected in sediment, such as fluoride, cyanide, and metals.
[2] Control-adjusted.
NS = Not statistically significantly different from control.
Source: Metcalfe-Smith et al. (1996).

Comparison of Assessment Area Fish Tissue PCB Concentrations to Literature-Based Adverse Effects Thresholds

Measured, site-specific COC concentrations in fish that exceed corresponding adverse effects thresholds are indicative of injury. Although there are a suite of COCs that have caused injury to fish (as indicated by the results of toxicity studies described above), this section focuses on potential injury to fish due to PCBs. PCB concentration data are the most extensive geographically and temporally, and literature information on the effects of PCBs on fish is substantial and readily available. The potential for injury to fish due to other COCs (e.g., aluminum, fluoride, cyanide, and PAHs) is presented in Appendix D.

Data on PCB concentrations in a variety of fish have been recorded within the assessment area since the late 1970s, and were compiled in the St. Lawrence Cooperative NRD Database (Exponent 2006, NOAA 2006). Additional data were provided by Alcoa (2010). Relevant data were queried from the database and are summarized in Exhibit 3-7. These data represent a mix of species, sizes, and genders; a mix of spatial and temporal coverage; and provide only a very general summary of data in the database.

EXHIBIT 3-7 FISH TISSUE PCB CONCENTRATIONS IN THE ASSESSMENT AREA

ASSESSMENT AREA SUB-SECTION	YEARS OF DATA	NUMBER OF SAMPLES	AVERAGE PCB CONCENTRATION (PPM WB WW)
Grasse River	1979-2009	2,133	15.06
Moses Saunders/Polly's Gut	1976-1991	32	8.84
Raquette River	1979-2004	84	7.12
Power Canal	1989-2005	84	2.20
Unnamed Tributary	1992-2004	41	2.04
Robinson Creek	1978-1980	4	1.10
RMC Remediation Area	--	--	--
St. Lawrence River Around RMC	1980-2001	39	10.07
RMC To Ship Channel	1980-1996	35	3.66
GM Remediation Area	1996-2001	32	2.07
St. Lawrence Around GM	1985-2004	87	9.11
GM to Ship Channel	--	--	--
Turtle Cove/Creek	1986-2002	13	65.83
St. Regis River	1987-2003	51	3.67

Notes:
WB WW = whole body wet weight. Data reported as fillet or muscle were converted using site-specific conversion factors (described in Appendix G).
-- indicates no data.
Source: Alcoa (2010), Exponent (2006), NOAA (2006).

The peer-reviewed literature contains substantial information describing the adverse effects of PCBs associated with a wide range of fish tissue PCB concentrations. Therefore, a literature review was conducted, focusing on studies that meet the following criteria:

- Examine the effect of total PCBs or Aroclors.
- Report PCB concentrations in whole body or muscle tissue.
- Describe an effect corresponding to body burden.
- Use fish species relevant to the St. Lawrence watershed.
- Do not incorporate food chain effects (i.e. impacts to organisms that consume fish).[9]

A summary of these studies, including fish species, PCB concentration in fish whole body, endpoint, and severity of effect, is presented in Exhibit 3-8.

[9] This avoids double-counting of adverse effects to upper trophic levels, as separate injury assessments were conducted for piscivorous birds and mammals.

EXHIBIT 3-8 SUMMARY OF TOXICOLOGICAL EFFECTS THRESHOLDS ASSOCIATED WITH TISSUE CONCENTRATIONS OF PCBS IN VARIOUS FISH SPECIES

PCB CONCENTRATION (PPM WB WW)	EFFECTS
<0.28	No relevant effects.
0.28-1.0	Salmonid species sustain biochemical and immunological effects (increased sensitivity to other contaminants, increased fin erosion, alteration of liver lipids; Jorgensen et al. 1999, Bills et al. 1981, Bills and Marking 1977 as cited in Meador et al. 2002). Reduced fecundity and EROD induction in barbel (Hugla and Thome 1999)
>1.0-3.0	Salmonid growth reduced (Fisher et al. 1994 as cited in Meador et al.2002). Increased lake trout fry mortality (Mac and Seeley 1981). Altered growth first generation of mummichog (Matta et al. 2001) No spawning first reproductive season, reduced fecundity and hatching , increased egg mortality in barbel (Hugla and Thome 1999) Renal lesions, increased hepatocytes, spleenic changes, and increased skin pigmentation in rainbow trout (Nestel and Budd 1975) Reduced hatchability of lake trout and minnows eggs collected from the field (Mac et al. 1993, Mac and Schwartz 1992). Increased fry mortality of lake trout (Berlin et al. 1981)
>3.0-7.0	Increased incidence of tumors, pre-neoplastic lesions, immunological changes, EROD induction, and disease prevalence in walleye (Barron et al. 2000). Impacts on larval survival of sheepshead minnow (Hansen et al. 1974, Schimmel et al. 1974, as cited in Monosson 1999). Alterations in larval phototropism, impairment of predator-avoidance ability, and other behavioral effects in Atlantic salmon (Fisher et al. 1994).
>7.0-10.0	Fry mortality in sheepshead minnow (Hansen et al. 1974) Moderate to severe erosion of the dorsal fin in rainbow trout (Thuvander and Carlstein 1991).
>10.0-25	Increased mortality of juvenile spot fish and pinfish (Hansen et al. 1971). Inhibition of reproductive development (e.g., spawning, premature and reduced hatching, increased fry mortality in common minnow; Bengtsson 1980). Increased sheepshead minnow fry mortality (Hansen et al. 1974). Decreased fecundity and frequency of reproduction in adult fathead minnows (Dillon and Engler 1988).

PCB CONCENTRATION (PPM WB WW)	EFFECTS
>25-50	Impairment of rainbow trout immune system of (Thuvander and Carlstein 1991). Increased mortality of juvenile spotfish (Hansen et al. 1971). Adverse effects on reproduction of brook trout (e.g., hatchability) (Freeman and Idler 1975 as cited in Monosson 1999) Increased trout fry mortality (Berlin et al. 1981). Degeneration of liver, spleen and thymus in rainbow trout (Thuvander et al. 1993).
>50-100	Increased severity and frequency of pathological effects (Nebeker et al. 1974). Changes in biochemical (increased hepatic microsomal enzyme activity) and immunological function (decreased steroid hormone levels) of rainbow trout (Sivarajah et al. 1978 and as cited in Meador et al. 2002). Increased mortality of brook trout fry, impairment of fry backbone development (Mauck et al. 1978).
>100	Adult mortality high (Niimi 1996).

Fish Consumption Advisories

As noted above, another type of injury to a biological resource is the existence of a fish consumption advisory. Because of the presence of PCBs in the assessment area, New York State Department of Health FCAs have been in place within the assessment area since 1984, and are currently in place to limit consumption of certain types of fish on the St. Lawrence, Raquette, and Grasse Rivers; the Massena Power Canal; and the Bay at St. Lawrence (Franklin County Line) (NYSDOH various years). NYSDOH releases FCAs annually. More detail is provided in Chapter 6. In addition, in 1978 the Akwesasne community issued a fish advisory warning the people not eat more than 1 meal of fish each week from any of the waters around the reservation (Graef 2008). In 1986, The St. Regis Mohawk Environmental Health Department specifically advised the following recommendations for health reasons: eat no more than one meal (1/2 lb.) per week of fish from any body of water in or around the St. Regis Mohawk Reservation; women of child bearing age, infants and children under the age of 15, should not eat fish; and all fish taken from the St. Lawrence River should be considered contaminated. These advisories constitute evidence of injury as defined in the DOI regulations.

Conclusion

Site-specific toxicity studies, measured concentrations of COCs in exceedence of literature-based adverse effects thresholds, and the existence of a FCA indicate that injury to assessment area fish has occurred.

3.3.2 BIRDS

Although the assessment area supports a high diversity and abundance of birds, data on contaminant concentrations in birds are limited. The Trustees focused on PCBs and PCDDs/PCDFs, two groups of contaminants that are Facility-related, can be toxic to birds, and for which site-specific and/or literature effects information are available. To demonstrate injury to birds within the assessment area due to these COCs, site-specific toxicity information is reviewed and contaminant concentrations in avian eggs and prey are compared to literature-based adverse effects thresholds.

Site-Specific PCB and PCDD/PCDF Toxicity To Birds

Two studies on PCBs and PCDD/PCDFs in birds have been conducted in and around the assessment area. Results link these contaminants to adverse effects in assessment area birds (e.g., great blue heron and tree swallow). Champoux et al. (2006) investigated nine great blue heron colonies along the St. Lawrence River from Dickerson Island (Akwesasne) downstream to the St. Lawrence Estuary. Of all the colonies studied, PCB concentrations were the greatest in eggs (6.1 ppm ww) and blood (27.3 ug/kg ww) from Dickerson Island great blue herons. Plasma retinol (the animal form of vitamin A) levels in fledglings were strongly and negatively correlated with PCB concentrations (low plasma retinol levels may adversely affect fledgling development and survival; Champoux et al. 2006).

Martinovic et al. (2003a) evaluated endpoints in tree swallows directly related to the birds' immune response capabilities. For example, they studied tree swallow nestling plasma corticosterone levels at sites along the Grasse, Raquette, and St. Lawrence Rivers. In 1999 and 2000, basal corticosterone levels were negatively correlated with PCDF. Total PCDF ranged from 4.8 to 120.5 ng/kg wet weight (Exhibit 3-10). The authors concluded that measured levels of organochlorines (the chemical class containing PCBs and PCDD/PCDFs) in the St. Lawrence River and connected tributaries may be interfering with hormone function in tree swallows.

As part of the same study, Martinovic (2003b) reported that the molar ratio of renal retinol to retinyl palmitate (two forms of vitamin A) was significantly and positively correlated with total PCDD. The results suggested that levels of organochlorine contaminants in the St. Lawrence River and connected tributaries may be interacting with the vitamin A pathway. Lower circulating levels and higher tissue concentrations of retinoids may result in compromised immune function and reduced reproductive success in adult birds.

Comparison of Site-Specific Avian Contaminant Concentrations to Literature-Based Adverse Effects Information

Measured, site-specific COC concentrations in birds that exceed corresponding adverse effects thresholds are indicative of injury. Although there are multiple COCs that have likely caused injury to birds (as indicated by the studies described above), this section focuses on potential injury to birds using two lines of evidence: PCBs in eggs and PCBs in diet. Egg and prey PCB concentration data as well as literature information on the corresponding effects of PCBs on birds are readily available. Additional detail is presented in Appendix D, including the limited information available on avian exposure to and potential effects from PCDDs/PCDFs in the assessment area.

Data on PCB concentrations in bird eggs from in and around the assessment area are available from 1995, 1999, and 2006, and were compiled in the St. Lawrence Cooperative NRD Database (Exponent 2006). Relevant data were queried from the database and are summarized in Exhibit 3-10.

EXHIBIT 3-10 AVIAN EGG PCB CONCENTRATIONS IN THE ASSESSMENT AREA

ASSESSMENT AREA SUB-SECTION	SPECIES	YEARS OF DATA	SAMPLE SIZE	AVERAGE PCB CONCENTRATION (PPM WW)	SOURCE
Dickerson Island	Great blue heron	1996-1997	9	6.1	Champoux et al. 2006
Akwesasne	Tree swallow	1992	3	11.1	Bishop et al. 1999
Akwesasne	Red-winged blackbird	1991	5	18.6	Bishop et al. 1995

The peer-reviewed literature contains substantial information describing the adverse effects of PCBs on birds. Literature reviewed for this assessment focused on studies that examine the effect of total PCBs or Aroclors and that report PCB concentrations in bird eggs or dietary dose. A summary of toxic effects thresholds is presented in Exhibits 3-11 and 3-12. Dietary doses are modeled in Chapter 4 and presented in more detail in Appendix G.

EXHIBIT 3-11 SUMMARY OF TOXICOLOGICAL EFFECTS THRESHOLDS ASSOCIATED WITH EGG CONCENTRATIONS OF PCBS IN VARIOUS BIRD SPECIES

ENDPOINT	SPECIES	EGG PCB CONCENTRATION ASSOCIATED WITH EFFECT (PPM WW)	SOURCE
LOAEC - Reduced hatchability	Chicken	1.3	Chapman (2003)
NOAEC - Productivity (young fledged per nest)	Bald eagle	4	Bowerman et al. 2003)
NOAEC - Reproductive success	Double crested cormorant	13.6	Custer et al. (1999)
No Effect - Reproduction	Screech owl	4 - 18	McLane and Hughes (1980)
Mortality	Double crested cormorant	4.4 - 14.8	Tillitt et al. (1992)
Reduced hatchability	Ring dove	16	Peakall and Peakall (1973)

ENDPOINT	SPECIES	EGG PCB CONCENTRATION ASSOCIATED WITH EFFECT (PPM WW)	SOURCE
Reduced hatchability	Common tern	7.6 - 10	Hoffman et al. (1993)
Reduced hatchability	Forster's tern	22	Kubiak et al. (1989)
Reduced reproduction	Kestrel	34.1	Fernie et al. (2001 a,b)
Impaired disease resistance	Mallard	25	Friend and Trainer (1970)
No reproductive effects	Mallard	150	Haseltine and Prouty (1980)
Eggshell thinning	Mallard	150	Haseltine and Prouty (1980)
Notes: NOAEC = No observed adverse effect concentration LOAEC = Lowest observed adverse effect concentration			

EXHIBIT 3-12 SUMMARY OF TOXICOLOGICAL EFFECTS THRESHOLDS ASSOCIATED WITH DIETARY DOSES OF PCBS ADMINISTERED TO VARIOUS BIRD SPECIES

ENDPOINT	PCB DIETARY DOSE (MG PCB/KG BODY WT/DAY) ASSOCIATED WITH EFFECT	SPECIES	SOURCE
Reduced Hatchability	0.5	Chicken	Chapman (2003)
Altered reproductive behavior	1.12	Mourning dove	Tori and Peterle (1983)
Reduced hatchability	1.8	Pheasant	Dahlgren et al. (1972), Dahlgren and Linder (1971)
Reduced hatchability	2.0	Ring Dove	Peakall and Peakall (1973)
Reproductive effects	7.0	Kestrel	Fernie et al. (2001a,b)
Porphyria [1]	7.0	Japanese quail	Elliott et al. (1997)
Note: [1] Porphyria is a genetic blood disorder.			

Bird Consumption Advisories

As noted for fish, existence of a consumption advisory due to a hazardous substance is also an injury to biological resources as defined in the DOI regulations. In the assessment area, advisories to limit consumption of certain species of wild waterfowl due to the presence of PCBs and other COCs have been in place for more than a decade (NYSDOH various years). For example, a NYSDOH statewide advisory recommends avoiding consumption of mergansers and consuming no more than two meals per month of other waterfowl. The US Food and Drug Administration (FDA) action level for PCBs in meat is three ppm; concentrations of PCBs in mallard fat were documented up to 613.6 ppm PCBs and in common merganser fat up to 166 ppm PCBs in the assessment area.[10]

Conclusion

Multiple lines of evidence indicate injury to birds in the assessment area. These include: 1) site-specific toxicity studies, 2) measured egg concentrations of PCBs in exceedence of literature-based adverse effects thresholds, 3) modeled dietary dose concentrations in exceedence of literature-based adverse effects thresholds (Chapter 4; Appendix G), and 4) existence of a wild waterfowl consumption advisory.

3.3.3 AMPHIBIANS AND REPTILES

The assessment area supports a variety of amphibian and reptile species, including a number of state threatened and of special concern species (Section 1.4). To demonstrate injury to reptiles and amphibians within the assessment area, site-specific toxicity information is presented and PCB concentrations in amphibian and reptile tissue and assessment area sediment are compared to literature-based adverse effects thresholds.

Site-Specific PCB Toxicity To Mudpuppies and Wood Frogs

Multiple site-specific studies on amphibians showed adverse effects on physiology, development, and survival due to exposure to PCBs. For example, a high prevalence of skeletal deformities was found in mudpuppies collected from the most contaminated sections of the St. Lawrence River within the assessment area (Gendron et al. 1994, 1995). At Akwesasne, adult mudpuppies were approximately seven times more likely to develop a limb defect than at the reference site (Batiscan along the Ottawa River); approximately 58 percent of mudpuppies from Akwesasne exhibited a limb defect, compared with approximately nine percent at the reference site. The frequencies of deformities were positively correlated with concentrations of PCBs in gonads. Savage et al. (2002) exposed wood frog tadpoles to sediment collected at Akwesasne that contained 325 ppm PCB. These PCB-exposed tadpoles exhibited reduced activity levels and swimming speed relative to reference tadpoles, and direct sediment contact resulted in greater tadpole mortality than if tadpoles were suspended over the sediment.

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[10] Service losses resulting from wild waterfowl consumption advisories were not evaluated in this assessment because they are state-wide advisories.

Comparison of Site-specific Amphibian, Reptile, and Sediment Contaminant Concentrations to Literature-Based Adverse Effects Information

Measured, site-specific COC concentrations in exceedence of corresponding adverse effects thresholds in amphibians and reptiles or in the sediment to which these organisms are exposed are indicative of injury. Limited amphibian/reptile egg PCB concentration data, sediment PCB concentration data, and literature information on the effects of PCBs on amphibians and reptiles are available and are presented below. Additional detail is presented in Appendix E.

Data on PCB concentrations in amphibians and reptiles were compiled in the St. Lawrence Cooperative NRD Database (Exponent 2006). Relevant data were queried from the database and are summarized in Exhibit 3-13. Assessment area sediment PCB concentration data are presented above in Exhibit 3-3.

EXHIBIT 3-13 SUMMARY OF PCB DATA IN AMPHIBIAN AND REPTILE EGGS FROM THE ASSESSMENT AREA

ASSESSMENT AREA SUB-SECTION	SPECIES	YEARS OF DATA	AVERAGE PCB CONCENTRATION (PPM WHOLE EGG WW)	SOURCE
Akwesasne	Snapping turtle	1998	188.2 [1]	deSolla et al. 2001
	Mudpuppy	1992-1993	58 [2]	Gendron et al. 1995, 1994

Notes:

[1] Calculated mean is from eight samples of five eggs each from a single clutch (four samples from Snye, one from Turtle Creek, one from Raquette and one from St. Regis).

[2] Composite sample, one egg from 6-15 females.

The peer-reviewed literature contains information describing the adverse effects of PCBs on amphibians and reptiles. Literature reviewed for this assessment focused on studies that examine the effect of total PCBs or Aroclors, report PCB concentrations in amphibian or reptile eggs, and exposed species relevant to the St. Lawrence environment. For example, Patnode et al. (1998) presented a PCB threshold of 15 ppm in snapping turtle eggs above which hatching success may be affected under certain conditions. Kelly et al. (2009) determined a statistically significant relationship between PCBs in snapping turtle eggs and juvenile mortality. At a concentration of 1.1 ppm ww in eggs, juvenile mortality is predicted to increase approximately 36 percent from uncontaminated reference sites (Kelly et al. 2009). Site-specific snapping turtle and mudpuppy egg PCB concentrations exceed these thresholds.

In addition, sediment PCB concentrations as low as 4.3 ppm and 25 ppm have been associated with adverse effects (e.g., reproductive effects, abnormal development, skewed sex ratios) in northern leopard frogs and wood frogs, respectively (EPA 2003). Site-specific sediment PCB concentrations exceed these thresholds (Exhibit 3-3).

Snapping Turtle Consumption Advisories

As noted for fish and birds above, existence of a consumption advisory due to a hazardous substance is an injury to biological resources as defined in the DOI regulations. In the assessment area, current advisories to limit consumption of snapping turtles due to the presence of PCBs and other COCs have been in place for more than a decade (NYSDOH various years). For example, a NYSDOH statewide advisory recommends that women of child bearing age, infants and children less than 15 years old should avoid consumption of snapping turtles or soups made with snapping turtle meat due to PCBs. The FDA action level for PCBs in meat is three ppm; concentrations of PCBs in snapping turtle fat and muscle were documented up to 613.6 ppm PCBs in the assessment area.[11]

Conclusion

Multiple lines of evidence indicate injury to amphibians and reptiles in the assessment area. These include: 1) site-specific toxicity studies with mudpuppies and frogs, 2) measured concentrations of PCBs in exceedence of literature-based adverse effects thresholds for snapping turtle eggs and for sediment to which frogs are exposed, and 3) existence of a snapping turtle consumption advisory.

3.3.4 MAMMALS – SEMI-AQUATIC AND TERRESTRIAL

Mammals are an important part of the St. Lawrence Environment, with roles in both the aquatic and terrestrial habitats. For example, mink feed along the shore and in the rivers but den on land, and bats spend most of their time on land (e.g., resting, breeding), but often feed on aquatic insects. To demonstrate injury to semi-aquatic and terrestrial mammals within the assessment area due to PCBs, contaminant concentrations in mammal tissue and prey are compared to literature-based adverse effects thresholds. To demonstrate injury to assessment area mammals due to fluoride, contaminant concentrations in vegetation are compared to NYS criteria for fluoride in forage for consumption by grazing ruminants, and site-specific evidence of fluoride toxicity.

PCBs

Data regarding contaminant concentrations in mammals in the assessment area reflect the PCB body burden of small terrestrial, large terrestrial, and semi-aquatic mammals. These data were compiled in the St. Lawrence Cooperative NRD Database (Exponent 2006). Relevant data were queried from the database and are summarized in Exhibit 3-14. Assessment area prey (i.e., fish, amphibian, and reptile) PCB concentration data are presented above in Exhibits 3-7 and 3-13.

[11] Service losses resulting from snapping turtle consumption advisories were not evaluated in this assessment.

EXHIBIT 3-14 PCB CONCENTRATIONS IN MAMMALS FROM THE ASSESSMENT AREA

SPECIES	YEARS OF DATA	NUMBER OF SAMPLES	AVERAGE (PPM)
Deer mouse	1985-1989	3	6.30
Eastern cottontail	1985-1987	2	5.03
Indiana bat	1979	1	1.45
Masked shrew	1985-1987	2	21.35
Meadow vole	1985-1990	9	0.59
Muskrat	1985-1987	2	0.21
Short-tailed shrew	1985	1	2.10
Snowshoe hare	1985	1	ND
Woodland jumping mouse	1985	1	0.40

Notes:
[a] Source: Exponent (2006).
ND = non-detect at a detection limit of 0.1 ppm.

Review of effects literature focused on the effects of PCBs on mammals, and included studies that examine the effect of total PCBs or Aroclors, and that report body burden PCB concentrations or PCB dietary dose. Body-burden toxicity data for small terrestrial mammals were found in relatively few studies. Most of these data are for laboratory rats, species commonly used in toxicity tests. For example, body burdens of 0.028-12.36 ppm whole body ww correspond to decreased reproductive activity and immune suppression in rats (Gehrs and Smialowicz 1998; Gehrs et al. 1997; Gray et al. 1997a,b; Shaw-Allen and McBee 1993).

A larger number of studies have evaluated the effect of dietary PCBs on mammals. PCBs have been found to impair reproduction, cause weight loss and immune suppression in species such as mink, rabbits, short-tailed shrews and meadow voles (Eisler 2000). One of the mammals most sensitive to PCBs, mink experience adverse effects when exposed to PCB levels as low as 0.25 ppm in the diet (Restum et al. 1998). Mink feeding in the assessment area are likely to consume prey containing PCBs in excess of this concentration (e.g., see Exhibits 3-7 and 3-13 for PCB concentrations found in area invertebrates, fish, and amphibians). Additional detail is provided in Appendix F.

Fluoride

Concentrations of fluoride in and around the assessment area vegetation exceed NYS criteria for fluoride in forage for consumption by grazing ruminants. These criteria are: for the growing season (not to exceed 6 consecutive months) – 40 ppm; for any 60 day period – 60 ppm; and for any 30 day period – 80 ppm. In the 1970s, fluoride concentrations in maple, dogwood, and butternut hickory near RMC and on the southwest side of Cornwall Island ranged from 389-1,171 ppm (Emerson 1987, Rice 1983). In the early 1980s, measured fluoride concentrations in vegetation (e.g., grasses and tree foliage) downwind of Alcoa and RMC ranged from 119-367 ppm (Miles 1983, Rice 1983). NYSDEC reported fluoride data in plants collected near Alcoa and RMC and on

Cornwall Island ranging from a mean of 21-194 ppm (NYSDEC 1997), and SRMT collected data on fluoride concentrations in assessment area plants from 2000-2004, with results ranging from approximately 1-111 ppm.

Evidence of fluoride toxicity to mammals has also been documented in the vicinity of Alcoa. For example, in 1979, Krook and Maylin reported evidence of chronic fluoride poisoning in cattle on Cornwall Island. Cattle exhibited stunted growth, lameness, decayed teeth, delayed emergence of teeth, swollen gums, general bone decay, and failure to reproduce. Increase in incidence and severity of these symptoms was correlated with increasing concentrations of fluoride in cattle bones (i.e., bone ash; Exponent 2006).

Tissue burden concentrations of fluoride in other mammal species in the assessment area and vicinity have also been reported in excess of literature-based adverse effects thresholds. Miles (1983) and Rice (1983) trapped small mammals on Cornwall Island in 1977 and determined fluoride concentrations in femur bones. Average fluoride in meadow vole (*Microtus pennsylvanicus*) femurs ranged from 1,153 to 3,775 ppm; in short-tailed shrew (*Blarina brevicauda*) femurs from 1,786 to 6,557 ppm and in deer mouse (*Peromyscus maniculatus*) femurs from 534 to 1,497 ppm (Rice 1983). The majority of these concentrations exceeds a threshold of 2,500 mg fluoride per kilogram dry weight femur for sublethal effects and shortened life span (Cooke et al. 1996).

Conclusion

Measured concentrations of PCBs in both mammal tissue and mammal prey in exceedence of literature-based adverse effects thresholds as well as site-specific documentation of fluoride toxicity and concentrations of fluoride in exceedence of NYS vegetative criteria, indicate that injury to assessment area mammals has occurred.

CHAPTER 4 | ECOLOGICAL LOSSES

Injured trust resources within the assessment area have likely sustained some loss in ecological services due to contamination. That loss is evaluated by comparing the resources in their contaminated condition with resources that are similar but are not exposed to contaminants released from the Facilities (i.e., reflect the baseline condition of the resources). The severity and magnitude of these potential losses are quantified, where possible, in order to establish a basis for scaling restoration (i.e., damages). Scaling in this case means determining restoration projects that provide sufficient type, quality, and quantity of ecological services to compensate for those ecological services lost due to contamination. Damages for ecological losses are measured as the cost to conduct those restoration projects. Below the Trustees discuss baseline conditions, the assumptions and methodologies used to quantify injury to ecological resources, and the resulting estimate of losses.

Following the DOI regulations, ecological injuries in the assessment area are quantified based on lost resource services (43 C.F.R. §11.71(a)). Ecological services are "the physical and biological functions performed by the resource" (43 C.F.R. § 11.14 (nn)). A reduction in the ability of a resource to provide these services, as compared to the baseline level of services, is considered a service loss. This loss is measured using habitat equivalency analysis (HEA), which incorporates injuries over both the geographic and temporal scope of the analysis in units of acre-years of habitat. See Text Box "What is Habitat Equivalency Analysis?"

For resources where sufficient exposure and effects data exist (i.e., sediment and macroinvertebrates, fish, birds, and mammals), injury is quantified as the percentage loss in ecological services as compared to baseline (discussed below). Although available data indicate that injury to additional trust resources that rely on assessment area habitat is likely (e.g., amphibians and reptiles), data are insufficient to quantify these losses. However, it is expected that restoration projects implemented to compensate for quantified losses will also provide benefits to these additional resources.

What is Habitat Equivalency Analysis?

The basic premise of habitat equivalency analysis is that the public can be compensated for past and expected future losses in ecological services through the provision of additional ecological services in the future. Compensable losses are “interim” losses – the loss in ecological services incurred from the time the resource is injured* until the services provided by the injured resource return to their baseline level. Baseline is defined as the level of services that would have been provided in the absence of the contamination. Recovery to baseline for each resource service may be achieved through remediation, restoration, and/or natural recovery. Compensatory restoration actions for these interim lost services are *in addition* to those actions required to restore injured resources to baseline conditions (i.e., primary restoration).

Within equivalency analyses, both service losses and compensatory service gains are typically measured in terms of “unit-time” (e.g., acre-years), which incorporates both the geographic and temporal nature of the analysis. Each acre-year represents the existence of one acre of a particular habitat for one year. The concept of an acre-year allows the analysis to consider not only the *number* of acres lost as a result of the contamination, but also the fact that these acres have not provided the baseline level of services *each year* for some period of time. For example, if an acre of aquatic habitat is injured (e.g., provides zero percent of baseline services due to contamination) in 1994, and remains injured until 2004, losses are accrued for the acre of injured habitat for each of the ten years of loss (e.g., ten acre-years, not accounting for the present value of these services). Use of the acre-year metric also allows losses to be scaled with gains in ecological services from restoration (i.e., the services provided by an acre of restored habitat over a period of time). For example, if one acre of fully-functional riparian habitat is expected to provide 100 percent of baseline services each year for the next ten years, it will provide ten acre-years** (again, not accounting for the present value of these services).
Equivalency between losses and gains is then established by determining the present value of each (i.e., compounding past losses and discounting future losses and gains). Losses and gains are expressed in terms of units of the diminished resource itself (e.g., acre-years rather than economic value; Unsworth and Bishop 1994). Dollar damages are calculated as the cost of compensatory restoration projects.

* Damages are calculated from the start of injury or 1981, whichever is later, in accordance with the promulgation of CERCLA.

** Assuming the habitat selected for restoration previously provided no ecological services (i.e., the *gain* in services is 100 percent).

4.1 BASELINE

To quantify injuries, the baseline condition of the affected resources and associated services must be established. Baseline is "the condition or conditions that would have existed at the assessment area had the…release of a hazardous substance…not occurred" (43 C.F.R. § 11.14 (e)), taking into account natural processes and changes resulting from human activities. Baseline conditions include all environmental parameters, not only concentrations of COCs. For example, water quality (e.g., nutrient load) and physical changes to the habitat are incorporated into the determination of baseline conditions. As described in the DOI regulations, establishing baseline requires either pre-release data or data from suitable reference locations.

For the St. Lawrence River, data describing pre-release conditions are not available (releases of hazardous substances began prior to the regular collection of environmental data). As a result, data from upstream of the assessment area are used to characterize likely baseline conditions within the assessment area. This includes the St. Lawrence River from the Moses Saunders Dam, Eisenhower Lock, and Long Sault Dam upstream to the confluence of the St. Lawrence River and Coles Creek, (Exhibit 1-2). Results indicate that the baseline concentration of PCBs in St. Lawrence sediment is approximately 0.02 ppm, and in fish is approximately 0.52 ppm whole body wet weight.

4.2 INJURY QUANTIFICATION

Losses in ecological services in the assessment area due to COCs are quantified for representative species groups, including sediment and macroinvertebrates, fish, aquatic birds, and terrestrial mammals. Each is described below; additional detail regarding PCB injury quantification is provided in Appendix G.

4.2.1 SEDIMENT AND BENTHIC MACROINVERTEBRATES

Sediment and benthic macroinvertebrates are essential to the continued function and viability of aquatic habitat. Together, they provide services such as substrate for burrowing and feeding, nutrient cycling, improved water quality, and prey (e.g., as the base of the food web). Service losses incurred by sediment and benthic macroinvertebrates resulting from contamination in the assessment area were quantified for PCBs, PAHs, and fluoride. Data were insufficient to quantify losses due to aluminum (Appendix D).

4.2.2 PCBS

Sediment losses due to PCBs were estimated using a relationship between PCB concentration in sediment and the severity and magnitude of corresponding lethal and sub-lethal effects as reported in site-specific studies and in the literature. This includes the following steps:

1. Calculate past sediment PCB concentrations using measured or modeled data (1981-2009).[12]
2. Model future sediment PCB concentrations in years 2010-2106.
3. Estimate the loss in sediment services due to PCBs for each sub-section of the assessment area for each year of the analysis (1981-2106).
4. Calculate the present value of sediment losses in discount service-acre years (DSAYs) in 2010 for each sub-section assessment area using a three percent discount rate.
5. Sum the present value acres lost over time to estimate the DSAYs lost for the entire assessment area.

Determine Past Sediment PCB Concentration: 1981-2009

The average PCB concentration in sediment in each section of the assessment area was calculated using surface sediment data (i.e., 0-20 cm) from 1981 to 2009 (Alcoa 2010, Exponent 2006, NOAA 2006) or estimated for years where data was unavailable.[13] Data for the Grasse River were sufficient to evaluate concentrations by year; data for each of the remaining sub-sections were combined across years. Remedial actions in relevant sub-sections are taken into account (i.e., data are split into pre- and post-remedy years for the GM remediation area, RMC remediation area, Unnamed Tributary, and Turtle Cove/Creek). In addition, the St. Lawrence River baseline PCB concentration of 0.02 ppm is subtracted from the average annual PCB concentration for each assessment area sub-section within the St. Lawrence River. Losses are evaluated using the resulting baseline-adjusted concentrations.

Model Future Sediment PCB Concentration: 2010-2106

Due to the physical and chemical properties of PCBs, future PCB concentrations are likely to decline slowly without remedial actions (i.e., natural attenuation of PCBs in sediments is extremely slow (Eisler 2000)). In addition, within the assessment area, remedial activities have been completed (e.g., GM Remediation Area), have not been selected (e.g., Grasse River), or are not planned (e.g., St. Regis River).

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[12] This analysis incorporated Grasse River sediment data through 2007 and sediment data for all other assessment area sub-sections through 2006.

[13] The majority of sediment-dwelling organisms are active in the upper 20 cm (eight inches) of bottom sediment (Bares and Hennes 2003, DOER 2001).

Estimate Service Losses

A relationship between sediment PCB concentration and the loss in benthic ecological services was developed using site-specific toxicity test results and data from the literature. Studies that reported both lethal (i.e., mortality) and sub-lethal (e.g., reproduction, growth) effects at a given PCB sediment concentration were included in this analysis (Ingersoll et al. 2005, ACOE and EPA 2004, MacDonald et al. 2000, O'Keefe 2002; Wood et al. 1997, Metcalfe-Smith et al. 1996). Results indicate that the total percentage service loss (the sum of losses associated with lethal and sub-lethal effects) increases with increasing sediment PCB concentration in a dose-response curve relationship (Appendix G).[14]

Using this PCB-service loss relationship, a percentage service loss for each sub-section and each year was estimated based on annual average sediment PCB concentration.[15] Two exceptions were the RMC remediation area and the GM remediation area, where sediment service losses are assumed to be 100 percent through the completion of remedial activities. This is due to the high concentrations of PCBs, PAHs, and other contaminants in sediment.

Annual service losses from PCBs for each sub-section of the assessment area from 1981 through 2010 are presented in Exhibit 4-1. Past service losses are constant every year except for those sub-section assessment areas with sufficient data to calculate annual service losses (Grasse River), or where full or partial remedies were implemented (RMC and GM Remediation Areas, Turtle Creek, Unnamed Tributary). Future PCB-related service losses through 2106 for each sub-section are assumed to attenuate to zero.

EXHIBIT 4-1 ANNUAL PERCENTAGE SEDIMENT SERVICE LOSS FROM PCBS FOR EACH SUB-SECTION OF THE ASSESSMENT AREA (1981-2010)[2]

ASSESSMENT AREA SUB-SECTION [1]	ANNUAL PERCENTAGE SERVICE LOSS (1981-2010)[2]
Raquette River	10%
Power canal	5%
Unnamed Tributary - Pre-Remedy (1981-1999)	39%
Unnamed Tributary - Post-Remedy (2000-2010) [3]	9%
Robinson Creek	9%
RMC Remediation Area - Pre-Remedy (1981-2009) [4]	100%
RMC Remediation Area - Post-Remedy (2010) [3]	9%
St. Lawrence River Around RMC	3%

[14] The relationship is based on the log sediment PCB concentration.

[15] Sediment concentrations in St. Lawrence River sub-sections are baseline-adjusted.

ASSESSMENT AREA SUB-SECTION [1]	ANNUAL PERCENTAGE SERVICE LOSS (1981-2010)[2]
RMC To Ship Channel	8%
GM Remediation Area – Pre-remedy (1981-1995) [4]	100%
GM Remediation Area – Post-remedy (1996-2010)	9%
St. Lawrence Around GM	4%
GM To Ship Channel	3%
Turtle Cove/Creek – Pre-remedy (1981-2005)	86%
Turtle Cove/Creek – Post-remedy (2006-2010) [3]	9%
Grasse River [5]	100% - 39%

Notes:

[1] Sub-sections upstream of the Facilities are not included, as contaminated sediments are unlikely to move against the prevailing hydrologic flow.

[2] Annual percentage service losses are for each year from 1981 through 2010 except in areas where remedial actions have been completed or are on-going, and in the Grasse River as noted below. Average annual PCB concentrations adjusted for baseline conditions in the St. Lawrence River.

[3] Average annual PCB concentrations for Unnamed Tributary, RMC remediation area, and Turtle Cove/Creek post-remedy are estimated based on the post-remedy PCB concentration reported for sediments in the GM remediation area.

[4] Pre-remedy service losses for RMC and GM remediation areas are assumed to be 100 percent due to PCBs, PAHs, and other COCs.

[5] Sediment service losses for the Grasse River are presented as a range because data were sufficient to evaluate PCB concentrations and associated service losses per year.

Calculate Present Value Losses

The percentage service loss per year for each sub-section is multiplied by the acreage of that sub-section to generate DSAYs for 1981-2106, and the present value (in 2010) of these lost acres is calculated using a discount rate of three percent.[16] Results indicate a loss of sediment services resulting from PCB contamination equal to approximately 24,223 DSAYs (Exhibit 4-2).

[16] This is a standard discount rate and is typically used in NRDAR (Freeman 1986, NOAA 1999).

EXHIBIT 4-2 LOST SEDIMENT DSAYS DUE TO PCBS (1981-2106)

ASSESSMENT AREA SUB-SECTION	LOST SEDIMENT DSAYS
Raquette River	2,059
Power Canal	305
Unnamed Tributary	89
Robinson Creek	161
RMC Remediation Area[1]	1,577
St. Lawrence River Around RMC	596
RMC To Ship Channel	301
GM Remediation Area[1]	297
St. Lawrence Around GM	2,256
GM To Ship Channel	414
Turtle Cove/Creek	439
Grasse River	15,729
Total	**24,223**

Notes:
Lost DSAYS in present value 2010.
Total may not sum due to rounding.
[1] Lost sediment DSAYs for RMC and GM remediation areas are due to PCBs, PAHs, and other COCs.

4.2.3 PAHS AND FLUORIDE

In addition to the PCB losses described above, sediment resources in some sub-sections of the assessment area were also exposed to PAHs and/or fluoride. These additional losses were estimated by evaluating the toxicity, based on site-specific and literature-based studies, of average PAH and fluoride concentrations on benthic organisms. Details are provided in Appendix D.

Determine Sediment PAH and Fluoride Concentration: 1981-2009

The average PAH and fluoride concentrations in sediment in each section of the assessment area were calculated using available surface sediment data (i.e., 0-20 cm) from 1981 to 2009 (Exponent 2006) or modeled for years without data.

Model Sediment PAH and Fluoride concentration: 2010-2106

Similar to PCBs, due to the physical and chemical properties of PAHs and fluoride, future concentrations of these contaminants are likely to decline slowly without remedial actions (i.e., natural attenuation in sediments is slow (Eisler 1987)). Within the assessment area, remedial activities have been completed (e.g., GM Remediation Area), final remedies have yet to be selected (e.g., Grasse River), or are not planned (e.g., Robinson Creek).

Estimate Service Losses

Service losses to sediment-dwelling organisms resulting from PAH and fluoride contamination in the assessment area are estimated by evaluating the weight-of-evidence provided by studies in the peer-reviewed literature regarding the severity and magnitude of effects associated with a range of concentrations. Site-specific losses were then estimated by comparing the average PAH and fluoride sediment concentrations in each assessment area sub-section to adverse effects thresholds and associated service losses.. Two exceptions were the RMC remediation area and the GM remediation area, where sediment service losses are assumed to be 100 percent through the completion of remedial activities. This is due to the high concentrations of PCBs, PAHs, fluoride, and other contaminants in sediment.

Annual service losses for each sub-section of the assessment area from 1981 through 2010 are presented in Exhibit 4-3. Past service losses for PAHs and fluoride are constant for assessment area sub-sections every year except for the Grasse River. Future PAH and fluoride-related service losses attenuate to zero in just under 100 years (2106); losses for remediated sub-sections are assumed to be zero post-remedy.

EXHIBIT 4-3 PERCENTAGE SEDIMENT SERVICE LOSS DUE TO PAHS AND FLUORIDE (1981-2010)

ASSESSMENT AREA SUB-SECTION	ANNUAL PERCENTAGE SERVICE LOSS[1]	
	PAHS	FLUORIDE
Grasse River	≤20%	≤6%
Power Canal	≤9%	9.5%
Downstream of Robinson Creek	--	10%
Robinson Creek	--	9%
RMC Remediation Area – Pre-Remedy (1981-2009)	100%[2]	100%[2]
RMC Remediation Area – Post-Remedy (2010)	0%[3]	0%[3]
GM Remediation Area – Pre-remedy (1981-1995)	100%[2]	--
GM Remediation Area – Post-remedy (1996-2009)	0%[3]	--
Total		

Notes:

[1] The percentage service losses reported are applied to the services remaining after injury due to other contaminants is quantified. For example, if injury due to PCBs is 80 percent and injury due to PAHs is ten percent, the ten percent loss is only applied to the 20 percent of services remaining. That is, service losses for multiple contaminants are not additive in the absolute sense.

[2] These areas were assigned 100% injury due to PCBs, PAHs and other COCs (see Exhibit 4-1).

[3] Post-remedy service loss due to PAHs and/or fluoride is assumed to be zero percent. Post-remediation PAH data was not available when analyses conducted.

-- indicates that injury was not quantified (e.g., due to insufficient data).

Calculate Present Value Losses

The percentage service loss for each contaminant per year (1981-2106) for each sub-section is multiplied by the acreage of that sub-section to generate DSAYs, and the present value of these lost acres is calculated using a discount rate of three percent. The percentage service losses reported above are applied to the services remaining after injury due to other contaminants is quantified. For example, if injury due to PCBs is 80 percent and injury due to PAHs is ten percent, the ten percent loss is only applied to the 20 percent of services remaining. That is, service losses for multiple contaminants are not additive in the absolute sense. Results indicate a loss of sediment services equal to approximately 5,361 DSAYs due to PAHs, and approximately 2,768 DSAYs due to fluoride (Exhibit 4-4).

EXHIBIT 4-4 LOST SEDIMENT DSAYS DUE TO PAHS AND FLUORIDE (1981-2106)

ASSESSMENT AREA SUB-SECTION	LOST DSAYS (1981-2106)	
	PAHS	FLUORIDE
Grasse River	4,804	1,406
Power Canal	557	614
Downstream of Robinson Creek *	--	588
Robinson Creek	--	158
RMC Remediation Area – Pre-Remedy (1981-2009)	No additional DSAYs calculated because service losses are already estimated as 100 percent.	
GM Remediation Area – Pre-Remedy (1981-1995)		
Total	**5,361**	**2,768**

Notes:
-- indicates that injury was not quantified (e.g., due to insufficient data).
Lost DSAYs in present value 2010.
Totals may not sum due to rounding.
* Only included depositional area at mouth of Robinson Creek, as data were insufficient to characterize the entire sub-section. Depositional area (i.e., Western basin) based on bathymetry (approximately two to 12-foot depth near mouth of Robinson Creek).

4.2.4 FISH

Fish are an integral ecological component of aquatic ecosystems, and serve as a link between aquatic and semi-aquatic biota. Occupying multiple trophic levels, fish provide ecological services such as nutrient cycling, benthic community control, and food web sustainability. Service losses to fish resulting from contamination in the assessment area were quantified for PCBs; data were insufficient to quantify losses due to PAHs, aluminum, cyanide, or fluoride (Appendix D). PCB-induced losses were estimated using the weight-of-evidence from the peer-reviewed literature that described PCB concentrations in fish and the severity and magnitude of the corresponding adverse effect.

This includes the following steps:

1. Calculate past whole body fish PCB concentrations using measured or modeled data (1981-2009).
2. Model future whole body fish PCB concentrations in years 2010-2106.
3. Estimate the loss for fish due to PCBs for each sub-section of the assessment area for each year of the analysis (1981-2106).
4. Calculate the present value of fish losses in discount service-acre years (DSAYs) in 2010 for each sub-section of the assessment area using a three percent discount rate.
5. Sum the present value acres lost over time to estimate the DSAYs lost for the entire assessment area.

Determine Past Fish PCB Concentration: 1981-2009

The average PCB concentration in fish in each sub-section of the assessment area was calculated using data from 1981 to 2009 (Exponent 2006, Alcoa 2010). Data for the Grasse River were sufficient to evaluate concentrations by year for three species;[17] data for each of the remaining sub-sections were combined across years and species.[18] Remedial actions in relevant sub-sections are taken into account (i.e., data are split into pre- and post-remedy years for the GM remediation area, RMC remediation area, Unnamed Tributary, and Turtle Cove/Creek). In addition, the St. Lawrence River baseline PCB concentration of 0.52 ppm is subtracted from the average annual PCB concentration for each assessment area sub-section within the St. Lawrence River. Losses are evaluated using the resulting baseline-adjusted concentrations.

Model Fish PCB Concentrations: 2010-2106

Within the assessment area, remedial activities have been completed (e.g., GM Remediation Area), have not been selected yet (e.g., Grasse River), or are not planned (e.g., St. Regis River). Due to the physical and chemical properties of PCBs, it is unlikely that PCB concentrations will decline rapidly in the future without remedial actions (e.g., PCBs are expected to take decades to be eliminated from the food chain to any significant degree since sediment concentrations are not expected to decline rapidly; Stow et al. 2004, 1995; Exponent 2003).

Estimate Service Losses

Service losses to fish resulting from PCB contamination in the assessment area were estimated by evaluating the weight-of-evidence provided by studies in the peer-reviewed literature regarding the severity and magnitude of effects associated with a range of PCB

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[17] Year data gaps in fish PCB concentrations for the Grasse River were filled using a regression model of fish concentrations per year from 1977-2009.

[18] One sub-section (GM to Ship Channel) has little or no data available. Fish in this sub-section are assumed to have PCB concentrations similar to fish in the closest sub-section with fish tissue data.

concentrations. Site-specific losses were then estimated by relating the average fish PCB concentration in each assessment area sub-section to the corresponding service losses.

Annual service losses for each sub-section of the assessment area from 1981 through 2010 are presented in Exhibit 4-5. Service losses are constant every year except for the Grasse River where monitoring data for three fish species were sufficient for temporal calculations and those sub-section assessment areas with completed or on-going remedial activities. PCB-related service losses estimated for 2009 for each sub-section are assumed to attenuate to zero by 2106.

EXHIBIT 4-5 ANNUAL PERCENTAGE FISH SERVICE LOSS FOR EACH SUB-SECTION OF THE ASSESSMENT AREA (1981-2010)

ASSESSMENT AREA SUB-SECTION	ANNUAL PERCENTAGE SERVICE LOSS (1981-2010)[2]
Moses Saunders/Polly's Gut	15%
Raquette River	15%
Power Canal	5%
Unnamed Tributary - Pre-Remedy (1981-1999)	10%
Unnamed Tributary - Post-Remedy (2000-2009) [3]	1%
Robinson Creek	5%
RMC Remediation Area - Pre-Remedy (1981-2009) [4]	100%
RMC Remediation Area - Post-Remedy (2010) [3]	5%
St. Lawrence River Around RMC	15%
RMC To Ship Channel	10%
GM Remediation Area - Pre-remedy (1981-1995) [4]	100%
GM Remediation Area - Post-remedy (1996-2009)	5%
St. Lawrence Around GM	15%
GM To Ship Channel	15%
Turtle Cove/Creek - Pre-remedy (1981-2005)	75%
Turtle Cove/Creek - Post-remedy (2006-2009) [3]	5%
St. Regis River	10%
Grasse River[1]	50% - 5%

ASSESSMENT AREA SUB-SECTION	ANNUAL PERCENTAGE SERVICE LOSS (1981-2010)[2]
Notes:	
[1] Fish service losses for the Grasse River are presented as a range because data were sufficient to evaluate PCB concentrations and associated service losses by year.	
[2] Annual percentage service losses are for each year from 1981 through 2010 except where noted in areas where remedial actions have been completed or are on-going. Average annual PCB concentrations adjusted for baseline conditions in the St. Lawrence River, where applicable.	
[3] Average annual PCB concentrations for RMC remediation area, and Turtle Cove/Creek post-remedy are estimated based on the post-remedy PCB concentration reported for fish in the GM remediation area.	
[4] Pre-remedy service loss for RMC and GM remediation areas assumed to be 100 percent due to PCBs, PAHs, and other COCs.	

Calculate Present Value Losses

The percentage service loss per year (1981-2106) for each sub-section is multiplied by the acreage of that sub-section to obtain DSAYs, and the present value (in 2010) of these lost acres is calculated using a discount rate of three percent. Results indicate a loss of fish services equal to approximately 31,047 DSAYs (Exhibit 4-6).

EXHIBIT 4-6 LOST FISH DSAYS DUE TO PCBS (1981-2106)

ASSESSMENT AREA SUB-SECTION	LOST FISH DSAYS
Moses Saunders/Polly's Gut	3,711
Raquette River	3,039
Power Canal	321
Unnamed Tributary	20
Robinson Creek	87
RMC Remediation Area	1,547
St. Lawrence River Around RMC	3,318
RMC To Ship Channel	392
GM Remediation Area	281
St. Lawrence Around GM	9,440
GM To Ship Channel	93
Turtle Cove/Creek	373
St. Regis River	1,360
Grasse River	7,064
Total	**31,047**
Notes:	

ASSESSMENT AREA SUB-SECTION	LOST FISH DSAYS
Lost DSAYs in present value 2010. Total may not sum due to rounding.	

4.2.5 BIRDS

Avian resources utilize the aquatic habitat for foraging and breeding. Rivers provide food items such as vegetation, insects, and fish. Birds also fill essential roles in the aquatic foodweb, serving as both predators and prey and assisting with nutrient cycling and trophic energy transfer. Service losses to birds resulting from contamination in the assessment area were quantified for PCBs; data were insufficient to quantify losses due to PCDDs and PCDFs (Appendix D). PCB-induced avian losses were estimated based on the weight-of-evidence from the peer-reviewed literature of impacts to four bird species, each representing a different foraging guild: common tern (small piscivores), osprey (large piscivores), mallard (herbivores), and tree swallow (aerial insectivores).[19]

This includes the following steps:

1. Develop species-specific dietary dose models for the four representative species.
2. Apply site-specific sediment and fish concentrations in each sub-section of the assessment area for each year of the analysis (1981-2009) to the dietary dose models.
3. Develop a correspondence between PCB dose, adverse effects, and service losses based on information from the peer-reviewed literature.
4. Estimate service losses and DSAYs for each sub-section of the assessment area for each representative bird species for each year of the analysis (1981-2106).
5. Average the DSAYs across the four representative species to estimate an overall avian injury for each sub-section and each year.
6. Calculate the present value of bird losses in 2010 for each subsection assessment area using a three percent discount rate.
7. Sum the present value acres lost over time to estimate the DSAYs lost for the entire assessment area.

Dietary Dose Model

To estimate the exposure of avian resources to PCBs in the assessment area, a dietary dose model was developed for each representative species, assuming that exposure to PCBs is via food only (i.e., not water or sediment). Models were developed using species-specific body weight and ingestion rate information.

[19] These species may not represent the range in sensitivity to PCBs of the overall avian community in the assessment area.

Site-specific sediment and fish concentrations for each sub-section in each year of the analysis (1981-2009), along with species-specific dietary information were then used to estimate dietary dose of PCBs.

- *Tree swallow*. Consume insects (EPA 1993). Because site-specific insect data are not available, a biota-sediment accumulation factor of 1.42 (Pickard et al. 2001, Gewurtz et al. 2000, Burzynski 2000, Baron et al. 1999, Froese et al. 1998) was used to convert sediment PCB concentrations (as described in Chapter 3) to insect PCB concentrations.
- *Mallard*. Consume vegetation (EPA 1993). Because site-specific vegetation data are not available, a biota-sediment accumulation factor of 0.12 (Vanier et al. 1999, Richard 1997) was used to convert sediment PCB concentrations (as described in Chapter 3) to vegetation PCB concentrations.
- *Common tern*. Consume fish less than 15 cm in length (Nisbet 2002). Data from Exponent (2006) was used to estimate PCB concentrations in fish in that size-class.
- *Osprey*. Consume fish greater than 10 cm in length (Poole et al. 2002, Van Daele and Van Daele 1982). Data from Exponent (2006) was used to estimate PCB concentrations in fish in that size-class.

Input of these data and parameters into the model resulted in an estimate of the dietary dose of PCBs (mg PCBs/kg body weight/day) for each sub-section for each year of the analysis.

Service Losses

Service losses to birds resulting from PCB contamination in the assessment area were estimated by evaluating the weight-of-evidence provided by studies in the peer-reviewed literature regarding the severity and magnitude of effects associated with a range of PCB doses. Site-specific losses were then estimated by comparing the average PCB dose for each representative species in each assessment area sub-section to adverse effects thresholds and associated service losses. Overall avian service losses were estimated as the averge percentage service loss across all four species.[20]

Annual service losses for each sub-section of the assessment area from 1981 through 2010 are presented in Exhibit 4-7. Service losses are constant every year except for the Grasse River and those areas with completed or on-going remedial activities. Future PCB-related service losses for each sub-section are assumed to attenuate to zero by 2106.

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[20] For assessment area sub-sections in Canada, losses to mallards and swallow, species whose food contaminant loads are directly tied to Canadian sediment (i.e., mallards consume vegetation and terns consume aquatic insects) are assumed to be zero for purposes of estimating a claim for natural resource damages (losses are only claimed for resources that are mobile and can actively cross the international border). For purposes of damage estimation, mallard and swallow losses are also assumed to be zero in assessment area sub-sections upstream of the Facilities, as contaminated sediments are unlikely to move against the prevailing hydrologic flow.

EXHIBIT 4-7 ANNUAL PERCENTAGE AVIAN SERVICE LOSS DUE TO PCBS FOR EACH SUB-SECTION OF THE ASSESSMENT AREA (1981-2010)

ASSESSMENT AREA SUB-SECTION [1]	ANNUAL PERCENTAGE SERVICE LOSS (1981-2010)[2]				
	TREE SWALLOW [4]	MALLARD [4]	COMMON TERN	OSPREY	AVERAGE [5]
Moses Saunders/Polly's Gut	NA	NA	0%	14%	4%-3%
Raquette River	46%	0%	0%	14%	15%
Power Canal	27%	0%	14%	0%	10%
Unnamed Tributary - Pre-Remedy (1981-1999)	100%	0%	14%	0%	29%
Unnamed Tributary - Post-Remedy (2000-2009) [3]	27%	0%	14%	0%	10%
Robinson Creek	46%	0%	0%	0%	12%-11%
RMC Remediation Area – Pre-Remedy (1981-2009)	100%	5%	14%	27%	37%
RMC Remediation Area – Post-Remedy (2010) [3]	46%	0%	14%	0%	15%
St. Lawrence River Around RMC	14%	0%	46%	27%	22%
RMC To Ship Channel	27%	0%	5%	5%	9%
GM Remediation Area – Pre-remedy (1981-1995)	100%	100%	46%	46%	73%
GM Remediation Area – Post-remedy (1996-2009)	46%	0%	14%	0%	15%
St. Lawrence Around GM	14%	0%	0%	14%	7%
GM To Ship Channel	14%	0%	0%	14%	7%
Turtle Cove/Creek - Pre-remedy (1981-2005)	100%	14%	100%	100%	79%
Turtle Cove/Creek - Post-remedy (2006-2009) [3]	46%	0%	14%	0%	15%
St. Regis River	NA	NA	0%	5%	1%
Grasse River	100%-99%	14% - 0%	100% - 5%	83% - 5%	74% - 29%

Notes:

[1] Avian service losses for the Grasse River are presented as a range because data were sufficient to estimate doses for individual years.

[2] Annual percentage service losses are for each year from 1981 through 2010 except in areas where remedial actions have been completed or are on-going, and for the Grasse River as noted above. Average annual PCB concentrations adjusted for baseline conditions in the St. Lawrence River, where applicable.

[3] Average annual PCB concentrations for Unnamed Tributary, RMC remediation area, and Turtle Cover/Creek post-remedy are estimated based on the post-remedy PCB concentration reported for fish in the GM remediation area.

[4] Service losses to avian species with food webs tied to sediment (i.e., tree swallows and mallards) are not included in areas where it is unlikely Facility-related contaminants have come to be located in the sediment (i.e., Moses Saunders/Polly's Gut and St. Regis River).

[5] Average assumes NA = 0% because losses are estimated for the overall bird community; if loss to a species is not included in the damage claim (e.g., St. Regis River), then that species' loss is not incorporated into the overall loss to the avian community. Average may not calculate due to rounding.

Calculate Present Value Losses

Ecological service losses to avian resources within the assessment area are quantified by using the following steps:

1. Multiply the average avian service loss per year for each sub-section by the area (acres) of that sub-section to generate DSAYs.

2. Calculate the present value (in 2010) of the lost acres for each sub-section assessment area using a three percent discount rate.
3. Sum the present value acres lost over time to estimate DSAYs lost over the entire assessment area.

Results indicate a loss of avian services equal to approximately 29,278 DSAYs (Exhibit 4-8).

EXHIBIT 4-8 LOST AVIAN DSAYS (1981-2106) DUE TO PCBS

ASSESSMENT AREA SUB-SECTION	LOST AVIAN DSAYS
Moses Saunders/Polly's Gut	866
Raquette River	3,039
Power Canal	659
Unnamed Tributary	70
Robinson Creek	199
RMC Remediation Area	663
St. Lawrence River Around RMC	4,811
RMC To Ship Channel	363
GM Remediation Area	247
St. Lawrence Around GM	4,405
GM To Ship Channel	43
Turtle Cove/Creek	421
St. Regis River	170
Grasse River	13,321
Total	**29,278**

Notes:
Lost DSAYs in present value 2010.
Total may not sum due to rounding.

4.2.6 ON-SITE INJURY

In addition to injury to assessment area avian resources, birds utilizing habitat within Facility boundaries have also likely been injured due to contamination. Quantification of these injuries focused on areas: 1) with sufficient habitat to support birds, 2) where birds have been reported, and 3) where contamination in birds either has been documented or is likely because contaminant concentrations are high enough to require remedial action. For example, FWS issued at least one permit allowing the harassment of waterfowl at the 60-Acre Lagoon, the RMC wetlands have and continue to support avian use, and a study of mallards on-site indicates exposure to site-specific contaminants, including PCBs

(CDM 1994; Engineering-Science 1991, 1989, 1987; Woodward-Clyde 1990; EPA 2003). Therefore, the areas in which injury has been quantified include the 60-acre Lagoon, East and West Marshes, and the RMC Wetlands (Exhibit 4-9).[21]

EXHIBIT 4-9 EXAMPLE CONTAMINANT CONCENTRATIONS (PRE-REMEDY) IN ON-SITE AREAS THAT LIKELY PROVIDE AVIAN HABITAT FOR WHICH INJURY IS ASSESSED

ON-SITE AREA	ACRES	CONTAMINANT	MAXIMUM CONCENTRATION PRE-REMEDY (MEDIA)
60-Acre Lagoon	83	Aluminum	15,600 ppm (sediment)
		Cyanide	89.4 ppm (sediment)
		PAHs	7,495 ppm (sediment)
		PCBs	289 ppm (sediment)
West Marsh	3	Aluminum	44,100 ppm (sediment)
		Cyanide	52.8 ppm (sediment)
		PCBs	29,000 ppm (sediment)
East Marsh	4	Aluminum	32,800 ppm (sediment)
		Cyanide	5 ppm (sediment)
		PCBs	24.7 ppm (sediment)
RMC Wetlands	50	Cyanide	91 ppm (sediment)
		PCBs	31,000 ppm (sediment) 690 ppm (soil)
Note: Sources: CDM (1994), Engineering-Science (1991, 1989, 1987), Woodward-Clyde (1990).			

Losses to birds in these areas are based on the following assumptions:

- Lagoon and marsh habitats are expected to provide services (e.g., feeding, resting, and nesting habitat) for birds in all guilds, including tree swallows, mallards, common tern, and osprey.
- Injury has likely occurred from at least 1981 though the completion of the remedy for each on-site location.
- Because of the significant time and effort required to undertake a detailed injury and damage assessment for on-site locations, a 100 percent loss in avian services is assumed for contaminated areas that provided habitat. This is supported by contaminant data (Exhibit 4-9).

The percentage service loss per year for each on-site area is multiplied by the acreage of that area to generate DSAYs, and the present value of these lost acres is calculated using

[21] More detail on these areas can be found in (EPA 2003).

a discount rate of three percent. Results indicate a loss of avian services equal to approximately 4,745 DSAYs (Exhibit 4-10).

EXHIBIT 4-10 LOST AVIAN DSAYS ON-SITE (PCBS, PAHS, ALUMINUM, CYANIDE)

ON-SITE AREA	YEARS OF LOSS [1]	LOST AVIAN DSAYS
60-Acre Lagoon	1981-2000	2,997
West Marsh	1981-1993	77
East Marsh	1981-2000	72
RMC Wetlands	1981-1997	1,598
Total [2]		**4,745**

Notes:
[1] Indicates years for which losses are quantified - 1981 through completion of the remedy.
Lost DSAYs are present value 2010.
[2] Total may not sum due to rounding.

4.2.7 MAMMALS (SEMI-AQUATIC AND TERRESTRIAL)

Mammals, both semi-aquatic (e.g., mink), and terrestrial (e.g., shrews) utilize assessment area habitat for all aspects of life. Rivers provide food items such as vegetation, insects, amphibians, and fish. Upland areas provide denning opportunities as well as additional foraging habitat. Mammals also fill essential roles in the aquatic and terrestrial foodwebs, serving as both predators and prey and assisting with nutrient cycling and trophic energy transfer. Service losses to mammals resulting from contamination in the assessment area were quantified for fluoride (Appendix H); data were insufficient to quantify losses due to PCBs (Appendix F). Losses due to fluoride were estimated based on consumption of contaminated vegetation.

This includes the following steps:

1. Review fluoride concentrations in assessment area vegetation.
2. Determine geographic scope of fluoride contamination.
3. Estimate service losses based on adverse effects as reported in the literature.
4. Assign a service loss for each geographic area for each year (1981-2009).
5. Calculate DSAYs for each geographic area for each year (1981-2009).
6. Calculate the present value of losses in 2010.
7. Sum the present value acres lost over time to estimate the DSAYs lost.

Fluoride Concentrations in Vegetation

Concentrations of fluoride in assessment area vegetation are summarized in Exhibit 4-11. Where data for a given year are not available, the concentration is estimated as the average concentration of the closest previous and following years.

Geographic Scope

There are two areas that data indicate have been contaminated with fluoride from the Alcoa and RMC facilities, including an area near Alcoa and an area near RMC (Exhibit 4-12). The aerial extent of these areas is calculated based on the estimated size of contaminated air plumes and associated deposition. The Alcoa area is approximately 1,358 acres and the RMC area is approximately 1,071 acres.

EXHIBIT 4-11 AVERAGE CONCENTRATION OF FLUORIDE IN VEGETATION PER YEAR (PPM)

YEAR	ALCOA	RMC
1981	*42*	*71*
1982	*42*	*71*
1983	*42*	*71*
1984	*42*	*71*
1985	*42*	*71*
1986	*42*	*71*
1987	*42*	*71*
1988	*42*	*71*
1989	38	56
1990	68	46
1991	92	32
1992	71	22
1993	51	36
1994	52	46
1995	64	24
1996	86	17
1997	69	42
1998	*42*	*17*
1999	*2*	*17*
2000	14	8
2001	48	11
2002	51	15
2003	28	17
2004	36	5
2005	*36*	*5*
2006	*36*	*5*
2007	*36*	*5*
2008	*36*	*5*
2009	*36*	*5*

Notes:

Italics indicate estimated concentration.

Sources: SRMT (2007, 2005), NYSDEC (1997), Emerson (1985), Miles (1981) as cited in Rice (1983).

Service Losses

Weight-of-evidence from the peer-reviewed literature was used to assign service losses to ranges of fluoride concentrations in vegetation (Exhibit 4-13).

Temporal Scope

This analysis focused on past injury (1981-2009) to mammals from fluoride exposure. Data indicated that concentrations of fluoride in vegetation near RMC have declined over time. For example, current concentrations of fluoride in vegetation near RMC are below those that would cause injury to mammals. Average fluoride concentrations in vegetation near Alcoa, however, do not appear to have declined between 1981 and 2004. Because future concentrations of fluoride in assessment area vegetation are uncertain, this analysis does not quantify future injury.

EXHIBIT 4-12 GEOGRAPHIC SCOPE OF ASSESSMENT OF MAMMAL INJURY FROM FLUORIDE

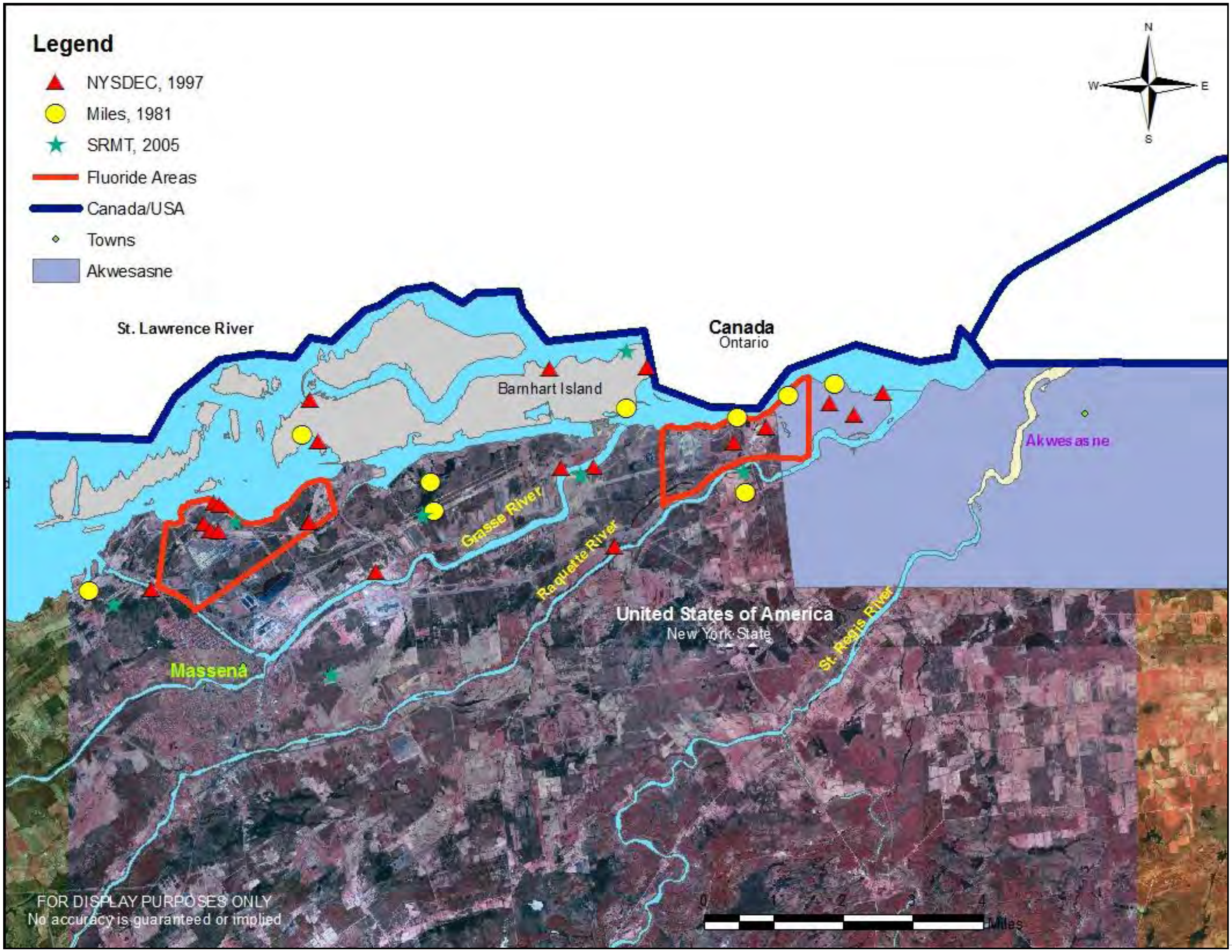


EXHIBIT 4-13 FLUORIDE CONCENTRATION IN VEGETATION AND ASSOCIATED SERVICE LOSSES

FLUORIDE CONCENTRATION IN VEGETATION (PPM)	PERCENTAGE ECOLOGICAL SERVICE LOSS	EXAMPLE ADVERSE EFFECTS
0-20	0%	Effects may occur but are not expected to cause a loss in ecological services
>20-40	5-10%	Adverse effects on herbivorous mammals: weight loss, bone and dental changes, and fatal intoxication (e.g., guinea pigs and deer mice; Cooke et al 1996, Newman and Markey 1976)
>40-60	10-15%	NYSDEC 6 month and 60-day forage effects thresholds.
>60-100	15-25%	Marked dental fluorosis and has led to death after two to three months of dietary exposure in experimental field voles, mortality in rabbits and field voles (Boulton et al. 1994, Davis 1961). NYSDEC 30-day forage effects threshold.
>100-187	25-40%	Significant impacts to mice and voles (e.g., depression, arched backs, dental lesions). Maximum concentration allowed to sustain breeding in mink (Boulton et al. 1994, Schupe et al. 1987, Mehdi et al. 1978).
>187-300	40-60%	Decreased blood copper and calcium, lower packed cell volume in sheep. Mortality 28 days mice (Boulton et al. 1994, Mehdi et al. 1978).
>300-600	60-100%	Severe dental lesions and mortality in field voles (Boulton et al. 1994).
>600	100%	Substantial and rapid mortality in field voles and deer mice (Newman and Markey 1976).

Injury Quantification

Average fluoride concentrations in vegetation in each of the three geographic areas (Exhibit 4-12) were compared per year to toxicological information and assigned service losses (Exhibit 4-13). Losses were then multiplied by the acreage for each corresponding area. Applying a three percent discount rate, results indicate approximately 12,115 DSAYs lost from 1981-2009 for mammals (Exhibit 4-14).

EXHIBIT 4-14 LOST MAMMAL DSAYS DUE TO FLUORIDE (1981-2009)

YEAR	PERCENTAGE SERVICE LOSS		LOST DSAYS	
	ALCOA	RMC	ALCOA	RMC
1981	11%	18%	336	448
1982	11%	18%	326	435
1983	11%	18%	317	422
1984	11%	18%	308	410
1985	11%	18%	299	398
1986	11%	18%	290	386
1987	11%	18%	281	375
1988	11%	18%	273	364
1989	10%	14%	240	279
1990	17%	12%	417	222
1991	23%	8%	548	150
1992	18%	6%	410	100
1993	13%	9%	286	159
1994	13%	12%	283	198
1995	16%	6%	339	100
1996	22%	0%	442	0
1997	17%	11%	344	165
1998	11%	0%	203	0
1999	11%	0%	197	0
2000	0%	0%	0	0
2001	12%	0%	213	0
2002	13%	0%	219	0
2003	7%	0%	117	0
2004	9%	0%	146	0
2005	9%	0%	142	0
2006	9%	0%	138	0
2007	9%	0%	134	0
2008	9%	0%	130	0
2009	9%	0%	126	0
Sub-Total Past Loss			**7,502**	**4,613**
Total Past Loss				**12,115**

Notes:
Fluoride concentrations are assigned a service losses based on a linear extrapolation of service loss across a given concentration range (i.e., rather than assign one percentage service loss to an entire concentration range).
DSAYS = Discount service-acre years.
Lost DSAYs in present value 2010.

4.2.8 INJURIES ASSESSED QUALITATIVELY

As a result of exposure to Facility-related COCs, natural resources in the assessment area have likely incurred injuries in addition to those quantified above. For example, PCB concentrations in amphibians and reptiles are sufficient to have caused adverse effects.

Evidence for these injuries has been described above in Section 3.3, and in Appendices E, F, G, and H. However, available data are insufficient to quantify the loss in ecological services that corresponds to these additional injuries. Therefore, these injuries will be addressed qualitatively in the context of restoration (Exhibit 4-15). The Trustees will ensure that restoration projects provide benefits to resources such as amphibians, reptiles, and beluga (qualitatively assessed injury) in addition to those resources assessed using the DSAY-based injury quantification described above. Chapter 5 provides additional details on restoration project selection.

EXHIBIT 4-15 POTENTIAL ECOLOGICAL INJURIES EVALUATED QUALITATIVELY

RESOURCE	CONTAMINANT
Sediment	Aluminum
Fish	Aluminum
	Cyanide
Amphibians and Reptiles	PCBs
Birds	PCDD/PCDF
Mammals	PCBs

4.2.9 RESIDUAL INJURIES FROM IMPLEMENTED OR PLANNED REMEDIAL ACTIONS

Remediation within the assessment area (Grasse, Raquette, and St. Lawrence Rivers; Unnamed Tributary; Turtle Cove/Creek) and on Facility properties is expected to reduce the total mass of contaminants to which trust resources within the St. Lawrence ecosystem could be exposed. One by-product of remedial activities, however, is physical damage to remediated areas. These adverse impacts are considered compensable injuries under the DOI regulations (43 CFR 11.15 (a)(1)).

The degree of remedy-induced injury depends on the natural resources impacted and the spatial and temporal scope of those impacts. In some cases, remedial injury can be reduced or minimized through sensitive approaches to remedial design and implementation, including habitat mitigation that integrates remediation and restoration. For example, at RMC, a habitat layer was constructed on top of the armored stone PAH and PCB caps to provide finer substrate for invertebrates and rooting aquatic vegetation. Where this type of approach has not been applied, injuries can be quantified and restoration costs and or projects identified to compensate for those injuries.

In areas where remedies have yet to be selected, such as the Grasse River, the Trustees could negotiate agreements with the PRPs to incorporate mitigation/restoration into the remedial design, or pursue injury for worst case scenarios (e.g., construction of ice control structure, armoring of shoreline, capping of river bottom, loss of wetland and submerged aquatic vegetation habitat).

To-date, portions of the GM remedy have been implemented, some of which the Trustees contend require compensation (Exhibit 4-16).

- In 1995, St. Lawrence River nearshore areas were excavated, deeper areas were dredged, the shoreline was riprapped (10-15 ft wide), the bank was replanted with grass, and a 1.72-acre armored cap was installed to address residual PCBs averaging 27 ppm (BBL 1996a,b). Additional stone was added to the cap in 1996-1998, 2003-2005, and 2007 (Arcadis 2009). Hardening of the river with shifting angular stone adversely and permanently harms the river bottom. Assuming 85 percent service losses from 1996 (year remedy was completed) in perpetuity and applying a three percent discount rate results in approximately 80 DSAYs of loss.
- An approximately 1.57-acre freshwater wetland was excavated during GM's 2005 remediation of Turtle Cove/Creek, and the shoreline was subsequently armored (Kimball 1995). To-date, no wetland mitigation has been conducted, and GM's bankruptcy suggests the Trustees are not assured of mitigation under the remedy. Assuming 90 percent service loss from 2005 (year remedy was completed) in perpetuity and applying a three percent discount rate results in approximately 55 lost DSAYs.
- Remediation of approximately 1.4 acres of Raquette River bank soils required removal of mature deciduous trees and a hardening of the shoreline with riprap (Arquette 2008, BBL 2004). Mitigation consisted of planting a monoculture of red-osier dogwood (*Cornus sericea*) a deciduous shrub that achieves maximum growth of 12 feet in 20 years (USDA 2009, BBL 2004). Subsequently, the Trustees negotiated with GM to plant willow whips along the shoreline; these were installed in April 2008. These actions, however, do not fully compensate for the ecological services lost due to the replacement of a diverse mix of mature trees along this steep embankment with a monoculture, or for the time required for planted shrubs to reach maturity. Assuming an initial 50 percent loss in services until planted shrubs reach maturity (2025), and a 25 percent loss through 2055, and applying a three percent discount rate, the Trustee estimate approximately 14 lost DSAYs.
- A total of 26,100 square feet (0.6 acres) of shoreline was hardened in 2003 as part of remedial actions at GM. This area was comprised of approximately 3,600 square feet (0.08 acres) along the St. Lawrence River armored during the Inactive Lagoon remediation, and another 22,500 square feet (0.52 acres) of shoreline armored during Raquette River remediation. Assuming an initial 100 percent loss declining to a 90 percent loss by 2017, assuming the 90 percent loss continues in perpetuity, and applying a three percent discount rate, the Trustees estimate approximately 23 lost DSAYs.
- Remediation in the Raquette River also resulted in hardening of approximately 0.26 acres of river bottom with four- to seven-inch stone in 2003. Assuming an initial 100 percent loss declining to an 85 percent loss by 2017, assuming the 85 percent loss continues in perpetuity, and applying a three percent discount rate, the Trustees estimate approximately 10 lost DSAYs.

EXHIBIT 4-16 QUANTIFIED REMEDIAL-INDUCED INJURY

REMEDIAL ACTION	LOST DSAYS
St. Lawrence River Cap	80
Turtle Cove/Creek Wetland	55
Raquette River Bank	14
Shoreline Hardening	23
Raquette River Riverbottom	10
Total	**181**
Note: Lost DSAYs in present value 2010. Total may not sum due to rounding.	

4.2.10 SUMMARY OF ECOLOGICAL LOSSES

Ecological losses quantified in the assessment area include injuries to sediment and benthic macroinvertebrates, fish, birds, and mammals for a suite of COCs. Present value losses in 2010, in terms of DSAYs, are presented in Exhibit 4-17.

EXHIBIT 4-17 QUANTIFIED ECOLOGICAL LOSSES

RESOURCE	CONTAMINANT	LOST DSAYS PER CONTAMINANT	LOST DSAYS PER RESOURCE
Sediment	PCBs	24,223	32,352
	PAHs	5,361	
	Fluoride	2,768	
Fish	PCBs	31,047	31,047
Birds	PCBs	29,278	34,023
	Aluminum, Cyanide, PAHs, PCBs	4,745	
Mammals	Fluoride	12,115	**12,115**
Remedial-Induced	All	181	181
Total			**109,718**
Notes: Lost DSAYs in present value 2010. Total may not sum due to rounding.			

4.3 SENSITIVITY AND UNCERTAINTIES

Estimates of ecological service losses presented above are sensitive to the assumptions made, methodologies applied, and data available. Changes in these or other aspects of the analysis could alter these loss estimates. Some significant considerations include assumptions and approaches used to generate service loss estimates, use of representative resources, data extrapolation, temporal scope of the analysis, baseline, and the nature of complex mixtures of contaminants. Details regarding each of these elements are described below. The direction of potential bias associated with the various assumptions made and approaches taken in the analysis, in terms of potentially overstating or understating losses, is summarized in Exhibit 4-18.

EXHIBIT 4-18 SUMMARY OF POTENTIAL BIAS IN DAMAGE ESTIMATES

PARAMETER	DIRECTION OF POTENTIAL BIAS ON MAGNITUDE OF DAMAGE CLAIM
Temporal scope of future losses	+/-
Contaminants of concern	-
Chemical mixtures	-
Use of representative resources	+/-
Data extrapolation to determine past and future losses	-
Estimation of service losses	+/-

Notes:
- indicates a likely underestimate of losses
+ indicates a likely overestimate of losses

- **Temporal scope.** The temporal scope of these analyses is based on estimates of the decline (i.e., fish in the Grasse River) or lack of decline (i.e., sediment and fish in the remainder of the assessment area) in contaminant concentrations over time. However, uncertainty in variables such as resource recovery rate, and remedial and/or restoration activities may lead to either an over- or underestimate of losses.
- **Contaminants of Concern.** This analysis quantifies injury for a limited set of contaminants that does not reflect the full suite of contaminants to which trust resources have been exposed, and which may be causing injury. The Trustees quantified losses for those contaminants for which data and threshold information were readily available. This is likely to underestimate losses.
- **Chemical mixtures.** Complex chemical mixtures of contaminants persist in the St. Lawrence Environment. Although chemicals in mixtures can interact to increase or decrease the toxicological effects expected due to an individual contaminant, cases of reduced toxicity are few, and, in general, contaminant mixtures are assumed to cause additive toxicity. The potential for synergistic effects is not incorporated. In addition, this analysis only quantifies losses based on a sub-set of Facility-related contaminants, and therefore may underestimate losses.

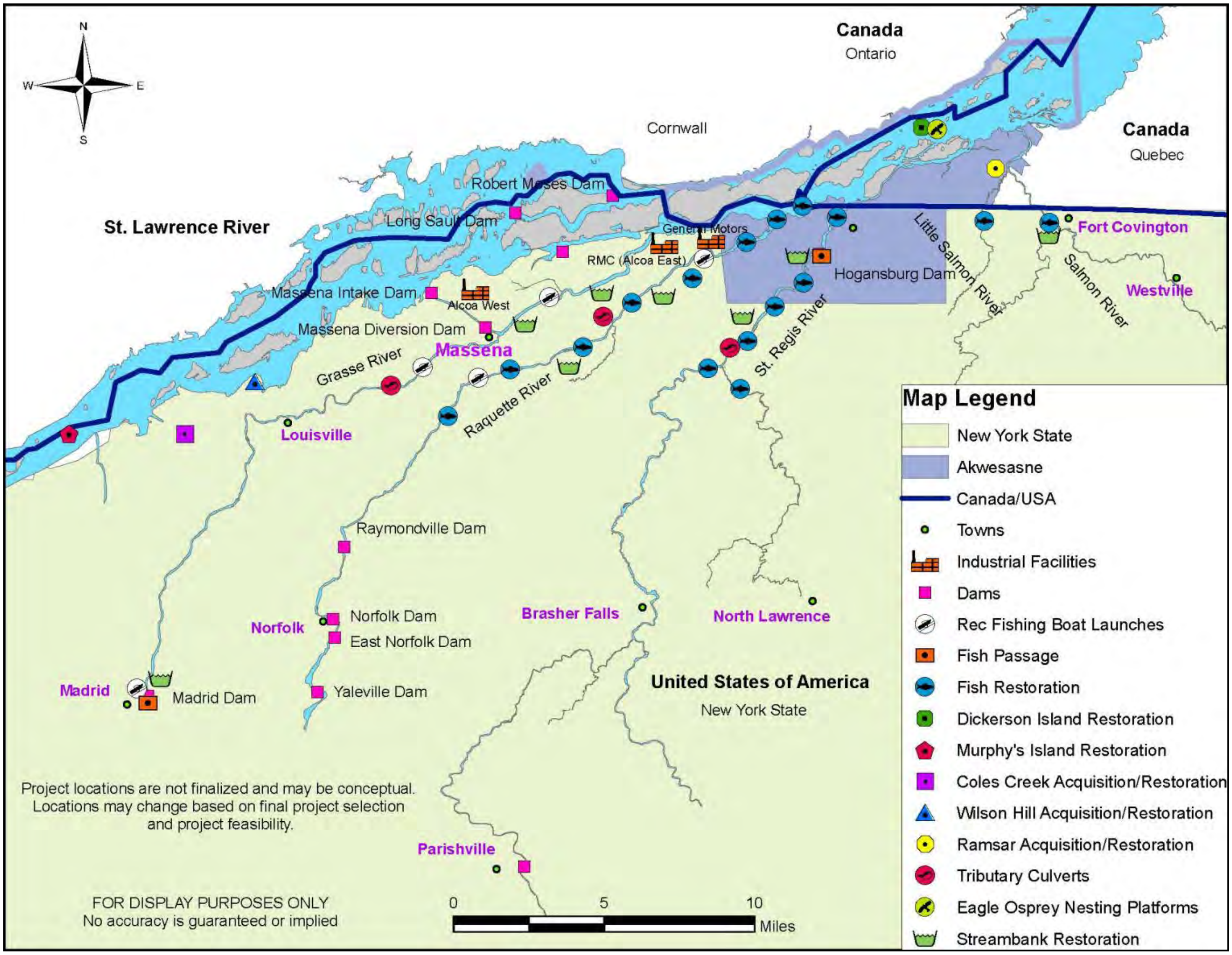
- **Representative species.** Although multiple species within the aquatic ecosystem have been exposed to hazardous contaminants, it is not possible to assess adverse effects to each individual species in the context of this assessment. Therefore, species/resources are chosen to represent large portions of the ecosystem, and may not accurately reflect site-specific species' sensitivity to contamination. This may lead to an over- or underestimate of losses.
- **Data extrapolation.** Geographic and temporal data gaps are filled by interpolation and extrapolation of existing data, which may not accurately reflect actual contaminant concentrations. Locations where media samples were taken may not accurately characterize the assessment area sub-section as a whole. Similarly, data are often available for only certain years, and may not accurately characterize temporal changes. For example, where no data are available for a given year, service losses are assumed to be at least as high as the most recent year. This approach likely underestimates service losses.
- **Service losses.** Service losses (expressed as a percentage of baseline services) are generated based on comparison of contaminant concentrations in sediment and fish to literature-based adverse effects thresholds, as well as site-specific toxicological information. Analysis of these data incorporates multiple levels of uncertainty. For example, sample collection methods and statistical approaches in the underlying studies (e.g., targeted sampling versus random sampling, sample size, etc.) may bias results, and adverse effects thresholds in some cases are based on literature rather than site-specific data. This may lead to an over- or underestimation of service losses. The degree to which adverse effects thresholds indicate a specific level of service loss and how representative those benchmarks are of all the services provided by a given resource is also a source of uncertainty.

CHAPTER 5 | ECOLOGICAL COMPENSATION

5.0 INTRODUCTION

To compensate the public for injuries (i.e., service losses) to natural resources resulting from releases of PCBs, PAHs, fluoride, and other hazardous substances from the Facilities, the Trustees are required to develop alternatives for the "restoration, rehabilitation, replacement, and/or acquisition of the equivalent of the natural resources and the services those resources provide" (42 C.F.R. §11.82 (a)). As described in Chapter 1, Alcoa's settlement with the Trustees for ecological losses includes a cash payment of approximately $7.28 million and purchase and legal transfer to NSYDEC of approximately 465 acres of property (the "Coles Creek" and "Wilson Hill" properties). This chapter describes the Trustees' restoration objectives and approach to selecting relevant and appropriate restoration projects with respect to the use of the ecological portion of the cash payment, in conjunction with the benefits that will result from the transfer of the Coles Creek and Wilson Hill properties to NYSDEC, which are assumed to provide partial compensation for the natural resource injuries and service reductions described in Chapter 4. Additional projects are also considered that may be conducted using funds from the GM settlement. Below, the Trustees outline the proposed alternatives and present the preferred alternatives. These preferred alternatives are then evaluated in the context of both site-specific and regulatory evaluation criteria (43 C.F.R. §11.82 (d)) and assessed for compliance with potentially applicable laws. The Trustees may implement restoration projects that are not specifically identified in this restoration plan, but are similar to those projects identified and consistent with our restoration objectives. Exhibit 5-1 depicts specific restoration projects (e.g., Coles Creek Acquisition/Restoration) and general concept restoration projects (e.g., Tributary Replacement Culverts). Exhibit 5-4 provides additional details on the estimate of benefits derived from restoration projects.

EXHIBIT 5-1 ST.LAWRENCE RIVER ENVIRONMENT NATURAL RESOURSE DAMAGE ASSESSMENT RESTORATION PROJECTS



5.1 RESTORATION OBJECTIVES

The Trustees' overall restoration objective is to compensate the public for interim and expected future ecological losses due to Facility-related contamination in the assessment area. As described in Chapter 4, losses were calculated beginning in 1981 and are expected to continue well into the future. The COCs have impacted the ability of trust resources to provide their baseline level of ecological services. Therefore, the Trustees focused on restoration projects that will compensate the public by providing additional (i.e., above and beyond baseline) ecological services in or near the assessment area. The following sections describe the no action alternative, as well as the ecological characteristics and benefits of restoration alternatives evaluated as part of this process.

5.3 NO ACTION ALTERNATIVE

As required under the National Environmental Policy Act (NEPA), the Trustees considered a restoration alternative of no action. Under this alternative, the Trustees would rely on natural recovery and would take no direct action to restore injured natural resources or compensate for interim lost natural resource services. This alternative would include the continuance of ongoing monitoring programs, such as those initiated by NYSDEC for fish, but would not include additional activities aimed at either reducing contamination, reducing potential exposure to contaminants, or enhancing ecosystem biota or processes. Under this alternative, no compensation would be provided for interim losses in resource services.

5.3 RESTORATION ALTERNATIVES CONSIDERED

The Trustees considered a broad set of restoration alternatives that could potentially improve ecological services relevant to the assessment area. In addition to alternatives proposed by Trustee agencies, alternatives were solicited from the Companies through cooperative discussion, and from the public through a request for restoration proposals that was distributed both directly to local governments, conservation organizations, and academic researchers, as well as to the broader public through a press release distributed to a suite of local media outlets. The broad categories of proposed restoration alternatives included:

- *Wetland Acquisition, Enhancement, and/or Restoration*. This project category focuses on protection, enhancement, and/or restoration of wetlands that have some hydrologic or resource connection to the aquatic habitat of the St. Lawrence Environment. Wetlands provide benefits to a wide array of birds, amphibians, reptiles, mammals and fish and also serve as floodwater retention and groundwater recharge areas.
- *Streambank Enhancement/Restoration*. These projects would improve riparian zones along tributaries to the St. Lawrence River, and could range from exclusion fencing to natural channel design projects. This project would benefit small mammals, birds, amphibians, reptiles and fish and serve to improve water quality by reducing erosion and runoff.

- *Upland Enhancement/Restoration*. This project category generally includes restoration of habitat for grassland dependent bird species, such as bobolink, savannah sparrow, Henslow's sparrow, short-eared owl, and northern harrier.
- *Fisheries Enhancement/Restoration*. These projects would encompass a range of projects in order to address the needs of various fish species in the assessment area. Projects may include improvements to fish passage (e.g., dam removal, fish passage, tributary culvert improvements); creation of, enhancement of, or access to spawning or nursery habitat for various species (e.g., northern pike, muskellunge, lake sturgeon); and/or selective restocking (e.g., lake sturgeon, salmon, American eel). These projects have ancillary benefits to a variety of wildlife species.
- *Amphibian and Reptile Enhancement and/or Restoration*. These projects would focus on habitat protection, enhancement, and/or restoration with specific emphasis on State and Tribal species of special concern (e.g., map turtles and Blanding's turtles). The potential for benefits to amphibians and reptiles will also be evaluated in the context of other restoration alternatives (e.g., wetland acquisition/restoration).
- *Avian Enhancement/Restoration*. These projects would focus on habitat protection, enhancement, and/or restoration and might include predator control for ground nesting species, platforms for nesting species such as osprey and bald eagle, or restoration of grassland habitat for species such as bobolink, Henslow's sparrow and short-eared owl.
- *Beluga Whale Conservation.* Restoration efforts would likely include providing funding for existing, on-going projects, such as summer critical habitat evaluation or carcass recovery. Additional data for existing programs would assist in revising management plans for beluga whales, including reducing disturbance, protecting spawning habitat of pelagic prey, providing stronger protection to critical beluga whale habitat areas, and developing sustainable restoration projects.
- *Benthic Restoration*. These projects would likely focus on developing improvements for benthic invertebrate mussel community. Projects might include mussel propagation and restocking, habitat improvement, and invasive species control. These projects have ancillary benefits to fish and wildlife species by improving water quality, stabilizing sediment, enhancing bottom structure, and increasing food abundance.
- *Submerged Aquatic Vegetation Restoration*. Restoration efforts would focus on enhancing/improving existing areas of submerged aquatic vegetation (SAV) in the assessment area and upstream in assessment area tributaries (e.g., Grasse, Raquette, and St. Regis Rivers), as well as creating new areas of SAV to benefit both the benthic and pelagic communities.
- *Walleye Fish Hatchery*. These projects would involve improvement of existing hatcheries and/or creation of a new hatchery to provide additional stocking

biomass and opportunities for walleye stocking within the St. Lawrence River watershed.

- *Fisheries Assessment and Management Plan.* This project would involve the implementation of a study of fishery resources on Akwesasne land and development of a plan to manage those resources. The plan would present guidelines for protecting, enhancing, and rehabilitating populations of important fish species while balancing benefits from harvesting fish.
- *Land Acquisition.* Land in and around Massena and Akwesasne (e.g., Franklin and St. Lawrence Co.) would be purchased and held in perpetuity for the public. Land should provide benefit to natural resources injured from Site releases and reduce habitat fragmentation. Lands targeted for acquisition should be under threat of development, display sensitive or unique attributes, provide habitat for State or federally protected species. Acquisition would likely include parcels proximate to State lands, Tribal lands, or other protected lands, and land of interest to environmental and international organizations.

5.4 EVALUATION CRITERIA

In order to ensure the appropriateness and acceptability of restoration options addressing ecological losses, the Trustees evaluated each option against site-specific restoration requirements. These site-specific requirements were developed through discussions with natural resource managers at each of the Trustee agencies. Projects that satisfied these site-specific requirements were then evaluated against the restoration criteria listed in the DOI damage assessment regulations. These criteria include:

Site-Specific Criteria

- Location within the St. Lawrence watershed.
- Linkage to injured resources or associated services.
- Proximity to injured resources.
- Habitat connectivity (e.g., result is larger individual habitat parcels rather than multiple, smaller, disconnected parcels).
- Proximity to lands with protected status.
- Potential contamination or other issues that might preclude project selection.
- Benefits to protected species or sensitive or unique habitats.
- Public enjoyment or use of natural resources.
- Likelihood of success as determined by project objectives and methodologies, land protection, and maintenance.
- Viability and sustainability of project.
- Part of larger local or regional restoration plan or vision.

DOI NRDA Criteria (43 C.F.R. §11.82(d))

- Technical feasibility.
- The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources.
- Cost-effectiveness.
- Results of any actual or planned response actions.
- Potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other resources.
- The natural recovery period and the ability of the resources to recover with or without alternative actions.
- Potential effects of action on human health and safety.
- Consistency and compliance with relevant Federal, State, and Tribal laws and policies.

5.5 PREFERRED ALTERNATIVES

The Trustees' preferred alternatives include a suite of restoration projects that compensate for interim losses and satisfy the site-specific and regulatory criteria listed above. These projects include:

- Wetland Enhancement/Restoration,
- Streambank enhancement/restoration,
- Upland enhancement/restoration,
- Avian enhancement/restoration,
- Fisheries enhancement/restoration,
- Amphibian and reptile enhancement/restoration,
- Mammal enhancement/restoration, and
- Land conservation.

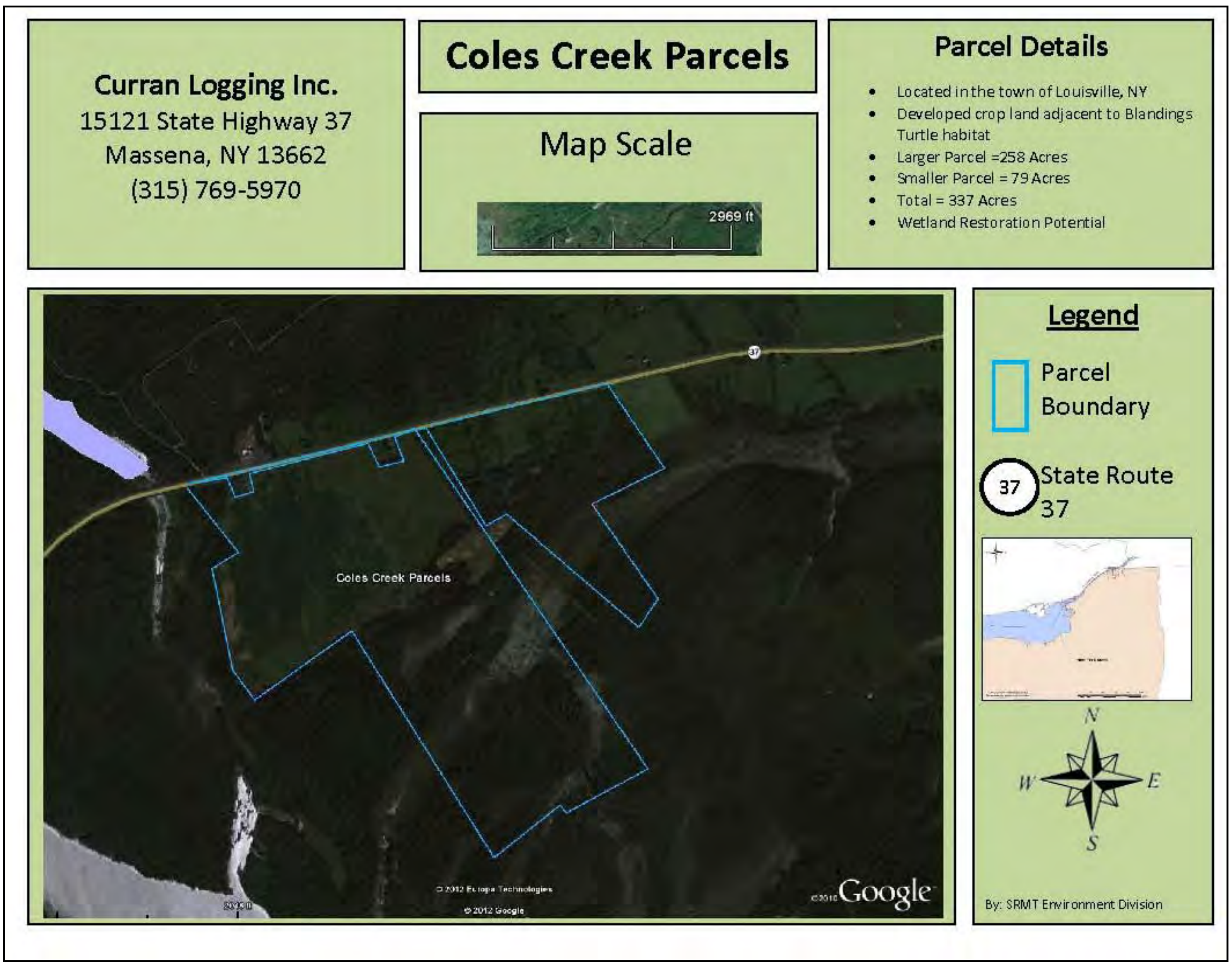
Additional restoration planning will include evaluation of specific projects with input and feedback from the public as described in Chapter 1.

A suite of specific projects within these categories were then identified, evaluated, and scaled so as to sufficiently compensate for ecological losses. Project attributes, resource benefits, and costs are provided below. These projects provide approximately 91,742 DSAYs of ecological benefit, at a cost of approximately $8.31 million (the cash settlement for ecological damages with Alcoa, including acquisition of the Coles Creek and Wilson Hill properties).

5.5.1 COLES CREEK ACQUISITION AND RESTORATION

Coles Creek is a tributary to the St. Lawrence River located upstream of the Grasse River outlet and Moses Saunders Power Project. The lower 4-5 miles of this creek support extensive beds of submerged aquatic vegetation and fringing emergent vegetation. Adjacent upland areas are largely undeveloped and support nesting habitat for the State threatened Blandings turtle (NYSDEC 2012a). The creek has been identified as Significant Coastal Fish and Wildlife Habitat (NYSDOS 1994a). Approximately 337 acres of habitat, including Coles Creek at or near its headwater and adjacent upland forest, shrub/scrub, forested and emergent wetland and agricultural fields will be acquired and managed in perpetuity as habitat for fish and wildlife. Parcels to be acquired are Lot # 14.002-01-22 (258 acres) and Lot # 14.002-01-19 (79 acres). Approximately 12.5 acres of upland restoration is targeted for this site to restore highly degraded area to native grassland habitat. Additional upland restoration might be accomplished with funds from the GM bankruptcy settlement. Ecological benefits would be achieved for fish, birds, mammals, amphibians and reptiles from parcel acquisition and restoration.

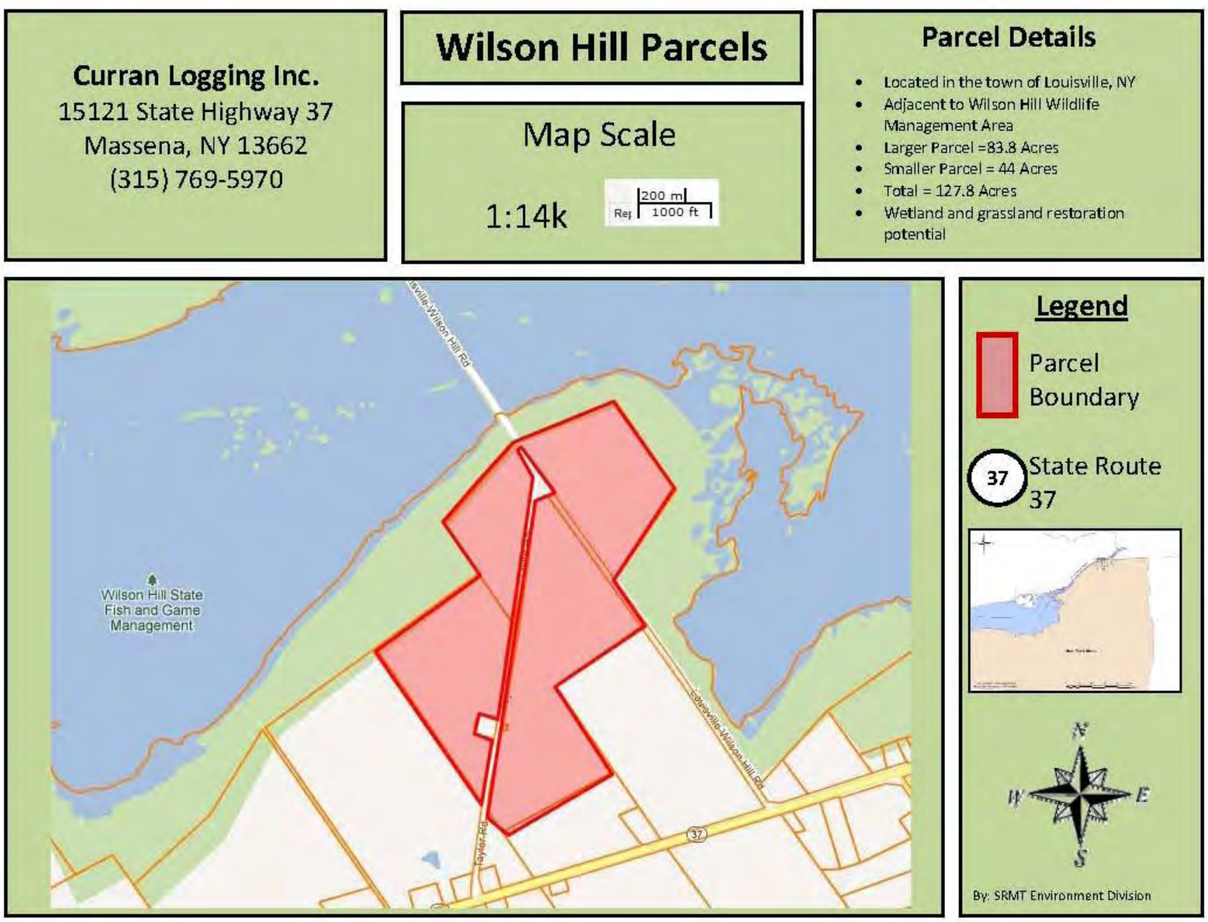
EXHIBIT 5-2 COLES CREEK RESTORATION/ACQUISITION PROJECT



5.5.2 WILSON HILL ACQUISITION AND RESTORATION

Wilson Hill is comprised of two parcels totaling 128 acres that are directly contiguous with New York State's Wilson Hill Wildlife Management Area (WMA), another Significant Coastal Fish and Wildlife Habitat (NYSDOS 1994b). These parcels are largely wooded uplands and agricultural land and adjoin the WMA's designated wetlands Refuge Area on three sides. This area and the adjacent St. Lawrence River provides important habitat for nesting waterfowl and marsh birds, American woodcock, common tern, black tern, pied billed grebe, bald eagle, harrier, least bittern, common loon, osprey, and blue-spotted salamander. The two parcels are a 44 acre piece (Lot# 8.003-2-1) and an 83.8 acre parcel (Lot# 15.001-1-11.11), Approximately 25 acres of upland restoration is proposed at this site to restore native grassland habitat. Another 10 acres of wetland restoration is proposed. Additional upland and or wetland restoration might be accomplished with funds from the GM bankruptcy settlement. Ecological benefits would be achieved for benthic invertebrates, fish, birds, mammals, amphibians and reptiles from parcel acquisition, grassland and wetland restoration.

EXHIBIT 5-3 WILSON HILL WILDLIFE MANAGEMENT AREA RESTORATION PROJECT



5.5.3 AKWESASNE (RAMSAR) WETLAND ACQUISITION AND RESTORATION

RAMSAR wetlands are wetlands of international importance (RAMSAR 2012). AKWESASNE (RAMSAR) is comprised of three parcels totaling 261 acres that are part of the Lac Saint-François wetlands (RAMSAR 361) on Tribal land. These lands are adjacent to the Canadian Lac Saint-François Wildlife Area. About 10 acres of wetland restoration is proposed (e.g. invasive species control). Additional wetland restoration might be accomplished with funds from the GM bankruptcy settlement. Ecological benefits would be achieved for benthic invertebrates, fish, birds, mammals, amphibians and reptiles from parcel acquisition, grassland and wetland restoration.

5.5.4 DICKERSON ISLAND PREDATOR CONTROL AND RESTORATION

Dickerson Island, located along the southern shore of the St. Lawrence River within Snye marsh, is a sanctuary for great blue herons, common egrets and black-crowned night herons within Akwesasne boundaries (Environment Canada 2012). Habitat degradation and nesting competition is associated with over usage by cormorants. Proposed restoration on 13 acres of Dickerson Island consists of predator control and vegetation management to restore critical habitat for colonial nesting common egret and black-crown night heron. Restoration primarily benefits birds with ancillary benefits to fish and benthos.

5.5.5 MURPHY ISLAND PREDATOR CONTROL AND RESTORATION

Murphy Island, Waddington, NY is in the St. Lawrence River upstream of the Moses Saunders Dam in the vicinity of Brandy Brook. This island was common tern nesting habitat, with vegetation lined nests constructed above the high tide line. Habitat degradation and nesting competition is related to competition from gulls and cormorants. Proposed restoration on 13 acres consists of predator control and vegetation management to restore critical habitat for common tern, a New York State threatened species (NYSDEC 2012).

5.5.6 BALD EAGLE/OSPREY NESTING PLATFORMS

Nesting platforms will be constructed in the St. Lawrence River or its tributaries to enhance nesting habitat for bald eagles and/or ospreys. Ospreys are designated species of special concern by NYS (NYSDEC 2012a); bald eagles are threatened within NY (NYSDEC 2012b). Proposed construction of 10 platforms will enhance bald eagle and osprey nesting opportunities in the vicinity of Massena and Akwesasne.

5.5.7 STREAMBANK RESTORATION

Streambank restoration consists of enhancing riparian buffers along 5 miles (~85 acres) of shoreline (e.g., St. Regis, Grasse, Raquette, Salmon River). Proposed restoration actions include fencing, acquisition, conservation easements, natural channel design and/or revegetation. Streambank restoration provides benefits to birds, mammals, reptiles, amphibians, benthic invertebrates and fish by improving shoreline habitat, reducing soil erosion and runoff, and enhancing water quality. Additional streambank restoration might be accomplished with funds from the GM bankruptcy settlement.

5.5.8 DAM MITIGATION

Dam construction on tributaries to the St. Lawrence has altered flows and sediment transport, increased habitat fragmentation, impeded fish passage, and restricted migratory corridors. Lake sturgeon and American eel have both been adversely impacted by dam construction. Dams such as the Madrid Dam on the Grasse River and the Hogansburg Dam on the St. Regis River prevent lake sturgeon and other species of fish from migrating further upstream. For example, removal of the Madrid Dam or development of fish passage would open up 15 miles of river and provide restoration for ~273 acres. This project would benefit fish, benthos, birds, and mammals. Some funds could also be used to support decommissioning of other dams.

5.5.9 TRIBUTARY CULVERT UPGRADE

Undersized, perch or blocked culverts alter stream flow and sediment transport, impede fish passage, restrict migratory corridors and reduce or eliminate fish access to historic foraging and breeding habitat. The proposed restoration would allow for assessment and upgrade of up to 10 culverts in St. Lawrence and or Franklin Counties providing~272 acres of restoration. Some or all of this funding could be used for other fish passage projects (including dam removal) if they are deemed more beneficial. Restoration would benefit fish, benthic invertebrates, birds, mammals, amphibians and reptiles.

5.5.10 LAKE STURGEON RESTORATION/HABITAT RESTORATION

Lake sturgeon is one of the largest fish species in NY and is listed as a State threatened species (NYSDEC 2012d). Habitat degradation, overharvesting and loss of spawning and nursery habitat due to dam construction are factors in their decline. New York State and its partners developed a lake stocking restoration program in an effort to re-establish them in their historic range. Efforts have also been made in the St. Lawrence River to enhance sturgeon spawning habitat. The Trustees will coordinate with existing sturgeon restoration programs. Proposed restoration (~915 acres) would enhance the population of lake sturgeon through active stocking of fingerlings in St. Lawrence tributaries (e.g., Raquette, St. Regis, Salmon Rivers) and or create additional spawning habitat in the St. Lawrence River.

5.5.11 NORTHERN PIKE HABITAT ENHANCEMENT

The spawning habitats of northern pike have been adversely affected by alterations to water flows and levels due to the operation of the St. Lawrence Seaway. This proposed project would enhance habitat or provide access to existing spawning habitat of northern pike or other esocids (e.g., muskellunge) at locations within the St. Lawrence ecosystem as yet to be identified. This effort will be coordinated with the State University of New York, College of Environmental Science and Forestry. The proposed 200 acre restoration would benefit fish, benthic invertebrates and birds.

5.5.12 SALMON OR OTHER FISHERY ENHANCEMENT

Atlantic salmon have been extirpated from the St. Lawrence River ecosystem. The U.S. Geological Survey and SRMT have been investigating potential strains of salmon for reintroduction. This proposed project would consist of stocking of fingerling Atlantic salmon in tributaries of the St Lawrence (e.g., St. Regis, Little Salmon, Salmon Rivers) providing for 56 acres of restoration. If salmon restoration was not deemed viable, an alternative fishery restoration project would be implemented.

5.5.13 WETLAND ACQUISITION/RESTORATION

Additional land acquisition for wetland restoration might be accomplished in St. Lawrence and or Franklin Counties with funds from the GM bankruptcy settlement to benefit fish, birds, mammals, benthic invertebrates, reptiles and amphibians.

5.5.14 ISLAND RESTORATION

Additional island restoration (e.g., invasive species control, replanting, breeding /foraging habitat improvements) might be accomplished in St. Lawrence and or Franklin Counties to benefit fish, birds, mammals, benthic invertebrates, amphibians or reptiles.

5.5.15 AMPHIBIAN AND REPTILE PROTECTION AND HABITAT ENHANCEMENT

Additional amphibian and reptile protection and habitat enhancement might be accomplished in and around Massena and Akwesasne to benefit fish, birds, mammals, benthic invertebrates, amphibians or reptiles.

5.5.16 UPLAND ACQUISITION/RESTORATION

Additional land acquisition for upland restoration (e.g., control of invasive species, creation of grasslands) might be accomplished in St. Lawrence and/or Franklin Counties to benefit fish, birds, mammals, benthic invertebrates, amphibians or reptiles

5.6 ENVIRONMENTAL ASSESSMENT OF PREFERRED RESTORATION ALTERNATIVES

5.6.1 ENVIRONMENTAL BENEFITS FROM PREFERRED ALTERNATIVES

Implementation of the preferred restoration alternatives are expected to generate long-term benefits to fish and wildlife resources that are substantially greater than any potential short-term adverse impacts that may occur. For example, short-term impacts arising from the project types listed above could include minor disruption of riverine and streambank habitats during project implementation (e.g., streambank enhancement activities may result in a decrease in vegetative cover prior to restoration planting activities or a slight increase in soil runoff while fencing is installed).

5.6.2 COMPLIANCE WITH NEPA AND OTHER POTENTIALLY APPLICABLE LAWS

Coordination and evaluation of required compliance with specific Federal acts, executive orders, and other policies for the preferred restoration plan is achieved, in part, through the coordination of this document with appropriate agencies and the public. All ecological restoration projects will be in compliance with all applicable Federal statutes, executive orders, and policies, including NEPA, 42 USC Section 4321 *et seq.*; the Endangered Species Act (ESA), 16 USC 1531, *et seq*.; the National Historic Preservation Act of 1966, 16 USC Section 470 *et seq.*; the Fish and Wildlife Coordination Act, 16 USC Section 661 *et seq*.; the Rivers and Harbors Act of 1899, 33 USC Section 403 *et* *seq*.; the Federal Water Pollution Control Act, 33 USC Section 1251 *et seq*.; Executive Order 11990, Protection of Wetlands; and Executive Order 11988, Flood Plain Management. Compliance with the laws cited above, and any necessary permitting, will be undertaken during specific restoration project planning stages.

The Federal Trustees are also required under Executive Order Number 12898, 59 Fed. Reg. 7629, to identify and address any policy or planning impacts that disproportionately affect the health and environment in low income and minority populations. Since the restoration alternatives will result in changes that benefit trust resources throughout the St. Lawrence watershed, including near Massena and Akwesasne, the Federal Trustees have concluded that there would be no adverse impacts on low-income or minority communities due to implementation of the restoration alternatives.

EXHIBIT 5-4 PREFERRED RESTORATION ALTERNATIVES TO BE FUNDED BY ALCOA SETTLEMENT

PROJECT	ACRES	RESOURCES BENEFITTED	SERVICES PROVIDED	DATE BENEFIT BEGINS	TIME FRAME	TIME TO FULL SERVICE	SEDIMENT DSAYS	FISH DSAYS	AVIAN DSAYS	MAMMAL DSAYS	HERP BENEFIT	DSAYS PER ACRE	PROJECT COST	NOTES
Akwesasne Wetland Acquisition (RAMSAR)	261	S, F, A, M, H	Provides 25% services for protection for all resources. Wetlands not imminently threatened and already high quality.	2009	In perpetuity	Immediate	2,240	2,240	2,240	2,240	X	26	$166,900	Cost includes acquisition and transaction costs, plus 20% for MCA coordination. Provided by SRMT. Does not include restoration costs.
Akwesasne Wetland Restoration (RAMSAR)	10	F, A, M, H	Restoration of wetland services: 50% benefit to fish, birds; 25% benefit to mammals.	2009	In perpetuity	5 years	0	160	160	80	X	40	$60,000	Assume $6,000/acre restoration based on FWS, GLNPO field efforts and existing quality. Cost includes adaptive management, follow-up restoration activities, corrective actions, contingency. Likely will consist of invasive control, revegetation, avian nesting sites, monitoring in years 1-5 and 10.
Wilson Hill Land Acquisition	128	F, A, M, H	Mainly upland . 75% provides habitat for birds - upland and some aquatic species.	2009	In perpetuity	Immediate	0	439	3,296	3,955	X	60	$1,030,300	Cost based on purchase price researched by Alcoa for both Coles Creek and Wilson Hill.

PROJECT	ACRES	RESOURCES BENEFITTED	SERVICES PROVIDED	DATE BENEFIT BEGINS	TIME FRAME	TIME TO FULL SERVICE	SEDIMENT DSAYS	FISH DSAYS	AVIAN DSAYS	MAMMAL DSAYS	HERP BENEFIT	DSAYS PER ACRE	PROJECT COST	NOTES
			90% provides habitat for mammals and herps. 10% benefit to fish. Area threatened by development. No restoration.											
Wilson Hill Wetland Restoration	10	S, F, A, M, H	Wetland restoration provides 75% services to birds, fish, herps, 50% for mammals, and 5% benefit to benthos.	2009	In perpetuity	5 years	16	240	240	160	X	64	$60,000	Assume $6,000 per acre restoration based on FWS and GLNPO field efforts and existing quality. Cost includes adaptive management and corrective actions, follow-up restoration activities, monitoring in years 1-5 and 10, and likely will consist of invasive control, revegetation, avian nesting sites, etc.
Wilson Hill Grassland Restoration	25	A, M	Grassland restoration provides 25% service benefit to birds and mammals.	2009	30 years	2 Years	0	0	120	120	0	10	$31,930	Assume $1,277 per acre for restoration based on similar local FWS projects. Includes grassland establishment (planting and seeding), maintenance and monitoring, invasive control for ten years, and mowing every 3

PROJECT	ACRES	RESOURCES BENEFITTED	SERVICES PROVIDED	DATE BENEFIT BEGINS	TIME FRAME	TIME TO FULL SERVICE	SEDIMENT DSAYS	FISH DSAYS	AVIAN DSAYS	MAMMAL DSAYS	HERP BENEFIT	DSAYS PER ACRE	PROJECT COST	NOTES
														years after initial restoration.
Coles Creek Acquisition	337	F, A, M, H	267 acres provides 25% services for protection of herps, birds, and mammals since land is not imminently threatened. Cornfield (70 acres) provides no habitat services. Benefits to fish are 5% because land is near/at the head-waters for Coles Creek and acquisition may help maintain water quality for fish downstream.	2009	In perpetuity	Immediate	0	458	2,291	2,291	X	15	See above	Cost based on purchase price researched by Alcoa for both Coles Creek and Wilson Hill.
Coles Creek Upland Restoration	12.5	A, M	Restoration of highly degraded area to native habitat provides 75% service gain	2009	30 years	2 Years	0	0	180	180	0	29	$19,430	Assume $1,554 per acre for restoration based on similar local FWS projects. Includes grassland establishment (planting and seeding),

PROJECT	ACRES	RESOURCES BENEFITTED	SERVICES PROVIDED	DATE BENEFIT BEGINS	TIME FRAME	TIME TO FULL SERVICE	SEDIMENT DSAYS	FISH DSAYS	AVIAN DSAYS	MAMMAL DSAYS	HERP BENEFIT	DSAYS PER ACRE	PROJECT COST	NOTES
			for birds, and mammals.											maintenance and monitoring, invasive control for ten years, and mowing every 3 years after initial restoration.
Murphy Island Restoration	7.28	A (Common tern)	Nesting habitat is critical for species viability, multiply acres by 2; rare species, multiply by 5 (Total multiplier =10); project requires initial/annual gull, cormorant control.	2009	20 years	5 Years	0	0	940	0	0	129	$60,000	Cost includes cormorant and gull control for multiple years, monitoring based on information from L. Harper. Assume 10 years of activity.
Dickerson Island Predator Control and Restoration	13	S, F, A (Black-crowned night heron, common egret)	Predator control and vegetation management to restore habitat for these species. Nesting habitat is critical for species viability, therefore	2009	30 Years	2 Years	101	101	2,495	0	0	200	$165,000	Cost of $100,000 covers avian predator control for multiple years and monitoring. Based on information from L. Harper. Assume 10 years of activity. Assume $5,000 per acre for upland restoration. Additional restoration

PROJECT	ACRES	RESOURCES BENEFITTED	SERVICES PROVIDED	DATE BENEFIT BEGINS	TIME FRAME	TIME TO FULL SERVICE	SEDIMENT DSAYS	FISH DSAYS	AVIAN DSAYS	MAMMAL DSAYS	HERP BENEFIT	DSAYS PER ACRE	PROJECT COST	NOTES
			multiply acres by 2; rare island habitat multiply by 5 (Total multiplier =10). Assume 75% benefit to fish and benthos in 100-ft buffer (7 acres).											activities such as osprey platforms could be added.
Bald Eagle/ Osprey Nesting Platforms	10 plat-forms	A	Nesting platforms	2009	30 years	Immediate	0	0	95	0	0	NA	$6,250	$125 per platform, 10 platforms, plus $500 installation/ maintenance per platform. Benefit based on average DSAY per $ of other avian restoration projects.
Riparian buffers (e.g., St. Regis, Grasse, and Salmon Rivers)	5 miles of shore-line, ~85 acres	S, F, A, M, H	Buffers provide 75% benefits to birds, mammals, herps, sediment, fish (some services already provided). Average width of 140 ft.	2009	In perpetuity	Immediate	2,189	2,189	2,189	2,189	X	39	$1,320,000	Assume $50/linear foot based on costs from FWS, NOAA. May include fencing, acquisition, or easement. Includes 20% monitoring/contingency. Area based on site reconnaissance and SRMT proposal.
Spawning Habitat -	200	S, F (Northern	Create access to spawning habitat,	2009	In perpetuity	2 Years	667	6,668	667	0	0	37	$216,000	Based on Delaney Bay cost $150,000 for ~ 200 acres of

PROJECT	ACRES	RESOURCES BENEFITTED	SERVICES PROVIDED	DATE BENEFIT BEGINS	TIME FRAME	TIME TO FULL SERVICE	SEDIMENT DSAYS	FISH DSAYS	AVIAN DSAYS	MAMMAL DSAYS	HERP BENEFIT	DSAYS PER ACRE	PROJECT COST	NOTES
unspecified location		Pike), A	develop projects based on input from Esocid strategy of Farrel - Phase II Implementation. Provides 100% benefit to fish, 10% to birds, 10% to benthos.											habitat opened for access, e.g., water control structure, fishway. Add 20% for site-specific design, 20% for contingency.
Lake sturgeon stocking/ enhance-ment: Raquette, Salmon, St. Regis Rivers	915	S, F (Lake sturgeon), A	If successfully spawn, lake sturgeon numbers to increase; if not still provides long-term benefit due to life history of this long-lived species. Assume 50% benefit in 5 years, 75% in 25, and 90% in 50 years. Assumes 10% benefit to sediment and birds.	2010	80 years	50 years	1,359	14,360	1,359	0	0	17	$1,686,000	Stocking program in existing hatchery for production of 3,000 fingerlings/ year (1,000 each in Raquette, Salmon, St. Regis Rivers) - tributary stocking is most viable alternative. Cost includes rearing in existing hatchery (egg collection/ transport, food, electricity, monitoring, fish tagging, staff) for ten years. Enhancement program based on cost of Iroquois dam project (~$200,000) plus 20% contingency, maintenance, monitoring. Based on information from sturgeon experts. Includes

PROJECT	ACRES	RESOURCES BENEFITTED	SERVICES PROVIDED	DATE BENEFIT BEGINS	TIME FRAME	TIME TO FULL SERVICE	SEDIMENT DSAYS	FISH DSAYS	AVIAN DSAYS	MAMMAL DSAYS	HERP BENEFIT	DSAYS PER ACRE	PROJECT COST	NOTES
														educational component.
Atlantic salmon stocking/ other fishery restoration	56	F (Atlantic salmon), A, M	Provides 90% benefit in 12 years to fish in rivers where stocking occurs, 45% benefit to birds, and 10% benefit to mammals. Provides half these benefits in the St. Lawrence as fish move into main channel.	2010	50 years	12 years	0	1,930	965	214	0	56	$400,000	Specific project to be determined. Cost based on USGS stocking project: $400,000 for 7 years (includes raising fingerlings, egg purchase, stream stocking, and fish survival and adult return monitoring). Assumes stocking in three locations (e.g., St. Regis, Little Salmon, Salmon Rivers). Includes educational component.
Tributary Culverts Assessment Implementation (dam removal could be implemented as a substitute for all or some of culvert	180 to 363	S, F, A, M, H	Assumes 1 watershed, 10 culverts per watershed. Benefits per culvert: Fish: 6 miles, 50ft width, 50% service gain. Benthos: 3 miles, 50ft width, 50% benefit. Mammals: 3 miles, 50ft width,	2010	50 years	3 years	2,164	4,328	541	1,082	X	22	$1,080,000	Cost includes $100,000 for assessment and $20,000 for education per 1000 sq mi watershed. Culvert cost is estimated at $96,000 per culvert, including materials, labor, equipment, documentation, monitoring, and 20% contingency. Assume 10 culverts in two watersheds.

PROJECT	ACRES	RESOURCES BENEFITTED	SERVICES PROVIDED	DATE BENEFIT BEGINS	TIME FRAME	TIME TO FULL SERVICE	SEDIMENT DSAYS	FISH DSAYS	AVIAN DSAYS	MAMMAL DSAYS	HERP BENEFIT	DSAYS PER ACRE	PROJECT COST	NOTES
upgrades)			25% benefit. Birds: 3 miles, 50ft width, 12.5% benefit. May also provide benefits to herps.											
Fish Passage Dam Removal (Madrid Dam used as example to quantify benefits)	273	S,F,A,M	Open up 15 miles river (150 ft wide) habitat to fish species that are currently blocked from passage by dams (not all fish and benthic species are affected by dams). Also would aid in mussel recovery. Provides 75% services for opened area to fish and benthic community (e.g., mussels), and half the fish/benthic benefit (37.5%) to avian and	2010	In perpetuity	5 years	6,535	6,535	3,268	3,268	0	48	$790,000	Estimated cost per dam mitigation (removal or fish passage) based on costs provided by NOAA from other sites. Includes all project components (e.g., design, deconstruction, removal of submerged dam upstream in the impoundment). The next impassable barrier is a rock falls at Canton (NYSDEC 2008), 15 miles upstream from the Madrid Dam. Includes macrobenthic survey, cost based on similar survey conducted for MED dam project and similar surveys in northern Maine.

PROJECT	ACRES	RESOURCES BENEFITTED	SERVICES PROVIDED	DATE BENEFIT BEGINS	TIME FRAME	TIME TO FULL SERVICE	SEDIMENT DSAYS	FISH DSAYS	AVIAN DSAYS	MAMMAL DSAYS	HERP BENEFIT	DSAYS PER ACRE	PROJECT COST	NOTES
			mammal resources.											
Total DSAYs from above projects							15,271	39,648	21,045	15,779				91,742
Total Cost of Projects with DSAYs														$7,091,810
Estimated cost for Trustee oversight/restoration planning (17.18% of project cost)														$1,218,373
Total cost of ecological damage claim														**$8,310,183**

Legend:
S = Sediment, F = Fish, A = Avian, M = Mammals, H = Herps
NA = Not applicable
X = Benefits provided but not quantified.

CHAPTER 6 | RECREATIONAL FISHING LOSSES

In addition to the ecological services described in Chapter 4 and the cultural services described in Chapter 8, natural resources within the assessment area also provide recreational services. For example, the aquatic habitat and fishery resources of the St. Lawrence Environment provide anglers with extensive opportunities for recreational fishing. This chapter describes the Trustees' approach to quantifying the losses in recreational fishing resulting from contaminant-related FCAs due to PCBs. The extent of these losses, that is, the estimated lost value, is determined to establish a basis for scaling restoration (i.e., damages). Scaling in this case means identifying restoration projects that will provide sufficient, additional (i.e., above and beyond baseline) recreational fishing opportunities to compensate for those lost due to contamination.

After reviewing the history of FCAs in the assessment area, the data and model used to quantify losses associated with these advisories are described, and the loss estimates are presented.

6.1 FISH CONSUMPTION ADVISORIES

As described in Chapter 3, FCAs in the assessment area have been in place since 1984, and are currently in place to limit consumption of certain types of fish on the St. Lawrence, Raquette, and Grasse Rivers; the Massena Power Canal; and the Bay at St. Lawrence (Franklin County Line) (NYSDOH various years). Advisories due to PCBs range from "Eat no more than one meal per month – certain species" to "Eat none – all species." [22]

Exhibit 6-1 provides a summary of the FCAs within the assessment area from 1984 to the present. FCAs are released annually by the New York State Department of Health.

[22] A river-wide fish consumption advisory for the St. Lawrence River is also in place due to mirex and dioxin (NYSDOH 2009).

EXHIBIT 6-1 FISH CONSUMPTION ADVISORIES IN THE VICINITY OF THE ASSESSMENT AREA

YEAR(S)	SPECIES	NYSDOH RECOMMENDATION
ST. LAWRENCE RIVER (includes entire St. Lawrence River and the Grasse River, Raquette River, and Massena Power Canal up to first impassable barrier)		
1983 - 1987	Eel, channel catfish, lake trout, chinook salmon, coho salmon > 21 inches, rainbow trout > 25 inches, and brown trout > 18 inches	Eat none
	White perch, smaller coho salmon, rainbow trout, and brown trout	Eat no more than one meal per month
1987 - 1990	Eel, channel catfish, lake trout, chinook salmon, coho salmon > 21 inches, rainbow trout > 25 inches, and *brown trout > 20 inches*	Eat none
	Carp, white perch, smaller coho salmon, rainbow trout, and brown trout	Eat no more than one meal per month
1990 - 1996	*American eel*, channel catfish, lake trout, *carp*, chinook salmon, coho salmon > 21 inches, rainbow trout > 25 inches, and brown trout > 20 inches	Eat none
	White perch, smaller coho salmon, rainbow trout, and brown trout	Eat no more than one meal per month
1996 - 1998	American eel, channel catfish, lake trout, carp, chinook salmon, *rainbow trout*, coho salmon > 21 inches, and brown trout > 20 inches	Eat none
	White perch, smaller coho salmon and brown trout	Eat no more than one meal per month
1998 - 2008	American eel, channel catfish, *lake trout > 25 inches*, carp, chinook salmon, and brown trout > 20 inches	Eat none
1998 - 1999	White perch, *white sucker*, *rainbow trout*, smaller *lake trout* and brown trout, and *coho salmon > 25 inches*	Eat no more than one meal per month
1999 - 2000	White perch, white sucker, rainbow trout, smaller brown trout, and coho salmon > 25 inches	Eat no more than one meal per month
2000 - 2008	White perch, white sucker, rainbow trout, smaller *lake trout* and brown trout, and coho salmon > 25 inches	Eat no more than one meal per month
2008 - 2010	Carp, channel catfish, lake trout > 25 inches, and brown trout > 20 inches	Eat none
	Chinook salmon, rainbow trout, white perch, white sucker, smaller lake and brown trout, and coho salmon > 25 inches	Eat no more than one meal per month
BAY AT ST.LAWRENCE / FRANKLIN COUNTY LINE		
1983 - 2010	Same as St. Lawrence River	
1990 - 2010	All species	Eat none
GRASSE RIVER (1983-1993: from mouth of river to dam in Massena; 1993 - 2010: from mouth of river to Massena Power Canal)		
1983 - 2010	Same as St. Lawrence River	
1990 - 1993	Smallmouth bass, brown bullhead, walleye	Eat no more than one meal per month

YEAR(S)	SPECIES	NYSDOH RECOMMENDATION
1993 - 2010	*All species*	Eat none
MASSENA POWER CANAL (entire Canal)		
1983 - 2010	Same as St. Lawrence River	
1993 – 2010	Smallmouth bass	Eat no more than one meal per month

Notes:

1. In addition to the fish consumption advisory data listed above, women of childbearing age, infants, and children under the age of 15 are advised not to eat any fish from the river sections listed above.
2. Fish consumption advisories are released mid-year (sometime between March and September), thus, individual advisories cover successive years (e.g., 1988/1989 or 1995/1996).
3. Changes to the fish consumption advisories for the same river section between years are italicized and colored red.
4. Fish consumption advisories for a specific waterbody cover all tributaries to that waterbody up to the first impassable barrier. Thus, the St. Lawrence River advisories also cover the Grasse River, Raquette River, and the Massena Power Canal up to the first impassable barrier.

NYSDOH = New York State Department of Health

Sources: NYSDOH (1983/1984 – 2009/2010).

6.2 METHODOLOGY FOR QUANTIFICATION OF DAMAGES AND GAINS FROM RESTORATION

This section discusses the economic losses associated with changes in angler behavior attributable to the presence of FCAs in the assessment area. The DOI regulations refer to such losses as *compensable value.* Specifically:

> *Compensable value is the amount of money required to compensate the public for the loss in services provided by the injured resources between the time of the discharge or release and the time the resources and the services those resources provided are fully returned to their baseline conditions (43 C.F.R. § 11.83(c)(1)).*

The Trustees have two potential approaches for determining compensable value: "value-to-cost" and "value-to-value" scaling. Under value-to-value scaling, the compensable value is equal to the *economic value* of losses; for example loss of 5,000 recreational fishing trips with a value of $40 per trip would be compensated with projects generating 5,000 recreational fishing trips with a value of $40 per trip. Under value-to-cost scaling, the compensable value is equal to the *cost* of projects that provide the same value as the value lost due to the FCAs; following on the example above, recreational fishing restoration projects totaling $200,000 in costs would be deemed sufficient in a value-to cost framework (5,000 lost trips multiplied by $40 per trip). Through the development of a random utility maximization (RUM) model specific to this site, the Trustees have chosen to apply the value-to-value approach to restoration scaling in this assessment to ensure that the selected restoration projects will provide sufficient gains to offset the damages resulting from FCAs.

6.2.1 GENERAL FRAMEWORK

Compensable value is typically measured in terms of changes in consumer surplus. Consumer surplus is the amount an individual would be willing to pay for a good or service above the market price. In the context of recreational activities such as fishing, this represents the additional amount a participant would be willing to pay to take part in an activity above and beyond any expenditures required to do so (e.g., the cost of traveling to the site). Consumer surplus is widely accepted as the appropriate measure of the value of environmental goods, and can be used to evaluate the losses associated with FCAs and the gains associated with restoration projects (Zerbe and Dively 1994). For example, FCAs and restoration projects may alter how often, where, and how anglers choose to fish, thus leading to changes in the consumer surplus associated with fishing trips.

6.2.2 SELECTED APPROACH TO QUANTIFICATION OF DAMAGES

There are generally two different approaches to quantifying recreational fishing losses: (1) "benefits transfer," which involves transferring information from valuation studies completed at other locations, and (2) collecting new data and developing an original, site-specific valuation model. Benefits transfer approaches are generally viewed as low-cost substitutes for an original study, but they are likely to result in loss estimates that have greater uncertainty.

The Trustees chose to develop an original, site-specific valuation model for this assessment. A review of the economics literature did not identify any high-quality recreational fishing valuation studies conducted in areas with similar fishing opportunities, making development of a solid benefits transfer estimate challenging. Furthermore, a detailed recreational fishing dataset was available for the local area from previous efforts, and the structure of the dataset was ideally suited for the development of an original valuation model.

The site-specific valuation model applied by the Trustees is known as a random utility maximization (RUM) model. RUM models are recognized in the DOI NRDA regulations as an appropriate methodology for quantifying recreational service losses (43 C.F.R. §11.83 (c)(2)(iv)), and are one of the most widely used economic methods for estimating consumer surplus from recreational activities (e.g., Parsons et al. 1999, Montgomery and Needelman 1997, Hausman et al. 1995, Morey et al. 1993).

RUM models utilize data on angler site choices to determine how anglers trade off site quality attributes (e.g., catch rates, access conditions, presence of FCAs) with travel costs. These trade-offs can be used to estimate the probability that an angler will choose to visit any given site, based on the characteristics of that site and the characteristics of available substitute sites. Losses and gains are determined by evaluating the impact on anglers of changes in site characteristics, taking into account the characteristics and locations of the available substitute fishing sites.

The Trustees use the RUM model to determine the "scale," or appropriate number and type of compensatory restoration projects needed to offset damages from FCAs. In this case, the RUM results are used to perform "value-to-value" scaling, the Trustees' selected approach for conducting compensatory restoration. The RUM results provide the estimated number of fishing trips "lost," or diverted from the assessment area due to FCAs, as well as the number of fishing trips "gained" from restoration projects. Within the context of the RUM, these trip estimates are simply scaled versions of consumer surplus measures of gains and losses.

6.3 DATA

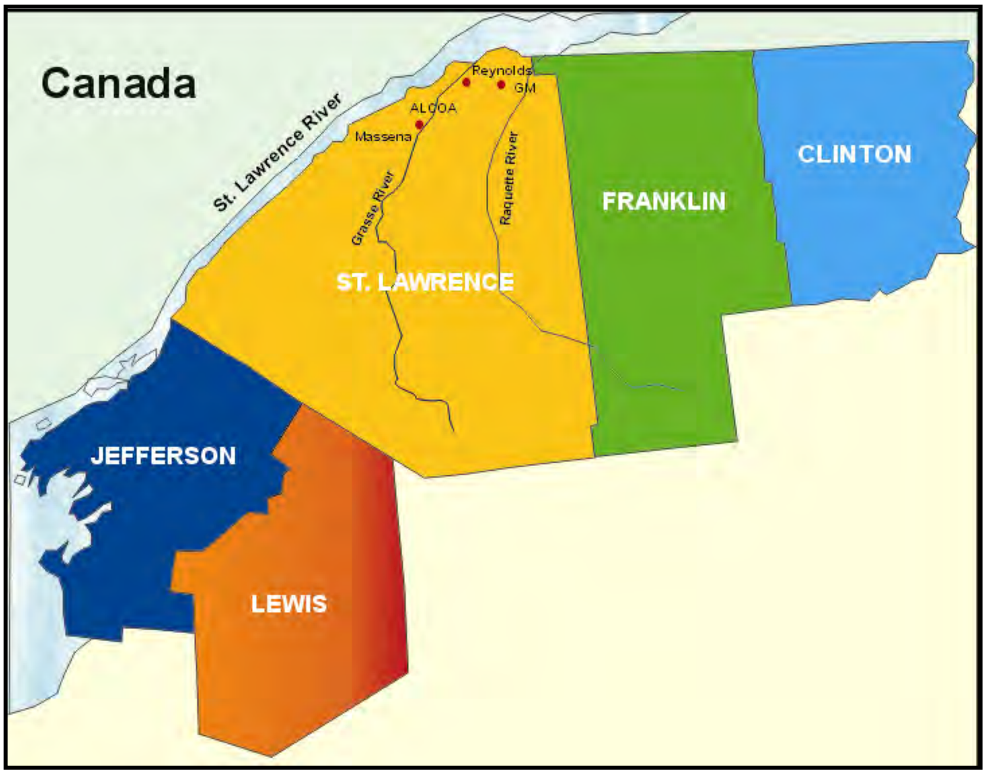
Two types of data are required to utilize a RUM model: data on fishing trip characteristics and data on fishing site characteristics. This section provides an overview of the trip and site characteristics data used to estimate the recreational fishing RUM model. Additional details are provided in Appendix I.

6.3.1 FISHING TRIP CHARACTERISTICS

Fishing trip characteristics were obtained from a survey conducted by the Research Triangle Institute (RTI) between June 11, 1991, and May 20, 1992. The survey (hereafter, RTI Survey) collected data on over 4,000 fishing trips taken between January 1991 and December 1991. Based on a detailed review of the survey data and methodology, the Trustees determined that the information was useful in developing a RUM model designed to quantify damages due to FCAs in the assessment area.

The target population for the survey included residents of five counties: St. Lawrence, Franklin, Clinton, Jefferson, and Lewis (Exhibit 6-3). Typically, anglers travel no more than 25 to 30 miles for a single-day recreation trip, therefore, anglers in these counties are most likely to be affected by FCAs in the assessment area (FWS 1993). Moreover, RUM models are usually limited to single-day trips because it is difficult to estimate the relative importance of site characteristics for multiple-day trips, which often have multiple purposes and include multiple locations (Montgomery and Needelman 1997, Parsons and Needelman 1992).

EXHIBIT 6-3 COUNTIES SAMPLED



The survey used a two-phase approach to collect information about outdoor recreation. The first phase, a telephone survey, was implemented between June 11 and July 17, 1991. The telephone survey used a random-digit-dialing (RDD) design, which helps ensure that the respondents are representative of the population by randomly selecting telephone numbers within the target population. The telephone survey collected data on up to five outdoor recreation trips and recruited participants for the second phase, a mail survey. The mail survey phase involved sending trip diaries to participants shortly after they were recruited through the telephone survey. Monthly trip diaries were sent to participants to record trips taken during the summer (June, July, and August), and an additional diary was sent to record trips taken between September and December. Participants recorded detailed information about each trip, such as the date, duration, location, fish species targeted, number of fish caught, and number of fish eaten.

A total of 446 anglers responded to the survey, providing data on 3,989 single-day fishing trips.[23] The typical angler in the survey is 38 years old and has lived in New York for 34 years. Nearly 40 percent of anglers are female, and over 45 percent are boat owners. The average angler took 9.5 fishing trips in 1991. Of the 3,989 single-day fishing trips reported by anglers, 54 percent were to the St. Lawrence River, six percent were to the Grasse River, eight percent were to the Raquette River, and 32 percent were to other waterbodies. For each of these fishing trips, the driving distance from the angler's home to the fishing site was calculated using the software PC*Miler.

6.3.2 FISHING SITE CHARACTERISTICS

Fishing sites were initially defined by RTI as part of the 1991-1992 survey effort through a combination of field reconnaissance work, a review of survey responses, and a review of other sources (e.g. maps). Each pond, creek, reservoir, and lake is considered a single site, while rivers are divided into multiple sites due to their length. In the vicinity of the assessment area, the boundaries between different river sites correspond to the boundaries for the NYSDOH FCAs.

Site characteristics selected by the Trustees for the RUM model included catch rates for various targeted species (walleye, trout, bass, panfish, pike, catfish, and other species), the number of fish stocked, the presence/absence of boat launches, the presence/absence of an FCA, and indicators for specific waterbodies in the area.[24] Additional site characteristics included in the model are described in Appendix I.

6.4 RESULTS

The estimation results for the recreational fishing RUM model are presented in Appendix I. Results indicate that holding all else constant; the typical angler prefers to visit sites without FCAs. Using information from the model about the extent to which anglers tend to prefer these sites over alternative fishing destinations, the losses associated with FCAs can be calculated. The losses are expressed in terms of the number of fishing trips "lost." In the context of the RUM model, "lost trips" represents the estimated number of fishing trips diverted away from sites with FCAs due to the consumption advisories. As we discuss in the next section, the model can also be used to estimate the number of trips gained from new or enhanced public access.

The RUM model provides an estimate of lost trips for 1991, the year that the survey was implemented. This 1991 estimate is applied to relevant past and future years, accounting for an increase in the severity of the Grasse River advisory in 1993. The relevant time period for damage calculations is all years between 1984 (when the first advisory was put into place) and the date when FCAs are expected to be removed (based on modeled future

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[23] In an effort to keep the recreational fishing and cultural assessments separate, the recreational fishing assessment omits fishing trips taken by Native Americans in Franklin County.

[24] An indicator is a binomial (yes/no) variable identifying the waterbody at which the site is located.

contaminant concentrations in fish). It is unclear however when contaminant levels will decline to levels sufficient to warrant the elimination of FCAs in the assessment area. As a result, lost trips are calculated assuming two different advisory removal dates, 2030 and 2050.

Using a standard discount rate of three percent, the Trustees estimate 221,075 present value trips were lost between 1981 and 2030. For the 1981 to 2050 period, the Trustees estimate 250,740 present value lost trips. These lost trip estimates can be compared to the range of trips expected to be gained from selected restoration projects to determine whether a proposed set of projects provides sufficient compensation.

CHAPTER 7 | RECREATIONAL FISHING COMPENSATION

This chapter reviews the Trustees' approach to selecting restoration projects intended to compensate the public for recreational fishing losses. It discusses the Trustees' restoration objectives, evaluation criteria, proposed alternatives, and preferred alternatives. It then evaluates the preferred alternatives with respect to the evaluation criteria and assesses compliance with potentially applicable laws.

7.1 RESTORATION OBJECTIVES

The Trustees' overall restoration objective is to compensate the public for interim and expected future recreational fishing losses due to PCB contamination in the assessment area. As described in Chapter 3, since 1984 a variety of FCAs have been issued for rivers in the assessment area due to PCB contamination, and these FCAs are expected to continue well into the future. The FCAs have impacted recreational anglers by reducing the quality of fishing opportunities in the assessment area. Therefore, the Trustees focused on restoration projects that will compensate recreational anglers by creating new or improving existing fishing opportunities in or near the assessment area (i.e., increasing the quality of fishing opportunities).

7.2 EVALUATION CRITERIA

In order to ensure the appropriateness and acceptability of restoration options addressing recreational fishing losses, the Trustees evaluated each option against site-specific restoration requirements. These site-specific requirements were developed through discussions with fisheries management staff at NYSDEC. Projects that satisfied these site-specific requirements were then evaluated against restoration criteria listed in the DOI damage assessment regulations. The specific criteria used to evaluate restoration alternatives were as follows:

Site-Specific Criteria

- Enhancement of recreational fishing opportunities in the Massena area through new/enhanced access to fishing areas or through increased catch rates.
- Compatibility with State fisheries agencies' management objectives.

DOI NRDA Criteria (43 C.F.R. §11.82(d))

- Technical feasibility.
- The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources.
- Cost-effectiveness.
- Results of any actual or planned response actions.

- Potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other resources.
- The natural recovery period and the ability of the resources to recover with or without alternative actions.
- Potential effects of action on human health and safety.
- Consistency and compliance with relevant Federal, State, and Tribal laws and policies.

7.3 NO ACTION ALTERNATIVE

As required under the NEPA, the Trustees considered a restoration alternative of no action. Under this alternative, the Trustees would rely on natural recovery and would take no direct action to restore injured natural resources or compensate for interim lost recreational fishing services. This alternative would include the continuance of currently available fishing opportunities (e.g., existing access points at their current quality and capacity), but would not include additional activities aimed at either increasing/improving current recreational fishing activities or undertaking habitat restoration to increase catch rates. Under this alternative, no compensation would be provided for interim losses in resource services.

7.4 RESTORATION ALTERNATIVES CONSIDERED

The Trustees considered a broad set of restoration alternatives that could potentially improve recreational fishing experiences in the local area. These alternatives were solicited from the public through: 1) a request for restoration proposals that was distributed to local governments and conservation organizations, and 2) a focus group with experienced recreational anglers from the Massena area. In addition, NYSDEC fisheries personnel at central and regional offices were interviewed to obtain ideas for restoration alternatives. The restoration alternatives considered fell into four classes:

- *New Shore Fishing Access*. Several restoration alternatives were considered that would provide recreational anglers with shore fishing access to the St. Lawrence, Grasse, and Raquette Rivers. These alternatives involve acquiring waterfront land and constructing a parking area, a raised fishing platform/pier, and a path from the parking lot to the fishing platform. The shore fishing access projects would allow recreational anglers to safely access local rivers without trespassing on private property. Safe shore fishing access is particularly important to handicapped, elderly, and low-income anglers who may have difficulty accessing local streams for fishing.
- *New Boat Fishing Access.* Boat fishing access alternatives considered include the construction or rehabilitation of boat launches on the St. Lawrence, Grasse, and Raquette Rivers. Depending on the location, these alternatives may involve acquiring waterfront land and constructing a parking area and access road, a boat ramp, and/or floating docks. New public boat access would provide enhanced fishing opportunities for anglers fishing from boats. For some of the boat access

alternatives, fishing would be enhanced through the provision of entirely new public access to sections of streams that are currently inaccessible via motorboat. For other boat launch alternatives, fishing would be enhanced through the provision of more convenient boat access to certain stream sections.

- *Fish Stocking*. Several alternatives considered involve improvements at existing fish hatcheries in the local area or the development of new fish hatcheries. These hatcheries would be capable of producing fish species targeted by local anglers. Hatchery improvements would enhance fishing opportunities by potentially allowing NYSDEC fisheries staff to stock larger quantities of fish in local rivers, which would increase angler catch rates.
- *Fish Habitat Improvements*. Fish habitat improvements considered included alternatives such as substrate restoration. Habitat improvements would potentially enhance recreational fishing experiences, as improved habitat likely would lead to higher reproduction and survival rates for fish targeted by local anglers. The resulting increased fish populations would potentially result in higher catch rates for anglers.

7.5 PREFERRED RESTORATION ALTERNATIVES

7.5.1 OVERVIEW OF PREFERRED PROJECT TYPE

After reviewing the restoration alternatives described above, the Trustees determined that projects providing new boat and shore access are the preferred alternatives. These projects were specifically highlighted as desirable by local anglers during focus groups and by regional fisheries staff. In addition, a review of recent State- and county-level planning documents and surveys indicates that increasing public access to these waterways would be very desirable.

One of the advantages of access-related projects relative to either fish stocking or fish habitat improvements is a reduction in uncertainty regarding potential future benefits to anglers. With stocking and fish habitat projects, benefits to recreational anglers require that the project succeed on two levels: (1) the projects must succeed ecologically, leading to larger fish populations, and (2) the larger fish populations must be observable to local anglers. In contrast, new or improved access benefits anglers more directly by allowing them to fish in locations that are currently difficult to access. Another advantage of access-related restoration projects is that they provide ancillary benefits to non-anglers (e.g., recreational boaters).

7.5.2 SPECIFIC PROJECTS PREFERRED

The Trustees are currently in the process of reviewing specific sites for implementation of the preferred restoration alternatives. Although the Trustees have not finalized which sites are most appropriate for implementing this type of restoration, they have identified a set of five restoration projects that provide adequate compensation for recreational fishing losses. This particular set of projects is attractive in that the projects provide new or improved access to all three major rivers in the Massena area (St. Lawrence, Grasse, and Raquette), and they provide a mix of shore- and boat-based fishing opportunities. Furthermore, several of the sites are located at informal angler access points, thereby increasing the likelihood that the new/improved sites would get substantial use.

The five preferred projects are described below (Exhibit 7-1). As the Trustee and public review process continues, these projects may be revised and/or more appropriate projects may be identified.

- *Springs Park Launch Pad*. This project would involve the reconstruction of a one-lane concrete boat launch at Springs Park in Massena and improvements to the paved parking area near the launch, including provision of car-top boat launching access. Springs Park is a popular, family-oriented park near downtown Massena with a playground, picnic area, ball field, and shore fishing pier. The existing launch, which is on the Raquette River, is in disrepair.
- *Lower Grasse River Boat Launch*. This project would involve the construction of a two-lane concrete launch, a floating dock, an Americans with Disabilities Act (ADA)-compliant shore fishing pier/walkway, a crushed stone access road, and a paved parking area for 5 to 10 cars and 10 to 15 trucks/trailers. The Lower Grasse River Boat Launch, at the intersection of Massena Point Road and Route 131, would be available for public use after the Grasse River remediation has been completed. The Lower Grasse River launch will provide important access to the Lower Grasse River and the St. Lawrence River downstream of the Moses-Saunders Dam, including car-top boat launching access.
- *Lower Raquette River Boat Launch*. This project would involve the construction of a small boat launch off Route 37 east of Massena Center. Specifically, the project would involve the construction of a one-lane concrete launch, an ADA-compliant shore fishing pier, a crushed stone access road, a parking area for five to ten vehicles, provision of car-top boat launching access, and an ADA-compliant walkway from the parking lot to the pier. The boat launch would provide access to a section of the Lower Raquette River that currently has no public boat access.
- *Upper Grasse River Launch*. There is currently an informal grass/gravel boat launch on the upper Grasse River adjacent to the Madrid water treatment facility. This project would involve formalizing this launch through the construction of a one-lane concrete launch (including providing car-top boat launching access), an ADA-compliant shore fishing pier, an ADA-compliant walkway, and a crushed stone access road and parking area for five to ten vehicles.
- *Mid Grasse River Launch.* Public access to the upper Grasse River between Louisville and Massena is currently very limited. This project would involve the construction of a one-lane concrete launch (including providing car-top boat launching access), an ADA-compliant shore fishing pier, an ADA-compliant walkway, a crushed stone access road, and parking area for five to ten vehicles. The location is to be determined.

EXHIBIT 7-1 LOCATIONS OF PROPOSED RECREATIONAL FISHING RESTORATION PROJECTS

7.5.3 LOSSES OFFSET BY THE PREFERRED PROJECTS

The Trustees use the RUM model described in Section 6.2.2 to evaluate recreational fishing benefits provided by the set of six access projects described above. In making this determination, each of the projects is assumed to have a 25-year lifetime, with no benefits provided beyond this 25-year period.[25] In addition, anglers are assumed to receive no benefits from the Lower Grasse River site during remedial work; benefits begin to accrue in 2012, when the site is expected to be available to the public. Consistent with the evaluation of losses due to FCAs, a three percent discount rate is applied to recreational fishing benefits provided in future years.

Under these assumptions, the RUM model indicates that the five recreational fishing access projects in the above locations would offset approximately 80 percent of the losses due to fish consumption advisories, assuming that the advisories are removed in 2030. That is, completion of the access projects would result in service gains equivalent to approximately 80 percent of the 221,075 present value fishing trips lost due to the FCAs. If the advisories are removed at the later date of 2050 rather than 2030, then the five projects would offset approximately 90 percent of the losses.

Although the calculations indicate that less than 100 percent of the losses would be offset, there are several reasons to believe that we may be underestimating the percentage of losses offset:

1. Our calculations assume 25-year project lifetimes. While this may be an appropriate lifetime for the physical infrastructure associated with the projects, three of these properties are currently private property yet will belong to the public at the end of the 25-year period. Thus, benefits are likely to accrue to the public beyond the 25-year project lifetimes.
2. In addition to a new boat launch, three of the projects will also have an ADA-compliant shore fishing pier/walkway. These three projects will likely provide benefits larger than those estimated by the model, as the model estimates the benefits associated with a boat launch that is similar to existing launches in the region.

7.6 EVALUATION OF PREFERRED ALTERNATIVES BASED ON CRITERIA

In order to ensure the appropriateness and acceptability of restoration alternatives for recreational fishing losses in the assessment area, the Trustees evaluated each option relative to site-specific criteria and the restoration criteria listed in the DOI damage assessment regulations (43 C.F.R. §11.82 (d)).

[25] After 25 years, the project infrastructure (e.g., fishing piers, boat launches, walkways) is assumed to have deteriorated to a point where anglers can no longer safely use the site for fishing. The 25-year period was selected after discussions with NYSDEC fisheries personnel.

7.6.1 COMPLIANCE WITH SITE-SPECIFIC CRITERIA

Two site-specific criteria were considered in evaluating the preferred restoration alternatives:

- *Enhancement of recreational fishing opportunities in the Massena area.*
  As described above, discussions with local anglers, a review of State- and county-level planning documents, and a review of recent survey results indicated that new or improved public access to Massena-area rivers would be desirable. The preferred projects will enhance recreational fishing opportunities by allowing boat- and shore-based anglers to fish in locations that are currently difficult to access.

- *Compatibility with State fisheries agencies' management objectives.* Discussions with regional and State-level fisheries staff indicated that the preferred restoration projects are compatible with State fisheries agencies' management objectives.

7.6.2 COMPLIANCE WITH DOI NRDA CRITERIA

Eight general criteria listed in the DOI regulations for damage assessment (43 C.F.R. §11.82 (d)) were considered in evaluating the preferred restoration alternatives:

- *Technical feasibility (43 C.F.R. §11.82 (d)(1)).* Boat and shore access projects are technically feasible. Several boat launches currently exist in the local area, including a recently constructed launch on the St. Lawrence River just upstream of the Power Canal intake and a launch several miles upstream at Coles Creek. The larger launches (i.e., the launch on the Lower Grasse) would incorporate removable docks so that winter ice damage can be avoided. The shore access fishing piers would be designed to be consistent with local building codes. The piers would be parallel to the shore with no footings or supports located in or near the water in order to minimize the risk of ice damage. A similar pier was recently constructed at Springs Park in Massena.

- *The relationship of the expected costs of the proposed actions to the expected benefits from the restoration, rehabilitation, replacement, and/or acquisition of equivalent resources (43 C.F.R. §11.*82 *(d)(2)).* The Trustees believe the expense of creating new boat and shore access sites is reasonable relative to the benefits these projects will generate. Anglers and NYSDEC fisheries personnel have indicated that additional access to local rivers is desirable.

- *Cost-effectiveness (43 C.F.R. §11.82 (d)(3)).* The boat and shore access sites presented in Section 7.4.2 are a cost-effective approach to providing new public access to recreational fishing opportunities. Existing infrastructure and land ownership were considered in selecting these sites. All sites are accessible via local roadways and will require only modest expenditures on access roads. Several of the sites would be located on publicly-owned parcels of land, thus reducing land acquisition expenses. Finally, cost efficiencies are achieved by combining shore and boat access at several of the sites. Although the Trustees continue to review specific sites for implementation, similar considerations will apply to the selection any new site.

- *Results of any actual or planned response actions (43 C.F.R. §11.*82 *(d)(4)).* EPA has not yet selected a remedy, but the Trustees anticipate that response actions will largely be focused on the Lower Grasse River, where one of the potential boat launches would be located. As discussed above, this particular launch would not be open to the public until response actions at the site have been completed. The Trustees do not expect that any of the remaining restoration projects would be impacted by planned response actions, as they are all located in areas where response actions are not anticipated.
- *Potential for additional injury resulting from the proposed actions, including long-term and indirect impacts, to the injured resources or other resources (43 C.F.R. §11.82 (d) (5)).* The development of new fishing access may result in short-term adverse effects to habitat at the preferred sites due to construction of boat launches, parking lots, and access roads. At the Lower Grasse River and Springs Park launch sites, these effects will be minimal as the launch sites and parking areas will exist regardless of NRDA-related activities. In addition, the effects at the Madrid site will be reduced due to pre-existing access roads. Where new parking areas are required, the Trustees will minimize runoff impacts through the use of permeable materials such as crushed gravel. Finally, the extent of impacts to sediment habitat will be minimized through the use of appropriately sized (i.e., one-lane) launches in the shallower sections of the Raquette and Grasse Rivers.
- *The natural recovery period and the ability of the resources to recover with or without alternative actions (43 C.F.R. §11.82 (d)(6-7).* The preferred recreational fishing restoration projects will not affect the rate or ability of assessment area resources to recover to their baseline condition.
- *Potential effects of action on human health and safety (43 C.F.R. §11.82(d)(8)).* Construction of public access facilities will require the use of heavy construction machinery and vehicles. These actions may affect human health and safety. The Trustees expect that the restoration sites will have no public access during construction, thereby limiting any risk. The boat launch on the lower Grasse River will be open to the public after remedial actions have been completed, so public exposure to contaminants in the Lower Grasse are unlikely to pose a health risk. Although fish in local rivers could potentially remain contaminated after remedial actions have been completed (due to the connection to the St. Lawrence River), New York State fish consumption advisories will advise the public regarding any potential health risks.
- *Consistency and compliance with relevant Federal, State, and Tribal laws and policies (43 C.F.R. §11.82 (d)(9-10)).* The Trustees' consideration of this criterion is discussed in detail in Section 7.6.2 below.

7.7 ENVIRONMENTAL ASSESSMENT OF PREFERRED RESTORATION ALTERNATIVE

7.7.1 ENVIRONMENTAL BENEFITS FROM PREFERRED ALTERNATIVES

As discussed in the context of restoration criteria above, the development of new or improved access sites is expected to generate significant long-term benefits to area anglers. Although related activities may cause short-term adverse impacts, such impacts are not likely to be significant relative to the recreational benefits provided by the projects.

Short-term impacts arising from the construction of boat launch and shore fishing sites could include minor disruption of sediments, benthic communities, and floodplain communities. Concrete boat launches will displace small areas of river sediments, and the construction activities may temporarily increase suspended sediments in the adjacent waters, potentially adversely affecting area fish. As shore fishing piers will be constructed entirely out of the water, river sediments are not expected to be impacted during construction. In addition, the Trustees expect that shore fishing piers and/or walkways will replace dispersed bank fishing, allowing for the recovery of trampled riverbank vegetation. The construction of parking areas for boat and shore fishing access sites may impact floodplain communities and increase runoff, but these impacts will be mitigated through the use of gravel rather than asphalt.

7.7.2 COMPLIANCE WITH NEPA AND OTHER POTENTIALLY APPLICABLE LAWS

Coordination and evaluation of required compliance with specific Federal acts, executive orders, and other policies for the preferred restoration plan is achieved, in part, through the coordination of this document with appropriate agencies and the public. All recreational fishing projects will be in compliance with all applicable Federal statutes, executive orders, and policies, including NEPA, 42 USC Section 4321 *et seq.*; the Endangered Species Act (ESA), 16 USC 1531, *et seq*.; the National Historic Preservation Act of 1966, 16 USC Section 470 *et seq.*; the Fish and Wildlife Coordination Act, 16 USC Section 661 *et seq*.; the Rivers and Harbors Act of 1899, 33 USC Section 403 *et seq*.; the Federal Water Pollution Control Act, 33 USC Section 1251 *et seq*.; Executive Order 11990, Protection of Wetlands; and Executive Order 11988, Flood Plain Management. Compliance with the laws cited above, and any necessary permitting, will be undertaken in the restoration project planning stages.

The Federal Trustees are also required under Executive Order Number 12898, 59 Fed. Reg. 7629, to identify and address any policy or planning impacts that disproportionately affect the health and environment of low income and minority populations. Since the restoration alternatives will result in changes that benefit area communities and anglers visiting the local area, the Federal Trustees have concluded that there would be no adverse impacts on low-income or minority communities due to implementation of the restoration alternatives.

CHAPTER 8 | TRIBAL LOST USE

Historically, natural resources within the assessment area have provided traditional and cultural services and opportunities to the Akwesasro:non (people of Akwesasne). The release of contaminants into the natural environment has forced Akwesasro:non to drastically reduce all traditional resource harvesting activities. As a result, they have been denied the ability to: provide their families with healthy foods; fulfill their traditional obligations toward the land, waters, plants and animals; or pass on practical, theoretical, philosophical, and linguistic knowledge of what it means to be Akwesasro:non. The following sections describe the methodology and information used to evaluate these losses relative to the baseline level of traditional services that clean natural resources would have otherwise provided.

8.1 METHODOLOGY

8.1.1 REVIEW OF EXISTING DATA

A study of changes in traditional practices was undertaken, based on a review and analysis of materials related to the environmental contamination of Akwesasne and subsequent impacts on local cultural practices of the Mohawks of Akwesasne. All materials used in this research had been collected previously for other efforts and were contained in the SRMT's database, except for a small set of interviews conducted specifically for the project. This database consists of various sources of information relating to the pollution and the culture of Akwesasro:non, such as newspaper articles, reports, and media coverage.

8.1.2 ORAL HISTORY PRIMARY STUDY

After reviewing existing data, SRMT determined that additional research was needed in order to address important research gaps, and in 2005 an Oral History Project was conducted. The Oral History Project was designed with input from all Trustees and the Companies. Questions were developed collaboratively with substantial input from the community and SRMT staff, and specifically focused on obtaining concise demographic information, specific locations of traditional practices, precise timelines, and personal histories relative to resource-based cultural practices. The Oral History Project involved training community researchers, who in turn contributed invaluable linguistic expertise in the Mohawk Language, addressing complex issues of interpretation and translation. The contributions of the community researchers to the reworking of questions greatly increased the intelligibility of interviews conducted in Mohawk. Collaboration with community researchers also brought awareness of other indicators of changes in traditional practices and generated further means for determining socio-cultural impacts.

Efforts were made by the researchers to quantify data on socio-cultural impacts that specifically related to resource use, and to separate impacts of contamination from other types of impacts (e.g., the St. Lawrence Seaway), but the data did not provide an adequate basis to support a rigorous quantitative analysis. In addition, the SRMT community expressed a fundamental objection to any quantification of cultural damage – the community perspective is that the data and associated questions do not lend themselves to quantitative analysis. Therefore, a qualitative analysis of available information was undertaken.

8.2 BASELINE

Baseline, that is, resource-based cultural practices relative to ecological conditions "but for" the release of contaminants, is determined to be pre-1955. At that time, 100 percent of the pre-pollution population (considered in terms of family units) was reliant on traditional resources and resource-based cultural practices, and the overall proportion of activities based on cultural practices related to the land, rivers and associated ecosystems of Akwesasne for subsistence was 95 percent. The Oral History Report concludes that prior to 1955 the Mohawks of Akwesasne were not detrimentally affected by industrialization and maintained the capacity to adapt to cultural diffusions and changes in the natural environment in ways that were consistent with their values and the responsibilities inherent in Haudenosaunee culture.[26]

8.3 TYPES OF TRIBAL USES LOST OR IMPACTED BY CONTAMINATION

Research completed for the Cultural Impact Study: Assessment and Overview of the Effects of Environmental Contamination on the Mohawks of Akwesasne (Appendix K) states that at least four areas of traditional cultural practices were harmed by the release of hazardous contaminants. They are (not in any particular order): 1) Water, fishing, and use of the river, 2) Horticulture, farming and basketmaking, 3) Medicinal plants and healing, and 4) Hunting and trapping. Language has also been detrimentally affected by the decline of traditional cultural practices; words associated with these activities are at risk of being lost. See Appendix J, "Anthropological Report: The Effects of Environmental Contamination on the Mohawks of Akwesasne". Each of these cultural practices is described in more detail below.

[26] Haudenosaunee ("People of the Longhouse" in Kanien'kehá), also known as the Iroquois Confederacy, is comprised of the five original Iroquois nations Mohawk, Oneida, Onondaga, Cayuga, and Seneca (Tuscarora nation joined the Confederacy in the 18th century). Akwesasne ("Land where the Partridge Drums" in Kanien'kehá) is a Mohawk Nation Territory and Mohawks are known as "Keeper of the Eastern Door" of the Haudenosaunee.

8.3.1 WATER, FISHING AND USE OF THE RIVER

Life in Akwesasne revolved around the rivers. Fishing as an economic and cultural activity was central to the identity of the people, as well as provided the people with their main sources of protein. The rivers also provided the people with a source of clean drinking water, a means of transportation, and a favorite recreation - swimming. Being cut off from the physical, psychological, and recreational sustenance that rivers provide to Akwesasro:non has impacted the people negatively in countless ways. For example, people miss the ability to fish and use the water of the St. Lawrence and other rivers. People noticed changes in the water quality, including the taste and smell of both the fish and water, and changed their resource harvesting activities accordingly. This was done long before the implementation of the fish consumption advisory by NYSDOH in 1984 (see Section 6.1).

8.3.2 HORTICULTURE, FARMING, AND BASKETMAKING

The people of Akwesasne relied on traditional horticulture and farming activities to support their subsistence, with further monies generated through the sale of handmade baskets and locally produced and/or collected food items. These activities were important aspects of the people's lives right up to the time when pollution made such activities difficult if not impossible. Until such time, people in Akwesasne were largely self-sufficient. The ability to produce most food items through horticulture and farming (along with that acquired through fishing, hunting and trapping), provided people with autonomy and independence and the power to manage changes to their traditional practices. Until the time of heavy industrialization, the people of Akwesasne were able to assert an effective measure of control over the impacts of the outside world on their culture and traditional practices; this autonomous existence and balanced organic pattern of survival was effectively destroyed by the ensuing effects of toxic by-products on the environment.

8.3.3 MEDICINE PLANTS AND HEALING

The contaminants released by the Companies have also had detrimental effects on the medicinal plants that knowledgeable Akwesasro:non gathered in order to deal with many health issues, resulting in a corresponding loss in traditional healing practices. For example, medicinal plants were used to increase the milk supply of nursing mothers, and treat fevers, pain, boils, toothache, and hair loss. In some cases, pollution led to the disappearance of medicine plants, and in other cases it changed the appearance or taste of the plants, alarming healers. Medicines also came from animal parts that can now no longer be obtained for similar reasons (i.e., animals have accumulated contaminants; Chapter 3). While some still travel to distant locations in order to attempt to acquire traditional medicines, much of this knowledge is at risk of being lost given that traditional healing can no longer be practiced without the local availability of medicines.

8.3.4 HUNTING AND TRAPPING

Along with fishing, horticulture and farming, people also depended on hunting and trapping in order to supplement their diet and income. Hunters and trappers tend to be experts in animal behavior and health. This is not only because of their continuous observation and recording of the health of animals while they skin and process them (including such areas as organ health, normality of fat layers, etc.), but also because of their detailed knowledge of the interdependencies of all plants and animals and the ecosystem they rely on (Nadasty 2004, Spak 2001, Berkes 1999, Freeman 1992, Feit 1973). Therefore, hunters and trappers tend to be "at the front line" of observing environmental change, which often includes an awareness as to why certain animals become sick, given that the hunters and trappers know what these animals eat and need in order to survive. It is therefore not surprising that the hunters and trappers of Akwesasne noted changes in the animals and decided against the consumption of their meat before any official advisories had been given. Following are quotes from interviews conducted with Tribal members regarding hunting:

> *"These days, and it might have started about twenty years ago, I hear them say that the muskrat, beaver and other animals became infested with disease. They did not feel like eating the meat anymore…They were afraid to get sick as a result" (Interview 31).*
>
> *" … And muskrats… Heard that muskrat and also fish started to have sores on them and that is when people stopped eating them. When? Not sure, maybe late fifties early sixties…" (Interview 32).*
>
> *"Before when you skinned the muskrat when you would pull its hide and you would see the fat in its legs it had turned yellow. It used to be white, like that paper right there. That's how you could tell it was healthy. And in the snow, we found piles of muskrats that were all dead. Something they were eating was not right. They ate mainly marsh and there was something wrong with it. That is what killed them? Yes" (Interview 48).*
>
> *Interviewer: "You said your father was a hunter".*
>
> *#62: "Yes".*
>
> *Interviewer: "During that period did he ever talk about things like the strange deer they see now?"*
>
> *#62: "No. There were none. Everything he hunted...and they also hunted in the spring…. They would bring home what they caught and salt them. In those days they used to salt them (laughing). You know that muskrat is good...My father used to say that the muskrat ate the best and that's why the meat was so good."*
>
> *Interviewer: "Roots?"*
>
> *#62: "Yes."*
>
> *Interviewer: "You don't [remember] him ever saying that there was anything wrong with the wild animals?"*

#62: "No. It was still good" (Interview #62).

Interviewer: "Uh, what were you trapping for?"

 # 72:   "Mostly muskrats... Beaver, oh anything…Fisher, everything".

Interviewer: "Did you notice ah, a change in the animals, those animals?"

 # 72:   "Ah, we, my brother and I used to hunt deer over there uh…And they're full of sores...So, we won't eat them anymore, in the Reynolds area…where the heavy pollutants hit the ground, must be heavier over that way…we skinned a few there and there was ah, sores all over them, awh…It was awful…You can't see them, you have to skin them…Then you'll see it under the skin".

Interviewer: "Did this happen with the muskrats too?"

 # 72:   "Uh, we don't eat muskrat no more, cause it's, they're too polluted, huh…we could see like funny looking...ah, almost like pus sores" (Interview #72).

8.3.5 LANGUAGE

Following a mandate resulting from the Community Advisory Committee meeting of August 12, 2004, language restoration was made a priority for cultural restoration work. The Cultural Impact Study showed how the Mohawk language has suffered because ties to the land and rivers have been damaged or destroyed by environmental contamination. Issues surrounding the serious concern about language loss have been reflected at gatherings and Council meetings throughout the Haudenosaunee Confederacy. One such gathering, which included representatives from Akwesasne, was held at the Onondaga Nation in May of 2002. The purpose of this gathering was to determine what should be done to ensure the survival and growth of all Haudenosaunee languages, and provided impetus for considering language restoration an urgent priority. The case of Akwesasne was discussed as being of particular concern. In spite of the fact that a number of middle-aged and elderly speakers still exist in the community, there is an extremely low number of speakers who are willing and able to teach the language. It was made clear at this gathering that the Mohawk language is seriously threatened, since fluency in the language is restricted to those 45 and older. The Mohawk Language is not a written language; it is passed down from generation to generation through daily oral use. The Akwesasro:non have now skipped a generation of Mohawk speakers, and in some families two generations no longer speak or understand the Mohawk language.

In the past, children would also have grown up in the gardens and farms, learning of the importance of honoring the seasons, taking care of plants and animals, and how to make a living off the product they provide. Again, people no longer grow gardens or work at farming due to fears for their health stemming from the release of PCBs and other hazardous substances into the environment. For the children and youth, this loss of traditional horticulture and farming activities is not only one of a simple practical skill but also one of language (i.e. focal vocabulary tied to such activities) and overall worldview since it is difficult to teach such things without the needed natural settings. The same can be said for the traditional hunting and trapping activities that have been drastically reduced due to pollution. Akwesasne's children and youth are not only denied these practical skills, they are also missing out on the overall cultural teachings of the proper relationships between human and animals that go hand in hand with such activities.

As the traditional teachers responsible for transmitting cultural and practical knowledge, the release of hazardous substances and the resultant abandonment of all traditional resource harvesting activities has meant that Elders can no longer fulfill their obligation to pass their traditional knowledge of what it means to be Akwesasro:non on to the younger generation. While they try to do so to some degree, this learning/teaching process is nearly impossible to practice without the traditional land-based activities within which the culture was framed. The loss of all resource harvesting activities has thus meant that Elders have to stand by and watch their children and grandchildren become more and more influenced by English and mainstream culture, without being able to take them "out on the land" to teach them about their true identity.

While past generations grew up with the St. Lawrence River as their main focal point, swimming in it from an early age and learning the proper way to interact with the waters, fish, plants, and animals, today's children cannot go fishing with their parents, grandparents or other relatives and are thus denied the ability to learn an important aspect of their culture. Thus, as a result of the release of hazardous substances, the children and youth of Akwesasne not only cannot learn traditional fishing and fishing processing methods, but are also unable to learn the traditional terminology and ways of relating to fish that go hand in hand with such activities.

CHAPTER 9 | TRIBAL COMPENSATION

9.1 OVERALL RESTORATION OBJECTIVE

The community's ultimate objective is to re-establish the harmed cultural practices to the level at which they were practiced but for the release of contaminants into the ecosystem, and to restore the natural resources to their full extent so they may be used the way they were prior to the release of contaminants.

This restoration plan seeks to return traditional practices to where:

1. These practices are spread among all age groups and throughout the family groups in the community;
2. The number of people participating in land-based cultural activities is increasing at pace with overall population numbers;
3. The practices are diffuse within the social, political, and economic life of Akwesasne;
4. The practices adapt to the changing culture of the community; and
5. People again gain a level of expertise in these areas such that specialized knowledge and the skill level within the community begin to increase, allowing each practice to continue to evolve.

This chapter outlines the general restoration framework for achieving these goals, describes the methodology for selecting and scaling restoration alternatives, and summarizes the preferred restoration alternatives.

9.2 GENERAL RESTORATION FRAMEWORK

The cultural restoration framework focuses on taking urgent action to prevent further loss of knowledge associated with land and river-based cultural practices, and addresses the immediate needs of the community in terms of identifying and supporting practices, programs, and persons in their efforts to ensure the survival of traditional Mohawk cultural life. The focus is on restoring necessary connections to natural resources, regenerating key cultural practices, and transferring crucial cultural knowledge. In taking this approach to restoration, the patterns of belief and practice that once characterized the Mohawk community can be restored over time and through focused efforts will achieve a regenerating point at which these traditional cultural practices will once again be widespread and self-sustaining, as well as fundamental parameters of existence in Akwesasne. This will ensure the long-term cultural integrity of Akwesasne as an indigenous community, but also promote physical health and serve as a major factor in the recovery of social stability and in the generation of economic self-sufficiency based on traditional practices.

Akwesasne's approach to cultural restoration seeks to restore land-based cultural practices and traditional economic activities within the community. It will do this in two ways. First, it will establish and directly support long-term master-apprentice relationships in the four areas of traditional cultural practice that were harmed by the release of hazardous contaminants, and promote and support the regeneration of practices associated with traditions in these areas:

1. *Water, fishing and the use of the river.* Restoring traditional community fishing practices and local economy; restoring language use and transmission of knowledge regarding traditional fishing and river practices.
2. *Horticulture and basket-making*. Restoring traditional and sustainable gardening practices that are vital to the local economy; restoring language use; restoring traditional roles and responsibilities for engaging in gardening and basket-making; provision of access to natural resources for horticulture or other traditional uses.
3. *Medicine plants and healing*. Preservation of cultural sites and/or species necessary for the spiritual survival of the community; restoration of traditional medicine plant use such as sweet grass; regeneration of intergenerational teachings, language, and relationships between elders and youth regarding medicine plants and healing.
4. *Hunting and trapping*. Restoration of traditional hunting practices as community livelihood; Preservation of animal habitats and populations; regeneration of intergenerational teachings, language and relationships between elders and youth regarding hunting and trapping.

This restoration plan will also support the enhancement of existing programs and institutions that demonstrate an ability to promote intergenerational cultural knowledge transfer in the identified areas of harm. This will be accomplished through the one-time Institutional Funding of proposals for the enhancement or expansion of existing programs.

9.3 METHODOLOGY FOR SELECTION AND SCALING OF RESTORATION PROJECTS TO COMPENSATE FOR LOST USE

9.3.1 COMMUNITY OUTREACH

SRMT has conducted extensive community outreach to develop ideas and planning for the Restoration Plan. Between 2004 and 2009, SRMT NRD Program outreach activities included the development of educational materials; solicitation of comments, suggestions, and proposals from Tribal members; the creation of a Community Advisory Committee; an Oral History Project of community member interviews; public meetings; radio announcements; the mailing of a Cultural Impacts DVD to the public; and a Traditional Activities Survey.

Through this extensive community outreach conducted over the years, it was concluded (with the help of the community) that a Master/Apprentice Program is a logical solution to revitalize traditional cultural practices. In order to fully embrace traditional activities, language would also be included. Community outreach has played an important role in the selection of some of the projects included in the Restoration Plan.

9.4 PREFERRED RESTORATION ALTERNATIVES

The preferred restoration effort will have two main elements, each addressing a significant need and reinforced in consultations with the community. The two main components of cultural restoration include:

1. Apprenticeship program
2. Institutional Funding

9.4.1 APPRENTICESHIP PROGRAM

The Master/Apprentice Program is a five-year program that provides opportunities for people who are interested in learning traditional cultural practices (apprentices) to work with knowledge holders in the community (masters). The program objective is to provide a viable plan of action for the continuance of traditional cultural practices through the transfer of knowledge between the masters and apprentices and future generations. The program will consist of 8 masters and 16 apprentices. Masters will be equipped as necessary with tools, supplies, and support and connected with an appropriate number of apprentices (varying according to the specific practice and based on the teaching capacity of specific masters) drawn from an established pool of younger Akwesasne individuals who have expressed interest and demonstrated commitment to learning cultural practices under this teaching model. It is anticipated that there will be sufficient numbers of masters and apprentices available to create numerous small-group teams in all four areas of harm. Financial support will be provided to both the masters and apprentices using a fellowship system; the fellowship will be provided in the form of stipend and will be in sufficient amount to replace other forms of wage income and to allow full-time participation by both teachers and learners for the expected period of time (i.e. five years) required for apprentices to gain a level of cultural knowledge and language fluency which allows them to practice autonomously and to take on a mentoring role for the next generation of learners.

The master-apprentice model is most appropriate to the objective of restoring harmed land-based cultural practices because it is both a structure and relationship which allow for the integration of an Indigenous learning-teaching approach. The goal of the process over time is to bring the apprentice to a point where he or she possesses the skills of the master and the confidence to assume a teaching role to others. An important measure of success of the program is through recognition by the community. Most commonly, apprentices are "certified" legally, but the Cultural Apprenticeship Program, beyond the awarding of a certificate, will require that apprentices take part in annual traditional knowledge community conferences to demonstrate their growing skill level and be recognized publically to ensure their credibility. Apprentices will then be promoted as cultural resources and sources of knowledge accessible to the community as a whole at the conclusion of the program.

A capacity for promoting and supporting the restoration of *Kanien'keha* (the Mohawk language) through both the master-apprentice relationships and existing institutional activities is a core feature of the overall restoration plan. Language development specialists will be supported for a five year period in conjunction with the Master/Apprentice Program described above. Sufficient program resources and infrastructure moneys will also be provided. This aspect of the plan addresses language deficits in the number of speakers in the community and the depth and complexity of the language itself, both of which were detrimentally affected by the community's disconnection from land-based and riverine cultural activities. Initiatives to maintain the transmission of language and important focal technical vocabulary embedded in traditional resource-harvesting practices are an important aspect of the effort to restore the health and vitality of the people.

The goal of this aspect of restoration is to increase the number of language speakers by having all participants in the Master/Apprentice Program and all of the main participants involved in institutional projects recover fluency in *Kanien'keha*. A community-wide strategy will also be supported through this program, with emphasis on working with other organizations and agencies to saturate Akwesasne with *Kanien'keha* /Mohawk using all available print and broadcast media (radio, newspapers, print, video, street signs, education materials, etc.).

9.4.2 CULTURAL INSTITUTIONAL FUNDING

A number of existing Akwesasne-based institutions and programs that have already begun the work of responding to the cultural harm caused by contamination are essential to the survival and regeneration of traditional land-based cultural practices. These institutions will be provided with the necessary financial resources to stabilize their relevant operations and meet their infrastructure and programming needs. Using the Cultural Evaluation tool described below (Section 9.4.3), a total of four projects were successful in meeting the criteria for funding. These projects provide extensive collection of benefits. Exhibit 9-1 describes each project.

9.4.3 CULTURAL EVALUATION TOOL

All proposals from organizations were evaluated based on a set of criteria (Appendix L). Proposals were ranked according to their strengths on two axes: 1) the degree to which they reflect the indigenous learning-teaching model outlined previously in relation to the Master/Apprentice Program and, 2) the extent to which they address the four main areas of cultural harm. Integration of language restoration capacity added value to a proposal, but none were penalized for a lack of language teaching capacity because of the language restoration element built into the general restoration framework as an overall objective.

1. Project proposals must restore a territory/species/cultural practice that has been impaired or damaged by contamination and have one or more of the following additional objectives:
   - Restoration of traditional community fishing practices;
   - Enhancement of the well-being of children, youth and families;
   - Increase in community food security and sustainable livelihoods;
   - Regeneration of the transmission of community knowledge to future generations through elder/youth and other community relationships; and
   - Promotion of both short-term and long-term improvements in terms of restoring land-based cultures and/or traditional community economies.
2. Project proposals from established organizations must demonstrate a record of stability and previous success in achieving the objective of cultural restoration.
3. Project proposals should utilize an indigenous learning-teaching model to achieve the objective(s) outlined in the proposal.

EXHIBIT 9-1 SUMMARY OF PROJECTS MEETING THE CRITERIA FOR CULTURAL INSTITUTION FUNDING

RESOURCE-USE BENEFITS	PROJECT DESCRIPTION
Horticulture; Medicine and Healing; Language	This type of institution would be committed to the preservation of Mohawk language, traditions, culture and beliefs and serve as an educational center, a living community and a spiritual retreat.
Horticulture; Medicine/Healing; Hunting; Trapping; Language	This type of institution incorporates Mohawk language, traditional Mohawk culture and the natural environment into daily activities. With stable funding, this restoration project ensures the regeneration of Mohawk language and culture in Akwesasne.
Horticulture; Medicine/Healing; Hunting/Trapping	This type of institution provides opportunities for Akwesasne youth as well as surrounding communities to receive outdoor educational experience. It is a natural and safe location for traditional teaching, respect for the land and survival skills.
Horticulture	This type of project would provide materials, plants, and nutritional information for raised bed gardens to community members.

9.4.4 ACCESS TO RESOURCES

There are natural resource needs specific to each cultural practice that may be lacking or where the existing resources in Akwesasne are not usable. Until resources are fully functional and safe for consumption Akwesasro:non will need to access certain resources in other areas (i.e., upstate New York or southern Ontario/Québec regions). The main practices of need in this respect are for fishing, natural foods and medicine gathering, and hunting and trapping.

Substitute sites for traditional activities are sparse and difficult to access. The acquisition of property in the vicinity of Akwesasne would provide community members the opportunity to engage in cultural practices in the categories of hunting, trapping, medicines, natural foods, and basketmaking.

Therefore, SRMT Environment Division will pursue additional land acquisition through other fund sources or partnerships. Criteria to be considered for desirable lands may include such attributes as diverse habitat with large acreage, location, access to fishery and purchase price.

9.5 OVERVIEW OF PREFERRED RESTORATION

The restoration for cultural harm caused by the release of contaminants focuses on preventing further loss of knowledge associated with natural resource-based cultural practices. It is key for the success of this restoration effort that all elements work in conjunction with one another. The Apprenticeship Program and Institutional Funding provide a collective and holistic approach to compensate for lost use and target a range of demographics of Akwesasne Mohawks. Each component is meant to integrate with the other. A great deal of effort was made to identify appropriate restoration projects using criteria and extensive evaluation, ensuring that restoration actions are not duplicative, but that each element integrates and enhances one another. The cost of these restoration actions are summarized in Exhibit 9-2.

EXHIBIT 9-2 SUMMARY OF CULTURAL RESTORATION PROJECT COSTS

PROJECT TYPE	COST (MILLIONS)
Apprenticeship Program	$5.1
Institutional Funding	$1.3
Planning and Oversight	$1.9
Total	**$8.3**

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