PENINSULA HARBOUR REMEDIAL ACTION PLAN

STAGE 2:
Remedial Strategies for Ecosystem Restoration

Peninsula Harbour Remedial Action Plan Team
November 2012

PENINSULA HARBOUR
RAP
NORTH SHORE
OF LAKE SUPERIOR
REMEDIAL ACTION PLANS

Photo (above): Environment Canada

Acknowledgements

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Thanks to those that reviewed the report and provided valuable expertise and comments.

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Eric Berglund	Ontario Ministry of Natural Resources
Tara George	Ontario Ministry of the Environment
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Thanks to the Peninsula Harbour Community Liaison Committee (CLC) for their review of the Stage 2 report and their input on the delisting criteria for the beneficial use impairments. Also, thanks to the former Public Advisory Committee for their input on the previous Stage 2 draft report and water use goals. Thanks to Jim Bailey, of EcoSuperior Programs, for all the dedication and enthusiasm he brought to his role as local coordinator and facilitator for the CLC.

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ACRONYMS AND ABBREVIATIONS

AIS	Aquatic Invasive Species
AOC	Area of Concern
BEAST	BEnthic Assessment of SedimenT
BOD	Biological Oxygen Demand
BUI	Beneficial Use Impairment
CDF	Confined Disposal Facility
CLC	Community Liaison Committee
COA	Canada Ontario Agreement Respecting the Great Lakes Basin Ecosystem
CPUE	Catch Per Unit Effort
DFO	Fisheries and Oceans Canada
EC	Environment Canada
ERA	Environmental Risk Assessment
FCIN	Fish Community Index Netting
GLWQA	Great Lakes Water Quality Agreement
Hg	Mercury
IJC	International Joint Commission
LaMP	Lakewide Management Plan
MNR	Ministry of Natural Resources
MOE	Ministry of the Environment
MoNR	Monitored Natural Recovery
PAC	Public Advisory Committee
PCBs	Polychlorinated biphenyls
PSQG-SEL	Provincial Sediment Quality Guideline - Severe Effect Level
PWGSC	Public Works and Government Services Canada
RAP	Remedial Action Plan
SEL	Severe Effect Level
TSS	Total Suspended Solids
UGLMU	Upper Great Lakes Management Unit (Ministry of Natural Resources)
WPCP	Water Pollution Control Plant

EXECUTIVE SUMMARY

As a result of the *Great Lakes Water Quality Agreement* (GLWQA) of 1978 and its 1987 revisions, participating federal, state and provincial agencies, in cooperation with the International Joint Commission, identified 43 degraded areas on the Great Lakes known as Areas of Concern (AOCs). The environmental issues identified in the 1991 Peninsula Harbour Stage 1 report include high levels of contaminants in fish and sediment, loss of fish habitat, and degraded fish and benthic communities. These environmental issues were caused by the discharge of wastewater from the municipal sewage treatment plant and former pulp mill, and associated chemical plant and log booming.

The 1991 Peninsula Harbour Stage 1 report provided a definition and detailed description of the environmental problems within the AOC and identified water use goals and the beneficial use impairments for the harbour and adjacent areas of the lake. This Stage 2 report identifies locally defined goals and remedial actions to restore environmental conditions and enable delisting of Peninsula Harbour as an AOC. This report also provides the status of the remaining beneficial use impairments, a set of updated delisting criteria and the remedial actions required to meet delisting criteria and ultimately remove Peninsula Harbour from the list of AOCs.

The Peninsula Harbour Remedial Action Plan development and implementation has been led by Environment Canada (EC) and the Ministry of the Environment (MOE), with support from the Ministry of Natural Resource (MNR), Fisheries and Oceans Canada (DFO), First Nations, the Town of Marathon, and the public to restore environmental conditions and remove Peninsula Harbour from the list of Great Lakes AOCs.

Of the 14 impairments of beneficial use outlined in the GLWQA, five were designated impaired and one required further assessment in the 1991 Stage 1 report. Currently there are two beneficial uses that remain impaired and two require further assessment (Table A).

Table A. Status of Beneficial Use Impairments, as identified in the Great Lakes Water Quality Agreement, in the Peninsula Harbour Area of Concern.

No.	Beneficial Use Impairment	1991 Status (Stage 1)	2012 Status (Stage 2)
1	Restrictions on fish and wildlife consumption	Impaired	Impaired
	♦ fish consumption	Impaired	Impaired
	♦ wildlife consumption	Not Impaired	Not Impaired
2	Tainting of fish and wildlife flavour	Not Impaired	Not Impaired
3	Degradation of fish and wildlife populations	Impaired	RFA
4	Fish tumours or other deformities	RFA	Not Impaired
5	Bird or animal deformities or reproduction problems	Not Impaired	Not Impaired
6	Degradation of benthos	Impaired	Impaired
	♦ Population	Impaired	Impaired
	♦ Body burden	RFA	Impaired
7	Restrictions on dredging activities	Impaired	Not Impaired
8	Eutrophication or undesirable algae	Not Impaired	Not Impaired
9	Restrictions on drinking water consumption, or taste and odour problems	Not Impaired	Not Impaired
10	Beach closings	Not Impaired	Not Impaired
11	Degradation of aesthetics	Not Impaired	Not Impaired
12	Added costs to agriculture or industry	Not Impaired	Not Impaired
13	Degradation of phytoplankton and zooplankton populations	Not Impaired	Not Impaired
14	Loss of fish and wildlife habitat	Impaired	RFA

RFA – Requires Further Assessment

Remedial Strategies for Ecosystem Restoration

The remaining impaired beneficial uses are due to mercury and polychlorinated biphenyls (PCB) contaminated sediment within Jellicoe Cove, a contaminated sediment hot spot area within the AOC. Thus, the sediment management plan is central to the remedial strategy for the Peninsula Harbour AOC.

The sediment management plan is the result of a number of studies and consultations, guidance from the *Canada-Ontario Decision Making Framework for Assessment of Great Lakes Contaminated Sediment* (EC and MOE 2007), the environmental risk assessment (ENVIRON 2008a), and the sediment management options report (ENVIRON 2008b).

The sediment management options study (ENVIRON 2008b) identified and evaluated various management options for the most effective and feasible option to address PCB and mercury contaminated sediment in Jellicoe Cove. Ultimately four alternatives were considered as potential sediment management options for Jellicoe Cove:

1. thin layer capping;
2. hydraulic dredging, thin layer capping and offsite disposal of dredged sediment;
3. hydraulic dredging, thin layer capping, and consolidation of dredged sediment in an onsite, land-based confined disposal facility; and
4. monitored natural recovery.

After a thorough assessment of the risks, benefits, costs and input from the community and Peninsula Harbour Sediment Management Technical Committee, EC and the MOE selected thin layer capping as the preferred method of managing contaminated sediment in the Peninsula Harbour AOC. The implementation of the thin layer cap is a priority action for this AOC. Public Works and Government Services Canada, on behalf of EC, will oversee the construction of the thin layer cap. The project will be funded by EC, the MOE, MNR and a former mill owner.

A sediment management long-term monitoring plan has been developed to address long-term monitoring goals. The long-term monitoring plan will look at short and long-term trends upwards of 20 years following the implementation of the thin layer cap.

Additional monitoring actions related to restored and impaired beneficial use impairments will continue. The monitoring of fish population health by MNR will continue as part of their lake wide assessment of fish communities and to confirm the status of fish populations in Peninsula Harbour. In addition, the MNR will conduct a targeted fish habitat survey in Beatty Cove to determine whether or not there is a need for habitat creation in the AOC. MOE will continue the sport fish monitoring program that provides advice on consumption of sport fish.

Implementation of the sediment management plan, subsequent monitoring, and the targeted fish habitat survey are the remaining actions for the restoration of this AOC.

1.0 INTRODUCTION

As a result of the *Great Lakes Water Quality Agreement* (GLWQA) of 1978 and its 1987 revisions, participating federal, state and provincial agencies, in cooperation with the International Joint Commission, identified 43 degraded areas on the Great Lakes known as Areas of Concern (AOCs). The environmental issues identified in the 1991 Peninsula Harbour Stage 1 report include high levels of contaminants in fish and sediment, loss of fish habitat, and degraded fish and benthic communities. These environmental issues were caused primarily by effluent from municipal wastewater, the kraft pulp mill and organic debris from log booming activities. The purpose of this Stage 2 report is to identify locally defined goals and remedial actions to restore environmental conditions and enable delisting of Peninsula Harbour as an AOC. This report also provides the status of the remaining beneficial use impairments, updated delisting criteria and the remedial actions, including the selected sediment management plan – thin layer capping, required to meet delisting criteria and remove Peninsula Harbour from the list of AOCs.

1.1 Stages and Processes of the Remedial Action Plan

The GLWQA established general and specific water quality objectives for the Great Lakes basin and affirmed the determination of Canadian and United States governments to restore and enhance Great Lakes water quality. An Area of Concern (AOC) is an area of the Great Lakes where historical pollution has caused environmental issues that affect the use and enjoyment of that area or may affect the health of the lake. Currently there are nine AOCs in Canada, 25 in the United States and five are shared by both countries (the St. Marys, St. Clair, Detroit, Niagara and St. Lawrence rivers) (Figure 1). Four AOCs, three in Canada and one in the United States, have been fully remediated and officially removed from the list of AOCs. Two Canadian AOCs and one United States AOC are recognized as Areas in Recovery. An Area in Recovery is a geographic area originally identified as an AOC, where, based on community and government consensus, all scientifically feasible and economically reasonable actions have been implemented and additional time is required for the environment to recover.

As part of the GLWQA, Remedial Action Plans (RAPs) have been developed for each area through a collaborative, methodical, and scientific approach. RAPs define the nature, extent, and causes of environmental problems and recommend actions to restore and protect the environment. Canada and Ontario work together with conservation authorities, municipalities, Aboriginal communities, environmental groups, industry and the public to develop and implement the plans. All RAPs proceed in three stages: Stage 1 identifies environmental problems and sources of pollution; Stage 2 evaluates and carries out actions to restore the area; and Stage 3 confirms that these actions have been effective and the environment has been restored (delisting of AOC). In addition, the GLWQA identified 14 potential impairments to beneficial uses that may impact human, wildlife and aquatic life through a change in the chemical, physical and biological integrity of the AOC ecosystem. The beneficial use impairments include the following:

1. restrictions on fish and wildlife consumption;
2. tainting of fish and wildlife flavour;
3. degradation of fish and wildlife populations;
4. fish tumours or other deformities;
5. bird or animal deformities or reproduction problems;
6. degradation of benthos;
7. restrictions on dredging activities;
8. eutrophication or undesirable algae;
9. restrictions on drinking water consumption, or taste and odour problems;
10. beach closings;
11. degradation of aesthetics;
12. added costs to agriculture or industry;
13. degradation of phytoplankton and zooplankton populations; and
14. loss of fish and wildlife habitat.

In 1971 the first *Canada-Ontario Agreement* (COA) *Respecting the Great Lakes Basin Ecosystem* was signed by the Ministry of the Environment (MOE) and Environment Canada (EC). Since then, COA has been renewed and modified six times, most recently in 2007, to co-ordinate provincial and federal government efforts and commitments for Great Lakes environmental protection and the implementation of the RAPs. The Ministry of Natural Resources (MNR) and Fisheries and Oceans Canada (DFO) also play important roles in the implementation of RAPs. RAP implementation is an important step towards virtual elimination of persistent toxic substances, and restoring and maintaining the chemical, physical, and biological integrity of the Great Lakes basin.

1.2 Overview of the Peninsula Harbour Remedial Action Plan

The Peninsula Harbour Stage 1 report provided a definition and detailed description of the environmental problems within the AOC, identified water use goals, and beneficial use impairments. The Stage 1 report was reviewed by various experts in federal and provincial agencies and was submitted to the International Joint Commission (IJC) in 1991. The IJC concluded that there was sufficient information to proceed with the Stage 2 report. A draft Stage 2 report was completed in 2002 but was never finalized because a preferred management action could not be determined. Contaminated sediment required further investigation as to whether management actions were needed and if so, what option(s) would be most suitable for the AOC. Since the draft Stage 2 report, a number of monitoring and sediment studies have been completed including an environmental risk assessment (ENVIRON 2008a) and a sediment management options report (ENVIRON 2008b). These efforts have provided valuable information to determine what remedial actions are required to rehabilitate the environment and subsequently delist Peninsula Harbour as an AOC. This Stage 2 report describes the assessment of remedial options and related monitoring in order to complete implementation of the RAP.

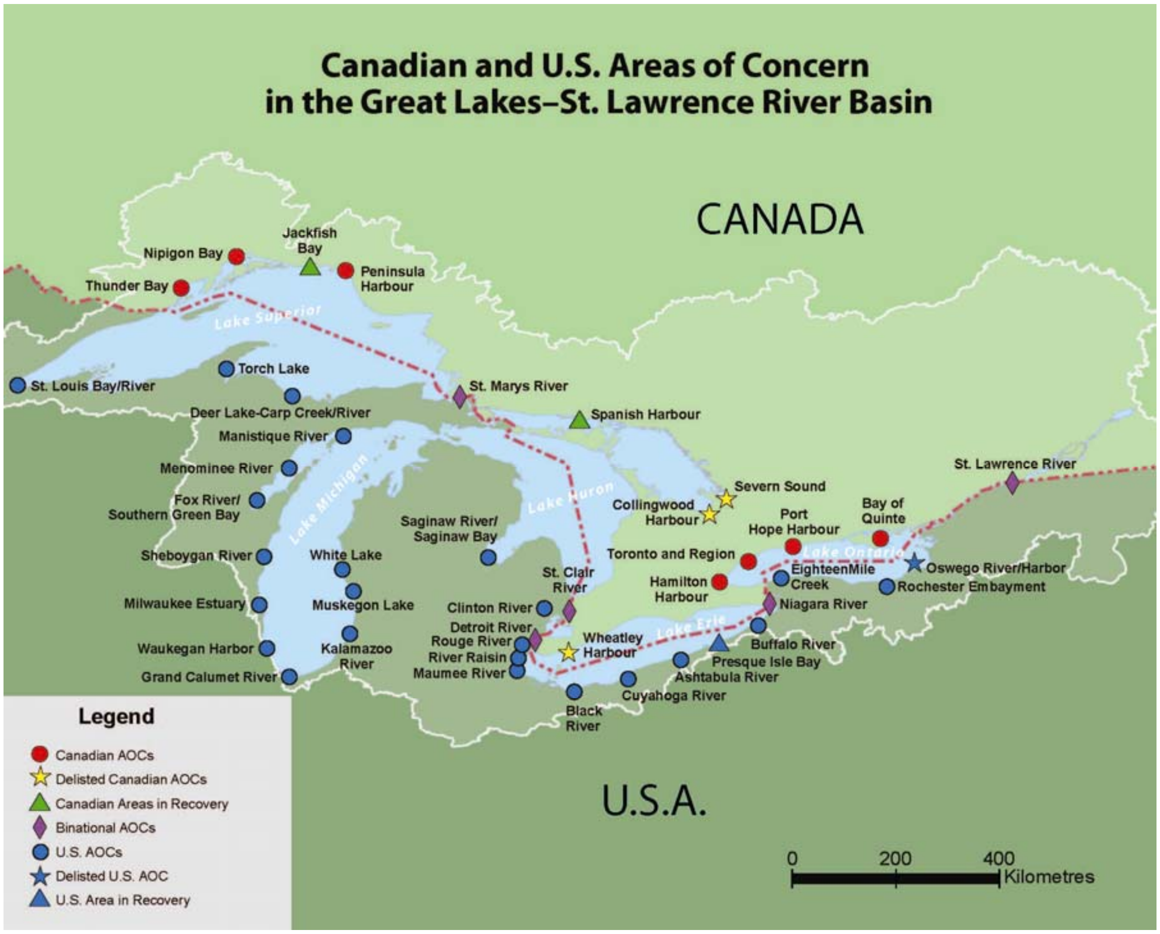


Figure 1. Canadian and United States Great Lakes Areas of Concern Map

1.2.1 Role of Agencies

Implementation of the Peninsula Harbour RAP and providing support in efforts to monitor ecosystem recovery is the responsibility of local, provincial and federal governments. The development and implementation of the Peninsula Harbour RAP has been led by EC, MOE, with support from MNR and DFO. Through COA and the GLWQA, the provincial and federal governments are committed to working with Aboriginal communities, municipal governments, local stakeholders and the public to restore environmental conditions and remove Peninsula Harbour from the list of Great Lakes AOCs.

1.2.2 Public Involvement and Committees

The federal and provincial governments recognize the importance of community involvement in RAP decision making. The combination of local knowledge and community-based goals with scientific data and expertise has resulted in a pragmatic approach to restoring environmental conditions.

The Peninsula Harbour Public Advisory Committee (PAC) was formed in 1989 and was composed of representatives from the Town of Marathon, James River-Marathon Ltd. (last known as Marathon Pulp Inc.), Friends of Pukaskwa National Park, Buchanan Forest Products, Ontario Federation of Anglers and Hunters, Marathon District Chamber of Commerce, Marathon Rod and Gun Club, and members of the public (Peninsula Harbour RAP Team 1991). The PAC evaluated the beneficial use impairments and developed water use goals for the AOC that provided community-based guidelines for the RAP. The PAC provided input throughout the 1990s on the draft Stage 2 report. The PAC successfully completed their objectives and subsequently disbanded.

Public involvement continued to play an important role in the development of the contaminated sediment management plan for the AOC. In the winter and spring of 2008, meetings were held with the Town of Marathon, Ojibways of the Pic River First Nation Band Council and Marathon Pulp Inc. This was followed by three community open houses in June 2008, two in Marathon and one in the Ojibways of the Pic River First Nation. The purpose of the open houses was to review information related to the RAP for the AOC. This included options for management of contaminated sediment, proposed delisting criteria, and the results of an ecological risk assessment and sediment stability study. Additional public open houses were held in November 2011 at the Ojibways of the Pic River First Nation and the Town of Marathon to update citizens on the status of the sediment management detailed engineering design and environmental assessment.

Following the selection of the preferred sediment management option by EC and the MOE in 2008, the Peninsula Harbour Community Liaison Committee (CLC) was formed to facilitate public involvement in the sediment management plan and other RAP related decisions. The CLC provides input to the RAP and assists with information sharing within the community of Marathon and the Ojibways of the Pic River First Nation. The CLC is composed of representatives from the Town of Marathon, Ojibways of the Pic River First Nation, Superior Greenstone District School Board, Conseil Scolaire De District Catholique Des Aurores Boreales, and local residents, including members of the previous PAC.

2.0 PENINSULA HARBOUR ECOSYSTEM

A detailed description of the Peninsula Harbour ecosystem including information on climate, sediment, geology, and land and water uses is included in the Peninsula Harbour Stage 1 report (Peninsula Harbour RAP Team 1991). The following section summarizes background information and provides recent and additional information relevant to this Stage 2 report.

2.1 Physical Description

Peninsula Harbour is located at the Town of Marathon, within the Terrace Bay District, on the north eastern shore of Lake Superior, approximately 290 kilometres east of the City of Thunder Bay. The AOC is roughly bounded by the harbour to the north of the peninsula and Pebble Beach to the south, and extends outward approximately four kilometres from the peninsula into Lake Superior to the west (Figure 2). Within Peninsula Harbour there are a number of small bays/coves including Jellicoe Cove, Carden Cove and Beatty Cove (Peninsula Harbour RAP Team 1991). Two small creeks, Shack Creek and another unnamed watercourse, drain into the harbour just north of Jellicoe Cove and the town. The average water depth is approximately 30 metres and offshore from the peninsula there are maximum depths up to 65 metres (Peninsula Harbour RAP Team 1991). The AOC is within the Superior Climatic Region that is characterized by moderate climate with milder winters, cooler summers and higher incidence of precipitation and wind compared to the other Terrace Bay climatic region – Height of Land (Peninsula Harbour RAP Team 1991).

Figure 2. Peninsula Harbour Area of Concern Map

2.1.1 Land Use

Current land use in the Town of Marathon is primarily residential; however, past land uses within the AOC have impacted the area's environmental conditions. The only urban settlement within the AOC is the Town of Marathon, located on the south eastern shore of Peninsula Harbour. The Canadian Pacific Railway, constructed in the 1880s, passes through the Town of Marathon along the harbour shoreline. The Trans-Canada Highway, which was completed in 1960, follows the north shore of Lake Superior up to Marathon and then follows a route north of the lake. A hydro corridor also extends through this region.

Waterfront property immediately north of the peninsula, in the Jellicoe Cove area, is zoned industrial for the operation of a bleached kraft pulp mill. The mill operated from 1944 until it was closed in 2009 with the bankruptcy of Marathon Pulp Inc. Adjacent to the mill, a chlor-alkali plant operated from 1952 until 1977 and manufactured caustic soda, chlorine, sodium chlorate and sodium hypochlorite for use in the mill's pulp process. The shoreline was used for storing softwood chips, and for storing, and occasionally debarking, hardwood logs. A wood waste site is located near the shoreline north of the mill and there is a limited mercury disposal site located south of Marathon. The mercury disposal site is owned and maintained by Georgia-Pacific, a former owner of the pulp mill.

Forestry was an important industry in the Peninsula Harbour AOC. Marathon Pulp Inc. and its predecessors were licensed to harvest timber from the Big Pic River Forest Management Unit and used the timber as raw materials for the production of pulp.

2.1.2 Water Use

Water from Peninsula Harbour was used primarily for the pulp mill process until the mill closed in 2009. The most recent Permit to Take Water, issued by the MOE in 2008, (7270-7CMP7B) allowed for a maximum amount of water taken per day as 98,064,000 L/day or 98,000 m^3/day. In 2007, the mill had a total annual flow of 16,037,389 m^3 which equates to an average of 43,938 m^3/day.

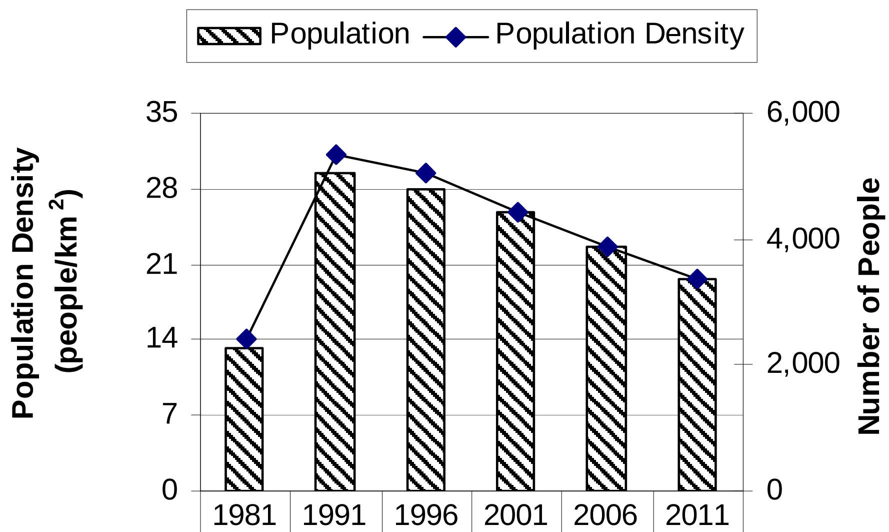
During mill operation, Peninsula Harbour was an active shipping channel from mid-April to mid-December. Between 10 to 12 ships per season arrived at the mill dock with supplies, and left with pulp. Jellicoe Cove was historically used as a log booming area in the winter months when shipping was not possible. Log booming was officially discontinued in 1983; however, Buchanan Forest Products used the harbour temporarily for log rafting in 1987 and 1988.

The water supply for the Town of Marathon is provided by five wells, which intercept a nearby sandy aquifer.

Currently, the only recreational boat launching facility on Peninsula Harbour is on mill property. The facility is available for public use under a memorandum of understanding between the town and the land owner.

2.2 Socioeconomic Profile

The population of the Town of Marathon has fluctuated with the economics of the local forest and mining industries. The discovery of a large gold deposit outside of the AOC in Hemlo in 1983 and the subsequent development of three mines more than doubled the number of residents of the Town of Marathon from about 2,300 people in 1983 to 5,064 people by 1991 (Statistics Canada 2002) (Figure 3). The population of the Town of Marathon has decreased since the closure of the pulp mill in 2009. According to the 2011 census, the population of the Town of Marathon was 3,353 (Statistics Canada 2012), which is a decrease of 510 people from the 2006 census (Statistics Canada 2007). In 2011 the environmental assessment began for a new mine, to be located approximately 10 kilometres north of Marathon. The copper mine, proposed by Stillwater Canada Ltd., would include an open pit mine, a mineral processing facility, a tailings area, waste rock stockpiles, access roads and related infrastructure.



	1981	1991	1996	2001	2006	2011
Population	2,277	5,064	4,791	4,416	3,863	3,353
Population Density	14.02	31.18	29.5	25.9	22.7	19.7

Figure 3. Population Fluctuations for the Town of Marathon (Statistics Canada Census Data 1996, 2002, 2007, 2012)

Moderate population growth during the mid to late 1980s generated an increase in services and facilities for the local population and resulted in a modest economic growth for the Town of Marathon (Schaefer 1992). In the 2006 census, there were a total of 2,360 people in the employed labour force in the Town of Marathon and the unemployment rate was 6.4% for total population, which was similar to provincial rates (Statistics Canada 2007) (Table 1).

Table 1. Labour Force Characteristics and Income of Adult Population in the Town of Marathon 2006 (Statistics Canada 2007)

Labour force and income	Marathon			Ontario		
	Total	Male	Female	Total	Male	Female
Persons in the employed labour force	2,360	1,290	1,075	6,587,580	3,437,670	3,149,905
Unemployed rate (%)	6.4	6.2	6.0	6.4	6.0	6.8

2.3 Sources of Pollution

2.3.1 Point Sources

The Town of Marathon water pollution control plant (WPCP) is the only remaining point source discharging into the Peninsula Harbour AOC. The effluent quality of Marathon's WPCP has improved significantly since the application of the secondary treatment in 1982 (Jardine and Simpson 1990). The facility operates in the 95-98% removal efficiency range for biological oxygen demand (BOD) and total suspended solids (TSS). Effluent is consistently below the MOE guideline of 25 mg/l for BOD and TSS at the secondary treatment facilities (Table 2) (MOE 1994).

Table 2. Average annual concentrations (mg/l) of biochemical oxygen demand (BOD), total suspended solids (TSS) at the Marathon WPCP from 1992 to 2010 (Ministry of the Environment compliance data)

Year	Annual Average Concentration (mg/l)	
	BOD	TSS
1992	4.50	6.80
1994	4.34	6.80
1996	4.30	7.60
1998	2.50	3.43
2000	2.20	3.60
2002	2.10	2.40
2004	2.08	3.88
2006	2.58	3.51
2008	2.50	2.80
2010	2.38	1.78

The Marathon bleached kraft pulp mill was the other point source discharge to the AOC. The treatment system was upgraded to include secondary treatment in 1995. From December 1995 until its closure in March 2009, treated effluent from the mill was discharged through a submerged diffuser (added in 1995) into Lake Superior southeast of the town (Figure 2). The addition of the secondary treatment system and a number of process changes, such as switching to an elemental chlorine free bleaching process in 1991 and the implementation of a diesel backup effluent pump in 1995, improved effluent quality (Table 3).

Table 3. Effluent flow, concentrations and loadings of biochemical oxygen demand (BOD), total suspended solids (TSS) and adsorbable organic halides (AOH) from the Marathon pulp mill: 1990 to 2008 (Ministry of the Environment compliance data)

Year	Flow	BOD		TSS		AOH	
	(m^3/d)	(g/m^3)	(kg/d)	(g/m^3)	(kg/d)	(g/m^3)	(kg/d)
1990	66,220	182	12,018	40	2,646	42.2	2,796
1992	46,450	260	12,060	34	1,590	11.0	509
1994	39,170	261	10,211	45	1,778	10.6	417
1996	40,078	28	1,132	47	1,863	4.6	184
1998	43,538	29	1,268	48	2,104	3.9	169
2000	45,806	30	1,381	54	2,479	4.9	222
2002	47,756	30	1,424	43	2,045	4.0	190
2004	56,714	26	1,480	35	1,973	3.7	207
2006	48,598	31	1,499	47	2,261	4.0	195
2008	44,480	34	1,522	52	2,329	3.9	173

The former chlor-alkali plant was the primary source of mercury contamination to Peninsula Harbour. The plant used a mercury-cell method to produce sodium hydroxide (caustic soda) and chlorine for use by the mill during the chemical pulping and chlorine bleaching process respectively. Effluent from the plant was discharged into Jellicoe Cove and contributed to elevated levels of mercury in the sediment (BEAK 2000). Mercury loadings from the mill occurred through improperly treated wastewater, spills, leaks, and vapour loss and contributed to elevated levels of mercury in sediment and fish (Peninsula Harbour RAP Team 1991). When the plant was decommissioned in 1977, mercury-contaminated materials were removed and disposed of at the Georgia-Pacific mercury disposal site.

2.3.2 Non-point Sources

Non-point sources of pollution are diffuse inputs that reach Peninsula Harbour from multiple points of origin through natural and constructed delivery channels. Non-point sources include atmospheric deposition, stormwater, groundwater flow, runoff from wood waste disposal sites, and release from sediment.

Atmospheric deposition is considered to be a lakewide management issue caused by the production of airborne pollution outside of the AOC. Heavy metals, polychlorinated biphenyls (PCBs) and toxaphene are contaminants known to be transported via long-range atmospheric processes; however, actual loadings are difficult to quantify.

Stormwater from the Town of Marathon is collected via storm sewers which discharge from three locations at pebble beach, outside of the harbour. Although the quality of the storm sewer discharge is not monitored, the characteristics are likely similar to that found in residential areas. The town's relatively small population and absence of industrial sites is likely to result in relatively low loadings of any contaminants via this source.

2.3.3 Contaminated Sediment

Sediment in Peninsula Harbour is contaminated with mercury, PCBs, and wood fibre. The highest zones of contamination occur within Jellicoe Cove, and represent the most significant non-point source of contamination to the AOC. Contaminated sediment is the most significant remaining environmental issue for the Peninsula Harbour AOC.

<u>Mercury Contamination in the Sediment</u>

Since 1984, a number of studies have been conducted to define the extent and magnitude of mercury contamination within the AOC (Jardine and Simpson 1990; Smith 1992; Richman 2004; Milani and Grapentine 2005; Grapentine *et al.* 2005). This data provides a wide coverage of the area, with a focus on the region of highest contamination adjacent to the former chlor-alkali plant – the primary source of mercury contamination in Jellicoe Cove (Peninsula Harbour RAP Team 1991).

A 1999 survey indicated that mercury concentrations in the surface water of Peninsula Harbour ranged from less than detection (0.05) to 3.2 ng/L (Richman 2004). Jellicoe Cove's mercury concentrations exceed the Provincial Sediment Quality Guideline - Severe Effect Level (PSQG-SEL) of 2.0 µg/g at 13 of 21 sites tested within Jellicoe Cove; compared to three of 12 sites from outside of Jellicoe Cove (Milani and Grapentine 2005). Total mercury concentrations in Jellicoe Cove range from 0.04 to 19.50 µg/g dry weight (median 3.46 µg/g); whereas, sediments outside range from 0.04 to 2.32 µg/g (median 0.99 µg/g) (Milani and Grapentine 2005).

The 2008 environmental risk assessment (ERA) determined that the mercury in the sediment does not pose a significant risk to benthic (sediment-dwelling) invertebrates. Mercury concentrations do not pose a significant risk to common loons and other waterfowl populations; however, mercury concentrations in fish may reduce bald eagle and other piscivorous (fish-eating) raptors reproductive success, and reproduction of sport fish and bottom dwelling fish (ENVIRON 2008a). Mink and other piscivorous mammals are not at significant risk from mercury concentrations in fish (ENVIRON 2008a).

<u>PCB Contamination in the Sediment</u>

Richman (2004) investigated PCB concentrations in Peninsula Harbour; the survey indicated total PCB concentrations range from 20 ng/g (0.02 µg/g) to 240 ng/g (0.24 µg/g). These concentrations do not exceed the PSQG-SEL for total PCBs of 530 µg/g (MOE 2008). The highest PCB concentrations were detected at the wharf in Jellicoe Cove (180 to 240 ng/g) and the index station in Beatty Cove (160 to 180 ng/g); however, concentrations were similar when normalized by total organic carbon (TOC) (%) (Richman 2004). The risk of PCB contaminated sediment on ecological and human health was evaluated in the ERA (ENVIRON 2008a). The ERA determined that PCBs in the AOC do not pose a significant risk to benthic invertebrates, common loons and other waterfowl populations, and piscviorous birds that forage in the AOC; and that most fish are not likely to be impacted by current PCB concentrations with the exception of the longnose sucker (ENVIRON 2008a). The risk estimates do not indicate acute toxicity or population impacts (ENVIRON 2008a). Current PCB concentrations in fish may pose a risk to adult fisherman and their families, and to mink and other piscivorous mammals that forage in the AOC (ENVIRON 2008a).

<u>Accumulated Wood and Bark in the Sediments</u>

As mentioned previously, Peninsula Harbour was subject to historical log booming and storage activities until 1983 and temporary log rafting in 1987 and 1988. The Stage 1 report identified that the deposition of wood fibres and bark affects the aquatic biota and water quality along the north shore of Peninsula Harbour (Peninsula Harbour RAP Team 1991). The accumulation of woody material over natural substrates has reduced the amount and quality of physical near shore fish habitat (Peninsula Harbour RAP Team 1991).

Lake bottom surface mapping revealed bark deposits in Jellicoe, Carden, and Beatty Coves at water depths ranging from 2 to 12 metres (Smith 1992). Based on the Smith 1992 study, there were extensive areas of bark throughout Jellicoe Cove, “but the majority of bark was restricted to the shallow shelf composed of silty sand and sand, as well as the occasional patches of clay in the deeper areas" (BEAK 2000, p.3.10-3.11). Logs and bark are abundant in Jellicoe Cove with the densest concentrations east of Skin Island (Northern Bioscience 2011). Most of the observed logs are near the shoreline in water less than 15 metres in depth which reflects booming activities; whereas some logs were found in deeper water reflecting logs lost from booms in transit (Northern Bioscience 2011). The MOE video found that most logs lacked bark. There was presence of dense accumulations of bark around many of the boom logs (Northern Bioscience 2011). The bark "often accumulates in shallow water in wave-scalloped grooves between ridges in sand flats off the boat launch" (Northern Bioscience 2011, p.33).

3.0 BENEFICIAL USE IMPAIRMENTS AND WATER USE GOALS

The Peninsula Harbour RAP was developed to identify beneficial use impairments, define specific goals for the region, and describe appropriate remedial and regulatory measures to rehabilitate the AOC and monitor results. EC, MOE and MNR sought input from the PAC to develop water use goals for the AOC. These goals were published in the Stage 1 report (Peninsula Harbour RAP Team 1991, Appendix 6.4). Unfortunately, the water use goals are difficult to measure as indicators of improved ecosystem health and restoration. In 2009 and 2010, the CLC provided input on the updated specific delisting criteria for the AOC. In the Peninsula Harbour Stage 1 report, there were five impaired beneficial uses and one that required further assessment. These beneficial use impairments are discussed in section 3.2, along with each of the revised delisting criteria.

3.1 Peninsula Harbour Area of Concern Water Use Goals

The PAC established water use goals designed to restore and protect the beneficial uses of Peninsula Harbour. Specific goals were developed through a series of public meetings involving representatives of various civic groups and the federal-provincial RAP team.

Water use goals are intended as guidelines to address specific beneficial use impairments in the Peninsula Harbour AOC. They have been divided into three categories based on the level of action required. The first category contains issues of primary importance that may require definite remedial action. The second category contains goals that are not presently impaired and do not require remedial action; nevertheless, they are important and should be considered. The third category contains measures to ensure the implementation of remedial actions and continued public involvement in the RAP process.

Primary Goals	Secondary Goals	Implementation Goals	Progress Towards Goals
Goal 1 The water quality of Peninsula Harbour should meet the requirements contained in the most stringent, current version of the MOE's *Water Management, Goals, Policies, Objectives, Guidelines and Implementation Procedures,* as well as the guidelines defined under the GLWQA. In the long term, ambient water should show virtual elimination of persistent toxic substances and other contaminants from human origin. To meet this goal, industrial and municipal sources are required to establish a timetable to achieve zero discharge of persistent toxic substances and hazardous contaminants. The Government of Canada is committed to the virtual elimination and zero discharge of persistent toxins as stated in the GLWQA. In addition, the Lake Superior Binational Program, through its Lake Superior Lakewide Management Plan (LaMP), is implementing a Zero Discharge Demonstration Program in the Lake Superior basin. *Goal 2* Fish health should be improved in order to eliminate the need for consumption guidelines and satisfy the criteria of the GLWQA. Over time, aquatic organisms should show the virtual elimination of persistent toxic substances and contaminants resulting from human origin. In addition, water quality and physical habitat should be able to promote a self-sustaining population of indigenous species. *Goal 3* The invasion of foreign organisms to the Great Lakes should be prevented through the control of ballast water. *Goal 4* All delisting criteria must be met in order to remove Peninsula Harbour as an Area of Concern.	*Goal 1* The condition of the harbour should be maintained to facilitate commercial shipping, industrial uses (intake and other uses), boating (recreational and charter) and water sports. *Goal 2* Industrial and municipal sources, including surface runoff, should be allowed to discharge into the harbour provided the primary goals are being addressed. *Goal 3* The atmospheric deposition of potentially hazardous substances resulting from human activity should have no adverse impacts on the ecosystem. *Goal 4* The water quality should be maintained such that the population and health of wildlife and fish do not differ significantly from surrounding regions.	*Goal 1* Public information sessions and consultation should occur throughout the RAP implementation phase. *Goal 2* Mechanisms should be in place for regular reviews of RAP goals based on random sampling of dischargers and updates to the environmental conditions database. Paramount to this is the timely analysis and reporting of information. *Goal 3* Unrestricted access is a basic underlying principle behind these water use goals. As such, public access for recreational boating and walking areas should be enhanced. *Goal 4* The natural features of this Area of Concern should be used as an educational tool. Educators and students should be informed of regional and global environmental problems, the RAP process, the importance of public involvement, and the interrelationship between humans and the environment. Government researchers should be encouraged to make presentations about their study to local schools.	The Government of Canada remains committed to virtual elimination of persistent toxic pollutants as stated in the GLWQA. In addition, the Lake Superior Binational Program, through its Lake Superior Lakewide Management Plan (LaMP), continues to implement and monitor the Zero Discharge Demonstration Program for the Lake Superior basin. Known sources of industrial and municipal discharge to the lake are controlled according to the relevant legislation and regulatory instruments, such as provincial compliance approvals. Efforts to control aquatic invasive species (AIS) in the Great Lakes, such as the Lamprey Control Program, have achieved positive results. Newer efforts, such as the *Lake Superior AIS Complete Prevention Plan* (Lake Superior Lakewide Management Plan Committee 2010) continue the work in this area. The condition of the harbour and possible future use of the former mill facility is of great interest and importance to the local community and was considered in the development of the Stage 2 RAP. The principle of comparison to surrounding areas has been an important one used for determining the delisting criteria for the AOC. As described in section 1.2.2, public involvement continues to play an important role in all RAP related decisions. Timely reporting of results and recreational and educational use of the harbour are important components of this involvement.

3.2 Beneficial Use Impairments in the Peninsula Harbour AOC

The guiding principle identified for removing an area from the list of Areas of Concern is that it is no longer more degraded than surrounding or comparable areas in the Great Lakes basin. To establish measurable indicators of a restored ecosystem, EC, MOE, MNR and the CLC developed delisting criteria for each of the impaired beneficial uses in Peninsula Harbour. Many of the delisting criteria use the principle of comparison as 1) a regulation or guideline, 2) a locally derived risk-based target, or 3) an appropriate reference site outside the AOC. Of the 14 impairments of beneficial use outlined in the GLWQA, two remain impaired, two require further assessment, one beneficial use status has been changed from impaired to not impaired, and one has been changed from requires further assessment to not impaired (Table 4). This section outlines the current status, delisting criteria and remediation actions for the remaining Peninsula Harbour beneficial use impairments.

Table 4. Status of Beneficial Use Impairments, as identified in the Great Lakes Water Quality Agreement) in the Peninsula Harbour Area of Concern

No.	Beneficial Use Impairment	1991 Status (Stage 1)	2012 Status (Stage 2)
1	Restrictions on fish and wildlife consumption	Impaired	Impaired
	♦ fish consumption	Impaired	Impaired
	♦ wildlife consumption	Not Impaired	Not Impaired
2	Tainting of fish and wildlife flavour	Not Impaired	Not Impaired
3	Degradation of fish and wildlife populations	Impaired	RFA
4	Fish tumours or other deformities	RFA	Not Impaired
5	Bird or animal deformities or reproduction problems	Not Impaired	Not Impaired
6	Degradation of benthos	Impaired	Impaired
	♦ Population	Impaired	Impaired
	♦ Body burden	RFA	Impaired
7	Restrictions on dredging activities	Impaired	Not Impaired
8	Eutrophication or undesirable algae	Not Impaired	Not Impaired
9	Restrictions on drinking water consumption, or taste and odour problems	Not Impaired	Not Impaired
10	Beach closings	Not Impaired	Not Impaired
11	Degradation of aesthetics	Not Impaired	Not Impaired
12	Added costs to agriculture or industry	Not Impaired	Not Impaired
13	Degradation of phytoplankton and zooplankton populations	Not Impaired	Not Impaired
14	Loss of fish and wildlife habitat	Impaired	RFA

RFA – Requires Further Assessment

3.2.1 Restrictions on Fish and Wildlife Consumption

Status: Impaired for fish only

Delisting Criterion
This beneficial use will no longer be impaired when a comparison study of fish tissue contaminant levels demonstrates that there is no statistically significant difference in fish tissue concentrations of contaminants causing fish consumption advisories in the AOC compared to suitable Lake Superior reference sites (Appendix A).

Reason for Impairment
The Peninsula Harbour Stage 1 report identified restrictions on fish consumption as impaired due to consumption advisories in effect at the time of beneficial use status designation. The 1991 designation was based on mercury concentrations in larger sizes of lake trout (*Salvelinus namaycush*), white sucker (*Catostomus commersonii*), longnose sucker (*Catostomus catostomus*) and redhorse sucker (*Moxostoma carinatum*) exceeding the Health and Welfare Canada guideline of 0.5 mg/kg, and PCB concentrations in white sucker (*Catostomus commersonii*) from 35 to 45 cm exceeding the guideline of 2.0 mg/kg (Peninsula Harbour RAP Team 1991). There were no restrictions, and continue to be no restrictions, on wildlife consumption in Peninsula Harbour.

Current State
Fish consumption advisories remain significantly different in Peninsula Harbour than in the reference area thus, fish consumption remains an impaired beneficial use. PCBs are the main consumption-limiting contaminant in lake trout, lake whitefish, and longnose suckers in Peninsula Harbour. Tissue concentrations of PCBs in these species remain higher than similar species in the surrounding area (MOE 2011b). PCB concentrations in lake trout have declined significantly over time, but PCB concentrations in lake whitefish and longnose sucker have not changed over the period of record (lake whitefish: 1976-2007; longnose sucker: 1978-2007) (MOE 2011b).

A consumption advisory, based on mercury levels in fish tissue, has been established for longnose suckers. The advisory limits consumption to one meal per month for fish 35 to 50 cm (MOE 2011a). Mercury concentrations in longnose suckers from Peninsula Harbour declined from 1975 to 2007; longnose suckers from Peninsula Harbour now have mercury concentrations comparable to those in the nearby sampling block of Lake Superior (MOE 2011b).

The human health risk assessment of the 2008 ERA for Peninsula Harbour, indicated that anglers and their families may be adversely impacted by PCBs in fish tissue, whereas the risk of adverse impacts related to methylmercury were not significant (ENVIRON 2008a). As part of the human health risk assessment in the ERA, a survey of the residents of the Town of Marathon and the Ojibways of the Pic River First Nation indicated no evidence of subsistence fishing in Peninsula Harbour and that the majority of sport-caught fish consumed were caught outside of the harbour. However, 17% of the survey respondents indicated that they consume fish caught in Peninsula Harbour (ENVIRON 2008a). The ERA suggested that avid sport anglers do not target Peninsula Harbour as a fishing destination (ENVIRON 2008a).

Remaining Actions and Monitoring

The implementation of the sediment management project, thin layer capping as described in detail in section 4, will effectively reduce the exposure to methylmercury and PCB concentrations in the AOC sediment (ENVIRON 2008b). Assessment of fish tissue contaminant levels and updating the sport fish consumption advice will continue to be conducted by the MOE through the Sport Fish Contaminant Monitoring Program. The sediment management long-term monitoring plan includes the assessment of trends in contaminant tissue in benthivorous fish to monitor ecological recovery. This monitoring will determine if contaminant tissue concentrations are steadily decreasing through time in longnose suckers by comparing the total mercury and PCB tissue concentrations in longnose suckers collected in Jellicoe Cove to historical data and data from appropriate reference sites. The sediment management project long-term monitoring plan will evaluate short (five years) and long-term trends.

3.2.2 Degradation of Fish and Wildlife Populations

Status: Requires further assessment for fish populations

Delisting Criteria

Fish populations will no longer be impaired when the fish community has the following structure:

- The Peninsula Harbour AOC fish community should be similar to near shore (0 – 80 m deep) fish communities adjacent to the AOC as measured by relative abundance and species composition of the community.
- The near shore fish community should be dominated by self-sustaining populations of native fishes
- Lake trout populations have the following characteristics:
  - ⇒ Mean age greater than eight years
  - ⇒ Populations are dominated by wild lake trout (greater than 50% wild)
  - ⇒ Length-at-age of age seven lake trout is stable and greater than 430 mm
  - ⇒ Populations are dominated by mature fish and many age classes present

Evidence that fish tissue concentrations are declining towards a local risk based target may be used to support delisting this beneficial use but is not required. Data about contaminants in fish are important for understanding the environmental impairments in Peninsula Harbour but are not a direct measure of healthy populations. The environmental risk assessment for Peninsula Harbour (2008a) suggests tissue values of less than 0.4 ppm PCBs and 0.2 ppm methylmercury is protective of anglers and fish respectively in Peninsula Harbour. Targeted species for concentration assessments should include longnose sucker.

NOTE: If fish populations do not meet the delisting criteria identified above because of issues that are beyond the scope of the RAP (e.g. an increase in sea lamprey populations) this beneficial use impairment could still be considered delisted. Issues beyond the scope of the RAP, although still an issue of concern, would be dealt with by management actions coordinated outside of the RAP.

Reason for Impairment

Peninsula Harbour fish populations were designated impaired because of a decline in lake trout populations. Lake trout, the dominant species for the AOC, declined as a result of the introduction of sea lamprey (*Petromyzon marinus*), exploitation through extensive commercial fishing, and habitat destruction due to industrial effluent and log booming. Log booming resulted in organic (wood debris) contamination in Jellicoe and Beatty Coves that reduced traditional (prior to 1955) lake trout spawning habitat.

Fish body burdens of contaminants were also believed to be higher than the surrounding area due to the presence of industrial contaminants in lake bottom sediments. Whole fish assessment of young-of-year emerald shiners (*Notropis atherinoides*) in 1979 and 1983 found average PCB levels of 159 ng/g that exceeded the IJC Aquatic Life Guideline of 100 ng/g (Peninsula Harbour RAP Team 1991).

Current State

The Peninsula Harbour fish community appears to be comparable to reference sites adjacent to the AOC for both species composition and abundance. However, further monitoring is required to confirm trend through time results which suggest that this beneficial use has been restored.

Lake trout stocking and sea lamprey control in Lake Superior may have resulted in an improved fishery and a substantial increase in sport fishing activities in Lake Superior including within the AOC. The results of the most recent co-operative angler creel survey for the portion of Lake Superior encompassing the AOC (i.e., grid 570 adjacent to Ypres point and grid 571 from the harbour to Craigs point) indicates relatively consistent sport fishing activity in the area (Table 5). Overall, the Peninsula Harbour AOC contributes to a viable sport fishery along the north shore of Lake Superior.

Table 5. Co-operative angler creel survey results for lake trout caught (kept and released) in fisheries Quota Management Area 19 (Grids 570 and 571) from 1987-1993 and 1998-2001 (Ontario Ministry of Natural Resources 2011)

Year	Total # of fishing trips	# lake trout caught	Time spent fishing in AOC (Angler Hours)	Time spent fishing for lake trout (hr)	Lake trout catch per time unit effort
1987	16	27	61.5	61.5	0.44
1988	8	18	58	52	0.35
1989	46	55	309.9	213.8	0.26
1990	31	49	189	189	0.26
1991	65	101	380.9	369.9	0.27
1992	18	23	96	95	0.24
1993	15	16	99.8	98.3	0.16
1998	7	4	78.95	0	0.05
1999	3	1	1.5	0	0.67
2000	1	6	6	0	1.00
2001	17	49	201.5	89.5	0.24

In 2010 and 2011, the MNR-Upper Great Lakes Management Unit (UGLMU) conducted their Lake Superior Fish Community Index Netting (FCIN) program in the AOC to evaluate the status of the fish community. The FCIN program provides an independent trend through time index of relative abundance of fish, particularly of lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*), and serves as a monitoring tool to track the dynamics of fish populations and their recovery within the Peninsula Harbour AOC.

FCIN findings show that species composition within the Peninsula Harbour AOC is similar to that outside of the AOC and is dominated by coldwater native species – particularly lake whitefish, lake trout, longnose sucker and round whitefish. A total of 10 different species were caught within the AOC in 2010 and 11 species in 2011.

The relative abundance of lake whitefish and lake trout was higher within the AOC in 2010 than in 2011 (Figure 4 and 5). It should be noted that catch per unit effort (CPUE) across all areas sampled in 2011 was lower than in 2010. This may be attributed to inter-annual variation in water levels and temperature. Also, the sampling period for Peninsula Harbour was close to a month later in 2011 than in 2010 and coldwater species may have moved to deeper waters outside of the AOC resulting in lower CPUE.

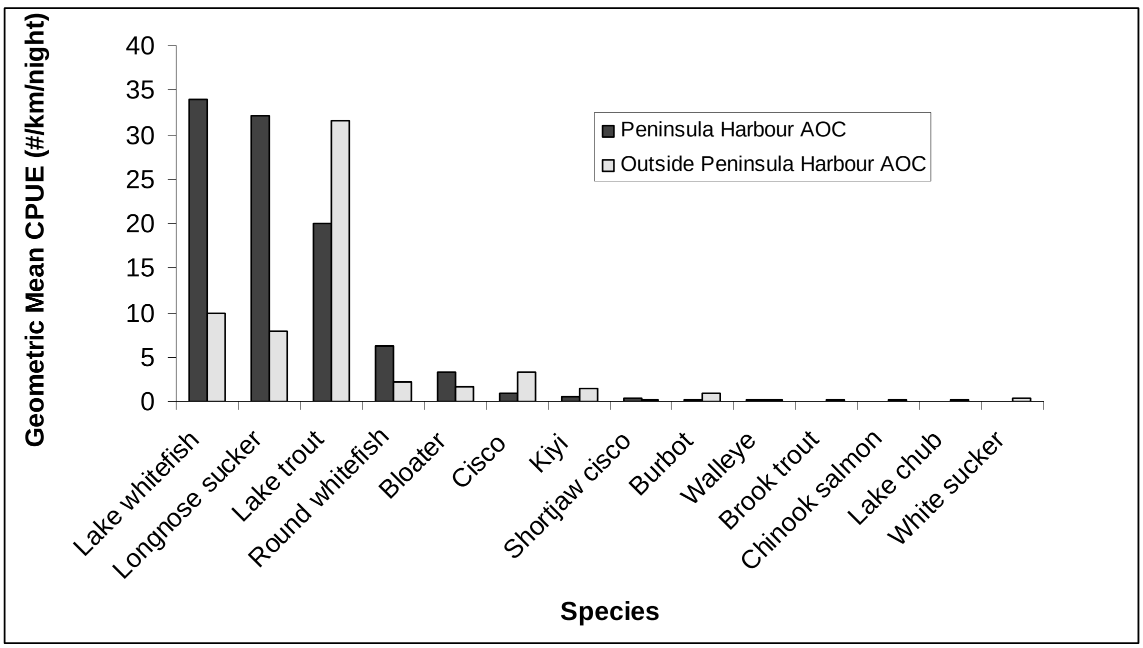


Figure 4. Geometric mean catch per unit effort of species caught during the 2010 Fish Community Index Netting survey inside and outside of the Peninsula Harbour AOC

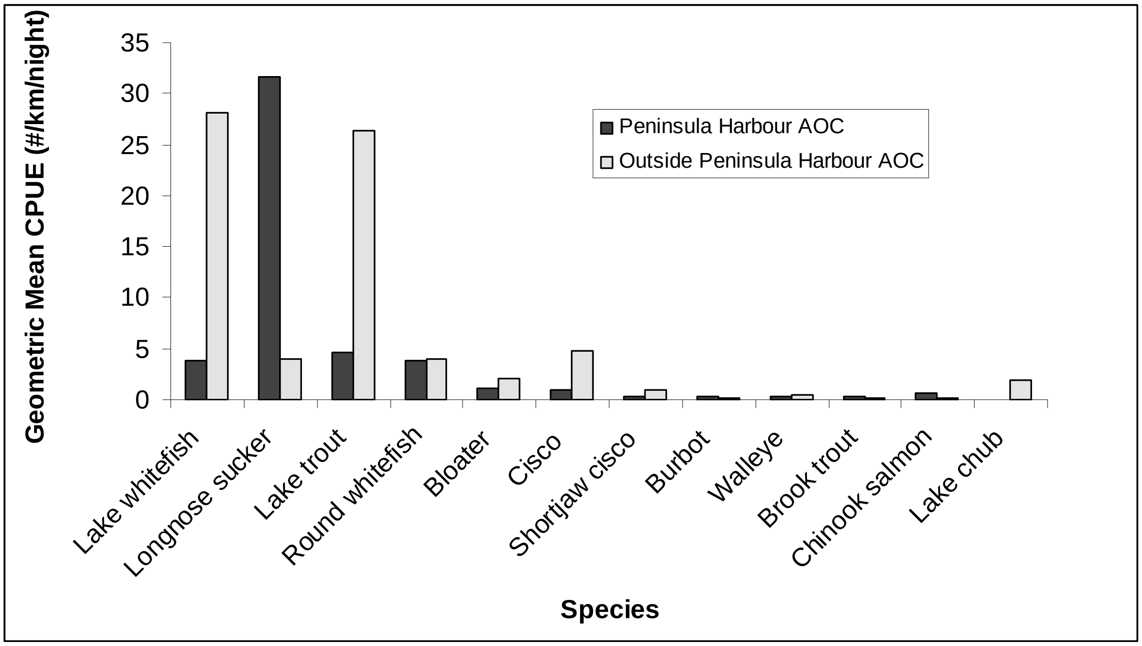


Figure 5. Geometric mean catch per unit effort of species caught during the 2011 Fish Community Index Netting survey inside and outside of the Peninsula Harbour AOC

Lake trout caught during the FCIN survey inside the AOC had a mean age of 12 years and 13 years in 2010 and 2011 respectively; whereas, lake trout outside of the AOC had a mean age of 14 and 13 years in 2010 and 2011 respectively (Table 6). This is significant because the delisting criteria calls for the mean age of lake trout to be greater than eight years.

Lake trout caught inside the AOC exhibited a mean total length of 456 mm in 2010 and 440 mm in 2011 (Table 6); however mean size at age seven was 410 mm in 2010 and 366 mm in 2011 (Table 6). The mean size at age seven is currently below the delisting target of greater than 430mm for lake trout at age seven but is consistent with trends in the rest of Lake Superior. Size at age is a reflection of growth rate and is typically based on data from spring lake trout index netting. In the absence of a suitable sample size of age seven lean lake trout from inside the AOC, this delisting criteria should be assessed with caution. That said, based on data from 1993-2000 when mean size at age seven lake trout was upwards of 500 mm for Canadian waters of Lake Superior, one could expect the decline in growth to be a consequence of increasing lake trout and siscowet abundances and declining abundance of prey fishes (Ebener 2007).

Table 6. Length ranges (total length), mean length (mm), mean size at age-7, mean weight (g) and mean age of lake trout caught inside and outside the Peninsula Harbour AOC in 2010 and 2011

	2010		2011	
Parameter	Inside	Outside	Inside	Outside
Sample (n)	195	326	51	183
Total Length (mm) Range	215-740	186-862	253-654	194-790
Mean Length (mm)	457 (8)	460 (6)	440 (13)	464 (7)
Mean Size @ Age-7	410 (19.7)	404.7 (18.8)	366.6 (30.8)	429 (22.51)
Mean Weight (g)	939 (56)	985 (45)	780 (82)	950 (54)
Mean Age (years)	12 (0.5)	14 (0.39)	11 (0.9)	13 (0.44)

Previous assessments of this beneficial use for Peninsula Harbour focused on fish body burdens due to a lack of fish community data; however, FCIN is now available and is the preferred method for assessment. While investigating and understanding contaminants in forage fish are important for understanding the environmental impairments in Peninsula Harbour, this is not a direct measure of the health of fish populations. The 2008 ERA found that ecological receptors potentially at risk are fish (as a result of tissue concentrations of methylmercury and, in the case of longnose sucker, PCBs) and mink and other piscivorous mammals (as a result of consumption of fish containing PCBs). Current PCB concentrations in fish may reduce reproductive success in mink and other fish-eating mammals that forage in Peninsula Harbour; although it is unlikely that this would have an impact on the local populations of those animals (ENVIRON 2008a).

As described in the previous section, mercury concentrations in longnose suckers from Peninsula Harbour declined from 1975 to 2007; longnose suckers from Peninsula Harbour now have mercury concentrations comparable to those in the nearby sampling block of Lake Superior (MOE 2011b). PCB concentrations remain higher in longnose suckers from Peninsula Harbour than in those from the surrounding area (MOE 2011b). In addition, PCB concentrations in longnose sucker have not changed over time, unlike mercury concentrations (MOE 2011b).

Remaining Actions and Monitoring

The MNR UGLMU Fish Community Index Netting program in Peninsula Harbour will collect at least five years of data, as part of the lake wide assessment, to confirm the status of the health of fish stocks within and adjacent to the AOC through both abundance and species composition. As described in section 3.2.5, the loss of fish habitat beneficial use currently requires further assessment. The results of the MNR 2012 fish habitat survey will be considered when the status of fish populations is re-evaluated.

Impacts on fish populations as a result of contaminated sediment will be addressed through the implementation of the sediment management plan that will reduce exposure to PCB and methylmercury concentrations in the AOC sediment (ENVIRON 2008b).

The sediment management long-term monitoring plan includes the assessment of short and long-term trends in contaminant tissue in benthivorous fish by comparing total mercury and PCB tissue concentrations in longnose suckers from Jellicoe Cove compared to reference sites. This monitoring will determine if contaminant tissue concentrations are steadily decreasing over time in longnose suckers.

3.2.3 Degradation of Benthos

Status: Impaired

Delisting Criteria

Dynamics of benthic populations (assessed via community structure):
This beneficial use will no longer be impaired when acute and chronic toxicity and benthic community composition and abundance (outside the shipping channel) are comparable to suitable reference sites.

Benthic invertebrate contaminant body burdens:
This beneficial use will no longer be impaired when invertebrate tissue concentrations are below levels associated with adverse impacts (such as potential effects in predator species due to biomagnification).

NOTE: For Peninsula Harbour, this is hypothesized to occur when average sediment concentrations are less than 0.060 mg/kg PCB and 0.002 mg/kg methylmercury within the AOC. This is based on locally derived risk-based tissue residue guidelines from the environment risk assessment for Peninsula Harbour (ENVIRON 2008a).

Reason for Impairment
Benthic community structure was identified as impaired in the Stage 1 report due to contaminated sediment within the AOC. In 1969 densities of pollution tolerant sludgeworms *(Tubifex tubifex)* were found to increase closer to the main sump overflow of the mill. In 1976 these sludgeworms were found to be the dominant species in Peninsula Harbour and in Lake Superior to the west and southwest of the main mill outfall; however, this relationship no longer exists (Peninsula Harbour RAP Team 1991). A 1989 study by Sibley et al. (1990) demonstrated that benthic community diversity and population had increased, suggesting improvement in water quality. Not surprisingly, Sibley et al. (1990) found that species common to pristine bays in Lake Superior (*Ephemeroptera*, *Plecoptera* and *Trichoptera*) were largely absent from parts of Peninsula Harbour suggesting that water quality remained impaired to some degree (Peninsula Harbour RAP Team 1991). Also, benthic community population densities and

diversity increased with further distance from the main mill outfall (Peninsula Harbour RAP 1991).

At the time of the Stage 1 report, the benthic body burdens required further assessment as the effects of water contaminants and bottom sediment on contaminant levels in benthos in the AOC were unknown (Peninsula Harbour RAP Team 1991).

Current Status

a) Dynamics of benthic populations

In 2000, Milani and Grapentine (2005) used the BEAST (BEnthic Assessment of SedimenT) methodology to evaluate the potential effects from contaminated sediment to benthic invertebrates in the Peninsula Harbour AOC. Multiple lines of evidence, such as sediment contaminant concentrations, sediment toxicity and benthic community structure were assessed. The assessment included 33 sites in Peninsula Harbour, with 21 sites located within Jellicoe Cove, the area of highest mercury concentration. Sediment mercury concentrations at 13 of the 21 sites sampled in Jellicoe Cove exceeded the provincial sediment Severe Effect Level (SEL) of 2 ppm. Total mercury concentrations in Jellicoe Cove ranged from 0.04 to 19.5 ppm in the top 10 cm of sediment. Concentrations in the rest of Peninsula Harbour ranged from 0.04 to 2.32 ppm. Methylmercury was measured in Jellicoe Cove sediments only, and ranged from 0 to 22.6 ppb. Invertebrate communities within Jellicoe Cove were very different from Great Lakes reference sites, and are deemed impaired. Benthic communities in the rest of Peninsula Harbour were more similar to reference sites (Milani and Grapentine 2005). However because communities within Jellicoe Cove are considered impaired, this BUI is considered impaired for the Area of Concern. This beneficial use will no longer be impaired when the above delisting criteria have been met and AOC benthic populations are comparable to appropriate reference sites.

Although the ERA determined that benthic invertebrates in the AOC are not at significant risk due to mercury or PCBs in sediment, the study agreed with Milani and Grapentine’s findings (2005) that benthic invertebrate community composition throughout Jellicoe Cove differs from that of reference.

b) Benthic invertebrate contaminant body burdens

Body burdens of benthic invertebrates can contribute to mercury and PCB levels in fish since benthic invertebrates form part of the diet of some fish (i.e. benthivorous fish). The 2008 ERA concluded that mercury and PCB levels in Peninsula Harbour may be harmful to forage fish and sport fish. The risk assessment also found that levels of PCBs may pose a risk to some wildlife and to people who eat fish from the harbour.

Grapentine, Milani and Mackay (2005) assessed the bioavailability of mercury in Jellicoe Cove sediments and its potential effects on fish, wildlife and humans through biomagnification. This study found that at the majority of sites in Jellicoe Cove, total mercury concentrations in invertebrates (midges and amphipods) are significantly elevated above concentrations at reference sites (Grapentine, Milani and Mackay 2005). Also methylmercury concentrations in amphipods from most sites in Jellicoe Cove are significantly higher than concentrations in reference sites (Grapentine, Milani and Mackay 2005). Mercury in sediment is a significant influence on total and methylmercury concentrations in midges and amphipods and is bioaccumulated by benthic invertebrates to a greater degree in Jellicoe Cove than in uncontaminated sites (Grapentine, Milani and Mackay 2005). Biomagnification of PCBs was not included in the study.

Remaining Actions and Monitoring

The implementation of the sediment management project will reduce benthic exposure to mercury and PCBs by reducing the exposure to contaminated sediment. This project should allow for the reestablishment of a benthic community in clean lake bottom material within Jellicoe Cove without significant mixing of underlying mercury and PCB contaminated sediment (ENVIRON 2008b).

Benthic invertebrate monitoring is a component of the sediment management long-term monitoring plan to evaluate ecological recovery. Benthic invertebrate community structure and benthic tissue concentrations of methylmercury and PCBs will be measured as part of the long-term monitoring plan. This will enable EC and MOE to assess short term and long-term contaminant concentration trends for methylmercury and total PCBs in benthic invertebrates and the reduction of exposure of fish and wildlife to mercury and PCBs. Following the implementation of the sediment management project in Jellicoe Cove, it is expected that the benthic community in Peninsula Harbour will be similar to those in other parts of Lake Superior.

3.2.4 Restrictions on Dredging Activities

Status: Not Impaired

Delisting Criteria

Contaminated sediment is addressed by other beneficial use impairments (BUIs) within the AOC. The ecosystem components of this BUI are addressed by other BUIs such as the benthic population BUI.

Reason for Initial Impairment

The restrictions on dredging activities beneficial use was considered impaired due to contaminated sediments in the AOC, despite dredging operations not occurring within the AOC. The AOC sediment, particularly in Jellicoe Cove, contains levels of mercury, PCBs, chromium, copper, iron, nickel, and total phosphorus as a result of the pulp mill and chlor-alkali plant. Organics were elevated in Jellicoe Cove as a result of historical log booming activities. These parameters exceed MOE’s open water disposal guidelines if they were dredged thus, this beneficial use was considered impaired in the Stage 1 report (Peninsula Harbour RAP Team 1991).

Current State

Sediments in Peninsula Harbour, particularly in Jellicoe Cove, contain levels of mercury, PCBs, chromium, iron, copper, and nickel that exceed the Provincial Sediment Quality Guidelines (PSQG) for dredging and open water disposal (Jardine and Simpson 1990). Dredging operations, however, have not been undertaken since the designation of Peninsula Harbour as an AOC. In addition, the primary sources of contamination – log booming, the pulp mill and chlor-alkali plant have all ceased operation. Without the demand for navigational dredging, contaminated sediments should be considered in the context of other categories of ecosystem impairment (Krantzberg *et al*. 1996) and are better represented by the degradation of benthos, fish and wildlife consumption and fish and wildlife populations BUIs. Operational and navigational dredging needs were considered in the sediment management plan (EC and MOE 2011). Future dredging activities, for development or navigational purposes, are subject to existing provincial dredging and disposal restrictions and regulations, which no longer permit open water disposal. Since contaminated sediment is more effectively addressed under the benthos beneficial use impairment and dredging is addressed by existing administrative controls, this beneficial use is no longer a concern.

Remaining Actions and Monitoring

This beneficial use is no longer applicable to the Peninsula Harbour AOC thus there are no remaining actions required.

3.2.5 Loss of Fish and Wildlife Habitat

Status: Requires further assessment for fish habitat

Delisting Criteria

This beneficial use will no longer be impaired when the amount and quality of physical, chemical, and biological habitat within the AOC has been established and protected and is not an impediment to achieving Lake Superior Fish Community Objectives.

- The aquatic habitat is capable of supporting a biologically diverse fish community
- The desired fish and benthic communities are showing signs of sustainable recovery post sediment remediation
- Monitoring and reporting systems are in place to track and guide recovery

Reason for Impairment
Fish habitat in the Peninsula Harbour AOC is impaired due to the loss of fish spawning areas. Goodier (1981 and 1982) documented historic spawning areas (prior to 1955) for lake trout and cisco in Peninsula Harbour; however, lake trout spawning grounds along the shorelines of Jellicoe and Beatty Coves have been destroyed through the accumulation of organic materials from mill activities such as log booming and effluent discharge.

Current State
The levels of organic matter entering the harbour have greatly reduced with the end of logging activities, upgrades to the pulp mill and wastewater treatment plant to secondary treatment in 1995 and the closure of the pulp mill in 2009. Removal of the organic materials may do little to enhance fish populations as lake trout spawning habitat is not considered a limiting factor in Lake Superior. The current fishery remains predominantly offshore (MNR UGLMU, personal communication, February 2012).

An assessment of the extent of quality habitat within the AOC was conducted by Northern Bioscience Ecological Consulting in 2010 to support the environmental assessment of the sediment management project (Northern Bioscience 2011). Longnose sucker and round whitefish are the most abundant fish species in Jellicoe Cove, based on the limited sampling to date (Northern Bioscience 2011). Historical lake trout spawning habitat along Ypres Point and west of Beatty Cove is in relatively good condition (Northern Bioscience 2011). In Beatty Cove, some lake trout habitat may be impaired in the deeper waters as a result of wood debris from log booming activities whereas, along the shoreline the impairments are minor (Northern Bioscience 2011). Spawning habitat west of Beatty Cove and along the north shore of Peninsula Harbour is relatively unimpacted (Northern Bioscience 2011). In Beatty Cove "clean cobble exists out to a depth of at least 14 m along portions of this shoreline" which is valuable lake trout spawning habitat (Northern Bioscience 2011, p.40).

In Jellicoe Cove, "there appears to be very little suitable potential cobble/gravel spawning habitat for lake trout in the nearshore cap area, apparently less than 1,000-2,000 m^2, which represents less than 1% of the proposed cap area (approximately 25 ha)" (Northern Bioscience 2011, p.43). There is no suitable spawning habitat in Jellicoe Cove for northern pike because the area lacks marshes and tributary access to suitable wetlands (Northern Bioscience 2011). However, the aquatic vegetation does provide foraging habitat (DFO, personal communication, February 3, 2012).

There is potentially suitable lake trout spawning habitat along Yser Point as video evidence has confirmed clean cobble and suitable water depths (Northern Bioscience 2011).

Overall, the Northern Bioscience study found that the implementation of the sediment management project, due to its submergent nature, would provide significant habitat for yellow perch at all stages and for adult longnose suckers (Northern Bioscience 2011). Northern pike may also prefer the habitat post-sediment remediation because of the prey base and the cover, but these species can forage in a variety of habitats (Northern Bioscience 2011). The sediment management project area has limited shallow water areas and lacks the presence of coarse substrates thus; the habitat will not be preferable to trout, whitefish and salmon species. Preferred lake trout, whitefish or salmon spawning and nursery habitat includes shallow waters with course sediment and adults prefer to forage in areas with vegetation in deeper waters (Northern Bioscience 2011). Adult longnose suckers prefer to forage over silt and sand, frequently where there are logs and submergents in water greater than 2 m deep; whereas round whitefish spawn in areas with rubble and gravel (Northern Bioscience 2011). The sediment management project will not provide the coarse substrate needed for round whitefish spawning; however, the sediment management project “potentially provides considerable habitat for other species that use soft sediments (sand or silt) in moderate to deep water, particularly those with an affinity for submergents (e.g., emerald shiner, spottail shiner, sticklebacks), although there are also abundant bare sediments preferred by lake whitefish or cisco” (Northern Bioscience 2011, p.48).

The Northern Bioscience report (2011) indicates that habitat surveys along the western shoreline of Beatty Cove are lacking. Due to this lack of data, the status of this beneficial use impairment requires further assessment.

Remaining Actions and Monitoring

The 2010 Northern Bioscience study found that the implementation of the sediment management project could provide considerable habitat for fish such as yellow perch, adult longnose suckers, emerald shiner, spottail shiner, sticklebacks and potentially northern pike (Northern Bioscience 2011).

The assessment of re-colonization of submerged aquatic vegetation is part of the sediment management project long-term monitoring plan’s ecological recovery component. Further monitoring by the MOE will evaluate the recovery of aquatic vegetation in the area of the sediment management project in years one, three, and five after sediment management implementation, with potential additional years based on results observed. The video transects used in previous surveys will be repeated to assess submerged aquatic vegetation recovery.

Targeted surveys of Beatty Cove will confirm if the habitat is indeed suitable for spawning lake trout, lake whitefish, cisco, or other species or if there is a need/potential for rehabilitation. MNR will complete the habitat surveys in 2012 to determine if remediation is required and indicate potential rehabilitation options, if required.

3.2.6 Fish Tumours or Other Deformities

Status: Not impaired

Delisting Criteria
There are no delisting criteria because this beneficial use is not impaired.

Reason for Initial Impairment
The Stage 1 report identified that the fish tumours and other deformities required further assessment as there was a potential impairment due to the discharge of chlorinated organics from the pulp mill (Peninsula Harbour RAP Team 1991).

Current State
To date, there have been no reports from fisheries personnel or the public to indicate the presence of tumours or deformities in Peninsula Harbour fish. The initial impairment based on the discharge of chlorinated organics has been addressed when the pulp mill began using 100% chlorine dioxide in the bleaching process in 1991 and, together with the implementation of the secondary treatment in 1995 and its closure in 2009, has effectively reduced chlorinated organics and eliminated the discharge of dioxins. This beneficial use, therefore, is not considered impaired in the AOC.

Remaining Actions and Monitoring
This beneficial use is not impaired, thus, further actions are not applicable.

4.0 CONTAMINATED SEDIMENT IN PENINSULA HARBOUR

Contaminated sediment is the main environmental issue in the Peninsula Harbour AOC. The majority of the remaining BUIs (restrictions on fish consumption, degradation of fish populations and degradation of benthos) are due to mercury and PCB contaminated sediment, within Jellicoe Cove. This section gives an overview of the Peninsula Harbour sediment management plan, specifically the environmental risk assessment (ERA), sediment management goals, sediment management remedial alternatives considered, and the selected remedial action—thin layer capping.

4.1 Management of Contaminated Sediment in Great Lakes AOCs

Under the 2002 COA, federal and provincial governments committed to developing a sediment decision-making framework for the Great Lakes AOCs. The *Canada-Ontario Decision Making Framework for Assessment of Great Lakes Contaminated Sediment* (EC and MOE 2007) provides standardized science-based guidance for assessing risks posed by contaminated sediment and determining whether management actions are required. The framework, which was used for Peninsula Harbour sediment, considers potential impacts to organisms living in the sediment and other aquatic organisms, and the potential for bioaccumulation in the food chain.

4.2 Environmental Risk Assessment for Peninsula Harbour

In 2008, an ERA was conducted by ENVIRON International Corporation (ENVIRON), with funding from EC and MOE, to evaluate the ecological and human health risks posed by PCBs and mercury in the sediment and biota in the Peninsula Harbour AOC, particularly for Jellicoe Cove. The ERA also identified sediment management goals to reduce risks.

The ERA evaluated potential risks to benthic invertebrates, piscivorous (fish-eating) birds, fish, and piscivorous mammals through the use of representative species as indicators for the latter three groups (Table 7). The representative or indicator species are intended to represent the full range of wildlife species that would likely inhabit the areas (ENVIRON 2008a).

Table 7. Environmental Risk Assessment Indicator Species Used by Ecological Receptor Group

Ecological Receptor Group	Indicator Species
Piscivorous (fish-eating) birds	Bald Eagle
	Common Loon
Fish	Sport fish (i.e., lake trout, walleye, lake whitefish)
	Bottom-dwelling fish (i.e., longnose sucker)
Piscivorous (fish-eating) mammals	Mink

The key findings from the ERA include:

- Mercury and PCB sediment concentrations do not pose a significant risk to benthic invertebrates in the AOC;
- Mercury and PCB concentrations do not pose a significant risk to common loons and other waterfowl populations;
- Mercury concentrations in fish populations may reduce bald eagles and other piscivorous raptors reproductive success, but PCB concentrations in fish do not pose a significant risk to piscivorous birds that forage in the AOC;
- Reproduction of sport fish (e.g. lake trout, walleye and lake whitefish) and bottom dwelling fish (e.g. longnose sucker) may be impaired by mercury concentrations;
- Reproduction of the longnose sucker may be impaired by PCBs, but most fish are not expected to be impacted by present PCB concentrations; and
- Mercury concentrations in fish do not pose a significant risk to mink and other piscivorous mammals, but PCB concentrations in fish may pose a risk to mink and other piscivorous mammals that forage in either Jellicoe Cove or in the rest of the harbour (ENVIRON 2008a).

The human health risk assessment, included as part of the ERA, focuses on the potential risks to humans from mercury and PCB concentrations in the fish they catch and consume from the AOC. Residents of the Town of Marathon, and the Ojibways of the Pic River First Nation, were surveyed to determine the amount of fish that was consumed from Peninsula Harbour. There was no evidence of subsistence fishing or that fish consumption advisories influence eating or fishing decisions (ENVIRON 2008a). While the majority of households (84%) consume sport fish they have caught, only 17% consume fish caught in the harbour (ENVIRON 2008a). Current PCB concentrations in fish tissue may pose a significant risk to adult fishermen and their families; whereas, methylmercury concentrations in fish tissue do not pose a significant risk.

Ultimately, the ERA helped to determine that management action was required for this AOC (ENVIRON 2008a).

4.3 Approach to Managing Contaminated Sediment in Peninsula Harbour

A sediment management options study for the Peninsula Harbour AOC was completed in 2008 (ENVIRON 2008b). Sediment management refers to an engineered or institutional control that reduces risk of potential ecological and human health exposure to hazardous contaminants in the sediment and/or provides source control by reducing the potential for off-site movement of those contaminants (ENVIRON 2008b). The study identified and evaluated various management options to determine the most effective and feasible option to address PCB and mercury contaminated sediment in Jellicoe

Cove. Ultimately four alternatives were evaluated as potential sediment management options for Jellicoe Cove:

1) thin layer capping;
2) hydraulic dredging, thin layer capping, and offsite disposal of dredged sediment;
3) hydraulic dredging, thin layer capping, and consolidation of dredged sediment in an onsite, land-based confined disposal facility; and
4) monitored natural recovery.

4.3.1 Jellicoe Cove, Sediment Management Area of Focus

Jellicoe Cove has the highest levels of sediment contamination in the AOC, and therefore, this area was the focus for the development of management options. Jellicoe Cove is located on the north shore of Lake Superior and has water depths ranging from less than 4 m to 28 m (Figure 6) with sediment that is mainly silty sand with organic matter (Carbonneau *et al*. 2010). Jellicoe Cove methylmercury and PCB concentrations exceed the risk-based management goals outlined in the ERA, and these contaminants have been transported to other areas of the harbour (ENVIRON 2008a).

The elevated mercury and PCB levels can be attributed to effluent from the pulp mill that operated from 1946 until 2009, and the chlor-alkali plant effluent that operated from 1952 until 1977. Historical log booming and log storage in the area, both ending by the mid-1980s, may have also impacted Jellicoe Cove water quality (ENVIRON 2008b). There is no physical barrier that separates the rest of Peninsula Harbour from Jellicoe Cove; thus, water, biota and/or sediment can move freely between the two areas by wind and currents (ENVIRON 2008a).

Although there is contaminated sediment outside of Jellicoe Cove, remediation in these areas was not recommended due to technical challenges and high costs. As such, the ERA recommended that remedial efforts focus on the most highly contaminated sediment, the hot spot, in Jellicoe Cove (ENVIRON 2008b). Remediation of the hot spot is expected to accelerate natural recovery and assist in eliminating the transport of contaminants to other areas of the harbour.

Figure 6. Jellicoe Cove Sediment Management Area of Focus Map (ENVIRON 2008a)

4.3.2 Sediment Management Goals and Remedial Action Objectives

Four types of sediment management goals were considered for the Jellicoe Cove sediment: 1) risk-based; 2) guideline-based; 3) background-based; and 4) source control of hotspots (ENVIRON 2008b). A hot-spot based approach was selected to manage the sediment containing elevated concentrations of PCBs and mercury. Through source control of hotspot areas that exceed 3 mg/kg of total mercury, it is expected that the risks to selected receptors will be reduced. Therefore, the overall goal of the sediment management project is to cover contaminated sediment equal to or exceeding 3 mg/kg of total mercury.

Remedial action objectives (RAO) were identified in the sediment options report (ENVIRON 2008b) and represent site-specific management goals for the AOC. "The RAOs for Peninsula Harbour are: 1) to minimize the potential for future exposure to sediment-associated PCBs and methylmercury in Jellicoe Cove and RPH [the rest of Peninsula Harbour]("risk reduction"); and 2) to reduce the potential for migration of methylmercury, total mercury, and PCBs away from the identified hot spot in Jellicoe Cove ("source control")" (ENVIRON 2008b, p.14).

4.3.3 Methodology

A number of preliminary sediment management options were assessed as a starting point for selecting the appropriate sediment management option for Jellicoe Cove. The initial sediment management options included: institutional controls, natural recovery, sediment capping, sediment removal, post-removal sediment management technologies, dredged material transportation, dredged material disposal, *in situ* treatment, and *ex situ* treatment. For further details on each of these options please see appendix B and/or see the sediment management options report (ENVIRON 2008b). Due to the large number of possible sediment management options, a preliminary screening analysis was conducted based on the following criteria: remedy effectiveness, relative cost, and implementability (feasibility) (Table 8). The preliminary screening eliminated those management options that were ineffective, not readily able to implement in Jellicoe Cove, and were more expensive than other options that were equally or more effective (ENVIRON 2008b).

Table 8. Preliminary Screening Criteria for Sediment Management Options (ENVIRON 2008b, p.27)

Criteria	Criterion Details
Effectiveness	Does the technology meet the remedial action objectives? Does the option provide long-term protection of environment and human health? Does the option protect against short-term environmental and human risks during remedy implementation and construction? Has the option been proven reliable at sites with similar conditions and chemical constituents?
Implementability (technical feasibility)	Is the option technically and administratively feasible of implementing a technology based on industry experience, site layout and geography, and technical maturity and availability?
Cost	The costs for each option are qualitatively estimated as low, medium or high where costs are based on engineering experience and judgment and available historical information. If the estimated cost is considered prohibitive, further judgment is not necessary.

Following the initial evaluation there were two principle management options remaining for Jellicoe Cove: 1) thin layer capping, and 2) hydraulic dredging combined with thin layer capping. Two separate disposal alternatives where identified following the remedy screening process for the combined dredging and capping option. Thus, three management options advanced for further evaluation.

The remaining three pre-screened sediment management options were evaluated in further detail using the eight criteria in table 9 in addition to, a weighting matrix (ENVIRON 2008b). Specific details on the weighting matrix are available in the ENVIRON sediment management report (2008b).

Table 9. Secondary Evaluation Criteria for Three Pre-screened Remedial Alternatives (ENVIRON 2008b, p.30)

Criterion 1	Ability to achieve the sediment management goals identified in the ERA;
Criterion 2	Technical feasibility, with respect to reliability, timeline, and construction and operation requirements
Criterion 3	Community acceptance;
Criterion 4	Environmental impacts and human health implications;
Criterion 5	Need for measures to control and address residual contamination;
Criterion 6	Requirements for chemical, biological, and/or physical monitoring, in order to achieve both short-term and long-term goals;
Criterion 7	Compliance with regulatory requirements and the effects of these requirements on implementation; and
Criterion 8	Overall detailed site-specific costs related to implementation, long-term maintenance and monitoring, and disposal.

4.4 Sediment Management Options

There were three management options carried forward after the preliminary and secondary evaluations that include: 1) thin layer capping; 2) combination of hydraulic dredging and thin layer capping with dredge materials disposed of at an offsite landfill; and 3) combination of hydraulic dredging and thin layer capping with dredged materials disposed at a local on land confined disposal facility (CDF) (ENVIRON 2008b). Institutional controls will be created and/or maintained in combination with each remedial alternative. Institutional controls include deed restrictions such as controlled navigational routes and/or recreation use restrictions such as fish consumption advisories (ENVIRON 2008b).

4.4.1 Remedial Alternative 1: Thin Layer Capping

The first remedial option is “thin layer capping of sediment defined by mercury concentrations exceeding 3 mg/kg in surface sediment” (ENVIRON 2008b p.63). A thin layer cap is the controlled placement of a thin layer (approximately 15 to 20 cm) of clean material, typically sand, over the contaminated sediment area (ENVIRON 2008b). The thin layer cap creates a physical barrier between the contaminants and the environment; however it is not an isolation cap. A thin layer cap reduces the potential for re-suspension of mercury contaminated material and reduces the risk of aquatic and human exposure to chemicals. Left uncapped, the sediments within the area of highest contamination are expected to be moved by lake bottom flow (Environmental Hydraulics Group 1993).

A sediment cap of 15 cm in depth is expected to be sufficient to cover the hot spot where total mercury concentrations exceed the ERA remedial goal for thin layer capping of 3 mg/kg or greater. This will allow minimal remixing with contaminated sediment, minimize changes to local bathymetry and aquatic habitat, and allow for benthic recolonization to occur in the clean sediment material (ENVIRON 2008b). The cap is designed to have little impact on current benthic invertebrates communities while rapidly improving their habitat through the creation of a new clean sediment surface, providing a barrier between contaminated sediment and the environment, diluting chemical concentrations, and reducing sediment scour potential (ENVIRON 2008b).

The ERA (2008a) concluded that a thin layer cap at a hot spot with total mercury concentrations equal or greater to 3 mg/kg would reduce risks to fish by 22-47%, with or without the addition of dredging, depending on the amount of time the fish is in Jellicoe Cove. This risk reduction meets the ERA target hazard level, i.e. hazard quotient for fish equal to 1 (ENVIRON 2008b). The thin layer cap will reduce the risks posed to mink by PCBs by 12-33% resulting in a hazard quotient within the target hazard level (ENVIRON 2008b). This value is dependent on the amount of fish the mink eat from Jellicoe Cove and the rest of the harbour. The thin layer cap can effectively mitigate the current risks posed to fish and mink (ENVIRON 2008b). Long-term monitoring of the thin layer cap would be required.

4.4.2 Remedial Alternative 2: Hydraulic Dredging, Thin Layer Capping, and Offsite Disposal of Dredged Sediment

Remedial alternatives 2 and 3 involve hydraulic dredging and the placement of a thin layer cap. The alternatives vary in disposal methods. Hydraulic dredges remove contaminated sediment as they minimize turbidity and work to contain contaminants and entrained water (Jaagumagi and Persaud 1995). Sediment removed through hydraulic dredging is pumped from the contaminated area as “water-rich slurry from the barge to a designated receiving area” (ENVIRON 2008b, p.22).

A thin layer cap over the approximate 200,000 m^2 area will effectively reduce current risks to fish and mink populations. In addition, the cap will enhance the dredged areas habitat recovery, create a stable bathymetric profile post dredging and limit the risk of dredge residuals being redistributed in the area (ENVIRON 2008b). Remedial targets for hydraulic dredging are based on surface sediment thresholds of mercury concentrations equal to or exceeding 14 mg/kg and 17 mg/kg (ENVIRON 2008b).

For this remedial alternative log debris will be removed from the remedial area, hydraulic dredging will take place, a thin layer cap will be placed over the dredged area, dredged sediment will be dewatered, and post dredging sediment trucked to an offsite disposal site in a Thunder Bay regional landfill. Prior to disposal, the sediment needs to be identified as hazardous or non-hazardous based on regulatory standards and handled accordingly. A double-contained high density polyethylene pipeline (HDPE) would transport dredged slurry to the designated materials handling area (ENVIRON 2008b). Monitoring of the cap and offsite disposal of dredged material would be required.

"While the reduction in hazard quotients is predicted to be comparable across all three Remedial Alternatives, the removal of 24 kg to 96 kg of mercury under remedial alternative 2 (associated with the 17 mg/kg and 14 mg/kg surface sediment threshold concentration footprints, respectively) offers the further reduction in risk associated with long-term transport of mercury from Jellicoe Cove to other areas of Peninsula Harbour" (ENVIRON 2008b, p.35). Dredging limitations, applicable for both remedial alternatives 2 and 3, are the generation of *in situ* or *ex situ* residuals. This may limit the ability of remedial alternatives 2 and 3 meeting the sediment management goals outlined in the ERA (ENVIRON 2008b). Both disposal methods have little influence on the ability to meet the sediment management goals.

4.4.3 Remedial Alternative 3: Hydraulic dredging, Thin Layer Capping, and Consolidation of Dredged Sediment in an Onsite, Land-Based CDF

As described in remedial alternative 2, a combination of hydraulic dredging, thin layer capping and disposal was also proposed for alternative 3. However for remedial alternative 3, sediment removed from the management area in Jellicoe Cove will be placed in an onsite land-based confined disposal facility (CDF). Dredged sediments could be placed within a CDF provided the structure has been designated to receive hazardous waste materials. CDFs are specially engineered disposal sites, designed to minimize contaminant leaching into the surrounding watershed. The CDF needs to be built prior to dredging and it must be "graded and lined to control runoff and water generated from dewatering and sediment consolidation" (ENVIRON 2008b, p.25). The CDF would be lined with a geosynthetic clay liner to prevent the risk of leaching dredge decant water (ENVIRON 2008b). Similar to remedial alternative 2, a HDPE pipeline would transport sediment material but in this case to the CDF. A cap would be placed on the CDF once the dredging and dewatering are finished (ENVIRON 2008b).

This remedial alternative includes the consolidation of dredged sediment in an onsite, land-based CDF. Short and long-term monitoring of both the remediation area and the CDF would be required.

4.4.4 Remedial Alternative 4: Monitored Natural Recovery

Natural remediation is best suited for depositional areas, such as harbours, once effective source controls have been achieved and where the addition of clean sediments forms a protective layer over contaminated materials (Jaagumagi and Persaud 1995). Monitored Natural Recovery (MoNR) involves leaving contaminated sediment in place and relying on natural processes (physical, biological and/or chemical), as opposed to anthropogenic intervention, to contain, reduce or eliminate the toxicity and bioavailability of the sediment related chemicals (ENVIRON 2008b). To be effective, the sedimentation rate must be adequate to ensure complete coverage and isolation of contaminated material within a reasonable period of time. Long-term monitoring is also required to track natural progress and to determine the effectiveness and rate at which natural processes are reducing sediment toxicity and bioavailability of sediment chemicals (ENVIRON 2008b).

MoNR was not one of the final remedial alternatives presented in ENVIRON's (2008b) sediment management options study. Although this alternative was identified in the initial process of determining options for sediment remediation. It did not meet the preliminary evaluation, primarily because it does not meet sediment remediation goals outlined in the ERA, and was subsequently rejected.

During public consultation in June 2008 however, the public and interested stakeholders showed a great acceptance in including MoNR as a remedial alternative for the Peninsular Harbour AOC. Thus, EC and the MOE reintroduced MoNR as another remedial alternative, despite it not being presented as such in the sediment management options report. A recovery rate would have to be established to determine if natural recovery rates are "reasonable" to address sediment management goals where mercury concentrations exceed 17 mg/kg or 14 mg/kg in sub – and surface sediment (ENVIRON 2008b). After further review by EC and MOE, in conjunction with public input and the sediment management options report, this option was rejected as the sediment management option for Peninsula Harbour.

4.5 Preferred Option for Management of Contaminated Sediment

After a thorough assessment of the risks, benefits, costs and input from the community, First Nation and Peninsula Harbour Sediment Management Technical Committee, EC and the MOE selected thin layer capping as the preferred method of managing contaminated sediment in the Peninsula Harbour AOC. The thin layer cap was selected based on public input, that it satisfied criteria established in the sediment management options analysis i.e. effectiveness, feasibility and cost, and met the sediment management goal to cover contaminated sediment equal to or exceeding 3 mg/kg of total mercury. The implementation of the thin layer cap is a priority action for this AOC. Public Works and Government Services Canada, on behalf of EC, will oversee the construction of the thin layer cap. The project will be funded by EC, MOE, MNR and a former mill owner. A number of government agencies may be involved in the approval and permit process for the thin layer cap including: MOE, MNR, DFO, and Transport Canada.

Since the preferred sediment management option decision in 2008, EC and the MOE have worked closely with the CLC and all interested parties to ensure that concerns are addressed throughout the implementation of the sediment management project. In light of the mill closure in March 2009 and at the request of the CLC, EC and the MOE conducted another review of the assessment criteria and determined that thin layer capping continued to be the best option for managing the contaminated sediment in Jellicoe Cove.

The sediment management options report (ENVIRON 2008b) identified that the thin layer cap was more suitable than the combined dredging and capping options. The dredging and capping remedial alternatives (alternatives 2 and 3) did not have a high level of community acceptance unlike the thin layer cap remedial alternative. Dredging also requires the removal of a significant amount of sediment which is costly and sometimes complex. The monitored natural recovery remedial option was not considered effective in meeting remedial objectives nor reducing environmental impacts despite being one of the favoured options by the community. As the sediments in Jellicoe Cove do not accumulate at an appreciable rate, the naturally occurring conditions do not provide a favourable time frame to address the contaminated sediment hot spots (sediment concentrations equal to or exceeding 3 mg/kg for mercury; 0.34 mg/kg for PCBs) (Carbonneau *et al.* 2010; ENVIRON 2008b). For these reasons, monitored natural recovery did not pass the initial screening of the options study as it was not considered a stand alone technology and could not meet the sediment management goals outlined in the ERA.

The thin layer cap will cover approximately 256,000 m^2 (25 hectares) of identified mercury and PCB contaminated sediment in the southern portion of Jellicoe Cove with approximately 15 - 20 cm of clean sand (Figure 7) (Carbonneau *et al.* 2010). Capping the surficial sediment with total mercury concentrations that are equal to or exceed 3 mg/kg will mitigate exposure risks to mink and fish species as outlined in the ERA (ENVIRON 2008a). The thin layer cap is expected to provide clean material for benthic re-colonization, limit the transport of contaminated sediment to other areas of the harbour, and withstand average hydrodynamic flow conditions and erosive forces from 100-year interval storm events (ENVIRON 2008b).

The thin layer cap implementation requires site preparation prior to the placement activities, such as construction of materials handling area and the installation of silt curtains. The implementation schedule takes into consideration the timeline for permit requirements and MNR water-construction timing restrictions. The detailed engineering design and environmental assessment (AECOM 2012) was completed in early 2012. The thin layer cap design accounts for the following complexities: rate and magnitude of cap settlement, bearing capacity and stability of surface sediments and potential sediment cap mixing with existing sediments (Carbonneau *et al.* 2010).

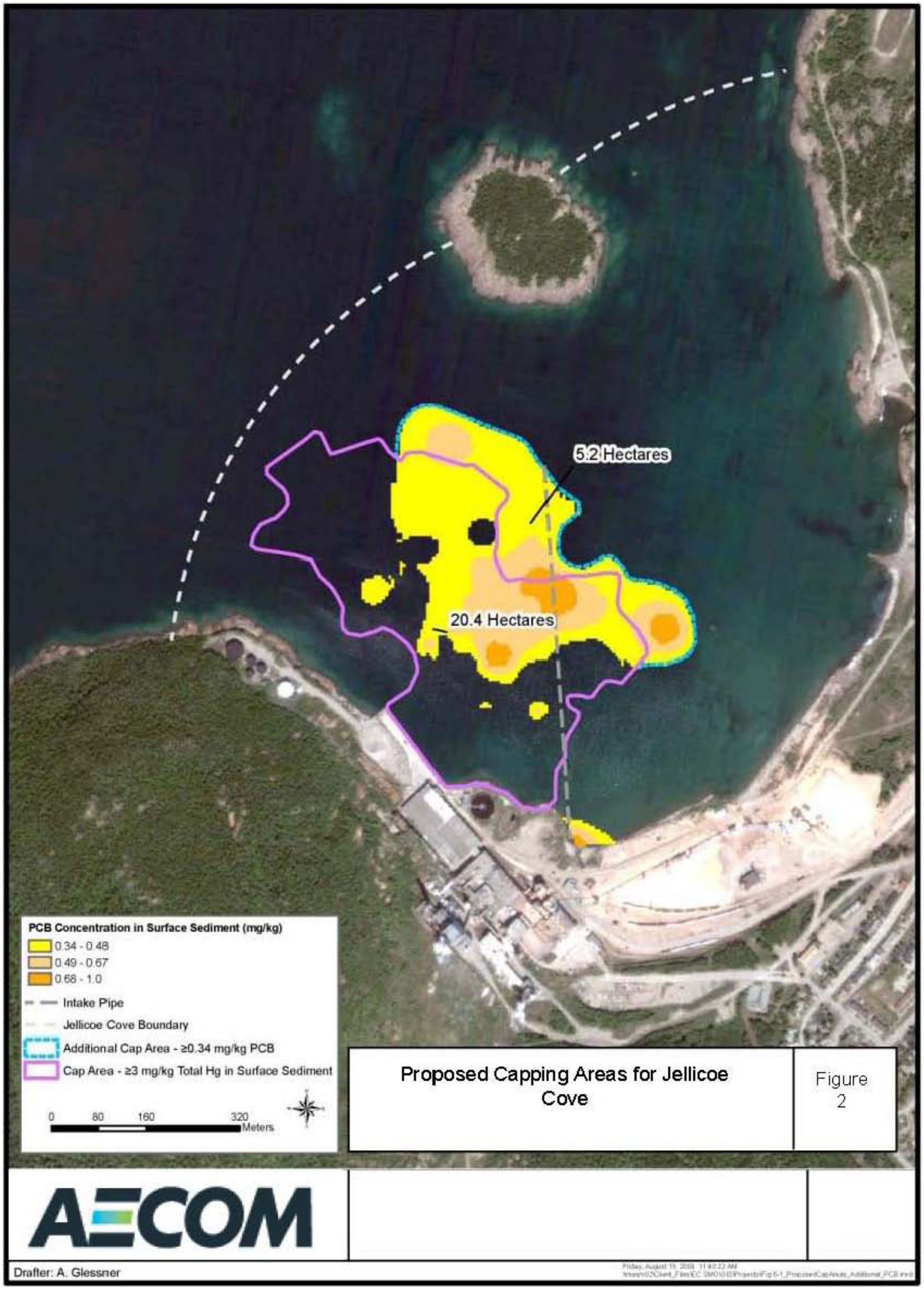


Figure 7. Proposed Capping Area for Jellicoe Cove (AECOM 2012)

4.6 Monitoring After Management of Contaminated Sediment

The thin layer cap is expected to reduce exposure to contaminants; however, long-term monitoring is essential to monitor the movement of cap material and determine whether the project meets its remediation objectives. A long-term monitoring plan has been developed by AECOM on behalf of PWGSC, EC and the MOE. Performance monitoring will be conducted immediately after cap placement to confirm that the contractor has met the engineering design specifications. Remedial goal monitoring will assess the cap's effectiveness at meeting sediment clean-up levels (i.e. area average sediment concentration of total mercury less than 3 mg/kg). Ecological recovery will be assessed through the evaluation and documentation of long-term trends for contaminant tissue levels in benthic invertebrates and benthivorous fish, the re-colonization of a benthic community, and the re-colonization of submerged aquatic vegetation. Monitoring will look at short and long-term trends for approximately 20 years following the implementation of the thin layer cap.

5.0 COMPLETING IMPLEMENTATION OF THE REMEDIAL ACTION PLAN

Implementation of the sediment management plan and subsequent monitoring along with the targeted fish habitat survey in Beatty Cove are the remaining actions for the restoration of this AOC.

The monitoring of fish population health by MNR will continue as part of their lake wide assessment of fish communities and to confirm the status of fish populations in Peninsula Harbour.

Benthos and contaminants in benthivorous fish will be monitored by EC and MOE, respectively over 20 years. It will require some time to detect the effects of reduced exposure to mercury and PCBs in fish and benthos in Peninsula Harbour. The early monitoring results will be available in 2018; with an anticipated recovery progression over 20 years.

It is the conclusion of EC, MOE, and MNR, that with the implementation of the sediment management plan (thin layer cap and associated monitoring), and pending the results of the Beatty Cove habitat survey and Fish Community Index Netting, all priority actions in the Peninsula Harbour RAP will have been implemented.

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Appendix A. Suggested Reference Locations for Each Beneficial Use Impairment

Beneficial Use Impairment	Suggested Reference Areas
Restrictions on fish consumption	Ministry of the Environment Sportfish Block 7
Degradation of fish and wildlife populations	Populations within the AOC will be compared to populations outside the AOC. The outside sampling sites are randomly selected within QMA 18.
Degradation of benthos a) Dynamics of benthic populations b) Body burdens of benthic organisms	a) BEAST reference sites (250 plus in total, 70 from Lake Superior, available on request from Environment Canada) b) Not applicable
Restrictions on dredging activities	Not applicable
Loss of fish and wildlife habitat	To be determined by the Ontario Ministry of Natural Resources

Appendix B. Preliminary Screening of Sediment Management Options Peninsula Harbour, Marathon, Ontario

General Response Action	Sediment Management Option	Effectiveness	Implementability	Cost	Overall Screening Conclusion
No Action	No Action	Would not be effective in meeting sediment management goals	Implementable, but not likely to be acceptable to public or regulatory agencies.	None.	Reject as ineffective for meeting sediment management goals.
Institutional Controls	Deed Restrictions	Potentially effective in reducing exposure to impacted media	Implementable, but may not be acceptable to public or regulatory agencies except when other active forms of remediation cannot provide complete remediation.	Very low, since this option only involves administrative actions.	Reject as a stand-alone approach. Institutional controls may be used as a component of other sediment management options.
	Recreational Use Restrictions	Potentially effective in reducing exposure to impacted media.	Implementable, but may not be acceptable to public or regulatory agencies except when other active forms of remediation cannot provide complete remediation.	Very low, since this option only involves administrative actions.	
Natural Recovery	Monitored Natural Recover (MoNR)	Highly effective at low-risk sites with strong evidence for natural recovery processes. However, given the lack of measured attenuation in PCB and mercury concentrations in Peninsula Harbour sediments and biota over the past two decades, MoNR is unlikely to immediately achieve sediment remediation goals of less than 10 mg/kg, 6 mg/kg, or 3 mg/kg for total mercury in sediment.	Readily implementable. Monitoring program and contingency plan required.	Relatively low for well characterized sites that involve only long-term monitoring costs. Site investigation costs for MoNR may be higher than for other remedies such as capping or dredging.	Reject as a standalone technology. To date, MoNR has not controlled sediment Hg concentrations within the >17, 14, 10, 6, or 3 mg/kg target areas of the harbour. May be effective for areas in the wider harbour.

General Response Action	Sediment Management Option	Effectiveness	Implementability	Cost	Overall Screening Conclusion
Sediment Capping	Isolation Capping with Armoring Layer	Effective at physical and chemical isolation of impacted sediments to reduce human and ecological exposures and potential off-site transport.	Implementable. Generally more easily placed in shallower areas. Caps along exposed shorelines may need additional erosion and stabilization controls. Monitoring is used to address long-term cap integrity and contaminant isolation.	Medium.	Reject since placement of an armored isolation cap may negatively affect bathymetry and obstruct ship traffic. An armored cap likely represents an over-engineered solution for the relatively quiescent JC environment.
	Engineered Capping with Reactive Materials	Innovative technology that is potentially effective at physical and chemical isolation of impacted sediments to reduce potential exposure of humans and aquatic organisms. May be used as a standalone remedy or to augment conventional isolation caps or thinlayer caps to improve cap effectiveness.	Potentially implementable, depending on the results of bench and pilot studies. Design issues are similar to isolation capping. Monitoring is used to address long-term maintenance of reactive materials and cap integrity.	High.	Consider for JC sediment, although technology is still evolving. May be used to address methylmercury and PCBs not explicitly addressed in remedial alternative selection.
	Thin Layer Capping	Effective at minimizing ecological exposure to impacted sediments, and limiting off-site sediment transport. Accelerates natural recovery via burial and dilution, by allowing for the mixing of clean cap material with underlying impacted sediment. Reactive materials can augment a thin layer cap.	Implementability in deep waters is more challenging. Caps along exposed shorelines may need additional erosion and stabilization controls. Monitoring is used to address long-term cap integrity.	Low-Medium.	Retain. Capping to the 3 mg/kg surface sediment mercury contour will mitigate exposure risks to fish species and mink in JC.

General Response Action	Sediment Management Option	Effectiveness	Implementability	Cost	Overall Screening Conclusion
Sediment Removal	Mechanical Dredging	Potentially effective for sediment mass removal. Physical disturbance of sediment may pose a risk of mobilization of mercury and PCBs. Site-specific pore water mercury data indicate that the risk for decant water discharge associated with closed bucket mechanical dredging operations is low (Beak 2003). Effectiveness with respect to achieving low surface sediment concentrations decreases when dredging to bedrock or hardpan.	Implementability at Peninsula Harbour is challenged due to dredging at depths greater than 10 m and due to potential hardpan subsurface conditions underlying contaminated soft sediment. Multiple passes would likely be required to achieve complete removal.	Relatively high.	Reject since impacted areas in PH include areas at depths greater than 10 m, and because of the limited ability of mechanical dredging to achieve low-concentration goals without significant (and potentially infeasible) over-dredging.
	Hydraulic Dredging	Potentially effective for sediment mass removal. The extent of sediment remobilization tends to be lower than with mechanical dredging. Achieving low concentrations when dredging to bedrock or hardpan is challenging, though hydraulic dredging may have more success doing so than mechanical dredging. Effectiveness may be encumbered by the presence of debris, which tends to impact hydraulic dredging. Separate staging for debris removal may be required.	Requires more extensive dewatering and water management than mechanical dredging. Water separation and water management are required for the up to 50,000 m_3 water estimated to be generated from dewatering following hydraulic dredging. May require specialized equipment to manage shallow sediments over potential hardpan. Debris removal is required.	Relatively high.	Retain
	Dry Mechanical Excavation	Potentially effective for sediment mass removal. Dry excavation provides more accurate targeted removal than wet excavation.	Requires extensive water diversion. Not implementable in JC due to water depths.	Relatively high.	Reject since technology is relatively infeasible.

General Response Action	Sediment Management Option	Effectiveness	Implementability	Cost	Overall Screening Conclusion
Dredged Material Dewatering	Onsite Drying Beds and Gravity Dewatering	Potentially effective for sediment dewatering. May have to be supplemented with pozzolanic materials to facilitate dewatering.	Requires relatively large onsite staging areas, which are available at Peninsula Harbour.	Low to medium. Use of pozzolanic materials increases costs.	Retain since coarse grained sediments similar to those found in Jellicoe Cove dewater relatively well with this technology.
	Barge Dewatering	Potentially effective, especially for small dredge volumes with low water content.	Requires less land area than on-site dewatering. Extra measures are required to protect against accidental spills. Generally not used for hydraulic dredging due to substantial water management requirements.	Relatively high, compared to onsite dewatering.	Reject due to significant implementation issues, and because land space is not a major limitation for this site.
	Mechanical Dewatering	Potentially effective.	Flow capacity is limited, which limits the size and capacity of associated hydraulic dredging systems.	Relatively high capital costs; expensive for relatively small sediment volumes.	Reject due to Significant effectiveness and implementability issues.
	Geosynthetic Tubes	Potentially effective; best suited for hydraulic dredging methods. Well suited for relatively coarse grained sediments such as those in Peninsula Harbour, which should dewater relatively easily.	Implementability at the site depends on successful bench-scale testing using representative site sediments. On-site areas are available for dewatering and dredged sediment management.	Relatively low.	Retain

General Response Action	Sediment Management Option	Effectiveness	Implementability	Cost	Overall Screening Conclusion
Dredged Material Transport	Barge	Effective process option for sediment transportation.	Requires bulkhead access, at Marathon and an offloading site in Lake Superior. If an existing bulkhead is not accessible, a temporary shoreline bulkhead would have to be constructed.	Relatively low.	Retain as potential component of the overall sediment transportation strategy, should dredging be selected as a component of the final remedy.
	Truck	Effective process option for sediment transportation.	Commonly used means of sediment transport. The shipping pier for Marathon Pulp Inc. has access to truck scales, onsite water treatment facilities, and an existing road base to support tractor trailers.	Relatively high.	Retain as potential component of the overall sediment transportation strategy, should dredging be selected as a component of the final remedy.
	Rail	Effective process option for sediment transportation.	Implementable. May be used for portions of the overall transport plan for off-site sediment transport. Shipping by rail from the site requires rail access at the site.	Relatively low, unless rail lines require construction.	Retain as potential component of the overall sediment transportation strategy, should dredging be selected as a component of the final remedy.

General Response Action	Sediment Management Option	Effectiveness	Implementability	Cost	Overall Screening Conclusion
Dredged Material Disposal	Offsite Waste Disposal Facility	Effective for containment of dredged sediments. Potential short-term impacts during materials handling and off-site transportation stages.	Based on Leachable Extract Procedure (LEP) testing, impacted PH sediment may be classified as non-hazardous, non-registerable waste for disposal in non-hazardous waste landfill. Suitably permitted non-hazardous waste landfills have been identified within 300 km of the site. On-site materials handling areas have been identified for dewatering and bulk storage of dredged sediment prior to off-site haulage.	Medium if all dredged sediments can be disposed of as non-hazardous wastes, as currently expected. High, if dredged sediments must be disposed of as hazardous wastes. May require additional TCLP testing.	Retain
In Situ Treatment	Disposal in a Local Confined Disposal Facility (CDF)	Effective for containment of dredged sediments with proper design and construction including liners, caps, and leachate control. Based on an environmental risk assessment completed at the Peninsula Harbour site, Beak (2003) concluded that the risk of permanent storage of mercury contaminated sediments in a CDF is negligible.	This approach could combine gravity or Geotube® dewatering within a lined, newly permitted disposal area. Requires long-term monitoring and maintenance. Requires permitting of an on-site landfill.	Medium	Retain
	Beneficial Reuse (following *ex situ* treatment)	Effective only with fully treated sediments.	Implementable where treatment of sediments is sufficient.	Relatively low.	Reject since technology depends on other treatment technologies not retained (see below).

General Response Action	Sediment Management Option	Effectiveness	Implementability	Cost	Overall Screening Conclusion
In Situ Treatment	Chemical Sequestration	Effectiveness of sediment amendments with respect to mercury and PCBs is uncertain, as technology is under development.	Implementability is uncertain since technology is still in the developmental stage.	Relatively high.	Reject since technology is relatively unproven. May be introduced during detailed design.
	Bioremediation	Ineffective for PCBs and mercury.	Limited implementability. Unproven at full scale.	Relatively low.	Reject as ineffective for PCBs and mercury.
	Phytoremediation	Potentially effective for reducing sediment and contaminant mobility.	Limited implementability. Unproven at full scale	Relatively low.	Reject as unproven.
	Stabilization	Effective for immobilizing mercury into a non-leachable, cement-like matrix. Limited effectiveness for sequestering PCBs. Not likely to be effective at Peninsula Harbour since technology works best at sites where the treatment area can be isolated.	Difficult to implement in a site setting similar to Peninsula Harbour due to inability to control mixing conditions and curing temperatures. Significant sediment resuspension would occur.	Relatively high.	Reject due to significant implementation issues as compared to more proven technologies.

General Response Action	Sediment Management Option	Effectiveness	Implementability	Cost	Overall Screening Conclusion
Ex Situ Treatment	Thermal Desorption	Effective for removal/volatization of organic constituents and mercury.	Difficult to implement due to difficulties in controlling mercury vapor generated and lack of full-scale sediment remediation applications to date. Permitting is expensive and may not be possible.	High.	Reject due to significant implementation issues as compared to more proven technologies.
	Incineration	Effective for destruction of organic constituents and mercury.			
	Dechlorination	Potentially effective in detoxifying specific types of organics, possibly PCBs. Not effective against mercury.	Difficult to implement due to excessive reagent requirements and lack of full-scale remediation applications.	High.	Reject due to significant implementation issues.
	Bioremediation	Ineffective for PCBs and mercury.	Lacks full-scale sediment remediation applications.	Medium.	Reject due to limited effectiveness.
	Stabilization	Effective for immobilizing mercury into a non-leachable, cement-like matrix. Limited effectiveness for sequestering PCBs. Improves material handling and dewatering.	Implementable. Addition of solidifying or stabilizing reagents may increase both volume and weight for disposal or containment.	Medium.	Retain if conventional dewatering methods do not adequately dewater sediments.
	Sediment Washing	Unproven physical separations technology expected to be ineffective for inorganic constituents. Potentially effective against PCBs.	Difficult to implement and lacks full-scale sediment remediation applications to date. Limited commercial availability.	High.	Reject due to significant implementation issues as compared to more proven technologies.
	Solids Separation	May be effective at sites with a large range of sediment grain sizes and with large fractions of low level contaminated sediment.	Potentially implementable	High.	Reject as expensive with limited potential benefit for the relatively small volume proposed for dredging.

(ENVIRON 2008b Table 5-1)