Jackfish Bay Remedial Action Plan

Stage 2: Remedial Strategies for Ecosystem Restoration

February 1998

Prepared by:
Jackfish Bay Remedial Action Plan Team

With assistance from:
Jackfish Bay Public Advisory Committee

JACKFISH BAY
RAP
NORTH SHORE
OF LAKE SUPERIOR
REMEDIAL ACTION PLANS

ACKNOWLEDGEMENTS

The Stage 2 document was prepared by the Lake Superior Programs Office with the assistance of the following members of the Jackfish Bay Remedial Action Plan Team:

Ken Cullis	Environmental Coordinator for Lake Superior Ontario Ministry of Natural Resources
Jim Murphy	Coordinator - Jackfish Bay RAP Ontario Ministry of Environment and Energy
Jake Vander Wal	Manager, Federal-Provincial Programs for Lake Superior
John Kelso	Research Scientist Canada Department of Fisheries and Oceans
Linda Melnyk-Ferguson	Ontario Ministry of Natural Resources, Nipigon District
Patrick Morash	Lake Superior Programs Office
Marilee Chase	Lake Superior Programs Office
Tim Cano	Lake Superior Programs Office

The RAP Team would like to thank the Jackfish Bay Public Advisory Committee for their assistance in preparing this document. PAC members provided assistance in investigating and evaluating remedial options. They developed Water Use Goals which laid the foundation for choosing remedial options and provided suggestions on how to achieve these Goals. Through the PAC, the RAP Team was better able to provide and implement a Remedial Action Plan that fulfills the goals and expectations of the community. Members of the Jackfish Bay PAC are:

Jim Bryson Public and Local Charter Services	David Daniels UPIU Local 665	Audrey Ferguson Jackfish Lake Residents
Jon Ferguson Chair - Jackfish Bay PAC	Rodger Ferguson Kimberly-Clark	Chris Joubert Township
Joe Kutcher Public	Ryan LeBlanc Save Ontario's Shipwrecks	Ron Martel Minnova Mines
Rod Mercure Public	Jack Moore Public	

Special thanks to Jim Bailey, the PAC facilitator, whose involvement is crucial to the RAP process.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

EXECUTIVE SUMMARY

As a result of the Canada - U.S. *Great Lakes Water Quality Agreement* of 1978 (GLWQA) and its 1987 revisions, participating federal, state, and provincial agencies, in cooperation with the International Joint Commission (IJC), identified 42 areas in the Great Lakes basin as individual Areas of Concern (AOC), for which a cleanup or Remedial Action Plan (RAP) was required. Sixteen AOCs are in Ontario, and four, including Jackfish Bay, are on the north shore of Lake Superior.

This Stage 2 document, *Remedial Strategies for Ecosystem Restoration*, is based on use impairments identified in the Stage 1 report and potential solutions to these impairments outlined in the Jackfish Bay Options Discussion Paper. It discusses further the present status of use impairments in the AOC using information gathered since the publication of the Stage 1 report (Table A), and outlines the strategy endorsed by both the Jackfish Bay RAP Team and the Public Advisory Committee (PAC) for the restoration of beneficial uses in the AOC.

Table A. Summary and current status of use impairments for the Jackfish Bay AOC (I = impaired; NI = not impaired; RFA = requires further assessment).

GLWQA IMPAIRMENT OF BENEFICIAL USE	Stage 1 Status	CURRENT CONDITIONS	Stage 2 Status
Restrictions of Fish and Wildlife Consumption			
Fish Consumption	RFA	Consumption restrictions exist for lake trout (*Salvelinus namaycush*) over 45 cm because of tissue concentrations of toxaphene (MOEE 1997). The apparent increase in dioxin levels for lake whitefish (*Coregonus clupeaformis*) greater than 55 cm is reflected in the latest consumption guide (MOEE 1997).	I
Wildlife Consumption	NI	No restrictions exist.	NI
Degradation of Fish and Wildlife Populations Dynamics of Fish Populations	I	Lake trout populations have declined since the mid-1950s probably because of the accidental introduction of sea lamprey (*Petromyzon marinus*) and other exotic species into Lake Superior, Kimberly-Clark mill operations, and over-harvesting. Blackbird Creek fish populations were eliminated as a result of pulp mill effluent; however, brook trout (*Salvelinus fontinalis*) and fathead minnows (*Pimephales promelas*) were captured in the creek in 1995. Fish populations in Moberly Bay have also declined.	I

Body Burdens of Fish	I	Low levels of hexachlorobenzene, mercury, and chlorinated pesticides were found in lake trout. The GLWQA Specific Objective for the protection of piscivorous wildlife from PCBs was exceeded in lake trout sampled in 1989, 1990, and 1992. Atmospheric inputs are believed to be the contributing factor. Improvements in mill processes have enhanced water quality; however, the recent increase in dioxins in lake whitefish suggests that further improvements may be warranted.	I
Dynamics of Wildlife Populations	RFA	A study of herring gulls (*Larus argentatus*) by the Canadian Wildlife Service indicated a decline in the number of nesting pairs in the AOC. Reproductive failure does not appear to be the result of exposure of eggs or adults to dioxins or halogenated aromatic hydrocarbons (Shutt 1994). Changes in diet from fish and insects to refuse is likely the cause of this impairment. Further assessment is warranted. CWS will monitor area for nesting gulls in 1998.	RFA
Body Burdens of Wildlife	RFA	Herring gull eggs collected from the AOC had relatively low levels of dioxins and other organochlorines, similar to background levels found elsewhere on Lake Superior (Shutt 1994). The gull eggs were not significantly contaminated with toxins normally associated with pulp mill effluent. Contaminant levels probably do not represent those of piscivorous gulls. If herring gulls had consumed fish from the AOC with elevated levels of toxins then they would have accumulated significant body burdens of these compounds.	RFA
Fish Tumours and Other Deformities	I	White suckers sampled from Jackfish Bay, prior to secondary treatment at Kimberly-Clark mill (1989), had an increased incidence of liver cancer (4-6%). Although the frequency of occurrence is greater in the AOC than in reference fish from Lake Superior (2-3%), it is still considered to be low (K. Munkittrick). Liver enzyme activity remains elevated in white suckers exposed to mill effluent. Increased liver size in lake whitefish (Munkittrick *et al.* 1992) and white suckers (Beak 1996) has also been reported.	I
Tainting of Fish and Wildlife Flavour	NI	There have been no recent reports from the public or fisheries/wildlife personnel. Unless new complaints are received, tainting will not be considered a problem.	NI
Bird and Animal Deformities or Reproductive Problems	RFA	Incidents of bird or animal deformities have not been reported in the AOC. Reproductive impairment in herring gulls over two breeding seasons was comparable to non-contaminated sites in Lake Superior (Shutt 1994). However, small egg size, low chick survival rate, and the lack of nesting of gulls in 1997 indicate a decline in reproductive productivity.	RFA

Degradation of Benthos Dynamics of Benthic Populations	I	Benthic communities in Moberly, Tunnel, and Jackfish Bays were severely impacted as a result of mill effluent. Following the installation of secondary treatment at the mill (1989) both density and diversity of benthic organisms has improved (Beak 1991a). Moberly Lake sediments remain acutely toxic to benthic fauna. Resuspension of sediments could severely impact downstream benthic communities (Beak 1991a).	I
Body Burdens of Benthic Organisms	I	Mussels (*Elliptio complanata*) and opossum shrimp (*Mysis relicta*) caged in Moberly Bay showed body burdens of dioxins and furans in concentrations approximating those contained in mill effluent (Sherman *et al.* 1990).	I
Restrictions on Dredging Activities	I	Sediments in the AOC contain several contaminants that exceed guidelines for dredging and open water disposal. However, without the demand for navigational or other dredging activities, contaminated sediments should be considered in the context of other ecosystem impairments.	NI
Eutrophication or Undesirable Algae	NI	There are no records of nuisance algal growths in the AOC.	NI
Restrictions on Drinking Water Consumption or Taste and Odour Problems	NI	Drinking water for the town of Terrace Bay is obtained from Lake Superior, west of Jackfish Bay. There have been no consumption restrictions or reported taste and odour problems for treated drinking water. However, on occasion, the mill effluent plume drifts towards cottages located in the old community of Jackfish, making nontreated water unsuitable for consumption.	NI
Beach Closings	NI	Bacterial levels are periodically elevated in the vicinity of the Terrace Bay beach as a result of mill discharge; however, this condition has not led to beach closings.	NI
Degradation of Aesthetics	I	Conditions have improved since the early 1970s; however, the presence of foam and dark coloured water in Blackbird Creek and Moberly Bay is still a concern.	I
Added Cost to Agriculture and Industry	NI	There are no agricultural or industrial activities that utilize water from the AOC. Water intake for Kimberly-Clark and the town of Terrace Bay is located in open Lake Superior, approximately 10 km west of Jackfish Bay.	NI
Degradation of Phytoplankton and Zooplankton Populations	NI	There have been no reported effects of contaminants on plankton populations in the AOC; however, community structure is likely altered in the vicinity of the mill discharge. *Daphnia* spp. are present in Blackbird Creek and in the secondary treatment system at the mill.	NI

Loss of Fish and Wildlife Habitat	I	Habitat mapping indicated spawning, nursery, and forage habitat in the Blackbird Creek system; however, water quality in the creek and in Moberly Lake remains impaired. Lake whitefish and lake trout spawning and nursery habitat was located on the eastern shore of Jackfish Bay. Contamination of existing habitat is not a limiting factor for fish populations in Lake Superior.	I

The Jackfish Bay PAC has contributed greatly to this endeavour, providing the local knowledge and community based goals crucial to the identification of beneficial use impairments and to their remediation. In combination with available scientific data and expertise, their participation has resulted in a promising strategy for the rehabilitation of the impaired uses found in the Jackfish Bay AOC.

The Jackfish Bay Ecosystem

The Kimberly-Clark bleached kraft pulp mill in Terrace Bay discharges effluent containing contaminants via the Blackbird Creek system into the Jackfish Bay area of Lake Superior. Contaminant levels in effluent and receiving waters have decreased since the installation of secondary treatment and changes in mill processes; however, historical contamination remains within the sediments of both Moberly Lake and Moberly Bay.

Remedial Strategy for Ecosystem Rehabilitation

The Jackfish Bay RAP Team and Jackfish Bay PAC explored a variety of options designed to rehabilitate the AOC, ranging from extensive physical alterations of the Blackbird Creek system to allowing the area to undergo natural rehabilitation while monitoring for incremental gains in environmental quality. Each solution was outlined in the Options Discussion Paper and evaluated on the basis of the potential benefits and disadvantages associated with implementation. Rejected options offered questionable benefits and extremely high capital and/or maintenance costs.

It was agreed that the AOC should be monitored for incremental progress with no further intervention at this time. Recovery and delisting of the AOC will not occur until there is a change in the Kimberly-Clark effluent being discharged to the Blackbird Creek system. Incremental progress might proceed based on actions implemented to date; however, total recovery is not foreseen without further active intervention by the mill.

A natural rehabilitation strategy will require maintenance of high standards of effluent quality by Kimberly-Clark, and continued monitoring of the Jackfish Bay AOC to document effects of historic deposits of contaminated material on the ecosystem. Recognizing that the RAP process is a dynamic one, we must be willing to acknowledge any deficiencies that arise and act accordingly to modify remedial strategies.

Section 1.0 - INTRODUCTION

1.0 INTRODUCTION

1.1 Stages of the Plan

As a result of the *Great Lakes Water Quality Agreement* of 1978 (GLWQA) and its 1987 revisions, participating federal, state, and provincial agencies, in cooperation with the International Joint Commission (IJC), identified 42 degraded areas on the Great Lakes as specific Areas of Concern (AOC), for which cleanup or Remedial Action Plans (RAPs) are required. Sixteen of these areas are in Ontario, and four are located on the north shore of Lake Superior.

Under the 1994 *Canada-Ontario Agreement* respecting the Great Lakes Basin Ecosystem (COA), the Ontario Ministry of Environment and Energy (MOEE) and Environment Canada will continue to coordinate the development of the 16 Canadian RAPs. The Ontario Ministry of Natural Resources (MNR) and the federal Department of Fisheries and Oceans (DFO) also play important roles in the development of the North Shore of Lake Superior RAPs. Remedial action planning serves as 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.

The cooperation and involvement of these and other agencies results from the necessity of viewing AOCs from an ecosystem perspective that incorporates land, water, air, plants, animals and, ultimately, people. To this end, the Great Lakes Health Effects Program (GLHEP) has also been working with RAP teams on the integration of human health considerations into the development and implementation of RAPs. The general public (ie. both individuals and organizations) participate in the RAP process as members of Public Advisory Committees (PACs), providing a forum for the spectrum of interests existing within a community. The Jackfish Bay PAC encompasses the interests of private citizens, industry, labour, tourism operators, and property owners.

The Stage 1 document, *Environmental Conditions and Problem Definition*, identified environmental impairments and objectives for the remediation of the AOC. The document was reviewed by both federal and provincial agencies and the IJC. An Options Discussion Paper was produced that lists remedial measures to address the identified environmental problems, weighs each option, and identifies the preferred course of action for the AOC.

The Stage 2 document uses the selected remedial options to outline stakeholder commitments and implementation timetables necessary to restore impaired beneficial uses. The resolutions developed herein lay the groundwork for the third stage which monitors the path of remediation in the AOC, documenting progress, and updating remedial efforts (Krantzberg 1996). An integral part of Stage 3 is the monitoring effort and the means (biological community properties, restoration of habitat function, sediment and water chemistry sampling, etc.) employed to assess ecosystem recovery.

The recommended options outlined in the following document are thought to be appropriate solutions to the environmental problems and conditions within the AOC and should restore beneficial uses over time. Recognizing that the RAP process is a dynamic one, we must be willing to acknowledge any deficiencies that arise and act accordingly to modify remedial strategies.

1.2 PAC Involvement

PAC involvement in Jackfish Bay RAP has been an extensive (Appendix 2) and integral part of the success of this project. The IJC recognized the importance of public participation as a mechanism to provide accountability to the public. The combination of local knowledge and community-based goals with scientific data and expertise has resulted in a pragmatic and defensible strategy to rehabilitate the AOC. The formal submission of the Stage 2 document (Recommended Plan) to the federal and provincial governments changes PAC involvement in the RAP process from plan development to assisting in the implementation of remedial strategies, and monitoring the progress of the plan. The cooperation, understanding, and stewardship that has been fostered will undoubtedly continue to affect the community and its outlook on future environmental concerns.

Section 2.0 - JACKFISH BAY AREA OF CONCERN

2.0 THE JACKFISH BAY AREA OF CONCERN

The Stage 1 document on the Jackfish Bay AOC (Jackfish Bay RAP Team 1991) provided extensive background material on the study area. This section summarizes information found in the Stage 1 report and documents additional data acquired since its completion.

2.1 Physical Features

The Jackfish Bay AOC is located on the north shore of Lake Superior, approximately 250 km northeast of Thunder Bay. The AOC consists of a 14 km stretch of Blackbird Creek between the Kimberly-Clark pulp mill and Jackfish Bay including Lake 'A', Moberly Lake (Lake 'C'), and Jackfish Bay (Fig. 1). The town of Terrace Bay (pop. 2477) is the closest community to the AOC, situated to the west of Jackfish Bay (outside of the AOC).

Blackbird Creek carries the wastewater discharge from the Kimberly-Clark Canada Inc. bleached kraft pulp mill. The creek drains a watershed with an area of 62 km^2 of rough, wooded terrain, wetlands, and several small lakes. It rises near the town of Terrace Bay and flows in a south-easterly direction for approximately 14 km into the northern tip of Moberly Bay. Historically, Blackbird Creek passed through two shallow lakes: Lake A and Moberly Lake. Lake A was originally 19 ha with a maximum depth of 6.1 m. The deposition of excessive volumes of wood fibre from the pulping process eventually resulted in the lake being partially filled in. As a result, Blackbird Creek was redirected around Lake A in the early 1980s. Moberly Lake was originally 28 ha with a maximum depth of 6.4 m. As of 1994, Moberly Lake was approximately 5 m deep (Dominion Soils Thunder Bay Ltd. 1994) and has also experienced some in-filling. Blackbird Creek was not visible from public lands until 1957, when Highway 17 was constructed east of Terrace Bay and a portion of the creek was re-routed alongside the highway. The creek was then directed away from the highway in 1989 when a tunnel was constructed to alleviate problems associated with the pulp mill effluent, such as ice and fog formation, and the aesthetic impairment of the AOC (Karl 1992).

Jackfish Bay contains two inner arms: Moberly Bay on the west into which Blackbird Creek drains and Tunnel Bay on the east (Fig. 1). A man-made tunnel connects Jackfish Lake with Tunnel Bay. Jackfish Lake receives runoff from a small drainage basin which extends to the north of the lake. Jackfish Bay is approximately 6.4 km^2, measuring a maximum of 4.5 km north to south and 3.0 km from east to west.

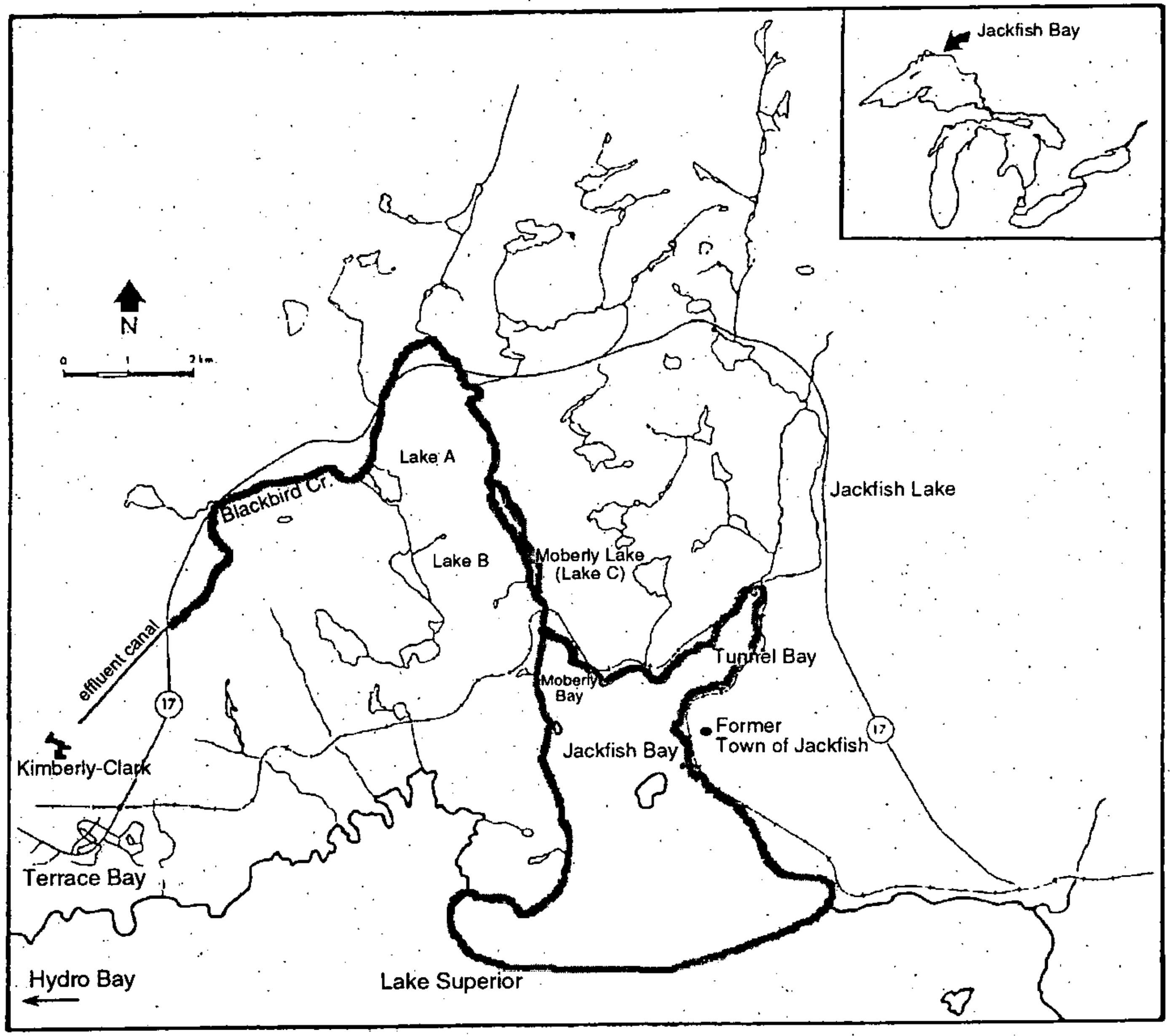

Figure 1: The Jackfish Bay AOC and Vicinity (limit of AOC ▬)

Resource Use: Land

Land use in the vicinity of Jackfish Bay is limited, for the most part, to the pulp mill and the community of Terrace Bay. Several mining companies have operated inland within the Jackfish Bay watershed, but have had no documented impact on the AOC. The Township of Terrace Bay was established in the late 1940s in response to the developing pulp and paper industry. The Kimberly-Clark Canada Inc. pulp mill remains the primary industry and source of employment in the area.

The watershed within the AOC consists mostly of second growth forest. There are no commercial, industrial, or agricultural land uses in this area. Development in the AOC consists of the Highway 17 corridor and cottages at the former townsite of Jackfish on the east side of Jackfish Bay (Fig. 1). An Ontario Ministry of Natural Resources landfill, receiving domestic waste produced by area cottagers, is the only such site located within the AOC and poses no environmental concern.

Resource Use: Water

Cottagers in the former town of Jackfish are the only consumers of water within the AOC. The water intake for the Kimberly-Clark mill and the town of Terrace Bay is located in open Lake Superior, approximately 10 km west of Jackfish Bay. Water based recreational activities are limited because of the cold water inherent to Lake Superior, limited access to the AOC, and aesthetic impairment resulting from effluent flow into Jackfish Bay. Water activities are essentially limited to scuba diving on the wreck of the Rappahannock, a freighter which sank in Tunnel Bay in 1911.

Implications For Remedial Action Planning

The most critical issue for the Jackfish Bay AOC is the use of the Blackbird Creek system as a route for effluent disposal from the Kimberly-Clark mill to Lake Superior and the associated effects of this effluent on the biota. Contaminant levels in effluent and receiving waters have decreased since the installation of secondary treatment at the mill (Flood *et al.* 1993); however, historical contamination remains within the sediments of both Moberly Lake and Moberly Bay. Remobilization of these contaminants could significantly impact the recovering ecosystem.

2.2 Biological Features

The Terrace Bay District of Ontario supports a variety of plant and animal life, some of which were documented in the Stage 1 report. Additional information regarding species occurrences is now available for plants (Appendix 1a), nesting birds (Appendix 1b), herpetofauna (Appendix 1c), mammals (Appendix 1d), and fishes (Appendix 1e).

Blackbird Creek may attract wildlife during the spring as the moderating influence of warm creek water tends to accelerate the greening of creekside vegetation. Moose activity appears to be unusually high along Blackbird Creek in the spring. In addition, the number of beaver and muskrat have increased in the Moberly Bay area (J. Kenny, pers. comm.).

Blackbird Creek was known as a brook trout (*Salvelinus fontinalis*) stream prior to the start up of the mill in 1948. Secondary treatment at Kimberly-Clark (1989) has improved effluent quality to the point that fish have returned to this portion of the AOC (Beak 1996). Recent surveys indicated the presence of brook trout and fathead minnows (*Pimephales promelas*) in the Blackbird Creek system and suitable spawning, nursery, and foraging habitat for many fish species (Beak 1996).

Historically, lake trout (*Salvelinus namaycush*) and lake whitefish (*Coregonus clupeaformis*) were present in numbers high enough to support a small commercial fishery in Jackfish Bay (Jackfish Bay RAP Team 1991). A combination of overfishing, sea lamprey (*Petromyzon marinus*) parasitism, and the introduction of pollutants has contributed to the decline of Lake Superior fish stocks. The current lake trout fishery is predominantly offshore, as nearshore communities have not recovered to substantial levels (Jackfish Bay RAP Team 1991). Significant spawning and nursery habitat has been located on the eastern shore of Jackfish Bay, an area relatively unaffected by the effluent plume (J. Murphy, pers. comm.). This may prove important in the eventual re-establishment of resident lake trout populations in the Jackfish Bay AOC.

Implications For Remedial Action Planning

To rehabilitate the fisheries within the Jackfish Bay AOC, habitat concerns must be addressed. The quality of spawning habitat must be maintained in order to provide the means for lake trout and lake whitefish populations to re-establish themselves in Jackfish Bay. Recent records of fathead minnows and *Daphnia* spp. in Blackbird Creek (Beak 1996) suggest that the creek is already beginning to return to a hospitable state similar to its condition prior to mill start up. Continued effluent monitoring will ensure that present water quality standards are achieved and that environmental conditions improve. In this manner, the ecological decline observed in the Jackfish Bay AOC can be reversed.

2.3 Socioeconomic Profile

A comprehensive approach to the remedial action process must include a fundamental awareness of the connection between land and water, and economic, social, and environmental factors. It is to the advantage of the RAP program and the people who stand to gain from the restoration of beneficial uses, that precisely who is affected and to what extent, is defined. This approach will allow for an informed review of available options that strive to be both realistic and sustainable in the long term.

Terrace Bay has a population of 2477 with approximately 700 residents employed at the Kimberly-Clark pulp mill. The mill employs another 400 people in its woodlands operations. Kimberly-Clark has remained a steady employer for several years and the outlook for the future is positive (Karl 1992).

Further growth is expected to occur in the tourism sector, especially as a result of winter activities such as ice climbing and downhill skiing (M. Moore, pers. comm.). However, Terrace Bay is not expected to undergo any significant changes in population in the future.

Health Effects

Part of the overall health of the ecosystem is the well-being of the residents in the Jackfish Bay AOC. The Great Lakes Health Effects Program (GLHEP) has been researching links between human health and the environment with the aim of integrating issues relative to human health into all area RAPs. The program is committed to long-term monitoring and resolution of health-related issues in the Great Lakes basin. To this end, the GLHEP has been developing tools to assist RAP teams and health professionals, collecting data for assessing human exposure, working on education programs, and addressing community concerns in all AOCs. The GLHEP is in the process of compiling databases on the incidence of environmentally related cancers, diseases, and birth defects in each AOC and comparing the results to the Ontario average. According to the *Cancer Incidences, Hospital Morbidity,* and *Birth Defects* atlases for Ontario (1992 and 1993), the incidence of disease in the Terrace Bay district is not significantly different from other north shore communities.

In the Jackfish Bay AOC, no adverse effects on human health have been directly associated with the presence of the Kimberly-Clark pulp mill (T. Pacifico, pers. comm.). Similarly, the 1995-1996 annual report of the *Effects on Aboriginals from the Great Lakes Environment* (EAGLE Project) does not indicate any health effects associated with Jackfish Bay (AFN/Health Canada 1996).

2.4 Sources of Pollution

Contaminants in the Jackfish Bay AOC come from a single point source and a number of non-point sources. The Kimberly-Clark bleached kraft pulp mill in Terrace Bay discharges effluent containing contaminants via the Blackbird Creek system into the Jackfish Bay area of Lake Superior. Historically, effluent introduced into Blackbird Creek resulted in a high organic and contaminant load throughout the AOC. Secondary treatment (1989) and increased chlorine dioxide substitution in the bleaching process have improved effluent quality and enabled the Kimberly-Clark mill to reduce BOD by 92%, suspended solids by 31%, and chlorinated organics by 40% (Table 1) (Karl 1992). The effluent presently has significantly reduced effects and is non-acutely toxic (Flood *et al.* 1993). There are no other industrial or municipal dischargers to the AOC.

Non-point sources of pollution to the AOC include atmospheric deposition, spills, and contaminants mobilized from sediments within Lake C and Moberly Bay. Bottom sediments in this area remain contaminated particularly with dioxins, furans, and organic material (Jackfish Bay RAP Team 1991). Other potential sources of contamination, corresponding to runoff from agricultural operations, groundwater leaching, and shipping, are not an issue in the Jackfish Bay AOC.

Table 1. Kimberly-Clark kraft pulp mill effluent flow, production, and loadings of total suspended solids (TSS), chlorinated organics (AOX), and biochemical oxygen demand (BOD) to Blackbird Creek, 1987-1996.

	1987	1990+	1991+	1992**	1994*	1995*	1996#
Flow Rate ($10^3 m^3$/day)	115	91.7	95.1	NA	103	107	103.7
Production (ADMT/day)	NA	1105	1110	NA	1167	1183	1239
BOD (kg/day)	24830	1450	1408	1920	2380	2730	3100
TSS (kg/day)	5570	3873	4279	4190	4290	4980	5469
AOX (kg/t)	NA	2.10	1.90	1.70	1.10#	1.18#	1.14

*1994 and 1995 values obtained from Beak (1996)
+1990 and 1991 values obtained from MISA report (MOEE, 1993)
**MOEE discharge data
#Kimberly-Clark (Terrace Bay) discharge data. Values based on monthly averages.
NA - information not available

Section 3.0 - JACKFISH BAY IMPAIRMENTS AND GOALS

3.0 JACKFISH BAY AOC: IMPAIRMENTS AND GOALS

The Jackfish Bay Remedial Action Plan was developed to identify use impairments, define specific goals for the region, and describe appropriate remedial and regulatory measures to rehabilitate the AOC. Incorporating the needs identified by the Public Advisory Committee Water Use Goals will ensure that the plan responds to community needs and enjoys a high level of public support for implementation.

3.1 Jackfish Bay Impairments

Of the 14 "Impairments of Beneficial Use" defined by the GLWQA (IJC 1989), eight have been identified as being impaired or requiring further assessment within the Jackfish Bay AOC. The Options Discussion Paper (Jackfish Bay RAP Team 1995) provided a review of the use impairments and their present status in the AOC. The following section summarizes this material and highlights recent and additional information.

CURRENT STATUS OF JACKFISH BAY IMPAIRMENTS

1. Restrictions on fish consumption

Some consumption advisories remain in effect

Consumption of lake trout greater than 45 cm is restricted because of tissue concentrations of toxaphene above the guidelines (MOEE 1997). No point source of toxaphene exists within either the AOC or on the Canadian side of Lake Superior. Restrictions on the basis of levels of this contaminant are a reflection of more stringent guidelines on fish consumption by Health Canada as opposed to recent increases in tissue contaminant concentrations. This advisory is similar for lake trout sampled in other areas of Lake Superior.

Dioxin levels in lake whitefish greater than 55 cm appear to have increased since the 1992 sampling program (MOEE 1995) with consumption restricted to one meal per month for this size category (MOEE 1997). Consumption of whitefish greater than 45 cm remains at four meals per month.

2. Degradation of fish and wildlife populations

a) dynamics of fish populations

Dynamics of fish populations remain impaired.

Lake trout populations in Jackfish Bay have declined since the mid 1950s for a number of reasons, including overharvesting, degraded water quality, and the accidental introduction of sea lamprey and other exotic fish species. With the initiation of control measures in the 1960s, lamprey populations have been more effectively reduced in Lake Superior. Since that time, lake trout populations have been increasing; however, they have not returned to previous levels.

Blackbird Creek fish populations, which included resident brook trout, were eliminated as a result of the pulp mill effluent. Brook trout and fathead minnows have, however, been captured within the Blackbird Creek system as of 1995 (Beak 1996). This may suggest a resurgence of the fish community in this portion of the watershed. Moberly Bay fish populations remain reduced in the vicinity of Blackbird Creek.

b) body burdens of fish

Body burdens of fish remain an impairment within the AOC.

Lake trout tissues contain low concentrations of mercury, hexachlorobenzene, and several chlorinated pesticides. PCBs in lake trout collected in 1989, 1990, and 1992 exceeded the GLWQA Specific Objective for the protection of piscivorous wildlife. Atmospheric inputs are believed to contribute to PCB loadings in the AOC (Jackfish Bay RAP Team 1991).

Improvements in mill processes, including secondary treatment of effluent (1989), increased chlorine dioxide subsuitution (1993), and the removal of a creosote treated sewer pipe (1994) suspected of releasing dioxins and furans to the environment, have enhanced water quality conditions in the AOC. However, the recent increase in consumption restrictions for dioxins in lake whitefish (MOEE 1997) suggests that further improvements may be warranted.

c) dynamics of wildlife populations

Dynamics of wildlife populations requires further assessment.

A study of herring gulls (*Larus argentatus*) by the Canadian Wildlife Service (CWS) indicated a continual decline in the number of nesting birds in the Jackfish Bay AOC between 1992 and 1996, with no nesting pairs located in 1997 (L. Shutt, pers. comm.). Reproductive failure does not appear to be the result of exposure of eggs or adults to dioxins or halogenated aromatic hydrocarbons (Shutt 1994). The study also found a lower condition factor for birds nesting in Jackfish Bay compared to other sites on the Great Lakes. Shutt (1994) concluded that changes in diet from fish and insects to refuse is likely the cause of this impairment. To date, there have been no studies to indicate the possible impact of contaminants on wildlife populations in the AOC. Further assessment of this use impairment is warranted. CWS will monitor the area in 1998 for nesting gulls as part of a survey of eastern Lake Superior.

d) body burdens of wildlife

This category requires further assessment.

The Stage 1 report noted that the potential bioaccumulation of contaminants by wildlife in portions of Jackfish Bay and the Blackbird Creek system required further assessment. To this end, the CWS monitored contaminant levels in herring gulls exposed to the Kimberly-Clark mill effluent. Shutt (1994) found that herring gulls eggs collected from the Jackfish Bay AOC had relatively low levels of dioxins, similar to background levels found elsewhere on Lake Superior. Levels of other organochlorines were also low (Shutt 1994). Further testing indicated that herring gull eggs were not significantly contaminated with toxins normally associated with pulp mill effluent (Shutt 1994). However, the levels of contaminants measured in gulls sampled from the AOC probably do not represent those of piscivorous birds, but more likely reflect garbage eating gulls. It is reasonable to assume that if herring gulls were consuming fish with elevated levels of toxins then they too would have accumulated significant body burdens of these compounds (L. Shutt, pers. comm.). For this reason, further assessment of this use impairment is required.

3. Fish tumours and other deformities

Fish tumours and other deformities remain an impairment within the AOC.

External fish tumours have not been reported in the AOC; however, white suckers collected from Jackfish Bay prior to the implementation of secondary effluent treatment had an increased incidence of liver cancer (4-6%) (Smith *et al.* 1991). Although the frequency of occurrence is greater in the AOC than in reference fish from Lake Superior (2-3%), it is still considered to be very low (K. Munkittrick, pers. comm.).

Liver enzyme activity remains elevated in white suckers exposed to the effluent plume near the mouth of Blackbird Creek (van den Heuvel *et al.* 1995). Increased liver size in lake whitefish (Munkittrick *et al.* 1992) and white suckers (Beak 1996) has also been reported in the AOC.

4. Bird and animal deformities or reproductive problems

This category requires further assessment.

Bird and animal deformities have not been reported in the AOC. Reproductive impairment of herring gulls in Jackfish Bay over two breeding seasons was comparable to non-contaminated sites on Lake Superior (Shutt 1994). Productivity, however, has declined with small egg size, low survival rate for chicks, and no nesting gulls recorded in 1997 (see Dynamics of Wildlife Populations). Changes in the traditional diet of the gulls was likely the cause of this impairment (Shutt 1994). Nevertheless, further assessment of reproductive problems is warranted.

5. Degradation of benthos

a) dynamics of benthic populations

Dynamics of benthic populations remain impaired.

Benthic communities in Moberly, Tunnel, and Jackfish Bays were severely impacted as a result of mill effluent. Impairment increased from 1969 to 1987 during which time pollution intolerant species declined and pollution tolerant species increased. However, following the installation of secondary treatment at Kimberly-Clark in 1989 both the density and diversity of benthic organisms has improved (Beak 1991a). Observations indicate that sediments are recovering, though at different rates throughout the AOC.

Sediments contained within Moberly Lake remain acutely toxic to benthic fauna and any resuspension of these materials would likely have severe impacts on downstream benthic communities (Beak 1991a). Reductions in benthic diversity are probably the result of high total organic carbon (TOC) levels and oily mud within the lake. Sampling stations in Moberly Bay and near St. Patrick Island indicate that sediment at these sites also remains toxic to invertebrates, though it is likely the result of historical pollution (Beak 1996).

A 1995 benthic survey in the Blackbird Creek drainage basin indicated a variety of *Daphnia* spp. in Blackbird Creek, Moberly Lake, and within the secondary treatment system (Beak 1996). In addition, invertebrates classed as moderately tolerant to pulp and paper mill wastes, including stonefly (Plecoptera) and caddisfly (Tricoptera) larvae, were found near the outfall of the secondary treatment system. These changes in the composition of the invertebrate community indicate further improvement and a possible trend towards healthier benthic communities (Beak 1996).

b) body burdens of benthic organisms

Body burdens of benthic organisms remain impaired.

Mussels (*Elliptio complanata*) caged in Moberly Bay for 21 days in 1993 showed dioxin and furan body burdens indicating mill effluent to be the major source (Hayton and Hollinger 1993). Similarly, resident populations of opossum shrimp (*Mysis relicta*) had body burdens of dioxins and furans in concentrations approximating those contained in mill effluent (Sherman *et al.* 1990).

6. Restrictions on dredging activities

It is recommended that the status of this impairment be changed to unimpaired.

Sediment surveys (Beak 1991a; Flood *et al.* 1993) in the AOC indicated concentrations of several contaminants exceeding current Provincial Sediment Quality Guidelines for dredging and open water disposal (Hayton *et al.* 1992) (Table 2). However, without the demand for navigational or additional dredging activities, contaminated sediments should be considered in the context of other categories of ecosystem impairment (Krantzberg *et al.* 1996). In this manner, the status of the sediments is already covered within the scope of the RAP and it is reasonable to remove dredging restrictions as an impairment in the AOC. Future dredging activities may be subject to restrictions as required.

Table 2. Present contaminant load of sediments in the Jackfish Bay AOC (Beak 1991a).

Parameter	LEL	SEL	Reference	Moberly Bay	Jackfish Bay	Tunnel Bay
zinc	120	820	29	108	101	89
cadmium	0.6	10		0.9*	1.0*	0.7*
lead	31	250	5	18	26	32*
cobalt	50	+	7	10	12	14
nickel	16	75	15	23*	27*	30*
manganese	460	1100	180	360	393	532*
chromium	26	110	30*	49*	55*	55*
copper	16	110	8	35*	44*	43*
silver	0.5	+		0.7*		
phosphorus	600	2000	417	903*	963*	922*
mercury	0.2	2		0.24*	0.13	0.008
oil and grease	1500	+		15667*		
TKN	550	4800	149	3967*	2300*	1920*
TOC (%)	1	10	0.33	10**	4.1*	3.8*
PAH (total)	2	11000		3.92*	1.48	1.04

All units are expressed as µg/g (ppm). Blank cells indicate levels below detection limits.
+ no established guideline.
* exceeds MOEE sediment quality guidelines (1993) lowest effect level (LEL).
**exceeds MOEE sediment quality guidelines (1993) severe effect level (SEL).

7. Degradation of aesthetics

Aesthetic values remain impaired.

Nuisance fog, ice, and aesthetic problems have improved since the early 1970s with the re-routing of Blackbird Creek away from Highway 17 (Karl 1992). However, the presence of foam and dark coloured water in Blackbird Creek and Moberly Bay is still a concern. Mill effluent remains on top of the water column for an extended time because of a temperature difference between the effluent and the water surface. As a result, the dark coloured effluent plume and foam create an aesthetics problem in the AOC. To date, a fabric barrier has been constructed to retain some foam at the mouth of Blackbird Creek (R. Ferguson, pers. comm.).

8. Loss of fish and wildlife habitat

Fish and wildlife habitat remains impaired.

Major lake trout spawning habitat in Moberly Bay has been destroyed through the deposition of organic materials and chemical contamination of sediments. However, in 1995, lake whitefish and lake trout spawning and nursery habitat was identified along the eastern shore of Jackfish Bay and appeared to be unaffected (J. Murphy, pers. comm.). Lake trout spawning habitat is not a limiting factor in Lake Superior.

The Blackbird Creek watershed was comprised of functional brook trout habitat prior to the start up of the mill in 1948. Habitat mapping indicates a variety of sites which provide spawning, nursery, and forage habitat for fish within the Blackbird Creek system (Beak 1996). However, water quality in the creek and Moberly Lake is such that re-establishment of a viable brook trout population is unlikely (J. Murphy, pers. comm.).

3.2 Jackfish Bay PAC Water Use Goals

The Public Advisory Committee (PAC) established short and long term water use goals designed to restore and protect the beneficial uses of the Jackfish Bay AOC. Specific goals were developed through a series of public meetings involving representatives of various civic groups and the Federal-Provincial Remedial Action Plan (RAP) team.

SHORT TERM WATER USE GOAL

Discharge of toxins, particularly chlorinated organic compounds, from point sources must be reduced to meet or exceed Federal and Provincial guidelines.

LONG TERM WATER USE GOALS

Safe Drinking Water

1. Jackfish Town cottagers should be able to drink the water from Jackfish Bay following standard treatment methods. Water entering the Jackfish Bay area of Lake Superior from the Blackbird Creek system must be safe for consumption.

Fisheries

2. Fish habitat and spawning areas in Blackbird Creek and Jackfish Bay must be rehabilitated to a healthy and hospitable state.

3. The Blackbird Creek and Jackfish Bay fisheries must be part of a balanced and healthy aquatic community.

4. All fish caught in Blackbird Creek and Jackfish Bay must be safe for consumption at any size or quantity. Contaminant levels must be less than or equal to background levels.

Recreational Uses

5. The water in Jackfish Bay must be clean and odourless for swimming, boating and scuba diving. Blackbird Creek and Jackfish Bay must be returned to natural conditions that are able support both trapping and hunting. The aesthetics of Blackbird Creek and Jackfish Bay should be improved to encourage tourism and educational trips.

Wastewater Receiver

6. Blackbird Creek and Jackfish Bay can continue to be used for mill effluent discharge provided

that it does not impair beneficial uses, inhibit indigenous biota, or produce other adverse impacts on the ecosystem. Ideally, a closed-loop system at the mill would eliminate the need for Blackbird Creek to be used for effluent disposal.

Delisting

7. Water quality conditions should be improved to the point that Jackfish Bay is no longer an Area of Concern as defined by the Great Lakes Water Quality Agreement.

A combination of the use impairments and related water use goals allows for the identification of specific areas that require remediation in order to rehabilitate the Jackfish Bay AOC. This information provides a simplified view of GLWQA beneficial use impairments, their status within the AOC, and future goals for rehabilitation (Table 3).

Table 3. GLWQA beneficial use impairments, PAC water use goals, and current status of degraded areas in the Jackfish Bay AOC.

Use Impairment	Water Use Goal	Problem Area and Status
• Restrictions on fish consumption • Degradation of fish and wildlife populations -dynamics of fish and wildlife populations -body burdens of fish and wildlife • Loss of fish and wildlife habitat • Fish tumours and other deformities • Bird/animal deformities and reproductive problems	• All fish caught in Blackbird Creek and Jackfish Bay must be safe to consume at any size and in any number. Fish contaminant levels must less than or equal to background levels for consumption. • Fish habitat and spawning areas in Blackbird Creek and Jackfish Bay must return to a state conducive to healthy fish populations. • The Blackbird Creek/ Jackfish Bay fishery must form part of a balanced and healthy aquatic community. • Water quality should be improved to the point that Jackfish Bay is no longer an Area of Concern.	• Fish consumption in the Jackfish Bay AOC is restricted due to a variety of chemicals, including dioxins and furans, attributed to mill effluent. • Fish populations have been adversely affected by loss of habitat attributed to sediment contamination, overfishing, and sea lamprey. Fish communities appear to be rebounding throughout the AOC. Fish spawning and nursery habitat in Jackfish Bay is healthy and can support populations of lake whitefish and lake trout. Habitat within Blackbird Creek remains impaired. • Reproductive failure and contaminant levels in herring gulls were not attributed to pulp mill effluent. Changes in diet from fish and insects to refuse is likely the cause of this impairment. Further assessment is warranted.
• Degradation of benthos dynamics of benthic populations -body burdens of benthic organisms	• Blackbird Creek can continue to convey mill effluent provided that it does not impair beneficial uses, inhibit indigenous biota, or produce other adverse effects on the ecosystem. • Discharge of toxins from point sources must be reduced to meet or exceed Federal and Provincial guidelines.	• Benthic habitat and population dynamics were severely impacted in Moberly, Tunnel, and Jackfish Bays; however, benthic communities have rebounded since the installation of secondary effluent treatment in 1989.
• Restriction on dredging activities • Degradation of aesthetics	• Fish habitat and spawning grounds must return to a healthy condition. • Aesthetic values within the Jackfish Bay AOC must be improved to encourage its use for recreation and to improve its tourism value. • Remove Jackfish Bay as an Area of Concern • Maintain present water uses in the AOC.	• Contaminants remain in the sediments of Jackfish, Tunnel, and Moberly Bay. These sediments are at a great depth and are being covered by cleaner material. No dredging is planned for the AOC. Aesthetic values remain degraded as a result of the discharge of mill effluent.

Section 4.0 - REMEDIAL STRATEGIES FOR ECOSYSTEM RESTORATION

4.0 REMEDIAL STRATEGIES FOR ECOSYSTEM RESTORATION

An Options Discussion Paper (1995) was produced by members of the Jackfish Bay RAP team and Public Advisory Committee to address each of the impaired water uses described in the Stage 1 report. The document provided available solutions to alleviate environmental impacts and to hasten rehabilitation of the AOC. Solutions were evaluated according to perceived benefits, disadvantages, and costs associated with implementation. Preferred solutions were deemed to be most beneficial to ecosystem rehabilitation with the fewest negative effects.

THE ROLE OF THE LAKE SUPERIOR PROGRAMS OFFICE

The North Shore of Lake Superior RAP Program is an integral component of the Lake Superior Programs Office (LSPO). The LSPO was formed in 1991 by Environment Canada, the Department of Fisheries and Oceans, the Ontario Ministry of Environment and Energy, and the Ontario Ministry of Natural Resources. The office provides a unique one-window approach to delivering projects recommended by Public Advisory Committees for the Remedial Action Plans in Thunder Bay, Nipigon Bay, Peninsula Harbour, and Jackfish Bay. This ongoing responsibility has expanded to include two additional RAPs (St. Mary's River and Spanish Harbour) and the coordination of a range of programs, including the Binational Program to Restore and Protect the Lake Superior Basin, the Great Lakes 2000 Clean Up Fund, and Lakewide Management Plans. The LSPO provides a critical link between the public, industry, and government agencies on issues concerning the Lake Superior ecosystem. In 1994, the Institute of Public Administration of Canada recognized the LSPO with a finalist award for the year's theme of "Reshaping Government". The office's four-agency partnership (MOEE, Environment Canada, MNR, and DFO) was viewed as an innovative approach to the administration of government programs. Strong public involvement and funding from a variety of partners has resulted in positive actions directed at cleaning up contaminated sediments, restoring native fish populations, rehabilitating fish and wildlife habitat, and increasing environmental awareness in North Shore communities.

As a result, the LSPO has the lead role in developing appropriate remedial strategies in Stage 2, as well as providing support in efforts to monitor ecosystem recovery. In this respect, the office is the lead organization in the implementation and monitoring of the entire RAP process. Their participation is essential to the success of the plan. Lake Superior Programs will thus assist various other proponents, such as the public, industry, and government agencies, in the execution of the RAP.

4.1 Specific Remedial Strategies

For clarity, the Jackfish Bay AOC has been divided into three distinct areas where remedial actions could potentially be directed: Blackbird Creek and Lake A; Moberly Lake (Lake C); and Moberly, Tunnel, and Jackfish Bays. This distinction is artificial, as the three divisions are based on geographical, rather than biological separation. Therefore, remedial actions enacted in any one region could potentially affect other areas in a variety of ways.

Section 1 - Blackbird Creek and Lake A

Recommended Action: Monitor for Incremental Progress; No Further Intervention at this Time

Lake A was effectively removed from the Blackbird Creek system in 1972 as a result of extensive accumulation of organic material. Further construction of a barrier in the 1980s stopped all flow of effluent into the lake, although a breach did occur during a flood event in 1993. Following the cessation of effluent flow, recovery has occurred within a fairly short time span (~10 years) and at a minimal cost (J. Murphy, pers. comm.). Over time, Lake A has become established as a productive wetland with the colonization of 13 species of aquatic macrophytes (Coote 1996). Revegetation of the area works to stabilize the sediments (Coote 1996) and further contain contaminants. Field studies of the vegetation in Lake A have indicated that the uptake of contaminants by local flora is limited (Coote 1996).

Aesthetic rehabilitation of the Lake A basin has already taken place; historic debris and a barge associated with dredging operations were removed from the shoreline in 1995.

The Jackfish Bay RAP Team concluded that the most reasonable option for Lake A would be to allow the natural recovery process to continue and to monitor for incremental gains in environmental improvement. No further intervention is warranted at this time as process effluent no longer flows into Lake A. With the stabilization of sediments by the expanding aquatic plant community, isolation from the creek system, and covering with clean material (J. Murphy, pers. comm.), the resuspension of contaminated sediments is less likely to occur. Any further action at this site would have limited benefits and result in the disturbance and mobilization of isolated contaminants.

At the present time, Blackbird Creek requires no remedial action. Sedimentation of contaminated material is minimal because of the relatively high effluent flow rates through the creek (Beak 1991b). Blackbird Creek supports a variety of invertebrate species as well as fathead minnows (Beak 1996), suggesting that the health of the aquatic community is improving. Based on the present state of the aquatic biota, any remedial actions undertaken in Blackbird Creek would have negligible beneficial results.

Section 2 - Moberly Lake (Lake C)

Recommended Action: Monitor for Incremental Progress; No Further Intervention at this Time

Relocating the effluent stream, either by pipeline to a second location, or through or around Moberly Lake, was considered an option that would prevent further contaminant burden on the lake and would ultimately accelerate recovery (Dominion Soil Thunder Bay Ltd. 1994). However, this option would not completely prevent contaminants from being flushed into Jackfish Bay; natural water flows would continue and as a result, the contaminated sediments would remain susceptible to scouring and resuspension (Jackfish Bay RAP Team 1995). Prohibitive costs and the potential for creating a second contaminated zone outside of the AOC were also identified as major drawbacks of this plan.

Sediment stabilization or isolation was also examined as a potential solution to contaminated sediments in Moberly Lake (Dominion Soil Thunder Bay Ltd. 1994). Several options were presented; however, the idea was rejected because of extremely high capital costs and the uncertainty that the methods suggested would provide assurance against the possibility of future resuspension of contaminants. On the other hand, dredging sediments from Moberly Lake could eliminate future problems associated with sediment contamination. However, this option would also be rather costly and would result in the disturbance and resuspension of contaminated materials.

Natural recovery of Moberly Lake seems a viable option for rehabilitation based on the continuing resurgence of plant and animal communities in the Blackbird Creek system and with no further increase in anthropogenic influence. Mechanical disturbance, resuspension of contaminants, and repercussions associated with relocating the effluent stream can thus be avoided and the associated costs of rehabilitation can be minimized. However, the potential for historic contaminants to be continuously mobilized, albeit at low levels, via scouring of sediments in Moberly Lake remains a concern for this portion of the AOC. Assuming that the Kimberly-Clark mill maintains or improves upon the quality of effluent, it is possible that the contaminated sediments will eventually be covered with clean material conveyed by Blackbird Creek. Separation from the water column should serve to isolate contaminants and minimize the resuspension of contaminated materials.

The Jackfish Bay RAP Team agreed that this area should be monitored for incremental progress towards recovery on the basis of its limited cost and the success illustrated by the present condition of Lake A. It has already been demonstrated that, following the cessation of effluent inputs, Lake A is recovering without any outside influence (Coote 1996). With significant improvements in effluent quality, the possibility exists that a similar recovery pattern can occur in Moberly Lake. Marginal recovery in benthic communities in the Blackbird Creek system was noted shortly after the installation of secondary treatment at the mill (Beak 1991a). Since that time, species diversity and population density have continued to improve (Beak 1996). Similarly, fish communities appear to be returning to Moberly Lake, including fathead minnows (Beak 1996). It is also possible that the time frame for ecosystem recovery (~30 - 60 years) (Beak 1991b) may be accelerated as available technology continues to improve effluent treatment or removes effluent load from the creek system altogether.

Section 3 - Moberly, Tunnel, and Jackfish Bays

Recommended Action: Monitor for Incremental Progress; No Further Intervention at this Time

The Options Discussion paper for the Jackfish Bay AOC identified a variety of methods with the potential to rehabilitate Moberly, Tunnel, and Jackfish Bays. Sediments within each bay are contaminated with a number of materials, including metals, organics, phosphorus, and nitrogen. Depositional zones of contaminants are located in areas that are extremely difficult to access, making mechanical remediation problematic and expensive (Beak 1991b). Economics and available technology proved to be limiting factors for most of the potential strategies, including reductions in waste discharge, dredging, and the application of a sediment barrier to contain contaminants. Although zero discharge of mill effluent is the ultimate goal for elimination of persistent toxic substances into the Jackfish Bay AOC, available technology is limited and expensive.

In Moberly, Tunnel, and Jackfish Bays, benthic invertebrates decreased dramatically in both range and diversity between 1969 and 1987, coincident with increases in populations of pollution tolerant oligochaetes. Improvements in effluent treatment reversed this trend and, by 1991, changes in invertebrate populations suggested that some sediment recovery had occurred (Beak 1991a). A recent survey (Beak 1996) indicates that benthic macroinvertebrate communities in both near field depositional areas of Moberly Bay and far field areas near St. Patrick Island in Jackfish Bay remain adversely affected, though benthic communities at the mouth of Blackbird Creek appear to be increasing in both density and species diversity. Impairment is considered to be the result of historic deposition of pulp mill wastes within the respective zones (Beak 1996). Improvements in mill processes, however, appear to be having a positive effect on the aquatic community in the AOC. As a result, effluent released from the mill exerts significantly reduced lethal and sublethal effects on both fish and invertebrates (Beak 1991a, 1996). In addition, healthy nearshore spawning and nursery areas have been identified in Jackfish Bay that are deemed to be both suitable and extensive enough to support lake trout populations. Over time, deposition of cleaner sediments will likely result in the stabilization of contaminants and the physical isolation of polluted materials from the water column.

Natural rehabilitation appears to be the most promising option for these areas. This option is also the most cost effective, since it eliminates any need for construction or long term maintenance costs. With the installation of secondary treatment at the Kimberly-Clark mill, the trend has been towards healthier sediments and aquatic communities. Although natural rehabilitation involves leaving contaminants in place, clean sediment will likely continue to cover the contaminated areas, effectively isolating them from the water column and food web. As well, natural degradation of contaminants contained deep within the sediment layer will occur over time.

4.2 Education and Stewardship

The involvement of the public and their commitment to both rehabilitation and continued vigilance of the ecosystem are important to the success of the Jackfish Bay RAP. The PAC plays a leading role in this process, making the public aware of progress made towards the final goal of a healthy, balanced ecosystem and the ways in which this can be accomplished. Ultimately, public involvement will ensure that the remedial action plan responds to community needs and enjoys a high level of community support for implementation.

The Lake Superior Community Education Project was developed to provide educational opportunities for local school districts on the restoration and protection of the Lake Superior watershed. St. Martin's School in Terrace Bay has participated in environmental education programs that focus on environmental issues relevant to the Lake Superior basin including remedial action plans for neighbouring areas of concern. It is hoped that this education project will expand to include other schools in the Terrace Bay district and will create opportunities for local organizations to contribute to environmental education in their communities.

Recent activities of the EAGLE project have centred around education and awareness programs among the Lake Superior First Nation communities (AFN/Health Can. 1996). The project has developed consumption guidelines for communities participating in eating pattern surveys. These guidelines are tailored to the individual consumer in order to encourage healthy consumption habits. Together with the MOEE recommendations, consumption guidelines are intended to prevent or minimize human exposure to contaminants until this use impairment can be removed. At present, this information is only available to participating communities; however, in the long run, it may provide information on the possible impacts of environmental issues outside the AOC.

4.3 Future Concerns

Ideally, a discussion of remedial options should outline stakeholder commitments and include an implementation schedule to ensure the restoration of impaired beneficial uses. The natural recovery strategy for the Jackfish Bay AOC makes it difficult to meet this requirement of the remedial action process. The success of natural remediation is dependent on the support and commitment of the PAC, in addition to government agencies, industry, and the surrounding community. For all area RAPs, the PAC provides a basis for broad community involvement in the review and implementation process. The ultimate goal of public participation is to ensure that the remedial action plan meets community standards for restoration and protection of the Jackfish Bay ecosystem.

Restoring the Jackfish Bay AOC would be irrational without a corresponding long-term plan to prevent future deterioration. Contamination problems could resurface from economic, urban, or industrial growth and development within both the AOC and the surrounding area. Paramount to the remedial action process is a commitment to pollution prevention strategies to prevent the need for future remedial actions.

The Kimberly-Clark mill at Terrace Bay was recognized as an example of the best available technology based on exemplary secondary treatment of effluent, changes in the bleaching process, and other mill improvements (MOEE 1993). It is expected that continued improvements in sediment quality and health of the aquatic community will eventually result in the delisting of the Jackfish Bay AOC. The Jackfish Bay PAC has suggested that the mill operate with a closed process system thus eliminating the discharge of persistent toxic substances into Blackbird Creek. A closed loop system represents a significant technical advance towards recycling process waters and enhanced chemical recovery and reuse (Price 1992). Undoubtedly, a closed loop system would accelerate natural recovery of the AOC; however, until such time that funding becomes available to convert Kimberly-Clark to a closed mill, continued compliance with federal and provincial regulations, including increased chlorine dioxide substitution, will contribute to improving the water quality of the area.

Monitoring Program

Allowing the natural recovery process to continue while monitoring for incremental gains in environmental quality is thought to be an appropriate solution to the problems and conditions within the Jackfish Bay AOC. Essential to remedial action planning is recognizing the dynamic nature of the staged process, acknowledging any deficiencies that may arise, and a willingness to act responsibly to modify remedial strategies when required. To this end, a monitoring program for the Jackfish Bay AOC should include, but is by no means limited to, the following:

- *Surface Water Surveillance Program*

The MOEE's surface water surveillance program will continue to monitor the sediment and benthos of the Jackfish Bay AOC at least once every ten years as part of their regular program, and at the specific request of the Region.

- *Environmental Effects Monitoring* (EEM)

The EEM program for the pulp and paper industry provides an objective basis for demonstrating the effectiveness of mitigative measures and helps to identify areas where improvements in mill processes are warranted (Environment Canada 1988). Fish, benthos, and sediment and water quality conditions are monitored through this federal program. An EEM survey is conducted every four years with the effluent characterization component completed on an annual basis.

- *Sport Fish Contaminant Monitoring*

The MOEE's long-term sensing program will continue to monitor contaminant levels in sport fish, at a minimum of every five years, until consumption advisories can be removed. The MNR and MOEE will continue to review program requirements and assess the need for additional collections on an annual basis. Contaminant monitoring provides a means to test the effectiveness of pollution control activities both within the AOC and the surrounding area.

- *Superior Lakewatch Monitoring Program*

Superior Lakewatch is a citizen-based monitoring program that uses secchi discs to document water transparency in nearshore areas of Lake Superior. Secchi disc monitoring has produced statistically valid information which can be used to document current water quality conditions and evaluate trends in water quality over time. This community based monitoring program has been supported by volunteer efforts in the Jackfish Bay area since 1991.

REFERENCES

Assembly of First Nations/Health Canada. 1996. Effects on Aboriginals from the Great Lakes Environment (EAGLE) Project Annual Report 1995-1996. Produced by The Assembly of First Nations, Ottawa, Ontario. 44 pp.

Beak Consultants. 1991a. Environmental Impact Assessment of Kimberly-Clark Effluent on the Aquatic Environment, Jackfish Bay, Lake Superior - 1991. A report for Kimberly-Clark of Canada Ltd. Terrace Bay, Ontario.

Beak Consultants. 1991b. Toxic Load of the Blackbird Creek System and Alternatives for Rehabilitation. Report prepared for the Ontario Ministry of the Environment.

Beak Consultants. 1996. First-Cycle Environmental Effects Monitoring Study - 1995. Draft report prepared for Kimberly-Clark Forest Products Inc. Terrace Bay, Ontario.

Coote, M. 1996. The effects of bleached kraft mill effluent on aquatic macrophyte communities in a lake system on the northern shore of Lake Superior. M.Sc. Thesis, Lakehead University.

Dominion Soil Thunder Bay Ltd. 1994. Lake 'C' Alteration Project. Kimberly-Clark Forest Products, Terrace Bay, Ontario. August, 1994.

Environment Canada. 1988. Effects Monitoring, National Operations Guidelines. Environmental Impact Systems Division, Ottawa.

Flood, K., D. Hollinger, L. Baxter, M. Mueller, and C. Logan. 1993. An acute bioassay study of the effluent discharge from the Kimberly Clark pulp mill to Jackfish Bay in July, 1990 after the commissioning of a secondary treatment system. Ontario Ministry of the Environment. 49 pp.

Hayton, A. and D. Hollinger. 1993. Lake C dioxin/dibenzofuran study. Unpublished data.

Hayton, A., D. Persaud, and R. Jaagumagi. 1992. Fill Quality Guidelines for Lakefilling in Ontario. Application of Sediment Quality Guidelines to Lakefilling. Ontario Ministry of the Environment (Water Resources Branch). 9 pp.+ appendices.

International Joint Commission. 1989. Great Lakes Water Quality Agreement of 1978 (revised 1987). Consolidated by the International Joint Commission, United States, and Canada, Windsor, Ontario, 84 pp.

International Joint Commission. 1992. Review of the Jackfish Bay Remedial Action Plan. Final Draft. 4 pp.

Jackfish Bay RAP Team. 1991. Jackfish Bay Area of Concern. Environmental Conditions and Problem Definition. Remedial Action Plan Stage 1. Ontario Ministry of Natural Resources. 157 pp. + appendices.

Jackfish Bay RAP Team. 1995. A Discussion of Remedial Options in the Jackfish Bay Area of Concern. Draft. 35 pp.

Karl, W. 1992. The New Terrace Bay. *Pulp and Paper Journal* 45(4): 12-15.

Krantzberg, G. 1996. The Canada Ontario guide to producing and reviewing remedial action plan stage 2 and stage 3 reports. Ontario Ministry of Environment and Energy. 35 pp.

McAllister, D.E., B.J. Parker, and P.M. McKee. 1985. Rare, endangered and extinct fishes in Canada. Syllogeus No. 54. National Museums of Canada.

McMaster, M.E., G.J. Van der Kraak, C.B. Portt, K.R. Munkittrick, P.K. Sibley, I.R. Smith, and D.G. Dixon. 1991. Changes in hepatic mixed function oxidase (MFO) activity, plasma steroid levels and age at maturity of a white sucker (*Catostomus commersoni*) population exposed to bleached kraft pulp mill effluent. *Aquatic Toxicology* 21: 199-218.

Ministry of Environment and Energy / Ministry of Natural Resources. 1995. Guide to eating Ontario sport fish (1995-96). Queen's Printer for Ontario, Toronto, Canada.

Munkittrick, K.R., C.B. Portt, G.J. Van der Kraak, I.R. Smith, and D.A. Rokosh. 1991. Impact of bleached kraft mill effluent on population characteristcs, liver MFO activity, and serum steriod levels of a Lake Superior white sucker (*Catostomus commersoni*) population. *Canadian Journal of Fisheries and Aquatic Sciences* 48: 1371-1380.

Munkittrick, K.R., M.E. McMaster, C.B. Portt, G.J. Van der Kraak, I.R. Smith, and D.G. Dixon. 1992. Changes in maturity, plasma sex steroids, hepatic mixed function oxygenase activity, and the presence of external lesions in lake whitefish (*Coregonus clupeaformis*) exposed to bleached kraft mill effluent. *Canadian Journal of Fisheries and Aquatic Sciences* 49: 1561-1569.

Ontario Ministry of the Environment and Energy (MOEE). 1993. Municipal/Industrial Strategy for Abatement (MISA). Draft Development Document for the Pulp and Paper Sectors Effluent Limits Regulation. Water Resources Branch, 91 pp.

Price, D. 1992. The closed mill concept. *PAPER for the International Pulp and Paper Industry* 217(3): 36-39.

Sherman, R.K., R.E. Clement, and C. Tashiro. 1990. The distribution of polychlorinated dibenzo-p-dioxins and dibenzofurans in Jackfish Bay, Lake Superior, in relation to a kraft pulp mill effluent. *Chemosphere* 20(10-12): 1641-1648.

Shutt, J.L. 1994. Reproductive success of herring gulls near a bleached kraft pulp mill. *In* Dioxin '93. 13th International Symposium on Chlorinated Dioxins and Related Compounds: 211-214.

Smith, I.R., C.B. Portt, and D.A. Rokosh. 1991. The impact of two great lakes bleached kraft mills (BKME) on receiving water mutagenicity and the biochemistry and pathology of wild white suckers inhabiting impacted areas. *Canadian Technical Report of Fisheries and Aquatic Sciences* 1774: 718-719.

Van den Heuvel, M.R., K.R. Munkittrick, G.J. Van der Kraak, M.R. Servos, and D.G. Dixon. 1995. Hepatic 7-ethoxyresorufin-*O*-deethylase activity, plasma steroid hormone concentrations, and liver bioassay-derived 2,3,7,8-TCDD toxic equivalent concentrations in wild white sucker (*Catostomus commersoni*) caged in bleached kraft pulp mill effluent. *Canadian Journal of Fisheries and Aquatic Sciences* 52: 1339-1350.

Van der Kraak, G.J., K.R. Munkittrick, M.E. McMaster, C.B. Portt, and J.P. Chang. 1992. Exposure to bleached kraft pulp mill effluent disrupts the pituitary-gonadal axis of white sucker at multiple sites. *Toxicology and Applied Pharmacology* 115: 224-233.

Personal Communications

Mr. Rodger Ferguson	Environmental Coordinator, Kimberly-Clark Forest Products Inc., Terrace Bay, Ontario.
Mr. Dave Hollinger	Technical Assessment, Northwest Region. Ministry of Environment and Energy, Thunder Bay, Ontario.
Mr. Michael Moore	Toursim/Economic Development Supervisor, Terrace Bay, Ontario.
Dr. Kelly Munkittrick	Research Scientist, Department of Fisheries and Oceans, Burlington, Ontario.
Mr. Jim Murphy	Coordinator, Jackfish Bay RAP, Ministry of Environment and Energy, Thunder Bay, Ontario.
Mr. Tony Pacifico	Thunder Bay District Health Unit, Thunder Bay, Ontario
Mr. Laird Shutt	National Wildlife Research Centre, Canadian Wildlife Service, Ottawa, Ontario.

GLOSSARY

AOC	Area of Concern: An area recognized by the International Joint Commission where water uses are impaired or where objectives of the Great Lakes Water Quality Agreement or local environmental standards are not being achieved.
AOX	Adsorbable organic halides, including chlorinated organics.
Benthic/benthos	Aquatic bottom living organisms.
Chlorinated organics	An organic compound which includes chemically bound chlorine. Thousands exist but only a small proportion of those formed in the kraft mill bleaching process (whenever chlorine is used) have been identified.
COA	Canada-Ontario Agreement Respecting Great Lakes Water Quality: A 1986 agreement whereby the governments of Canada and Ontario recognize their shared responsibility to maintain the aquatic ecosystem of the Great Lakes Basin.
CWS	Canadian Wildlife Service
DFO	Canadian Department of Fisheries and Oceans
Dioxins and Furans	Popular names for two classes of *chlorinated organic compounds*, known as polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). Only a few of the 75 PCDDs and 135 PCDFs are highly toxic. The most toxic dioxin is 2,3,7,8 tetrachloro-dibenzo-p-dioxin (2,3,7,8 TCDD). Dioxins and furans are formed either as by-products during some types of chemical production that involve chlorine at high temperatures or during combustion where a source of chlorine is present, for example, chlorine bleaching of pulp (in kraft process paper mills) and petroleum refining operations. Dioxins can also occur in airborne particulate material from incinerators that burn trash containing chlorinated compounds and in exhaust from diesel engines.
Ecosystem	An integrated and stable association of living and nonliving resources functioning within a defined physical location.
Effluent	Any liquid and associated material discharged from industrial or municipal sewage treatment plants directly or indirectly to any waters.

Exotic species	Species that are not native to an area and have been intentionally introduced or have inadvertently infiltrated the system.
GLHEP	Great Lakes Health Effects Program.
Great Lakes Water Quality Agreement (GLWQA)	A joint agreement between Canada and the United States (1987) which commits both countries to development and implementation of a plan to to restore and maintain desirable uses of the Great Lakes Basin.
Habitat	The environment in which a *population* or individual occurs. The concept of habitat includes not only the place where a species is found, but also the particular characteristics of that place, such as climate or the availability of suitable food and water, which make it especially well-suited to meet the life-cycle needs of that *species*.
IJC	International Joint Commission: A binational organization established in 1909 by the Boundary Waters Treaty. Through the IJC, Canada and the United States co-operatively resolve problems along their common border, including water and air pollution, lake levels, power generation and other issues of mutual concern.
LEL	Lowest Effect Level. Under Provincial Sediment Quality Guidelines, the LEL indicates the level of sediment contamination that can be tolerated by the majority of benthic organisms.
LSPO	Lake Superior Programs Office
MISA	Municipal-Industrial Strategy for Abatement: A program whose principle goal is the clean up of Ontario's waterways. MISA will reduce the amount of toxic contaminants in all industrial and municipal effluents discharged into Ontario's surface waters. The ultimate goal of this program is the virtual elimination of toxic contaminants from all municipal and industrial discharges into the province's waterways.
MNR/OMNR	Ontario Ministry of Natural Resources
MOEE/OMOEE	Ontario Ministry of the Environment and Energy
Non-point source	Source of pollution in which pollutants are discharged over a widespread area or from a number of small inputs rather than from distinct, identifiable sources.

Oligochaeta	An order of segmented terrestrial or aquatic worms (e.g. earthworm).
PAC	Public Advisory Committee. A group of members of industry, the public and organisations with interests in specific AOCs. The PAC serves to provide a link between RAPs and the community.
ppm	parts per million (µg/g)
PCBs	Polychlorinated biphenyls: A class of persistent organic chemicals that bioaccumulate.
Persistent toxic substance	Any toxic substance with a half-life in water of greater than eight weeks.
Phytoplankton	Minute, microscopic aquatic vegetative life.
Plume	A localised area of effluent discharge. Due to temperature differences between effluent and the receiving waters, an effluent discharge will form a surface plume/bottom plume when it is warmer/cooler than the receiving waters.
Point source	A source of pollution that is distinct and identifiable, such as an outfall pipe from an industrial plant.
population	A group of organisms of the same *species* living within a specified region.
RAP	Remedial Action Plan. A plan developed with citizen involvement and aimed at the restoration and protection of water quality within the Great Lakes.
Resuspension	The remixing of sediment particles and pollutants contained therein back into the water by storms, currents, organisms and human activities such as dredging.
Secondary treatment	A stage of wastewater treatment in which microorganisms decompose organic constituents in the *effluent*. In the process, they use oxygen for their metabolism and to oxidise the waste material. Most secondary treatment processes also reduce toxicity. Also removes some of the phosphorus (30%) and nitrate (50%).
Sediments	Fine particulate material deposited on the bottom of a body of water.

SEL	Severe Effect Level. Under Provincial Sediment Quality Guidelines, the SEL indicates the level at which pronounced disturbance of the sediment-dwelling community can be expected. This is the sediment concentration of a compound that would be detrimental to the majority of benthic species.
TCDD	tetrachlorinated dibenzo-p-dioxin (*see* dioxins and furans)
TKN	total kjeldahl nitrogen: A measure of nitrogen present in organic form and as free ammonia. It is often used in interpreting the effectiveness of waste stabilization ponds.
TOC	total organic carbon
Toxic substance	As defined by the GLWQA, any substance that adversely affects the health or well-being of any living organism.

APPENDIX 1

BIOLOGICAL FEATURES OF JACKFISH BAY

APPENDIX 1a. Flora of the Terrace Bay District and the corresponding habitats in which they are commonly found.

Plant		Habitat													
Scientific Name	**Common Name**	1	2	3	4	5	6	7	8	9	10	11	12	13	14
EQUISETACEAE	HORSETAIL FAMILY														
Equisetum arvense	Field Horsetail					x		x	x	x	x	x		x	x
Equisetum fluviatile	Water Horsetail	x	x												
Equisetum hyemale	Common Scouring-Rush													x	x
Equisetum palustre	River Horsetail		x												
Equisetum pratense	Meadow Horsetail							x	x						
Equisetum scirpoides	Dwarf Scouring-Rush								x	x					
Equisetum sylvaticum	Woodland Horsetail			x	x		x	x	x	x	x				x
Equisetum variegatum	Variegated Horsetail		x											x	x
LYCOPODIACEAE	CLUB-MOSS FAMILY														
Lycopodium annotinum	Stiff Club-moss			x	x		x	x	x	x	x				
Lycopodium clavatum	Running Club-moss						x	x	x	x	x				
Lycopodium complanatum	Flatbranch Club-moss									x					
Lycopodium dendroidum	Round-branched Club-moss						x	x	x	x	x	x			
Lycopodium digitatum	Crowfoot Club-moss						x	x							
Lycopodium lucidulum	Shining Club-moss								x	x	x	x			
Lycopodium selago	Mountain Club-moss								x						
OSMUNDACEAE	FLOWERING FERN FAMILY														
Osmunda claytoniana	Interrupted Fern							x							
POLYPODIACEAE	FERN FAMILY														
Athyrium filix-femina	Lady Fern							x	x	x	x				
Botrychium pallidum	Pale Moonwort Fern							x?	x?						
Botrychium virginianum	Rattlesnake Fern							x	x						
Cryptogramma stelleri	Slender Cliff Brake Fern								x?	x?					
Cystopteris bulbifera	Bulblet Fern								x	x			x		
Dryopteris carthusiana	Spinulose Wood-Fern			x				x	x		x				
Dryopteris cristata	Crested Wood-Fern		x	x											
Dryopteris fragrans	Scented Fern												x		
Dryopteris intermedia	Glandular Wood-Fern											x			
Gymnocarpium dryopteris	Oak Fern			x				x	x	x	x	x			
Phegopteris connectilis	Northern Beech Fern								x	x					
Polypodium vulgare	Rock Polypody								x	x		x	x		
Pteridium aquilinum	Bracken Fern								x	x	x	x			x
Thelypteris palustris	Marsh Fern					x	x		x						
Woodsia ilvensis	Rusty Woodsia								x	x		x	x		
PINACEAE	PINE FAMILY														
Abies balsamea	Balsam Fir			x		x	x	x	x	x	x	x			x
Juniperus communis	Common Juniper									x			x		x
Larix laricina	Tamarack			x		x	x								
Picea glauca	White Spruce					x	x	x	x	x	x	x	x		x
Picea mariana	Black Spruce			x	x	x	x	x	x	x	x	x	x		x
Pinus banksiana	Jack Pine								x	x		x	x		x
Pinus resinosa	Red Pine									x					
Pinus strobus	White Pine								x	x	x	x	x		
Thuja occidentalis	White Cedar			x		x			x	x	x	x	x		x
TYPHACEAE	CATTAIL FAMILY														
Typha latifolia	Common Cattail		x	x											
SPARGANIACEAE	BUR-REED FAMILY														

	Sparganium angustifolium	Slender Bur-reed	x													
	Sparganium eurycarpum	Greater Bur-reed	x	x												
	ZOSTERACEAE	PONDWEED FAMILY														
	Potamogeton alpinus	Red Pondweed	x													
	Potamogeton amplifolius	Bigleaf Pondweed	x													
	Potamogeton filiformis	Threadleaf Pondweed	x													
	Potamogeton friesii	Fries Pondweed	x													
	Potamogeton gramineus	Variable Pondweed	x													
	Potamogeton pectinatus	Sago Pondweed	x													
	Potamogeton praelongus	Whitestem Pondweed	x													
	Potamogeton richardsonii	Richardson's Pondweed	x													
	Potamogeton zosteriformis	Flatstem Pondweed	x													
	NAJADACEAE	NAIAD FAMILY														
	Najas flexilis	Bushy Naiad	x													
	JUNCAGINACEAE	ARROW-GRASS FAMILY														
	Triglochin maritimum	Greater Arrow-grass	x	x												
	SCHEUCHZERIACEAE	SCHEUCHZERIA FAMILY														
	Scheuchzeria palustris	Arrow-grass			x											
	ALISMATACEAE	WATER-PLANTAIN FAMILY														
	Alisma plantago-aquatica	Water Plantain	x	x												
	Sagittaria latifolia	Broad-leaved Arrowhead	x	x	x											
	HYDROCHARITACEAE	FROG'S-BIT FAMILY														
	Elodea canadensis	Water-weed	x													
	POACEAE	GRASS FAMILY														
+	*Agropyron repens*	Quack Grass								x	x			x	x	x
+	*Agrostis gigantea*	Redtop		x						x		x			x	x
	Agrostis scabra	Ticklegrass		x	x					x	x	x	x	x		x
+	*Agrostis stolonifera*	Creeping Bent-Grass		x												x
	Alopecurus aequalis	Foxtail		x												
	Bromus ciliatus	Fringed Brome Grass			x	x		x		x	x	x				x
+	*Bromus inermis*	Awnless Brome														x
	Calamagrostis canadensis	Bluejoint		x		x		x	x	x		x		x	x	x
	Cinna latifolia	Wood Reedgrass		x				x	x	x	x	x			x	
	Danthonia spicata	Poverty Grass								x	x	x	x	x		x
	Deschampsia caespitosa	Tufted Hairgrass		x										x	x	
	Deschampsia flexuosa	Common Hairgrass								x	x	x	x	x		
+	*Festuca longifolia (trachyphylla)*	Hard Fescue												x		
	Glyceria borealis	Float Grass		x											x	
	Glyceria canadensis	Rattlesnake Grass		x		x										
	Glyceria grandis	Reed Meadow-Grass		x												
	Glyceria striata	Fowl Meadow-Grass		x	x			x	x			x				
	Milium effusum	Wood Millet								x						
	Oryzopsis asperifolia	White Mountain-Rice								x	x	x				
	Oryzopsis pungens	Northern Mountain-Rice								x	x					
	Phalaris arundinacea	Reed Canary-Grass													x	x
+	*Phleum pratense*	Timothy										x				x
	Poa compressa	Canada Bluegrass								x	x		x	x	x	x
	Poa interior	Inland Bluegrass												x		
	Poa palustris	Fowl Meadow-Grass		x												
+	*Poa pratensis*	Kentucky Bluegrass							x	x	x	x	x	x	x	x
	Schizachne purpurascens	False Melic-Grass								x	x	x				
	Trisetum spicatum	Trisetum												x		
	CYPERACEAE	SEDGE FAMILY														
	Carex aenea	Bronze Sedge											x			
	Carex arctata	Drooping Wood Sedge								x	x	x				

	Carex aquatilis	Water Sedge		x											x	
	Carex aurea	Golden-fruited Sedge		x	x											x
	Carex bebbii	Bebb's Sedge		x	x		x									
	Carex brevior	Sedge								x						
	Carex brunnescens	Brownish Sedge		x												
	Carex buxbaumii	Buxbaum's Sedge		x												
	Carex canescens	Silvery Sedge		x												
	Carex deweyana	Dewey's Sedge						x	x	x			x			
	Carex diandra	Lesser Panicled Sedge		x	x											
	Carex disperma	Soft-leaved Sedge			x			x	x							
	Carex echinata	Little Prickly Sedge		x	x											
	Carex flava	Yellow Sedge		x	x											
	Carex houghtoniana	Houghton's Sedge														x
	Carex hystericina	Porcupine Sedge		x			x									
	Carex intumescens	Bladder Sedge								x		x				
	Carex lenticularis	Lenticular Sedge			x											
	Carex leptalea	Bristle-stalked Sedge			x	x	x	x	x							
	Carex leptonervia	Two-edged Sedge								x		x				
	Carex oligosperma	Few-seeded Sedge				x										
	Carex cf. ormostachya	Sedge									x					
	Carex pauciflora	Few-flowered Sedge				x										
	Carex paupercula	Bog Sedge			x	x										
	Carex projecta	Necklace Sedge		x												
	Carex retrorsa	Retrorse Sedge		x			x									
	Carex stipata	Awl-fruited Sedge		x												
	Carex trisperma	Three-fruited Sedge				x										
	Carex umbellata s.l.	Umbel-like Sedge											x	x		
	Carex utriculata (rostrata)	Beaked Sedge		x	x		x									
	Carex vaginata	Sheathed Sedge			x			x	x							
	Carex vesicaria	Inflated Sedge			x											
	Carex viridula	Green Sedge		x	x											
	Carex vulpinoidea	Fox Sedge														x
	Dulichium arundinaceum	Three-sided Sedge		x												
	Eleocharis sp.	Spike-Rush				x										
	Eleocharis elliptica	Elliptic Spike-Rush			x											
	Eleocharis erythropoda	Spike-Rush		x												
	Eleocharis ovata	Ovate Spike-Rush		x												
	Eleocharis palustris	Creeping Spike-Rush		x	x											
	Eriophorum angustifolium	Tall Cotton-Grass			x											
	Eriophorum spissum	Hare's-Tail				x										
	Scirpus acutus	Hard-stemmed Bulrush		x												
	Scirpus cyperinus	Wool-Grass		x	x	x										
	Scirpus hudsonianus	Hudsonian Club Rush			x											
	Scirpus microcarpus	Small-fruited Bulrush		x												
	Scirpus validus	Soft-stemmed Bulrush		x												
	ARACEAE	ARUM FAMILY														
	Acorus americanus	Sweet Flag		x												
	Calla palustris	Wild Calla			x											
	JUNCACEAE	RUSH FAMILY														
	Juncus alpinoarticulatus	Alpine Rush		x	x	x									x	
	Juncus articulatus	Jointed Rush		x												
	Juncus bufonius	Toad-Rush													x	
	Juncus dudleyi	Dudley's Rush		x												
	Juncus effusus	Soft Rush		x												
	Juncus nodosus	Knotted Rush		x												
	Juncus tenuis	Slender Rush														x

	Luzula parviflora	Small-flowered Wood Rush						x								
	LILIACEAE	LILY FAMILY														
	Clintonia borealis	Bluebead Lily				x	x	x	x	x	x	x	x			x
	Maianthemum canadense	Wild Lily-of-the-Valley			x	x	x	x	x	x	x	x	x	x		x
	Smilacina trifolia	Bog Solomon's Seal			x	x	x	x	x							
	Streptopus roseus	Rose Twisted-Stalk							x	x		x				
	Trillium cernuum	Nodding Trillium								x		x				
	IRIDACEAE	IRIS FAMILY														
	Iris versicolor	Larger Blue Flag		x	x	x	x									
	ORCHIDACEAE	ORCHIS FAMILY														
	Corallorhiza maculata	Spotted Coral-root							x							
	Cypripedium acaule	Moccasin Flower									x		x			
	Goodyera repens	Dwarf Rattlenake Plaintain						x	x	x	x	x	x			
	Goodyera tesselata	CheckeredRattlesnake Plaintain								x						
	Listera auriculata	AuricledTwayblade						x?	x?							
	Listera cordata	Heart Leaf Twayblade						x	x							
	Platanthera clavellata	Green Woodland Orchis							x							
	Platanthera hyperborea	Northern Green Orchid		x	x		x			x						
	Platanthera obtusata	Small Northern Bog Orchid								x						
	Platanthera orbiculata	Large Round-leaved Orchid								x						
	SALICACEAE	WILLOW FAMILY														
	Populus balsamifera	Balsam Poplar					x			x	x	x			x	x
	Populus tremuloides	Trembling Aspen								x	x	x	x	x		x
	Salix bebbiana	Bebb's Willow			x		x								x	
	Salix candida	Sage-leaved Willow		x	x											
	Salix discolor	Pussy Willow		x			x					x			x	x
	Salix eriocephala	Heart-leaf Willow			x											
	Salix humilis	Prairie Willow									x		x			x
	Salix lucida var. intonsa	Shining Willow		x	x										x	x
	Salix pellita	Willow		x		x										
	Salix serissima	Autumn Willow								x						
	MYRICACEAE	WAX-MYRTLE FAMILY														
	Myrica gale	Sweet Gale		x	x		x									
	BETULACEAE	BIRCH FAMILY														
	Alnus viridis ssp. crispus	Green Alder			x	x	x	x		x	x	x	x	x		x
	Alnus incana ssp. rugosa	Speckled Alder		x			x			x	x	x				x
	Betula papyrifera	White Birch				x	x		x	x	x	x	x	x		x
	Betula pumila	Dwarf Birch				x										
	Corylus cornuta	Beaked Hazel								x		x				x
	SANTALACEAE	SANDALWOOD FAMILY														
	Geocaulon lividum	Toadflax				x										
	ARISTOLOCHIACEAE	BIRTHWORT FAMILY														
	Asarum canadense	Wild Ginger								x	x	x				
	POLYGONACEAE	BUCKWHEAT FAMILY														
+	*Polygonum aviculare*	Prostrate Knotweed													x	
+	*Polygonum convolvulus*	Black Bindweed									x		x	x	x	x
	Polygonum lapathifolium	Pale Smartweed													x	
+	*Polygonum persicaria*	Lady's Thumb													x	
+	*Rumex crispus*	Curled Dock		x												x
	Rumex orbiculatus	Great Water Dock		x												
+	*Rumex thrysiflorus*	Green Sorrel														x
	CHENOPODIACEAE	GOOSEFOOT FAMILY														
+	*Chenopodium album*	Lamb's-Quarters														x
	CARYOPHYLLACEAE	PINK FAMILY														
+	*Cerastium fontanum*	Mouse-ear Chickweed														x
+	*Dianthus armeria*	Deptford Pink														x

+	*Silene vulgaris*	Bladder Campion														x
	NYMPHAEACEAE	WATER-LILY FAMILY														
	Nuphar variegatum	Bullhead Lily	x													
	RANUNCULACEAE	CROWFOOT FAMILY														
	Actaea rubra	Red Baneberry								x		x				
	Anemone canadensis	Canada Anemone		x			x					x				x
	Anemone virginiana	Thimbleweed								x						
	Aquilegia canadensis	Columbine								x	x	x	x	x		x
	Caltha palustris	Marsh Marigold		x			x					x				
	Coptis trifolia	Goldthread			x		x	x	x	x	x	x				
+	*Ranunculus acris*	Common Buttercup		x						x		x		x		x
	Ranunculus pensylvanicus	Bristly Buttercup		x	x		x								x	
	Ranunculus reptans	Creeping Spearwort		x											x	
	Ranunculus subrigidus	White Water-crowfoot	x													
	Thalictrum dasycarpum	Tall Meadow-Rue		x			x							x		x
	FUMARIACEAE	FUMITORY FAMILY														
	Corydalis sempervirens	Pink Corydalis											x	x		
	BRASSICACEAE	MUSTARD FAMILY														
	Arabis divaricarpa	Rock-cress												x		
	Arabis holboelli	Holboell's Rock-cress												x		
+	*Barbarea vulgaris*	Yellow Rocket														x
+	*Capsella bursa-pastoris*	Shepherd's Purse														x
	Draba aurea	Arctic alpine disjunct												x?		
+	*Erysimum cheiranthoides*	Wormseed Mustard													x	x
+	*Lepidium densiflorum*	Peppergrass														x
	Rorippa palustris	Yellow Cress		x											x	
	SARRACENIACEAE	PITCHER-PLANT FAMILY														
	Sarracenia purpurea	Pitcher-plant				x										
	DROSERACEAE	SUNDEW FAMILY														
	Drosera rotundifolia	Round-leaved Sundew		x	x	x										
	SAXIFRAGACEAE	SAXIFRAGE FAMILY														
	Mitella nuda	Naked Mitrewort			x		x	x	x	x	x	x				
	Parnassia palustris	Grass-of-Parnassus		x	x											
	Ribes glandulosum	Skunk Currant										x				
	Ribes hudsonianum	Northern Wild Black Currant						x								
	Ribes lacustre	Bristly Black Currant								x						
	Ribes oxyacanthoides	Bristly Wild Gooseberry											x			
	Ribes triste	Swamp Red Currant						x								
	Saxifraga virginiensis	Early Saxifrage											x	x		
	ROSACEAE	ROSE FAMILY														
	Agrimonia striata	Britton's Agrimony								x		x				x
	Amelanchier alnifolia	Serviceberry			x											
	Amelanchier bartramiana	Oblong-fruited Juneberry								x	x	x	x	x		
	Amelanchier sanguinea	Smooth Juneberry								x						
	Fragaria vesca	Woodland Strawberry								x	x			x		
	Fragaria virginiana	Common Strawberry			x				x	x	x	x		x		x
	Geum aleppicum	Yellow Avens								x		x				x
	Potentilla anserina	Silverweed		x											x	x
	Potentilla norvegica	Rough Cinquefoil			x									x		x
	Potentilla palustris	Marsh Cinquefoil		x	x											
	Potentilla tridentata	Three-toothed Cinquefoil											x	x		
	Prunus pensylvanica	Pin Cherry								x	x	x	x			x
	Prunus virginiana	Chokecherry							x							
	Rosa acicularis	Prickly Wild Rose					x	x	x	x	x	x	x	x		x
	Rubus idaeus	Red Raspberry			x				x	x	x	x	x	x		x
	Rubus parviflorus	Thimbleberry									x					

	Rubus pubescens	Dwarf Raspberry			x		x	x	x	x		x				
	Sorbus americana	American Mountain-Ash			x		x		x	x	x		x			
	Sorbus decora	Northern Mountain-Ash			x		x	x	x	x	x	x	x	x		x
	Spiraea alba	Narrow-leaved Meadowsweet		x			x									x
	FABACEAE	PEA FAMILY														
	Lathyrus ochroleucus	Pale Vetchling							x	x	x	x				
	Lathyrus palustris	Marsh Vetchling		x												
+	*Lotus corniculatus*	Birdsfoot Trefoil														x
+	*Medicago lupulina*	Black Medick														x
+	*Melilotus alba*	White Sweet Clover										x		x		x
+	*Melilotus officinalis*	Yellow Sweet Clover														x
+	*Trifolium pratense*	Red Clover														x
+	*Trifolium repens*	White Clover													x	x
	Vicia americana	Purple Vetch								x	x					
+	*Vicia cracca*	Cow Vetch		x						x					x	x
	POLYGALACEAE	MILKWORT FAMILY														
	Polygala paucifolia	Gaywings								x	x	x				
	CALLITRICHACEAE	WATER-STARWORT FAMILY														
	Callitriche hermaphroditica	Hermaphroditic Water-Starwort	x													
	Callitriche palustris	Common Water-Starwort	x													
	ACERACEAE	MAPLE FAMILY														
	Acer spicatum	Mountain Maple					x		x	x	x	x				
	BALSAMINACEAE	TOUCH-ME-NOT FAMILY														
	Impatiens capensis	Spotted Touch-me-not		x			x			x	x			x		x
	RHAMNACEAE	BUCKTHORN FAMILY														
	Rhamnus alnifolia	Alder-leaved Buckthorn			x											
	CLUSIACEAE	ST. JOHN'S-WORT FAMILY														
	Hypericum majus	St. John's-Wort		x												
	Triadenum fraseri	Marsh St. John's-Wort		x	x											
	VIOLACEAE	VIOLET FAMILY														
	Viola sp.	Violet						x	x			x				x
	Viola renifolia	Kidney-leaved Violet								x	x					
	ONAGRACEAE	EVENING PRIMROSE FAMILY														
	Circaea alpina	Small Enchanter's-Nightshade						x		x		x				
	Epilobium angustifolium	Fireweed					x		x	x	x	x	x			x
	Epilobium ciliatum	Sticky Willow-Herb													x	
	Epilobium leptophyllum	Willow-Herb		x	x											
	Oenothera biennis	Common Evening-Primrose								x	x	x	x	x		x
	HALORAGACEAE	WATER-MILFOIL FAMILY														
	Myriophyllum sibiricum	Northern Water-milfoil	x													
	Myriophyllum farwellii	Farwell's Water-milfoil	x													
	ARALIACEAE	GINSENG FAMILY														
	Aralia hispida	Bristly Sarsaparilla											x			
	Aralia nudicaulis	Wild Sarsaparilla					x	x	x	x	x	x	x	x		x
	APIACEAE	PARSLEY FAMILY														
	Cicuta bulbifera	Bulb-bearing Water-Hemlock		x	x											
	Heracleum maximum	Cow-Parsnip														x
	Sium sauve	Water Parsnip		x											x	
	HIPPURIDACEAE	MARE'S TAIL FAMILY														
	Hippuris vulgaris	Mare's Tail	x													
	CORNACEAE	DOGWOOD FAMILY														
	Cornus canadensis	Bunchberry			x	x	x	x	x	x	x	x	x			x
	Cornus rugosa	Round-leaved Dogwood								x						
	Cornus stolonifera	Red-osier Dogwood		x	x		x					x			x	x
	PYROLACEAE	WINTERGREEN FAMILY														
	Moneses uniflora	One-flowered Pyrola						x	x	x	x		x			

	Monotropa hypopithys	Pinesap									x					
	Monotropa uniflora	Indian Pipe								x	x					
	Pyrola asarifolia	Pink Pyrola										x				
	Pyrola secunda	One-sided Pyrola						x	x	x						
	Pyrola virens	Green Pyrola						x	x	x						
	ERICACEAE	HEATH FAMILY														
	Andromeda glaucophylla	Bog Rosemary				x										
	Chamaedaphne calyculata	Leatherleaf				x										
	Gaultheria hispidula	Wintergreen			x	x		x	x	x	x		x			
	Kalmia angustifolia	Sheep-laurel				x										
	Kalmia polifolia	Bog Laurel			x	x		x	x							
	Ledum groenlandicum	Labrador Tea			x	x		x	x	x	x		x			
	Vaccinium angustifolium	Low Blueberry					x	x	x	x	x		x	x		
	Vaccinium myrtilloides	Velvet-leaf Blueberry			x				x		x					x
	Vaccinium oxycoccus	Small Cranberry			x	x		x	x							
	PRIMULACEAE	PRIMROSE FAMILY														
	Lysimachia ciliata	Fringed Loosestrife					x			x		x				
	Lysimachia terrestris	Yellow Loosestrife		x												
	Lysimachia thyrsifolia	Tufted Loosestrife		x	x											
	Trientalis borealis	Starflower			x		x	x	x	x	x	x	x			x
	OLEACEAE	OLIVE FAMILY														
	Fraxinus nigra	Black Ash								x						
	GENTIANACEAE	GENTIAN FAMILY														
	Gentiana linearis var. latifolia	Purple-stemmed Gentian		x	x											
	Halenia deflexa	Spurred Gentian		x		x				x		x				
	Menyanthes trifoliata	Bog Buckbean		x	x	x										
	APOCYNACEAE	DOGBANE FAMILY														
	Apocynum androsaemifolium	Spreading Dogbane											x	x		
	CONVOLVULACEAE	MORNING-GLORY FAMILY														
+-	*Convolvulus sepium*	Hedge Bindweed														x
	BORAGINACEAE	BORAGE FAMILY														
	Hackelia deflexa	Stickweed												x		
	Mertensia paniculata	Northern Lungwort							x	x		x				
	LAMIACEAE	MINT FAMILY														
+	*Galeopsis tetrahit*	Hemp-Nettle								x		x				x
	Lycopus uniflorus	Bugleweed		x	x											
	Mentha arvensis	Field Mint		x	x											
+-	*Prunella vulgaris*	Heal-All		x												x
	Scutellaria epilobiifolia	Common Skullcap		x	x											
	Scutellaria lateriflora	Mad-dog Skullcap		x												
	SCROPHULARIACEAE	FIGWORT FAMILY														
+	*Euphrasia nemorosa*	Eyebright								x						x
+	*Linaria vulgaris*	Butter-and-Eggs														x
	Melampyrum lineare	Cow-wheat			x	x				x	x	x	x			x
+	*Rhinanthus minor*	Yellow Rattle		x												x
+	*Verbascum thapsus*	Common Mullein														x
	Veronica peregrina	Purslane Speedwell													x	
	LENTIBULARIACEAE	BLADDERWORT FAMILY														
	Utricularia intermedia	Flat-leaved Bladderwort		x												
	PLANTAGINACEAE	PLANTAIN FAMILY														
+	*Plantago major*	Common Plantain								x	x				x	x
	RUBIACEAE	MADDER FAMILY														
	Galium boreale	Northern Bedstraw														x
	Galium trifidum	Small Bedstraw		x	x					x						
	Galium triflorum	Fragrant Bedstraw							x	x	x	x				
	CAPRIFOLIACEAE	HONEYSUCKLE FAMILY														

	Diervilla lonicera	Bush-Honeysuckle					x		x	x	x	x				x
	Linnaea borealis	Twinflower			x		x	x	x	x	x	x	x			
	Lonicera canadensis	Canada Honeysuckle							x	x		x				
	Lonicera dioica	Glaucous Honeysuckle			x											
	Lonicera hirsuta	Hairy Honeysuckle						x		x						
	Lonicera involucrata	Bracted Honeysuckle			x				x	x		x				
	Lonicera villosa	Mountain Fly Honeysuckle			x											
	Sambucus racemosa	Red Elderberry		x			x		x	x	x	x				x
	Viburnum edule	Mooseberry					x		x	x	x	x	x			x
	Viburnum rafinesquianum	Downy Arrow-wood										x				
	CAMPANULACEAE	BLUEBELL FAMILY														
	Campanula aparinoides	Marsh Bellflower		x	x		x									
+	*Campanula rapunculoides*	Creeping Bellflower														x
	Campanula rotundifolia	Harebell									x		x	x		
	ASTERACEAE	ASTER FAMILY														
+-	*Achillea millefolium*	Yarrow					x			x	x	x		x	x	x
	Anaphalis margaritacea	Pearly Everlasting		x					x	x	x	x			x	x
	Antennaria howellii	Field Pussytoes											x	x		
	Artemisia campestris	Sagewood Wormwood											x			x
+	*Artemisia vulgaris*	Common Mugwort														x
	Aster ciliolatus	Fringed Blue Aster					x	x	x	x	x	x				x
	Aster macrophyllus	Large-leaved Aster					x	x	x	x	x	x				x
	Aster puniceus	Purple-stemmed Aster		x	x		x									x
	Aster umbellatus var. pubens	Flat-topped White Aster		x			x	x	x	x		x				x
+	*Centaurea maculosa*	Knapweed														x
+	*Chrysanthemum leucanthemum*	Ox-eye Daisy												x		x
+	*Cirsium arvense*	Canada Thistle														x
	Cirsium muticum	Swamp Thistle			x											
	Conyza canadensis	Horseweed									x				x	x
	Erigeron philadelphicus	Common Fleabane										x				
	Eupatorium maculatum	Joe-Pye-Weed		x	x		x									x
	Gnaphalium obtusifolium	Catfoot														x
+	*Hieracium aurantiacum*	Orange Hawkweed											x			x
	Hieracium canadense	Canada Hawkweed											x			
	Lactuca canadensis	Wild Lettuce								x						
+	*Matricaria matricariodes*	Pineapple Weed													x	x
	Petasites frigidus	Sweet Coltsfoot							x	x		x				
+	*Rudbeckia serotina*	Black-eyed Susan														x
	Solidago canadensis	Canada Goldenrod								x	x	x	x		x	x
	Solidago graminifolia	Lance-leaved Goldenrod		x											x	
	Solidago hispida	Hairy Goldenrod											x			
	Solidago simplex var. randii	Rand's Goldenrod												x		
	Solidago uliginosa	Bog Goldenrod		x	x	x			x							
+	*Sonchus arvensis*	Field Sow-Thistle														x
+	*Sonchus asper*	Spiny-leaved Sow-Thistle													x	x
+	*Taraxacum officinale*	Common Dandelion													x	x
	Total Number of Species	All Habitats = 364	24	102	85	37	54	50	71	126	92	94	63	53	43	115
	Total Number of Introduced Species	All Habitats = 45	0	6	0	0	0	0	1	8	4	4	4	6	13	42
	Percent of Introduced Species	All Habitats = 12.4	0	5.9	0	0	0	0	1	6.3	4.3	4.3	6.3	11	30	36

NOTES: + = introduced species
Habitat Classification: 1) Submerged Aquatic 2) Marsh 3) Open Fen 4) Open Bog 5) Mixed Swamp 6) Black Spruce Swamp 7) Coniferous Forest 8) Mixed Forest - Deep Till 9) Mixed Forest - Shallow Till 10) Deciduous Forest - Deep Till 11) Rockland 12) Cliffs and Talus Slopes 13) Beach 14) Successional Fields and Forests

APPENDIX 1b. Bird species of the Terrace Bay District.

Scientific name	Common name
Accipiter striatus	Sharp-shinned hawk
Actitius macularia	Spotted sandpiper
Agelaius phoenicus	Red-winged blackbird
Anas discors	Blue-winged teal
Anas platyrhynchos	Mallard
Anas rubripes	Black duck
Archilochus colubris	Ruby-throated hummingbird
Ardea herodias	Great blue heron
Aythya collaris	Ring-necked duck
Bombycilla cedorum	Cedar waxwing
Bonasa umbellus	Ruffed grouse
Bucephala clangula	Common goldeneye
Buteo jamaicensis	Red-tailed hawk
Buteo platypterus	Broad-winged hawk
Carduelis pinus	Pine siskin
Carduelis tristis	American goldfinch
Carpodacus purpureus	Purple finch
Catharus fuscenscens	Veery
Catharus guttatus	Hermit thrush
Catharus ustulatus	Swainson's thrush
Erthia americana	Brown creeper
Chordeiles minor	Common nighthawk
Circus Cyaneus	Northern harrier
Coccothraustes vespertinus	Evening grosbeak
Colaptes auratus	Northern flicker
Contopus borealis	Olive-sided flycatcher
Columba livia	Rock dove
Corvus brachrhynchos	Common crow
Corvus corax	Common raven
Cyanocitta cristata	Bluejay
Dendragapus canadensis	Spruce grouse
Dendroica castanea	Bay breasted warbler
Dendroica coronata	Yellow rumped warbler
Dendroica fusca	Blackburnian warbler
Dendroica magnolia	Magnolia warbler
Dendroica pensylvanica	Chestnut sided warbler
Dendroica petechia	Yellow warbler
Dendroica tigrina	Cape may warbler
Dendroica virens	Black throated green warbler
Dryocopus pileatus	Pileated woodpecker
Dumatella carolinensis	Gray catbird
Empidonax alnorum	Alder flycatcher
Empidonax flaviventris	Yellow bellied flycatcher
Empidonax minimus	Least flycatcher

APPENDIX 1b. Continued.

Scientific name	Common name
Falco columbarius	Merlin
Falco sparverius	American kestrel
Gavia immer	Common loon
Geothlypis trichas	Common yellowthroat
Hirundo rustica	Barn swallow
Junco hyemalis	Dark eyed junco
Larus argentatus	Herring gull
Larus delawarensis	Ring billed gull
Melospiza georgiana	Swamp sparrow
Melospiza lincolnii	Lincoln's sparrow
Melospiza melodia	Song sparrow
Mergus merganser	Common merganser
Mergus serrator	Red breasted merganser
Mniotilta varia	Black and white warbler
Oporornsis philadelphia	Mourning warbler
Pandion haliaetus	Osprey
Parula americana	Northern parula warbler
Parus atricapillus	Black capped chickadee
Parus hudsonicus	Boreal chickadee
Passer domesticus	House sparrow
Passerculus sandwichensis	Savannah sparrow
Perisoreus canadensis	Gray jay
Phalacrocorax auritus	Double crested cormorant
Pheuticus ludovicianis	Rose-breasted grosbeak
Picoides pubescens	Downy woodpecker
Picoides villosus	Hairy woodpecker
Pirangea olivacea	Scarlet tanager
Quiscalus quiscula	Common grackle
Regulus calendula	Ruby crowned kinglet
Regulus satrapa	Golden crowned kinglet
Scolopax minor	American woodcock
Seiurus aurocapillus	Ovenbird
Seiurus noveboracensis	Northern waterthrush
Setophaga ruticilla	American redstart
Sitta canadensis	Red-breasted nuthatch
Sitta carolinensis	White breasted nuthatch
Sphyrapicus varius	Yellow bellied sapsucker
Spizella passerina	Chipping sparrow
Strix nebulosa	Great gray owl
Sturnus vulgaris	European starling
Tachycineta bicolor	Tree swallow
Troglodytes aedon	House wren
Troglodytes troglodytes	Winter wren
Turdus migratorius	American robin
Tyrannus tyrannus	Eastern kingbird
Vermivora peregrina	Tennessee warbler
Vermivora ruficapilla	Nashville warbler
Vireo olivaceus	Red eyed vireo
Vireo philadelphicus	Philadelphia vireo
Vireo solitarius	Solitary vireo
Wilsonia canadensis	Canada warbler
Wilsonia pusilla	Wilson's warbler

APPENDIX 1b. continued.

Scientific name	Common name
Zenaida macroura	Mourning dove
Zonotrichia albicollis	White throated sparrow

APPENDIX 1c. Herpetofauna of the Terrace Bay District

Scientific name	Common name
Hyla crucifer	Spring Peeper
Pseudacris triseriata maculatis	Boreal Chorus Frog
Bufo americanus	American Toad
Rana septentrionalis	Mink Frog
R. clamitans melanota	Green Frog
R. pipiens	Northern Leopard Frog
R. sylvatica	Wood Frog
Chelydra serpentina	Common Snapping Turtle
Chrysemys picta belli	Western Painted Turtle
Storeria occipitomaculata	Northern Red-bellied Snake
Thamnophis sirtalis	Eastern Garter Snake
Necturus maculosus	Mudpuppy
Ambystoma jeffersonianum	Jefferson Salamander
A. Laterale	Blue-spotted Salamander
A. Maculatum	Spotted Salamander
Diemictylus viridescens	Red-spotted Newt
Plethodon cinereus	Red-backed Salamander

APPENDIX 1d. Mammals of the Terrace Bay District.

Scientific name	Common name
Alces alces	moose
Blarina brevicauda	short-tailed shrew
Canis lupus	timber wolf
Canis latrans	coyote
Castor canadensis	beaver
Condylura cristata	star-nosed mole
Eptesicus fuscus	big brown bat
Erethizon dorsatum	American porcupine
Eutamias minimus	least chipmunk
Felis concolor	eastern cougar
Glaucomys sabrinus	northern flying squirrel
Gulo luscus	wolverine
Lasiurus borealis	red bat
Lasiurus cinereus	hoary bat
Lepus americanus	snowshoe hare
Lutra canadensis	river otter
Lynx canadensis	lynx
Lynx rufus	bobcat
Marmota monax	woodchuck
Martes pennanti	fisher
Martes americana	American marten
Mephitis mephitis	striped skunk
Mustela erminea	short-tailed weasel

APPENDIX 1d. continued.

Scientific name	Common name
Mustela vison	mink
Myotis lucifugus	little brown bat
Odocoileus virginianus	white-tailed deer
Ondatra zibethicus	muskrat
Procyon lotor	raccoon
Rangifer caribou	woodland caribou
Sorex cinereus	masked shrew
Tamias striatus	eastern chipmunk
Tamiasciurus hudsonicus	red squirrel
Ursus americanus	black bear
Vulpes vulpes	red fox

APPENDIX 1e. Fishes of the Terrace Bay District.

Scientific name	Common name
Acipenser fulvescens	lake sturgeon
*Alosa pseudoharengus**	alewife
Catastomus catastomus	longnose sucker
Catastomus commersoni	common white sucker
Couesius plumbeus	lake chub
Coregonus artedii	lake herring
Coregonus clupeaformis	lake whitefish
Cottus bairdii	mottled sculpin
Cottus cognatus	slimy sculpin
Cottus bairdii X Cottus cognatus	sculpin hybrid
Culea inconstans	brook stickleback
Cyprinus carpio	common carp
Esox lucius	northern pike
Etheostoma exile	iowa darter
Etheostoma microperca	least darter
Etheostoma nigrum	johnny darter
Ichthyomyzon fossor	northern brook lamprey
Ichthyomyzon unicuspis	silver lamprey
Lota lota	burbot
Micropterus dolomieu	smallmouth bass
Moxostoma anisurum	silver redhorse
Moxostoma macrolepidotum	shorthead redhorse sucker
Notropis atherinoides	emerald shiner
Notropis heterolepis	blacknose shiner
Notropis hudsonius	spottail shiner
*Oncorhynchus gorbuscha**	pink salmon
*Oncorhynchus mykiss**	rainbow trout
*Oncorhynchus tshawytscha**	chinook salmon
*Osmerus mordax**	rainbow smelt
Perca flavescens	yellow perch
Percina caprodes	logperch
Percopsi omiscomaycus	trout-perch
*Petromyzon marinus**	sea lamprey
Phoxinus eos	northern redbelly dace

APPENDIX 1e. continued.

Scientific name	Common name
Phoxinus neogaeus	finescale dace
Pimephales promelas	fathead minnow
*Polydon spathula***	paddlefish
Prosopium cylindraceum	round whitefish
Pungitius pungitius	nine-spine stickleback
Rhinichthys cataractae	longnose dace
*Salmo trutta**	brown trout
Salvelinus fontinalis	brook trout
Salvelinus namaycush	lake trout
Semotilus margarita	pearl dace
Stizostedion canadense	sauger
Stizostedion vitreum	walleye

*introduced
**extirpated

APPENDIX 2

JACKFISH BAY PAC ACTIVITIES

Ongoing Participation:

Ontario PAC Council

Publications:

1990 Beak Consultants Ltd. Benthic community evaluation of Jackfish Bay, Lake Superior: 1969, 1975 and 1987. Ministry of the Environment. Technical Report #3. 208p.

1990 1990 Guide to Eating Ontario Sport Fish. Ministry of Natural Resources and Ministry of the Environment.

1990 Sherman, K. and Jardine, C. Jackfish Bay Water Quality Study 1987/1988. Ministry of the Environment.

1990 Jackfish Bay Water Use Goals. RAP Report #2.

1991 Remedial Options for Contaminated Sediments. RAP Report #9.

1991 North Shore of Lake Superior Remedial Options Workshop RAP Report #10

1991 Stage I Report: Environmental Conditions and Problem Definitions (Jackfish Bay) presented to the International Joint Commission.

1991 Sherman, K. Report of the Jackfish Bay Environmental Survey, 1987/88.

1992 Beak Consultants Ltd. Toxic Load of the Blackbird Creek System and Alternatives for Rehabilitation. 109p.

1992 Non-chlorine bleached paper products fact sheet insert for local newspaper. Enviro-kids fact sheet for elementary school children.

1992 International Joint Commission Stage 1 Review Teams Tour North Shore of Lake Superior Areas of Concern. RAP Report #18.

Presentations and Participation:

October 1989	Kimberly-Clark Mill Tour
November 1989	MISA Presentation for all four North Shore of Lake Superior PACs

March 1990	Making a Great Lake Superior Conference
September 1990	Open House for Presentation of Water Use Goals to the Public
March 1991	Remedial Options Workshop for all four North Shore of Lake Superior RAPs
June 1991	Lake Superior Vision Conference, Thunder Bay, representation and display
October 1991	International Joint Commission Biennial, representation and display
April 1992	North Shore of Lake Superior RAP Team Remedial Action Workshop: Sediment Remediation, representation
July 1992	Lake Superior Day, Thunder Bay
July/August 1992	MOE water quality and benthic sampling, PAC participation
September 1992	Terrace Bay Fall Fair, display
July 1993	Lake Superior Day, Thunder Bay
September 1993	Terrace Bay Fall Fair, display

Special Projects:

February 1992	Lake Superior Poster/Calendar
February 1993	Lake Superior Poster/Calendar

Area of Concern Newsletters:

April 1992	
November 1992	
March 1993	North Shore Report
October 1993	North Shore RAP Newsletter

Meetings:

May 9, 1989
June 22, 1989
August 10, 1989
November 9, 1989
December 7, 1989

May 18, 1989
July 13, 1989
September 14, 1989
November 21, 1989

January 4, 1990
February 1, 1990
February 22, 1990
March 29, 1990
April 4, 1990
May 17, 1990

June 21, 1990
July 26, 1990
September 27, 1990
November 22, 1990
December 13, 1990

February18,1991
May 23, 1991
April 11, 1991

October 17, 1991
November 21, 1991
December 11, 1991

January 22, 1992
February 17, 1992
April 30, 1992
June 25, 1992

July 21, 1992
October 8, 1992
November 19, 1992
December 22, 1992

February 25, 1993
March 4, 1993
April 15, 1993
September 30, 1993

December 1993
February 1994
November 1994
March 1995
May 1996

APPENDIX 3

SUMMARY OF REMEDIAL STRATEGIES TAKEN FROM THE JACKFISH BAY OPTIONS DISCUSSION PAPER

Appendix 4a: Remedial options to restore impaired beneficial uses in Blackbird Creek and Lakes A and C (Options Discussion Paper 1995).

OPTION	CONSEQUENCES	
	POSITIVE	NEGATIVE
1)Incremental Progress; No Further Intervention at this time (Blackbird Creek, Lakes A and C)	• no cost • no disturbance	• 30-60 years • contaminated sediments transported to Lake Superior
2) Physical removal (Lakes A + C)	• fast, contained, stable and controllable	• cost • sediments are disturbed and results in the potential loss of material to Lake Superior
3) Sediment stabilization: Moberly Lake (Lake C)		
i) membrane over sediments	• isolate sediment from water column	• gas from decomposition may lift membrane
ii) cover with clean sediment	• isolate sediment from water column	• may flush through and not remain intact • cost
iii) establish aquatic vegetation	• stabilize sediments	• potential for contaminant uptake
iv) raise lake level by damming	• reduce sediment scouring	• installation of a structure that requires ongoing maintenance • results in flooded land
v) reduce feeder stream flow	• reduce area of sediment/water interface	• requirement for diversion structures
vi) lower level and establish a channel	• reduce area of sediment/water interface	• potential for increased erosion and subsequent flushing of contaminants to Lake Superior • cost
vii) construct a pipeline through or around the lake	• isolate sediments from the water column	• cost • maintenance

Appendix 4a cont'd.

OPTION	CONSEQUENCES	
	POSITIVE	NEGATIVE
4) Effluent Stream Location i) Remain in Blackbird Creek	• not contaminating another area • characteristics are well documented	• system will require a long time to recover
ii) Divert effluent a) divert effluent through the natural drainage basin west of Cape Victoria	• accelerated recovery of Blackbird Creek and Jackfish Bay	• contamination of another area • cost • historic sites on beaches west of Cape Victoria would be impacted
b) construct pipeline to 'Hydro' Bay	• accelerated recovery of Blackbird Creek and Jackfish Bay • could be used to generate electricity	• contamination of another area • cost • potential detriment to commercial fishing • marina proposed for this area
c) construct pipeline to mouth of the Aguasabon River	• accelerated recovery of Blackbird Creek and Jackfish Bay	• contamination of another area • cost • potential for a marina in this area • detriment to tourism

Appendix 4b: Remedial options to restore impaired beneficial uses in Moberly, Tunnel, and Jackfish Bays (Options Discussion Paper 1995).

OPTION	CONSEQUENCES	
	POSITIVE	NEGATIVE
1) Diffuse effluent	• reduce area of impact • aesthetic improvement • potential for the restoration of lake trout spawning beds	• false sense of security • net loading remains the same • potential degradation of a new area • impediment to fish migration • cost
2) Dredge sediment	• reduce contaminant leaching into water column	• simply results in the transfer of waste from one area to another • potential to resuspend contaminants into the water column
3) Sediment barrier across the mouth of Moberly Bay	• contain contaminated sediments in Moberly Bay • clean sediment will eventually cover contaminated sediment	• available technology • cost • contaminants can still be introduced to the water column/food chain
4) Incremental Progress; No Further Intervention at this Time	• clean sediments are covering those that are contaminated • cost	• contaminants can still be introduced to the water column/food chain • potentially long time-frame
5) Restore lake trout spawning habitat	• potential benefit to lake trout population • minimal cost	• water quality may still preclude lake trout from using this habitat

Appendix 4c: Remedial options for problems associated with the effluent stream (Options Discussion Paper 1995).

OPTION	CONSEQUENCES	
	POSITIVE	NEGATIVE
1) Additional treatment • trickling, sand or charcoal filters • coagulants and polymers in conjunction with filters • remove or collect foam • selective stream treatment	• removal of additional contaminants	• very expensive • production of sludges or other waste material that requires disposal (landfill site)
2) Zero discharge	• eliminate the discharge of persistent toxic substances • supports IJC recommendation	• expensive • 10-15 year timeframe • limited available technology
3) Waste stream separation • domestic waste to municipal system •drainage/runoff from property	• decreased volume of waste entering Blackbird Creek	• may overload municipal system • results in a more concentrated waste stream
4) Process modifications • no chlorine or chlorine compounds • reduce amount of chlorinated process water	• eliminate or reduce the discharge of persistent toxic substances	• expensive • limited available technology
5) Other uses for discharge • recover waste components - perhaps for fertilizer or fuel • recover heat •screen sludge to recover fibre • compost sludge	• potential economic benefit • reduced volume of waste	• startup cost • available technology
6) MISA and federal regulations to govern wastewater	• legislated reduction in contaminants	• long time-frame • eliminates stakeholder input
7) Reduce overall flow • water conservation • reduce the volume of water requiring treatment	• increased retention time in treatment system • longterm reduction in operating costs	• high initial capital cost
8) Dilute waste water stream • pump additional water from Hays Lake	• results in a less 'toxic' waste stream	• cost • dilution of effluent is not an acceptable treatment