GREAT LAKES CLEANUP FUND - SEDIMENT REMEDIATION

IJC Workshop on Remediation of Contaminated Sediments in Areas of Concern
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ABSTRACT

The Great Lakes Cleanup Fund, one of three components to the Government of Canada's Great Lakes Action Plan, is providing $55 million over the next several years to help develop and demonstrate innovative cleanup technologies and remedial programs in the 17 Canadian Great Lakes Areas of Concern. One of the priorities of the Cleanup Fund is the remediation of contaminated sediments. Through the Cleanup Fund, Environment Canada is demonstrating techniques for the assessment, removal, in-place and off-site treatment of contaminated sediments.

KEYWORDS

Area of Concern, Remedial Action Plan, Assessment, Removal, Treatment

INTRODUCTION

The message to our governments is clear: The citizens of the Great Lakes Basin will no longer tolerate the use of these magnificent bodies of fresh water as waste receptors. They want action now. They want pollution sources stopped, cleanup actions undertaken and pollution prevention programs put in place.

The 1972 Canada-United States Great Lakes Water Quality Agreement (GLWQA) was the first major step by governments toward cleaning up the Great Lakes. The focus of this historic binational agreement was nutrients. Within six years, the recognition and documentation of toxic chemical contamination of the Great Lakes led to the Revised Great Lakes Water Quality Agreement of 1978. The purpose of this Agreement was to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem. The 1978 Agreement focused mainly on controlling toxic chemicals which went into the Lakes. The Agreement's second priority is on the use of an "ecosystem approach to toxic chemical management".

By the late 1980's, there was a growing recognition that even further measures had to be taken as areas of the Great Lakes were still seriously polluted. After extensive consultations with governments, environmental groups, industrial organizations and private citizens around the basin, Canada and the United States amended the 1978 Agreement. The 1987 Protocol to the GLWQA clearly recognizes the need for extending and increasing existing programs as well as for the establishment of new programs.

The GLWQA was signed by the federal governments of Canada and the United States (the Parties). It is implemented in cooperation with the Great Lakes States and the Province of Ontario. Federal programs are delivered by several federal agencies and coordinated through the Great Lakes Working Group (GLWG). The GLWG is made up of representatives from Environment Canada, Fisheries and Oceans, Agriculture, Transport and Health and Welfare. The Federal/Provincial commitments are delivered under the Canada-Ontario Agreement (COA) Respecting Great Lakes Water Quality and under the direction of the COA Board of Review. Ontario Ministries of Environment and Energy and Natural Resources have major roles in the delivery of provincial programs.

Under the GLWQA, Canada and United States are required to meet twice a year to review progress and agree on binational efforts and programs. The Parties are also required to submit biennial reports to the International Joint Commission (IJC). The IJC in turn, evaluates the progress of the Parties in meeting the requirements of the 1987 Protocol. Then, with advice from experts on its Water Quality and Science Advisory Boards, the IJC reports back to the federal governments. These reports are filed every two years.

As mentioned earlier, the 1987 Protocol to the GLWQA clearly recognizes the need for existing programs to be extended and for new programs to be added. The Protocol is a renewed commitment to virtual elimination of persistent toxic substances in the Great Lakes. The new provisions cover issues such as:

- Remediation of severely polluted areas - called Areas of Concern (AOCs) - through Remedial Action Plans (RAPs) and for lakewide problems, through Lakewide Management Plans (LAMPs).

- Development and demonstration of technology for the assessment, removal, treatment and disposal of contaminated sediments.

- Monitoring airborne toxic deposition and the development of a binational monitoring network.

- Addressing human health issues.

- Development of new objectives along with environmental and human health indicators for the Great Lakes Basin Ecosystem.

In response to the signing of the 1987 Protocol, the Canadian federal government introduced a $125 million Great Lakes Action Plan (GLAP) to meet the ongoing and new GLWQA commitments.

There are three components of the Great Lakes Action Plan:

1.	Preservation Program	-	$50 million
2.	Health Effects Program	-	$20 million
3.	Cleanup Fund	-	$55 million

The Preservation Program is under the lead of the Great Lakes Working Group. The program is designed to address, in a comprehensive manner, the widespread contamination of the Great Lakes ecosystem by toxic chemicals. The program has seven components which address the major pollution concerns of the Great Lakes as well as the requirements of the 1987 Protocol. Those components are:

- Cleanup Plans - RAPs and LAMPs
- Ecosystem health
- Pollution from land-based sources
- Shipping
- Contaminated sediments
- Airborne contaminants
- Groundwater pollution

The second program under the Great Lakes Action Plan is the Health Effects Program which is managed by Health and Welfare Canada. This program is designed to meet the new human health requirements of the 1987 Protocol:

- Evaluation of environmental data as they relate to human populations

- Assessment of health risks within the Basin

- Protection from exposures to mixtures of chemicals

- Providing environmental health information to the public

The third GLAP program is the Great Lakes Cleanup Fund (CuF). CuF is used to support the development, demonstration, and implementation of cleanup programs in Canada's 17 Areas of Concern.

There are a total of forty-three Areas of Concern on the Great Lakes designated by the IJC (Figure I). Twelve AOCs are solely Canadian with five (St. Lawrence, Niagara, Detroit, St. Clair and St. Marys Rivers) shared by both countries.

The Cleanup Fund was established to ensure that remedial measures for the AOCs, which fall within federal jurisdictions and for which there are no existing programs, are adequately funded.

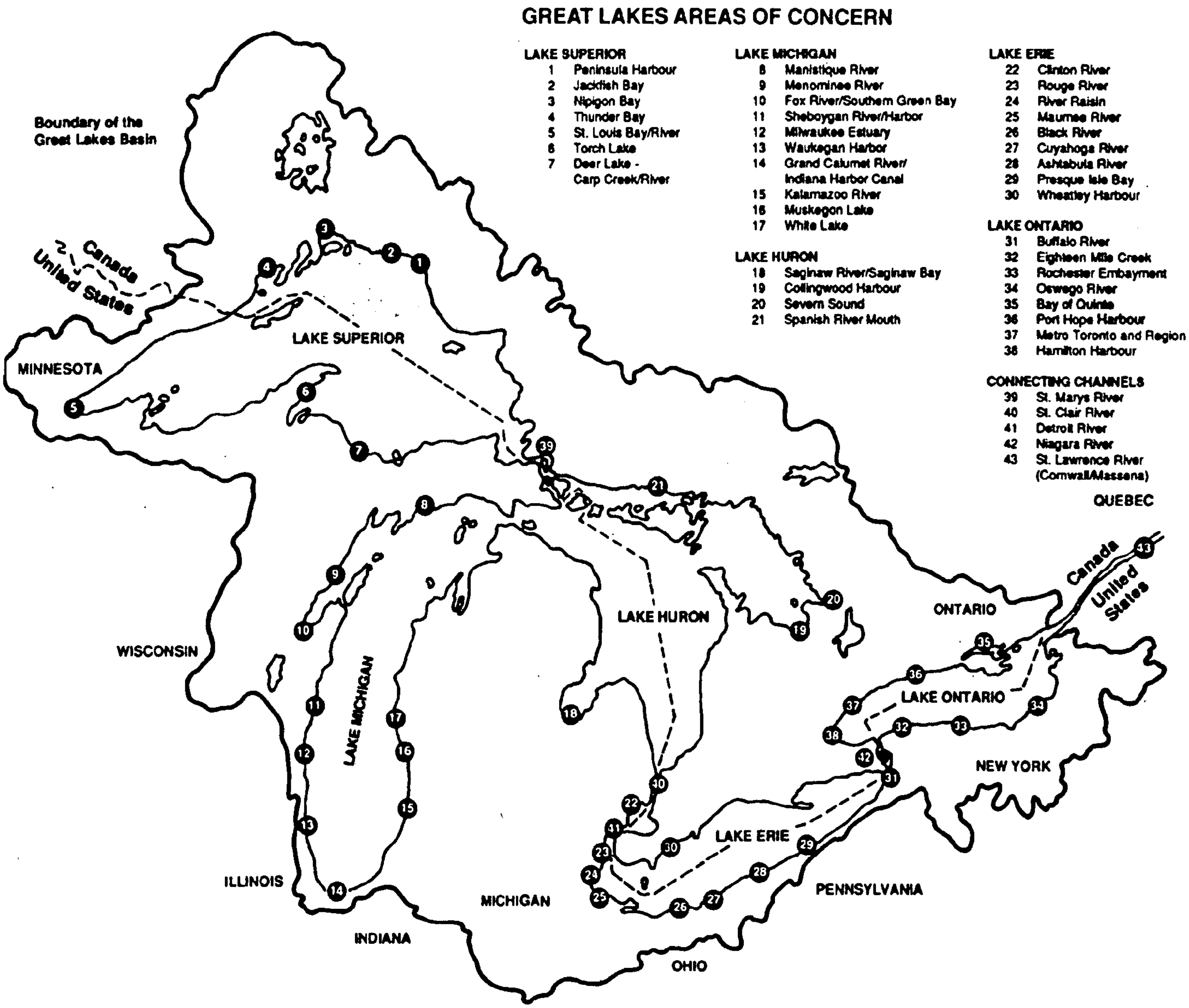
GREAT LAKES AREAS OF CONCERN
LAKE SUPERIOR
1 Peninsula Harbour
2 Jackfish Bay
3 Nipigon Bay
4 Thunder Bay
5 St. Louis Bay/River
6 Torch Lake
7 Deer Lake - Carp Creek/River
LAKE MICHIGAN
8 Manistique River
9 Menominee River
10 Fox River/Southern Green Bay
11 Sheboygan River/Harbor
12 Milwaukee Estuary
13 Waukegan Harbor
14 Grand Calumet River/ Indiana Harbor Canal
15 Kalamazoo River
16 Muskegon Lake
17 White Lake
LAKE HURON
18 Saginaw River/Saginaw Bay
19 Collingwood Harbour
20 Severn Sound
21 Spanish River Mouth
LAKE ERIE
22 Clinton River
23 Rouge River
24 River Raisin
25 Maumee River
26 Black River
27 Cuyahoga River
28 Ashtabula River
29 Presque Isle Bay
30 Wheatley Harbour
LAKE ONTARIO
31 Buffalo River
32 Eighteen Mile Creek
33 Rochester Embayment
34 Oswego River
35 Bay of Quinte
36 Port Hope Harbour
37 Metro Toronto and Region
38 Hamilton Harbour
CONNECTING CHANNELS
39 St. Marys River
40 St. Clair River
41 Detroit River
42 Niagara River
43 St. Lawrence River (Cornwall/Massena)
Boundary of the Great Lakes Basin
Canada
United States
MINNESOTA
LAKE SUPERIOR
WISCONSIN
LAKE MICHIGAN
LAKE HURON
ONTARIO
QUEBEC
LAKE ONTARIO
NEW YORK
LAKE ERIE
PENNSYLVANIA
ILLINOIS
MICHIGAN
INDIANA
OHIO

Figure I

The program operates under the following principles:

- Polluter pays
- Pollution prevention
- Zero discharge
- Ecosystem approach
- Partnerships

Great Lakes Cleanup Fund projects focus on the following priority issues:

- Contaminated sediments (assessment, removal, treatment)
- Wastewater technology (controlling urban runoff)
- Habitat rehabilitation (fish and wildlife)
- Non-point source pollution (rural runoff)
- Communications (technology transfer)

Since its implementation in 1990, the CuF has provided approximately $25 million to over 100 projects. Figure II presents a breakdown of resource allocation by priority area. Another $50 million (Figure III) has been provided by various contributors including other federal agencies, the Ontario Ministries of Environment and Energy (OMOEE) and Natural Resources, municipal governments, regional conservation authorities, private industry and public interest groups.

CONTAMINATED SEDIMENT PROGRAM

One of the first priority areas to be addressed by CuF was contaminated sediments. All but one of the AOCs has beneficial uses impaired by contaminated sediments. Contaminated sediments not only impair benthic organisms directly or through the food chain, but represent a source of pollution to the water column by releasing adsorbed contaminants.

To initiate the sediments program, a notice was published seeking proposals or expressions of interest to demonstrate technology suitable for "safely" removing and then treating contaminated sediments. Approximately 300 companies responded to the treatment notice and 125 to the removal notice. Details on specific technologies for treating contaminated sediments were submitted under the following categories:

• Chemical treatment	16
• Biological treatment	20
• Solidification/Stabilization	18
• Extraction	26
• Incineration	11
• Alternate heat	12
• Pre or Post treatment	12
Total:	115

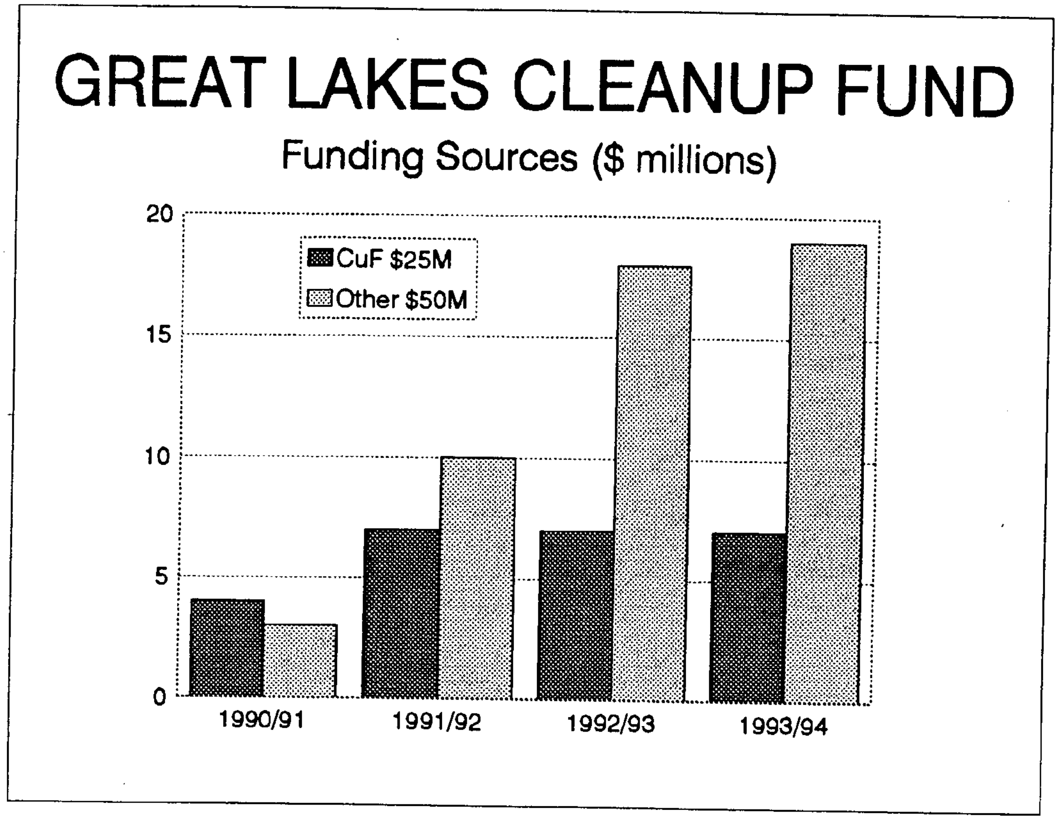

Figure II

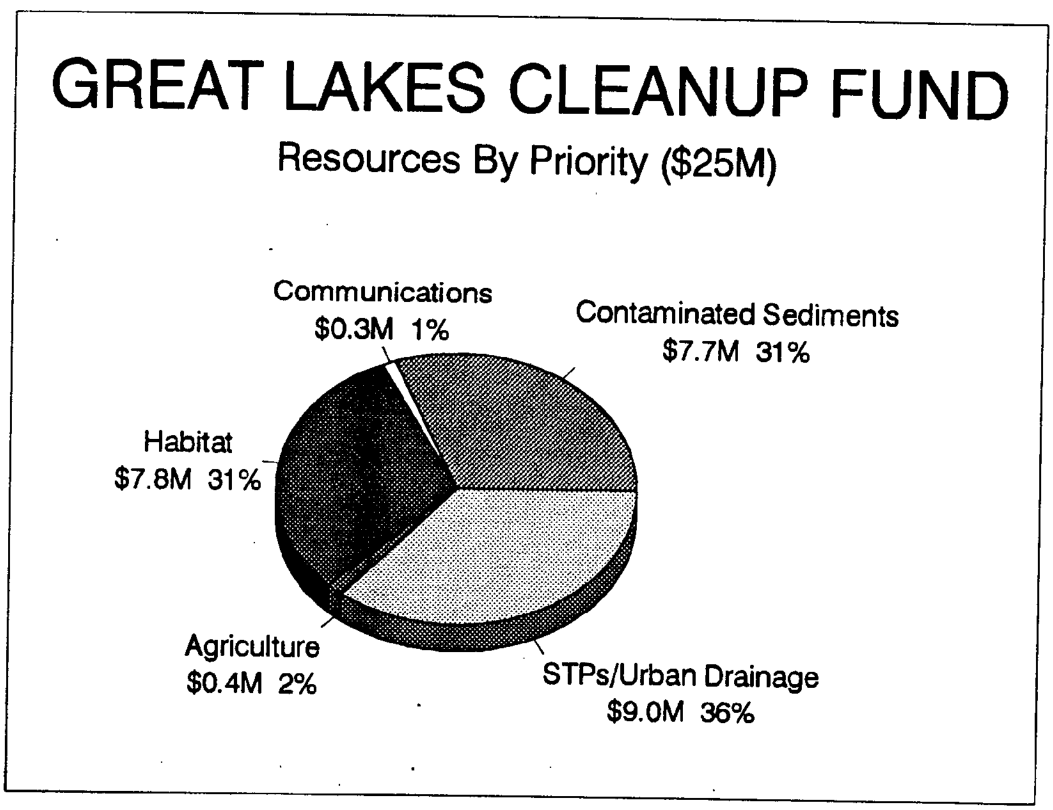

Figure III

Twenty-two treatment technologies were selected for potential bench, pilot and full scale testing.

The responses to the removal program included 60 detailed proposals for technologies to remove, handle, transport and pre-treat sediments with minimal adverse environmental impact. Twelve are believed to be suitable for field demonstration in a number of AOCs.

Since the original notice was published, the Cleanup Fund's Sediment Remediation Program has been expanded to cover a wider range of remediation options including projects on the assessment of contaminated sediments, and demonstration of in-place treatment technology.

CONTAMINATED SEDIMENT ASSESSMENT

One of the measures of success of a sediment remediation technique is a reduction in toxicity to aquatic biota. To help provide a consistent measure of the success of sediment remediation conducted through the Great Lakes Cleanup Fund, Environment Canada's National Water Research Institute has developed a protocol which uses bioassay techniques to determine whether the remediation process has effected a reduction in sediment toxicity. This project is known as the Contaminated Sediment Assessment Project.

In the past, government agencies have tended to designate sediments as contaminated almost exclusively on the basis of bulk chemical analyses. However, if the ultimate concerns of remediation are: 1) the recovery and sustainability of the biological community, and 2) whether the sediment contaminants will continue to stress the ecosystem after controls of point and non-point pollution sources have been implemented, there is a requirement for additional biological assessment.

The suite of tests employed covers a range of organisms with differing ecological requirements. The species used are: 1) the freshwater amphipod *Hyalella azteca* (common name, scud), 2) the chironomid *Chironomus riparius* (common name, midge), 3) the mayfly *Hexagenia* (common name, shad fly), and 4) the tubificid worm *Tubifex tubifex* (common name, sludge worm). These organisms live in or near the bottom sediments of lakes, ponds and streams throughout North America and have desirable characteristics as test species for sediment bioassays (i.e. short generation time, easy to culture in the laboratory, sensitive to many toxicants, etc.).

The route of exposure to sediment contaminants varies with the organisms' burrowing and feeding characteristics. Tubificids burrow in the sediments, ingesting and moving organic particles upward from deeper layers. Therefore, this animal is exposed to contaminants through surface adsorption as well as through ingestion of contaminated particles of sediment. In contrast, epibenthic amphipods live near the surface of sediments and graze on detritus and other organic material near the water-sediment interface. Mayflies and chironomids construct tubes in the sediment and filter organic particles which pass through the tubes from the interstitial waters. Thus each bioassay provides a different exposure route for bioavailability of contaminants.

Three of the bioassays are chronic toxicity tests (the amphipod, chironomid, and mayfly test) which monitor survival and growth as endpoints for determining toxicity. The tubificid bioassay is a reproductive bioassay which evaluates the effects of contaminants on total production of young.

Standardized operating procedures have been established for each species which consist of the following:

Culture and Bioassay Conditions: Bioassays are all conducted in environmental chambers with controlled temperature and light regimes (23$\pm$1 C; 16L:8D) using charcoal-filtered dechlorinated City of Burlington tap water. Sediment in bioassays is allowed to settle for 24 h prior to introduction of animals.

Species-specific conditions for bioassays:

Chironomus riparius

Age/size:	organisms in first instar (approx 72 h from egg deposition)
Chamber:	250 mL beakers with sediment:water ratio 1:4
Density/Beaker:	15 instars/beaker; replication 5 per sediment
Duration:	10 days
Endpoints:	Percent survival; mean growth in dry weight

Hyalella azteca

Age/size:	juvenile instars (approx 1-10 days old)
Chamber:	250 mL beakers with sediment:water ratio 1:4
Density/Beaker:	15 animals/beaker; replication 5 per sediment
Duration:	28 days
Endpoints:	Percent survival; mean growth in dry weight

Hexagenia sp.

Age/size:	5-10 mg wet weight or 6-8 weeks old
Chamber:	1 L glass jars with sediment:water ratio 1:5
Density/Beaker:	10 nymphs/beaker; replication 5 per sediment
Duration:	21 days
Endpoints:	Percent survival; mean growth in dry or wet weight

Tubifex tubifex

Age/size:	approx. 8 week old sexually mature worms
Chamber:	250 mL beaker with sediment:water ratio 1:1
Density/beaker:	4 mature worms; replication 5 per sediment
Duration:	28 days
Endpoints:	Percent survival; reproduction (total young, total cocoons, empty cocoons)

In order to determine remediation success the bioassays are run with a reference sediment from the Canadian Wildlife Service Bird Sanctuary at Long Point, Lake Erie. This allows comparison of results as well as continuous monitoring of the health of culture organisms and the laboratory QA/QC. Moreover, the results from a set of 50 reference sediments, collected from various regions in the near-shore areas of the Great Lakes, are used for comparison. These sediments are from areas known to be "clean" and vary in their physical or chemical characteristics in terms of particle size distribution, organic carbon content etc. Bioassays are also conducted on uncontaminated sediment within the AOC, (e.g. upstream of a point-source) for comparison.

If high cost sediment remediation decisions are to be based on laboratory bioassays, these bioassays must provide a realistic indication of in-place conditions. Due to the unavoidable manipulation of sediment for laboratory bioassays (i.e. removing the sediment from its environment, transporting it to the lab, modifying of the oxygen content through aeration, changing the overlying water, and controlling the temperature, etc.), it is necessary to verify that the responses of test organisms observed in the laboratory reflect conditions at the site where sediment contamination is the principle problem. Therefore, the Cleanup Fund is supporting an In-Place Bioassay project with the Ontario Ministry of Environment and Energy. The fore-mentioned organisms and a few others are put in cages which are placed at the site being investigated. The results of the in-place bioassays are compared to those obtained through laboratory bioassays. A more comprehensive understanding of the forces governing lake bottom community structure and laboratory sediment bioassay endpoints will be obtained through this project. This knowledge will assist in developing remediation strategies for sediment contamination problems.

CONTAMINATED SEDIMENT REMOVAL

The principal objectives of the Sediment Removal Program are to: identify and develop an inventory of existing sediment removal technologies; assist in the development and demonstration of new and innovative sediment removal technologies; and demonstrate to RAP teams and others involved with sediment remediation that sediment removal is a viable remedial option.

To date, 60 detailed proposals to demonstrate innovative technologies for removal of contaminated sediment have been screened and four sediment removal demonstrations have been initiated using three technologies.

DEMONSTRATIONS

In November 1991, approximately 230 cubic metres of sediment, characterized by industrial mill scale and contaminated clay/silt, were removed from the Atlas Specialty Steel site on Welland River (part of the Niagara River AOC) using a modified Mud Cat MC 915 ENV Dredge. The Mud Cat, a horizontal auger suction dredge, was manufactured by Ellicott Machine Corp. The modifications to minimize sediment resuspension, made prior to and during the demonstration, included changes to the auger head, the boom, hull and hydraulic system. An instruments package was added to allow for dredge performance verification. Results showed that use of the modified dredge resulted in little sediment resuspension - all water quality parameters were met, and the operations could have been performed without the use of a silt curtain. The sediment slurry was transported in a floating and land-based flexible pipeline to the company's plant for treatment.

A second demonstration took place in Toronto's inner harbour at the Parliament Street Slip in June 1992. A Cable Arm 100E modified closed clamshell bucket was demonstrated by L.B. Tanker Inc. The Cable Arm 100E is designed with moveable top plates which allow water to pass through the bucket as it submerges. Less downward force is exerted on the water column as the open bucket is lowered, thereby minimizing turbulence. Unlike other mechanical dredging equipment, the Cable Arm clamshell bucket makes a horizontal level cut across the sediment. Approximately 250 cubic metres of sediment were removed with minimal disturbances to the water column. Sediments containing up to 70 percent solids were treated in a three-stage process at the Toronto Harbour Commissioners Soil Recycling Pilot Plant.

In November 1992, a third sediment removal demonstration was carried out in the east and west slips and a portion of the inner harbour of Collingwood. Historically, these slips were used for ship building, and the sediment was found to contain vast quantities of debris including welding rods, rivets, bolts and larger items such as steel bars, cables, barrels and sheets of plastic. A Pneuma Pump, a special three chamber vacuum pump technology, was used to remove 2,000 cubic metres of sediment. The Pneuma Pump was modified by Voyageurs Marine Construction Co. to improve pumping efficiency and maintenance operations. Modifications, including shovels suited to the bottom profile of the harbour allowing it to be more readily embedded in the sediment, and access ports on each cylinder in anticipation of problems with debris, were also made. The Pneuma Pump was submerged into the sediment and pulled along the bottom by a barge. Results are encouraging - the pump was able to remove sediments with a solids concentration of 40 to 50 per cent. This demonstration has led to its full scale application in the remediation of Collingwood Harbour.

CONTAMINATED SEDIMENT TREATMENT

The mandate of the sediment treatment program is to foster the development and demonstration of technologies to remediate contaminated sediment and communicate the results to RAP teams and others involved in sediment remediation. The program has three levels of projects which it is supporting: bench scale, pilot scale, and full scale.

Following the review of the proposals received, 22 technologies were selected for potential bench scale testing. To be selected for demonstration, a technology must be rated superior to other technologies in the same category. The criteria used to evaluate technologies are: technical merit, innovative nature, cost / value, company reputation, laboratory capabilities, environmental benefit, applicability to AOCs, and scale-up potential.

In addition, technologies which are mobile, can treat sediment near the site, and Canadian owned companies, or those companies demonstrating a high level of commitment to establishing themselves in Canada are preferred.

Bench scale demonstrations have been initiated for 17 technologies. To date, 14 have been completed. For those technologies with promising bench scale results, pilot scale demonstrations of four technologies have been initiated in three AOCs.

DEMONSTRATIONS

After bench scale testing using Hamilton Harbour, Thunder Bay and Sheboygan Harbor sediment, the EcoLogic thermal destructor was tested at pilot scale in Hamilton. The Cleanup Fund, OMOEE Environmental Technologies Program and Eli Ecologic funded a demonstration of the technology. The destruction process is based on the theory that at elevated temperatures hydrogen in the gas phase reacts with the organic molecules to produce smaller, lighter and less toxic compounds. The demonstration confirmed that the Destructor will successfully destroy hazardous organic contaminants (particularly polynuclear aromatic hydrocarbons [PAHs]).

A treatment demonstration using sediment removed from the Welland River was conducted using a solid/liquid separation and solids classification process, a series of vibrating screens. A screw classifier and centrifuge were also employed to separate the sediment by grain size. This treatment and classification of the sediment substantially reduced the volume of sediment requiring further treatment.

Approximately 200 cubic metres of sediment removed from the Parliament Street Slip during the Cable Arm removal demonstration was treated at the Toronto Harbour Commissioners (THC) Soil Recycling Facility. The treatment was a three step process beginning with Bergmann USA's soil washing plant, followed by THC-Metanetix metals extraction process, and finally SNC-Lavalin's bioslurry process. The sediment was processed as four distinct (roughly 25 tonne) packages over a four month period. Two of the four packages were treated in the sequence: soils washing, metals extraction, and bioslurry; while the other two were processed in the sequence: soils washing, bioslurry and metals extraction. The soils washing plant efficiently separated the sediment into distinct fractions such as: clean coarse material, highly contaminated fine organics, and contaminated fine sediment. Overall, the demonstration showed that the THC facility reduced the concentrations of metal and organic contaminants in a fine-grained sediment.

Bioremediation of Hamilton Harbour sediments is being tested. This technology is characterized by the addition of proprietary organic amendments, low intensity tillage relative to other land farming processes and strict control of the water content of the material being treated. The organic amendment provides sites at which contaminants, nutrients, water and oxygen are all present, providing an ideal environment for promotion of indigenous bacterial growth and contaminant destruction. The sediment has been placed on a treatment area prepared with two successive layers of both sand and high density polyethylene liner to contain any mobilized contaminants. The demonstration will continue until late 1993.

In addition, Tallon Metal Technologies is currently running Hamilton Harbour sediment through their pilot scale plant. The unit will process approximately 35 cubic metres of sediment and will attempt to reduce both organic and metal contamination below the"Lowest Effect Level" of the Ontario Sediment Quality Guidelines.

To successfully communicate the results of the sediment treatment demonstrations, a sediment treatment technology database (SEDTEC) was created. This database contains hardcopy summaries of technology vendor supplied information for all technologies reviewed by the program. SEDTEC is reviewed annually and is currently in its second edition.

IN-PLACE TREATMENT OF CONTAMINATED SEDIMENT

Treating contaminated sediments in-place is being demonstrated as a potentially less expensive alternative to removal and treatment options. The goal is to accelerate the natural recovery that should occur at many sites, but would take decades without stimulation. Environment Canada's National Water Research Institute has developed a system for injecting treatments into sediments. In-place treatment technologies are still at the early developmental stage, but recent demonstrations in the St. Marys River and Hamilton Harbour are showing promise.

Toxicity in sediments is being treated in-place by injecting an oxidant into the sediment (either ferric chloride or more recently calcium nitrate is used). A boat is used to drag a spray boom through the sediments. The addition of the oxidant reduces the acute toxicity of the sediment by oxidizing hydrogen sulphide to sulphate and enhances bioremediation of organic contaminants in the sediment. Positive results have been obtained in the St. Marys River although long-term monitoring is still being carried out. The St. Marys River demonstration showed that up to 50 percent of the oil in the sediment biodegraded within seven months of treatment. The technique has also been tested at laboratory scale using sediment from the Nipigon Bay AOC.

Successful in-place sediment treatment will i) biodegrade organic compounds (including polynuclear aromatic hydrocarbons [PAHs]), ii) remove acute toxicity to benthos, iii) biodegrade volatile compounds (BTXs, hydrogen sulphide) to reduce odour problems, and iv) flocculate sediments to reduce sediment resuspension during dredging. The potential for cost-savings is great. Conventional dredging will cost 50-200 times more than in-place treatment.

URBAN DRAINAGE

An additional issue being addressed by the Cleanup Fund is urban runoff, specifically combined sewer and stormwater. A study of urban source pollution in Canadian AOCs was commissioned. The study developed techniques, strategies and proposed technologies for the alleviation of problems caused by combined sewer overflows (CSOs) and stormwater discharges. A workshop was held with experts from Europe, England, Canada, and the United States, to discuss the various issues and available technology. A technical committee was then formed with representation from Environment Canada, the Ontario Ministry of Environment and Energy, and the Ontario Municipal Engineers Association.

Current control practices for urban runoff at many sites includes sewer separation, and infiltration and inflow controls through repair and replacement of sewer elements. One of the innovative alternatives being implemented at a few locations is the storage of combined sewage in wet weather, with return of stored combined sewage to the sanitary interceptor in dry weather for treatment. This type of control option is seen to be more cost effective than sewer separation for CSO control.

HABITAT

While technology demonstration projects are underway for contaminated sediments and urban drainage, one of the final products of cleaning up an AOC is the implementation of habitat rehabilitation projects. Destruction and degradation of fish and wildlife habitat have occurred throughout the Great Lakes basin. Loss in the quantity and quality of habitat may be the greatest reason for reduced abundance, and even loss, of species in the Great Lakes. The overall goal of the Cleanup Fund habitat component of the program is to provide funding for projects which embody an ecosystem approach and have the potential to improve habitat quantity and quality from a local, lakewide, and basinwide perspective. We recognize that in order to advance the science of habitat rehabilitation, it is necessary not only to develop and test innovative methods and techniques of habitat rehabilitation, but also to evaluate and document the success of the project.

To date, $7.6 million has been allocated from the Great Lakes Cleanup Fund to initiate 20 habitat rehabilitation projects in Areas of Concern throughout the Great Lakes. Through collaborative efforts with a number of other agencies, study teams have raised an additional $15 million of support for these projects. Collectively, they are aimed at demonstrating capabilities in restoring degraded fish and wildlife habitats, increasing habitat diversity through the expansion of littoral habitats and creation of wetlands, as well as developing experimental techniques to restore historic fish and wildlife populations. Projects are taking place in riverine and coastal environments, and will lead to the development and demonstration of innovative methods for habitat rehabilitation.

CONCLUSION

To meet the GLWQA objective of "restoring and maintaining the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem" is an enormous task for everyone involved. It is obvious that the total cost of cleaning up the Great Lakes will be in the hundreds of millions of dollars. Just as important however, is the need to develop, demonstrate and put in use the proper cleaning technologies and equipment. Both countries must continue to share ideas and solutions for the many Great Lakes Cleanup challenges.