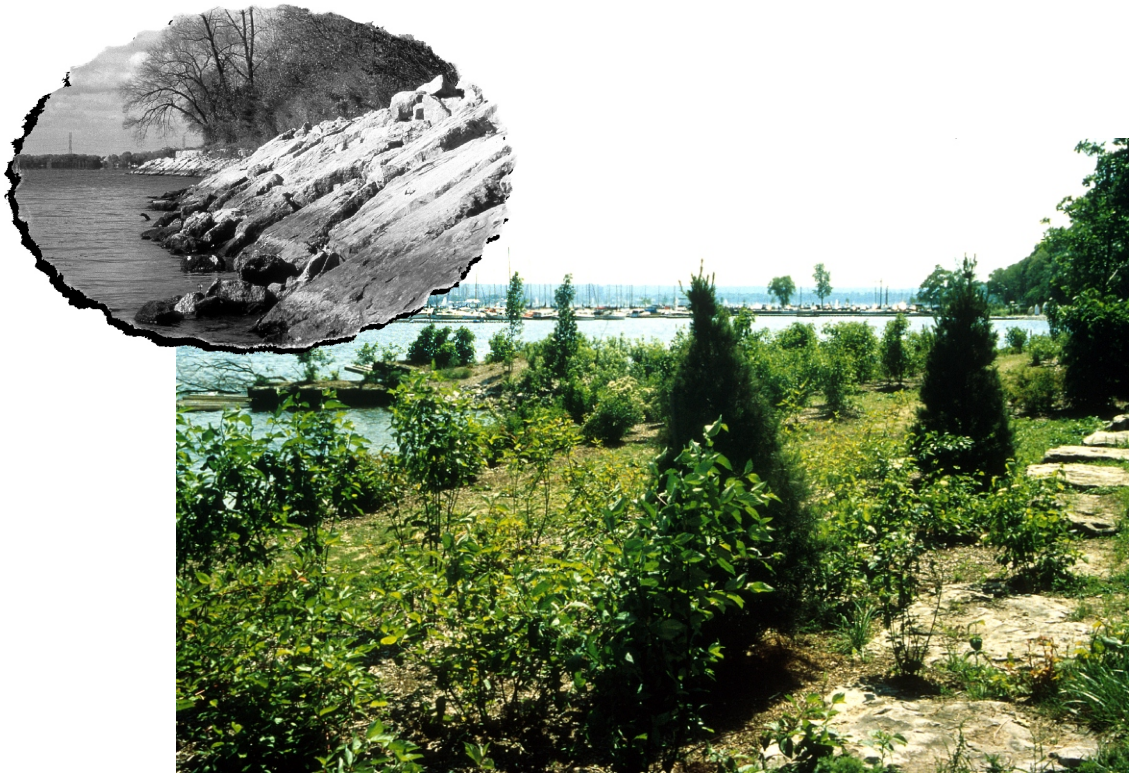
Best Management Practices for soft engineering of Shorelines

Based on a Binational Conference Sponsored by the Greater Detroit American Heritage River Initiative and Partners



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Our tie to history. Our tie to prosperity. Our tie to each other.

Greater Detroit American Heritage River Initiative

The Detroit River was designated as an American Heritage River by President Clinton in July 1998. In Greater Detroit, a multi-stakeholder, action-oriented approach is used to select and implement projects intended to enhance the environmental, economic development, and historic/cultural potential of the 32-mile Detroit riverfront. Program oversight is provided by an Executive Committee composed of:

- Mr. Peter Stroh, Director of The Stroh Companies, Inc. and Chairman of the Executive Committee;
- Detroit Mayor Dennis Archer (Alternate: Ms. Nettie Seabrooks, Chief of Staff to Mayor Archer);
- Wayne County Executive Edward McNamara (Alternate: Mr. Dewitt Henry, Assistant County Executive); and
- Supervisor W. Curt Boller, Supervisor of Brownstown Township and member of the Downriver Community Conference.

A steering committee, chaired by Mr. Mark Breederland of Michigan Sea Grant, and composed of governmental, business, community, and environmental representatives provides advice on project activities to the Executive Committee. Efforts are also coordinated with Canada since the Detroit River is an international boundary. Metropolitan Affairs Coalition (MAC), a public-private partnership of business, labor, and governmental leaders that facilitates solutions to regional issues affecting Southeast Michigan, serves as the project manager and facilitator of the Greater Detroit American Heritage River Initiative.

Dr. John Hartig is the initiative's River Navigator. Dr. Hartig is a federal employee who works with communities to help identify resources to implement high-priority projects. Support for the River Navigator position comes from U.S. Department of Transportation (DOT). DOT partners include the St. Lawrence Seaway Development Corporation, Federal Highway Administration, and the U.S. Coast Guard.

Best Management Practices

for Soft Engineering of Shorelines

Based on a Binational Conference held November 23, 1999
Sponsored by the Greater Detroit American Heritage River Initiative and Partners

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Abstract

Historically, many river shorelines were stabilized and hardened with concrete and steel to protect developments from flooding and erosion, or to accommodate commercial navigation or industry. Typically shorelines were developed for a single purpose. Today, there is growing interest in developing shorelines for multiple purposes so that additional benefits can be accrued. Soft engineering is the use of ecological principles and practices to reduce erosion and achieve the stabilization and safety of shorelines, while enhancing habitat, improving aesthetics, and saving money. The purpose of this best management practices manual is to provide insights and technical advice to local governments, developers, planners, consultants, and industries on when, where, why, and how to incorporate soft engineering of shorelines into shoreline redevelopment projects and reap subsequent benefits. More specific technical advice and contact information can be found in the soft engineering case studies presented in this manual.

Our tie to history. Our tie to prosperity. Our tie to each other.

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Cover Photos

Top: Goose Bay along the Detroit River (Chapter 6)
Bottom: LaSalle Park along Hamilton Harbour, Lake Ontario (Chapter 8)

This report is also available electronically at www.tellusnews.com/ahr/report_cover.html.

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Summary and Overview

The Problem of Single Purpose Shoreline Development

Historically, many river shorelines were stabilized and hardened with concrete and steel to protect developments from flooding and erosion, or to accommodate commercial navigation or industry. Typically shorelines were developed for a single purpose. Today, there is growing support for development of shorelines for multiple purposes so that additional benefits can be accrued.

Up and down our Detroit River, efforts are underway to reshape the riverfront from being concealed in our backyard to becoming the focal point of our attention. General Motors is switching the front door of the Renaissance Center from Jefferson Avenue to the Detroit River with the building of a five-story Wintergarden (Figure 1). The Promenade stretching east from the Renaissance Center will further showcase our river for businesses and residents. In Windsor, another three miles of continuous riverfront greenway were opened in 1999 to promote our river and help create an exciting venue for people to work, play, and socialize downtown. In Wyandotte, a new golf course, rowing club, and greenways have directed attention to our river and have resulted in considerable spin-off benefits. People want to increase access to our river, incorporate trails and walkways to it, improve the aesthetic appearance of the shoreline, and reap recreational, ecological, and economic benefits from it. Our Detroit River has been rediscovered as an incredible asset and a key ingredient in achieving quality of life.

Our Detroit River has been rediscovered as an incredible asset and a key ingredient in achieving quality of life.

Figure 1 General Motors Corporation's Wintergarden at the Renaissance Center facing the Detroit River.

Rendering courtesy of Hines Development and Skidmore Owings & Merrill, LLP Master Architects.

Hard engineering typically has no habitat value for fish or wildlife. Soft engineering incorporates habitat for fish and wildlife.

It is critically important that the right people get involved up-front in redevelopment projects to be able to incorporate principles of soft engineering into future waterfront designs.

Hard vs. Soft Engineering of Shorelines

On November 23, 1999, the Greater Detroit American Heritage River Initiative held its first major stakeholder event to look at options on how to reshape the Detroit River shoreline using techniques of soft engineering. Hard engineering of shorelines is generally defined as the use of concrete breakwalls or steel sheet piling to stabilize shorelines and achieve safety. There are many places along our working river where hard engineering is required for navigational or industrial purposes. Much of the Detroit River shoreline is already hardened. However, there is growing interest in using soft engineering of shorelines in appropriate locations. Soft engineering is the use of ecological principles and practices to reduce erosion and achieve the stabilization and safety of shorelines, while enhancing habitat, improving aesthetics, and saving money. Soft engineering is achieved by using vegetation and other materials to soften the land-water interface, thereby improving ecological features without compromising the engineered integrity of the shoreline.

Rationale for Soft Engineering

Hard engineering typically has no habitat value for fish or wildlife. Soft engineering incorporates habitat for fish and wildlife. The Detroit River is one of the most biologically diverse areas in the Great Lakes Basin. In 1998, the U.S.-Canada State of the Lakes Ecosystem Conference (SOLEC) identified the Detroit River-Lake St. Clair ecosystem as one of 20 Biodiversity Investment Areas in the entire Great Lakes Basin Ecosystem with exceptional diversity of plants, fish, and birds, and the requisite habitats to support them (Reid et al. 1999). The State of the Lakes Ecosystem Conference went on to call for special efforts to protect these unique ecological features. Many people who appreciate the outdoors know that the Detroit River supports a nationally renowned sport fishery. For example, the City of Trenton, located on the Trenton Channel at the lower end of the Detroit River, hosted a major walleye fishing tournament called "Walleye Week" in 1999. "Walleye Week" attracted people from all over North America to compete in the In-Fisherman Professional Walleye Tournament, the Team Walleye Tournament, and the Michigan Walleye Tournament offering $240,000 in prize money. It is estimated that walleye fishing alone brings in $1,000,000 to the economy of communities along the lower Detroit River each spring.

Another reason why soft engineering practices should be encouraged is because it is well recognized that there is limited public access to the Detroit River, particularly on the United States side. Use of multiple-objective soft engineering of shorelines will increase public access to the river.

There are also economic benefits associated with use of soft engineering. In general, soft engineering of shorelines is less expensive than hard engineering of shorelines. Additionally, long-term maintenance costs of soft engineering are generally lower because soft engineering uses living structures, which tend to mature and stabilize with time.

Technology Transfer

Over 200 people attended the November 23rd conference to:

- learn from case studies of soft engineering of shorelines from places like Toronto, Hamilton Harbour, and Thunder Bay, Ontario, the Upper Mississippi River in Minnesota, and the Kenai River in Alaska;
- hear about recent work on cost-benefit analysis of soft vs. hard engineering of shorelines; and
- discuss where and how soft engineering might be used along the Detroit River (see Appendix A for the program and Appendix B for a list of participants).

The soft engineering case studies presented at the conference and additional ones contributed for this

best management practices manual are listed in Table 1.

Participants in the November 23rd soft engineering conference learned that it is important to redevelop and redesign our shorelines for multiple objectives. Shorelines can be stabilized and achieve safety, while increasing public access, enhancing habitat, improving aesthetics, and saving money. Hard engineering of shorelines, in the form of steel sheet piling, can cost as much as $1,000 per linear foot. We cannot afford to use hard engineering along the entire length of the Detroit River shoreline, nor do we want fully hard engineered shorelines because they have no habitat value and will not support the diversity of fish and wildlife found in our river. Participants also learned that hard and soft engineering are not mutually exclusive, there are places where attributes of hard and soft engineering can be used together. This makes sense in a high-flow river like the Detroit River through which the entire upper Great Lakes pass.

It is critically important that the right people get involved up-front in redevelopment projects to be able to incorporate principles of soft engineering into future waterfront designs. The design process must identify opportunities and establish partnerships early in the process which achieve integrated ecological, economic, and societal objectives.

Integrated Approach to Design, Implementation, and Evaluation of Effectiveness

Figure 2 presents one potential design and implementation framework which encourages incorporating soft engineering practices into shoreline developments. As noted above, it is critically important that the right people get involved up-front in shoreline redevelopment projects to be able to incorporate principles of soft engineering into future waterfront designs. However, project leaders must first perform a preliminary assessment which:

- defines the geographic extent of the project or study area;
- inventories existing shoreline uses (habitat, public access, etc.); and
- evaluates existing uses against historical conditions and desired future uses.

A multi-disciplinary team should be formed to reach agreement on goals and multiple objectives for the waterfront and its shoreline.

Table 1 A list of soft engineering case studies presented.

Soft Engineering Case Study	Chapter	Page
Recommendations from the Incidental Habitat and Access Workshop	1	10
Multiple Objective Soil Bioengineering for Riverbank Restoration	2	16
Comparison of Soil Bioengineering and Hard Structures for Shore Erosion Control: Costs and Effectiveness	3	21
MacDonald Park Wetland and Prairie Restoration Project, St. Clair River	4	25
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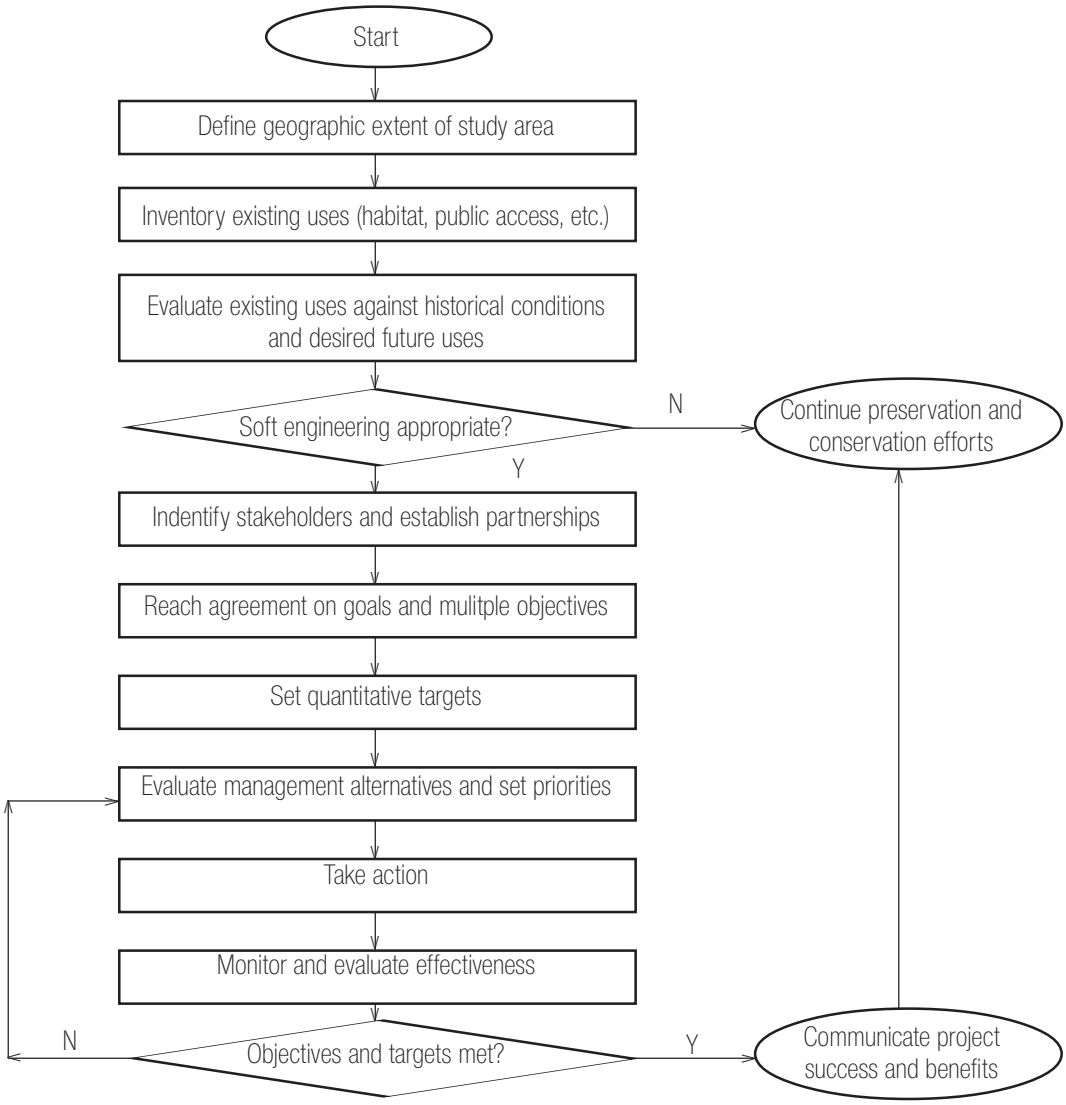
Ford Field Park Streambank Stabilization Project, Rouge River	11	55
Soil Bioengineering for Streambank Protection and Fish Habitat Enhancement, Black Ash Creek	12	62
Achieving Integrated Habitat Enhancement Objectives, Lake Superior	13	66
Battle Creek River, Bringing Back the Banks	14	71

Once agreement on goals and multiple objectives has been reached, the multi-disciplinary team must set quantitative targets to measure progress.

Project leaders must then make a determination of whether or not soft engineering is appropriate. If it is not, resource managers continue with ongoing preservation and conservation efforts. There may also be an opportunity to incorporate habitat in the form of rock rubble at the tow of the hard structure. If soft engineering is appropriate, an inclusive multidisciplinary process will be required to reap the desired benefits. A multidisciplinary team should be formed to reach agreement on goals and multiple objectives for the waterfront and its shoreline. For the design process to be successful, it must identify opportunities and establish partnerships early in the process which achieve integrated ecological, economic, and societal objectives.

Once agreement on goals and multiple objectives has been reached, the multidisciplinary team must set quantitative targets to measure progress. The team next evaluates management alternatives and sets priorities. The preferred management practices are then implemented. Following the implementation of these actions, monitoring is performed to evaluate effectiveness. If objectives are met, project success and its benefits are communicated and management agencies continue with preservation and conservation efforts.

Figure 2 A framework to help incorporate soft engineering practices into shoreline developments.



If objectives and targets are not met, the team evaluates further management alternatives, sets priorities, and takes additional actions in a continuous improvement fashion until objectives and targets are met. Other frameworks may also be as useful to achieve the multiple benefits that soft engineering of shorelines can provide.

Another way of furthering the use of soft engineering practices along shorelines is to make sure that a number of key elements are addressed in the shoreline design and implementation process. Table 2 presents a checklist of key elements to consider in the decision-making process and selected references (i.e., case studies, web sites, literature) for further information. This checklist is designed to help developers, municipal planners, consultants, resource mangers, and others to consider using soft engineering practices in shoreline development projects.

Table 2 **A checklist of key elements to consider in evaluating soft engineering practices for shorelines and related references for further information.**

Key Element	Selected References for Further Information
Stakeholder involvement	Chapter 4 (p. 25); Chapter 9 (p. 46); Tulen et al. (1998)
Forming a multidisciplinary technical team	Chapter 9 (p. 46); Chapter 11 (p. 55); Chapter 13 (p. 66)
Hydraulic constraints and concerns	Chapter 7 (p. 38); Chapter 10 (p. 49); Chapter 14 (p. 71); Federal Interagency Stream Restoration Working Group (1998) (Chapter 2)
Setting goals and multiple objectives for shoreline use	Chapter 2 (p. 16); Chapter 13 (p. 66); Chapter 14 (p. 71); North Shore of Lake Superior Remedial Action Plans and Scollen and Company, Inc. (1998)
Setting quantitative targets	Hartig et al. (1997); Smokorowski et al. (1998); Environmental Canada, Ontario Ministry of Natural Resources, and Ontario Ministry of Environment (1998)
Evaluating alternative designs	Chapter 1 (p. 10); Chapter 2 (p. 16); Hamilton Harbour Remedial Action Plan Writing Team (1992); U.S. Army Corps of Engineers (1997); Federal Interagency Stream Restoration Working Group (1998) (Chapter 5); Fuller (1997); U.S. Army Corps of Engineers (1984); U.S. Army Corps of Engineers (2000); Waldron (1997); Environment Canada (1996)
Monitoring and assessing effectiveness	Federal Interagency Stream Restoration Working Group (1998) (Chapter 6); U.S. Army Corps of Engineers (1997); Jones (1999); Kelso and Hartig (1995); Environment Canada (1999b)
Ecological benefits	Hartig et al. (1997); Jones (1999)
Economic and societal benefits	Chapter 3 (p. 21); Environment Canada (1999a); Environment Canada (2000)
Maintenance	Chapter 1 (p. 10); Henderson et al. (1999); Federal Interagency Stream Restoration Working Group (1998) (Chapter 9)
Safety/ Liability	Schacht (1995); Schueler (1992)
Technical Consultants	U.S. Army Corps of Engineers (1999); Canada-Ontario Agriculture Green Plan (1996); Land and Water, Inc. (2000); U.S. Army Corps of Engineers (1997); Leonard (2000); Society for Ecological Restoration-Ontario Chapter (2000); Canada Centre for Inland Waters (2000); Ontario Streams (1999); Society for Ecological Restoration (2000); Grillmayer (1995); Fuller (1997)

Healthy communities and economies require healthy environments and "green infrastructure."

The time is right to incorporate soft engineering practices into our efforts to redevelop and improve our shorelines. In addition, soft engineering practices should be incorporated in municipal operating manuals and day-to-day operations.

Concluding Remarks

Urban infrastructure is generally understood to mean the substructure (i.e., roads, sewers) and underlying foundation that provides essential community services. For example, communities need basic services provided by roads and sewers. Recently, the concept of "green infrastructure" has been used to communicate importance of the natural resource foundation that provides essential ecological services and related social and economic benefits. Parks, conservation areas, ecological corridors, linked greenways, and open spaces under best management practices all provide essential ecological services and related social and economic benefits.

There are numerous examples around North America that demonstrate that putting money into "green infrastructure" and watershed rehabilitation, enhancement, and protection is not merely a matter of paying for past mistakes, but a sound investment that pays immediate and long-term returns. For example, through the work of the Toronto Waterfront Remedial Action Plan (RAP) and the Toronto Waterfront Regeneration Trust, full costs and benefits of restoration projects in the Lower Don River Valley have been estimated. Capital expenditure on watershed restoration is estimated to be about $964 million (Canadian), along with $1.4 million (Canadian) in annual operating costs. This will lead to capital savings of approximately $42 million (Canadian), annual user benefits of approximately $55 million (Canadian), and annual savings of approximately $11 million (Canadian). In addition, the direct economic development benefits include province-wide increases in income of about $3.6 billion (Canadian) associated with capital investment and $5 billion (Canadian) per year associated with expanded economic activity. Such estimates of full costs and benefits help to provide compelling rationale for watershed management actions.

Further, there is growing recognition of the importance of "green infrastructure" in sustaining our communities, environments, and economies. Healthy communities and economies require healthy environments and "green infrastructure." "Green infrastructure" is a key element for:

- achieving community renewal;
- increasing community awareness, participation, and pride; and
- sustaining communities and economies.

It is the intent of the Greater Detroit American Heritage River Initiative that the advantages of soft engineering practices be recognized and incorporated into many shoreline projects along the Detroit River as a standard for future development. Clearly, greater emphasis must be placed on project evaluation and communication of lessons learned in order to expand the use of soft engineering practices. Participants at the November 23rd conference identified many places where soft engineering practices might be used, including:

- Belle Isle;
- Windsor's Goose Bay on its east waterfront;
- Henderson Park and the promenade in Detroit;
- Hennepin Marsh on Grosse Ile;
- Wayne County's Elizabeth Park and Black Lagoon in Trenton;
- the Gateway Project along the Rouge River within the Automobile National Heritage Area (Figure 3);
- land owned by National Steel Corporation; and
- other projects.

The time is right to incorporate soft engineering practices into our efforts to redevelop and improve our shorelines. In addition, soft engineering practices should be incorporated in municipal operating manuals and day-to-day operations that affect shoreline use and management. Soft engineering projects also lend themselves to volunteer participation. Let's work together to showcase the use of multiple-objective soft engineering practices along the Detroit River shoreline and proudly display our region's new front door.

Figure 3 The concrete channel of the lower Rouge River as it exists today (right) and a graphic depiction of what this portion of the lower Rouge River might look like in the future (below). The vision for this area includes greenways, parks, soft engineering of the shoreline, and mixed use redevelopment.

Photo credit: Wayne County Department of Environment

Design credit: Hamilton Anderson Associates.

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Chapter 1

Recommendations

from the Incidental Habitat and Access Workshop

Philip Moy, University of Wisconsin Sea Grant Institute

Introduction

Many structures have been built along Great Lakes shorelines, harbors, tributaries, connecting channels, and embayments to serve primary engineering functions of shoreline protection, aid to navigation, and other economically related purposes. Such structures include breakwalls, marinas, jetties, intake and discharge channels, confined disposal facilities (CDFs), navigation cells, and dredge spoil islands. They generally have not been designed to create or enhance habitat or to provide public access, but "incidentally" serve such functions to various degrees.

There was interest within the Great Lakes natural resources management community to explore the ways and means of modifying engineered structures in the Great Lakes to provide an economical and ecological "win-win", and to purposefully improve the habitat and recreational value of the structures without adversely affecting their primary engineered purpose. Consequently, the Great Lakes Fishery Commission's Habitat Advisory Board sponsored the Incidental Habitat and Access Workshop in March of 1994. Participants, including engineers, regulators, biologists, planners, and economists, were challenged in a workshop setting to work together on design features for improving incidental habitat and access associated with physical structures. Ideas developed in the workshop are conducive to soft engineering concepts and principles. A synopsis of the workshop is provided here along with basic information about breakwater, revetment components, and information on which features can most easily be modified for enhancing incidental habitat and public access.

Workshop Synopsis

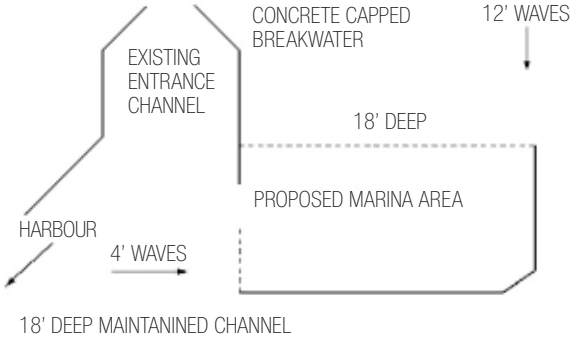
In preparation for the workshop, a questionnaire was sent to 138 Great Lakes resource managers in 1992. They were asked to characterize incidental habitat use in their region. The responses indicated that incidental habitat at Great Lakes structures is an important feature for humans, fish, and wildlife. These structures attract and provide habitat for sport fish and panfish. Incidental habitat also allows anglers access to the fisheries. These structures provide nesting and roosting sites for waterfowl, as well as supporting many human recreational activities.

The structures are constructed of rock of varying sizes, construction and demolition materials (concrete), and sheet pilings. Many structures use a combination of materials, often in different segments. Some structures have features that facilitate access, while others are unimproved. Handicapped accessibility is increasingly common with the inclusion of concrete walks, guardrails, and fishing piers as design features and additions to existing facilities. Sport fishing, from shore and small boats, is the most common human activity. These structures attract fish, intercept seasonal movements, and provide shore anglers access to deeper water. Other human activities associated with the structures include swimming, boating, walking, camping, rowing, diving, picnicing, and sunbathing. Breakwaters that have paved walkways allow anglers and strollers better access to the water than unimproved, rubble mound revetments.

At the workshop, attendees were divided into inter-disciplinary teams. Each team was given a diagram of a physical structure and assigned the task of creating incidental habitat and improving public access. Results of one of the breakout sessions is included here.

This sub-group was given a sketch of a breakwater that provided protection for a harbor and that was used as a navigation aid for an entrance channel (Figure 4). They were also told that a new marina was proposed to be developed adjacent to the existing channel. The results of their deliberations are illustrated in Figure 5. The economic value of the area has been improved by designing the marina as well as improving public access for fishing (boat ramp and fishing access from the breakwall) and hiking (observation platform, footpath, and boardwalk). Concurrently, the ecology of the area has been greatly enhanced by creating a vegetated breakwater between the existing channel and a littoral refuge that creates terrestrial, wetlands, and aquatic habitat. A cross-section through the vegetated breakwater (Figures 6) illustrates how traditional steel sheet piling, widely used in hard engineering approaches, can be used in combination with cobble, geotextile materials, and top soil to create a soft engineered structure that achieves the necessary aid to navigation and shoreline protection, while improving incidental habitat and public access.

Figure 4 **Diagram of a Great Lakes breakwater with hard engineering. Workshop participants were challenged to develop a marina at this site and include soft-engineered incidental habitat and public access features.**



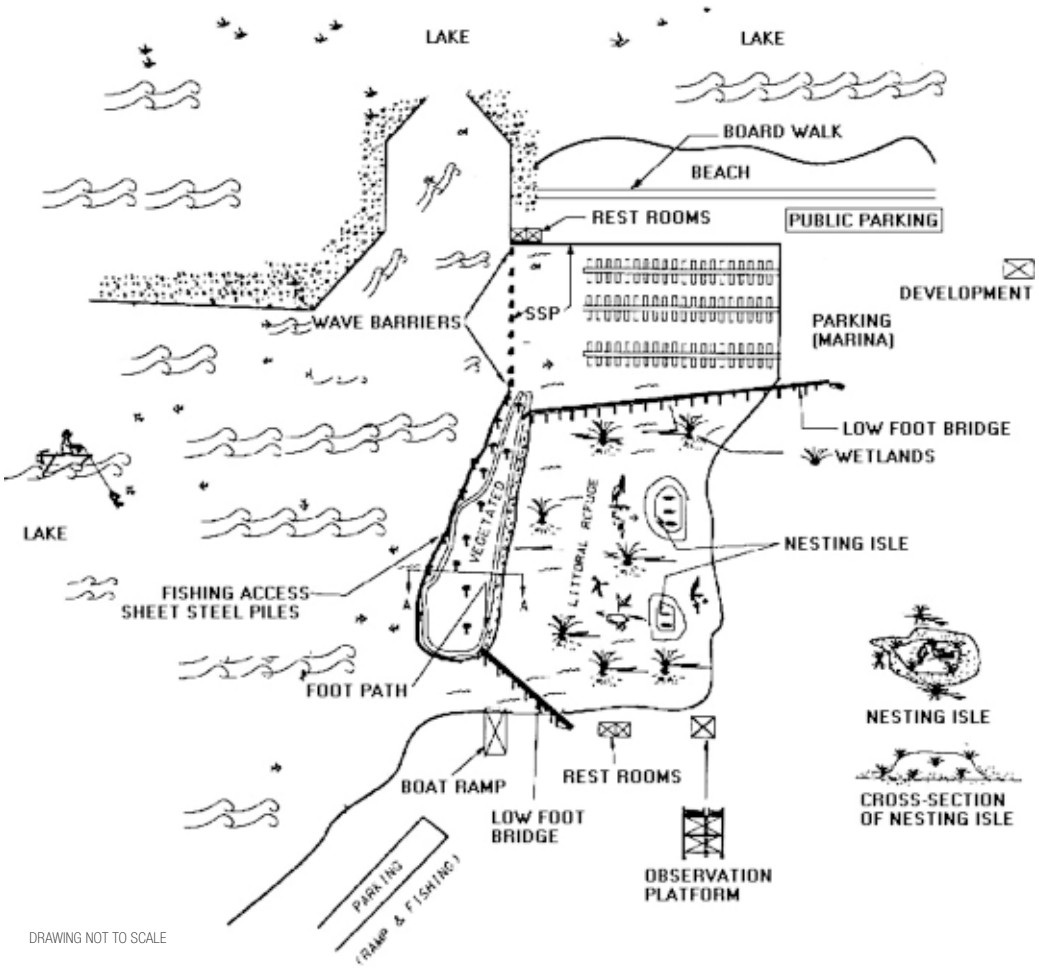
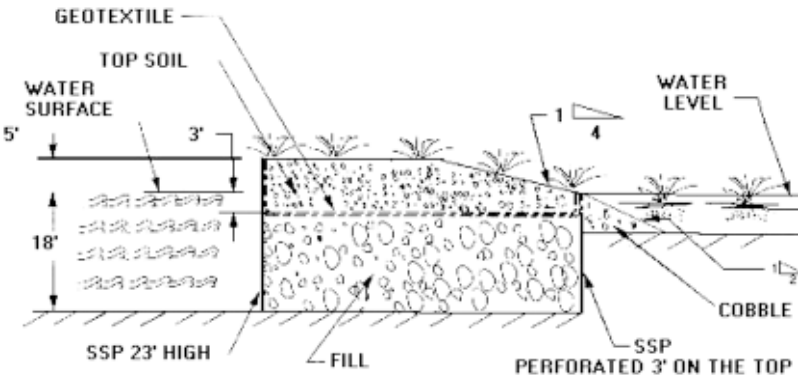


Figure 5 **The same site as in Figure 4 with the soft engineered design features added by workshop participants. See Figure 6 for cross-section view at AA in the middle of Figure 5.**
SSP= steel sheet piling.

Figure 6 **Cross-section view at AA on Figure 5, showing combination of hard and soft engineered features.**
SSP= steel sheet piling.



DRAWING NOT TO SCALE

Workshop participants concluded that it is highly possible to modify the physical features of Great Lakes navigational structures to improve the habitat and recreational value without adversely affecting the primary navigation or shoreline protection purposes. Encouragingly, existing manuals, such as the U.S. Army Corps of Engineers Shore Protection Manual (1984), can be used to create or modify physical structures to enhance incidental habitat, usually with only minor adjustments.

For example, Figure 7 illustrates a cross-section of a rubble mound breakwater; revetments are essentially a half breakwater laying against the shore.

Figure 7 **Typical cross-section of a rubble mound breakwater.**

DRAWING NOT TO SCALE

The main components are the armor stone, core stone, and underlying bedding or mattress stone. The portion of the bottom-most layer that extends from the foot of the structure is toe stone. The armor stone is the largest and most visible stone of the structure, it is what breaks the waves to protect the harbor. The size or weight of the armor stone is determined by the wave or ice forces expected at the location of the structure. The armor stone weight determines the dimensions of the structure and the other material used in the structure. The core stone supports the armor stone, is relatively unexposed for use as either habitat or access, and has little or no flexibility for habitat modification. The bottom layer of the structure, the bedding stone, covers the lake or river bottom to help support the other components. Bedding stone is the smallest stone used in the construction and has more flexibility in the dimension used than the other components. Bedding stone extends out from the foot of the structure and is exposed for use as habitat. Based on information from river and lake ecology, a wide range of rock sizes in the bedding stone will provide a mosaic of micro-habitats for fish food organisms, thereby attracting fish for food and shelter (Gannon et al. 1985).

Workshop participants also concluded that the primary hurdle to overcome when enhancing incidental habitat and public access is improving communication between the agency that constructs or maintains the structure and the entity that desires to improve the habitat. Regulators at the workshop strongly emphasized the importance of including incidental habitat and public access features early in the application and design process. Experience has shown that early and effective communication about public access features and incidental habitat is essential to realize such benefits in waterfront designs.

Including Incidental Habitat and Public Access in the Design Process

Technical information used in the design of U.S. and Canadian Great Lakes coastal structures is based largely on the Shore Protection Manual published by the U.S. Army Corps of Engineers (1984). When presented with a project requiring breakwater or revetment construction/repair, the design team will often use a standard approach. On a lake shore, the design condition may be the expected wave or ice climate; in a riverine environment, the design condition may be the water velocity depth associated with a 100-year flood. Since the standard breakwater or revetment design does not include incidental habitat as a component or consideration, ongoing coordination with the design team throughout the design process is required to ensure incorporation of incidental habitat features.

Interdisciplinary Teams: An interdisciplinary design team of engineers, biologists, planners, and, when appropriate, regulators must be developed. The team should identify potential areas of the structure for incidental habitat improvement, possible means to incorporate them, and engineering constraints. Modification of the incidental habitat proposal may be necessary for the project to remain feasible within the engineering constraints. The team should continue coordination through the development of plans and specifications to assure that the incidental habitat improvements are carried through design to construction.

Regulatory Considerations: In the United States, engineering projects have five basic phases: reconnaissance, feasibility, design, construction, and operation and maintenance. Coordination for a new project begins at the reconnaissance phase, usually through interagency correspondence requesting information on potential impacts to natural resources. Additional coordination may follow during the feasibility phase, as the National Environmental Policy Act (NEPA) document is prepared. This document is either an Environmental Assessment or an Environmental Impact Statement. Once the NEPA documentation is complete, the project can operate for up to 10 years without preparation of new NEPA documents. New documentation during that period is required if there is a significant change in the operation or dimensions of the structure.

Harbor and shoreline protection structures may be operated by a federal, state, municipal, or private entity. The primary federal agency in the United States is the U.S. Army Corps of Engineers; in Canada it is the Department of Fisheries and Oceans. One should contact the appropriate agency as soon as possible regarding incidental habitat possibilities; the earlier coordination begins prior to a maintenance activity, the greater the likelihood that incidental habitat can be incorporated. In addition, it is more cost effective to modify the structure for incidental habitat during regular maintenance activities than to mobilize equipment specifically for incidental habitat modification.

It is easiest to incorporate incidental habitat at the reconnaissance or feasibility phase. It quickly becomes difficult to insert incidental habitat modifications once the project enters the design phase, and is extremely unlikely that incidental habitat modifications presented during construction will be incorporated. It is advised to maintain close coordination with the project manager or design team to ensure that recommended incidental habitat features are included throughout the design process and are included in the plans and specifications for construction.

Maintenance Opportunities: New construction on the Great Lakes is increasingly rare, so maintenance activities offer more opportunities to modify an existing structure for incidental habitat. Stone must periodically be replaced at rubble mound breakwa-

ters and revetments. As the timbers begin to decay and the stone weathers, timber crib breakwaters may be encapsulated with either rubble mound or steel sheet pile (Figures 8 and 9). In this process, the old timber crib is surrounded by a new rubble mound or sheet pile structure. Generally the new structure cannot be higher than the original timber crib structure. Rubble mound encapsulation may not be possible if the larger "footprint" infringes upon the navigation channel or other harbor feature.

Sheet pile encapsulation can provide a smaller cross-section at the base. Part of sheet pile encapsulation involves clearing a driving line in the toe or scour stone for the sheet piles at the base of the crib. Instead of removing this old stone from the site, consider placing it nearby to form a small reef (Figure 9), or consider creating a central "disposal" location for the old rock. With material from other maintenance projects this location can become an artificial reef (Gannon 1990). Determine whether there is any flexibility in the size of new scour stone to be used at the project. In addition, sheet pile encapsulation can allow the addition of a concrete cap to provide a smooth walkway.

Figure 8 Typical cross-section of a rubble mound encapsulation.

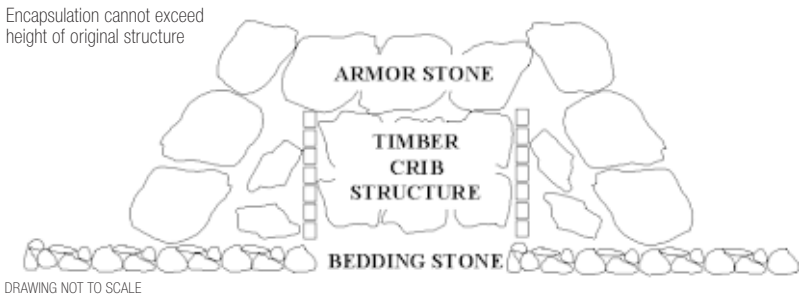
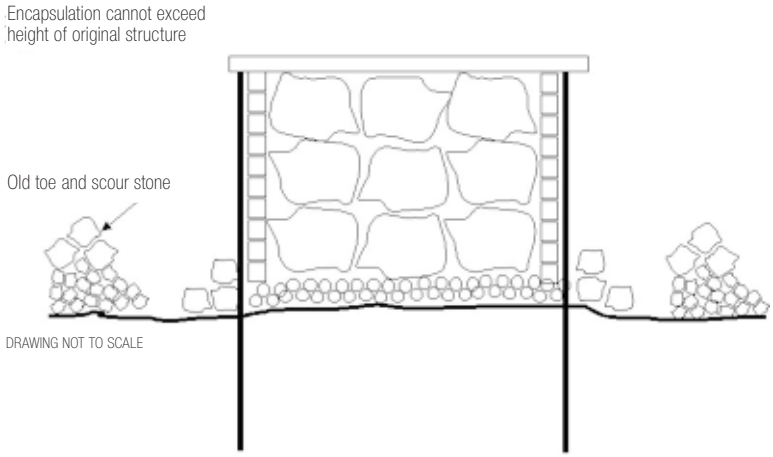


Figure 9 Typical cross-section of a sheet pile encapsulation.



Aesthetics and Biodiversity: It is advised to use a variety of textures and vegetation to make accessible areas aesthetically pleasing; use curves rather than straight lines. Non-traditional materials can be incorporated into the structure to diversify the habitat. Vegetation, stone, or wood can be combined to diversify habitat complexity and gradients to help maximize biodiversity. Woody material such as root-wads, brush piles, timbers, or native, endangered, or threatened plants should be used if possible. Water velocity or depth should be varied. Other questions to consider include:

- Is it possible to include wetlands or shallows?
- Are there educational or research opportunities?

One should consider optimal patch use and island biogeography in development of habitat at man-made structures.

Assess Ecosystem Impacts: All projects produce many impacts on the ecosystem. Asking a few questions before the project starts can help to determine what type of projects should be used. One should assess existing conditions and needs in a watershed, ecosystem, or regional context. What are the indirect and cumulative impacts of the project? Will the project have local or regional impacts? Will there have to be a trade-off of resource impacts? How will the proposed project impact existing resources? By answering these and other questions, the project can produce maximum benefits.

Public Access Considerations: What types of access are desired? What kinds of opportunities will be created by

improved access? How much access is desirable or acceptable? Should access be restricted in some areas to create refuges for fish or waterfowl? How will people be managed to avoid conflicts between uses, privacy, and operation and maintenance activities? One should develop project management plans that include human and wildlife users. Structures that attract fish also attract anglers. Fixed or floating fishing platforms and boat ramps improve angler access. Consider non-angling activities too; add parking, sanitary facilities, and picnic areas. Providing access to the water and creating attractive habitat can enhance urban recreation opportunities. Access should be barrier-free or barrier-reduced to make the experience available to as many users as possible.

Project Evaluation

Monitoring Plan: In order to improve future projects, one should develop a monitoring plan to determine whether the incidental habitat modification was beneficial or successful. The plan should monitor fish, wildlife, and human use of the area before and after the project. Recognize that it may take years for algae, macroinvertebrates, and other forage organisms to colonize the structure. Monitoring and research will help determine how to improve incidental habitat and what habitat and access features should be included at new and existing facilities.

Reporting: Once the success (or failure) of the incidental habitat has been determined, the results should be reported so that others may benefit from the experience. A report should be distributed to all agencies involved and the results posted on the Internet through the Great Lakes Information Network (GLIN; http://www.great-lakes.net). If the incidental habitat modification was not successful, consider how to modify the design and what operational changes to make. Operational changes may be implemented relatively quickly; design changes may have to wait for funding or until routine maintenance is required. An incidental habitat guidance manual describing successful projects and suggested approaches should be developed for planners, developers, and regulators.

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Chapter 2

Multiple Objective

Soil Bioengineering for Riverbank Restoration

Alton Simms and Robbin Sotir, Robbin B. Sotir & Associates, Inc.

Introduction

Today, stream and riverbank protection efforts are expected to address issues such as habitat, aesthetics, and water quality in addition to such needs as flood control and erosion protection. It is common knowledge that integrated streambank protection designs that include vegetation are likely to satisfy these multiple objectives. Soil bioengineering systems utilize vegetation as a principal component and can provide sound streambank protection while maximizing ecological and water quality benefits. Streambank protection designs that consist of riprap, concrete, or other inert structures alone are being accepted less frequently because of their lack of environmental and aesthetic benefits. Consequently, there is greater interest in designs that combine vegetation and inert materials into living systems that can reduce erosion while providing environmental and aesthetic benefits. This integratable technology is therefore responsive to these increasing concerns.

This case study describes soil bioengineering systems that have been used to meet specific aquatic and riparian habitat objectives, such as providing overhanging cover for fish and riparian habitat. Examples are presented to illustrate the use of these systems.

Information has been prepared in tabular form that may be a useful guide for evaluating alternative soil bioengineering streambank protection measures and selecting those that best achieve the desired project objectives (Table 3). This procedure has been developed and used on several projects where environmental objectives were major concerns, including a major sport fishing stream in Alaska and the Ottawa River in Canada, which divides the Provinces of Ontario and Quebec.

Environmental Benefits of Soil Bioengineering Systems

Soil bioengineering systems for stream and riverbank protection consist of structural engineering components and integrated ecological systems that provide protection for the entire riverbank over a reach or an entire system. There may be several soil bioengineering components capable of providing erosion protection for a given site, depending on the type of erosion or failure problem that exists. The specific design chosen may depend on several factors, including the level of risk that is acceptable, cost, and/or environmental and aesthetic objectives.

Table 3 summarizes the flood conveyance, habitat, water quality, recreation, and aesthetic benefits. Table 4 summarizes the major environmental benefits of the most common soil bioengineering methods employed in streambank protection that utilize woody vegetation. Such tables can be useful in helping to select specific soil bioengineering methods that can be incorporated into streambank protection designs to maximize specific environmental requirements. For example, the branches that overhang the water along the riverbank provide shade and protection from predators making it an excellent choice as part of a bank protection system on streams where such habitat is scarce. There may be other constraints that affect the choice however. Some methods might cause too much flow constriction or might cause erosion of the opposing bank if used on very small systems. However, this is not typical in the case of rivers. All of the soil bioengineering methods have a common geotechnical benefit of providing root reinforcement in the soil mantle. The more deeply installed methods, such as brushlayer,

positively affect the direction of seepage. Hydrologically, these methods serve as horizontal drains converting parallel flow to vertical flow. Hydraulically, vegetation reduces velocities and redirect flows. Soil bioengineering projects are typically considered aesthetically pleasing and become more so over time.

Table 3 **A matrix to help compare the benefits of different streambank protection measures.**

Method	Flood Conveyance	Aquatic Habitat	Riparian Habitat	Water Quality	Recreation	Aesthetic
Live Staking	negligible, except on small streams	fair to good	good	negligible, except on small streams	poor to fair	good
Live Fascines	negligible, except on small streams	good to very good	good	negligible, except on small streams	fair to good	good to very good
Branch-Packing	none	negligible	fair	negligible	negligible	fair
Vegetated Geogrid	negligible to high flows, depends on stream size and design	good to excellent	fair to good	good on small and medium streams	good	good to excellent
Live Cribwall	negligible to high flows, depends on stream size and design	good to very good	fair	fair on small and medium streams	negligible	good to very good
Joint Planting	negligible, except on small streams	fair to good	good	negligible, except on small streams	fair	good to very good
Brush-Mattress	negligible, except on small streams	good	very good to excellent	fair to good	fair to good	good to excellent
Live Bloom	varies, negligible if length less than $^1/_4$ channel width and height less than $^1/_2$ bank height	excellent	negligible to fair	good	fair to good	fair to good
Conventional Vegetation	negligible, except on small streams and none if maintained	negligible to good	fair	negligible to fair	fair	good
Tree Reventment	none	fair to good	negligible	negligible	none	fair

Table 4 **Environmental benefits of soil bioengineering for streambank protection.**

Method	Create or Preserve Scour Holes	Shade and Overhang	Riparian Habitat
Vegetated Geogrid	good	excelent	fair to good
Live Cribwall	very good	excellent	fair to good
Live Boom(s)	excellent	very good	not applicable
Live Siltation Construction	not applicable	excellent	very good to excellent
Brush-Mattress	not applicable	good to very good	excellent
Live Fascine	not applicable	good	good to very good

Figure 10 Soil preparation along the shoreline of Jacques Cartier Park.

Figure 11 Placement of live fascines on contour with erosion control fabric along the Jacques Cartier Park.

Figure 12 Vegetated shoreline resulting from the use of bioengineering techniques in Jacques Cartier Park.

The species of woody vegetation selected for inclusion in soil bioengineering systems can have a significant effect on the habitat benefits. Various species of willow are the most common woody plants used in soil bioengineering because of their excellent rooting ability. While willow can provide good overhanging cover and shade for streams, good nesting habitat for some species of birds, and some cover for mammals, it is not noted as an excellent food source for land animals. There are other plants that may be better choices for accomplishing specific habitat objectives. Such plants can be added to soil bioengineering designs to provide specific habitat benefits for target species. Chapter 18 of the Natural Resources Conservation Service Engineering Field Handbook (Soil Bioengineering for Upland Slope Protection and Erosion Reduction) provides information about growth habits, habitat value, and rooting characteristics for a variety of plants adapted in the United States.

Ottawa River

In 1996, Public Works and Government Services Canada undertook the stabilizing and remediation of a biomedical disposal site along the banks of the Ottawa River in Hull, Quebec, Canada. This site is situated adjacent to a highly visible, popular, and passive recreational green space known as Jacques Cartier Park. This area offers spectacular views of the River and Parliment Hill (Ottawa) on the opposite bank.

As part of the remediation of the site, excavation of the contaminated soils and materials was replaced with a sand/clay subsoil mix (Figure 10). The resulting embankment was then topped off with an approved topsoil blend. Due to the steepness of the constructed slope and the river below, surface stability was of vital importance. This was accomplished via the use of live fascines on the contour with erosion control fabric known as coir (Figure 11).

Other project objectives included: preparing a foundation, where over time a natural community of indigenous plant materials for upland and riverine habitat would evolve; improving aesthetics; and establishing a long-term, maintenance-free natural slope along the Ottawa River within its highly urbanized context. The success of this project to meet the desired goals enabled Public Works to designate the area as an extension of Jacques Cartier Park (Figure 12).

Kenai River

The Kenai River in Alaska is a world class sport fishing stream noted for its trophy Chinook salmon fishing. In heavily used public access areas, such as Soldotna Creek Park and Centennial Park, bank vegetation had been destroyed by foot traffic and the streambank was eroding rapidly (Figure 13). Because of the potential impacts on rearing habitat and movement of young Chinook, Alaska Fish and Game would not permit dikes of any kind or hard structures such as bulkheads. They also discouraged the use of riprap above the elevation of the ordinary high water-mark.

Figure 13 **Rapid streambank erosion caused by heavy public use along the Kenai River in Alaska.**

Figure 14 **Overhanging cover was provided by live siltation and live cribwall constructions along the Kenai River.**

Figure 15 **Large rocks placed in front of the live cribwalls provided additional fish cover.**

A 650 foot section of streambank at Soldotna Creek Park was stabilized using soil bioengineering methods. Overhanging cover was provided by live siltation constructions and live cribwalls (Figure 14). In wet areas, native sod rolls and live fascines were used to stabilize the bank line and reestablish vegetation. Large rocks, placed randomly in the shallow water in front of the live cribwalls, and small rootwads, anchored further out, were used to create additional fish cover (Figure 15). The soil bioengineering installations survived the 1995 flood, the largest on record, with minimal damage. This same flood ravaged banks protected with riprap and other hard structures.

Summary

Water resource projects, by their very nature, involve multiple objectives, and streambank protection is no exception. In addition to controlling erosion, we must meet water quality, habitat, aesthetics, and other environmental objectives. Integrated soil bioengineering designs that employ woody vegetation meet these environmental objectives better than other types of streambank protection alone. Maximum benefits are derived by choosing soil bioengineering methods and selecting the vegetation to achieve specific environmental objectives. The success of soil bioengineering on the Ottawa River and the Kenai River indicates that this approach to riverbank protection and restoration is applicable to address multiple objective goals.

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Comparison of

Soil Bioengineering and Hard Structures for Shore Erosion Control: Costs and Effectiveness

Tim Patterson, Environment Canada

Introduction

The objective of this case study is to compare the costs and effectiveness associated with both soil bioengineering and hard structures. Through research, the common principles and materials used in bioengineering were discovered. An investigation of how these principles were applied to various sites across Southern Ontario was then conducted. This included visitation of the sites, as well as interviews with people involved.

Manufactured "hard" structures designed to prevent erosion will often become cracked and damaged as they age. Since they are "dead" materials, they cannot maintain or repair themselves as plant materials can. Hard structures do, however, provide immediate effective erosion control against severe elements that would wash away newly placed plant materials. This is especially true for lake front lands. For this reason, some constructed bioengineered sites incorporate hard structures.

The main thrust of bioengineering involves the harvesting and planting of dormant cuttings or branches from tree and plant species in order to provide a natural basis for erosion control. These cuttings are arranged into individual stakes (live stakes) and/or put into bundles. These bundles can be arranged in a variety of ways. The most common arrangements are called fascines, brushlayers, and brushmattresses. Cuttings are usually taken from dogwoods and/or willows. This is mainly because the cut branches of these species are able to take root and grow on their own. As the cuttings grow and extend their root structure, the soil becomes more stable.

Bioengineering is used as a natural, long-term solution to erosion control. A bioengineered site is considered successful when there is little or no evidence of human intervention, usually several years after planting. The site should become better protected with time. For example, cuttings planted into a bank beside a watercourse can go through additional stages of erosion control for the bank. The cuttings add a bit of protection against soil sliding down the bank, immediately after being planted. Roots from the cuttings begin to hold the soil together more as they grow and interconnect with each other. Eventually, some of these roots will likely extend out into the watercourse, slowing down flows and creating fish habitat. As the trees mature more, the thicker roots in the watercourse are able to partially deflect flows away from the bank, decreasing erosion. During flooding conditions, these roots not only help protect against erosion, but can trap soil, sand, and small stones which add to the bank material.

For the majority of applications in bioengineering, the only types of tree cuttings that may be successfully used are those that can grow on their own after being cut (when dormant). There are three common types of trees in Ontario that can provide such cuttings: willows, dogwoods, and poplars. Willow and dogwood cuttings are the most commonly used for bioengineering projects. Although these species are used to establish a firm root structure in the soil, native plants tend to invade a bioengineered site over time, mixing in with the willows and dogwoods. These invading species usually do not harm the integrity of the bioengineered site and are often beneficial in aiding to the root structure.

The technique of bioengineering is becoming more popular among

municipalities and Conservation Authorities (CAs) in Ontario. Where most municipalities and CAs did not incorporate bioengineering techniques only 10 years ago, most do today for at least some of their erosion control projects.

There are two main reasons municipalities and CAs choose bioengineering over concrete and steel. The first reason is that it is considered to be more environmentally friendly. The second reason is financial. For most sites, it is actually cheaper to implement bioengineering than it is to create a hard structure, especially for the long term. Material, transportation, and labor costs are generally more expensive for hard structures.

The main reason that some local governments do not choose to utilize bioengineering is because they are unsure of its effectiveness. Bioengineering principles are relatively unknown (although not unproven), and thus an uncertain solution to erosion in the minds of many. The limits of the ability of bioengineered sites to resist erosion are even less certain and very site specific.

Because municipalities typically have larger budgets than CAs, some of the best combinations of bioengineering techniques can be found at projects paid for by cities. Often, these techniques are in combination with hard structures.

Costs

Costs vary for different types of bioengineering techniques. There is often no cost for labor and/or materials. Labor is often done by volunteers. Materials, such as cuttings for live stakes, fascines, and brushlayers are sometimes found either on or off site, or are donated.

Hard structures have a specific design life to them, but bioengineering designs typically do not. This may be partly because bioengineering was little used in North America 10 years ago compared to its use now, so there are few projects older than 10 years to compare with (except for sites in Europe). While this may be true, the theory behind bioengineered designs is that they are living and self-repairing. Once established with a good design, they increase in strength, and after a period of 2 to 3 years they should be capable of resisting high stream flows. They should also be capable of self-repair. Branches or roots that become broken or die are gradually replaced with more growth. Since hard structures cannot repair themselves, they require long-term maintenance. This means that the gap in costs between a hard structure and a bioengineered site will continually grow.

Most of the case studies detailed have successfully achieved stable erosion control using bioengineering. Proper planning and adaptation to site conditions played a big role in these successes. This included knowing the limitations to each type of planting or soft structure and deciding if and where they should be used. Recognizing where rip-rap or rocks should be used instead of, or in conjunction with, a soft structure was also very important.

Although careful planning went into most of the case studies, unforeseen or unanticipated problems have occurred at some sites, resulting in partial or complete failures in the bioengineering designs. There are many problems that can occur due to the combined complexities of factors such as the characteristics of tree species used, soil conditions, local climate, random storm events, immediate and surrounding land use, area wildlife, pedestrian traffic, skill of the laborers, and the project design, among other things.

The success of a bioengineered site can only be conclusively determined after the first 2 or 3 years. Live stakes, fascines, brushlayers, and brushmattresses are very vulnerable to poor site conditions, erosion, and vandalism during this time, while their root structures are growing. It is essential that the required amount of sunlight and soil moisture, necessary for the species of cuttings used, be a part of the site conditions, as this was the main reason for failed areas of sites in the case studies.

Natural channel design goes well with bioengineering. Because this involves the removal or relocation of soil, this adds to the cost considerably.

Bioengineering could still use more public and municipal support. Although it is becoming a popular alternative to hard structures, there are still some municipalities that seldom or never use bioengineering designs. This support should come gradually, as the overall effectiveness of bioengineering projects become better known and understood.

Bioengineering is much more widely used in riverine environments over lake shores. This accounts for the fact that few case studies involve lake shore sites. Where bioengineering is used at such sites, it is often in combination with hard structures such as armorstone or boulders. This is because the erosive force of waves along a shoreline is frequent and usually too overpowering to allow tree cuttings to grow, even if aided by geotextiles and cribwalls. For adequate erosion control in many low flow creeks, however, hard structures may be limited or avoided altogether in favor of bioengineering.

Comparing costs taken from the case studies, live stakes, fascines, brushlayers, brushmattresses, root wads, and log jams are the lowest costing components of bioengineering, followed by geotextiles, rip-rap, and live cribwalls (Table 5). Natural channel design is above these costs. Hard structures cost even more (Table 6).

Bioengineering in a riverine environment is usually significantly less expensive than hard structures on a per meter basis (Figure 16). Comparing natural channel design case studies with large concrete channels, the difference is about threefold. Comparing case studies using basic bioengineering designs with those using large concrete channels, the difference is even more, depending on site conditions.

Environmental Benefits

In addition to the cost benefits of bioengineering, the environmental benefits, which are not as easily measured, are an important factor. Wildlife habitat, green space, and aesthetic qualities are in high demand. This is apparent by the number of citizens' and special interest groups that have made contributions to several case studies.

Lack of information and understanding is a big obstacle to soft engineering practices. Authoritative guidelines for soft engineering are not nearly as abundant, or as clear, as specifications that exist for hard structures. Municipalities and other government bodies will be more likely to approve soft engineering designs if specifications are known and carry the same weight as those for hard structures.

Table 5 Unit costs of selected materials or components of bioengineering.

Item	Cost
Live stakes (each)	$ 0.50
Geotextile netting (per m^2)	$ 1.46
Geotextile filter material 270R (per m^2)	$ 1.74
Aquatic plants (each)	$ 2.00
Cuttings for brushlayers and brush-mattresses (bundle of 50, 1-3 m long)	$ 8.50
Rip-rap (per ton)	$ 14.40
Cedar poles for cribwalls (3 m each)	$ 20.00
Fascines (5 m length)	$ 35.00
Root wads (each)	$ 35.00
Coir logs (m)	$ 80.00
Constructed cribwall (m)	$182.26

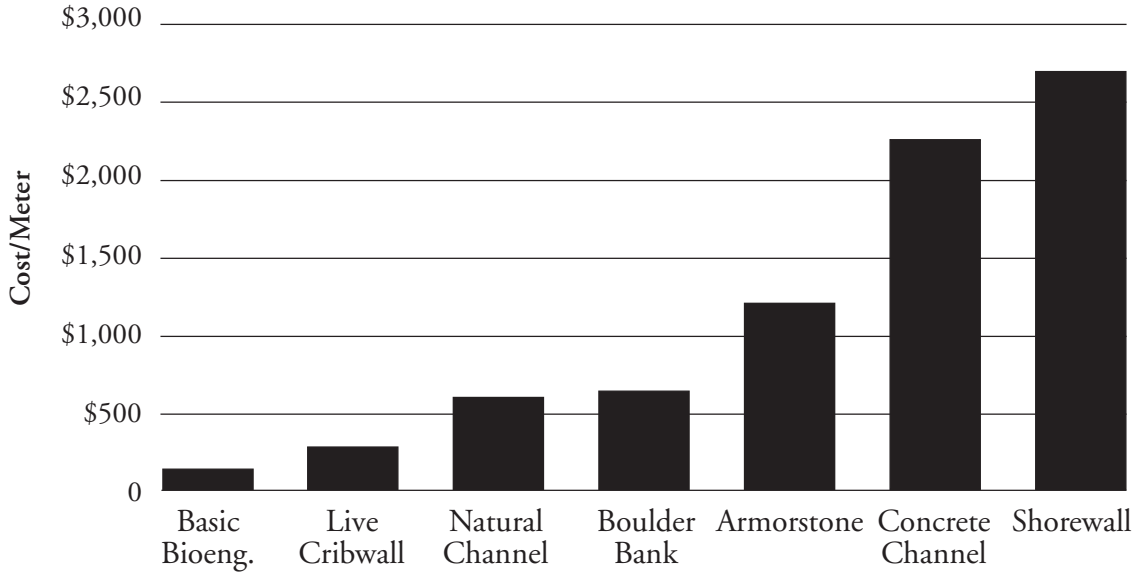
Sources: City of Mississauga, Cooksville Creek Tender Contract; Environment Network; Grillmayer, 1995; Belton Industries, Inc.; Brad Glasman, personal communication.

Table 6 Sample costs per meter of hard structures.

Item	Cost
1996 Rip-rap – 400-900 mm diameter	$ 656
1997 Concrete storm sewer extension – 750 mm diameter	$ 797
1996 Armorstone wall on Binbrook Lake	$ 984
1985 Armorstone average cost for Lake Ontario 20 year design	$ 1,225
1993 Armorstone wall on Lake Superior	$ 1,500
1994 Shorewall on Lake Ontario	$ 1,981
1998 Shorewall on Lake Ontario	$ 3,364

Sources: Ken Cullis & Jake Vander Wal, personal communication; Joe Hollick, personal communication; Otonabee Region Conservation Authority, Scott's Plains Park Tender Contract; R.V. Anderson Associates Ltd., 1992.

Figure 16 The cost for bioengineering compared to hard structures (cost/meter).



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MacDonald Park

Wetland and Prairie Restoration Project
St. Clair River, Ontario, Canada

Don Hector, Ontario Ministry of Natural Resources.

Introduction

A wetland and prairie restoration project was carried out in a day-use park area (MacDonald Park) along the St. Clair River (Chenal Ecarte) from September 1995 to July 1997. MacDonald Park is one of 17 river-side park areas owned and managed by the St. Clair Parkway Commission. Use of this network of parks includes picnicking, camping, boat launching/mooring, swimming, and associated passive recreational activities. This particular site was chosen due to its high potential for a variety of aquatic and upland restoration techniques, the visibility and accessibility along a commonly traveled roadway, and the strong interest of the landowner (St. Clair Parkway Commission). The project involved the creation of 1 ha (2.5 acres) of wetland, 1 ha (2.5 acres) of Tallgrass Prairie complete with an interpretive trail, improvement of 200 m (219 yards) of shoreline riparian area, and interpretive signs and brochures.

Project Goals

The work was initiated through the St.Clair River Remedial Action Plan (RAP) process in order to help restore fish and wildlife habitat in the St. Clair River watershed. This particular project was one of 28 areas originally identified in an earlier report (Survey of Candidate Sites on the St. Clair and Detroit River for Potential Habitat Rehabilitation/Enhancement). Creation of wetlands, improvement of shoreline riparian areas, and establishment of Tallgrass Prairie habitat were the main objectives. The secondary objectives were to use this project as a key demonstration area for a variety of aquatic and riparian restoration techniques.

Project Description

The original site consisted of maintained grass, used mainly as a picnic area. The wetland component consisted of the excavation of 4,588 cubic meters (6,000 cubic yards) of material, treatment of the littoral areas with topsoil, and stabilization using a biodegradable coir mat. A variety of wildlife and fisheries components were included; spawning mounds, submerged habitat structures, aquatic vegetation plantings, and basking logs. These components were placed in the newly created wetland area. The bank areas of the wetland were planted with shrubs.

Shoreline areas surrounding the site and bordering dredged canal areas were reshaped, gently sloped, and stabilized using live willow stakes and brush bundles to establish riparian cover and as a means to reduce erosion. Planting of aquatic vegetation in the nearshore waters adjacent to these areas occurred in a subsequent phase. Experimental biolog floating barriers and bogmat islands were installed to establish in-water structure and provide erosion protection to local shoreline areas. Approximately 200 m (219 yards) of shoreline area were rehabilitated using these techniques.

In the 1 ha (2.5 acres) upland site, 22,000 Tallgrass Prairie plugs of 23 different forb (flower) and grass species were planted. A slightly elevated horseshoe shaped trail system was constructed using excavated material from the wetland area to allow trail users an improved view of the prairie plant species, at the height of their growing season.

Regulatory Considerations

The project was subject to both provincial and federal environmental assessment act requirements. Through this process, including a series of public notices, no significant environmental impacts were identified and the project proceeded with minor modifications. A number of positive suggestions and offers of volunteer help from local landowners were also received.

Project Evaluation

A variety of qualitative and quantitative monitoring has occurred on the site. A fish inventory was undertaken in the newly created wetland in late August 1996, one month following the completion of the wetland component. These results indicated four fish species present in the system: largemouth bass, bluegill, central mudminnow, and an esocid species. In 1997, young-of-the-year northern pike and largemouth bass were documented in the wetland area. Visual monitoring of both the wetland and prairie components have indicated excellent establishment of plant communities. Informal records are being maintained for amphibians, birds, and reptiles that appear at the project site. A butterfly count, through the North American Butterfly Association, was also organized to monitor butterfly use of the prairie habitat.

Project Benefits

Although the total area of habitat created was relatively small (2 ha or 5 acres), the benefits of this project lie in its demonstration value, both visually and as an example of how local community groups can make a meaningful contribution to the environment. It is also an example of how some of the traditional views of waterfront park design or usage can be broadened. These new concepts and techniques can be transferred to many other shoreline park areas along the Great Lakes, particularly where artificial steel or concrete shorelines are predominant. The St. Clair Parkway Commission is extremely pleased with the results of this project and are interested in exploring further habitat restoration projects along their other waterfront park properties. This site continues to be of interest to new groups wishing to become involved in activities at this site. For example, a turtle nesting habitat project was completed on site and a prescribed burn was carried out in 1999, with another one proposed for spring 2000.

Funding and Partners

This initiative involved a wide variety of non-governmental groups, government agencies, and numerous funding partners in completing its many components. Up to 20 different groups assisted in direct funding support ($97,500), in-kind support ($26,000), and volunteer labor. During the length of this project, over 75 individuals contributed 1,300 hours of hands-on work. Key groups in this volunteer effort included Wallaceburg District High School students, local naturalist groups, fish and game organizations, local landowners, and Scouts Canada.

The MacDonald Park Restoration Project was supported by the following funders and volunteers:

Great Lakes 2000 Cleanup Fund;

National Fish and Wildlife Foundations;

Roy Investment Ltd.;

St. Clair Parkway Commission;

Rural Lambton Stewardship Network;

Ontario Ministry of Natural Resources;

Eastern Habitat Joint Venture;

Ontario Ministry of Environment and Energy;

Shell Environmental Fund;

St. Clair Region Conservation Authority;

Aqua-Terre Environmental Consultants;

Wallaceburg District Secondary School;

Wallaceburg and District Boy Scouts;

Bluewater Anglers Association;

Farmers and Friends Conservation Club of Lambton;

St. Clair Binational Public Advisory Council; and

Lambton Wildlife Inc.

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Chapter 5

Constructing Islands for Habitat Rehabilitation

in the Upper Mississippi River

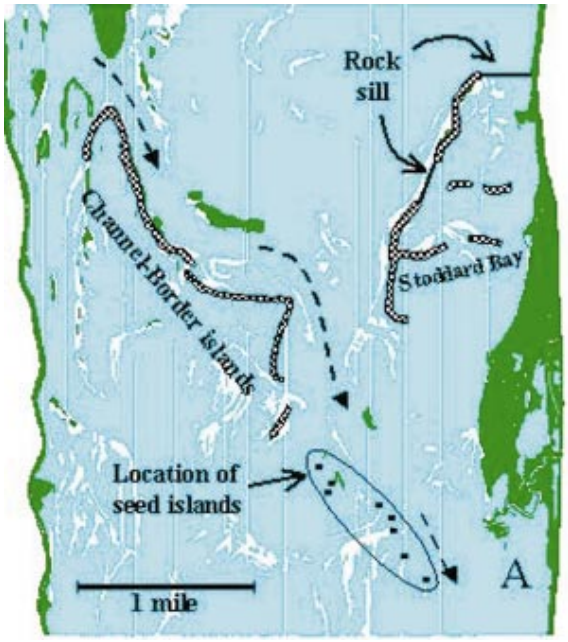
Barry Johnson, U.S. Geological Survey and Jeff Janvrin, Wisconsin Department of Natural Resources

Introduction

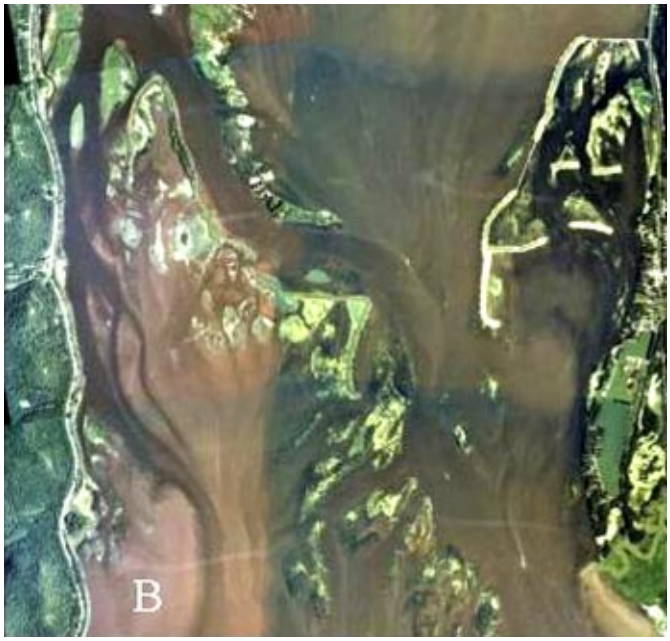
Loss of habitat diversity is a common problem in many large rivers of the world (Ward and Stanford 1989). Islands can increase habitat diversity within large rivers because they provide shallow-water habitats, they shelter areas from wind and currents, and they trap sediments and organic matter (Thorp 1992). They also provide terrestrial habitats for birds, reptiles, and small mammals. In many large rivers, islands are being lost due to channel modifications, erosion from wave action, and inundation after impoundment (Figure 17A; Funk and Robinson 1974; Sedell and Froggatt 1984). In addition, the natural processes that build islands have been constrained in most large rivers due to dams, flood control, and channelization.

On the Upper Mississippi River, managers, agencies, and industry have worked together to restore habitat diversity by building islands, often from dredge spoils. In this case study, we relate our experience with three island construction projects that illustrate techniques and concepts that might be applied in other rivers. Two projects, the Channel-Border Islands project (also called the Pool 8 - Phase I Project; U.S. Army Corps of Engineers 1989a) and the Stoddard Bay Backwater

Figure 17 Section of the Upper Mississippi River near La Crosse, Wisconsin.



A. Map with white areas depicting islands existing in 1939; dark gray areas are islands remaining in 1998; cross-hatched areas are island construction projects described in the text. Dashed arrows show flow in the main channel.



B. Aerial photo of the same area in summer 1999 showing constructed islands and aquatic vegetation.

project (also called the Pool 8 - Phase II Project; U.S. Army Corps of Engineers 1996), are near La Crosse, Wisconsin. The third project, the McCartney Lake project (U.S. Army Corps of Engineers 1989b), is near Cassville, Wisconsin, just north of Dubuque, Iowa.

Making Projects Happen: Cooperation, Partnerships, and Regulations

These island construction projects, like most other habitat rehabilitation projects on the Upper Mississippi River, are a cooperative effort among multiple stakeholders. These projects were conducted mainly through the federally-funded Environmental Management Program (EMP), which began in 1986 and is coordinated by a group of federal and state agencies. The U.S. Army Corps of Engineers is responsible for maintaining navigation on the river, the U.S. Fish and Wildlife Service has responsibility for managing national trust species and for managing federal refuges (which constitute much of the river's floodplain), the five border states are responsible for managing other fish, wildlife, and lands, and the U.S. Geological Survey coordinates a Long-Term Resource Monitoring Program as part of the Environmental Management Program. These agencies work together to plan, prioritize, and coordinate rehabilitation projects through the EMP and to assure that projects meet all state and federal environmental regulations. Industry and citizen groups are involved in project planning through agency representatives or through membership on planning committees. In addition, the general public is involved through public meetings, providing written comments on planning documents, and participating in tours of rehabilitation projects.

With all these partners involved, planning for rehabilitation projects can be time consuming. However, in the end a consensus is reached among participants so that project implementation usually goes smoothly.

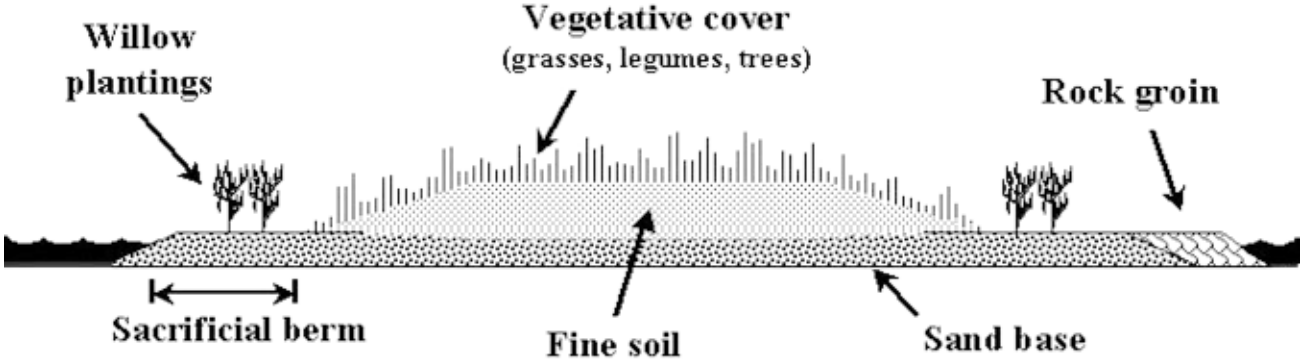
Island Construction Techniques

The basic techniques for building two types of islands used in the Upper Mississippi River projects are described below. The design features incorporated into these islands were derived from surveys of existing stable islands in the area and from analysis of hydraulic conditions at the project site. Thus far, all islands have been built in areas that are 3-4 feet deep during low water periods (usually summer and winter). Building islands in deeper areas may require changes in the techniques described here.

Building Artificial Islands

Construction of an artificial island begins by building a sand base (Figure 18). Sand is supplied by dredging nearby main-channel or backwater sites. This technique often provides a useful method for disposing of dredge material. Hydraulic dredging is typically used because it is generally

Figure 18 **Typical cross-section of a constructed island, Upper Mississippi River, near La Crosse, Wisconsin, in water 3 to 4 feet deep (not to scale).**



cheaper than mechanical dredging for large amounts of sand. Final shaping and contouring of the sand is accomplished with the use of bulldozers. For safe operation of heavy equipment, the top of the sand base should be at least one foot above water level. The desired shoreline slope of 20:1 is very difficult to build. Thus, a sacrificial berm, designed to erode naturally to a 20:1 slope, is placed along the shoreline (Figure 18). On shorelines that may be subject to severe erosion, protective features are often added. This can be limestone rip-rap applied around the upstream head and tips of islands, but where possible, limestone groins (about 30 feet long) are used instead. Building groins are cheaper than armoring the entire shoreline with rip-rap and the beach areas between groins provide better access to the island for shorebirds, reptiles, and other animals.

After the sand base is complete, a cap of 1-4 feet of fine soil is applied (Figure 18). The height of the island is typically the elevation of a 10-year flood event at that site. Higher mounds can be added to support plants that require dryer habitats. Finally, the island is planted with willows along the sandy shoreline and a mix of grasses, trees, and legumes in the fine soil. Using legumes in the mixture helps to maintain adequate nitrogen in the soil.

To help reduce erosion during flooding, islands are designed with higher elevations at the upstream end. As water levels rise, the downstream portion of the island floods first, which helps maintain similar water levels on upstream and downstream sides. Thus, when the island is finally over-topped, the hydraulic head across the island is low, which reduces current velocity and erosion.

Constructing Seed Islands

A second type of island, called a seed island, has also been used in the Upper Mississippi River. A seed island is a linear pile of rip-rap placed perpendicular to the current in areas of high sediment transport and uses the river's natural processes to build a new island. As water is deflected around the seed island, sediments are deposited in the area of slower-moving water, which forms behind the rock pile. In addition, increased current velocity around the sides of the seed island scours the river bottom and creates deeper areas. These processes occur primarily during floods because high flows and current velocities are needed to mobilize and transport the sand substrate that is deposited to form islands. The dimensions of seed islands, especially their elevation, should be based on an analysis of hydraulic conditions and sediment transport occurring at the project site during flooding.

Upper Mississippi River Island Projects

The projects described below were selected to illustrate specific features of different types of island construction.

The Channel-Border Island Project

In this project, conducted within an impounded area of the Upper Mississippi River (Figure 17), existing islands were protected from erosion, while new barrier islands were built along the border of the main channel. The objective was to shelter off-channel areas from currents and wakes to create better conditions for plant growth in shallow water (U.S. Army Corps of Engineers 1989a). The project began in 1990 by installing rip-rap on shorelines of existing islands to prevent further erosion. Then, downstream of the existing islands, approximately 13,000 linear feet of barrier islands were built (totaling 30 acres) using 320,000 cubic yards of dredge spoil. Groins were installed to protect shorelines of the new islands, which were completed in 1993.

Seed islands were also constructed near the Channel-Border islands (Figure 17A). Most seed islands were about 200 feet long, 30 feet wide at the base, and the tops 3-5 feet above the water level at low flows. Two seed islands near the Channel-Border project have been in place since 1995, with six additional islands built in 1998. Substrate monitoring around these islands has shown that scouring and deposition are occurring as expected.

The Channel-Border Islands Project benefited an estimated 1,000 acres of aquatic habitat. The islands have weathered waves, wakes, and annual flooding, including the Great Flood of 1993, with very little loss of material. Lush vegetation has become established on the islands from the original seeding. In the shallow protected areas behind the islands, water transparency has increased as has the abundance of aquatic plants (Figure 17B), which is a key component for increasing fish abundance (Johnson and Jennings 1998).

The Stoddard Bay Islands Project

Stoddard Bay is a backwater area along the town of Stoddard, Wisconsin (Figure 17) that was previously protected by a line of barrier islands extending about 3,000 feet from the east shore of the Mississippi River and curving downstream about 6,000 feet (U.S. Army Corps of Engineers 1996). These islands enclosed an area of about 600 acres. By the 1970s, these islands had been lost to erosion and the site had become a relatively homogenous open-water basin. The purpose of this project, begun in 1997, was to rebuild those barrier islands. These islands would reduce wind fetch and improve habitat conditions within the enclosed area, including over-wintering habitat for fishes. Sand for island construction came from dredging 15 acres of nearby backwater habitat.

To improve flow conditions within Stoddard Bay, low rock sills were incorporated into the barrier islands (Figure 17). Sills were constructed of limestone rip-rap and incorporated a fine-mesh barrier fabric to help reduce water seepage through the sill. These low sills are over-topped during floods, which allows high flows to flush the bay. However, to allow some inflow during low-water periods, a notch was placed into the upstream sill.

Sill heights were determined based on concerns for winter habitat. Good over-winter habitat for backwater fishes should have current velocities less than 1 cm/sec (Knights et al. 1995). Under normal winter conditions, inflow to the bay occurs only through the notch in the sill, which produces acceptable current velocities. However, if the sills are overtopped, current velocities increase to undesirable levels. To reduce this possibility, we analyzed winter water elevations at the site and built the sills to an elevation that produced only a 10% chance of being overtopped for more than five consecutive days during winter. That sill height also corresponded to a two-year spring flood elevation.

To help design the Stoddard Bay island complex, computer modeling was used (J. Hendrickson, U.S. Army Corps of Engineers, St. Paul) to predict current velocities within the bay under alternative island configurations and various flow conditions (high flow, low flow, and low flow with two feet of ice cover). The design objective was to produce a variety of current velocities within the bay, with low velocities always available somewhere and high velocities occurring in some areas during high water to scour the substrate. Modeling helped determine the number of the sills to incorporate into the barrier islands and the number and location of interior islands.

For the Stoddard Bay Project, 27 acres of islands were constructed, which provided benefits to at least 600 acres of aquatic habitat. Since this project was completed in 1999, there has been little time for evaluation. However, during summer 1999, water transparency in the bay was much greater than outside the bay and aquatic plants were much more abundant than in previous years (Figure 17B). Angling success was high within the backwater and along the exterior of the barrier islands, causing the area to quickly gain a reputation as a great fishing spot. In addition, the project protects much of the shoreline along the town of Stoddard from excessive wave action.

The McCartney Lake Project

McCartney Lake is an extensive backwater complex that has experienced considerable sedimentation, with subsequent loss of deep water areas. Rehabilitation of the lake was begun in

1989 and included stabilizing an inlet channel to reduce sediment inflow to the system and dredging 8,200 feet of connected channels, about 10 feet deep, within the lake (Figure 19; U.S. Army Corps of Engineers 1989b). The resulting 400,000 cubic yards of dredge material were used to construct a single 22-acre island at the downstream end of the lake to reduce wind-generated waves on McCartney Lake (Figure 19).

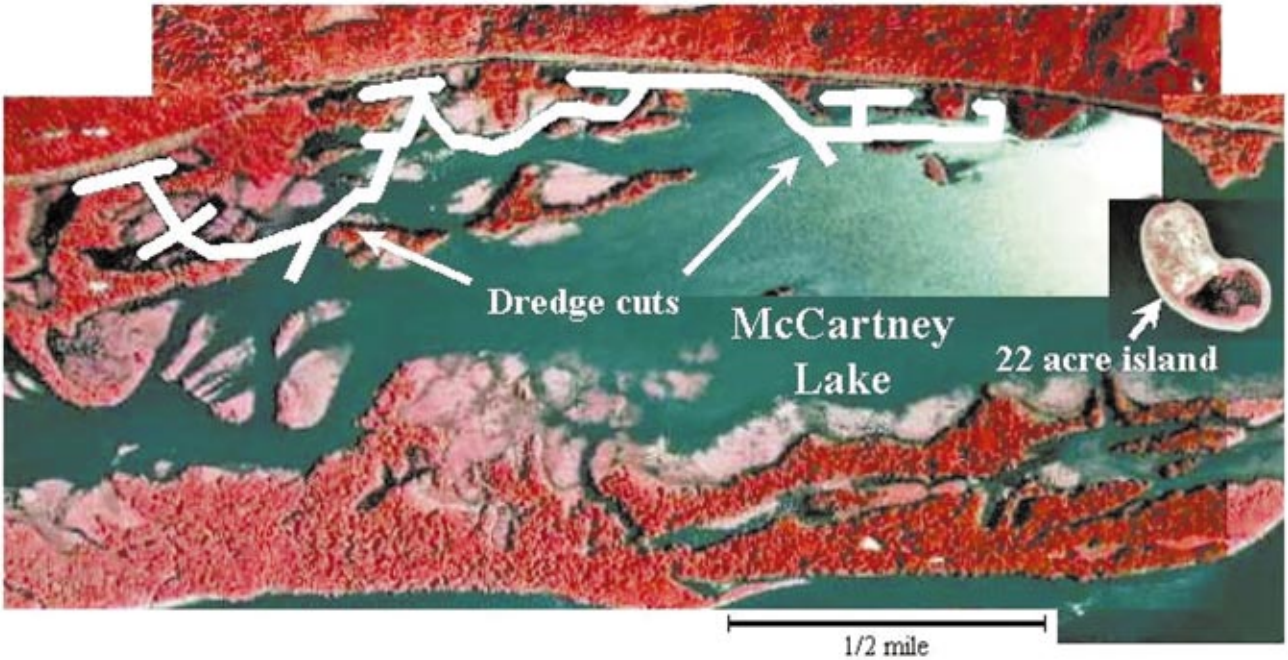
McCartney Island was constructed using techniques similar to those described above, but the design was different. Rather than a barrier island, this was a large island designed to provide a variety of aquatic and terrestrial habitats. Thus, a 10-acre wetland was built on one end of the island and upland habitat at the other end (Figure 19). In addition, because of the large size of the island no shoreline protection was used.

The McCartney Lake project was completed in 1991 and since then, the island has remained stable. Immediately upon completion, dissolved oxygen levels and water depth improved within the dredged areas. The island was used almost immediately by waterfowl, shorebirds, turtles, amphibians, and small mammals. However, increases in adult fish populations were not evident until six years after project completion due to time lags in fish reproduction and growth.

Funding for Island Projects

Funding for habitat rehabilitation projects on the Upper Mississippi River typically comes from a variety of sources. Funding for construction costs comes mostly from the Environmental Management Program and occasionally from operation and maintenance funds of the U.S. Army, Corps of Engineers, Fish and Wildlife Service, or state agencies. Costs for project planning and evaluation are typically shared among agencies with funds coming from the Environmental Management Program (including the Long-Term Resource Monitoring Program) and from in-kind contributions of labor, equipment, and supplies from partner agencies.

Figure 19 McCartney Lake, on the Mississippi River near Cassville, Wisconsin, showing dredge cuts made to provide more deep-water habitat. The photo also shows a 22-acre island constructed from the dredged sediments. The dark area inside the island is a 10-acre wetland.



The islands constructed in the projects described above have a life expectancy of 50 years. For all three projects the costs of island construction were similar. Costs averaged about $75,000 per acre (1995 U.S. dollars). This does not include costs for planning or evaluation of the projects.

Evaluation Techniques and Learning as You Go

Evaluation of each island project has produced more effective island designs and more efficient construction techniques. The evaluation process has typically involved pre- and post-construction assessment of various features of islands and habitats including physical (flow patterns, current velocity, wave activity, water depth, substrate erosion/deposition), water quality (temperature, dissolved oxygen, transparency), and biological (aquatic and terrestrial vegetation, invertebrates, fish, birds) components; relative abundance and diversity of habitats; and stability of island shorelines. Changes in physical and chemical variables are relatively easy to measure and often show improvement immediately after construction. However, many biological changes are slower and less obvious.

Quantitative monitoring has shown that islands can be very effective at modifying currents, wind, and waves, which in turn affects water transparency, plant growth, and sedimentation rates. In fact, the Channel-Border Island Project changed flow patterns enough that the design of new island projects downstream had to be modified. Qualitative observation and photographs of islands over time, especially in relation to on-site reference points, have provided useful evaluation of how shorelines and vegetation are fairing. Detecting changes in invertebrates and fishes usually requires more intensive on-site sampling. In addition, long-term quantitative monitoring will be needed to determine if projects have actually increased biological productivity in the system as a whole.

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Goose Bay Shoreline

Chapter 6

Stabilization and Habitat Enhancement

Stan Taylor, Essex Region Conservation Authority

Introduction

The purpose of the Goose Bay Shoreline Stabilization and Habitat Enhancement project was to restore and enhance the shoreline of the embayment. This included the construction of submerged fish habitat enhancements along the embayment's littoral fringe and deeper water areas.

Project Description

Goose Bay Park is located on the Detroit River approximately 200 m west of the foot of Pillette Road, on Windsor's near east side. The site is owned by the City of Windsor and is a passive use park approximately 0.9 ha (2.1 acres) in size with a shoreline frontage (east property line to west property line) of approximately 172 m. Goose Bay is one of the last remaining sheltered embayment habitats along the upper Detroit River shoreline. This area has been previously identified as important for fish and wildlife habitat.

The restoration and stabilization work at Goose Bay involved the protection of the shoreline with rip-rap and native materials, such as willows, dogwoods, and other hardwood species (Figure 20 and 21). Selected submerged enhancements, such as groyne and rock apron construction, were undertaken to improve fish spawning and refuge habitat (Figure 22). Two small sheltered wetland areas were created along with cobble stone beaches.

In addition to contributing to progress toward delisting impaired beneficial uses in the Detroit River Area of Concern and meeting Canada-Ontario Agreement Habitat Targets, other highlights of the project include:

- re-establishing the Goose Bay shoreline and riparian areas using native materials (native plant species and rock) to provide habitat for waterfowl and passerines;

Figure 20 Goose Bay Park shoreline, prior to rehabilitation, was badly eroding.

Figure 21 Goose Bay Park shoreline, after rehabilitation, is protected from erosion and enhanced for fish and wildlife habitat.

Figure 22 **Goose Bay Park enhancements, such as rock groynes, were undertaken to improve fish spawning and refuge habitat.**

- enhancing submerged fish habitat features to increase fish use for spawning and rearing/refuge; and
- improving submerged fish habitat features (i.e., groynes) to help protect the embayment from swift current regimes and wave action.

The project is nearing completion, with final plantings of aquatic/wetland vegetation to be done in 2000. In addition to pre-project site monitoring, future monitoring activities will demonstrate the effectiveness of in-water enhancement projects in creating habitat in sheltered river embayments.

Advice to Overcome Obstacles When Using Soft Engineering Practices

All necessary permits and approvals (i.e., Department of Fisheries and Oceans, Canada Coast Guard) were obtained by the project proponent prior to construction. The approval process involved a Federal Canadian Environmental Assessment Agency screening co-ordinated by Environment Canada and was also facilitated by the Essex Region Conservation Authority's 'one-window' review and permit process. The project will result in a net improvement in the extent and quality of fish habitat in the embayment, and therefore is self-compensating. This project also avoids any impacts on river flow capacities. The "soft engineering" approach which enhanced habitat was in harmony with other needs, such as navigation, river flows, and meeting the main objective of enhancing and protecting the Public Parkland. This balanced planning and design of the project avoided any obstacles.

Cost, Funding, and Implementation Partners

The total project cost was $161,000, with $50,000 being funded by Environment Canada's Great Lakes Cleanup Fund. The remaining balance was paid for by funding from the City of Windsor. The project was carried out as a partnership between the City's Parks and Recreation Department and the Essex Region Conservation Authority, with the assistance of BTS Consulting (Windsor). It was undertaken as part of the Detroit River Canadian Cleanup program.

Post Project Evaluation

A detailed monitoring program will be undertaken at the site on an annual basis for two years following construction. The pre-construction bio-inventory and habitat assessment, with photographic records, will provide a baseline for the monitoring program. Annual post-construction monitoring will be undertaken during the late spring/early summer, and will include at a minimum:

- an assessment of bank stability;
- an assessment of riparian plant mortality;
- extent and composition of emergent vegetation communities in the embayment;
- extent and composition (by dominant size classes) of embayment substrates;
- a description of basic water quality parameters;
- qualitative assessment of existing fish spawning and rearing/refuge habitats;
- an assessment of fish use and relative densities using snorkel or SCUBA techniques; and
- a description of upland characteristics including a qualitative assessment of wildlife habitat.

Benefits of Project

By restoring and enhancing fish and wildlife habitat, the project will aid in delisting the impaired beneficial use of "loss of fish and wildlife habitat". In addition, the project will aid in meeting Canadian-Ontario Agreement Habitat Targets. The project has also stabilized an eroding shoreline and provides an accessible and aesthetically pleasing public park setting which also provides an enhanced view of the Detroit River from Riverside Drive.

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Chapter 7

Fish and Wildlife Habitat and Shoreline

Treatments Along the Toronto Waterfront

Gord MacPherson, Toronto and Region Conservation Authority

Introduction

The Toronto and Region Conservation Authority (TRCA) is the agency that is responsible for shoreline management initiatives within the Toronto Waterfront. Over the years, this has led to the development of a series of regional parks, public marinas, erosion protection for shoreline residents, acquisition of vulnerable properties, and development of significant shoreline parklands. Within the Conservation Authority, the Coastal Ecology Unit is a small group of individuals that is charged with the responsibility of monitoring the shoreline ecosystem, providing community outreach, and designing, developing, and implementing significant shoreline restoration projects.

Over the years, the collective efforts toward monitoring the shoreline have led to the development of habitat classifications and a general philosophy for the design of shoreline structures. Simply, within the north shore of Lake Ontario, there are three major types of shoreline habitat:

- open coasts (highly energetic exposed shorelines that are typically beaches and do not support diverse, or strong, resident populations of fish; however, on a seasonal basis these shorelines are critical spawning areas for pelagic forage species as well as a connective corridor and staging area for a broad suite of species);
- sheltered warm water embayments (Lake Ontario is a cold, deep, oligothrophic lake and therefore, the isolated warm water shoreline habitats attract/hold a variety of species by providing significant critical habitat; sheltered embayments along the Toronto waterfront are either natural geologic features like the Toronto Harbour/ Toronto Island Complex or man-made structures, including the many waterfront parks and marinas); and
- coastal marshes (many of the rivers that drain into the Toronto waterfront reach Lake Ontario through a coastal marsh complex; the size, morphology, and thermal characteristics of these habitat structures make them the most important habitat features within the waterfront).

Monitoring of these habitats has provided meaningful insight into the design of habitat restoration projects and principally, the best lesson learned to date, is the concept of critical habitat. We design critical fish and wildlife habitat components at the shoreline to facilitate the creation of:

- reproductive habitats;
- nursery habitat;
- foraging and resting areas; and
- over-wintering habitats.

The conscious development of critical habitat features in a restoration project guarantees that the appropriate terrestrial and aquatic species are attracted to your site and are capable of colonizing the site successfully. Two newly created projects that exemplify the concept of integrating fish and wildlife habitat creation into the shoreline are the Humber Bay Shores and the Spadina Quay Wetland projects.

Humber Bay Shores

Situated close to the mouth of the Humber River and adjacent to the Humber Bay Waterfront Park, the

former Motel Strip was the cause of many problems within the local lakeshore community (Figure 23). To provide a catalyst for redevelopment, and clean up the problematic uses within the area, the Toronto and Region Conservation Authority (TRCA) led a partnership of agencies in the development of a public amenity scheme for this waterfront area. The TRCA proposed limited lake-filling to facilitate a desirable building envelope, attract development, and avoid encroaching on private property in an effort to create this important public waterfront area. Our understanding of this shoreline ecosystem assisted in the development of a park plan that truly integrated the needs of the community, allowed redevelopment, and created significant habitat features. Our local knowledge provided valuable insight that was utilized during the design of shoreline structures, as well as the development of habitat components, which were required for regulatory approval of the project.

The design of the shoreline was dictated by the wave climate of the site. In response, we developed habitat components that were suitable for the local wave conditions and included cobble beaches, offshore islands, sheltered shorelines, and a wetland complex (Figure 24). The beach shoreline consists of a series of "T" shaped headlands that secure three cobble beach cells. The cobble beach was considered the best treatment because it provided a shallow beach profile that is so important for spawning forage fish. In addition, it was determined to be the best shoreline treatment technique to attenuate the waves while still providing a significant habitat function. Additional features such as shoals, reefs, and randomly placed stones were attached to the headlands in an effort to attract and hold pelagic fish.

The islands were designed to provide, to a degree, sheltered back water areas and to reduce the wave conditions so that the site was suitable for habitat features (Figure 24). The islands are vegetated with shrubs and have large clusters of anchored woody material attached to the back-shore. Also, a diversity of substrate types have been placed between the islands and shoreline. The overall configuration of the shoreline was undulated to enhance the characteristics of the back-shore area of the islands. Back-shore conditions, such as shoreline slope, crest height, and habitat features, were altered to take into account the shadow effect of the islands. In selected locations we provided areas of finer substrates by constructing a shelf within the shoreline structure in the hope of establishing emergent vegetation.

The most challenging aspect of this project was the development of a 3 ha wetland complex (Figure 24). Our desired wetland shoreline consists of a shrub buffer, sedge strand, and emergent, submergent, and floating leaf vegetation. To create this shoreline condition, we filled in the perimeter and closed off an existing embayment with a rock-rubble berm that was covered by a 1 m veneer of clean fill. To ensure that we had the proper elevations for wetlands plants, we initially surveyed our coastal marshes to determine the elevations of naturally occurring coastal wetlands. Using this information, we created a pilot project at one of our earlier habitat creation projects to determine the critical elevations for plant material. We created a gradual shoreline slope that was planted with emergents and monitored, over the course of five years, to determine the exact elevations at which wetland plants would establish. These elevation data have since been used at all of our wetland project sites. Our general philosophy, in creating coastal plant communities, is to create the conditions suitable for the desired community and inoculate the site, rather than plant a plantation. To inoculate this wetland, we planted our emergent material in nodes to facilitate colonization and connected these areas with perimeter plantings.

One unique aspect of this project was the material we received from the TRCA initiative, the "Aquatic Plants Program." This program was started a number of years ago and now involves more than seven hundred classrooms in the Toronto area growing a variety of aquatic and terrestrial plants for our rehabilitation projects. The TRCA provides materials, equipment, and technical support to the classroom instructors and in return we receive quality plant material at a fraction of the cost, with the added benefit of an effective community outreach program.

Additional habitat features were also detailed within the wetland complex. In an effort to diversify the deep water areas of the wetland, five log crib structures were sunk in the open water. The cribs were constructed of logs eight foot long, five feet high, and filled with a rock ballast. They attract a variety of fish in the area. We also deployed a number of brush bundles that were anchored to cinder blocks and sunk in the same vicinity of the log cribs. A variety of log stumps, whole trees, and logs were placed along the shoreline to mimic woody debris along the shore. To facilitate pike spawning, we created a braided network of shallow channels that were planted with slender emergent wetland plants. During construction, we noticed that the created island, when we closed off the embayment, was attracting a large number of Caspian Terns. We altered our original plans and left this island feature barren of vegetation and put a veneer of sand and gravel down to mimic the back-shore beach feature utilized by nesting Caspian Terns.

Figure 23 **The shoreline of Humber Bay prior to rehabilitation. The former hotel strip was a problematic area for the lakeshore community.**

Figure 24 **After rehabilitation of Humber Bay, a desirable building envelope encourages development. This new interest in redevelopment has provided more, safer public access to the water.**

Spadina Quay Wetland

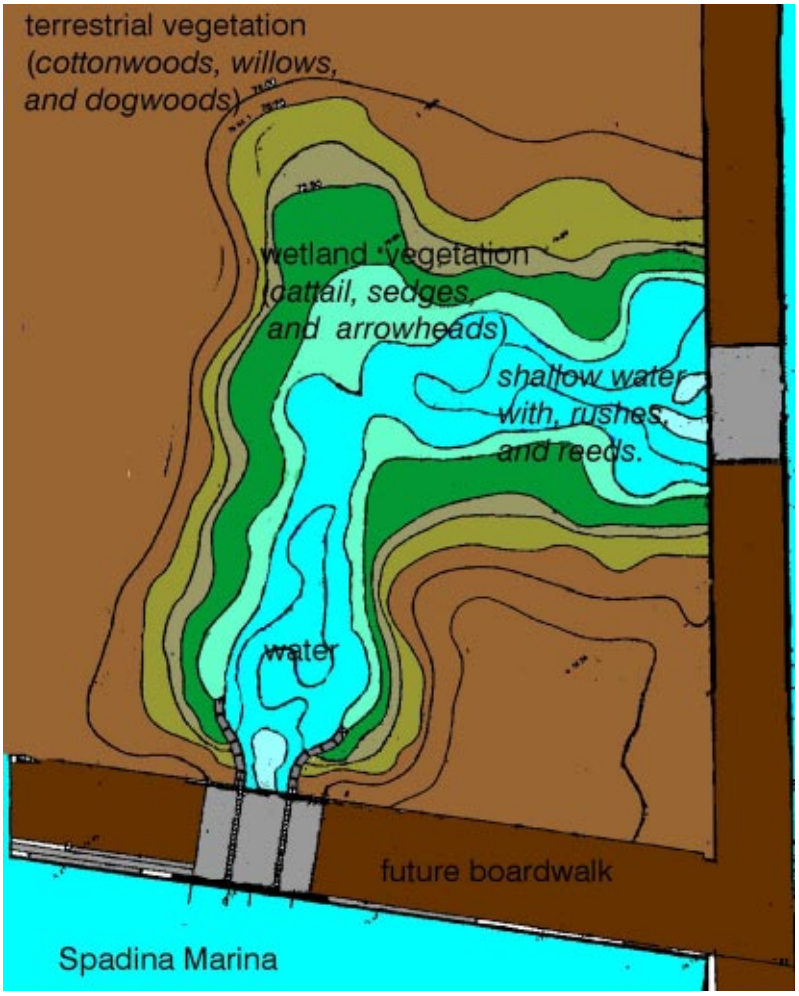
Over the past ten years the Toronto and Region Conservation Authority has monitored the fish communities along the Toronto Waterfront. About four years ago, we started to receive reports from anglers fishing at the foot of Spadina Avenue in the Inner Harbour. They called in stating that they were catching tagged northern pike during the spawning season. This was significant because we never tagged any fish along the north shore of the Inner Harbour of Toronto and we couldn't believe that northern pike would be trying to utilize the marginal habitats of the Inner Harbour. We later verified, that indeed, many pike moving from the Toronto Islands were congregating in the Inner Harbour during the early spring spawning season.

Two years ago, a colleague in the Toronto Parks Department asked if we had any ideas for the parking lot at the eastern portion of the existing Spadina Parklands in light of some major redevelopment within the area. Our immediate response was to suggest the creation of a spawning and wetland area for the pike we were seeing at that location. The challenge faced by us was to fit a viable wetland in such a small physical space in such a high profile area.

To get water onto the site, we cut the seawall in two locations and removed the top wall section down to the waterline (Figure 25). A new wooden boardwalk bridged the gap and a set of gates were installed to separate any floating harbor debris from the wetland and to control and exclude carp during their spawning season. The openings were designed to take advantage of the Lake Ontario water level regime and strategically time the extent and duration of inundating water.

Essentially, we were hoping to allow for shallow water in the spring, maximum water depth throughout the summer, gradual recession of the water in the fall, and a dry condition in the winter months. The criteria for setting the elevation were focused on providing conditions suitable for pike spawning in the spring, allowing for a permanent water feature during the tourist season, and allowing for complete draw-down to ensure the viability of slender emergents and ensure some dynamic stability to the system.

Figure 25 **The Spadina Quay Wetland, which was once a parking lot, is now a spawning habitat for northern pike.**



We focused on creating three plant communities within the Spadina Quay Wetland: Eastern cottonwoods; staghorn sumach; and a variety of shoreline grasses were planted in the upland riparian zone. The lowland riparian zone was planted with a variety of sedges, grasses, and herbaceous plants. The wetland zone was planted with a variety of slender emergents, including hard and soft-stem bulrush, giant burreed, and arrowhead. The site was prepared before planting with a mixture of compost and sand that was mixed with the parent material to 30 cm. To

control the colonization of undesirable weeds and plants, and to control our site maintenance, we also extensively seeded the site with annual oats. This provided a quick and extensive ground cover that helped control weeds, retain soil moisture, contribute to the soil conditioning on site, and turn a barren construction site green in a matter of weeks.

The Spadina Quay Wetland was the source of some pointed criticisms. Concerns were raised that it was too small to provide any functional habitat and that the Inner Harbour is not an appropriate location for habitat creation. The jury is still out on whether or not the site will be utilized by the pike or become problematic in the future. But we are very optimistic about the potential of this site and anxiously await next spring when we fully expect the first spawning northern pike. As for the value of this project, we are convinced that wetlands in urban areas are priceless when it comes to raising public awareness surrounding habitat restoration in the Great Lakes.

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Restoring Habitat

Chapter 8

Using Soft Engineering Techniques at LaSalle Park, Hamilton Harbour, Burlington, Ontario, Canada

John Hall

Introduction

This harbor project was aimed at enhancing fish and wildlife habitat, reducing turbidity, and encouraging passive recreational opportunities. This is more in keeping with improved water quality and closer to the park's previous relationship with Lake Ontario (Figure 26).

Project Description

The design included five restoration components:

- a westerly promontory to create a permanent sheltering of the near-shore area to enhance aquatic plant production and create food sources for waterfowl;
- offshore reefs and emergent shoals to provide spawning habitat for fish and food sources for wading birds;
- a bioengineered complex shoreline integrating near-shore fish habitat and replacing the existing armor-stone edge with trees and shrubs;
- restoration of an existing sand beach, thereby providing a linkage for wildlife between a wooded swamp and the harbor; and
- incorporation of a walking trail, lookouts, and interpretive signs.

The overall goal was to diversify the fish community by encouraging native predators such as bass or pike. This has been carried out with the creation of 11.9 ha of fish habitat, 1.4 km of rehabilitated littoral edge, 145 m of emergent shoals, 2 rocky reefs of 950 square meters, and over 125 fish habitat modules.

A rock breakwater extends approximately 160 m into the harbor sheltering the marina basin and creating 11.9 ha of fish habitat. The west side of the promontory contains a wave-washed spawning reef and habitat for invertebrates, such as crayfish (Figure 27). The easterly lee is vegetated with overhanging native plants providing shade and protection. The fine gravel bottom provides protected spawning habitat for bass and sunfish. Tree stumps, logs, open concrete pipes, and poles are anchored into the promontory providing refuge and feeding habitats for fish. Five large shoals and a submerged reef provide more spawning habitat.

Figure 26 The sand beach at LaSalle Park prior to restoration.

Figure 27 The sand beach at LaSalle Park after restoration using soft engineering.

Restoration of the beach area involved the removal of many tons of rock fill that had been added over the years. In its place is a sandy pebble beach where frogs, turtles, and salamanders can travel freely between the water and the natural wetland located at the base of the forested bluff. The beach contains a small pond for frogs and salamanders and a nesting mound for turtles. In low water conditions, some of the rocks used to create fish habitat modules become visible. These provide loafing areas for birds and turtles. In the basin where logs and brush bundles have been anchored to the bottom, turtles, frogs, and shorebirds use the branches and trunks for basking and loafing.

The meandering shoreline creates a complex edge preferred by fish and wildlife. The diverse vegetation attracts a greater variety of insects, small animals, and birds. The wetland, shrubs, and trees along the water's edge provide a connection with the forested slope. Over time, the natural forest edge should creep down to join the wetland and form a corridor for mammals and birds along the edge of the bay.

A waterfront trail, complemented with interpretive signs, allows visitors in LaSalle park to view and understand the fish and wildlife restoration carried out at the site. East of the pier, the trail passes a recreational marina on its way to a boardwalk crossing the restored beach. This boardwalk, constructed at the back of the beach through the edge of a wetland, provides clearance to accommodate the movement of amphibians. Further east along the shoreline, the trail contains several lookouts and seating areas which have become an excellent area for viewing flocks of migrating, nesting, and feeding waterfowl (Figure 28). Over time, as the trees and shrubs planted along the shoreline mature, the trail will become more complex, coursing between woodlands and lookouts.

Figure 28 **The improved habitat and plant diversity is easily viewed from the boardwalk. The boardwalk provides improved public access.**

Regulatory Considerations

Regulatory considerations included:

- Federal Department of Fisheries and Oceans, Fisheries Act permit required;
- Federal Department of Fisheries and Oceans, Navigable Waters Act permit required; and
- a permit from the Halton Region Conservation Authority was required under the Fill, Construction, and Alterations to Waterways Regulation.

Cost

Engineering and design	**$ 219,000**
Construction of islands/landscaping/ public access:	**$2,320,000**
Total:	**$2,539,000**

Post project evaluation for effectiveness

LaSalle Park is responding to restoration efforts. There is an increase in abundance of aquatic plants and greater diversity in fish and wildlife (Figure 28).

Benefits of the Project

Benefits included:

- construction of 11.9 ha of fish habitat and 6 hectares of wildlife habitat;

- construction of 1.4 km of new littoral edge and 900 m of shoreline re-vegetation including wetland plantings;
- construction of 145 square meters of emergent shoals, 2 spawning reefs of 960 square meters, and 125 fish habitat structures;
- restoration of 130 m of beach; and
- construction of a pedestrian bridge, 1 km of new trails, 160 m of board-walk, and the installation of interpretive signage.

Advice for Overcoming Obstacles When Using Soft Engineering Practices

The proponents felt that the best thing this project did, once a concept for rehabilitation was developed, was to form a project advisory group of stakeholders. This group was a combination of local interest groups, science community, and relevant agencies. The group worked through the detailed design and environmental assessment stages. Since these groups had been involved from the design stage, permits/funding approvals were easier to obtain.

Funding and Implementation Partners

Bay Area Restoration Council (representing citizens, interest groups, municipalities, industries, and landowners);
Department of Fisheries and Oceans;
Environment Canada;
Friends of the Environment Foundation;
Great Lakes 2000 Cleanup Fund;
Halton Region Conservation Authority;
Hamilton Harbour Commissioners;
Hamilton Harbour Remedial Action Plan Stakeholders (RAP);
Hamilton Naturalists' Club;
Hamilton Region Conservation Authority;
McMaster University;
Ontario Ministry of the Environment;
Ontario Ministry of Natural Resources;
Royal Botanical Gardens Project Paradise;
The Regional Municipality of Hamilton-Wentworth;
The Regional Municipality of Halton;
City of Burlington;
City of Hamilton; and
Waterfront Regeneration Trust.

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Chapter 9

Enhancing Habitat

Using Soft Engineering Techniques at the Northeastern Shoreline of Hamilton Harbour, Western Lake Ontario, Burlington, Ontario, Canada

John Hall

Introduction

This harbor project is aimed at restructuring the fish community, from a community dominated by carp, to one more diverse and dominated by top order predators. The project is also aimed at providing rare colonial nesting birds with a safe, clean, and permanent habitat. This condition is more in keeping with improved water quality and closer to the harbor's previous relationship with Lake Ontario.

Project Description

The project included the creation of three islands, isolated from the shore, to protect nesting birds from predators (Figure 29). Beaches and headlands along the shore provide vegetation and habitat for wading birds. The islands and a chain of underwater shoals create a quiet lagoon, resulting in aquatic plant growth, which is a requesite habitat for fish spawning and nursery. Mudflats, exposed in the fall, attract migratory birds. Construction began in 1993 and was completed in 1995.

Figure 29 The Northeastern shoreline of Hamilton Harbour following island construction and enhancement of the shoreline using soft engineering techniques. Note the traditional shoreline at the top.

Shoreline

The shoreline restoration components include a beach, headlands, wetland, and upland areas. The shoreline extends approximately 400 m and contains two headlands anchoring three beaches. An upland complex of woodland and meadow is planted between the beach and adjacent highway. A trail follows the length of the shoreline, terminating in a natural lookout. At the south end of the project site is a launch ramp for windsurfers.

The upland portion of the shoreline contains a woodland, demonstrating natural succession of plant communities. Some oaks and Carolinian woodland species are included, since these species are native to the area and were recorded as previously growing on the beach.

Islands

The South Island, closest to the Burlington Ship Canal, is planted with shrubs and small trees, creating habitat for black-crowned night herons. Its windward side is constructed of armorstone and an underwater reef extending approximately 4 m. The cobble slope of the reef is similar to habitat used by spawning lake trout and whitefish. The lee side of the island contains a wetland flooded during high water levels and exposed during low levels. Fish habitat structures are integrated into the shoreline of the island.

The Center Island has shrubs and small trees vegetating the south half of the island, while sand and pebbles cover the north half. At the island's center, cormorant nesting platforms are constructed on wooden poles with a 5 m buffer from the vegetated south half of the island. A raised knoll at the north end of the island is covered with substrate suitable for common terns. A fish spawning reef, approximately 4 m wide, extends the length of the windward side of the island, while a small natural beach is constructed on the lee. Drift material accumulates on the beach. Fish habitat structures are integrated into the shoreline.

The North Island is covered with a sand, pebble, and cobble surface. The surface also has randomly placed driftwood logs and other structures. Nesting knolls were constructed for Caspian and common terns. A reef extends from the windward side of the island. The lee shoreline contains a mudflat, which emerges during the low water levels in the fall, making it available for migratory shorebirds. Fish habitat structures are also integrated into the shoreline.

Shoals

The three shoals are connected by 9 emergent shoals which provide spawning habitat for fish and shelter the adjacent shoreline. Every second shoal is submerged during the spring and early summer. Alternate shoals contain higher breakwater mounds, which are visible to boaters. In the fall, when water levels in Lake Ontario drop, the shoals are used by wading shorebirds.

Regulatory Considerations

Many permits were required under the following agencies:

Federal Department of Fisheries and Oceans, Fisheries Act;
Federal Department of Fisheries and Oceans, Navigable Waters Act;
Conservation Authority Act;
Ontario Ministry of Environment guidelines for open lake disposal;
Ontario Ministry of Transportation, since project was adjacent to a major highway; and
Halton Region Conservation Authority, required under the Fill, Construction, and Alterations to Waterways Regulation.

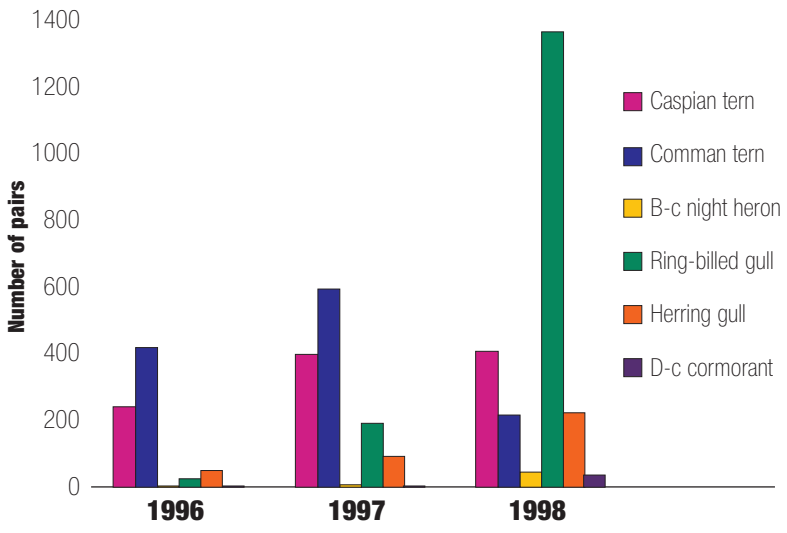
Cost

Engineering and design	**$ 175,000**
Construction of islands/landscaping	**$ 2,287,000**
Public access and interpretive features	**$ 80,000**
Total:	**$ 2,542,000**

Post Project Evaluation of Effectiveness

This site has proven to be a major success for colonial nesting birds and fish (Figure 30). The Canadian Wildlife Service identified the following bird species using the islands in 1997: Caspian terns, common terns, black-crowned night herons, ring billed gulls, and herring gulls. With the reduction in wave action, the aquatic plant community has increased from zero plants to at least 50% vegetated cover. The fish community has responded to this improvement. Fish species using this area have increased in diversity from 6 to 16 species after rehabilitation.

Figure 30 **Nesting pairs of colonial birds on islands in Hamilton Harbour.**



Advice for Overcoming Obstacles When Using Soft Engineering Practices

The proponents felt that the best thing this project did was to form a project advisory board of stakeholders once a concept for rehabilitation was developed. This group was a combination of individuals from local interest groups, the science community, and relevant agencies. This group worked through the detailed design and environmental assessment stages. Since these groups had been involved from the beginning of the design stage, permits/funding approvals were easier to obtain.

Funding and Implementation Partners

Bay Area Restoration Council (representing citizens, interest groups, municipalities, industries, and landowners);
Department of Fisheries and Oceans;
Environment Canada;
Friends of the Environment Foundation;
Great Lakes 2000 Cleanup Fund;
Halton Region Conservation Authority;
Hamilton Harbour Commissioners;
Hamilton Harbour Remedial Action Plan Stakeholders (RAP);
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The Regional Municipality of Halton;
The Regional Municipality of Hamilton-Wentworth;
Royal Botanical Gardens Project Paradise;
City of Burlington;
City of Hamilton; and
Waterfront Regeneration Trust.

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Bioengineering for

Chapter 10

Erosion Control and Environmental Improvements, Carson River, Nevada

Hollis Allen, Craig J. Fischenich, and Rebecca Seal, U.S. Army Engineer Research and Development Center, Waterways Experiment Station

Project Purpose

This case study is an excerpt from a conference proceeding (Piper et al. 2000) and Power Point presentation prepared by Hollis Allen and Craig Fischenich of the U.S. Army Engineer Waterways Experiment Station. In January 1997, the Carson River watershed experienced a 100-year flood event of approximately 23,000 cfs, leaving many reaches of the Carson River in need of restoration. Landowner property as well as the native overstory cottonwoods and willows were threatened by the erosion. A restoration workshop was held to determine the best means for repairing the damage and conveying the long-term success and benefits of bioengineering treatments for controlling erosion in an environmentally compatible manner. The bioengineering workshop/restoration project was completed November 2-4, 1998 in Carson City, Nevada. The river restoration project was implemented on a portion of the Carson River within Dayton Valley, Lyon County, Nevada (Figure 31). With the involvement of the local coordinated resource management group, landowners, local, state, and federal agencies worked together to provide technical assistance, funding, and permitting. The coordinated efforts of these various groups made this bioengineering workshop/restoration project a success.

Figure 31 Location of the multi-agency bioengineering project along the Carson River, Nevada.

Project Description

Key features of the site prior to restoration include:

- an outside curve (bendway) approximately 600 feet in length;
- vertical banks ranging from 8-12 feet in height;
- soils comprised of a fine sandy loam surface, with a permanent water table at 86-94 inches deep;
- vegetation consisting of an older overstory of cottonwoods with no vegetative understory, especially along the streambank;
- wildlife habitat for various bird species that utilize the older overstory of cottonwoods for nesting and roosting, and for various waterfowl that utilize the river for water and feed, but no cover for nesting;
- deer, rabbits, and coyotes made up the major mammal species in the area; and
- the local fishery was comprised primarily of carp (no sustainable populations of trout were present).

A reconnaissance of the river restoration site, by resource professionals involved in the bioengineering workshop and river restoration project, indicated that bioengineering treatments alone would probably not be effective. This determination was based on existing soil conditions, lack of existing vegetation, and the potential for long durations of high streamflows resulting from annual spring runoff conditions. Streamflows on the Carson River, during the spring runoff of 1999, peaked at approximately 4,000 cfs.

Hard structures that consisted of stream spurs or barbs, rock refusal trenches, rock toe protection, and a peaked stone dike were determined to be the best options. After an analysis of project site and river velocities, five barbs were designed to cover the entire bendway. In addition to the two rock refusal trenches and the rock toe protection, a peaked stone dike was added to the lower third of the bendway where there was a change in landowners and where the main force of the current had eroded the streambank back into a horse corral. This area also had several large willows and cottonwoods that would have to be removed if the bank was sloped back. The peaked stone dike would allow the bank to be built out without sloping. More details on the design and layout of the hard structures can be found in the reference Piper et al. (2000).

Figure 32 Installation of a brush mattress to reduce accelerated erosion.

Bioengineering Treatments Installed

Upon completion of bank sloping and installation of the hard structures, a number of bioengineering treatments were installed to demonstrate several techniques that can be used for streambank stabilization, restoration, and management (Allen and Leech 1997; Hoag and Bentrup 1998). A brush mattress was installed along 36 linear feet of streambank, between the first rock refusal trench and the first stream barb (Figure 32). This brush mattress was selected to demonstrate a specific treatment that could be installed to reduce accelerated erosion to an existing eroding streambank and to establish plant growth along the streambank.

Vertical bundles with a juniper tree revetment and seeding, and erosion control fabric, were installed along 114 linear feet of streambank between the first stream barb and the second stream barb. Vertical bundles were chosen to

demonstrate another variation for the treatment of reducing soil erosion and encouraging plant material establishment along eroded streambanks when using the willow plant. In conjunction with the vertical bundles, a juniper tree revetment was installed at the toe of the bank to protect the vertical bundles and assist with trapping suspended sediments. This encourages additional deposition of soil during high flow events. The top portion of the streambank was seeded and covered with an erosion control blanket.

Willow clumps with a juniper tree revetment and seeding, and erosion control fabric, were installed along 98 linear feet of streambank between the second stream barb and the third stream barb (Figure 33). Willow clumps are live willows that have been transplanted with the root ball intact. Within this area, a total of 40 willow clumps were transplanted into two rows behind the juniper tree revetment. This treatment was selected to establish willow plant growth to reduce erosion, encourage deposition of suspended sediment, and improve wildlife habitat associated with the immediate streambank. A juniper tree revetment was installed at the toe of the streambank, in front of the willow clumps, to protect the willow clumps and to assist with trapping suspended sediments and encourage additional deposition of soil during high flow events. The top portion of the streambank was seeded and covered with an erosion control blanket.

A brush trench was installed along 49 linear feet of the streambank, with rock toe protection, between the third stream barb and the second rock refusal trench (Figure 34). The brush trench was installed as another bioengineering treatment to stabilize the streambank. This treatment requires adequate toe protection be installed to ensure that the brush trench does not erode during high flow events. This treatment, once established, provides streambank stability, filters runoff (from the thick willow root matrix), and provides cover for wildlife.

Brush layering and seeding, with an erosion control blanket, was the final bioengineering treatment installed along a total of 196 linear feet of the streambank. This treatment was installed along with the peaked stone dike structure located between the second rock refusal trench and the fifth stream barb. The brush layering was selected to assist with stabilizing the streambank, provide shade to the river, and provide food for the fishery. This treatment was installed on the inside slope of the peaked stone dike. Topsoil was placed on the inside slope of the peaked stone dike to provide good soil

Figure 33 **Willow clumps with Juniper Tree Revetment at the toe.**

Figure 34 **The willow brush trench between barb three and refusal. No erosion control blanket is used.**

contact with the willow brush layer. The willow brush layer was placed on this inside slope of the dike with the tops of the willows projecting out over the water and covering the top of the peaked stone dike. Upon completion, a willow brush layer fill material was placed over the stems of the willow brush layering and a 3:1 slope was created to tie back into the top of the existing slope. This fill material was then seeded and covered with erosion control fabric.

Regulatory Considerations

The consortium of agencies participating in this project included the U.S. Army Corps of Engineers Regulatory Office out of Reno, Nevada (part of the Sacramento District Office of the U.S. Army Corps of Engineers). They were working under a Section 404 Permit of the Clean Water Act that the Corps was overseeing.

Project Costs

The total project costs for this bioengineering streambank stabilization and restoration project was $61,000 ($101/lineal foot). Cash expenses for this project were $44,762 ($75/lineal foot). Cash expenses were construction and materials costs. In-kind expenses contributed to this project were $16,184 ($27/lineal foot). In-kind expenses were plant materials, labor, and equipment. In-kind expenses made up 26.5% of the total costs of this project. The neighboring landowners and local river management group provided the in-kind services.

Figure 35 A view of the project site looking upstream about 10 months after construction.

Funding and Implementation Partners

The following is a list of the local, state, and federal agencies who sponsored and collaborated together to make this a successful project:

Carson Truckee Water Conservancy District;
Carson Water Subconservancy District;
Dayton Valley Conservation District;
Lyon County;
Middle Carson River Coordinated Resource Management Plan;
Natural Resources Conservation Service;
Nevada Division of Environmental Protection;
Nevada Division of Forestry;
Nevada Division of Water Resources;
U.S. Army Corps of Engineers – Waterways Experiment Station;
U.S. Forest Service; and
Western Nevada Resource Conservation and Development Council.

Post Project Monitoring

Vegetative monitoring along 9 fixed transects was used to help evaluate the success of the bioengineering treatments installed. From the data collected, there was an average of 74% cover on all treatments, with the highest first year vegetative cover established on the erosion control blankets, vertical willow bundles above the juniper tree revetment, and the willow brush trench treatment. The highest number of re-sprouts of willows occurred on the vertical willow bundles above the juniper tree revetment, followed by the willow brush trench, and the willow brush layering above the peaked stone dike located between the second rock refusal trench and the fourth stream barb. Figure 35 shows all 5 barbs and bioengineering treatments looking upstream.

Further inspection of the treatments revealed large amounts of sediment definitely impacted the success of the bioengineering treatments by burying the lower half of many of the treatments (such as the willow clumps). This sediment, however, was the reason there was such a high number of cottonwood seedlings on many of the treatments.

The willow clump bioengineering treatment presently has 14 out of 40 (35%) of the willow clumps regenerating, while the other 26 (64%) willow clumps are buried by the large amounts of deposited sediment within the treatment area.

Six vegetative line intercept cross-section composition transects have been established and will be part of the long term monitoring program for this bioengineering project. No data comparison is available at this time.

Topographical surveys of the site done before construction and 9 months following construction have revealed that 430 cubic yards of sediment were deposited between the first stream barb and the fifth stream barb along the bendway.

A total of 6 fixed cross-sections have been established to monitor the change in channel morphology. The 6 cross-sections are located in conjunction with each of the bioengineering treatments installed. The present cross-sectional information illustrates the successful movement of the low flow channel (thalwag) away from the bendway. This suggests that the stream barbs have deflected the higher stream flow velocities away from the bendway causing the low flow channel (thalwag) to migrate to the ends of the stream barbs as designed. This in turn can also be linked to the amount of deposition that has occurred between the stream barbs as a result of the calm water areas developed between the stream barbs, which have allowed the river to deposit sediment within these areas by design.

Benefits of Project

The benefits accrued by this project are manifest both in the achievement of changes in the physical characteristics of the river and in the successful collaboration of the multiple stakeholders that actively supported the effort. The series of barbs and the peaked stone dike successfully moved the thalwag away from the cutbank and induced sediment deposition where it was needed. The bioengineering treatments in between the barbs are gradually covering areas with vegetation that have the potential to improve fishery and wildlife habitat in the stream. The treatments will serve as good examples of stream stabilization techniques for future projects.

The U.S. Army Corps of Engineers recognizes the relevance of bioengineering practices for a number of important reasons. Bioengineering is a "greener approach" to erosion control that is being explored by many agencies, including environmental and non-government organizations, for enhancing new projects. It is also useful for preserving cultural resources without hard armor that may be less aesthetically pleasing or present barriers to access. Also, bioengineering methods are often more cost-effective than traditional approaches.

Advise for Overcoming Obstacles When Using Soft Engineering Practices

When addressing social obstacles for the use of bioengineering, it is useful to look at what has been successfully done elsewhere, such as in Germany, Austria, and in various parts of the United States. It is important to emphasize that bioengineering, when properly designed and employed, can provide good habitat features, improve water quality, and help to control erosion. The Carson River Case Study is a good example of employing both "hard" and "soft" methodologies to safely achieve erosion protection goals, while also enhancing the environmental quality of the same area.

Additional information about the successes and failures of bioengineering in this country will be available through the U.S. Army Corps of Engineers web site in the future.

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Note: Technical input was also provided by:

Kevin Piper – Dayton Valley Conservation District, Lyon Co., Nevada;
Chris Hoag – NRCS Plant Materials Center, Aberdeen, Idaho;
Gail Durham – Nevada Division of Forestry; and
Rebecca Seal Soileau – U.S. Army Engineer Research and Development Center, Waterways Experimental Station.

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Ford Field Park

Chapter 11

Streambank Stabilization Project, Rouge River, Michigan

John Lambert, City of Dearborn- Parks Division

Introduction

The primary goal for the Ford Field Park Streambank Stabilization Project was to stabilize the eroding streambanks along the Lower Rouge River as it passes through Ford Field Park. Over the past several years, streambank erosion has accelerated causing the loss of trees and park area along the river. Further, streambank erosion threatens utilities and park amenities that are in close proximity to the river.

A secondary goal for the project was to emphasize passive recreational park uses. This is accomplished by better integrating the park areas into the stream corridor. Park visitors are able to better access and personally experience the river and stream corridor environment. The river and stream corridor benefits through improved water quality, wildlife, and fish habitat.

A third goal of this project was to provide a working laboratory for stream corridor restoration. The City of Dearborn, in partnership with the U.S. Department of Agriculture – Natural Resources Conservation Service (USDA–NRCS) and the Wayne County Conservation District, hosted three soil bioengineering workshops. At these workshops, participants from the community, public sector, and private sector learned soft engineering principles and experienced the construction of soil bioengineering techniques. In partnership with the Ford Motor Company, University of Michigan – Dearborn (UM–D), Dearborn Public Schools, Friends of the Rouge, and Rouge Remedial Action Plan Advisory Committee, the city also hosted a native plant and wildflower planting exercise. A second planting exercise is tentatively scheduled for 2000.

Project Description

The streambank stabilization project was implemented at Ford Field Park in Dearborn, Wayne County, Michigan. Ford Field park can best be described as an urban park. The park area was donated to the City of Dearborn by Henry Ford with the stipulation that the property would remain a public park.

The park is located three blocks north of the West Dearborn business district, with residential neighborhoods to the north and to the west of the park. The park is connected to the University of Michigan–Dearborn Natural Areas and the Henry Ford Estate by a wooded floodplain. The park is located approximately three-quarters of a mile upstream of the convergence of the lower and middle branches of the Rouge River.

To date, the project has involved stabilizing approximately 900 feet of streambank using soft engineering methods (Figure 36). Various techniques of soil bioengineering were applied to the various conditions found along the streambank. The streambank was analyzed for many factors, including slope, stability, vegetation, stream meander, water level, ordinary and high water flows, man-made conditions, and the natural conditions found along the river. Experts, including engineers, geologists, hydrologists, naturalists, biologists, foresters, and plant specialists, played an important role for the appropriate application of soil bioengineering techniques to the streambank.

The actual project construction involved City of Dearborn employees, workshop participants, and interested members of the community. After installation of soil erosion and sedimentation control measures, a small backhoe and operator cut back the

Figure 36 The soil bioengineering workshop construction area on the north (left) side of the Rouge River. Existing unstable streambank conditions are illustrated on the south (right) side.

Figure 37 The workshop construction area where the three various techniques were used (from left to right: the brushmattress, vegetative geogrid, and live fascine).

Figure 38 The workshop construction area where the three various techniques were used after one season of growth.

nearly vertical streambanks and excavated for the installation of the rock toe. A geotextile fabric was placed in the excavation and then stone was placed from below the bottom of the streambed to the bank-full level. The bank-full level is the elevation of the streambank where vegetation will not grow due to the rise and fall of water levels, and it is critical in the design of any soil bioengineering system.

After the rock toe was installed, vegetative plantings were used to stabilize the streambank in the area above the rock toe. Soil bioengineering techniques such as live fascine, brushmattress, and vegetative geogrid were constructed using dormant plant material (Figure 37 and 38). The dormant plant material was cut off-site and included willow and dogwood cuttings. Containerized dogwood and native grasses completed the plantings used for this project. Native species and wildflower plantings completed the vegetative buffer sections adjacent to the river.

The vegetative planting installations require special care and attention for successful plant growth. The planting activities are extremely labor intensive and were accomplished through the soil bioengineering workshops and the wildflower planting exercises.

Regulatory Considerations

The Ford Field Park Streambank Stabilization Project falls under the jurisdiction of the Michigan Department of Environmental Quality (MDEQ). An application was submitted and a permit issued for each phase of the project. The applicable regulation for the project was under the Natural Resources and Environmental Protection Act 451, PA 1994 (Part 301-Inland Lakes and Streams; Part 31-Floodplain/ Water Resources Protection).

As part of the permit process, the MDEQ maintains a database of endangered plant species. The database indicated the possible presence of the cup plant (*Silphium perfoliatum*) in the project area. A USDA–NRCS plant specialist checked the project area for the cup plant species. No cup plants were found.

Soil erosion and sedimentation control permitting fell under the jurisdiction of the City of Dearborn. The City of Dearborn is a local enforcement agency (LEA) responsible for issuing permits and for enforcing the provisions of the soil erosion and sedimentation control act. The specific act is the Natural Resources and Environmental Protection Act 451, PA 1994 (Part 91-Soil Erosion and Sedimentation Control).

Cost

A cost estimate for the Ford Field Park Streambank Stabilization Project is included (Table 7). The cost estimate is broken down into specific activities. Labor, equipment, and material costs are included for each activity.

The cost for stabilizing approximately 300 lineal feet of streambank was $35,921. The unit cost for soft engineering streambank stabilization methods was $120 per foot of streambank. The cost estimate reflects the most recent project activity. Equipment costs were based on the 1999 Michigan Department of Transportation equipment rental rates.

The cost estimate does not include a dollar value placed on the volunteer labor used for the installation of the vegetative plant material. For example, if someone were to place a value of $30/hour (wages and fringe benefits) for each of the 40 volunteers, an additional $12,000 ($30/hour * 40 volunteers * 10 hours/volunteer) would be added to the cost estimate. This would increase the total project cost to $47,921 and the unit cost to $160 per foot of streambank. The use of volunteers can provide substantial cost savings.

Funding and Project Partners

The City of Dearborn has developed numerous partnerships during the course of the Ford Field Streambank Stabilization Project. Funding partnerships have developed through the acquisition and use of grants and an interagency exchange of materials. More important are the working partnerships created as a result of this project. Through the soil bioengineering workshops, numerous groups and individuals have come together, shared information, and learned new ideas. The effect is multiplied as workshop participants spread the information and ideas with others.

The Ford Field Park Streambank Stabilization Project is funded through a combination of the Rouge River National Wet Weather Demonstration Grant and local matching funds. To date, approximately $108,000 out of a total project budget of $320,000 has been spent to stabilize approximately 900 lineal feet of streambank using soft engineering methods. Grant funding and local matching funds each provide 50% of project costs. Local matching funds come out of the City of Dearborn general operation and capital improvement budgets.

The workshops started in November 1998, when the City of Dearborn hosted a two-day soil bioengineering workshop for city employees, other governmental agencies, private sector consultants, and other individuals interested in streambank stabilization utilizing soft engineering principles. Nearly forty people attended the two-day workshop. The highlight of the workshop was an all day exercise at Ford Field Park. Over 120 feet of streambank was stabilized using brushmattress, vegetative geogrid, and live fascine techniques of streambank stabilization.

Since the November 1998 workshop, the City of Dearborn has hosted two week-long USDA–NRCS soil bioengineering training courses. USDA–NRCS personnel from all over the United States, city employees, and interested individuals have participated in the training courses. The highlight of the week-long courses is still the on-site workday.

The training courses have included contributions from local and international speakers. Speakers from the University of Michigan – Dearborn (UM–D) include Orin G. Gelderloos, Ph.D., professor of biology and environmental studies, Kent S. Murray, Ph.D., professor of geology, and Dorothy F. McLeer, a naturalist at the

Table 7 Ford Field Park Streambank Stabilization Project estimated costs.

	Excavation and Rock Toe Installation		
Labor	**Wages**	**Fringe Benefits**	**Cost**
Direct Labor Costs	$5,358	$4,063	$9,421
Supervisory Labor Costs	$2,144	$1,626	$3,770
Other Labor Costs	$779	$452	$1,232
Equipment	**Hours**	**Rate**	**Cost**
Pickup-Dump	96	$9.63	$924
Dump Truck	96	$24.05	$2,309
Backhoe	96	$33.35	$3,202
Bobcat and Trailer	96	$37.70	$3,619
Supervisory Equipment Costs	96	$6.83	$656
Other Equipment Costs	54	$6.03	$326
Material	**Quantity**	**Unit Cost**	**Cost**
Geotextile	600	$1.00	$600
Rock Toe Material			$2,900
Miscellaneous			$52
Total Rock Toe Installation Costs			**$29,010**
	Plant Material Harvest		
Labor	**Wages**	**Benefits**	**Cost**
Direct Labor Costs	$546	$414	$961
Supervisory Labor Costs	$175	$133	$308
Other Labor Costs	$164	$95	$259
Equipment	**Hours**	**Rate**	**Cost**
Pickup	8	$5.74	$46
Bobcat and Trailer	8	$37.70	$302
Chain Saw	8	$3.48	$28
Supervisory Equipment Costs	8	$6.83	$55
Other Equipment Costs	8	$6.03	$48
Total Plant Material Installation Costs			**$2,006**
	Soil-bioengineering Installation		
Labor	**Wages**	**Benefits**	**Cost**
Director Labor Costs	$1,098	$832	$1,930
Supervisory Labor Costs	$197	$149	$346
Other Labor Costs	$164	$95	$259
Equipment	**Hours**	**Rate**	**Cost**
Pickup-Dump	10	$9.63	$96
Pickup	10	$5.74	$57
Stake-Truck	10	$5.74	$57
Van	10	$5.74	$57
Dump Truck	10	$24.05	$241
Backhoe	10	$33.35	$334
Bobcat and Trailer	20	$37.70	$754
Chain Saw	20	$3.48	$70
Supervisory Equipment Costs	8	$6.83	$55
Other Equipment Costs	8	$6.03	$48
Miscellaneous			$600
Total Soil-engineering Installation			**$4,905**
		Project Costs	**$35,921**
		Unit Cost/($/lineal foot)	**$120**

UM–D Natural Areas. Accomplished landscape architect and soil bioengineering expert Beat Scheuter, from Switzerland, gave an international perspective on soft engineering principles.

The Five Star Partnership Grant sponsored by the Environmental Protection Agency provided monies for the native plant and wildflower planting exercises. The six grant partners include Ford Motor Company, the City of Dearborn, Dearborn Public Schools, the University of Michigan – Dearborn, Friends of the Rouge, and the Rouge Remedial Action Plan Advisory Committee.

Through the Ford Field Park Streambank Stabilization Project, the City of Dearborn and the USDA–NRCS have developed a strong relationship and partnership for promoting soft engineering in streambank stabilization projects. The city would like to thank Dave Burgdorf, Frank Cousin, Sean Duffey, and Steve Olds of the USDA–NRCS for their contribution to this project. Without their help, this project would not have been possible.

Post Project Evaluation for Effectiveness

The Ford Field Streambank Stabilization Project has been monitored and evaluated since November 1998. Photographs, videos, and personal site visits were used to document the condition and growth rate of the vegetative plantings. It is important to closely monitor the soil bioengineering installations on a regular basis and after all high water storm events. Remedial and/or supplementary plantings are made based on the findings and recommendations from the on-site inspections.

A testimonial to the effectiveness of soil bioengineering is told in the following story: Approximately two months after the November 1998 soil-bioengineering workshop installation, the Lower Rouge River experienced a week long high water event with a peak mean-daily-discharge rate of nearly 900 cfs. An on-site inspection after the water receded revealed only minor topsoil loss in the brushmattress area. Previous to the installation of the soft engineering techniques, high water events with this intensity and duration would have washed out the adjacent gravel parking area.

The streambank stabilization project is only one growing-season old. The results have been excellent and are illustrative of projects in their second or third year of growth. Only small, scattered areas required a second planting.

Project Benefits

The use of soft engineering methods is not a "cure-all" for streambank stabilization problems, but an important and effective tool for appropriate locations. Soft engineering methods can provide benefits not possible with the use of hard engineering measures.

The benefits of soft engineering over hard engineering methods include:

- use of soft engineering methods is aesthetically pleasing (soft engineering provides greater opportunity for incorporating trees, bushes, flowers, and grasses along the stream corridor; vegetative plantings offer an alternative to the sterile environment associated with hard engineering techniques);
- use of soft engineering methods provide wildlife habitat (vegetative plantings provide shelter, protective cover, and homes for birds, turtles, and small animals; plantings are also important for providing corridors for animals to travel; year-round, the area is alive with animal wildlife);
- use of soft engineering methods provide fish habitat (soft engineering can provide shelter and breaks in the stream current; this is important for fish to live and reproduce; overhanging vegetation also provides shelter);
- use of soft engineering improves water quality (vegetative plantings and buffer areas reduce streambank erosion and filter overland runoff into the river; vegetative growth shades the river and reduces water

temperature);

- use of soft engineering reduces maintenance costs (after the initial installation, areas are allowed to revert to their natural state, reducing maintenance costs; regular maintenance is virtually eliminated); and
- park visitors can experience the stream corridor environment; (the environment created by the use of soft engineering methods provides many opportunities for park visitors to come down to the river and enjoy the stream corridor; workshops and planting exercises provide a sense of stewardship, community pride, and ownership of the Ford Field Park area).

Previous streambank stabilization efforts at Ford Field Park included lining the streambank with interlocking concrete blocks. The blocks have stopped the streambank erosion, however they are showing signs of deterioration. Sections of block are missing, especially near the ends of the installation. Maintenance requires the use of string trimmers to trim vegetative growth between the blocks. There are few signs of fish and wildlife along this section of the river. Supplementing the interlocking blocks with vegetative plantings will produce many of the benefits previously mentioned.

Advice for Overcoming Obstacles When Using Soft Engineering Practices

The problems of the Lower Rouge River are highly visible at Ford Field Park. Visitors to the park can see the eroding streambank, trees falling into the river, picnic tables and debris floating down the river, and high levels of turbidity. Problem identification was easy; determining how to solve the problem was more difficult.

Change is always hard and new ideas such as soil bioengineering (soft engineering) always carry a certain degree of risk in execution, and more importantly, being accepted by the community. The Ford Field Park Streambank Stabilization Project was the result of many individuals and groups coming together with an interest in trying soil bioengineering (soft engineering) methods to stabilize the streambank of the river.

Ecological awareness and informational programs are an important tool in educating the community of the advantages of using soft engineering methods. The workshops and wildflower planting exercises provide an opportunity for the community to participate in the projects, become more aware of the stream corridor, and develop a sense of ownership and stewardship towards the river. This will go a long way in gaining support for this type of project in the future.

Michigan Department of Environmental Quality (MDEQ) personnel have visited the Ford Field Park Streambank Stabilization Project to see the application of soil bioengineering techniques. Feedback from the MDEQ personnel has been very positive. Exchanging information and opening the lines of communication will benefit both the permit applicant and the permitting agency.

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Chapter 12

Soil Bioengineering

for Streambank Protection and Fish Habitat Enhancement, Collingwood, Ontario

Rick Grillmayer, Nottawasaga Valley Conservation Authority

Introduction

The goal of this project was to repair and stabilize an eroding streambank with the use of vegetation, to create in-stream cover by constructing a vegetated structure, and to create a demonstration site that displays the effective use of soil bioengineering technology.

Project Description

The Black Ash Creek Project was initiated in 1992 as a component of the Collingwood Harbour Remedial Action Plan. The overall objectives of this watershed project were to reduce sediment loading from the creek into the harbor and enhance fish and wildlife habitat. Black Ash Creek was identified as contributing approximately 90% of the suspended sediment load for Collingwood Harbour (Collingwood Harbour RAP Stage 2 Document 1992). Sources of this sediment include erosion induced by cattle grazing on steep escarpment areas and eroding streambanks.

The location of this project is the Thompson Property on the 10th concession, Town of Collingwood. The reduction of channel sinuosity and elimination of a functioning floodplain had created an unstable reach of stream with significant erosion. The channel had been placed in a roadside ditch and the shoulder of the road was eroding. A previous attempt to stabilize this channel with field stone had failed because the improperly sized and placed stone was being eroded by high stream velocities. The stream gradient was steep (3.1%) and once the bed armor was missing the streambed degraded, aggravating the eroding bank. The bank slope on both sides was nearly vertical. The stream is intermittent, with flows occurring only during snowmelt and storm events. The catchment area upstream of the project site is approximately 10 km^2.

Bank stabilization and streambed armoring took place during the fall of 1993. The confined nature of the channel prevented excavating a flood plain or sloping the banks to a stable angle. The east side of the channel was privately owned and the owner was not open to any loss of property that would occur if regrading was used. It was decided to construct a bioengineered cribwall. This structure would stabilize a vertical bank and require little room. The streambed was armored to prevent down cutting. No attempt was made at this time to stabilize the road shoulder directly opposite the project site, however, the Town of Collingwood did attempt to stabilize the road shoulder by constructing a concrete wall during the early summer of 1995. By the late fall of 1999, the concrete wall was beginning to show signs of failure. The soil bioengineered cribwall was holding well.

A soil bioengineered cribwall is a hollow, interlocking arrangement of timbers constructed as a wall. This structure is filled with suitable soil and a layer of live branch cuttings. Once the cuttings have taken root and grown, they will eventually take over the structural functions of the timbers. The end result is a stable, vegetated slope.

The cribwall was built into the bank so the face of the cribwall would be at the same location as the original face of the slope. This was done so the capacity of the channel would not be reduced. A hi-hoe was used to excavate the cribwall site. The logs for the cribwall were cut from a Nottawasaga Valley Conservation Authority jack pine plantation. The wall itself was built by hand and measured 30 m long, 1 m high, and 2.2 m wide at the bottom. The wall was canted back so that the top brush layers would not shade the bottom ones.

Shrub willow cuttings were harvested from sites within the watershed and transported to the cribwall site. Care was taken to time the harvest so that only fresh material would be used. Species of willow used at this site were:

- Willow (*Salix eriocephala*);
- Sandbar Willow (*Salix exigua*); and
- Autumn Willow (*Salix serrisima*).

The cribwall was built by alternating layers of timbers, soil, and cuttings. Once the cribwall was completed, unused soil was removed from the site. Exposed soil was seeded with annual rye and oats. The soil was then covered with anti-wash geojute to prevent surface erosion. Live stakes (live rootable cuttings tamped into the ground) were placed at random into the geojute. The streambed was protected from down-cutting by placing 28 tons of rip-rap stone.

Due to the absence of any horizontal sinuosity, stream energy had to be dissipated by vertical sinuosity. This was achieved by placing the stone in a series of steps, attempting to establish a step-pool formation common to high gradient streams.

Regulatory Considerations

Whenever a project may impact the natural ecosystem, approvals and permits are needed. The project was approved by the local Ministry of Natural Resources (Midhurst District) and a work permit was issued under the Lakes and Rivers Improvement Act. A permit from the Nottawasaga Valley Conservation Authority was required under the Fill, Construction, and Alterations to Waterways Regulation.

The stream at this site is intermittent. The fish community is predominantly cyprinids and catostomids, and is non-existent through summer, fall, and winter. Fish are present, likely as migrants, during the spring. The cribwall was built during the fall, while the channel was dry. Sedimentation during construction was minimal. The addition of bed material would not have affected any fish or macroinvertebrates. Materials used were native and harvested from within the same sub-watershed as the cribwall.

Table 8 Soil bioengineering costs associated with soft engineering of Black Ash Creek.

Requirements		Cost (in dollars)
Consultants		800
Logs for Cribwall		50
Contractors		1,423
Rock		300
Geojute		297
Spikes		122
Refreshments		56
Fertilizer/seed		40
Topsoil		250
Rental of Lawn Rollers		10
Total Materials		3,348
Requirements	**Time (hours)**	**Cost (in dollars)**
Measuring and Design	48	772
Site Preperation	27	311
Cutting/transpoting Materials	48	553
Placement of Materials	148	1,244
Repairs to Lawns	72	138
Total Wages	343	3018

Note: Costs listed were specific to this site only.

Cost

Project costs are presented in Table 8. Costs do not include tools, truck rental, fuel, office costs, indirect support for the crew, or permit fees. It would be impossible to separate these costs as they were used/required on more than one site.

Funding and Implementation Partners

Environment Canada Great Lakes 2000 Cleanup Fund;
Environment Canada Environmental Partners Fund;
Ontario Ministry of Natural Resources;
Ontario Ministry of Environment;
Nottawasaga Valley Conservation Authority;
Collingwood Collegiate Institute;
Collingwood Rotary Club; and
Landowners in the Black Ash Creek Watershed.

Figure 39 Conditions of Black Ash Creek project site on June 28, 2000. Soil bioengineered cribwall is on the left side of the photograph, the concrete block wall is on the right.

Figure 40 Deterioration of the concrete block wall, showing undermining and slumping of the structure on June 28, 2000.

Figure 41 Close-up of soil bioengineering cribwall on June 28, 2000.

Post Project Evaluation of Effectiveness

1995: Two years after completion, the streambank at this site was completely vegetated (Figure 39). Any erosion was insignificant. The soil bioengineered cribwall successfully weathered the spring flows, which often saw the structure completely submerged. Growth from the cuttings has been vigorous, with *Salix eriocephala* becoming the dominant willow.
2000: Seven years after completion, the streambank at this site is still doing very well. The concrete block wall built by the Town of Collingwood is beginning to show signs of failure (Figure 40). This failure is apparent in the form of undercutting, the slumping of several sections of wall, and widespread cracking and deterioration of the concrete. The soil bioengineered cribwall is more than adequately maintaining stability (Figure 41). This project was an overwhelming success.

Benefits of the Project

Soil bioengineering was chosen as the preferred method of streambank stabilization for several reasons:

- It is an applied science that combines structural, biological, and ecological concepts to construct living structures for erosion, sediment, and flood control. Conventional methods of erosion and flood control provide little habitat for terrestrial or aquatic organisms. Conventional structures often have the effect of an ecological barrier, separating aquatic and terrestrial; conversely, the vegetation used in bioengineered structures provides a wide range of habitats for many organisms.
- Soil bioengineered structures are labor intensive, not capital or energy intensive (limited budget dollars were put into wages, not materials).
- This is a living wall (there is usually less long-term maintenance than conventional structures since soil bioengineered structures tend to be self-repairing).

- The project serves as an excellent demonstration of the strength and applicability of soil bioengineering as a method of managing erosion in high-energy stream channels. The site can be readily seen by the public and the presence of a conventional concrete block wall directly opposite of the soil bioengineered wall provides a direct comparison of the two methods.

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Chapter 13

Achieving Integrated

Habitat Enhancement Objectives, Lake Superior

Ken Cullis, Ontario Ministry of Natural Resources

Introduction

The Remedial Action Plan (RAP) process can be viewed as a successful model for addressing a variety of aquatic and terrestrial habitat issues within the Great Lakes. This process, which has been a true partnership between government agencies and local communities, has provided the framework to identify specific habitat problems within Areas of Concern (AOC) and achieve many habitat rehabilitation targets. Combining expertise and resources through the RAP process has provided an opportunity to demonstrate current habitat rehabilitation technologies and to complete large-scale habitat projects, which could not be addressed by single agencies or organizations.

Drawing on the RAP experience in Lake Superior, there are four key aspects which have contributed to success: clear objectives, interagency approach, funding source, and community involvement.

Clear Objectives

There must be clear objectives in place, which are compatible at all levels of regulation and involvement. For example, The Great Lakes Water Quality Agreement established water quality objectives for the Great Lakes. The RAP process specifically addressed impairments to an established list of 14 beneficial uses. Within the bounds of the above two objective structures, the Public Advisory Committees (PAC) set Water Use Goals that pertain to the specific environmental issue in their area.

Interagency Approach

The Lake Superior Programs Office, which brought together four government agencies under one roof, provided coordination for the habitat projects on Lake Superior. This is a demonstration of how federal and provincial agencies, in times of severe financial constraints, can effectively share resources and expertise to reduce program costs, minimize overlapping mandates on environmental issues affecting Lake Superior, and develop real partnerships with industry and the public.

Funding Source

For many of the Lake Superior programs, the Great Lakes 2000 Cleanup Fund provided base funding. The objective of this fund was to develop and implement cleanup technologies and techniques in the Great Lakes. The Cleanup Fund provided monies for up to one third of the proposed cost of the project, with the remaining cost being covered by other partners who contributed with both funding and in-kind support. Having one established funding source generally provides a catalyst for securing other funding partners.

Community Involvement

When members of the community are involved with developing and implementing a plan, they will share accountability for the project. On Lake Superior, strong support has been fostered through local Public Advisory Committees (PAC). These committees were true advisory groups who assisted in project planning and implementation. All proposed projects were first approved by the local PAC before being considered by the Cleanup Fund for funding support. This process resulted in strong community partnerships during implementation, a community structure that was accountable for projects, and ownership for the successes which were achieved.

Demonstration Projects

There are many completed habitat projects in Lake Superior which demonstrate soft engineering technology in shoreline developments. The following are three examples, located in the lower reaches of the Kaministiquia River in Thunder Bay and Nipigon River in Nipigon Bay.

Red Rock Harbourfront and Marina Breakwater Enhancement – Nipigon Bay

In order to improve access to Lake Superior and enhance tourism opportunities for the Township of Red Rock, construction of a full service marina was proposed. The project included construction of a 1.2 km long backwater and dredging 6 ha for the marina base.

The design of this project was initiated at the same time as a separate program was being undertaken by the RAP to restore the Nipigon Bay aquatic ecosystem. Through the forging of a partnership between proponents of both projects, concepts were developed with an emphasis on integrating habitat and water quality enhancement initiatives as components of the design of the marina basin and breakwater. The product successfully achieves both functional and ecosystem objectives while providing additional recreational, aesthetic, and interpretive attributes (Figure 42).

The standard armorstone breakwall was overlaid with a number of habitat features to enhance habitat diversity and create a functional littoral zone along the inner breakwall. Following reconstruction of the inner breakwall, fine material and topsoil were added before the structure was planted with trees and shrubs. Two islands, which included log and canopy shelter structures, spawning shoals, and littoral zone extensions, were constructed on the outside to protect a second opening in the breakaway from wave action. On the inside of the breakwall, habitat diversity was maximized by the addition of a wide variety of habitat structures, including log crib shelters, shallow sandy areas for aquatic plants, rock and bolder edging, gravel shoals, and partially submerged trees.

Functionally, structurally, and ecologically the Red Rock Breakwall is a demonstration of Great Lakes shoreline development utilizing soft engineering techniques. The final structure is an extension of the Marina Park, providing productive habitat for fish and other aquatic organisms and is a functional breakwater for the marina.

The cost of constructing the Red Rock full service marina, which will accommodate 253 boats, was $2.1 million. For the additional cost of $230,000, the ecological productivity of the shoreline has been enhanced and the breakwater is now an extension of the Marina Park.

Project Partners

Nipigon Bay Remedial Action Plan;
Township of Red Rock;
Great Lakes 2000 Cleanup Fund;
Ministry of Northern Development and Mines;
Ministry of Natural Resources;
Domtar Packaging;
Ontario Ministry of the Environment;
Public Works Canada – Small Craft Harbour Branch;
Province of Ontario – Jobs Ontario Capital Program; and
Todhunter Schollen and Associates.

McKellar River Wetland Expansion Project – Thunder Bay

The site of the McKellar River Wetland Project is located at the confluence of the McKellar River and Lake Superior, adjacent to the Mission Marsh. The goal of the project was to extend the influence of the remnant coastal wetland and to increase the diversity and productivity of the fishery within the river and Thunder Bay. Coastal wetlands in Thunder Bay have been degraded or lost as a result of urban, industrial, and commercial waterfront development. This type of nearshore habitat, although critical for the survival of many cool water fish species, is limited in Lake Superior.

Figure 42 The Red Rock Harbourfront and Marina Breakwater project improved access to Lake Superior, enhanced tourism opportunities, and improved fish and wildlife habitat.

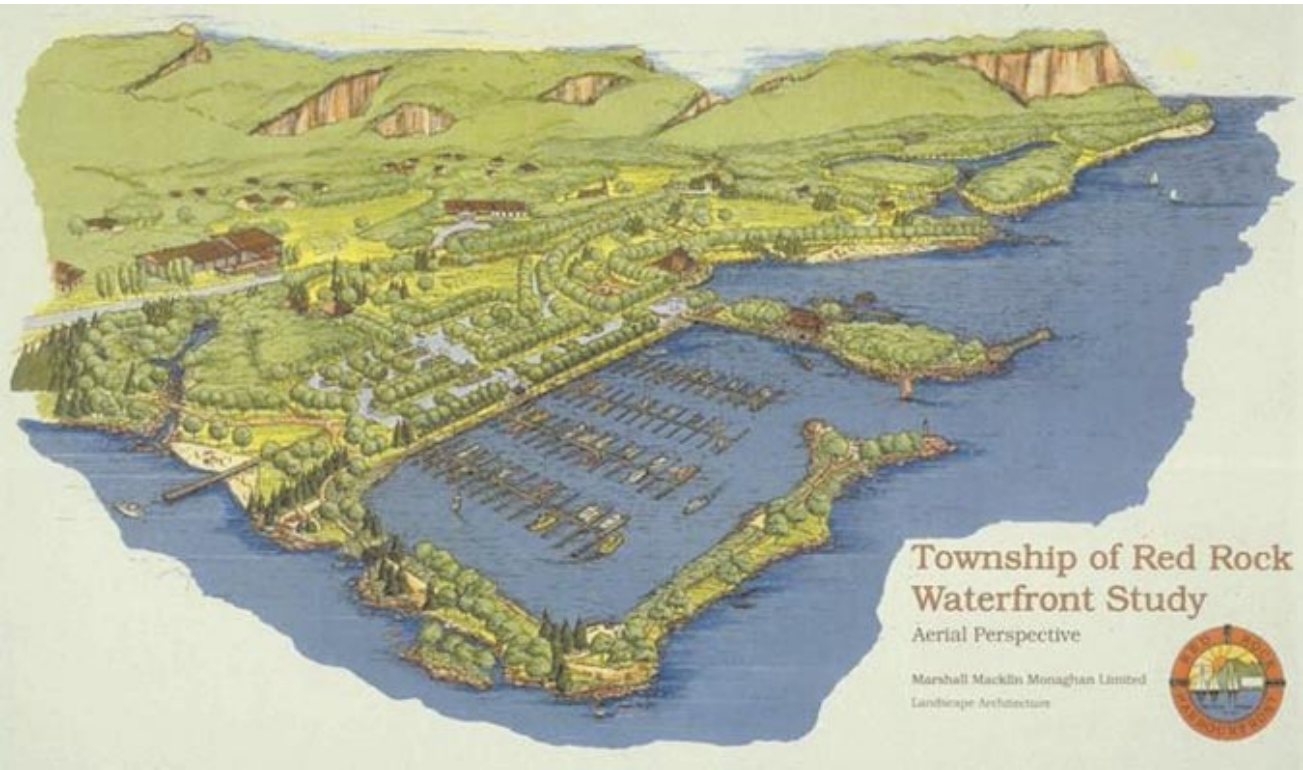

Figure 43 An example of recreating coastal wetlands along the McKellar River that were degraded and lost as a result of waterfront development. The far side of the river depicts urbanized shoreline development and the near side of the river depicts restored wetlands.

This project presented an opportunity to restore critical coastal wetland habitat in an urban waterfront setting. Two warm water embayments were constructed on the City of Thunder Bay land adjacent to the Mission Marsh Conservation Area (Figure 43). Although clearly focused on habitat creation and enhancement, the location of the embayments in a conservation area also presented the opportunity to integrate interpretive and recreational components into the project.

The two embayments, approximately 1.5 ha each, were constructed in dry winter conditions and opened to the river in March 1994. A complex contour grading plan included a network of channels with a maximum depth of 6 m, a number of islands, and a variety of habitat treatments in the nearshore zone. Treatments included sand, gravel and rock shoals, boulder edges, submerged tree crowns, and river stone banks. In addition, wetland pockets were constructed to accommodate stormwater runoff and enhance aquatic vegetation production.

Surrounding the embayments, over 4,000 trees and shrubs were planted by volunteers to stabilize the area disturbed during construction and to provide food and cover for wildlife. Additional habitat treatments included shallow micro-pools for amphibians, a mud flat for shore birds, a sand bluff for shore birds, and rock and log piles for reptiles and mammals.

Colonization of the embayments by fish, aquatic plants, and benthic organisms will provide valuable information for future habitat restoration initiatives. In addition, monitoring activities will provide information on the contributions of the embayments to the surrounding aquatic and terrestrial ecosystems. Recreational and aesthetic benefits were evident immediately following construction. One year after completion, many conservation area users were surprised to learn that the embayments were constructed and not natural features.

Project cost, including concept development, design, and construction, amounted to $650,000.

Project Partners

Thunder Bay Remedial Action Plan;
City of Thunder Bay;
Lakehead Conservation Authority;
Great Lakes 2000 Cleanup Fund;
Ontario Ministry of Natural Resources;
Ontario Ministry of the Environment;
Public Works Canada – Department of Fisheries and Oceans; and
Todhunter, Schollen and Associates.

Kaministiquia River Heritage Park – Thunder Bay

For over a century, aquatic and terrestrial habitat has been modified or destroyed in the Thunder Bay Area of Concern. The surrounding watershed has been degraded by industrial, residential, and recreational development. Dredging, channelization, and the release of a number of pollutants have eliminated a significant portion of the quality habitat that once existed along the waterfront. Habitat degradation has resulted in loss of species abundance, diversity, and recreational opportunities. Habitat degradation has also resulted in a decline of aesthetic value for the harbor and its tributaries.

Rehabilitation projects undertaken by the City of Thunder Bay, in the lower reaches of the Kaministiquia River, represent an integrative approach

Figure 44 The open pile construction of this scenic overlook provides instream cover for aquatic habitat and increased public access without destroying or degrading the existing wetland areas along the shoreline.

to waterfront development and habitat restoration. Shoreline degradation had left the area void of ecological, recreational, and economic value. The Kaministiquia River Heritage Park was developed to restore the environmental integrity and natural history of the region. The park features a scenic overlook and riverfront promenade running alongside an existing wetland area (Figure 44). The open pile construction of the boardwalk maximizes development and substrate diversity of the aquatic habitat by providing instream cover. This design, however, was not part of the original park plan. Initially the approximately 600 m of waterfront was to be developed with steel sheet piling and concrete construction. This would have destroyed the natural shoreline and left a hard, straight edge with no benefit to the aquatic ecosystem. Convinced that a soft engineering approach would not only provide the same protective and access functions as the traditional design, the design was altered to enhance aesthetic and biological benefits. In the initial waterfront construction phase (approximately 600 m), project costs were actually reduced from $850,000 to $450,000. The remainder of the project was completed with open pile construction and shoreline enhancements. This project has convinced many people that habitat rehabilitation can be ecologically desirable and economically viable.

Project Partners

Thunder Bay Remedial Action Plan;
City of Thunder Bay;
Great Lakes 2000 Cleanup Fund;
Ontario Ministry of Natural Resources;
Ontario Ministry of the Environment;
Todhunter, Schollen and Associates;
Canadian Pacific Rail; and
Northern Ontario Heritage Fund.

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Battle Creek River,

Chapter 14

Bringing Back the Banks

Douglas Denison, Smith Group JJR, Inc.

Introduction

Like many large metropolitan areas, Battle Creek historically utilized its river system as a workhorse supplying power and transporting raw materials and products. Economic priorities at the time resulted in extensive industrial development along the banks of the river system. The river served to remove waste materials and stormwater from the land, severely impacting their ecological and aesthetic integrity. Frequently, communities turned their backs to the rivers long ignoring their potential value as public spaces or cultural and natural resource amenities.

The Battle Creek River was a working river in its time. It had become the "back door" to the community suffering from neglect, hydrologic instability, and ecological abuse. Large building complexes infringed on its floodplain and squeezed its banks into narrow channels. Parking lots were built along the riverbanks, and at times enclosed it entirely underground. Vegetation was removed from its banks, eliminating valuable habitat for aquatic organisms and wildlife. Serious erosion resulting from extreme flashiness of stormwater runoff promoted *ad hoc* stabilization techniques of poured concrete, rock, and debris.

During the 1980s, public and private community leaders began to recognize the potential of the Battle Creek River as an amenity and not a liability. Smith Group JJR developed regional concept plans that focused the community's vision back to the river, providing for opportunities of rehabilitation, redevelopment, and increased public visibility. Projects are now starting to be implemented that provide for pedestrian linkages along the river, removal of parking lot decking to allow the river to be "daylighted" again, and new urban re-development.

Utilizing a shared vision of improving the quality of public life in Battle Creek, Smith Group JJR assisted the W.K. Kellogg Foundation in selecting a site for their new world headquarters. The site, located along the eastern edge of downtown, was traversed by the Battle Creek River. The goal of the project was to revitalize an urban commercial block and transform a seldom seen urban stream into a highly used public riverfront park. The rehabilitation of the Battle Creek River included ecological planning of bank stabilization techniques to provide for a more natural edge, recapture lost floodplains, and enhance habitat and landscaping while protecting the banks and buildings from erosion caused by urbanized river flows (Figure 45).

Project Description

In an era when many corporations flee the established infrastructure of the city to new suburban campuses, the W. K. Kellogg Foundation committed to build their new world headquarters on a 14 acre site in downtown Battle Creek, Michigan. This allowed this international foundation to reconnect with and celebrate its community and cultural heritage while assisting in the revitalization of the downtown area. The site is surrounded by both urban and natural settings that provided the opportunity for the public to access a rich environment. The project included a new 280,000 square foot headquarters campus, a new urban park and public square linked by an enhanced streetscape, and a public greenway along the Battle Creek River (Figure 46).

An integral element of this project was the rehabilitation of the Battle Creek River into a public focal point of the Kellogg Foundation and the community. It was critical to establish the stabilization of the banks while

Figure 45 The new headquarters of the W. K. Kellogg Foundation sits on the rehabilitated shoreline of Battle Creek.

Figure 46 A new urban park allows greater public access within the commercial core. The materials used to create this park appear "soft" and invite the public to the river.

providing a soft appearance, improving access to the river's edge, and enhancing aquatic and wildlife habitat. The rehabilitation of the river's banks incorporated a biotechnical stabilization technique that utilized sandstone boulders and vegetation to create a "soft" look that invited the public to the river, while providing the necessary protection of the river banks from extensive erosional forces exhibited by a urbanized stream. The design of the bank edges incorporated elements that provided increased wildlife and aquatic habitat. The project greatly expanded public access to and use of the Battle Creek River inside the commercial core.

Regulatory Issues

The rehabilitation of the riverbanks included extensive construction along and into the water edge. State regulatory agencies had permitting authority for the project while the U.S. Army Corps of Engineers had commenting authority. Michigan Department of Environmental Quality specific authority included: Natural Resources and Environmental Protection Act: P.A. 451: Part 13: Floodplains and Floodways; Part 21: Rule revisions of Act 245 of Michigan Water Resources Act; Part 31: Water Resources Protection; Part 301: Inland Lakes and Streams Act; and Part 303: Wetlands Protection. Calhoun County had jurisdiction of the Soil Erosion and Sedimentation Control Act 347. The City of Battle Creek completed preliminary and final site plan approvals and issued demolition, utilities, and building permits. The re-grading of the channelized riverbanks to expand the 100 year floodplain was very favorably received by permitting authorities.

Cost

The W. K. Kellogg Foundation privately funded all aspects of this project. The total costs for the site work was approximately $7.5 million. The rehabilitation of the Battle Creek River was approximately $750,000. The majority of the costs was associated with demolition of the concrete walls

channeling the river. The establishment of the bank stabilization, including the sandstone rock work, was approximately $300,000.

Post Evaluation

The W.K. Kellogg Foundation's headquarters project represents a highly successful example of how corporate investment in a city can lead to benefits far beyond simply establishing a new home for employees. Their commitment to an improved quality of life, as interpreted and implemented by Smith Group JJR, set the stage for long-term economic growth and reunited the community with its cultural heritage. Elements such as the public greenway along the river reinforce the Foundation's philanthropic goals and its support for the City of Battle Creek.

The Battle Creek River flowing through the commercial core of Battle Creek was a river that had long been forgotten and neglected. Buried beneath parking lots or hidden behind the back doors of storefronts and warehouses, the river was seriously suffering from stream bank erosion, lack of vegetation, and no public access. Today the river is a focal point of both Foundation employees and the community. The rehabilitation of the banks of the Battle Creek River included restoration of a lost floodplain and stabilization of its banks. The project has been very successful. There is no evidence of continued erosion along this reach of the river. The combination of undulating rock edges, deep water pools, and overhanging vegetation adds geomorphologic diversity along the river's edge that was lacking prior to re-construction. The sandstone created suitable habitat for fish, macro-invertebrates, and mammals that immediately took refuge along this shoreline.

Through the implementation of the linear river park and trail system, the site now affords the public direct access to the river. The public has taken advantage of this newly created open space and public park land, utilizing the spaces for summer festivals and passive recreation.

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Appendix A

November 23, 1999

program for the technology transfer session for soft engineering of shorelines sponsored by the Greater Detroit American Heritage River Initiative

8:30 AM	Registration and Coffee
9:30 AM	Welcome and Introductions – Nettie Seabrooks, Chief of Staff for Detroit Mayor Dennis Archer; Peter Stroh, Chairman of the Executive Committee for the Greater Detroit American Heritage River Initiative; The Honorable John D. Tennant, Consul General for Canada in Detroit
9:45 AM	Multi-Objective Soil Bioengineering Riverbank Restoration – Alton P. Simms, Robbin B. Sotir & Associates, Inc.
10:15 AM	McDonald Park Wetland Rehabilitation Project (St. Clair River) – Don Hector, Ontario Ministry of Natural Resources
10:45 AM	Achieving Integrated Habitat Enhancement Objectives for Lake Superior – Ken Cullis, Lake Superior Management Unit
11:15 AM	Comparison of Soil Bioengineering and Hard Structures for Shore Erosion Control – Costs and Effectiveness – Tim Patterson, Environment Canada
11:45 AM	Overcoming regulatory challenges and making it happen (brief commentaries from David Gesl, U.S. Army Corps of Engineers; Stan Taylor, Essex Region Conservation Authority; Andrew Hartz, Michigan Department of Environmental Quality; Moderator: John Gannon, U.S. Geological Survey)
Noon	Lunch
1:00 PM	Battle Creek River, Bringing Back the Banks - Doug Denison, JJR, Inc.
1:30 PM	Fish and Wildlife Habitat and Shoreline Treatments – A Toronto Region Conservation Authority Perspective - Gord McPherson, Toronto Region Conservation Authority
2:00 PM	Coffee Break
2:15 PM	Constructing Islands for Habitat Rehabilitation in the Upper Mississippi River – Barry L. Johnson, U. S. Geological Survey, Upper Midwest Environmental Sciences Center
2:45 PM	Panel Discussion "Where and How Can Soft Engineering be used?"
	Panelists: Ernest Burkeen, Detroit Parks and Recreation; John Blanchard, General Motors Corporation; Faye Langmaid, City of Windsor; Wendy White, National Steel Corporation; Hurley Coleman, Wayne County Parks; Joe Derkowski, Ford Motor Land Development Corporation; Moderators: Mark Breederland, Michigan Sea Grant and John Gannon, U.S. Geological Survey
3:45 PM	Concluding Remarks – Curt Boller, Supervisor of Brownstown Township; John Hartig, River Navigator for the Greater Detroit American Heritage River Initiative
4:00 PM	Adjourn

List of participants

Appendix B

in the November 23, 1999 technology transfer session for soft engineering of shorelines

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Wildlife Habitat Council
c/o Detroit Edison

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Michigan Dept. of Natural Resources

Mark Breederland
Michigan Sea Grant

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Southeast Michigan Council of Governments

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U.S. Army Corps of Engineers

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Rosanne Ellison
U.S. Environmental Protection Agency

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Grand River Conservation Authority

Tom Fegan
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