

# North Shore Management Board

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## Erosion Hazard Area Planning Process Definition

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May 2008

### North Shore Management Board

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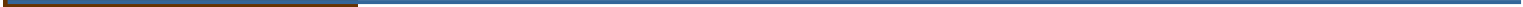
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## SECTION 1: Board Background

The North Shore Management Board (NSMB) is a joint powers agreement among 10 local governments (counties, cities, and townships) along Minnesota's Lake Superior coast. The NSMB was created in 1987 to develop a plan for uniform land use regulations for properties on and near Lake Superior (see inset below). The lake is valuable resource that provides natural, recreational, economic, and cultural assets to Minnesota. The NSMB completed and implemented its original plan in 1988 with an update in 2004. The Plan sets the minimum shoreland standards for the North Shore of Lake Superior including densities, lot size, setbacks and several other standards. Implementation of the Plan's minimum standards with local units of government is now nearly complete.

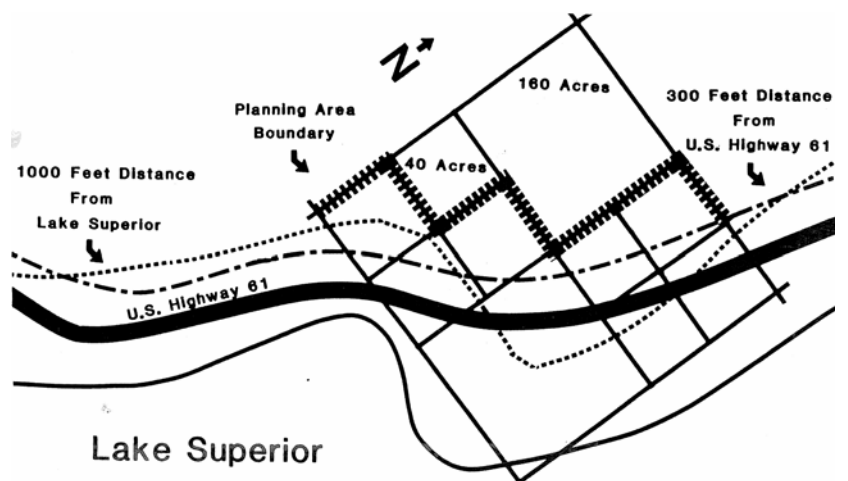
The NSMB is responsible for the North Shore Management Plan (NSMP). The NSMB serves as a forum for land use and environmental discussion between the member entities. The Board discusses development trends, newly identified issues, and other concerns that are common among the entities. The Board has organized a Technical Advisory Committee (TAC) of zoning professionals and agency officials to add expertise to the discussions.

The North Shore Management Plan area boundary is defined along the 40-acre subdivision lines of the rectangular coordinate system established in the U.S. Public Land Survey, nearest to the landward side of a line 1000 feet from the shoreline of Lake Superior or 300 feet landward from the center line of U.S Highway 61, whichever is greater. However, the boundary between Lakewood Township and the western corporate limits of Two Harbors is the centerline of the U.S. Highway 61 Expressway. (See Figure 2 below).

**The North Shore of Lake Superior**



**Definition of the North Shore Management Plan Area Boundary**



Source: 1988 North Shore Management Plan



## **SECTION 2: Project Introduction**

### **History of North Shore Erosion Efforts**

The North Shore Management Plan identifies erosion hazard areas along the shores of Lake Superior. The NSMP acknowledged that erosion was an issue along the North Shore and identified several areas to be considered as erosion hazard areas on maps. In 1988, the majority of the erosion was the result of high water levels, however there continues to be other factors that contribute to shoreline erosion. The NSMP did not identify specific properties as hazard areas, but left defining individual parcels up to the local governments. The goal for the NSMP regarding erosion was to properly manage erosion hazard areas to protect private property and protect public safety by guiding the development in areas prone to excessive shoreline erosion.

The erosion hazard areas were defined as areas that had a long term erosion rate greater than one foot per year. Soils maps and many surveys from a 1986 shoreline erosion survey coupled with revisiting fifty sites along the shoreline and taking measurements. Many of the areas that were identified as erosion hazard areas had high clay banks that continued to show signs of failure despite the two intervening years of relatively low, calm water.

The identified erosion hazard areas represent the more severe problems of erosion on the shore. Detailed mapping by local zoning officials was still needed before the erosion hazard areas could be effectively addressed in local zoning ordinances. As the result of this plan there were varying degrees of utilization. Some local governments went through and identified precise boundaries of the designated erosion hazard areas while others did not address the plan's erosion recommendations.

Since the 1988 erosion planning by the NSMB, there have been further efforts to address the shoreline erosion problems on the North Shore. Besides erosion work performed by Soil and Water Conservation Districts and other local efforts, Natural Resources Research Institute (Duluth, MN) completed a report called Erosion Hazard of Minnesota's Lake Superior Shoreline. This process identified areas of high, low, and unknown erosion potential. This process also used the determiner of erosion greater than one foot per year; equating to high erosion potential.

An outcome of the 2004 North Shore Management Plan Update process was a list of priority projects. These were projects that the Board, TAC, and NSMB Staff identified as relevant issues that needed to be addressed. Developing an updated Erosion Hazard Area Map was one of

the priorities. Other objectives in the NSMP Update were to continue to promote education, awareness, and understanding of shoreline erosion. The NSMP also calls for the designation of special provisions for erosion hazard areas.

The NSMB assumed this project to define a process for developing an Erosion Hazard Area Map for the North Shore. The NSMB understands the detail, time, and collaborative efforts that are needed to develop a successful erosion hazard map that will provide a useful tool to the local government's planning efforts. This process had input from Minnesota Department of Natural Resources, Coastal Program, Minnesota Pollution Control Agency, Lake and Cook Soil and Water Conservation Districts, and other contributors to the NSMB and the Technical Advisory Committee.

### **Why the NSMB is Addressing Erosion**

The Lake Superior shoreline is prone to erosion, due to large fluctuation of water levels and also the wave volume and force that can quickly destroy and relocate shorelines. Erosion continues to be an important topic because it can cause dangerous living conditions, property destruction, and affect values on lakeshore properties. As the North Shore continues to grow in popularity, there continues to be more development focused on the lakeshore.

Continued shoreline development is inevitable and contributes to erosion problems. Erosion rates can accelerate with increases in impervious surfaces, changing and eliminating vegetation cover, and alterations to beach makeup. Serious situations are rare but massive/fast erosion can occur during one storm event leaving houses dangling from cliffs or beginning to slide down hillsides. The effective management of areas with high erosion potential is necessary to protect property owners, and provide measures for reducing erosion.

### **Planning for Erosion Areas**

The NSMP sets standards that are aimed at reducing stormwater runoff, which has a large impact on bluff deterioration. The NSMP advocates for stormwater runoff plans conducted by professionals, vegetation management, and managing soil when performing construction activities.

The other way the NSMP protects property owners from the direct affects of erosion is through lake setbacks. The current riparian setback from the permanent vegetation line of Lake Superior is 40 feet or 75 feet from the average water level, whichever is greater. This provides a buffer from the bluffline to protect the structures.

The NSMP also has structure setbacks for erosion hazard areas:

*Structures and soil absorption areas shall be setback the annual erosion rate times 50 plus 25 feet (to allow for structure relocation) from the top edge of the eroding bluff. Where slumping is evident, the setback shall be measured from the uppermost shear zone (point at which the soil separates and slumping begins). In the absence of an established long-term erosion rate, the setback shall be 125 feet.*

*The structure setback and the location of the soil absorption areas can be modified by variance if the landowner provides technical data proving a different recession rate or that the erosion hazard, although correctly estimated, can be mitigated by structural protection. The setback, however, shall not be reduced to less than the setback standards detailed in the zoning standards portion of this chapter.*

To properly plan for erosion along the North Shore, there needs to be a redefinition of the areas. The definition will involve a process for accurately identifying boundaries to the known areas so that they can be more readily utilized through local zoning ordinances.





## SECTION 3: Process Definition

There are many different methods that could be considered for developing a map identifying specific erosion hazard areas. Some of the methods contain new technologies that provide more accurate measurements of shoreline erosion over time including high resolution aerial photographs and Global Positioning System measurements.

### **OPTION 1: Full Historical Aerial Photograph Analysis**

Erosion hazard area identification on the North Shore should involve two items; monitoring and evaluation. Monitoring of erosion along the shore is important because it will allow the NSMB, as well as the local governments to continue to make adjustments to regulations when erosion conditions change. Evaluating how the shoreline has changed in the past will help in proactively regulating the areas that are likely to continue to hazardously erode in the future. Both of these methods are individually important to effectively addressing erosion-related issues.

A committee should be organized to provide oversight throughout the process of refining and identifying the location of erosion hazard areas. The makeup of this committee is detailed in project partners; but should include representatives from Board of Water and Soil Resources, Department of Natural Resources, Minnesota Pollution Control Agency, Minnesota Department of Transportation, counties, cities, townships, and local universities (University of Minnesota-Duluth and Natural Resources Research Institute) from along the North Shore.

#### Step 1: Aerial Photograph Review

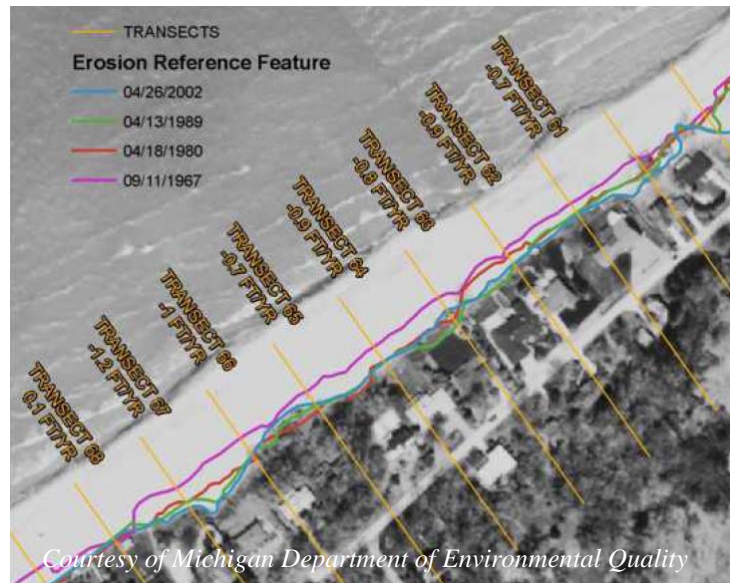
The first step needed to identify erosion hazard areas will be reviewing historic and current aerial photographs. The project will begin with reviewing several sets of aerial photographs from the past 30 or more years. Aerials that are available will be reviewed to get a basis for how the shoreline has changed over that period of time. Currently the DNR possesses four sets of aerials for the entire North Shore for the following years: 1948, 1961, 1990, and 1998. There are other resources available that may have additional years' aerial photos. Using more than two different time periods is going to indicate if the erosion has been consistent over a many years or if a short-term event was the main contributor to erosion.

Using reference features (building structure, tree, rock formation, etc) the shoreline should be measured every 150 feet. Doing this at a regulated interval should help with the accuracy of the erosion hazard map. This will also be helpful later in the process when erosion hazard areas are defined on maps and boundaries are drawn. It is important to use this many reference points, and take an average erosion measurement will ensure that hazard areas are correctly identified.

Since the 1988 review of the North Shore for erosion hazard areas, there have been several developments in the

technology used to identify shoreline changes. Air photos are now controlled using Differential Global Positioning System which improves accuracy when comparing photos. Using several aerial photos from multiple years will give a better depiction of past erosion. The technology of Geographic Information Systems (GIS) and orthorectified photographs increases accuracy and will substantially help to identify the hazard areas. Using orthorectified photographs is important because this means that the photographs are spatially aligned to make for accurate comparisons. USGS has also developed a Digital Shoreline Analysis System (DSAS) that automates the process for calculating rates, which could be used for the aerial review.

There are currently many information hubs within Minnesota and nationally, where historic aerial photos can be accessed. However, many photos dating pre-1990 are not yet in digital format. Collecting and converting aerials to digital files could prove to be a time consuming process, and should be considered when budgeting. Much coordination is necessary to get quality aerials that span the shoreline for the correct time periods. Photographs need also to be orthorectified to be sure they are spatially accurate when comparing multiple photographs. If the aerial photographs have high resolution and are spatially accurate; the project will be that much more useful to local units of government.



## Step 2: Determine Erosion Rates

Maps will be developed to track the shoreline movements over time. The shoreline will need to be measured from the same identifier, whether it is the original high water line, edge of vegetation, or the toe of the slope. In areas where there is significant erosion the erosion reference lines will be spaced further and areas with minimal erosion will have minimal space between the erosion reference lines. This will provide a visual analysis of the shoreline movement over the timeframe. During the process of locating the erosion reference lines oblique photographs should be available for reference as some locations identifying the erosion reference lines will be difficult.

Using the oblique photographs will aid in locating the bluffs and accurately identify the erosion areas. Also when erosion reference lines are being identified a qualifier needs to be identified. As analyzing photographs can become subjective, qualifiers that note the confidence in the location and other aspects taken into account should be recorded for taking into account when determining rates in later steps. This will also help with overall continuity throughout the project.

An erosion rate will be determined by dividing the distance of erosion (feet), by the time (years).

Movements of the shorelines should be measured at a standard distance



to keep the information consistent. Using programs, like DSAS, can simplify the process by keeping a consistent measuring point (measuring the shore 150 ft transects) along the entire shore. When determining how much a shoreline has eroded, using each rate could cause problems. For instance a section of the shoreline has the following rates; 1.2 ft/yr, 1.33 ft/yr, 1.43 ft/yr, .3 ft/yr, and 1.4 ft/yr. Using similar erosion rates will be more accurate, because given the surrounding rate, the .3 ft/yr should not be validated unless there are at least two figures that vary widely from the rest of the set. The method used should be determined and used throughout the process to maintain stability and continuity. Figure 1 is an example of erosion rate grouping that could be used.

### **Figure 1. Erosion Rate Grouping**

- $\geq 1.00 - 1.99$
- $\geq 2.00 - 2.99$
- $\geq 3.00 - 3.99$
- $\geq 4.00 - 4.99$

### Step 3: Rate Analysis and Determining Factors

The most subjective, yet imperative, aspect of this effort is determining what erosion rate will constitute designation as an erosion hazard area. This can be difficult because an area that has eroded rapidly over the previous 30 years may not necessarily erode as rapidly in the future. After the initial erosion rates of the North Shore are determined the steering committee will review the erosion rates that span the North Shore and identify preliminary erosion hazard areas.

These areas will be compared to the original maps created in 1988, to evaluate the change in the past 20 years. In the past erosion identification processes, shorelines that were eroding greater than 1 ft/yr were identified as erosion hazards. This continues to be the trend in other efforts around the nation. During this process the committee will reassess the use of the rate 1 ft/yr to be sure this is a reliable indicator in identifying hazard areas. The NSMP Update currently uses the rate of 1 ft/yr to demarcate erosion areas.

### Step 4: Soil and Bedrock Review

One of the primary indicators of high erosion rates is the presence and depth of soil. The soils are a major contributor to erosion rates, and with the wide variety of soil types up and down the North Shore, this will be an important consideration. Soil maps and other available resources will be utilized. Soil types and patterns will be identified for the entire stretch of the North Shore.

In the work completed by NRRI in the Erosion Hazard of Minnesota's Lake Superior Shoreline project, non-bedrock areas were found to have the highest erosion rates. This includes areas with glacial deposits, post-glacial beach deposits, clay bluffs, and peat deposits. Additional information developed by the Board of Water and Soil Resources could contribute valuable information to the project. This information includes surface geology erodibility, shoreline erosion potential, and slope ratings.

### Step 5: Final Identification of Erosion Hazard Areas

The areas with high erosion rates (over the rate of 1 ft/yr or preferred new determiner) will be compared with the soil types and erodibility information. If these conditions and the erosion rate from the aerial review, point towards future erosion, then these areas should be identified as erosion hazard areas. This will be a time when other factors are taken into effect as well such as, current vegetation cover, slope, or other elements that could effect erosion by increasing or decreasing it. Other construction projects could affect the erosion rates, including; the addition of marinas safe harbors.

### Step 6: Official Erosion Hazard Map Development

After the erosion hazard areas are identified they need to be documented on a map. Using GIS the shoreline will be reviewed with aerial photographs and parcel information. The areas that the committee identifies as hazard areas will be identified and distinct boundaries will be drawn- following parcel boundaries. Parcels will either need to be totally within hazard areas or not identified as hazard areas. This will help with implementing standards that regulate the hazard areas that are developed.

### Step 7: Recommendation Development

The committee working to steer this process should also develop recommendations that will help with the implementation of the hazard maps. This will include identifying erosion control methods that may help in erosion hazard areas. This should also include recommendations for designating special provisions for the erosion hazard areas such as setbacks for structures and land use. These recommendations could also support the gathering and compiling of further shorewide data that could be used in erosion control planning. Also included could be information on how erosion control can be addressed and mitigated.

### Step 8: Long-term Monitoring

Once the mapping process is completed, and the erosion hazard areas are determined, erosion should still be monitored. Part of effectively managing erosion is continuing to monitor the shoreline of Lake Superior as erosion rates will increase and decrease due to different factors, especially lake levels. Monitoring is necessary because properties will be directly affected by the restrictions placed on an erosion hazard area.

Further erosion monitoring may reveal that erosion has considerably slowed and certain properties are no longer in need of erosion management techniques. To continue monitoring aerial Photographs will need to continue to be taken consistently of the entire shoreline. When the previous steps of this process are developed a timeline should be identified to continue with similar efforts along the North Shore.

A detailed project will be time consuming and will require substantial resources. The NSMB and local governments will need to determine the detail and implementation of the final product. At this time the following budget for the project has been estimated:

Step 1: Aerial Photograph Review	\$12,000
Step 2: Determine Erosion Rates	\$25,000
Step 3: Rate Analysis and Determining Factors	\$5,000
Step 4: Soil and Bedrock Review	\$5,000
Step 5: Final Identification of Erosion Hazard Areas	\$5,000
Step 6: Official Erosion Hazard Map Development	\$15,000
Step 7: Recommendation Development	\$5,000
Step 8: Long term monitoring	Ongoing

This estimated budget totals \$72,000 and will vary depending on the level of local involvement and detailing.

### **OPTION 2: Aerial Photograph Pilot Project**

Substantial time and funding is needed to complete the full aerial photograph review for the entire North Shore, as budgeted in Option 1. As there are questions and concerns to the positives and negatives the aerial photograph review and how exactly the map will be used, a test project may be desirable in defining the process.

Option 2 would follow the same 8-step process that is defined by Option 1, except that it would be for a specific area. The project consist of working closely with an entity (likely a city or township). The project lead would collaborate with the entity to identify what is needed for erosion information and how the process could best suit their needs. The result of this project would be the development of the Erosion Hazard Area map, that outlines the areas that have had high erosion rates in the past and are likely to continue to have high erosion rates. Follow-up would be performed to work with the entity on how the map will be used, and what changes are necessary for using the process to develop an Erosion Hazard Map for the rest of the North Shore. More funding would then be sought for carrying out the project for the entire shore.

Depending on the location and size of the pilot area, the budget would most likely be under \$20,000. This is more attainable and would give some measureable results, before undertaking the project of creating an Erosion Hazard Area Map for the entire North Shore.

### **OPTION 3: Data Compilation and Benchmarking**

There are other ways to develop reference maps showing erosion hazards, than the sole use of aerials photographs. Using other data that could include, shoreland soils, beach type (cobble, sand, clay, bedrock, etc), beach direction, oblique photos, and other available datasets could help to develop maps that show which areas may have future erosion

potential. It would also be beneficial to establish benchmarks that identify where the bluff lines are today, so they can be compared to future years.

The information would then be compiled to develop a map that could be reference for erosion information. However this map would not be an update of the Erosion Hazard Map of the North Shore Management Plan, but it would be a tool that the local entities could use as a reference when making land use decisions and identifying setbacks from Lake Superior. Because these maps would use historical erosion trends to identify the hazard areas, the map would not officially regulate standards.

The cost of this project would also likely be much less than Option 1, depending on the support received from local natural resource specialists and the accessibility of data.

#### Step 1: Organization of data and map making

The project would have to start with the collection and organization of data that could contribute to the project. The data would be compiled into Geographic Information Systems and geo-referenced to be sure of its accuracy. Each set of data would be developed into a layer that can be readily accessed.

After compiling the data, there will also need to be collaboration as to how to develop parameters for what dictates higher or lower erosion. This process would not determine and definite erosion rates but would more simply identify areas that are susceptible to impactful erosion in the future. For instance studies will be referenced and local natural scientists and specialists would be consulted for identifying the erosion processes and determiners. For instance, it would need to be determined which beach makeup is going to yield higher erosion rates. This information will be paired with the other information and data sets including the oblique photographs of the North Shore.

Areas would then be identified as high risk erosion areas and maps would be developed. This would include developing GIS layers that could be distributed to the local governments that identify the areas. This information would be provided for the local entities to use as reference when going through public hearings or making other land use related projects.

#### Step 2: Benchmark creation

A very important part of compiling data is establishing benchmarks that can be reviewed in the future. Lidar imagery is a growing technology that would be much more helpful in showing accuracy of erosion over time.

There is currently no lidar imagery for the North Shore. Lidar uses remote sensing rather than air photography and produces much more detailed imagery; projecting even through leaf cover. Having two or more sets of imagery would be ideal for creating erosion maps, so that the two could be compared similar to the process in Option 1.

To effectively manage erosion in the long run, lidar imagery will need to be used for analysis. However, there is a high cost for lidar imagery and it is not yet available for the North Shore.

This project would be less intensive and would provide mostly reference materials for the local units of governments, but it would build a strong foundation for erosion work to be developed from in the future.



## SECTION 4: Outcomes

There are several ways in which the project could be performed. The North Shore Management Board identified that the project should be done along the entire North Shore at once. This will provide stability and continuity throughout the process and provide a similar product along the entire shoreline. As the process will be the same for each community, how the local units of government use the information to study, implement, or regulate the erosion hazard areas will be up to the local units of government.

There is a variety of ways in which an erosion hazard map and definition can be used. Then North Shore Management Board has structure setback standards. The current formula for determining structure setbacks within erosion hazard areas is 50 times the annual erosion rate plus 25 feet. This is based off of a long term erosion rate, if such rate is not available on certain properties the setback shall be 125 feet. As the last map detailing the erosion hazard area maps was produced in 1988, there is a need for an updated map. The way in which the erosion hazard maps will be used may vary between the local governments. Some may choose to use the map provided to create a zoning layer with erosion hazard standards incorporated into that layer. Others may use the map as a reference that field surveys are completed when an area falls within an erosion hazard area to identify the exact setback and related standards.

### **Project Partners**

This project should involve several partners that have scientific expertise, planning knowledge, and local voices. The potential partners include:

- North Shore Management Board
- Minnesota Department of Natural Resources
- County Soil and Water Conservation Districts
- Board of Water and Soil Resources
- Minnesota Pollution Control Agency
- Minnesota's Lake Superior Coastal Program
- United States Forest Service
- Local units of government
- Other relevant organizations

These players will have a chance to contribute to the process and provide different perspectives and insight.

### **Cost**

The Michigan Department of Environmental Quality identified and mapped erosion hazard areas in Berrien and Sanilac Counties along Lake Michigan and Lake Erie in 1997. They used a similar process that is outlined in this document. The project used six staff people and assistance from local planning administrators. The project totaled approximately \$120,000. There were some additional steps that included mapping the structures along the shore that fall within the erosion area setbacks. The length of the North Shore from Duluth to Grand Portage is considerably longer. However some of the processes undergone by Michigan would not be integrated into the NSMB efforts. Technology has also advanced as to making some of the steps more streamlined. However, the NSMB can expect to incur significant costs for any of the options outlined, especially because every project area has unique sets of consequences.

### **Potential Funding Sources**

Minnesota's Lake Superior Coastal Program (Coastal Program) is a natural fit for funding a project of this type because of similar boundaries and the goals of their Annual Grant Program. The Annual Grant Program targets studies, plans, research, administration, and education and interpretation projects that directly relate to Lake Superior Coastal Resources. The program is very successful in bringing federal dollars to the North Shore of Lake Superior.

If funding for developing the lidar imagery becomes available, the NSMB should work to acquire the funding, as this would be a great asset for the NSMB and the local entities.

There are other avenues that should be approached as well especially using local resources that could include, staff time, equipment, and other areas of expertise. Other possible sources include the Natural Resources Conservation Service which makes money available or provides support for projects dealing with erosion. The Environmental Protection Agency makes available funds at different times, which may be possibilities to fund the erosion efforts along the North Shore.

### **Next Steps**

The North Shore Management Board should determine if the process as defined in this report is adequate, affordable, and able to be well utilized by government bodies along the North Shore. If the NSMB does determine that the process would be beneficial than the process work plan will need to be finalized and funding secured. The work plan should include a budget that identifies the cost and outcome of each task, and lay out the steps that need to be taken.

This project will be costly and time-consuming project. To make this project useful there will have to be considerable follow-up by the NSMB and the local units of government. Adjustments to ordinances (i.e. setback fluctuations) and how properties within erosion hazard areas are regulated, are a few possibilities of making the project worth the time and effort.

PROJECT DEVELOPED BY:  
**NORTH SHORE MANAGEMENT BOARD**

North Shore Management Board  
221 W. First Street  
Duluth, MN 55802

PH: (218) 529-7513

