

**EROSION HAZARD  
OF MINNESOTA'S LAKE SUPERIOR SHORELINE**

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**Maps prepared by: James Salés, John Bonde, Tim Aunan, and Richard Raby**

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**MINNU-M-94-001 C3**

## INTRODUCTION

The rugged beauty of bedrock cliffs rising from the waters of Lake Superior creates a memorable impression of Minnesota's Lake Superior coast. But unlike the resistant bedrock that creates beautiful vistas, some sections of the Minnesota shoreline are erosive sand or clay banks. Buildings and roads built in these areas are threatened by the gradual wearing away of the coast by the powerful waves of Lake Superior.

While shoreline erosion can only be prevented at great expense, economic losses are minimized by knowing where and how fast shoreline erosion is likely to occur. Future problems are avoided by locating new structures and septic fields back from the bluff line to allow for the erosion that is expected to occur. Fortunately, the Minnesota Lake Superior shoreline has had relatively little development in comparison to other Great Lakes shorelines, so good planning can prevent future problems.

There are several ways to identify erosion hazard areas. On-site monitoring of erosion is the most precise way to measure short-term erosion rates, but can be misleading as an indicator of long-term hazard if unusual conditions during the monitoring period cause uncharacteristically high or low erosion rates. Measuring shoreline recession from a time sequence of maps or aerial photos provides longer-term erosion rates. Shoreline

geology also provides an indication of erosion hazard, because some types of geologic materials are more resistant to erosion than others. This study combined the latter two methods to produce maps of long-term shoreline erosion potential.

### Long-Term vs. Short-Term Erosion

Shoreline erosion does not occur at a constant rate, because the factors that cause erosion are continually changing. Lake Superior can be as smooth as glass one day, and have 20 foot high waves another. The waves that reach the Minnesota shoreline are highest during storms with strong easterly winds. Erosion of beaches and the base of bluffs is most rapid during these storms.

In shorelines with clay soils, erosion can occur as a large block of material breaking off and slumping down toward the lake, often during storms. The short-term erosion rate in this case is equal to the size of the slump block measured perpendicular to the shore, but the long-term erosion rate is equal to the width of the slump block divided by the number of years between slumpages. If slumping occurs infrequently at that location, the long-term erosion rate would be small, even when the short-term erosion is large. Placing a heavy load on the soil surface, such as a building, increases this type of erosion.

Rainfall erodes sloping bare soil, and causing gullies to form. Gully erosion can be rapid in localized areas, and is hard to stop once started. Surface and gully erosion is highest during intense rainfall, especially when the ground is already saturated or where water moves slowly into the soil. When the soil becomes super-saturated, mud flows occur. Leaking septic fields can worsen this situation.

All of these short-term erosion factors add up to long-term shoreline recession, the gradual landward movement of the shore. This study measured long-term recession of the Lake Superior shoreline by comparing shoreline location on aerial photos taken 14 years apart or more.

#### How Was Erosion Hazard Determined?

Shore location was determined at selected sites using aerial photographs taken in the 1930s, 1975, and 1988/89. The distance over which the shoreline receded during the time period between air photo dates was divided by the number of years between photos to figure an annual erosion rate for these sites. Recession rates below the detection limits of the measurement method used were marked as "BD" (below detection). Values less than 0.3 ft/yr were below detection limits for the 1930s-1975 time period, and values less than 0.6 ft/yr were below detection for the 1975-1988/89 time period.

The recession rates were statistically compared with coastal characteristics, and the presence or absence of bedrock was found to be the best predictor of erosion.

Non-bedrock areas (glacial deposits, post-glacial beach deposits, clay bluffs, peat deposits) had the highest erosion rates, even when they overlaid bedrock at the shoreline. Although clay bluffs were expected to have the highest erosion rates, post-glacial sand & gravel beach deposits were equally erosive. The highest erosion rates measured for both time periods occurred in a sand & gravel deposit (T61N, R3E: map 31). Clay bluffs are most common between Duluth and Castle Danger (maps 1-9), while post-glacial sand & gravel deposits are most common in Cook County. Some types of thinly-layered bedrock were also subject to erosion and sea cave formation.

Based on these relationships, maps of shoreline surficial geology published by the Minnesota Geological Survey were used to classify erosion hazard. Sites with any of the following geologic types occurring within sixty meters of the shoreline were classified as "high erosion potential": organic deposits, sand & gravel, clay & silt, unsorted glacial deposits.

Because the factors that influence long-term recession vary over time, recession rates may also vary. For example, map 2 contains three sites at which recession was measured over both time periods. Although two of the sites had high erosion rates during 1939-1975 (0.69 and 0.81 ft/yr), erosion at these sites was below detection (<0.6 ft/yr) in 1975-1989. In contrast, a site southwest of the Split Rock River (map 11) had lower average annual erosion between 1939 and 1975 than it did between 1975 and 1989. These findings illustrate that while we can predict relative erosion hazard, exact erosion rates are impossible to predict.

## WHAT DO THE MAPS SHOW?

The 39 maps in this publication show erosion hazard potential for the Minnesota North Shore from Duluth to the Canadian border. Each map shows about 4 miles of shoreline, classified into one of the following three erosion potential categories:

- **High.** These shoreline areas have high potential for erosion because they have non-bedrock areas at or near the shoreline. Measured erosion rates during the 1930s-1975 averaged 0.46 ft/yr in these areas, and were as high as 1.1 ft/yr (Table 1). Nearly all detectable erosion during the 1975-1988/89 period occurred in these areas, with a maximum measured value of 4.5 ft/yr (see map 31).
- **Low.** These shoreline areas have low potential for erosion because they are predominantly resistant bedrock. Erosion rates during the 1930s-1975 averaged 0.16 ft/yr in these areas, but measured values were as high as 0.64 ft/yr (Table 1).
- **Unknown.** These are areas of artificial shoreline, such as Taconite Harbor (see Map 20), or areas west of the Lester River in Duluth for which there were no geologic maps.

Measured erosion rates in feet/year are shown by the open triangles ( $\Delta$ ) for the 1930s-1975 time period, and closed ( $\blacktriangle$ ) triangles for the 1975-1988/89 time period. Other features shown include place names, township, range, and section numbers, major and minor roads, railroads, and rivers and streams. The maps also contain information about erosion hazard areas designated by county and regional management groups (see section on Erosion Hazard Zoning).

Table 1. Average and maximum recession rates measured, 1930s-75, ft/yr.

	Average	Maximum
High Erosion Potential	0.46	1.09
Low Erosion Potential	0.16	0.64

### Erosion Hazard Zoning

The North Shore Management Plan (NSMP) was developed by a joint powers board consisting of county, city, and township governments to provide environmental protection for and guide the orderly growth of the North Shore of Lake Superior. The plan is intended to improve state mandated shoreland management regulations, and includes erosion hazard guidelines "to protect public and private property and protect private interest and safety by guiding development in areas prone to excessive shoreline erosion." It defines Erosion Hazard Areas as "those areas of Lake Superior's North Shore where the long term average annual rate of recession is one foot or greater per year." The plan includes a general guide map indicating erosion hazard areas for use by local zoning authorities in adopting, amending, and administering local zoning ordinances. Only those areas deemed to be of high potential for erosion were put on the guide map, which except in cases was limited to the areas where high clay banks border the lake. These areas have been noted on maps 2,3,4,6,7,8,9,10,11,17,18,33, and 34 of this brochure.

In preparation for adopting zoning regulations consistent with the the North Shore Management Plan, Lake County conducted field studies of areas thought to be erosion prone. These areas have been noted on maps 6,7,8,9,10,11,17, and 18 of this publication.

## FOR MORE INFORMATION

For more information about shoreline erosion and what you can do to minimize it, contact any of these agencies:

Minnesota Sea Grant Extension Program  
208 Washburn Hall  
University of Minnesota  
Duluth, MN 55812

Minnesota Board of Water and Soil Resources  
394 S. Lake Avenue  
Duluth, MN 55802

U.S. Soil Conservation Service  
4850 Miller Trunk Highway  
Duluth, MN 55811

Soil & Water Conservation District  
Lake County Courthouse  
Two Harbors, MN 55616

For more information about the North Shore Management Plan, contact:

North Shore Management Board  
330 Canal Park Drive  
Duluth, MN 55802

For more information about shoreland zoning regulations, contact:

St. Louis County Health Department  
222 E. Superior Street  
Duluth, MN 55810

Lake County Zoning & Health Department  
Lake County Courthouse  
Two Harbors, MN 55616

Cook County Zoning Department  
Cook County Courthouse  
Grand Marais, MN 55802

Minnesota Department of Natural Resources  
Duluth Area Hydrologist  
5351 North Shore Drive  
Duluth, MN 55804

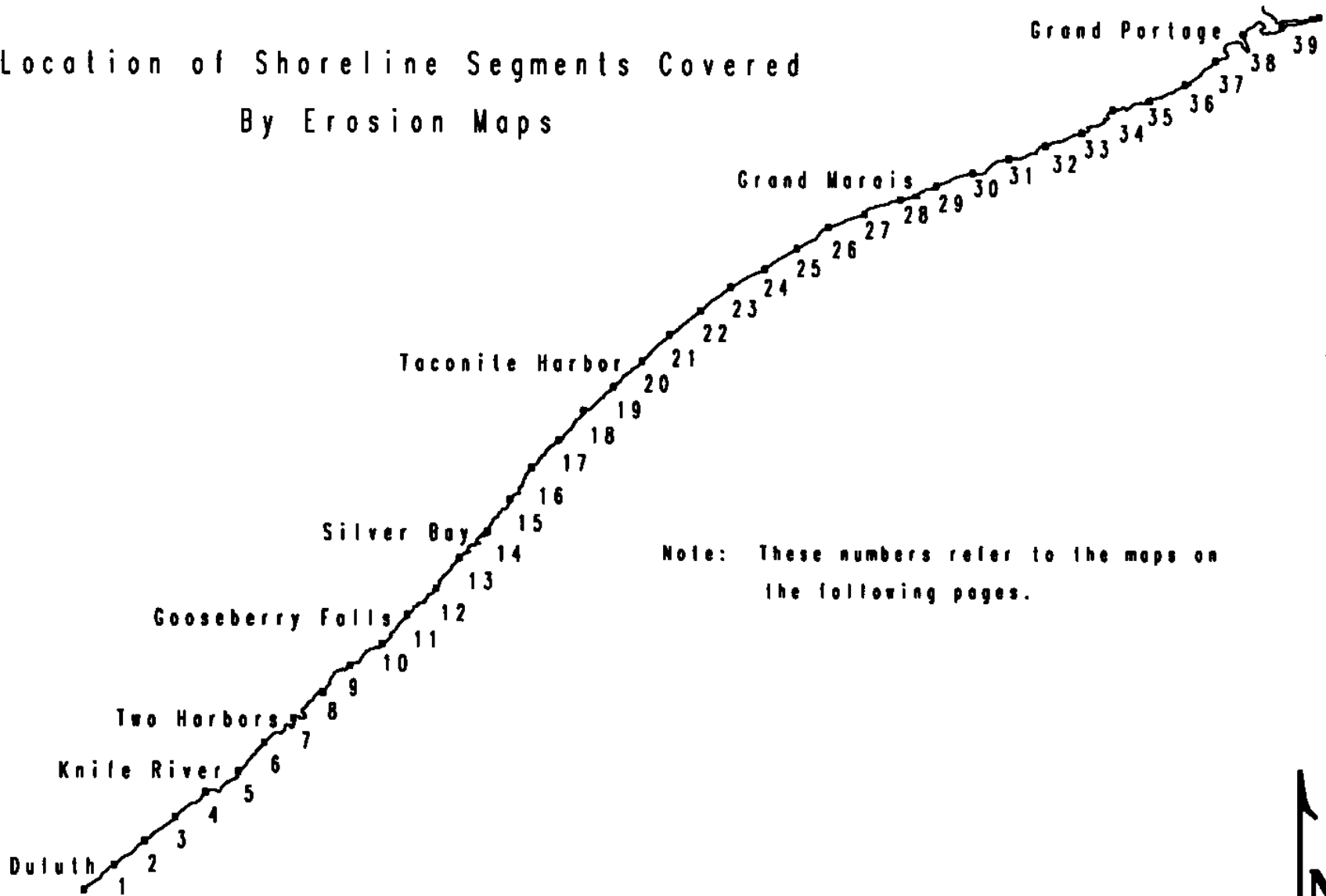
### References

*North Shore Management Plan.* North Shore Management Board, 1988. 50 pp.

*Slip Sliding Away: Erosion on Lake Superior's North Shore.* Minnesota Sea Grant Extension, 1987. 4 pp.

*Environmental Geology of the North Shore.* J. Green, M.A. Jirsa, and C.M. Moss, 1977. Minnesota Geological Survey, University of Minnesota, St. Paul. 99 pp.

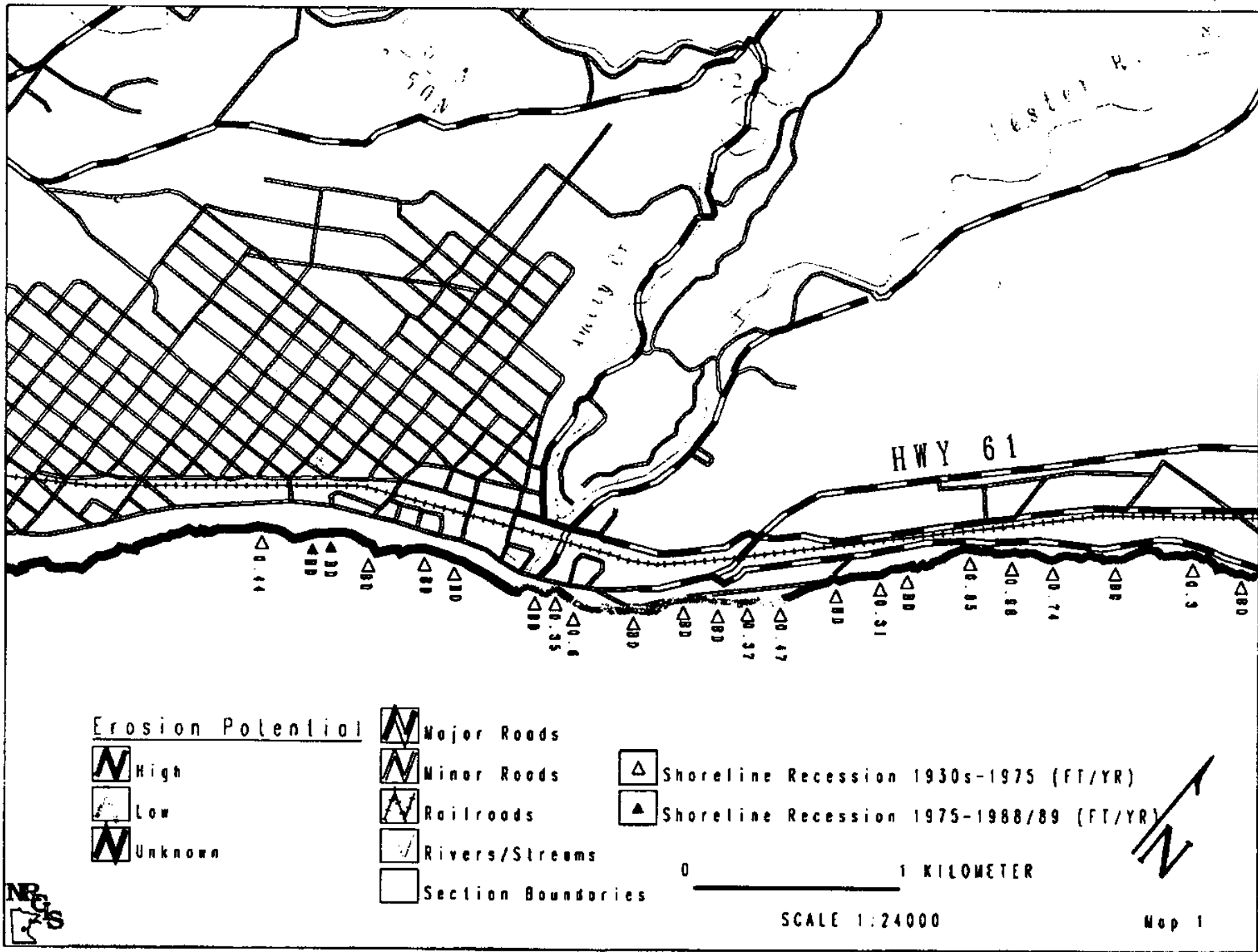
Location of Shoreline Segments Covered  
By Erosion Maps



Note: These numbers refer to the maps on  
the following pages.

Scale = 1:940000





Erosion Potential

- High
- Low
- Unknown

- Major Roads
- Minor Roads
- Railroads
- Rivers/Streams
- Section Boundaries

- Shoreline Recession 1930s-1975 (FT/YR)
- Shoreline Recession 1975-1988/89 (FT/YR)

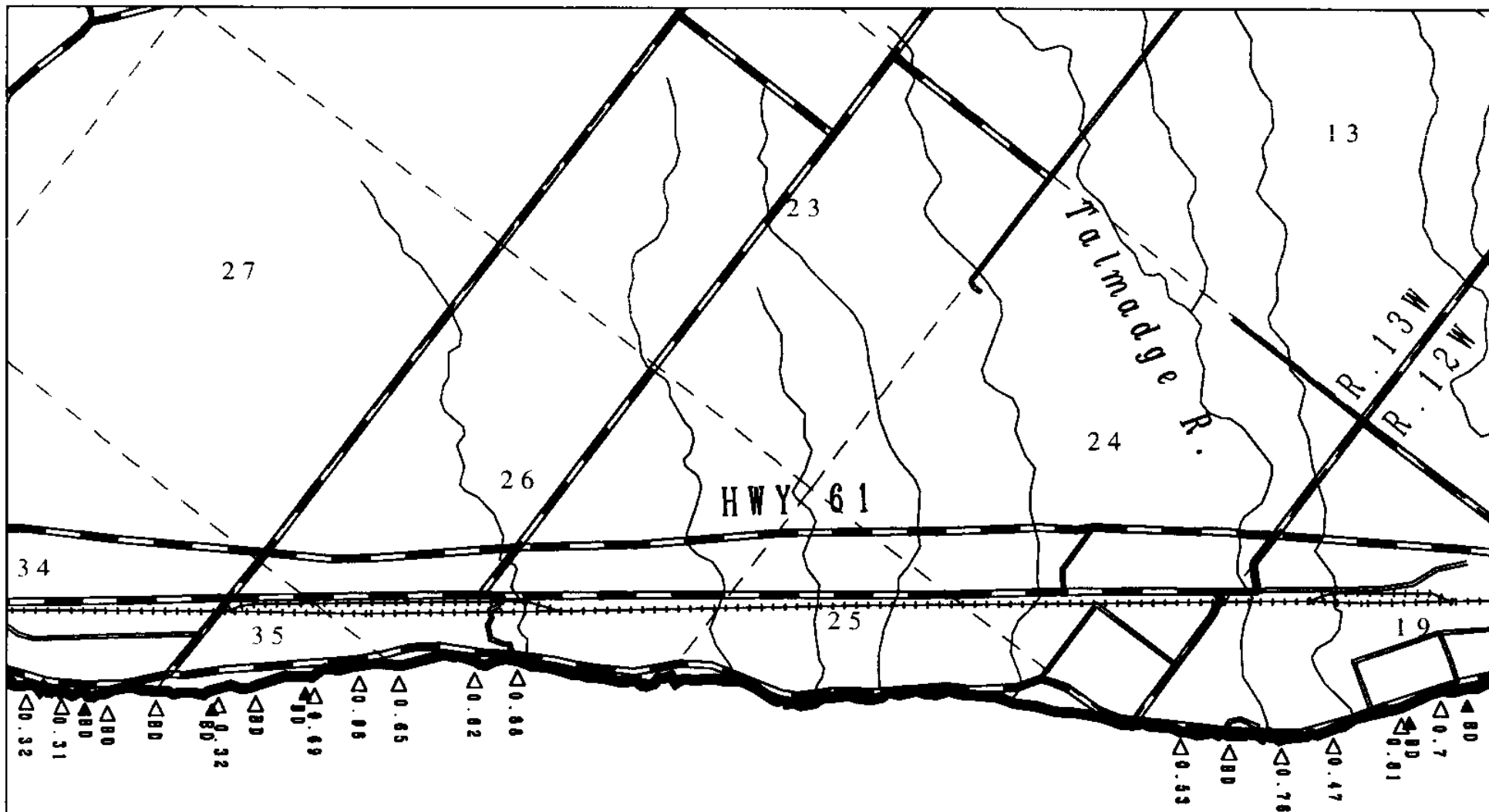
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Map 1





Erosion Potential

-  High
-  Low
-  Unknown

-  Major Roads
-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

-  Shoreline Recession 1930s-1975 (FT/YR)
-  Shoreline Recession 1975-1988/89 (FT/YR)

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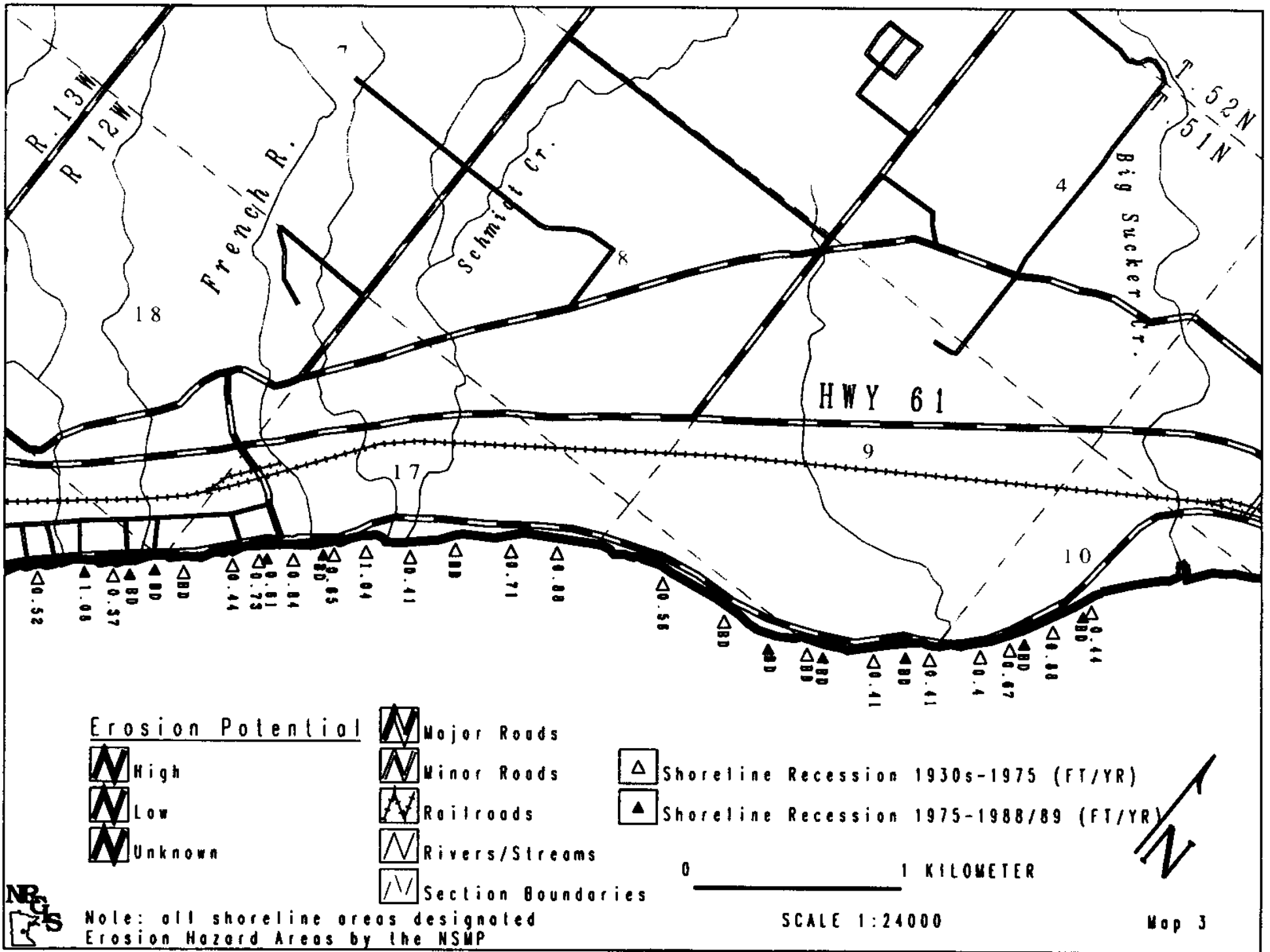


Note: shoreline areas in T.51N, R.12W designated  
Erosion Hazard Areas by the North Shore Management Plan (NSMP)

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Map 2

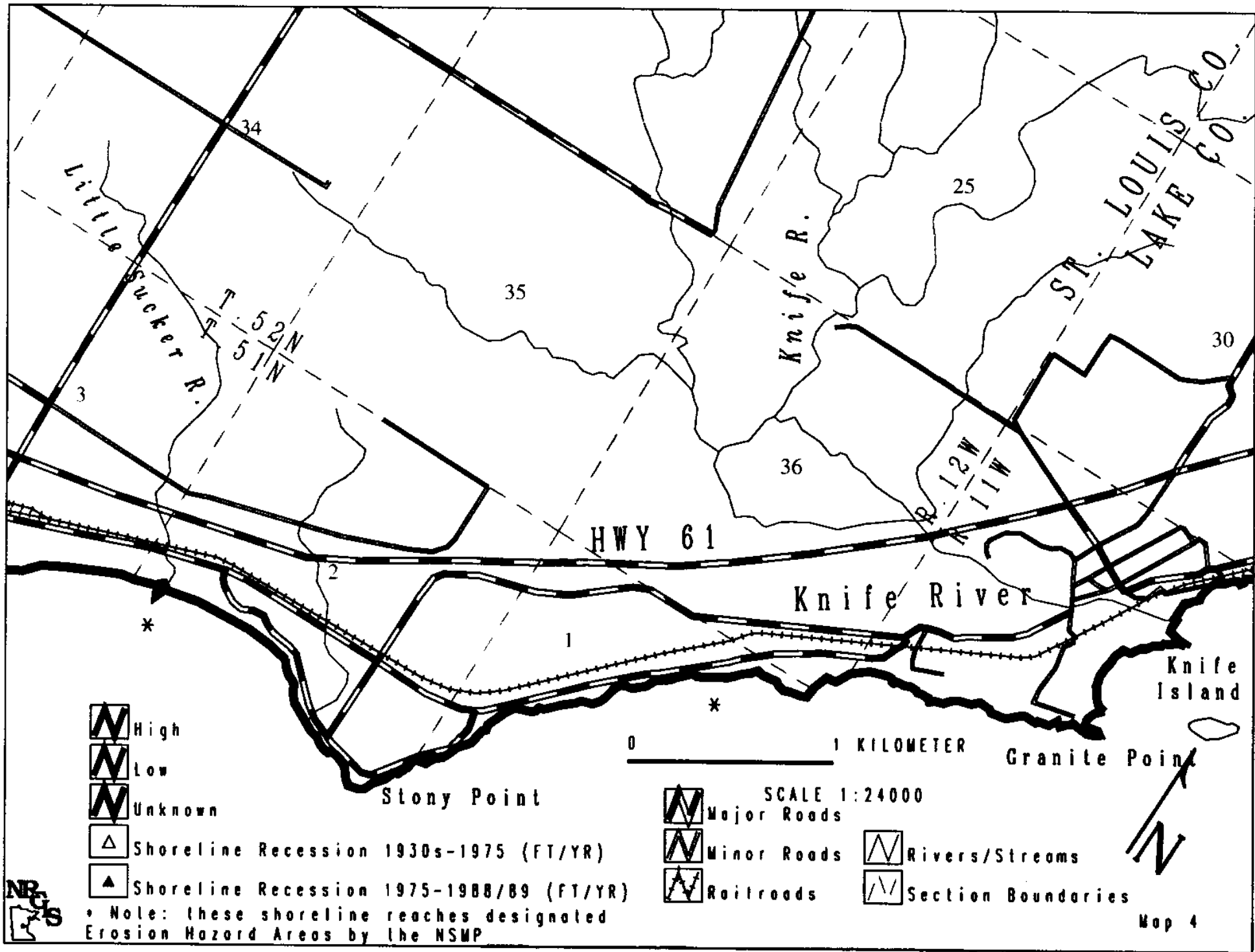




Note: all shoreline areas designated Erosion Hazard Areas by the NSMP

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Map 3



Little  
Sucker R.

T. 52 N  
R. 51 W

Knife R.

ST. LOUIS CO.  
LAKE CO.

HWY 61

Knife River

Knife Island

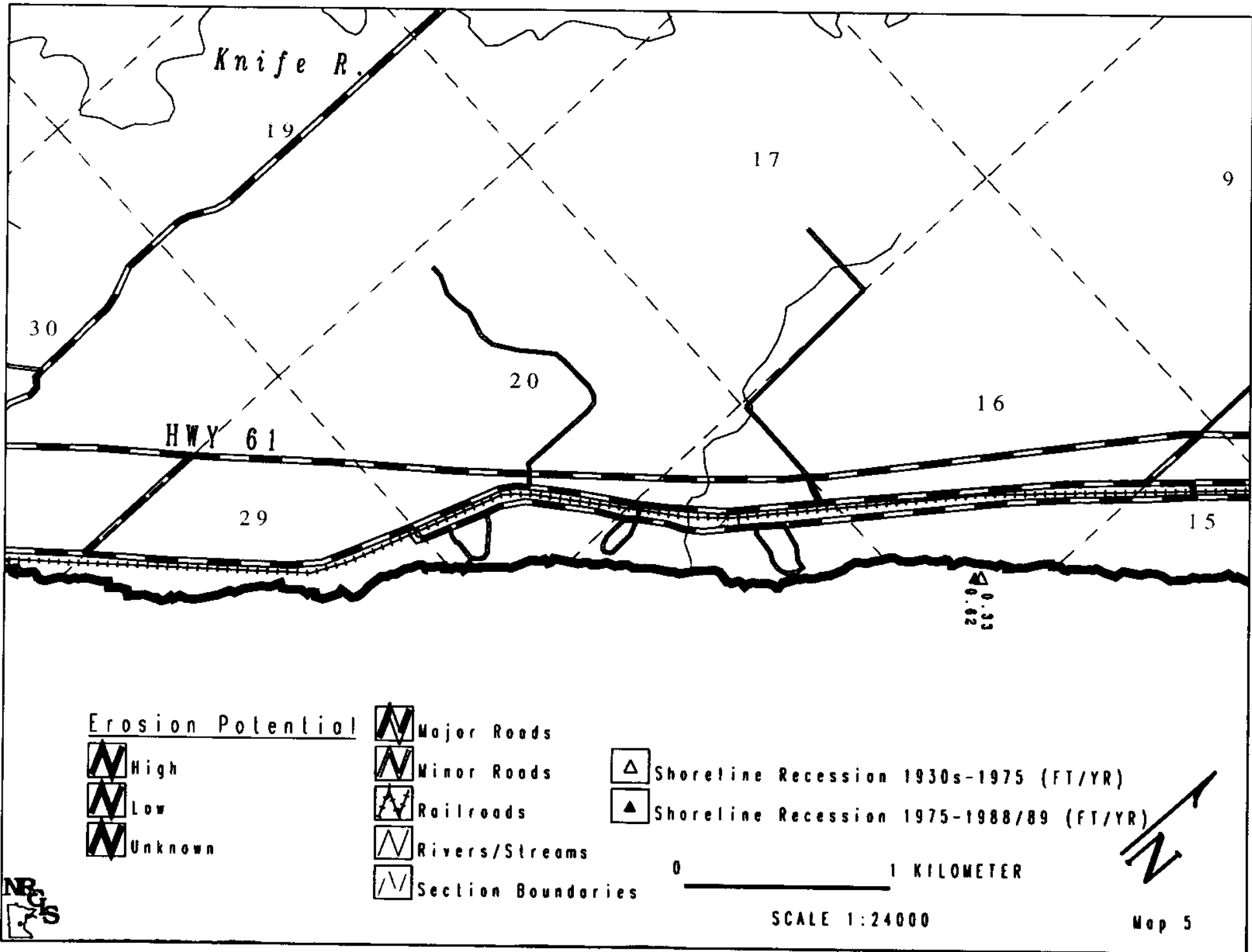
Stony Point

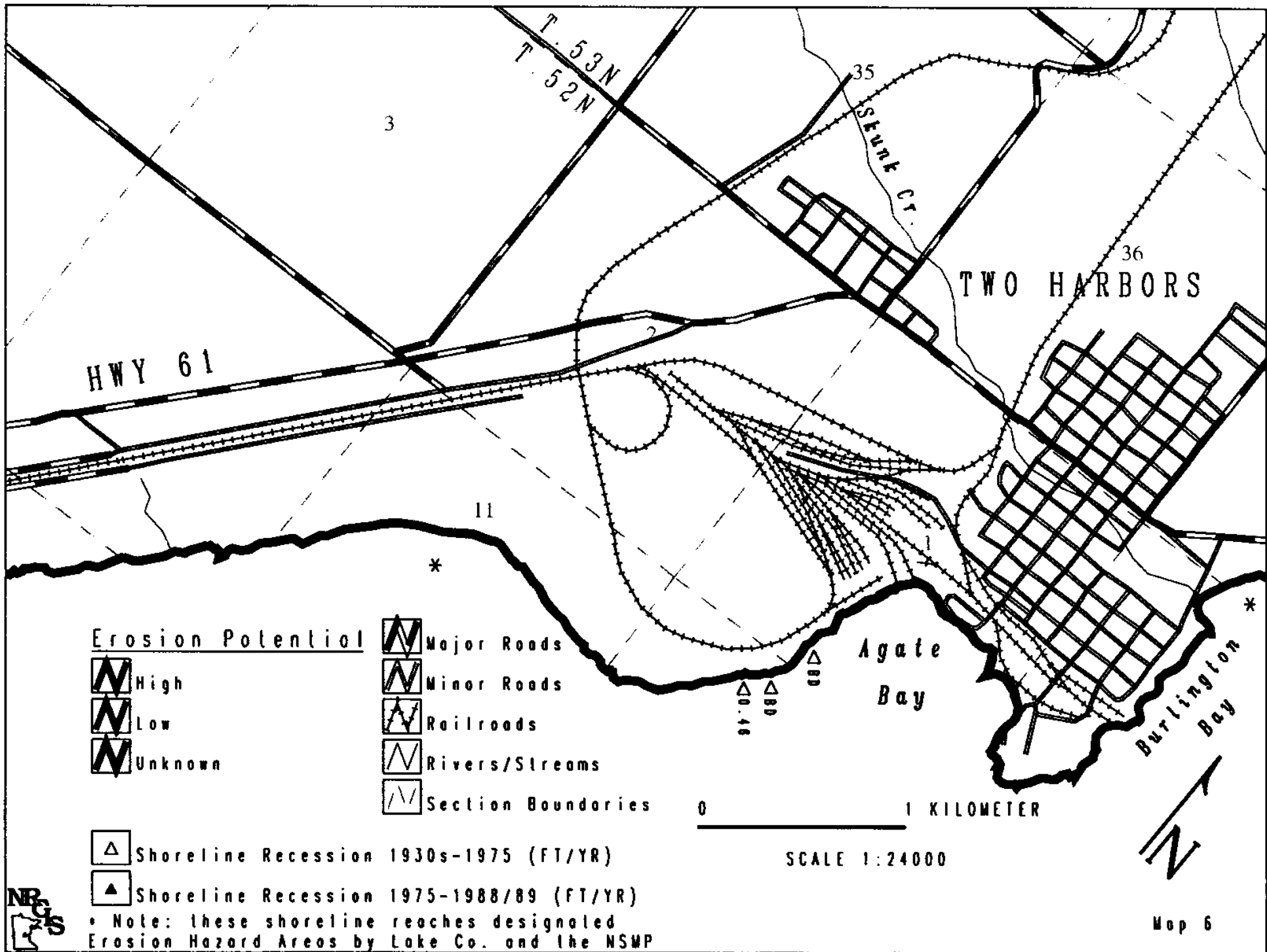
Granite Point

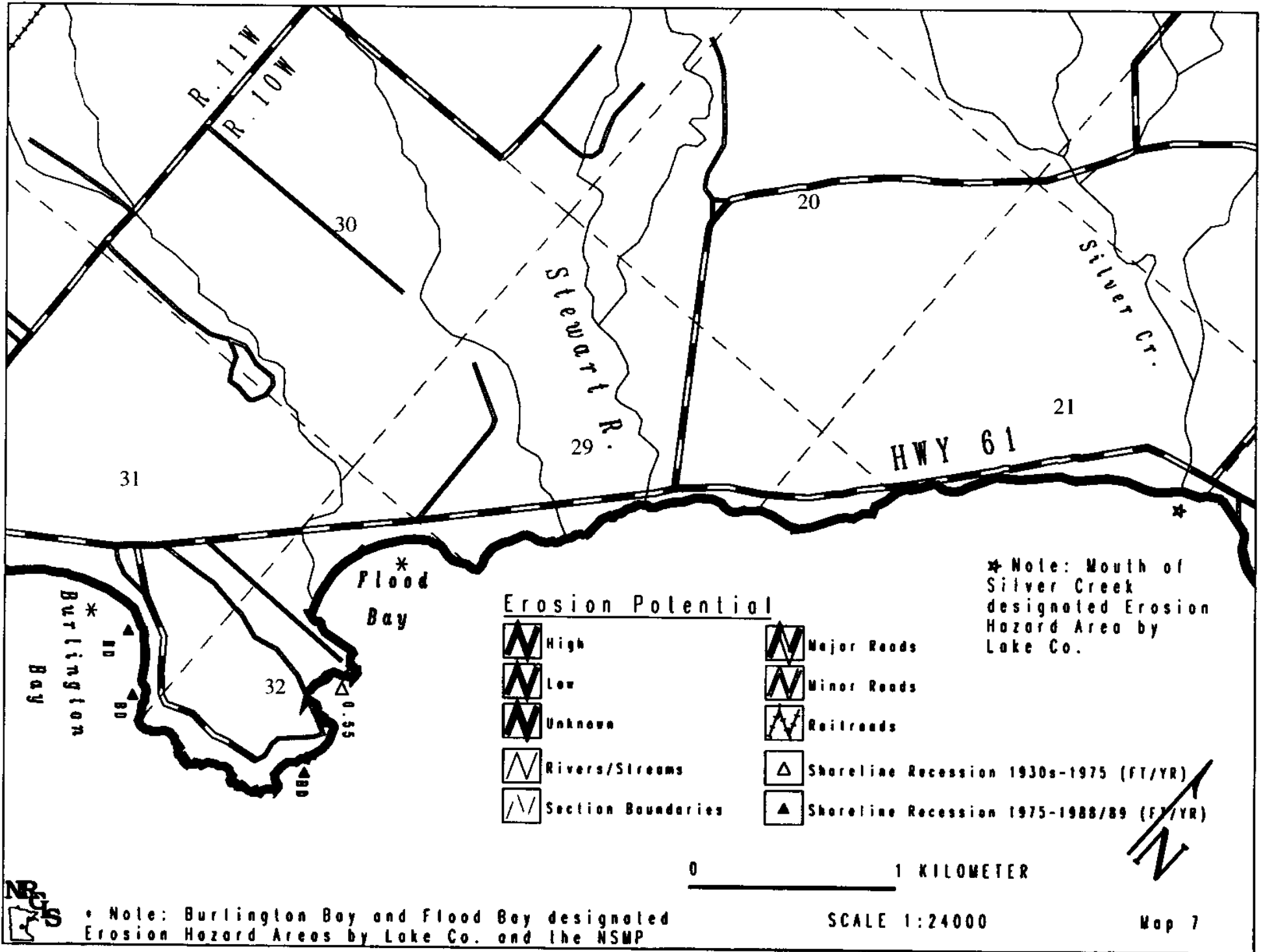
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Map 4





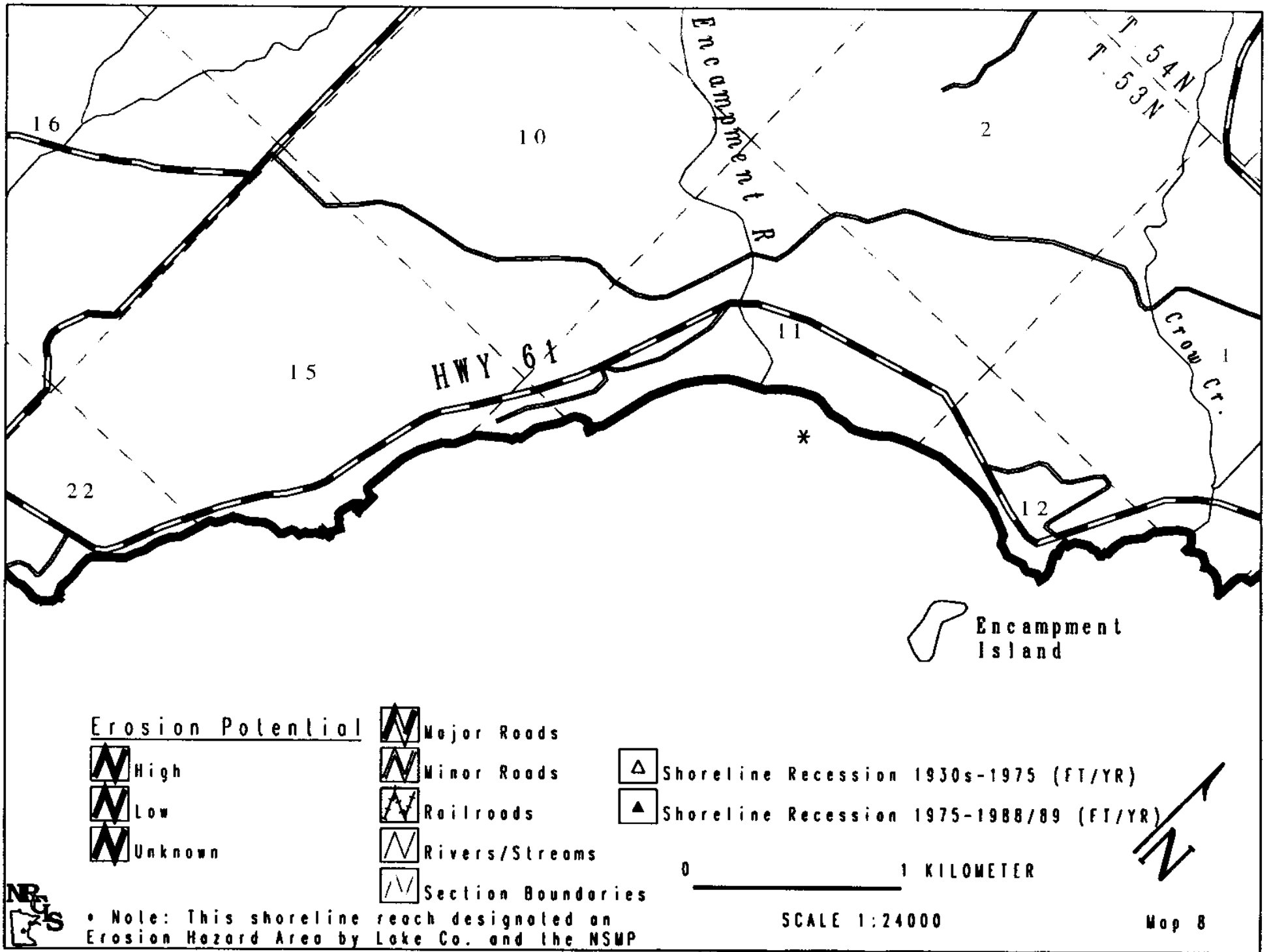


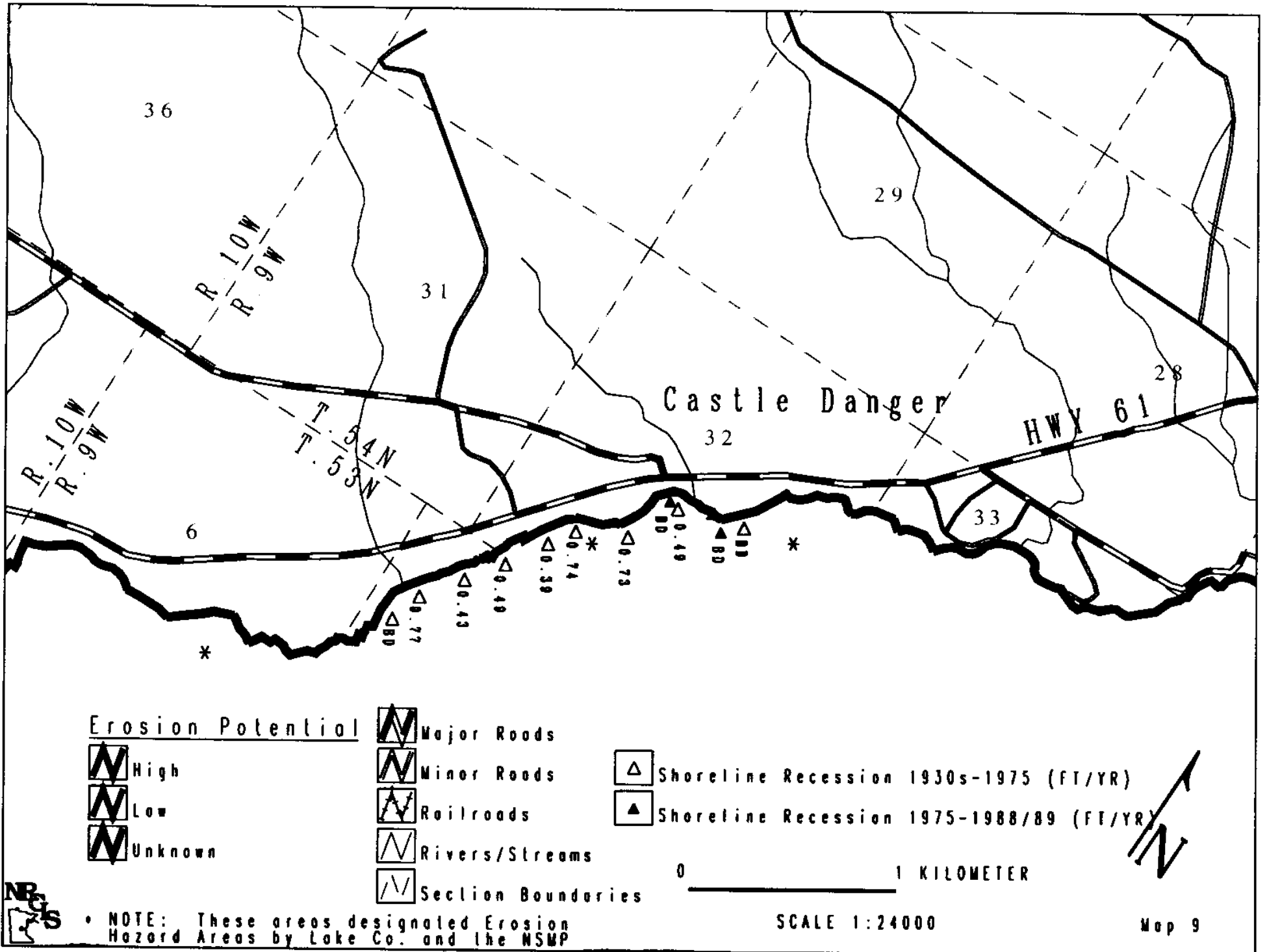
\* Note: Burlington Bay and Flood Bay designated Erosion Hazard Areas by Lake Co. and the NSMP

\* Note: Mouth of Silver Creek designated Erosion Hazard Area by Lake Co.

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Map 7





**Erosion Potential**

-  High
-  Low
-  Unknown

-  Major Roads
-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

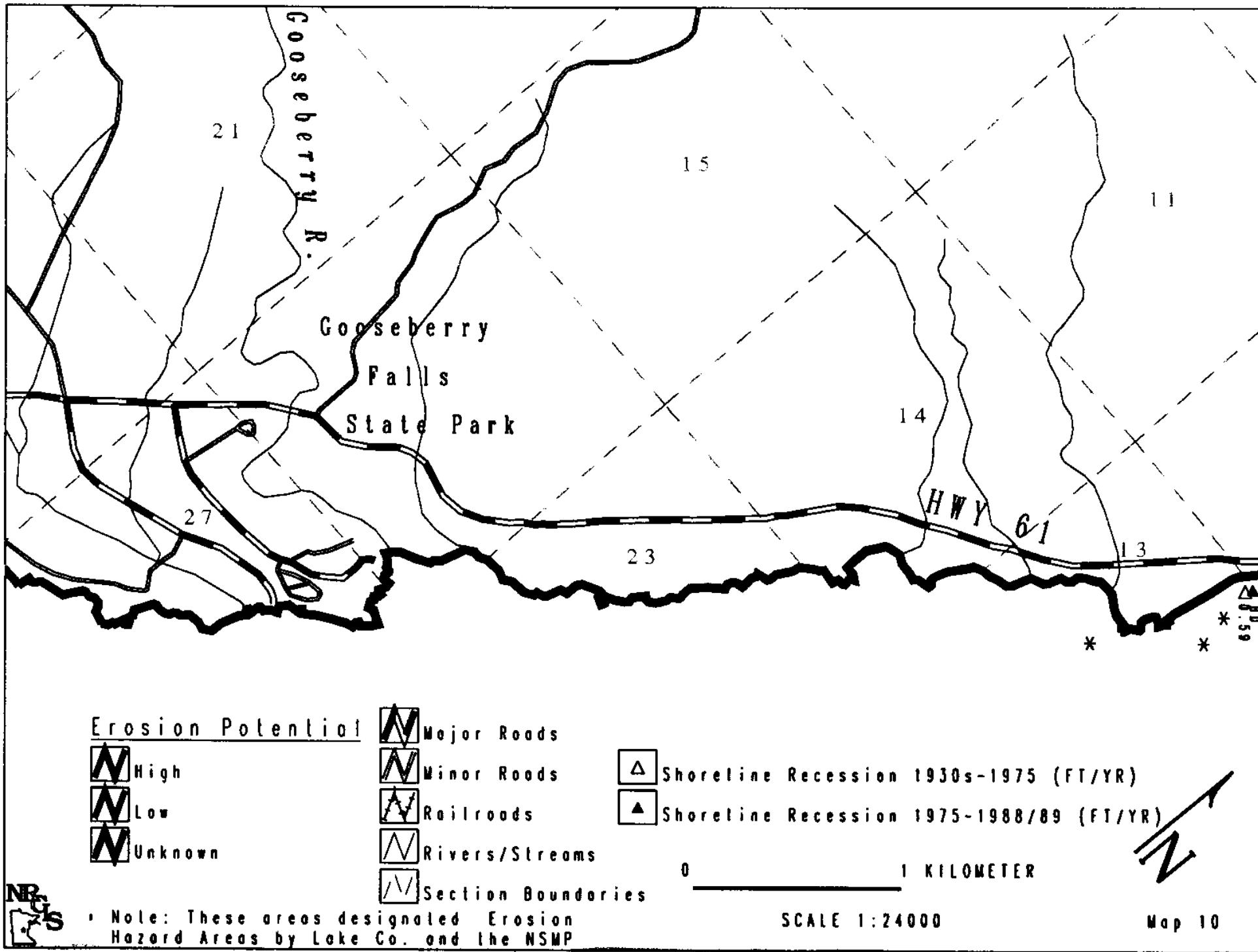
-  Shoreline Recession 1930s-1975 (FT/YR)
-  Shoreline Recession 1975-1988/89 (FT/YR)

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


• NOTE: These areas designated Erosion Hazard Areas by Lake Co. and the NSMP



Erosion Potential

-  High
-  Low
-  Unknown

-  Major Roads
-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

-  Shoreline Recession 1930s-1975 (FT/YR)
-  Shoreline Recession 1975-1988/89 (FT/YR)

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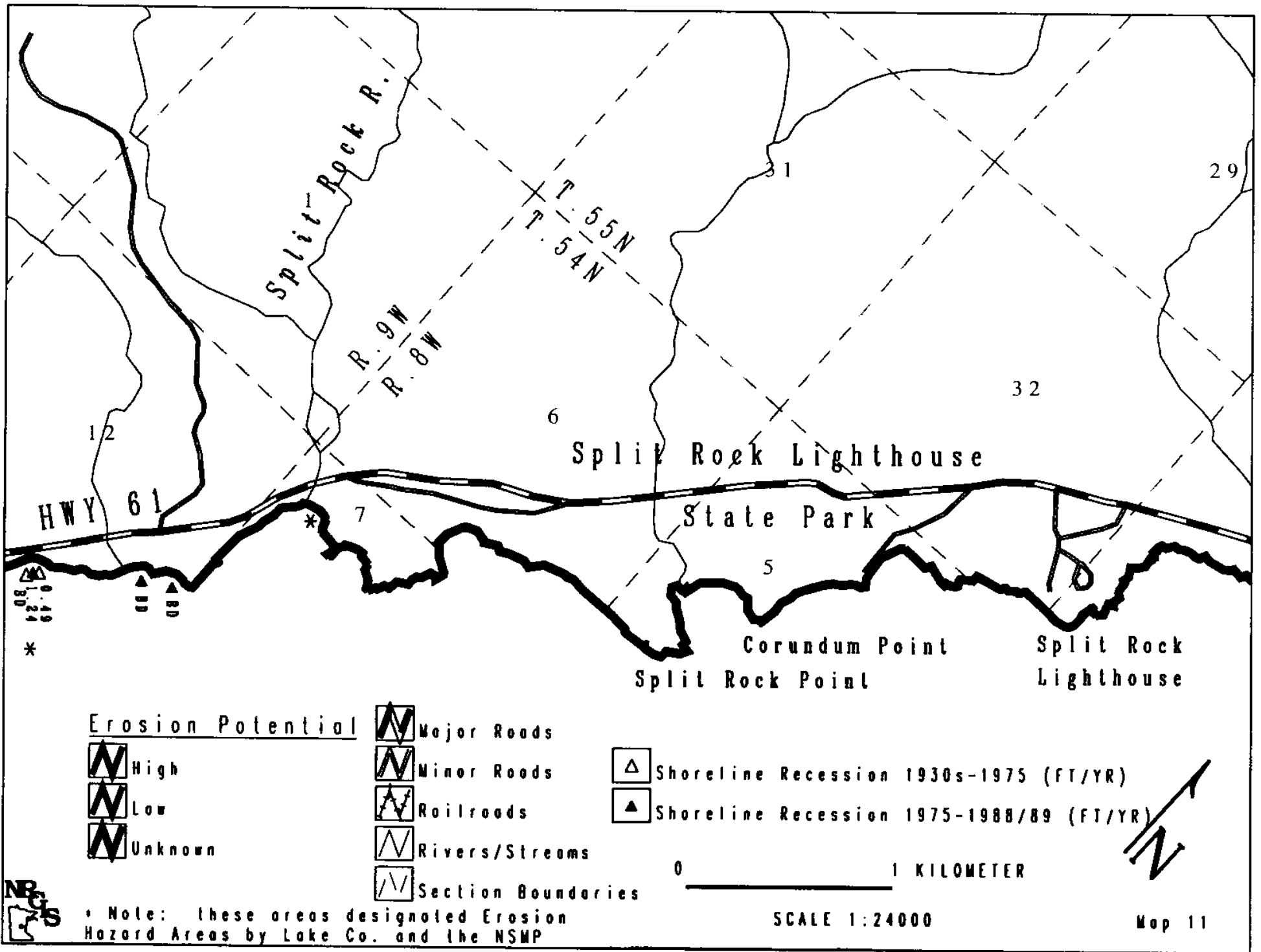


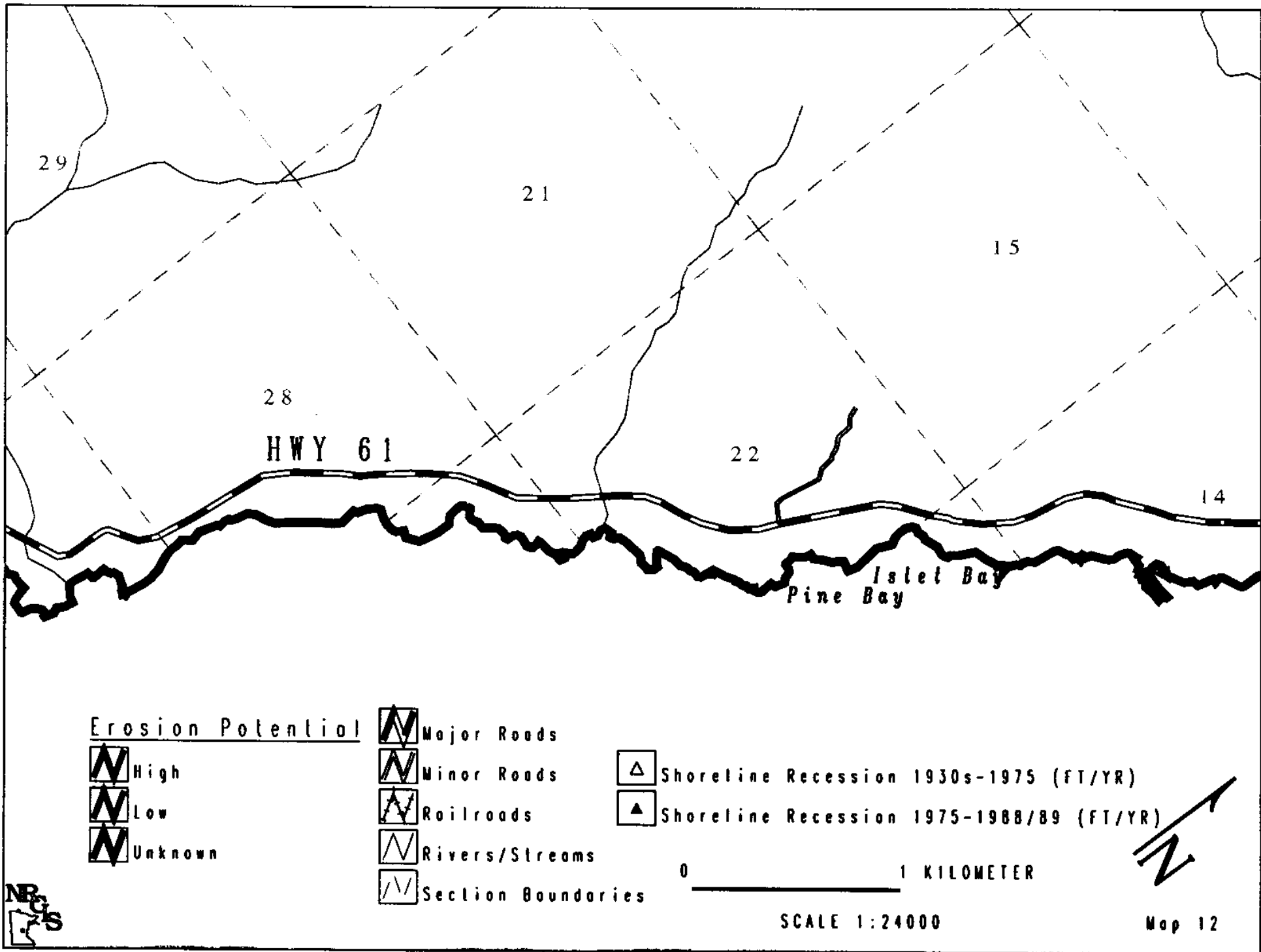
Map 10

Note: These areas designated Erosion Hazard Areas by Lake Co. and the NSMP









Erosion Potential

- High
- Low
- Unknown

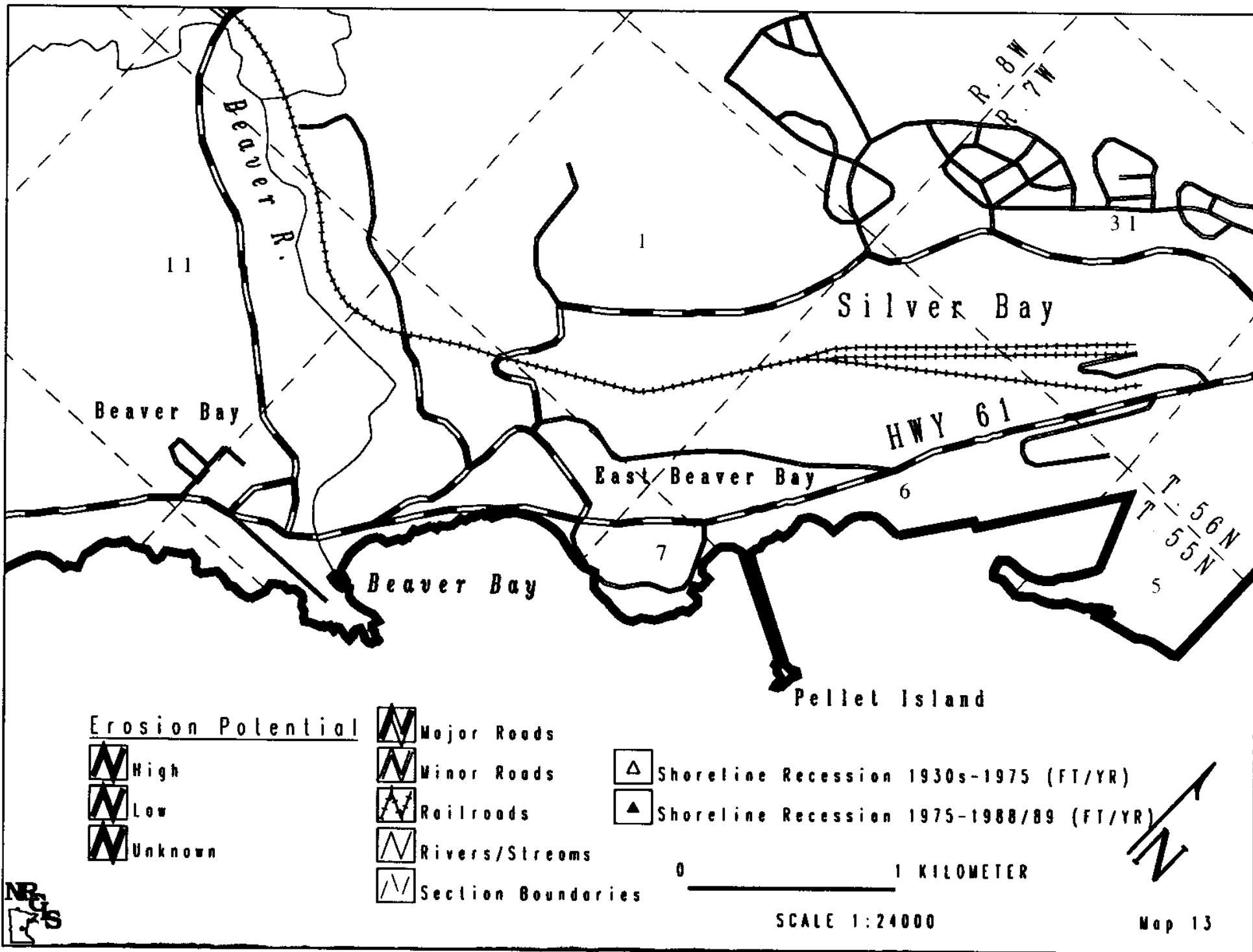
- Major Roads
- Minor Roads
- Railroads
- Rivers/Streams
- Section Boundaries

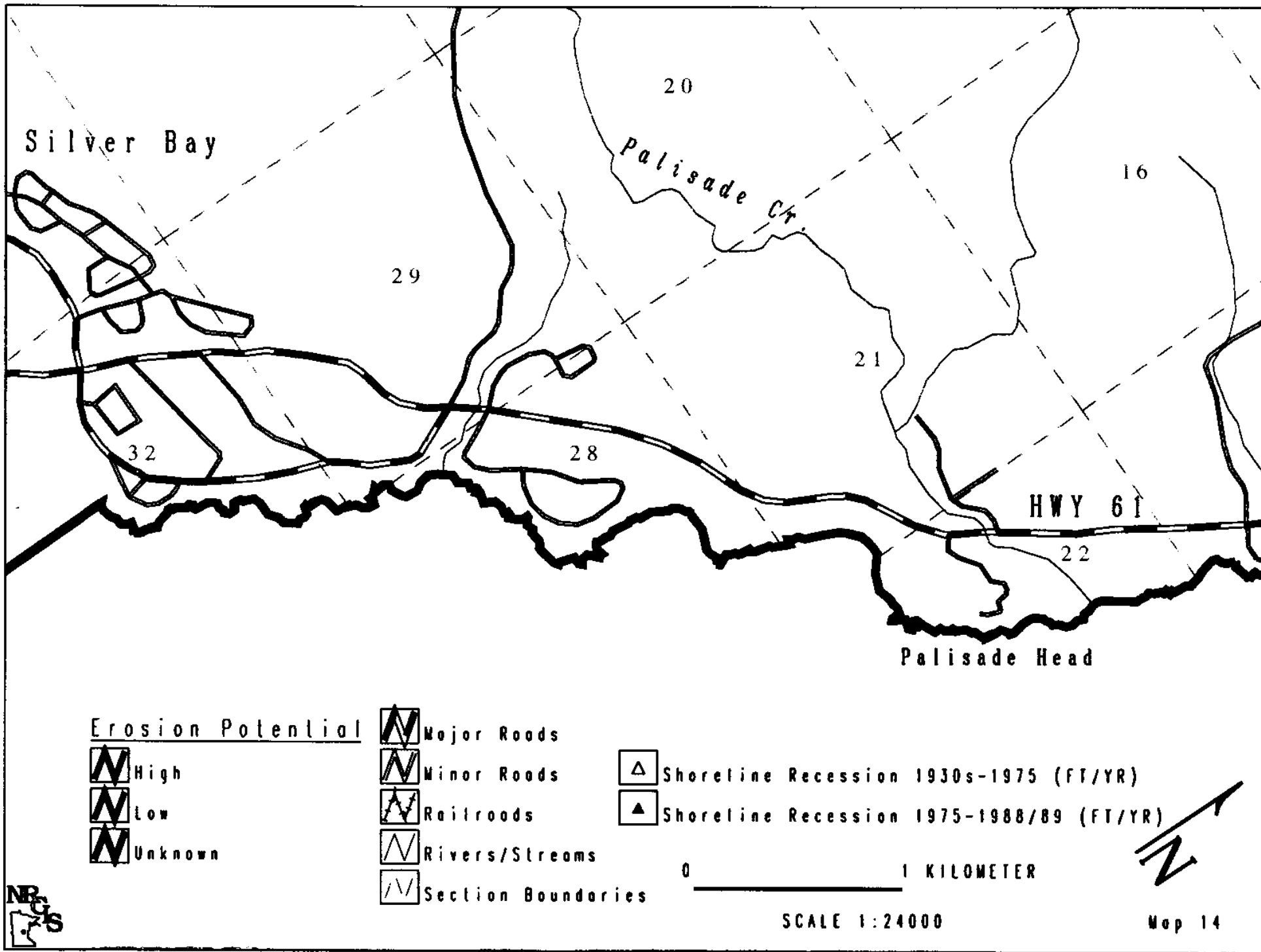
- Shoreline Recession 1930s-1975 (FT/YR)
- Shoreline Recession 1975-1988/89 (FT/YR)

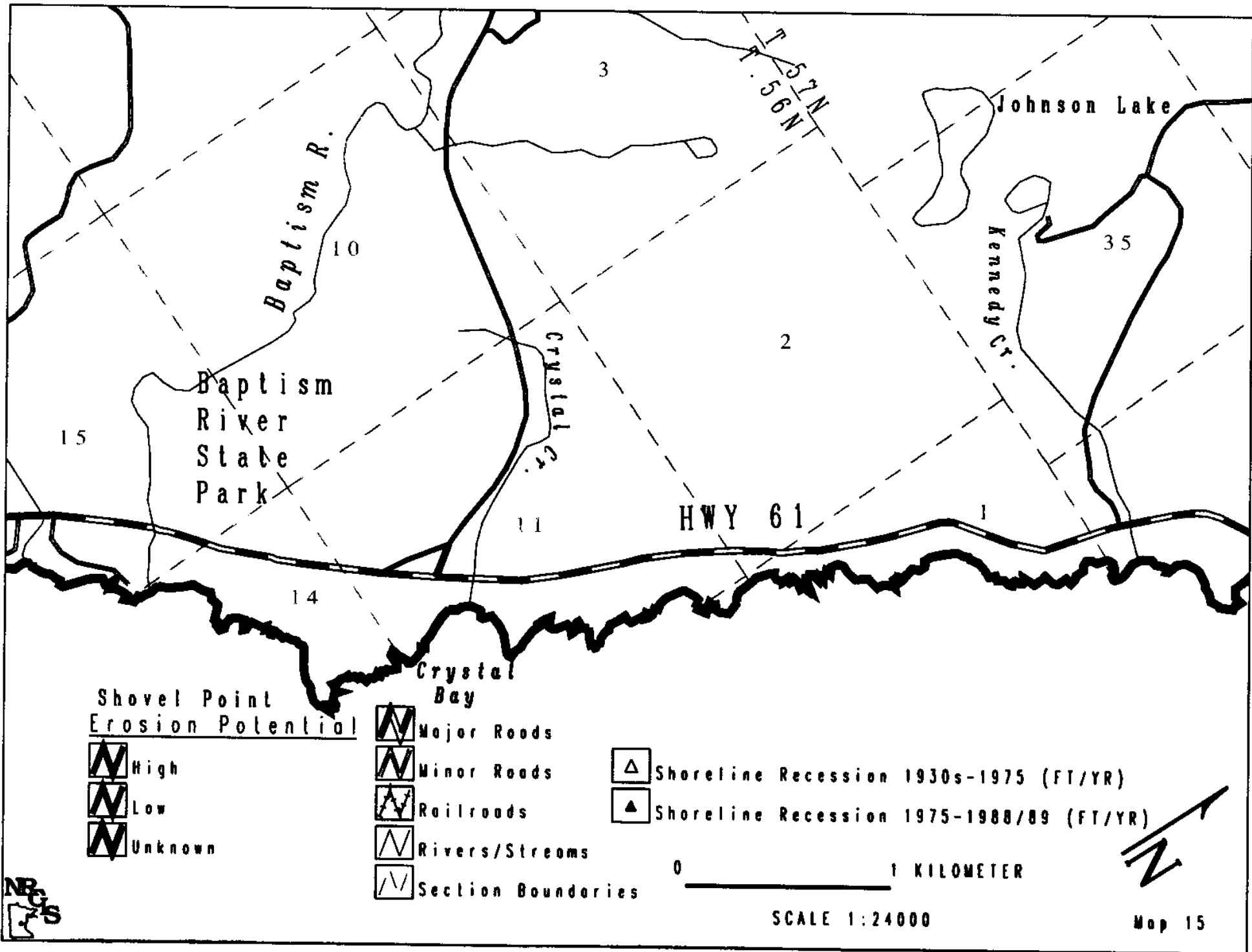
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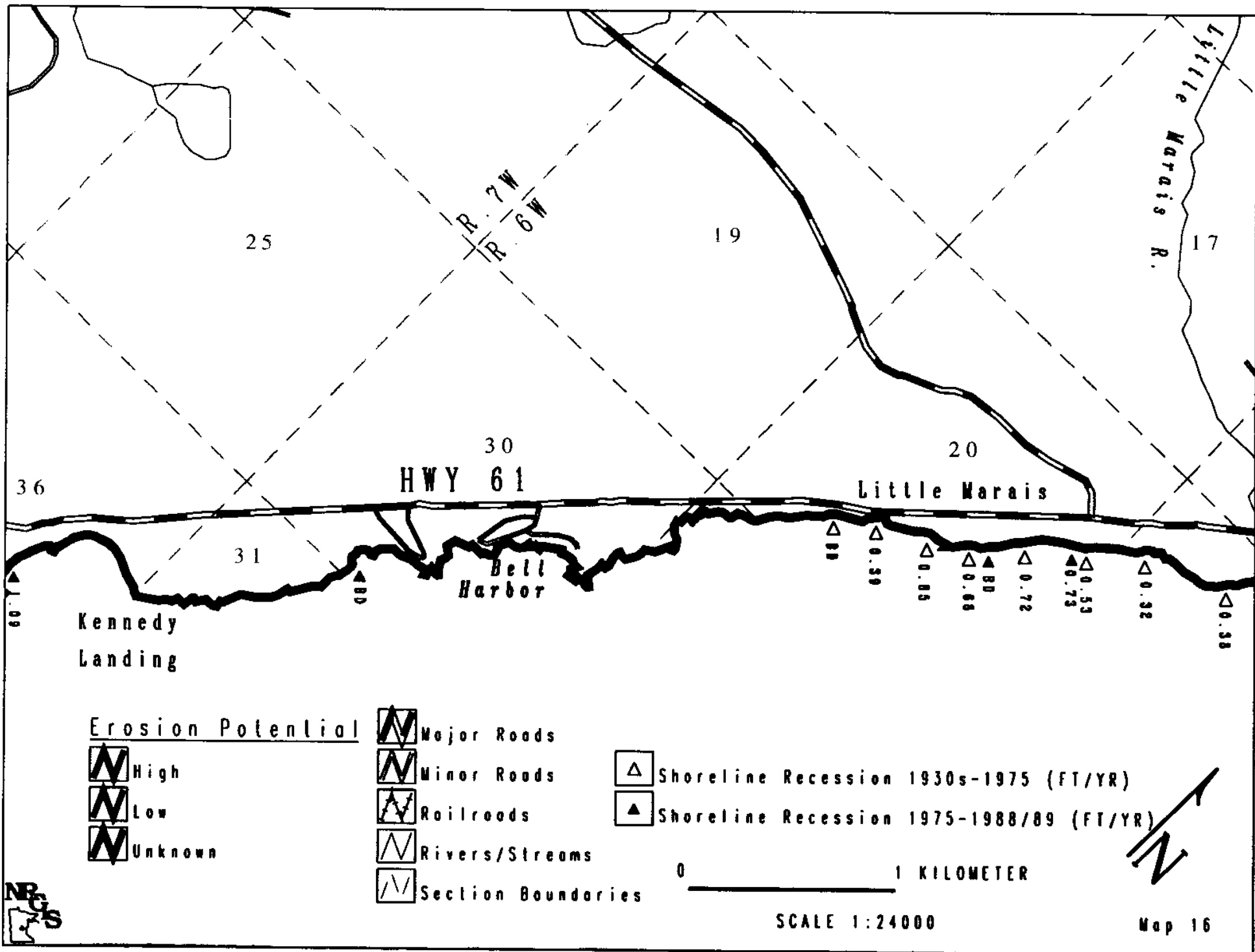
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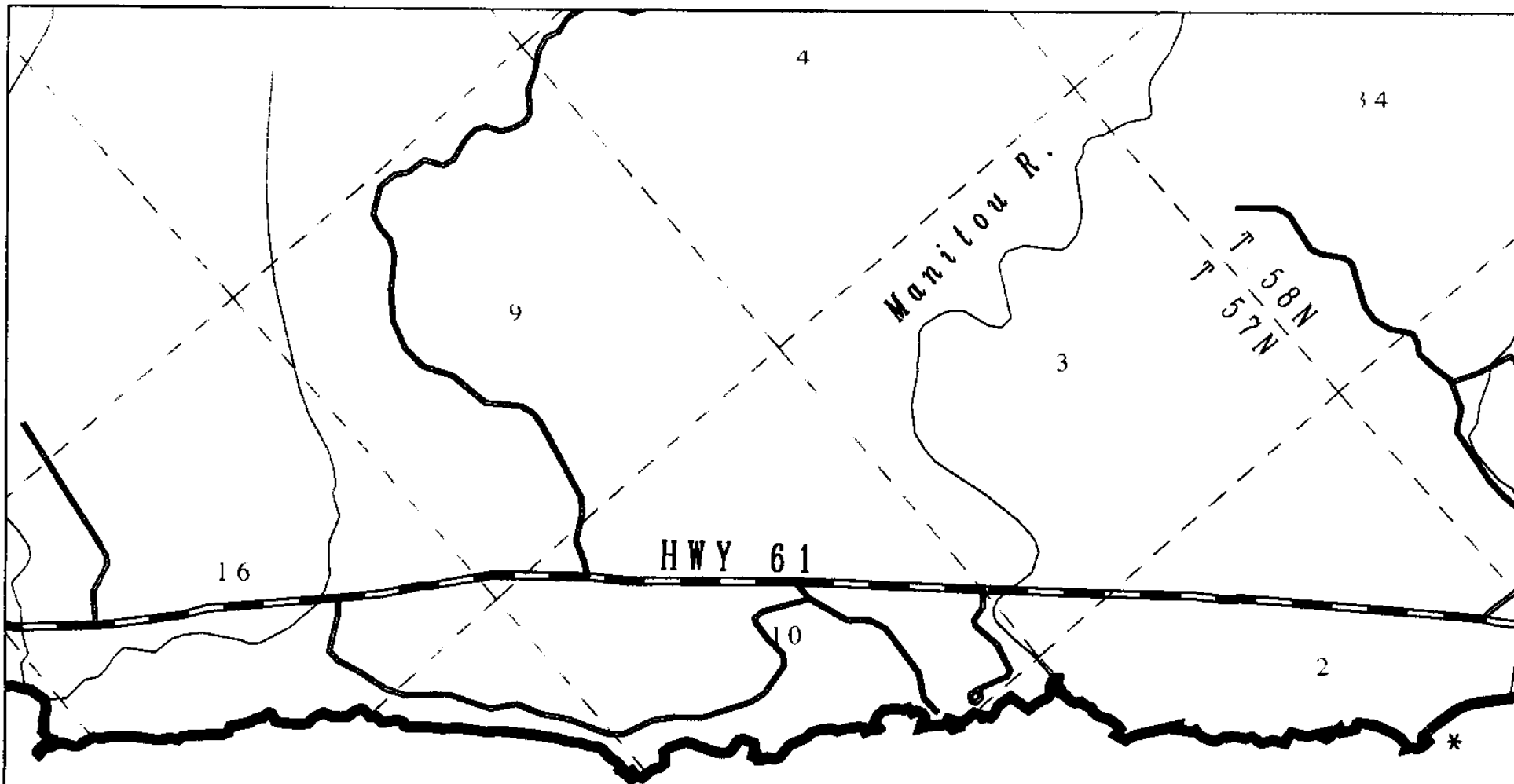












Erosion Potential

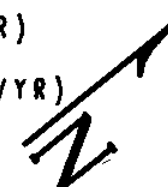
- High
- Low
- Unknown

- Major Roads
- Minor Roads
- Railroads
- Rivers/Streams
- Section Boundaries

- Shoreline Recession 1930s-1975 (FT/YR)
- Shoreline Recession 1975-1988/89 (FT/YR)

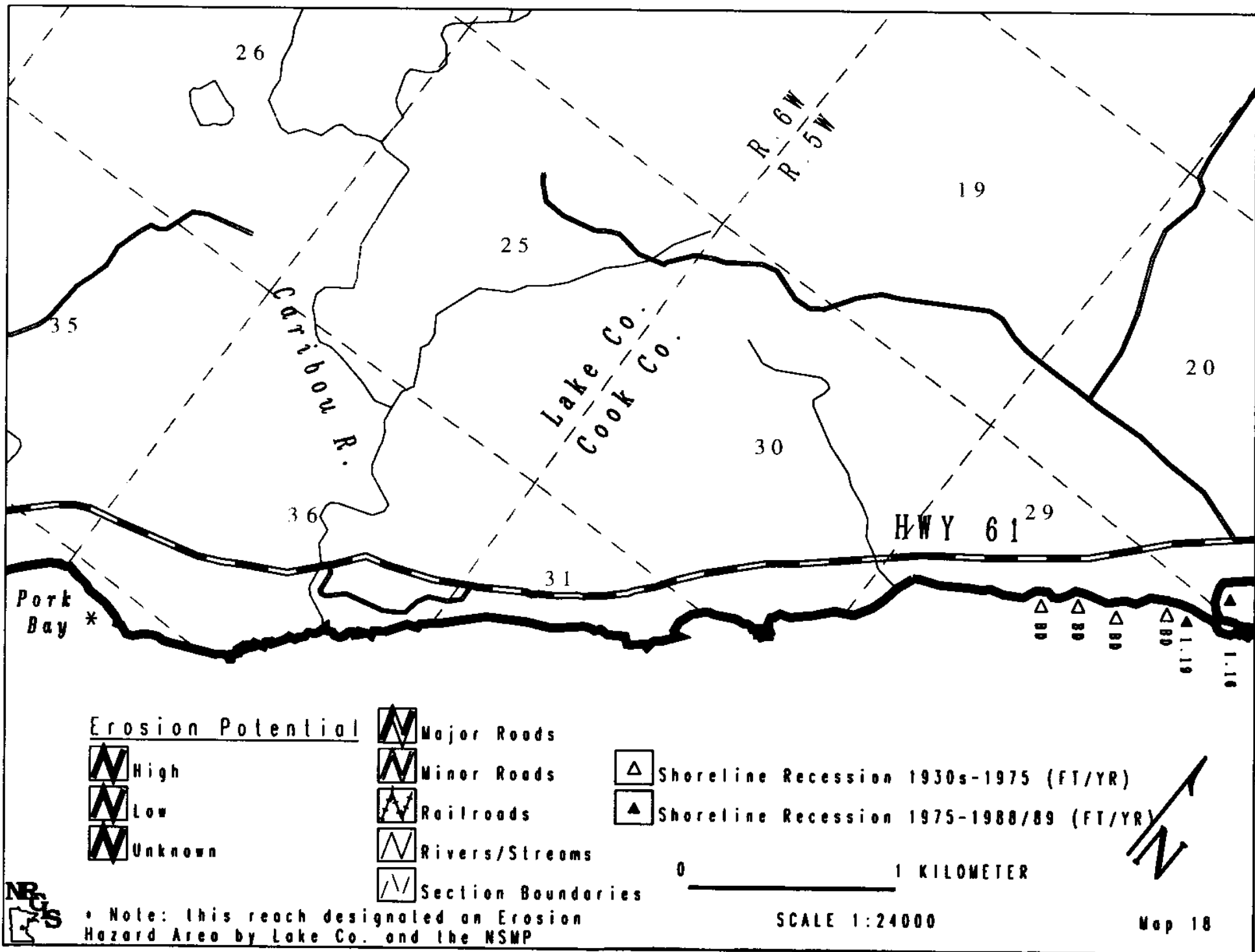
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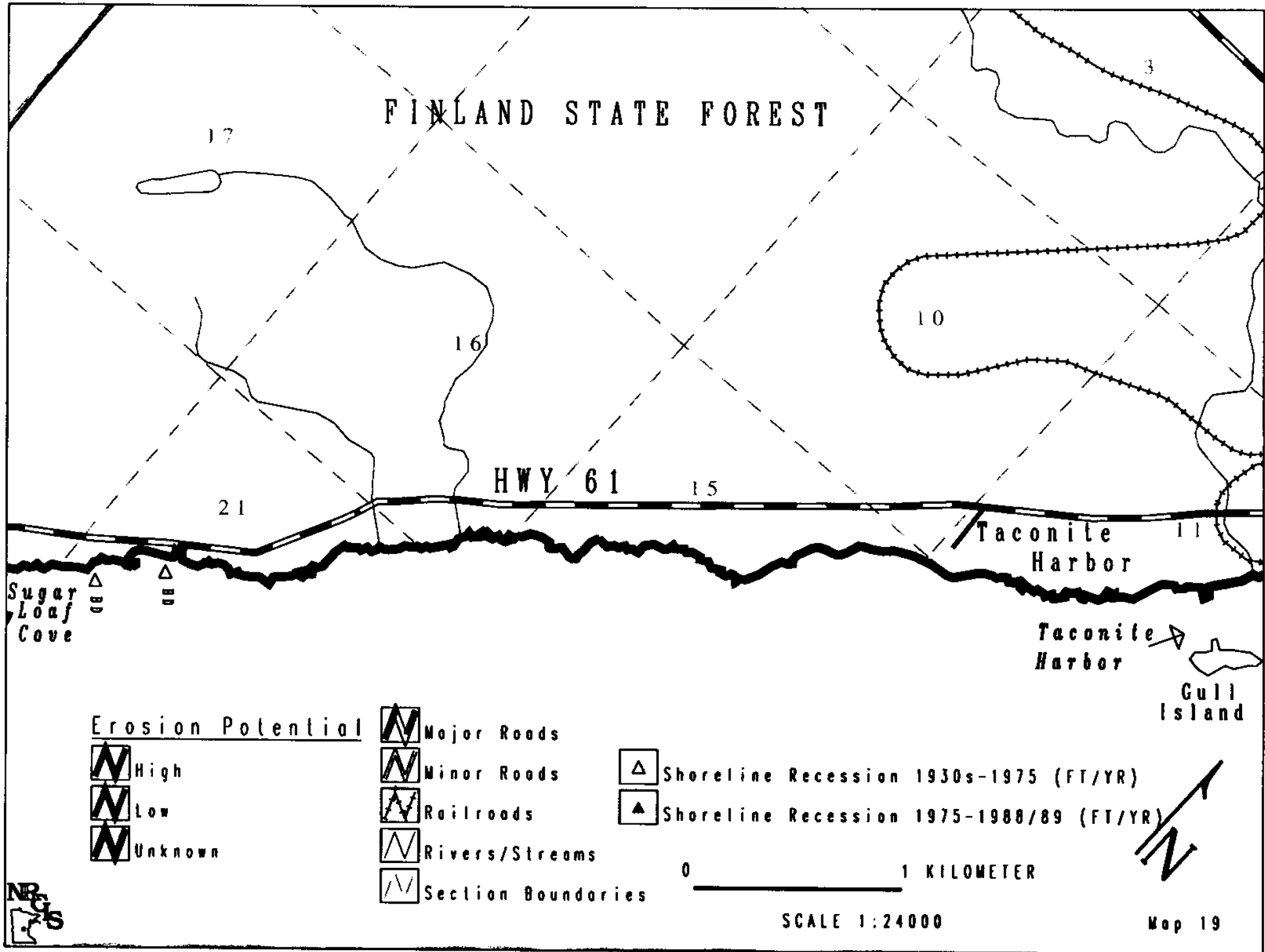
\* Note: This reach designated an Erosion Hazard Area by Lake Co. and the NSMP

Map 17










# FINLAND STATE FOREST



## Erosion Potential

-  High
-  Low
-  Unknown

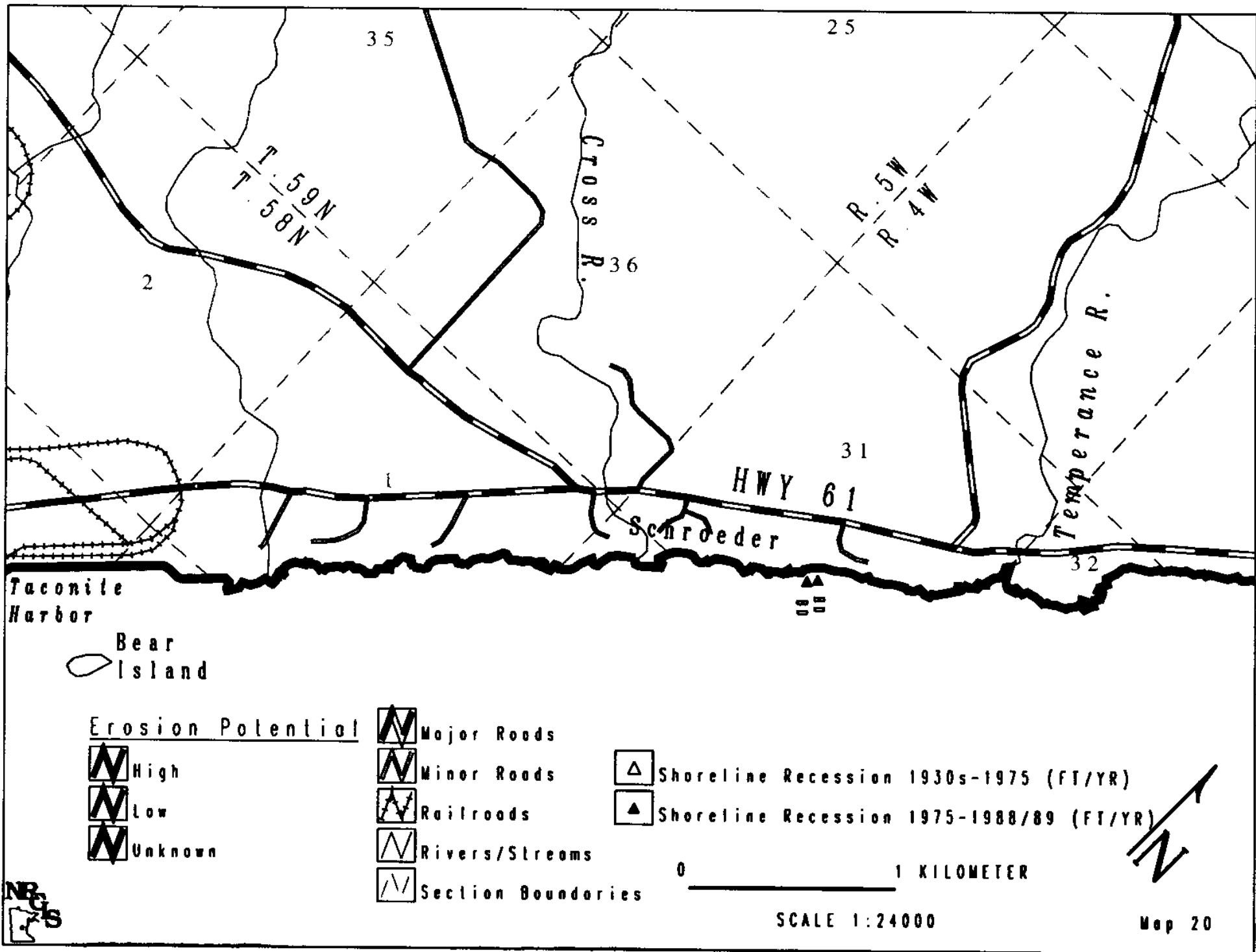
-  Major Roads
-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

-  Shoreline Recession 1930s-1975 (FT/YR)
-  Shoreline Recession 1975-1988/89 (FT/YR)

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Erosion Potential

-  High
-  Low
-  Unknown

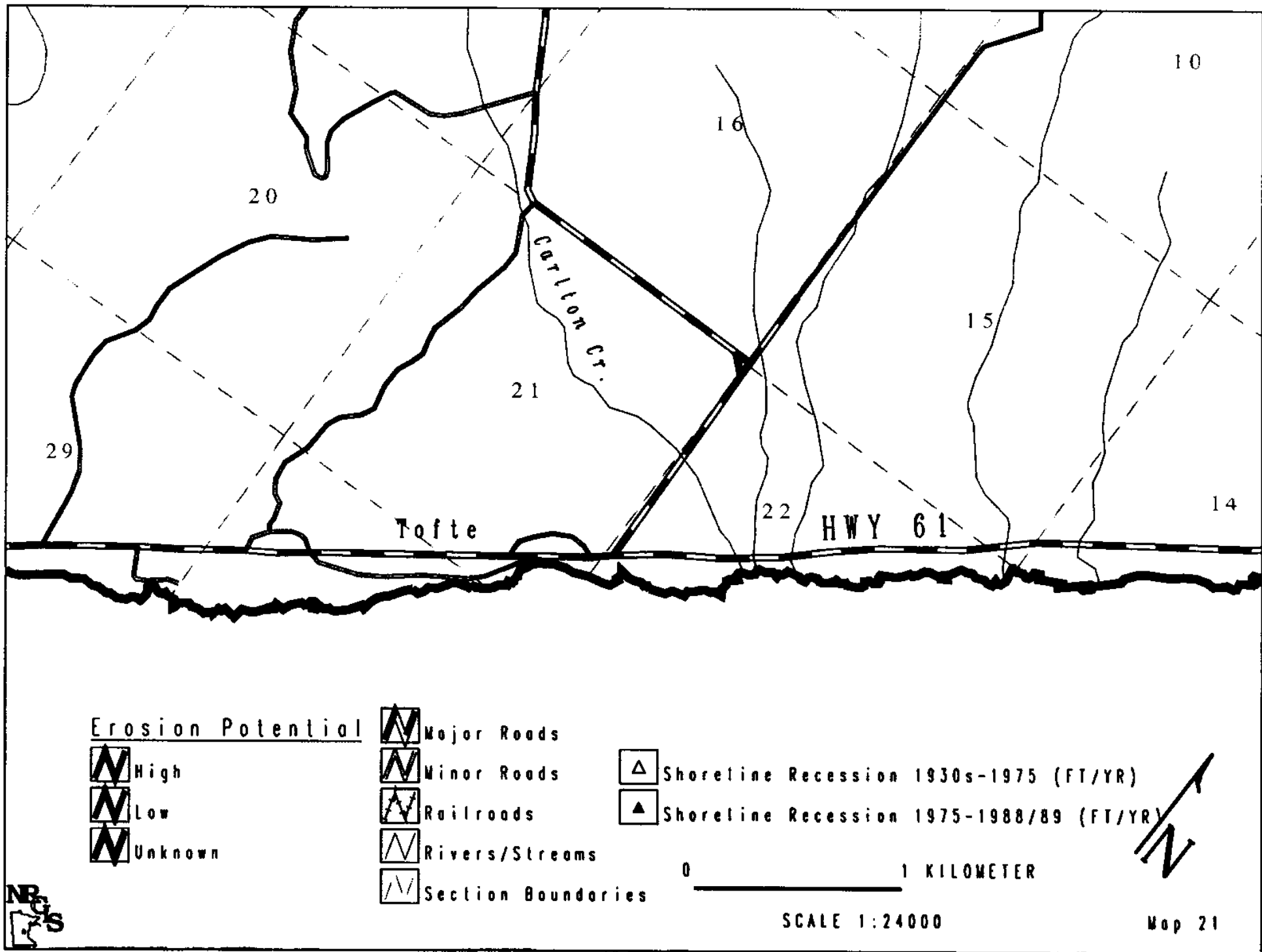
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-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

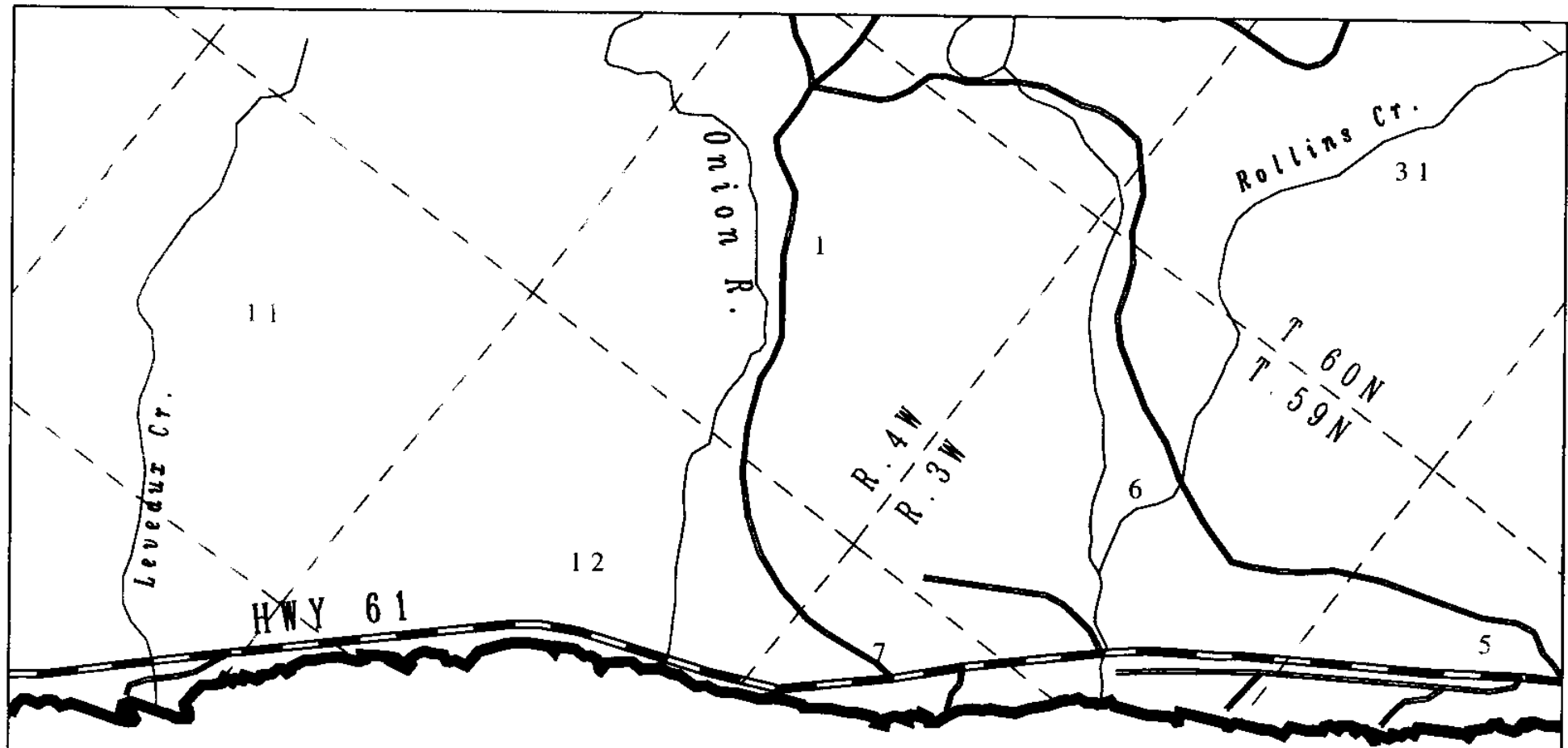
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Map 20





Erosion Potential

-  High
-  Low
-  Unknown

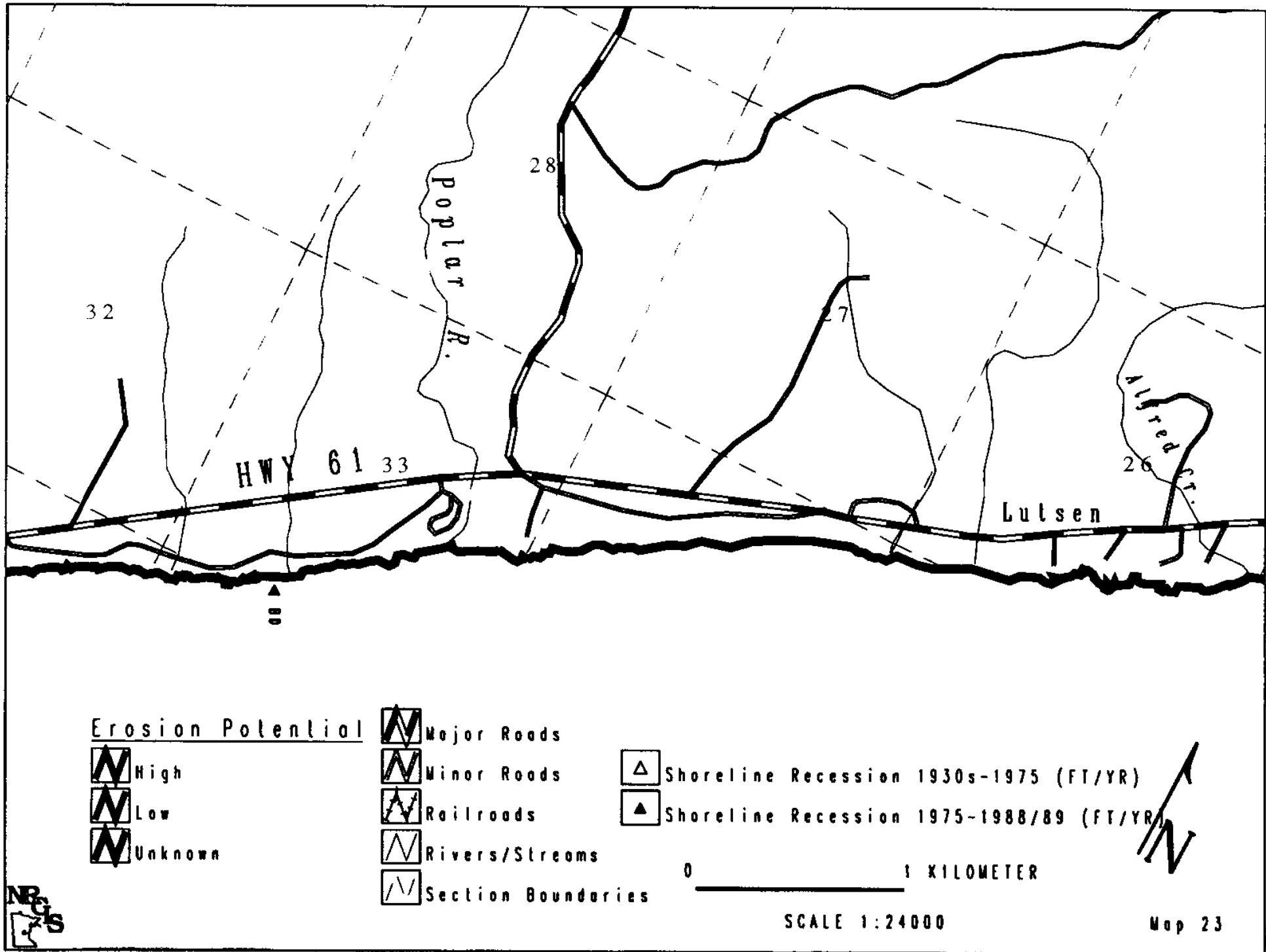
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-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

-  Shoreline Recession 1930s-1975 (FT/YR)
-  Shoreline Recession 1975-1988/89 (FT/YR)

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





Erosion Potential

-  High
-  Low
-  Unknown

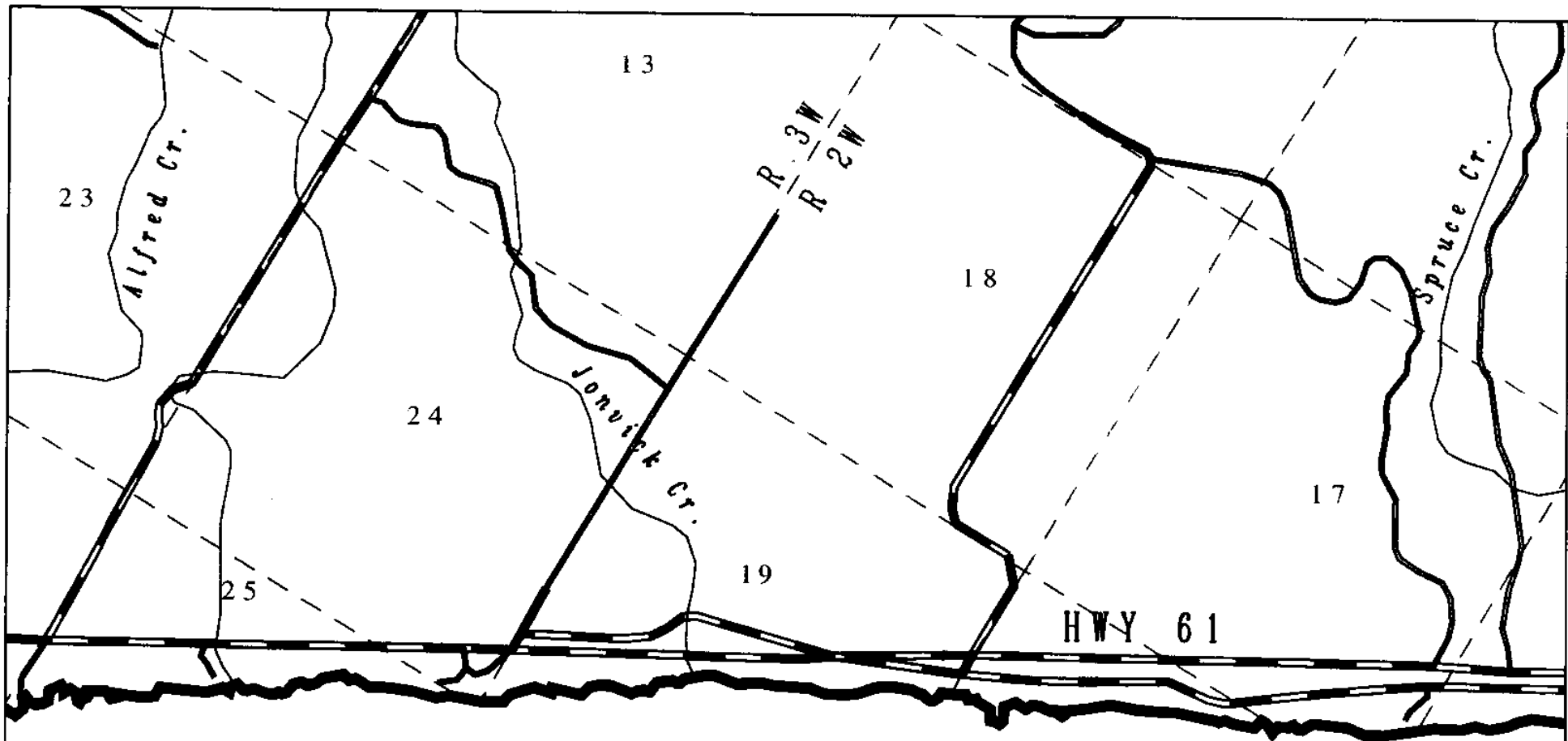
-  Major Roads
-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

-  Shoreline Recession 1930s-1975 (FT/YR)
-  Shoreline Recession 1975-1988/89 (FT/YR)

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SCALE 1:24000





Erosion Potential

- High
- Low
- Unknown

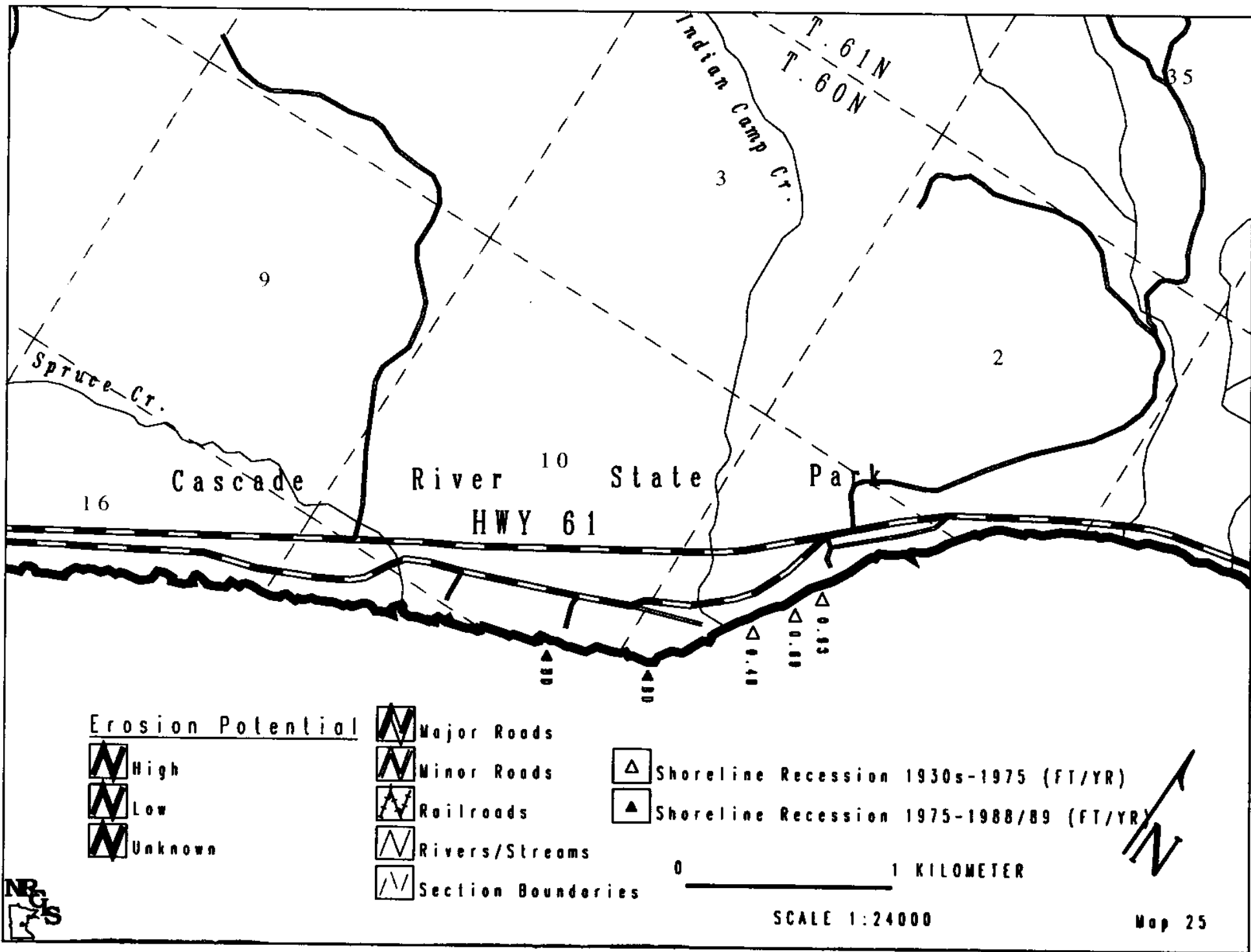
- Major Roads
- Minor Roads
- Railroads
- Rivers/Streams
- Section Boundaries

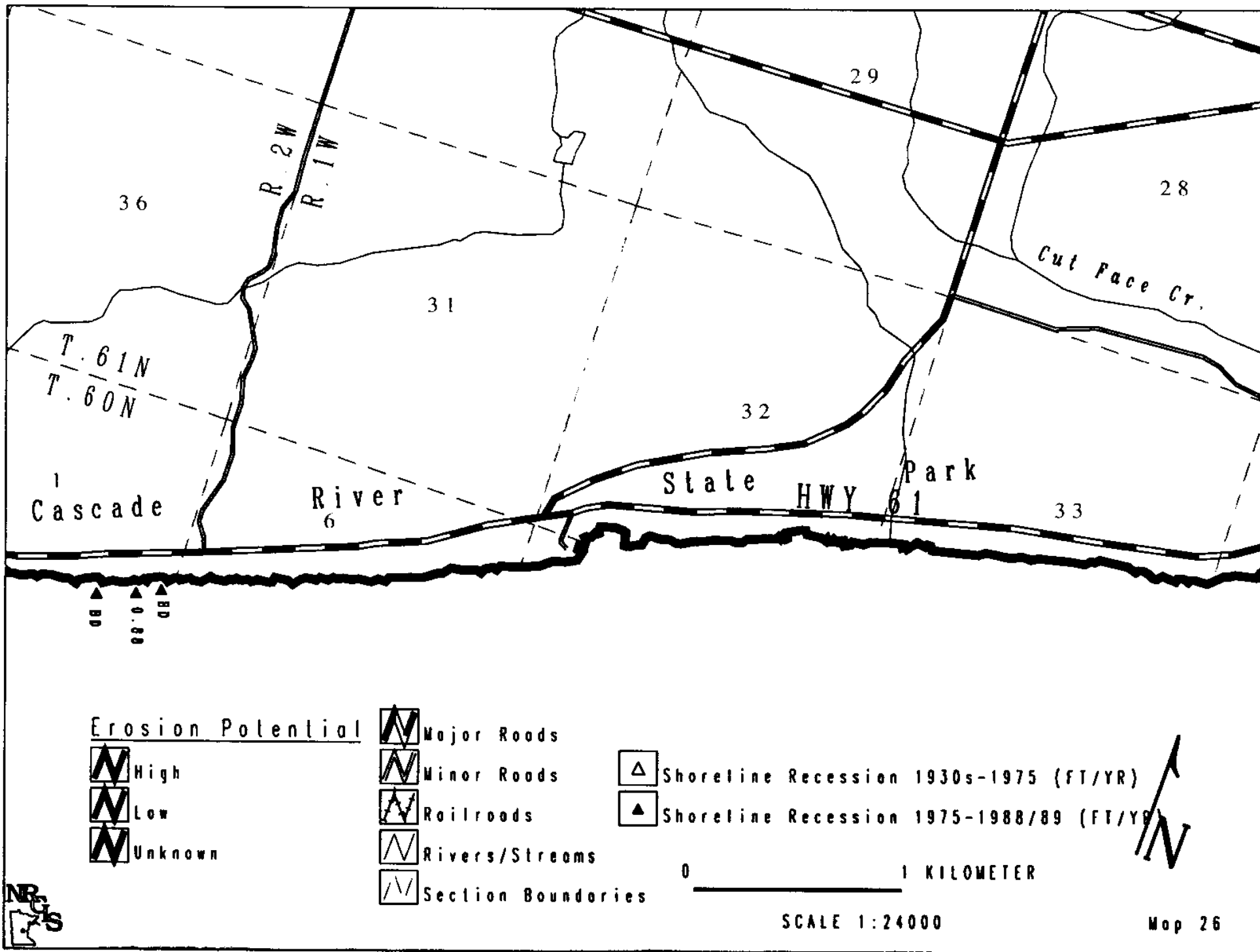
- Shoreline Recession 1930s-1975 (FT/YR)
- Shoreline Recession 1975-1988/89 (FT/YR)

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Erosion Potential

-  High
-  Low
-  Unknown

-  Major Roads
-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

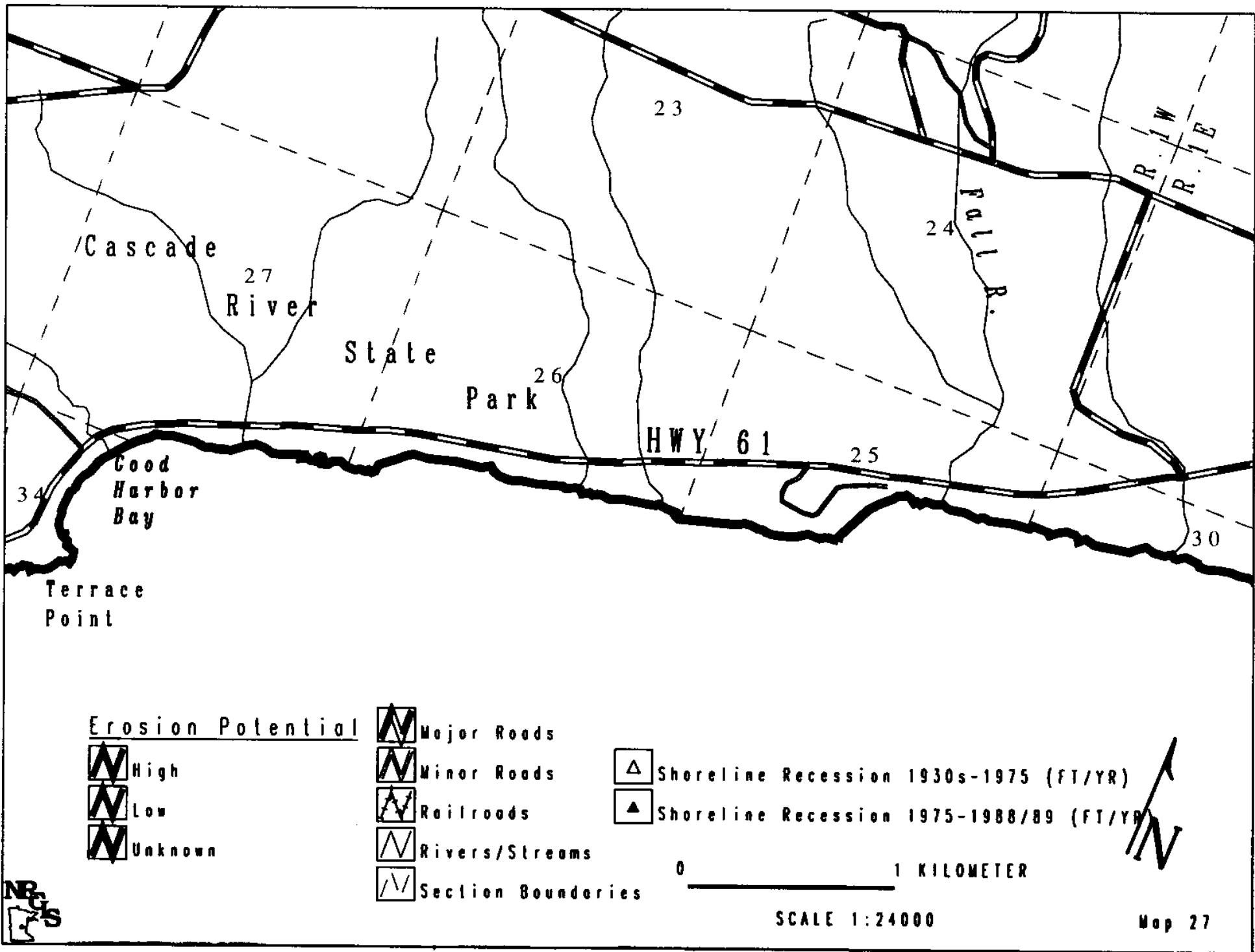
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-  Shoreline Recession 1975-1988/89 (FT/YR)

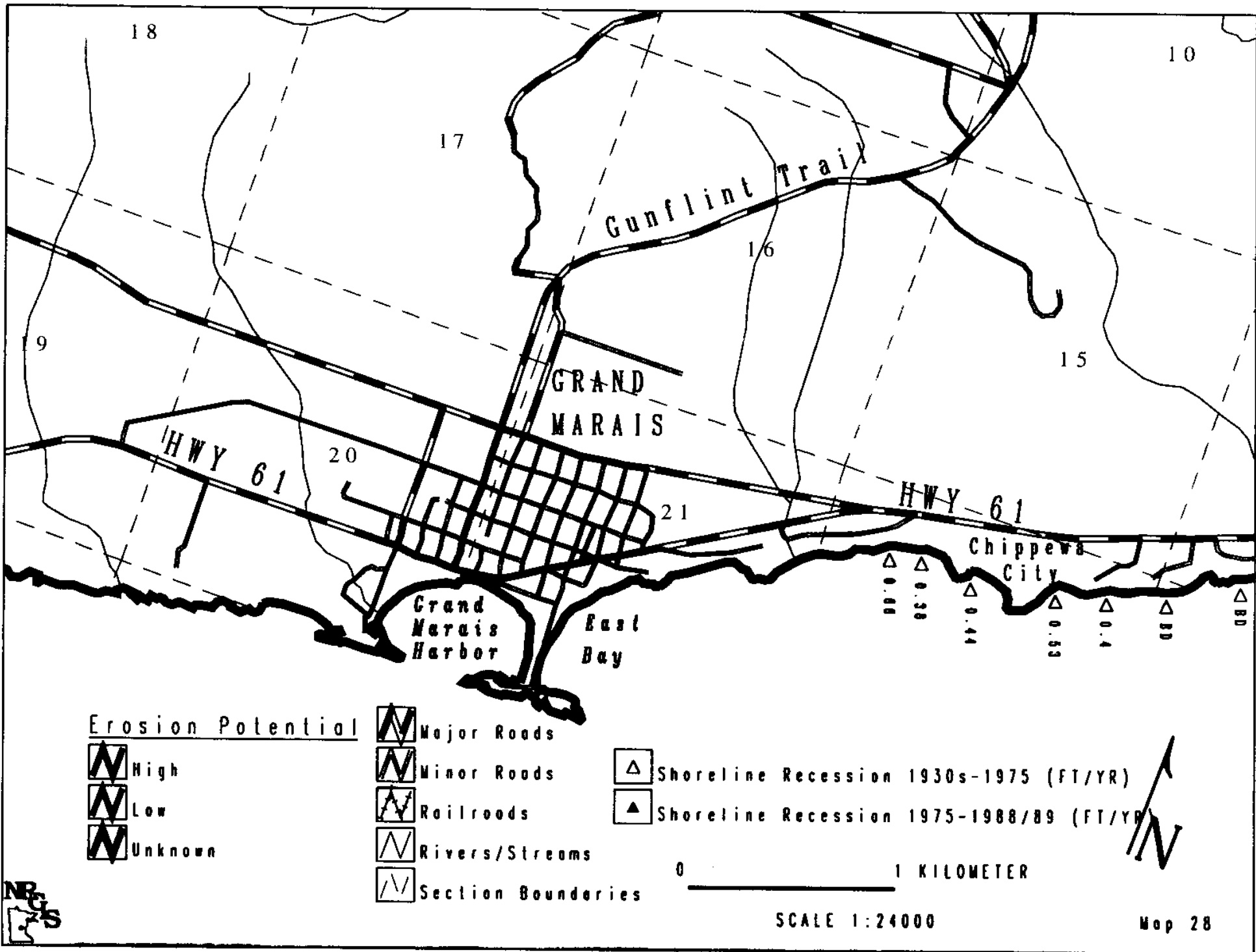
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Map 26







**Erosion Potential**

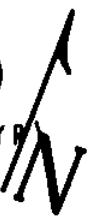
- High
- Low
- Unknown

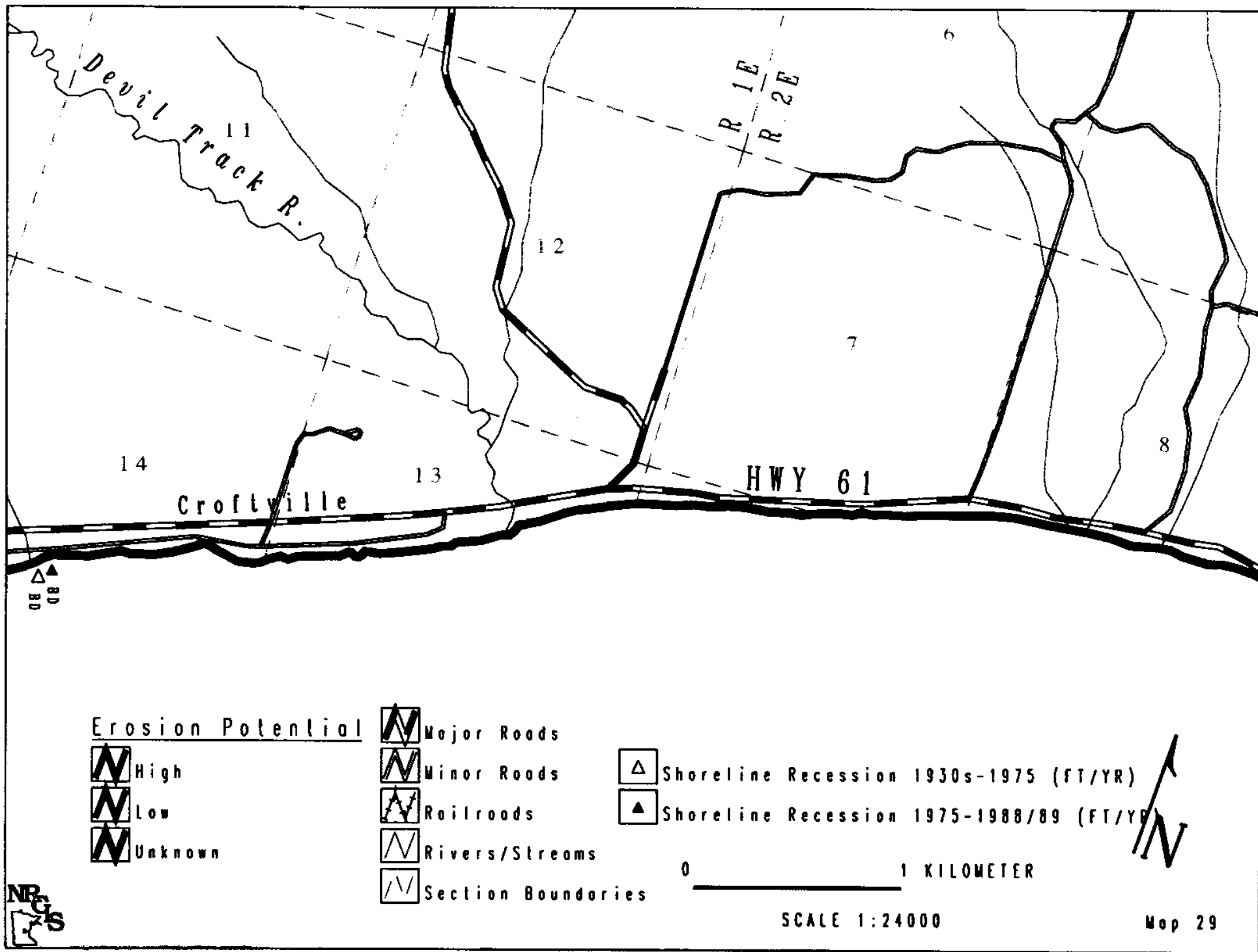
- Major Roads
- Minor Roads
- Railroads
- Rivers/Streams
- Section Boundaries

- Shoreline Recession 1930s-1975 (FT/YR)
- Shoreline Recession 1975-1988/89 (FT/YR)

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SCALE 1:24000





Erosion Potential

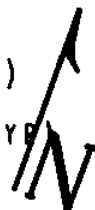
-  High
-  Low
-  Unknown

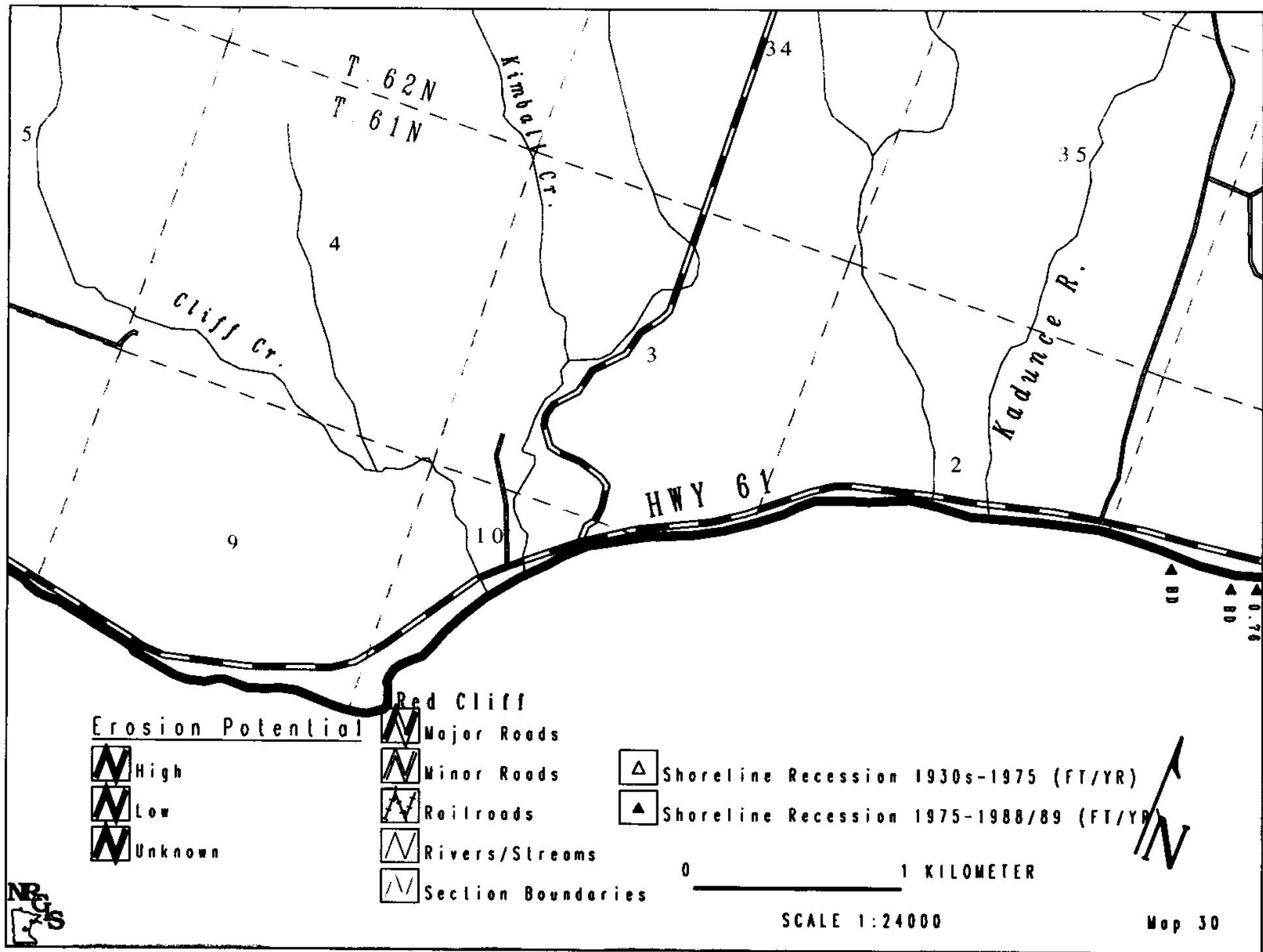
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-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

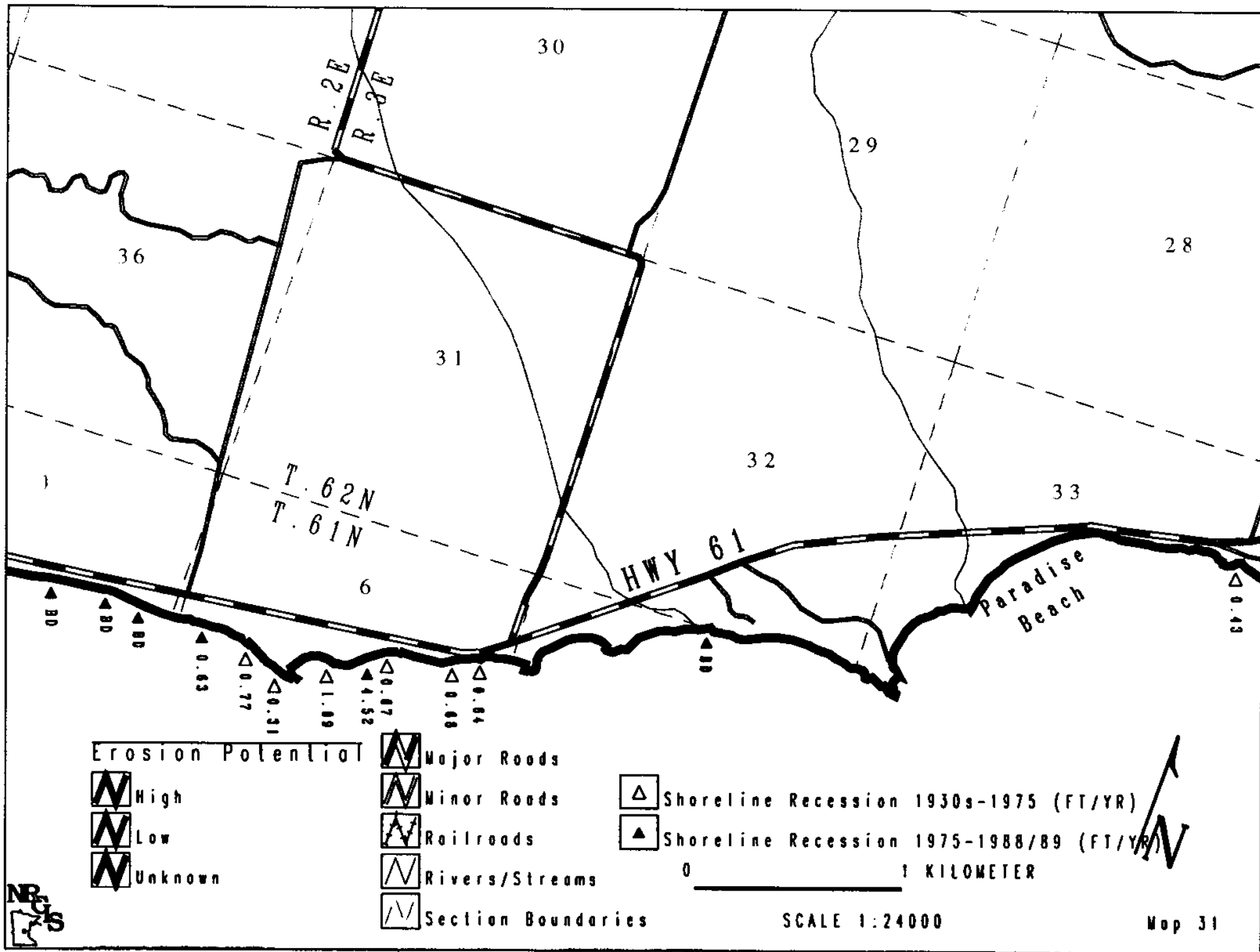
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-  Shoreline Recession 1975-1988/89 (FT/YR)

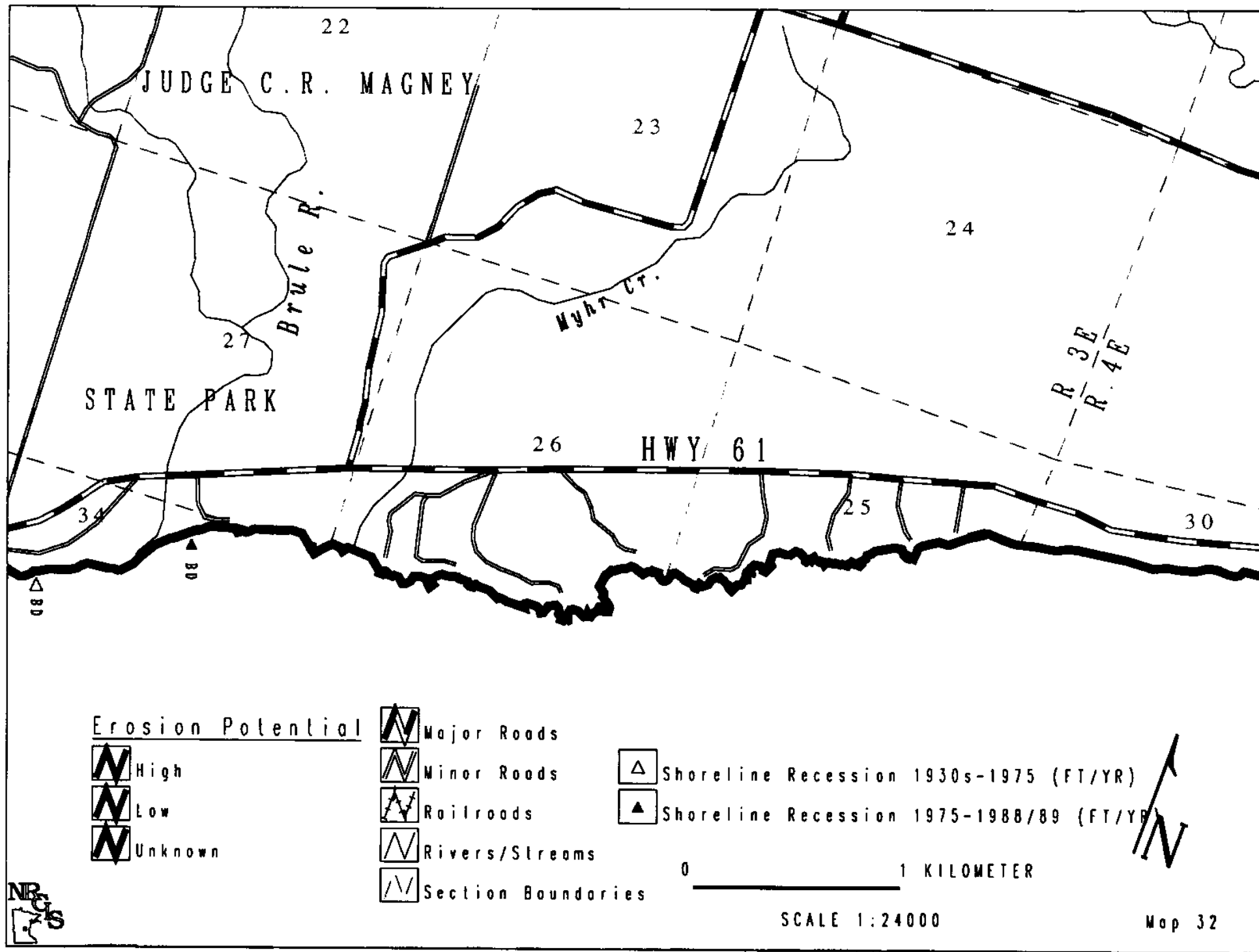
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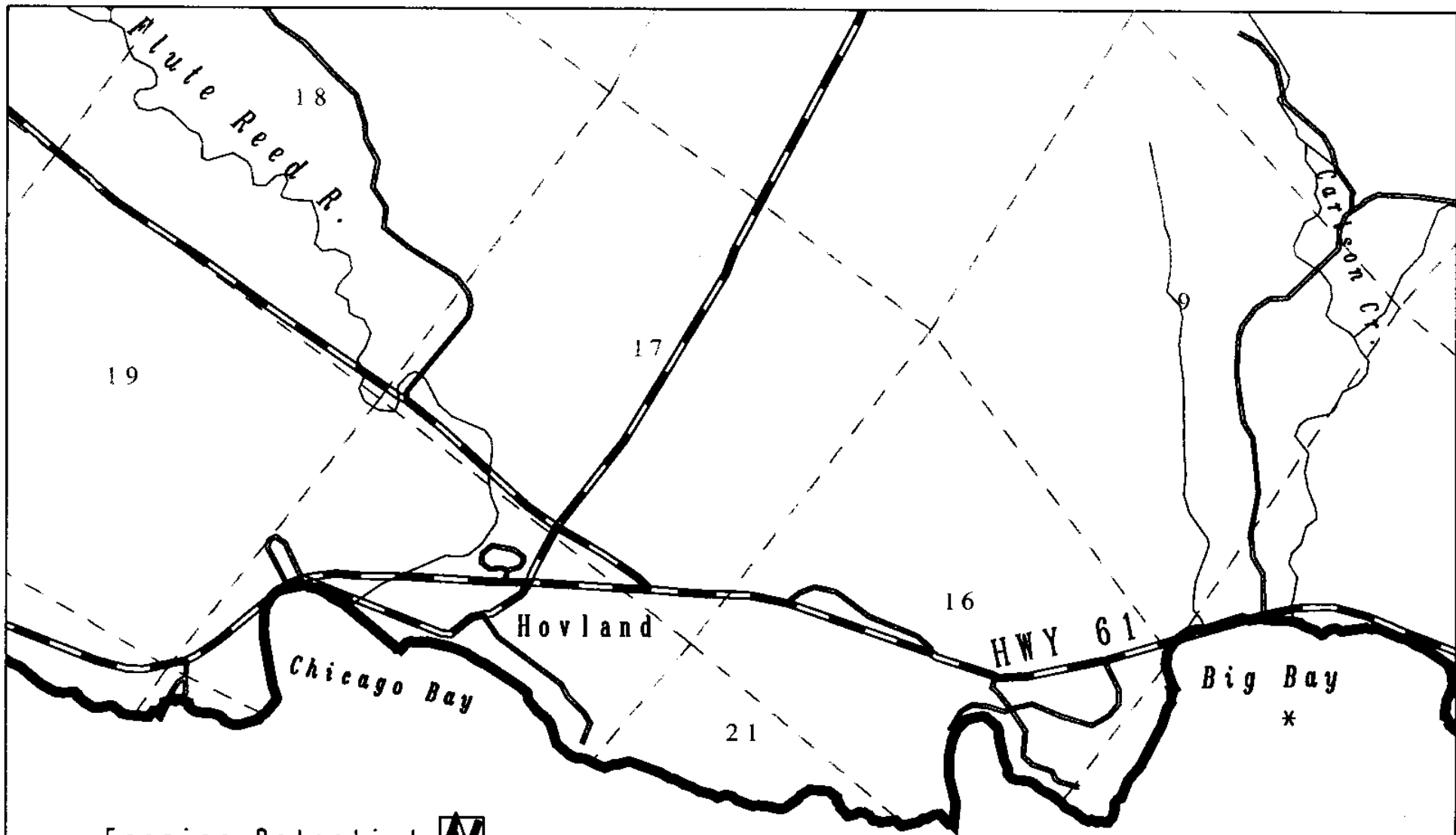
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Erosion Potential

- High
- Low
- Unknown

- Major Roads
- Minor Roads
- Railroads
- Rivers/Streams
- Section Boundaries

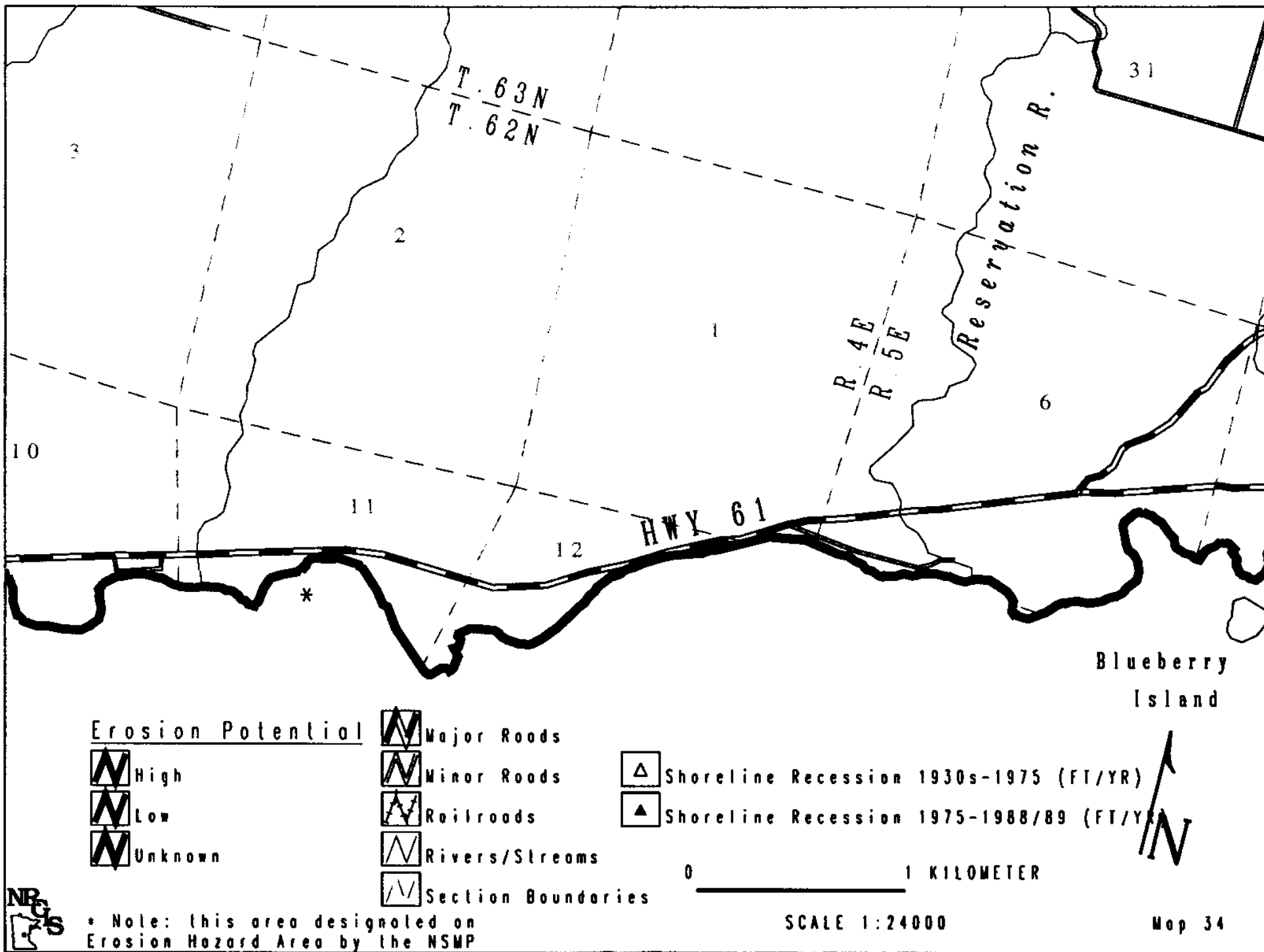
- Shoreline Recession 1930s-1975 (FT/YR)
- Shoreline Recession 1975-1988/89 (FT/YR)

0 \_\_\_\_\_ 1 KILOMETER

SCALE 1:24000



\* Note: Big Bay designated as Erosion Hazard Area by the NSMP



31

T. 63N  
T. 62N

Reservation R.

R. 4E  
R. 5E

3

2

1

6

10

11

HWY 61

12

\*

Blueberry  
Island

Erosion Potential

-  High
-  Low
-  Unknown

-  Major Roads
-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

-  Shoreline Recession 1930s-1975 (FT/YR)
-  Shoreline Recession 1975-1988/89 (FT/YR)

0 \_\_\_\_\_ 1 KILOMETER

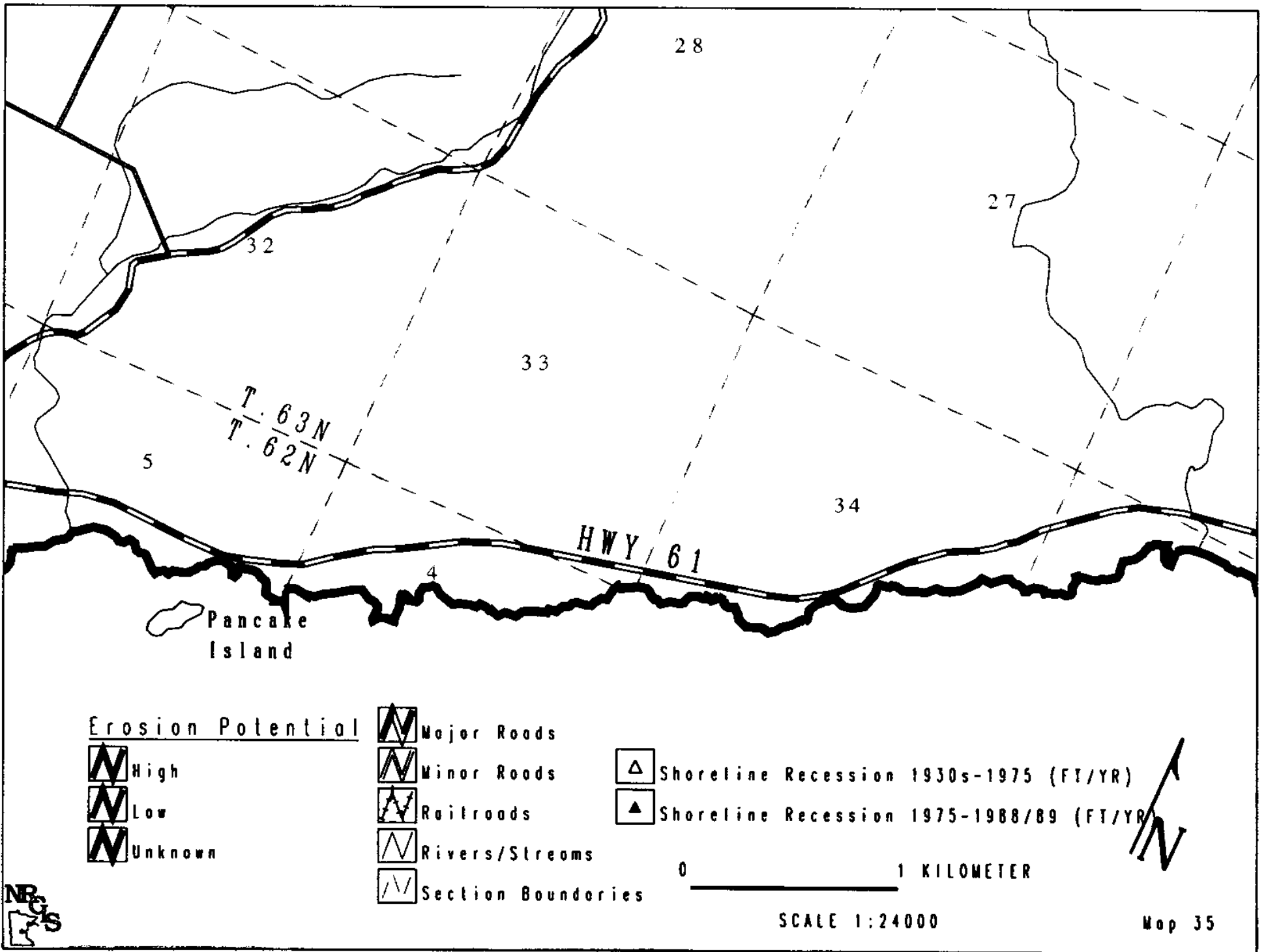
SCALE 1:24000



\* Note: this area designated on Erosion Hazard Area by the NSMP






Map 34







Erosion Potential

-  High
-  Low
-  Unknown

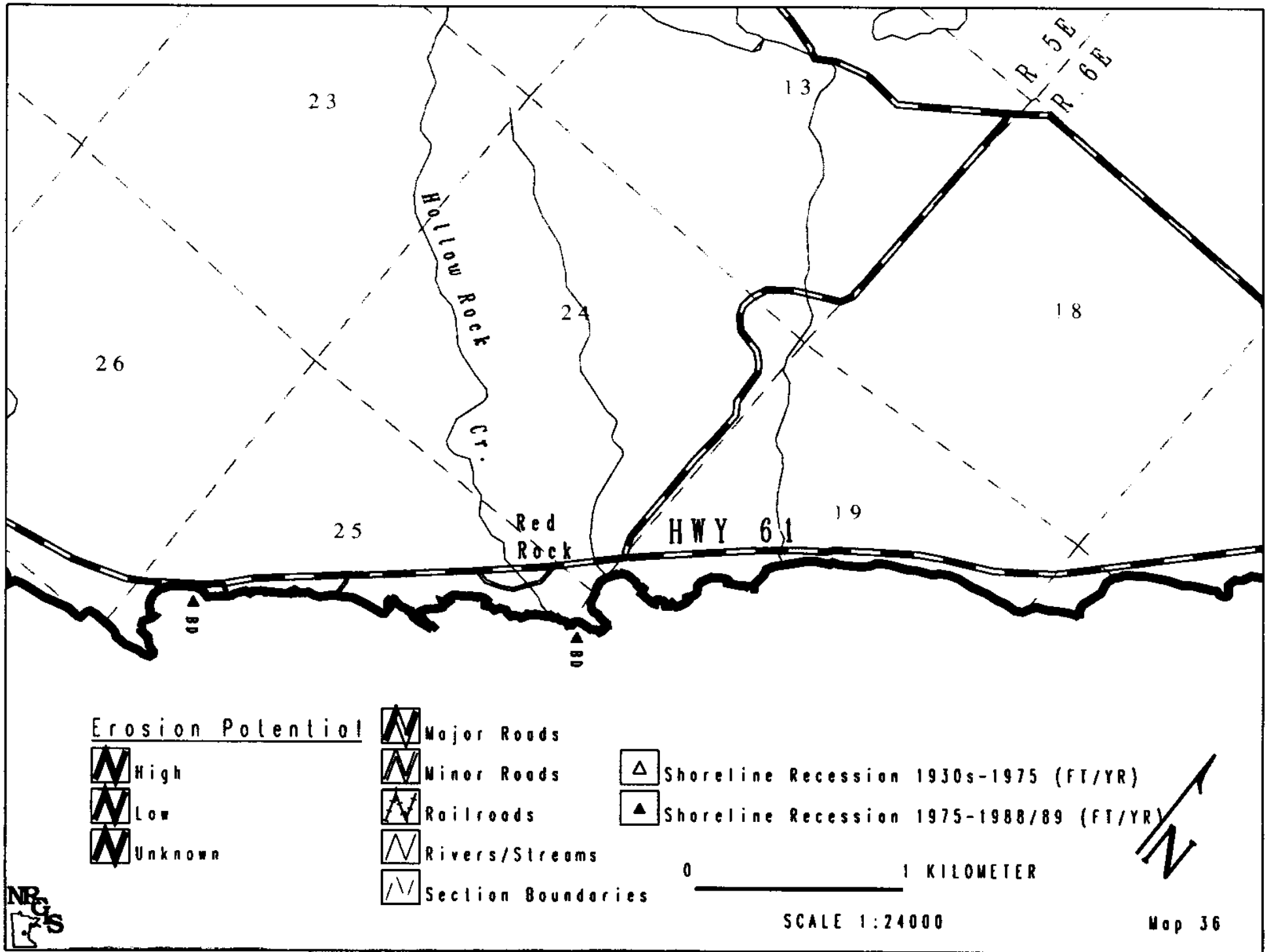
-  Major Roads
-  Minor Roads
-  Railroads
-  Rivers/Streams
-  Section Boundaries

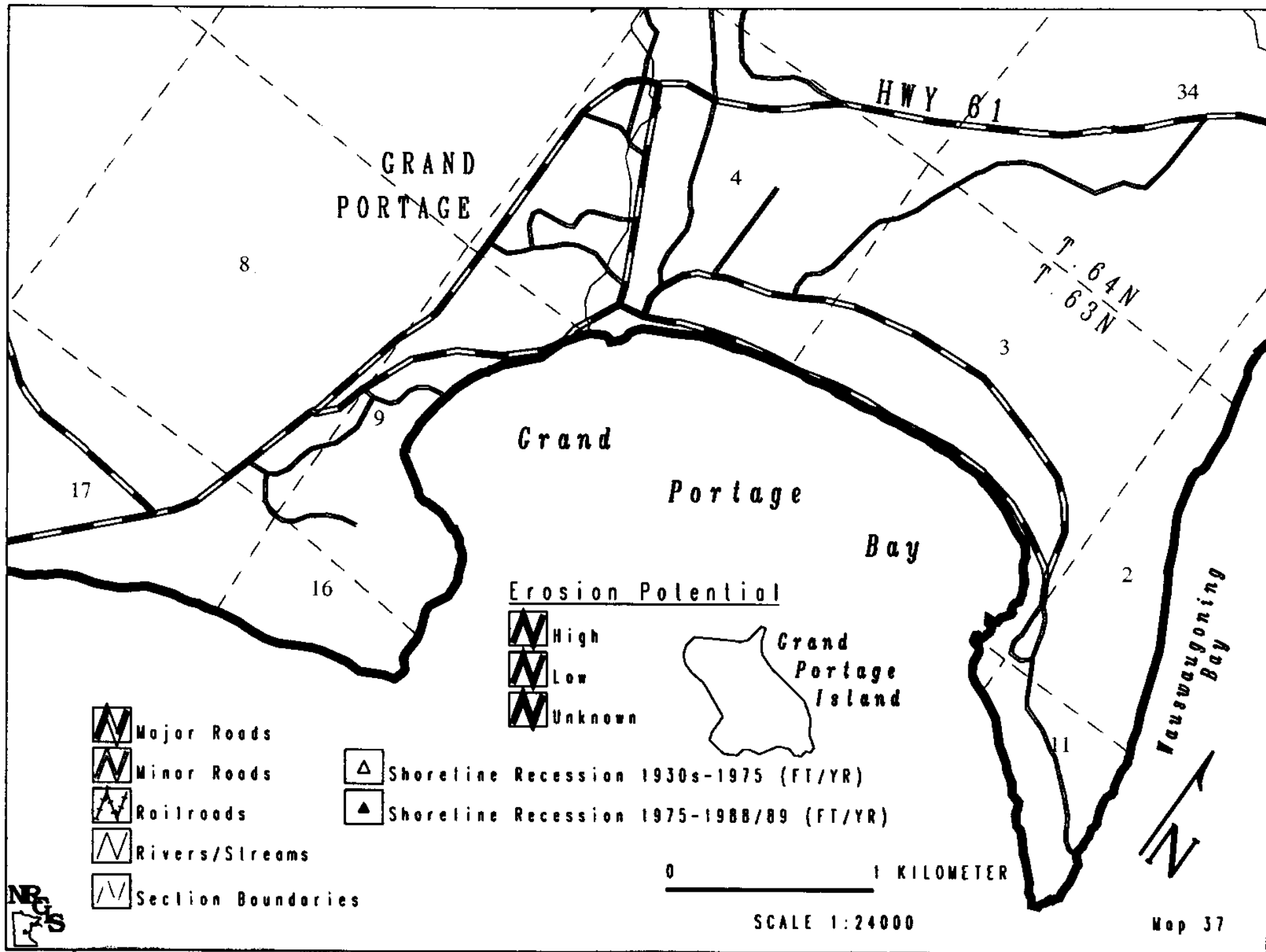
-  Shoreline Recession 1930s-1975 (FT/YR)
-  Shoreline Recession 1975-1988/89 (FT/YR)

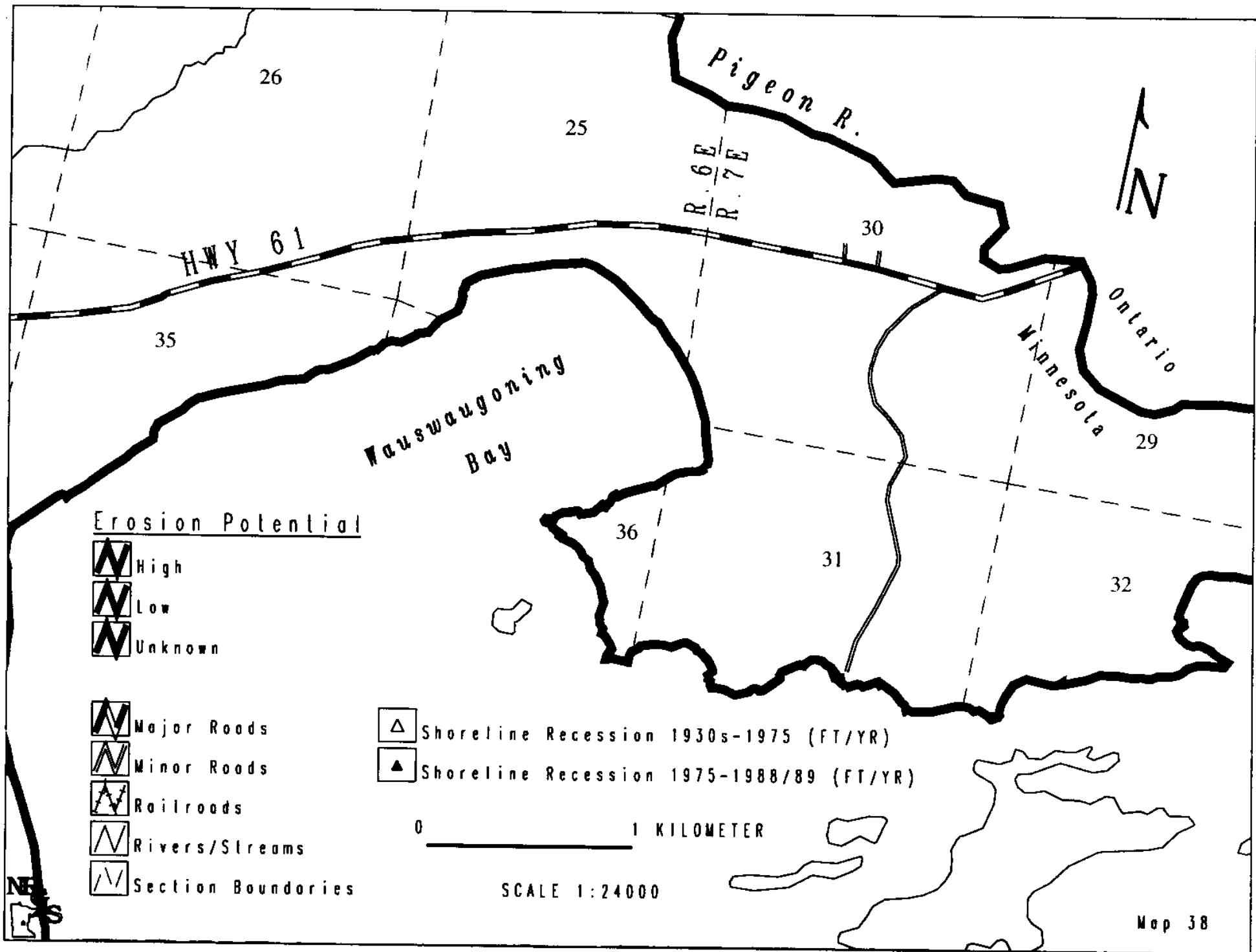
0  1 KILOMETER

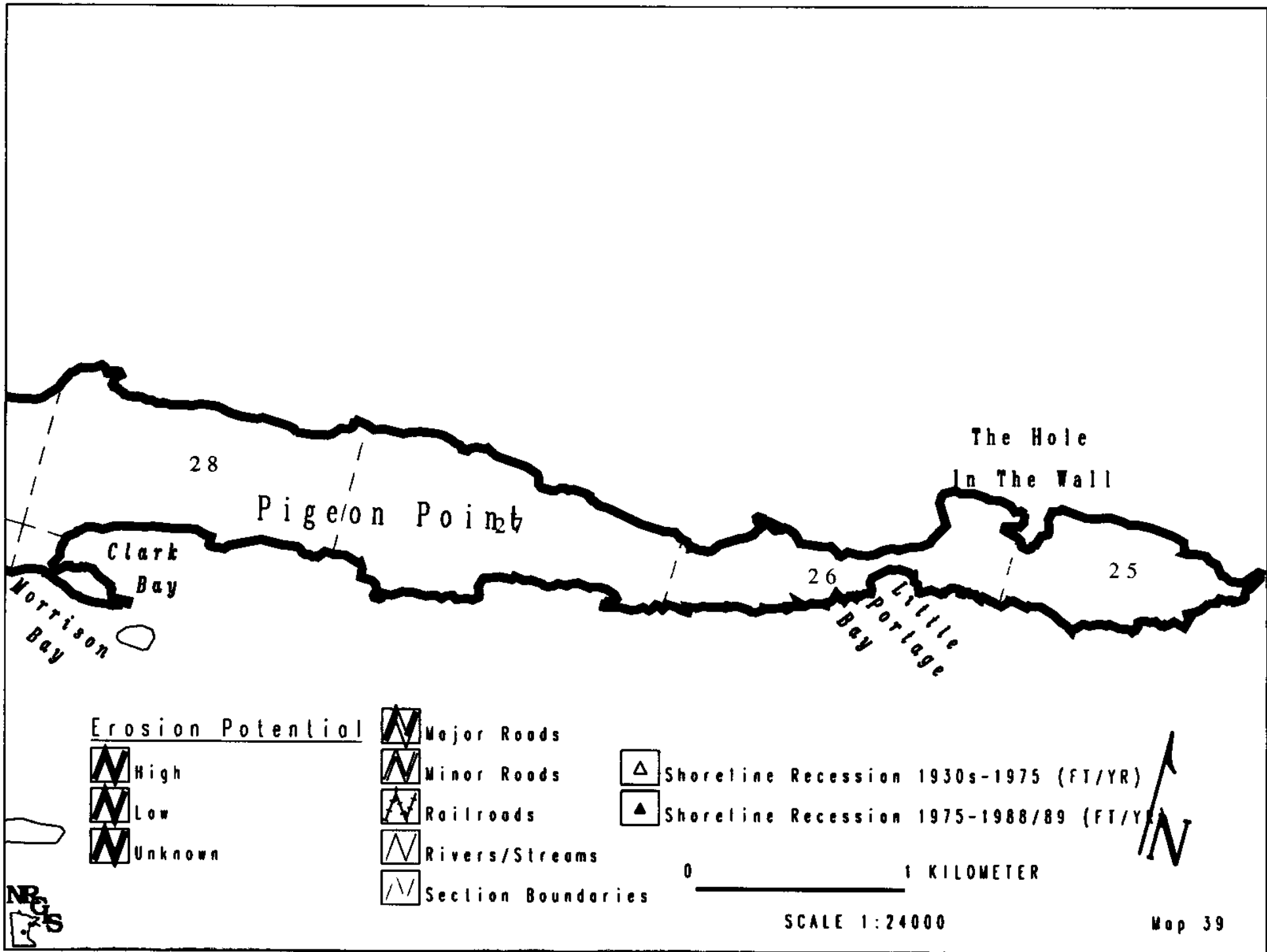
SCALE 1:24000











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Pigeon Point

The Hole  
In The Wall

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Clark Bay

Morrison Bay

Little Portage Bay

