



# EROSION HAZARDS

## Location

The City lies at the southern range of the Superior Lobe of the Wisconsin Glacier, which existed during the last ice age, about 12,000 years ago. This period of glaciation dictates the soil properties of much of Northern Wisconsin, including the area that is now the City of Superior. According to the Wisconsin Geological and Natural History Survey, Superior rests on the Keweenaw Rocks, which prior to glaciation consisted of sandstone and igneous (gabbro) rock. Glacial recession left behind unconsolidated lake till, predominantly red clay texture, smallest in size among the soil classes. While unconsolidated material on the immediate surface of the earth serves as a natural medium for the growth of land plants, it is less stable than consolidated rock and is much more prone to weathering and erosion over time. In the City, this unconsolidated substrate ranges from 100-600 feet deep and is especially deep along St. Louis Bay at Billings Park.

The clay soil upon which Superior is built has temperamental properties that make it very vulnerable to slumping, a term used when large amounts of sediment move downhill under gravity. Clay particles are small and flat and thus have a large surface area-volume ratio. If a grain of sand were the size of a basketball, then a piece of silt would be the size of a marble and a particle of clay would be a pinpoint. Weathering, a phenomenon soil particles undergo as they age, is accelerated by factors including hydration, impact and frost. Weathering weakens soil structure, which destabilizes the ground and increases the likelihood of slumping.

## Hazard Profile

Erosion is caused by wave action, water currents, winds that fuel wave action, water flow over land and through points of groundwater discharge and the freeze-thaw activity in winter and especially in spring. Temporary fluctuations in water levels from storm events or storm-induced surges producing elevated wave activity are the principal causes of coastal bluff erosion.

The effects of water on Superior's clay soils can be harsh. When dry, these clay soils are stable. However, when undergoing saturation, clay soils will shrink and swell contributing to the instability of the soil.

Within the City, limited topographic relief, vegetative cover and wetland presence serve to limit soil erosion potential. Areas of the City susceptible to high erosion rates tend to be localized in areas with steep slopes and open areas with limited vegetative cover. City areas most vulnerable to erosion include steep slopes along the banks of waterways. Minor steep slope areas are located adjacent to Bluff, Bear, Newton and other smaller

creeks in the southeastern portion of the City. Major hazard areas include along the shores of the Nemadji and Pokegama rivers and along the inlets of the St. Louis River and St. Louis Bay in the western portion of the City, including edges of Billings Park and the Superior Municipal Forest.

Erosion poses a common and continuous threat along stream banks and shores throughout the City. Since the whole of the City is built on unconsolidated clay material, land throughout is vulnerable to sinkholes and minor erosion, though the flat topography limits the tendency for landslides and slumping in most areas. The Wisconsin Coastal Management Program has identified the erosion of coastal bluffs, banks, and beaches as a primary natural hazard affecting Wisconsin's Great Lakes shores.

Fortunately, the City is sheltered from the open, ocean-like lake mass by both Minnesota and Wisconsin points, which are natural, filled sandbars. They span over 8.5 miles and separate the Superior and St. Louis bays from Lake Superior. This natural "breakwater" reduces the impact waves and other coastal processes have on eroding away City shorelines. Superior and St. Louis bays are shallow and narrow enough not to allow significant wave formation, thus erosion rates in the City are not especially influenced by wave energy from Lake Superior.

On the other hand, land-based storm events involving heavy rain, rapid snowmelt and seiche events are major sources of energy that wear down riverbanks, expose soils and shrink shores in the City. Many rivers and streams, some with steep banks, also have the potential to erode, especially during heavy storms and snowmelt, when streams experience increased volume and flow velocity. The Nemadji River has particularly hazardous areas with steep banks where erosion and landslides have been problematic.

Erosion rates on bluffs in Lake Superior are variable due to the unpredictability in lake levels and storm surges. The Great Lakes have experienced a series of high lake levels in the past three decades, with the highest peak occurring in 1987 (U.S. Army Corps of Engineers Detroit District, 1997). High lake levels increase bluff recession rates by increasing wave attack on the base of the bluff. Rates of bluff and dune erosion along the shores of the Great Lakes vary from near zero to tens of feet per year because of annual variability in wave climate and lake levels (National Research Council, 1990). In the *Evaluation of Erosion Hazards* study conducted by the Heinz Institute for Science, Economics, and the Environment, April 2000, various sites on Lakes Michigan and Huron demonstrated erosion rates from less than 1 foot up to 2 feet per year. However, these areas consist of predominantly consolidated materials, which are less vulnerable to erosion than the unconsolidated clay soils around the City.

The Red Clay Project (EPA) study conducted in the 1970's found that much of the erosion in this area was due to naturally occurring bank slumpage. Removal of native vegetation during the logging era significantly changed the hydrology of the watershed. The result has been a phenomenon of stream down cutting, leaving the steep slopes exposed and vulnerable to slumping. Other natural processes intensify red clay erosion, including waves, storm surges, annual freezing and thawing of the ground and water

seepage. However, land use practices in the watersheds can contribute significantly to erosion. In addition to sediment input, nutrients can attach to sediment particles causing excess nutrient loading.

There are no erosion rates for areas of the City inside the barrier of Minnesota Point and Wisconsin Point. Data has been gathered on erosion rates at the far eastern edges of Superior beyond the Itasca neighborhood. These rates, however, cannot be applied to land not exposed to Lake Superior, as the hydrologic and soil conditions are too different.

Landslides are downhill movements of rock, debris, or soil mass. Landslides occur when the stress on a slope is greater than the strength of the slope material. Since the soil in the City is predominantly unconsolidated, slope strength is minimal. Landslides vary greatly in volume of rock and soil; length, width, and depth of the area affected; frequency of occurrence; and speed of movement. Some characteristics that determine the type of landslide include slope of the hillside, moisture content and the nature of the underlying materials.

Landslides are typically triggered by periods of heavy rainfall or rapid snowmelt; however, the incidences of landslides and their impacts on people can be intensified by human activities. Grading for road construction and development can increase slope steepness. Grading and construction, excavation, drainage and groundwater alterations and changes in vegetation can decrease the stability of a hill slope by adding weight to the top of the slope, removing support at the base of the slope and increasing water content.

Ice ridges that form and break up each winter along the shoreline also cause erosion by trapping sand in floating fragments of ice that are carried offshore into deep water. This continuing natural process is one of the principal mechanisms by which sand is lost from the near shore system (U.S. Geological Survey, 1992). Ice also disturbs vegetation in wetland and other coastal habitats by uprooting dormant perennials and displacing seeds. This contributes to further erosion since vegetation is the single most effective method for holding soils in place.

### ***Historical Events***

- Several instances of non-disastrous, erosion-related actions have been documented within the City. In 1992, the City laid 50 feet of riprap along the bank of the Nemadji River. In 1994, 500 feet of riprap was laid along the St. Louis River to prevent further erosion. Rip-rap, large rocks/boulders piled along shores, is methodically used for erosion control at parks and other recreational facilities including the Arrowhead fishing pier and the walking trail at Billings Park.
- In 2001, a home in the City of Superior was endangered as the entire yard started slipping downhill toward the Nemadji River. Although the house was not in the floodplain and was 100 yards from the river, streambank erosion from the spring floods had caused the ground within 15 feet of the house to slide downhill. The City applied for and received a Hazard Mitigation Grant under Disaster 1369 to purchase the threatened structure from the landowner and demolish it to protect public safety.

The transaction was completed in October 2002. In the Village of Oliver, southwest of the Superior Municipal Forest, three properties were mitigated with Hazard Mitigation Grant funds as they were threatened by flooding and slumping along the St. Louis River in 2002.

- In 2012, the City and surrounding communities faced over 8” of rainfall in a 24-hour period. The aftermath left the city with millions in damage. With the assistance of Wisconsin Emergency Management and FEMA, The City of Superior and UW-Superior completed the following projects; Billings Drive Repairs, CSTP #2 Dredging, K Street Sewer Repairs, Road Blvd debris cleanup, Wyoming Ave Culvert Repairs, UW-Superior-completed their ‘Steam Distribution System’.
- In 2012, the City also, in response to the erosion worked with Federal Highway and City General Funds to repair/improve; Marina Drive (complete washout), North 28<sup>th</sup> Culvert, Hill Ave and North 28<sup>th</sup> Street repairs, Woodlawn Ave repairs and 25<sup>th</sup> Ave East Culvert repairs.

### ***Probability & Predictability***

Based on local events, erosion has a moderate (2-5% annually) probability of causing damage to residential or commercial property in the City. In 1983, studies showed that the south shore of Lake Superior eroded at a rate of 2-6 feet per year. The University of Wisconsin-Superior has been working with Douglas County, the City of Superior and the Village of Oliver in a cooperative effort to map and further study slumping and other erosion activity along the St. Louis, Nemadji and Pokegama rivers and in St. Louis and Superior bays. Erosion rates and probability of ground failure could be predicted with careful evaluation of the area in question, when new data is available.

State of Wisconsin research indicates that the City of Superior lies in an area moderately susceptible to erosion, but frequently suffers from its effects. This susceptibility applies to greater than 15% of the City. Much of the City exists on flat, clay soils that are not imminently threatened by erosion or, especially, landslides. Hazard prone residential areas include along the St. Louis Bay (Billings Park), Nemadji River and Barker’s Island. Hazard prone commercial areas include the Duluth-Superior Harbor at the northern peak of Superior, Connor’s Point and the eastern edge of Superior along Superior Bay and Barker’s Island Inn and Marina in Superior Bay.

In 2015 the City completed two erosion control projects on Billings Drive, Kilner Bay and Keely Bay with funding from “Great Lakes Commission for Erosion Control. These projects assisted in stabilization efforts realized by the City for mitigation efforts of any future events.

## Vulnerability Assessment

### *Land*

Coastal erosion poses significant threats to properties along St. Louis and Superior bays, Lake Superior and the Pokegama and Nemadji rivers. Threats of erosion along smaller streams including Bluff, Faxon, Bear and Newton creeks, as well as other unnamed tributaries may be less significant, but are still potentially damaging. Unlike many other hazards, erosion poses direct threats to the land on which structures rest. Erosion reduces the total land area and in turn reduces the value of the land, affecting 1,223 improved and unimproved parcels of land totaling more than 11,344 acres of which lay adjacent to coastal water bodies and major rivers and streams.

### *Duluth-Superior Harbor*

Port facilities in the Duluth-Superior Harbor are vulnerable to erosion. Nearly all the dock and pier sites in the harbor are man-made of dredge fill taken from the bay and channel bottom during the creation of the harbor in the late 1800s. Wood, metal, concrete, or other types of sediment retention structures are vulnerable to degradation, thus sediments can spill out, undermining the facility.

### *Public Property*

Most of the parcels along the Pokegama and Nemadji rivers, all parcels on Wisconsin Point and most parcels along Allouez Bay and Lake Superior are owned by the United States Federal Government, State of Wisconsin, Douglas County, or the City. Most of these parcels are undeveloped.

The Parks and Recreation Division of Public Works manage most of the improved parcels in coastal and riverine areas owned by the City. These improvements include fishing piers, boat ramps, public parks and playgrounds, walking/skiing/biking/motorized vehicle trails and museums. The Parks and Recreation Division utilize extensive riprap, vegetation and other soil retaining methods to protect facilities.

The Wastewater Treatment Plant is the only critical facility located along the coastal edge of the City. This facility also utilizes extensive riprap along its entire edge to protect it from coastal erosion. The University of Wisconsin-Superior's Halbert Steam Heating Plant, a critical facility for the campus, is located adjacent to Faxon Creek.

Two cemeteries lie near two major rivers that run through the City. St. Francis Cemetery is on the north bank of the Nemadji River and Cavalry Cemetery is on a parcel spanning both sides of the Pokegama River. Both rivers have highly erodible, steep, clay banks that may threaten structures placed too near the river, including headstones. An ancient Indian Burial Ground located on Wisconsin Point, the Annishinabe Cemetery, is also threatened by erosion of the unstable sand material that makes up the Point.

Roads, culverts and bridges are particularly vulnerable to erosion that results in washouts, especially during heavy rain or snowmelt events. Roads on Wisconsin Point on the

Allouez Bay side and areas of Moccasin Mike Road in Itasca, are threatened by coastal erosion of sand. Roads in the Superior Municipal Forest, including Billings Drive, also suffer from erosion due to overland runoff and weak clay soil properties.

***Commercial Property***

The City includes 32 manufacturing parcels totaling 366 acres and 162 commercial parcels totaling 810 acres along the coastline or waterbody. Most are located at the northern point of the City at or near the Duluth-Superior Harbor and include Great Lakes shipping docks, grain elevators, railroad transport operations and materials holding facilities. Corrugated steel, concrete and/or wood piling retention structures and riprap retain the mostly man-made piers, docks and equipment that make up the Superior Port facilities. Most facilities were created from sand material dredged from the shipping channels when the harbor area was created in the late 1800s and early 1900s. Ship propellers tend to influence the wear and tear on these structures the most.

Lakeside Terrace, a 25-acre mobile home park contains approximately 150 homes located adjacent to Allouez Bay. Most of these homes are at least 200 feet from the shore of the bay.

Barker's Island Marina is a private, pleasure craft facility with secure, all weather, floating slips available for vessels. Construction of the Marina began in 1978 and was opened in 1980. A survey conducted by the City found that the harbor has suffered minimal erosion. Dredging has never been needed in this facility. Rock riprap buffers the shore from lake ice push. The harbor location shelters boats and the facility from wind, waves, changing lake levels and coastal storm surges, thus weather-related problems are rare.

***Residential Property***

There are 366 improved residential erosion prone parcels totaling 1036 acres located mostly in the Billings Park area of the City. A few homes are located along the Nemadji River with many others located on smaller streams; the latter face minimal threat of hazardous erosion. Few of these homes employ erosion prevention.

Using GIS based aerial photography, the estimated distance between primary residences and the edges of coastal bluffs or riverbanks was determined. The few improvements that exist along the Nemadji River sit at least 100 feet from the bank, except one structure, which appears approximately 15 feet from the outlet of the Nemadji River. This structure appears to be vacant.

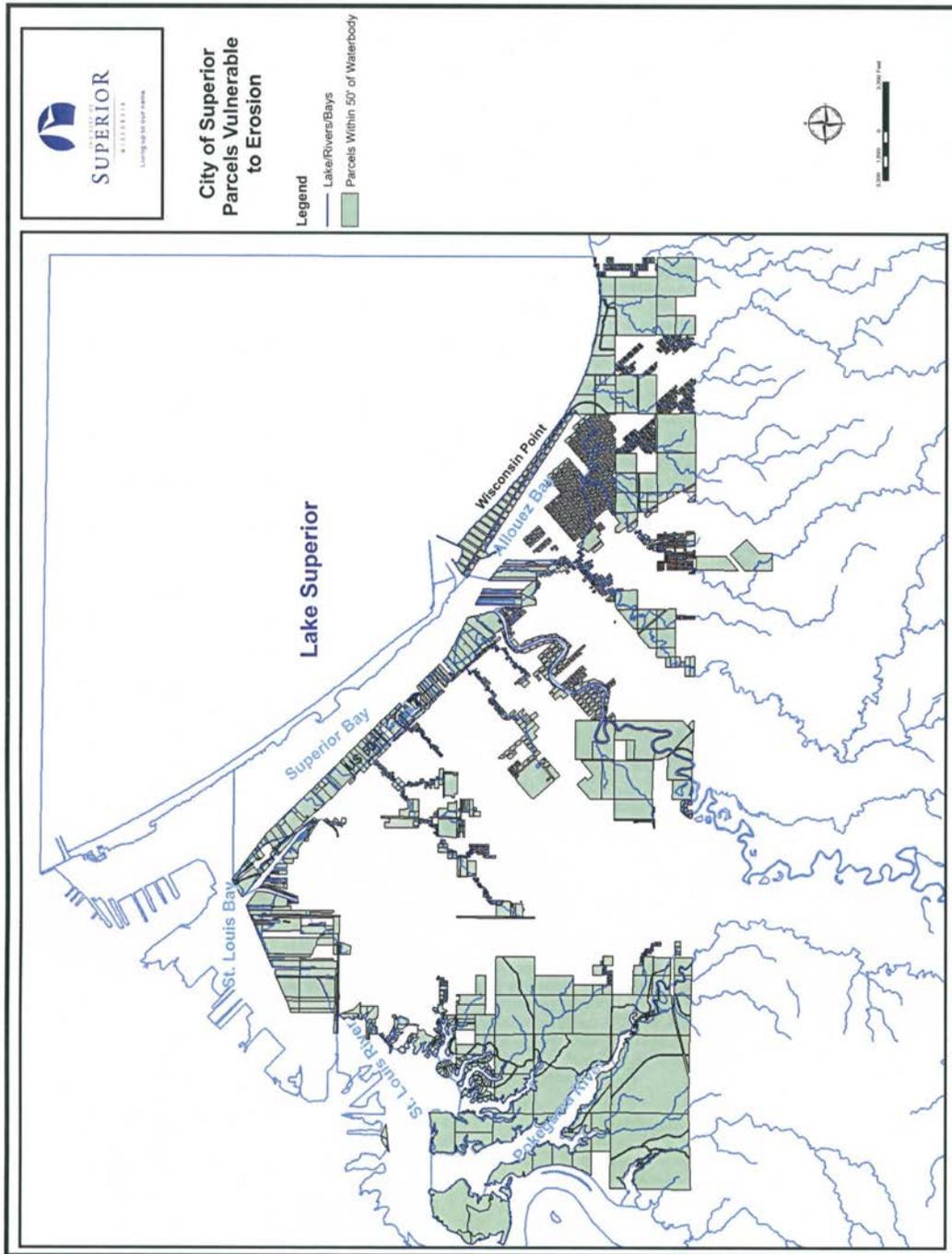
In Billings Park, homes in sheltered Kelly Bay are between 40 and 175 feet from the edge of the bluff. A few homes in sheltered Woodstock Bay are as close as 25 feet from the edge of the bluff, others as far back as 280 feet. Homes on St. Louis Bay points are between 50 and 180 feet from the edge of the bluff. Most homes are approximately 100 feet from the edge of the bluff in these bays.

**Future Development**

The control for new development is governed by Superior City Code Chapter 34, Article III. Site Erosion Control.

Map 7.1 shows parcels that may be vulnerable to erosion in the City of Superior.

Map 7.1: City of Superior Parcels Vulnerable to Erosion



## Loss & Replacement Estimates

Based on the low probability of any of significant or major erosion events occurring in the City and the extent of damage experienced during previous events, the damage from a significant future event may result in a structural loss of approximately 10% of the current improvement value as well as approximately 5% or more loss of land value. This potential damage could total nearly \$23 million to improvement value and \$2.9 million in damage to land value.

Landslides due to erosion in coastal or riverine areas, which have occurred on the Nemadji River, may pose larger potential losses. Homes may sustain a higher percent of damage and the property may have to be completely mitigated to prevent further loss. If the City were forced to mitigate 25% of residences on coastal or riverine parcels the potential loss would be approximately \$18+ million. Other loss potentials, including economic impact, are discussed below.

Table 7.1 Values of Improved Parcels Located Within 50’ of a Waterbody

Parcel Land Classification	Total Parcels	Acreage	Land Value	Improvement Value	Total Value
Residential	378	636	\$17,156,800	\$55,592,600	\$72,749,400
Commercial	196	705	\$42,966,800	\$179,061,500	\$222,028,300
Manufacturing	34	192	\$88,600	\$1,324,300	\$1,412,900
Federal	4	20	n/a	n/a	n/a
State	35	449	n/a	n/a	n/a
County	521	1975	n/a	n/a	n/a
City	338	5562	n/a	n/a	n/a
Other	141	523	n/a	n/a	n/a

Source: City of Superior’s GIS data of parcels located within 50 feet of a waterbody.

For tax-exempt properties, including City, county, state, and federal land, a general value of \$1,000 per acre was established by the City Assessor. This value applies to both improved and unimproved parcels. Improvement values for exempt property were not available and were not included in all areas.

Properties in areas exposed to Lake Superior along Wisconsin Point and the south shore of Lake Superior include undeveloped, vacant land owned by the United States Navy, United States Coast Guard, City of Superior, Douglas County and the State of Wisconsin.

Much of the land bordering St. Louis, Superior and Allouez bays is privately owned for residential or commercial use.

***Residential Property***

Erosion is one of the few hazards that affect not only the structures built on land, but also the land itself. The annual cost of erosion is the sum of the expected annual damage to structures plus the loss of land. Damage reimbursement by programs, including the NFIP, applies to structures only, not to land. In Superior, land value ranges from \$100 to over \$400,000 per parcel.

Coastal edges of the Billings Park area, located along the western edge of the City, north of St. Louis Bay, are residentially populated with about 80 middle- to upper-class homes valued between \$89,000 and \$600,000 (median home value \$196,000). Many homes are near the bluff overlooking the St. Louis River and have private docks and outbuildings. These homes are vulnerable to erosion from long-term effects of coastal water processes on these bluffs and heavy rain induced landslides. In general, these coastal homes are situated in protected bays, which offer some shelter from erosive activity occurring in St. Louis Bay. This protection does not prevent erosion, but may perhaps prolong the process.

The southeastern end of Barker’s Island has been parceled for private, residential development. Homes average approximately \$374,500 and are situated approximately 30 to 75 feet from the sandy shore.

Given an average erosion rate of 1 foot per year in the Great Lakes (*Evaluation of Erosion Hazards, April 2000, Heinz Center for Science, Economics and the Environment*), the average home, situated 100 feet from a bluff or bank, could have approximately 100 years before the edge of the bluff or bank reached the front door. In Billings Park, however, hazards lie in the specific erosive processes acting on the bluffs. Since the bluffs are made up of more than 100 feet of unconsolidated clay till, they are prone to undercutting, where erosion occurs mainly at the base of the bluff from water activity. Undercutting weakens the structural capacity of the bluff and can cause major landslides. Storm surges, high lake levels, and seiche events can whittle away at the base of the bluff faster than may seem apparent from the top of the bluff. Undercutting is not always apparent from the top of the bluff. The velocity and volume from high flow storms and snowmelts, especially in the spring, can easily erode the clay riverbanks.

***Commercial Property***

In the Duluth-Superior Harbor, the slow breakdown of erosion control structures has lead to problems for both ships and dock facilities. Some facilities used routine dredging to maintain 30’ depths at docks. Erosion control structures are made from wood or steel material and over time have degraded to the point that maintenance or replacement has become necessary at many facilities. Several facilities have recently invested millions of dollars in upgrading and repairing failing sediment retention structures.

***Public Property***

Damage to City roads, culverts, and bridges from erosion-induced washouts is very costly. Though labor wages and material costs can be quantified, lost travel time and

inaccessibility to roads has not. Inaccessible roads during summer months can cause considerable delays for travelers on primary trunks in and out of the City. Emergency vehicle accessibility becomes limited as alternative routes may also be affected by washouts. Communications Center coordination is necessary to prevent further hazard complications in the event of road closures.