



**ASSESSING COASTAL  
DEVELOPMENT ALONG  
MANITOWOC COUNTY'S  
LAKE MICHIGAN  
SHORELINE:  
1978 - 1992**

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**THE WISCONSIN COASTAL MANAGEMENT PROGRAM**, part of Wisconsin Department of Administration, and overseen by the **WISCONSIN COASTAL MANAGEMENT COUNCIL**, was established in 1978 to preserve, protect and manage the resources of the Lake Michigan and Lake Superior coastline for this and future generations.

The Project Team

This project required coordination and completion of several steps including map documentation, photo preparation, photo interpretation, digital area/linear measurement and data sheet preparation. The following students worked as a team to help complete this project.

- Brentt Michalek
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## TABLE OF CONTENTS

INTRODUCTION . . . . .	1
PROJECT GOALS . . . . .	1
STUDY AREA . . . . .	1
PROJECT METHODS . . . . .	3
Aerial Photography . . . . .	3
Project Aerial Photos . . . . .	4
Photo Preparation . . . . .	4
Aerial Photo Interpretation (API) . . . . .	5
CLASSIFICATION SCHEME . . . . .	5
Residential Land . . . . .	5
Commercial and Industrial Land . . . . .	6
Industrial Land . . . . .	7
Transportation Land . . . . .	7
Extractive Land Use . . . . .	8
Agricultural and Natural Land . . . . .	8
Open and Other Land . . . . .	10
Shoreline Modification . . . . .	10
Structures - Industrial, Commercial and Residential . . . . .	11
THE PHOTOINTERPRETIVE PROCESS . . . . .	11
MEASUREMENT OF AREA, LINE AND POINT TYPES LOCATED WITHIN THE COASTAL ZONE . . . . .	12
TALLY OF DATA . . . . .	12
LIMITATIONS AND SOURCES OF ERROR . . . . .	13
Photo Scale and Enlargements . . . . .	13
"Leaves-On" Versus "Leaves-Off" Aerial Photography . . . . .	14
Stereo Versus Photographic Coverage . . . . .	14
Incomplete Photo Coverage . . . . .	14
Missing Photo Coverage . . . . .	15
Location of 1000' Coastal Zone Boundary . . . . .	15
Lack of Beach Type in Classification Scheme . . . . .	15
Positional Changes to the Shoreline: Natural vs. Urban Development . . . . .	15
RESULTS . . . . .	16
Manitowoc County Statistics . . . . .	16
Residential Land . . . . .	18
Commercial and Industrial Land . . . . .	18
Transportation Land . . . . .	18
Extractive . . . . .	18
Agricultural and Natural Land . . . . .	19
Open and Other Land . . . . .	19
Shoreline Modifications . . . . .	19
Results by Community . . . . .	19
Town of Centerville . . . . .	19
Village of Cleveland . . . . .	20
City of Manitowoc . . . . .	21

Town of Manitowoc . . . . .	22
Town of Newton . . . . .	22
Town of Two Creeks . . . . .	23
City of Two Rivers . . . . .	24
Town of Two Rivers . . . . .	25
 REFERENCES . . . . .	 26
 APPENDIX . . . . .	 30
 LIST OF TABLES	
Table 1. County Results of Linear Accuracy Tests . . .	17
 LIST OF FIGURES	
Figure 1. Coastal Counties of Lake Michigan and Lake Superior . . . . .	2

Assessing Coastal Development Along Wisconsin's  
Great Lakes Shoreline: 1978 - 1992

Coastal Management Program Contract No. 840005-501.15

INTRODUCTION

The Wisconsin Coastal Management Program mission includes developing an understanding of change along the state's Great Lakes shoreline. Such change, of course, can be natural or human-based. This study was undertaken to document natural and human-based development within the coastal zone of the state's Lake Michigan and Lake Superior shorelines. The Wisconsin legislature has defined coastal zone as land within 1,000' (304.8 meters) of the shoreline (Ordinary High Water Mark - OHWM).

Future coastal zone planning and risk assessment requirements defined the types of data to be collected. Assessment of risk to structures built in the coastal zone requires a temporal analysis of structural development and shoreline modification(s). Planning of the coastal zone requires, as well, determination of the natural resource base. This study utilized U.S. Army Corps of Engineers historic color aerial photographs taken in 1978 and 1992.

This report documents both the original and amended contract to assess natural and developmental change within the coastal zone of Wisconsin's Great Lakes shorelines. Although the original contracted work was interrupted to include elements of the amended contract, no attempt will be made in this report to keep separate original vs. amended objectives, procedures or results. Goals of the amended contract include and expand those of the original.

PROJECT GOALS

Planning and assessment of hazards within the coastal zone defined the goals of this study. Within the Lake Michigan and Superior coastal zones, project goals included:

- Development of land use databases for 1978 and 1992
- Development of 1978 and 1992 databases of human modification of the shorelines
- Develop a database of built structures for 1992

Additional goals included:

- Assess land use change within the coastal zone from 1978 to 1992
- Assess human modification of the shoreline from 1978 to 1992

STUDY AREA

The project study area comprises the Wisconsin portion of the Lake Michigan and Lake Superior coastal zone (Figure 1). In 1982, the Wisconsin state legislature defined coastal zone as being that land within 1,000 feet (304.8 meters) of lake shoreline. Accordingly, the study area represents a 1,000' wide



Figure 1. Coastal Counties of Lake Michigan and Lake Superior

zone, the landward boundary of which is parallel to the coastline.

## PROJECT METHODS

### Aerial Photography

Using aerial photos to assess coastal development requires clear statement of goals, appropriate definition of coastal zone, meaningful classification scheme, appropriate historical and current aerial photos, appropriate interpretation procedure and method of documentation, and trained personnel.

Application of aerial photography to assess urban and natural resource features is documented well (Smith, 1968; Avery and Berlin, 1985; Lo and Noble, 1990; Ciciarelli, 1991; Boge et al., 1992; Hinckley and Walker, 1993). Specific applications to urban/human activities cover a wide range including urban nonpoint pollution assessment (Kim and Ventura, 1993), gully erosion analysis (Welch et al., 1985), historical analysis of urban development into coastal wetlands (Niedzwiedz and Batie, 1984), identifying structural additions to urban residential property (Niedzwiedz, 1990), and studying agricultural land use (Marsh et al., 1990).

Aerial photos have been used to map archeological sites, urban features, and to document changes to the landscape (Smith, 1968). MacConnell (1975) reports the use of black and white aerial photography (scale 1:20000) to map 20 years of land use change within the state of Massachusetts, including the coastal zone. As part of a larger Great Lakes study, the International Joint Commission (1993) used 1:24000 scale photos to map land use features along the Berrien County, Michigan segment of the Lake Michigan shoreline. Results of the photo analysis were used to assess residential riparian erosion/recession rates caused by fluctuating water levels.

Wisconsin's coastal zone includes diverse land use, from forests and wetlands, to land devoted to agricultural or urban uses. The uses of aerial photos long have been applied to study such land uses. Befort and Viliman (1985) studied aerial photos to classify forest habitat. McCarthy et al. (1982) evaluated spruce-fir forests to aid management. Wetlands analysis is possible with aerial photos of appropriate format, scale and seasonal timing. Scarpace et al. (1981) used digitized aerial photos to map wetlands, while Ferguson et al. (1993) and Barrett and Niering (1993) have monitored sawgrass habitat and marsh vegetation change using aerial photos.

Extensive use of aerial photography has been directed at coastal resources. Scherz and Van Domelsen (1973) used aerial photos to help assess water quality in Lake Superior near Duluth, Minnesota. Numerous studies have been made with aerial photos to aid management of coastal resources (Benton et al., 1978; Hill et al., 1985; Norton et al., 1985; Welch et al., 1992), to address change in coastal wetlands (Lyon and Greene, 1992), and to

examine urban development into coastal wetlands (Niedzwiedz and Batie, 1984).

### Project Aerial Photos

In 1978, the U.S. Army Corps of Engineers (USACE) obtained panchromatic color aerial photos of the Wisconsin portion of the Lake Michigan coastline. In 1992, USACE obtained color aerial photo coverage of the Wisconsin portion of both Lake Superior and Lake Michigan coastlines. Both the 1978 and 1992 photos were flown at a scale of 1:6000 (1" = 500') and enlargements made at 1:2400 (1" = 200'). The 1978 photos were taken April 16<sup>th</sup>. The 1992 photos were flown May 13<sup>th</sup>.

Unlike most historical aerial photos covering the same area and flown at the same scale, the USACE photos of 1978 and 1992 were not flown with coincident photo centers or coverage. No individual flight lines were documented for the 1978 photos. Beginning at the Michigan border, the 1978 photos were taken incrementally to the Illinois border. Photos are documented with the photo date and photo number on the northern edge of each photo.

Flight lines were documented for the 1992 photos. Flight line #1 begins just south of the Wisconsin-Illinois border. The northern edge of each 1992 photo displays the photo date, flight line and photo number.

Both the 1978 and 1992 photo contact prints (1:6000) were flown to produce stereo coverage of the coastline. Adjacent photos overlap (endlap) about 60% with each other. The enlarged photos (1:2400) available for this study represent every other photo contact print, therefore, only photographic, not stereo coverage, is provided by the enlarged photos. Approximately 1,800 photos (1:2400) cover Wisconsin's Lake Michigan shoreline, 900 for each flight year. About 1,200 photos covering the shoreline from Marinette to Sheboygan are on file at the Green Bay office of USACE. The Waukesha office of USACE has on file about 600 photos covering the shoreline from Sheboygan to the Illinois border.

### Photo Preparation

Photos used in this study are owned by USACE. As a result, all photo documentation and interpretive work was applied to acetate affixed to each photo. Preparing photos for interpretation included the following:

1. Affix label and document photo number/flight line, photo date and Public Land Survey System (PLSS) information.
2. Mark photo fiducials (orange ink). Fiducials allow the registration of acetate overlays to the photos, if required.
3. Mark control points (orange ink). Typically these points are road intersections and, or buildings, stable objects



- that could be referenced against controlled maps for future mapping applications.
4. Locate and mark interpretation boundary lines (black ink). These lines are used to denote a common boundary between adjacent photos. Land use interpretive lines end at these boundary lines, which eliminates redundant interpretive work.
  5. Locate, mark and label PLSS section lines (red ink).
  6. Locate, mark and label civil boundary lines (green ink).
  7. Locate and mark 1,000' coastal zone boundary line (blue ink). A divider was used to scribe a line 1000' away and parallel to the line defined by land meeting water. In cases where large streams entered Lake Michigan, a straight dashed line was drawn to represent a continuation of the shoreline.
  8. Locate and mark top of bluff, and bottom of bluff if slumpage is evident (black ink). In practice, these lines were not drawn until the shoreline portion of the classification scheme was applied to the photos. Refer to the section Photointerpretive Process (page 11) for additional discussion.

#### Aerial Photo Interpretation (API)

The landscape within the coastal zone can represent a complex mix of natural to urban uses. The land use classification scheme developed for this study addresses the complexity of Wisconsin's coastal zone. The scheme is a modification of the scheme developed by International Joint Commission (1993) and includes the general use categories of residential, commercial, industrial, transportation, extractive, agricultural, natural, open land and other uses. Land uses have been measured by area (acres, hectares). Structures per land use have been located and marked for spatial reference. Structures are tallied by type for 1992.

Modification of the shoreline also has resulted. Sea walls, revetments, groins and permanent docks have been constructed. Sea walls and revetments are linear types. Their interpretation and measurement are presented in feet (meters). Groins and docks were counted.

#### CLASSIFICATION SCHEME

##### Residential Land

All residential areas include infrastructure to service the area. Boundary placement is made to separate residential areas by type. No attempt is made to distinguish roads/streets from the residential areas they serve. This convention is true for other classification types as well.

- 111 Multi-Family: Medium to High Rise. Large residential structure of five (5) or more stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.
- 112 Multi-Family: Low Rise. Large residential structures up to four (4) stories. Access roads, parking areas, open space and recreational facilities associated with the structure(s) would be included in the type.
- 113 Single Family, Duplex. Structures large and small used for residential use. The type includes lawn, landscaped areas, garage and driveways. Duplex structures are identified by twin driveways or a very wide driveway leading to an architecturally balanced structure.
- 115 Mobile Home Park. Residential area developed exclusively for mobile units.

#### Commercial and Industrial Land

Commercial land includes three (3) types: central business district; shopping center/mall; and, neighborhood business district. Each type includes all building structures, access roads/streets, parking facilities and other features commonly associated with each type.

- 121 Central Business District (CBD). Commercial land predominantly used for distribution or merchandizing of goods and services. Stores, hotels, office buildings, parking facilities and smaller warehouses constitute the components of this type. The CBD spatially is tight, vegetation is rare.
- 122 Shopping Center/Mall. These commercial areas have developed away from the CBD. The type includes both "strip" type development and malls. Structures can range from large, flat roofed and rectangular (centers) to large, geometrically shaped. Both types include large parking areas adjacent to or completely surrounding the commercial structures.
- 124 Neighborhood Business District (NBD). This type denotes small commercial areas within, or adjacent to residential areas. The type may be found in established or newer subdivision areas. NBD structures can range from conventional architecture to unusual geometric shapes. Small parking areas are associated with NBD commercial areas.

- 126 Institutional Land. The type reflects areas devoted to public or quasi-public uses. Examples include schools, churches, hospitals, prisons, etc., and their associated "grounds," green space, landscaping and parking facilities. When located within the CBD, public buildings without "grounds" often cannot be identified on aerial photos and would be classified as commercial (121).

#### Industrial Land

- 138 Industrial Park. The type includes both heavy and light industrial use areas.

Heavy industrial land contains facilities for the manufacture, storage and assembly of raw or partially processed products such as machinery, metals, chemicals, petroleum, or electrical power. Such industries often have large smokestacks and large storage areas. Warehouses and transportation facilities for bulk products and an open and interrupted street pattern characterize this type.

Light industrial land contains facilities for the manufacture or assembly of smaller, partially processed products such as electronics, appliances, and other secondary process products. Large smokestacks or raw material storage facilities are never present. Many modern light industries are well landscaped and are indistinguishable from commercial activity on aerial photographs.

#### Transportation Land

- 141 Air Transportation. Includes areas with airports and associated facilities, landing strips, hangers, parking areas and adjacent open areas.
- 142 Rail Transportation. This type includes railyards, terminal freight and storage facilities as well as stations for passengers. The type may include liquid storage facilities such as tank farms.
- 143 Water Transportation. This designation is applied to several water-based areas, including docks, warehouses and related land-based facilities for water transportation and commercial fishing. The type includes, as well, public marinas and their associated facilities: boat slips, buildings and parking areas.
- 143.1 Private Marina. Boat mooring areas adjacent to residential land are designated as private marinas. Often such areas include a protected slip(s), dredged waterway and, or a permanent docking structure built into the waterway.

- 143.2 Public Boat Landing. This type is applied to boat launching areas. Typically, facilities include only a ramp(s) from which boats may be launched and parking areas.
- 144 Divided Highway. This type includes transportation corridors with median strips between lanes. Typically, such roads are four or more lanes wide. Local streets are not included in this type.
- 145 Communications. Facilities and structures devoted to communications. These include radio/television towers, lighthouses and their grounds, buildings and parking areas.
- 146 Utilities. This type includes facilities for the production and distribution of energy. Such areas can include large buildings, towers, roads/parking facilities and, in the case of coal fired plants, large piles of raw coal.
- 147 Sewage Treatment Plant. Buildings, treatment lagoons, parking areas, access roads and grounds are included in this type.
- 148 Landfill. Landfill sites used to bury garbage define this type. Landfills cover an extensive area and are dominated by large excavated areas, mounds of exposed soil and access roads.

#### Extractive Land Use

- 171 Open Pit. The type represents open pit mining areas for extraction of sand, gravel, stone or rock. The type includes access roads and any structures.
- 172 Underground Mine. Mining of underground resources via shaft extraction. Surface features captured on aerial photos would be limited to small structures and access roads.
- 173 Well. Features associated with wells are limited. Identification of wells using only aerial photos is difficult.
- 179 Other Extractive Uses.

#### Agricultural and Natural Land

- 181 Abandoned Field (AF). These are agricultural units reverting to wild land. Woody vegetation and grass are abundant but tree crown cover is less than 30%. If tree crown cover were greater than 30%, the land would be classified as forest.

- 182 Agriculture Active (AG). Tilled or tillable crop land which is or recently has been intensively farmed. The boundaries on the ground usually are sharply defined and well maintained. The land supporting farm buildings is included as part of this type.
- 183 Forest (F). Areas of forest, deciduous, coniferous or mixed, having canopy closure of at least 30%. Areas with less than 30% canopy closure are classified as abandoned field.
- 184 Heath (H). Areas of heath plant community as well as grass, shrubs, and other low vegetation found on poor sandy soils.
- 185 Open Water (W). Areas of open water found in lakes, rivers and large streams. Water depth is greater than three feet during the growing season. The boundary of coastal water is located by drawing a line at the river mouth to connect the edges of the coastline, or man-made features like roads, railroads or bridges crossing rivers or inlets are used to establish such a line.
- 186 Rock Ledge (RL). Rock outcrop areas at the coastline or within the coastal zone. Such outcrops are common in Door County.
- 187 Slump Zone (SL). Land located between upland bluff and beach. Slump zones begin at the bluff line and slope down to the beach.
- 188 Wetland (WT). This type covers the full spectrum of wetlands. These include seasonally flooded flats, shrub swamps, meadows, bogs, shallow and deep marshes, and forested wetlands. Each is described below.
- Seasonally flooded basins or flats occur principally on stream floodplains. The most common plants are grasses and herbaceous species. The soil is waterlogged or covered with water during spring freshets, but well-drained during the growing season.
- Shrub swamps often have waterlogged soil during the growing season, as much as six (6) inches of water may be present. Vegetation types include elder, buttonbush, dogwood and willow. Sedges usually are present in tussocks.
- Meadows are vegetated with grasses, rushes and sedges. Soils are waterlogged through most of the growing season. Surface water is present only for a short period during the spring.
- Bogs are unique wetland types that support a distinctive plant community, including most of the following: heath shrubs, cranberries, pitcher plants and sedges. Scattered black spruce, tamarack and red maple may be present. A mat of sphagnum moss is the most common feature of bogs.

Shallow marsh is wetter than meadow. The soil is completely waterlogged and often covered with up to six inches of water during the growing season. The predominant vegetation is emergent, including such plants as cattails, bulrushes, burreed, pickerelweed and arrowhead with some grasses and sedges present. The type is common to open water bodies.

Deep marsh has water depth ranging from six inches to three feet. Fairly large open water areas are bordered by, or interspersed with, emergent vegetation like that found in shallow marsh. Floating and submergent plants such as water lilies, duckweed, watershield and pondweeds also are present.

Forested Wetlands. This type represents areas of moist to saturated soil covered by forest canopy. The type is difficult to identify without stereo photography and, or with "leaves-on" photography.

#### Open and Other Land

191 Outdoor-Public Assembly

192 Urban Open Lots. Urban open is undeveloped land lying idle in the midst of urban areas or adjacent to them. This type includes land which has been cleared for urban development of an unknown use.

193 Outdoor Recreation. Outdoor recreation types are either mainly for participation, mainly for spectators, or are environmental in character. Each recreational type includes the recreational complex: access roads, parking facilities, buildings and other related facilities.

194 Cemeteries

#### Shoreline Modification

Development along the lakeshore often means modification at, or near, the shoreline. Land along the lakeshore is exposed to significant erosional forces. Recession of land mass is common. Agricultural and urban land uses destabilize shoreland, in effect accelerating erosion and land recession. To protect real estate and property, many property owners have constructed walls or revetments along their shoreline. Some owners also have built non-flow-through docks at the shoreline to provide mooring and protection for their boats. Groins, large rock structures perpendicular to the shoreline, have been built along Wisconsin's Lake Michigan shoreline.

195 Sea Walls (V 195 V). These structures are built parallel to the shoreline and typically are well defined, linear

features. Construction materials can include concrete, wood or interlocking sheet steel.

- 196 Revetments (V 196 V). Large rock or slab structures built parallel to the shoreline. Interpretively, revetments are less well defined, and appear wider than do sea walls.
- 197 Groins ( \* [red] ). Groins are large rock structures built perpendicular to the shoreline into the water. Except for their distinct orientation and placement, groins appear similar to revetments.
- 198 Non-Flow-Through Dock ( \* [blue] ). Such docks are permanent structures built into near-shore waters. Typically these docks are straight, their upper surface wide and well defined.

#### Structures - Industrial, Commercial and Residential

On the 1992 photos, buildings within the coastal zone are classified by type and location. Using a template of rectangles, for each building, a rectangle is selected that best represents the area of the building's "footprint." The selected rectangle then is positioned so that the leading edge of the building (relative to the shoreline) is located. Buildings for 1978 were counted by type. However, due to photo format differences, comparison of 1978 and 1992 structural counts may be inaccurate.

#### THE PHOTOINTERPRETIVE PROCESS

After photo preparation, each photo was interpreted using the classification scheme defined above. Area (land uses), linear (shoreline modification) and point (urban structures, groins, docks) types are represented in this study. Lines and, or symbols were used to define all types. Area types are represented by perimeter boundary lines and symbols to define and identify the areas. Line types representing modification to natural shoreline were defined using both lines and symbols. All area and line type symbols are recorded in black ink. Point types are defined by symbols and colored ink (see above).

Modifications to the shoreline, such as sea walls or revetments, are delineated by placing (painting) the 'V' symbol at the beginning and end of the modification. The type of modification is represented by placing the appropriate number between the 'V' symbols. For example, 195 positioned between two 'V' symbols means that a sea wall has been built along this section of shoreline. Shoreline classification was conducted before land use so that land use boundary lines placed along the shoreline would not 'hide' shoreline information.

Groins and non-flow-through docks were defined by point symbols (see above). In both cases, the symbol was placed at the point where the structure meets land. As discussed above, for

1992, buildings also were classified using point symbols. The delineation of buildings represents the last API procedure.

#### MEASUREMENT OF AREA, LINE AND POINT TYPES LOCATED WITHIN THE COASTAL ZONE

Area types (land use polygons) and line types (shoreline modification) measurements were made using the hardware/software facilities of the GIS Lab at the University of Wisconsin-Green Bay. Photo acetate overlays were affixed to large-format digitizers and each land use polygon digitized along the perimeter. Measurements recorded in square inches were converted to acres/hectares. Line measurements (in inches) of shoreline modifications were made using digitizers as well. Linear inch measurements were converted to linear feet/meters for each type of modification.

Point types (groins, structures) simply were tallied by count for each type. The area covered by each acetate was broken into civil jurisdiction and PLSS section designations. Measurements (above) were separated by civil and PLSS designations as well, and documented permanently on each acetate overlay.

#### TALLY OF DATA

Measurements recorded on each photo acetate were transferred to data sheets. Three (3) levels of data sheets were used: PLSS Section Data; Civil Jurisdiction Summary Data; and County Summary Data (Appendix).

PLSS Section Data Sheet: One (1) PLSS Section Data sheet was used for each section located on a photo/acetate. Generally, 1-2 PLSS sections are located on a photo, however, up to four (4) sections per photo were recorded. Section level data sheets record photo documentation including photo year, photo number, county and community(ies) covered, and complete PLSS section location. Also recorded were number of residential, commercial, industrial and institutional structures (1992), area of land use by type, linear distance of sea walls and revetments, and the number of groins and non-flow-through docks.

Civil Jurisdiction Summary Data Sheet: This tally sheet summarizes the data for all PLSS section sheets found within each township, village or city. The sheet records photo year, county, name of civil jurisdiction, a complete listing of PLSS sections included in the summary, as well as all land use, shoreline and structure count data discussed above.

County Summary Data Sheet: The County Summary sheet summarizes all data for the towns, villages and cities located within the county. Documented information includes photo year, county name, an alphabetical listing of all civil jurisdictions within the county, and a summary of all land use, shoreline and



structure count data reported on Civil Jurisdiction Summary Data sheets.

#### LIMITATIONS AND SOURCES OF ERROR

The U.S. Army Corps of Engineers contracted for aerial photography of the Wisconsin portion of the Lake Michigan shoreline on April 21, 1978 and May 19, 1992. Both sets of photos are 1:6000 scale and panchromatic color, however, the 1978 photos are "leaves-off" while the 1992 photos are "leaves-on."

Copies of the original stereo photos (1:6000 scale) were not available for this study. Instead, enlargements (1:2400 scale) of the original photos were borrowed from Corps district offices in Green Bay and Waukesha. The enlargements provided photographic coverage only, not stereo coverage. Normally, for a project of this magnitude, photos would have been taken to meet the specific objectives of the study. The enlarged photos used for this project present limitations and introduce error beyond what would be reported with original photos flown specifically for this study. Limitations and errors associated with the photographs used are discussed below. Also presented below is discussion regarding methodological inconsistencies.

The following discussion of Limitations and Sources of Error is presented in an attempt to provide the reader a basic understanding of the issues. Any section of the discussion could apply to any of the results reported below. The Results sections of this report present findings without any comprehensive attempt to explain anomalies within, or between, the photo study years (1978 and 1992).

#### Photo Scale and Enlargements

All vertical aerial photographs not ratioed (enlarged or reduced to a common average scale) or rectified (common tilt/tip corrected to a horizontal reference plane) inherently are scale inaccurate. The original USACE photos (1978 and 1992) were not ratioed or rectified, therefore, their scale varies relative to topographic changes of the coastal zone, tip/tilt of the camera and changing elevation of the camera (aircraft). Enlargements of the original photos simply accentuate the inaccuracies found on the original photos.

Area and linear measurements taken off of the USACE enlarged photos reflect the inaccuracies inherent in those photos. Simple tests of shoreline distances for numerous PLSS sections within each county were conducted to establish linear accuracies of the photos. USGS topo sheets at 1:24000 scale were used to establish base shoreline distance measurements against which photo (1978 and 1992) shoreline distance measurements could be compared. No systematic errors were detected for the 1978 photos. However, only one (1) of 21 tests of the 1992 photos varied in the positive direction from USGS measurements. The remaining 20 tests varied in the negative direction and ranged from -0.8% to

-13.1%. The range of error, for 1978 was -5.3% to +9.6%, while the range of error for 1992 was -13.1% to +1.9% (see Table 1 page 17). Without a test of error for each photo used, there is no means to judge the direction or the amount of error relative to statistics associated with each photo. However, given the range of error found for the 1978 and 1992 photos, it is possible that 1,000 acres (405 ha) (actual) of coastal zone area could be reported as 1,096 acres (444 ha) in 1978 and 869 acres (352 ha) in 1992, a 227 acre (92 ha) difference.

#### "Leaves-On" Versus "Leaves-Off" Aerial Photography

There are distinct advantages and disadvantages of both "leaves-on" and "leaves-off" aerial photography. However, given the goals of this project, the 1978 "leaves-off" photography offers important advantages over the 1992 "leaves-on" photography. Vegetation in leaf can hide the details of built structures, including buildings and shoreline modifications. Roads can be hidden under tree crowns, as well as portions of lots landscaped and managed as residential land. Leaved canopies increase the effect of shadows. Shadows mask ground, understory and structural information leading to inaccurate interpretation. Land uses and/or structures hidden under the canopy of vegetation or masked by shadows can be underestimated in area, length or count. Land use types particularly affected (underestimated) are single family residential and wetland.

#### Stereo Versus Photographic Coverage

Both the 1978 and 1992 photo sets were taken to capture stereo (3-D) coverage of the Lake Michigan coastal area. This means that adjacent photos overlap approximately 60%. Stated another way, 60% of the shoreland area located on one photo also is located on an adjacent photo. The shoreland common to adjacent photos is "seen" from two different perspectives which allows stereo viewing (using a stereoscope).

The enlarged photos borrowed from USACE for this study represent photographic coverage only, or every other photo taken of shoreland. While photo (2-D) coverage at large scales can be used to interpret accurately many land use types (agricultural and most urban land), the lack of stereo viewing makes difficult the identification of wetland types and the exact location of bluff lines. Stereo viewing generally would have increased the interpretive accuracy of most land use, structural and shoreline features.

#### Incomplete Photo Coverage

For this study, the coastal zone is defined as a 1000' strip of land adjacent and parallel to the shoreline. Occasionally, photo coverage did not include all shoreland within 1000' of the water. As a result, total land area is underrepresented, the

exact land use types not covered are not known. In such cases, the area not captured on a particular photo was estimated by reference and comparison to coverage photos of the other flight year.

#### Missing Photo Coverage

Occasionally, photo coverage was missing from the USACE photo library. In such cases, as described above, coverage area missing was estimated by reference to photos of the other flight year. However, the exact land use types and shoreline features not represented on photos remain unknown.

#### Location of 1000' Coastal Zone Boundary

On each photo set, 1978 and 1992, a boundary line was drawn representing the 1000' coastal zone parallel to the shoreline. This line was located by scribing a landward line parallel to the line defined by the shoreline (where water meets land). The landward extent of the boundary line is a function of shoreline location, which in turn, is dependent on the water elevation of Lake Michigan. USACE (1978, 1992) reports that in April of 1978 Lake Michigan water elevation was about 578.4 feet (176.3 meters) and about 579.16 feet (176.5 meters) in May, 1992. The nine (9) inch difference in water elevation, while seemingly insignificant, could have shifted substantially landward the shoreline in extremely low slope beach or mud flat areas. The result of such a shift would be inclusion of inland areas NOT included in the 1978 coastal zone.

#### Lack of Beach Type in Classification Scheme

The width or extent of beach is dependent on slope of an area and water elevation. Since changes in the area of beach likely would reflect more the differences in 1978 and 1992 water levels (9 inches higher in 1992) than actual losses/gains due to erosion or development, no beach type was included in the study.

The lack of a beach type does affect measurement of area within the 1000' coastal zone. The landward extent of the coastal zone is 1000' from the shoreline. Any beach area lies between the shoreline and the base of the bluff, however area measurements of land use types were made only for those types lying between the base of the bluff and the interior boundary of the coastal zone. In most cases, beach strips represent only about five (5) acres per photo.

#### Positional Changes to the Shoreline: Natural vs. Urban Development

As discussed above, the landward extent of the 1000' coastal boundary is dependent on the location of the shoreline. Natural changes to shoreline position include both water elevation and

erosion/deposition of soil. Filling of coastal waters to accommodate urban development artificially changes shoreline location. In such cases, not only does the shoreline move "offshore," the interior coastal zone boundary line shifts toward the water. This "shift" in coastal boundaries skews area measurement. For example, in 1978 assume the coastal zone in an area to be all residential and that by 1992 100 acres of lake water is filled to develop commercial land. A "lakeward" shift in the location of the shoreline will occur due to the land filled for commercial use. However, this "shift" in the shoreline created by the filled commercial site also will result in a shift toward the water of the interior coastal zone boundary. The effect of the latter shift will be that 100 acres of residential land will not be included as part of the 1992 coastal zone. In such a case, the "raw" statistics misleadingly suggest that 100 acres of residential land use were eliminated to make room for 100 acres of commercial use.

## RESULTS

### Manitowoc County Statistics

Manitowoc County communities lying within the Lake Michigan coastal zone include the townships of Centerville, Manitowoc, Newton, Two Creeks and Two Rivers, the village of Cleveland, and the cities of Manitowoc and Two Rivers. The area measured within the coastal zone of Manitowoc County was 3,794 acres (1,536 ha) in 1978 and 3,643 acres (1,476 ha) in 1992. This represents a difference of 151 acres (64 ha) or 4%. The discrepancy likely is the result of errors inherent in the enlarged aerial photos, as discussed on pages 12 through 15. Using USGS maps as control, tests were conducted on the linear accuracy of the Manitowoc County photos. Results of tests applied to the 1978 photos indicate some departure (-1.7% and +2) from USGS measurements. Results of tests applied to the 1992 photos indicate errors of -6.4% to -7.4%. The range of error could yield a 357 acre (145 ha) difference between the 1978 and 1992 totals (Table 1).

Statistical summaries for Manitowoc County and all communities included in this study are located in the Appendix.<sup>1</sup> Summary data sheets present land use types by area, structural counts by type (1992), shoreline modification types by length, and a count of shoreline structures by type. Data were collected at the PLSS section level. While the section level data sheets are not included in this report, copies are available upon written request.

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<sup>1</sup>Area figures used in the Results discussion reflect totals (not rounded) reported on the original tally sheets. Figures presented on the tally sheets found in the Appendix of this report have been rounded to the nearest whole number.

Table 1. County Results of Linear Accuracy Tests

Percent Deviation From USGS Base Map Measurements

<u>County</u>	<u>1978 Enlarged Photos (1:2400)</u>	<u>1992 Enlarged Photos (1:2400)</u>
Brown	-0.4%	-8.5%
	0.03%	-5.5%
Door	1.3%	-1.1%
	3.9%	-3.6%
Kenosha	-2.5%	-9.0%
	3.1%	-1.6%
Kewaunee	-1.5%	-5.4%
	2.1%	-9.6%
Manitowoc	-1.7%	-6.4%
	2.0%	-7.4%
Marinette (one test)	9.6%	-1.7%
Milwaukee	-4.9%	-6.9%
	-5.3%	1.9%
Oconto	2.9%	-10.8%
	8.5%	-13.1%
Ozaukee	0.2%	-5.7%
	1.3%	-4.4%
Racine	-3.0%	-5.0%
	2.2%	-0.8%
Sheboygan	-2.5%	-1.2%
	4.6%	-3.0%
Mean	0.95%	-5.18%
Range	-5.3% to 9.6%	-13.1% to 1.9%

## Residential Land

Within the 1992 coastal zone of Manitowoc County, 2,119 residential structures were identified on 561 acres (227 ha) of land. Of the total were 1,291 residential units (single family or duplexes), 596 detached garages, 207 sheds and 21 barns. New in 1992 were 2.2 acres (.9 ha) of land devoted to medium rise multi-family dwellings and 1.9 acres (.8 ha) devoted to low rise multi-family dwellings. Since the 1992 photos are "leaves-on," these numbers likely underestimate the actual number of structures and area devoted to residential uses. In 1978, 519 acres (210 ha) of residential land were measured.

## Commercial and Industrial Land

Commercial land represented 120 acres (49 ha) in 1992 and 111 acres (45 ha) in 1978. Eighty-eight (88) commercial structures were noted within the coastal zone. Two (2) commercial types experienced growth over the 14 year period studied. The type central business district increased by 3.3 acres (1.3 ha) while neighborhood business district increased by 21 acres (8.5 ha). Institutional land, however, experienced a decrease from 48 acres (19 ha) to 33 acres (13 ha) for the same period.

Industrial land within the coastal zone increased from 89 acres (36 ha) to 121 acres (48 ha), a gain of 32 acres (13 ha) or 36%.

## Transportation Land

Sixty-four (64) structures were located on 205 acres (83 ha) of transportation land in 1992. In 1978, 164 acres (66 ha) of transportation land were reported. With the exception of rail transportation (about 21 acres [8.5 ha] for each year of study), land use types within this category experienced considerable change. Land developed for public/private boating increased by about 12 acres (4.7 ha). Increases in area also were observed in land developed for highway, from 26 acres (10.6 ha) to 58 acres (24 ha), sewage treatment facilities, from 15 acres (6.1 ha) to 58 acres (24 ha), and landfill, from no observed area in 1978 to 21 acres (8.7 ha) in 1992. Two transportation types lost area from 1978-1992. Land developed for communications declined from about 21 acres (10.7 ha) to no observed area in 1992. Area devoted to utilities lost nearly 43 acres (17 ha), from 56 acres (23 ha) in 1978 to 13 acres (5.3 ha) in 1992.

## Extractive

Extractive land uses increased modestly (6.4 acres, 2.6 ha) over the period studied, all of the increase was observed within the type open pit mine.

## Agricultural and Natural Land

In 1978, land uses within the category Agricultural and Natural represented 71% of all land within the coastal zone of Manitowoc County. In 1992, this category declined to 65%.

Overall, 324 acres (131 ha) of agricultural and natural lands were reported lost from 1978 to 1992, a trend that continues nationally. Land actively being cultivated declined by 330 acres (134 ha) or by 20.5%. Both abandoned fields and forest lands decreased in area as well, by 40 (16 ha) and 45 acres (18 ha), respectively.

Heath vegetation declined from a 1978 total of 163 acres (66 ha) to 115 acres (47 ha) in 1992. The type open water, however, experienced a 21 acre (8.5 ha) increase by 1992, to a total of 67 acres (27 ha).

Areas of erosion along Lake Michigan's shoreline are a major concern of coastal resource planners. Data show that slump zone area remained stable at about 72 acres (29 ha) for both study years. Also of note is a 119 acre (48 ha) increase of wetland types. Given state, regional and national trends, this finding is unusual. Increases in wetland areas could be associated with the nine (9) inch rise in Lake Michigan water level.

## Open and Other Land

Open and other land increased from 177 acres (72 ha) in 1978 to 220 acres (89 ha) in 1992. Sixty-one (61) acres (25 ha) of outdoor recreational land were added during the period while land devoted to open lot declined by 19 acres (7.8 ha).

## Shoreline Modifications

Ostensibly, sea walls and revetments are used to protect shorelines from erosion. Significant increases of both types of structures were reported. In 1978, 8,913 feet (2,717 m) of sea wall were reported compared to 11,740 feet (3,579 m) in 1992, representing an increase of 2,827 feet (862 m) or 32%. However, just as significant is the 6,660 foot (2,030 m), 24% increase in revetment development since 1978. Shoreline revetment was measured at 27,315 feet (8,328 m) in 1978 and 33,975 feet (10,358 m) in 1992.

## Results by Community

### Town of Centerville

Land within Centerville's coastal zone was measured at 593 acres (240 ha) in 1978 and 557 acres (226 ha) in 1992. The difference of 36 acres (15 ha) represents 6.1%. The 1992 total, however, does not include about 24 acres (9.7 ha) of land annexed by the Village of Cleveland. The source of the difference could be photo scale anomalies as discussed above.

In 1992, 52 residential structures were located on 32 acres (13 ha) of land. Most of these structures (30) were single family or duplex. Other structures associated with residential areas included 11 detached garages, (8) sheds and (3) barns. In 1978, 39 acres (16 ha) of residential are reported.

No commercial, industrial or transportation types were located in 1978 or 1992. In the extractive category, in 1978, 2.7 acres (1.1 ha) of open pit mine were observed. No areas of extractive types were observed on the 1992 photos.

Agricultural and natural areas decreased from 552 acres (224 ha) in 1978 to 524 acres (213 ha) in 1992 or by 28 acres (11 ha). Active agricultural land declined by 41 acres (17 ha) or 13% while forest land increased by 40 acres (16 ha) or 6.2%. The type abandoned field lost 42 acres (17 ha) during the period. Area of slump zone increased by about 12 acres (4.9 ha) to a 1992 total of 32 acres (13 ha). Wetlands remained stable at about 26 acres (10.5 ha).

From 1978 to 1992, shoreline modifications have decreased within the town. Revetment declined from 1,640 feet (500 m) to 697 feet (213 m). The loss, while unexplained, could be the result of "leaves-on" photos which make detection under tree canopy more difficult.

#### Village of Cleveland

A very small area of Cleveland falls within the coastal zone of Lake Michigan. Coastal zone area within the village was measured at 82 acres (33 ha) in 1978 and 93 acres (37 ha) in 1992.

In 1992, a total of 85 residential structures were identified on 42 acres (17 ha) (26 acres [11 ha] in 1978) of residential land. Of these, 63 were single family/duplex, 12 were detached garages and 10 were sheds.

Just over (8) acres (3.3 ha) of commercial land were recorded in 1992. This represents a 3.7 acre (1.5 ha) increase over the 1978 total of 4.6 acres (1.9 ha). Area increases were experienced in both the central business and neighborhood business district types.

Less than one acre (.6 acres [.2 ha]) of transportation land was observed in 1978. No area observations of transportation were recorded for 1992. Neither commercial nor extractive uses were observed for either study year. The agricultural and natural category decreased from 46 acres (19 ha) to 41 acres (16.5 ha) for the period studied. Other changes include a (5) acre (2 ha) decrease in abandoned field, a 12.5 acre (5 ha) decrease in active agricultural fields, and a 2.7 acre (1.1 ha) increase in forest land.

The remaining notable change to be reported includes shoreline modifications. Results indicate a loss of 287 feet (86 m) of sea wall. The loss likely represents masking by leaves and shadows rather than actual losses of shoreline structures. However, revetment structures increased by 1,772 feet (540 m) or



by 454%, from 390 feet (119 m) in 1978 to 2,162 feet (659 m) in 1992.

#### City of Manitowoc

The analysis of land use change within the coastal zone of the city of Manitowoc is made difficult by annexation of land after 1978. The coastal zone in 1992 consisted of 629 acres (255 ha), 86 acres (35 ha) of which were annexed from the town of Manitowoc. In 1978, 497 acres (201 ha) of coastal zone area were estimated.

Residential land encompassed 173 acres (70 ha) in 1992. Over 840 structures, of which 525 were single family/duplex, were located within the 1992 coastal zone. Other structures included 252 detached garages and 60 sheds. In 1978, 146 acres (59 ha) of residential land were recorded.

Commercial uses covered 78 acres (32 ha) in 1992. Thirty-one (31) structures were located in 53 acres (21 ha) of neighborhood business district area while (5) structures were reported on 24 acres (10 ha) of institutional land. Also in 1992, 33 industrial structures were located on 52 acres (21 ha) of land.

Transportation types covered 94 acres (38 ha) of area in 1992. Of these, highways covered the largest area, 28 acres (11 ha). While no marina facilities were found in 1978, over 17 acres (7 ha) were developed by 1992. Highway transportation area increased from 17 acres (6.8 ha) in 1978 to 28 acres (11.4 ha) in 1992. Modest changes were observed within the types rail transport and utilities, the former losing about (2) acres (.8 ha) while the latter gained about (2) acres (.8 ha).

Results indicate that sewage treatment plant area declined from 12 acres (4.8 ha) in 1978 to no area in 1992 and that landfill area, with no observed area in 1978, increased to 21 acres (8.7 ha) in 1992. While possible, such shifts seem unlikely and could be the result of misclassification.

No extractive uses were recorded for either study year. The problem of annexation skews the statistics regarding agricultural and natural lands against observed trends. Local and national trends suggest that such lands generally are declining, especially adjacent to urban areas. In 1992, 117 acres (47 ha) of area were identified within the agricultural and natural use category. Of these, 40 acres (16 ha) were abandoned field, 23 acres (9.1 ha) active agriculture and 6.1 acres (2.5 ha) wetland. A major change in open water was observed, from 8.3 acres (3.4 ha) in 1978 to 32 acres (13 ha) in 1992.

In the open/other land use category, 115 acres (46 ha) were identified as outdoor recreation in 1992. Sixteen (16) structures were counted on these areas. Urban open lots declined significantly from 21 acres (8.3 ha) in 1978 to 1.9 acres (.8 ha) in 1992.

Even considering land annexed to the city, considerable shoreline modification has occurred since 1978. In 1978, 7,649

feet (2,332 m) of sea wall were recorded compared to 11,045 feet (3,367 m) in 1992. The increase of sea wall represents 3,396 feet (1,035 m) or over 44%. Revetments increased substantially as well, from 9,528 feet (2,905 m) in 1978 to 17,055 feet (5,200 m) in 1992. The increase in revetment represents 7,527 feet (2,295 m) or 79%.

#### Town of Manitowoc

The coastal zone for the town of Manitowoc was determined to be 343 acres (139 ha) in 1978 and 240 acres (92 ha) in 1992. However, annexation to the city of Manitowoc resulted in a loss of 86 acres (35 ha) of land. The annexed portion represents a 25% loss relative to the 1978 total. Given the annexation, a comparison of 1978-1992 land use within the coastal zone is problematic.

The amount of residential land located within the coastal zone was 48 acres (20 ha) in 1992. Within the residential area were counted 75 structures, 52 of which were identified to be single family/duplex. Other structures observed were 14 detached garages, (8) sheds and (1) barn.

No commercial, industrial, transportation or extractive land uses were identified for 1992.

In 1992, agricultural and natural lands covered an area of 189 acres (76 ha). Most area fell within the use types abandoned field 72 acres (29 ha), active agricultural 67 acres (27 ha), forest 25 acres (10 ha), slump zone 14 acres (5.7 ha) and wetland 10 acres (4 ha).

Open/other land areas represented 3.7 acres (1.5 ha) in 1992, the majority of which (3.2 acres, 1.3 ha) were urban open lot.

No sea walls or revetments were identified in 1992.

#### Town of Newton

The coastal zone of the town of Newton was determined to be 410 acres (166 ha) in 1978 and 369 acres (149 ha) in 1992. The 41 acre (16.6 ha) difference is 10% of the 1978 total. The town of Newton was one of the sites tested to determine linear accuracy of the enlarged photos. The 1978 photos of Newton were determined to deviate +2% from USGS 1:24000 maps. The 1992 photos deviated by -7.4% from the USGS basis.

Total residential land located within the 1978 coastal zone was 13 acres (5.3 ha) compared to 30 acres (12 ha) in 1992. In 1992, 46 structures were located within the residential area, of which were 26 single family/duplex units, (8) detached garages and 12 sheds.

Within the coastal zone, no commercial or industrial lands were identified for either study year.

In 1978, no transportation area was identified. In 1992, only .8 acres (.3 ha) of transportation land was observed within the coastal zone.

Agricultural and natural lands made up 89% of the town's coastal zone in 1978 and 81% in 1992. In 1978, 366 acres (148 ha) of coastal zone area were classified within the agricultural and natural lands category. In 1992, lands classified within this category fell to 299 acres (121 ha). Over the 14 year period, the type abandoned field remained stable in area. However, active agricultural land decreased from 267 acres (108 ha) in 1978 to 175 acres (71 ha) in 1992. The loss represents 92 acres (37 ha) or 34%. The area of slump zone also declined for the period, from 22 acres (9 ha) to 17 acres (6.8 ha). Increases in area were observed in forest land and wetland. Forests increased by 26 acres (10.6 ha), from 24 acres (9.6 ha) in 1978 to 50 acres (20 ha) in 1992. Wetlands increased a modest 2.7 acres (1.1 ha) to 6 acres (2.4 ha) in 1992.

No open/other land areas were observed for either study year.

In 1978, no sea walls or revetments were observed. In 1992, 150 feet (46 m) of revetment were documented.

#### Town of Two Creeks

Land within the coastal zone of the town of Two Creeks was measured at 726 acres (294 ha) in 1978 and 652 acres (264 ha) in 1992. The source of the difference (74 acres, 30 ha) could be photo scale anomalies as discussed above. The town of Two Creeks was one of the sites tested to determine linear accuracy of the enlarged photos. The 1978 photos of Two Creeks were determined to deviate -1.7% from USGS 1:24000 maps. The 1992 photos deviated by -6.4% from the USGS basis.

In 1992, 97 residential structures were located on 57 acres (23 ha) of land. Most of these structures (56) were single family or duplex. Other structures associated with residential land included (8) detached garages, 16 sheds and 17 barns. In 1978, the same area of residential land was reported.

In 1992, no commercial area was reported compared to .7 acres (.3 ha) reported in 1978. Results indicate that no industrial park land was observed for either study year.

Land area devoted to transportation types increased a modest 5.7 acres (2.3 ha), from 46.4 acres (18.8 ha) in 1978 to 52 acres (21 ha) in 1992. Within the transportation category, however, considerable change is reported. Area of public boat landing increased by 1.5 acres (.6 ha) to 2.3 acres (.9 ha) in 1992. Communication and utilities, with 1.7 acres (.7 ha) and 44 acres (17.8 ha) reported in 1978, were reported with no area in 1992, while land devoted to sewage treatment plant increased from no area in 1978 to nearly 50 acres (20 ha) in 1992. Likely, these dramatic changes reflect misclassification rather than actual change.

Extractive of the type "other" was observed on both sets of photos. In 1978, 7.7 acres (3.1 ha) of other extractive were noted while 7.3 acres (3 ha) were noted in 1992.

Agricultural and natural areas decreased from 611 acres (248 ha) in 1978 to 522 acres (211 ha) in 1992. The types abandoned field, heath vegetation, open water and wetland remained relatively unchanged during the 14 year period. However, active agriculture, forest and slump zone experienced considerable losses of area. Active agricultural land decreased by 73 acres ([30 ha] 17.5%) from 424 acres (172 ha) in 1978 to 351 acres (142 ha) in 1992. Forests declined from 85 acres (34 ha) to 70 acres (28 ha) while area of slump zone fell from 10.7 acres (4.3 ha) to 2.7 acres (1.1 ha).

Two open/other land types showed change during the period studied. Urban open lot areas increased from .3 acres (.1 ha) in 1978 to 4.6 acres (1.9 ha) in 1992. The type outdoor recreation also increased from 3.9 acres (1.6 ha) in 1978 to 9.8 acres (4 ha) in 1992.

From 1978-1992, results suggest shoreline modification has decreased within the township. Sea wall construction decreased from 977 feet (298 m) to 695 feet (212 m). Likewise, revetment decreased from 3,913 feet (1,193 m) to 3,789 feet (1,155 m).

No groins or non-flow-through docks were recorded for either study year.

#### City of Two Rivers

Because of land annexation of about 200 acres (81 ha) since 1978, meaningful analysis of land use change within the coastal zone of the city of Two Rivers is made difficult.

The coastal zone area within the city was measured at 276 acres (112 ha) in 1978 and 459 acres (186 ha) in 1992. The 184 acre (75 ha) difference is more than accounted for by the area annexed from the town of Two Rivers.

In 1992, a total of 864 residential structures were identified on 163 acres (66 ha) of residential land. Of these, 502 were of the single family/duplex type, while 275 and 87 were detached garages and sheds, respectively.

In 1992, 32 commercial structures were located on 32 acres (13 ha) of commercial land. Industrial land covered 69 acres (28 ha) in 1992, on which 38 structures were observed.

Agricultural and natural areas increased from 37 acres (15 ha) to 81 acres (33 ha) for the period studied. Area changes within the category include a 21 acre (8.4 ha) increase in forest land, a 10 acre (4.1 ha) loss of heath community and a 40 acre (16.1 ha) increase in wetland.

Total Open and Other Lands increased from 45 acres (18 ha) in 1978 to 57 acres (23 ha) in 1992. Most of the increase was observed in outdoor recreation land.

Shoreline modifications increased significantly during the 14 year period studied. Revetment construction increased by 68% from 6,025 feet (1,837 m) in 1978 to 10,121 feet (3,086 m) in 1992.

## Town of Two Rivers

Since 1978, about 200 acres (81 ha) of town land within the coastal zone has been annexed to the city of Two Rivers. This transfer of land makes difficult analysis of land use change within the town's coastal zone. In 1978, land within the town's coastal zone was estimated to be 867 acres (351 ha). In 1992, the town's coastal zone area was estimated to be 644 acres (261 ha).

Residential land covered 91 acres (37 ha) in 1978. In 1992, total residential land covered but 17 acres (6.8 ha), much of the land lost to annexation. Fifty-nine (59) structures were documented on the 1992 residential areas. Of these, there were 37 single family/duplex units, 16 detached garages and (6) sheds.

Commercial land covered only 1.8 acres (.7 ha) in 1992, compared to 11.4 acres (4.6 ha) in 1978. Neither industrial nor extractive areas were observed for either study year. A total of 17.8 acres (7.2 ha) of transportation land was recorded in 1978, by 1992 all had been lost through annexation.

As is common in rural counties, lands within the category of agricultural and natural represent the greatest area of the coastal zone. In 1992, this category covered 600 acres (243 ha) or 93% of the coastal zone. Of these, there were 362 acres (147 ha) of active agriculture, 94 acres (38 ha) of forest and 131 acres (53 ha) of wetland.

Twenty-five (25) acres (10.1 ha) of open/other land was observed in 1992, most of which were of the outdoor recreation type.

No shoreline modification features were recorded in 1992. The 4,925 feet (1,502 m) observed in 1978 appear to have been on land annexed to the city of Two Rivers.

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APPENDIX

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

County Summary Data Sheet

Year: 1978  
County: Manitowoc  
Coastal Civil Jurisdiction included in summary (in alphabetical order).

Town of Centerville  
Village of Cleveland  
City of Manitowoc  
Town of Manitowoc  
Town of Newton  
Town of Two Creeks  
City of Two Rivers  
Town of Two Rivers

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	1214	518	210
garages	543		
sheds	276		
barns	19		
115 Res. units	6	1	<1
garages			
sheds			
Subtotal	2058	519	210
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	68	64	26
126 Institutional	17	48	19
Subtotal	85	111	45
<u>13 Industrial</u>			
138 Industrial Park	58	89	36

	# of structures	Area	
		Acres	Hectares
<b><u>14 Transportation</u></b>			
141 Air Transportation			
142 Rail Transportation	1	20	8
143 Water Transportation			
143.1 Private Marina	7	3	1
143.2 Public Boat Landing	9	17	7
144 Highways		26	11
145 Communications		26	11
146 Utilities	11	56	23
147 Sewage Treatment Plant		15	6
148 Landfill			
Subtotal	28	164	66

**17 Extractive**

171 Open Pit		33	14
172 Underground			
173 Well			
179 Other Extractive		8	3
Subtotal		41	17

**18 Agricultural and Natural**

181 AF Abandoned Field	2	341	138
182 AG Agriculture Active	14	1244	504
183 F Forest		694	281
184 H Heath		163	66
185 OW Open Water		46	19
186 RL Rock Ledge		<1	<1
187 SL Slump Zone		73	29
188 WT Wetland		133	54
Subtotal	16	2693	1091

**19 Open Land, Other**

191 Outdoor-Public Assembly			
192 Urban Open Lots	1	31	12
193 Outdoor Recreation	31	147	59
194 Cemeteries			
Subtotal	32	177	72

Total Acres 3794  
Total Hectares 1536

**Shoreline Modifications**

		Linear	
		Feet	Meters
195 Sea Walls		8913	2717
196 Revetments		27315	8328
197 Groins	# of Groins	1	
198 Dock Non-Flow-Through	# of Docks		

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

County Summary Data Sheet

Year: 1992  
 County: Manitowoc  
 Coastal Civil Jurisdiction included in summary (in alphabetical order).

- Town of Centerville
- Village of Cleveland
- City of Manitowoc
- Town of Manitowoc
- Town of Newton
- Town of Two Creeks
- City of Two Rivers
- Town of Two Rivers

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	4	2	1
garages			
sheds			
112 Res. units		2	1
garages			
sheds			
113 Res. units	1291	557	225
garages	596		
sheds	207		
barns	21		
115 Res. units			
garages			
sheds			
Subtotal	2119	561	227
<u>12 Commercial</u>			
121 Central Business Dist	12	3	1
122 Shopping Center/Mall			
124 Neighborhood Business Dist	61	84	34
126 Institutional	15	33	13
Subtotal	88	120	49
<u>13 Industrial</u>			
138 Industrial Park	71	121	49

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation	2	22	9
143 Water Transportation			
143.1 Private Marina	13	29	12
143.2 Public Boat Landing	1	3	1
144 Highways		58	24
145 Communications			
146 Utilities	9	13	5
147 Sewage Treatment Plant	39	59	24
148 Landfill		21	9
Subtotal	64	205	83

17 Extractive

171 Open Pit		40	16
172 Underground			
173 Well			
179 Other Extractive		7	3
Subtotal		47	19

18 Agricultural and Natural

181 AF Abandoned Field	7	301	122
182 AG Agriculture Active		914	370
183 F Forest		649	263
184 H Heath		115	47
185 OW Open Water		67	27
186 RL Rock Ledge			
187 SL Slump Zone		71	29
188 WT Wetland		252	102
Subtotal	7	2369	960

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots		11	5
193 Outdoor Recreation	46	208	84
194 Cemeteries			
Subtotal	46	220	89

Total Acres 3643  
Total Hectares 1476

Shoreline Modifications

		Linear	
		Feet	Meters
195 Sea Walls		11740	3579
196 Revetments		33975	10358
197 Groins	# of Groins		
198 Dock Non-Flow-Through	# of Docks		

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978

County: Manitowoc

Township, Village or City name: Town of Centerville

PLSS section data sheets included in summary (give full description):

T17N R23E SEC 1	SEC 27
SEC 2	SEC 34
SEC 11	
SEC 12	
SEC 14	
SEC 15	
SEC 22	
SEC 23	

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<b><u>11 Residential</u></b>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	32	39	16
garages	10		
sheds	24		
barns	3		
115 Res. units			
garages			
sheds			
Subtotal	69	39	16

**12 Commercial**

121 Central Business Dist	
122 Shopping Center/Mall	
124 Neighborhood Business Dist	
126 Institutional	
Subtotal	

**13 Industrial**

138 Industrial Park	
---------------------	--

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
		Subtotal	

<u>17 Extractive</u>			
171 Open Pit		3	1
172 Underground			
173 Well			
179 Other Extractive			
		Subtotal	
		3	1

<u>18 Agricultural and Natural</u>			
181 AF Abandoned Field		118	48
182 AG Agriculture Active		320	130
183 F Forest		65	26
184 H Heath			
185 OW Open Water		3	1
186 RL Rock Ledge			
187 SL Slump Zone		21	9
188 WT Wetland		25	10
		Subtotal	
		552	224

<u>19 Open Land, Other</u>			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation			
194 Cemeteries			
		Subtotal	

Total Acres 593  
Total Hectares 240

		Linear	
		Feet	Meters
<u>Shoreline Modifications</u>			
195 Sea Walls			
196 Revetments		1640	500
197 Groins		# of Groins	
198 Dock Non-Flow-Through		# of Docks	



Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Manitowoc  
Township, Village or City name: Town of Centerville  
PLSS section data sheets included in summary (give full description):

T17N R23E SEC 1                    SEC 27  
                  SEC 2                    SEC 34  
                  SEC 11  
                  SEC 12  
                  SEC 14  
                  SEC 15  
                  SEC 22  
                  SEC 23

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	30	32	13
garages	11		
sheds	8		
barns	3		
115 Res. units			
garages			
sheds			
Subtotal	52	32	13
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
	Subtotal		

<u>17 Extractive</u>			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
	Subtotal		

<u>18 Agricultural and Natural</u>			
181 AF Abandoned Field	1	76	31
182 AG Agriculture Active		279	113
183 F Forest		105	43
184 H Heath		<1	<1
185 OW Open Water		3	1
186 RL Rock Ledge			
187 SL Slump Zone		32	13
188 WT Wetland		28	11
	Subtotal	1	524
			213

<u>19 Open Land, Other</u>			
191 Outdoor-Public Assembly			
192 Urban Open Lots		<1	<1
193 Outdoor Recreation			
194 Cemeteries			
	Subtotal	<1	<1

Total Acres 557  
Total Hectares 226

<u>Shoreline Modifications</u>	Linear	
	Feet	Meters
195 Sea Walls		
196 Revetments	697	213
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978

County: Manitowoc

Township, Village or City name: Village of Cleveland

PLSS section data sheets included in summary (give full description):

T17N R23E SEC 27

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	45	26	11
garages	14		
sheds	17		
barns	3		
115 Res. units			
garages			
sheds			
Subtotal	79	26	11
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	3	5	2
126 Institutional			
Subtotal	3	5	2
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<b>14 Transportation</b>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities	2	1	<1
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	2	1	<1

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field		3	1
182 AG Agriculture Active		33	13
183 F Forest		3	1
184 H Heath			
185 OW Open Water		2	1
186 RL Rock Ledge			
187 SL Slump Zone		1	<1
188 WT Wetland		4	2
Subtotal		46	19

**19 Open Land, Other**

191 Outdoor-Public Assembly			
192 Urban Open Lots		3	1
193 Outdoor Recreation	1	1	<1
194 Cemeteries			
Subtotal	1	4	2

Total Acres 82  
Total Hectares 33

**Shoreline Modifications**

	Linear	
	Feet	Meters
195 Sea Walls	287	88
196 Revetments	390	119
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
 County: Manitowoc  
 Township, Village or City name: Village of Cleveland  
 PLSS section data sheets included in summary (give full description):

T17N R23E SEC 22  
 SEC 23  
 SEC 27

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	_____	_____	_____
garages	_____	_____	_____
sheds	_____	_____	_____
112 Res. units	_____	_____	_____
garages	_____	_____	_____
sheds	_____	_____	_____
113 Res. units	63	42	17
garages	12	_____	_____
sheds	10	_____	_____
barns	_____	_____	_____
115 Res. units	_____	_____	_____
garages	_____	_____	_____
sheds	_____	_____	_____
Subtotal	85	42	17
<u>12 Commercial</u>			
121 Central Business Dist	10	2	1
122 Shopping Center/Mall	_____	_____	_____
124 Neighborhood Business Dist	4	6	2
126 Institutional	_____	_____	_____
Subtotal	14	8	3
<u>13 Industrial</u>			
138 Industrial Park	_____	_____	_____

		Area	
	<u># of structures</u>	<u>Acres</u>	<u>Hectares</u>

14 Transportation

141 Air Transportation	_____		
142 Rail Transportation	_____		
143 Water Transportation	_____		
143.1 Private Marina	_____		
143.2 Public Boat Landing	_____		
144 Highways	_____		
145 Communications	_____		
146 Utilities	_____		
147 Sewage Treatment Plant	_____		
148 Landfill	_____		
Subtotal			

17 Extractive

171 Open Pit	_____		
172 Underground	_____		
173 Well	_____		
179 Other Extractive	_____		
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field	_____	8	3
182 AG Agriculture Active	_____	20	8
183 F Forest	_____	6	2
184 H Heath	_____		
185 OW Open Water	_____	2	1
186 RL Rock Ledge	_____		
187 SL Slump Zone	_____	1	<1
188 WT Wetland	_____	4	2
Subtotal		41	17

19 Open Land, Other

191 Outdoor-Public Assembly	_____		
192 Urban Open Lots	_____	1	1
193 Outdoor Recreation	_____	4	2
194 Cemeteries	_____		
Subtotal		4	3

Total Acres	93
Total Hectares	38

Shoreline Modifications

		Linear	
		<u>Feet</u>	<u>Meters</u>
195 Sea Walls	_____		
196 Revetments	_____	2162	659
197 Groins	_____	# of Groins	
198 Dock Non-Flow-Through	_____	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Manitowoc  
Township, Village or City name: City of Manitowoc  
PLSS section data sheets included in summary (give full description):

T18N R24E SEC 5  
T19N R24E SEC 16  
SEC 17  
SEC 20  
SEC 29  
SEC 32

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units		<1	<1
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	482	146	59
garages	233		
sheds	49		
barns			
115 Res. units			
garages			
sheds			
Subtotal	764	146	59
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	36	32	13
126 Institutional	11	45	18
Subtotal	47	77	31
<u>13 Industrial</u>			
138 Industrial Park	20	27	11

	# of structures	Area	
		Acres	Hectares
<b>14 Transportation</b>			
141 Air Transportation			
142 Rail Transportation	1	16	6
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways		17	7
145 Communications			
146 Utilities	5	11	5
147 Sewage Treatment Plant		12	5
148 Landfill			
Subtotal	6	56	23

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field		43	18
182 AG Agriculture Active		16	7
183 F Forest		11	4
184 H Heath			
185 OW Open Water		8	3
186 RL Rock Ledge			
187 SL Slump Zone		4	2
188 WT Wetland		8	3
Subtotal		91	37

**19 Open Land, Other**

191 Outdoor-Public Assembly			
192 Urban Open Lots	1	21	8
193 Outdoor Recreation	12	80	32
194 Cemeteries			
Subtotal	13	101	41

Total Acres 497  
Total Hectares 201

**Shoreline Modifications**

		Linear	
		Feet	Meters
195 Sea Walls		7649	2332
196 Revetments		9528	2905
197 Groins	# of Groins	1	
198 Dock Non-Flow-Through	# of Docks		



Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Manitowoc  
Township, Village or City name: City of Manitowoc  
PLSS section data sheets included in summary (give full description):

T18N R24E SEC 5  
SEC 8  
T19N R24E SEC 9  
SEC 16  
SEC 17  
SEC 20  
SEC 29  
SEC 32

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	4	2	1
garages			
sheds			
112 Res. units		2	1
garages			
sheds			
113 Res. units	525	169	69
garages	252		
sheds	60		
barns			
115 Res. units			
garages			
sheds			
Subtotal	841	173	70
<u>12 Commercial</u>			
121 Central Business Dist	2	1	<1
122 Shopping Center/Mall			
124 Neighborhood Business Dist	31	53	21
126 Institutional	5	24	10
Subtotal	38	78	32
<u>13 Industrial</u>			
138 Industrial Park	33	52	21

	# of structures	Area	
		Acres	Hectares
<b>14 Transportation</b>			
141 Air Transportation			
142 Rail Transportation	2	14	6
143 Water Transportation			
143.1 Private Marina	7	17	7
143.2 Public Boat Landing			
144 Highways		28	11
145 Communications			
146 Utilities	9	13	5
147 Sewage Treatment Plant			
148 Landfill		21	9
Subtotal	18	94	38

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field		40	16
182 AG Agriculture Active		23	9
183 F Forest		9	4
184 H Heath		1	1
185 OW Open Water		32	13
186 RL Rock Ledge			
187 SL Slump Zone		4	2
188 WT Wetland		6	3
Subtotal		115	47

**19 Open Land, Other**

191 Outdoor-Public Assembly			
192 Urban Open Lots		2	1
193 Outdoor Recreation	16	115	46
194 Cemeteries			
Subtotal	16	117	47

Total Acres 629  
Total Hectares 255

**Shoreline Modifications**

	Linear	
	Feet	Meters
195 Sea Walls	11045	3367
196 Revetments	17055	5200
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Manitowoc  
Township, Village or City name: Town of Manitowoc  
PLSS section data sheets included in summary (give full description):

T18N R24E SEC 5	T19N R24E SEC 9
SEC 6	SEC 16
SEC 7	
SEC 8	
SEC 18	

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	88	64	26
garages	31		
sheds	38		
barns	3		
115 Res. units			
garages			
sheds			
Subtotal	160	64	26

12 Commercial

121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	2	6	3
126 Institutional			
Subtotal	2	6	3

13 Industrial

138 Industrial Park			
---------------------	--	--	--

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing	2	6	2
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	2	6	2

<u>17 Extractive</u>			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

<u>18 Agricultural and Natural</u>			
181 AF Abandoned Field		47	19
182 AG Agriculture Active		181	73
183 F Forest		17	7
184 H Heath			
185 OW Open Water		<1	<1
186 RL Rock Ledge			
187 SL Slump Zone		14	6
188 WT Wetland		5	2
Subtotal		265	107

<u>19 Open Land, Other</u>			
191 Outdoor-Public Assembly			
192 Urban Open Lots		3	1
193 Outdoor Recreation		<1	<1
194 Cemeteries			
Subtotal		3	1

Total Acres 344  
Total Hectares 139

	<u>Linear</u>	
	<u>Feet</u>	<u>Meters</u>
195 Sea Walls	895	273
196 Revetments		
197 Groins	<u># of Groins</u>	
198 Dock Non-Flow-Through	<u># of Docks</u>	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Manitowoc  
Township, Village or City name: Town of Manitowoc  
PLSS section data sheets included in summary (give full description):

T18N R24E SEC 5  
SEC 6  
SEC 7  
SEC 18

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	52	48	20
garages	14		
sheds	8		
barns	1		
115 Res. units			
garages			
sheds			
Subtotal	75	48	20
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
		Subtotal	

<u>17 Extractive</u>			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
		Subtotal	

<u>18 Agricultural and Natural</u>			
181 AF Abandoned Field	2	72	29
182 AG Agriculture Active		67	27
183 F Forest		25	10
184 H Heath			
185 OW Open Water		1	<1
186 RL Rock Ledge			
187 SL Slump Zone		14	6
188 WT Wetland		10	4
		Subtotal	
	2	189	76

<u>19 Open Land, Other</u>			
191 Outdoor-Public Assembly			
192 Urban Open Lots		3	1
193 Outdoor Recreation		1	<1
194 Cemeteries			
		Subtotal	
		4	2

Total Acres 240  
Total Hectares 97

<u>Shoreline Modifications</u>	Linear	
	Feet	Meters
195 Sea Walls		
196 Revetments		
197 Groins		# of Groins
198 Dock Non-Flow-Through		# of Docks

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Manitowoc  
Township, Village or City name: Town of Newton  
PLSS section data sheets included in summary (give full description):

T18N R23E SEC 13  
SEC 24  
SEC 25  
SEC 35  
SEC 36

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	15	13	5
garages	2		
sheds	14		
barns	2		
115 Res. units			
garages			
sheds			
Subtotal	33	13	5
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
	Subtotal		

<u>17 Extractive</u>			
171 Open Pit		31	12
172 Underground			
173 Well			
179 Other Extractive			
	Subtotal	31	12

<u>18 Agricultural and Natural</u>			
181 AF Abandoned Field		49	20
182 AG Agriculture Active		267	108
183 F Forest		24	10
184 H Heath			
185 OW Open Water		<1	<1
186 RL Rock Ledge			
187 SL Slump Zone		22	9
188 WT Wetland		3	1
	Subtotal	366	148

<u>19 Open Land, Other</u>			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation			
194 Cemeteries			
	Subtotal		

Total Acres 410  
Total Hectares 166

<u>Shoreline Modifications</u>	Linear	
	Feet	Meters
195 Sea Walls		
196 Revetments		
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	



Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Manitowoc  
Township, Village or City name: Town of Newton  
PLSS section data sheets included in summary (give full description):

T18N R23E SEC 13  
SEC 24  
SEC 25  
SEC 35  
SEC 36

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	26	30	12
garages	8		
sheds	12		
barns			
115 Res. units			
garages			
sheds			
Subtotal	46	30	12
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional			
Subtotal			
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina		<1	<1
143.2 Public Boat Landing		1	<1
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal		1	<1

<u>17 Extractive</u>			
171 Open Pit		40	16
172 Underground			
173 Well			
179 Other Extractive			
Subtotal		40	16

<u>18 Agricultural and Natural</u>			
181 AF Abandoned Field	2	49	20
182 AG Agriculture Active		175	71
183 F Forest		50	20
184 H Heath			
185 OW Open Water		2	1
186 RL Rock Ledge			
187 SL Slump Zone		17	7
188 WT Wetland		6	2
Subtotal	2	299	121

<u>19 Open Land, Other</u>			
191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation			
194 Cemeteries			
Subtotal			

Total Acres 369  
Total Hectares 149

		Linear	
		Feet	Meters
<u>Shoreline Modifications</u>			
195 Sea Walls			
196 Revetments		150	46
197 Groins		# of Groins	
198 Dock Non-Flow-Through		# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Manitowoc  
Township, Village or City name: Town of Two Creeks  
PLSS section data sheets included in summary (give full description):

T21N R24E SEC 2	T21N R25E SEC 30
SEC 11	SEC 31
SEC 12	
SEC 13	
SEC 14	
SEC 24	
SEC 25	
SEC 36	

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	39	56	23
garages	12		
sheds	39		
barns	8		
115 Res. units			
garages			
sheds			
Subtotal	98	56	23
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	3	1	<1
126 Institutional			
Subtotal	3	1	<1
<u>13 Industrial</u>			
138 Industrial Park			

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing		1	<1
144 Highways			
145 Communications		2	1
146 Utilities	3	44	18
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	3	46	19

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive		8	3
Subtotal		8	3

18 Agricultural and Natural

181 AF Abandoned Field	2	43	17
182 AG Agriculture Active	14	424	172
183 F Forest		85	34
184 H Heath		19	8
185 OW Open Water		2	1
186 RL Rock Ledge			
187 SL Slump Zone		11	4
188 WT Wetland		28	11
Subtotal	16	611	248

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots		<1	<1
193 Outdoor Recreation	1	4	2
194 Cemeteries			
Subtotal	1	4	2

Total Acres 727

Total Hectares 294

Shoreline Modifications

	<u>Linear</u>	
	<u>Feet</u>	<u>Meters</u>
195 Sea Walls	977	298
196 Revetments	3913	1193
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
 County: Manitowoc  
 Township, Village or City name: Town of Two Creeks  
 PLSS section data sheets included in summary (give full description):

T21N R24E SEC 2	T21N R25E SEC 30
SEC 11	SEC 31
SEC 13	
SEC 14	
SEC 24	
SEC 25	
SEC 36	

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	_____	_____	_____
garages	_____	_____	_____
sheds	_____	_____	_____
112 Res. units	_____	_____	_____
garages	_____	_____	_____
sheds	_____	_____	_____
113 Res. units	56	57	23
garages	8	_____	_____
sheds	16	_____	_____
barns	17	_____	_____
115 Res. units	_____	_____	_____
garages	_____	_____	_____
sheds	_____	_____	_____
Subtotal	97	57	23
<u>12 Commercial</u>			
121 Central Business Dist	_____	_____	_____
122 Shopping Center/Mall	_____	_____	_____
124 Neighborhood Business Dist	_____	_____	_____
126 Institutional	_____	_____	_____
Subtotal	_____	_____	_____
<u>13 Industrial</u>			
138 Industrial Park	_____	_____	_____

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing	1	2	1
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant	25	50	20
148 Landfill			
Subtotal	26	52	21

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive		7	3
Subtotal		7	3

18 Agricultural and Natural

181 AF Abandoned Field	2	49	20
182 AG Agriculture Active		351	142
183 F Forest		70	28
184 H Heath		19	8
185 OW Open Water		2	1
186 RL Rock Ledge			
187 SL Slump Zone		3	1
188 WT Wetland		28	12
Subtotal	2	522	211

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots		5	2
193 Outdoor Recreation	1	10	4
194 Cemeteries			
Subtotal	1	14	6

Total Acres 652  
Total Hectares 264

Shoreline Modifications

	Linear	
	Feet	Meters
195 Sea Walls	695	212
196 Revetments	3789	1155
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978  
County: Manitowoc  
Township, Village or City name: City of Two Rivers  
PLSS section data sheets included in summary (give full description):

T19N R24E SEC 1                      T19N R25E SEC 6  
   SEC 2  
   SEC 11

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	342	84	34
garages	166		
sheds	50		
barns			
115 Res. units			
garages			
sheds			
Subtotal	558	84	34
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	14	9	4
126 Institutional	6	3	1
Subtotal	20	11	5
<u>13 Industrial</u>			
138 Industrial Park	38	62	25

	# of structures	Area	
		Acres	Hectares
<b>14 Transportation</b>			
141 Air Transportation			
142 Rail Transportation		4	2
143 Water Transportation			
143.1 Private Marina	7	3	1
143.2 Public Boat Landing	3	7	3
144 Highways		9	4
145 Communications		10	4
146 Utilities	1	<1	<1
147 Sewage Treatment Plant		3	1
148 Landfill			
Subtotal	11	37	15

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field		12	5
182 AG Agriculture Active			
183 F Forest		1	1
184 H Heath		10	4
185 OW Open Water		13	5
186 RL Rock Ledge			
187 SL Slump Zone			
188 WT Wetland			
Subtotal		37	15

**19 Open Land, Other**

191 Outdoor-Public Assembly			
192 Urban Open Lots		1	1
193 Outdoor Recreation	5	43	18
194 Cemeteries			
Subtotal	5	45	18

Total Acres 276  
Total Hectares 112

**Shoreline Modifications**

	# of Groins	Linear	
		Feet	Meters
195 Sea Walls			
196 Revetments		6025	1837
197 Groins	# of Groins		
198 Dock Non-Flow-Through	# of Docks		



Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
 County: Manitowoc  
 Township, Village or City name: City of Two Rivers  
 PLSS section data sheets included in summary (give full description):

T19N R24E SEC 1	T19N R25E SEC 6
SEC 2	T20N R25E SEC 31
SEC 10	
SEC 11	
SEC 15	

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units	_____		
garages	_____		
sheds	_____		
112 Res. units	_____		
garages	_____		
sheds	_____		
113 Res. units	502	163	66
garages	275		
sheds	87		
barns	_____		
115 Res. units	_____		
garages	_____		
sheds	_____		
Subtotal	864	163	66
<u>12 Commercial</u>			
121 Central Business Dist	_____	<1	<1
122 Shopping Center/Mall	_____		
124 Neighborhood Business Dist	26	25	10
126 Institutional	6	7	3
Subtotal	32	32	13
<u>13 Industrial</u>			
138 Industrial Park	38	69	28

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation		8	3
143 Water Transportation			
143.1 Private Marina	6	11	5
143.2 Public Boat Landing			
144 Highways		30	12
145 Communications			
146 Utilities			
147 Sewage Treatment Plant	14	9	4
148 Landfill			
Subtotal	20	58	24

17 Extractive

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

18 Agricultural and Natural

181 AF Abandoned Field		4	2
182 AG Agriculture Active			
183 F Forest		22	9
184 H Heath		<1	<1
185 OW Open Water		15	6
186 RL Rock Ledge			
187 SL Slump Zone			
188 WT Wetland		40	16
Subtotal		81	33

19 Open Land, Other

191 Outdoor-Public Assembly			
192 Urban Open Lots			
193 Outdoor Recreation	13	57	23
194 Cemeteries			
Subtotal	13	57	23

Total Acres 459  
Total Hectares 186

Shoreline Modifications

		Linear	
		Feet	Meters
195 Sea Walls			
196 Revetments		10121	3086
197 Groins	# of Groins		
198 Dock Non-Flow-Through	# of Docks		

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1978

County: Manitowoc

Township, Village or City name: Town of Two Rivers

PLSS section data sheets included in summary (give full description):

T19N R24E SEC 10	T20N R25E SEC 4	SEC 21
SEC 15	SEC 6	SEC 28
	SEC 9	SEC 29
	SEC 16	SEC 31
	SEC 20	SEC 32

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	171	90	36
garages	75		
sheds	45		
barns			
115 Res. units	6	1	<1
garages			
sheds			
Subtotal	297	91	37

12 Commercial

121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist	10	11	5
126 Institutional			
Subtotal	10	11	5

13 Industrial

138 Industrial Park			
---------------------	--	--	--

	# of structures	Area	
		Acres	Hectares
<b>14 Transportation</b>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing	4	3	1
144 Highways			
145 Communications		15	6
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
Subtotal	4	18	7

**17 Extractive**

171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
Subtotal			

**18 Agricultural and Natural**

181 AF Abandoned Field		26	11
182 AG Agriculture Active		3	1
183 F Forest		489	198
184 H Heath		133	54
185 OW Open Water		16	7
186 RL Rock Ledge		<1	<1
187 SL Slump Zone			
188 WT Wetland		60	24
Subtotal		727	294

**19 Open Land, Other**

191 Outdoor-Public Assembly			
192 Urban Open Lots		3	1
193 Outdoor Recreation	12	18	7
194 Cemeteries			
Subtotal	12	21	8

Total Acres 867  
Total Hectares 351

**Shoreline Modifications**

	# of Groins	Linear	
		Feet	Meters
195 Sea Walls			
196 Revetments		4925	1502
197 Groins	# of Groins		
198 Dock Non-Flow-Through	# of Docks		

Lake Michigan Coastal Development Inventory Project:  
1978 - 1992

Civil Jurisdiction  
Summary Data Sheet

Year: 1992  
County: Manitowoc  
Township, Village or City name: Town of Two Rivers  
PLSS section data sheets included in summary (give full description):

T20N R25E SEC 4	SEC 21
SEC 9	SEC 29
SEC 16	SEC 31
SEC 20	SEC 32

LAND USE CATEGORIES

	<u># of structures</u>	<u>Area</u>	
		<u>Acres</u>	<u>Hectares</u>
<u>11 Residential</u>			
111 Res. units			
garages			
sheds			
112 Res. units			
garages			
sheds			
113 Res. units	37	17	7
garages	16		
sheds	6		
barns			
115 Res. units			
garages			
sheds			
Subtotal	59	17	7
<u>12 Commercial</u>			
121 Central Business Dist			
122 Shopping Center/Mall			
124 Neighborhood Business Dist			
126 Institutional	4	2	1
Subtotal	4	2	1
<u>13 Industrial</u>			
138 Industrial Park			

	# of structures	Area	
		Acres	Hectares
<u>14 Transportation</u>			
141 Air Transportation			
142 Rail Transportation			
143 Water Transportation			
143.1 Private Marina			
143.2 Public Boat Landing			
144 Highways			
145 Communications			
146 Utilities			
147 Sewage Treatment Plant			
148 Landfill			
	Subtotal		

<u>17 Extractive</u>			
171 Open Pit			
172 Underground			
173 Well			
179 Other Extractive			
	Subtotal		

<u>18 Agricultural and Natural</u>			
181 AF Abandoned Field		2	1
182 AG Agriculture Active			
183 F Forest		362	147
184 H Heath		94	38
185 OW Open Water		11	4
186 RL Rock Ledge			
187 SL Slump Zone			
188 WT Wetland		131	53
	Subtotal	600	243

<u>19 Open Land, Other</u>			
191 Outdoor-Public Assembly			
192 Urban Open Lots		<1	<1
193 Outdoor Recreation	12	25	10
194 Cemeteries			
	Subtotal	12	25

Total Acres 644  
Total Hectares 261

<u>Shoreline Modifications</u>	Linear	
	Feet	Meters
195 Sea Walls		
196 Revetments		
197 Groins	# of Groins	
198 Dock Non-Flow-Through	# of Docks	

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