

SEWRPC Memorandum Report No. 248

MILWAUKEE COUNTY COASTLINE MANAGEMENT GUIDELINES

**Section 1**

**INTRODUCTION AND PURPOSE**

**BACKGROUND**

In 2019, Milwaukee County requested that the Southeastern Wisconsin Regional Planning Commission (SEWRPC) prepare a set of coastline management guidelines intended be used by County staff to evaluate projects affecting County-owned assets with respect to coastline area impacts. To develop the guidelines, SEWRPC conducted an inventory of existing conditions, including natural resources and urban development along the Milwaukee County Lake Michigan coastline; a review of existing municipal, State, and Federal coastline management guidelines/policies and best management practices; and an examination of trends in the stability of the Lake Michigan bluffs within the County. This process also involved community outreach through which the County was able to share information and gather feedback from municipal representatives and community stakeholders in regards to coastline management.

**Coastline Management Definitions**

For the purposes of this report, coastline management is defined as a means by which the County may mitigate coastline impacts, such as shoreline erosion or bluff recession.<sup>1</sup> Coastline management may incorporate structural or nonstructural measures. Examples of structural coastline management measures include retaining walls within a bluff slope, shoreline revetments, and breakwaters. Examples of nonstructural coastline management measures include regulations or guidelines for land uses or

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<sup>1</sup> *Definitions of coastline management terms used in this report are presented in Appendix A.*

development, such as promoting landscape management techniques that are appropriate for bluffs. Whether located on-shore or near off-shore, structural and nonstructural coastline management techniques are intended to mitigate or prevent damage from the impacts of coastline dynamics.

## **Coastline Dynamics<sup>2</sup>**

Coastlines are dynamic environments that are constantly changing under the influence of many factors, including natural processes and human activity. The impacts that factors have upon coastlines can vary significantly and may result in coastline changes that are abrupt and easy to see, as with bluff face failure, or discreet and gradual, as with lakebed erosion. Ultimately changes in bluff or beach shape depend on the feature's composition and how the feature handles various forms of water. Composition factors for coastal dynamics include geology, soil composition, and vegetation. Water factors for coastal dynamics, depicted in Figure 1.1, include Lake Michigan water levels, storms, stormwater runoff, and groundwater.

The potential impacts of coastline dynamics are contingent upon bluff and beach geology and soil composition, including glacial deposits. The properties of a coastline area's geology and soil influence the movement of stormwater and groundwater within that area and contribute to that area's resistance to variances in lake water levels and the erosive forces of waves. Soil properties also influence an area's ability to support different types of vegetation, which can stabilize the feature by intercepting precipitation, holding soil in place, and removing groundwater through transpiration. In addition, a bluff's soil composition affects its ability to hold its shape.

Lake Michigan water levels change at varying durations and water levels in the Great Lakes are primarily controlled by natural processes. Changes in Lake Michigan water levels occur seasonally, from year to year, and cyclically over decades, primarily due to changes in hydrology.<sup>3</sup> Over the course of one year, Lake Michigan water levels undergo regular seasonal fluctuations, with levels typically at their lowest in fall/early winter and at peak levels in summer.<sup>4</sup>

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<sup>2</sup> Numerous references were used to summarize coastal dynamics, including *Community Assistance Planning Report No. 163, A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin (SEWRPC 1989)*; *Living with the Lakes (Gauthier and Manninen, 1999)*; *Living on the Coast (Keillor 2003)*; *Managing Coastal Hazard Risks on Wisconsin's Dynamic Great Lakes Shoreline (Lulloff and Keillor 2016)*; and *Protecting Coastal Investments (Ohm 2016)*. Additional resources used to develop this report are listed in Appendix B.

<sup>3</sup> The net water supply to a lake is positive when the sum of water contributors, including precipitation, tributary rivers or streams, and groundwater flows, is greater than the amount of water lost via evaporation and outflows.

<sup>4</sup> See Figure B.1 in Appendix C for a historical depiction of such seasonal, annual, and cyclical changes in Lake Michigan water levels.

Storm influences on Lake Michigan water levels can include the impact of high wind events, also called storm surge or seiche. Storm impacts can also be influenced by the Lake Michigan water level. During periods of low water levels, the waters retreat from coastline bluffs and beaches, allowing newly exposed bluffs and beaches to foster vegetation or grow through substrate addition (accretion). With shallower waters along the shoreline, wave energy also dissipates within the nearshore lakebed, which protects the beach and bluffs. When Lake Michigan water levels rise, the water encroaches upon the shoreline and creates deeper waters closer to lakeside bluffs. As result, wave energy increases along the shoreline and the bluff toe and portions of the bluff slope can become exposed to breaking waves.

## **NEED FOR COASTLINE MANAGEMENT GUIDELINES**

Milwaukee County has a substantial interest in protecting County-owned assets along Lake Michigan. County-owned lakefront lands feature diverse, high-quality natural resources, support unique resource-oriented recreational opportunities, and provide access to exceptional views. As County-owned lakefront lands are also the site of municipally owned infrastructure, including storm sewers and outfalls, it is also in the County's interest to ensure that local governments can access and maintain such infrastructure in a manner that would not negatively impact County-owned coastline assets.

In the 1970s, high water levels in the Great Lakes caused widespread bluff recession and extensive damage to coastline property. The Wisconsin Coastal Management Program (WCMP) subsequently funded studies to identify areas susceptible to erosion and to examine potential structural and nonstructural approaches to mitigate coastline impacts.<sup>5</sup> The studies, which indicated that structural erosion control strategies generally did not prove practical or effective, called for nonstructural preventative approaches to protect facilities, infrastructure, and new development from coastline impacts. Several Wisconsin communities initiated such nonstructural preventative approaches after high and record-breaking Great Lakes water levels in 1985 and 1986, which caused extensive flooding, shoreline erosion, and significant property damage.<sup>6</sup> Subsequent

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<sup>5</sup> A.R. Lulloff and P. Keillor, *Managing Coastal Hazard Risks on Wisconsin's Dynamic Great Lakes Shoreline, Wisconsin Coastal Management Program, 2016.*

<sup>6</sup> K. Dolan and H. Hendrickson, *Protecting the Coastal Zone Through Growth Management: The Experience of Five Coastal States, National Network for Environmental Management Studies, 1989.*

studies found that nonstructural preventative approaches like guidelines for development and land and water management practices initiated by these communities effectively reduced the risk of coastline impacts.<sup>7</sup>

Water levels in the Great Lakes rose significantly again in 2019. As Lake Michigan water levels approached the lake's highest measured level, sections of bluffs along Milwaukee County's coastline collapsed. Bluff sloughs in Sheridan and Warnimont Parks carried away several trees and positioned infrastructure in the County-owned parks closer to the new bluff edge. These properties and others along Milwaukee County's lakefront are becoming increasingly vulnerable to coastline impacts. As indicated by the aforementioned studies and reports,<sup>8</sup> lakefront property may be best protected from future coastline impacts through the implementation of coastline management guidelines based upon best practices as identified in previous studies and analyses.

## **PURPOSE**

The purpose of this report is to establish a set of coastline management guidelines for Milwaukee County to utilize as follows:

- to maintain the unique coastline resources that support recreational opportunities within County-owned lakefront lands;
- to proactively manage the risks that coastline impacts present to the public, to County-owned assets, and to other publicly owned infrastructure;
- to mitigate adverse coastline impacts and protect County-owned assets adjacent to Lake Michigan;
- to standardize and expedite the process by which the County responds to local government requests to conduct land-disturbing activities while managing municipally owned infrastructure within County-owned lakefront lands;
- to address the interests of the public and owners of property in proximity to County-owned lakefront land in maintaining a view of Lake Michigan through County-owned land; and
- to prioritize programs and activities in a manner that accounts for the vulnerability and value of coastline resources and County-owned assets.

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<sup>7</sup> *International Joint Commission Levels Reference Study Board, Levels Reference Study: Great Lakes-St. Lawrence River Basin—Annex 2: Land Use and Management, 1993; National Research Council, Managing Coastal Erosion, 1990.*

<sup>8</sup> *Including Community Assistance Planning Report (CAPR) No. 155, A Lake Michigan Shoreline Erosion Management Plan for Northern Milwaukee County, Wisconsin (1988); CAPR No. 163, A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin (1989); and Memorandum Report No. 156, Lake Park Bluff Stability and Plant Community Assessment: 2003, Milwaukee County, Wisconsin (2004).*

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MILWAUKEE COUNTY COASTLINE MANAGEMENT GUIDELINES

**Section 2**

**INVENTORY**

**INTRODUCTION**

It is important to collect and collate sufficient amounts of pertinent information when devising strategies as part of a planning effort. Correspondingly, this report contains an inventory of numerous factors relevant to managing Milwaukee County's Lake Michigan coastline. As noted in Section 1 of this report, coastline areas are under the influence of numerous forces. Many of the factors and forces that influence the County's coastline are described within this inventory of natural resources and urban development. The Southeastern Wisconsin Regional Planning Commission maintains inventories of natural resources, land uses, and other existing conditions through the organization's regional planning programs. Critical inventory information for this Section came primarily from two reports prepared by the Regional Planning Commission: *A Lake Michigan Shoreline Erosion Management Plan for Northern Milwaukee County, Wisconsin*<sup>1</sup> and *A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin*,<sup>2</sup> which were developed with

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<sup>1</sup> SEWRPC Community Assistance Planning Report No. 155 (December 1988) was initiated upon the request of local communities within northern Milwaukee County.

<sup>2</sup> SEWRPC Community Assistance Planning Report No. 163 (October 1989) was initiated upon Milwaukee County's request.

the purpose of assisting public and private lakefront property owners by providing more definitive information and proper guidelines and procedures for protecting property from shoreline erosion. Supplemental existing conditions inventoried for this report include an account of municipal coastline management strategies as well as National and State efforts and best practices related to coastline management. This section also sets forth a summary of the community input process undertaken for the development of this report and the results of that process.

## **EXISTING CONDITIONS**

The geographical area inventoried for this report includes lands within the jurisdiction of nine municipalities that border Milwaukee County's Lake Michigan coastline. These municipalities include the Villages of Bayside, Fox Point, Shorewood, and Whitefish Bay and the Cities of Cudahy, Milwaukee, Oak Creek, St. Francis, and South Milwaukee. The study area utilized in this report, the Coastline Management Study Area, includes County-owned parcels located within 430 feet of the Milwaukee County Lake Michigan shoreline.<sup>3</sup>

Lands along the County's Lake Michigan coastline feature some of the best remaining natural resources in the County—many of which are within County-owned lands—intermixed with assorted urban development. Correspondingly, coastline management techniques vary along the County's Lake Michigan coastline from maintaining relatively natural bluff slopes and beaches with set-back development to establishing highly armored development with man-made defenses at the water's edge. An inventory of elements, including natural resources; urban development; factors influencing coastline stability; and coastline management policies, zoning, and design guidelines, relevant to coastline management along Milwaukee County's Lake Michigan coastline follows.

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<sup>3</sup> *The Coastline Management Study Area, established using a similar approach to that of the Milwaukee County Coastal Resources Inventory (discussed later in this Section), is determined using the Milwaukee County shoreline as of 2015.*

## **Natural Resources Inventory**

### ***Bedrock Geology, Glacial Deposits, and Soils***

Knowledge of bedrock geology, glacial deposits, and soils is important to land use and other public facility planning. Bedrock elevations along the Milwaukee County coastline<sup>4</sup> vary from 600 feet above sea level to fewer than 400 feet above sea level. The generalized depth to bedrock<sup>5</sup> ranges from 50 to 300 feet along the Milwaukee County coastline.<sup>6</sup> As the depth to bedrock varies, so does the thickness of glacial deposits covering the bedrock: expanses of the coastline where the bedrock is farthest from the land surface are filled with hundreds of feet of glacial deposits. The properties of glacial deposits, which influence the ability of bluffs to resist erosive processes, ultimately affect the severity and rate of bluff recession. Bluffs along the Milwaukee County coastline are largely composed of unconsolidated glacial till and glacial deposits consisting primarily of erodible sand and silt.

Like glacial deposits, soil properties also influence the ability of bluffs to withstand erosive force. Soil properties affect the rate and amount of stormwater runoff as well as the type of vegetative cover that the bluffs and coastline can support—thereby affecting the severity of surface erosion on the face, and at the top, of the bluffs. Glacial deposits and soil properties are also important considerations in the evaluation of shallow groundwater seepage from the bluff face, which can play a significant role in bluff stability.

### ***Surface Water Resources***

Surface water resources, which include lakes and streams, constitute a particularly valuable element of the natural resource base; such resources enhance the County's aesthetic quality, influence the County's physical development, and provide valuable recreational opportunities. The primary surface water feature relative to the Milwaukee County coastline is Lake Michigan, which makes up the entire eastern boundary of the County. The Lake Michigan shoreline through Milwaukee County, which measures approximately 32

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<sup>4</sup> *Bedrock elevations for Southeastern Wisconsin are documented in SEWRPC Technical Report No. 37, Groundwater Resources of Southeastern Wisconsin (June 2002).*

<sup>5</sup> *Generalized depth to bedrock in the Southeastern Wisconsin Region is documented in SEWRPC Technical Report No. 37, Groundwater Resources of Southeastern Wisconsin (June 2002)*

<sup>6</sup> *It should be noted that actual depth-to-bedrock information for specific localities can only be verified by onsite drilling.*

miles in length, was an early focus for County parkland acquisition and the major focus of water-related activities in the County.

The State of Wisconsin holds navigable water in trust for the public under the Public Trust Doctrine. However, the State Legislature can authorize a lake bed grant through special legislation to convey defined areas of lake bed lands to specified local units of government for clearly defined public purposes, such as a park or beach or for navigation. Any facilities constructed on lakebed grant areas must be widely available to the public and support the primary purpose for which the State Legislature made the grant. As of 2015, the County had authority over the lakebed lands along approximately 22.5 linear miles of Milwaukee County's 32-mile Lake Michigan coastline.<sup>7</sup>

As shown on Map 2.1, surface water resources also include minor natural and man-made lakes and ponds ranging from five to 49 acres in size,<sup>8</sup> most of which are park lagoons within County-owned lands. The County's coastline area also features four major streams, or streams that maintain, at a minimum, a small continuous flow throughout the year—except under unusual drought conditions. These major streams include Oak Creek and the Kinnickinnic, Menomonee, and Milwaukee Rivers, which comprise a majority of Milwaukee County's parkway system.

Each of the major streams within the County's coastline area defines a major watershed, including the Oak Creek Watershed and the Kinnickinnic River, Menomonee River, and Milwaukee River Watersheds, and are tributary to Lake Michigan. Also tributary to Lake Michigan are the numerous smaller natural watercourses and artificial drainageways within localized catchment areas. Watersheds and tributaries play an important role in relation to coastlines: watershed drainage contributes to the particles in coastal waters that help supply beach materials, tributary waterways form gullies and ravines at the bluff edge, and runoff that flows directly into coastal waters can erode materials from coastline bluffs.

Surface waters are susceptible to degradation through improper land use development and management. Water quality can be degraded by excessive pollutant loads, including nutrient loads; from sanitary sewer

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<sup>7</sup> *The City of Milwaukee has authority over 2.8 miles of Milwaukee County's Lake Michigan coastline and the State of Wisconsin maintains sole authority of the remaining 2.3 miles.*

<sup>8</sup> *Major lakes, lakes of 50 acres or more, are typically part of a surface water resource inventory but there are no such lakes within Milwaukee County.*

overflows; and from construction and other urban runoff (e.g., sediment, road salt, heavy metals, oil, and trash).<sup>9</sup> Surface water quality may also be adversely affected by the excessive development of riparian areas, streambank failure, the filling of wetlands,<sup>10</sup> and by coastal beach and bluff erosion, which can contribute substantial amounts of sediment to coastal waters. Thus, it is important that existing and future development in riparian areas and wetland buffer areas be managed carefully to avoid further water quality degradation and to enhance the recreational and aesthetic values of surface water resources.

### **Floodplains**

Floodplains are the wide, gently sloping areas contiguous to, and usually lying on both sides of, a stream or river channel, often containing wetlands. For planning and regulatory purposes, floodplains are normally defined as the areas adjacent to rivers, streams, and lakes that are inundated during the 1-percent-annual-probability (100-year recurrence interval) flood event. Floodplain areas often contain important natural resources, such as high-value riparian woodlands, wetlands, and refuges for wildlife, and, therefore, are compatible with nature-based uses for park and open space uses, such as hiking, bird watching, and nature study.<sup>11</sup>

Floodplain mapping for Milwaukee County was updated as part of a Federal Emergency Management Agency (FEMA) "Map Modernization Program." The updated maps were approved by the Wisconsin Department of Natural Resources (WDNR) and FEMA in 2008. Minor revisions were made to the maps in 2009. Map 2.1 depicts floodplains as identified in the FEMA mapping in 2009. As shown on the map, floodplains extend along the County's entire Lake Michigan coastline.

### **Wetlands**

Wetlands are important resources for the ecological health and diversity of the County. They can support a significant diversity of flora and fauna and provide essential breeding, resting, and feeding grounds and escape cover for many forms of fish and wildlife. Wetlands trap sediments, nutrients, and other water pollutants, helping to protect water resources from siltation and pollution. In addition, wetlands naturally

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<sup>9</sup> *It may be noted that many park lagoons within County-owned lands are in an ecologically compromised state, suffering from excessive nutrients, sedimentation, aquatic invasive species, and low biological oxygen levels, which restricts recreational fishing opportunities.*

<sup>10</sup> *The filling of wetlands removes valuable nutrient and sediment traps while adding nutrient and sediment sources.*

<sup>11</sup> *Floodplain areas are generally not well suited to urban development, not only because of the flood hazard, but also because of the presence of high water tables and, generally, of soils poorly suited to urban uses.*

store excess runoff temporarily, contributing to the stabilization of lake levels and streamflows and flood mitigation by providing areas for floodwater impoundment and storage.

Additional advantages are provided by coastal wetlands, which are differentiated by their location alongside a waterbody. Great Lakes coastal wetlands can help to protect the coastline and coastline properties. As wave energy dissipates within vegetated coastal wetlands, the coastline may be protected from potentially erosive damage associated with storm surges and high water levels.

Map 2.1 shows the location and extent of wetlands in the County,<sup>12</sup> including coastal wetlands, in 2015. Numerous permanent wetland types<sup>13</sup> are found within County-owned parks, one of which—the Warnimont Bluff Fens in Warnimont Park—has been designated a “Wetland Gem” by the Wisconsin Wetland Association.<sup>14</sup>

### **Groundwater Resources**

Surface water and groundwater are interrelated components of a single hydrologic system. In Milwaukee County, groundwater resources often provide the base flow of streams and sustain wetland and surface water levels. Groundwater resources also serve to moderate water temperatures, promote water quality, and support fish and aquatic life habitat. As groundwater is susceptible to deterioration in quality and to depletion in quantity as a result of contamination and overuse, the protection of this valuable resource is an important consideration for any land use planning and policy development effort.

Along the Milwaukee County coastline, groundwater generally flows toward the lake and discharges into Lake Michigan either at, or below, the base of the bluff, or seeps out of the bluff face at some elevation above the Lake’s water level. While groundwater inflow represents an important portion of the total water budget of Lake Michigan, the occurrence, distribution, direction, and quantity of groundwater flow impact the stability of bluff slopes. As certain unconsolidated glacial deposits within the study area may act as water-bearing units, the presence of groundwater and seepage pressure in the direction of groundwater

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<sup>12</sup> As delineated by the Southeastern Wisconsin Regional Planning Commission (SEWRPC).

<sup>13</sup> As defined by the Wisconsin Department of Natural Resources (WDNR).

<sup>14</sup> “Wetland Gems” are considered to be critically important to the State’s biodiversity.

flow can add weight to the bluff and reduce the frictional resistance of the bluff to stress forces thereby reducing bluff slope stability.

### **Woodlands**

Woodlands are defined as those upland areas one acre or more in size having 17 or more deciduous trees per acre, each measuring at least four inches in diameter at breast height, and having 50 percent or more tree canopy coverage.<sup>15</sup> Under good management, woodlands can serve a variety of beneficial functions, including reducing heat islands and improving air and water quality. Woodlands provide an attractive natural resource, immeasurable scenic beauty, and recreational opportunities. In addition, woodlands contribute to sustaining a diversity of plant and animal life by providing flora and fauna habitat.

As shown in Map 2.2, woodlands occur in scattered locations throughout the Coastline Management Study Area. Existing woodlands in the County, many of which required a century or more to develop, could be destroyed through mismanagement or by invasive species within a comparatively short time period. The destruction of woodlands along hillsides, ravines, and bluff areas contributes to rapid stormwater runoff, the sedimentation of lakes and streams, bluff failure, and the destruction of wildlife habitat.

### **Bluffs and Ravines**

Bluffs and the ravine systems that cut through the bluffs adjacent to Lake Michigan make up regionally rare ecological and landscape features. Bluffs and ravines create unique microclimates that allow more northerly orientated species of flora and fauna to persist farther south in Wisconsin than is typical for the rest of the State. It has been well documented that Milwaukee County falls within Wisconsin's Ecological Tension Zone, an area of mixing for northern and southern ecosystems, due to the presence of Lake Michigan and its ability to moderate local climate conditions. The majority of the ravines in the County are located within the following County-owned parks: Bender, Doctors, Grant, Lake, and Warnimont Parks. These parks, along with Bay View and Sheridan Parks, also contain the largest and tallest bluffs in the County.

The bluffs along Milwaukee County's Lake Michigan coastline exhibit a variety of height, slope, composition, vegetative cover, and groundwater conditions, which affect the degree and rate of bluff recession. Field

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<sup>15</sup> *Coniferous tree plantations and reforestation projects are also classified as woodlands.*

surveys conducted to measure the geometry of the bluff slope in 1995<sup>16</sup> indicated that bluff heights along the Milwaukee County coastline ranged from approximately 25 feet to 140 feet. Bluffs within the northern and southern extents of the County were higher than the central portion of the County, where conditions ranged from the absence of natural bluffs to bluffs of up to 25 feet in height.

While bluffs and ravines define and shape the coastline, they are also natural features that are continually changing under the influence of natural forces such as wind and water. Various factors that contribute to bluff and ravine erosion include wave action, groundwater seepage, precipitation runoff, lake level elevation, freeze-thaw action, lake ice movement, and the type of vegetative cover. Ravines incorporated into municipal infrastructure systems, which aggregate and convey stormwater within a watershed to a nearby waterbody, and bluffs with stormwater outfalls, where stormwater is deposited in a nearby waterbody, are particularly susceptible. As stormwater systems efficiently convey large volumes of water through ravines and along bluffs, stormwater runoff and ravine water volumes increase with increases in impervious surfaces due to urban development and exacerbate erosion.

### ***Natural Areas, Critical Species Habitat Sites, and Geological Sites***

Natural and geological resources in the Region are inventoried by the Southeastern Wisconsin Regional Planning Commission as part of the regional natural areas and critical species habitat protection and management planning program.<sup>17</sup> The comprehensive inventory systemically identifies high-quality natural areas, critical species habitat sites, and sites having geological significance as defined by the Regional Planning Commission. Natural areas, critical species habitat sites, and significant geological sites along Milwaukee County's Lake Michigan coastline as of 2009 are shown on Map 2.3. This inventory is likely to grow to reflect additional occurrences of endangered or threatened species or species of special concern<sup>18</sup> that were documented within County-owned parks during extensive surveys conducted by Milwaukee County Parks staff since 2010.

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<sup>16</sup> Conducted at 192 sites to provide a basis for site-specific assessments of the bluff conditions as part of SEWRPC Technical Report No. 36, Lake Michigan Shoreline Recession and Bluff Stability in Southeastern Wisconsin: 1995.

<sup>17</sup> SEWRPC's inventory of natural and geological resources was initially conducted in 1994 and updated in 2009 as part of the regional natural areas and critical species habitat protection and management plan.

<sup>18</sup> As listed by the State of Wisconsin or the Federal government.

### Natural Areas

Natural areas are tracts of land or water so little modified by human activity, or sufficiently recovered from the effects of such activity, that they contain intact native flora and fauna communities believed to be representative of the landscape before European settlement. Natural areas are classified into one of three categories: natural areas of statewide or greater significance (NA-1), natural areas of countywide or regional significance (NA-2), and natural areas of local significance (NA-3).<sup>19</sup> Natural areas along Milwaukee County's Lake Michigan coastline as of 2009, which together encompassed 185 acres, are listed in Table 2.1.

### Critical Species Habitat Sites

Critical species habitat sites are sites located outside of natural areas where the chief value lies in the site's ability to support rare, threatened, or endangered species. Such sites constitute critical habitat that is important to ensure survival of a particular species or group of species of special concern. Critical species habitat sites along Milwaukee County's Lake Michigan coastline as presented in the 2009 update to regional natural areas plan are depicted on Map 2.3 and listed in Table 2.1.

Aside from sites identified under the regional natural areas planning program, additional significant habitat resources have also been identified within County-owned park and open space sites. Such sites are notable for supporting "species of greatest conservation need" for at least a portion of their lifecycles. As classified by the WDNR, species of greatest conservation need are species with low abundance and/or distribution within their natural range as well as declining species that demonstrate downward trends in their populations or habitat even though they may currently be well distributed, common, or abundant in part or all of their range. The WDNR lists species of greatest conservation need in the State-wide wildlife action plan.<sup>20</sup>

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<sup>19</sup> *Classification of an area into one of these three categories is based upon consideration of the diversity of plant and animal species and community types present; the structure and integrity of the native flora and fauna community; the extent of disturbance from human activity, such as logging, agricultural use, and pollution; the commonness of the plant and animal community; unique natural features; the size of the site; and the educational value of the site.*

<sup>20</sup> *Wisconsin Department of Natural Resources, Wisconsin Wildlife Action Plan: 2015-2025, 2015.*

### Flora and Fauna Resources

County-owned parks play a major role as a repository for Milwaukee County's remaining biodiversity. Extensive surveys conducted by Milwaukee County Parks staff have documented numerous flora and fauna species of concern using resources within County-owned parks. As the surveys have only been conducted for 30 percent of eligible areas, additional flora and fauna species may have yet to be documented using resources within County-owned parks. Without the proper management of such areas and the resources within them, or with the loss of buffer lands around those areas, many species of flora and fauna could become more vulnerable to genetic isolation, ecological degradation, and, ultimately, local extinction.

### Significant Geological Sites

Significant geological sites are identified on the basis of scientific importance, significance in industrial history, natural aesthetics, ecological qualities, educational value, and public access potential. Sites of geological importance are classified as being of statewide significance (GA-1), of countywide or regional significance (GA-2), or of local significance (GA-3). Significant geological sites identified along the Milwaukee County coastline as of 2009 are shown on Map 2.3 and listed in Table 2.1.

### ***Environmental Corridors and Isolated Natural Resource Areas***

Identifying areas in which concentrations of the best remaining elements of the natural resource base occur is one of the most important tasks the Commission carries out under the regional planning program. These important, high-value elements of the natural resource base, many of which are described in preceding parts of this inventory, include rivers, streams, lakes and associated riparian buffers and floodplains; wetlands; woodlands; prairies; wildlife habitat areas; wet, poorly drained, and organic soils; and rugged terrain and high relief topography. The presence of natural resource-related features, including park and open space sites, natural areas, historic sites, and scenic viewpoints, are also considered in distinguishing such areas. When distinguished on a map, these natural resource and resource-related elements form an essentially linear pattern of relatively narrow and elongated areas that have been termed "environmental corridors" by the Regional Planning Commission. Environmental corridors and isolated natural resource areas along Milwaukee County's Lake Michigan coastline are shown on Map 2.4.

Environmental corridors and isolated natural resource areas and the resources that they contain serve many beneficial purposes. Lands within environmental corridors and isolated natural resource areas can serve to store flood waters away from developed areas and promote water quality by filtering runoff before it enters

surface waters. Such lands also provide wildlife habitat and dispersal corridors for the movement of wildlife.<sup>21</sup> Environmental corridors and isolated natural resource areas contribute to the natural heritage and beauty of the Region and provide recreational opportunities in scenic outdoor settings. The preservation of such areas in essentially natural, open uses is vital to maintaining a high level of environmental quality and quality of life in the Region.

### Environmental Corridors

Environmental corridors contain concentrations of important, high-value natural resource elements that often form a linear pattern of relatively narrow, elongated areas in the landscape. Primary environmental corridors, which contain a variety of the aforementioned elements and natural resource-related features, are at least 400 acres in size, two miles in length, and 200 feet in width.<sup>22</sup> Significant portions of Milwaukee County's Lake Michigan coastline are classified as a primary environmental corridors.<sup>23</sup> These primary environmental corridors contain a composite of some of the County's best remaining woodlands, wetlands, and wildlife habitat areas—and have immeasurable environmental and recreational value.

### Isolated Natural Resource Areas

Isolated natural resource areas also contain concentrations of important, high-value natural resource elements albeit within a smaller area than an environmental corridor. Isolated natural resource areas range from five to 100 acres in size and are physically separated from primary environmental corridors. Isolated natural resource areas may provide the only available wildlife habitat within the vicinity, lend natural diversity and aesthetic character, and serve as good locations for park or open space uses. Isolated natural resource areas along Milwaukee County's Lake Michigan coastline include a variety of isolated wetlands, woodlands, and wildlife habitat areas.

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<sup>21</sup> As noted in the 1989 Lake Michigan shoreline erosion management plan for Milwaukee County, many of the bluffs, parks, and other open areas along the County's coastline constitute significant wildlife habitat areas—providing important habitat for migrating birds along the Mississippi flyway.

<sup>22</sup> As of 2015, the study area did not contain any secondary environmental corridors, which contain concentrations of important, high-value natural resource elements and have significant environmental and recreational value like primary environmental corridors but are smaller in area—encompassing at least 100 acres in size and one mile in length.

<sup>23</sup> Other areas classified as primary environmental corridors in Milwaukee County—many of which are within County-owned park and open space sites—are located along major rivers and their tributaries and in large wetland areas.

## **Urban Development Inventory**

The significant value of Milwaukee County's Lake Michigan coastline extends well-beyond the extents of the study area. The coastline provides a unique setting for development and opportunities that attract users from throughout the greater Milwaukee area. The County's Lake Michigan coastline is of enormous value in regards to both the economy and quality of life within Milwaukee County and the Southeastern Wisconsin Region. It is therefore important to take into account how coastline management can be implemented to maintain a desirable and usable shoreline for private property owners as well as for the general public.

## **Land Use**

Urban development along Milwaukee County's Lake Michigan coastline was initially devoted primarily to handling waterborne commerce, with later coastline development for boating facilities, residential use, industrial use, and park and open space. As shown on Map 2.2, which depicts generalized land use<sup>24</sup> along the Milwaukee County coastline, the most prevalent land uses as of 2015 were residential uses, open space, recreational uses, and woodlands. Residential uses in proximity to the County's Lake Michigan boundary are primarily single-family and are concentrated within the northern and southern extents of the County within the Villages of Bayside, Fox Point, Shorewood, and Whitefish Bay and the Cities of Cudahy and South Milwaukee. Multi-family residential uses are concentrated within the Cities of Milwaukee and St. Francis.

As previously noted, intermixed with urban development along Milwaukee County's Lake Michigan coastline are some of the best remaining natural resources in the County—many of which are within County-owned park and open space sites. County-owned parks account for a significant proportion of the recreational lands along Milwaukee County's Lake Michigan border. These parklands include approximately 382 acres within Lake Michigan North, a cluster of parks comprised of Back Bay, Bradford Beach, and Juneau, Lake Park, McKinley, and Veterans Parks; approximately 856 acres within Lake Michigan South, which is comprised of Bay View, Cupertino, Grant, Sheridan, South Shore, and Warnimont Parks; as well as additional scattered County-owned parks, including Big Bay Park, Bender Park, and Doctors/Tietjen Park, which together amount to approximately 367 acres.

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<sup>24</sup> *The 2015 land use inventory is generalized to account for differences in the land use categories used by the nineteen municipalities with the County.*

## ***Infrastructure***

### Port Milwaukee

Port Milwaukee is a County-owned multi-modal transportation and distribution center located near the confluence of the Kinnickinnic, Menomonee, and Milwaukee Rivers that supports domestic and international supply chains. The Port features a total of 18 berths to serve vessels and barges, direct connections to Interstate Highway 794/94 (IH 794/IH 94) and to the Union Pacific (UP) and Canadian Pacific (CP) Railways, and is the only Lake Michigan port Federally approved to access the Mississippi River inland waterway system. In 2020, the Port handled approximately 2.3 million metric tons of cargo, playing a significant role in supporting the local, regional, and State economy.

Coastline dynamics can have significant direct impacts on Port operations. Water levels are an important consideration for Port operations. Cargo restrictions may be required during low water levels in order to ensure that berths can service vessels. High water levels can expose berths, terminals, other Port infrastructure, vessels, and cargo to damage from flooding, the extent of which can be drastically increased during periods of stronger wave action and/or extreme weather events.

### Stormwater Infrastructure

Numerous communities along Milwaukee County's coastline utilize stormwater drainage systems designed to efficiently carry large amounts of stormwater that discharge into Lake Michigan. In such cases, precipitation and other runoff intercepted from impervious surfaces is directed into stormwater sewer systems that discharge into the Lake via outfalls located along the coastline.

Stormwater infrastructure that discharges into the Lake can be potentially damaging to the coastline and is susceptible to damage from coastline impacts. Negative impacts from such outfalls include declines in water quality and erosion. These impacts can be exacerbated during periods of heavy rainfall as high amounts of stormwater, the volume of which fluctuates with the amount of precipitation collected in a stormwater system, may be conveyed and discharged over relatively short time spans. Increases in water volume and speed can significantly increase the erosive impact of stormwater discharge. In addition, stormwater infrastructure can be susceptible to potential damage from coastline impacts particularly as result of high water levels in the Lake. High lake levels can flood an outfall and cause debris to enter stormwater infrastructure, or subject stormwater infrastructure to damage from erosion around outfalls. The general locations of outfalls in Milwaukee County that discharge into Lake Michigan are shown on Map 2.5.

### ***Historic Sites and Districts***

The City of Milwaukee and municipalities to the north contain residential uses that are designated as historic sites and/or exist within a historic district.<sup>25</sup> These sites and districts are shown on Map 2.6 and listed on Table 2.2. Historic sites and districts within the Lake Michigan Coastline Management Area often have important recreational, educational, and cultural value. Preserving these sites and districts helps to retain historic elements that give an area a distinctive identity and may provide tangible benefits, such as stabilizing property values and encouraging overall neighborhood improvement. It is important that coastline protection measures are sensitive to historic considerations in order to avoid adversely affecting the aesthetic qualities, vistas, and coastline uses historically and traditionally enjoyed by area residents.

### **Current Coastline Stabilization Activities and Practices**

#### ***National and State Coastline Management Efforts***

The U.S. Army Corps of Engineers (USACE), which has been involved in civil works projects in the Nation's coastal zones since its establishment in 1802, began conducting research on coastal processes in 1930.<sup>26</sup> Since formalizing the Federal government's role in unifying and coordinating the coastal management efforts of multiple states with coastal resources, USACE has become a leading environmental preservation and restoration agency that maintains a rigorous research and development program in support of water resources. USACE's Chicago District now has jurisdiction for Wisconsin's entire Great Lakes coastline, providing technical expertise and assistance to address coastline impacts like erosion and flooding.

Passage of the Coastal Zone Management Act in 1972 established the National Coastal Management Program (NCMP), whose mission is to ensure the conservation and responsible use of the Nation's coastal resources. The voluntary program instituted a means by which states with coastal resources (including Great Lakes states), local governments, and other partners may access Federal funding for implementing coastal management programs. State and local governments and other partners meeting basic requirements are given the flexibility to design unique programs that best address their coastal challenges. The program encourages partnering governments and organizations to develop and implement coastal zone

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<sup>25</sup> *A historic site is a property that was the location of a significant event, activity, building, structure, or archaeological resource; a historic district is a geographically definable area possessing a significant concentration, linkage, or continuity of sites, buildings, or structures that are united by plan or by physical development.*

<sup>26</sup> *J.R. Houston, Coastal Engineering Research in the Corps of Engineers. Journal of Coastal Research, Vol. 4, No. 2 (Spring 1988).*

management plans with the goal of preserving, protecting, developing, and, where possible, restoring or enhancing coastal communities and resources.

In 1978, the Wisconsin Coastal Management Program (WCMP) was established under the NCMP with the following objectives:

- To improve the implementation and enforcement of existing state regulatory and management policies and programs affecting key coastal uses and areas;
- To improve the coordination of existing policies and activities of governmental units and planning agencies on matters affecting key coastal uses and areas;
- To strengthen local governmental capabilities to initiate and continue effective coastal management consistent with identified state standards and criteria;
- To provide a strong voice to advocate for the wise and balanced use of the coastal environment and for the recognition of the uniqueness of the coastal environment in federal, state, and local policies; and
- To increase public awareness and opportunity for citizens to participate in decisions affecting the Great Lakes resources.

To meet these objectives, WCMP has developed numerous resources, including a review of publicly-funded coastal erosion and shore protection studies done in Wisconsin from 1930 to 2007<sup>27</sup> and informative publications on coastline dynamics focused on protecting coastline property.<sup>28</sup> While guidance on coastline management strategies has evolved since the inception of the NCMP, Federal and State recommendations present best practices that account for the benefits and challenges presented by a variety of coastline management measures.

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<sup>27</sup> P. Keillor, *Modern Studies of Coastal Erosion in Wisconsin, Wisconsin Coastal Management Program, 2011.*

<sup>28</sup> *Such documents include Living with the Coast (2003) and Adapting to a Changing Coast (2016).*

## Recommended Best Practices

### *Low-Impact Adaptive Practices*

A crucial approach to low-impact coastline management is adapting to natural coastal processes, which ultimately requires a property owner to recognize that development cannot be protected from coastline dynamics indefinitely. It is vital for coastline property owners to be familiar with their property in relation to key reference points, including the shoreline, which is generally the water's edge or ordinary high-water mark (OHWM),<sup>29</sup> accounting for lake level; and bluff features, including the location of the bluff toe, crest, and height. As lakeside land is constantly under the influence of coastline dynamics, these initial reference points are certain to change but may help property owners to place development at a setback from the bluff and shoreline that provides a protective buffer during the course of that development's useful life.<sup>30</sup>

Another low-impact practice is recognizing the impacts of vegetation on coastline property. Vegetation can stabilize a property's lakeside area between development and the coastline bluff by intercepting precipitation, holding soil in place, and removing groundwater through transpiration. However, vegetation may detract from the lake view—often a preferred feature of lakeside property—for development set back from the bluff. Thus, in developing a lakeside property, it is advisable to maintain beneficial vegetation while providing a lake view via a detached, semi-permanent structure located closer to the bluff crest. Designing such a structure that can be relocated relatively easily is considered a low-impact practice for its ability to avert coastline alterations. Similar low-impact coastline management methods include relocating existing structures threatened by coastal impacts and constructing homes that can be easily moved, as with modular construction. It should also be noted that adapting to natural coastal processes may entail forgoing the occupation of a structure on or the development of a property threatened by coastal impacts.

### *Promoting Bluff Stability*

Federal and State guidelines also recommend multiple methods of promoting bluff stability as means of managing coastline impacts. One such method is to regrade coastline bluffs to create a gradual slope. Another bluff stability practice is to prevent stormwater from flowing over the bluff. Stormwater from precipitation and snowmelt, which increases with development of impervious surfaces, can erode the bluff

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<sup>29</sup> As defined by the Wisconsin Supreme Court in 1914, the OHWM is defined as "the point on the bank or shore up to which the presence and action of the water is so continuous as to leave a distinct mark either by erosion, destruction of terrestrial vegetation or other easily recognized characteristic."

<sup>30</sup> Additional information relating to such setbacks is set forth in Section 3 of this report.

top and bluff face and affect bluff stability. Managing stormwater on site in a manner that prevents runoff from flowing over the bluff top or face can mitigate stormwater impacts to bluffs.

At the same time, negative impacts to bluff stability can occur as stormwater infiltration increases within a coastline property. Increases in stormwater infiltration can raise groundwater levels and magnify the negative impacts of seeps and springs. Bluff stability practices therefore also include managing infiltration and groundwater levels on coastline property. Utilizing bluff dewatering drainage systems and planting or maintaining appropriate vegetation are some techniques for moderating groundwater levels. Bluff stability is also improved through protection of the bluff toe and shoreline, as through natural shoreline protection techniques.

#### *Nature-Based Shore Protection*

Federal and State guidance recommending the restoration of natural shoreline defenses include shore protection measures like the creation of artificial beaches or nourishment of existing beaches and the establishment of living revetments and living seawalls<sup>31</sup>. Creating artificial beaches and nourishing existing beaches can help protect the coastline by reducing wave energy and by providing sediment that the lake can transport to accumulate on other beaches. Artificial and nourished beaches may retain sand by incorporating vegetation or other obstructions, such as dune grass or fencing. Living revetments and living seawalls also incorporate vegetation, such as native wetland plants, for the establishment or restoration of coastal wetlands.

#### *Structural Shore Protection*

Federal and State guidance recommend structural shore protection methods as a last resort and primarily to prevent damage to structures that would be challenging to relocate or replace. Shore protection structures should be site-specific and designed by an experienced professional. Examples of structural shore protection methods include armoring of the lakebed, which entails the piling of submerged stone nearshore parallel to the coastline to dissipate wave energy. Additional structural coastline management measures include shore-parallel structures, such as revetments, seawalls, and breakwaters, and shore-perpendicular structures, such as jetties and groins. Revetments, which are sloped piles of stone or concrete, and seawalls,

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<sup>31</sup> *Living revetments and living seawalls are much like traditional revetments and seawalls, which are described with coastline management terminology in Appendix A in their objective to help prevent shoreline and bluff toe erosion.*

which include more accessible vertical or sloped structures, are protective hardscapes that deflect wave energy at the water's edge. Breakwaters, on the other hand, are hardscaped structures situated offshore. Groins and jetties, which may be constructed of stone, concrete, or other materials, extend from the land into the water with the purpose of inhibiting littoral drift, or the movement of sediment along the water's edge.

Federal and State guidance also recommend inspecting and improving existing protective structures. Structures that have issues or provide inadequate protection may be repairable or may provide salvageable materials for better coastline management applications. Due to their potential to adversely affect nearby coastline areas and their susceptibility to failure as result of natural forces, structural shore protection measures are less favorable solutions compared to other coastline management measures.

### ***Coastline Management in Milwaukee County***

In 2020, Milwaukee County completed a comprehensive study identifying its coastal resources, including facilities, assets, and infrastructure, to assess their vulnerability to extreme weather. The study was funded by a coastal resilience grant from the National Oceanic and Atmospheric Administration (NOAA), administered by WCMP, aimed at helping the County to plan and prepare for hazards like shoreline recession, bluff failure, beach erosion, coastal flooding, and damage to waterfront infrastructure. An important step initiating the County's preparedness for extreme weather events, the study may also be of value as the County pursues additional grants related to coastline management, which may promote increased State and Federal investment in funding coastline management projects within the County.

Shoreline protection structures, erosion control measures intended to reduce coastal erosion, are among the County's assets inventoried in the study. Such structures provide an artificial protective barrier against direct wave and ice attacks on the beach and bluff toe, increase the extent of the beach to absorb wave energy by dissipating wave energy, and/or by stabilizing bluff slopes. Shoreline protection structures inventoried in the study, including breakwaters, bulkheads, groins, and revetments (or rip rap), are shown on Map 2.8 and summarized in Table 2.3. As shown on the map, Grant and Warnimont Parks have the least structural shoreline protection. However, while numerous groins adorn the Sheridan Park shoreline, Sheridan and Warnimont Parks suffered extensive damage in 2019. This contrast can be attributed, at least in part, to the potential for shore protection structures to adversely affect nearby coastline areas or to otherwise fail during extreme weather events or high lake levels.

### Trends in Coastline Stability

The features and composition of Milwaukee County's Lake Michigan coastline are significant factors in the coastline's stability, which can be compromised by beach or bluff erosion. In addition to detailed information on the natural resources presented in this inventory, the 1989 Milwaukee County shoreline erosion management plan contains field surveys and a stability analysis of the County's coastline that describe coastline erosion and trends in coastline stability. Though coastline characteristics, like beach widths and slopes, have evolved since field surveys were conducted for the 1989 plan due to coastline dynamics, the plan's inventory and analysis are critical to understanding the County's current coastline conditions.

Bluff and beach erosion are the primary forms of erosion occurring along the Milwaukee County Lake Michigan coastline. Factors that contribute to bluff instability and bluff and beach erosion include wave action, groundwater seepage, and stormwater runoff. The impact of these factors is dependent on the composition of and vegetation present on bluffs and beaches as well as the presence of any shore protection structures<sup>33</sup> and can be exacerbated by fluctuations in lake levels, freeze-thaw weathering, and land disturbance caused by human activity.<sup>34</sup> Lakebed erosion, or downcutting, contributes to bluff toe erosion along the Milwaukee County coastline and is exacerbated by changes in lake levels. As nearshore sand and sediment are carried away by wave action, the lakebed becomes exposed to turbulent waters that wear away and deepen the lake bottom.

Bluff slope failure along the Milwaukee County Lake Michigan coastline can occur in a variety of manners. The two most common forms of bluff slope failure in the County are translational slides and rotational slides. Translational slides occur when a single mass or a few closely related masses of soil or rock move quickly downslope in a planar manner. Rotational slides (or slumps) are classified as a soil mass with a curved rupture surface moving slowly downslope. Bluff slope failures in the County also occur as creeping, sloughing, and solifluction.<sup>35</sup> A proportionately small part of the County's coastline is subject to rock or soil fall, which is associated with extreme undercutting and near-vertical cliffs. Beaches along the Milwaukee

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<sup>33</sup> *While shore protection measures can mitigate the impact of wave action, it should be noted that wave action combined with high lake levels can damage shore protection measures such as revetments, bulkheads, breakwaters, and groins.*

<sup>34</sup> *Such land-disturbing activities may include—but are not limited to—landscape management, the removal of invasive species, accessing infrastructure, and constructing permanent structures or other facilities.*

<sup>35</sup> *See Appendix A for definitions of coastline terminology.*

County coastline are subject to erosion via littoral drift, where coastline sediment is transported via longshore currents.<sup>36</sup>

The County's Lake Michigan bluffs experience occasional and sometimes massive recession. Extreme weather—and high lake levels—exacerbate bluff recession and can cause severe damage to the County's coastline. One SEWRPC report<sup>37</sup> documents recession rates in the County averaging up to approximately 13 feet annually between 1963 and 1985,<sup>38</sup> which resulted in an average annual loss of nearly 330,000 cubic yards of shore material and about 2.7 acres of land. In 1985 and 1986, record-breaking water levels in Lake Michigan<sup>39</sup> caused extensive flooding, shoreline erosion, and significant property damage. A subsequent report<sup>40</sup> documented average bluff recession rates of 10 feet annually between 1963 and 1995, including recession rates associated with major storm events as high as 100 feet per year. As Lake Michigan water levels rose significantly again in 2019, sections of bluffs along Milwaukee County's coastline collapsed with bluff sloughs in Sheridan and Warnimont Parks carrying away trees and positioning County-owned infrastructure in the parks closer to the new bluff edge. County-owned parks suffered damage estimated at more than \$8 million in January 2020 due to a major storm event with high waves and record-breaking Lake Michigan water levels.<sup>41</sup> Lake Michigan's water level continued to exceed the maximum average monthly water level documented over the previous 100 years for nine continuous months through August 2020.

The approximate location of the bluff crest and toe along the Milwaukee County Lake Michigan coastline as of 2015 is shown in Map 2.7.<sup>42</sup> With high and rapidly changing lake levels anticipated in the future, it is important to continue to monitor and assess bluff stability as extreme weather events are expected to continue to occur in the future, potentially with increased severity due to the effects of climate change.

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<sup>36</sup> While longshore currents within the County's coastal zone may move northerly or southerly in response to the direction of the incident waves, the net sediment transport along the County's coastline is southerly. Thus, beaches in the County exhibit accretion on the north side of groins, piers, and other structures while erosion occurs on the southerly side of such structures. As noted in CAPR No. 163, the net transport rate of littoral materials southward along the Milwaukee County shoreline is estimated at 8,000 cubic yards annually.

<sup>37</sup> SEWRPC Community Assistance Planning Report No. 163.

<sup>38</sup> The average incorporated bluff crest recession measurements and shoreline recession measurements for the portions of the County coastline without bluffs.

<sup>39</sup> USACE provides vital public engineering and planning services to reduce risks from disasters and has measuring Great Lakes water levels since 1918.

<sup>40</sup> SEWRPC Technical Report No. 36.

<sup>41</sup> It is estimated that Port Milwaukee suffered \$2 million of damage during the same storm event.

<sup>42</sup> Based on data provided to SEWRPC by the Wisconsin Coastal Management Program and adjusted in various locations to align with 2015 topographic data based on Lidar, a remote sensing method that uses light to measure elevation.

### Municipal Coastline Management Methods

Municipalities within Milwaukee County that are situated along the Lake Michigan coastline generally utilize an assortment of coastline management strategies to protect existing property and proposed development from potential bluff instability and erosion/recession hazards. Some such methods are establishing bluff setbacks, conducting site specific bluff stability studies, and constructing coastline protection structures. In Milwaukee County, multiple municipalities that border Lake Michigan regulate development around and activity relating to lake bluffs within their jurisdiction.<sup>43</sup> Descriptions of existing coastline management strategies utilized by municipalities located along the County's Lake Michigan boundary follow.

#### *City of Oak Creek*

The City of Oak Creek zoning ordinance places requirements related to coastline management on development within the Lakefront Overlay District. Development within the Lakefront Overlay District is required to include coastline stabilization and lakefront access plans for Plan Commission review and approval. In addition, conditional use permits for lakefront development require plans for approval by the Common Council that take into account site topography, ordinary high water elevations, and surface water flow and controls.

#### *Village of Bayside*

In acknowledging the danger of disturbing the natural runoff of surface and percolating water and adding to the problem of erosion of ravine and lake bluffs, the Village of Bayside has established Land Development Ordinances related to coastline management. Per these ordinances, landscaping and construction of a building or structure on a lot along a ravine or lake bluff are subject to special requirements.

The construction of a building or structure on a lot along the lake bluff must be limited to the flat area of a lot at the top of the lake bluff. The foundations or footings of any building or structure on a lot along the lake bluff must be on or below the surface of the flat area at the top of the bluff; cantilever over the lake bluff is prohibited. In addition, any building or structure may be required to be set back a specified number of feet from the edge of the lake bluff. The construction of a building or structure on a lot along the lake bluff also requires certification by a registered professional engineer that certain criteria are met. These

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<sup>43</sup> *Some municipalities' lake bluff regulations also relate to the bluffs of ravines that are tributary to Lake Michigan.*

criteria include that the construction methods, footings, and materials are adequate so as not to either disturb the natural runoff of surface or percolating water or to create or increase lake bluff erosion and that any excavation for the construction will not adversely affect any building or structure on adjoining lots.

The only structures permitted to be constructed in whole or in part on or below the lake bluff are retaining walls that are designed by a registered professional engineer for the purpose of preventing or impeding lake bluff erosion or slippage. In addition, such retaining walls are only permissible if the opinion of the Village Manager is that the construction, footings, and materials of the proposed retaining walls are adequately designed to prevent and impede bluff erosion and provide proper drainage for surface and percolating water. In addition, the alteration of any natural vegetation on a ravine or lake bluff with an average slope of 12 degrees or more is prohibited without a permit approved by the Village Manager upon finding that the proposed work is minor in nature and primarily for the improvement and care of the plant life involved.

#### *Village of Fox Point*

The Village of Fox Point municipal code, which acknowledges the potential for unstable soil conditions, underground water pressure, and disruptions to natural drainage patterns to compromise bluff stability along Lake Michigan and its tributary ravines, incorporates numerous requirements related to coastline management. To administer regulations relating to the Lake Michigan bluff slope or the bluff of tributary ravines, the code defines "top of the bluff" as the area on a lot that is up-slope of the Village of Fox Point bluff line delineated by SEWRPC.<sup>44</sup> Most of the regulations related to coastline management in the Village's municipal code are within Chapter 285, Stormwater Management, Erosion Control, and Bluff Regulation.

The Village of Fox Point has established special requirements for the division or subdivision of any parcel containing land on a ravine or lake bluff. These special requirements may be met if either the opinion of the Village Board is that the proposed lot contains sufficient area landward of a lake or ravine exclusive of the area on the face of the lake or ravine bluff to permit construction or the opinion of the Village Board is that

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<sup>44</sup> *The bluff line is the area where slopes steeper than six horizontal to one vertical (6H:1V) transition to slopes shallower than 6H:1V measured perpendicular to the one-foot contour lines across the entire parcel.*

the area and topography of the proposed lot—with the lake or ravine bluff area included in determining the parcel’s open area setback requirements—would make construction possible.

The construction of retaining walls built for the purpose of preventing and impeding bluff erosion requires certification from the Director of Public Works/Village Engineer that the construction methods, footings, and materials of the proposed retaining walls are adequately designed to prevent and impede bluff erosion and provide proper drainage for surface and percolating water. New construction is allowed to cantilever over the top of lake or ravine bluffs but construction of a building or structure downslope from the top of or at the foot of a ravine or lake bluff is prohibited in much of the Village. The exception to this provision relates to land along North Beach Drive, which features existing development at the foot of the bluff of Lake Michigan and tributary ravines.<sup>45</sup> The Village also prohibits the deposit of yard waste and other refuse on a ravine or lake bluff.

#### *Village of Shorewood*

Requirements related to coastline management as set forth in the Village of Shorewood zoning ordinance apply to properties located in Lake Drive Districts 1 (R-1) and 4 (R-4). Development is required to be set back from the bluff area at a distance sufficient to allow the natural runoff or percolation of water. In addition, requirements call for the footings, materials, and construction methods used for any building or structure to not adversely affect the natural runoff or percolation of water or to otherwise cause or promote either coastline erosion or the degradation of nearby structures.

#### *Village of Whitefish Bay*

In the Village of Whitefish Bay, requirements related to coastline management apply to properties located on the bluff of Lake Michigan within District 1, the Lake Shore Residence District, or District 1A, Single-Family Residence District. These requirements necessitate that a registered professional engineer with certain qualifications<sup>46</sup> certify the safety of any proposed building or structure within 100 feet of the top edge of the bluff. The registered professional engineer is specifically required to certify the following:

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<sup>45</sup> and is subject to certification by the Director of Public Works/Village Engineer that the planned construction will be done with minimum soil or natural cover disturbance and provides adequate drainage for surface and percolating water

<sup>46</sup> Qualifications include a minimum of 10 years of geotechnical experience involving foundation investigation/engineering and shoreline slope stability evaluation.

- a proposed building or structure will not adversely affect existing buildings or structures on adjacent or adjoining sites;
- a proposed building or structure will not adversely disturb ravine or lake bluff, interfere with surface or subsurface drainage, or create new or exacerbate existing problems of erosion and recession;
- the drainage system will not adversely affect adjacent or adjoining properties;
- there is no danger to a proposed or existing building or structure and its occupants from slippage of the slope above or below the proposed building or structure.

The engineer's certification is required to be accompanied by a technical report that includes the following:

- recommendations regarding site preparation, foundation design, lateral earth pressure, and support of slabs on grade;
- the stability of the bluff slope before, during, and after construction of a proposed building or structure;
- the effect of the construction of a proposed building or structure on natural drainage in the area, including the effect on any existing measures designed to improve natural drainage.

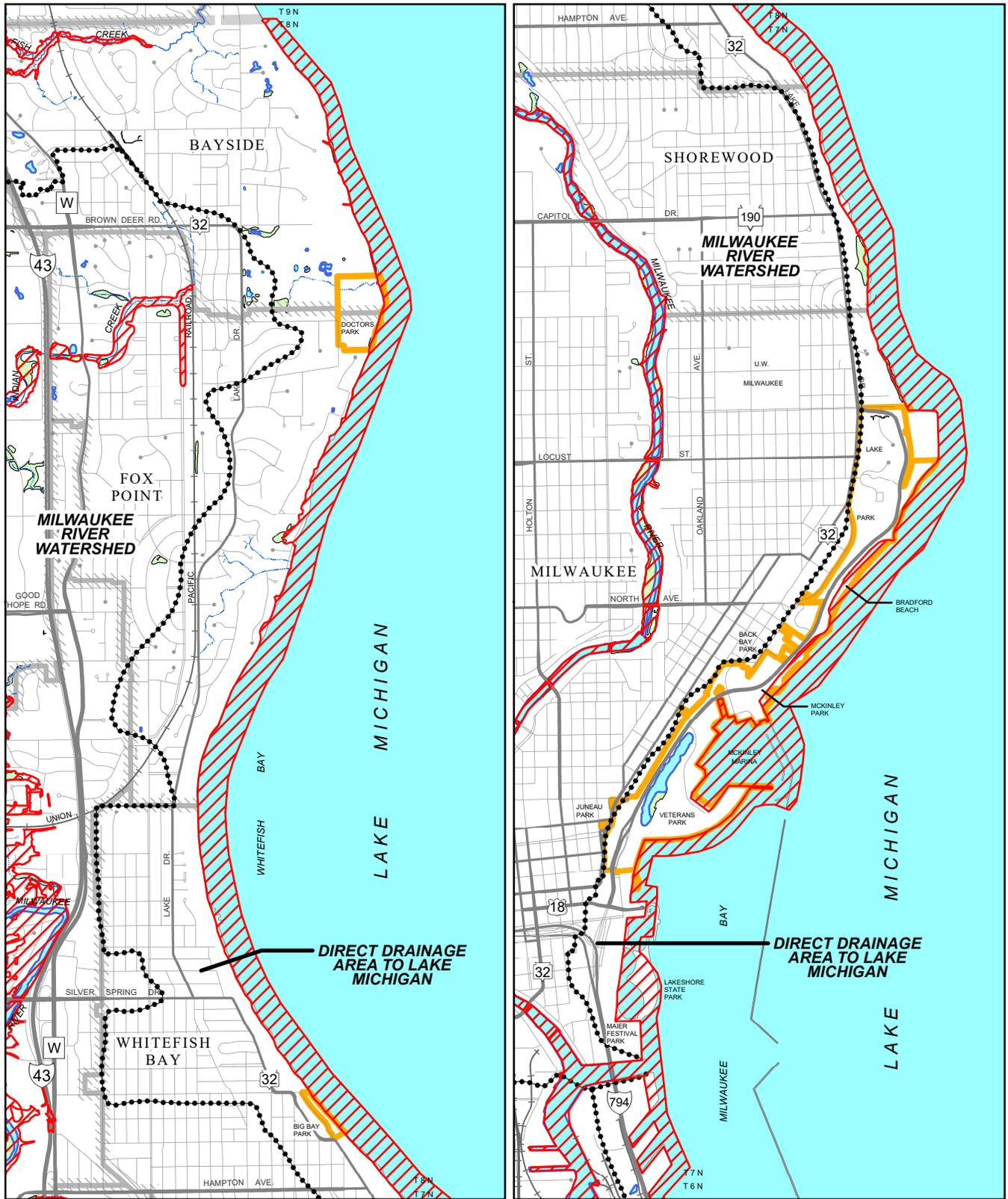
The Village of Whitefish Bay also requires owners of property on the bluff of Lake Michigan within District 1 or District 1A to certify that they are aware of potential problems related to lake shore erosion as well as being aware of potential solutions, such as the need to garner a permit to add fill in compliance with Village ordinances, and their costs. A memorandum of each property owner's certification is to be kept on record with the Milwaukee County Register of Deeds.

In addition, the Village of Whitefish Bay municipal code declares the Lake Michigan shore<sup>47</sup> as necessary to protecting the bluff and to preserving lakefront property and land within the Village, deeming it an offense to remove sand, gravel, stone, etc. from the Lake Michigan shore.

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<sup>47</sup> *The shore or beach of Lake Michigan is defined as the space between the lake's high-water mark and low-water mark.*

**Map 2.1**  
**Surface Waters, Wetlands, and Floodplains along the Milwaukee County Lake Michigan Coastline**

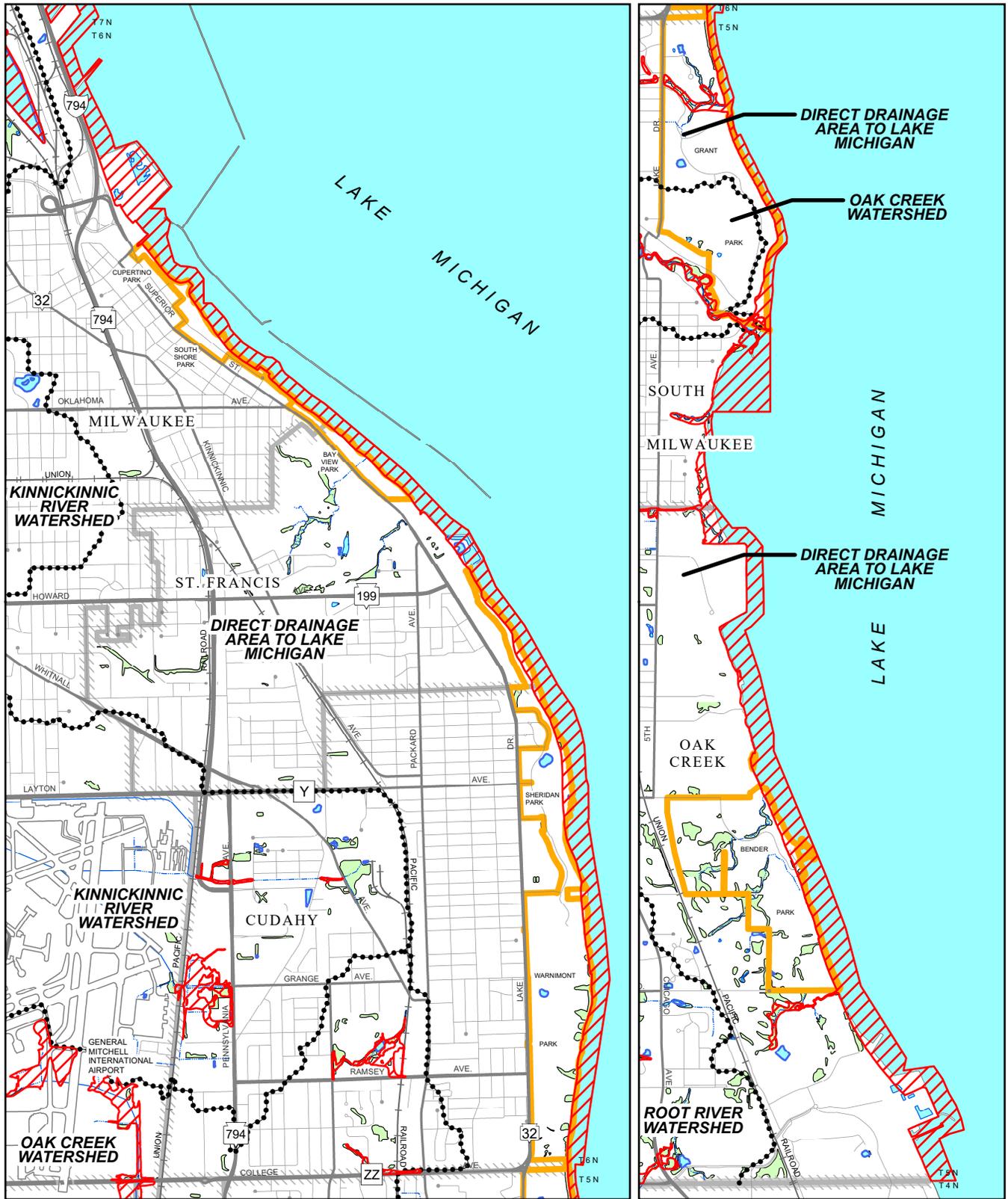


- WETLAND (2015)
- SURFACE WATER (2015)
- WATERSHED BOUNDARY
- COASTLINE MANAGEMENT STUDY AREA
- PERENNIAL STREAM
- INTERMITTENT STREAM
- ONE-PERCENT-ANNUAL-PROBABILITY (100-YEAR RECURRENCE INTERVAL) FLOODPLAINS: 2009



Source: FEMA, WDNR, Milwaukee County, and SEWRPC

**Map 2.1**  
**Surface waters, Wetlands, and Floodplains along the Milwaukee County Lake Michigan Coastline**

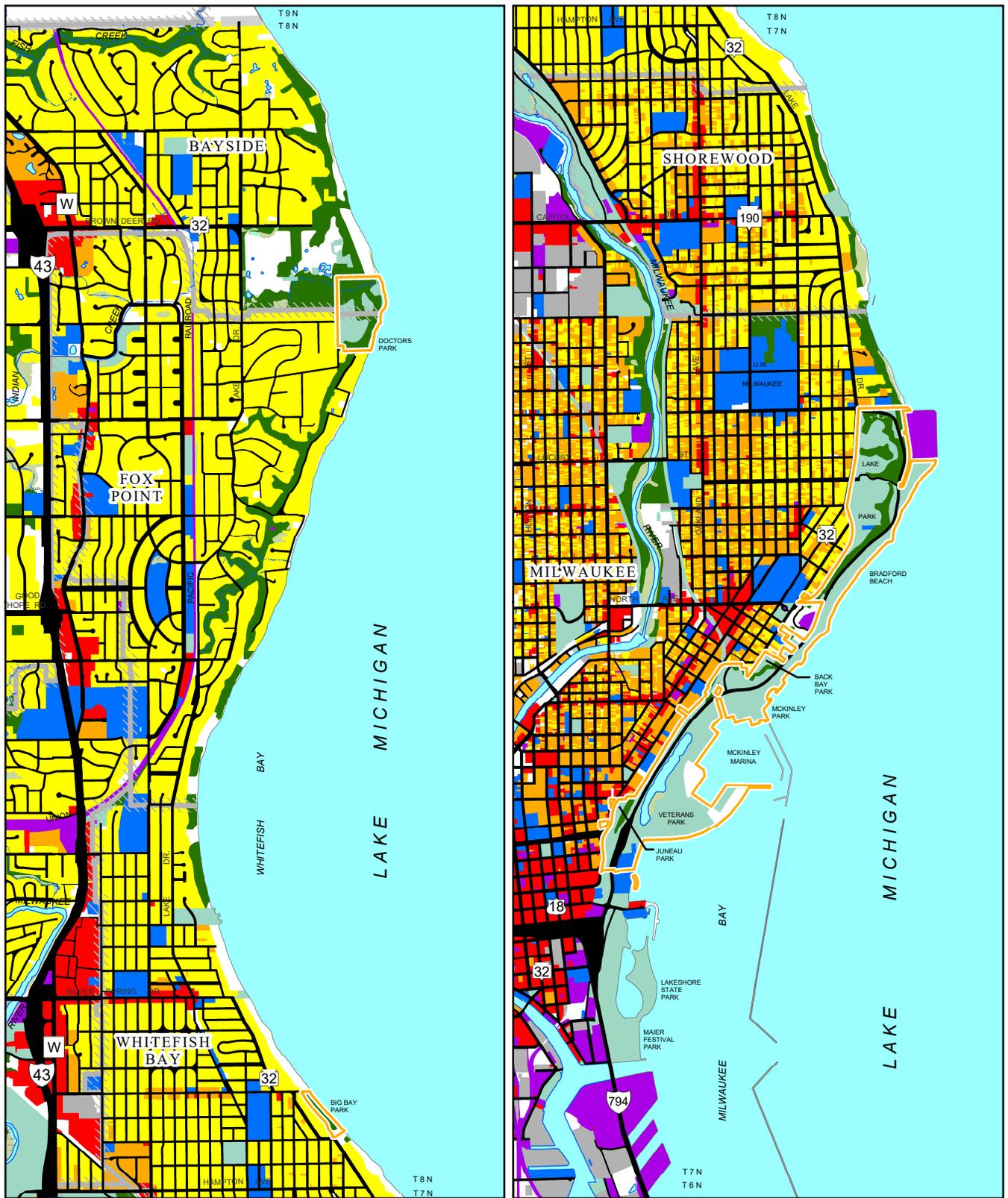


- WETLAND (2015)
- SURFACE WATER (2015)
- WATERSHED BOUNDARY
- COASTLINE MANAGEMENT STUDY AREA
- PERENNIAL STREAM
- INTERMITTENT STREAM
- ONE-PERCENT-ANNUAL-PROBABILITY (100-YEAR RECURRENCE INTERVAL) FLOODPLAINS: 2009

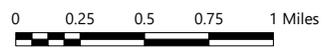


Source: FEMA, WDNR, Milwaukee County, and SEWRPC

**Map 2.2**  
**Generalized Land Use within the Milwaukee County: 2015**



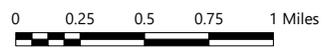
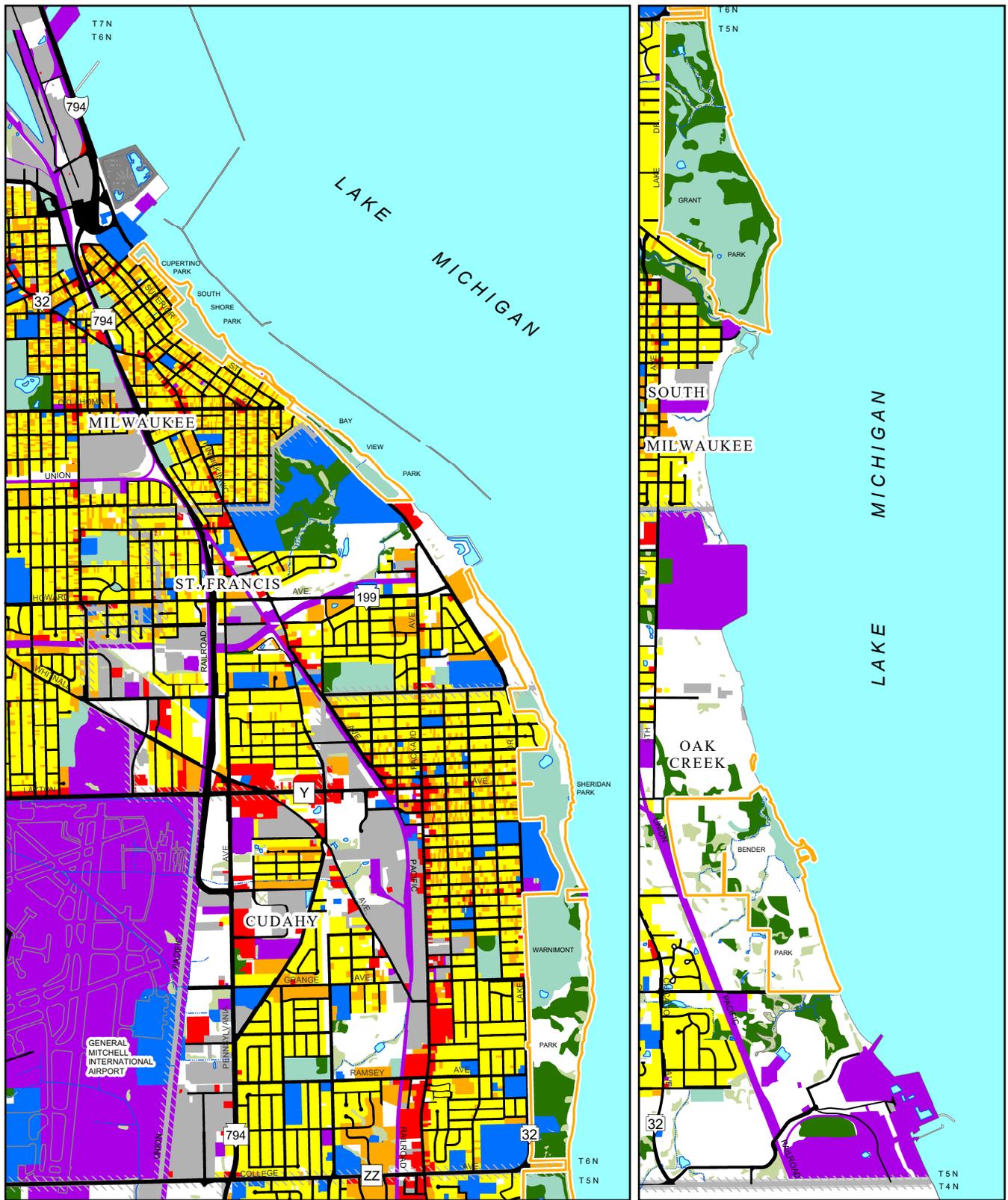
SINGLE-FAMILY RESIDENTIAL	GOVERNMENTAL AND INSTITUTIONAL	WOODLANDS	SURFACE WATER
MULTI-FAMILY RESIDENTIAL	RECREATIONAL	WETLANDS	COASTLINE MANAGEMENT STUDY AREA
COMMERCIAL	STREETS AND HIGHWAYS	EXTRACTIVE OR LANDFILL	
INDUSTRIAL	TRANSPORTATION, COMMUNICATION, AND UTILITIES	OPEN LANDS	



Source: SEWRPC

PRELIMINARY DRAFT

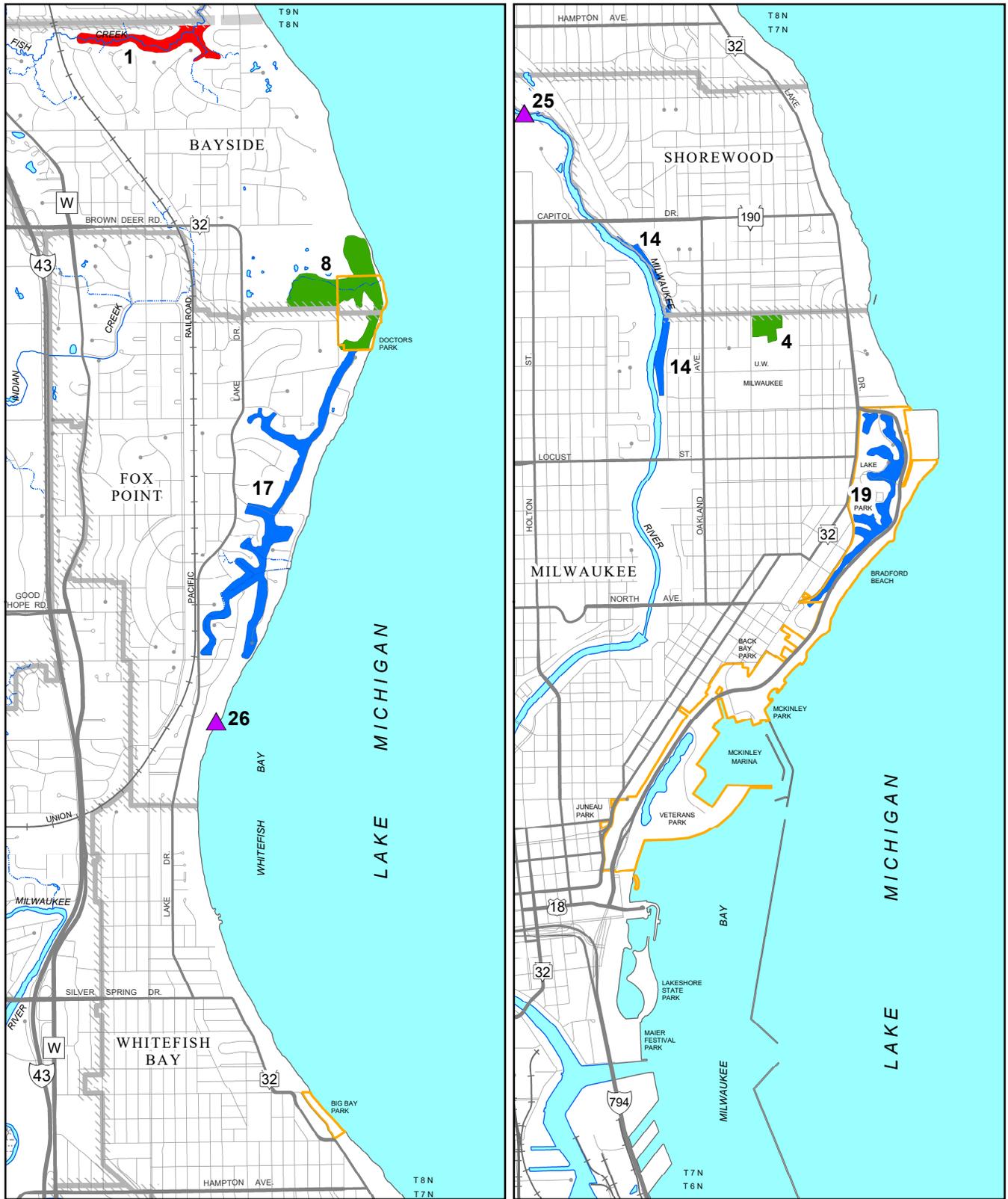
**Map 2.2**  
**Generalized Land Use within the Milwaukee County: 2015**



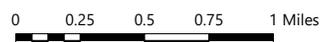
Source: SEWRPC

PRELIMINARY DRAFT

**Map 2.3**  
**Natural Areas, Critical Species Habitat Sites, and Significant Geological Sites**  
**along the Milwaukee County Lake Michigan Coastline: 2009**



- NATURAL AREAS OF STATEWIDE OR GREATER SIGNIFICANCE (NA-1)
- NATURAL AREAS OF COUNTYWIDE OR REGIONAL SIGNIFICANCE (NA-2)
- NATURAL AREAS OF LOCAL SIGNIFICANCE (NA-3)
- CRITICAL SPECIES HABITAT SITES
- ▲ GEOLOGICAL AREA SITE
- COASTLINE MANAGEMENT STUDY AREA
- 6** REFERENCE NUMBER (SEE TABLE 2.1)



Source: WDNR, Wisconsin Geological and Natural History Survey, and SEWRPC

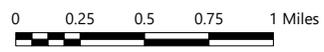
**Map 2.3**  
**Natural Areas, Critical Species Habitat Sites, and Significant Geological Sites**  
**along the Milwaukee County Lake Michigan Coastline: 2009**



- NATURAL AREAS OF STATEWIDE OR GREATER SIGNIFICANCE (NA-1) (NONE)
- NATURAL AREAS OF COUNTYWIDE OR REGIONAL SIGNIFICANCE (NA-2)
- NATURAL AREAS OF LOCAL SIGNIFICANCE (NA-3)
- CRITICAL SPECIES HABITAT SITES
- ▲ GEOLOGICAL AREA SITE
- COASTLINE MANAGEMENT STUDY AREA
- 6** REFERENCE NUMBER (SEE TABLE 2.1)

0 0.25 0.5 0.75 1 Miles  
 Source: WDNR, Wisconsin Geological and Natural History Survey, and SEWRPC

**Map 2.4**  
**Environmental Corridors and Isolated Natural Resource Areas**  
**along the Milwaukee County Lake Michigan Coastline: 2015**



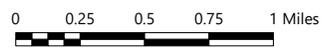
Source: SEWRPC

PRELIMINARY DRAFT

**Map 2.4**  
**Environmental Corridors and Isolated Natural Resource Areas**  
**along the Milwaukee County Lake Michigan Coastline: 2015**

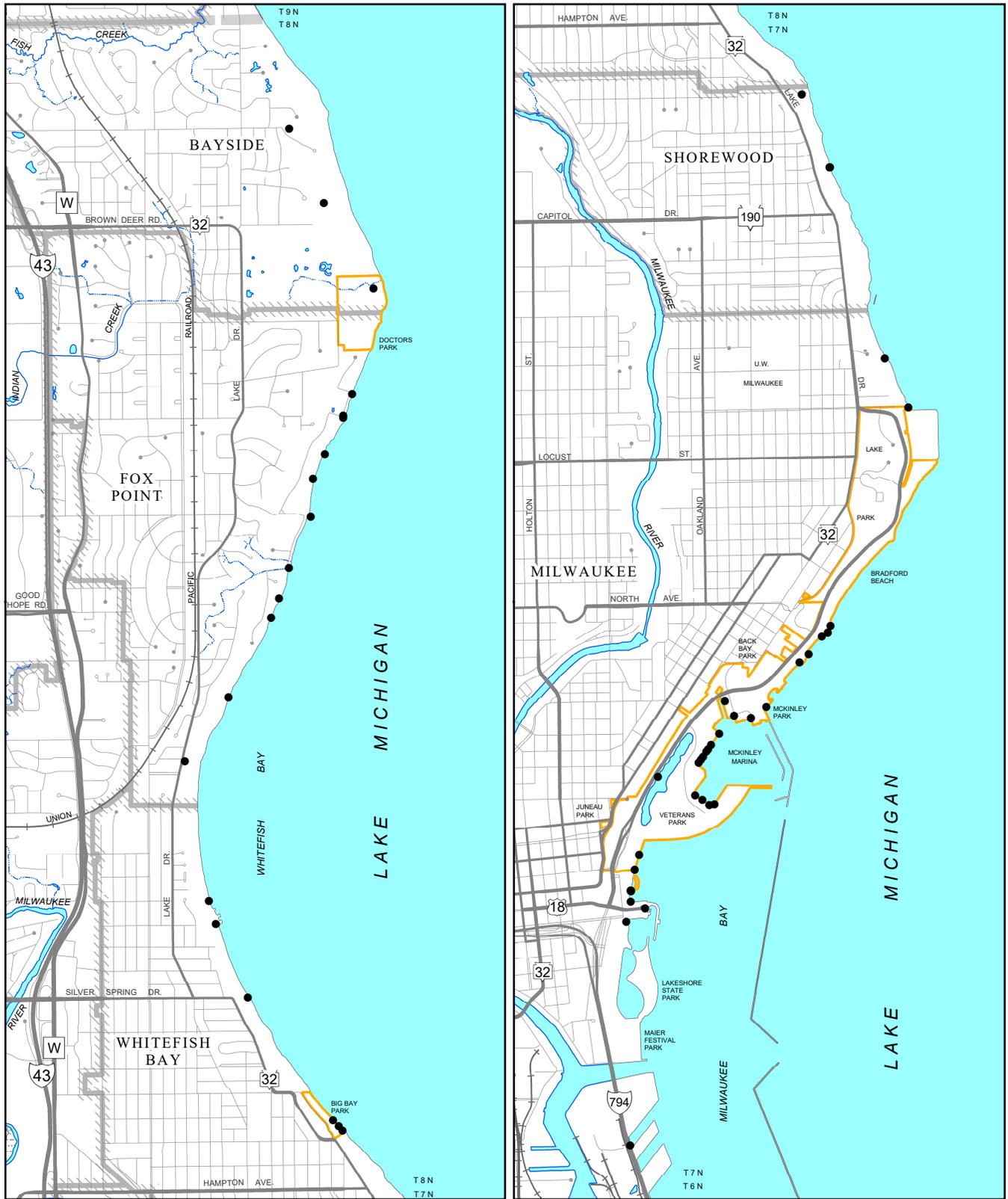


- PRIMARY ENVIRONMENTAL CORRIDOR
- SECONDARY ENVIRONMENTAL CORRIDOR
- ISOLATED NATURAL RESOURCE AREA
- SURFACE WATER
- COASTLINE MANAGEMENT STUDY AREA

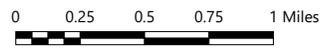


Source: SEWRPC

**Map 2.5**  
**Stormwater Outfalls along the Milwaukee County Lake Michigan Coastline**



- STORMWATER OUTFALL
- ▭ COASTLINE MANAGEMENT STUDY AREA



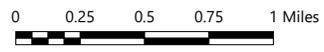
Source: Milwaukee County Municipalities, Milwaukee County, Wisconsin Coastal Management Program, and SEWRPC

PRELIMINARY DRAFT

**Map 2.5**  
**Stormwater Outfalls along the Milwaukee County Lake Michigan Coastline**



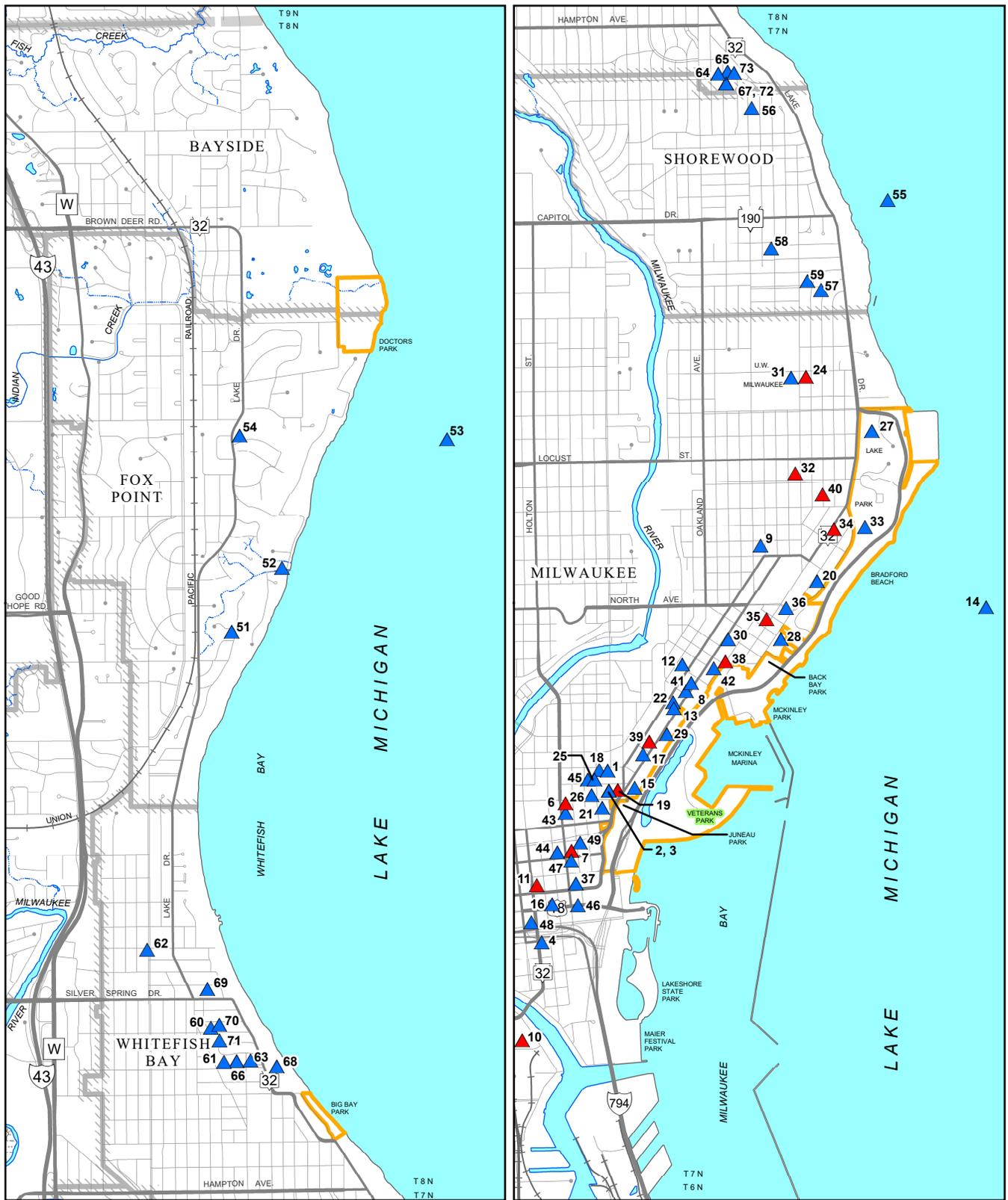
- STORMWATER OUTFALL
- ▭ COASTLINE MANAGEMENT STUDY AREA



Source: Milwaukee County Municipalities, Milwaukee County, Wisconsin Coastal Management Program, and SEWRPC

PRELIMINARY DRAFT

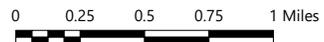
## Map 2.6 Historic Sites and Districts along the Milwaukee County Lake Michigan Coastline



- ▲ HISTORIC SITE
- ▲ HISTORIC DISTRICT
- 33** REFERENCE NUMBER  
(SEE TABLE 2.2)

Note: Historic sites and districts are only being shown within one-half mile from the Lake Michigan shoreline.

COASTLINE MANAGEMENT STUDY AREA



Source: SEWRPC

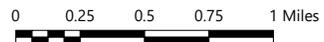
**Map 2.6**  
**Historic Sites and Districts along the Milwaukee County Lake Michigan Coastline**



- ▲ HISTORIC SITE
- ▲ HISTORIC DISTRICT
- 33** REFERENCE NUMBER (SEE TABLE 2.2)

Note: Historic sites and districts are only being shown within one-half mile from the Lake Michigan shoreline.

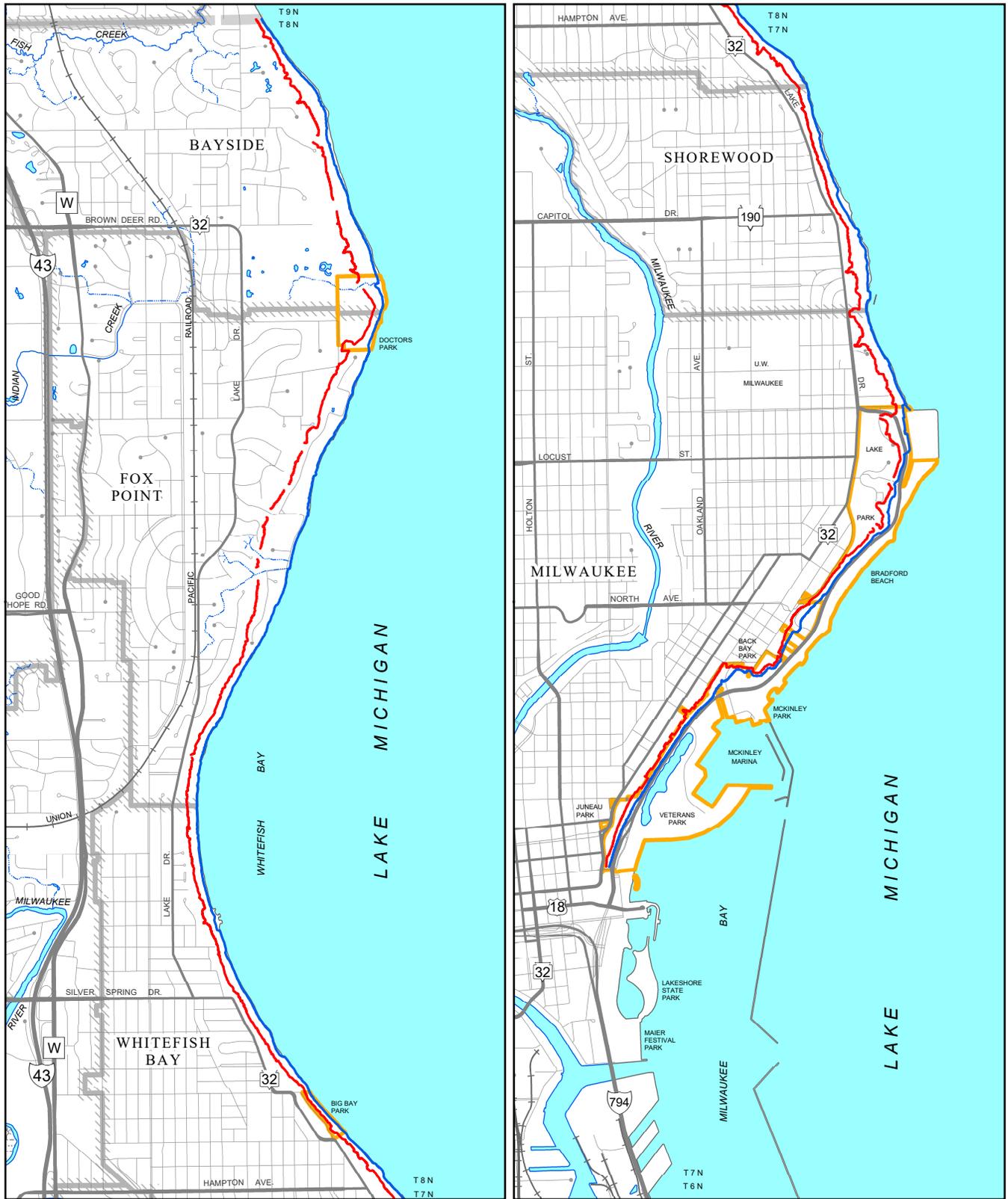
COASTLINE MANAGEMENT STUDY AREA



Source: SEWRPC

**Map 2.7**

**Approximate Bluff Crest and Bluff Toe locations along the Milwaukee County Lake Michigan Coastline**



- BLUFF CREST
- BLUFF TOE

- COASTLINE MANAGEMENT STUDY AREA



Note: Based on 2015 Lidar Topo but aligned in various locations to data provided to SEWRPC by Wisconsin Coastal Management Program

Source: University of Wisconsin Sea Grant Institute, Milwaukee County, and SEWRPC

**Map 2.7**  
**Approximate Bluff Crest and Bluff Toe locations along the Milwaukee County Lake Michigan Coastline**



- BLUFF CREST
- BLUFF TOE

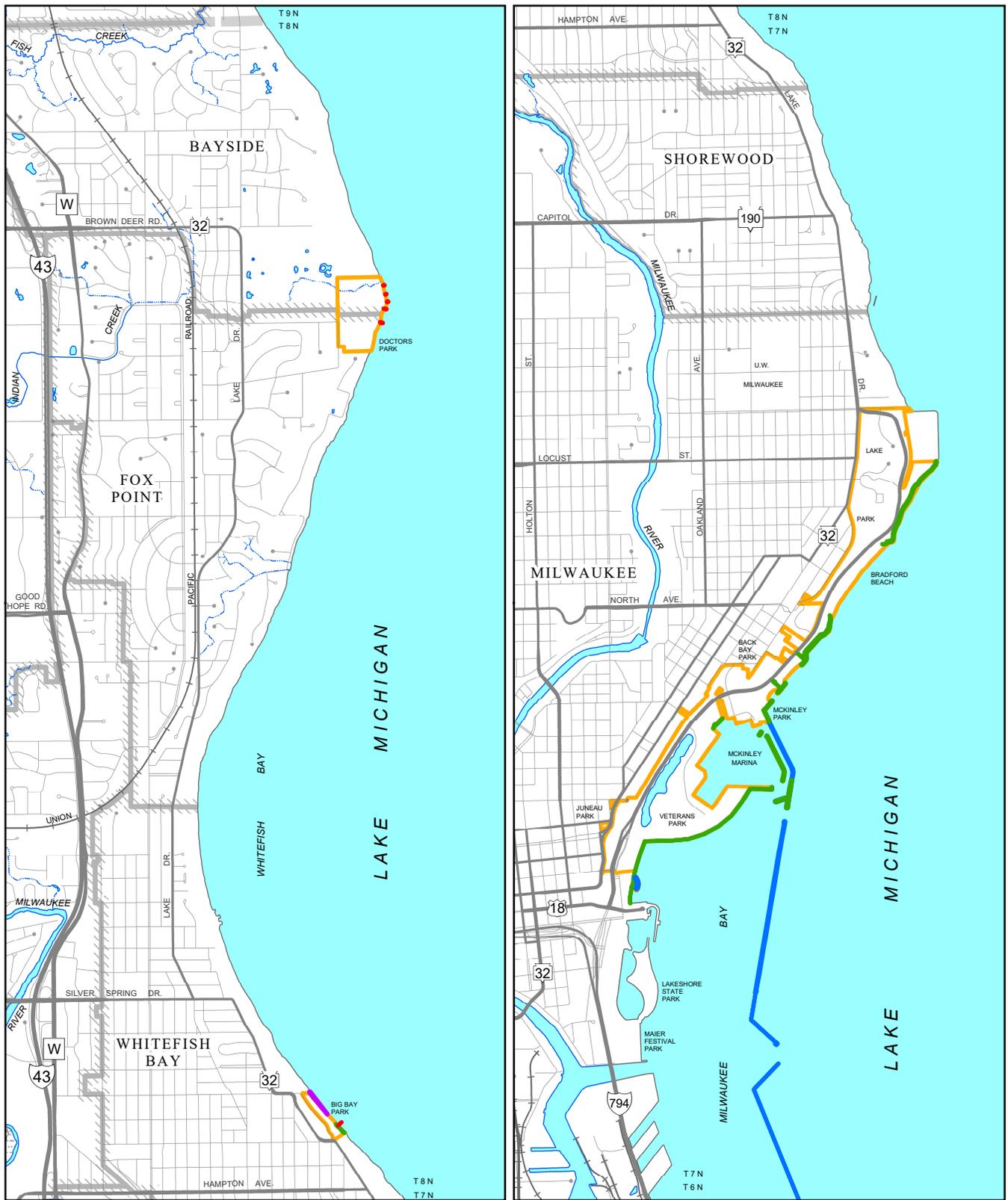
- COASTLINE MANAGEMENT STUDY AREA



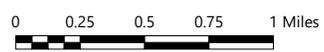
Note: Based on 2015 Lidar Topo but aligned in various locations to data provided to SEWRPC by Wisconsin Coastal Management Program

Source: University of Wisconsin Sea Grant Institute, Milwaukee County, and SEWRPC

**Map 2.8**  
**Shoreline Protection Structures along the Milwaukee County Coastline**



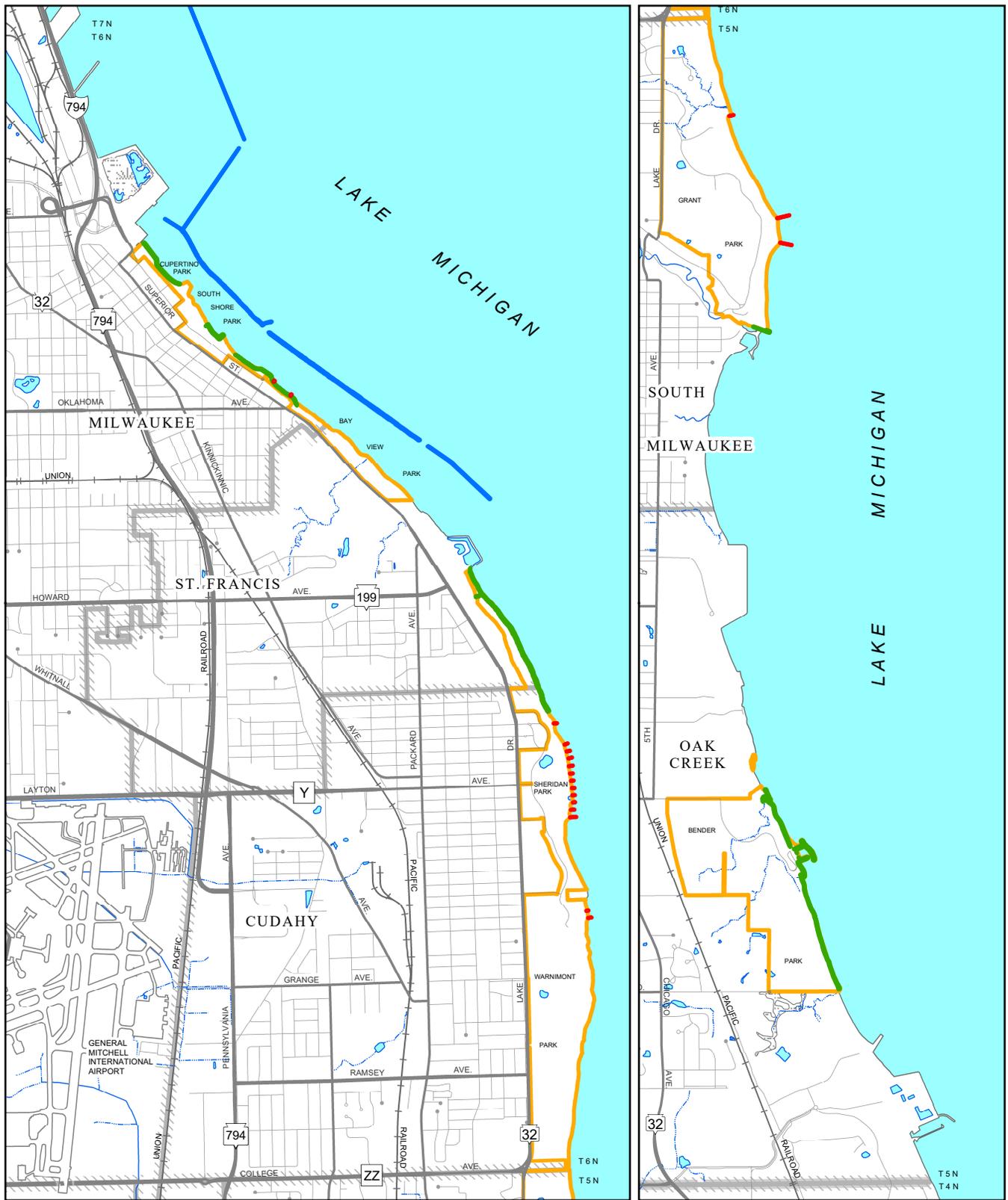
- BREAKWATER
- BULKHEAD
- GROIN
- REVETMENT (INCLUDING RIP RAP)
- COASTLINE MANAGEMENT STUDY AREA



Source: Milwaukee County and SEWRPC

PRELIMINARY DRAFT

**Map 2.8**  
**Shoreline Protection Structures along the Milwaukee County Coastline**



- BREAKWATER
- BULKHEAD
- GROIN
- REVELTMENT (INCLUDING RIP RAP)
- COASTLINE MANAGEMENT STUDY AREA



Source: Milwaukee County and SEWRPC

**Table 2.1**  
**Natural Areas, Critical Species Habitat Sites, and Significant Geological Sites along the Lake Michigan Coastline: 2009**

<b>Natural Areas</b>		
<b>Number on Map 2.3</b>	<b>Site Name</b>	<b>Size (acres)</b>
<b>NA-1</b>		
1	Fairy Chasm State Natural Area	33
Total		33
<b>NA-2</b>		
2	St. Francis Seminary Woods	52
3	Warnimont Park Fens	2
Total		54
<b>NA-3</b>		
4	Downer Woods	11
5	Grant Park Woods - Old Growth	42
6	Grant Park Woods - South	45
7	Oak Creek Parkway Woods	24
8	Schlitz Audubon Center/Doctors Park Woods and Beach	72
9	Warnimont Park Woods	47
Total		241
Total Natural Areas		328
<b>Critical Species Habitat Sites</b>		
<b>Number on Map 2.3</b>	<b>Site Name</b>	<b>Size (acres)</b>
10	Bender Clay Banks and Ravine - South	2
11	Bender Park Stream and Meadow	2
12	Bender Park Woods - North	11
13	Bender Park Woods - South	5
14	Cambridge Avenue Woods	17
15	Clay Ravine Woods	12
16	Cudahy Park Woods	4
17	Fox Point Bluffs and Ravines	93
18	Greene Park Woods	7
19	Lake Park Woods	46
20	Oak Creek Bluffs and Beach - South	24
21	Oak Creek Bluffs and Beach-North	4
22	Oak Creek Power Plant Woods	16
23	Schmidt/Johnson Woods	6
24	Trestle Ravine Woods	3
Total		252

<b>Significant Geological Sites</b>		
<b>Number on Map 2.3</b>	<b>Site Name</b>	<b>Classification</b>
25	Estabrook Park - Lincoln Park Area	38
26	Whitefish Bay Shore Exposure	2
27	Warnimont Park Clay Banks	16
Total		56

Source: Wisconsin Department of Natural Resources, Wisconsin Geological and Natural History Survey, and SEWRPC

SEWRPC Memorandum Report No. 248

MILWAUKEE COUNTY COASTLINE MANAGEMENT GUIDELINES

**Section 3**

**COASTLINE MANAGEMENT GUIDELINES**

**OVERVIEW**

This section sets forth goals, guidelines, and requirements designed to enable Milwaukee County to evaluate and manage potential coastline impacts to County-owned assets.<sup>1</sup> The guidelines offer a framework for promoting bluff slope stability within County-owned lands along the Lake Michigan coastline. The guidelines will serve as a reference tool as the County considers conducting work or evaluates proposals from property owners, Friends Groups and other organizations, municipalities, and others interested in conducting work that could impact bluff slope stability within County-owned lands along the Lake Michigan coastline.

Any and all parties interested in conducting such work should prepare and submit to the County a scope of work as laid out in this Section. Applicable work may include—but is not limited to—development, such as the construction of infrastructure, occupiable buildings, and other facilities; landscape management, such as the removal and/or pruning of vegetation, including invasive species; landscape restoration; the maintenance of existing infrastructure; and shore protection modifications and structures. Proposal requirements set forth herein would be supplementary to the application that such property owners, organizations, and municipalities would need to complete a proposed bluff project.<sup>2</sup> While the guidelines

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<sup>1</sup> County-owned assets include lands and facilities that are adjacent to the waters of Lake Michigan.

<sup>2</sup> A Parks Improvement Project (PIP) form is required for all proposed park improvements. Information on project considerations that should be addressed by community project requests and on the project request review process are set forth in the County's Community Project Request Guide.

and requirements set forth in this Section are to serve as a tool by which the County can evaluate a scope of work, the County may adjust the guidelines and requirements presented in this report as necessary.

A critical component of coastline management as set forth in this report is the Coastline Management Zone (CMZ).<sup>3</sup> The CMZ incorporates a stable bluff slope and an appropriate site-specific distance from the existing bluff crest for development. As depicted in Figure 3.1, the CMZ encompasses the projected 60-year bluff recession distance from the current bluff toe, future stable slope distance, an additional distance of 100 feet, and any features lakeside from the bluff toe. The future stable slope distance is calculated from the existing bluff toe to the future stable bluff crest using the ratio of a one-foot vertical rise to a 2.5-foot horizontal run.<sup>4</sup> The projected 60-year bluff recession distance<sup>5</sup> is calculated using a minimum recession rate of one foot per year—unless information revealed during the site analysis necessitates using a greater recession rate per year. The additional 100-foot distance provides for uncertainties related to future recession rates, stable slope angles, the effect of nearby shore protection structures, fluctuations in Lake Michigan water levels, and other factors.

Once the CMZ is established in relation to a proposal,<sup>6</sup> the Milwaukee County Coastal Resources Inventory, which sets forth the vulnerability and value of County-owned assets in the Lake Michigan Coastline Management Zone, may be used to prioritize implementation activities and help the County conduct long-range capital planning. Additional information on implementation is presented in Section 4 of this report.

This report uses a study area that encompasses the full extent of the Lake Michigan coastline in Milwaukee County and includes the County-owned land adjacent to the waters of Lake Michigan outlined on Map 3.1. While this report and its guidelines and requirements apply only to County-owned facilities and land within

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<sup>3</sup> *The Coastal Management Setback is based on recommendations for bluff setbacks published by the University of Wisconsin Sea Grant Institute in 2008. Established to provide bluff setbacks for new development and redevelopment along Lake Michigan, the Coastal Management Setback is intended to protect structures and properties from slope erosion and failure without reliance on shore protection measures.*

<sup>4</sup> *The stable slope of 2.5 to 1 is an average estimate that will vary depending on bluff geology, including soil types, and other conditions.*

<sup>5</sup> *The 60-year bluff recession distance is designed to accommodate bluff recession over a time period that is twice that of a typical home mortgage loan.*

<sup>6</sup> *The CMZ, calculated as described in this Section, needs to be determined for each PIP to account for site-specific conditions. Due to coastline dynamics, the locations of the bluff toe and bluff crest will likely change over time from the 2015 conditions shown on Map 2.7.*

the study area, local municipalities are encouraged to consider the addition of similar goals and guidelines for applicable local proposals within their own jurisdictions.

## **COASTLINE MANAGEMENT GOALS**

- Protect Milwaukee County's financial investment in County-owned assets within the Lake Michigan Coastline Management Zone.
- Protect the ecology, resources, and natural character of County-owned lands within the Lake Michigan Coastline Management Zone.
- Provide efficiency and consistency when reviewing proposals for a scope of work to be completed within the Lake Michigan Coastline Management Zone.

## **COASTLINE MANAGEMENT GUIDELINES**

### ***Guidelines/Objectives***

Milwaukee County will seek to attain the following as part of long-term management of the Lake Michigan Coastline Management Zone:

- ▶ Ensure appropriate public access to and recreational opportunities within the Lake Michigan Coastline Management Zone without compromising the stability of the Lake Michigan bluff slope or the integrity of the Lake Michigan shoreline.
- ▶ Ensure access for the maintenance of stormwater facilities within the Lake Michigan Coastline Management Zone.
- ▶ Limit land-disturbing activities within the Lake Michigan Coastline Management Zone that adversely impact natural functions of the land.<sup>7</sup>
- ▶ Prevent erosion and sedimentation that would be detrimental to or increase the area of the natural drainage system.
- ▶ Assess bluff conditions around existing facilities and infrastructure within the Lake Michigan Coastline Management Zone in order to identify both short- and long-term detrimental impacts.

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<sup>7</sup> Land disturbing activities may include—but are not limited to—landscape management, the removal of invasive species, accessing stormwater infrastructure, and constructing permanent structures or other facilities.

- ▶ Severely limit actions that may detrimentally alter natural and ecologically stable conditions characteristic of the Lake Michigan coastline.
- ▶ Preserve or enhance the natural character and aesthetic values of the Lake Michigan viewshed in a sustainable way.
- ▶ Preserve undeveloped areas within the Lake Michigan Coastline Management Zone that contain a unique or sensitive resource, including—but not limited to—areas designated by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) as environmental corridors or isolated natural resource areas.
- ▶ Account for areas protected by the Public Trust Doctrine and lakebed grants issued to Milwaukee County.<sup>8</sup>

### ***Guidelines for Proposed Development within the Lake Michigan Coastline Management Zone***

For work involving the construction of infrastructure, occupiable buildings, and other facilities within the Lake Michigan Coastline Management Zone, the following guidelines should apply:

- ▶ A proposal prepared by a Professional Engineer (P.E.) or Registered Architect (R.A.) licensed in the State of Wisconsin should be submitted to assess compliance with these guidelines and requirements. Any proposal for infrastructure and/or buildings shall adequately assess surface and subsurface soil conditions to address the proposed design.
- ▶ Stormwater management within the Lake Michigan Coastline Management Zone should meet the following requirements:
  1. Stormwater produced on-site should be directed away from the bluff, potentially landward, and stormwater discharges to groundwater should be limited;
  2. Low-impact development (LID) stormwater management practices<sup>9</sup> should be properly modified for the bluff top or constructed as far from the bluff crest as possible; and
  3. Maintain existing stormwater drainage patterns to protect tributary ravines.

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<sup>8</sup> Under the Public Trust Doctrine, the State of Wisconsin holds navigable water in trust for the public. In addition, through special legislation, the State Legislature has authorized a lakebed grant making Milwaukee County the trustee of 22.5 linear miles of Milwaukee County's 27.6 miles of Lake Michigan coastline. Any facilities constructed on lakebed grant areas must be widely available to the public and support the primary purpose for which the Legislature made the grant.

<sup>9</sup> Including but not limited to rain barrels, rain gardens, and porous pavements.

### ***Guidelines for Proposed Landscape Management***

- ▶ A proposal for a scope of work for landscape management within the Lake Michigan Coastline Management Zone, including but not limited to the removal of invasive species, should to be prepared by a Landscape Architect licensed by the State of Wisconsin and shall include a landscape management plan that meets the following requirements:
  1. Inventory the existing vegetation, including the variances in heights of existing low groundcovers; size, species, and health of shrubs and trees, specifying any proposed alterations to existing vegetation;<sup>10</sup> and
  2. Describe the vegetation that is to be removed and the means by which the vegetation will be removed, which should be in a manner that does not displace or remove existing forest litter or decrease bluff stability, and identify replacement vegetation to be planted in place of the vegetation proposed to be removed, including the rational use in selecting the proposed replacement vegetation.<sup>11</sup>
- ▶ Landscape management proposals related to viewshed management within the Lake Michigan Coastline Management Zone should account for the need to retain and maintain bluff vegetation in a variety of heights to promote bluff stability.<sup>12</sup> Soil types and vegetation establishment periods shall be prioritized. Appropriate native vegetation for bluff stabilization that takes into account height at maturity, soil type and moisture, sun/shade tolerance, and other characteristics is presented in Appendix D.<sup>13</sup>

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<sup>10</sup> *The use of mulch material is discouraged.*

<sup>11</sup> *Essential information on appropriate vegetation to promote bluff stability is presented in a reference guide, A Property Owner's Guide to Protecting Your Bluff, which was under development by the Wisconsin Coastal Management Program as this report was being prepared.*

<sup>12</sup> *Soil stability can be improved by incorporating a variety of vegetation of different type, heights, and with varying root characteristics. Combinations of trees and shrubs, many of which have deep roots that can serve as vertical anchors, with low-growing herbaceous plants, whose roots tend to prevent lateral shear, can create an interlocked root system to mitigate the impact of both groundwater and surface water runoff. In addition, incorporating evergreen vegetation ensures moisture can be extracted from the soil over longer durations than may be accomplished by strictly deciduous vegetation.*

<sup>13</sup> *Vegetation for bluff stabilization is taken from a publication under preparation by the University of Wisconsin Sea Grant Institute and the Southeastern Wisconsin Regional Planning Commission, A Property Owner's Guide to Protecting Your Bluff, as this report was being prepared.*

### **Guidelines for Proposed Shore Protection Modifications and Structures<sup>14</sup>**

- ▶ Prioritize non-structural shore protection measures<sup>15</sup> for existing assets within the Lake Michigan Coastline Management Zone that are vulnerable to damage from coastal hazards.<sup>16</sup>
- ▶ Enhance, restore, and create coastline wetlands and other appropriate aquatic ecosystem resources where feasible.
- ▶ Limit the construction of shore protection structures within the Lake Michigan Coastline Management Zone to areas where non-structural shore protection measures would be ineffective at protecting the value of County-owned land and structural assets. Shore protection structure designs should include the following:
  1. A site investigation of slope stability, lakeshore erosion, and near-shore bathymetry;
  2. A plan for ensuring adequate quality control of materials used in the designed structure; and
  3. Adequate monitoring and maintenance plans, as determined by Milwaukee County.

### **Submittal Requirements for Proposed Projects within the Lake Michigan Coastline Management Zone<sup>17</sup>**

- ▶ A proposal for a scope of work for any bluff or shoreline modification<sup>18</sup> within the Lake Michigan Coastline Management Zone should be submitted for review by and approval of the Milwaukee County Park Planning & Development and Environmental Services Divisions prior to work being performed. The proposed work should be performed under the supervision of a Professional Engineer (P.E.) with a minimum of 10 years of experience involving geotechnical investigation and/or engineering and shoreline slope stability evaluation. A proposal for a scope of work should include the following:

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<sup>14</sup> All shore protection modifications and structures are regulated by the Wisconsin Department of Natural Resources (WDNR) and the U.S. Army Corps of Engineers (ACOE).

<sup>15</sup> Examples of which include bluff top stormwater and wastewater management, maintaining and enhancing vegetation along shoreline and on bluff slopes, and beach enhancement.

<sup>16</sup> Coastal hazards may include bluff toe erosion, bluff slumping or sliding, or damage related to groundwater seepage or lakebed erosion.

<sup>17</sup> Proposals for a scope of work are required for all land-disturbing activities within the Lake Michigan Coastline Management Zone.

<sup>18</sup> Bluff or shoreline modifications may include—but are not limited to—the construction of shoreline protection structures, such as beach nourishment; the installation of bulkhead, groin, jetty, revetment, or rip rap, or the establishment of wetlands; and development or landscape management within the Coastline Management Zone.

1. A slope stability analysis<sup>19</sup> that meets the following requirements:
    - Calculations are based upon the highest groundwater conditions that can occur at the site—not the elevation of the groundwater on the day of the analysis;
    - An appropriate safety factor<sup>20</sup> should be used to account for the intensity of the planned use (see Table 3.1);
    - The analysis shall evaluate existing surface and subsurface conditions. Collection of soil data is the responsibility of the applicant, and all work must be permitted through a Parks right-of-entry permit from Milwaukee County.
  2. A no adverse impacts (NAI)<sup>21</sup> analysis stamped by a Professional Engineer (P.E.) with a minimum of 10 years of experience involving geotechnical investigation and/or engineering and shoreline slope stability evaluation that meets the following requirements:
    - Accounts for the stability of surrounding bluffs and structures;
    - Accounts for the conditions of the surrounding shoreline;
    - Accounts for the stormwater managed and produced on-site and for the site's natural drainage system;
  3. A landscape management plan describing the practices and materials, including replacement vegetation, that would be used to implement the plan and maintain the landscape;
  4. Adequate monitoring and maintenance plans as determined by Milwaukee County; and
  5. A statement from the P.E. establishing that the proposed scope of work will not decrease the stability of the bluff area.
- Milwaukee County will determine the veracity and appropriateness of the proposal.

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<sup>19</sup> Detailed components of the required slope stability analysis are described in Section 4 of this report.

<sup>20</sup> An engineer's assessment utilizing a safety factor of 1.0 would identify the point at which a bluff would fail; the P.E. should use a safety factor greater than 1.0 to account for the intensity of the planned use, which would result in development being subjected to a greater setback from the existing bluff toe.

<sup>21</sup> Established by the Association of State Floodplain Managers (ASFPM), NAI is a managing principle under which the actions of a property owner to manage water on that property are not allowed to adversely affect the rights of other property owners.

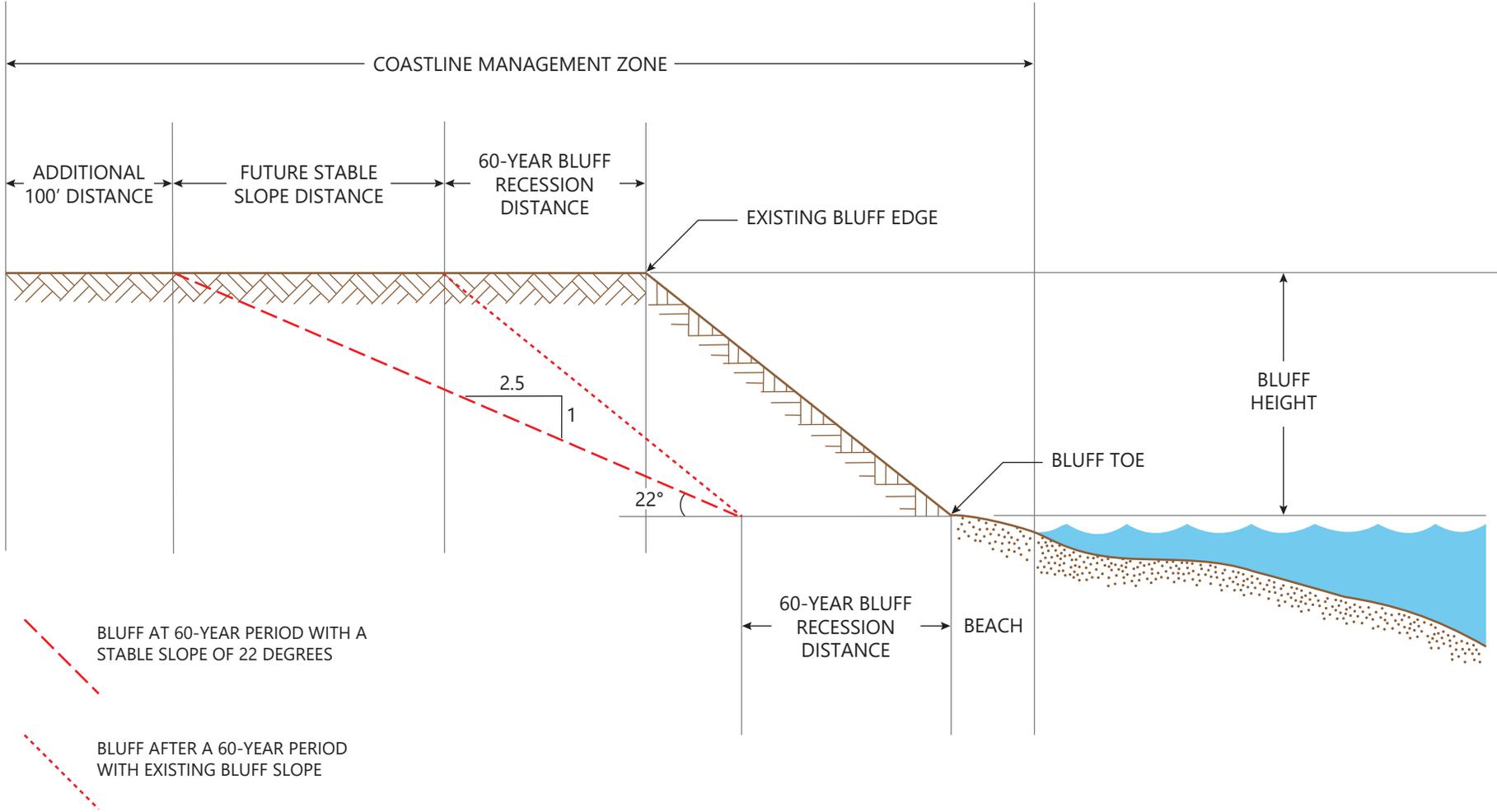
### ***Application of the Coastline Management Guidelines***

When considering the County's Coastline Management Guidelines, Milwaukee County will recognize and protect Milwaukee County's broad public interest via the following:

- ▶ Solicit input from individuals and groups representative of local public interests.
- ▶ Consider the County's duty to preserve natural resources, provide recreational opportunities, maintain public infrastructure, and address coastline impacts/bluff stability risks, in a balanced and sustainable fashion.
- ▶ Take into account the policies, programs, and recommendations of municipalities within the County.
- ▶ Solicit information and recommendations from individuals with expertise in technical areas pertinent to the proposed project, such as ecology, geology, hydrology, limnology, aquaculture and other scientific fields pertinent to shoreline management.
- ▶ Consider more up-to-date information from pertinent State and Federal coastline management guidelines, policies, and best management practices.
- ▶ Adhere to local regulations and approval processes.

Determinations regarding project proposals shall be made by licensed Professional Engineers and Landscape Architects working for Milwaukee County, or consultants working on their behalf.

**Figure 3.1**  
**Coastline Management Zone: 2020**

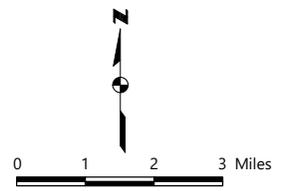


Source: University of Wisconsin Sea Grant Program and SEWRPC

### Map 3.1 Lake Michigan Coastline Management Zone: 2019



 LAKE MICHIGAN COASTLINE MANAGEMENT ZONE



Source: SEWRPC

SEWRPC Memorandum Report No. 248

MILWAUKEE COUNTY COASTLINE MANAGEMENT GUIDELINES

**Section 4**

**IMPLEMENTATION**

**ADOPTION OF GUIDELINES**

An important step in implementing the coastline management guidelines for Milwaukee County is their formal adoption by the County. Upon formal adoption, the guidelines become an important guide to administering projects along and related management decisions involving lands adjacent to the County's Lake Michigan coastline. Such adoption serves to signify agreement with and official support of the recommendations set forth in this report and enables government officials and staff to begin integrating this report's recommendations into other ongoing County and municipal programs, such as parks and public works development planning and programming.

An informational report on the working draft of this report was provided to the Milwaukee County Parks, Energy, and Environment Committee (PEEC) and County Board of Supervisors in December 2020. In advance of the final review of this report by the PEEC and County Board in January 2020, the final draft of this report was shared with leaders of municipalities within and directly adjacent to the Coastline Management Zone who were part of initial project outreach efforts. It is intended that these guidelines will be applied internally by Milwaukee County Parks after this report is adopted by the County Board.

Establishing an education plan is an important component to adopting these guidelines. In order to ensure that all interested and affected parties are aware of the requirements established in these coastline management guidelines and what actions the guidelines apply to, the County will conduct internal trainings for County staff. External education efforts will also be conducted and will include provision of this

information to the general public and to other communities within the County. The guidelines will also be placed on the Milwaukee County Parks' website, in conjunction with information on the Park Improvement Project (PIP) review process through which proposals should be submitted.

Realization of the goals in this report will require a long-term commitment to these guidelines, as well as coordination and cooperation among County officials and staff and various County and municipal departments. Success will also require coordination with any and all parties interested in conducting a PIP and the participation of other affected and interested parties, including Friends Groups of Milwaukee County Parks, other concerned units and agencies of government and their respective officials and staffs, and concerned private citizens, in undertaking the substantial investments and series of actions needed to implement the plan.

## **PROPOSED PROJECT REVIEW PROCESS**

As noted in Section 3 of this report, a proposal for a scope of work for any bluff or shoreline modification<sup>1</sup> within the Lake Michigan Coastline Management Zone should be submitted for review by and approval of the Milwaukee County Parks Planning & Development and Environmental Services Divisions prior to work being performed. The first step that any and all parties interested in a PIP should undertake to initiate such a proposal is to complete an online Parks Improvement Project form via a link in the Milwaukee County Parks *Community Project Request Guide*,<sup>2</sup> which contains valuable information for completing a PIP form and the PIP review process. The guide sets forth various factors that should be incorporated into PIPs, including, but not limited to, the following:

- Serve the general public
- Reflect the character of and enhance the park and/or park system
- Address the park system's need for ongoing improvement
- Be compatible with surrounding uses (within and adjacent to the park site)
- Be implemented by Milwaukee County Park standards

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<sup>1</sup> Bluff or shoreline modifications may include—but are not limited to—the construction of shoreline protection structures, such as beach nourishment; the installation of bulkhead, groin, jetty, revetment, or rip rap, or the establishment of wetlands; and development or landscape management within the Coastline Management Zone.

<sup>2</sup> The Community Project Request Guide is accessible via the [Milwaukee County Parks website](#). Individuals may email Parks staff regarding the PIP form (and other project request forms) at [parkprojects@milwaukeecountywi.gov](mailto:parkprojects@milwaukeecountywi.gov).

- Align with Milwaukee County Parks planning efforts
- Comply with zoning, land use and building requirements.

A PIP form should also incorporate considerations for funding any PIP. As outlined in the *Community Project Request Guide*, resource constraints limit the number of parks capital projects<sup>3</sup> that the County is able to fund each year. Identifying alternative funding sources like grants and sponsorships enhance the viability of a PIP and are taken into consideration during the PIP review process. Thus, a PIP should have identified funding sources that address the initial implementation and long-term maintenance of a PIP and should maximize resources by identifying leveraging opportunities and supporting partners. A PIP should ultimately help to mitigate Parks fiscal challenges while addressing the need for improvements in County-owned parks.

As noted in the *Community Project Request Guide*, PIPs may be submitted year round but are typically reviewed on a biannual basis<sup>4</sup> by a team of Milwaukee County Parks staff using objective, predetermined scoring criteria. Parks staff responds to proposals as soon as possible but response time varies with the complexity of a PIP. As County Parks staff may be unable to expedite projects due to the legislative process and established monthly meeting cycle of the Milwaukee County Board of Supervisors, proposed project timelines are subject to change. The review process ascertains the need, relevance, and priority of proposed PIPs. General review criteria, which align with the aforementioned factors, are laid out in the *Community Project Request Guide* and include, but are not limited to, the following:

- Supports or improves public health and safety
- Reduces deferred maintenance
- Promotes operational efficiency, innovation or best management practices
- Considers life cycle costs
- Positively impacts the environment or preserves natural resources
- Integrates quality design and aesthetics
- Leverages non-County resources
- Supports an area of need.

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<sup>3</sup> Capital parks projects, which include projects under \$100,000 in value, may be financed with major maintenance funding on a very limited basis.

<sup>4</sup> Milwaukee County Parks will not be reviewing project proposals in 2021.

If approved, Milwaukee County Parks staff will work with the point of contact for a PIP to refine the project scope and develop final terms and agreements during the project development phase. If a PIP is not approved, or if Milwaukee County Parks and the PIP point of contact do not agree to final terms, Parks staff will inform the PIP point of contact of the project's denied status, including relevant information on the review of the PIP. Depending on the scale and complexity of an approved project, the project may be shared with other County departments and leaders, including the County Facility Plan Steering Committee, the County Executive, and the Board of Supervisors, for final approval after the project development phase.<sup>5</sup>

## **GUIDELINE UPDATE PROCESS**

As noted in Section 3 of this report, the County may adjust or update the coastline management guidelines set forth in this report in order to recognize and protect Milwaukee County's broad public interest. Such adjustments or updates could be made after soliciting input from individuals and groups representative of local public interests and would take into account the policies, programs, and recommendations of municipalities within the County. In addition, the County could solicit information and recommendations from individuals with expertise in technical areas pertinent to coastline management, such as ecology, geology, hydrology, limnology, aquaculture and other scientific fields pertinent to shoreline management.

The guidelines review and update process would be similar to the process undertaken to adopt this report, whereas an updated draft report would be provided to the Milwaukee County PEEC and County Board of Supervisors and shared with the appropriate municipalities prior to a final review of the updated report by the PEEC and adoption by the County Board.

## **ORDINANCES RELATED TO COASTLINE MANAGEMENT**

The County should evaluate existing Milwaukee County ordinances related to coastline management to address any potential conflicts that may arise as these guidelines are implemented. Such existing ordinances may include those that involve or relate to coastline beaches and bluffs, development setbacks, maintenance of County-owned parks and/or vegetation, and stormwater infrastructure and management. As noted in Section 3 of this report, the Southeastern Wisconsin Regional Planning Commission drafted model regulations for Lake Michigan bluff setbacks based on bluff setback recommendations developed by

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<sup>5</sup> *As County departments and leaders meet on a regular cycle, communication regarding a project is integrated into meeting schedules as appropriate.*

Wisconsin Sea Grant (see Appendix \_\_ of this report). The model ordinance is intended to help protect structures and properties from bluff erosion and failure without reliance on shore protection measures through incorporation as a section in an existing zoning ordinance. The regulations can be used to calculate a setback for development along Lake Michigan that features a stable bluff slope based on the recession rate and distance providing for uncertainties related to future stable slope angles, recession rates, the effect from nearby shore protection structures, and other factors. The County may utilize the model ordinance as a reference while implementing and administering the coastline management guidelines set forth in this report.

## Appendix A

### Coastline Management Terminology

Term	Definition
Accretion	The gradual growth of a beach or shoreline as sediment is deposited by lake currents
Beach	An area of unconsolidated material, usually sand or pebbles, that is located along the edge of a body of water, extending lakeward from the bluff to the body of water's mean low water line
Bluff	A high steep bank facing an adjacent body of water
Bluff crest	The point of abrupt topographical change at the top of the bluff where the relatively flatter upland area meets the steeper bluff slope
Bluff face	Lakeward-facing portion of the bluff, inclined from the relatively flatter coastline area to the bluff top; bluff slope
Bluff recession	The landward retreat of the bluff, bluff crest, or bluff toe from the adjacent body of water as material within the bluff is lost due to coastline impacts
Bluff toe	The point of abrupt topographical change at the bottom of the bluff where the steeper bluff slope meets the relatively flatter coastline area
Bluff slope	Lakeward-facing portion of the bluff land, inclined from the relatively flatter coastline area to the bluff top; bluff face
Breakwater	A structure, usually parallel to the shore in the nearshore zone, built to protect a shore area by reducing wave activity
Bulkhead	A vertical structure separating land and water areas designed to retain soil
Creeping	The imperceptibly gradual downslope movement of unconsolidated material
Coastline	The boundary between a water body and adjacent land; shoreline
Groin (groyne)	A shore protection structure typically built perpendicular to the shoreline for the purpose of constraining littoral drift, trapping sediment, or preventing shoreline erosion
Jetty	A shore protection structure extending into a water body from adjacent lands designed to manage water currents
Littoral current	Nearshore water current
Littoral drift	The movement of nearshore sand and sediment via littoral currents
Moveable structure	A permanent structure designed for relocation
Nearshore	Relating to the area near the shoreline
Nourishment	A shore protection measure entailing adding sand/gravel to restore a beach or shoreline
Permanent structure	An unmovable structure or occupiable building for residential, commercial, industrial, or institutional use, including accessory and related buildings, and other unmovable structures or infrastructure
Revetment	A shore protection measure constructed of piled stone, concrete, or other similar impermeable materials placed along the shoreline to protect the shoreline from erosion; rip rap
Riprap	A shore protection measure constructed of piled stone, concrete, or other similar impermeable materials placed along the shoreline to protect the shoreline from erosion; revetment
Seawall	A vertical concrete structure separating land and water areas designed to retain soil and absorb wave energy
Seiche	Periodic brief lake level fluctuations typically caused by changes in atmospheric pressure
Shoal	A naturally occurring nearshore mound of sand or other unconsolidated material that rises from the lakebed to near the lake surface
Shoreland	Land between the toe of a lake bluff or first major change in terrain and a lake
Shoreline	The boundary between a water body and adjacent land; coastline
Slide/sliding	A type of bluff slope failure involving the downslope movement of unconsolidated bluff material
Solifluction	The slow downward movement of material on a slope, often occurring when frozen subsoil or near-surface bedrock prevents water in the soil from percolating into the slope

<b>Term</b>	<b>Definition</b>
Sloughing	The shedding of the uppermost layer or layers of soil or other unconsolidated material from the toe of a bluff
Storm surge	The temporary downwind rise in water levels attributable to strong winds during a storm or extreme weather event

Note: Adapted from information gathered from resources identified in Appendix B of this report.

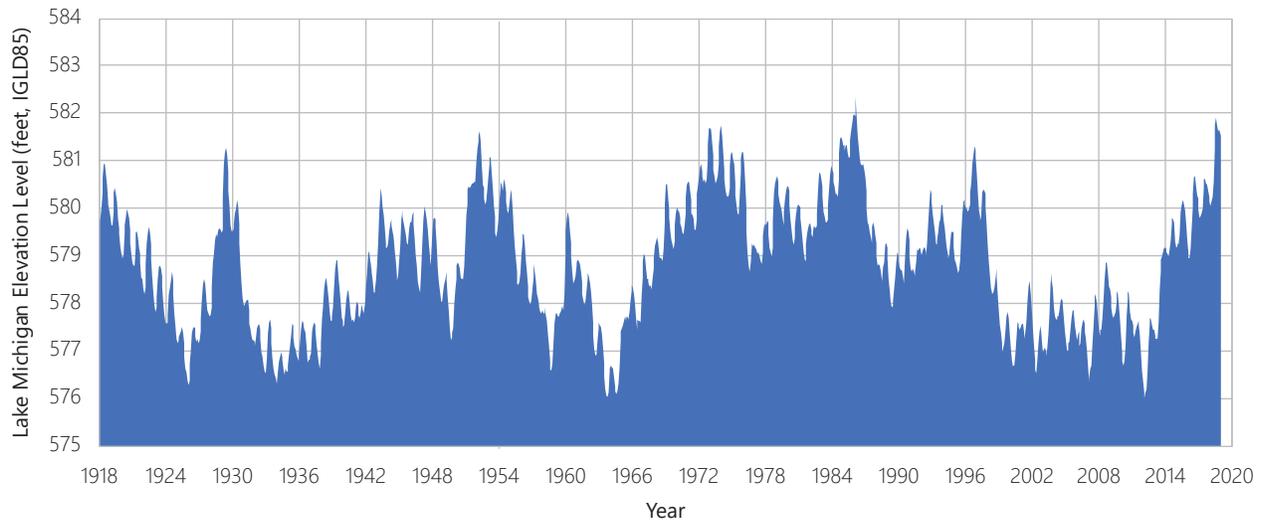
Source: *U.S. Army Corps of Engineers (USACE) and SEWRPC*

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## Appendix B Resource List

- Community Assistance Planning Report No. 155, *A Lake Michigan Shoreline Erosion Management Plan for Northern Milwaukee County, Wisconsin*, Southeastern Wisconsin Regional Planning Commission, 1988.
- Community Assistance Planning Report No. 163, *A Lake Michigan Shoreline Erosion Management Plan for Milwaukee County, Wisconsin*, Southeastern Wisconsin Regional Planning Commission, 1989.
- Flora of Wisconsin*, Consortium of Wisconsin Herbaria. [www.wisflora.herbarium.wisc.edu/index.php](http://www.wisflora.herbarium.wisc.edu/index.php) (2020).
- Levels Reference Study Great Lakes-St. Lawrence River Basin*, Levels Reference Study Board, International Joint Commission, 1993.
- Levels Reference Study Great Lakes-St. Lawrence River Basin - Annex 2: Land Use and Management*, Levels Reference Study Board, International Joint Commission, 1993.
- Living on the Coast*, Philip Keillor, University of Wisconsin Sea Grant Institute, 2003.
- Living with the Lakes*, Roger Gauthier, U.S. Army Corps of Engineers, 1999.
- Managing Coastal Erosion*, National Academy of Sciences, National Academy Press, 1990.
- Managing Coastal Hazard Risks on Wisconsin's Dynamic Great Lakes Shoreline*, Alan Lulloff and Philip Keillor, Wisconsin Coastal Management Program, 2016.
- Protecting the Coastal Zone Through Growth Management: The Experience of Five Coastal States*, Kari Dolan and Heidi Bly, Hendrickson National Network for Environmental Management Studies, United States Environmental Protection Agency, 1989.
- Shrubs and Woody Vines of Indiana and the Midwest*, Sally Weeks and Harmon Weeks Jr., Purdue University, 2012.

## Appendix C Lake Michigan Mean Monthly Water Levels: 1918-2019



Source: U.S. Army Corps of Engineers-Detroit District and SEWRPC

## Appendix D Vegetation for Bluff Stabilization<sup>a</sup>

Herbaceous Plants							
Common Name(s)	Scientific Name(s)	Typical Mature Height	Soil Type	Moisture	Sun/Shade Tolerance	Root Type	Usage Area
Asters	<i>Symphyotrichum</i> <i>Eurybia spp.</i>	1-4'	Any	Wet to dry, depending on species	Full sun to shade, depending on species	Fibrous, some species spreading by rhizomes	Table, ravine, bluff face, toe
Bergamot	<i>Monarda fistulosa</i>	3-4'	Any	Moist to somewhat dry	Full sun to partial shade	Deep branched roots and shallow rhizomes	Table, face, toe
Blue Vervain	<i>Verbena hastata</i>	3-5'	Any	Wet to moist	Full sun	Fibrous	Table, toe
Common Milkweed	<i>Asclepias syriaca</i>	2-6'	Any	Moist to dry	Full sun to partial shade	Fibrous, spreading rhizomes	Table, bluff face, toe
Goldenrods	<i>Solidago</i> and <i>Euthamia spp.</i>	2-6'	Any	Wet to dry, depending on species	Full sun to shade, depending on species	Fibrous, some species spreading by rhizomes	Table, ravine, bluff face, toe
Great Blue Lobelia	<i>Lobelia siphilitica</i>	2-4'	Any	Moist to medium	Full sun to light shade	Fibrous, shallow	Table, ravine, toe
Mountain Mint	<i>Pycnanthemum virginianum</i>	2-3'	Any	Moist to medium	Full sun to partial shade	Fibrous with shallow rhizomes	Table, face, toe
Sedges	<i>Carex spp.</i> and <i>Scirpus spp.</i>	0.5-3'	Any	Wet to dry, depending on species	Full sun to shade, depending on species	Fibrous, some species spreading by rhizomes	Table, face, ravine, toe
Tall Boneset	<i>Eupatorium altissimum</i>	3-4'	Any	Medium to dry	Full sun to partial shade	Fibrous	Table, face, toe
Warm-season grasses (Switchgrass, Big Bluestem, Little Bluestem, Indiangrass, etc.)	<i>Panicum virgatum</i> , <i>Andropogon gerardii</i> , <i>Schizachyrium scoparium</i> , <i>Sorghastrum nutans</i> , etc.	2-8'	Any	Moist to dry, depending on species	Full Sun	Fibrous, deeply penetrating root systems, some species spreading by rhizomes (esp. switchgrass)	Table, face, toe, help prevent erosion
White Snakeroot	<i>Ageratina altissima</i>	1-3'	Any	Moist to somewhat dry	Shade	Fibrous with shallow rhizomes	Table, ravine, toe
Wild Ryes	<i>Elymus spp.</i>	3-5'	Any	Moist to dry, depending on species	Full sun to shade, depending on species	Fibrous	Table, face, ravine, toe, quick to establish
Yellow Coneflower	<i>Ratibida pinnata</i>	3-5'	Any	Medium to dry	Full sun	Fibrous	Table, face, toe

**Shrubs**

<b>Common Name(s)</b>	<b>Scientific Name(s)</b>	<b>Typical Mature Height</b>	<b>Soil Type</b>	<b>Moisture</b>	<b>Sun/Shade Tolerance</b>	<b>Root Type</b>	<b>Usage Area</b>
American Hazelnut	<i>Corylus americana</i>	10-12'	Any	Wet to dry	Full sun to light shade	Spreading	Bluff face
American Highbush Cranberry Viburnum	<i>Viburnum trilobum</i>	8-15'	Any	Moist	Full sun to light shade	Spreading, suckering	Table, ravine, toe
Blackhaw Viburnum	<i>Viburnum prunifolium</i>	10-15'	Any	Somewhat moist to somewhat dry	Shade	Branching, woody, suckering	Table, ravine
Bladdernut	<i>Staphylea trifolia</i>	10-13'	Any	Moist, rich soils	Shade to full sun	Spreading, suckering	Ravine
Bush Honeysuckle	<i>Diervilla lonicera</i>	2-3'	Sandy to rocky	Dry	Shade to partial shade	Suckering	Bluff face
Common Ninebark	<i>Physocarpus opulifolius</i>	5-10'	Any	Moist to somewhat dry	Full sun to partial shade	Spreading, fibrous, extensive, suckering	Table, ravine, face, toe
Common Juniper	<i>Juniperus communis</i>	1-4'	Any	Wet to dry	Full sun	Spreading	Bluff face
Common Snowberry	<i>Symphoricarpos albus</i>	2-5'	Any	Moist to dry	Shade	Spreading, suckering	Table, ravine
Hop Tree	<i>Ptelea trifoliata</i>	10-20'	Any	Medium to dry	Full sun to partial shade	Extensive, but does not sucker from roots or rhizomes	Table, bluff face, toe
Leatherwood	<i>Dirca palustris</i>	5-7'	Any	Moist, rich soil	Shade to partial shade	Variable	Ravine
Maple-Leaf Viburnum	<i>Viburnum acerifolium</i>	4-6'	Any	Moist to dry	Shade to partial shade	Shallow	Ravine
Meadow Sweet	<i>Spiraea alba</i>	3-6'	Silt, clay, organic	Moist	Full sun	Suckering	Bluff face
Nannyberry Viburnum	<i>Viburnum lentago</i>	14-25'	Any	Moist to medium	Full sun to light shade	Spreading, fibrous, suckering	Table, ravine, toe
New Jersey Tea	<i>Ceanothus americanus</i>	1-3'	Sandy to silt	Dry	Full sun to partial shade	Deep, extensive, nitrogen fixing	Bluff face
Pussy Willow, Missouri River Willow, and Bebb's Willow	<i>Salix discolor, Salix eriocephala, Salix bebbiana</i>	6-20'	Any	Wet to moist	Full sun to partial shade	Extensive, Fibrous, suckering	Table, ravine, face, toe
Red Elderberry	<i>Sambucus racemosa</i>	8-14'	Any	Moist to medium	Partial shade to light shade	Spreading, suckering	Table, ravine
Red-Osier Dogwood, Gray Dogwood, and Silky Dogwood	<i>Cornus sericea, Cornus racemosa, and Cornus amomum</i>	6-15'	Any	Wet to medium, depending on the species	Full sun to partial shade	Deep, extensive, suckering	Table, ravine, face, toe

**Shrubs**

<b>Common Name(s)</b>	<b>Scientific Name(s)</b>	<b>Typical Mature Height</b>	<b>Soil Type</b>	<b>Moisture</b>	<b>Sun/Shade Tolerance</b>	<b>Root Type</b>	<b>Usage Area</b>
Round-leaved Dogwood	<i>Cornus rugosa</i>	10-15'	Any	Medium to somewhat dry	Partial sun to light shade	Deep, extensive, suckering	Table, ravine, toe
Sandbar Willow	<i>Salix interior</i>	8-20'	Sands and loams	Wet to moist	Full sun to partial shade	Extensive, Fibrous, suckering to form large colonies	Table, ravine, face, toe
Soapberry	<i>Shepherdia canadensis</i>	3-9'	Neutral to Alkaline	Moist to dry	Full sun to partial shade	Spreading, suckering	Bluff face, toe (naturally occurs most often on exposed bluff headlands)
Sweet Fern	<i>Comptonia peregrina</i>	1-3'	Sandy	Dry	Full sun	Suckering, nitrogen fixing	Bluff face
Arrowwood Viburnum	<i>Viburnum rafinesquianum</i>	6'	Any	Moist to dry	Shade to partial shade	Suckering, spreading	Ravine
Winter Berry	<i>Ilex verticillata</i>	10-15'	Silt, clay, organic, prefers acidic	Wet to moist	Full sun to light shade	Spreading	Bluff face
Witch-Hazel	<i>Hamamelis virginiana</i>	15-20'	Any	Moist to dry	Shade to partial shade	Variable	Ravine

Trees							
Common Name(s)	Scientific Name(s)	Typical Mature Height	Soil Type	Moisture	Sun/Shade Tolerance	Root Type	Usage Area
Alternate-leaved Dogwood	<i>Cornus alternifolia</i>	15-25'	Loamy	Well drained, moist to medium	Full shade (understory tree)	Shallow, spreading root system benefits from leaf litter	Table, ravine
Balsam Poplar	<i>Populus balsamifera</i>	75-100'	Loamy	Well drained, moist to medium	Full sun	Shallow, spreading	Bluff face, ravine, toe
Basswood	<i>Tilia americana</i>	50-100'	Any	Moist to somewhat dry	Full sun to partial shade	Mostly lateral roots, can form adventitious roots when base is buried	Table, ravine
Black Cherry	<i>Prunus serotina</i>	45-80'	Any	Medium to dry	Full sun to partial shade	Tap root with shallow spreading roots, some roots up to four feet deep	Table, ravine
Bog Birch	<i>Betula pumila</i>	4-13'	Alkaline	Wet	Full sun	Shallow	Bluff face
Eastern Arborvitae	<i>Thuja occidentalis</i>	40-60'	Loams and clays	Moist to medium	Full sun to partial shade	Shallow, spreading root system	Table, ravine, bluff face
Hophornbeam	<i>Ostrya virginiana</i>	25-50'	Any	Well drained, moist to somewhat dry	Full sun to light shade (understory tree)	Variable, shallow in heavy soils	Table, ravine
Oaks (esp. Bur Oak and Chinquapin Oak)	<i>Quercus</i> spp. (esp. <i>Quercus macrocarpa</i> and <i>Quercus muehlenbergii</i> )	40-120'	Any	wet to dry, depending on species	Full sun	Deep and wide-spreading roots, will re-sprout from stump or crown if top-killed	Table, ravine (where relatively stable)
Paper Birch	<i>Betula papyrifera</i>	50-70'	Any	Moist to somewhat dry	Full sun	Shallow, spreading root system, good for stabilization	Table, ravine, bluff face, toe
Peach-leaved Willow	<i>Salix amygdaloides</i>	35-70'	Any	Wet to moist	Full sun	Dense, shallow roots, forms adventitious roots when base is buried	Table, ravine (especially along waterways), bluff face, toe
Red Maple	<i>Acer rubrum</i>	50-80'	All but the most high pH (>7.4) soils	Moist to medium	Full sun to partial shade	Shallow roots	Table, ravine

Trees							
Common Name(s)	Scientific Name(s)	Typical Mature Height	Soil Type	Moisture	Sun/Shade Tolerance	Root Type	Usage Area
Speckled Alder	<i>Alnus incana</i>	15-30'	Silt, clay, organic	Wet to moist	Full sun	Spreading, suckering, nitrogen fixing	Bluff face
Wild Plum	<i>Prunus americana</i>	15-25'	Any	Medium to dry	Full sun	Spreading, shallow to medium depths.	Table, ravine, bluff face

<sup>a</sup> As identified in *A Property Owner's Guide to Protecting Your Bluff*, a publication under preparation by the University of Wisconsin Sea Grant Institute and the Southeastern Wisconsin Regional Planning Commission as this report was being prepared, and adapted to suitability for local conditions.

Source: Milwaukee County, University of Wisconsin Sea Grant Institute, and SEWRPC.

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