City of St. Joseph Coastal Engineering Study Update 2017

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Table of Contents

List of Appendices

1.0 PURPOSE

This report is intended to re-evaluate the Lake Michigan coastal conditions within the St. Joseph City Limits and to verify recommendations for shoreline management set forth in the 2012 St. Joseph Coastal Engineering Study.

The purpose of the previous study was to preserve the public trust property along the shoreline and to protect private interests and property, while taking into consideration the unique characteristics and circumstances of the shoreline in different areas of the City. The previously recommended shoreline management approaches were also intended to help City policymakers as they evaluate options to further public purposes such as protecting natural resources; preserving the Lake Michigan shoreline; advancing the economic and environmental well-being, health, safety, and general welfare of the City; and preserving/enhancing property values by preserving the natural character of the shoreline.

Due to changing Lake Michigan water levels, increased development, and the 5-year timespan that has passed since the initial evaluation, previous recommendations are being re-evaluated to ensure that they are still applicable and that they are consistent with the City's goals of preserving the public trust and protecting private property.

2.0 STUDY AREAS

The 2012 study divided the City's shoreline into three areas of distinguishable characteristics. This update includes re-evaluation of conditions within all three Areas.

Image courtesy of Google earth; © 2017 TerraMetrics; NOAA

Figure 1: Project Overview Map

The project areas included in this study update are as follows:

2.1 AREA 1

Area 1 includes the St. Joseph shoreline from the south limit of Jean Klock Park (City of Benton Harbor) to the northerly limits of the St. Joseph River. The public trust property in this area varies in width and extends from the water line to the Natural Ordinary High Water Mark (NOHWM). Structures in this area are generally located at least 300 feet inland from the Ordinary High Water Mark (OHWM), with a few exceptions that are within 150 feet of the OHWM. Further definitions of OWHM and public trust property is located below in Section 4.6.

Figure 2: 2016 Area 1 Aerial (Google Earth, Terrametrics)

Area 1 is bordered on both ends by public parks, with Jean Klock Park to the north and Tiscornia Beach to the south. Between the parks, private properties exist and many of the lots extend several hundred feet southeast to Ridgeway. Currently, no shoreline protection structures exist within Area 1, apart from the federal navigation structure at the southerly limit of the area. The entire shoreline here is sandy beach with dune grass vegetation established in the foredune areas. Due to the interaction of the Northern USACE jetty with the typical movement of sand along the lakeshore, Area 1 is typically an accretion zone especially at its southerly end, but is subject to erosion at times of higher than average water levels.

2.2 AREA 2

Area 2 includes the shoreline from the south jetty of the St. Joseph River to the northern limit of the St. Joseph Water Plant. This area includes two public parks, with Silver Beach located at the north end and Lions Park Beach located at the south end.

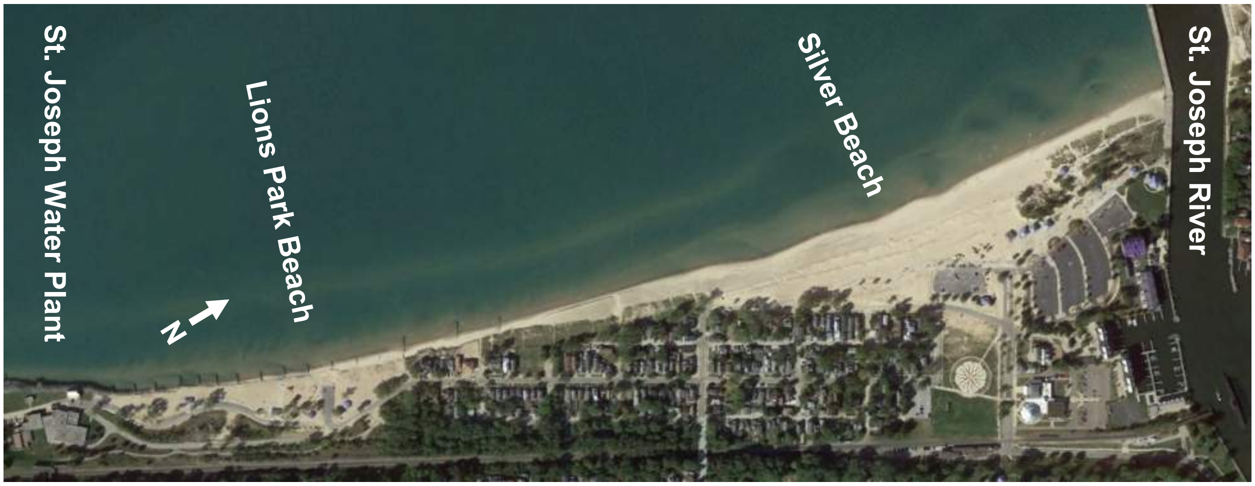


Figure 3: 2016 Area 2 Aerial (Google Earth, Terrametrics)

The entire shoreline in Area 2 is publicly-owned under most lake conditions, and includes existing publically-owned shore protection structures along with some private shore protection structures on adjacent private property. During times of high water and during significant storm events, the Lake Michigan water line reaches private property at the southern extents of the residential neighborhood. When this occurs, water is in close proximity to the existing homes, threatening property damage and restricting the public way.

2.3 AREA 3

Area 3 includes the St. Joseph shoreline from the north limit of the St. Joseph Water Plant to the south City Limit, just south of Orleans Circle.

Figure 4: 2016 Area 3 Aerial (Google Earth, Terrametrics)

Little to no meaningful public trust property exists here due to limited access, high bluffs, stone revetments, and other existing shoreline protection structures with little to no area between existing structures and the waterline. The shores within Area 3, in contrast to Areas 1 and 2, are composed of cohesive material and the majority of the shoreline here contains shore protection of varying types and states of repair. These structures are intended to protect private property, railroad infrastructure and public roadways. Isolated failures have been identified in recent years and are in process of being repaired. Existing shoreline structures should be monitored continuously by their respective owners and any deficiencies repaired to prevent secondary effects to adjacent infrastructure and property.

3.0 EXECUTIVE SUMMARY

3.1 AREA 1

Area 1 is bookended by public parks at either end that are connected by uninterrupted public trust property adjacent to private property. To preserve this public trust property, reduce the risks of coastal hazards to private property, and maintain the natural shoreline, we recommend continued enforcement of the existing setback line described in the City's zoning ordinance, as part of the Edgewater Beach Overlay District (henceforth "EBOD line"). Based upon the new survey data collected, updated water level/wave runup calculations, and review of site conditions, the current location of the EBOD line is sufficient for achieving the stated goals of the EBOD.

Beach and dune grading is apparent throughout Area 1. If these activities continue, property owners could be increasing risks to their properties by lowering the elevation of the foredune, allowing waves to reach further landward. Impacts could include accelerated dune erosion and the possibility that waves will reach further inland. We recommend an outreach program regarding the impacts these actions could cause.

3.2 AREA 2

Area 2 contains public parks at both ends and publicly-owned shoreline along its entire length during typical lake conditions. This area is shadowed by the USACE jetties to the north and as a result is almost entirely an erosion zone that is highly dependent upon annual beach nourishment used as erosion mitigation though the placement of dredge spoils from USACE harbor maintenance work. The adjacent residential lots in this area are fully developed and the shallow lot depths prevent structures from being built significantly further from the lake than existing structures. We recommend the development of a concept design to preserve public access along the shoreline, while allowing property owners to construct, if necessary, properly designed shoreline protection structures which could ultimately become one unified structure. One option for this method would be to construct a shoreline protection system lakeward of the residential lots on public property to protect both public and private interests. This way public access could be maintained along the shoreline during times of low water and beach nourishment, and above the protection system during times of high water and heavy erosion, while still protecting adjacent private property. Such a measure would likely require funding and maintenance agreements to be established between the City and adjacent property owners, the details of such are outside the scope of this study update.

3.3 AREA 3

Area 3 contains little to no public trust shoreline and exhibits a completely armored condition. Therefore, additional regulation of shore protection measures above the regulations currently administered by the Michigan Department of Environmental Quality and the U.S. Army Corps of Engineers is not recommended. We do recommend continued coordination and support for private monitoring and repairs to existing protective measures which may be nearing the end of their useful lives.

4.0 DEFINITIONS & COASTAL CONSIDERATIONS

4.1 VERTICAL DATUM

As with the original study, all elevations within this study update are in reference to the International Great Lakes Datum, 1985 (IGLD 85), unless otherwise noted. Some elevations within the study are converted from other datums which were referenced in original documents.

4.2 WAVE HEIGHT

Wave height is defined as the difference in elevation between the wave's crest to its neighboring trough. In order to standardize wave heights for statistical analysis, wave heights are generally referred to as significant wave heights. A significant wave height was originally defined as the average wave height of the largest third of the waves; it is now commonly defined as four times the standard deviation of the surface elevation of the water.

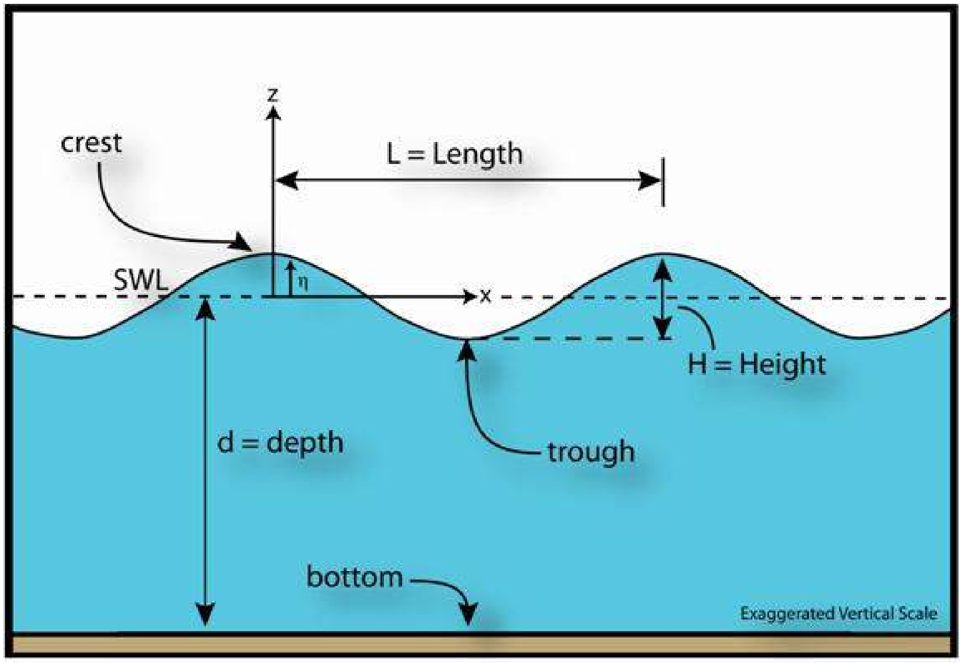


Figure 5: Wave Definition Graphic (Courtesy of US FHWA)

According to the U.S. Army Corps of Engineers Wave Information Studies (WIS) for the shoreline near St. Joseph, the 50-year event peak deep water wave height is 7.2 meters, or 23.6 feet, while the 100-year event peak deep water wave height is 7.7 meters, or 25.3 feet. A 50-year event has a 2% chance of being equaled or exceeded in any single year and a 100-year event has a 1% chance of being equaled or exceeded in any single year.

These wave heights are derived by the USACE assuming that the waves develop in deep water conditions with deep enough water depths that the bottom does not affect the height of the waves. As waves move toward land, the water depth becomes shallower and limits the possible height of the waves. In order to account for this relationship, deep water waves are transformed into nearshore waves using current lake bed bathymetry and applicable wave transformation equations to estimate the size of waves that reach the shore. Current observations and predictions of coastal conditions around the Great Lakes region indicate that weather patterns will continue to become more variable with a broader range of extremes. For this reason, the 100-year wave events were used a basis for analysis in this study update while the original study analysis was performed using the 50-year event data.

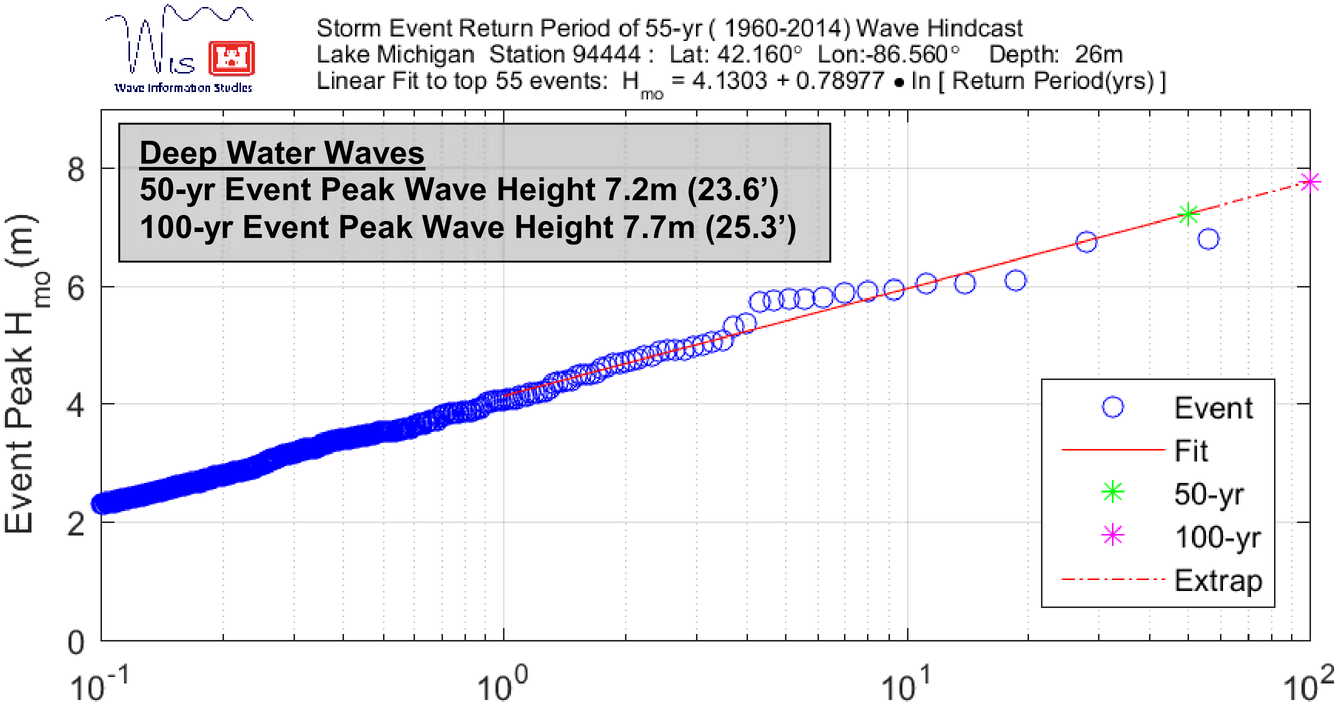


Figure 6: U.S. Army Corps of Engineers WIS Data

Also according to the Wave Information Studies, wind forces along the St. Joseph coast occur most frequently from the south-southwest direction, while high frequencies of wind also occur from the southwest and north-northwest directions (Figure 7). The greatest frequency of wave occurrence, however, is from the north-northwest, due to the long wave fetch in the north-northwest direction (Figure 8).

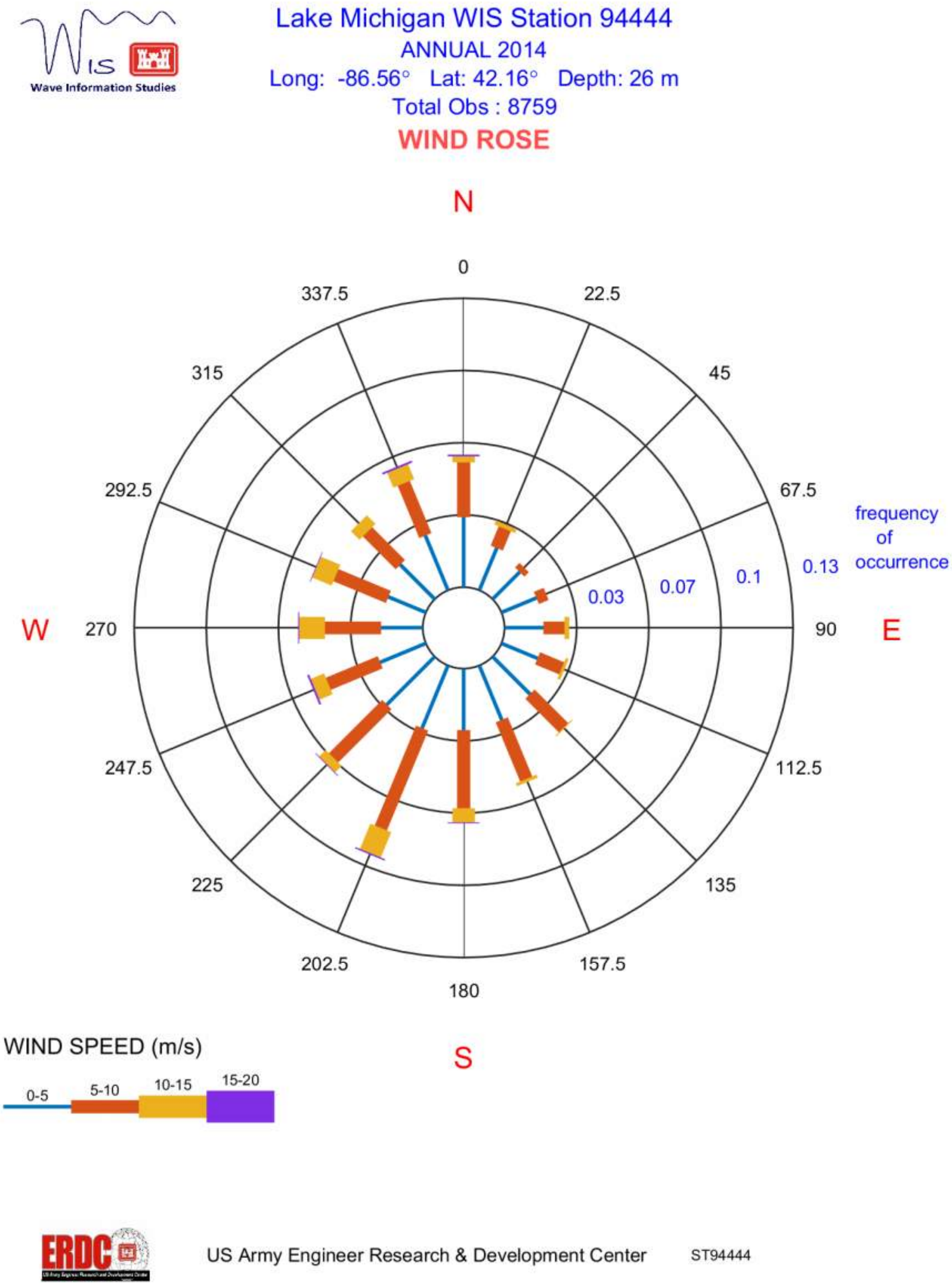


Figure 7: U.S. Army Corps of Engineers WIS Wind Rose

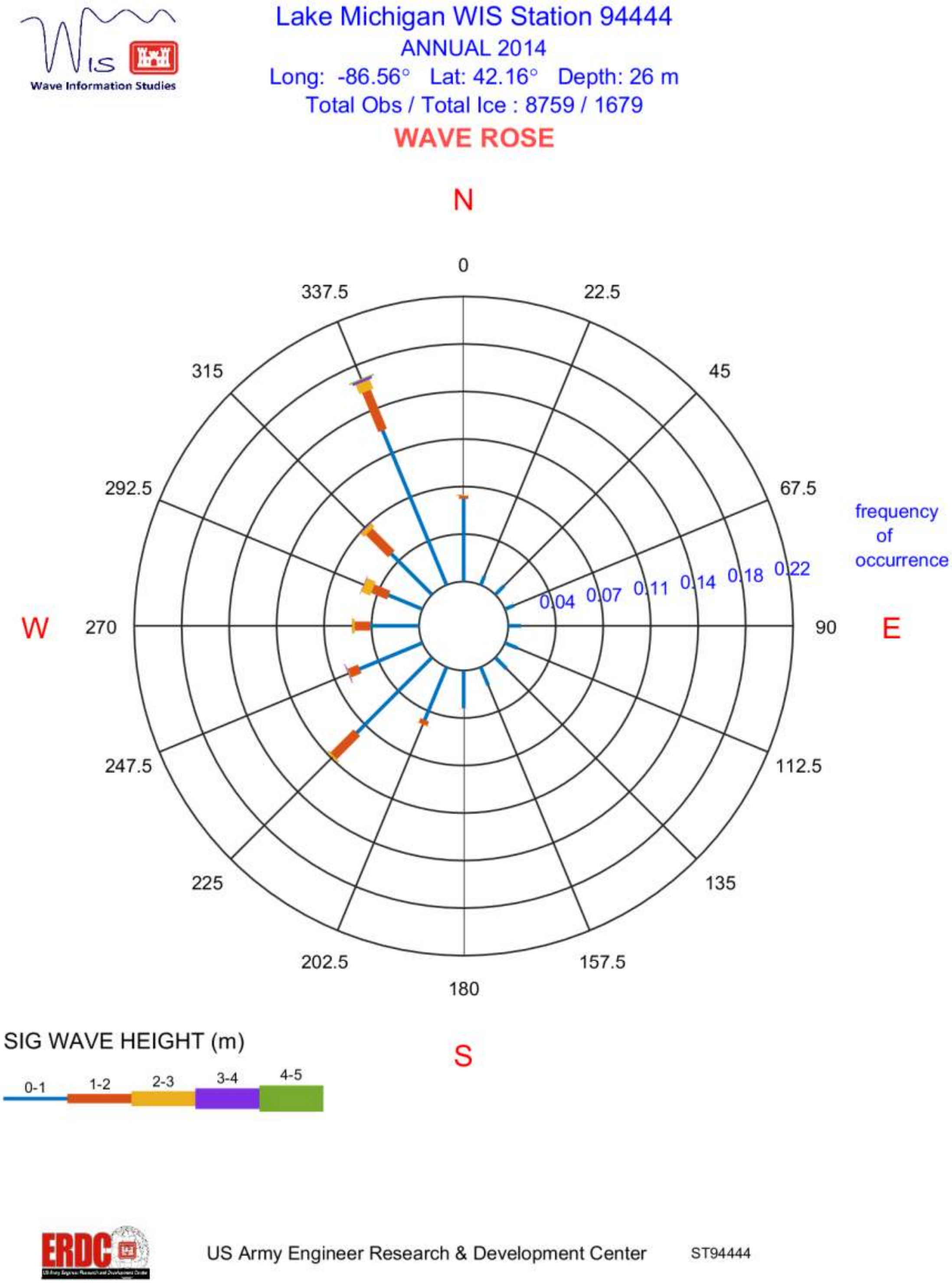


Figure 8: U.S. Army Corps of Engineers WIS Wave Rose

Wave fetch is the distance which wave-generating winds travel over water. In St. Joseph, although winds come from the south-southwest most frequently, the fetch in that direction is only 25 miles, so waves have a relatively short distance to form. This relatively short fetch means that the duration of the wind event needs to be significant to generate waves and the waves that are generated have a smaller significant wave height due to the limited amount of force transferred to the water. When winds come from the north-northwest, the fetch distance is 150 miles and extreme waves can be generated due to the longer duration of wind and water contact to allow for the transfer of more energy. Figure 9 illustrates the St. Joseph fetch distances for each of the two most predominant wind directions.

Figure 9: Fetch Distances for St. Joseph

As a strong, sustained wind with a large fetch blows across open water, some of its energy is transferred to the water. This energy transfer causes water to be dragged with the wind, causing a storm surge, or set-up, to occur on the leeward (downwind) side of the water body. This set-up inversely causes a set-down on the windward (upwind) side of the water body. This relationship is shown in Figure 10. Set-ups and set-downs can also be caused by sudden changes in atmospheric pressure on the lake. Since it is located on the side of Lake Michigan that is typically leeward, St. Joseph is highly susceptible to wave set-ups ranging from two to three feet. These set-ups, combined with large wave heights during a storm event, can create extreme shoreline conditions.

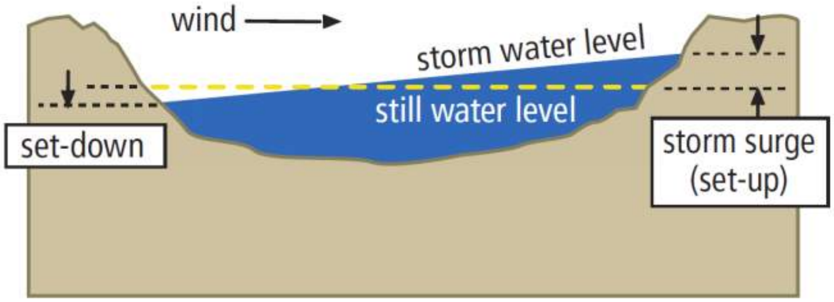


Figure 10: U.S. Army Corps of Engineers/University of Wisconsin. *Living on the Coast*. USA: U.S. Army Corps of Engineers/University of Wisconsin, 2003. Print.

4.3 WAVE RUNUP

Wave runup is defined as the landward extent of wave uprush measured vertically from the still water level (Figure 11). Runup is largely dependent on deep water wave height, wave period, lake bottom slope, and shoreline slope.

Wave runup (*R*) is a combination of two components: set-up ($\bar{\eta}_{max}$) and swash (*S*), represented by the following general wave runup equation (Stockdon et al. 2006):

$$R = \bar{\eta}_{max} + \frac{S}{2} \tag{1}$$

Set-up, as described in Section 4.2, is a mean water surface elevation that is sustained over a longer time scale relative to the swash component. Swash is the relatively short-term variation of water level about the set-up elevation due to incident wind waves and infragravity (surface gravity) waves. The Stockdon universal beach runup formula, expanded from equation 1 with empirical data, is seen below:

$$R_{2\%} = 1.1\left(0.35\beta\sqrt{(H_{m0} \cdot L_{0p})} + \frac{1}{2}\sqrt{H_{m0} \cdot L_{0p}(0.563\beta^2 + 0.004)}\right) \tag{2}$$

$$\therefore where \rightarrow \quad H_{m0} = deep\ water\ spectral\ wave\ height$$
$$L_{0p} = deep\ water\ peak\ wave\ length$$
$$\beta = cross - shore\ beach\ slope$$

There are a multitude of factors that influence wave transformation and subsequent wave runup, which cannot be accounted for analytically; instead an empirical approach (as seen above) has been historically favored to develop a broad spectrum of formulae to correlate constant coefficients with wave characteristics through experiments and field testing. The surf similarity parameter (ζ) is a dimensionless parameter that has served as the basis for many empirical equations, as defined by Battjes (1974):

$$\zeta = \frac{\tan\beta}{\sqrt{H_0/L_0}} \tag{3}$$

$$\therefore\ where \rightarrow \quad H_0 = deep\ water\ wave\ height$$
$$L_0 = deep\ water\ wave\ length$$

The surf similarity parameter is essentially a ratio between the effective cross-shore beach slope (*tanβ*) and the steepness of a deep water wave, and is used to predict the type of wave breaking that will occur on a particular beach. The Hunt-based Holman and modified Mase formulae was originally derived from the surf similarity relationship and lab experiment data; it was further refined with a range of beach data by Melby (2012) to develop the Mase relative runup equation with Melby modification, seen below:

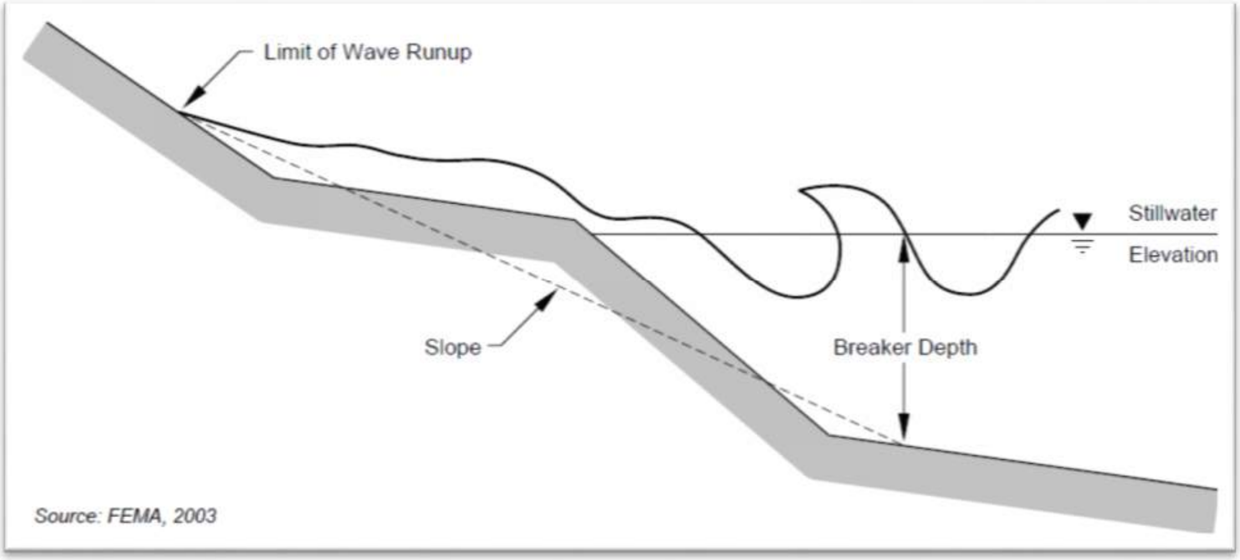
$$R_{2\%} = a \cdot H_{m0}\left(\frac{\tan\beta}{\sqrt{H_{m0}/L_{0p}}}\right)^{b} \tag{4}$$

Through comparison with beach data and CSHORE data, the Melby modification resulted in coefficients values *a* and *b* equal to *1.1* and *0.7* respectively.

The empirical approach to predicting wave runup is inherently imprecise, however when applied properly it is accurate enough for flood hazard assessment purposes. According to Melby (2012) the nondimensional root mean square (RMS) error for Stockdon and Melby (Mase modified) methods is 0.27 and 0.28 respectively when compared to beach data. In addition negligible error is seen when H_s (significant wave height) and L_0 are interchanged with H_{m0} and L_{0p} respectively.

For the purpose of this study, both of the aforementioned methods were used in conjunction with local bathymetric data to determine wave runup predictions. Wave data from a virtual buoy in transitional water off the coast of St. Joseph was used, which was then deshoaled using an iterative method based on Airy wave theory to determine deep water wave characteristics for a 100-year storm. The deep water wave characteristics were input into both Melby and Stockdon wave runup equations, resulting in an average 2% wave runup for Area 1 of 7.3 feet (range 6.3' – 8.7') and an average 2% wave runup for Area 2 of 7.8 feet (range 6.3' – 8.1'), both relative to still water elevation.

Based upon the resulting ranges, a runup value of 8.0 feet was used for mapping purposes in both areas. The primary difference in runup is attributed to slope/bathymetry differences between the areas. The overall results are in keeping with expectations for the relatively dissipative beach.



Source: FEMA, 2003

Figure 11: FEMA Wave Runup Graphic

Total water level is the sum of still water level, storm setup, and wave runup. Utilizing the methods above and the 2017 survey data, total water levels were calculated for each section in both Area 1 and Area 2.

4.4 LAKE MICHIGAN WATER LEVELS

Water levels are typically expressed in reference to a static elevation referred to as low water datum (LWD). The low water datum of Lake Michigan is elevation 577.5' IGLD 85. As of the December 2017 U.S. Army Corps of Engineers (USACE) Lakes Michigan-Huron Water Level Bulletin (see Appendix), the current water level is +2.7 LWD. The long-term average level for November is +1.2' LWD, meaning that Lake Michigan is currently in a high lake level condition. During the time of the 2012 study, the lake was at a low lake level condition.

The USACE has monitored and recorded Great Lakes water levels since 1918. Over this period, the long term lake water level fluctuates between -1.5' LWD and +4.9' LWD, a range of 6.4 feet. The record high water level occurred in October of 1986 and the record low occurred in January of 2013, after the completion of the previous study. Figure 12 illustrates an example of the horizontal movement of the water line in Area 1, resulting from long term water level fluctuations and accretion.

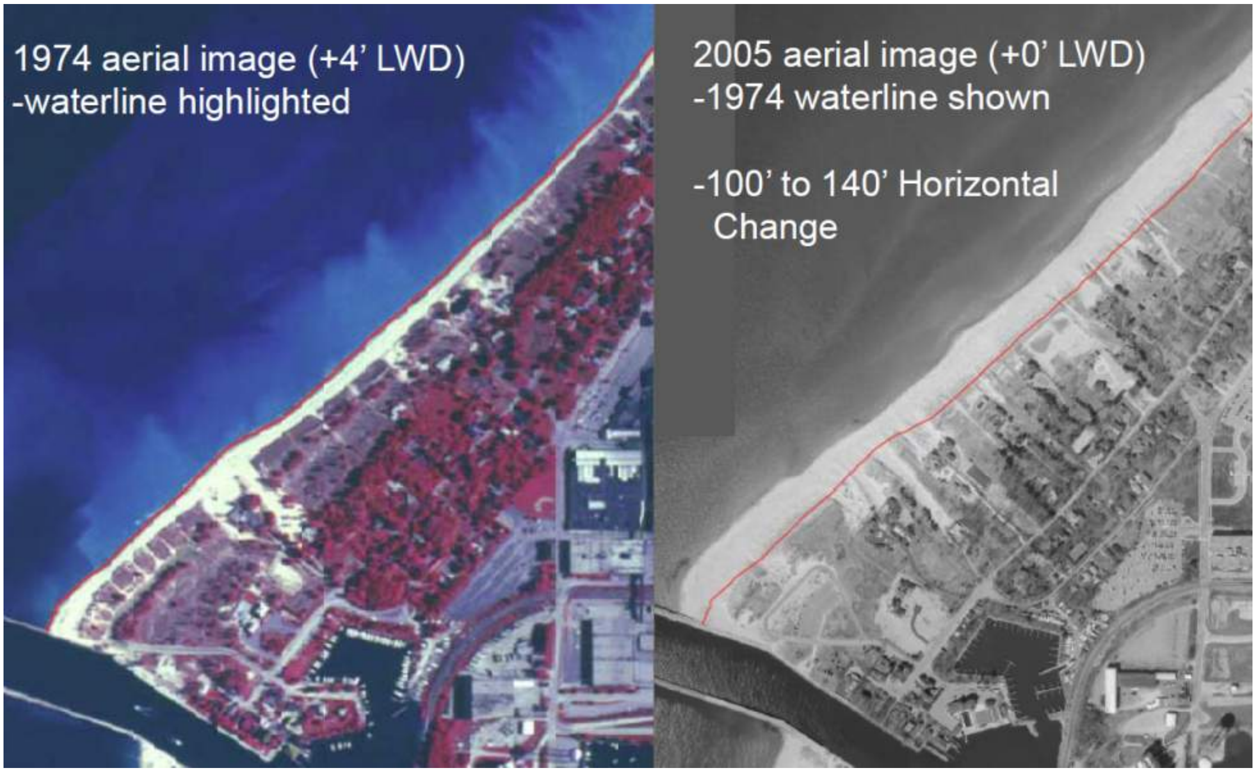


Figure 12: Aerial comparison of 1974 waterline and 2005 waterline

Although the records only extend back to 1918, they are still commonly referred to as "all-time high"/ "all-time low". However, prior to 1918, there are few records of Lake Michigan's long term water level fluctuations. Record data from Milwaukee, Wisconsin suggests that in 1838 Lake Michigan may have reached an even higher level than the 1986 "all-time high". The data indicates that a level of +6.6' LWD was reached in 1838, which is 1.7 feet higher than the 1986 level. Due to the uncertainty of water levels and the relatively small available record period, a factor of safety is recommended. It is important to note that this report and its assumptions are based on the currently available information (including existing studies, historic data, local, state and federal documentation) however coastal conditions may exceed the conditions projected herein.

Since 1918, Lake Michigan water levels have exhibited three 10-year periods of low lake level, in which water levels are at least one foot below the long-term annual average (Figure 13). These periods occurred from approximately 1931 to 1942, from 1957 to 1967, and from 1999 to 2014. Each of the previously recorded low-level periods was followed by high water levels. Based on the long term fluctuations of the Lake Michigan water level, average to above-average water levels can be expected to continue for several years.

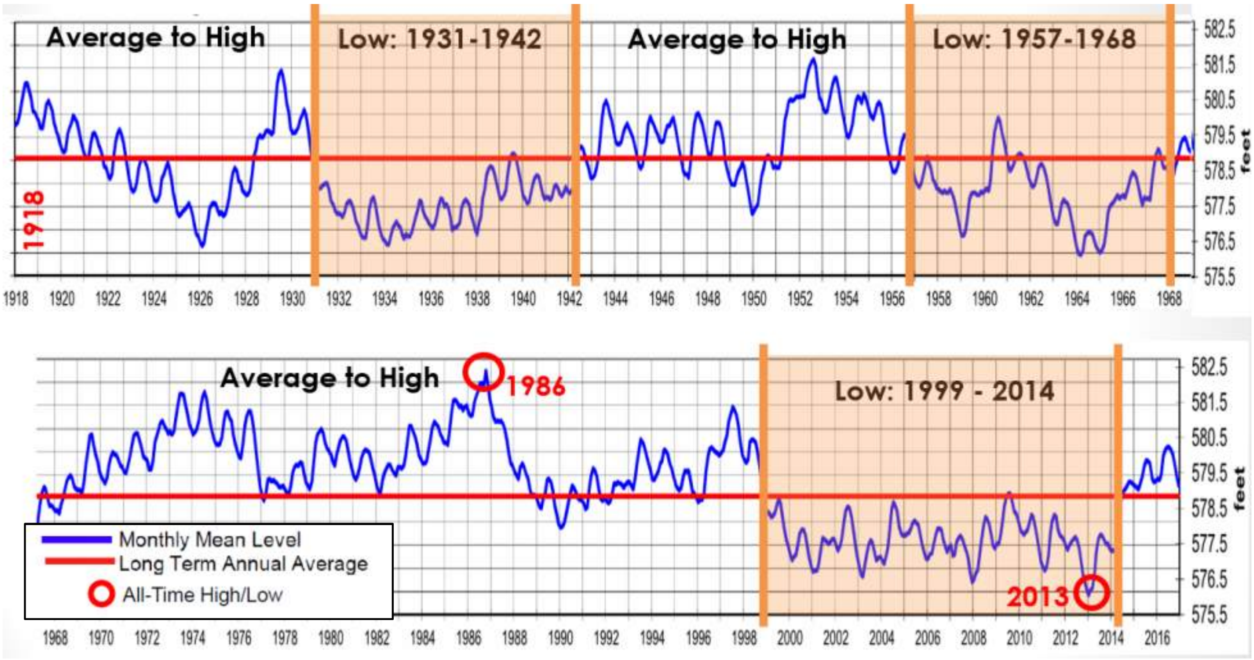


Figure 13: U.S. Army Corps of Engineers long term water level chart

In addition to long term fluctuations, Lake Michigan fluctuates on an annual cycle. Typically, water levels will fluctuate one to two feet per year, with lowest water levels in the winter and highest water levels in the summer. Figure 14 below depicts the annual cycle of the Lake Michigan water level and shows the relationship between the long term average water level, current water level, OHWM, all-time high water level, and all-time low water level.

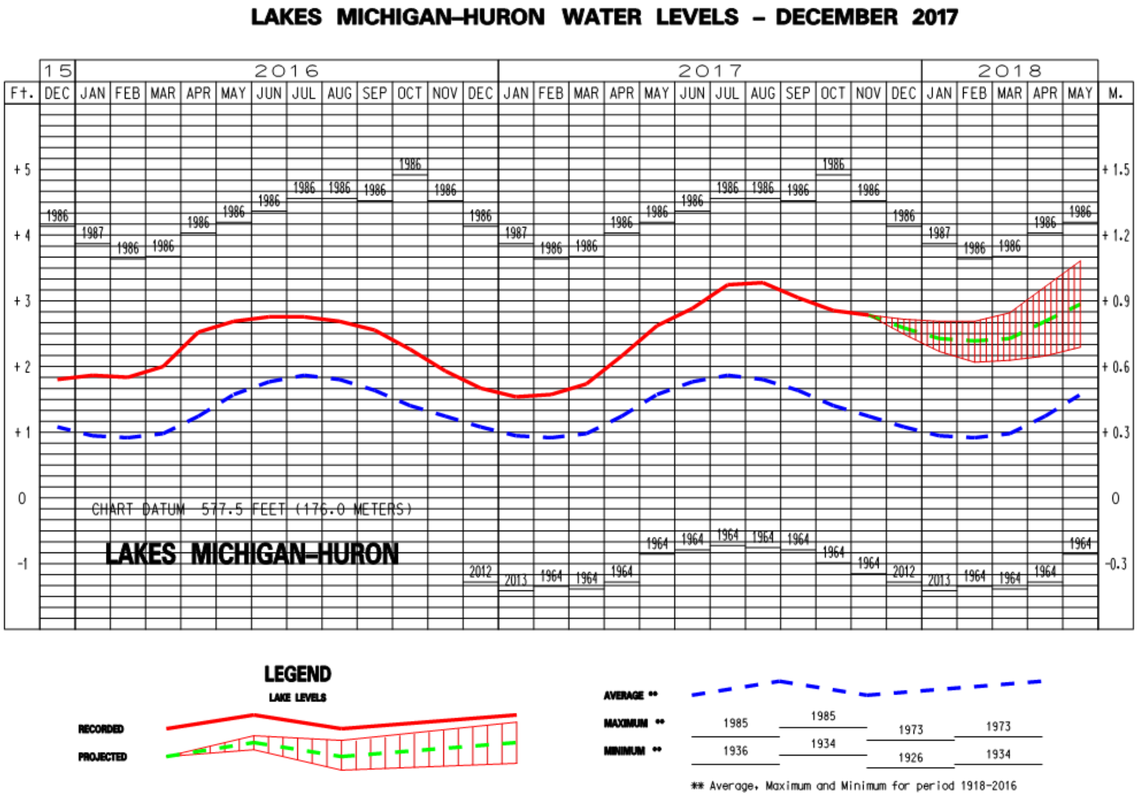


Figure 14: U.S. Army Corps of Engineers short term water level chart

4.5 FLOODPLAIN (FEMA)

According to the Federal Emergency Management Agency (FEMA), areas that will be inundated by the base flood, or 100-year flood, are identified as a Special Flood Hazard Area (SFHA). The base flood is the flood event that has “a 1-percent chance of being equaled or exceeded in any given year”. The base flood is defined by FEMA as a base flood elevation using historical flood events and floodplain studies. The elevations are published by FEMA Flood Insurance Studies (FIS) and on Federal Insurance Rate Maps (FIRMs). These maps also show areas that are outside of the SFHA, but still susceptible to other flood risks.

FEMA recommends and the State of Michigan requires that structures built in the SFHA are constructed at least one foot of freeboard (height) above the base flood elevation to lower the risk of flooding. FEMA’s freeboard recommendations increase when building near the coast to compensate for changing shoreline conditions, water levels and storm events. However, currently there are no FEMA requirements to account for these hazards on the Great Lakes beyond the base flood elevation, which is a still water level and does not account for waves, setup, or other coastal conditions.

Per the Berrien County Flood Insurance Study No. 26021CV000A, effective April 17, 2006, the 1% annual chance flood elevation is 584.0’ south of the St. Joseph River and 583.8’ north of the St. Joseph River (both elevations are IGLD 85, converted from NGVD 29). This document is the authoritative document for flood levels. FEMA Flood Insurance Rate Map

Number 26021C0101C, revised March 1, 2007, indicates a Base Flood Elevation of 584.0' IGLD 1985 (converted from 585.0' NGVD 1929) along the shoreline, within the study limits. This map is shown as Figure 15.

Figure 15: Part of FEMA Flood Insurance Rate Map Number 26021C0101C, Revised March 1, 2007

FEMA is currently collaborating with the USACE, the Association of State Floodplain Managers (ASFPM), and state partners to conduct a Great Lakes Coastal Flood Study. The study began in 2010 and will provide updated flood risk information serving the U.S. communities with Great Lakes shorelines. Currently, data collection and the application of modern analysis of historic storm and high water events are ongoing. In order to account for the unique flooding risks associated with the nearshore areas of the Great Lakes, FEMA has developed new risk zones called "VE" Zones. These zones represent high hazard coastal zones with wave heights of 3' or more and wave runup of at least 3' above ground elevation. The preliminary draft workmaps illustrating these VE Zones have been produced and are currently being reviewed by applicable agencies and stakeholders to identify discrepancies. Following these updates, draft final maps are expected to be produced for consideration by FEMA. According to recent outreach events, draft maps will not be completed for three to five years, subject to funding and acceptance. A section of the preliminary draft workmaps showing Study Area 1 is shown below in Figure 16.

Based upon the information provided during FEMA draft workmap presentations, the total water level used for creation of "VE" Zones does not include storm setup in addition to the calculated runup elevations. In the 2012 St. Joseph Coastal Engineering Study and in this study, a two foot storm setup was added to still water level and wave runup to determine total water level.

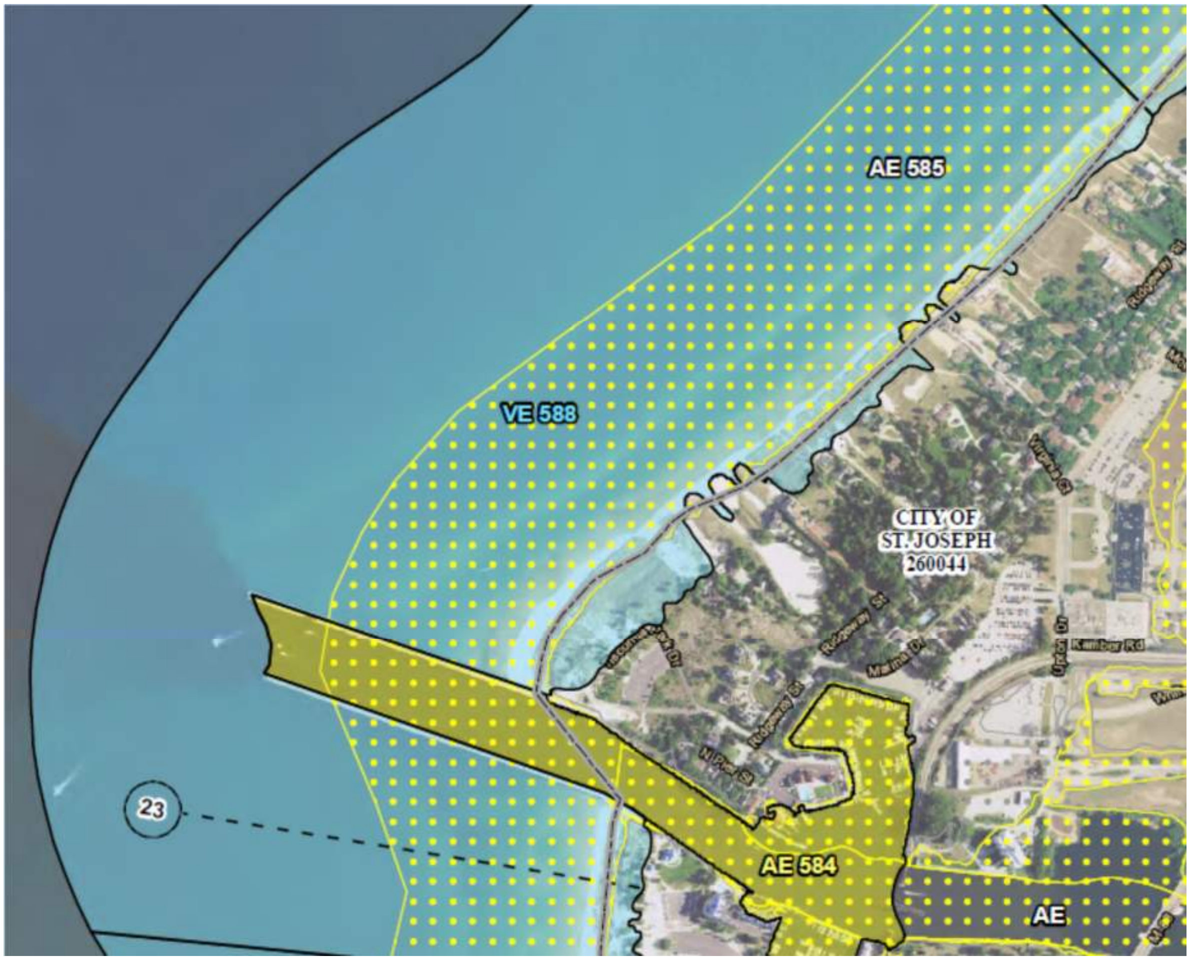


Figure 16: Berrien County Coast Flood Hazard Study Draft Workmap 23, June 2017

4.6 ORDINARY HIGH WATER MARK & PUBLIC TRUST SHORELINE

The Michigan Department of Environmental Quality (MDEQ) provides a guidance document for clarifying the authority of the MDEQ under Part 325 of the Natural Resources and Environmental Protection Act, also referred to as the Great Lakes Submerged Lands Act (GLSLA), as it relates to the Ordinary High Water Mark (OHWM). The document refers to Section 324.32502 of the Michigan legislature, which says:

"For the purposes of this part, the ordinary high-water mark shall be at the following elevations above sea level, international Great Lakes Datum of 1955; …Lakes Michigan and Huron 579.8 feet…"

Although Section 324.32502 does not provide a conversion between IGLD 1955 and IGLD 1985, the MDEQ Guidance Document Number 325-06-02 does. It specifically names an elevation of 580.5' IGLD 1985 as the OHWM of Lakes Michigan and Huron. This elevation will be used as OHWM for the purposes of this study and it is this elevation that constitutes the limit of the MDEQ's jurisdiction under the GLSLA. The OHWM is +3' LWD, which is 1.9 feet below the all-time Lake Michigan high water level. The USACE defines the OHWM and limit of USACE jurisdiction of Lake Michigan as elevation 581.5’ IGLD 1985, which is one foot higher than the MDEQ OHWM elevation.

Additional definitions are provided within the MDEQ guidance document to explain what is commonly referred to as the Natural Ordinary High Water Mark (NOHWM). The NOHWM is the upland boundary of the public trust property. According to the guidance document, “prior to 1968 amendments to the Part 325, the rules contained the following definition:

> *‘Ordinary high water mark means the line between upland and bottomland which persists through successive changes in water levels, and below which the presence and action of the water is so common or recurrent as to mark upon the soil a character, distinct from that which occurs on the upland, as to the soil itself, the configuration of the surface of the soil and the vegetation. When the soil, configuration of the surface, or vegetation has been altered by man’s activity, the ordinary high water mark shall be located where it would have been if this alteration had not occurred.’*

It is important to note that the horizontal locations of both OHWM and NOHWM change over time, depending on water level, waves, and coastal processes. For instance, after a period of erosion, although the determining elevation remains unchanged, the OWHM will intersect the shoreline at a more landward point than pre-erosion. After a period of accretion, the OWHM, likewise, will intersect the shoreline at a more lakeward point than pre-accretion. Figure 17 illustrates this concept.

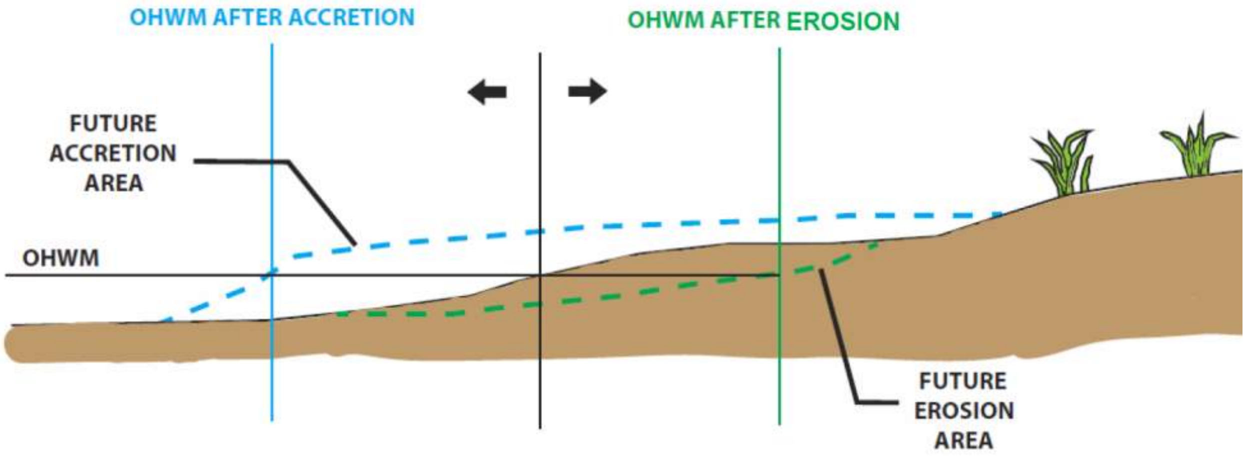


Figure 17: Illustration of OHWM movement

For the purposes of this study, the public trust shoreline is intended to refer to the area located lakeward of the OHWM, upon which the Supreme Court of Michigan ruled in Glass v. Goeckel (Glass v. Goeckel, 703 N.W.2d 1 (Mich. 2005) that the general public has the right to walk.

4.7 LITTORAL DRIFT & CROSS SHORE TRANSPORT

Two of the key processes that affect St. Joseph coastline are littoral drift (longshore transport) and cross shore transport. Littoral drift is the transportation of sediment in the littoral zone of a water body. Littoral drift is a function of wind and wave direction, wind and wave amplitude, shoreline material, sediment supply, water circulation patterns, water level, and shoreline structures. Littoral drift is typically used to describe the movement of sediment along a shoreline.

The creation of groins and piers create barriers that alter the sediment transportation process. This process has a major effect on a shoreline by adding material through accretion in some locations and by interrupting the supply of sediment in others, thereby resulting in an erosion-like process.

Cross shore transport is the movement of sediment perpendicular to the shoreline. Cross shore transport can result in accretion or erosion, depending upon shoreline conditions, water levels, and storm frequency and amplitude. Typically during times of lower water and calm conditions, cross shore transport results in accretion, whereas during times of high water levels and stormy conditions, cross shore transport results in erosion.

Generally, sandy shores are identified by what seems to be an unlimited supply of cohesionless beach material. Oppositely, cohesive shores are classified by having a cohesive sub layer (typically beneath a cohesionless surface) consisting of such materials as glacial till, soft rock and other various deposits. This cohesive sub layer determines the long-term shoreline condition. On cohesive shores, the thin surface layer of cohesionless (such as sand and gravel) material is eroded by coastal forces and replenished by littoral drift. When replenishment is interrupted, the cohesive sub layer can become exposed and susceptible to increased erosion.

Near the City of St. Joseph, the lake bed is comprised of cohesive material with a cohesionless surface layer with varying thickness of 0-4 meters (0-13 feet). Large deposits of sand accumulate near the mouth of the harbor and are dredged on a regular basis. Since the 1970s, this material has been deposited as beach nourishment on the designated feeder beach south of the St. Joseph River, typically south of Park Street, as shown in Figure 18. This material helps to protect the existing cohesive sub layer; however, since it is primarily fine to very fine grain, it is easily eroded by coastal forces. The quantity of dredging that is completed per year ranges from 20,000 to 150,000, cubic yards, although not all of the material is used for beach nourishment. It is important to consider that USACE funding is often an issue and that beach nourishment may not always be available. A summary of dredging quantities by year is included in Appendix 3.

Figure 18: 2012 photo of beach nourishment south of Park Street showing the dredge in background

Immediately north of the St. Joseph River, sand accumulates via littoral drift, creating an accretion zone. The piers act as a barrier, interrupting sediment as it is moved along the coast in a southerly direction. This accretion zone exhibited growth during the nearly 15-year period of low lake levels from 1999 to 2014. This area, as well as Area 2, experiences short term erosion during significant storm events and has experienced erosion during the recent transition period from low to high water conditions (Figures 19-22).

Figure 19: November, 2017 - Area 1 foredune erosion

Figure 20: November, 2017 - Area 2 foredune erosion

Figure 21: October, 2004 - Area 2 short term erosion

Figure 22: December, 2004, Area 2 short term erosion (Note the amount material lost from in front of the house in approximately two months when compared to Figure 21)

Based on the 1997 USACE study, "Effectiveness of Beach Nourishment on Cohesive Shores, St. Joseph, Lake Michigan", Figure 23 illustrates the modeled longshore transport of sediment during the early 1990s. Net transport quantities are depicted, along with northerly and southerly components.

Figure 23: Graphic representation of longshore sediment transport

4.8 HIGH RISK EROSION AREA

The MDEQ identifies and designates High Risk Erosion Areas (HREAs) and defines them as:

Those shorelands of the Great Lakes and connecting waters where recession of the zone of active erosion has been occurring at a long-term average rate of one foot or more per year, over a minimum period of 15 years.

Within the study area, only one designated HREA exists, located at the southern extent of Area 3. The HREA has a projected 30-year recession of 65 feet and a projected 60-year recession of 115 feet (Figure 24). Based on aerial imagery, shoreline protection has been constructed in this area within the past five years, so recession projections will likely be revised as the HREA studies are revisited and updated.

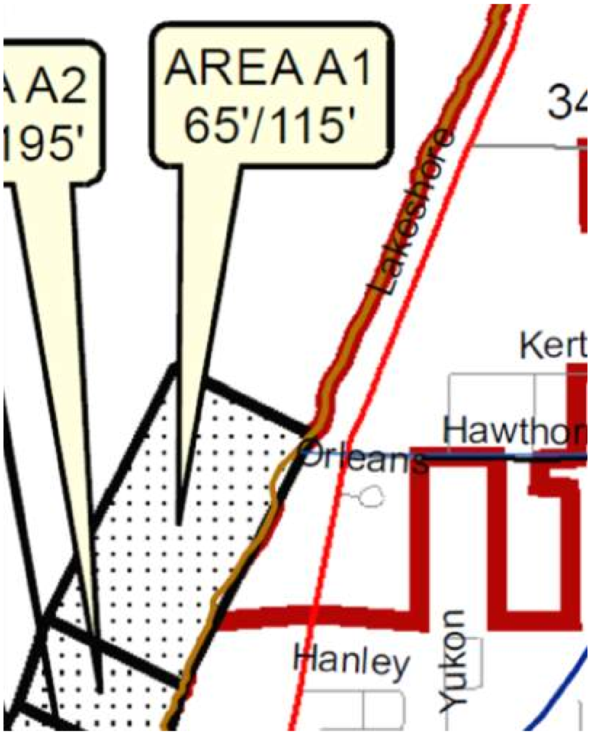


Figure 24: MDEQ High Risk Erosion Area Map

Figure 25: HREA Area A1 Aerial

4.9 SEICHES

According to the U.S. Army Corps of Engineers (Vol. 162 2006), a seiche is a periodic oscillation of lake levels caused by either a rapid change in air pressure or a rapid shift in wind direction as weather systems pass over the lakes. This process is often compared to water sloshing from side to side in a bathtub. A seiche can last anywhere from seconds to minutes, occurring at intervals of tens of minutes to multiple hours until stored energy is dissipated from the lake. In St. Joseph, seiches typically range from one to three feet in height.

Although data regarding seiche events is scarce, the following is a sample of events that have occurred in southern Lake Michigan since 1900:

- On August 24, 1900, a huge seiche-like wave was reported hitting the shores of St. Joseph, washing away small boats and various other items along the shoreline. (1900 New York Times)
- In 1929, a seiche occurred in Grand Haven during a 4th of July Celebration with 20' waves sweeping people off of the piers. 10 people were killed by the event. (Michigan State University Report)
- On August 3, 1960 a seiche temporarily raised the water levels in Chicago 2.5'-4' and St. Joseph residents were warned against 4'-6' waves. (1960 Lawrence Journal)
- On July 11, 2011, a seiche of unrecorded height hit near Holland causing significant damage. (2011 Holland Sentinel)

4.10 BERRIEN COUNTY COASTAL DAMAGE, 1957-1977

For the ten year period 1957 to 1967, Lake Michigan experienced low to average water levels, similar to the conditions experienced today. The ten year period that followed until 1977 saw water levels rise to high levels, reaching 581.8' (+4.3) in 1974, which is only 0.6' below the Lake Michigan all-time high water level. This water level fluctuation is part of the normal cycle of Lake Michigan as observed from 1918 to 2012 and discussed above.

High water conditions and severe storms culminated in 1973, when President Nixon declared Berrien County a disaster area, according to articles from the Herald Palladium. Damage that occurred during the early 1970s included the loss of beach, bluff erosion, damage to structures, and the loss of structures. Figures 26-29 illustrate some of the damage that occurred.

Figure 26: 1973 Herald Palladium photo of Jean Klock Park

Figure 27: 1973 Herald Palladium photo of Jean Klock Park sidewalk

Figure 28: 1970s Herald Palladium photo of bluff erosion south of St. Joseph, MI

Figure 29: 1970s Herald Palladium photo of bluff erosion south of St. Joseph, MI

The period of 1957-1977 is an important example of what can happen as the conditions of Lake Michigan change. During times of low water, building structures closer to the lake is a dangerous temptation for many property owners resulting in structures which are exposed to the risk of erosion, wave action, and damage when water levels rise again. Based on 100+ years of Lake Michigan water level records and the cycles that have occurred in the past, water levels will continue to fluctuate and coastal residents and communities must plan and prepare for these ever-changing conditions.

4.11 OTHER GREAT LAKES STATES

Other Great Lakes states have developed standard setbacks and/or guidelines for various reasons. These states provide valuable examples of setbacks and coastal guidelines. This study will focus on the setbacks and guidelines that have been implemented in Wisconsin and Ohio.

WISCONSIN

The State of Wisconsin implemented setbacks to "…conform to health, safety and welfare requirements, preserve natural beauty, reduce flood hazards and avoid water pollution". Chapter NR 115 of the Wisconsin Administrative Code requires all buildings and structures to be setback a minimum of 75 feet from the OHWM of navigable lakes, rivers, and streams. This requirement applies to Wisconsin's coastline on both Lake Michigan and on Lake Superior. In addition to the statewide setback, some counties have increased minimum setbacks. For instance, the setback in Sheboygan County is 225 feet from OHWM. Michigan does not currently have a similar setback.

Additional methods are provided within NR 115 for the reduction of setbacks for lots with minimal depth or for vacant lots between lots that were developed before setbacks. Some counties require new structures to be setback as far as lots allow. Others average the setbacks of adjacent developed substandard lots to provide a requirement to an undeveloped lot. The third and most flexible method for reducing setbacks is what is called "the formula approach". This method allows limited reduction of a roadway setback first; then allows reduction of the shoreline setback until a 30 foot deep building envelope is created. Typically, when any setback reduction is allowed, mitigation measures are required to compensate for the reduction of buffers.

OHIO

In 2011, the Ohio Department of Natural Resources, Office of Coastal Management published the Ohio Coastal Design Manual to "promote better projects along the Ohio shore of Lake Erie". It provides guidance in the design of commonly constructed structures for engineers, surveyors, and landowners, while attempting to balance erosion control needs with lake access and protection of natural resources.

The manual does not provide specific setback requirements but does include guidance for the design of shoreline structures, including considerations such as erosion, existing structures, geology, habitat, near shore bathymetry, wave climate, submerged lands, water levels, littoral drift, revetment flanking, and revetment materials.

Based on conversations with the Ohio Office of Coastal Management, setbacks have not been implemented. However, where a proposed structure is within a designated Coastal Erosion Area, plans must be submitted to the Office of Coastal Management for review and approval before construction can commence. In Ohio, the Coastal Erosion Areas are updated every ten years and are based upon recession rates observed from aerial photos, similar to Michigan's High Risk Erosion Areas.

5.0 GREAT LAKES SHORELINE PROTECTION

According to the USACE Coastal Engineering Manual (Section III-5-13):

> *(1) The two most important issues in the planning and management of cohesive shores relate to* ***implementing setbacks for development*** *and to managing human influences on the sediment supply.*
>
> *(2) Many Jurisdictions along U.S. shorelines impose a setback for new development consisting of some multiple of the average annual recession rate (e.g., 30 to 100 times the average recession rate). The purpose of the setback is* ***to avoid the need for shore protection*** *within the life of the new development,* ***recognizing the irreversible and inevitable erosion that occurs*** *along cohesive shores (and some sandy shores as well).*
>
> [**emphasis added**]

Shoreline protection structures reflect and accelerate wave energy, causing unnatural erosion and resulting in irreversible changes to the shoreline. However, in many cases, these structures are necessary. Where possible, it is recommended to avoid the need for shore protection and in Area 1 this opportunity still exists. Most Area 1 structures are set back from Lake Michigan and the public trust property is uninterrupted between two public parks. It is possible, however, that shoreline protection could be needed in the future, given sustained, extreme high water and storm conditions.

In Area 2, existing homes are located closer to Lake Michigan, necessitating the construction and/or repair of shoreline protection structures during periods of high water to prevent damage to these homes.

In Area 3, cohesive bluffs would be exposed to erosion, were it not for the existing shoreline protection structures that line the shore. These structures are necessary to prevent erosion and protect property and infrastructure.

In summary, the best armoring is not to need it. Where feasible, a no armor approach should be sought. Area 1 is an example of a shoreline where this approach is feasible. However, not armoring or protecting a shoreline is not always a feasible option and enforcement may be needed to ensure protection approaches are properly designed and implemented. Areas 2 and 3 provide examples of shorelines where not armoring is generally not a feasible option.

5.1 DESIGN CONSIDERATIONS

Shoreline protection must be designed with an awareness of the following considerations:

- Height: The top of the structure must be built to an elevation that will prevent or minimize wave overtopping.
- Surface: Irregular shapes and permeable materials absorb wave energy, whereas flat, planar surfaces reflect and accelerate wave energy.
- Toe Protection: Sufficient toe protection must be incorporated to prevent scour of the toe of the structure which can result in slip failure of the structure.

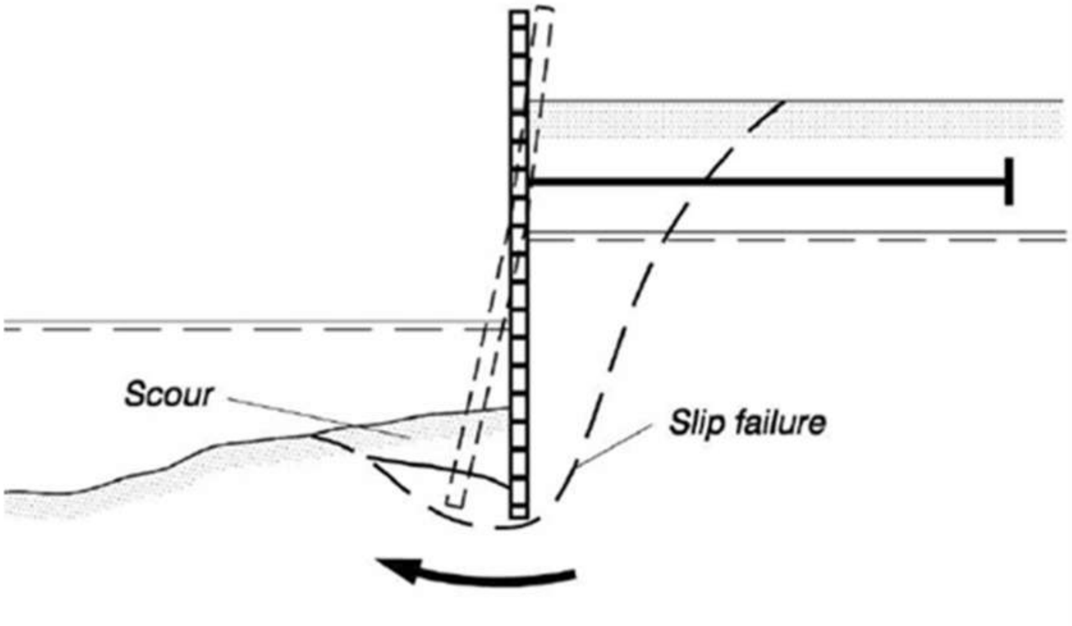
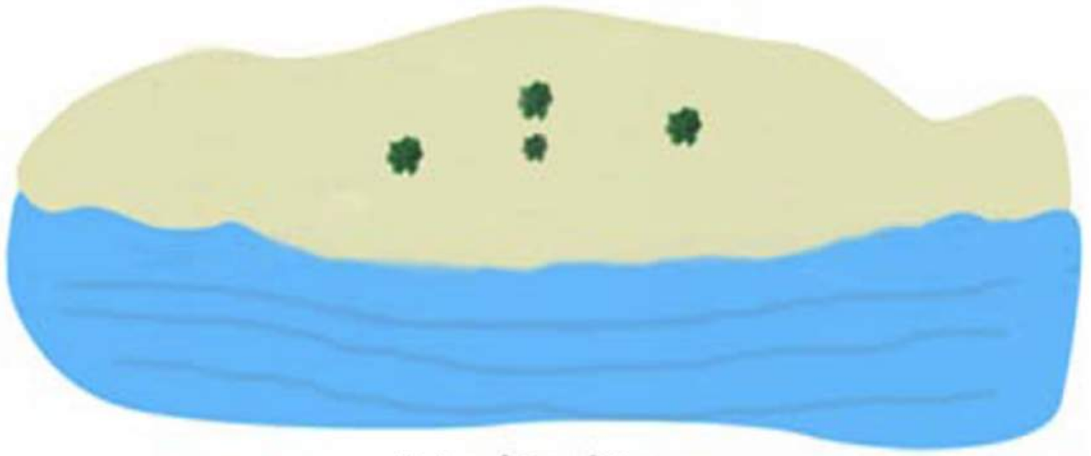
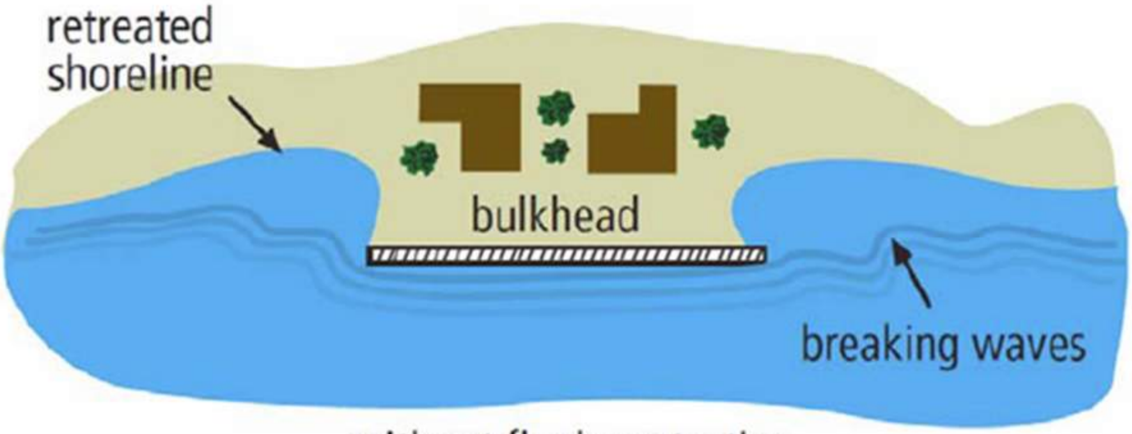


Figure 30: Graphic from USACE Coastal Engineering Manual

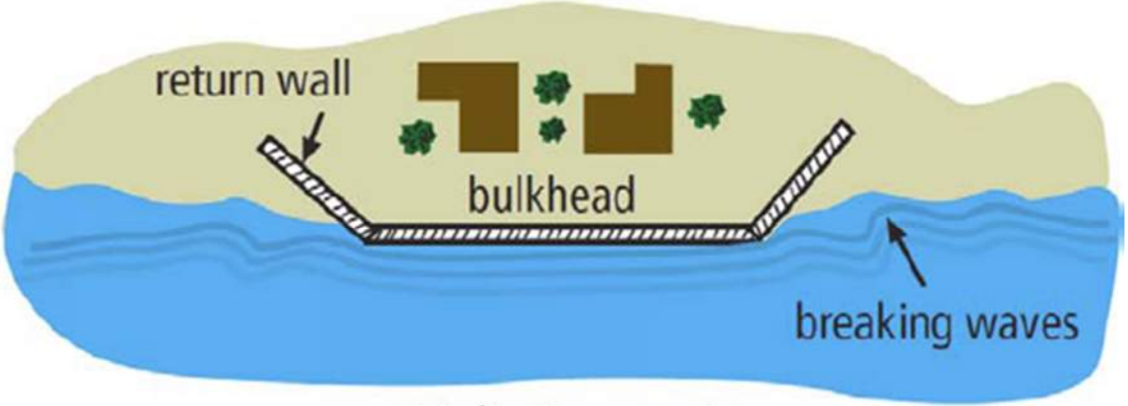
- Length: Sufficient structure length and/or return walls are required to prevent flanking of the structure and produce potential adverse effects on neighboring properties. As depicted in Figures 31-33, flanking is the erosion that occurs on either side of a shoreline structure caused by the reflection and acceleration of wave energy.



Natural Condition



without flank protection



with flank protection

Figures 31-33: Graphics from USACE/University of Wisconsin, “Living with the Coast” Booklet

5.2 FAILURE EXAMPLES

Berrien County coastal structures are subjected to severe coastal conditions on a regular basis. Any weaknesses will be exposed by these conditions. The USACE Coastal Engineering Manual includes examples of the effects Lake Michigan can have on these structures in order to help guide the design of new structures.

Figure 34: Example of flanking in southern Berrien County. Note how this failure has resulted in the loss of the public trust property lakeward of the structure and public passage is only possible in the lake itself.

Figure 35: USACE CEM Photo, “A toppled concrete seawall along the Lake Michigan coast of Berrien County. Failure probably resulted from undermining of the underlying glacial till foundation, April 1991.”

Figure 36: USACE CEM Photo, “A steel sheet-pile wall and groin field has been ineffective at protecting this section of cohesive shore along the Berrien County shore of Lake Michigan, south of the town of St. Joseph, April 1994.”

5.3 SUCCESSFUL EXAMPLES

Within the study area, two successful examples of shore protection have been identified. The first is the shoreline that borders the St. Joseph Water Plant, located at the north end of Area 3. The structure consists of armor stone, laid on a slope of 1 vertical on 2 horizontal to a minimum top elevation of 591.20 feet. The toe of the revetment extends several feet below the lake bottom to prevent scour.

Figure 37: St. Joseph Water Plant Revetment Oblique Photo (U.S. Army Corps of Engineers)

Figure 38: St. Joseph Water Plant Revetment, spring 2012

Portions of the stone revetment along South Lakeshore Drive provide another example of a successful shoreline protection structure. Sections of this revetment are comprised of armor stone set at a slope of approximately 1 vertical on 2 horizontal. These revetments protect the high bluffs on which South Lakeshore Drive is constructed.

While both of these stone revetments have been successful in protecting upland infrastructure from erosion, they have had a dramatic effect on the public trust property along the shoreline.

Figure 39: Stone Revetment along South Lakeshore Drive Oblique Photo

6.0 SURVEY

6.1 DATA COLLECTION & DATA AVAILABILITY

Topographic and bathymetric surveys were completed in May of 2017 in Areas 1 and 2. Bathymetric data was collected by boat using a global positioning system (GPS) and a single-beam sonar. Topographic data was collected using GPS. Both datasets were combined into a single surface model intended to inform the planning-level analysis found herein. The combined set of geospatial data was produced per Federal Geospatial Data Committee (FGDC) metadata standards and will be made available to users.

Figure 40: Bathymetric data points map, plan view (Aerial Image Credit: Google Earth)

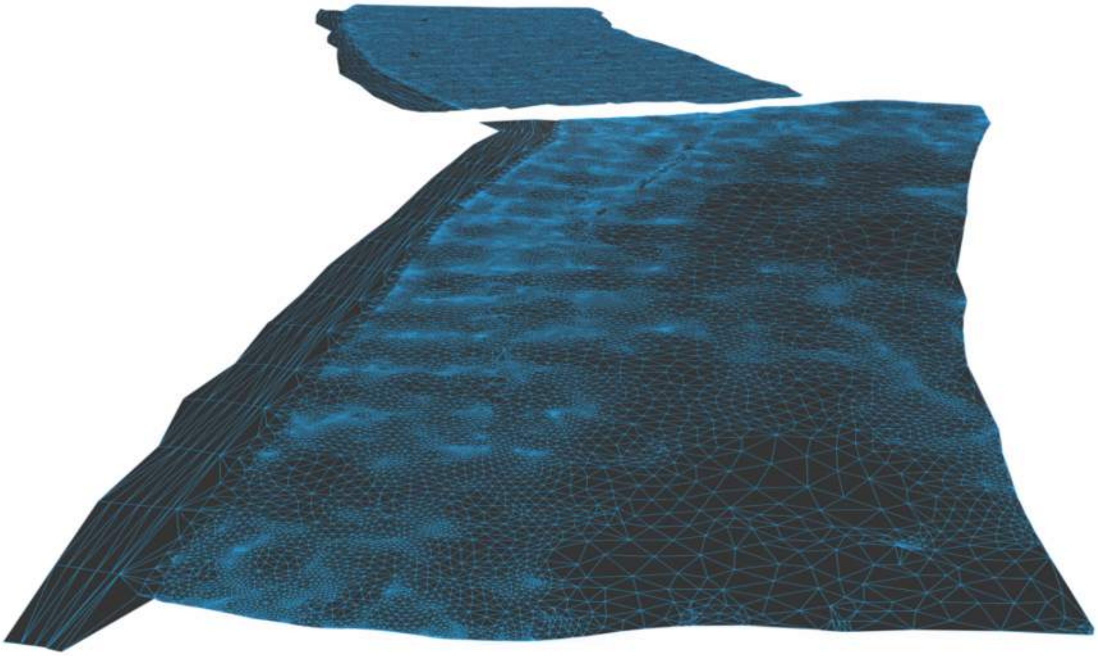


Figure 41: Combined surface model, isometric view (Looking South)

6.2 NEARSHORE CHANGES

Data collected in 2012 included only topographic data. Both the 2012 data and 2017 data have been mapped to cross sections in Areas 1 and 2 and are included in the Appendices. In Area 1, nearshore changes included the following:

- Nearly all sections exhibited local erosion in the vicinity of the still water line between 2012 and 2017
- Many sections exhibited foredune growth, likely due to the accretion of wind-blown sand within vegetated areas, containing mostly dune grass (Figure 42)
- Several sections exhibited apparent grading activities; overall loss of material and lowering of foredune aligning with aerial images where bare/non-vegetated areas were observed

Figure 42: Area 1 dune grass (November, 2017)

In Area 2, nearshore changes are difficult to compare due to the regular beach nourishment of the Area 2 shoreline. In 2012, topographic data was collected just after a beach nourishment project was completed, while in 2017, data was collected before the nourishment was completed. These two datasets help to visualize the impact nourishment has upon Area 2 and the overall littoral system. One section within Lion's Park Beach illustrates a loss of beach approximately 160 feet wide with a 9-foot maximum depth. This is likely sand that was placed in 2012 that later eroded due to high water conditions, wave action, and the lack of stability of unconsolidated sand. The timing of the 2017 survey before nourishment efforts illustrates that the gains and losses of beach from nourishment efforts can be extreme.

7.0 AREA 1 FINDINGS

7.1 CURRENT CONDITIONS

Area 1 is bordered by Jean Klock Park to the north and Tiscornia Beach to the south. Between the parks, private properties exist and many of the lots extend several hundred feet from the street known as Ridgeway to Lake Michigan. Currently, no shore protection structures exist within Area 1. The entire shoreline is sandy beach. The southern half of Area 1 is typically an accretion zone, but subject to erosion as well. The public trust property in this area varies in width and extends from the water line to the NOHWM, connecting the public parks.

Figure 43: Area 1 typical shoreline during a low water condition (2012 USACE Oblique photo)

7.2 HUMAN IMPACTS

Review of site conditions, survey data, and recent aerial imagery has revealed the following two primary human impacts to Area 1 since the 2012 study:

- Construction & new structures (see below)
- Pathways & grading activities

Pathways and grading activities have left an imprint upon Area 1. Measurements taken from 2016 aerial imagery indicate the following:

- Approximately 4,000 feet of shoreline in Area 1 between Tiscornia Park and Jean Klock Park
  - Total width of all non-vegetated, graded “pathways” is 970 feet
  - 24% of the 4,000 feet of shoreline have been graded or maintained as a “pathway”
  - In many cases, “pathways” exhibit grading of the foredune to lower an area

- 44 shoreline parcels are present in Area 1 between Tiscornia Park and Jean Klock Park
    - 34 non-vegetated, graded “pathways”
        - 14 are 10 feet wide or less
        - 20 are greater than 10 feet wide

As exhibited below in Section No. 19 (Figure 44), grading activities have reduced the height of the foredune by five feet or more in some cases. As a foredune is lowered, the risk that wave runup will reach further inland is increased. During a severe storm on October 31. 2014, the impacts of grading were observed first hand (Figure 45)

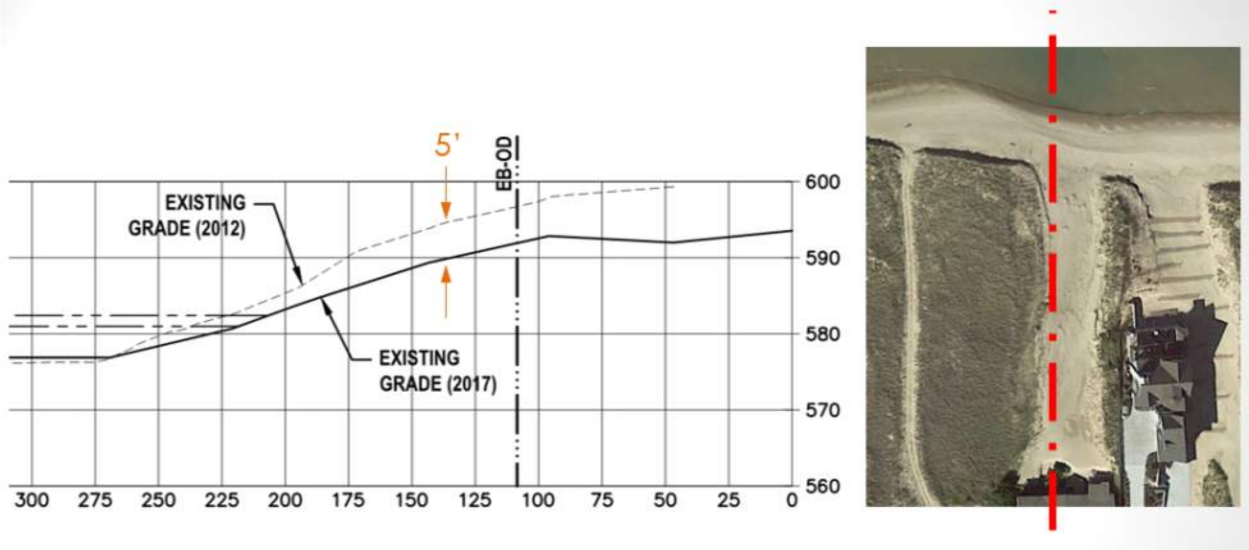


Figure 44: Section No. 19 illustration of the vertical change resulting from apparent grading

Figure 45: Wave runup where beach/dune grading was done (October 31,2014)

Figure 46 below exhibits the relationship of the calculated total water level (blue) to the EBOD setback line (orange). There are two locations (indicated with green ovals) in Area 1 where the calculated total water level either approaches the EBOD line or extends landward of the line. In both sections, aerial imagery and cross sections indicate significant beach/dune grading has occurred, creating a risk that wave runup will extend further landward.

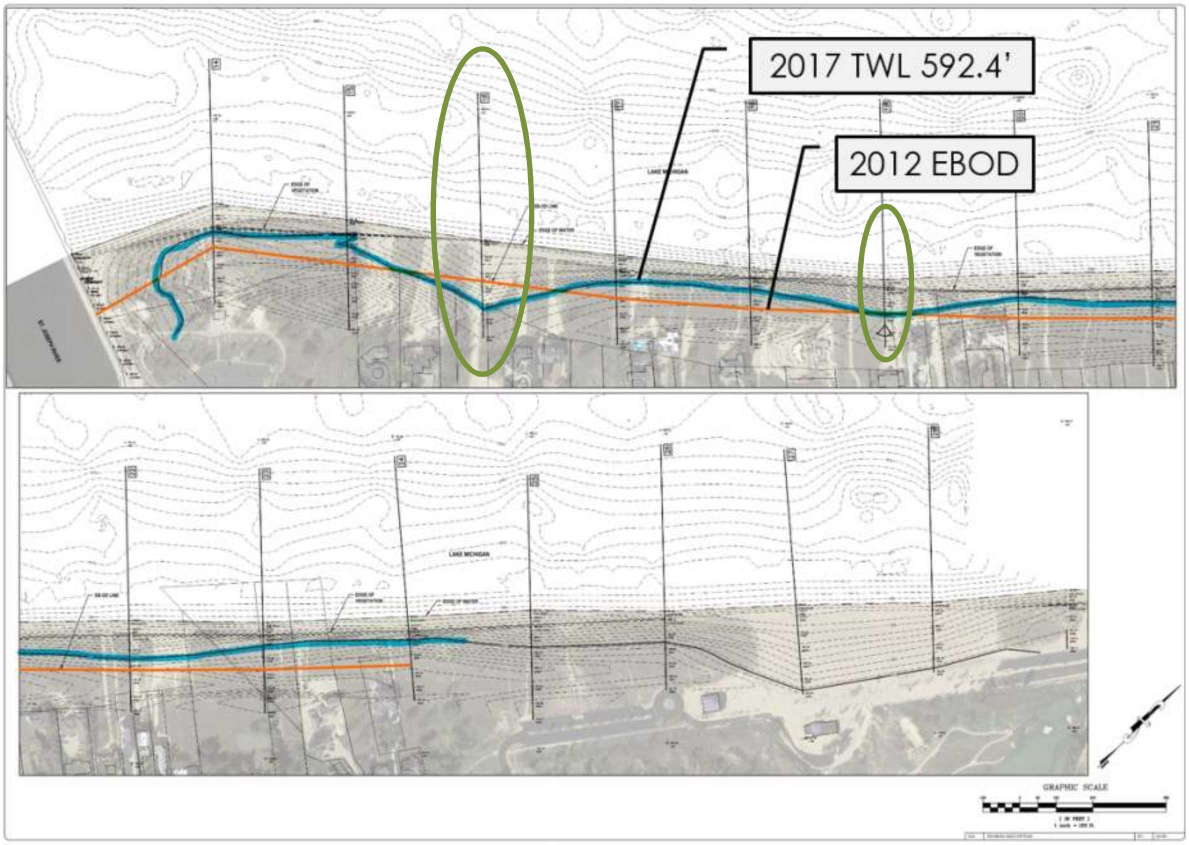


Figure 46: Total water level overlay with EBOD

Grading and grooming activities also remove dune grass from the foredune. The presence of dune grass tends to capture and retain wind-blown sand, resulting in growth of the foredune which buffers the shore from coastal conditions. Removal of dune grass can slow the natural growth of the dune and cause wind scour, further reducing the size of the dune.

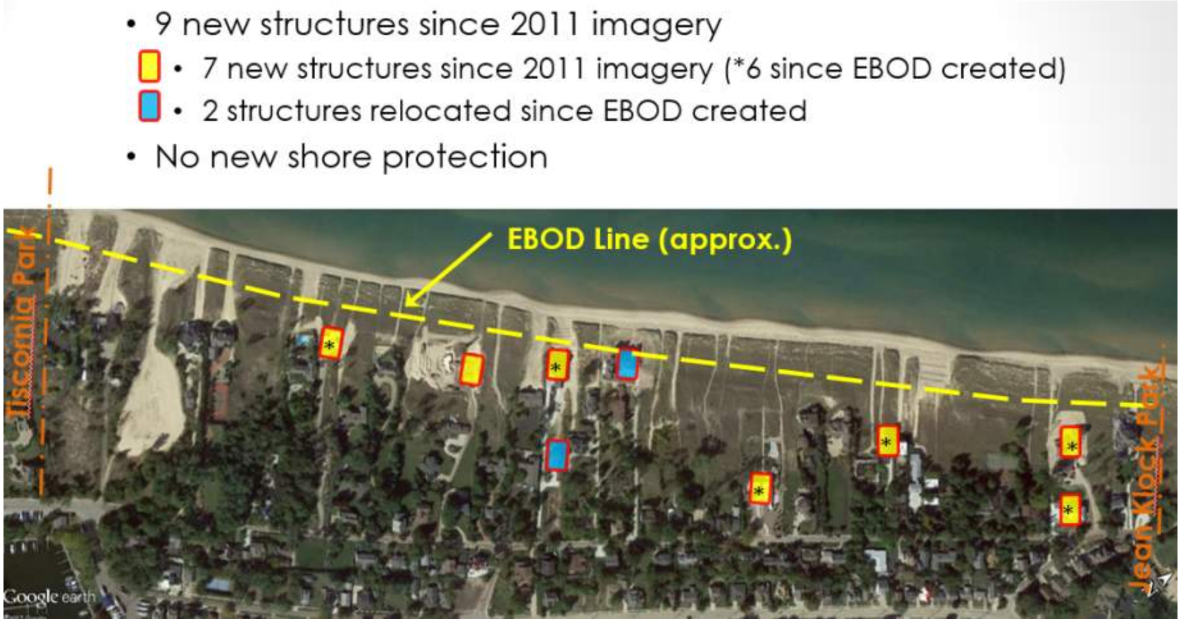
7.3 396 RIDGEWAY RELOCATION

In 2011, Lake Michigan water levels were below the long-term average for the 12th straight year. The beach in Area 1 had grown during the recent low water period, creating the illusion to many that the land buffer to Lake Michigan had increased in size permanently. A home was constructed in 2008, at 396 Ridgeway, and it was sited further lakeward than any other home in Area 1. After completion of the home, erosion of the shoreline in front of the structure led to the submittal of a permit application to the USACE and MDEQ. The application resulted in significant public opposition due to potential impacts upon the public trust shoreline. Thus, the City began a coastal engineering study to determine scientifically how best to manage its coastlines to protect the public trust shoreline and minimize risks to private properties. The study and subsequent recommendations ultimately led to the creation of a new zoning district, called the Edgewater Beach Overlay District (EBOD). In the EBOD, a “no-build” line was established to prevent the construction of structures lakeward of the line. The line was based upon record water levels, existing topography and bathymetry, storm setup, wave runup, available data, and other coastal considerations. The full text of the EBOD may be found in the appendices.

After reaching a record monthly mean low level in January, 2013, water levels began to rise. In 2014, the owner of 396 Ridgeway decided to have the home moved landward. The relocated home now sits approximately 60 feet landward of its original location. It could not be moved further landward due to the location of a second structure of the same owner.

7.4 NEW HOMES BUILT SINCE CREATION OF EBOD

Since the creation of the EBOD, six homes have been constructed in Area 1 (Figure 47). All of the homes were built landward of the EBOD line, but several of the homes were constructed within in close proximity to line. The intent of the EBOD line has always been to provide a reasonable means of maintaining the public trust shoreline, while minimizing the risks of coastal damage to homes. The siting of individual structures must balance the owners’ desire for lake proximity with acceptable levels of risk, because the EBOD line is not intended to be a “build-to” line at which homes will be completely safe from coastal flooding/damage.



- 9 new structures since 2011 imagery
  - 🟨 • 7 new structures since 2011 imagery (*6 since EBOD created)
  - 🟦 • 2 structures relocated since EBOD created
- No new shore protection

Figure 47: New Structures in Area 1

Input has been sought from the homeowners of the six new homes above. Three responses were received. Below is a summary of the responses describing how the locations of three new homes were determined:

Response 1 (homeowner)

- Relative to neighboring property lines, side setbacks were used
- Relative to the lake and EBOD line, several factors were considered:
  - Neighbor's requests for site line preservation
  - Comparison to other home locations in Area 1
  - Location of the high point of the dune within the parcel

Response 2 (homeowner)

- Relative to the lake and EBOD line, several factors were considered:
  - The EBOD line was referenced as a minimum zoning requirement that limited options
  - "*Would not have built closer to the lake than 50' beyond the 585' elevation point in any event*."
  - "*It was chosen because we wanted to be fairly close to the other homes owned by family members. We were trying to create a family community rather than positioning our home far away from the others and out on its own closer to the lake.*"

Response 3 (architect)

- Relative to the lake and EBOD line, several factors were considered:
  - The location was chosen based upon a combination of all considerations – including viewsheds, coastal considerations, proximity to the lake
  - "*The EBOD was certainly helpful in understanding the changing lake effects and appropriate building locations. We viewed this as helpful on two levels: 1- Helping us understand long term vulnerabilities, 2- Setting a building line away from the immediate proximity of the lake helps preserve the lake front, both physically and visually, for the entire community.*"
  - "*As Architect and part of the design team we discussed the placement with the owners, builder and consulted with an Environmental Engineer to study a building placement that was appropriate. Having seen the lake level very high a number of years ago, the EBOD proved to reinforce the impact that can be expected as the lake level and the shoreline move and change.*"

Based upon the responses above, owners and designers completed independent assessments of their properties to determine where the homes would be constructed. The EBOD served as both a limitation to the available building area and as a helpful reference for potential coastal impacts.

7.5 SHORELINE MANAGEMENT RECOMMENDATION

After review of the current conditions and the analysis of total water level, including storm setup and wave runup, we recommend that the City of St. Joseph continue to enforce the Edgewater Beach Overlay District (EBOD) as originally intended. The current location of the line continues to provide a reasonable means to protect the public trust shoreline and to minimize the risk to private properties. While we will continue to seek feedback from those who have sited new homes in Area 1, we recommend issuing clarification to ensure that the EBOD language expressly includes the intent and limitations of the line and that the line should not be solely used to determine the location at which new structures should be constructed.

In Area 1 the theoretical total water level is summarized as follows:

• Lake Michigan record high water level	+ 4.9’ LWD
• Storm Surge	+ 2.0’
• Wave Runup	+ 8.0’
Area 1 Total Water Level	**+ 14.9’ LWD = Elevation 592.4’**

In 2012, a lesser total water level of +14’ LWD (591.5’) was calculated using a 50-year wave and survey data at that time. However, due to the inclusion of a factor of safety in 2012, the increased estimated runup does not necessitate adjustment to the current location of the EBOD line.

The fixed line provides a basis for proactively managing the Area 1 shoreline. Nevertheless, the coastal conditions will continue to change over time and reviews consistent with the original recommendations should be completed:

> *The location of the setback line should be reviewed, at minimum, every ten years or with a change in the Lake Michigan water level of four feet or more from the current water level of +2.7’ LWD to ensure it is performing its intended function based on continuing experience and then current conditions.*

Reviewing the location of the setback line on a regular basis will help to ensure the fixed line is in a location that will achieve its stated purpose. In summary, the location of the line and the basis for this study is approximately 100 years of Lake Michigan water level data and fifty years of wave data. Recognizing that we do not have data extending beyond these time periods, an even more conservative approach could be considered to account for future unpredictable events such as a 500-year event, which would consider layered design waves and higher lake levels, if that data were available.

Lastly, during the study, it was noted that a significant portion of the shoreline in Area 1 has been groomed and/or graded. Changing the contour of the dune in Area 1 could impact the landward extent to which waves can be expected to reach. In addition, removal of dune grass can slow the natural growth of the dune and cause wind scour. Therefore, these actions could lead to increased risks to both private property and the public trust. We recommend continuing to provide outreach opportunities to homeowners regarding the impacts of grading activities within the Area 1 environment.

8.0 AREA 2 FINDINGS

8.1 CURRENT CONDITIONS

Area 2 is fully-developed by homes along the shoreline, with the exception of the two public parks at its ends. Under most lake levels, the entire shoreline is publicly-owned and consists of a sandy beach. Area 2 is primarily an erosion zone, but typically receives beach nourishment from the USACE on an annual basis. Existing structures are built on shallow lots that do not allow structures to move significantly closer or further from Lake Michigan. In order to protect structures, in reasonably foreseeable coastal conditions, shore protection may be required because limited lot sizes restrict private property owners' options.

Figure 48: Area 2 typical shoreline (2012 USACE Oblique Image)

Area 2 consists of a sandy beach containing some coarse fill from past beach nourishment projects. This area receives beach nourishment from federal dredging operations on a regular basis, typically annually, through Section 111 (Rivers and Harbors Act of 1968) measures and because it is subject to erosion. Based upon U.S. Army Corps of Engineers records, well over 300,000 cubic yards of beach nourishment has been placed in Area 2 since 2012.

Public access along the public trust property can vary, depending on lake conditions, erosion, and beach nourishment. Private properties that border Area 2 between Silver Beach and Lions Park Beach are fully developed and parcels are typically very shallow in comparison to those in Area 1, none exceeding 132 feet in depth.

Figure 49: Area 2 Public Property

The narrowest of these parcels are located between Lion's Park and Park Street. These parcels are currently dependent upon the annual beach nourishment to maintain a buffer of sacrificial sand between the Lake and their properties. The southernmost 5 properties have installed a revetment shoreline protection system to mitigate erosion of their properties once the annual nourishment material has dissipated. Due to the close proximity of the home on these parcels, the revetments were constructed at the back property line, as close to the lake as possible. During late winter and early spring, prior to the year's nourishment, public property in this area can become restricted as the previously placed nourishment erodes and the waterline reaches private property. The shoreline at southern end of the private properties along Lions Park Drive in particular, where these revetments exist, can become impassable as the beach can be eroded all the way back to the shoreline protection system.

Figure 50: Area 2 Existing Shoreline Protection (Looking South)

8.2 HUMAN IMPACTS

Human impacts to Area 2, since the 2012 study, have included the following:

- Two new structures (homes)
- One reconstructed structure (home)
- Approximately 130 linear feet of new/reconstructed shoreline protection
- Beach nourishment (See below)

These impacts and their influence upon shoreline management are further discussed above.

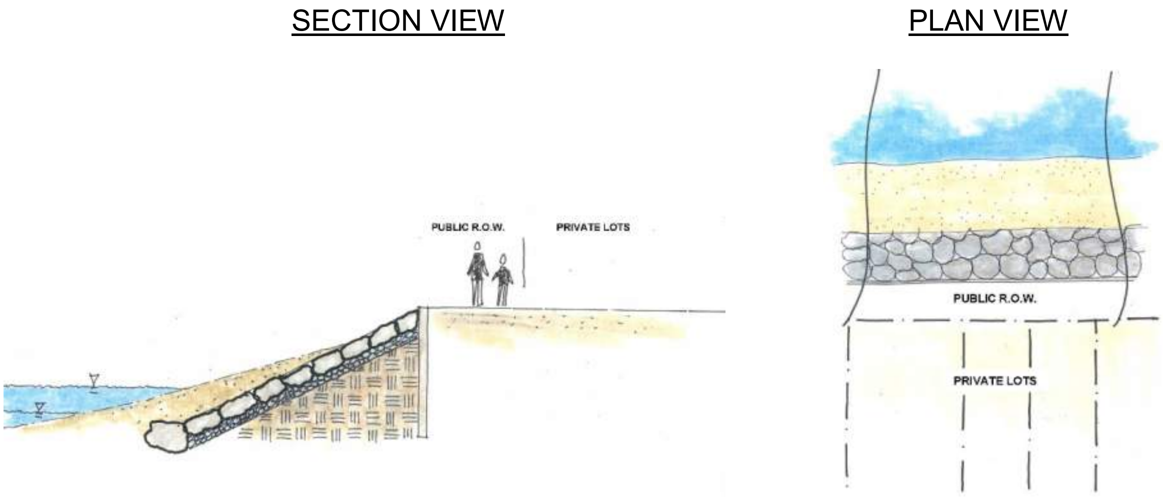
Figure 51: 2017 Beach nourishment in Area 2

8.3 SHORELINE MANAGEMENT RECOMMENDATION

To provide the best protection to private property while maintaining meaningful public access along the shoreline, we recommend that future shoreline protection structures within the area bounded on the north by the St. Joseph River, on the east by Lions Park Drive, and on the south by the St. Joseph Water Plant be subject to the following requirements:

- Design must be prepared by a licensed professional engineer experienced in coastal engineering to account for coastal engineering factors including, but not limited to wave overtopping, scour protection, and flanking prevention.
- Approval must be granted by the City of St. Joseph City Engineer prior to construction
- Vertical walls are prohibited
- Perpetual public access landward of the structure must be provided to ensure continued public access along the coast regardless of lake levels.
- Structures must not adversely affect other/neighboring properties and must connect to adjacent shoreline protection structures, if present, to eventually create one unified structure

In the event that annual beach nourishment ceases, a plan should be in place to regulate shoreline protection measures in this Area. Due to the narrow lots in this area and their proximity to public property, a uniform standard protection system is recommended to ensure that the shoreline protection system is continuous and consistent in order to prevent areas of flanking or localized failure. This system would need to be located such that preservation of public access and private property are balanced. One approach in balancing these goals would be to implement a shoreline protection system that is offset from the lakeward (westerly) private property limits to preserve public access in this area and to ensure continued connectivity of the two prominent public beaches on either side of these parcels. Further coordination with City staff would be required to determine allowable assessment and funding opportunities. The following concept shows an example of how this system could be implemented to meet multiple goals. Such a system would need to be further developed along with a funding and ownership strategy prior to implementation.


SECTION VIEW

PLAN VIEW

Figure 52: Area 2 Concept Shoreline Plan

Such a system would need to be designed to accommodate both high and low water conditions. The toe stone would need to be set a low enough elevation to prevent scour and undermining during times of low water and no sacrificial nourishment in place. The top elevation would need to be designed to accommodate the wave runup possible in that area during storm events at high water conditions. The theoretical runup calculated in Area 2 is summarized as follows:

• Lake Michigan record high water level	+ 4.9’ LWD
• Storm Surge	+ 2.0’
• Wave Runup	+ 8.0’
Area 2 Total Water Level	**+ 14.9’ LWD = Elevation 592.4’**

9.0 AREA 3 FINDINGS

9.1 CURRENT CONDITIONS

The entire shoreline of Area 3 contains existing shoreline protection structures, including stone revetments, sheet piling, groins, and timber structures. Steep bluffs containing cohesive soils line the shoreline and the structures are necessary for the protection of the bluffs against erosion. While a site inspection of existing protection systems was outside of the scope of this study, several shoreline repair and reconstruction projects are currently underway.

Figure 53: Area 3 typical shoreline

One such project included the repair of a portion of failed seawall along property owned by CSX Railroad (Figure 54). Over the course of years a steel sheet pile seawall failed and CSX appears to have completed repairs to that portion of the shore protection system during the summer and fall of 2017. The local failure occurred in one portion of the protection system and the failure could be an indication that other portions of the aging system may be nearing the end of their design lives.

Figure 54: Area 3 CSX Shore Protection Project – placement of armor stone

The recent failure represented a risk to the CSX property and its rail line. However, if left unaddressed, the issue could have resulted in risks to infrastructure and possibly adjacent properties. The City worked with CSX and other political representatives, including Congressman Fred Upton, to support CSX's efforts to repair the system. The level of support provided likely aided in the timely completion of the project before further erosion occurred.

Figure 55: Area 3 – cohesive bluff erosion

9.2 HUMAN IMPACTS

The shoreline in Area 3 is completely armored with various forms of shoreline protection. The apparent lack of a gently-sloped, sandy beach in Area 3, as well as the exposed cohesive bluffs necessitates shore protection. As such, lakefront properties and infrastructure have become dependent upon the existing protection systems, which are now aging. Recent impacts have and will likely continue to include repair and/or reconstruction of existing systems.

9.3 SHORELINE MANAGEMENT RECOMMENDATIONS

As concluded in 2012, we do not recommend additional regulation of shoreline protection within Area 3, beyond the regulation already administered by both the USACE and the MDEQ. Because Area 3 contains little to no public shoreline access and existing shoreline protection structures extend across its full shoreline, additional regulation is unnecessary.

Continued coordination with private owners, especially those who own comprehensive shore protection systems, is recommended. As the existing systems are continuously exposed to the coastal conditions of Lake Michigan, they will lose functionality and failures will increase over time. It will be critical to maintain, repair, and reconstruct these systems over time in order to prevent the loss of cohesive bluffs in Area 3.

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