Bay Beach
Restoration Action Plan

Green Bay, Wisconsin

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BAY-LAKE REGIONAL PLANNING COMMISSION
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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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Executive Summary

Historic water quality monitoring by the Green Bay Board of Public Health determined that the nearshore waters off of Bay Beach Park were unsafe for full contact recreation and a permanent prohibition against swimming was posted in the 1930's. Since that time, various agencies, including the Brown County Health Department and NEW Water have periodically assessed water quality at, or in the vicinity of, Bay Beach. However, additional data was needed to begin the process of restoration. In 2012, the Bay-Lake Regional Planning Commission secured funding through a US EPA Urban Waters Grant and engaged the University of Wisconsin – Oshkosh (UWO) to conduct intensive summer sampling and beach sanitary surveys in an effort to determine potential pollutions sources and conditions which result in degraded water quality.

Water quality sampling was conducted at Bay Beach in Green Bay, Wisconsin over a three-year period to determine the water quality at the beach from a public health perspective and to provide the basis for the development of a restoration plan that outlined a strategy towards restoring a once-popular downtown beach. Bay Beach is located in Green Bay, Wisconsin on Green Bay adjacent to the east bank of the Fox River at its confluence with Lake Michigan (Map 1). Bay Beach Amusement Park is a destination for thousands each year in the summer, but the beach has not been used as a swimming beach since 1943 when it was forced to close due to pollution.

Although the Bay is scenic and water quality has improved in the area, it is possible to live in the community and rarely see or use the Bay. This relationship results from the fact that there are few overlooks, and it is lined with wetlands, floodplains, heavy industry, open storage, a power plant, and a sewage treatment plant. Bay Beach presents one of the few opportunities within the City to view, and come in contact with the Bay. Unfortunately, there is no safe access to the beach and it has become overgrown with invasive vegetation, primarily the invasive *Phragmites australis*. *Phragmites* is a highly invasive terrestrial species that has established itself in the area around Bay Beach with tall, dense stands limiting water access.

Water quality conditions at Bay Beach were assessed by conducting beach sanitary surveys and gathering past water quality data. The assessments and data gathering provided useful information for the development of a beach restoration action plan to help mitigate water quality impairments and to restore a safe beach.

Water Quality Assessment

From a public health perspective, recreational water quality was assessed at Bay Beach by sampling and acquiring data on *E. coli*, microcystin, Polychlorinated biphenyls (PCBs), and Mercury. Water and sand sampling was conducted a multiple points and depths at Bay Beach over three years (2012 (partial), 2013, and 2014) and tested for levels of *E. coli* and microcystin. Additional *E. coli* data was collected on past sampling by NEW Water from 2004 to 2007. Data on PCBs was collected from the U.S.

Army Corps of Engineers (ACOE) sampling around Renard Island in 2013. Mercury information was obtained through discussions with the University of Wisconsin – Sea Grant Institute (UW-Sea Grant).

E. coli is a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. The U.S. Environmental Protection Agency (EPA) recommends *E. coli* sampling as the best indicator of health risk from water contact in freshwater recreational waters.

Microcystin is a toxin released from some algae blooms and is present throughout the Great Lakes. Not all algal blooms are toxic, but harmful algal blooms that produce microcystin can cause liver damage. The EPA considers harmful algal blooms to be an environmental problem. No federal or Wisconsin community health standards exist for microcystin, although some states have regulations based on World Health Organization (WHO) guidelines. WHO guidelines were used for the purposes of the assessment at Bay Beach (WHO, 1999).

High levels of PCBs and Mercury have been an issue in Green Bay for many years. However, concerns and advisories have been targeted at fish consumptions. A recreational water quality assessment of Bay Beach for PCBs and Mercury involved discussions with the UW-Sea Grant and the review of samples collected around Renard Island compared to guidelines based on the "Great Lakes Protocol" Health Protection Value and a study conducted for the U.S. Department of Health And Human Services, Agency for Toxic Substances and Disease Registry.

Summary Results

Of the data collected, analyzed, and reviewed, no concerns were found with utilizing the beach for swimming and recreation. Although Bay Beach has access, safety, and aesthetic concerns, none of the water quality data collected and analyzed raised concerns with restoring the beach to swimming.

Of 91 samples collected for *E. coli* at the center of the beach at 24' depth of water, 14 samples (15 percent) had exceedances above 235 MPN/100mL, which would result in a beach advisory. Two samples (4 percent) had exceedances above 999 MPN/100mL, which would result in a beach closure. The mean E. coli was 221.0 MPN/100mL – below the advisory level for a beach. These results put Bay Beach on par with recreation water quality seen at other Lake Michigan beaches in Wisconsin.

Of the 57 samples collected for microcystin at Bay Beach, 38 samples (67 percent) had concentrations below 4 ppb, which is considered a *low risk* based on WHO guidelines. 19 samples (33 percent) had concentrations between 4 and 20 ppb, which is considered a *moderate risk*. No samples were collect that exceeded 20 ppb to be considered a *high risk*. However, continued attention to algae and effective sampling methods are needed.

Of the PCB samples collected by the ACOE in 2013, concentrations were in the range of 45-72 ug/kg dry, with the samples collected near Renard Island being 72 ug/kg dry and those closer to the shore just south of Renard Island being 45 ug/kg dry. The higher 72 ug/kg dry concentration measured at Renard Island is much lower (>30 times) than the "Great Lakes Protocol" Health Protection Value (Anderson, Amrhein, Shubat & Hesse, 1993) and is also lower (>10 times) than the Minimum Risk Level established by the Agency for Toxic Substance and Disease Registry (Wisconsin Department of Health Services, 2011). Indicating, that the risk of exposure from contaminated sediment at Renard Island is very low. Assuming that the concentrations continue to drop with increased distance from Renard Island, Bay Beach concentrations would be even lower.

The recommended actions in this plan target necessary beach improvements or further efforts needed towards restoration of Bay Beach to address issues of safety, access, pollution mitigation, aesthetics, regulatory issues, and others. This plan also includes an engineered concept beach design plan.

Introduction

Green Bay, Wisconsin is a Great Lakes coastal city with no beach. There has not been a swimming beach in Green Bay in nearly 80 years. A century ago, Bay Beach was a popular swimming destination that saw hundreds of visitors every day during the summer. Excessive source pollution into the Fox River and Green Bay resulted in the loss of the beach. But the pollution that resulted in its closure has not been a problem for the area in over 35 years, since the enactment of the Clean Water Act in 1972. Although, the area has seen more than its share of other pollution problems since, explorations into the potential to restore the beach are long overdue.

This plan explores the concerns -- real or perceived, to restoring a swimming beach or recreational water access site at Bay Beach. The plan defines the actions and resources necessary for restoration.

Scope/Project Area Description

Bay Beach is an urban beach within the Green Bay, Wisconsin metropolitan area (MSA). The Green Bay MSA has a population of 306,241 (2010 Census). The City of Green Bay is the principal city of the Green Bay MSA, and is the third largest city in Wisconsin. It has a population density of 2,370 persons per square mile. For comparison, Brown County, in which Green Bay is located, has a population density of 469 persons per square mile. The neighborhood area around Bay Beach is one of Green Bay's oldest.

Bay Beach is located within Bay Beach Amusement Park at 1313 Bay Beach Road in the City of Green Bay, Wisconsin. It is on the Bay of Green Bay adjacent to the east bank of the Fox River at its confluence with Lake Michigan (Map 1). It is bound to the north by the opens waters of Green Bay, to the south by Bay Beach Park, to the east by residential housing near the shoreline and the Bay Beach Wildlife Sanctuary further inland, and to the west by the causeway leading to Renard Island. The beach sits on the end of a northeast facing partial embayment formed by the causeway to the west and mainland to the southwest and northeast. This configuration limits circulation and the exchange of water within the embayment with the open waters of Green Bay.

Bay Beach Amusement Park is a popular picnic and amusement park area with a large wildlife sanctuary nearby. About 800 feet northwest off shore from Bay Beach, is Renard Isle, a 55-acre manmade island. The island was designed by the U.S. Army Corps as a confined disposal site for polluted dredge from the Green Bay harbor entrance and channel. The island has been closed and capped (with more than 10 feet of soil) and alternatives are being considered for the transition of Renard Island into a community asset.

Purpose

The purpose of developing this restoration action plan is to begin a discussion about what it would take to restore Bay Beach and establish a plan of action for implementation. Stifling heat and humidity during recent summers have encouraged a newfound motivation to make Bay Beach swimmable again. Anyone in Green Bay looking for a beach to escape the heat has to escape the city for now.

In 2011, Green Bay Mayor Jim Schmitt affirmed that revitalizing Green Bay's only beach is a long-term goal (Walter, 2011). The Friends of the Bay Beach, a non-profit established to guide development of the amusement park, are supportive and enthusiastic about the restoration of Bay Beach. Furthermore, beach restoration was identified as an element of the Bay Beach Amusement Park Master Plan.

The NEW Wilderness Alliance, a collaboration of organizations committed to sustainability and livability in northeast Wisconsin, resolved to focus on the restoration of Bay Beach as a tangible symbol of a watershed in recovery.

The Clean Bay Backers, the citizen advisory committee for the Lower Green Bay and Fox River Area of Concern (AOC), has made restoring Bay Beach a top priority. The Clean Bay Backers served as the advisory committee for this plan. The group is hopeful that restoring a swimmable Bay Beach will raise public concern about the overall health of the watershed and encourage public support for further restoration efforts.

Bay Beach History

Bay Beach's history dates to the 1890s, when entrepreneur Mitchell Nejedlo purchased the land. Originally intended to be divided and sold for summer cottages, he turned it into Bay View Beach, a private beach resort in 1892. Bay View Beach had a dance hall, a bar, and a bathhouse. However, it had a difficult time attracting visitors since the area was marshy and infested with mosquitoes, and the roads were in poor condition. In 1908, Captain John Cusick bought the resort from Nejedlo. Cusick built an 8-foot wide dock extending 570 feet into the bay, then bought a steamboat to transport customers from the Walnut Street Bridge to Bay View Beach. At the end where the boat anchored, there was a 90 square-foot, 2-story covered pavilion. When swimming became popular, Cusick began renting swimsuits for 10 cents apiece, grossing up to $450 on a good day – even though the suits were never quite dry or free of sand when rented. In 1908, Cusick built a ride called "Shoot the Chutes." The ride was an early version of the modern log rides. Twelve passengers boarded a flat-bottomed boat at the top of an approximately 50-foot tower. The boat would slide down the chute, hitting the Bay with a splash, and skim across the water for several yards. After each ride, the boat would be cranked back to the top of the ramp by a winch (Freiss, 2010).

In 1911, Bay View Beach was sold to Frank Murphy and Fred Rahe. In 1920, they donated the 11 acres, along with all its buildings and attractions, to the City of Green Bay and it became Bay Beach. From the 1930s to the early 1970s, Bay Beach's pavilion hosted concerts, political rallies, dances, Fourth of July fireworks, and other events (Freiss, 2010). In 1934, President Franklin D. Roosevelt visited Bay Beach in celebration of Green Bay's tercentennial (Rudolph, 2004). Today the park is a family place, with scenic views and rides for children, including bumper cars, a small-scale passenger train ride, a large slide, and a Ferris wheel.

Through the years, amusement rides were added, and today the park consist of approximately 45 acres with 19 rides, seven shelters, a dance hall, restrooms, picnic areas, playground, and softball and volleyball areas – but no swimming (SAA Design Group, 2013). From the site's earliest days as a private park, a public beach was available, but pollution of the bay eventually caused the swimming beach to close.

Bay Beach began experiencing frequent beach closings in the 1930's due to raw sewage, oil slicks, and wastes from canning factories, cheese factories, and paper mills. By 1938, increasing pollution began causing skin sores and the Green Bay Board of Public Health was forced to permanently close the beach to swimming – one of the earliest beach closings in the country. However, many residents continued to swim at Bay Beach until ten years later when the closure began to be enforced and the beach was finally abandoned. Today, the beach is still abandoned.

Stakeholder Involvement

Along with the Bay-Lake Regional Planning Commission, this project brought together stakeholders from the City of Green Bay Parks, Recreation and Forestry Department with researchers from the University of Wisconsin – Oshkosh and the City of Racine Health Department, and stakeholders from the Clean Bay Backers to focus attention on the present water quality, and future restoration potential of Bay Beach.

The City of Green Bay Parks, Recreation and Forestry Department ("Parks Department") ensured that the concept beach redesign plan met the needs of the city, and was compatible with the master plan for the Bay Beach Amusement Park. The Parks Department also assisted in gathering city department concerns and perceived limitations to restoring the beach.

University of Wisconsin – Oshkosh conducted the water quality sampling and site assessments at Bay Beach using U.S. EPA Sanitary Survey Protocols to determine potential contamination sources and inventory beach characteristics.

The City of Racine Health Department provide consulting from an on-staff Great Lakes beach expert (Dr. Julie Kinzelman) to conduct a comprehensive assessment of Bay Beach and develop mitigation recommendations and best management practices before and after beach restoration.

The Clean Bay Backers, the citizen advisory committee for the Lower Green Bay and Fox River AOC, assisted with community engagement and provided review and feedback on elements of this plan. The Clean Bay Backers are comprised of citizens; representatives from Neighborhood Associations, conservation groups, universities; and government agencies. The Clean Bay Backers will sustain the long-term effort and community interest to restore Bay Beach.

The beach redesign engineering contractor (Miller Engineers & Scientists; Sheboygan, WI) conducted a comprehensive assessment of Bay Beach and the surrounding area and developed mitigation measures in the form of an engineering plan for the conceptual redesign of Bay Beach.

The U.S. Army Corps of Engineers and the Wisconsin Department of Natural Resources assisted with the project by reviewing the concept plans and providing information on potential permitting issues and requirements.

Vision

The Clean Bay Backers, serving as the advisory committee for this plan, developed the following vision for Bay Beach.

"To restore and sustain a health, safe, attractive, and swimmable beach at Bay Beach."

Their vision is a simple statement; however, there is much to be done to achieve this vision. This plan begins to lay the groundwork to accomplish the goals that will achieve this vision.

Goals

One of the main goals of the Clean Water Act and the RAP is to make water bodies fishable and swimmable (FWPCA, 2002). The overarching goal of this project was to explore the potential to restore a swimmable beach in a Lake Michigan coastal city with no natural swimming beaches. This goal was accomplished by accurately characterizing the pollution that impacts water quality and providing a basis on which to develop a beach restoration plans, a redesign concept plan, and recommendations on best management practices (BMPs).

Water Quality Information Gathering and Analysis

Information gathering and analysis for Bay Beach included conducting Beach Sanitary Surveys and annual surveys to characterize bacterial levels (*E. coli*); sampling for microcystin levels to determine presence of toxic algae; and data gathering on PCB sampling that had been conducted near Bay Beach over recent years.

Historical Recreational Water Quality

Improving water quality at Bay Beach builds upon ongoing work in the Lower Green Bay and Fox River Area of Concern (AOC). Contaminated sediment, poor water quality, and habitat problems affected the use of the water in the AOC such that it needed priority attention. The AOC consists of the lower seven miles of the Fox River and a 21 square mile area of southern Green Bay out to Point au Sable and Long Tail Point. Bay Beach is the only swimming beach on the southern shore of Green Bay and near the downtown.

The Remedial Action Plan (RAP) developed for the Lower Green Bay and Fox River AOC identified impairments to beneficial uses associated with AOCs. “Beach closings” is one of the eleven beneficial use impairments impacting the Lower Green Bay and Fox River AOC. Surveys conducted as part of the initial 1988 Remedial Action Plan (RAP) for the Lower Green Bay Area of Concern revealed that restoring swimming to Bay Beach was a “major change” the public hoped would result from the RAP. Additional monitoring at Bay Beach is listed as a needed action in the 2011-2014 RAP Updates (WDNR, 2011-2014).

An evaluation was conducted of historical water quality using previously collected data at Bay Beach (Table 1). Since routine monitoring has not been conducted, the data provided was intermittent from multiple sources over select years. Historical data was collected by NEW Water (a.k.a. Green Bay Metropolitan Sewerage District) and analyzed by the Brown County Health Department. These data show water quality trends for the past several years. A total of 91 samples have been collected at Bay Beach and analyzed for *E. coli* since 2004, with over 60% of the collected within the last three years. There was additional data collected prior to 2004, but samples were analyzed for fecal coliforms. While *E. coli* is one type of fecal coliform, the data cannot be directly compared. It appears that 2007 was an outlier year and may inflate the overall *E. coli* average at Bay Beach (Table 1). If this year is removed, the average *E. coli* concentration at Bay Beach would be 111.3 MPN/100mL, which is below the EPA regulatory standards of 235 MPN/100mL for posting an advisory at a beach.

In addition to samples collected at Bay Beach, there were sites located on the Fox River and off of Long Tail Island where NEW Water collected water samples and evaluated them for several water quality parameters. Some of these parameters include wind direction and speed, air temperature, rain, relative humidity, turbidity, pH, TDS, total coliforms, and *E. coli*. While these samples were not collected directly at Bay Beach these data can assist in pinpointing potential pollution sources possibly impacting Bay Beach. Figure 1 shows the historical monitoring locations, dates when these sites were monitored for *E. coli,* and mean *E. coli* concentrations. *E. coli* concentrations at each of the monitoring sites were well below the regulatory threshold of 235 MPN/100 mL for posting an advisory at a beach.

Figure 1. Map of the Bay of Green Bay indicating monitoring sites where NEW Water and UW Oshkosh monitored for *E. coli* over several years. All text in YELLOW indicate these data were collected by NEW Water. All text in PINK indicate data was collected by UW Oshkosh.

Sample Collection (*E. coli* and microcystin)

A sample plan was developed based on the initial site assessment to evaluate all potential pollution sources. Routine sanitary surveys (RSS) were conducted for Bay Beach two times per week from 2012 to 2014. Each survey consisted of recording general beach conditions including air and water temperature, wind speed and direction, rainfall and intensity, weather conditions, wave height and intensity, and alongshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, and south) and depths (12 inches, 24 inches, and 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity (Figure 2). In addition to spatial sampling, a water sample was collected at the center of the beach at 24 inches and analyzed for microcystin toxin (Envirologix ELISA Quantiplate; Portland, ME) each time a RSS was conducted. There were no major stormwater outfalls identified at this beach; however the mouth of the Fox River is located approximately 1.3 miles northwest of Bay Beach.

Figure 2. Bay Beach sampling locations.

Annual sanitary surveys were conducted in all three years of the study (2012-2014). An annual sanitary survey is more comprehensive than a RSS in that it not only evaluates the beach, but includes the surrounding area as well. With an annual sanitary survey, the length and width of the beach are measured, potential pollution sources are identified, topography of the beach is documented, the surrounding area is categorized (e.g. rural, agricultural, residential), and RSS data is compiled and analyzed for the entire beach season.

Beach Sanitary Surveys

Beach sanitary surveys, a methodology used to determine recreational water quality for this project, are a proven effective approach to restoring water quality to an established beach that has been blighted with closings. The process, which includes using beach sanitary surveys and detailed site assessments to inform a beach improvement plan, has been used at a number of beaches along Lake Michigan and Lake Superior in Wisconsin. The project team used at the beaches throughout Wisconsin, is the same team used for this project, which includes the University of Wisconsin - Oshkosh (UWO) to conduct sanitary survey water quality monitoring and testing, the City of Racine to recommend non-engineered improvements, and an experienced engineering firm to develop the beach improvement and redesign recommendations with local stakeholder input.

The success of the sanitary survey process has been shown through improved water quality at Wisconsin beaches that have implemented the recommendations. This project differed from the other beach improvement projects in Wisconsin because Bay Beach is not currently used as a swimming beach and has not been routinely monitored to determine if it would experience beach closings; rather it is a permanently closed beach. However, the methodology still proved effective to help establish the steps that would be necessary to make the beach swimmable again from a recreational water quality standpoint, as well as an aesthetic, safety, and accessibility standpoint.

Beach sanitary surveys are a low cost technique designed to determine sources and variables associated with excess Fecal Indicator Bacteria (FIB) in recreational waters. Sanitary surveys are a unified, reliable, and replicable data collection method. Ambient environmental and beach conditions that have the potential to impact beach water quality are recorded using a routine on site sanitary survey form at each beach visit. Conditions recorded at the time of sample collection include: wind speed, wind direction, rainfall amount, rainfall intensity, amount of cloud cover, air/water temperature, the amount of algae present in water or stranded ashore, longshore current direction, wave height, turbidity, the amount/type of wildlife present, and the presence of beach litter.

In addition to examining environmental variables, local infrastructure is evaluated such as stormwater outfalls or other potential point sources of bacteria. Variables recorded when conducting beach sanitary surveys describe sources of bacteria, conditions that may increase the amount of bacteria introduced from non-point sources, environmental conditions that can alter bacteria die off rates and factors that affect the transportation of bacteria once in the nearshore environment. Other supportive information, collected on an annual basis, includes: topographical (physical) characteristics, the location of infrastructure such as stormwater outfalls, surrounding land use, and the location/condition of sanitary facilities near the beach.

Routine and annual sanitary surveys were collected at Bay Beach over three seasons from 2012 to 2014. However, due to a late start with the project, 2012 monitoring was limited to sampling from late August to mid-September. The complete sanitary survey results and methodology are contained in the *Bay Beach Monitoring Results 2012-2014* final report compiled by UWO (Appendix A).

Site Assessments

Bay Beach Amusement Park is roughly 45 acres in size, with turf grass and parking lots dominating the upland portion of the park, and an approximate 1.9 miles of wetland/sandy deposits below the retaining wall/dike (revetment). Sediments are comprised of silts, fines, and decaying organic matter until about 10 feet from the extent of the *Phragmites*. Subsurface sediments are comprised of fine sand. Invasive species, predominantly *Phragmites*, comprises the majority of the vegetation below the dike.

Annual walking site assessments and intensive sampling/data analysis, conducted as part of the beach sanitary survey and site assessment process, identified potential point (direct) sources of pollution including a pipe extending from a small white concrete block structure which discharges onto the beach at the east end of the small white building (Figure 3).

Figure 3. Localized infrastructure may be a point source of pollution.

Significant amounts of rusty deposits on trees, rocks and other hard surfaces below the revetment provide evidence of frequent discharge (Figure 4).

Figure 4. Deposits of rust on beach substrate.

In addition, high waves, onshore winds, and surface runoff were noted as likely mechanisms of transport, contributing non-point source (indirect) pollution to the nearshore waters off of Bay Beach Park. High waves and surface runoff can increase turbidity by suspending or transferring sediment particles into the water column. Therefore, beach sands/sediments and submerged sediments could also be potential non-point sources of pollution (Figure 5). Other potential non-point pollution sources noted were: avian wildlife populations (contributing fecal matter to both the nearshore water and/or beach sands) and algae (*Cladophora*) (stranded mats create a hospitable habitat for bacterial persistence and/or growth, Figure 5).

Figure 5. Examples of fine beach sediments with organic matter and stranded algae.

Recreational Water Quality Monitoring Results

Bay Beach has not been routinely monitored prior to this study (Table 1). However, intermittent data was collected by NEW Water and analyzed by the Brown County Health Department. In total, 91 samples were collected at Bay Beach by other agencies since 2004, over 60% within the last 3 years. 2007 may represent a one off experience, resulting in inflated average *E. coli* values across the study period at Bay Beach (Table 1). If this data is removed, the average *E. coli* concentration at Bay Beach would be 111.3 *E. coli* MPN/100mL. If retained, the mean value is 221.0. In either instance, mean values fall below the US EPA/WDNR single sample advisory limit of no more than 235 E. coli MPN/100mL.

Table 1. Historical water quality at Bay Beach, 2004 - 2014. Red italicized text indicates data collected by NEW Water and analyzed by the Brown County Health Department.

Number of Samples Exceeding Water Quality Standards				
Year	**# of Exceedances (>235 MPN/100mL)**	**# of Samples**	**% Exceedances**	**Mean *E. coli* (MPN/100mL)**
2004	*1*	*10*	*10%*	*97.0*
2005	*2*	*14*	*14%*	*107.4*
2006	*0*	*9*	*0%*	*20.3*
2007	*1*	*2*	*50%*	*879.7*
2012	1	7	14%	84.5
2013	6	26	23%	148.3
2014	3	23	13%	210.0
Totals	14	91	18%	221.0

NOTE: Only E. coli concentrations collected directly at Bay Beach were included.

A total of 571 surface water and sediment samples were collected at Bay Beach by UWO from 2012 - 2014 (2012 n=78; 2013 n=258; 2014 n=235) (Table 2). Due to a late start with the project, only a partial, late season of sampling was undertaken in 2012.

Table 2. Total number of samples collected, by type, over the duration of the study at Bay Beach.

Bay Beach Number of Samples Collected (2012-2014)						
Year	**Monitoring Frequency (per week)**	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Microcystin Samples**	**Total**
2012	3	7	56	15	0	78
2013	3	26	208	0	24	258
2014	3	23	184	0	28	235
Total	NA	56	448	15	52	571

E. coli concentrations steadily increased from 2012 to 2014 (Figure 6). Concentrations were significantly higher in 2014 than in 2012 ($p<0.05$). Mean E. coli concentrations in 2014 exceeded US EPA/WI DNR single sample advisory limit of no more than 235 E. coli MPN/100mL, the first time since 2007. Drought conditions in 2012 may have contributed to the lower *E. coli* concentrations and also indicates that at least a portion of the contamination is wet weather mediated.

There was evidence of geese and gulls noted at the initial site assessment. This was confirmed on the routine sanitary surveys, were both geese and gulls were observed loafing in the nearshore water and grassy areas surrounding the beach (Table 3). Significant amounts of *Phragmites* along the shore were observed to trap debris and algae as well as restrict water movement. This could be a contributor to the elevated mean turbidity values observed (Table 3). High turbidity is frequently associated with instances of poor water quality.

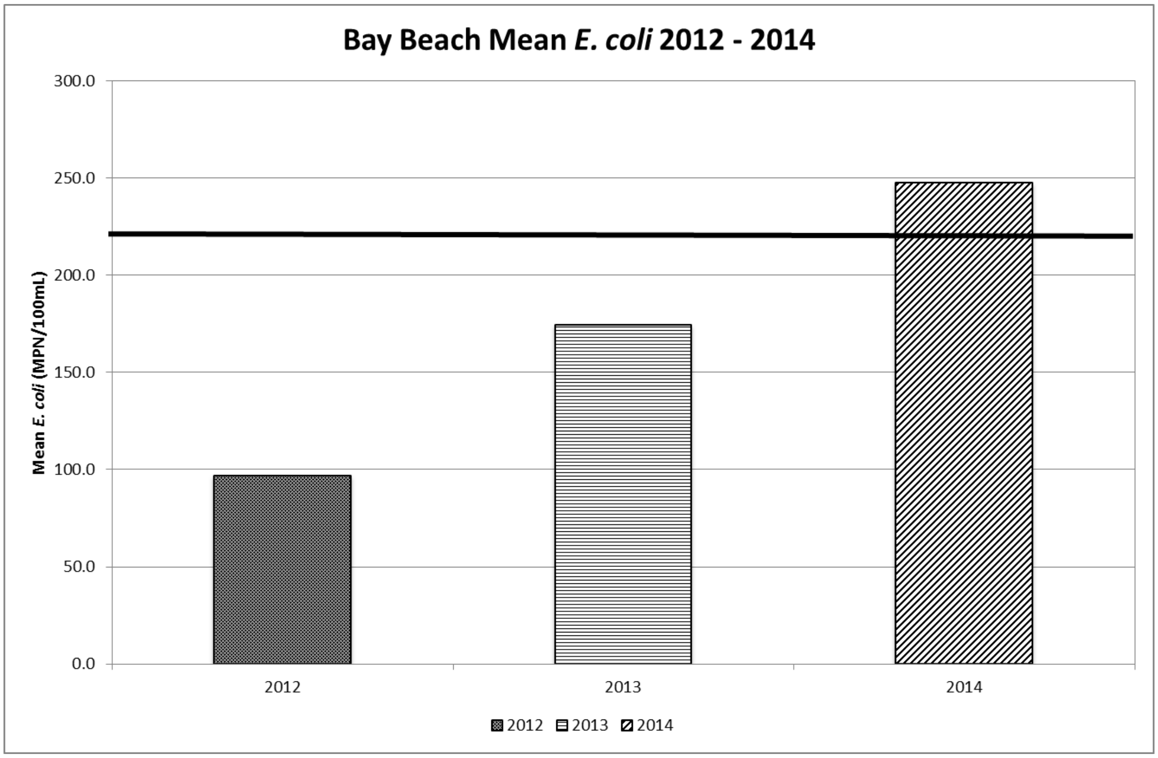

Figure 6. Mean E. coli (MPN/100mL) at Bay Beach (2012 n=63; 2013 n=234; 2014 n=207) ANOVA p=0.000.

Table 3. Mean seasonal results of select sanitary survey and water quality parameters (2012-2014) at Bay Beach.

Bay Beach Mean Sanitary Survey Summary 2012-2014							
***E. coli* Center 24" (MPN/100mL)**	***E. coli* Sand (MPN/g)**	**Microcystin (ppb)**	**Water Temp (°C)**	**Turbidity (NTU)**	**# Gulls**	**# Geese**	**Bathers (# people)**
164.9	11.7	3.2	21.9	95.0	12.7	5.3	0
n=56	n=15	n=52	n=54	n=27	n=54	n=54	n=54

At the conclusion of the three years of data collection, statistical linear regression was conducted between physical/chemical/biological parameters and *E. coli* concentrations at the center of beach location (24 inches). Parameters with the highest R2 value at Bay Beach included wave height, water and air temperature, and wind direction (Table 4). These parameters alone do not contribute for 100% of the fecal contamination; however, in combination they account for a significant amount.

The primary avian species noted at Bay Beach were gulls. On average, 13 gulls were observed per day over the three-year study. Geese were also observed but in smaller numbers (n = 5 per day, Table 3 and Table 5). No dogs were observed at the beach. Wildlife present at the beach can contribute to fecal bacteria loading to the beach and surrounding area. During rain or high wind events it can be subsequently washed into the nearshore water, delivering E. coli and other potential human pathogens to the swimming area.

Algae was observed and recorded as the amount submerged in the nearshore water only since there is no delineated beach area at Bay Beach. No algae was observed in 2012 (Table 4). In 2013 and 2014 there were moderate amounts of algae observed in the water. On a scale of zero to three (zero being no algae and three being high amounts of algae), an average of 1.8 (n=54) abundance of algae was observed during the three year study period.

Table 4. Relationship of biological, physical, or chemical parameters to log E. coli concentrations.

Bay Beach	R^2 Value		
Physical/Chemical/Biological Parameter vs. *E. coli*	**2012**	**2013**	**2014**
Wind Direction (°)	0.1596	x	0.0483
Wind Speed (mph)	0.0162	x	0.0364
Water Temperature (°C)	0.2476	0.0209	0.0016
Air Temperature (°C)	0.3941	0.0551	0.0921
Turbidity (NTU)	0.1344	x	0.0195
Wave Height (ft)	x	0.2397	0.6419
Within 24hr Rain (cm)	0.0017	0.0071	0.0003
Algae (1-3 scale)	x	0.0236	0.0357
Gulls (#)	x	0.0321	0.0000
Geese (#)	x	0.0375	0.0295
Other Avian (#)	0.0034	0.0751	0.0109
Bathers at Beach (#)	x	x	0.0004
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	x	x	0.0127
Longshore Current Direction (°)	x	x	0.0002

*x indicates insufficient data collected for statistical analysis.

Table 5. Wildlife at Bay Beach, number and days observed.

Number and Type of Wildlife Present on Bay Beach													
		Gulls			Geese			Other Birds			Dogs		
Year	Total Days	Amount	Days Observed	Min/Max	Amount	Days Observed	Min/Max	Amount	Days Observed	Min/Max	Amount	Days Observed	Min/Max
2012	5	7	5	0/5	0	0	0	37	2	2/35	0	0	0
2013	26	223	15	4/40	233	9	1/50	137	15	1/35	0	0	0
2014	23	458	23	1/50	54	9	2/21	50	18	1/6	0	0	0
Total	54	681	38	NA	287	18	NA	224	33	NA	0	0	NA

In addition to assessing *E. coli* and parameters indicative of potential pollution sources, surface water samples were collected twice weekly in 2013 and 2014 and analyzed for microcystin toxin. Microcystin toxin concentrations increased significantly from 2013 to 2014 ($p<0.05$) (Figure 7). The average microcystin concentration for 2013 was 1.95 ppb versus 4.29 ppb in 2014.

Allowable concentrations for microcystin in surface water, as suggested by the World Health Organization are <4 ppb, Low Risk; 4-20 ppb, Moderate Risk; and visible scum, High Risk (WHO, 1999). In 2013, microcystin concentrations were in the Low Risk category. However, microcystin concentrations increased and were in the Moderate Risk category in 2014. In Wisconsin, contact should be prohibited if a visible scum layer is observed or microcystin levels exceed 100,000 cells/mL. In Illinois, the beach action limit is 10.0 ppb. Therefore, based on these guidelines, microcystin levels did not exceed dangerous levels during the course of this study.

Blue-green algae events are temporal and very difficult to catch. Microcystin test results from this study could be an indication of a sampling plan that missed the release of toxins. Continued attention to algae and an effective method of monitoring is needed in the Lower Green Bay.

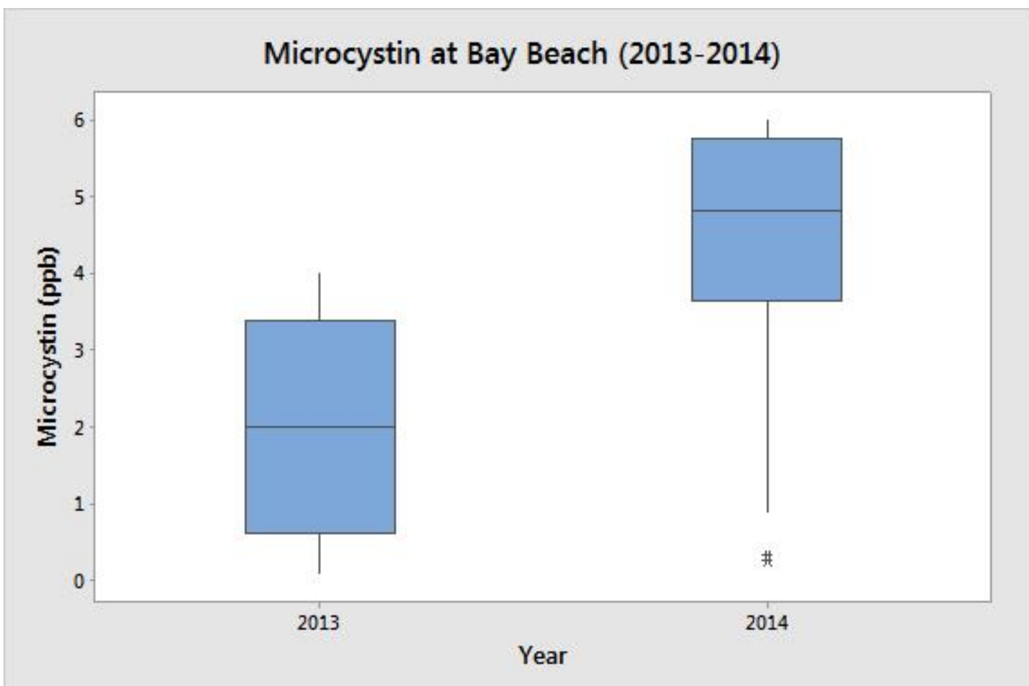

Figure 7. Boxplot of microcystin concentrations in 2013 and 2014. (2013 n=24, 2014 n=28)

Polychlorinated biphenyls (PCBs)

History

PCBs are the toxic substance of greatest concern in Green Bay and the Fox River. PCBs are chemical compounds that were used in commercial and industrial applications. As a result of the recycling of PCB-containing carbonless copy paper, area mill operations discharged PCBs in waste streams, contaminating sediment in the Lower Fox River. From 1957 to 1971, the Fox River-Green Bay system was contaminated with an estimated 110,000 pounds of PCBs (Qualls, Harris & Harris, 2013). The level of PCBs measured in the Fox River during 1994 and 1995 reached 70 ng/l (ppt) (EPA, 2004). This level is 500 to 600 times the Wisconsin Water Quality standard to protect wildlife (0.12 ng/l) (Qualls, Harris & Harris, 2013).

PCBs have ecological and human health impacts as they bioaccumulate in organisms and increase in potency as they are passed up the food chain through consumption having a negative effect on fish, wildlife, and humans at the top of the food chain. Once consumed, PCBs are deposited in body fat and can accumulate in the body over time. Consumption of fish produces the greatest risk of PCB exposure for humans.

Sampling Data

In 2013, the U.S. Army Corps of Engineers, Detroit District (USACE) retained RTI Laboratories, Inc. (RTI) as a contractor to perform sediment sampling services at the sediment loading area at Cat Island and at Renard Island. RTI collected sediment samples from a proposed sediment loading area at Cat Island and around the Renard Island causeway. RTI and its subcontractor, Coleman Engineering Company, provided sediment sampling services using vibra-core sampling devices from a pontoon boat at each site. Appendix B provides RTI's soil analytical results for Renard Island.

The samples nearest Bay Beach were collected at two sites at the Renard Island causeway on October 11, 2013 (Figure 8). Sampling for PCBs by RTI at Renard Island causeway returned results of concentrations in the range of 45-72 ug/kg dry, with the samples collected nearer Renard Island (Site #1, Figure 8) being <72 ug/kg dry[1] and those closer to the shore just south of Renard Island (Site #2, Figure 8) being <45 ug/kg dry[1]. The higher <72 ug/kg dry concentration measured at Renard Island is much lower (>30 times) than the "Great Lakes Protocol" Health Protection Value (Anderson, Amrhein, Shubat & Hesse, 1993) and is also lower (>10 times) than the Minimum Risk Level established by the Agency for Toxic Substance and Disease Registry (Wisconsin Department of Health Services, 2011). Indicating, that the risk of exposure from contaminated sediment at Renard Island is very low. Assuming that the concentrations continue to drop with increased distance from Renard Island, Bay Beach concentrations would be even lower.

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[1] "<" refers to the *Limit of Quantitation*, which describes the smallest concentration of a measurement that can be reliably measured by an analytical procedure.

Future PCB sampling will be release for the Bay Beach area (Operable Unit-5A) as part of the remediation efforts and the long-term monitoring. Continued review of this data is recommended, although concentrations are expected to continue decreasing.

Figure 8. PCB Sampling Sites at Renard Island Causeway (October 2013)

Mercury

While total mercury concentrations are high in the Fox River and Green Bay, methylmercury concentration are relatively low, resulting in lower bioaccumulation factors. Atmospheric anthropogenic sources of mercury include coal-fired power plant emissions, cinnabar mining, and other industrial processes. Sources of inorganic mercury to aquatic ecosystems include atmospheric deposition and industrial and municipal effluents. Once mercury enters rivers and lakes it accumulates up the food chain. Mercury accumulates in the muscle of fish, rather than in the fat like PCBs. Also, unlike PCBs, mercury can be slowly eliminated from your body over time. Fish advisories for the Fox River are based on PCBs, not mercury. Even though mercury is present in most Wisconsin fish, PCBs in the Fox River and Green Bay at this time pose a greater health risk (Qualls, Harris & Harris, 2013).

No sampling was conducted and no data was gathered for mercury near Bay Beach. Based on conversations with UW-Sea Grant it would not be necessary to test the water because the form of mercury harmful to humans is methylmercury, which is "present in such low (diluted) amounts that it is not feasible for a person to ingest a harmful amount from recreational contact with the water." (Noordyk, 2014).

Potential Obstacles to Restoring Swimming

In additional to evaluating the water quality for recreational use of Bay Beach, an assessment of other potential obstacles to restoring swimming was undertaken. Potential obstacles to restoring swimming a Bay Beach were identified through sessions held with the City of Green Bay Parks, Recreation, and Forestry Department, a technical advisory group of science professionals in the area, the Clean Bay Backers, and through presentations to various civic groups.

The primary potential obstacles that were identified for restoring swimming at Bay Beach include (in alphabetical order) algal blooms, *Phragmites*, public perception, regulatory permitting, safe access, and water clarity. Although not an all-inclusive list, these are some of the primary obstacles that were identified. Some additional potential obstacles that were identified were categorized as those that may arise after swimming is restored to the beach, such as additional parking and a providing bathhouse.

Harmful Algal Blooms

Harmful algal blooms (HABs) are overgrowths of cyanobacteria, often called blue-green algae, in a waterbody that can produce toxins, such as mycrocystin, which can damage the liver, nervous system and skin. These toxins can sicken people and pets, increase treatment costs for drinking water, close beaches, and hurt industries that depend on clean water. Not all algae blooms produce dangerous toxins, but even nontoxic blooms have a negative impact on the environment and local economies. The dead zone in Green Bay has been attributed to excessive blue-green algae growth.

HABs are caused by excess nutrients (nitrogen and phosphorus), slow-moving water, and sunlight. Nutrient pollution from human activities makes the problem worse, leading to more severe blooms that occur more often. The primary sources of nutrient pollution are agriculture, stormwater, and wastewater. Researchers are working to develop predictive capabilities for the presence of toxic cyanobacterial blooms in Great Lakes recreational and drinking water supplies. Future water quality monitoring at Bay Beach should include sampling for microcystin and/or other blue-green algae, and develop an accurate monitoring strategy.

Common Reed (*Phragmites*)

Common reed, or *Phragmites australis*, is a large perennial grass wetland plant species. It can grow up to 20 feet high in dense stands and is long-lived. *Phragmites* spreads rapidly by reproducing primarily via rhizomes, but also by seed. *Phragmites* is well-established along the Green Bay shoreline, including Bay Beach, making it difficult to maintain access to – and views of – the water. Large stands of dry *Phragmites* stems can also be a fire hazard. *Phragmites* would need to be removed and continually managed in order to maintain physical and visual access to Bay Beach.

Public Perception

Public perception was identified as a potential obstacle to restoring Bay Beach because it is believed by many that the public seems to generally perceive the water quality of Green Bay as worse than indicated in technical studies. This negative perception may derive from comments at various public meetings or in the comment sections of the local newspaper related to discussions on Green Bay water quality. However, no research or surveys have been conducted specifically about public opinions regarding the restoration of Bay Beach.

A number of public presentations were given to various civic groups and students as part of this project, and the response has been overwhelmingly positive. The majority of comments have been in support of restoring Bay Beach, and an expression of willingness to utilize Bay Beach once restored.

Regulatory Permitting

Meetings and correspondence with the U.S. Army Corps of Engineers (ACOE) and Wisconsin Department of Natural Resources (WDNR) has established that federal, state, and county permits would likely be required for the work associated with restoring Bay Beach as beach nourishment and any other fill/work associated with the project would be occurring below the ordinary high water mark (OHWM), Compensatory mitigation would also likely be required for impacts to wetlands/vegetated shallows. Additionally, there is potential that an Environmental Impact Statement (ESA) and/or an Archaeological Survey will be required.

Required permits may include, but are not limited to the following:

- *Establishment of a Bulkhead Line* (WDNR (Ch. 30.11), ACOE (Sec. 404), Brown County)[2],
- *Work in U.S. Waters* (ACOE, Sec. 404),
- *Wetland Fill or Disturbance* (WDNR, Ch. 281.36),
- *Removal of Plant and Animal Nuisance Deposits* (WDNR, Ch. 30.208),

[2] References were found regarding a bulkhead line along the south shore of Green Bay that was established by Ordinance No. 46-72 and amended by Ordinance No. 21-73. It was unknown at the time of this report whether the bulkhead line is expired or still valid and legal, and attached uses.

- *Removal of Material from Beds of Navigable Waters* (WDNR, Ch. 30.20)
- *Structures and Deposits in Navigable Waters* (WDNR, Ch. 30.12), and/or
- *Construction Site Stormwater Runoff* (WDNR, Ch. 283).

Safe Access

Bay Beach is enclosed at the back of the beach by an U.S. Army Corp of Engineers flood control dike. The dike makes it difficult and potentially dangerous to access the beach. A redesign concept plan developed for Bay Beach proposed a dune feature at the back of the beach that would bury the dike in sand and provide cordwalk paths over the dune and dike down to the beach. This design recommendation would leave the dike intact and fully functioning. In addition, improvements are needed to the asphalt path at the top of the dike to reduce potential for injury from potholes that are present and may not be obvious when the path is leaf or snow covered.

Water Clarity

Water clarity is a measure of the amount of particles in the water, or the extent to which light can travel through the water. Water clarity is important for a number of reasons. It affects the depth to which aquatic plants can grow, dissolved oxygen content, water temperature, and healthy fish and wildlife habitat. Water clarity is important aesthetically and can affect property values and recreational use of a water body (Asplund, 2000). It relates directly to the human-use perceptions of water quality, with clear water being preferred for swimming.

Water clarity can be affected by suspended sediments, algal growth, runoff, shoreline erosion, wind mixing of the lake bottom, and humic matter (natural derivatives from plants that produce the brown stain in wetlands and water draining from forested areas). Water clarity often fluctuates seasonally and can be affected by storms, wind, normal cycles in food webs, and rough fish such as carp, suckers, and bullheads.

According to the 2013 State of the Bay Report, the water clarity in Green Bay is poor – averaging half a meter (Qualls, Harris & Harris, 2013). Suspended sediments and algal growth (due to phosphorus levels) are the largest contributing factors to lack of water quality in Green Bay. Improvements in water clarity are anticipated with the achievement of the Total Maximum Daily Load (TMDL) targets for the Lower Fox River. A TMDL is the total amount of a pollutant that a given waterbody can receive without violating water quality standards. The Lower Fox River TMDL set achievable pollutant limits that are protective enough to correct water quality impairments and meet water quality standards in the river and bay (The Cadmus Group, Inc., 2012).

Restoration Action Plan

The restoration action plan defines the actions (projects, plans, studies, or activities) necessary or desirable for the restoration of Bay Beach. A number of studies may be needed before swimming can be restored, or at least before permits can be obtained for beach redesign. However, intermediate steps can be taken towards reclaiming a safe and welcoming public space along the water's edge without fully restoring a swimming beach all at once. Bay Beach has the potential to provide a rare opportunity within the City of Green Bay to visit the shore of Green Bay and look out over the Bay.

Study Phase

Recommended actions for the study phase primarily include those activities that will likely be required to secure permitting such as (1) confirmation of feasibility from a certified engineer; (2) researching the existence of a bulkhead in front of the dike at Bay Beach; (3) a wetland delineation survey and habitat assessment for potential compensatory mitigation opportunities; (4) an environmental impact assessment and an archaeological study; and (5) an assessment of threatened or endangered species on the site.

Additional activities recommended in the study phase include (6) a hydrodynamic and beach stability study to determine potential impacts to beach sand longevity; (7) trail planning to provide connectivity to the Bay Beach Wildlife Sanctuary, UWGB, and potentially Renard Island; and (8) routine monitoring of *E. coli* and microcystin.

Pre-Implementation Phase

Recommended actions for the pre-implementation phase include non-study related activities to be addressed prior to implementation – primarily permit acquisition activities including (1) acquire WDNR permit for *Removal of Plant and Animal Nuisance Deposits*; (2) *Phragmites* removal and management; (3) explore opportunities for beneficial re-use of dredge material from the Fox River channel and the Port of Green Bay (i.e. dredged sand); (4) acquire ACOE permit for *Work in U.S. Waters* (Sec. 404); (5) WDNR permit to add sand and cordwalks below the OHWM; (6) acquire WDNR permit for *Construction Site Storm Water Runoff* (Ch. 283, Wis. Stats.); (7) acquire WDNR permit for *Removal of Plant and Animal Nuisance Deposits* (Ch. 30.208, Wis Stats.); and (8) acquire WDNR Wetland Fill or Disturbance permit (Ch. 281.36, Wis. Stats.).

Implementation Phase

Recommended actions for the implementation phase include activities to consider during construction such as (1) implementing a beach designed for fluctuating water levels; (2) providing safe access over the breakwall down to beach, including ADA access; (3) beach nourishment (i.e. sand addition) to raise the beach profile; and (4) implementing a beach design that limits gull and geese loafing through planned placement of vegetation that interferes with avian sense of security from predation.

Post-Implementation Phase

Recommended actions for the post-implementation phase include activities to undertake after the beach has been restored such as (1) acquire WDNR permit to groom the beach below the OHWM (Ch. 30.20 Removal of material from beds of navigable waters); (2) expand parking as needed; (3) construct bathhouse/changing rooms as needed; (4) install color-coded flags to coordinate with approved signage regarding beach water quality status; (5) clearly delineate a swim zone perimeter with physical markers (such as buoys); (6) install signage indicating that no lifeguards are present at the beach, signage regarding NOAA water quality hazard (rip current), and user accessible rescue equipment; (7) develop a management and control plan for each hard engineered or naturalized control measure implemented; including stormwater control structures, dune features and wetlands; and (8) waste receptacles and recycling bins should be placed in the park within easy reach of beach patrons.

On-going Phase

Recommended actions for the on-going activities after the beach has been restored include (1) monitor for *E. coli* and microcystin; and (2) address water clarity issues resulting from suspended sediments (will be addressed through the TMDL implementation); (3) review data of continued PCB sampling near Bay Beach; (4) manage zebra and quagga mussel shells on the beach should an issue develop; (5) routine street sweeping along Bay Beach Road and any adjacent parking lots to reduce stormwater pollution to beach; and (6) beach grooming should occur to remove anthropogenic debris and algae that accumulates onshore.

Table 6 and Appendix C provides a list of recommended actions and potential partners categorized by project planning phases.

Table 6. Bay Beach Restoration Action Plan.

	Phase	Recommended Actions	Partners	Notes
1	Study	Confirmation of feasibility from a certified engineer.	City, Engineering firm	Desired by the City of Green Bay before proceeding with restoration.
2	Study	Research Green Bay bulkhead identified in City Ordinance. Seek potential ACOE, WDNR, and Brown County permits to reestablish bulkhead line.	City, WDNR, ACOE, Brown County	May be needed as part of permitting under Ch. 30.11 Establishment of Bulkhead Lines, *Wis. Stats.*
3	Study	Wetlands delineation survey and habitat assessment for potential compensatory mitigation opportunities.	City, Green Bay Conservation Partners, WDNR	May be needed as part of permitting.
4	Study	Environmental Impact Assessment and/or archaeological study.	City	May be required as part of permitting.
5	Study	Endangered or Threatened Species Assessment.	City, WDNR	Required as part of permitting.
6	Study	Conduct Hydrodynamic and Beach Stability Modeling.	City	Determine potential impacts to beach longevity from coastal processes/hazard Impacts.
7	Study	Trail planning to provide connectivity to Bay Beach Wildlife Santuary/UWGB and Renard Island.	City	
8	Study	Monitor for *E. coli* and microcystin.	City	Routine monitoring of *E. coli* and Microcystin is recommended. Consider routine rapid or real-time testing in the long term.
1	Pre-Implementation	WDNR permit for Removal of Plant and Animal Nuisance Deposits.	City, WDNR	
2	Pre-Implementation	Phragmites removal and management.	City, WDNR, BLRPC	Bay Beach is an identified treatment site for *Phragmites* removal under 2015 GLRI grant secured by BLRPC.
3	Pre-Implementation	Explore opportunities for beneficial re-use of dredge material from the Fox River channel and the Port of Green Bay (i.e. dredged sand).	City, Brown County Port Dept.	Referenced in *Dredged Material Management Plan, Phase II Report for Green Bay Harbor* (U.S. Army Corps of Engineers, Detroit District, 2010). Sediments are currently being directed to the restoration of the Cat Island chain.

Table 6 (cont'd). Bay Beach Restoration Action Plan

	Phase	Recommended Actions	Partners	Notes
4	Pre-Implementation	ACOE permit for Work in U.S. Waters (Sec. 404).	City, ACOE County Port Dept.	Potential for needed compensatory mitigation, Environmental Impact Assessment, and Archaeological Survey.
5	Pre-Implementation	WDNR permit to add sand and cordwalks below the OHWM.	City, WDNR	Ch. 30.12 Structures and deposits in navigable waters, *Wis. Stats.*
6	Pre-Implementation	WDNR permit for Construction Site Storm Water Runoff (Ch. 283, *Wis. Stats.*).	City, WDNR	
7	Pre-Implementation	WDNR permit for Removal of Plant and Animal Nuisance Deposits (Ch. 30.208, *Wis Stats.*).	City, WDNR	
8	Pre-Implementation	WDNR Wetland Fill or Disturbance permit (Ch. 281.36, *Wis. Stats.*).	City, WDNR	
1	Implementation	Design for fluctuating water levels.	City, Engineering firm	A restored, adaptable shoreline with permeable cordwalks over the breakwall should be designed to handle fluctuating water levels.
2	Implementation	Provide safe access over breakwall down to beach, including ADA access.	City, Engineering firm	Based on engineered concept plan, safe access could be provided by covering breakwall with sand and providing cordwalks to the beach.
3	Implementation	Beach nourishment to raise profile.	City, Engineering firm	Public health objective.
4	Implementation	Implement beach design that limits gull and geese loafing.	City, Engineering firm	Based on engineered concept plan, gull and geese loafing could be limited through planned placement of vegetation that interferes with avian sense of security from predation.
1	Post-Implementation	WDNR permit to groom the beach below the OHWM (Ch. 30.20 Removal of material from beds of navigable waters).	City, WDNR	
2	Post-Implementation	Expand parking as needed.	Friends of Bay Beach (FOBB), City	Add additional parking, connect trails, ensure adequate bus routes.
3	Post-Implementation	Construct a bathhouse/changing rooms as needed.	FOBB, City	
4	Post-Implementation	Install color-coded flags to coordinate with approved signage regarding beach water quality status.	FOBB, City	Green is to be posted continuously, with yellow or red posted when water quality conditions occur that could negatively impact human health.
5	Post-Implementation	Clearly delineate a swim zone perimeter with physical markers (such as buoys).	FOBB, City	

Table 6 (cont'd). Bay Beach Restoration Action Plan

	Phase	Recommended Actions	Partners	Notes
6	Post-Implementation	Install signage indicating lifeguards status, signage regarding NOAA water quality hazard (rip current), and user accessible rescue equipment.	FOBB, City	
7	Post-Implementation	Develop a management and control plan for each hard engineered or naturalized control measure implemented.	City, Engineering firm	Including stormwater control structures, dune features, and wetlands.
8	Post-Implementation	Waste receptacles and recycling bins should be placed in the park within easy reach of beach patrons.	City	
1	On-going	Monitor for *E. coli* and microcystin.	City, County, WDNR, UWO	Continued monitoring of *E. coli* is recommended at all Lake Michigan public beaches during the summer. Microcystin sampling is also recommended at all beaches along Green Bay. Routine rapid or real-time testing is recommended long term.
2	On-going	Address water clarity issues resulting from suspended sediments.	WDNR, many other TMDL partners	TMDL will address with reductions in runoff (loading and stormwater issue); hydrodynamic modeling
3	On-going	Review data of continued PCB sampling around Renard Island.	ACOE, WDNR	Future PCB sampling will be release for the Bay Beach area (Operable Unit-5A) as part of the remediation efforts and the long-term monitoring.
4	On-going	Manage zebra and quagga mussel shells on beach.	City	Does not appear to be an issue at Bay Beach.
5	On-going	Routine street sweeping along Bay Beach Road and any adjacent parking lots to reduce stormwater pollution to beach.	City	
6	On-going	Beach grooming should occur to remove anthropogenic debris and algae that accumulates onshore.	City	Improve aesthetics, reduce health risks associated with hazardous materials, and remove food sources/debris that attract nuisance wildlife.

Redesign Recommendations

A beach redesign concept plan was developed with the aim of reducing the amount of stormwater and microbial contamination entering the nearshore waters, and improving access and aesthetics. The concept plan was developed based on feedback from the City of Green Bay Recreation Department to ensure compatibility with the Bay Beach Amusement Park Master Plan.

The redesign concept plan includes measures to address the processes responsible for the delivery of contaminants to the nearshore waters for Bay Beach. It was designed to reduce the amount of *E. coli* and other pollutants found in stormwater discharge from entering the designated swimming area in order to improve the overall surface water quality at the beach.

After the preliminary concept plan was completed, it was presented to the City of Green Bay Recreation Department for their review to ensure the beach redesign plan addresses contamination as well as community concerns by remaining consistent with the vision that the City of Green Bay and the Friends of Bay Beach had for the beach when they developed the master plan for the amusement park. The final redesign plan was prepared based on beach survey data, city feedback, and a determination of the most cost-effective methods to address beach issues.

The plan includes itemized cost estimates for each proposed site modification to be constructed and/or implemented at Bay Beach; estimations of the capacity of best management practices to retain stormwater during typical and atypical rain events; a comprehensive manual for the short- and long-term maintenance and management of the structural and non-structural practices (inclusive of estimated costs); and a report that explains the merits of each design element.

Urban non-point source pollution is one of the most complex environmental challenges facing the Great Lakes. The amount of impervious surfaces, such as roadways, parking lots, and rooftops, has significantly increased as urban areas in the basin have developed. These impervious surfaces convey pollutants such as bacteria, nutrients, oils, sediment, and heavy metals. While considered “green space”, even turf grass areas provide little infiltration. Primary contact recreational standards for bacteria almost always exceed limits in stormwater runoff, regardless of the originating land use type. Therefore, capital investments, by way of engineering control measures, are required to properly treat stormwater runoff prior to its entering receiving bodies of water, such as coastal beaches.

Engineering control measures may be either structural (hard engineered features such as permeable pavements, bio-infiltration swales, retention/detention basins, or other infrastructure improvements) (Figure 9) or naturalized (restoring buffer strips, wetlands, dunes and/or planting native vegetation). In some locations, beach redesign plans may call for the removal or alteration of legacy engineered structures, such as jetties, piers, groins or impervious surfaces. At other sites, construction of devices to mimic natural coastal attributes or alteration of existing land features may be needed to elicit necessary water quality improvements. Site specific engineered solutions have been recommended as a result of the intensive monitoring conducted at Bay Beach. The remainder of this section serves to provide a rationale for, and reinforce, the importance of such measures in maintaining or restoring ecosystem health and is meant to be complimentary to the merit report and redesign plan. Appendix D contains a copy of *Beach Engineering Package for Bay Beach* (2014) developed by Miller Engineers & Scientists.

Figure 9: Porous pavement and vegetated swale at a Door County beach parking lot.

High waves and storm surges frequently flood shoreline areas. To guard against future flooding a dike, or revetment, was placed along the shoreline at Bay Beach Park (Figure 10). Historical photographs indicate that the waters of Green Bay abutted the revetment at the time of installation. However, due to successive years of accretion and reliction the shoreline has retreated several meters at times exposing lakebed. The removal of this shoreline erosion control measure is not recommended.

Figure 10. Shoreline erosion control feature at Bay Beach.

To the west and north of Bay Beach Park lies Renard Island. Renard Island is connected to the mainland by a causeway (Figure 12 and Figure 12). While the removal of the causeway may not be permissible or desirable, culverts could be installed to improve circulation in the nearshore area off of Bay

Beach. Improving circulation could reduce blue-green algae. Additionally, a permanent barrier is likely to create a depositional area in the longer term.

Figure 11: Renard Island before causeway (oblique view).

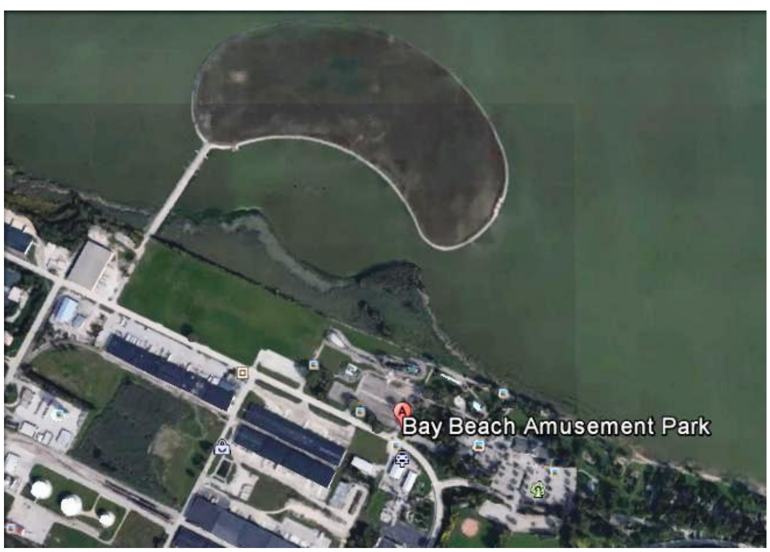


Figure 12: Renard Island and causeway (aerial view).

Engineered Stormwater Control Measures

Stormwater management must take place as non-point source (NPS) runoff is widely acknowledged to be a primary source of water quality degradation. With the exception of the one small pipe, there were no stormwater outfalls at Bay Beach. It is recommended that future engineering plans refrain from placing any future outfalls at the beach.

Restoration recommendations at Bay Beach make use of green infrastructure to reduce the impact of runoff. Dunes and wetlands serve as an important buffer between terrestrial activities and aqueous environments, improving water quality through a series of chemical, biological and physical processes. In addition to water filtration, they provide habitat for a variety of plant and animal species, are home to unique ecology, reduce flood hazards, lessen erosion, and serve as an important temporary storage element. Improvements to the asphalt pathway will also reduce pooling and shunting of runoff onto the beach.

Figure 13. Dunes provide infiltration of urban runoff at Samuel Myers Park (Racine, WI).

Structural and naturalized engineering solutions frequently attempt to address loss of natural coastal features through the implementation of design features that mimic the environment by reducing, retaining and/or infiltrating direct stormwater discharge and surface runoff, for example at Samuel Myers Beach in Racine, Wisconsin (Figure 13).

Redesign plans at Bay Beach recommend naturalized stormwater control measures. The construction of small dunes in the back beach area coupled with overall beach nourishment will capture impervious surface and landscape runoff. The construction of a dune and swale system will assist the City of Green Bay in managing non-point source pollution by improving the capture and infiltration of stormwater runoff as it is delivered to the site from upland areas, as well as better manage invasive species (higher and drier beach environments are less favorable for the growth and propagation of hydrophilic invasive species, like *Phragmites*).

Sediment Management

Sediment grain size and the proximity of surface sands to the water table can contribute to impairment. Fine grain sands have greater surface area and serve as a point of attachment for bacteria. Larger sand particles promote greater infiltration that supports higher and drier beach conditions. Larger and heavier sand particles are also less susceptible to wind erosion, decreasing the amount of sand that is blown off the beach. Increasing the distance between the sand surface and water table will result in a higher and dryer beach. Low and flat beaches remain wet due to capillary draw, a constant interaction with the water table due to a lack of adequate separation. Strategic beach nourishment can also serve as a natural stormwater management measure. Constructed or encouraged dunes, when strategically placed, can reduce overland flow and promote infiltration from impervious surface abutting the beach. Permits are required from the WDNR to do any beach nourishment in Wisconsin.

Vegetation

Native vegetation, within constructed or encouraged dunes, is incorporated into beach redesigns for several reasons. The root systems of most native plants are deep and help water infiltrate into the ground, reducing runoff. The plants root systems also retain soil, including sand, in place, reducing erosion and drifting on dynamic beaches. Native plant species may also facilitate infiltration of non-point source pollution and provide nutrient uptake. Native plants are naturally low maintenance, saving time, money and energy once established. Native plans have adapted to local conditions, which makes them hearty and resistant to most pests and diseases. Native vegetation also improves coastal habitat by providing food and shelter for migratory birds, butterflies, and other desirable wildlife along the Lake Michigan coast.

Restricted/invasive species must be managed in order for Great Lakes restoration to progress. As part of the restoration process, invasive species must be removed and replaced with native grasses, sedges, forbs, shrubs and trees. The full planting list is available on the engineering plan sheets.

Improving Public Access

Defined public access points should be established based on local foot traffic and usage patterns, to provide controlled ingress/egress points through existing or created dunes, wetlands and other features. These pathways will allow vegetation to become established by protecting them from foot traffic. Curved pathways may also deter wildlife loafing behavior by reducing the line of sight (thus instilling a fear of potential predation). Pathways can be made from a variety of permeable materials including cord walk, tree mulch, recycled planking, or fiber mesh. All pathways should be ADA compliant whenever possible. Both Simmons Island Beach (Kenosha, WI) and North Beach (Racine, WI) have improved public access through the use of fixed and movable permeable pathways (Figure 14, Left and Right).

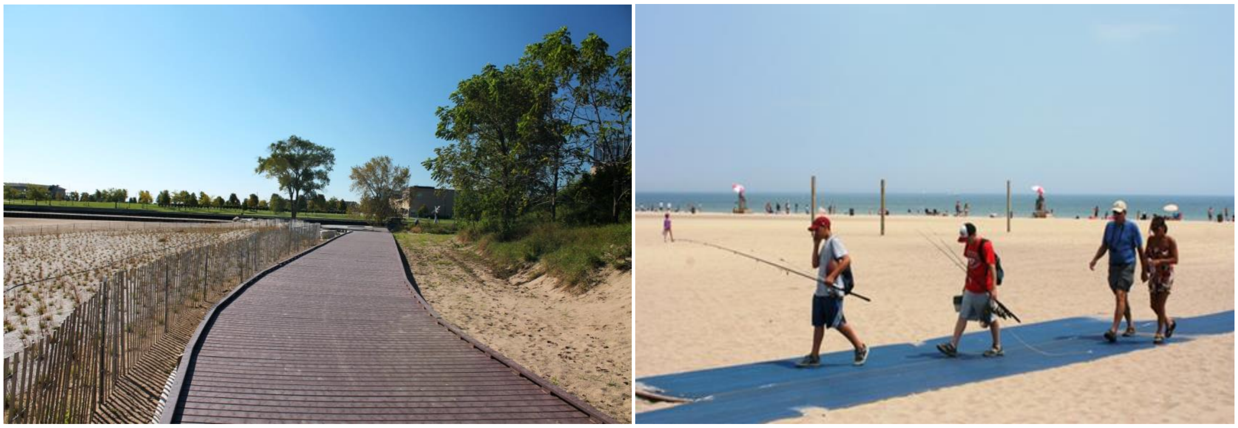


Figure 14: Left: Defined pathways protect vegetated areas during the establishment phase (Simmons Island Beach, Kenosha, WI), Right: Example of Mobi-Mat™ pathway (North Beach, Racine, WI).

Proper access points to the beach are beneficial to patrons, mangers, and the environment. Improved points of ingress/egress to Bay Beach are currently lacking. Access to the beach area consists of traversing the revetment and making ones way through the dense stands of *Phragmites* by way of makeshift paths. The asphalt pedestrian path running along the top of the revetment, between the train tracks and beach, is also in very poor condition and presents a health hazard (Figure 15, A - C). The proposed design elements in the Bay Beach restoration plan will provide easy access to the water's edge while limiting the negative impacts of excessive foot traffic on native vegetation. Proposed pathways can be made ADA compliant by being cognizant of the necessary grade transitions and utilization of Mobi-Mat™ extensions. Temporary mulch pathways may be utilized during active restoration; however, they must be replaced every 2-3 years.

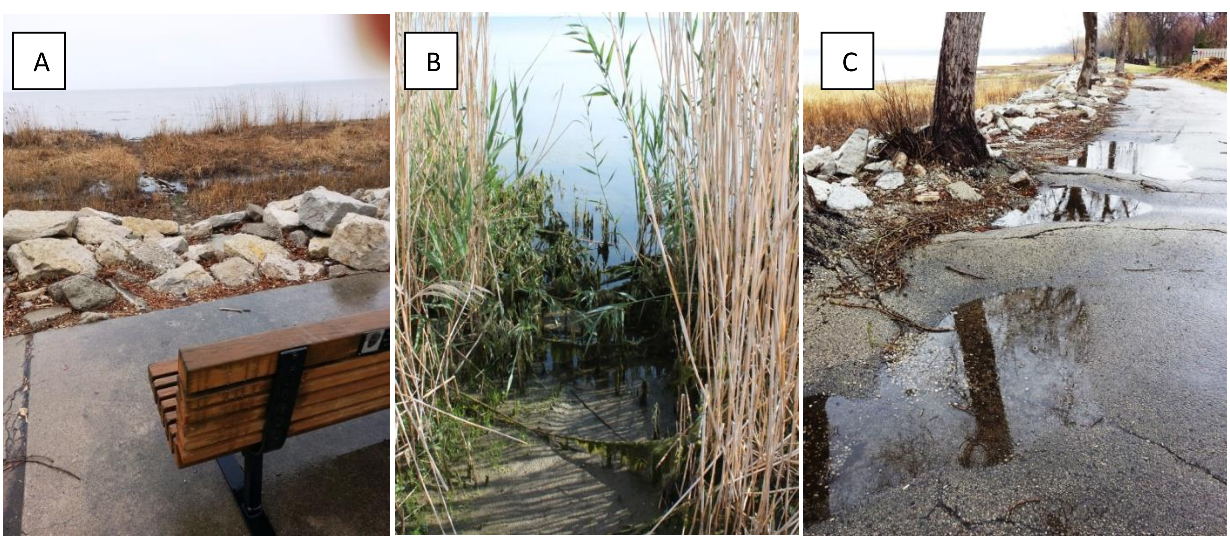


Figure 15 (A – C): Current points of ingress/egress: (a) over revetment, (b) footpath and (c) asphalt path.

Best Management Practices Recommendations

The purpose of beach BMPs are to reduce the adverse impacts of localized pollution on nearshore water quality. To provide the best results they should be used in conjunction with the site specific engineered control measures. The application of best management resources to abate pollution will vary by location and a single solution will likely not be the "silver bullet", removing all water quality impairments. The appropriate suite of BMPs deployed must be science-based and result from a critical review of monitoring data, utilization studies, feasibility, and current/future land use. BMPs should also contain an educational component to increase public awareness of water quality problems and engage the community in solutions. Implementation of BMPs will require a combination of local government and municipal department cooperation/coordination and may require capital investment, although many can be carried out at little to no cost. The BMPs recommended for Bay Beach include developing water quality, native plant community, and invasive species monitoring plans, as well as public notification and beach maintenance plans. Appendix E contains a copy of *Beach Health Assessment and Recommended Best Management Practices for Bay Beach* (2015) developed by Julie Kinzelman, Ph. D.

Developing a Beach Water Quality Monitoring Plan

Regular monitoring of water quality at the beach, especially during peak usage (i.e. summer weekdays, weekends and holidays) is extremely important in protecting public health. The frequency of routine, regulatory monitoring should be guided by the WDNR beach priority list. Based on its prior WDNR use designation, Bay Beach should be monitored at least once weekly throughout the swimming season.

A predictive model may be a cost effective supplement or alternative to traditional laboratory-based testing. Predictive models, developed using sanitary survey or readily available web-based data, estimate bacterial levels based on environmental conditions that influence fecal indicator bacteria concentrations at beaches. The US EPA has developed a software application called Virtual Beach and many coastal communities are in the process of using it to develop models capable of predicting recreational water quality in near real time (http://tinyurl.com/EPAVirtualBeach). Models not only provide an element of rapidity; they can serve as a cost saving measure when the availability of staff and laboratory resources makes traditional analytical methods difficult. Predictive models have been developed and are currently at several coastal beach locations in Wisconsin.

In addition to routine, regulatory monitoring, Bay Beach should continue to be monitored to test the efficacy of mitigation measures, once implemented, and/or to gain further insight into environmental conditions/pollution sources impacting water quality if any are outstanding. Specifically, the beach should be monitored no less than once monthly from May to September for the following parameters: *E. coli*, turbidity, microcystin and water temperature. Post-restoration values should be compared to 2012-2014 baseline values as a measure of progress. This type of comparative data, pre- and post-mitigation, will clearly demonstrate whether the desired water quality improvements have occurred due to mitigation. Depending on when implementation of mitigation measures occurs, annual sanitary surveys may need to be redone to ensure the identified sources of contamination remain relevant.

Developing an Invasive Species Monitoring Plan

Research has indicated a relationship between standing water and persistent contamination by fecal indicator bacteria (FIB). Studies from Racine, Wisconsin and elsewhere have also demonstrated a positive correlation between high concentrations of *E. coli* and wetted beach sands. Standing water and wetted beach sands can be caused by rainfall, but also lack of appropriate elevation/grade. Bay Beach has several physical attributes which act to deliver, maintain and subsequently discharge water high in FIB into the embayment. Data also supports the likelihood that the low quality wetlands may be acting as sources of fecal indicator bacteria (rather than a sink) and that the density of *Phragmites* may exacerbate this problem due its ability to block UV penetration (which has a bacteriocidal effect). Literature has brought under question whether wetland areas can act as sources of contamination to nearshore waters. The exposed lakebed below the revetment at Bay Beach is likely to be classified as wetland due to its frequently wetted state. Perpetual standing water has resulted in an environment favorable for the growth and propagation of invasive species such as *Phragmites*. While this was the dominant species noted during the site assessments, it is recommended that a wetland delineation be performed to identify both native and invasive species. Invasive species should be removed and replaced with native varieties whenever feasible. Once invasive species have been removed, it is important to develop a monitoring plan to prevent re-infestation. See merit report for further information on invasive species management.

Developing a Public Notification Plan

Relaying the latest water quality results to the public without delay is an important step in protecting public health. Rapid and effective methods must be chosen and may include: notification at the beach (flags, digital and/or traditional signage), RSS feed from the Wisconsin Beach Health website (http://tinyurl.com/WIBeaches), posting on municipal websites, blast emails, radio and TV announcements, newspapers, social media and/or text messages.

Figure 16. WDNR approved water quality signage and beach rules; Blue Harbor Beach, Sheboygan, WI.

The use of color-coded flags, which coordinate with approved signage, increases visibility. WDNR approved signage should be installed at popular public access points, possibly two or three signs depending on size and layout of the beach. The statewide signage procedure calls for the default water quality testing notification sign (green) to be posted continuously (Figure 16). Water quality results signs (yellow or red) must accompany the notification sign when water quality conditions occur that could negatively impact human health. The use of the blue sign is optional.

Once established, the swim zone at Bay Beach should be clearly delineated with physical markers around the perimeter of the swim zone (such as buoys). Signage containing a map of the swim zone should be placed at points of ingress as well as approved WDNR water quality signage. Signage indicating that no lifeguards are present at the beach or offshore swim zone and NOAA water quality hazard (rip current) signage, along with user accessible rescue equipment, should also be placed on the beach.

Developing a Beach Maintenance Plan

Routine beach management should occur on a regular basis, the frequency dictated by the type of activity, amount of use, and need. In addition, a management and control plan should be developed for each hard engineered or naturalized control measure implemented; including stormwater control structures, dune features and wetlands (refer to the examples provided in the merit report). General and site specific recommendations for common beach maintenance activities are provided below.

Stormwater Management

Stormwater runoff from impervious surfaces can contain high levels of bacteria, which is typically attached to fine particles. By sweeping impervious surfaces regularly, the sediment load in runoff is reduced, indirectly reducing bacteria loading into nearshore waters. Routine sweeping along Bay Beach Road and any adjacent parking lots is recommended.

Funding for implementation of stormwater management features should be sought as soon as possible in order to reduce the amount of runoff discharging from the upland areas of the park to the beach and embayment. This should also include an assessment and retrofit, if necessary, of any localized stormwater infrastructure (e.g. the pipe originating in the concrete block structure to the west of the train tracks).

Grooming and Grading of Beach Sands

Beach grooming is an important aspect of beach management. When properly done, grooming will improve aesthetics; reduce health risks associated with hazardous materials (e.g. broken glass, sharp metal objects, etc.); and remove food sources/debris that attract nuisance wildlife. Studies have shown that deep grooming, without compaction of beach sands, promotes desiccation. Fecal indicator bacteria density in beach sands has been shown to be a function of moisture content; therefore deep grooming which exposes bacteria to UV radiation and promotes drying and may reduce the amount of FIB available for transport to nearshore water. Grooming at Bay Beach should occur as needed to remove anthropogenic debris and algae that accumulates onshore. Grooming should not occur in areas containing native vegetation.

Litter Removal

The accumulation of litter decreases aesthetic appeal and can present a hazard to wildlife and human health. Food-related litter also attracts nuisance wildlife (Figure 17a). The use of waste receptacles with liners and covers is recommended to deter wildlife and prevent accidental release (Figure 14b). The presence of litter can be controlled through active removal, public education and enforceable municipal ordinances. A sufficient number of waste receptacles and recycling bins should be placed in the park and on the beach, within easy reach of beach patrons, and emptied in an adequate timeframe depending on usage. The use of solar trash compacters can reduce the frequency with which waste receptacles need to be emptied. Waste receptacles are also a great place to post public information (Figure 17b). Event-based beach clean-ups can be coordinated with volunteer or academic organizations with a service component to help manage the accumulation of debris.

Figure 17 (a): Overflowing open waste receptacle; prone to attracting gulls and scatter windblown debris.

(b): Waste receptacle designed to deter gulls as well as provide public information.

Some amount of debris was present on 100% of sampling events at Bay Beach (2012 - 2014). The majority was anthropogenic in nature and likely deposited by beach patrons and/or washed ashore. The ubiquitous presence of debris suggests that it was rarely removed from the beach or was constantly deposited. Only a single waste receptacle was noted at Bay Beach, located on the western end adjacent to the granite marker. Placement of waste receptacles with liners and lids along walking paths will encourage patrons to properly dispose of their refuse. Designated pickup schedules are needed as well, so that waste receptacles are not filled beyond their capacity. Continual inspection and cleaning of impervious surfaces adjacent to the beach is necessary to contain litter/debris before it is transported to the nearshore water via wind or water.

Managing Algae and Other Natural Debris

While some amount of natural debris accumulating on the beach is to be expected, large amounts of water-washed refuse, animal waste and other items should be promptly removed. Filamentous green algae, such as *Cladophora*, and other natural debris may accumulate on the shore, trapping insects and other organisms, which decay to generate a pungent odor that many people mistake as sewage. Algae and natural debris may serve as a reservoir for bacteria, some of which may cause illness. Prompt removal will help preserve water quality, improve perceptions of beach cleanliness and reduce disuse due to aesthetic reasons. A permit may be required from the WDNR to remove unwanted vegetation below the high water mark by mechanical means.

Algal mats were often observed at Bay Beach (2013 – 2014). The presence of moderate amounts of algae submerged along the shore was positively correlated with increased concentrations of *E. coli* in surface water. Algae stranded on the shore, while not necessarily contributing to poor water quality, negatively affects beach aesthetics. Therefore, regular observation of the beach is needed and any stranded algal mats should be promptly removed. Mechanical removal, using the beach groomer, may be possible on the fine sandy portions of the beach; manual removal would likely be needed at areas with coarser sediments or denser vegetation. The WDNR should be consulted prior to any mechanical removal below the ordinary high water mark.

Invasive Species Management and Control

Invasive species can be detrimental to beach ecosystems, impacting native flora, erosion, and hydrology. Invasive plants such as purple loosestrife, *Phragmites*, Zebra and Quagga mussels, Blue Dune Lyme Grass, reed canary grass, non-native cattails, Teasel, Eurasian watermilfoil, and frogbit are found at beaches in Wisconsin. Annual beach assessments and site surveys will identify the presence and extent of these terrestrial invaders. Monitoring protocols and early detection is extremely important. Invasive species can quickly establish themselves in coastal areas, becoming difficult or costly to eradicate. See WDNR field guide: http://tinyurl.com/WIPlantFieldGuide.

Phragmites was the predominant species at Bay Beach. Eradication efforts, including repeated herbicide applications and manual removal by volunteers and/or City of Green Bay park staff, can reduce the stands by roughly 80% or more. Mechanical removal is not effective as a standalone treatment option because shoots may sprout from underground rhizomes and root fragments within the soil. Mechanical removal, in conjunction with an imazapyr and/or glyphosate application to the stems in late summer (when the shoots transfer carbohydrates to the root system), has been successful. The existing stands east of Bay Beach have been well managed by private landowners, and little to no *Phragmites* remains (Figure 18).

Figure 18. Phragmites are well managed on private property adjacent to Bay Beach.

Wildlife Management

Avian species, primarily ring-billed gulls, herring gulls and Canada geese, have been demonstrated to increase bacteria levels in nearshore water. This is further compounded by the fact the resident waterfowl populations are increasing in the Great Lakes Region due to the abundance of food and federal legislation which makes reducing their numbers through hunt, take or capture illegal unless granted a waiver (WI State Statues grants full protection to any bird parts including eggs and nest under the U.S. Federal Migratory Bird Act of 1918). Removing or limiting access to potential food sources in landfills, parking lots, and recreational areas is recommended to deter gull and geese loafing behavior, as are the conspicuous placement of wildlife resistant waste receptacles and city ordinances prohibiting the feeding of wildlife by beach visitors. Naturalized engineering control measures, such as buffer strips and sand dunes, are also effective control measures as they remove the direct line of site that these species prefer. Gull numbers have also been reduced at beaches where human activity has increased as a result of water quality improvements.

Wildlife was frequently observed at Bay Beach; primarily gulls, followed by Canada geese. The most sustainable method to deter gulls from loafing would be through habitat modification and removal of food sources. Habitat modification can be accomplished in conjunction with the proposed stormwater management measures, i.e. the installation of low dune ridges at the interface of the asphalt pathway and beach, extending onto the beach. Additional covered waste receptacles and routine pick-up will reduce the availability of food. Due to potential as a bird flyway, wildlife control methods that are not protective of migratory species, such as the use of Border Collies, distress calls, and static or mechanized birds of prey, should be avoided. Additionally, dogs are prohibited at Bay Beach Amusement Park.

Public Education and Outreach

Besides water quality data, other informational/educational signs and enforceable ordinances should be visible at the beach (Figure 19). Examples of other notices include:

- Rip-current warnings (http://www.ripcurrents.noaa.gov)
- Waste disposal requirements
- Impacts of animals on water quality (Don't feed the birds)
- Dogs on the beach
- Rules of behavior
- Locations of restrooms, showers, lifeguard station, first aid
- Designated sites for swimming and launching boats (no wake zone)
- Stormwater education (http://runoffinfo.uwex.edu/pdf/StormwaterE&O.pdf)
- Lifeguard hours/no lifeguard on duty (swim at your own risk)
- Do not swim if you are sick (http://www.cdc.gov/healthywater/swimming)

In addition to providing the public with information directly related to their beach experience, broader education and outreach efforts can decrease the need for mitigation measures by promoting personal best management practices in the home. Many communities have encouraged the use of rain barrels, rain gardens and downspouts disconnect programs; some offer financial offsets (http://tinyurl.com/MMSDHelp). Environmental education at the K-12 levels (http://tinyurl.com/WisEE) can create lifelong stewardship with students advocating for changes in personal practices at home and into adulthood. Whenever possible, it is desirable to engage the public in restoration activities. Being a participant creates a stakeholder base and instills community pride as citizens see a return on their investment through increased water quality at their beaches.

Figure 19. Examples of informational beach signage.

Economic Value of Beaches

Healthy beaches are not only valuable natural and community resources, but they are also an economic resource that can provide great value in a coastal community. Beaches provide recreation, visual beauty, and community sense of place. Beaches also provide services that have economic value. They generate positive impacts for the economy and tax base, and provide economic development opportunities. Recreation and tourism serve as important economic contributors to many parts of the Great Lakes region. Boats, marinas, resorts, restaurants, and the production and sale of outdoor sports equipment, all contribute to the region's economy.

If the Great Lakes/St. Lawrence River region (including the United States and Canada) were a country, it would have the fourth-largest economy in the world (World Business Chicago, 2011). More than 1.5 million jobs in the United States are directly tied to the Great Lakes, with 200,000 jobs supported by recreation and tourism (Mida Hinderer et al., 2011). Spending on boats and boating activities in the Great Lakes states totaled nearly $16 billion and directly supported 107,000 jobs in 2003. (Great Lakes Commission, 2007).

Various studies have been done on the economic value of Great Lakes beaches. One such study found the average consumer value of a beach visit to Lake Erie in Ohio to range from $22.20 and $36.53 per person per trip[3], and that the annual value of single day trips ranged from $5 million to $8.7 million (Sohngen et al., 1999). Another study found the average value per trip to a Lake Michigan beach ranged from $42.75 to $58.45 (Song et al., 2010)[3]. A study done on Lake Michigan beaches in Chicago found the average value per trip to be $44 (Shaikh, 2006)[3].

Based on these studies, one can begin to picture the magnitude of the economic value of beaches and what has been lost in the City of Green Bay in the 72 years since Bay Beach was closed. However, the loss to the City, and the potential gains with restoring Bay Beach, could go beyond the economic value from beach visits and into the value of an increased quality of life and the benefits to attracting millennials to Green Bay.

Conclusions

The overall goal of this project was to identify pollution sources at Bay Beach located on Green Bay/Lake Michigan in Green Bay Wisconsin. In order to accurately identify sources of fecal pollution, three years of data were collected and analyzed to determine which parameters influenced *E. coli* concentrations, and two years of data were collected on microcystin.

E. coli concentrations increased from 2010 to 2012 likely due to changes in rainfall, wave action, or other weather conditions, an increase of waterfowl observed in 2013 and 2014, or other hydrogeological changes occurring within the Bay of Green Bay.

The pollution sources identified at Bay Beach include wave height, sheet flow from the adjacent walk path, and restricted water flow from the abundance of *Phragmites*. Even though samples were not collected from the Fox River and historical monitoring data did not show significantly high levels of *E. coli*, this tributary may still be a potential contamination source at Bay Beach.

Bay Beach has the potential to be impacted by agricultural runoff and stormwater contamination from the Fox River. This is due in part to a number of tributaries to the Fox River that drain agricultural fields and large areas of impervious surfaces that discharge to the Fox River. There was also a tendency

[3] Adjusted for inflation to 2015.

for gulls to loaf in the nearshore water and grassy area south of the beach. Particularly at Bay Beach, geese tended to loaf on the grassy areas and gulls in the near shore water.

Microcystin was also evaluated at this location due to evidence of algal blooms in Green Bay. Microcystin increased from 2013 to 2014. Although both *E. coli* concentrations and Microcystin increased from 2012 to 2014, there was no correlation between the two. While causes are unclear with the data collected to date, it is evident that monitoring should continue, especially if swimming is to be restored to the beach.

The beach redesign plans were based on scientifically sound identification of pollution sources at the beach and incorporated “green” infrastructure and low maintenance designs. Before mitigation can occur to design a sustainable beach at Bay Beach, invasive *Phragmites* removal must occur.

Although Bay Beach occasionally experiences episodes of elevated *E. coli*, the water quality for recreational contact is comparable to other Lake Michigan beaches in Wisconsin. Based on water quality testing, no reason has been found to maintain closure of Bay Beach. Permanent closure of Bay Beach resulted from pollution that is no longer allowable under the Clean Water Act. Other pollution such as PCBs and mercury are still affecting the Bay; however, not to an extent that raises any concern for recreational water contact.

Project Area

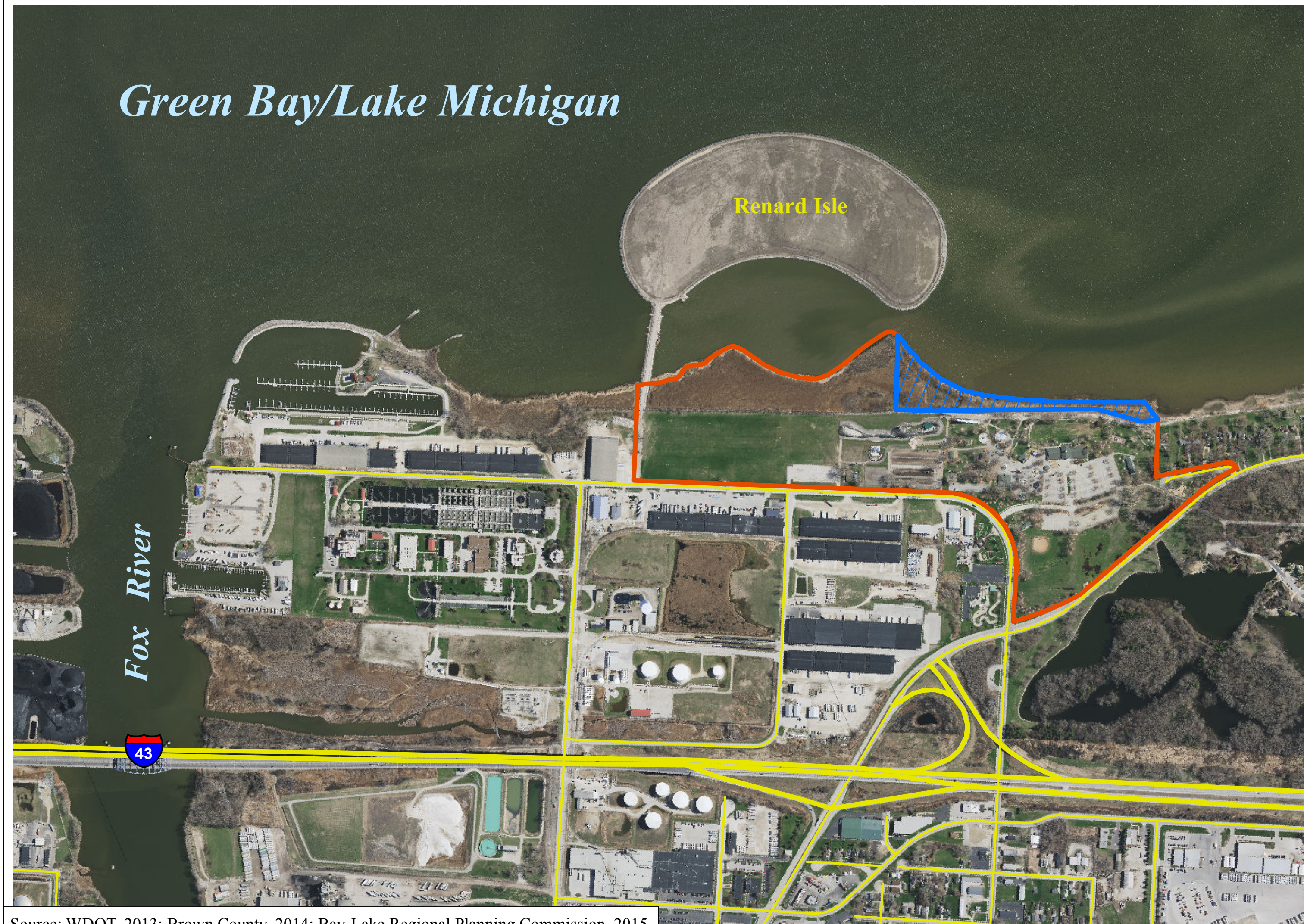
Bay Beach Restoration Action Plan

City of Green Bay, Brown County

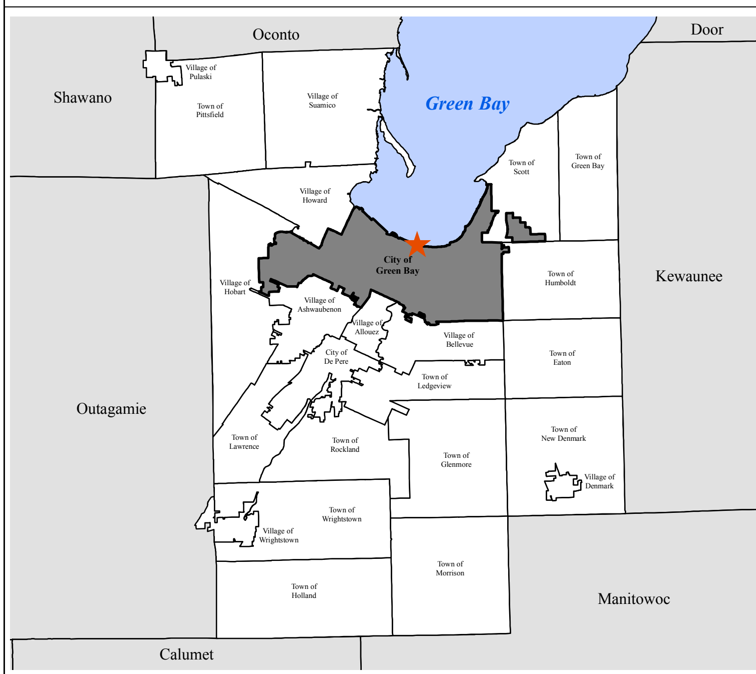
Bay-Lake Regional Planning Commission

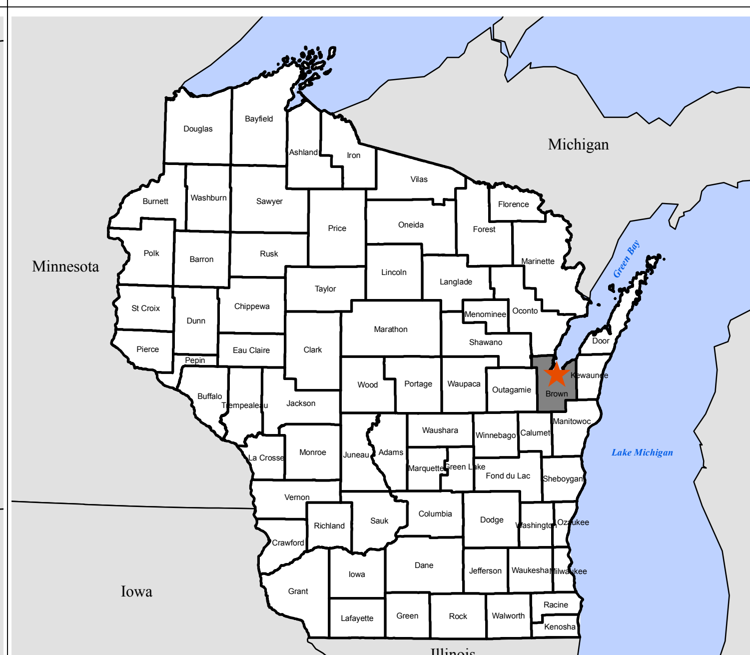
Bay Beach Property

Beach Area



Source: WDOT, 2013; Brown County, 2014; Bay-Lake Regional Planning Commission, 2015.





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Appendix A: Bay Beach Monitoring Results 2012-2014 Final Report (University of Wisconsin – Oshkosh, 2015)

Bay Beach Monitoring Results
2012-2014

Prepared By: Kimberly Busse

Table of Contents

Tables

Figures

Results

In this project, approximately 571 water, sand, and microcystin samples were collected over the three-year study at Bay Beach (Table 1). These samples were collected from multiple transects and depths equidistant apart. Samples were analyzed for *Escherichia coli* (*E. coli*) and microcystin-LR. In addition to sample collection, other parameters were recorded including weather conditions, water conditions, animals, and debris and litter on the beach. All of these parameters have been analyzed and later correlated with *E. coli* concentrations to identify potential pollution sources.

Table 1. Summary of *E. coli* samples collected over the duration of the study (2012-2014) at Bay Beach.

Bay Beach Number of Samples Collected (2012-2014)						
Year	**Monitoring Frequency (per week)**	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Microcystin Samples**	**Total**
2012	3	7	56	15	0	78
2013	3	26	208	0	24	258
2014	3	23	184	0	28	235
Total	NA	56	448	15	52	571

Historical Water Quality

An evaluation was conducted of historical water quality using previously collected data at Bay Beach (Table 2). Since there were no prior funds from BEACH Act to conduct routine monitoring, the data provided was intermittent from multiple sources over select years. Historical data was collected by NEW Water (a.k.a. Green Bay Metropolitan Sewerage District) and analyzed by the Brown County Health Department. These data can at least show water quality trends for the past several year. A total of 91 samples have been collected at Bay Beach and analyzed for *E. coli* since 2004; which over 60% of these were collected within the last 3 years. There was additional data collected prior to 2004, but samples were analyzed for fecal coliforms. While *E. coli* is one type of fecal coliform, the data cannot be directly compared. It appears that 2007 was an outlier year and may inflate the overall *E. coli* average at Bay Beach (Table 2). If this year is removed, the average *E. coli* concentration at Bay Beach would be 111.3 MPN/100mL which is below the EPA regulatory standards of 235 MPN/100mL.

Table 2. Historical water quality at Bay Beach (intermittently from 2004-2014). Text that is in italics and RED in color indicates data was not collected by UW Oshkosh. These data were collected by NEW Water in Green Bay.

Number of Samples Exceeding Water Quality Standards				
Year	**# of Exceedances (>235 MPN/100mL)**	**# of Samples**	**% Exceedances**	**Mean *E. coli* (MPN/100mL)**
2004	*1*	*10*	*10%*	*97.0*
2005	*2*	*14*	*14%*	*107.4*
2006	*0*	*9*	*0%*	*20.3*
2007	*1*	*2*	*50%*	*879.7*
2012	1	7	14%	84.5
2013	6	26	23%	148.3
2014	3	23	13%	210.0
Totals	14	91	18%	221.0

Only E. coli concentrations were used in previous data sets collected directly at Bay Beach.

In addition to samples collected at Bay Beach, there were sites located on the Fox River and off of Long Tail Island where NEW Water collected water samples and evaluated them for several water quality parameters. Some of these parameters include wind direction and speed, air temperature, rain, relative humidity, turbidity, pH, TDS, total coliforms, and *E. coli*. While these samples were not collected directly at Bay Beach these data can assist in pinpointing potential pollution sources possibly impacting Bay Beach. Figure 1 shows the historical monitoring locations, dates when these sites were monitored for *E. coli,* and mean *E. coli* concentrations. *E. coli* concentrations at each of the monitoring sites were well below the regulatory threshold of 235 MPN/100 mL for posting an advisory at a beach.

Annual Sanitary Survey

Several physical parameters were evaluated by conducting the annual sanitary survey and site assessment. An annual survey was conducted each year of the project (2012-2014) at Bay Beach. The main physical parameters are described in Table 3. Beach length, width, slope, and sand particle size were evaluated each year and averaged. The other physical parameters including, location, primary land use, bounding structures, and outfalls/tributaries remained the same over all three years. Bay Beach is located along the Lower Green Bay shoreline which is designated as an Area of Concern (AOC). Bay Beach is part of the East River Watershed (LF01), which is the largest in Brown County (206 square miles). Rural land uses are predominant (73%)

in this watershed consisting primarily of agricultural land (80%) (WDNR). Wodlands and wetlands (15%) and urban land uses (27%) occupy the remainder of the land use (WDNR). Bay Beach is in an urban setting with some bounding structures (Renard Island and associated piers) and the Fox River northwest of the beach. The physical attributes of the beach include dense amounts of *Phragmites*, rocky riprap between the walking path and water, and a shallow decline into the water. The submerged sediments were very fine throughout the beach transects and depths that were monitored. There were no outfalls observed directly at the beach. Those that were monitored historically on the Fox River had *E. coli* levels below the regulatory limit of 235 MPN/100mL.


E. coli 2010-2013
9.7 MPN/100mL (n=31)
Long Tail North
E. coli 2010-2013
3.0 MPN/100mL (n=41)
Long Tail South
E. coli 2010-2013
89.2 MPN/100mL (n=38)
GB YC City Launch (Northern Dock)
E. coli 2010-2013
118.9 MPN/100mL (n=38)
MSD Pipe (NEW Water Effluent)
Bay Beach
E. coli 2004-2007
126.0 MPN/100mL (n=35)
E. coli 2012-2014
163.5 MPN/100mL (n=56)

Figure 1. Map of the Bay of Green Bay indicating monitoring sites where NEW Water and UW Oshkosh monitored for *E. coli* over several years. All text in YELLOW indicate these data were collected by NEW Water. All text in PINK indicate data was collected by UW Oshkosh.

Water Quality

Routine sanitary surveys (RSS) were conducted two times per week for the duration of the summer beach season (May – August) from 2013 - 2014. Samples collected in 2012 were collected during August and September only. Water samples were collected at three transects (left, center, and right) and 3 depths (12 inches, 24 inches, and 48 inches). The overall average *E. coli* collected at the center 24" monitoring point was 164.9 MPN/100mL (Table 3). Table 3 shows an overall summary of water quality over the 3 years of the project based on average RSS data collected at Bay Beach. *E. coli* concentrations statistically increased from 2012 to 2014 (ANOVA $p<0.05$). *E. coli* concentrations on the left transect of the beach appear to be higher than concentrations at the other two transects (center and left), however an ANOVA was performed and no statistical difference was shown ($p=0.146$) (Figure 2).

Table 3. Mean seasonal results of select sanitary survey and water quality parameters (2012-2014) at Bay Beach.

Bay Beach Mean Sanitary Survey Summary 2012-2014							
E. coli **Center 24" (MPN/100mL)**	***E. coli*** **Sand (MPN/g)**	**Microcystin (ppb)**	**Water Temp (°C)**	**Turbidity (NTU)**	**# Gulls**	**# Geese**	**Bathers (# people)**
164.9	11.7	3.2	21.9	95.0	12.7	5.3	0
n=56	n=15	n=52	n=54	n=27	n=54	n=54	n=54

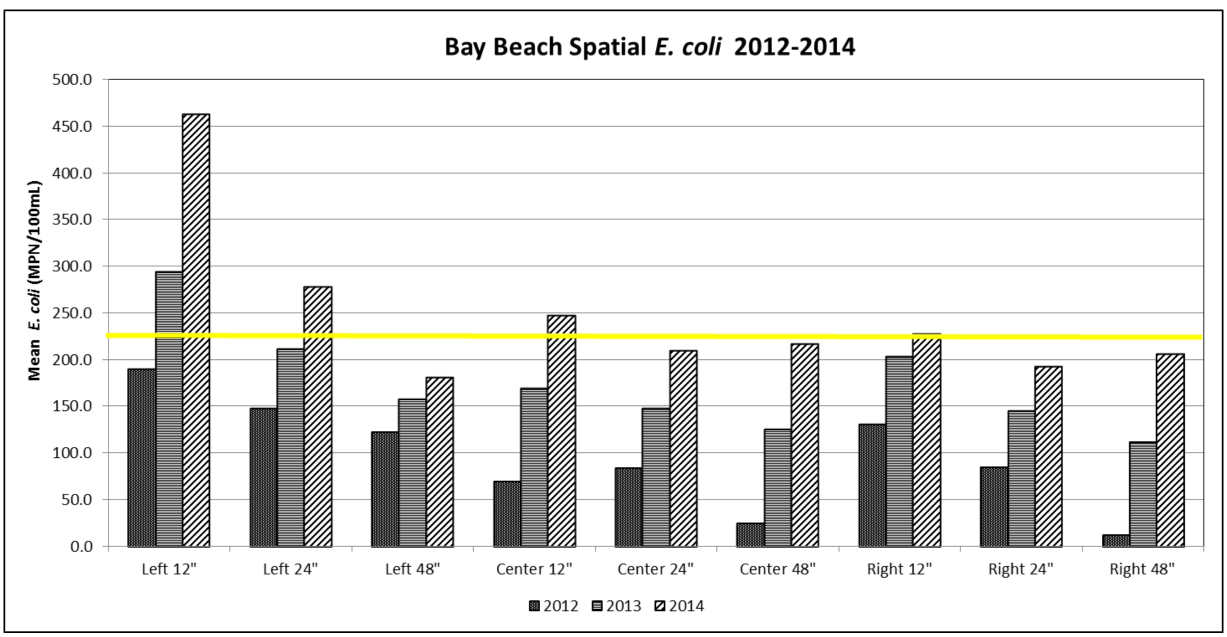

Figure 2. Routine Sanitary Survey average log *E. coli* results for Bay Beach over three years of sampling all located on Lake Michigan (2012 n=63; 2013 n=234; 2014 n=207 $p<0.05$). The yellow line indicates the *E. coli* exceedance level for a beach advisory at 235 MPN/100 mL. If *E. coli* exceeds 999 MPN/100mL the beach would be under a closure (line not shown).

Waterfowl

The primary avian species identified at the beach were gulls over all three years. In 2012, slightly more geese were observed. An average of 12 gulls was observed per day over the three-year study. There were no dogs observed at the beach. The waterfowl present at the beach contribute fecal material on the beach that can be washed into the nearshore water during rain or wind and contribute *E. coli* and other pathogens to the swimming area. A majority of gulls were observed in the nearshore water and most likely came from offshore.

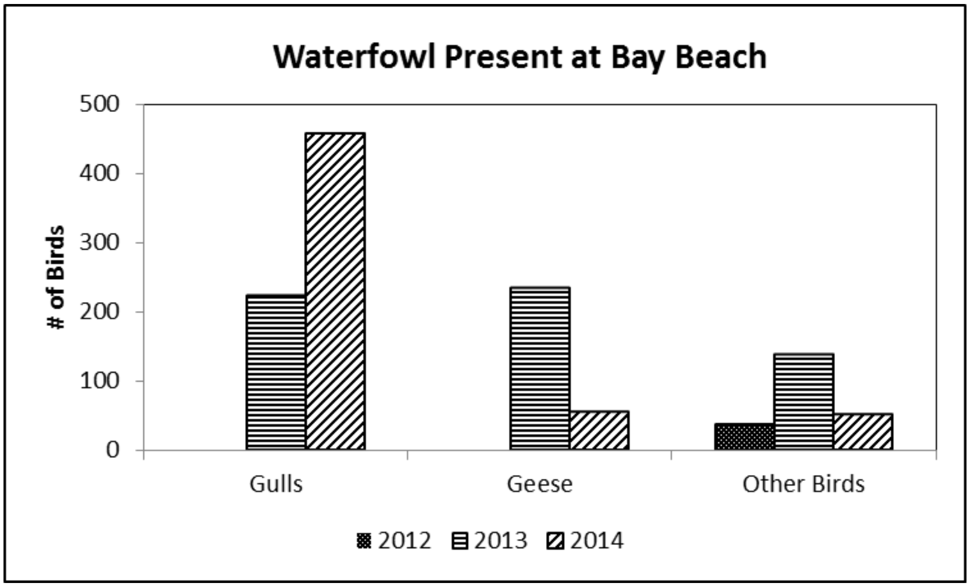

Figure 3. Waterfowl at Bay Beach, total number of each bird type identified over three years.

Microcystin

Water samples were collected twice per week in 2013 and 2014 and analyzed for microcystin-LR toxin using an ELISA procedure (Envirologix; Portland, ME). There were a total of 52 samples collected and analyzed for microcystin at a frequency of two times weekly. There was an increase in concentration from 2013 to 2014 ($p<0.05$). The average microcystin concentration for 2013 was 1.95 ppb and 4.29 ppb in 2014 (Figure 4). According to the World Health Organization (WHO), risk to human health from recreational contact with microcystin-LR is considered low for concentrations <4 ppb, moderate between 4 and 20 ppb, and > 20 ppb (or scum) is considered a high risk (WHO, 2003). An evaluation was also done to assess seasonal changes in microcystin-LR toxin during the summer months (Figure 5). In 2013, concentrations of microcystin-LR were significantly lower in June than July/August ($p<0.005$). In 2014, this was not the case. There was no statistical difference in microcystin-LR toxin from June to August ($p>0.05$).

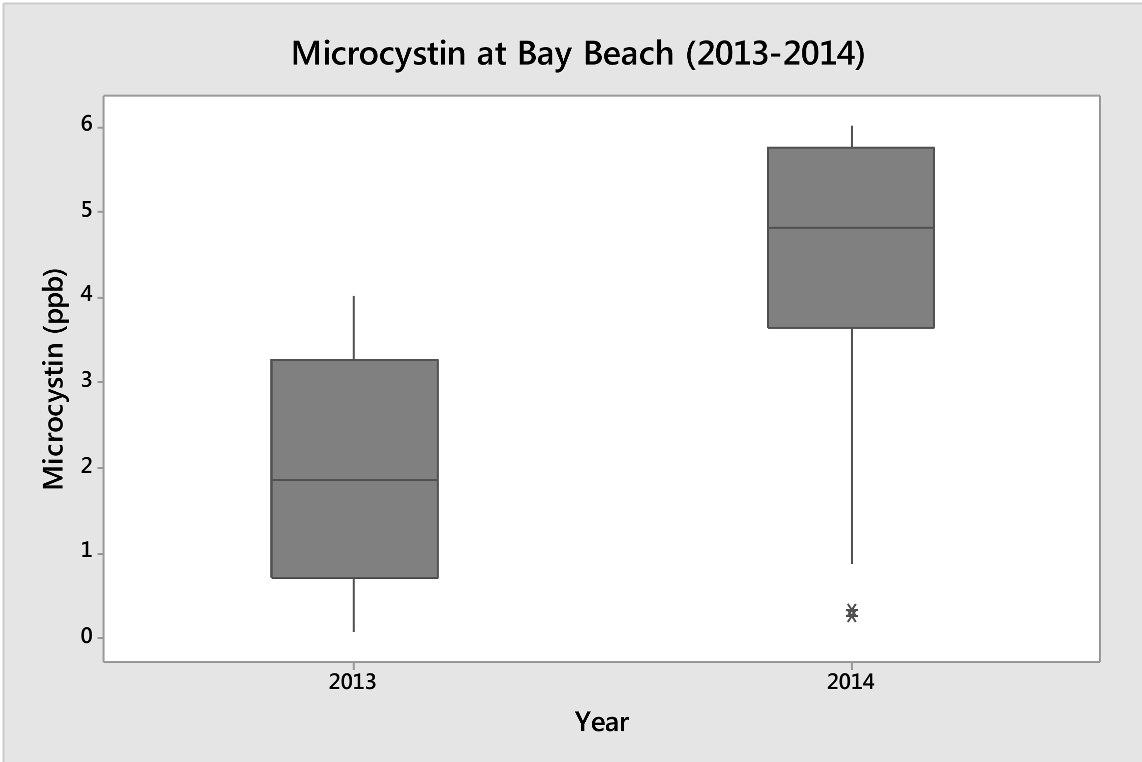

Figure 4. Boxplot of microcystin concentrations in 2013 and 2014. (2013 n=24, 2014 n=28).

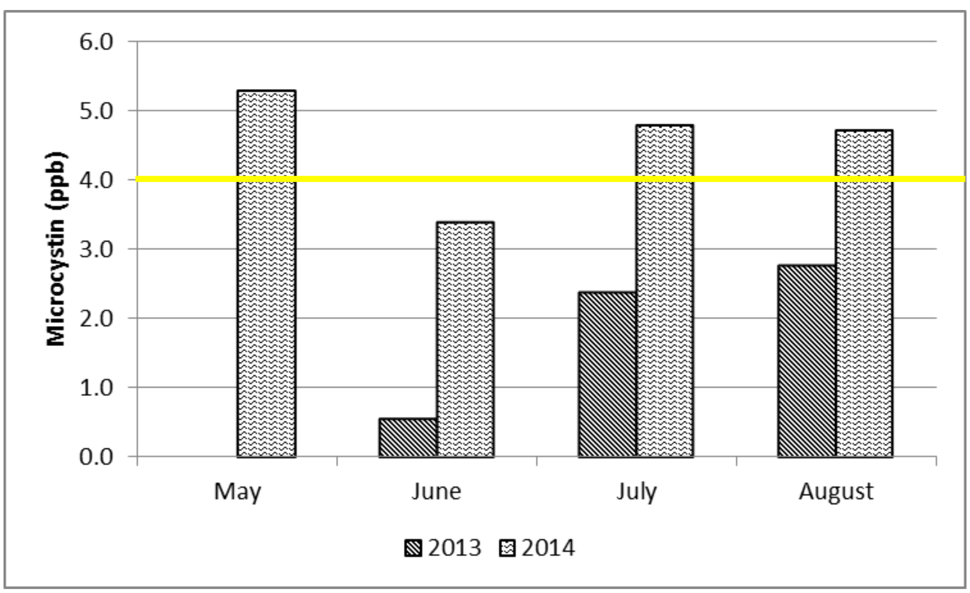

Figure 5. Mean microcystin-LR concentrations in 2013 and 2014 by month during the collection season. According to the WHO recreational contact is considered moderate risk for microcystin concentrations exceeding 4.0 ppb (WHO, 2003).

Source Identification

In addition to collecting water samples as part of the routine sanitary survey, other physical and chemical data is also evaluated. These data were collected to determine if parameters like wave height, turbidity, and waterfowl have an impact on *E. coli* concentrations and therefore contribute to poor water quality. Linear regression analysis was performed to determine correlation between ancillary parameters and *E. coli* concentrations (Table 4). Parameters with the highest R^2 values in combination with other physical observations were used to determine the contamination sources at each beach.

Table 4. Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log E. coli concentrations.

Bay Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. *E. coli*	**2012**	**2013**	**2014**
Wind Direction (°)	0.1596	x	0.0483
Wind Speed (mph)	0.0162	x	0.0364
Water Temperature (°C)	0.2476	0.0209	0.0016
Air Temperature (°C)	0.3941	0.0551	0.0921
Turbidity (NTU)	0.1344	x	0.0195
Wave Height (ft)	x	0.2397	0.6419
Within 24hr Rain (cm)	0.0017	0.0071	0.0003
Algae (1-3 scale)	x	0.0236	0.0357
Gulls (#)	x	0.0321	0.0000
Geese (#)	x	0.0375	0.0295
Other Avian (#)	0.0034	0.0751	0.0109
Bathers at Beach (#)	x	x	0.0004
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	x	x	0.0127
Longshore Current Direction (°)	x	x	0.0002
DO (mg/L	0.3258	x	0.0070
pH	0.0923	x	0.2031
% DO	x	x	0.1223
ORP (mV)	0.0793	x	0.1790
Microcystin-LR	x	0	0.0097

Sources identified based on 3 years of data collection and performing statistical correlations between environmental parameters and *E. coli.* Data was considered to be a significant source of contamination with an R^2 value above 0.1. These data are displayed per year where sources were slightly different each year (Table 5). The major source identified in multiple years was wave height (2012 and 2013). Wave action and current can transfer contaminated sediments (from feces; i.e. birds) onshore out or vice versa.

Table 5. Potential pollution sources identified through statistical correlation between E. coli and ancillary parameters.

Sources Identified	Wind Direction (°)	Water Temp (°C)	Air Temp (°C)	Turbidity (NTU)	Wave Height (ft)	DO (mg/L)	pH	% DO	ORP (mV)
2012	x	x	x	x		x			
2013					x				
2014					x		x	x	x

Conclusions

The overall goal of this project was to identify pollution sources at Bay Beach located on Lake Michigan in the Bay of Green Bay. In order to accurately identify sources of fecal pollution, three years of data were collected and analyzed to determine which parameters had an effect on *E. coli* concentrations. This stepwise approach was successful in identifying pollution sources that were specific to this beach.

E. coli concentrations increased from 2010 to 2012 perhaps due to changes in rainfall or other weather conditions, an increase of waterfowl observed in 2013 and 2014, or other hydrogeological changes occurring within the Bay of Green Bay.

The pollution sources identified at Bay Beach include wave height, sheet flow from the adjacent walk path, and restricted water flow from the abundance of *Phragmites*. Even though samples were not collected from the Fox River and historical monitoring data did not show significantly high levels of *E. coli*, this tributary may still be a potential contamination source at Bay Beach.

Bay Beach has the potential to be impacted by agricultural runoff and stormwater contamination from the Fox River. This is due in part to a number of tributaries to the Fox River that drain agricultural fields and large areas of impervious surfaces that discharge to the Fox River. There was also a tendency for gulls to loaf in the nearshore water and grassy area south of the beach. Particularly at Bay Beach, geese tended to loaf on the grassy areas and gulls in the near shore water.

Microcystin-LR was also evaluated at this location due to evidence of algal blooms in Green Bay. Microcystin-LR increased from 2013 to 2014. Although both E. coli concentrations and Microcystin-LR increased from 2012 to 2014, there was no correlation between the two. While causes are unclear with the data collected to date, it is evident that monitoring should continue, especially if swimming is to be restored to the beach.

The beach redesign plans were based on scientifically sound identification of pollution sources at the beach and incorporated "green" infrastructure and low maintenance designs.

Before mitigation can occur to design a sustainable beach at Bay Beach, invasive *Phragmites* removal must occur first.

Future Projects and Recommendations

As a result of this project a continued step-wise approach should be used in the process of beach restoration. This project addressed historical water quality review, source identification through the use of sanitary surveys, and the development of a beach redesign plan. Future projects should address the following:

- Continued monitoring of *E. coli*.
- Additional monitoring of Microcystin-LR.
- Bathymetric mapping in an attempt to see possible contamination sources in the bay area.
- Watershed assessments for Fox River to determine its potential as a source of contamination at Bay Beach.
- Investigate phosphorus concentrations where *Phragmites* impacts the beach.
- Implementation a redesign plan based on data collected through the sanitary surveys.
- If mitigation occurs, conduct post-remediation sampling to evaluate if the mitigation was effective.

If mitigation is not a cost effective option it is still important to establish best management practices (BMPs). These BMPs are an inexpensive way to maintain a beach and reduce water quality exceedances. BMPs could include things like easily accessible trash cans, signage for not feeding the birds, or prohibiting dogs on the beach. All of these BMPs can improve water quality without actual mitigation and construction.

The environmental and financial advantages of beach mitigation and BMPs are noticeable. Not only will water quality improve and provide a healthier and safer recreational experience, but also if a beach can be restored at Bay Beach tourism will likely increase, therefore stimulating the local economy. For every beachgoer it is estimated that approximately $35 is generated per person with a trip to the beach. This includes gas, food, hotel stay, and other expenses associated with attending the beach. If money is invested in mitigating a beach with a history of poor water quality it will improve the health of the beach, which allows for less beach closures, increased usage, and local tourism stimulus. This investment will benefit the local community for years to come.

Work Cited

WDNR. 1999. Watersheds and Basins.
http://dnr.wi.gov/water/watershedDetail.aspx?code=LF01&Name=East%20River.

Appendix A: Microcystin-LR Sampling Methods

The method utilized to analyze Microcystin LR was an ELISA based assay from EnviroLogix called the QuantiPlate™ Kit. Samples were collected, separated, and frozen at -20°C until analysis. Samples were batched prior to analysis to utilize one full QuantiPlate™ Kit. Prior to analysis, all reagents and strips were allowed to reach room temperature. Wash Solution was made by mixing the provided Wash Solution packet with one liter of deionized water in acid washed glassware and placed in a clean empty wash bottle. The first two strips contained the Negative Control, strip three was designated for the 0.16 ppb Calibrator, strip four contained 0.6 ppb Calibrator, and strip five held the 2.5 ppb Calibrator solution. Samples were run in duplicate in the remaining strips.

First, 125 µL of Microcystin Assay Diluent was pipetted into all strips. Next, 20 µL of the Negative Control, three Calibrators, and samples were each pipetted into the designated wells. The wells were mixed by quickly swirling the plate for 20 to 30 seconds on a bench top. After the plate was mixed, it was covered with parafilm and incubated for 30 minutes at room temperature. After 30 minutes had passed, 100 µL of Microcystin-enzyme Conjugate was pipetted into each well. The wells were mixed again by swirling and the plate was allowed to incubate for 30 minutes at room temperature. After 30 minutes, the plate was emptied into the sink. Each well was washed with the Wash Solution and emptied. The washing step was repeated four times. The plate was shaken onto a paper towel to remove any remaining liquid. After shaking, 100 µL of the manufacturer's "Substrate" was pipetted into each well. The plate was swirled to mix, covered with new parafilm, and incubated for 30 minutes at room temperature. After 30 minutes had passed, 100 µL of the Stop Solution was pipetted into each well. The plate was read in a microtiter spectrometer at 450 nanometers (Molecular Devices SpectraMax 384 Plus Microtiter Plate Spectrophotometer; Sunnyvale, CA). A standard curve was developed using software SoftMax Pro version 5.4.5; where samples were analyzed in duplicated and compared to the three known Calibrators. Results were reported on parts per billion (ppb).

Appendix B: Chemical Analytical Results of Sediment Samples collected at Renard Island (RTI, 2013)

RTI LABORATORIES

TABLE 2A: RENARD ISLAND SOIL ANALYTICAL RESULTS

Parameter	Sample ID		Site #1 (RI-13-01)	Site #2 (RI-13-02)
	Lab ID		240-30220-1	240-30220-2
	Date Collected		10/11/2013	10/11/2013
Physical Kit	**Method**	**Units**		
In Place Density	**ASTM D_2937**	**g/cc**	0.608	1.53
Specific Gravity	**SM 2710F**		1.4	1.7
% Moisture	Moisture	% by Wt.	55	26
% Solids	Moisture	% by Wt.	45	74
Nutrients Kit	**Method**	**Units**		
Phosphorus, total	SM 4500 P-E-1999	mg/Kg dry	190	76
Nitrogen, Ammonia	SM4500 NH3-E	mg/Kg dry	270	<65
Nitrogen, Kjeldahl, total	SM4500_NH3_E	mg/Kg dry	490	1,400
Organic Indicators Kit	**Method**	**Units**		
(HEM) Oil & Grease, total	SW 9071B	mg/Kg dry	1,100	<650
Cyanide, total	SW 9012A	mg/Kg dry	<1.2	<0.67
Chemical Oxygen Demand*	EPA 410.4	mg/L	21	<20
Total Volatile Solids	EPA 160.4	% by Wt	5.8	0.60
Total Organic Carbon	SW 9060	g/Kg	19	<4.0
Organochlorine Pesticides (GC)	**Method**	**Units**		
4,4'-DDD	8081A	ug/kg dry	<3.7	<2.3
4,4'-DDE	8081A	ug/kg dry	<3.7	<2.3
4,4'-DDT	8081A	ug/kg dry	<3.7	<2.3
Aldrin	8081A	ug/kg dry	<3.7	<2.3
alpha-BHC	8081A	ug/kg dry	<3.7	<2.3
alpha-Chlordane	8081A	ug/kg dry	<3.7	<2.3
beta-BHC	8081A	ug/kg dry	<3.7	<2.3
delta-BHC	8081A	ug/kg dry	<3.7	<2.3
Dieldrin	8081A	ug/kg dry	<3.7	<2.3
Endosulfan I	8081A	ug/kg dry	<3.7	<2.3
Endosulfan II	8081A	ug/kg dry	<3.7	<2.3
Endosulfan sulfate	8081A	ug/kg dry	<3.7	<2.3
Endrin	8081A	ug/kg dry	<3.7	<2.3
Endrin aldehyde	8081A	ug/kg dry	<3.7	<2.3
Endrin ketone	8081A	ug/kg dry	<3.7	<2.3
gamma-BHC (Lindane)	8081A	ug/kg dry	<3.7	<2.3
gamma-Chlordane	8081A	ug/kg dry	<3.7	<2.3
Heptachlor	8081A	ug/kg dry	<3.7	<2.3
Hepatchlor epoxide	8081A	ug/kg dry	<3.7	<2.3
Methoxychlor	8081A	ug/kg dry	<7.2	<4.5
Toxaphene	8081A	ug/kg dry	<150	<92
PCBs	**Method**	**Units**		
Aroclor-1016	SW 8082	ug/kg dry	<72	<45
Aroclor-1221	SW 8082	ug/kg dry	<72	<45
Aroclor-1232	SW 8082	ug/kg dry	<72	<45
Aroclor-1242	SW 8082	ug/kg dry	<72	<45
Aroclor-1248	SW 8082	ug/kg dry	<72	<45
Aroclor-1254	SW 8082	ug/kg dry	<72	<45
Aroclor-1260	SW 8082	ug/kg dry	<72	<45
Aroclor-1262	SW 8082	ug/kg dry	<72	<45
Aroclor-1268	SW 8082	ug/kg dry	<72	<45
Metals Kit	**Method**	**Units**		
Arsenic	SW 6020	ug/kg dry	2.3	<1.1
Barium	SW 6020	ug/kg dry	<40	<21
Cadmium	SW 6020	ug/kg dry	<0.40	<0.21
Chromium	SW 6020	ug/kg dry	19	4.0
Copper	SW 6020	ug/kg dry	19	5.2
Iron	SW 6020	ug/kg dry	9,600	2,600
Lead	SW 6020	ug/kg dry	17	3.6
Manganese	SW 6020	ug/kg dry	240	61
Mercury	SW 7471A	ug/kg dry	0	<0.15
Nickel	SW 6020	ug/kg dry	11	<4.3
Selenium	SW 6020	ug/kg dry	<1.0	<0.54
Silver	SW 6020	ug/kg dry	<1.0	<0.54

Non-detected results = "<" Limit of Quantitation

RTI LABORATORIES

TABLE 2A: RENARD ISLAND SOIL ANALYTICAL RESULTS

Parameter	Sample ID		Site #1 (RI-13-01)	Site #2 (RI-13-02)
	Lab ID		240-30220-1	240-30220-2
	Date Collected		10/11/2013	10/11/2013
Zinc	SW 6020	ug/kg dry	50	14
Semi-Volatile Organic Compounds/PAH	**Method**	**Units**		
Benzo(a)anthracene	SW 8270C	ug/kg dry	230	<9.2
Benzo(a)pyrene	SW 8270C	ug/kg dry	250	15
Benzo(b)fluoranthene	SW 8270C	ug/kg dry	290	14
Benzo(g,h,i)perylene	SW 8270C	ug/kg dry	180	17
Benzo(k)fluoranthene	SW 8270C	ug/kg dry	140	<9.2
Anthracene	SW 8270C	ug/kg dry	<99	<9.2
Chrysene	SW 8270C	ug/kg dry	280	<9.2
Dibenz(a,h)anthracene	SW 8270C	ug/kg dry	<99	<9.2
Fluoranthene	SW 8270C	ug/kg dry	440	<9.2
Fluorene	SW 8270C	ug/kg dry	<99	<9.2
Indeno(1,2,3-cd)pyrene	SW 8270C	ug/kg dry	150	12
Phenanthrene	SW 8270C	ug/kg dry	190	<9.2
Pyrene	SW 8270C	ug/kg dry	400	<9.2
Acenaphthene	SW 8270C	ug/kg dry	<99	<9.2
Acenaphthylene	SW 8270C	ug/kg dry	<99	<9.2
Naphthalene	SW 8270C	ug/kg dry	<99	<9.2

*Analysis performed on Leach sample, Method ASTM-D3987-85

Non-detected results = "<" Limit of Quantitation

Appendix C: Bay Beach Restoration Action Plan (Table 6), 2015

Appendix C: Bay Beach Restoration Action Plan (Table 6), 2015

	Phase	Recommended Actions	Partners	Notes
1	Study	Confirmation of feasibility from a certified engineer.	City, Engineering firm	Desired by the City of Green Bay before proceeding with restoration.
2	Study	Research Green Bay bulkhead identified in City Ordinance. Seek potential ACOE, WDNR, and Brown County permits to reestablish bulkhead line.	City, WDNR, ACOE, Brown County	May be needed as part of permitting under Ch. 30.11 Establishment of Bulkhead Lines, *Wis. Stats.*
3	Study	Wetlands delineation survey and habitat assessment for potential compensatory mitigation opportunities.	City, Green Bay Conservation Partners, WDNR	May be needed as part of permitting.
4	Study	Environmental Impact Assessment and/or archaeological study.	City	May be required as part of permitting.
5	Study	Endangered or Threatened Species Assessment.	City, WDNR	Required as part of permitting.
6	Study	Conduct Hydrodynamic and Beach Stability Modeling.	City	Determine potential impacts to beach longevity from coastal processes/hazard Impacts.
7	Study	Trail planning to provide connectivity to Bay Beach Wildlife Santuary/UWGB and Renard Island.	City	
8	Study	Monitor for *E. coli* and microcystin.	City	Routine monitoring of *E. coli* and Microcystin is recommended. Consider routine rapid or real-time testing in the long term.
1	Pre-Implementation	WDNR permit for Removal of Plant and Animal Nuisance Deposits.	City, WDNR	
2	Pre-Implementation	Phragmites removal and management.	City, WDNR, BLRPC	Bay Beach is an identified treatment site for *Phragmites* removal under 2015 GLRI grant secured by BLRPC.
3	Pre-Implementation	Explore opportunities for beneficial re-use of dredge material from the Fox River channel and the Port of Green Bay (i.e. dredged sand).	City, Brown County Port Dept.	Referenced in *Dredged Material Management Plan, Phase II Report for Green Bay Harbor* (U.S. Army Corps of Engineers, Detroit District, 2010). Sediments are currently being directed to the restoration of the Cat Island chain.
4	Pre-Implementation	ACOE permit for Work in U.S. Waters (Sec. 404).	City, ACOE County Port Dept.	Potential for needed compensatory mitigation, Environmental Impact Assessment, and Archaeological Survey.
5	Pre-Implementation	WDNR permit to add sand and cordwalks below the OHWM.	City, WDNR	Ch. 30.12 Structures and deposits in navigable waters, *Wis. Stats.*
6	Pre-Implementation	WDNR permit for Construction Site Storm Water Runoff (Ch. 283, *Wis. Stats.*).	City, WDNR	
7	Pre-Implementation	WDNR permit for Removal of Plant and Animal Nuisance Deposits (Ch. 30.208, *Wis Stats.*).	City, WDNR	
8	Pre-Implementation	WDNR Wetland Fill or Disturbance permit (Ch. 281.36, *Wis. Stats.*).	City, WDNR	
1	Implementation	Design for fluctuating water levels.	City, Engineering firm	A restored, adaptable shoreline with permeable cordwalks over the breakwall should be designed to handle fluctuating water levels.
2	Implementation	Provide safe access over breakwall down to beach, including ADA access.	City, Engineering firm	Based on engineered concept plan, safe access could be provided by covering breakwall with sand and providing cordwalks to the beach.
3	Implementation	Beach nourishment to raise profile.	City, Engineering firm	Public health objective.
4	Implementation	Implement beach design that limits gull and geese loafing.	City, Engineering firm	Based on engineered concept plan, gull and geese loafing could be limited through planned placement of vegetation that interferes with avian sense of security from predation.
1	Post-Implementation	WDNR permit to groom the beach below the OHWM (Ch. 30.20 Removal of material from beds of navigable waters).	City, WDNR	
2	Post-Implementation	Expand parking as needed.	Friends of Bay Beach (FOBB), City	Add additional parking, connect trails, ensure adequate bus routes.
3	Post-Implementation	Construct a bathhouse/changing rooms as needed.	FOBB, City	
4	Post-Implementation	Install color-coded flags to coordinate with approved signage regarding beach water quality status.	FOBB, City	Green is to be posted continuously, with yellow or red posted when water quality conditions occur that could negatively impact human health.
5	Post-Implementation	Clearly delineate a swim zone perimeter with physical markers (such as buoys).	FOBB, City	
6	Post-Implementation	Install signage indicating lifeguards status, signage regarding NOAA water quality hazard (rip current), and user accessible rescue equipment.	FOBB, City	
7	Post-Implementation	Develop a management and control plan for each hard engineered or naturalized control measure implemented.	City, Engineering firm	Including stormwater control structures, dune features, and wetlands.
8	Post-Implementation	Waste receptacles and recycling bins should be placed in the park within easy reach of beach patrons.	City	
1	On-going	Monitor for *E. coli* and microcystin.	City, County, WDNR, UWO	Continued monitoring of *E. coli* is recommended at all Lake Michigan public beaches during the summer. Microcystin sampling is also recommended at all beaches along Green Bay. Routine rapid or real-time testing is recommended long term.
2	On-going	Address water clarity issues resulting from suspended sediments.	WDNR, many other TMDL partners	TMDL will address with reductions in runoff (loading and stormwater issue); hydrodynamic modeling
3	On-going	Review data of continued PCB sampling around Renard Island.	ACOE, WDNR	Future PCB sampling will be release for the Bay Beach area (Operable Unit-5A) as part of the remediation efforts and the long-term monitoring.
4	On-going	Manage zebra and quagga mussel shells on beach.	City	Does not appear to be an issue at Bay Beach.
5	On-going	Routine street sweeping along Bay Beach Road and any adjacent parking lots to reduce stormwater pollution to beach.	City	
6	On-going	Beach grooming should occur to remove anthropogenic debris and algae that accumulates onshore.	City	Improve aesthetics, reduce health risks associated with hazardous materials, and remove food sources/debris that attract nuisance wildlife.

Appendix D: Beach Engineering Package for Bay Beach Concept Design (Miller Engineers & Scientists, 2014)

Merit Report

for

Bay Beach
(Bay Beach Amusement Park Beach)
Green Bay, Wisconsin

Prepared For:
City of Green Bay
100 North Jefferson Street
Green Bay, WI 54301

Prepared By:
Miller Engineers & Scientists
5308 South 12th Street
Sheboygan, WI 53081

Project No. 12-19165 20-100

TABLE OF CONTENTS

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1. INTRODUCTION

This merit report was produced as an accompaniment to the beach redesign plans for Bay Beach (Bay Beach Amusement Park Beach) in Green Bay, Wisconsin. The purpose of the redesign is to improve water quality at the beach, manage invasive species, and provide public access to the waterfront for recreational opportunities.

Public beach monitoring provided by the University of Wisconsin-Oshkosh at Bay Beach has historically shown relatively poor water quality. The results of beach monitoring and accompanying beach sanitary surveys have identified several problem areas at the existing beach that need to be addressed. These areas are shown on the attached *Beach Issues and Concerns* figure. The purpose for remediating each issue, and the benefits of the redesign elements utilized, are discussed herein.

All of the redesign elements have been designed with sustainability, minimal maintenance and aesthetic appeal in mind. Implementation of the design will result in an overall improvement in beach function through the removal of invasive species, the establishment native landscapes and a subsequent increase in infiltration of storm water runoff, resulting in a healthier near shore environment.

2. INVASIVE SPECIES CONTROL

Invasive species (primarily *Phragmites australis*) must be eradicated/managed/controlled at Bay Beach in order to improve beach health and create more favorable habitat. Phragmites crowd out native vegetation and create impassable stands of long, cane-like reeds. Dense stands of Phragmites alter surface water hydrology, destroy wildlife habitat, prevent UV light penetration (UV light penetration aids in the reduction of bacteria), promotes biofilm formation (another potential source of bacteria), and compromises ecosystem services such as recreation and public access.

Eradication of Phragmites will be a multi-step process. The successful restoration of this location will require herbicide applications, manual removal, and also a combination of: habitat modification to reduce the conditions which are now favorable for its propagation (i.e. soil amendment/nourishment to reduce low, flat, and wet terrain), the introduction of resilient native vegetation, and a long-term management and control plan.

For Phragmites control, apply the proper aquatic herbicide during the approved time period. This is between June and September for Imazapyr and between August and September for Glyphosate. State and/or local permits will be required for the use of aquatic herbicides. Wait two weeks after application to allow new growth stands to become exposed before mowing. Only mow when ground is dry or frozen. Reapply herbicide and repeat mowing as needed in the next three growing seasons. Do not disc vegetation.

BEACH ISSUES AND CONCERNS

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BAY-LAKE RPC
BAY BEACH
BAY BEACH ROAD
GREEN BAY, WISCONSIN

SCALE HOR. VER.	
DATE	8-13-2014
JOB	12-19165
BY	TRO
CK	PGP
SHEET	1 OF 1

3. INFILTRATION PRACTICES

Infiltration will be utilized to improve the quality and reduce the quantity of storm water runoff at this location. As storm water infiltrates, sediments and debris are removed and other contaminants such as oils, heavy metals and bacteria are also filtered or treated as they move through the soil. For Bay Beach, infiltration will be used to reduce non-point source pollution through a sustainable, naturalized approach.

The construction of small dune areas on the upland portion of the beach will serve to interrupt the surface flow of storm water and to enhance infiltration before this water enters the lower beach area or near shore waters. The use of native vegetation in these areas also enhances infiltration by slowing the flow of water and enhancing permeability due to the extensive root structure that is inherent to these plants. Vegetation in these areas will also stabilize the dune sand, provide for phytoremediation and serve as coastal habitat.

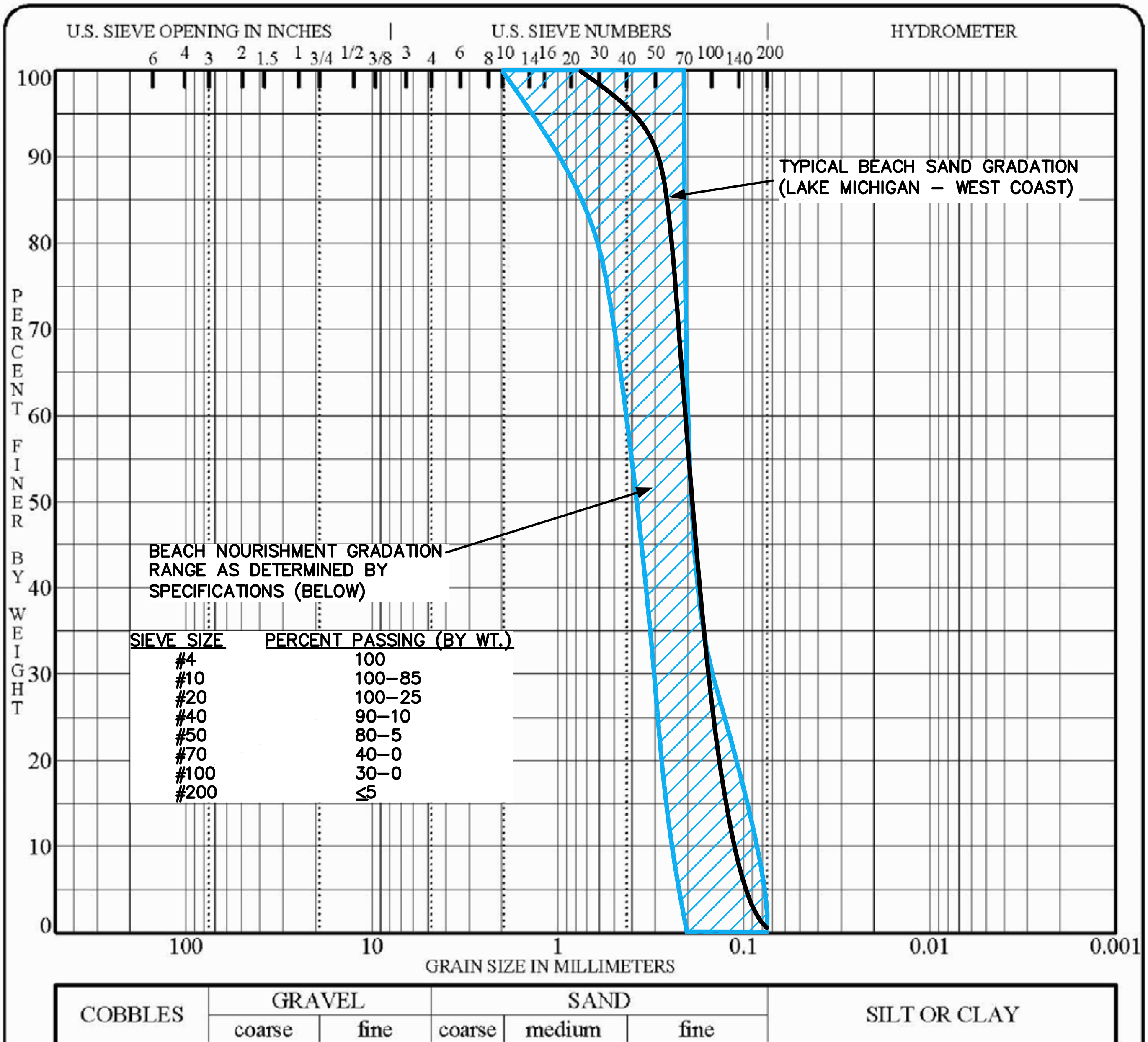
Compaction of soil in all infiltration areas should be avoided during construction and at all other times. All vegetation for project elements should be obtained from a reputable supplier, and it is preferable to have a local ecotype of the species used. It is best to let the vegetation become established before bringing the systems “online,” but if this is not possible, more rigorous maintenance will be needed to establish vegetation and prevent erosion. When completed and established, vegetated areas will require periodic inspection and maintenance.

4. BEACH NOURISHMENT

Beach nourishment is included as a design element for the entire beach area. The purpose of beach nourishment is to raise grades on the beach to allow for infiltration as storm water flows down the beach profile. Utilizing nourishment to increase the grade of the beach area will also result in decreased ponding of water (by improving drainage) and will raise more of the beach above the water table, which will create a drier beach. Because bacteria do not survive well in dry conditions, beach nourishment helps to decrease bacteria levels in the sand and creates an environment less favorable to hydrophilic invasive plants like Phragmites.

An example of what a “healthy beach” should look like. Note the small dune features, dune grass, and sloping beach.

The beach nourishment sand has a specified gradation as shown on the following page. The slightly increased size of the sand particles specified promotes greater infiltration, which provides for a drier beach. Larger sand particles are also less susceptible to wind erosion, decreasing the amount of sand that will be blown off the beach.



Specimen Identification	Classification	MC%	LL	PL	PI	Cc	Cu
	Beach Nourishment Sand						

Specimen Identification	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay

CLIENT :
PROJECT:

JOB NO.:
TEST DATE:
SOURCE:
SAMPLED BY:
TESTED BY:
REVIEWED BY:

MILLER ENGINEERS SCIENTISTS

GRAIN SIZE ANALYSIS
ASTM D422

5. PUBLIC ACCESS

Cord walk pathways are one alternative for public access points to the beach.

Public access points will be established to provide controlled access through the dunes and vegetation while protecting these features from foot traffic. The paths are designed to provide access to the beach and lakeshore. The paths are designed to be “curved” to reduce the line of sight for birds, thus discouraging them from using the paths for access from the water to upland areas. A “groomer access path” has been designated on the plans for access for mechanical grooming and/or emergency access.

6. NATIVE VEGETATION

Native vegetation is incorporated into all of the beach redesign elements for a variety of reasons. The root systems of most native plants are very deep and help water soak into the ground, thereby increasing water infiltration and reducing runoff. These root systems also hold soil in place, reducing erosion. Native species are also inherently low maintenance, resulting in saving of time, money and energy. They are adapted to local conditions, which makes them vigorous and resistant to most pests and diseases. Once these plants are established they require minimal care.

Example of native vegetation plantings

Small dune features are included along the existing revetment and at the lateral margins of the beach. These dunes are comprised of beach nourishment sand and will be planted with native dune vegetation. Dune grass is extremely effective in stabilizing dune features by trapping blowing sand above ground and by holding sand in-place with its below ground root system. This will result in a stabilized beach area with improved aesthetics. **Permits from the Wisconsin DNR and/or the Army Corps of Engineers may be required for beach nourishment.**

Several planting areas have also incorporated into the design. These plantings will provide a buffer between impervious surfaces and the beach, increase storm water infiltration, provide a visual screen to discourage waterfowl from congregating on the beach, and improve aesthetics.

All plant species chosen for this redesign are native to Brown County, which is especially important along a valuable ecological resource such as the Lake Michigan shoreline. The native vegetation chosen will improve habitat by providing food and shelter for songbirds, butterflies and other desirable wildlife, and is unlikely to become invasive.

7. PERMITS

Permits may be required from local, county, state and federal agencies to implement the work described herein. These permits may include, but are not limited to: Establishment of a Bulkhead Line (WDNR, ACOE, BCPL), Work in US Waters (ACOE), Removal of Plant and Animal Nuisance Deposits (WDNR), Wetland Fill or Disturbance (WDNR), and/or Construction Site Storm Water Runoff (WDNR). Please contact your municipal and county planning agencies, WDNR water resources specialist and regional ACOE representative to determine which permits may apply to your specific project.

8. BEST MANAGEMENT PRACTICES

The purpose of non-engineered best management practices (BMPs) is to remove or reduce possible sources that contribute to contamination of the beach. These sources include storm water, waterfowl and other wildlife, debris, invasive species and pets. Using BMPs to eliminate or reduce possible sources of contamination is a low cost technique that will reduce beach contamination. In addition, BMPs can increase public awareness of water quality problems and engage the community in solutions. Implementation of the BMPs will require a combination of local government cooperation and coordination, and will require little capital investment. The BMPs are as follows:

- Remove accumulated *Cladophora* and aquatic vegetation from the beach as required. **A permit may be required from WDNR to do this.**
- Implement storm water ordinances for future development and/or existing development.
- Avoid/minimize the use of pesticides and fertilizers on adjacent lawn areas.
- Install signs (and provide enforcement) in the park and beach area reading:
  - "Don't Feed the Birds"
  - "No Pets Allowed"
  - "Pick Up Trash"
- Storm water stenciling projects and other efforts to reinforce that storm water catch basins discharge untreated water into waterways and onto our beaches.
- Implement and maintain an invasive species management plan.
- Implement sand control with fencing during winter months.

9. ESTIMATED COSTS FOR PLANNED IMPROVEMENTS[1]

Beach Nourishment	$415,440
Public Access	$16,250
Vegetation[2]	$195,138
Erosion Control[3]	$700
Permitting/Bonding/General[4]	$37,975
Total	**$665,503**

[1] **All costs include professional installation.** Some costs may be reduced by using volunteer or City staff for installation.

[2] Estimated costs for vegetation include a wide variety of native plantings. Cost will vary considerably based on the actual plants selected. Vegetation costs also include 12 months of professional maintenance for planted areas.

[3] Erosion control costs include professional maintenance during the period when erosion control measures are necessary.

[4] Permitting/bonding/general costs include fees associated with obtaining required permits with the assistance of a Professional Engineer.

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Maintenance Plan

for

Bay Beach
(Bay Beach Amusement Park Beach)
Green Bay, Wisconsin

Prepared For:
City of Green Bay
100 North Jefferson Street
Green Bay, WI 54301

Prepared By:
Miller Engineers & Scientists
5308 South 12th Street
Sheboygan, WI 53081

Project No. 12-19165 20-100

1. INTRODUCTION

Miller Engineers & Scientists (Miller) prepared this manual to provide the owners of Bay Beach (Bay Beach Amusement Park Beach) with the information necessary to maintain the elements of the storm water management system and beach redesign. These facilities are shown on the *Site Plan* and include dunes and native landscape plantings. The purpose of the maintenance is to keep the storm water management systems in working order and reduce contamination on the beach, and is intended for the long-term care and management of the elements within the beach redesign.

2. BACKGROUND

The beach redesign is intended to reduce *E. coli* contamination by reducing storm water flow to the beach and near shore waters, raising the grade of the beach to provide a dry sand area that is less conducive to harboring bacteria, and eradicating invasive Phragmites to improve beach health and function. The redesign includes beach nourishment, native vegetation plantings and best management practices. Both the purpose and the function of these design elements are discussed in detail in the accompanying Merit Report.

3. INSPECTION AND MAINTENANCE

Individuals who understand the purpose and function of the storm water management system components should perform the inspection and maintenance of these facilities. These facilities are living systems; therefore, the components should be aesthetically pleasing as well as functional. Both preventative and corrective maintenance will be needed and some long-term maintenance, such as periodic (every 5-10 years) additional beach nourishment to maintain proper grades, must be considered as the system ages. Records of inspection and maintenance should be kept on a long-term basis. *Maintenance Logs* are included in this Maintenance Plan and will be useful in determining system function and long-term maintenance needs.

This facility should be inspected semi-annually (after spring melt and in autumn) and after heavy rain events (defined as 4 inches or more rain from one storm or storms with less than 1 day interval between rainfalls) irrespective of the next scheduled inspection date. The inspection should consist of a walk around each component of the facility to identify any items detailed in the *Inspection and Maintenance Forms* provided. The owner should hold a regular, yearly review of storm water management system status where future needs and long-term planning are discussed.

Typically, maintenance will need to be performed in the spring and the fall; however, maintenance of facilities should occur as soon as possible after issues are detected no matter the season. As maintenance may require personnel and equipment, it should be scheduled in advance if possible and performed when the components are dry to minimize damage and compaction caused by working in wet soils.

Healthy vegetation is required for the system to function properly. The plant species that have been chosen for the redesign are all native to Wisconsin and are adapted to living within lakeside conditions, require little maintenance, and should not require the use of herbicides or pesticides. All of the shrubs can be pruned if desired to control height; however, the native grasses and wildflowers should not be cut or mowed, as tall, thick vegetation is preferred in all areas specified. Invasive vegetation should be removed from dunes and landscape plantings if discovered. Examples of invasive species include common reed (*Phragmites australis*), reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), spotted knapweed (*Centaurea maculosa*) and cattails (*Typha sp.*). Vegetation should not be fertilized.

4. INFILTRATION AREAS

Infiltration areas consisting of sand dunes and upland garden areas are located over and in front (north) of the revetment and at the back of the beach to capture and treat surface water runoff before it reaches the beach. These areas should be functional as well as aesthetically appealing and will require maintenance to keep them in proper order.

Water enters the infiltration areas via overland sheet flow, and should not be obstructed. Check for any pools, scouring, rills, erosion, or short circuiting within and adjacent to the infiltration areas and repair and replant promptly. Dispersed flow should be maintained. Infiltration areas are designed to dewater or drain completely within a day after a storm event. Any areas that have pockets of standing water should be re-graded and re-vegetated according to the planting plan.

Sediments may accumulate over time in the infiltration areas and need to be removed once the sediment exceeds 1-inch in depth. As an alternative, the sediment may be worked into the soil matrix as a method of removal as long as the soil matrix maintains the specified permeability. After sediments are removed, the area should be re-graded and re-vegetated. Dispose of the removed material as regulations allow. Sources of excessive sedimentation should be identified and repaired. Long-term records should be kept to determine when sediment removal is warranted.

Invasive plants, woody plants, trash, and debris should be removed. Do not fertilize the native species planted in infiltration areas and minimize the use of pesticides if they become necessary. Infiltration areas should not be mowed as this will cause soil compaction and rutting of moist soils.

4.1 Dunes

Sand dunes are located along the beach and should require little to no maintenance once they have established vegetation. They are designed to be naturally dynamic systems, and may change shape or height over time.

Cord walks have been placed through the dune area to protect the dunes from erosion by foot traffic. The cord walks may require maintenance due to normal wear and tear.

Pedestrian traffic should be limited to the paths. Tractor traffic should be limited to the groomer access path as designated on the plans.

The dune grasses, once established, will spread and stabilize the sand dunes. Shrubs and wildflowers may also spread across the dunes until the area comes to a natural balance. If there are areas where the dune grass is significantly damaged by storms or foot traffic, the grass may be replanted according to original planting specifications. Invasive species should be removed.

Sand in the nourished areas may need to be replaced in the future. The amount of sand that will need to be replaced will depend on amount of sand lost to drift, winds, etc. Beach sand replacement should be considered at a minimum of approximately every 10 years.

4.2 Upland Garden Areas

Upland garden areas are located along the southern margins of the project area and should require little to no maintenance once they have established vegetation. Cord walks be placed around the garden areas to protect them from foot traffic. The cord walks may require maintenance due to normal wear and tear. Pedestrian traffic should be limited to the paths.

The native vegetation, once established, will spread and stabilize the side slopes and base of these areas. Shrubs and wildflowers may spread across these areas until the vegetation comes to a natural balance. If there are areas where the vegetation is significantly damaged by storms or foot traffic, it may be replanted according to original planting specifications. Invasive species should be removed.

5. INVASIVE SPECIES MANAGEMENT

Invasive species must be eradicated/managed/controlled at Bay Beach in order to promote beach health and create more favorable habitat. This will be a multi-year, multi-step process. The successful restoration of this location will require not only successive herbicide applications and manual removal but also a combination of habitat modification to reduce the conditions which are now favorable for its propagation (i.e. soil amendment/nourishment to reduce low, flat, and wet terrain), the introduction of resilient native vegetation (seeding or planting) and a long-term, effective management and control plan.

For Phragmites control, apply the proper aquatic herbicide during the approved time period. This is between June and September for Imazapyr and between August and September for Glyphosate. State and/or local permits will be required for the use of aquatic herbicides. Wait two weeks after application to allow new growth stands to become exposed before mowing. Only mow when ground is dry or frozen. Reapply herbicide and repeat mowing as needed in the next three growing seasons, but do not disc.

6. BEACH GROOMING

Beach grooming should be a part of all routine beach maintenance activities. At a minimum, beach grooming should take place in the open sand areas north of the vegetated dunes and along the east and west margins of the beach in the areas designated on the landscape plan. Beach grooming should **not** take place in areas designated for the planting of native vegetation.

It is important that proper beach grooming techniques are used. Improper beach grooming can be detrimental to beach health. We suggest consulting an expert in beach grooming techniques (UW-Oshkosh) to establish a protocol for your specific location.

7. BEST MANAGEMENT PRACTICES

Several Best Management Practices (BMPs) should be initiated at the beach area. These practices are designed to prevent contaminants from entering the beach area, thus minimizing contamination problems.

- Street/Hard Surface Cleaning – The driveway, roads and other hard surfaces near the beach should be cleaned at least four times per year. This can be accomplished by using a street sweeper or equivalent equipment.
- *Cladophora*/Aquatic Vegetation Removal – When significant amounts of *Cladophora* and other aquatic vegetation accumulate in the swash zone it should be removed and disposed of properly.
- Storm Water Ordinances – The City of Green Bay should implement storm water ordinances for future development. This ordinance should address both water quality and quantity.
- Public Signage – Signs should be posted in and around the beach and park areas. Signs should address contaminant sources such as pets and waterfowl. Examples are:
    - "Don't Feed the Birds"
    - "No Pets Allowed"
    - "Pick Up Trash"

Proper enforcement will be necessary to prompt public compliance.

8 CONTACTS

Beach Owner	Engineer
City of Green Bay	Miller Engineers & Scientists
100 N Jefferson Street	5308 S. 12th Street
Green Bay, WI 54301	Sheboygan, WI 53081
(920) 448-3365	(920) 458-6164

9. INSPECTION AND MAINTENANCE FORMS

Inspection and Maintenance Form

Inspector Name			Overall Facility Condition	
Inspection Date				Acceptable
Maintenance Date				Unacceptable

Design Components	Inspected (Y/N)	Maintenance Needed (Y/N)	Maintenance Performed (Y/N)	Comments
Vegetation				
1. vegetation adequate/no bare soil areas				
2. woody or invasive vegetation or weeds				
3. vegetation composition matches plan				
4. plants in good condition				
5. overgrowth/trimming				
6. mulch				
Paths				
1. cordwalk gaps free of debris/undesirable weeds				
2. erosion around cordwalk edges				
3. cordwalk boards not cracked or damaged				
Dunes				
1. vegetation adequate/no bare soil areas				
2. woody or invasive vegetation or weeds				
3. evidence of storm/foot traffic damage				
Beach Nourishment				
1. low flat spots on beach				
2. blowing sand in lawn areas				
3. litter/debris				
BMPs				
1. sediment/trash in parking lot				
2. aquatic vegetation in swash zone				
3. public signage				
Invasive Vegetation				
1. phragmites stands				
2. aquatic vegetation in swash zone				

Inspector Remarks:

Maintenance Needs:

Maintenance Log

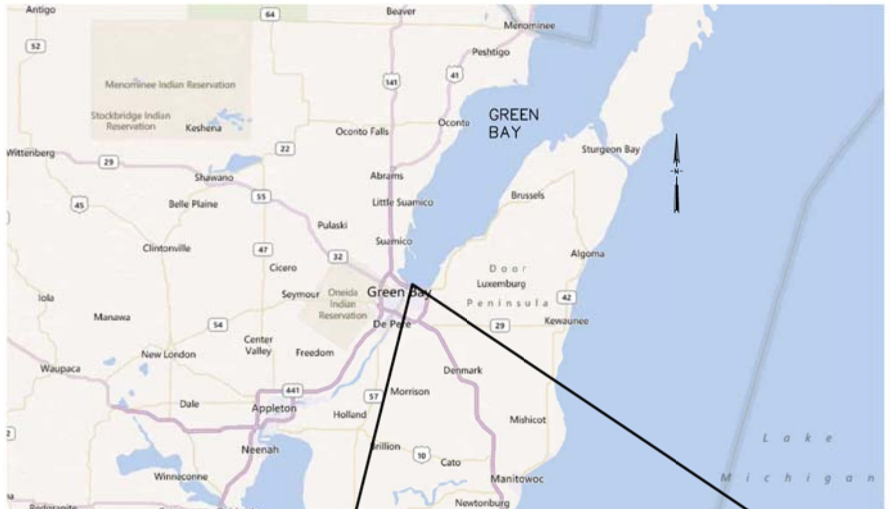
Name	Date	Maintenance Performed

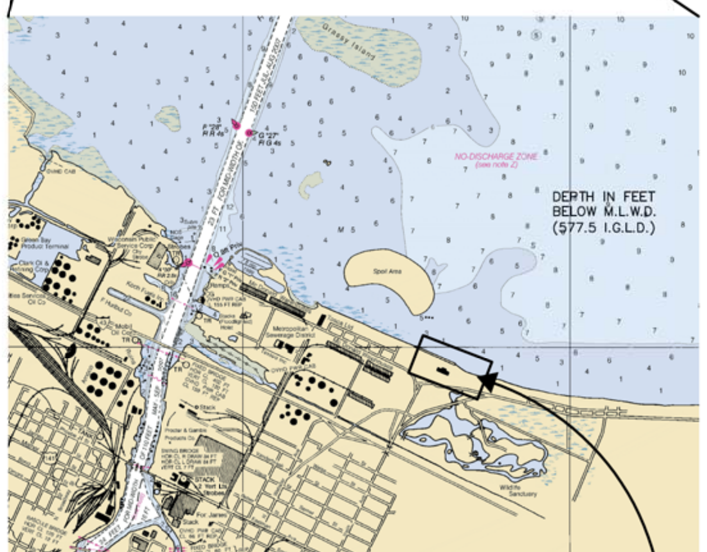
10. SITE PLANS

BAY BEACH

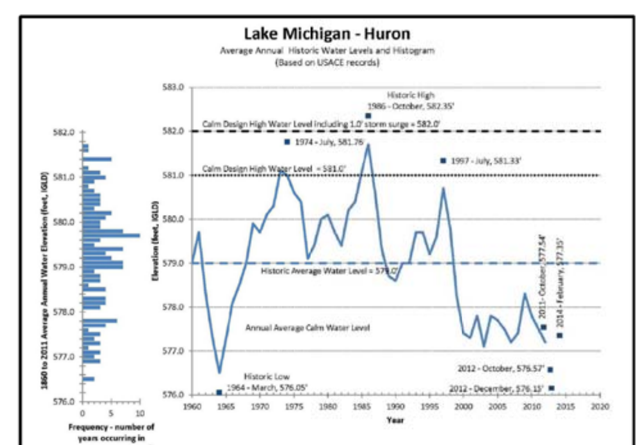
CITY OF GREEN BAY
BROWN COUNTY, WISCONSIN

LOCATION MAP





BEACH LOCATION



TO OBTAIN LOCATION OF PARTICIPANTS' UNDERGROUND FACILITIES BEFORE YOU DIG IN WISCONSIN

CALL DIGGERS HOTLINE
1-800-242-8511
TOLL FREE

TELEFAX (414) 259-0947
TDD (FOR HEARING IMPAIRED) 1-800-542-2289

WIS. STATUE 182.0175 (1974)
REQUIRES MIN. OF 3 WORK DAYS
NOTICE BEFORE YOU EXCAVATE.

ALL UNDERGROUND UTILITY LOCATIONS SHOWN HEREON ARE BASED UPON; FIELD SURVEY OF VISIBLE ABOVE GROUND STRUCTURES, RECORD MAPS OR DIGGERS HOT LINE MARKINGS. THE SURVEYOR HAS NOT LOCATED THE ACTUAL UNDERGROUND UTILITY. THE EXACT LOCATION OF ALL UTILITIES MUST BE FIELD VERIFIED BY THE CONTRACTOR PRIOR TO BEGINNING ANY CONSTRUCTION.

INDEX TO DRAWINGS

SHEET NO.	DESCRIPTION
1	TITLE SHEET, INDEX, AND LOCATION MAP
2	GRADING PLAN
3	LANDSCAPING PLAN

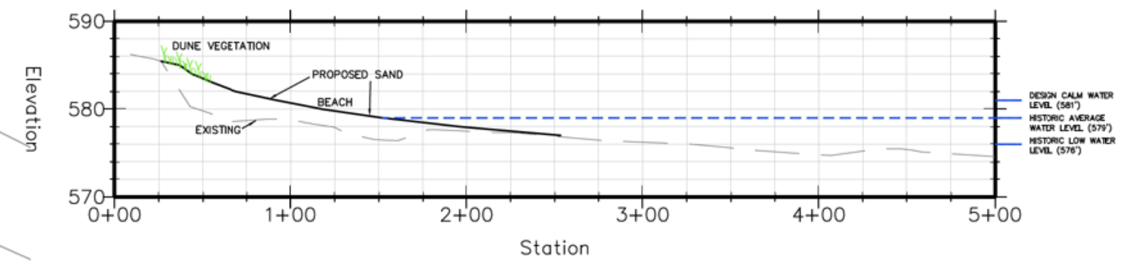
TITLE SHEET

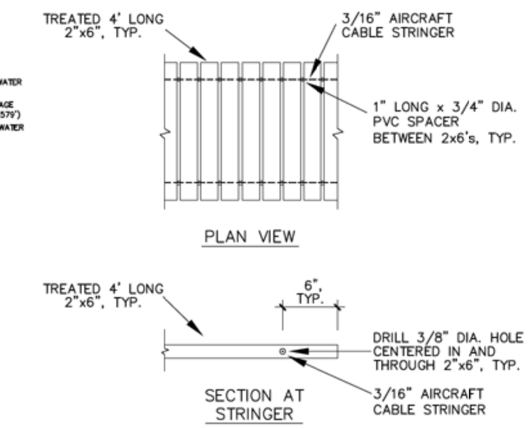
MILLER ENGINEERS SCIENTISTS
Celebrating 50 Years
www.StartWithMiller.com
5308 S. 12th Street
Sheboygan, WI 53081-8099
Phone 920-458-6164
Fax 920-458-0369
www.startwithmiller.com

NO.	DATE	DESCRIPTION	BY

CITY OF GREEN BAY
BAY BEACH
BAY BEACH ROAD
GREEN BAY, WISCONSIN

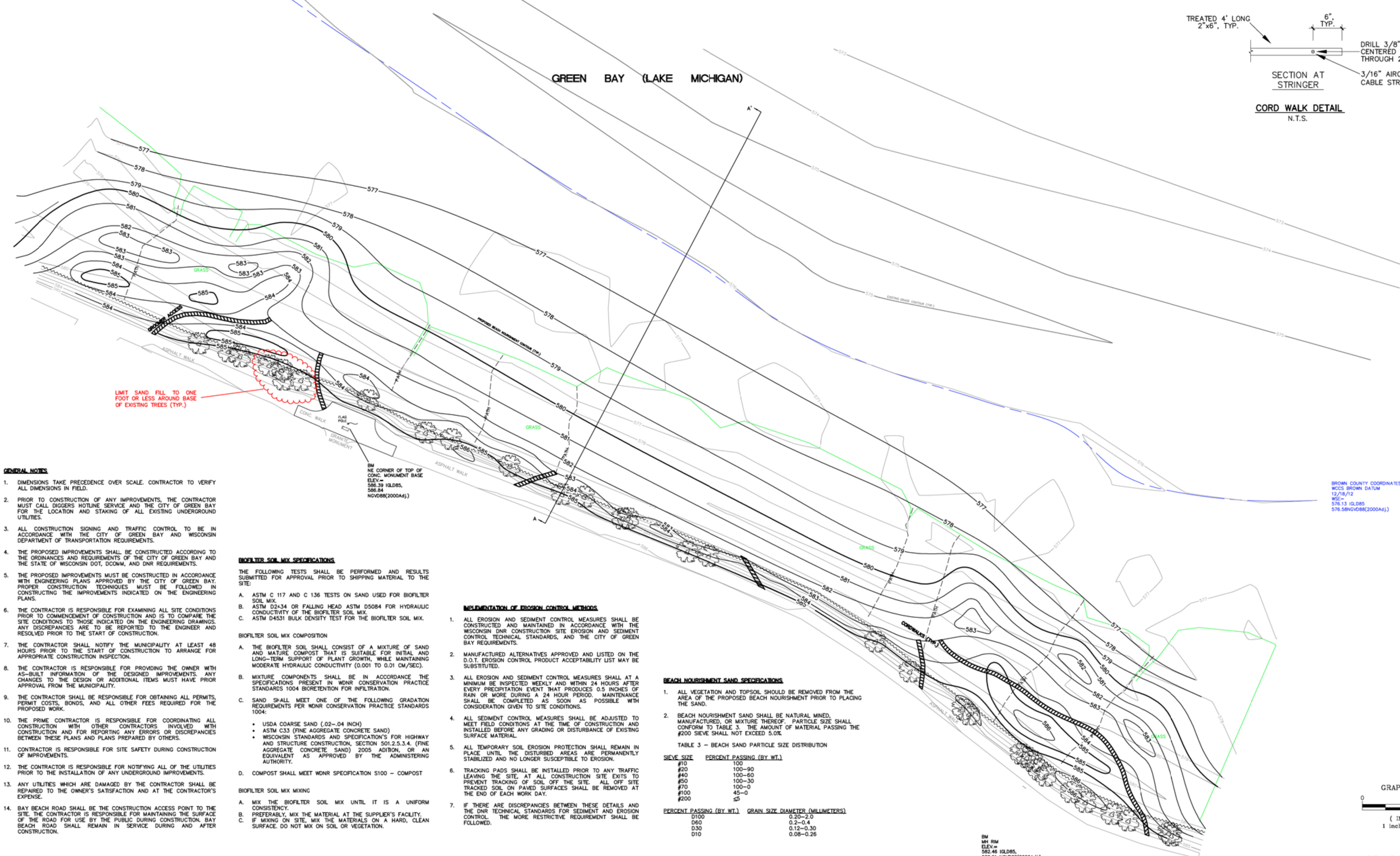
SCALE HOR. VER.	N/A
DATE	3-1-2013
JOB	12-19165-A
BY	WGF
CK	RGM
SHEET	1 OF 3





CORD WALK DETAIL

N.T.S.



GENERAL NOTES

1. DIMENSIONS TAKE PRECEDENCE OVER SCALE. CONTRACTOR TO VERIFY ALL DIMENSIONS IN FIELD.
2. PRIOR TO CONSTRUCTION OF ANY IMPROVEMENTS, THE CONTRACTOR MUST CALL DIGGERS HOTLINE SERVICE AND THE CITY OF GREEN BAY FOR THE LOCATION AND STAKING OF ALL EXISTING UNDERGROUND UTILITIES.
3. ALL CONSTRUCTION SIGNING AND TRAFFIC CONTROL TO BE IN ACCORDANCE WITH THE CITY OF GREEN BAY AND WISCONSIN DEPARTMENT OF TRANSPORTATION REQUIREMENTS.
4. THE PROPOSED IMPROVEMENTS SHALL BE CONSTRUCTED ACCORDING TO THE ORDINANCES AND REQUIREMENTS OF THE CITY OF GREEN BAY AND THE STATE OF WISCONSIN DOT, DCOMM, AND DNR REQUIREMENTS.
5. THE PROPOSED IMPROVEMENTS MUST BE CONSTRUCTED IN ACCORDANCE WITH ENGINEERING PLANS APPROVED BY THE CITY OF GREEN BAY. PROPER CONSTRUCTION TECHNIQUES MUST BE FOLLOWED IN CONSTRUCTING THE IMPROVEMENTS INDICATED ON THE ENGINEERING PLANS.
6. THE CONTRACTOR IS RESPONSIBLE FOR EXAMINING ALL SITE CONDITIONS PRIOR TO COMMENCEMENT OF CONSTRUCTION AND IS TO COMPARE THE SITE CONDITIONS TO THOSE INDICATED ON THE ENGINEERING DRAWINGS. ANY DISCREPANCIES ARE TO BE REPORTED TO THE ENGINEER AND RESOLVED PRIOR TO THE START OF CONSTRUCTION.
7. THE CONTRACTOR SHALL NOTIFY THE MUNICIPALITY AT LEAST 48 HOURS PRIOR TO THE START OF CONSTRUCTION TO ARRANGE FOR APPROPRIATE CONSTRUCTION INSPECTION.
8. THE CONTRACTOR IS RESPONSIBLE FOR PROVIDING THE OWNER WITH AS-BUILT INFORMATION OF THE DESIGNED IMPROVEMENTS. ANY CHANGES TO THE DESIGN OR ADDITIONAL ITEMS MUST HAVE PRIOR APPROVAL FROM THE MUNICIPALITY.
9. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING ALL PERMITS, PERMIT COSTS, BONDS, AND ALL OTHER FEES REQUIRED FOR THE PROPOSED WORK.
10. THE PRIME CONTRACTOR IS RESPONSIBLE FOR COORDINATING ALL CONSTRUCTION WITH OTHER CONTRACTORS INVOLVED WITH CONSTRUCTION AND FOR REPORTING ANY ERRORS OR DISCREPANCIES BETWEEN THESE PLANS AND PLANS PREPARED BY OTHERS.
11. CONTRACTOR IS RESPONSIBLE FOR SITE SAFETY DURING CONSTRUCTION OF IMPROVEMENTS.
12. THE CONTRACTOR IS RESPONSIBLE FOR NOTIFYING ALL OF THE UTILITIES PRIOR TO THE INSTALLATION OF ANY UNDERGROUND IMPROVEMENTS.
13. ANY UTILITIES WHICH ARE DAMAGED BY THE CONTRACTOR SHALL BE REPAIRED TO THE OWNER'S SATISFACTION AND AT THE CONTRACTOR'S EXPENSE.
14. BAY BEACH ROAD SHALL BE THE CONSTRUCTION ACCESS POINT TO THE SITE. THE CONTRACTOR IS RESPONSIBLE FOR MAINTAINING THE SURFACE OF THE ROAD FOR USE BY THE PUBLIC DURING CONSTRUCTION. BAY BEACH ROAD SHALL REMAIN IN SERVICE DURING AND AFTER CONSTRUCTION.

BIOFILTER SOIL MIX SPECIFICATIONS

THE FOLLOWING TESTS SHALL BE PERFORMED AND RESULTS SUBMITTED FOR APPROVAL PRIOR TO SHIPPING MATERIAL TO THE SITE:

A. ASTM C 117 AND C 136 TESTS ON SAND USED FOR BIOFILTER SOIL MIX.
B. ASTM D2434 OR FALLING HEAD ASTM D5084 FOR HYDRAULIC CONDUCTIVITY OF THE BIOFILTER SOIL MIX.
C. ASTM D4531 BULK DENSITY TEST FOR THE BIOFILTER SOIL MIX.

BIOFILTER SOIL MIX COMPOSITION

A. THE BIOFILTER SOIL SHALL CONSIST OF A MIXTURE OF SAND AND MATURE COMPOST THAT IS SUITABLE FOR INITIAL AND LONG-TERM SUPPORT OF PLANT GROWTH, WHILE MAINTAINING MODERATE HYDRAULIC CONDUCTIVITY (0.001 TO 0.01 CM/SEC).
B. MIXTURE COMPONENTS SHALL BE IN ACCORDANCE THE SPECIFICATIONS PRESENT IN WDNR CONSERVATION PRACTICE STANDARDS 1004 BIORETENTION FOR INFILTRATION.
C. SAND SHALL MEET ONE OF THE FOLLOWING GRADATION REQUIREMENTS PER WDNR CONSERVATION PRACTICE STANDARDS 1004:
   - USDA COARSE SAND (.02-.04 INCH)
   - ASTM C33 (FINE AGGREGATE CONCRETE SAND)
   - WISCONSIN STANDARDS AND SPECIFICATION'S FOR HIGHWAY AND STRUCTURE CONSTRUCTION, SECTION 501.2.5.3.4. (FINE AGGREGATE CONCRETE SAND) 2005 ADITION, OR AN EQUIVALENT AS APPROVED BY THE ADMINISTERING AUTHORITY.
D. COMPOST SHALL MEET WDNR SPECIFICATION S100 – COMPOST

BIOFILTER SOIL MIX MIXING

A. MIX THE BIOFILTER SOIL MIX UNTIL IT IS A UNIFORM CONSISTENCY.
B. PREFERABLY, MIX THE MATERIAL AT THE SUPPLIER'S FACILITY.
C. IF MIXING ON SITE, MIX THE MATERIALS ON A HARD, CLEAN SURFACE. DO NOT MIX ON SOIL OR VEGETATION.

IMPLEMENTATION OF EROSION CONTROL METHODS

1. ALL EROSION AND SEDIMENT CONTROL MEASURES SHALL BE CONSTRUCTED AND MAINTAINED IN ACCORDANCE WITH THE WISCONSIN DNR CONSTRUCTION SITE EROSION AND SEDIMENT CONTROL TECHNICAL STANDARDS, AND THE CITY OF GREEN BAY REQUIREMENTS.
2. MANUFACTURED ALTERNATIVES APPROVED AND LISTED ON THE D.O.T. EROSION CONTROL PRODUCT ACCEPTABILITY LIST MAY BE SUBSTITUTED.
3. ALL EROSION AND SEDIMENT CONTROL MEASURES SHALL AT A MINIMUM BE INSPECTED WEEKLY AND WITHIN 24 HOURS AFTER EVERY PRECIPITATION EVENT THAT PRODUCES 0.5 INCHES OF RAIN OR MORE DURING A 24 HOUR PERIOD. MAINTENANCE SHALL BE COMPLETED AS SOON AS POSSIBLE WITH CONSIDERATION GIVEN TO SITE CONDITIONS.
4. ALL SEDIMENT CONTROL MEASURES SHALL BE ADJUSTED TO MEET FIELD CONDITIONS AT THE TIME OF CONSTRUCTION AND INSTALLED BEFORE ANY GRADING OR DISTURBANCE OF EXISTING SURFACE MATERIAL.
5. ALL TEMPORARY SOIL EROSION PROTECTION SHALL REMAIN IN PLACE UNTIL THE DISTURBED AREAS ARE PERMANENTLY STABILIZED AND NO LONGER SUSCEPTIBLE TO EROSION.
6. TRACKING PADS SHALL BE INSTALLED PRIOR TO ANY TRAFFIC LEAVING THE SITE, AT ALL CONSTRUCTION SITE EXITS TO PREVENT TRACKING OF SOIL OFF THE SITE. ALL OFF SITE TRACKED SOIL ON PAVED SURFACES SHALL BE REMOVED AT THE END OF EACH WORK DAY.
7. IF THERE ARE DISCREPANCIES BETWEEN THESE DETAILS AND THE DNR TECHNICAL STANDARDS FOR SEDIMENT AND EROSION CONTROL. THE MORE RESTRICTIVE REQUIREMENT SHALL BE FOLLOWED.

BEACH NOURISHMENT SAND SPECIFICATIONS

1. ALL VEGETATION AND TOPSOIL SHOULD BE REMOVED FROM THE AREA OF THE PROPOSED BEACH NOURISHMENT PRIOR TO PLACING THE SAND.
2. BEACH NOURISHMENT SAND SHALL BE NATURAL MINED, MANUFACTURED, OR MIXTURE THEREOF. PARTICLE SIZE SHALL CONFORM TO TABLE 3. THE AMOUNT OF MATERIAL PASSING THE #200 SIEVE SHALL NOT EXCEED 5.0%.

TABLE 3 – BEACH SAND PARTICLE SIZE DISTRIBUTION

SIEVE SIZE	PERCENT PASSING (BY WT.)
#10	100
#20	100–90
#40	100–60
#50	100–30
#70	100–0
#100	45–0
#200	≤5

PERCENT PASSING (BY WT.)	GRAIN SIZE DIAMETER (MILLIMETERS)
D100	0.20–2.0
D60	0.2–0.4
D30	0.12–0.30
D10	0.08–0.26

GRADING PLAN

MILLER ENGINEERS SCIENTISTS
www.StartWithMiller.com
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Sheboygan, WI 53081-8099
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NO.	DATE	DESCRIPTION	BY

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BAY BEACH ROAD
GREEN BAY, WISCONSIN

SCALE HOR. 1"=50' VER.

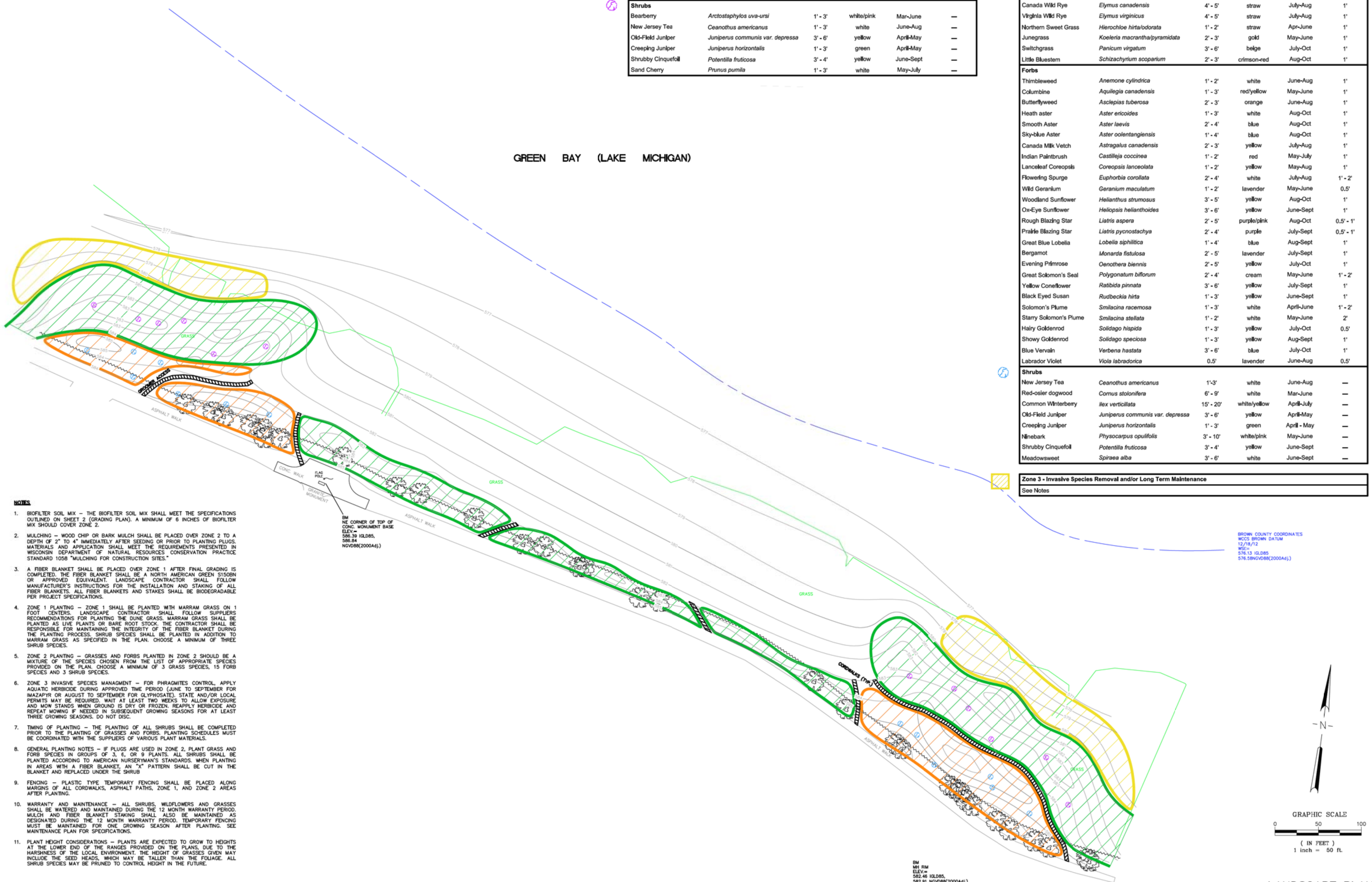
DATE 3-1-2013

JOB 12-19165-A

BY TRO

CK RGM

SHEET 2 OF 3



Zone 1 - Dune Vegetation

Common Name	Species Name	Mature Plant Height	Flower Color	Bloom Time	Spacing From Adjacent Plants
Grasses					
Marram Grass	*Ammophila breviligulata*	1' - 3'	yellow	July-Sept	1'
Shrubs					
Bearberry	*Arctostaphylos uva-ursi*	1' - 3'	white/pink	Mar-June	—
New Jersey Tea	*Ceanothus americanus*	1' - 3'	white	June-Aug	—
Old-Field Juniper	*Juniperus communis var. depressa*	3' - 6'	yellow	April-May	—
Creeping Juniper	*Juniperus horizontalis*	1' - 3'	green	April-May	—
Shrubby Cinquefoil	*Potentilla fruticosa*	3' - 4'	yellow	June-Sept	—
Sand Cherry	*Prunus pumila*	1' - 3'	white	May-July	—

Zone 2 - Upland Vegetation

Common Name	Species Name	Mature Plant Height	Flower Color	Bloom Time	Spacing From Adjacent Plants
Grasses					
Big Bluestem	*Andropogon gerardii*	5 '- 8'	bronze/red	Aug-Oct	1' - 2'
Canada Wild Rye	*Elymus canadensis*	4' - 5'	straw	July-Aug	1'
Virginia Wild Rye	*Elymus virginicus*	4' - 5'	straw	July-Aug	1'
Northern Sweet Grass	*Hierochloe hirta/odorata*	1' - 2'	straw	Apr-June	1'
Junegrass	*Koeleria macrantha/pyramidata*	2' - 3'	gold	May-June	1'
Switchgrass	*Panicum virgatum*	3' - 6'	beige	July-Oct	1'
Little Bluestem	*Schizachyrium scoparium*	2' - 3'	crimson-red	Aug-Oct	1'
Forbs					
Thimbleweed	*Anemone cylindrica*	1' - 2'	white	June-Aug	1'
Columbine	*Aquilegia canadensis*	1' - 3'	red/yellow	May-June	1'
Butterflyweed	*Asclepias tuberosa*	2' - 3'	orange	June-Aug	1'
Heath aster	*Aster ericoides*	1' - 3'	white	Aug-Oct	1'
Smooth Aster	*Aster laevis*	2' - 4'	blue	Aug-Oct	1'
Sky-blue Aster	*Aster oolentangiensis*	1' - 4'	blue	Aug-Oct	1'
Canada Milk Vetch	*Astragalus canadensis*	2' - 3'	yellow	July-Aug	1'
Indian Paintbrush	*Castilleja coccinea*	1' - 2'	red	May-July	1'
Lanceleaf Coreopsis	*Coreopsis lanceolata*	1' - 2'	yellow	May-Aug	1'
Flowering Spurge	*Euphorbia corollata*	2' - 4'	white	July-Aug	1' - 2'
Wild Geranium	*Geranium maculatum*	1' - 2'	lavender	May-June	0.5'
Woodland Sunflower	*Helianthus strumosus*	3' - 5'	yellow	Aug-Oct	1'
Ox-Eye Sunflower	*Heliopsis helianthoides*	3' - 6'	yellow	June-Sept	1'
Rough Blazing Star	*Liatris aspera*	2' - 5'	purple/pink	Aug-Oct	0.5' - 1'
Prairie Blazing Star	*Liatris pycnostachya*	2' - 4'	purple	July-Sept	0.5' - 1'
Great Blue Lobelia	*Lobelia siphilitica*	1' - 4'	blue	Aug-Sept	1'
Bergamot	*Monarda fistulosa*	2' - 5'	lavender	July-Sept	1'
Evening Primrose	*Oenothera biennis*	2' - 5'	yellow	July-Oct	1'
Great Solomon's Seal	*Polygonatum biflorum*	2' - 4'	cream	May-June	1' - 2'
Yellow Coneflower	*Ratibida pinnata*	3' - 6'	yellow	July-Sept	1'
Black Eyed Susan	*Rudbeckia hirta*	1' - 3'	yellow	June-Sept	1'
Solomon's Plume	*Smilacina racemosa*	1' - 3'	white	April-June	1' - 2'
Starry Solomon's Plume	*Smilacina stellata*	1' - 2'	white	May-June	2'
Hairy Goldenrod	*Solidago hispida*	1' - 3'	yellow	July-Oct	0.5'
Showy Goldenrod	*Solidago speciosa*	1' - 3'	yellow	Aug-Sept	1'
Blue Vervain	*Verbena hastata*	3' - 6'	blue	July-Oct	1'
Labrador Violet	*Viola labradorica*	0.5'	lavender	June-Aug	0.5'
Shrubs					
New Jersey Tea	*Ceanothus americanus*	1'-3'	white	June-Aug	—
Red-osier dogwood	*Cornus stolonifera*	6' - 9'	white	Mar-June	—
Common Winterberry	*Ilex verticillata*	15' - 20'	white/yellow	April-July	—
Old-Field Juniper	*Juniperus communis var. depressa*	3' - 6'	yellow	April-May	—
Creeping Juniper	*Juniperus horizontalis*	1' - 3'	green	April - May	—
Ninebark	*Physocarpus opulifolis*	3' - 10'	white/pink	May-June	—
Shrubby Cinquefoil	*Potentilla fruticosa*	3' - 4'	yellow	June-Sept	—
Meadowsweet	*Spiraea alba*	3' - 6'	white	June-Sept	—

Zone 3 - Invasive Species Removal and/or Long Term Maintenance

See Notes

NOTES

1. BIOFILTER SOIL MIX – THE BIOFILTER SOIL MIX SHALL MEET THE SPECIFICATIONS OUTLINED ON SHEET 2 (GRADING PLAN). A MINIMUM OF 6 INCHES OF BIOFILTER MIX SHOULD COVER ZONE 2.
2. MULCHING – WOOD CHIP OR BARK MULCH SHALL BE PLACED OVER ZONE 2 TO A DEPTH OF 2" TO 4" IMMEDIATELY AFTER SEEDING OR PRIOR TO PLANTING PLUGS. MATERIALS AND APPLICATION SHALL MEET THE REQUIREMENTS PRESENTED IN WISCONSIN DEPARTMENT OF NATURAL RESOURCES CONSERVATION PRACTICE STANDARD 1058 "MULCHING FOR CONSTRUCTION SITES."
3. A FIBER BLANKET SHALL BE PLACED OVER ZONE 1 AFTER FINAL GRADING IS COMPLETED. THE FIBER BLANKET SHALL BE A NORTH AMERICAN GREEN S150BN OR APPROVED EQUIVALENT. LANDSCAPE CONTRACTOR SHALL FOLLOW MANUFACTURER'S INSTRUCTIONS FOR THE INSTALLATION AND STAKING OF ALL FIBER BLANKETS. ALL FIBER BLANKETS AND STAKES SHALL BE BIODEGRADABLE PER PROJECT SPECIFICATIONS.
4. ZONE 1 PLANTING – ZONE 1 SHALL BE PLANTED WITH MARRAM GRASS ON 1 FOOT CENTERS. LANDSCAPE CONTRACTOR SHALL FOLLOW SUPPLIERS RECOMMENDATIONS FOR PLANTING THE DUNE GRASS. MARRAM GRASS SHALL BE PLANTED AS LIVE PLANTS OR BARE ROOT STOCK. THE CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTAINING THE INTEGRITY OF THE FIBER BLANKET DURING THE PLANTING PROCESS. SHRUB SPECIES SHALL BE PLANTED IN ADDITION TO MARRAM GRASS AS SPECIFIED IN THE PLAN. CHOOSE A MINIMUM OF THREE SHRUB SPECIES.
5. ZONE 2 PLANTING – GRASSES AND FORBS PLANTED IN ZONE 2 SHOULD BE A MIXTURE OF THE SPECIES CHOSEN FROM THE LIST OF APPROPRIATE SPECIES PROVIDED ON THE PLAN. CHOOSE A MINIMUM OF 3 GRASS SPECIES, 15 FORB SPECIES AND 3 SHRUB SPECIES.
6. ZONE 3 INVASIVE SPECIES MANAGMENT – FOR PHRAGMITES CONTROL, APPLY AQUATIC HERBICIDE DURING APPROVED TIME PERIOD (JUNE TO SEPTEMBER FOR IMAZAPYR OR AUGUST TO SEPTEMBER FOR GLYPHOSATE). STATE AND/OR LOCAL PERMITS MAY BE REQUIRED. WAIT AT LEAST TWO WEEKS TO ALLOW EXPOSURE AND MOW STANDS WHEN GROUND IS DRY OR FROZEN. REAPPLY HERBICIDE AND REPEAT MOWING IF NEEDED IN SUBSEQUENT GROWING SEASONS FOR AT LEAST THREE GROWING SEASONS. DO NOT DISC.
7. TIMING OF PLANTING – THE PLANTING OF ALL SHRUBS SHALL BE COMPLETED PRIOR TO THE PLANTING OF GRASSES AND FORBS. PLANTING SCHEDULES MUST BE COORDINATED WITH THE SUPPLIERS OF VARIOUS PLANT MATERIALS.
8. GENERAL PLANTING NOTES – IF PLUGS ARE USED IN ZONE 2, PLANT GRASS AND FORB SPECIES IN GROUPS OF 3, 6, OR 9 PLANTS. ALL SHRUBS SHALL BE PLANTED ACCORDING TO AMERICAN NURSERYMAN'S STANDARDS. WHEN PLANTING IN AREAS WITH A FIBER BLANKET, AN "X" PATTERN SHALL BE CUT IN THE BLANKET AND REPLACED UNDER THE SHRUB
9. FENCING – PLASTIC TYPE TEMPORARY FENCING SHALL BE PLACED ALONG MARGINS OF ALL CORDWALKS, ASPHALT PATHS, ZONE 1, AND ZONE 2 AREAS AFTER PLANTING.
10. WARRANTY AND MAINTENANCE – ALL SHRUBS, WILDFLOWERS AND GRASSES SHALL BE WATERED AND MAINTAINED DURING THE 12 MONTH WARRANTY PERIOD. MULCH AND FIBER BLANKET STAKING SHALL ALSO BE MAINTAINED AS DESIGNATED DURING THE 12 MONTH WARRANTY PERIOD. TEMPORARY FENCING MUST BE MAINTAINED FOR ONE GROWING SEASON AFTER PLANTING. SEE MAINTENANCE PLAN FOR SPECIFICATIONS.
11. PLANT HEIGHT CONSIDERATIONS – PLANTS ARE EXPECTED TO GROW TO HEIGHTS AT THE LOWER END OF THE RANGES PROVIDED ON THE PLANS, DUE TO THE HARSHNESS OF THE LOCAL ENVIRONMENT. THE HEIGHT OF GRASSES GIVEN MAY INCLUDE THE SEED HEADS, WHICH MAY BE TALLER THAN THE FOLIAGE. ALL SHRUB SPECIES MAY BE PRUNED TO CONTROL HEIGHT IN THE FUTURE.

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Appendix E: Best Management Practices Recommendations (Julie Kinzelman, Ph. D., 2015)

Beach Health Assessment and Recommended Best Management Practices for Bay Beach (Green Bay, WI)

Prepared for:

City of Green Bay, WI

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Racine Health Department

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UW-Oshkosh

Angela Pierce
Bay-Lake Regional Planning Commission

2015

Contents

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Bay Beach
Green Bay, WI

I. INTRODUCTION

Deterioration of beach health is of concern in the Great Lakes region because of serious public health and economic consequences. Public health risks at beaches are associated with high concentrations of fecal indicator bacteria (FIB), based on epidemiological research linking high levels to increased risks of illness in exposed individuals. High FIB concentrations result in beach advisories and closures, leading to underutilization, which may have economic repercussions. Beaches are a primary interface between people and the environment, a significant asset to any community. Beaches are America's top tourist destination, generating more than $640 billion a year for the U.S. economy according the Clean Beaches Coalition (http://www.cleanbeaches.com/beaches.html). Economic losses due to beach closures can adversely impact community pride, recreation, tourism, aesthetics, property values, quality of life, and future sustainability. Conversely, increased swimming can have a $2-3 billion dollar direct economic benefit to the Great Lakes, under the assumption of 8 million swimmers and 80 million swimming days annually with a 20% reduction in closures (Austin, et al. 2007). Water quality improvements are protective of human health and can actualize direct and indirect economic benefits.

In order for water quality improvements to occur, the sources of pollution must be identified. Unidentified pollution sources at beaches have made it difficult to develop effective remediation strategies, especially considering the number of point and non-point sources that can impact recreational water quality. These sources can act alone in some cases, and in others amplify one another to negatively impact water quality. Discharges from tributaries, sanitary sewer overflows, crumbling sewer infrastructure, stormwater drainage and urban/agricultural runoff have all been linked to impaired water quality. Additionally, nearshore wildlife, such as gulls and geese, can be responsible for direct bacteria loading to surface water or beach sand. Beach sand and other sediments can act as a reservoir for bacteria, with FIB concentrations a magnitude higher than adjacent surface water. Remediation efforts must consider additive effects from multiple sources compounding recreational water quality at beaches. Historically, 90 – 95% of Great Lakes water quality failures could not be attributed to a specific source. However, with funding for beach sanitary surveys through the Great Lakes Restoration Initiative (GLRI), Urban Waters Program and other federal grant programs, many sources have been identified and conceptual redesigns plans have been developed to provide mitigation.

Design plan elements, first and foremost, seek to improve natural resource function and surface water quality. Design elements may be engineered (structural) or natural (vegetation and natural coastal features such as dunes). Used in combination with the engineered solutions, best management practices (BMPs) help to create a healthy, sustainable beach environment. BMPs are managerial practices used to treat, prevent or reduce water pollution. Used together, they will aid the City of Green Bay, Department of Parks, Recreation and Forestry in restoring and maintaining Bay Beach while protecting public health, providing access and preserving recreational value.

The best mitigation measures are those that are based on sound science. Beach sanitary surveys and other data collection methods have allowed us to develop site specific recommendations. The steps taken to arrive at these recommendations are:

1. Collected and examined available historical monitoring data
2. Identified data gaps and collected additional data as needed
3. Analyzed data
4. Identified potential causes and sources of pollution
5. Identified site specific solutions (beach redesign plans and/or BMPs)
6. Made recommendations for future monitoring needs

II. SITE ASSESSMENT

History. Bay Beach Park's history dates back to 1892 when was it was established as a private beach resort. It had a dance hall, bar, bathhouse, and a 90 square-foot, 2-story covered pavilion. Swimming became so popular at Bay Beach in the early 1900's that a trolley ran from downtown Green Bay out to the park. It was also became a significant source of revenue. Swimsuit rentals (at 10¢ apiece) alone grossed up to $450 a day, even though the suits were never quite dry or free of sand when rented.

In spite of its popularity, Bay Beach began experiencing frequent beach closures in the 1930's due to raw sewage, oil slicks, and wastes from canning factories, cheese factories, and paper mills. By 1933, increasing pollution began causing skin sores and the Green Bay Board of Public Health was forced to permanently close the beach to swimming – one of the earliest beach closings in the country. However, many residents continued to swim at Bay Beach until ten years later when the closure began to be enforced and the beach was finally abandoned.

Through the years, amusement rides were added, and today the greater Bay Beach Park area consists of approximately 45 acres with 16 rides, seven shelters, a dance hall, restrooms, picnic areas, playground, and softball and volleyball areas. Bay Beach Amusement Park is a popular summer destination for thousands of people annually. However, the beach is still abandoned.

Surrounding Area: Bay Beach is located within Bay Beach Park, 1313 Bay Beach Rd., in the City of Green Bay, WI. It is adjacent to the east bank of the Fox River as it flows into the southern end of the bay of Green Bay. It is bound to the northeast by the opens waters of Green Bay, to the southwest by Bay Beach Park, to the east by residential housing near the shoreline and the Bay Beach Wildlife Sanctuary further inland, and to the west by the causeway leading to Renard Island. The beach sits on the southwestern end of a northeast facing partial embayment formed by the causeway to the west and mainland to the southwest and northeast. This configuration limits circulation and the exchange of water within the embayment with the open waters of Green Bay.

Park Attributes: Bay Beach Park is roughly 45 acres in size, with turf grass and parking lots dominating the upland portion of the park, and an approximate 1.9 miles of wetland/sandy deposits below the retaining wall/dike (revetment). Sediments are comprised of silts, fines and decaying organic matter until about 10 feet from the extent of the *Phragmites*. Subsurface sediments are comprised of fine sand. Invasive species, predominantly *Phragmites* (a tall reed grass), comprises the majority of the vegetation below the dike (revetment).

Potential Pollution Sources: Annual walking site assessments and intensive sampling/data analysis, conducted as part of the beach sanitary survey and site assessment process (2012-2014), identified potential point (direct) sources of pollution including a pipe extending from a concrete block structure which discharges onto the beach at the east end of the white building (Figure 1).

Figure 1. Localized infrastructure may be a point source of pollution.

Significant amounts of rusty deposits on trees, rocks and other hard surfaces below the revetment provide evidence of frequent discharge (Figure 2).

Figure 2. Deposits of rust on beach substrate.

In addition, high waves, onshore winds, and surface runoff were noted as likely mechanisms of transport, contributing non-point source (indirect) pollution to the nearshore waters off of Bay Beach Park. High waves and surface runoff can increase turbidity by suspending or transferring sediment particles into the water column. Therefore, beach sands/sediments and submerged sediments could also be potential non-point sources of pollution (Figure 3). Other potential non-point pollution sources noted were: avian wildlife populations (contributing fecal matter to both the nearshore water and/or beach sands) and algae (*Cladophora*) (stranded mats create a hospitable habitat for bacterial persistence and/or growth, Figure 3).

Figure 3. Examples of fine beach sediments with organic matter and stranded algae.

III. OVERVIEW OF HISTORICAL AND RECENT MONITORING DATA

Previous monitoring by the Green Bay Board of Public Health determined that the nearshore waters off of Bay Beach Park were unsafe for full contact recreation and a permanent prohibition against swimming was posted in the 1930's. Since that time, various agencies, including the Brown County Health Department and NEW Water have periodically assessed water quality at, or in the vicinity of, Bay Beach. However, additional data was needed to begin the process of restoration. In 2012, the Bay-Lake Regional Planning Commission secured funding through a US EPA Urban Waters Grant and engaged the University of Wisconsin – Oshkosh (UWO) to conduct intensive summer sampling and beach sanitary surveys in an effort to determine potential pollutions sources and conditions which result in degraded water quality.

Sample Collection

A sample plan was developed based on the initial site assessment to evaluate all potential pollution sources. Routine sanitary surveys (RSS) were conducted for Bay Beach two times per week from 2012 to 2014. Each survey consisted of recording general beach conditions including air and water temperature, wind speed and direction, rainfall and intensity, weather conditions, wave height and intensity, and alongshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, and south) and depths (12 inches, 24 inches, and 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity (Figure 4). In addition to spatial sampling, a water sample was collected at the center of the beach at 24 inches and analyzed for microcystin toxin (Envirologix ELISA Quantiplate; Portland, ME) each time a

RSS was conducted. There were no major stormwater outfalls identified at this beach; however the mouth of the Fox River is located approximately 1.3 miles northwest of Bay Beach.

Figure 4. Bay Beach sampling locations.

Bather load was recorded to evaluate beach usage. Bather load was determined by recording the total number and activities of the people in the water and on the beach. Potential pollution sources were also quantified (if needed) and recorded via the RSS, including sources of discharge, floatables, debris/litter, algae, wildlife and domestic animals.

Annual sanitary surveys were conducted in all three years of the study (2012-2014). An annual sanitary survey is more comprehensive than a RSS in that it not only evaluates the beach, but includes the surrounding area as well. With an annual sanitary survey, the length and width of the beach are measured, potential pollution sources are identified, topography of the beach is documented, the surrounding area is categorized (e.g. rural, agricultural, residential), and RSS data is compiled and analyzed for the entire beach season.

Results Summary

Bay Beach has not been routinely monitored prior to this study (Table 1). However, intermittent data was collected by NEW Water (Green Bay Metropolitan Sewerage District) and analyzed by the Brown County Health Department. In total, 91 samples were collected at Bay Beach by other agencies since 2004, over 60% within the last 3 years. 2007 may represent a one off experience, resulting in inflated average *E. coli* values across the study period at Bay Beach (Table 1). If this data is removed, the average *E. coli* concentration at Bay Beach would be 111.3 *E. coli* MPN/100mL. If retained, the mean value is 221.0. In either instance, mean values fall below the US EPA/WI DNR single sample advisory limit of no more than 235 *E. coli* MPN/100mL.

Table 1. Historical water quality at Bay Beach from routine BEACH Act monitoring, 2004 - 2014. Red italicized text indicates data collected by NEW Water and analyzed by the Brown County Health Department.

Number of Samples Exceeding Water Quality Standards				
Year	**# of Exceedances (>235 MPN/100mL)**	**# of Samples**	**% Exceedances**	**Mean *E. coli* (MPN/100mL)**
2004	*1*	*10*	*10%*	*97.0*
2005	*2*	*14*	*14%*	*107.4*
2006	*0*	*9*	*0%*	*20.3*
2007	*1*	*2*	*50%*	*879.7*
2012	1	7	14%	84.5
2013	6	26	23%	148.3
2014	3	23	13%	210.0
Totals	14	91	18%	221.0

NOTE: Only E. coli concentrations collected directly at Bay Beach were included.

A total of 571 surface water and sediment samples were collected at Bay Beach by UWO from 2012 - 2014 (2012 n=78; 2013 n=258; 2014 n=235) (Table 2).

Table 2. Total number of samples collected, by type, over the duration of the study at Bay Beach.

Bay Beach Number of Samples Collected (2012-2014)						
Year	**Monitoring Frequency (per week)**	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Microcystin Samples**	**Total**
2012	3	7	56	15	0	78
2013	3	26	208	0	24	258
2014	3	23	184	0	28	235
Total	NA	56	448	15	52	571

E. coli concentrations steadily increased from 2012 to 2014 (Figure 5). Concentrations were significantly higher in 2014 than in 2012 ($p<0.05$). Mean *E. coli* concentrations in 2014 exceeded US EPA/WI DNR single sample advisory limit of no more than 235 *E. coli* MPN/100mL, the first time since 2007. Drought conditions in 2012 may have contributed to the lower *E. coli* concentrations and also indicates that at least a portion of the contamination is wet weather mediated.

There was evidence of geese and gulls noted at the initial site assessment. This was confirmed on the routine sanitary surveys, were both geese and gulls were observed loafing in the nearshore water and grassy areas surrounding the beach (Table 3). Significant amounts of *Phragmites* along the shore were observed to trap debris and algae as well as restrict water movement. This could be a contributor to the elevated mean turbidity values observed (Table 3). High turbidity is frequently associated with instances of poor water quality.

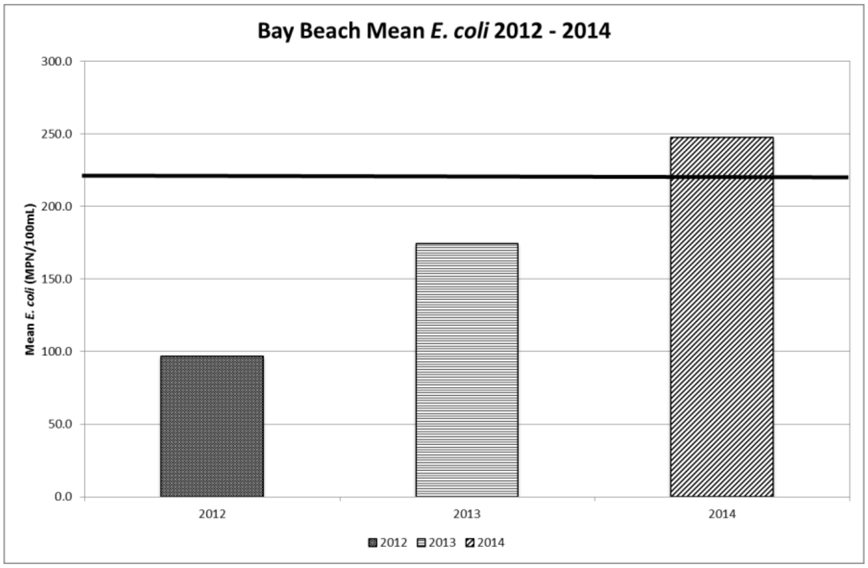

Figure 5. Mean *E. coli* (MPN/100mL) at Bay Beach (2012 n=63; 2013 n=234; 2014 n=207) ANOVA p=0.000.

Table 3. Mean seasonal results of select sanitary survey and water quality parameters (2012-2014) at Bay Beach.

Bay Beach Mean Sanitary Survey Summary 2012-2014							
E. coli Center 24" (MPN/100mL)	*E. coli* Sand (MPN/g)	Microcystin (ppb)	Water Temp (°C)	Turbidity (NTU)	# Gulls	# Geese	Bathers (# people)
164.9	11.7	3.2	21.9	95.0	12.7	5.3	0
n=56	n=15	n=52	n=54	n=27	n=54	n=54	n=54

At the conclusion of the three years of data collection, statistical linear regression was conducted between physical/chemical/biological parameters and *E. coli* concentrations at the center of beach location (24 inches). Parameters with the highest R^2 value at Bay Beach included wave height, water and air temperature, and wind direction (Table 4). These parameters alone do not contribute for 100% of the fecal contamination, however, in combination they account for a significant amount.

The primary avian species noted at Bay Beach were gulls. On average, 13 gulls were observed per day over the three-year study. Geese were also observed but in smaller numbers (n = 5 per day, Table 3 and Table 5). No dogs were observed at the beach. Wildlife present at the beach can contribute to fecal bacteria loading to the beach and surrounding area. During rain or high wind events it can be subsequently washed into the nearshore water, delivering *E. coli* and other potential human pathogens to the swimming area.

Algae was observed and recorded as the amount submerged in the nearshore water only since there is no delineated beach area at Bay Beach. No alga was observed in 2012 (Table 4). In 2013 and 2014 there were moderate amounts of algae observed in the water. On a scale of zero to three (zero being no algae and three being high amounts of algae), an average of 1.8 (n=54) abundance of algae was observed during the three year study period.

Table 4. Relationship of biological, physical, or chemical parameters to log *E. coli* concentrations.

Bay Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. *E. coli*	**2012**	**2013**	**2014**
Wind Direction (°)	0.1596	x	0.0483
Wind Speed (mph)	0.0162	x	0.0364
Water Temperature (°C)	0.2476	0.0209	0.0016
Air Temperature (°C)	0.3941	0.0551	0.0921
Turbidity (NTU)	0.1344	x	0.0195
Wave Height (ft)	x	0.2397	0.6419
Within 24hr Rain (cm)	0.0017	0.0071	0.0003
Algae (1-3 scale)	x	0.0236	0.0357
Gulls (#)	x	0.0321	0.0000
Geese (#)	x	0.0375	0.0295
Other Avian (#)	0.0034	0.0751	0.0109
Bathers at Beach (#)	x	x	0.0004
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	x	x	0.0127
Longshore Current Direction (°)	x	x	0.0002

*x indicates insufficient data collected for statistical analysis.

Table 5. Wildlife at Bay Beach, number and days observed.

Number and Type of Wildlife Present on Bay Beach													
		Gulls			Geese			Other Birds			Dogs		
Year	Total Days	Amount	Days Observed	Min/Max	Amount	Days Observed	Min/Max	Amount	Days Observed	Min/Max	Amount	Days Observed	Min/Max
2012	5	7	5	0/5	0	0	0	37	2	2/35	0	0	0
2013	26	223	15	4/40	233	9	1/50	137	15	1/35	0	0	0
2014	23	458	23	1/50	54	9	2/21	50	18	1/6	0	0	0
Total	54	681	38	NA	287	18	NA	224	33	NA	0	0	NA

In addition to assessing *E. coli* and parameters indicative of potential pollution sources, surface water samples were collected twice weekly in 2013 and 2014 and analyzed for microcystin toxin. Microcystin toxin concentrations increased significantly from 2013 to 2014 ($p<0.05$) (Figure 6). The average microcystin concentration for 2013 was 1.95 ppb versus 4.29 ppb in 2014.

Allowable concentrations for microcystin in surface water, as suggested by the World Health Organization (WHO) are <4 ppb, Low Risk; 4-20 ppb, Moderate Risk; and visible scum, High Risk (WHO, 1999). In 2013, microcystin concentrations were in the Low Risk category. However, microcystin concentrations increased and were in the Moderate Risk category in 2014. In

Wisconsin, contact should be prohibited if a visible scum layer is observed or microcystin levels exceed 100,000 cells/mL. In Illinois the beach action limit is 10.0 ppb. Therefore, based on these guidelines, microcystin levels did not exceed dangerous levels during the course of this study. Liver damage can occur with repeated exposure (ingestion) of microcystin as a result of recreational exposure. Risk of ingestion is greater in children. Allergic and toxic skin reactions can result from direct exposure, without ingestion (WHO 1999).

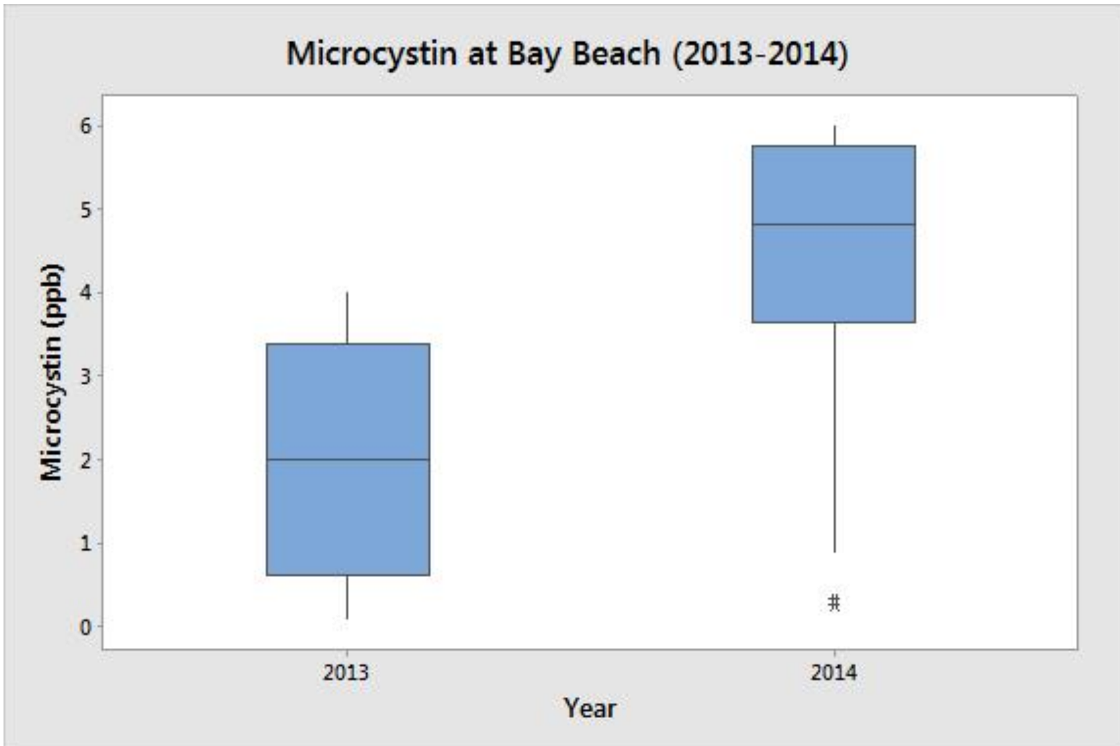

Figure 6. Boxplot of microcystin concentrations in 2013 and 2014. (2013 n=24, 2014 n=28)

RECOMMENDED BEACH REDESIGN ELEMENTS

Engineering Controls

Urban non-point source pollution is one of the most complex environmental challenges facing the Great Lakes. The amount of impervious surfaces, such as roadways, parking lots, and rooftops, has significantly increased as urban areas in the basin have developed. These impervious surfaces convey pollutants such as bacteria, nutrients, oils, sediment, and heavy metals. While considered "green space", even turf grass areas provide little infiltration. Primary contact recreational standards for bacteria almost always exceed limits in stormwater runoff, regardless of the originating land use type. Therefore, capital investments, by way of engineering control measures, are required to properly treat stormwater runoff prior to its entering receiving bodies of water, such as coastal beaches.

Engineering control measures may be either structural (hard engineered features such as permeable pavements, bio-infiltration swales, retention/detention basins, or other infrastructure improvements) (Figure 7) or naturalized (restoring buffer strips, wetlands, dunes and/or planting native vegetation). In some locations, beach redesign plans may call for the removal or alteration of legacy engineered structures, such as jetties, piers, groins or impervious surfaces. At other sites, construction of devices to mimic natural coastal attributes or alteration of existing land features may be needed to elicit necessary water quality improvements. Site specific engineered solutions have been recommended as a result of the intensive monitoring conducted at Bay Beach. The remainder of this section serves to provide a rationale for, and reinforce, the importance of such measures in maintaining or restoring ecosystem health and is meant to be complimentary to the merit report and redesign plans.

Figure 7: Porous pavement and vegetated swale at a Door County beach parking lot.

Legacy Engineered Structures. High waves and storm surges frequently flood shoreline areas. To guard against future flooding a dike, or revetment, was placed along the shoreline at Bay Beach Park (Figure 8). Historical photographs indicate that the waters of Green Bay abutted the revetment at the time of installation. However, due to successive years of accretion and reliction the shoreline has retreated several meters, exposing lakebed. The removal of this shoreline erosion control measure is not recommended.

Figure 8. Shoreline erosion control feature at Bay Beach.

To the west and north of Bay Beach Park lies Renard Island. Renard Island is connected to the mainland by a causeway (Figure 9). While the removal of the causeway may not be permissible or desirable, culverts could be installed to improve circulation in the nearshore area off of Bay Beach. Improving circulation could reduce conditions which result in moderate levels of microcystin.

Figure 9: Renard Island and causeway.

Engineered Stormwater Control Measures:

Stormwater management must take place as non-point source (NPS) runoff is widely acknowledged to be a primary source of water quality degradation. Restoration recommendations at Bay Beach make use of green infrastructure to reduce the impact of runoff. Dunes and wetlands serve as an important buffer between terrestrial activities and aqueous environments, improving water quality through a series of chemical, biological and physical processes. In addition to water filtration, they provide habitat for a variety of plant and animal species, are home to unique ecology, reduce flood hazards, lessen erosion, and serve as an important temporary storage element. Improvements to the asphalt pathway will also reduce pooling and shunting of runoff onto the beach.

Figure 10: Dunes provide infiltration of urban runoff at Samuel Myers Park (Racine, WI).

Structural and naturalized engineering solutions frequently attempt to address loss of natural coastal features through the implementation of design features that mimic the environment by reducing, retaining and/or infiltrating direct stormwater discharge and surface runoff, for example at Samuel Myers Park in Racine, WI (Figure 10).

Redesign plans at Bay Beach also recommend naturalized stormwater control measures. The construction of small dunes in the back beach area coupled with overall beach nourishment will capture impervious surface and landscape runoff. The construction of a dune and swale system will assist the City of Green Bay to manage NPS pollution by improving the capture and infiltration of stormwater runoff as it is delivered to the site from upland areas, as well as better manage invasive species (higher and drier beach environments are less favorable for the growth and propagation of hydrophilic invasive species, like *Phragmites*).

Sediment Management: Sediment grain size and the proximity of surface sands to the water table can also contribute to impairment. Fine grain sands have greater surface area and serve as a point of attachment for bacteria. Larger sand particles promote greater infiltration that supports higher and drier beach conditions. Larger and heavier sand particles are also less susceptible to wind erosion, decreasing the amount of sand that is blown off the beach. Increasing the distance between the sand surface and water table will result in a higher and dryer beach. Low and flat beaches remain wet due to capillary draw, a constant interaction with the water table due to a lack of adequate separation. Strategic beach nourishment can also serve as a natural stormwater management measure. Constructed or encouraged dunes, when strategically placed, can reduce overland flow and promote infiltration from impervious surface abutting the beach. Permits are required from the WDNR to do any beach nourishment in Wisconsin.

Vegetation: Native vegetation, within constructed or encouraged dunes, is incorporated into beach redesigns for several reasons. The root systems of most native plants are deep and help water infiltrate into the ground, reducing runoff. The plants root systems also retain soil, including sand, in place, reducing erosion and drifting on dynamic beaches. Native plant species may also facilitate infiltration of NPS pollution and provide nutrient uptake. Native plants are naturally low maintenance, saving time, money and energy once established. Native plans have adapted to local conditions, which makes them hearty and resistant to most pests and diseases. Native vegetation also improves coastal habitat by providing food and shelter for migratory birds, butterflies, and other desirable wildlife along the Lake Michigan coast.

Restricted/invasive species must also be managed in order for Great Lakes restoration to progress. As part of the restoration process, invasive species must be removed and replaced with native grasses, sedges, forbs, shrubs and trees. The full planting list is available on the engineering plan sheets.

Improving Public Access

Defined public access points should be established based on local foot traffic and usage patterns, to provide controlled ingress/egress points through existing or created dunes, wetlands and other features. These pathways will allow vegetation to become established by protecting them from foot traffic. Curved pathways may also deter wildlife loafing behavior by reducing the line of sight (thus instilling a fear of potential predation). Pathways can be made from a variety of permeable materials including: cord walk, tree mulch, recycled planking, or fiber mesh. All pathways should be ADA compliant whenever possible. Both Simmons Island (Kenosha, WI) and North Beach (Racine, WI) have improved public access through the use of fixed and movable permeable pathways (Figure 11, Left and Right).

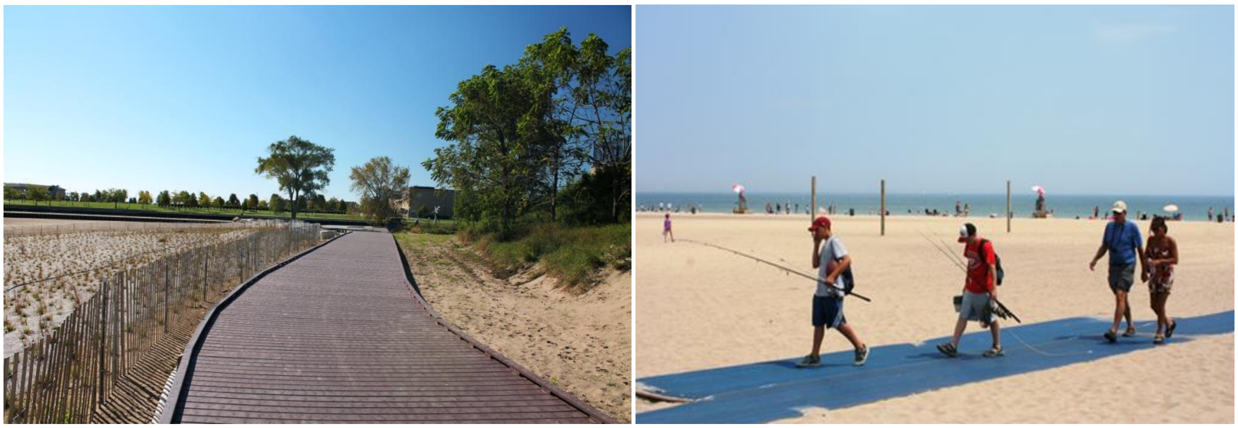

Figure 11: Left: Defined pathways protect vegetated areas during the establishment phase (Simmons Island Beach, Kenosha, WI), Right: Example of Mobi-Mat™ pathway (North Beach, Racine, WI).

Proper access points to the beach are beneficial to patrons, mangers, and the environment. Improved points of ingress/egress to Bay Beach are currently lacking. Access to the beach area consists of traversing the revetment and making ones way through the dense stands of *Phragmites* by way of makeshift paths. The asphalt pedestrian path running along the top of the revetment, between the train tracks and beach, is also in very poor condition and presents a health hazard (Figure 12, A - C). The proposed design elements in the Bay Beach restoration plan will provide easy access to the water's edge while limiting the negative impacts of excessive foot traffic on native vegetation. Proposed pathways can be made ADA compliant by being cognizant of the necessary grade transitions and utilization of Mobi-Mat™ extensions. Temporary mulch pathways may be utilized during active restoration; however, they must be replaced every 2-3 years.

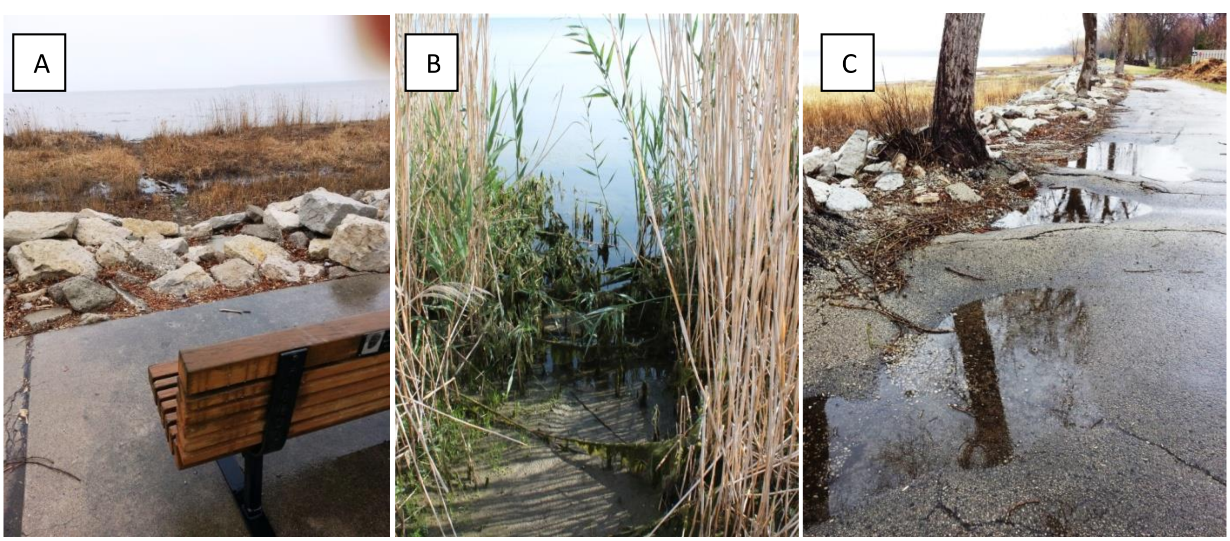

Figure 12 (A – C): Current points of ingress/egress: (a) over revetment, (b) footpath and (c) asphalt path.

V. BEST MANGEMENT PRACTICES (BMPs)

The purpose of beach BMPs are to reduce the adverse impacts of localized pollution on nearshore water quality. To provide the best results they should be used in conjunction with the site specific engineered control measures. The application of best management resources to abate pollution will vary by location and a single solution will likely not be the "silver bullet", removing all water quality impairments. The appropriate suite of BMPs deployed must be science-based and result from a critical review of monitoring data, utilization studies, feasibility, and current/future land use. BMPs should also contain an educational component to increase public awareness of water quality problems and engage the community in solutions. Implementation of BMPs will require a combination of local government and municipal department cooperation/coordination and may require capital investment, although many can be carried out at little to no cost. The BMPs recommended for Bay Beach include developing water quality, native plant community, and invasive species monitoring plans, as well as public notification and beach maintenance plans.

Developing a Beach Water Quality Monitoring Plan

Regular monitoring of water quality at the beach, especially during peak usage (i.e. summer weekdays, weekends and holidays) is extremely important in protecting public health. The frequency of routine, regulatory monitoring should be guided by the WDNR beach priority list. Based on its prior WDNR use designation, Bay Beach should be monitored at least once weekly throughout the swimming season.

A predictive model may be a cost effective supplement or alternative to traditional laboratory-based testing. Predictive models, developed using sanitary survey or readily available web-based data, estimate bacterial levels based on environmental conditions that influence fecal indicator bacteria concentrations at beaches. The US EPA has developed a software application called Virtual Beach and many coastal communities are in the process of using it to develop models capable of predicting recreational water quality in near real time (http://www2.epa.gov/exposure-assessment-models/virtual-beach-vb). Models not only provide an element of rapidity; they can serve as a cost saving measure when the availability of staff and laboratory resources makes traditional analytical methods difficult. Predictive models have been developed and are currently at several coastal beach locations in Wisconsin.

In addition to routine, regulatory monitoring, Bay Beach should continue to be monitored to test the efficacy of mitigation measures, once implemented, and/or to gain further insight into environmental conditions/pollution sources impacting water quality if any are outstanding. Specifically, the beach should be monitored no less than once monthly from May to September for the following parameters: *E. coli*, turbidity, microcystin and water temperature. Post-restoration values should be compared to 2012-2014 baseline values as a measure of progress. This type of comparative data, pre and post mitigation, will clearly demonstrate whether the desired water quality improvements have occurred due to mitigation. Depending on when implementation of mitigation measures occurs, annual sanitary surveys may need to be redone to ensure the identified sources of contamination remain relevant.

Developing an Invasive Species Monitoring Plan

Research has indicated a relationship between standing water and persistent contamination by fecal indicator bacteria (FIB). Studies from Racine, WI and elsewhere have also demonstrated a positive correlation between high concentrations of *E. coli* and wetted beach sands. Standing water and wetted beach sands can be caused by rainfall, but also lack of appropriate elevation/grade. Bay Beach has several physical attributes which act to deliver, maintain and subsequently discharge water high in FIB into the embayment. Data also supports the likelihood that the low quality wetlands may be acting as sources of fecal indicator bacteria (rather than a sink) and that the density of *Phragmites* may exacerbate this problem due its ability to block UV penetration (which has a bacteriocidal effect). Literature has brought under question whether wetland areas can act as sources of contamination to nearshore waters. The exposed lakebed below the revetment at Bay Beach is likely to be classified as wetland due to its frequently wetted state. Perpetual standing water has resulted in an environment favorable for the growth and propagation of invasive species such as *Phragmites*. While this was the dominant species noted during the site assessments, it is recommended that a wetland delineation be performed to identify both native and invasive species. Invasive species should be removed and replaced with native varieties whenever feasible. Once invasive species have been removed, it is important to develop a monitoring plan to prevent re-infestation. See merit report for further information on invasive species management.

Developing a Public Notification Plan

Relaying the latest water quality results to the public without delay is an important step in protecting public health. Rapid and effective methods must be chosen and may include: notification at the beach (flags, digital and/or traditional signage), RSS feed from the WI Beach Health website (http://www.wibeaches.us/apex/f?p=BEACH:HOME:1501040814068010), posting on municipal websites, blast emails, radio and TV announcements, newspapers, social media and/or text messages.

Figure 13. WDNR approved water quality signage and beach rules; Blue Harbor Beach, Sheboygan, WI.

The use of color-coded flags, which coordinate with approved signage, increases visibility. WDNR approved signage should be installed at popular public access points, possibly two or three signs depending on size and layout of the beach. The statewide signage procedure calls for the default water quality testing notification sign (green) to be posted continuously (Figure 13). Water quality results signs (yellow or red) must accompany the notification sign when water quality conditions occur that could negatively impact human health. The use of the blue sign is optional.

Once established, the swim zone at Bay Beach should be clearly delineated with physical markers around the perimeter of the swim zone (such as buoys). Signage containing a map of the swim zone should be placed at points of ingress as well as approved WDNR water quality signage. Signage indicating that no lifeguards are present at the beach or offshore swim zone and NOAA water quality hazard (rip current) signage, along with user accessible rescue equipment, should also be placed on the beach.

Developing a Beach Maintenance Plan

Routine beach management should occur on a regular basis, the frequency dictated by the type of activity, amount of use, and need. In addition, a management and control plan should be developed for each hard engineered or naturalized control measure implemented; including stormwater control structures, dune features and wetlands (refer to the examples provided in the merit report). General and site specific recommendations for common beach maintenance activities are provided below:

Stormwater Management: Stormwater runoff from impervious surfaces can contain high levels of bacteria, which is typically attached to fine particles. By sweeping impervious surfaces regularly, the sediment load in runoff is reduced, indirectly reducing bacteria loading into nearshore waters. Routine sweeping along Bay Beach Road and any adjacent parking lots is recommended.

Funding for implementation of stormwater management features should be sought as soon as possible in order to reduce the amount of runoff discharging from the upland areas of the park to the beach and embayment. This should also include an assessment and retrofit, if necessary, of any localized stormwater infrastructure (e.g. the pipe originating in the concrete block structure to the west of the train tracks).

Grooming and Grading of Beach Sands: Beach grooming is an important aspect of beach management. When properly done, grooming will improve aesthetics; reduce health risks associated with hazardous materials (e.g. broken glass, sharp metal objects, etc.); and remove food sources/debris that attract nuisance wildlife. Studies have shown that deep grooming, without compaction of beach sands, promotes desiccation. Fecal indicator bacteria density in beach sands has been shown to be a function of moisture content; therefore deep grooming which exposes bacteria to UV radiation and promotes drying and may reduce the amount of FIB available for transport to nearshore water. Grooming at Bay Beach should occur as needed to remove anthropogenic debris and algae that accumulates onshore. Grooming should not occur in areas containing native vegetation.

Litter Removal: The accumulation of litter decreases aesthetic appeal and can present a hazard to wildlife and human health. Food-related litter also attracts nuisance wildlife (Figure 14a). The use of waste receptacles with liners and covers is recommended to deter wildlife and prevent accidental release (Figure 14b). The presence of litter can be controlled through active removal, public education and enforceable municipal ordinances. A sufficient number of waste receptacles and recycling bins should be placed in the park and on the beach, within easy reach of beach patrons, and emptied in an adequate timeframe depending on usage. The use of solar trash compacters can reduce the frequency with which waste receptacles need to be emptied. Waste receptacles are also a great place to post public information (Figure 14b). Event-based beach clean-ups can be coordinated with volunteer or academic organizations with a service component to help manage the accumulation of debris.

Figure 14 (a): Overflowing open waste receptacle; prone to attracting gulls and scatter windblown debris.
Figure 14 (b): Waste receptacle designed to deter gulls as well as provide public information.

Some amount of debris was present on 100% of sampling events at Bay Beach (2012 - 2014). The majority was anthropogenic in nature and likely deposited by beach patrons and/or washed ashore. The ubiquitous presence of debris suggests that it was rarely removed from the beach or was constantly deposited. Only a single waste receptacle was noted at Bay Beach, located on the western end adjacent to the granite marker. Placement of waste receptacles with liners and lids along walking paths will encourage patrons to properly dispose of their refuse. Designated pickup schedules are needed as well, so that waste receptacles are not filled beyond their capacity. Continual inspection and cleaning of impervious surfaces adjacent to the beach is necessary to contain litter/debris before it is transported to the nearshore water via wind or water.

Managing Algae and Other Natural Debris: While some amount of natural debris accumulating on the beach is to be expected, large amounts of water-washed refuse, animal waste and other items should be promptly removed. Filamentous green algae, such as *Cladophora*, and other aquatic plants may accumulate on the shore, trapping insects and other organisms, which decay to generate a pungent odor that many people mistake as sewage. *Cladophora* may serve as a reservoir for bacteria, some of which may cause illness. Prompt removal of algae stranded on the beach or in the nearshore water will help preserve water quality, improve perceptions of beach cleanliness and reduce disuse due to aesthetic reasons. A permit may be required from the WDNR to remove unwanted vegetation below the high water mark by mechanical means.

Algal mats were often observed at Bay Beach (2013 – 2014). The presence of moderate amounts of algae submerged along the shore was positively correlated with increased concentrations of *E. coli* in surface water. Algae stranded on the shore, while not necessarily contributing to poor water quality, negatively affects beach aesthetics. Therefore, regular observation of the beach is needed and any stranded algal mats should be promptly removed. Mechanical removal, using the beach groomer, may be possible on the fine sandy portions of the beach; manual removal would likely be needed at areas with coarser sediments or denser vegetation. The WI DNR should be consulted prior to any mechanical removal below the ordinary high water mark.

Invasive Species Management and Control: Invasive species can be detrimental to beach ecosystems, impacting native flora, erosion, and hydrology. Invasive plants such as purple loosestrife, *Phragmites*, Blue Dune Lyme Grass, reed canary grass, non-native cattails, Teasel, Eurasian watermilfoil, and frogbit are found at beaches in Wisconsin. Annual beach assessments and site surveys will identify the presence and extent of these terrestrial invaders. Monitoring protocols and early detection is extremely important. Invasive species can quickly establish themselves in coastal areas, becoming difficult or costly to eradicate. See WDNR field guide: (http://dnr.wi.gov/topic/invasives/documents/wi%20inv%20plant%20field%20guide%20web%20version.pdf)

Phragmites was the predominant species at Bay Beach. Eradication efforts, including controlled burns, repeated herbicide applications and manual removal by volunteers and/or City of Green Bay park staff, can reduce the stands by roughly 80% or more. Mechanical removal is not effective as a standalone treatment option because shoots may sprout from underground rhizomes and root fragments within the soil. Mechanical removal, in conjunction with a glyphosate solution application to the stems in late summer (when the shoots transfer carbohydrates to the root system), has been successful. The existing stands east of Bay Beach have been well managed by private home owners; little to no *Phragmites* remains (Figure 15).

Figure 15. Phragmites are well managed on private property adjacent to Bay Beach.

Wildlife Management: Avian species, primarily ring-billed gulls, herring gulls and Canada geese, have been demonstrated to increase bacteria levels in nearshore water. This is further compounded by the fact the resident waterfowl populations are increasing in the Great Lakes Region due to the abundance of food and federal legislation which makes reducing their numbers through hunt, take or capture illegal unless granted a waiver (WI State Statues grants full protection to any bird parts including eggs and nest under the U.S. Federal Migratory Bird Act of 1918). Removing or limiting access to potential food sources in landfills, parking lots, and recreational areas is recommended to deter gull and geese loafing behavior, as are the conspicuous placement of wildlife resistant waste receptacles and city ordinances prohibiting the feeding of wildlife by beach visitors. Naturalized engineering control measures, such as buffer strips and sand dunes, are also effective control measures as they remove the direct line of site that these species prefer. Gull numbers have also been reduced at beaches where human activity has increased as a result of water quality improvements.

Wildlife was frequently observed at Bay Beach; primarily gulls, followed by Canada geese. The most sustainable method to deter gulls from loafing would be through habitat modification and removal of food sources. Habitat modification can be accomplished in conjunction with the proposed stormwater management measures, i.e. the installation of low dune ridges at the interface of the asphalt pathway and beach, extending onto the beach. Additional covered waste receptacles and routine pick-up will reduce the availability of food. Due to potential as a bird flyway, wildlife control methods that are not protective of migratory species, such as the use of Border Collies, distress calls, and static or mechanized birds of prey, should be avoided.

Domestic animal waste can also be a source of pollution to surface water. Therefore, some municipalities have ordinances that prohibit domestic animals, such as dogs, on public bathing beaches. Dog parks have become increasing popular throughout the Great Lakes region and are an alternative that may satisfy the needs of pet owners while preventing direct fecal contamination to beach sediment or nearshore water. If a portion of the beach, or a contiguous area of shoreline, is designated as a dog park, it is important to evaluate the impact of surface runoff on the areas specified for human recreational contact. Even if all pet owners are compliant with dog waste disposal requirements, residual fecal matter can remain in the soil and on vegetation. In these instances, buffer strips or other low impact development options for reducing runoff should be explored.

Dogs were not observed at Bay Beach (observations were confined to early morning collection date/times only). However, it is likely that dogs frequent the asphalt pathway which runs adjacent to and above the beach. It is recommended that dogs should be prohibited from entering the beach portions of Bay Beach. Appropriate signage, designating where pets are allowed/prohibited, pet waste bag dispensers and additional litter bins will help reduce the potential for domestic animal wastes to adversely impact water quality.

Public Education and Outreach

Besides water quality data, other informational/educational signs and enforceable ordinances should be visible at the beach (Figure 16). Examples of other notices include:

- Rip-current warnings (http://www.ripcurrents.noaa.gov/)
- Waste disposal requirements
- Impacts of animals on water quality (Don't feed the birds)
- Dogs on the beach
- Rules of behavior
- Locations of restrooms, showers, lifeguard station, first aid
- Designated sites for swimming and launching boats (no wake zone)
- Stormwater education (http://runoffinfo.uwex.edu/pdf/StormwaterE&O.pdf)
- Lifeguard hours/no lifeguard on duty (swim at your own risk)
- Do not swim if you are sick (http://www.cdc.gov/healthywater/swimming/)

In addition to providing the public with information directly related to their beach experience, broader education and outreach efforts can decrease the need for mitigation measures by promoting personal best management practices in the home. Many communities have encouraged the use of rain barrels, rain gardens and downspouts disconnect programs; some offer financial offsets (http://www.mmsd.com/HowToHelp.aspx). Environmental education at the K -12 levels (http://eeinwisconsin.org/resource/about.aspx?s=83585.0.0.2209) can create lifelong stewardship with students advocating for changes in personal practices at home and into adulthood. Whenever possible, it is desirable to engage the public in restoration activities. Being a participant creates a stakeholder base and instills community pride as citizens see a return on their investment through increased water quality at their beaches.

Figure 16. Examples of informational beach signage.

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