Comprehensive Sanitary Survey Project for High Risk Wisconsin beaches – Northern WI (Lake Superior and Northern Lake Michigan. (Project 1 of 2 Sate-wide)

FINAL REPORT
Submitted: March 30, 2013

GL-00E00587-0

USEPA-GREAT LAKES RESTORATION INITIATIVE PROJECTS

Grant Duration: January 01, 2010 to December 31, 2012

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FINAL REPORT

USEPA-GREAT LAKES RESTORATION INITIATIVE PROJECTS

Funding Opportunity Number, Focus Area, and Program

Funding Opportunity Number: EPA-R5-GL2010-1

Focus Area: Nearshore Health and Nonpoint Source Pollution

Program Area: Beach Sanitary Surveys

Name of Project

Comprehensive Sanitary Survey Project for High Risk Wisconsin beaches – Northern WI (Lake Superior and Northern Lake Michigan. (Project 1 of 2 Sate-wide)

EXECUTIVE SUMMARY

In 2008 13% of Great Lakes beaches exceeded health standards; approximately 90% of those exceedances were attributed to unknown pollution sources. In this project, sanitary surveys were conducted at all impaired beaches [CWA, 303(d)] in WI to identify pollution sources and drive mitigation. This project covered the entire Lake Superior and Lake Michigan shoreline. This was proposal/project #1 of 2 for this integrated and coordinated effort. This effort covered approximately one-half of the State of Wisconsin and coupled with its allied project covered the entire Great Lakes shoreline of Wisconsin.

This study developed a state-wide partnership between State of Wisconsin academic institutions (UW-Oshkosh lead), local municipalities, and researchers (Dr. Julie Kinzelman lead), to evaluate all Wisconsin beaches listed (and proposed) on the 2010 WI DNR 303d list on Lakes Michigan and Superior including those which participated in the 2007 pilot study using the Sanitary Survey form and procedures developed for the Great Lakes by the U.S. EPA. One inland beach in the northern region and one inland beach in the southern region were also selected to assess the transferability of the Great Lakes Beach sanitary survey tool to inland beaches (located on still or flowing waters

This project clearly addressed this goal by not only investigating sources of contamination at numerous locations around Wisconsin, but also began the process of planning for the mitigation of these microbial contamination sources. In years one and two of this project sanitary surveys (SS) were conducted at all Wisconsin beaches listed (and proposed) on the 303d list. Study beaches were located on the northern shore of Lake Michigan and Lake Superior, encompassing both rural and urban settings and various stages within the investigative process (none to fairly extensive monitoring with/without mitigation measures). The US EPA Sanitary Survey tool (routine and annual) were used to conduct site assessments for the purpose of determining probable pollutant sources and suggesting mitigation measures. Data collected as part of the sanitary survey process was entered into and archived within the WI "Beach Health" website such that they were accessible for the construction of predictive models.

In year three of the study, the sanitary survey data was used to assist to develop 4 conceptual beach redesign plans in the northern region to reduce or prevent microbial contamination. This redesign would likely be targeted at pollution mitigation in the form of stormwater treatment, and identified non-point sources. These redesign plans were developed and presented to the local communities. In some cases, through additional GLRI funding (2011 and 2012) these conceptual redesign plans were finalized and mitigation dollars given to the communities for full implementation.

In this project, approximately 15,000 samples were collected over the 3 year study which averaged approximately 750 samples per beach. Sources of contamination were identified, remediation plans were developed, and data generated was suitable for the development of predictive models and/or health-risk approaches to managing surface waters. Water quality improvements and the protection of public health were achieved.

PROJECT SUMMARY

Goals and Objectives

The specific goals and objectives of this project are outlined below in a multi-step process aimed at the identification of microbial contamination and the formulation of recommendations for the mitigation of this contamination:

Step One: Each beach listed on the Wisconsin 303d list, or proposed for listing will be visited. The U.S. EPA Sanitary Survey Protocols will be used to assess each of the selected locations in terms of potential microbial contamination sources. This includes all potential contamination sources adjacent to the beach itself as well as locations inland that may not initially appear to be significant contributors to beach contamination at first glance.

Step Two: A comprehensive assessment of each beach will be conducted using all available GIS and GPS information. Each location identified in Step One and associated potential contamination sources will be ground-truthed so that each site can be accurately placed in GIS inventories.

Step Three: Microbial contamination sources will be identified via preliminary bacterial testing and through Steps One and Two. Following the identification of possible sources at each location, samples for microbial source tracking (MST) may be collected at each beach included in the study. This will be in addition to any regularly beach monitoring data collected in accordance with the BEACH Act. This effort will yield samples to begin characterization pathogen sources in this phase of the project and will allow for a quantifiable measure of the significance of each source on the overall beach water quality. Other measures such as bather counts, microbial enumerations in adjacent watersheds, evaluation of outfalls in proximity to the beach, wind speed and direction, algae, avian counts, water clarity, etc. will also be collected at each sampling event in accordance with the US EPA sanitary survey tool.

Step Four: Data collected during the project will be recorded daily and placed on-line for easy dissemination in a similar manner to data recorded during BEACH Act monitoring. Data entry of routine sanitary survey data will also facilitate predictive modeling efforts under way and proposed by the WI DNR (Adam Mednick, project lead). Additionally, daily beach sanitary survey data from this project may be leveraged by a Madison, WI USGS team (Steve Corsi, project lead) to inform a broad USGS project dealing with pathogens in beach water. Routine reports will be provided to all partner communities and interested parties. Final project reports with all data collected will be provided to any interested group.

Step Five: Beach water movement (current) and depth profiles of each location will be evaluated as part of this project. Additionally, the beach substrate will be characterized at each location in terms of its chemical and physical composition.

Step Six: It is anticipated that during the aforementioned sampling and microbial source identification work that the potential sources of microbial contamination will be both identified and quantified in terms of their overall contribution to beach water contamination. Once the sources are identified, a plan to mitigate the microbial input from each source will be developed in conjunction with community partners at the proposed study sites. While, this project does not have the resources to implement these mitigation plans at all identified sources of microbial contamination it would have the funds to develop conceptual engineering plans for eight selected communities. These plans would have preliminary cost estimates and all general information needed for remediation of the beach location. Once these conceptual engineering plans are received by the communities the local unit of government can gather additional public input and then easily obtain construction ready engineering plans as the next step that are tailored to the specific needs of the community. However, it is anticipated that some mitigation may require little, if any, cost and can be implemented at the local level. At a minimum, affected communities will have a plan to act upon at the local level when resources and interest allow. Should additional funds become available in the future, this project will lay the foundation for remedial plans at all beaches listed as impaired in Wisconsin.

Step Seven: The use of data collected as part of this study may be used as a tool to establish preemptive beach closures when conditions warrant. Based on results from other studies the impact of rain on the microbial water quality may warrant pre-emptive beach closures in some situations. This should be easily identifiable as a result of data collected during this project. The data obtained from this study would also be available to others (e.g. WI DNR) for the development or validation of forecasting and predictive models.

Cooperators Involved

This project brought together researchers from the University of Wisconsin-Oshkosh, UW Parkside, and the City of Racine Health Department, local public health officials and laboratories, local beach managers, Soil and Water Conservation Departments, local conservation groups, and the Wisconsin Department of Natural Resources to focus attention on a serious water quality issue - microbial contamination at beaches.

MAJOR ACCOMPLISMENTS

Nature and Extent of Project

This project followed the aforementioned stepwise approach objectives to assess 20 beaches in northern Wisconsin (northern Lake Michigan – 15 beaches and Lake Superior – 5 beaches). Each beach received an initial site assessment to identify potential pollution sources, a devised sampling plan unique to each beach, 3 years of data collection using the sanitary survey tool, complete statistical analysis to identify correlations between potential sources and *E. coli* at the beach, and conclusions based on the data collected and future recommendations. Four beaches received conceptual redesign plans based on mitigating potential pollution sources identified by the sanitary survey tool. Public meetings were held in all communities where GLRI sanitary survey work was being conducted to inform the general public and its officials of the progress and share data of their select beaches. Several beaches evaluated in this current GLRI FY10 were also part of continuing GLRI projects which allowed for additional funding to develop preliminary and final redesign plans and even in some cases full implementation of these plans.

Methodologies Employed

Methodologies were followed according to the previously approved Quality Assurance Project Plan (Appendix A). In summary, our program objectives included the following:

a) Beach Assessment and Identifying Possible Sources of Contamination
b) Sampling Design, Methods Assessment and Procedures
c) Monitoring Report Submission
d) Begin Development of Beach Forecasting Models
e) Develop complete redesigns of eight beaches (4 northern and 4 southern) using data gathered from this project and develop complete engineering plans for the local municipality.

Significant Events and Experiences

In this study, several milestones were achieved throughout each step of the process from data collection to conceptual redesign plans completed.

- 20 beaches were fully assessed and potential pollution sources identified
- Recommendations for future monitoring were made
- Conceptual redesign plans completed for 4 beaches in the northern region
- Several public meetings held to provide updates on data collection and analyses, and to obtain feedback on beaches with conceptual redesign plans.
- Assess an inland beach using sanitary surveys to compare Great Lake tools to inland beaches.

ANALYSIS OF DATA, CONCLUSIONS RECOMMENDATIONS

INITIAL SITE ASSESSMENT

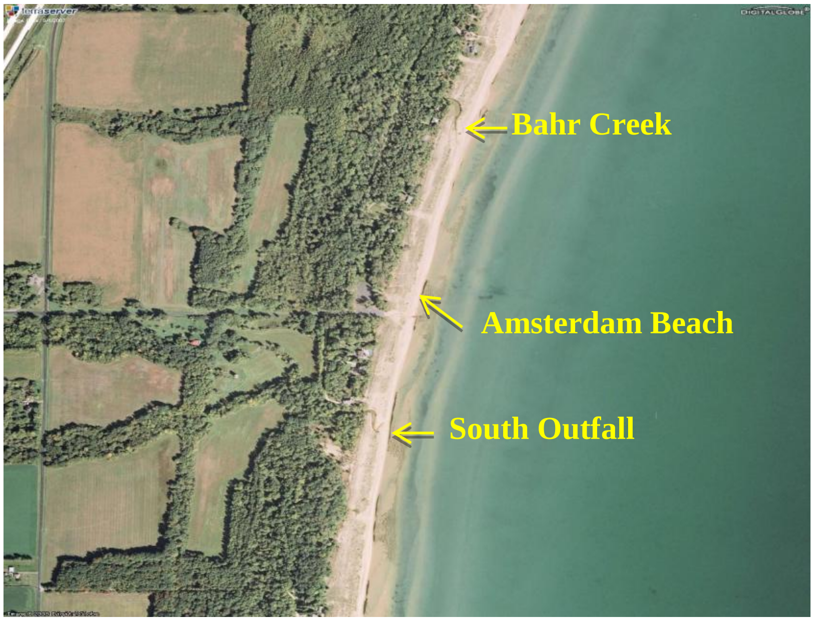


Photo 1: Aerial photo of Amsterdam Beach, including Bahr Creek and the south outfall.

Preliminary Site Assessment:
Amsterdam Beach is a rural beach in a moderately residential area.

Surrounding Area. Amsterdam Beach is located in southern Sheboygan County in a rural area with limited public access. Several houses line the area upshore of the beach. The beach extends for over half a mile, with a sizeable tributary (Bahr Creek) to the north, and a stormwater outfall and small boat launch to the south. The surrounding area is primarily rural with some residential houses and agricultural influences.

Physical Attributes. The foreshore area is comprised of medium sand (Mean Grain Size = 0.01148 inches). Submerged sediments are formed primarily of fine sand. The beach is naturalized with a significant slope, dune grass in the upshore region of the beach, and a small swashzone.

- Length of beach: 351 feet
- Average width of beach: 36 feet

Potential Pollution Sources. On the day of the site assessment, there were several gulls in the swashzone of the beach. Birds such as these deposit fecal material on the beach and in the nearshore water. Bahr Creek, which flows into Lake Michigan to the north of beach, may also be a potential pollution source since it is influenced by agricultural inputs. The outfall south of the beach could be another contamination source, especially following significant rain events.

Photo 2: Boat launch located at public access on the south end of Amsterdam Beach.

Photo 3: Looking north over the naturalized Amsterdam Beach

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 at Amsterdam Beach three times a week in 2010 and 2011, and once a week in 2012. 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 longshore 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. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. The outfalls identified at Amsterdam Beach were Bahr Creek (north) and a large stormwater outfall (south). Sand samples were also collected up to three times a week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 1: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Amsterdam Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2005	1	13	8%	160
2006	9	20	45%	588.45
2007	6	24	25%	205.25
2008	0	14	0%	40.6
2009	2	19	11%	75.7
2010	1	15	7%	63.5
2011	2	37	5%	72.7
2012	1	13	8%	44.6
Totals	**22**	**155**	**14%**	**156.4**

Table 2: Summary of total *E. coli* samples collected over the duration of the study at Amsterdam Beach.

Summary of *E. coli* Samples Collected (2010-2012) Amsterdam Beach					
Year	Routine Monitoring (Center 24")	Spatial Samples	Sand Samples	Investigative Samples (Tributaries, outfalls, etc.)	Total *E. coli* Samples per Year
2010	14	111	88	21	234
2011	28	125	81	44	278
2012	13	0	0	1	14
Total	**55**	**236**	**169**	**66**	**526**

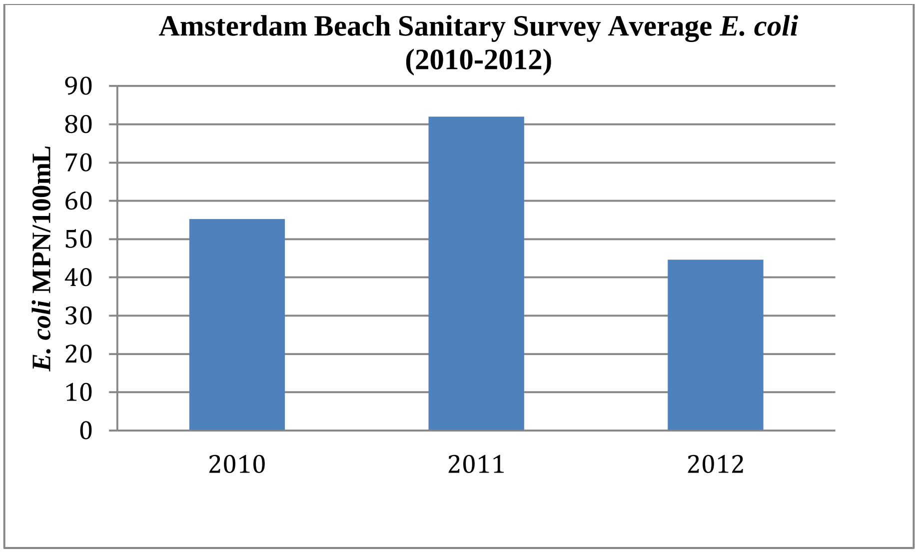


Figure 1: Average *E. coli* (MPN/100mL) at Amsterdam Beach in Sheboygan, Wisconsin, from 2010-2012.

Table 3: Mean Seasonal Results 2010-2012

Amsterdam Beach Mean Results–2010-2012								
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Bahr Creek 1 *E. coli* (MPN/100mL)	Bahr Creek 2 *E. coli* (MPN/100mL)	South Outfall *E. coli* (MPN/100mL)
60.7	72.2	16.5	4.12	27.41	5	624.4	266.1	849.7
n=55	n=9	n=71	n=59	n=73	n=43	n=34	n=9	n=18

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

Amsterdam Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0008	0.0002	0.5851
Wind Speed (mph)	0.0051	0.0004	0.2857
Water Temperature (°C)	0.0532	0.0127	0.3166
Air Temperature (°C)	0.0262	0.0793	0.0073
Turbidity (NTU)	0.1256	0.0626	0.0001
Wave Height (ft)	0.1709	0.3248	0.3894
Within 24hr Rain (cm)	0.0049	0.0051	0.0281
Algae (1-3 scale)	x	0.0042	0.0649
Gulls (#)	0.0052	0.0344	x
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	0.2483	0.0793	0.0156
Bathers In Water (#)	0.2175	0.0384	x

Longshore Current Speed (cm/sec)	0.5215	0.3492	0.2687
Longshore Current Direction (°)	0.0123	0.0077	0.1205
Tributaries/Outfalls *E. coli* - Bahr Creek 1	0.0053	0.0510	x
Tributaries/Outfalls *E. coli* - Bahr Creek 2	x	0.2212	x
Tributaries/Outfalls *E. coli* - South Outfall	x	0.3902	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Amsterdam Beach has been monitored routinely through the BEACH Act since 2005 and was previously on the impaired waters (EPA 303d) list. The historical water quality (Table 1) shows 2006 as the only year where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). A total of 526 samples were collected at Amsterdam Beach from 2010-2012 (2010 n=234, 2011 n=278, 2012 n=14) as shown in Table 2. *E. coli* concentrations during the GLRI study from 2010-2012 did not exceed water quality standards (Figure 1).

There were few potential pollution sources identified in the initial site assessment including gull populations, stormwater, and tributary influence (Bahr Creek). Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of the beach at 24 inches. Parameters with the highest R^2 value at Amsterdam Beach included wind direction, turbidity, wave height, gull populations, and outfall contribution (Table 3). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations. In addition, the mean *E. coli* concentrations over all three sample seasons for tributaries/outfalls exceeded water quality standards (Table 4), indicating a potential pollution source for Amsterdam Beach.

Additional statistical analyses (SYSTAT v.11) were conducted to evaluate average *E. coli* concentrations at three transects at Amsterdam Beach in order to assess potential tributary and outfall input and its effect on *E. coli* concentrations. An ANOVA (Estimate Model) was used to evaluate mean differences between the three transects (left, center, right) and calculate a $p=0.722$ ($p>0.05$). This demonstrates that there may be little-to-no influence from Bahr Creek or the adjacent south outfall on *E. coli* concentrations.

RECOMMENDATIONS AND FUTURE WORK

Amsterdam Beach was not chosen to receive preliminary redesign plans due to little stormwater or tributary influence, low *E. coli* levels in the nearshore waters, and no other readily identifiable sources. This beach exhibits a naturalized upshore area with healthy dune grass, limited invasive species, and nourished medium-grained sand. Future recommendations for this beach include low priority monitoring once a week, observing for significant increases in *E. coli* concentrations, and reevaluation when necessary.

Site: Barker's Island Inner Beach –Superior, Wisconsin

INITIAL SITE ASSESSMENT

Photo 4: Aerial photo of Barker's Island Inner in Superior, Wisconsin, looking at Barker's Island Marina.

Preliminary Site Assessment:
Barker's Island Inner is a municipal beach located in Superior, WI.

Surrounding Area. The region surrounding the beach is largely residential and industrial. The beach is located on the harbor side of Barker's Island where there is limited circulation. There are flow-through stormwater drains to the west of the beach. There are also large municipal stormwater drains on the south side of the harbor. There is a designated swimming area (Photo 4), trash receptacles, and a sitting area at the beach.

Physical Attributes. The foreshore area is comprised of fine sand and silt (Mean Grain Size = 0.00946 inches). Submerged sediments are also fine sand and silt. The initial assessment showed litter and other woody debris on the beach. Sheet flow streams were present running from the walkway lining the upshore beach area into the nearshore water.

- Length of beach: 135 feet
- Average width of beach: 19 feet

Potential Pollution Sources. Trash, debris, and sheet flow runoff from the above walkway were found on the beach on the day of the assessment. The profile of the beach is low and flat, with continuously saturated sand. In addition, municipal stormwater is a potential source of fecal bacteria and can be a large contributor to high *E. coli* concentrations, especially after a significant rain event (>0.5 in). The adjacent marina has extensive boat traffic which could also contribute pollution to the beach.

Photo 5: Barker's Island Inner Beach looking southward from beachfront.

Photo 6: Looking outward at Barker's Island Inner Beach as a whole.

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 Barker's Island Inner Beach three times a week from 2010 to 2012. 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 longshore 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. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There were no outfalls identified at Barker's Island Inner Beach that were able to be sampled. Sand samples were collected up to three times a week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 5: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Barker's Island Inner Beach Historical Data				
Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	2	40	5%	87.7
2004	2	30	7%	172.0
2005	19	44	43%	527.2
2006	5	31	16%	127.6
2007	3	28	11%	83.8
2008	6	29	21%	198.8
2009	3	28	11%	92.8
2010	4	38	11%	91.5
2011	4	38	11%	86.2
2012	12	48	25%	301.6
Totals	**60**	**354**	**17%**	**176.9**

Table 6: Summary of total *E. coli* samples collected over the duration of the study at Barker's Island Inner Beach.

Summary of *E. coli* Samples Collected (2010-2012) Barker's Island Inner Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	15	125	126	0	266
2011	32	128	135	0	295
2012	48	0	81	0	129
Total	95	253	342	0	690

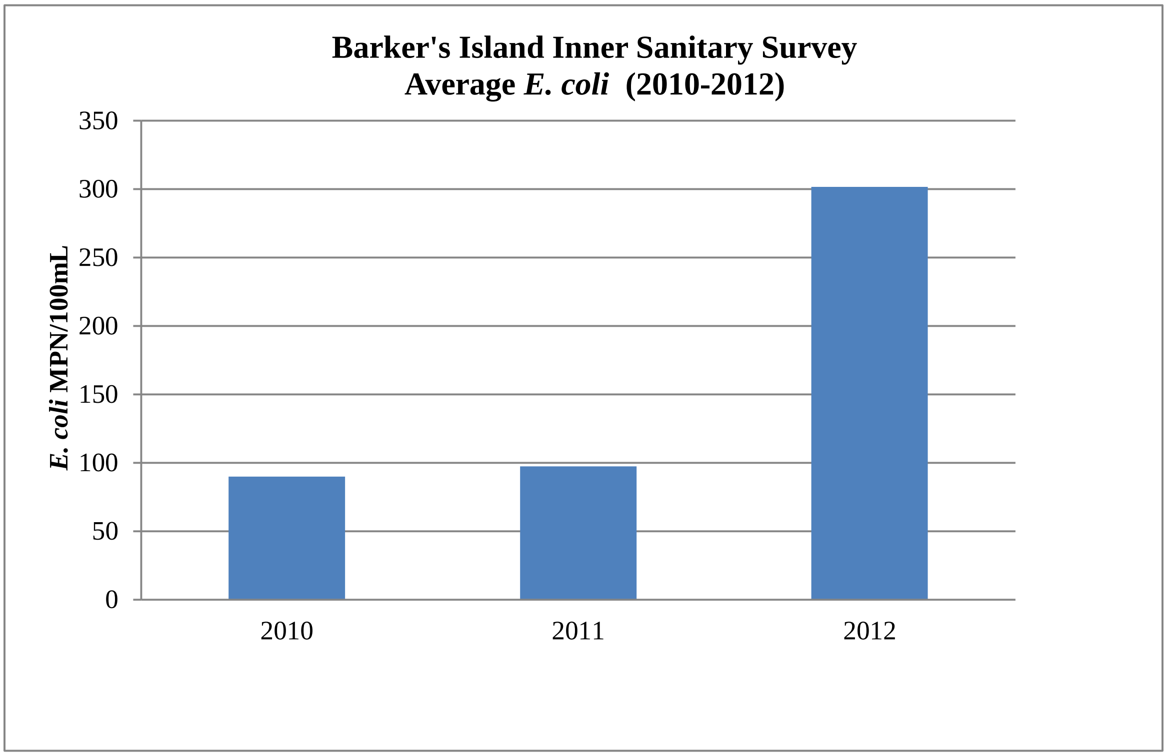


Figure 2: Average *E. coli* (MPN/100mL) at Barker's Island Inner Beach in Superior, Wisconsin (2010-2012).

Table 7: Mean Seasonal Results 2010-2012

Barker's Island Inner Beach Mean Results–2010-2012					
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)
196.1	509.2	21.5	8.3	1.2	0.75
n= 95	n= 37	n= 115	n= 96	n= 113	n= 116

Table 8: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Barkers Island Inner Beach	R^2 Value		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0489	0.0023	0.0002
Wind Speed (mph)	0.0026	0.0720	0.0013
Water Temperature (°C)	0.1467	0.0001	0.0016
Air Temperature (°C)	0.1590	0.0000	0.0003
Turbidity (NTU)	0.0143	0.0321	0.0177
Wave Height (ft)	0.0458	0.0009	0.0007
Within 24hr Rain (cm)	0.3053	0.0002	0.1245
Algae (1-3 scale)	x	x	0.0036
Gulls (#)	x	x	x
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	x	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.0000	0.0613	0.0171
Longshore Current Direction (°)	x	0.0026	x
Sand *E. coli* Swashzone (MPN/g) Same Day	Over all 3 years: 0.0003 (n=21)		
Sand *E. coli* Swashzone (MPN/g) 24 hrs	Over all 3 years: 0.0442 (n=21)		
Sand *E. coli* Swashzone (MPN/g) 48 hrs	Over all 3 years: 0.0045 (n=21)		

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Barker's Island Inner Beach has been monitored routinely through the BEACH Act since 2003 and was on the impaired waters (EPA 303d) list from 2006 to 2011. The historical water quality (Table 5) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). A total of 690 samples were collected at Barker's Island Inner Beach from 2010-2012 (2010 n=266, 2011 n=295, 2012 n=129) as shown in Table 6. *E. coli* concentrations exceeded water quality standards in 2012 (Figure 2) during the GLRI study from 2010-2012. There were a few potential pollution sources identified in the initial site assessment, including trash and debris, municipal stormwater, the nearby marina, and sheet flow runoff from the adjacent walkway. Sand averages over the three-year study were elevated (509.2 MPN/g) when compared to typical water quality standards (235 MPN/100mL), which could also be a possible pollution source at Barker's Island Inner Beach (Table 7).

Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of the beach at 24 inches (Table 8). The parameter with the highest R^2 value at Barker's Island Inner Beach was rainfall within 24 hours. This could be expected due to the large amount of stormwater that is drained into the harbor directly across from the beach. There is also limited circulation due to the marina and bridge located on either side of the beach.

RECOMMENDATIONS AND FUTURE WORK

Barker's Island Inner Beach was not recommended for a redesign plan in the GLRI FY10 funding. The usage of this beach is very low and the infrastructure changes would be extremely expensive. That being said, there is a great deal of potential for this beach to be an attraction for tourists. If funding would become available, this beach could be mitigated in stages with intention to provide beach nourishment, modification of the walkway to decrease sheet flow, infiltration beds, and re-engineering of the stormwater infrastructure. In the meantime, routine monitoring should continue to adequately inform the public of current water quality at Barker's Island Inner Beach.

Site: City of Kewaunee Beach (Selner Park) – Kewaunee, Wisconsin

INITIAL SITE ASSESSMENT

Photo 7: Aerial photo of City of Kewaunee Beach (Selner Park) in Kewaunee.

Preliminary Site Assessment:
Selner Park Beach is the official City of Kewaunee public bathing beach.

Surrounding Area. There is parkland and single-family beachfront residential property to the west, Pioneer Park and a breakwater to the north, and residential property to the south. Pioneer Park is located approximately 100 yards north of City of Kewaunee Beach (Selner Park) and is treated essentially as one beach.

Physical Attributes. The foreshore area is comprised of medium sand with a few pebbles (Mean Grain Size = 0.024036 inches). Submerged sediments are also formed of fine sand and pebbles. Significant algal biomass, extending 6 to 10 feet into the nearshore waters of Lake Michigan to the north of the beach, was observed during the initial site survey. Algal biomass was also present to a lesser degree adjacent to Selner Park beach (note green-tinged water in Photo 7). There is a moderately-defined berm crest and a well-developed small dune system in the back beach area. A large sand bar is located 100 feet offshore running parallel to the beach which could act to retain algae.

- Length of beach: 251 feet
- Average width of beach: 160 feet

Potential Pollution Sources. No animals were seen during the initial site survey, though there was evidence of gulls. A small amount of litter was observed. A paved parking area is situated on a bluff above the beach, which likely drains to the beach proper; the turf grass likely does not provide adequate infiltration (Photo 8). Additional surface runoff is likely contributed from the paved surfaces located in and adjacent to Selner Park to the north (Photo 9). There is also a municipal stormwater infrastructure discharging in the back beach area.

Photo 8: Looking south at the naturalized back beach area of City of Kewaunee Beach (Selner Park).

Photo 9: Looking east over the north end of the City of Kewaunee Beach (Selner Park) from the top of the bluff, west of the parking lot.

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 the City of Kewaunee (Selner Park) three times a week in 2010 and 2011 and once a week in 2012. 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 longshore 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. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. The outfall identified at City of Kewaunee Beach (Selner Park) was a stormwater outfall upshore near the adjacent parking lot. Sand samples were also collected up to three times a week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 9: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

City of Kewaunee (Selner Park) Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	7	26	27%	178.4
2004	4	19	21%	180.3
2005	3	17	18%	431.0
2006	7	21	33%	398.9
2007	6	21	29%	480.4
2008	3	17	18%	335.4
2009	0	13	0%	51.5
2010	13	53	25%	304.7
2011	15	47	32%	329.1
2012	1	15	7%	150.1
Totals	**59**	**249**	**24%**	**284.0**

Table 10: Summary of total *E. coli* samples collected over the duration of the study at City of Kewaunee Beach (Selner Park).

Summary of *E. coli* Samples Collected (2010-2012) City of Kewaunee Beach (Selner Park)					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	17	136	135	0	288
2011	31	144	99	2	276
2012	15	0	0	0	15
Total	63	280	234	2	579

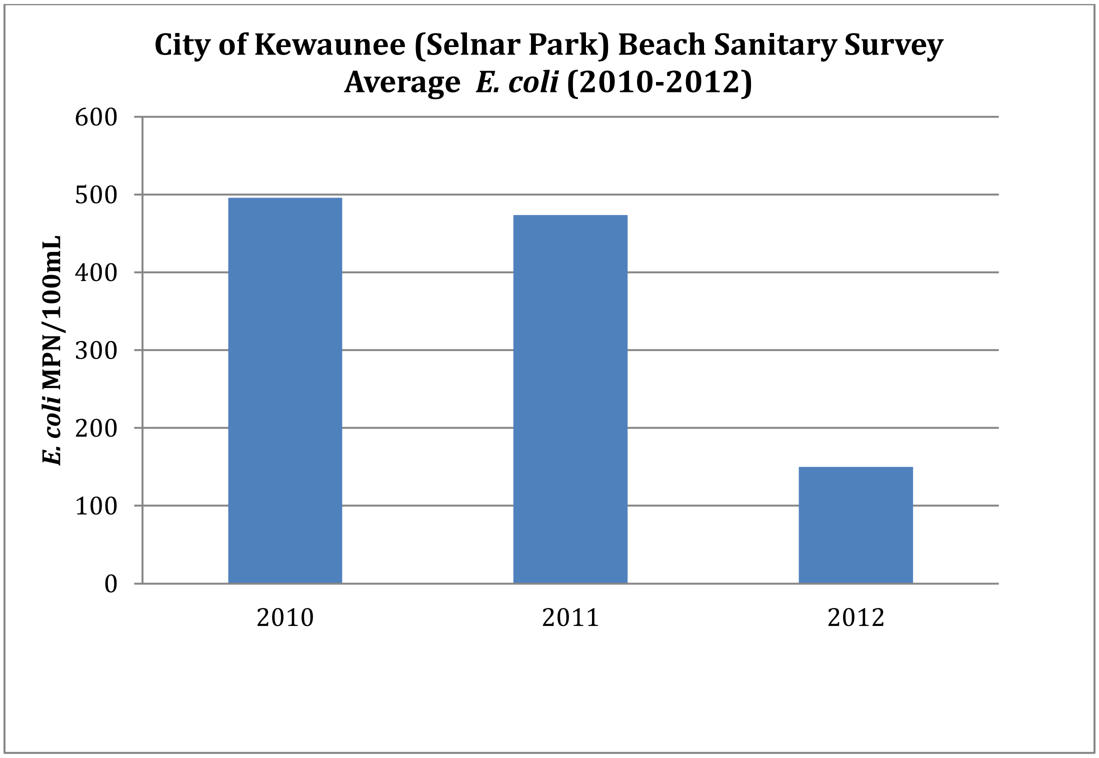


Figure 3: Average *E. coli* (MPN/100mL) at City of Kewaunee (Selner Park) Beach in Kewaunee, Wisconsin, from 2010-2012.

Table 11: Mean Seasonal Results 2010-2012

City of Kewaunee (Selner Park) Beach Mean Results–2010-2012						
E. coli Center 24" (MPN/100mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Outfall 1 *E. coli* (MPN/100mL)
302.6	171.8	17.8	38.4	6	2	1123.5
n=64	n=26	n=89	n=87	n=89	n=88	n=2

Table 12: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

City of Kewanuee (Selner Park) Beach	R^2 Value		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0838	0.2781	0.0187
Wind Speed (mph)	0.0194	0.0242	0.1395
Water Temperature (°C)	0.2764	0.0041	0.0623
Air Temperature (°C)	0.0600	0.1365	0.0919
Turbidity (NTU)	0.0894	0.4709	0.0343
Wave Height (ft)	0.0035	0.2848	0.0661
Within 24hr Rain (cm)	0.0208	0.1061	0.1491
Algae (1-3 scale)	0.2094	0.2361	0.0546
Gulls (#)	0.0158	x	0.1070
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	x	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.0635	0.3083	0.0376
Longshore Current Direction (°)	0.1230	0.0130	0.0030
Tributaries/Outfalls *E. coli* – Outfall 1	x	x	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

City of Kewaunee (Selner Park) Beach has been monitored routinely through the BEACH Act since 2003 and has been on the impaired waters (EPA 303d) list since 2006. The historical water quality (Table 9) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). The average *E. coli* concentration from 2003 to 2012 exceeds the advisory standard of 235 MPN/100mL. A total of 579 samples were collected at City of Kewaunee (Selnar Park) from 2010-2012 through the GLRI project (2010 n=288, 2011 n=276, 2012 n=15) as shown in Table 10. *E. coli* concentrations exceeded water quality standards in 2010-2011 (Figure 3) during the GLRI study from 2010-2012.

There were a few potential pollution sources identified in the initial site assessment, including gull populations, stormwater infrastructure in the back beach, and sheet flow run off from the adjacent parking lot. Over all three years of data collection, the stormwater outfall averaged 1123.5 *E. coli* MPN/100mL (n=2) (Table 11). Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at City of Kewaunee (Selner Park) Beach included wind direction, turbidity, wave height, algae, and longshore current speed (Table 12). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

The physical impacts determined by significant correlation can be expected due to high algal concentrations at City of Kewanee Beach, which increase turbidity; wave action drives the algae onto the beach front, and therefore allows for *E. coli* attachment to particulate matter-in this case, algae in the nearshore water.

Additional statistical analyses (SYSTAT v.11) were also conducted to evaluate average *E. coli* concentrations at three depths at City of Kewaunee Beach in order to assess the impact of algae (*Cladophora*) in nearshore water on *E. coli* concentrations. The difference between *E. coli* concentrations at 12 inches, 24 inches, and 48 inches were not significant (ANOVA $p=0.144$ where $p<0.05$). These results may be due to homogenous mixing of the algae due to wave action extending outward greater than 48 inches in depth.

RECOMMENDATIONS AND FUTURE WORK

The City of Kewaunee (Selner Park) Beach was not recommended for a redesign plan in the GLRI FY10 funding. However, through additional GLRI funding from UW Oshkosh in 2012, and with assistance from the Bay-Lake Regional Planning Commission in 2011, a preliminary design plan was developed to mitigate some of the aforementioned pollution sources. The design plan integrates an infiltration trench/rain garden at the east edge of the parking lot to absorb sheet flow runoff from the adjacent parking lot. Dune grass will also be planted upshore of the beach to hold nourished sand in place and further infiltration of stormwater. A public meeting will be held in Kewaunee in 2013 to discuss the preliminary redesign plan with the local community. Once the preliminary plan is approved by the community and its officials, final plans will be drafted and handed over to the community. Bay-Lake Regional Planning Commission (with the help of UW Oshkosh) has recently provided mitigation dollars to the City of Kewaunee for construction at City of Kewaunee Beach (Selner Park) to begin in Spring of 2013. Once the beach is fully reconstructed, sampling should be conducted in the following years to evaluate if the mitigation was effective.

Site: Crescent Beach – Algoma, Wisconsin

INITIAL SITE ASSESSMENT

Photo 10: Aerial photo of Crescent Beach, marina, and Ahnapee River.

Preliminary Site Assessment:
Crescent Beach is a municipal beach.

Surrounding Area. Crescent Park Beach is located at the base of a small bluff. It is bounded on the north side by a jetty and on the west side by parkland. A major roadway and multi-purpose trail are above and run parallel to the beach.

Physical Attributes. The foreshore area is comprised of medium sand with some pebbles and cobbles (Mean Grain Size = 0.00835 inches). Submerged sediments are formed primarily of fine sand. Significant amounts of algae and macrophytes were observed, especially at the junction of the beach and the breakwater. There was a wide sand bar located 100 to 200 feet offshore running parallel to the entire beach, which could enable retention of algae. The berm crest was eroded in places. The beach also lacked sufficient elevation to promote adequate drainage in some areas; the drainage at the narrow end to the north was better than the wide and flat end to the south. Multiple stormwater outfalls exit onto the bluff. The back beach area has moderate-to-heavy vegetation, but the amount of turf grass and hard-packed earth may act as a conduit for landscape runoff. Beach sand is groomed twice a week during the summer months.

- Length of beach: 2632 feet
- Average width of beach: 101 feet

Potential Pollution Sources. A large flock of loafing gulls was observed at this site (Photo 11). Coyote decoys were placed to deter this behavior but appeared to have little effect. Low amounts of litter were observed on the beach proper, and there was a significant accumulation of litter, algae, and numerous rotting fish at the junction of the beach and the jetty (Photo 2). The beach has multiple stormwater outfalls; each a potential source of pollution (Photo 2). Due its location, this beach may also be influenced by direct surface runoff from the surrounding parkland and impervious surfaces. Excessive algae present at this location will adversely impact water quality, especially on the north end where algae is being trapped by the adjacent breakwall.

Photo 11: Looking north over groomed sand at a loafing gull flock at Crescent Beach in Algoma.

Photo 12: Looking northeast of Crescent Beach in Algoma toward the break-wall. Accumulation of Cladophora can be seen at the base. Northern stormwater discharge is visible at the bottom of the photo.

Photo 13: Looking north toward the southern stormwater outfall at Crescent Beach in the City of Algoma.

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 three times a week from 2010 to 2012 at Crescent Beach. 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 longshore 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. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. The outfalls identified at Crescent Beach include the Ahnapee River to the north and six stormwater outfalls evenly spaced over the entire beach. Sand samples were also collected up to three times a week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 13: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Crescent Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	13	47	28%	354.2
2004	16	37	43%	656.6
2005	12	35	34%	483.2
2006	11	35	31%	258.5
2007	13	39	33%	383.6
2008	2	28	7%	226.6
2009	4	31	13%	97.2
2010	8	52	15%	144.0
2011	9	33	27%	361.0
2012	5	47	11%	191.6
Totals	**93**	**384**	**24%**	**315.7**

Table 14: Summary of total *E. coli* samples collected over the duration of the study at Crescent Beach.

Summary of *E. coli* Samples Collected (2010-2012) Crescent Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	18	144	126	0	288
2011	29	180	91	96	396
2012	47	437	63	44	591
Total	94	761	280	140	1275

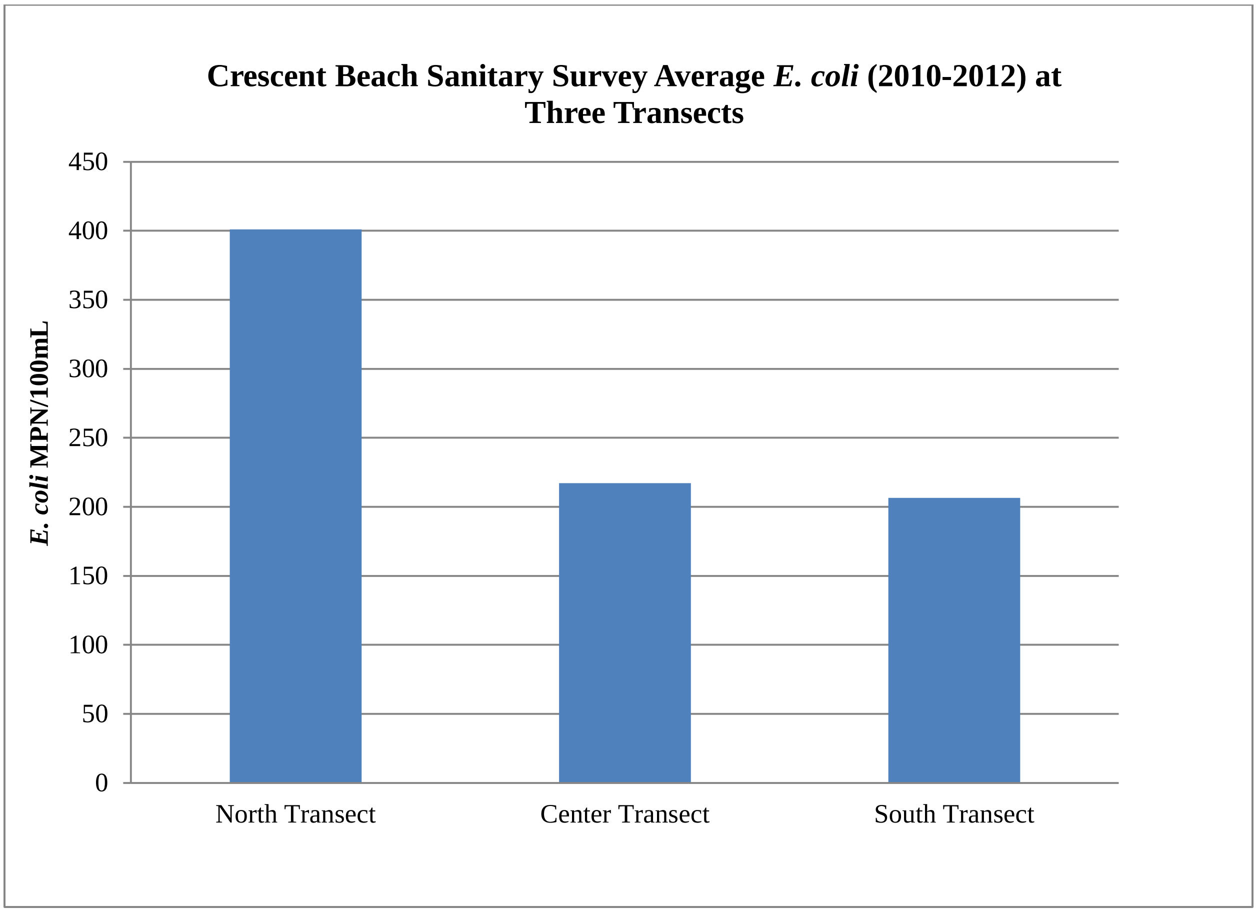


Figure 4: Average *E. coli* (MPN/100mL) at Crescent Beach in Algoma, Wisconsin, from 2010-2012 (ANOVA p=0.002).

Table 15: Mean Seasonal Results 2010-2012

Crescent Beach Mean Results– 2010-2012							
E. coli Center 24" (MPN/100mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Pipe 1 Outfall *E. coli* (MPN/100mL)	Pipe 6 Outfall *E. coli* (MPN/100mL)
236.3	25.1	17.7	12.8	100.3	3.7	1106.8	606.6
n=95	n=31	n=120	n=118	n=120	n=120	n=8	n=56

Table 16: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Crescent Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.3477	0.0473	0.1029
Wind Speed (mph)	0.0020	0.0481	0.0059
Water Temperature (°C)	0.0162	0.0056	0.0835
Air Temperature (°C)	0.0149	0.1969	0.0032
Turbidity (NTU)	0.2348	0.1556	0.0567
Wave Height (ft)	0.1984	0.1991	0.2520
Within 24hr Rain (cm)	0.0116	0.0059	0.0294
Algae (1-3 scale)	0.0006	0.0975	0.0128
Gulls (#)	0.0171	0.2724	0.0344
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	0.0007	0.0041
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.0358	0.1358	0.0876
Longshore Current Direction (°)	0.0744	0.0045	0.0003
Tributaries/Outfalls *E. coli* Pipe 1	x	0.0098	x
Tributaries/Outfalls *E. coli* Pipe 2	x	0.0010	x
Tributaries/Outfalls *E. coli* Pipe 3	x	0	x
Tributaries/Outfalls *E. coli* Pipe 4	x	0.0008	x
Tributaries/Outfalls *E. coli* Pipe 5	x	x	x
Tributaries/Outfalls *E. coli* Pipe 6	x	x	0.2105

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Crescent Beach has been on the impaired waters (EPA 303d) list since 2006. Crescent Beach was recently removed from the 303d Impaired Waters List in 2012. The historical water quality (Table 13) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). A total of 1275 samples were collected at Crescent Beach from 2010 to 2012 through the GLRI project (2010 n=288, 2011 n=396, 2012 n=591) as shown in

Table 14. Average *E. coli* concentrations (2010-2012) collected from the north transect exceeded water quality standards (Figure 4).

There were several potential pollution sources identified in the initial site assessment, including stagnant algae mats (northern region), extensive gull and geese populations, stormwater (six outfalls), and surface runoff from impervious surfaces in conjunction with a low, flat, sand-starved beach. The average *E. coli* from Pipe 1 located on the north end of the beach was 1106.8 (n=8). The average *E. coli* from Pipe 6 on the south end of the beach was 606.6 (n=56) (Table 15). Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Crescent Beach include wind direction, turbidity, wave height, gull populations, and tributary contribution (Table 16). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

Additional statistical analyses (SYSTAT v.11) were conducted at Crescent Beach to evaluate average *E. coli* concentrations at three transects in order to assess the possibility of moving the designated swimming area from the north end of the beach to the south end. An ANOVA (Estimate Model) was used in conjunction with a Post Hoc Tukey Test between the three transects and a $p=0.002$ was calculated ($p<0.05$). The Tukey test revealed that the *E. coli* at the north transect was significantly higher than the center and south transects, which was expected. The stagnant algal mats, which are trapped by the adjacent breakwall and nearby stormwater drain, have a significant impact on *E. coli* concentrations within this transect.

A separate grant awarded by Wisconsin Coastal Management Program (WCMP) assessed the adjacent Ahnapee River for *E. coli*, total phosphorus, and if its inputs to Lake Michigan affect water quality at Crescent Beach. At this time, *E. coli* and total phosphorus are well below regulatory limits at the mouth of the river and show little to no impact to *E. coli* concentrations at Crescent Beach (further results given upon request).

RECOMMENDATIONS AND FUTURE WORK

Crescent Beach was not recommended for a redesign plan in the GLRI FY10 funding. However, through additional GLRI funding from UW Oshkosh in 2012, and with assistance from the Bay-Lake Regional Planning Commission in 2011, a preliminary design plan was developed to mitigate the aforementioned pollution sources. The design plan addresses stormwater infiltration at all six stormwater drains, beach nourishment, and movement of the swimming beach from the north end to the south end of the beach. Unfortunately, the large breakwall on the north end of the beach is unable to be removed due to cost and extent of the infrastructure. By moving the swimming beach area south this addresses the extensive algae at that end of the beach. A meeting was held with the Algoma City Council where the preliminary design plan was approved and a plan for mitigation at Crescent Beach was also put into place. The final design plans will be presented in the spring of 2013 with construction beginning in the spring of 2014 at the latest. Once the beach is fully reconstructed, sampling should be conducted in the following years to evaluate if the mitigation was effective. UW Oshkosh applied for funding through the UW Sea Grant, but has not been notified if funding will be awarded at this time.

Site: Fisher Park Beach – Manitowoc, Wisconsin

INITIAL SITE ASSESSMENT

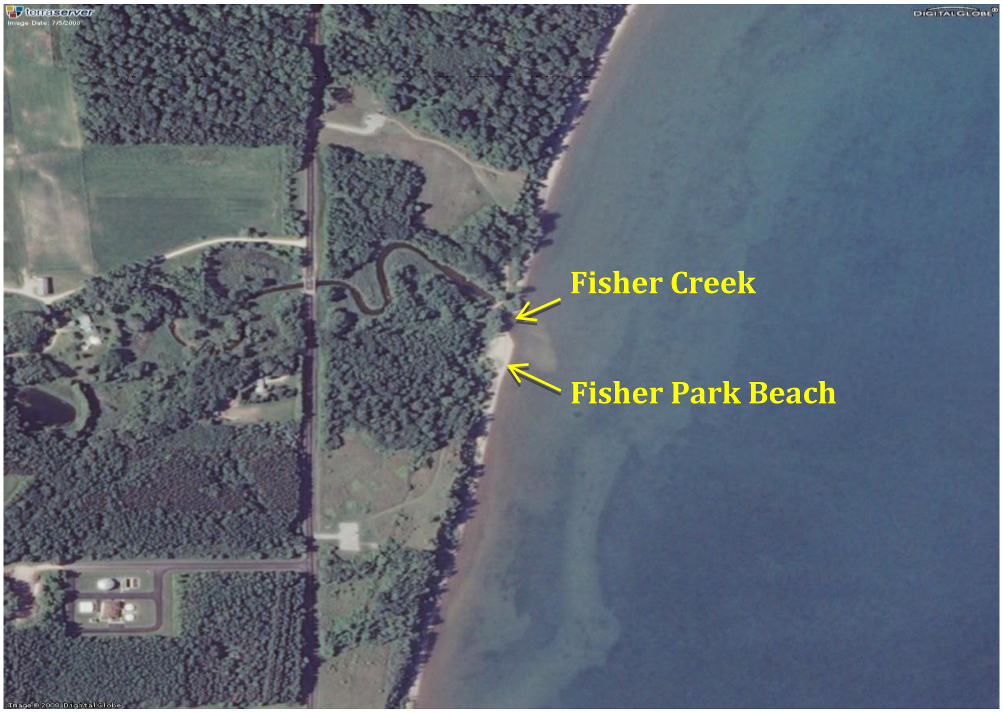


Photo 14: Aerial photo of Fisher Park Beach in Manitowoc, Wisconsin.

Preliminary Site Assessment:
Fisher Park Beach is located in Manitowoc County south of the City of Manitowoc.

Surrounding Area. Fisher Park is located in southern Manitowoc County. The surrounding area is comprised mostly of agricultural land with some residential properties. The beach is located at the bottom of a bluff with a park located on the top with public access to the beach on both the north and south ends of the park.

Physical Attributes. The foreshore area is comprised of medium sand with a few pebbles and larger cobble (Mean Grain Size = 0.0102 inches). Submerged sediments are comprised of cobble and course sand. Significant algal biomass, extending 6 to 10 feet into the nearshore waters of Lake Michigan to the north of the beach, was observed on the initial site survey. The mouth of Fisher Creek flows on the north end of the beach. Woody debris, zebra mussel shells, and some litter were observed on the upshore area of the beach.

- Length of beach: 637 feet
- Average width of beach: 31 feet

Potential Pollution Sources. Fisher Creek, directly adjacent to Fisher Park Beach, has the potential to contribute *E. coli* and phosphorus to the nearshore water. Large algal mats may also harbor fecal bacteria when the mats are stagnant for several days. Gulls were observed on the day of the survey and serve as another potential pollution source.

Photo 15: Looking north from the public access to Fisher Park Beach in Manitowoc, WI.

Photo 16: Looking South from the public access of Fisher Park Beach in Manitowoc, WI.

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 three times a week from 2010 to 2012 at Fisher Park Beach. 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 longshore 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. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. The outfalls identified at Fisher Park Beach include Fisher Creek, which was sampled at multiple points upstream (north). Sand samples were also collected up to three times a week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 17: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Fisher Park Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	12	24	50%	303.3
2004	11	25	44%	361.6
2005	2	18	11%	84.4
2006	6	16	38%	682.9
2007	10	23	43%	298.1
2008	16	36	44%	569.8
2009	1	25	4%	80.1
2010	20	64	31%	502.1
2011	7	54	13%	231.4
2012	11	52	21%	375.9
Totals	**96**	**337**	**28%**	**349.0**

Table 18: Summary of total *E. coli* samples collected over the duration of the study at Fisher Park Beach.

Summary of *E. coli* Samples Collected (2010-2012) Fisher Park Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	53	0	0	0	53
2011	37	120	81	76	314
2012	52	0	63	90	205
Total	142	120	144	166	572

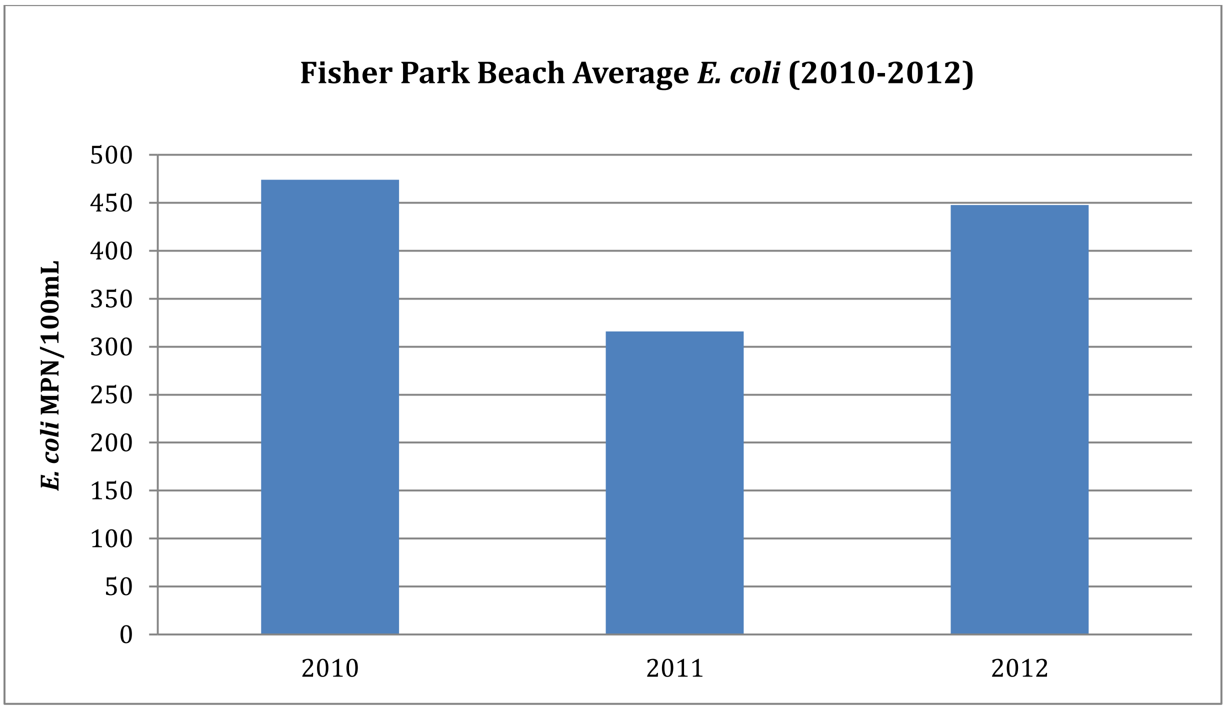


Figure 5: Average *E. coli* (MPN/100mL) collected at the center of the beach at 24" at Fisher Park Beach in Manitowoc, Wisconsin, from 2010-2012.

Table 19: Mean Seasonal Results 2010-2012

Fisher Park Beach Mean Results–Summer 2010 - 2012							
E. coli Center 24" (MPN/100mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Fisher Creek 1 *E. coli* (MPN/100mL)	Fisher Creek 2 *E. coli* (MPN/100mL
370.9	6.3	19.4	14.5	2	1	534.2	501.2
n= 53	n= 6	n= 53	n=53	n= 53	n= 53	47	45

Table 20: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Fisher Park Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0626	0.0110	0.0040
Wind Speed (mph)	0.1183	0.0760	0.1757
Water Temperature (°C)	0.0048	0.1874	0.0083
Air Temperature (°C)	0.0897	0.0119	0.0000
Turbidity (NTU)	0.4096	0.3032	0.3071
Wave Height (ft)	0.1823	0.2355	0.2138
Within 24hr Rain (cm)	0.0145	0.0005	0.0399
Algae (1-3 scale)	x	0.0618	0.0496
Gulls (#)	x	x	x
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	x	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.1182	0.0650	0.0012
Longshore Current Direction (°)	x	0.0589	0.0964
Tributaries/Outfalls *E. coli* Fisher Creek 1	x	0.3027	0.4474
Tributaries/Outfalls *E. coli* Fisher Creek 2	x	0.6705	0.4091
Tributaries/Outfalls *E. coli* Fisher Creek Mouth	x	0.6029	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Fisher Park Beach was on the Impaired Waters (EPA 303d) list since 1998 but was recently delisted. Fisher Park Beach has been monitored since 2003 and exceeded water quality standards (235 MPN/100mL) 7 out of 10 years (Table 17). A total of 572 samples were collected at Fisher Park Beach from 2010 to 2012 through the GLRI project (2010 n=53, 2011 n=314, 2012 n=205) as shown in Table 18.The average results of *E. coli* from the sanitary surveys conducted from 2010 to 2012 also exceeded water quality standards in all three sample seasons (Figure 5). Fisher Creek has exhibited high levels of *E. coli* from 2010 to 2012, resulting in average concentrations exceeding 500 MPN/100 mL (Table 19).

There were several potential pollution sources identified in the initial site assessment including stagnant algae mats, extensive gull populations, and potential pollution contribution from Fisher Creek. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Fisher Park Beach included turbidity, wave height, and Fisher Creek sample points (Table 20). The most significant correlation was calculated from regression between *E. coli* from Fisher Creek and *E. coli* from Fisher Park Beach at the center transect at 24 inches (R^2=0.6705).

Additional statistical analyses (Minitab16) were also conducted to evaluate impact of Fisher Creek *E. coli* concentrations on Fisher Park Beach water quality. An ANOVA (Estimate Model) was used to determine if there was a statistical difference between mean *E. coli* concentrations at three transects ($p=0.488$). This evaluation shows that there is no statistical difference between mean *E. coli* concentrations at Fisher Park Beach. Fisher Park Beach is a small beach, and *E. coli* concentrations may not differ between transects in such a small geographic area. A 2-sample t-test (SYSTAT v.11) was performed to evaluate differences in means of *E. coli* in Fisher Creek and Fisher Park beach. The results of the 2-sample t-test showed a P-value of 0.025 ($p<0.05$) indicating a significant difference between mean *E. coli* concentrations in Fisher Creek and Fisher Park Beach. Finally, a paired t-test was performed between Fisher Creek sampling sites (one upstream and one near the mouth) to determine if mean *E. coli* concentrations were different. The result of the t-test showed no statistical difference between sample sites ($p=0.878$). At this time it would be difficult to assume significant pollution input upstream since *E. coli* concentrations are not statistically different upstream or near the mouth of the river.

After statistical analysis, it is evident that Fisher Creek is a significant source of pollution contributing to high *E. coli* concentrations at Fisher Park Beach. In addition to the creek's pollution input, high levels of algae were present at the beach, which potentially contributed to the high turbidity levels measured. The algae particles and particulates from Fisher Creek allow for *E. coli* attachment, serving as a suitable environment for *E. coli* survival in the nearshore water at Fisher Park Beach.

RECOMMENDATIONS AND FUTURE WORK

The recommendation for Fisher Park Beach is to evaluate bovine and human markers upstream in Fisher Creek. The creek is the largest contamination source at Fisher Park Beach and therefore requires additional watershed studies that include microbial source tracking to determine the sources of *E. coli* being deposited into Fisher Creek. The source will need to be identified in order to develop a plan for remediation. In the meantime, it is recommended that Fisher Park Beach be monitored for *E. coli*, and its water quality status be posted at the beach to protect public health.

Site: Hika Bay Beach – Manitowoc, Wisconsin

INITIAL SITE ASSESSMENT

Photo 17: Aerial photo of Hika Bay Park, Beach, and Centerville Creek.

Preliminary Site Assessment:
Hika Bay is a municipal beach with a boat launch and fishing pier.

Surrounding Area. Surrounding area is parkland and low-density residential housing. In the extended surrounding area, there is a high volume of agricultural farming land.

Physical Attributes. The foreshore area is comprised of fine sand covered with medium to large cobbles. Submerged sediments are indeterminate due to excessive amount of stranded and submerged algal mats. The beach is at the bottom of a rise (remnant dune system) approximately six feet high. The berm crest and beach grade could not be assessed due to the large accumulation of algae. A large sand bar extended from the shore to about 300 feet out, running parallel to the entire beach.

- Length of beach: 318 feet
- Average width of beach: 31.3 feet

Potential Pollution Sources. There was no evidence of gulls or geese at the initial site assessment, but around 50 small birds were feeding on the stranded *Cladophora* mats. There were extensive *Cladophora* mats in varying stages of decay extending 100 feet into Lake Michigan with a pronounced septic smell. Low amounts of litter were observed. A tributary discharges to the left (north) of the beach. This may be a source of nutrients as the algal blooms appeared significantly greater downstream. The boat launch is paved and could convey stormwater and nutrients directly to the beach area.

Photo 18: Looking west, northwest at Hika Bay Beach in Manitowoc, Wisconsin.

Photo 19: Looking west from a boat dock over a large *Cladophora* accumulation at Hika Bay Beach.

Photo 20: Looking northeast at the mouth of Centerville Creek, just north of Hika Bay Park.

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 three times a week from 2010 to 2012 at Hika Bay Beach. 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 longshore 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. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. The outfalls identified at Hika Bay Beach include Centerville Creek, which was sampled at multiple points upstream (north). Sand samples were also collected up to three times a week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 21: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Hika Bay Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**# of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	20	36	56%	377.2
2004	10	23	43%	386.9
2005	0	17	0%	48.8
2006	9	18	50%	602.4
2007	14	28	50%	733.7
2008	6	22	27%	402.7
2009	2	15	13%	226.3
2010	25	63	40%	520.5
2011	11	55	20%	272.2
2012	12	54	22%	447.8
Totals	**109**	**331**	**33%**	**401.8**

Table 22: Summary of total *E. coli* samples collected over the duration of the study at Hika Bay Beach.

Summary of *E. coli* Samples Collected (2010-2012) Hika Bay Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	56	0	0	0	56
2011	35	120	117	85	357
2012	54	0	0	93	147
Total	145	120	117	178	560

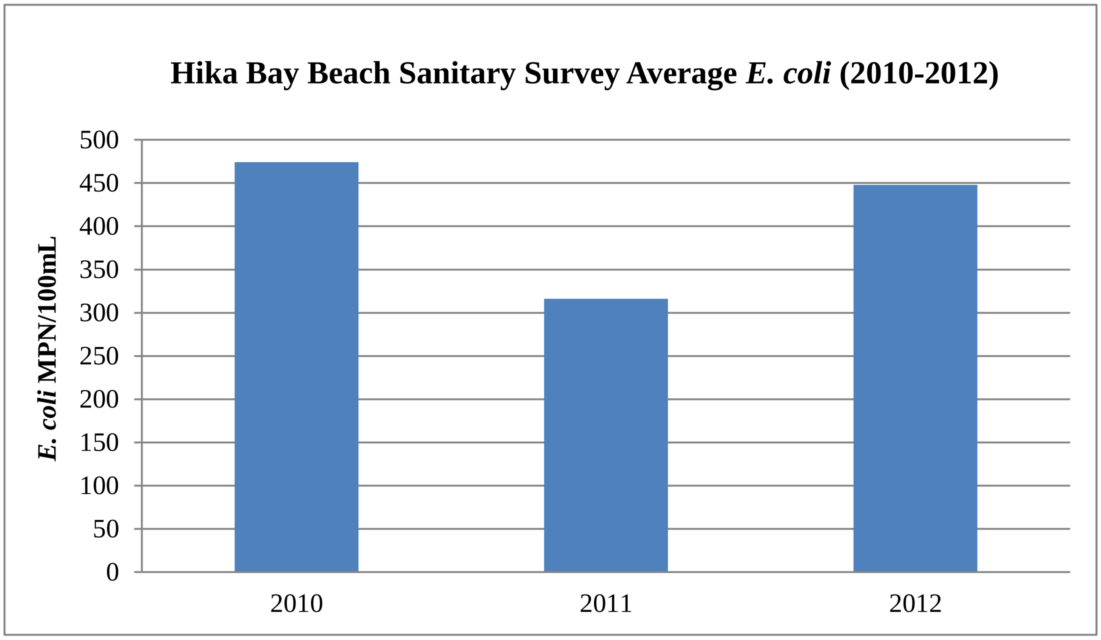


Figure 6: Average *E. coli* (MPN/100mL) at Hika Bay Beach in Manitowoc, Wisconsin, from 2010-2012.

Table 23: Mean Seasonal Results 2010-2012

Hika Bay Beach Mean Results–2010 - 2012							
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (#)	Bathers (# people)	Centerville Creek 1 *E. coli* (MPN/100mL)	Centerville Creek 2 *E. coli* (MPN/100mL)
425.1	47.3	18.6	23.5	5.2	1	754.2	735.9
n =146	n=12	n= 154	n= 143	n= 155	n= 151	n= 83	n= 70

Table 24: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Hika Bay Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0490	0.0025	0.0232
Wind Speed (mph)	0.0243	0.0315	0.0887
Water Temperature (°C)	0.0045	0.1487	0.0079
Air Temperature (°C)	0.0129	0.0668	0.0000
Turbidity (NTU)	0.0034	0.1490	0.1614
Wave Height (ft)	0.0220	0.0818	0.1675
Within 24hr Rain (cm)	0.0219	0.0637	0.0367
Algae (1-3 scale)	x	0.0502	0.0052
Gulls (#)	0.0007	x	x
Geese (#)	x	x	x
Other Avian (#)	x	0.0007	x
Bathers at Beach (#)	x	x	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	x	0.0003	0.0880
Longshore Current Direction (°)	x	x	0.0350
Tributaries/Outfalls *E. coli* Centerville Creek 1	x	0.2007	0.3313
Tributaries/Outfalls *E. coli* Centerville Creek 2	x	0.3434	0.2972
Tributaries/Outfalls *E. coli* Centerville Creek 3	x	0.4753	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Hika Bay Beach has been on the impaired waters (EPA 303d) list since 2007. The historical water quality (Table 21) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). A total of 560 samples were collected at Hika Bay Beach from 2010 to 2012 through the GLRI project (2010 n=56, 2011 n=357, 2012 n=147) as shown in Table 22.The average results of *E. coli* from the sanitary surveys conducted from 2010 to 2012 also exceeded water quality standards in all three sample seasons (Figure 6). Hika Bay Beach has one tributary (Centerville Creek) which had high levels of *E. coli* from 2010 to 2012, resulting in average concentrations exceeding 700 MPN/100 mL at all sample sites (Table 23).

There were several potential pollution sources identified in the initial site assessment including stagnant algae mats, extensive avian population, surface runoff from the adjacent boat landing and parking lot, and a tributary (Centerville Creek) that drains directly north of the beach. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Hika Bay Beach are the sample sites where *E. coli* was measured on Centerville Creek (Table 24).

Additional statistical analyses (Minitab16) were also conducted to evaluate average *E. coli* concentrations at Hika Bay Beach and Centerville Creek in order to assess potential impact of the creek on *E. coli* concentrations at the nearby beach. A 2-Sample t-test was used to evaluate the difference *in E. coli* means between three sample sites on Centerville Creek and Hika Bay Beach. There was a significant difference between means at all three sites on Centerville Creek when compared to *E. coli* concentrations at Hika Bay Beach (Centerville Creek 1 p=0.017, Centerville Creek 2 p=0.002, Centerville Creek 3 p=0.042, $p<0.05$). This analysis may show that Centerville Creek is a significant pollution input at Hika Bay Beach. Other physical or chemical parameters may still be a factor contributing to high *E. coli* concentrations even though statistical correlations were low. Physical observations show continuous stagnant algae mats at Hika Bay Beach throughout the summer months. This limits access to the nearshore water and consistent sample points on a daily basis.

RECOMMENDATIONS AND FUTURE WORK

Hika Bay Beach was not recommended for a redesign plan in the GLRI FY10 funding. Centerville Creek is the largest contamination source at Hika Bay Beach and therefore requires additional watershed studies that include microbial source tracking to determine the sources of *E. coli* being deposited into Fisher Creek. The source will need to be identified in order to develop a plan for remediation. It is recommended that Hika Bay Beach be utilized as a boat landing and picnic area, not as a recreational swimming beach. Beach usage is extremely low, but the landing is heavily used by boaters. This conversion from a swimming beach to a picnic recreation area would maximize usage of the public beach access while limiting potential exposure to high *E. coli* levels at the beach, therefore protecting public health.

Site: KK Road Beach – Sheboygan, Wisconsin

INITIAL SITE ASSESSMENT

Photo 21: Aerial photo of KK Road Beach in Sheboygan, Wisconsin.

Preliminary Site Assessment:
KK Road Beach is located in a rural residential area in southern Sheboygan County.

Surrounding Area. This area is comprised of low volume residential homes. A bluff runs along the western edge of the beach. A small path leading from a dead end road serves as the beach access. Private beach borders each side of the public beach area. There is a creek that drains to the north of KK Road Beach.

Physical Attributes. The foreshore area is comprised of medium sand with a few pebbles (Mean Grain Size = 0.01058 in). The upshore area is comprised of fine sand. Submerged sediments are also formed of fine sand and pebbles. Water clarity at KK Road Beach was extremely clear with little debris in the nearshore water. There is a moderately-defined berm crest and a well-developed dune system in the back beach area. The beach has a 10% approximate slope with dry sand in the upshore area. This beach exhibits a naturalized beach front with little feces on the beach. There were no birds seen on the day of the site assessment.

- Length of beach: 900 feet
- Average width of beach: 18.4 feet

Potential Pollution Sources. There is a creek to the north of the beach (approximately 1,000 feet) which may potentially contribute to beach contamination. There were some gull tracks on the beach. This may be evidence of gull loafing at the beach, which is a potential threat of fecal contamination. There were very small amounts of *Cladophora* laying on the swashzone but none in the nearshore water. *Cladophora* can serve as a reservoir for *E. coli* survival.

Photo 22: Public access at KK Road Beach, looking north at private beach area

Photo 23: Swashzone area with evidence of gulls and small amounts of *Cladophora*.

Photo 24: Looking south from the public access at KK Road Beach.

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 three times a week from 2010 to 2011 and once a week during 2012 at KK Road Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. The outfalls identified at KK Road Beach include a creek which is approximately 1,000 feet north of the beach. Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 25: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

KK Road Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2005	3	11	27%	105.5
2006	11	20	55%	352.8
2008	0	13	0%	49.5
2010	1	13	8%	239.9
2011	0	30	0%	25.3
2012	2	13	15%	148.9
Totals	**16**	**87**	**18%**	**153.7**

Table 26: Summary of total *E. coli* samples collected over the duration of the study at KK Road Beach.

Summary of *E. coli* Samples Collected (2010-2012) KK Road Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	13	104	76	25	218
2011	26	132	72	5	235
2012	13	0	0	0	13
Total	52	236	148	30	466

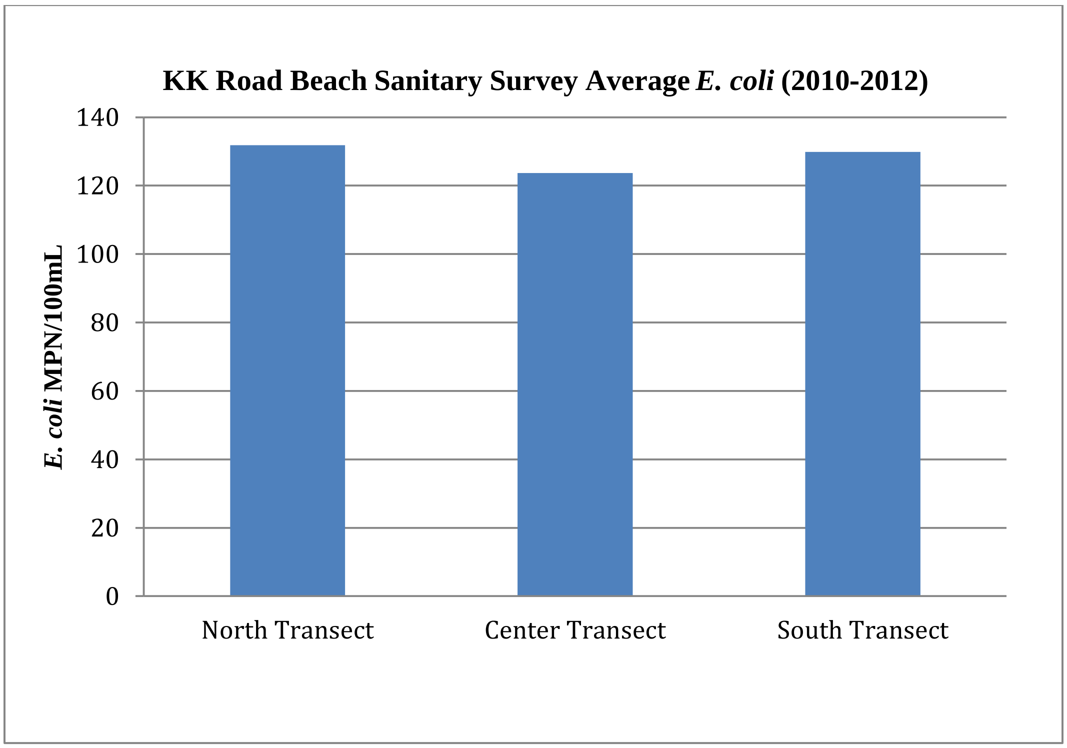


Figure 7: Average *E. coli* (MPN/100mL) at KK Road Beach in Sheboygan, Wisconsin, from 2010-2012.

Table 27: Mean Seasonal Results 2010-2012

KK Road Beach Mean Results–Summer 2010 - 2012						
E. coli C 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Creek *E. coli* (MPN/100mL)
104.7	0.042	17.1	6.1	52.1	1.7	491.7
n= 52	n= 17	n= 62	n= 53	n= 68	n= 68	n= 25

Table 28: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

KK Road Beach	R^2 Value		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0126	0.2654	0.2574
Wind Speed (mph)	0.0521	0.0121	0.2543
Water Temperature (°C)	0.0027	0.0084	0.2543
Air Temperature (°C)	0.0099	0.1182	0.0067
Turbidity (NTU)	0.0020	0.0496	0.0117
Wave Height (ft)	0.0200	0.4960	0.2558
Within 24hr Rain (cm)	0.0105	0.0000	0.0073
Algae (1-3 scale)	x	0.0144	0.1289
Gulls (#)	0.1822	x	0.1045
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	x	0.0541
Bathers In Water (#)	x	x	0.0223
Longshore Current Speed (cm/sec)	0.0006	0.0041	0.2390
Longshore Current Direction (°)	0.0172	0.0137	0.1412
Tributaries/Outfalls *E. coli* Creek	0.5347	x	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

KK Road Beach has been monitored routinely through the BEACH Act intermittently since 2005 and was on the impaired waters (EPA 303d) list. The historical water quality (Table 25) shows two years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). A total of 466 samples were collected at KK Road Beach from 2010 to2012 through the GLRI project (2010 n=218, 2011 n=235, 2012 n=13) as shown in Table 26. *E. coli* averages in recent years (when sanitary surveys were conducted) were all below 235 MPN/100mL (Figure 7). The data collected prior to 2010 was not collected by UW Oshkosh staff.

There were few potential pollution sources identified in the initial site assessment including gull fecal material, tributary contribution, and minimal *Cladophora* algae found. The only outfall at the beach was a small creek at which average *E. coli* exceeded water quality standards for over three years (491.7 MPN/100mL) (Table 27). Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at KK Road Beach included water temperature, wind speed and direction, wave height, tributary contribution, and longshore current speed and direction, and the nearby creek (Table 28). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

Additional statistical analyses (Minitab 16) were also conducted to evaluate average *E. coli* concentrations at three transects at KK Road Beach in order to assess the impact of the nearby creek on *E. coli* concentrations. The difference between *E. coli* concentrations at the north, center, and south transects were not significant (ANOVA $p=0.982$ where $p<0.05$). These results may show that there is not a significant impact on one side of the beach or the other. Since linear regression showed a R^2 of 0.5347 between *E. coli* concentrations at the center of the beach and the northern creek, there is still sufficient statistical evidence that the creek may have an impact on water quality at KK Road Beach.

RECOMMENDATIONS AND FUTURE WORK

KK Road Beach was not recommended for a redesign plan in the GLRI FY10 funding. Even though there were two years with average *E. coli* concentrations exceeding water quality standards, the only potential pollution sources identified was the creek to the north of the beach and gull populations. Best management practices can be developed to mitigate gull loafing on the beach. This beach is already naturalized with dune grass on the upshore area, a significant slope, and small swashzone. This beach is small and embayed by private beach property and therefore be difficult to make any significant improvements at this time. It is recommended that routine monitoring continue and the beach be deemed a low priority beach. If *E. coli* levels spike or increase over time, a reassessment should be completed at that time.

Site: Kohler Andrae Picnic Beach – Sheboygan, Wisconsin

INITIAL SITE ASSESSMENT

Photo 25: Aerial photo of Kohler Andrae Picnic Beach in Sheboygan, WI.

Preliminary Site Assessment:
Kohler Andrae Picnic Beach is located in southern Sheboygan County and is in Kohler Andrae State Park.

Surrounding Area. Kohler Andrae Picnic Area is one of four beaches at Kohler Andrae State Park. There is an extensive area of natural dune grass in the upshore region of the beach. The surrounding area is primarily a wetland and forest region. There is a campground in Kohler Andrae State Park directly to the west of the beachfront.

Physical Attributes. The foreshore area is comprised of medium sand with some small pebbles (Mean Grain Size = 0.01148 in). Submerged sediments are formed primarily of fine sand. The back beach has significant dune grass which generates a >10% slope to the beach. A defined berm crest exists with a small swashzone.

- Length of beach: 498 feet
- Average width of beach: 46.6 feet

Potential Pollution Sources. Since this beach is naturalized there are a limited number of potential pollution sources. However, sheet flow was evident on the day of the preliminary site assessment from the adjacent parking lot. There were several people bathing at the beach and recreating on the beach. There was also a small flock of gulls loafing on the beach to the north of the swimming area which could contribute fecal contamination in the sand and nearshore water.

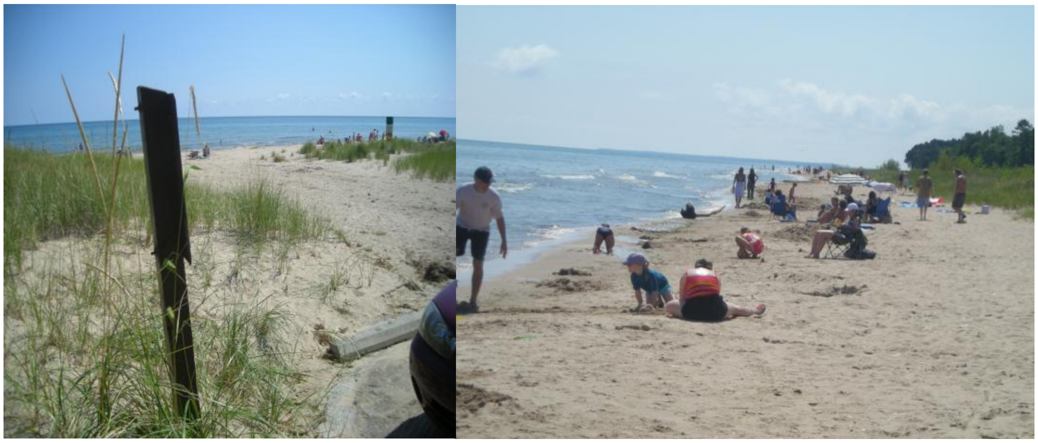


Photo 26: Public access to Kohler Andrae Picnic Beach through naturalized dunes and looking south at the beach.

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 three times a week from 2010 to 2012 at Kohler Andrae Picnic Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There were no outfalls identified at Kohler Andrae Picnic Beach. Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 29: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Kohler Andrae Picnic Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	18	71	25%	175
2004	21	60	35%	279.8
2005	18	53	34%	246.4
2006	28	51	55%	551
2007	29	60	48%	431.5
2008	9	54	17%	214.1
2009	7	57	12%	109.6
2010	9	55	16%	192.1
2011	5	56	9%	71.3
2012	21	40	53%	596.7
Totals	**165**	**557**	**30%**	**286.8**

Table 30: Summary of total *E. coli* samples collected over the duration of the study at Kohler Andrae Picnic Beach.

Summary of *E. coli* Samples Collected (2010-2012) Barker's Island Inner Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	13	104	72	0	189
2011	29	136	70	0	235
2012	40	0	64	0	104
Total	82	240	206	0	528

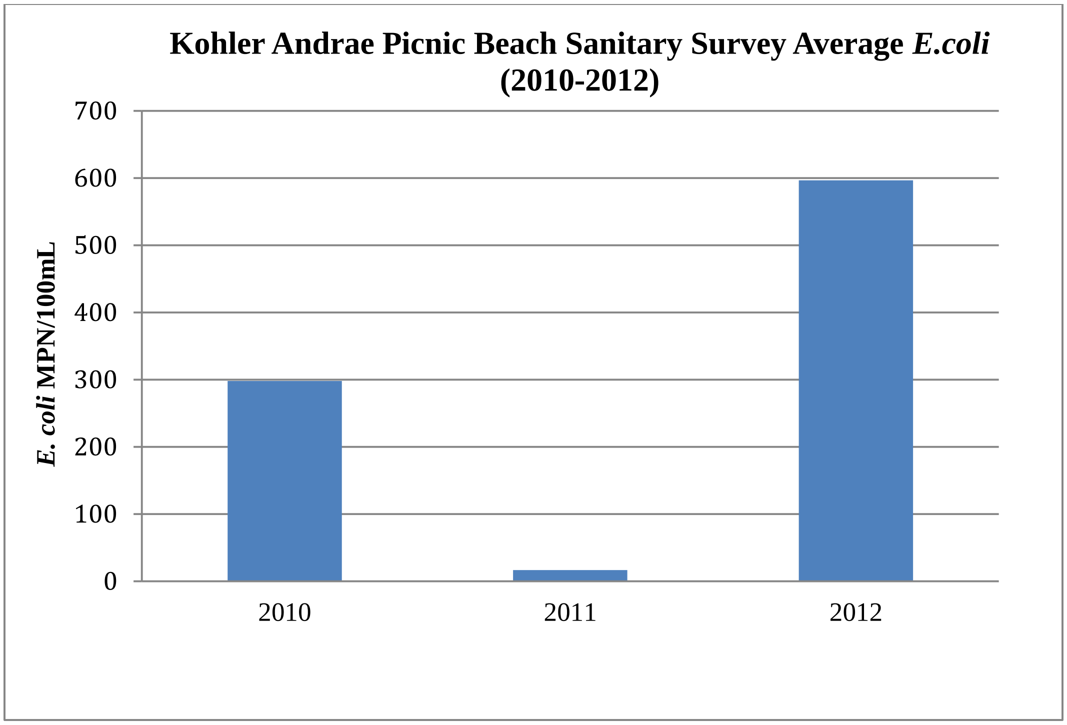


Figure 8: Average *E. coli* (MPN/100mL) at Kohler Andrae Picnic in Sheboygan, WI from 2010-2012.

Table 31: Mean Seasonal Results 2010-2012

Kohler Andrae Picnic Beach Mean Results– 2010-2012					
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)
350.1	16.7	17.9	7.1	16.8	39.4
n= 83	n= 24	n= 99	n= 85	n= 98	n= 98

Table 32: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Kohler Andre Picnic Beach	R^2 Value		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0010	0.0046	0.0197
Wind Speed (mph)	0.0000	0.0838	0.0273
Water Temperature (°C)	0.1111	0.0479	0.5147
Air Temperature (°C)	0.0167	0.0000	0.2401
Turbidity (NTU)	0.0002	0.1212	0.0024
Wave Height (ft)	0.1091	0.1707	0.1050
Within 24hr Rain (cm)	0.1316	0.0332	0.0024
Algae (1-3 scale)	x	0.1178	0.0082
Gulls (#)	0.0293	x	0.0795
Geese (#)	x	x	x

Other Avian (#)	x	x	x
Bathers at Beach (#)	0.2410	0.0276	0.0175
Bathers In Water (#)	0.2319	0.0001	0.0939
Longshore Current Speed (cm/sec)	0.4488	0.1126	0.0767
Longshore Current Direction (°)	x	0.0843	0.0477

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Kohler Andrae Picnic Beach has been on the impaired waters (EPA 303d) list since 2006. The historical water quality (Table 29) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). A total of 528 samples were collected at KK Road Beach from 2010 to 2012 through the GLRI project (2010 n=189, 2011 n=235, 2012 n=104) as shown in Table 30. Since the 2012 average *E. coli* was so high, the average *E. coli* for all three years exceeded water quality standards (350.1 MPN/100mL) (Table 31).

There were some potential pollution sources identified in the initial site assessment including gull and geese populations, surface runoff from impervious surfaces, and bathers recreating at the beach. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters and *E. coli* concentrations at the center of beach at 24 inches. Kohler Andrae Picnic Beach was unique in that correlations between *E. coli* and physical/chemical parameters changed significantly from 2010 to 2012. In 2010 (*E. coli* average = 300 MPN/100mL), parameters that correlated the most were wave height, rain, bathers, and longshore current (Table 32). In 2011 (*E. coli* average = 70 MPN/100mL) (Figure 8), no significant correlation was calculated. In 2012, (*E. coli* average = 600 MPN/100mL) (Figure 8) the highest correlations were water and air temperature (Table 32). The variation of possible contamination sources makes it difficult to directly identify the sources of contamination at Kohler Andrae Picnic Beach.

RECOMMENDATIONS AND FUTURE WORK

Kohler Andrae Picnic Beach was not recommended for a redesign plan in the GLRI FY10 funding. Kohler Andrae's historical data does show repeated exceedances over a number of years. Since only "possible" sources of contamination were identified, it is essential that additional years of data are collected using the sanitary survey tool. There is a sand bar approximately 100 feet from shore which could cause variation in sample results due to inconsistent sampling depths. Since there are no apparent pollution sources readily identifiable, additional assessments should be conducted in future years and routine monitoring continue to inform the public of potential health risk at the beach.

Site: Kreher Park Beach – Ashland, Wisconsin

INITIAL SITE ASSESSMENT

Photo 27: Aerial photo of Kreher Park Beach in Ashland, Wisconsin.

Preliminary Site Assessment:
Kreher Park Beach is a municipal beach located in central Ashland, Wisconsin, on Lake Superior.

Surrounding Area. This beach is located next to a historical oar dock which was recently named a "Super Fund" site. This oar dock is currently being removed. The beach is below a large bluff which has a large municipal stormwater drain. This drain only flows during and after rain events. There is a marina west of the beach with heavy boat traffic. There is also a park and campground directly west of the beach.

Physical Attributes. The foreshore area is comprised of medium sand with a few pebbles (Mean Grain Size = 0.024036 in). Submerged sediments are also formed of fine and pebbles. This beach is low, flat, and sand starved with evidence of significant surface runoff from paved surfaces surrounding the beach. The beach is embayed on both sides by the marina and oar dock, restricting water flow.

- Length of beach: 232 feet
- Average width of beach: 45.3 feet

Potential Pollution Sources. Kreher Park Beach is located at the bottom of a bluff with extensive impervious surfaces surrounding the beach. These paved surfaces (along with the steep bluff) allow for contaminated stormwater washing over the roads, parking lots, and walkways onto the beach and into the nearshore water. Additionally, there is wooded debris that washes up on the shore daily which serves as a surface for *E. coli* attachment.

Photo 28: Kreher Park Beach in Ashland, Wisconsin, looking east.

Photo 29: Kreher Park Beach after a significant rain event (>0.5 in) showing stormwater runoff.

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 three times a week from 2010 to 2012 at Kreher Park Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. The outfalls identified and sampled at Kreher Park Beach were a nearby creek and an outfall near the bottom of the bluff. Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 33: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Kreher Park Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	1	41	2%	40.7
2004	6	34	18%	147.2
2005	2	32	6%	85.4
2006	3	30	10%	134.2
2007	1	33	3%	57.8
2008	1	37	3%	42.8
2009	5	32	16%	150.4
2010	5	37	14%	104.7
2011	8	55	15%	144.4
2012	4	51	8%	143.8
Totals	**36**	**382**	**9%**	**105.1**

Table 34: Summary of total *E. coli* samples collected over the duration of the study at Kreher Park Beach.

Summary of *E. coli* Samples Collected (2010-2012) Kreher Park Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	19	145	116	0	280
2011	47	144	165	36	392
2012	51	345	80	0	476
Total	117	634	361	36	1,148

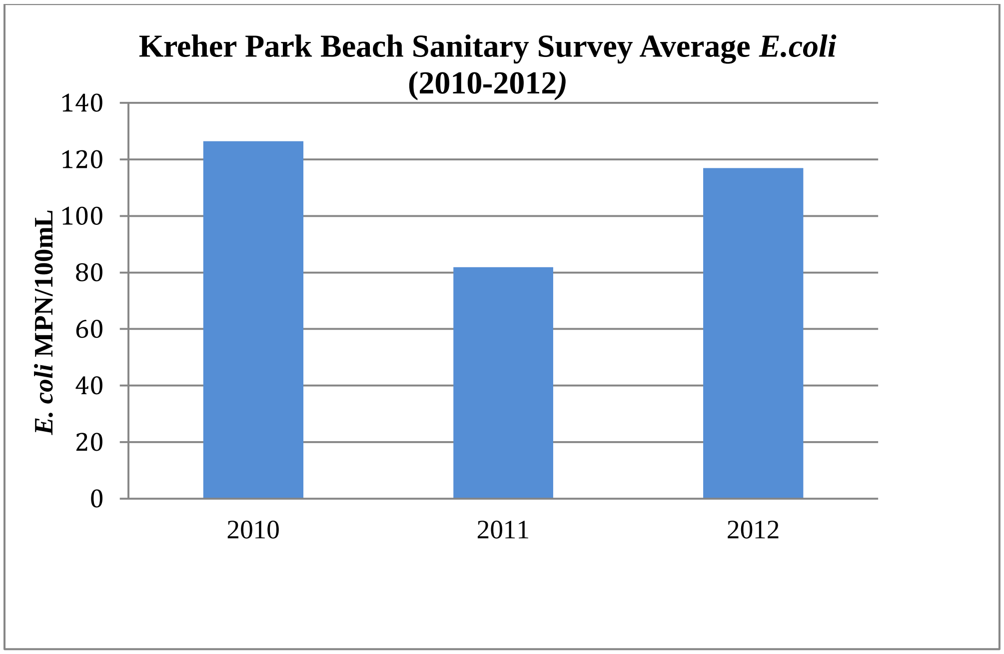


Figure 9: Average *E. coli* (MPN/100mL) at Kreher Park Beach in Ashland, Wisconsin, from 2010-2012.

Table 35: Mean Seasonal Results 2010-2012

Kreher Park Beach Mean Results– 2010-2012						
E. coli C 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Creek 1 *E. coli* (MPN/100mL)
142.7	159.7	20.5	7.6	5.3	2.5	1118.2
n= 118	n= 37	n=139	n= 106	n= 139	n=1 39	n= 45

Table 36: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Kreher Park Beach	R^2 Value		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0046	0.0076	0.0181
Wind Speed (mph)	0.1530	0.0976	0.0004
Water Temperature (°C)	0.1725	0.0428	0.0000
Air Temperature (°C)	0.1170	0.0317	0.0000
Turbidity (NTU)	x	0.1706	0.0331
Wave Height (ft)	0.0009	0.0490	0.0080
Within 24hr Rain (cm)	0.1599	0.0009	0.0027
Algae (1-3 scale)	x	x	0.0013
Gulls (#)	0.1015	x	0.0265
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	0.0118	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.0157	0.0015	0.0181
Longshore Current Direction (°)	0.0841	0.0400	x
Tributaries/Outfalls *E. coli* Creek 1	x	0.0372	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Kreher Park Beach has been monitored routinely through the BEACH Act since 2003. The historical water quality is fairly good; however, since 2003, the beach has been under advisory 9% of beach days where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL) (Table 33). A total of 1,148 samples were collected at Kreher Park Beach from 2010 to 2012 through the GLRI project (2010 n=280, 2011 n=392, 2012 n=476) as shown in Table 34. The yearly average *E. coli* from 2010 to 2012 did not exceed water quality standards (Figure 9). The nearby creek appeared as an obvious contributor of fecal indicator bacteria since the average *E. coli* was 1118.2 (n=45) over three years (Table 35).

Pollution sources identified during the initial site assessment were primarily related to stormwater influences including sheet flow and direct stormwater flow. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Kreher Park Beach included turbidity and rain (Table 36). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

The major source of contamination at Kreher Park Beach is stormwater (municipal and sheet flow), as shown in Photo 29. Visual observation showed little-to-no stormwater infiltration due to extensive impervious surfaces surrounding the beach. Since the beach is encased on both sides, normal hydrological circulation is unable to occur. These characteristics along with the low, flat, sand starved beach serve as an optimal reservoir for *E. coli* survival.

RECOMMENDATIONS AND FUTURE WORK

Kreher Park Beach was not recommended for a redesign plan in the GLRI FY10 funding. This beach is currently closed to the public while the nearby oar dock is under construction and being removed. Once the oar dock is removed, it is recommended that Kreher Park Beach be reassessed for water quality and beach usage. If the community has increased interest in mitigating Kreher Park Beach, UW Oshkosh will offer to aid in applying for alternative funding for design plans and implementation dollars.

Site: Maslowski Beach – Ashland, Wisconsin

INITIAL SITE ASSESSMENT

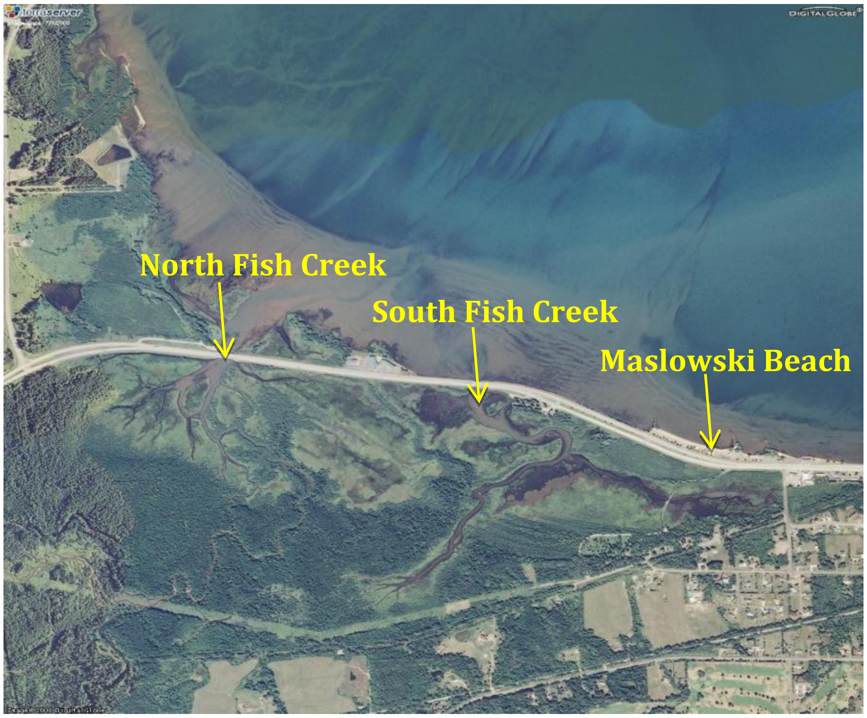


Photo 30: Aerial photo of Maslowski Beach in Ashland, Wisconsin, located on Lake Superior. North Fish Creek and South Fish Creek are west of the beach and potential pollution sources.

Preliminary Site Assessment:
Maslowski Beach is a municipal beach located in Ashland, Wisconsin, along the shores of Lake Superior.

Surrounding Area. Maslowski Beach is located on a major highway (Hwy 2) on the western edge of the City of Ashland. There is a large area of impervious surfaces surrounding the beach. Municipal stormwater drains from a seven-foot stormwater pipe east of the beach. There are two tributaries (North and South Fish Creek) west of Maslowski Beach which flow into Lake Superior and potentially contribute to poor water quality at the beach.

Physical Attributes. The foreshore area is comprised of course sand with some pebbles and cobbles (Mean Grain Size = 0.0226 in). An abundant amount of woody debris is located in the swashzone area of the beach. Significant amounts of algae and macrophytes were observed near the high water mark and storm high water mark (HWM). An artesian well, which deposits potable water for public consumption, exists on the east end of the beach. Sheet flow was evident on the day of the assessment where runoff paths were seen in the sand leading from the parking lot to the nearshore area. A bath and field house are located on the east side of the beach along with park benches and picnic area.

- Length of beach: 360.8 feet
- Average width of beach: 53.1 feet

Potential Pollution Sources. At the initial site assessment, stormwater was an obvious influence at the beach due to the sheet flow, the low flat beach, and no infiltration barrier between the parking lot and beach. Both nearby tributaries could also contribute to high *E. coli* concentrations at the beach. Gulls and geese were also observed loafing in the nearby water. Woody debris that is washed up on shore may serve as a site of attachment for fecal indicator bacteria.

Photo 31: Looking east at Maslowski Beach where woody debris and algae was observed.

Photo 32: Looking west at Maslowski Beach at the adjacent parking lot and subsequent sheet flow.

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 three times a week from 2010 to 2012 at Maslowski Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. Samples were collected from a stormwater outfall (Pipe 1), upstream from North and South Fish Creek, parking lot, and artesian well runoff. Sand samples were also collected up to 3X/week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 37: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Maslowski Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	5	44	11%	187
2004	8	36	22%	220.2
2005	5	33	15%	164
2006	2	28	7%	98.1
2007	5	36	14%	107.8
2008	7	42	17%	137.8
2009	1	30	3%	89.1
2010	6	42	14%	201.6
2011	4	54	7%	178.8
2012	20	62	32%	280.5
Totals	**63**	**407**	**15%**	**166.5**

Table 38: Summary of total *E. coli* samples collected over the duration of the study at Maslowski Beach.

Summary of *E. coli* Samples Collected (2010-2012) Maslowski Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	24	191	117	0	332
2011	43	144	135	195	517
2012	62	0	0	54	116
Total	129	335	252	249	965

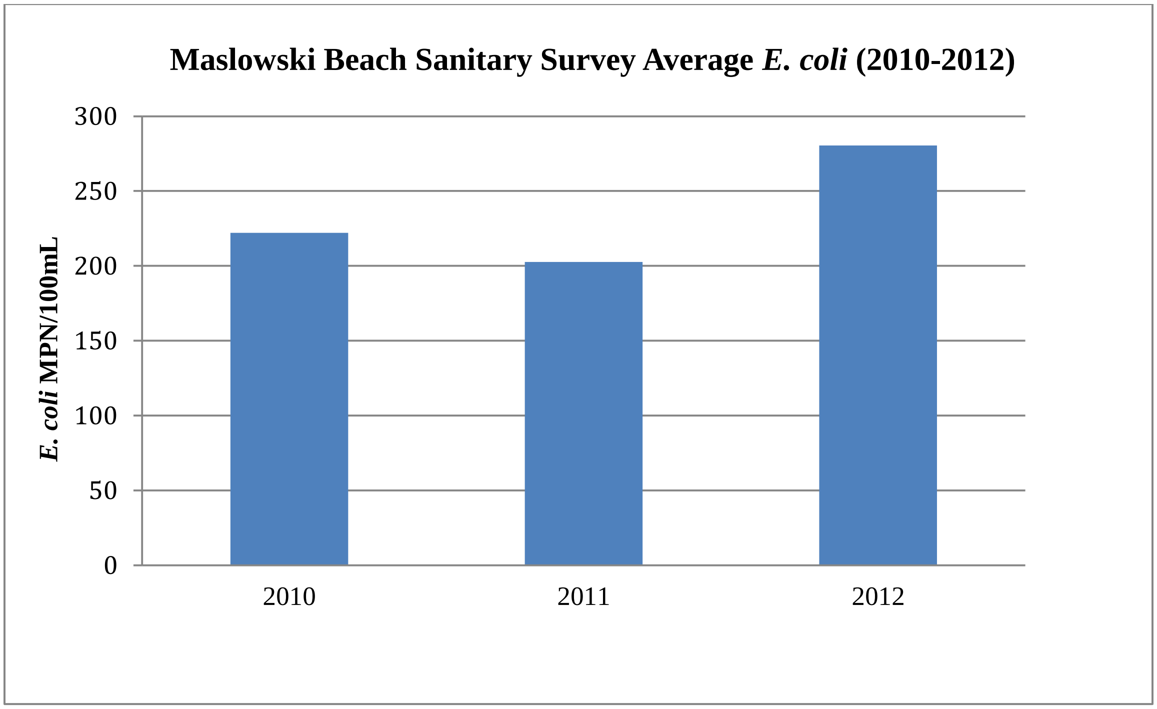


Figure 10: Average *E. coli* (MPN/100mL) at Maslowski Beach in Ashland, Wisconsin, from 2010-2012.

Table 39: Mean Seasonal Results 2010-2012

Maslowski Beach Mean Results– 2010-2012									
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	South Fish Creek *E. coli* (MPN/100mL)	North Fish Creek (MPN/100mL)	Whittlesey Creek *E. coli* (MPN/100mL)	Maslowski Pipe *E. coli* (MPN/100mL)
225.3	228.7	11.4	11.4	37.7	2.6	432.7	383.0	545.1	1226.4
n=134	n=28	n=117	n=117	n=151	n=151	n=46	n=46	n=45	n=61

Table 40: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Maslowski Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0811	0.0000	0.0027
Wind Speed (mph)	0.0152	0.0461	0.0169
Water Temperature (°C)	0.0436	0.0019	0.0199
Air Temperature (°C)	0.0992	0.0009	0.0000
Turbidity (NTU)	0.6362	0.1251	0.0169
Wave Height (ft)	0.0558	0.0045	0.0476
Within 24hr Rain (cm)	0.0221	0.0225	0.0048
Algae (1-3 scale)	x	0.0225	0.0001
Gulls (#)	0.0291	0.1148	0.0622
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	0.0004	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.0115	0.0135	0.0250
Longshore Current Direction (°)	0.0075	0.0069	x
Tributaries/Outfalls *E. coli* N Creek	x	0.0133	x
Tributaries/Outfalls *E. coli* S Creek	x	0.0056	x
Tributaries/Outfalls *E. coli* Whittlesey Creek	x	0.0070	x
Tributaries/Outfalls *E. coli* Pipe 1	x	x	0.0808

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Maslowski Beach has been monitored routinely through the BEACH Act since 2003, and was previously on the impaired waters (EPA 303d) list from 2006 to 2011. The historical water quality (Table 37) shows multiple years where the average *E. coli* concentration approaches water quality standards (235 MPN/100mL). A total of 965 samples were collected at Maslowski Beach from 2010 to 2012 through the GLRI project (2010 n=332, 2011 n=517, 2012 n=116) as shown in Table 38. The yearly mean *E. coli* from 2010 to 2012 was not significantly different ($p=0.342$) (Figure 10). The nearby creeks appeared as an obvious contributor of fecal indicator bacteria since the average *E. coli* from all tributaries exceeded water quality standards (Table 39).

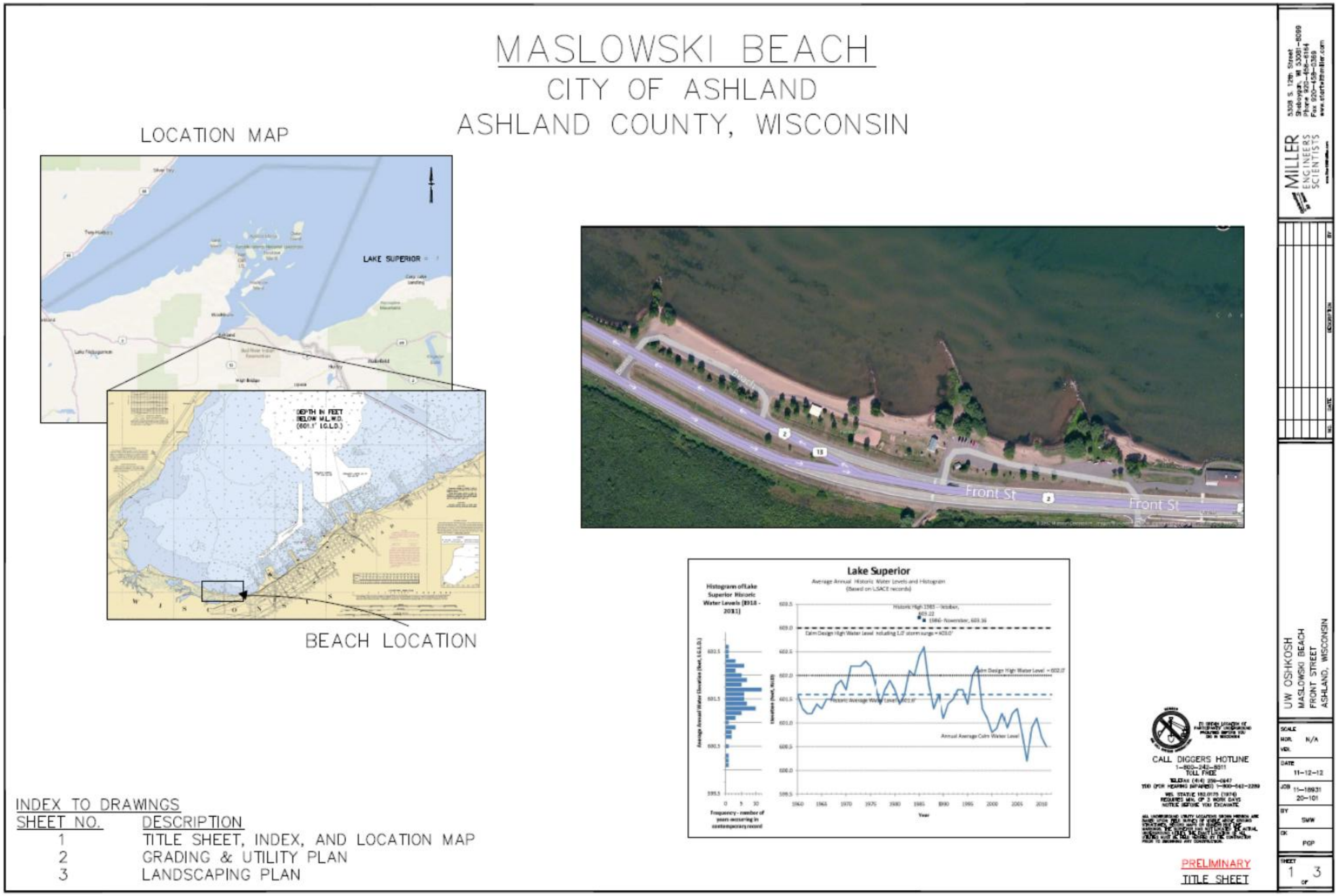
The potential pollution sources identified in the initial site assessment included gull and geese populations, stormwater influence to the east of the beach, sheet flow runoff from the adjacent parking lot, and nearby tributaries. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters and *E. coli* concentrations at the center of beach at 24 inches. The parameter with the highest R^2 value at Maslowski Beach was turbidity (Table 40). This result was not anticipated since there were several creeks and a nearby stormwater outfall with high concentrations of *E. coli*. Assumptions can be made, however, about the significant amount of sheet flow from the impervious surfaces surrounding the beach. Several pictures depict direct impact from stormwater running from the parking lot into the nearshore water.

Additional statistical analyses (Minitab16) were also conducted to evaluate average *E. coli* concentrations at three depths at Maslowski Beach in order to assess the impact of surface runoff in nearshore water on *E. coli* concentrations. The difference between *E. coli* concentrations at 12 inches, 24 inches, and 48 inches was significant (ANOVA $p=0.026$ where $p<0.05$). Further analysis was done using a Tukey's Post Hoc test to determine which mean depths were different from each other. The Tukey test revealed that mean *E. coli* concentrations were different between 12-inch and 48-inch depths. This indicates that *E. coli* contamination may be coming from onshore rather than offshore, and could be linked to stormwater.

RECOMMENDATIONS AND FUTURE WORK

Maslowski beach was recommended for a preliminary redesign plan in the GLRI FY10 funding. A preliminary design plan was developed to mitigate some of the aforementioned pollution sources. The design plan integrates transition infiltration beds at the north edge of the parking lot to absorb sheet flow runoff. Dune grass will also be planted on the upshore of the beach to hold nourished sand on the beach and further infiltration of stormwater. The jetties located on the east edge of the beach will be removed to restore proper hydrodynamic flow. A public meeting will be held in spring of 2013 to discuss the preliminary redesign plan with the local community and city officials in Ashland, Wisconsin. UW Oshkosh will assist the community (if desired) to investigate funding sources to allow for final plan development and full or partial implantation of the redesign plans. Once the beach is fully reconstructed, sampling should be conducted in the years following to evaluate if the mitigation was effective.

CONCEPTUAL REDESIGN PLAN *(Following 3 pages)*


MASLOWSKI BEACH
CITY OF ASHLAND
ASHLAND COUNTY, WISCONSIN
LOCATION MAP
LAKE SUPERIOR
DEPTH IN FEET BELOW M.L.W.D. (601.1' I.G.L.D.)
BEACH LOCATION
Front St
Lake Superior
CALL DIGGERS HOTLINE
TOLL FREE
INDEX TO DRAWINGS
SHEET NO.
DESCRIPTION
1
TITLE SHEET, INDEX, AND LOCATION MAP
2
GRADING & UTILITY PLAN
3
LANDSCAPING PLAN
PRELIMINARY
TITLE SHEET
MILLER
ENGINEERS
SCIENTISTS
UW OSHKOSH
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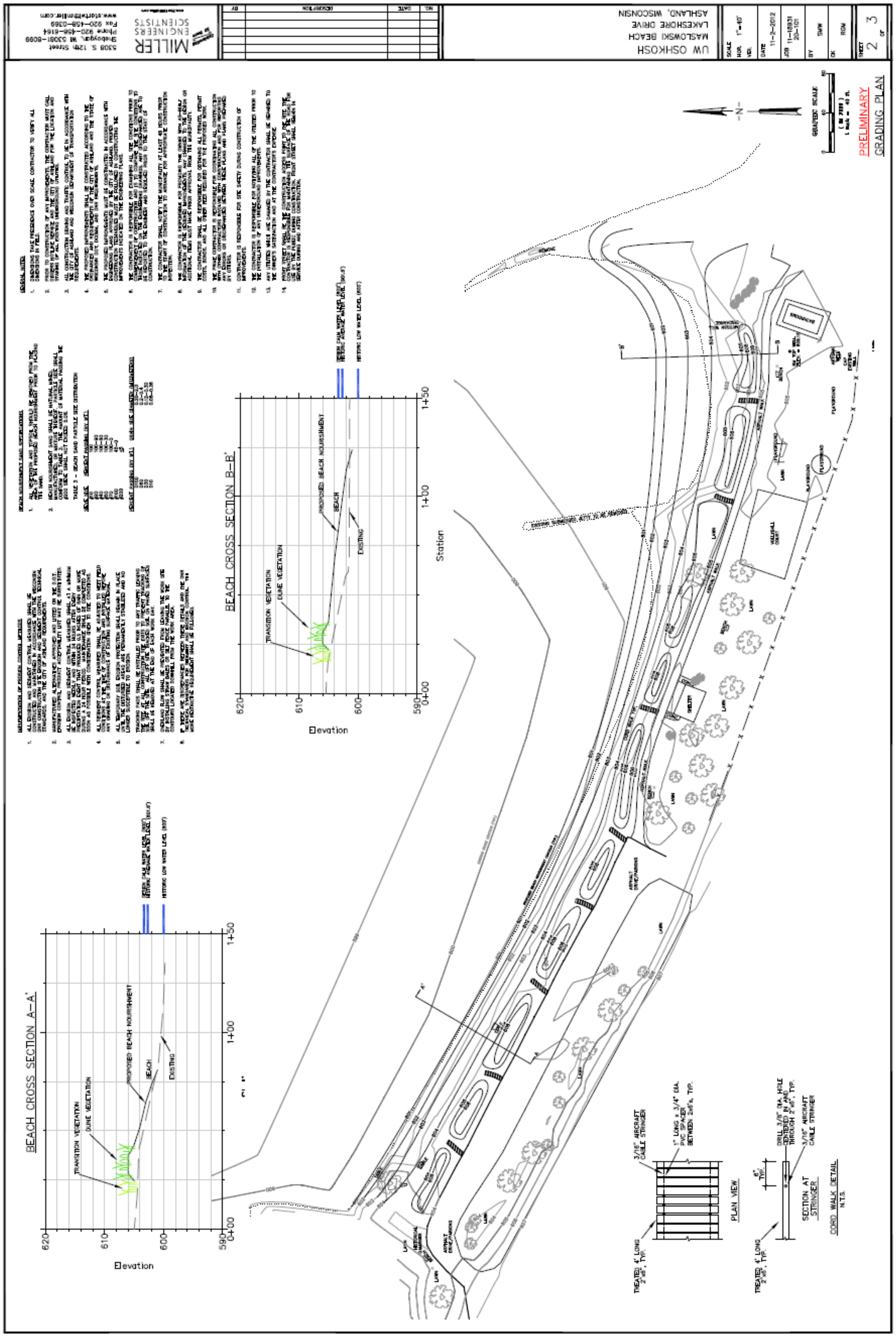
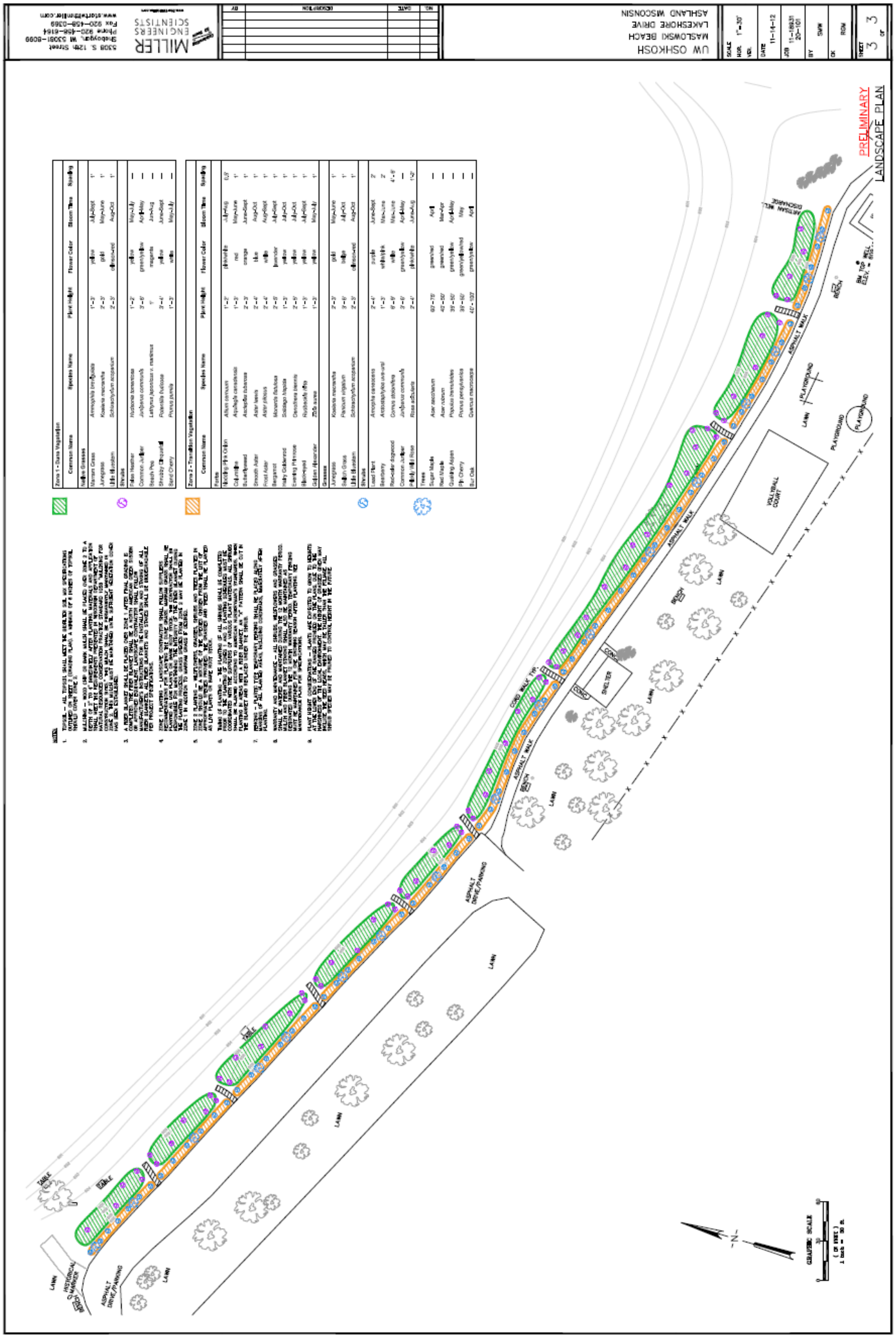

MILLER
ENGINEERS
SCIENTISTS
5308 S. 12th Street
Sheboygan, WI 53081-8069
UW OSHKOSH
MASLOWSKI BEACH
LAKESHORE DRIVE
ASHLAND, WISCONSIN
PRELIMINARY
GRADING PLAN
BEACH CROSS SECTION A-A'
BEACH CROSS SECTION B-B'
Elevation
Station
TRANSITION VEGETATION
DUNE VEGETATION
PROPOSED BEACH NOURISHMENT
BEACH
EXISTING
PLAN VIEW
SECTION AT STRINGER
CORD WALK DETAIL


PRELIMINARY
LANDSCAPE PLAN
UW OSHKOSH
MASLOWSKI BEACH
LAKESHORE DRIVE
ASHLAND WISCONSIN
MILLER
ENGINEERS
SCIENTISTS

Site: Memorial South Beach – Manitowoc, Wisconsin

INITIAL SITE ASSESSMENT

Photo 33: Aerial photo of Memorial South Beach. Little Manitowoc River is not shown, but is south of Memorial South Beach.

Preliminary Site Assessment

Memorial South Beach is an extension of Memorial Middle & North Beaches located in Manitowoc, Wisconsin.

Surrounding Area. Beach is bounded to the north by a stormwater outfall and associated plunge pool/streams and to the south by a jetty. The back beach area is heavily vegetated with rip rap lining the bluff. A major roadway and multi-purpose trail (Mariner Trail) are above and run parallel to the beach.

Physical Attributes. The foreshore area is comprised of fine sand (Mean Grain Size = 0.00864 in). Submerged sediments are formed of fine sand with no visible pebbles or cobbles. Minimal amounts of algae and macrophytes were observed and the nearshore water was clear. There was a wide sand bar located 100 to 200 feet offshore running parallel to the entire beach. Sand bars could act to retain algae, when present. The beach is in a naturalized state, steep, with a narrow swash zone. Wave action impacts the entire width up to the start of the vegetation in the back beach area; area could become submerged if the lake level rises.

- Length of beach: 2,176 feet
- Average width of beach: 38 feet

Potential Pollution Sources. Few gulls, sandpipers, and geese were observed on the initial site assessment, but there was evidence of heavy usage by avian populations due to the presence of large amounts of feathers and bird droppings. Low amounts of litter were observed. The beach appears to be used as a dog beach (Photo 36) although there is no such designation. Beach is bounded to the north by a stormwater outfall, which is a potential source of pollution.

Photo 34: Memorial South Beach looking north in Manitowoc, Wisconsin.

Photo 35: Stormwater outfall on the north end of Memorial South Beach.

Photo 36: Walking dog on the beach with no designation.

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 three times a week from 2010 to 2012 at Memorial South Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. Samples were collected from a stormwater outfall (Pipe 1) and the Little Manitowoc River. Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 41: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Memorial South Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	9	31	29%	320.6
2004	6	23	26%	187.8
2005	4	19	21%	134.2
2006	12	22	55%	841.8
2007	4	31	13%	127.6
2008	12	34	35%	381.8
2009	1	26	4%	101.4
2010	4	52	8%	116.4
2011	7	47	15%	182.1
2012	10	45	22%	311.7
Totals	**69**	**330**	**21%**	**270.5**

Table 42: Summary of total *E. coli* samples collected over the duration of the study at Memorial South Beach.

Summary of *E. coli* Samples Collected (2010-2012) Memorial South Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	15	119	117	0	251
2011	28	141	118	62	349
2012	45	152	45	45	287
Total	88	412	280	107	887

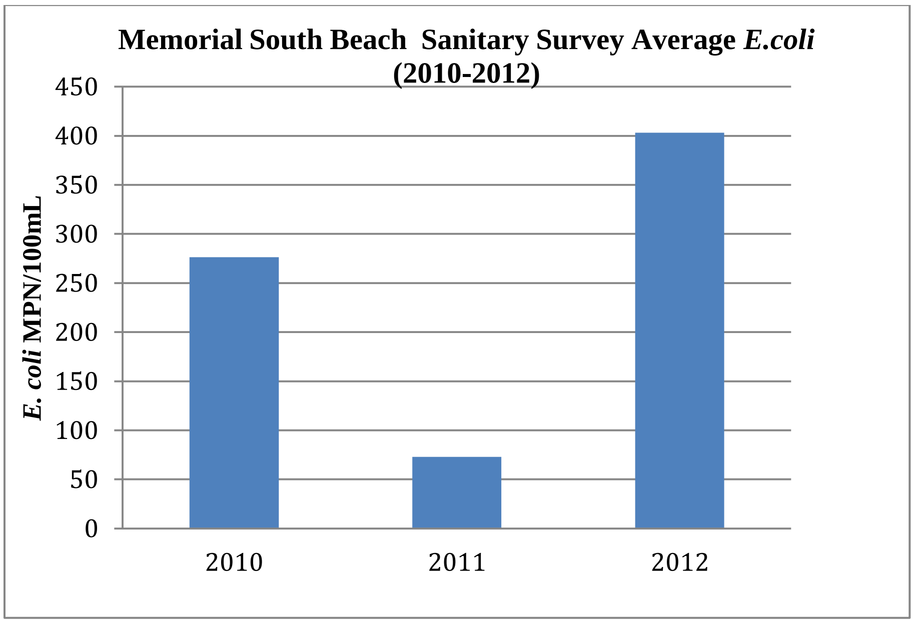


Figure 11: Average *E. coli* (MPN/100mL) at Memorial South Beach in Manitowoc, Wisconsin, from 2010-2012.

Table 43: Mean Seasonal Results 2010-2012

Memorial South Beach Mean Results– 2010-2012							
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Pipe 1 *E. coli* (MPN/100mL)	Little Manitowoc River *E. coli* (MPN/100mL)
231.2	20.8	17.5	6.9	9.4	0.92	792.1	5403
n= 87	n= 33	n= 126	n= 125	n= 128	n= 128	n= 6	n=71

Table 44: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Memorial South Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.2007	0.0026	0.0182
Wind Speed (mph)	0.0255	0.0132	0.0004
Water Temperature (°C)	0.0391	0.0717	0.0290
Air Temperature (°C)	0.0190	0.0006	0.0112
Turbidity (NTU)	0.0146	0.2537	0.0146
Wave Height (ft)	0.1558	0.0806	0.1558
Within 24hr Rain (cm)	0.0101	0.0554	0.1626
Algae (1-3 scale)	x	0.0037	0.0106
Gulls (#)	0.0251	0.0026	0.0031
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	x	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	x	0.0299	0.0297
Longshore Current Direction (°)	x	0.1356	0.0027
Tributaries/Outfalls *E. coli* Pipe 1	Over all 3 years: 0.8939 (n=6)		
Tributaries/Outfalls *E. coli* Little Manitowoc River	x	0.0098	0.3488

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Memorial South Beach has been monitored routinely through the BEACH Act since 2003 and has been on the impaired waters (EPA 303d) list since 1998. The historical water quality (Table 41) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). The average *E. coli* concentration since 2003 exceeds the advisory standard of 235 MPN/100mL. A total of 887 samples were collected at Memorial South Beach from 2010 to 2012 through the GLRI project (2010 n=251, 2011 n=349, 2012 n=287) as shown in Table 42. The mean *E. coli* from 2010 to 2012 was not significantly different (p=0.201) (Figure 11). The Little Manitowoc River and Pipe 1 appeared as obvious contributors of fecal indicator bacteria since the average *E. coli* from all outfalls/tributaries drastically exceeded water quality standards over the three year time period (Table 43).

The potential pollution sources identified in the initial site assessment included gulls, geese, and other bird types, stormwater infrastructure in the back beach, and sheet flow runoff from the adjacent parking lot and road. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Memorial South Beach included wind direction, turbidity, wave height, longshore current direction, Little Manitowoc River, and Pipe 1 (Table 44). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

The nearby stormwater drain correlated to 89% of the variability in *E. coli* concentrations at Memorial South Beach. This pipe was only flowing during high rain events, but clearly impacts the water quality at the beach. Located south of Memorial South Beach, Little Manitowoc River contributed to 35% of *E. coli* variation at the beach in 2012. It is very evident that stormwater is the main contributor to *E. coli* concentrations at Memorial South Beach.

Additional statistical analyses (Minitab16) were also conducted to evaluate average *E. coli* concentrations at three transects at Memorial South Beach in order to assess the impact of stormwater in nearshore water on *E. coli* concentrations. The difference between *E. coli* concentrations left, center, and right of the beach were not significant (ANOVA $p=0.990$ where $p<0.05$). These results may be due to homogenous mixing of the stormwater due to wave action, current speed and direction.

RECOMMENDATIONS AND FUTURE WORK

Memorial South Beach was not recommended for a redesign plan in the GLRI FY10 funding. Since Memorial South Beach only exists in times of low lake levels, additional studies should be conducted to determine the long term viability of the beach before mitigation is carried out. In the meantime, it is recommended to post signs prohibiting dogs at the beach and place additional garbage receptacles to decrease pet waste and other litter on the beach. This beach should continue to be monitored to inform and protect public health.

Site: Menominee Park Beach – Oshkosh, Wisconsin (*Inland Demonstration Beach)

INITIAL SITE ASSESSMENT

Photo 37: Aerial photo of Menominee Park Beach and surrounding area.

Preliminary Site Assessment

Menominee Park is an inland municipal beach located on Lake Winnebago in Oshkosh, Wisconsin.

Surrounding Area. Menominee Park Beach is located within Menominee Park; a large park with a small zoo, baseball diamonds, and a marina. There is a large play area near the beach and a concession stand/bath house located on the upshore of the beach. The Oshkosh Water Treatment plant is directly south of the beach. Water intake is several hundred yards offshore from the beach.

Physical Attributes. The foreshore area is comprised of medium sand with some crushed zebra/quagga mussel shells. Submerged sediments are formed of fine sand with visible zebra/quagga mussel shells. This beach has a moderate slope and a small swashzone. The beach, however, has no vegetative barrier between the parking lot, walkway and the upshore beach. There is extensive turf grass surrounding the beach with little-to-no infiltration of stormwater.

- Length of beach: 141 feet
- Average width of beach: 36 feet

Potential Pollution Sources. There is a large area of turf grass surrounding the beach. The turf grass does not allow for sufficient stormwater infiltration and attracts geese that tend to land in large open areas and deposit fecal material in and around the beach and nearshore water. There are no rain gardens or infiltration swales between the impervious surfaces and the beach area. The beach proper appears sand starved, with areas of turf grass growing which do not allow for proper infiltration.

Photo 38: Looking north over Menominee Park Beach in mid-afternoon.

Photo 39: Play area west of the Menominee Park Beach, encased by large areas of turf grass.

Photo 40: Looking east from behind Menominee Park Beach, showing turf grass and concession stand.

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 three times a week from 2010 to 2012 at Menominee Park Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There were no outfalls identified at Menominee Park Beach, except for the Fox River to the south of the beach. Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 45: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Menominee Park Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2010	2	33	6%	109.2
2011	2	27	7%	87.6
2012	2	37	5%	128.1
Totals	**6**	**97**	**6%**	**108.3**

Table 46: Summary of total *E. coli* samples collected over the duration of the study at Menominee Park Beach.

Summary of *E. coli* Samples Collected (2010-2012) Menominee Park Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	33	258	107	0	398
2011	14	87	77	0	178
2012	29	174	68	0	271
Total	76	519	252	0	847

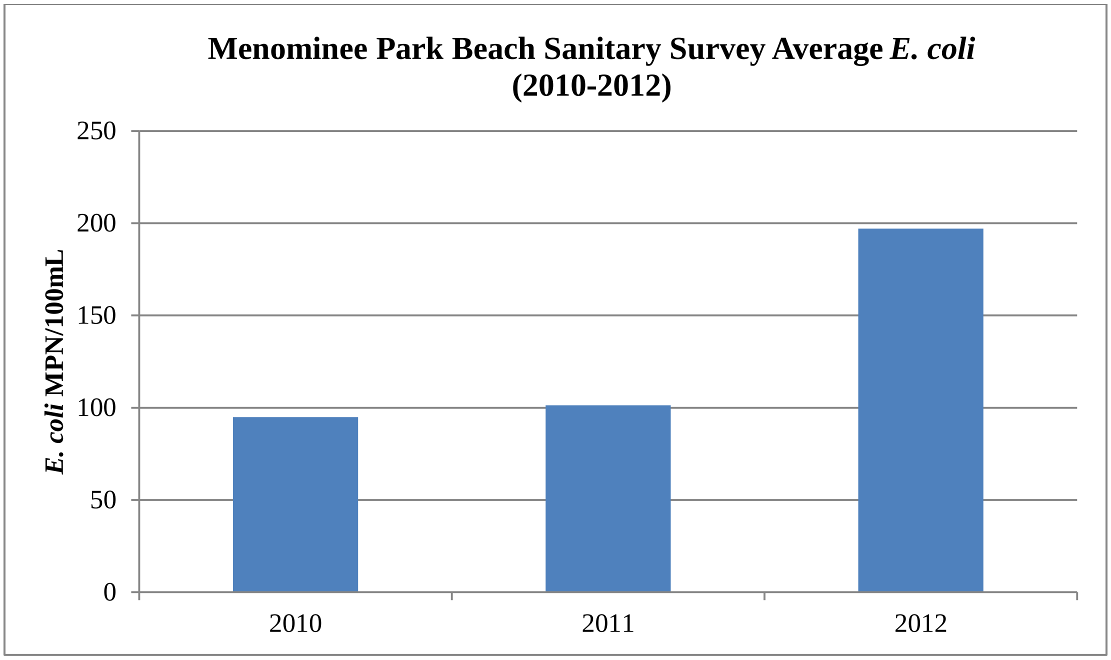


Figure 12: Average *E. coli* (MPN/100mL) at Menominee Park in Oshkosh, Wisconsin, from 2010-2012.

Table 47: Mean Seasonal Results 2010-2012

Menominee Park Beach Mean Results– 2010-2012					
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)
114.9	203.2	24.4	4.2	23.2	14.2
n= 76	n= 30	n= 92	n= 58	n= 91	n= 92

Table 48: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Menominee Park Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	x	0.1001	0.0460
Wind Speed (mph)	0.0001	0.1149	0.0100
Water Temperature (°C)	0.0501	0.0206	0.0021
Air Temperature (°C)	0.0000	0.0513	0.0327
Turbidity (NTU)	0.1851	0.0040	x
Wave Height (ft)	0.1475	0.1137	0.0565
Within 24hr Rain (cm)	0.1423	0.0679	0.2333
Algae (1-3 scale)	x	x	0.0691
Gulls (#)	0.0066	0.0507	0.0002
Geese (#)	x	0.0032	x
Other Avian (#)	x	x	x

Bathers at Beach (#)	x	0.0114	0.0000
Bathers In Water (#)	x	0.0489	0.0103
Longshore Current Speed (cm/sec)	0.0500	0.2522	0.2152
Longshore Current Direction (°)	x	0.0929	0.0326

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Menominee Park Beach has only been monitored since 2010 by the City of Oshkosh. Since Menominee Park Beach is an inland beach, BEACH Act funding does not apply. This beach was chosen as a pilot beach for conducting sanitary surveys on an inland beach in order to serve as a comparative model using methods approved for Great Lake beaches. Menominee Park has moderate water quality with only six water quality exceedances since 2010 (Table 45). A total of 847 samples were collected at Menominee Park Beach from 2010 to 2012 through the GLRI project (2010 n=398, 2011 n=178, 2012 n=271) as shown in Table 46. The mean *E. coli* from 2010 to 2012 was not significantly different between the three years of collection (p=0.813) (Figure 12). The overall average of *E. coli* from 2010 to 2012 was well below the 235 MPN/100mL exceedance level (Table 47).

The potential pollution sources identified in the initial site assessment include geese populations and runoff from impervious surfaces. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Menominee Park Beach include wave height and rain (Table 48). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

RECOMMENDATIONS AND FUTURE WORK

Menominee Park Beach was not recommended for a redesign plan in the GLRI FY10 funding. However, this beach is receiving a preliminary and final redesign plan through GLRI FY11 funding. Based on the aforementioned pollution sources, a redesign plan will be constructed to address stormwater management, geese deterrence, and beach nourishment. If the City of Oshkosh is unable to provide funds for implantation of these plans, UW Oshkosh will aid in applying for alternative funding.

These data show that conducting sanitary surveys to identify potential pollution sources is effective at inland beaches. Menominee Park Beach exhibited similar characteristics to Great Lake beaches, including ineffective stormwater management, lacking deterrence of waterfowl, and sand starved beach front with little or no sand dunes. With this in mind, Menominee Park Beach is located on a large inland lake (Lake Winnebago). These results may not be the same for beaches located on smaller inland lakes where longshore current, wave action, and macrophytic algae are not present. It is recommended that Menominee Park Beach continue to be monitored to keep the public informed of the water quality. If mitigation is feasible in the future, an assessment should be conducted afterwards to evaluate the effectiveness of the newly mitigated beach.

Site: Neshotah Beach – Two Rivers, Wisconsin

INITIAL SITE ASSESSMENT

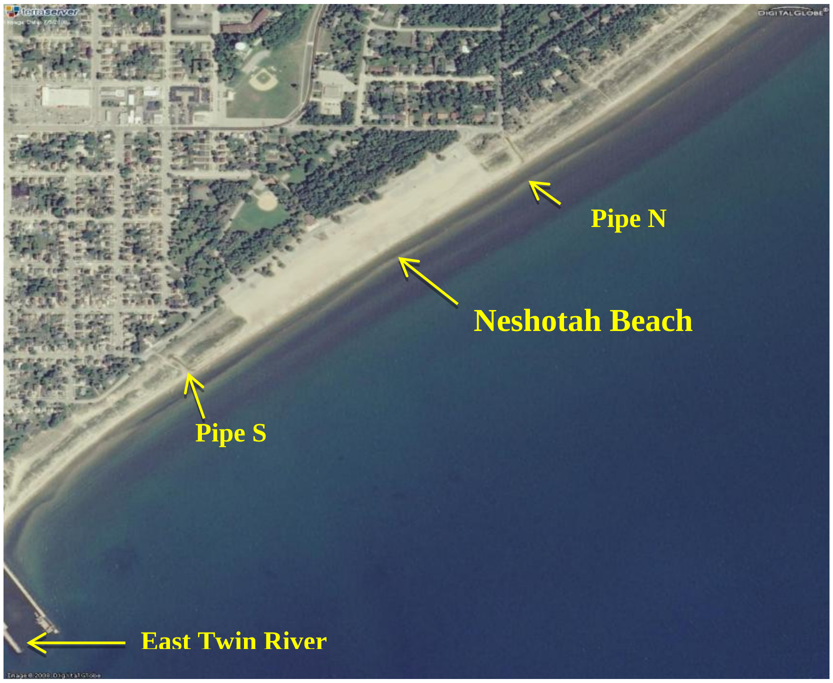


Photo 41: Aerial photo of Neshotah Beach in Two Rivers, Wisconsin, and nearby outfalls.

Preliminary Site Assessment:
Neshotah Beach is a municipal/county beach used for swimming, walking, kite flying, and basketball. On the day of the visit there were 30 individuals engaged in these activities, 6 in the water.

Surrounding Area. The beach is bounded by a road and parkland to the west.

Physical Attributes. The foreshore area is comprised of fine- to medium-grained sand (Mean Grain Size = 0.01186). Submerged sediments are formed of fine sand with no visible pebbles or cobbles. Low amounts of algae and macrophytes were observed; however, some was incorporated into the berm crest, indicating the potential for larger blooms at this location. There is a poor- to moderately-developed berm crest, and little-to-no elevation from the paved parking lot to the shore. Large sand bars were located 20, 60 and 100 feet offshore running parallel to the entire beach. Sand bars could act to retain algae. In the absence of recent rain, wet sand extended approximately 50 feet inland from the water's edge. Preliminary excavation indicated that the water table was close to the sand surface (12 inches deep 10 feet from the shore, and 18 inches deep 22 feet from the shore). Fine, wet sand is more likely to harbor micro-organisms. There is a fairly well-developed dune system to the north of the beach, less so to the south. The beach is groomed once weekly during the swimming season.

- Length of beach: 2,158 feet
- Average width of beach: 245.7 feet

Potential Pollution Sources. There was evidence of a large flock of gulls, but only 180 gulls and 4 sandpipers were observed at the south end of the beach during the initial site assessment. There were also two dogs on the beach. Low amounts of litter (food waste, cigarette butts, and dead fish) were observed. There are three large parking lots to the west of the beach, all lacking a curb and gutter system. Municipal infrastructure exits to the north and south of this beach. A tributary discharges to the south (East Twin River).

Photo 42: Looking south along the edge of the east parking lot at Neshotah Beach, Two Rivers, Wisconsin.

Photo 43: North outfall flowing into Lake Michigan at Neshotah Beach.

Photo 44: Looking southeast from the parking lot and walkway at Neshotah Beach.

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 three times per week from 2010-2012 at Neshotah Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. Samples were collected from two stormwater outfalls (Pipe N and Pipe S). Sand samples were also collected up to 3X/week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 49: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Neshotah Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**# of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	16	35	46%	308.9
2004	10	26	38%	473.8
2005	5	20	25%	197.0
2006	13	27	48%	669.1
2007	12	41	29%	199.5
2008	16	39	41%	246.3
2009	0	25	0%	67.9
2010	2	53	4%	59.1
2011	7	53	13%	122.8
2012	1	55	2%	55.1
Totals	**82**	**374**	**22%**	**240.0**

Table 50: Summary of total *E. coli* samples collected over the duration of the study at Neshotah Beach.

Summary of *E. coli* Samples Collected (2010-2012) Neshotah Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	50	0	0	0	50
2011	38	169	146	38	391
2012	55	346	71	64	536
Total	143	515	217	102	977

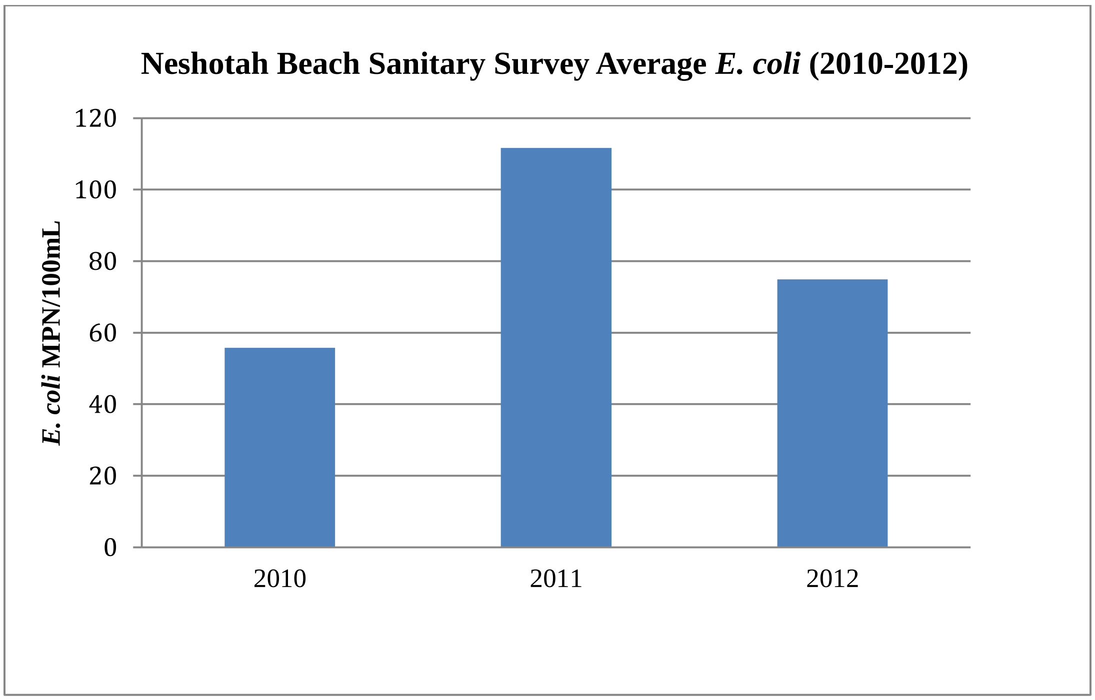


Figure 13: Average *E. coli* (MPN/100mL) at Neshotah Beach in Two Rivers, Wisconsin, from 2010-2012.

Table 51: Mean Seasonal Results 2010-2012

	Neshotah Beach Mean Results– 2010-2012						
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Pipe N *E. coli* (MPN/100mL)	Pipe S *E. coli* (MPN/100mL)
637	68.1	18	5.2	202.9	25	108.4	234.6
n =143	n= 23	n= 151	n= 141	n= 152	n= 152	n= 61	n= 35

Table 52: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Neshotah Beach	R^2 Value		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0130	0.0251	0.0342
Wind Speed (mph)	0.0000	0.1619	0.0062
Water Temperature (°C)	0.0606	0.0000	0.0147
Air Temperature (°C)	0.0000	0.0999	0.0000
Turbidity (NTU)	0.0321	0.0804	0.1424
Wave Height (ft)	0.0429	0.5893	0.0047
Within 24hr Rain (cm)	0.0295	0.0144	0.0047
Algae (1-3 scale)	x	0.0284	x
Gulls (#)	0.0000	0.1372	0.0081
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	0.0055	0.1176	0.0091
Bathers In Water (#)	0.0017	0.1483	0.0085
Longshore Current Speed (cm/sec)	0.0085	x	0.1999
Longshore Current Direction (°)	0.0158	x	0.0542
Tributaries/Outfalls *E. coli* Pipe N	x	0.5968	0.0223
Tributaries/Outfalls *E. coli* Pipe S	x	0.2431	0.0076

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Neshotah Beach has been intermittently listed on the impaired waters (EPA 303d) list since 2003. The historical water quality (Table 49) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). The overall water quality from 2003 to 2012 was 240 *E. coli* MPN/100mL, which exceeds water quality standards. A total of 977 samples were collected at Neshotah Beach from 2010 to 2012 through the GLRI project (2010 n=50, 2011 n=391, 2012 n=536) as shown in Table 50. The mean *E. coli* from each year was well below the 235 MPN/100mL exceedance level (Figure 13). The overall mean *E. coli* for Pipe S from 2010-2012 was 234.6 MPN/100mL (Table 51).

There were several potential pollution sources identified in the initial site assessment, including extensive gull and geese populations, stormwater, and surface runoff from impervious surfaces in conjunction with a low, flat beach which is sand starved. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Neshotah Beach include wind turbidity and outfall contribution (Table 52). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

Additional statistical analyses (Minitab16) were also conducted to evaluate average *E. coli* concentrations at three transects at Neshotah Beach in order to assess the impact of stormwater on *E. coli* concentrations. An ANOVA (Estimate Model) was used in conjunction with a Tukey Test between the three transects, and a p=0.542 was calculated where p<0.05. There is no statistical evidence that mean *E. coli* concentrations are different between transects; however, there is a positive correlation (R^2=0.5968 and 0.2431 in 2011) (Table 52) between the north and south outfalls, and therefore still potentially impacts Neshotah Beach.

RECOMMENDATIONS AND FUTURE WORK

Neshotah Beach was not recommended for a redesign plan in the GLRI FY10 funding. However, through additional GLRI funding with Bay-Lake Regional Planning Commission in 2011, a preliminary design plan was developed to mitigate the aforementioned pollution sources. The design plan addresses stormwater infiltration at the two stormwater drains, beach nourishment, a curb and gutter system lining the parking lot and walkway along with infiltration basins, and dune plantings to mitigate runoff of stormwater and hold sand on the beach. A meeting was held with Two Rivers officials where the preliminary design plan was reviewed. The final design plans will be presented in the spring of 2013, when UW Oshkosh will work with the local community to evaluate alternative funding sources for implementation of the redesign plans in the near future. Once implementation is complete, the water quality should be assessed to ensure the mitigation was effective.

Site: Point Beach Concession– Two Rivers, Wisconsin

INITIAL SITE ASSESSMENT

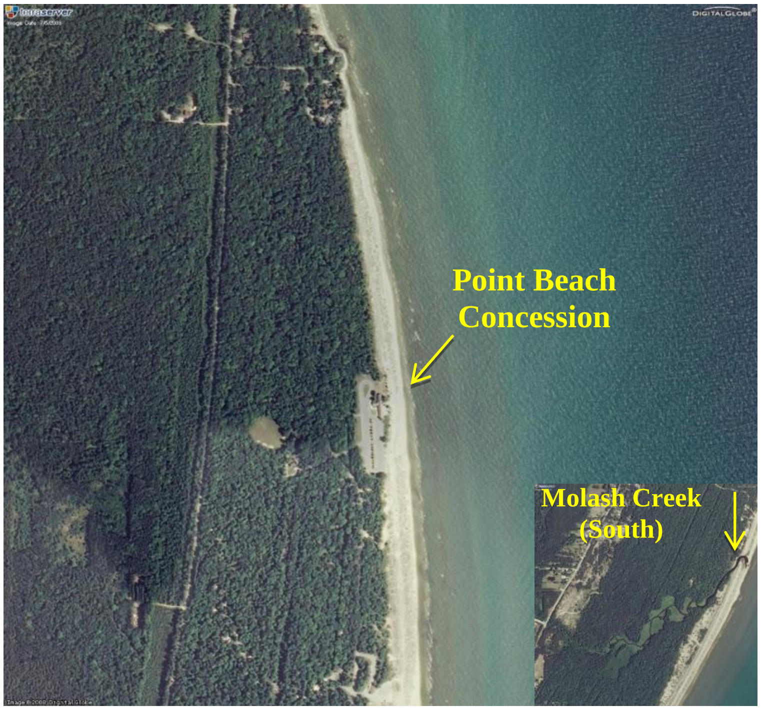


Photo 45: Aerial photo of Point Beach Concession at Point Beach State Park in Two Rivers, Wisconsin.

Preliminary Site Assessment:
Point Beach Concession is a designated swimming area within a state park.

Surrounding Area. Point Beach Concession is located in Point Beach State Park north of two other beaches that are not included in this project. There is a concession building with a restroom and showers above the steep bluff.

Physical Attributes. The foreshore area is comprised of fine sand (Mean Grain Size=0.00878). Submerged sediments are also formed of fine sand. Significant algal biomass, extending six feet into the nearshore waters of Lake Michigan, was observed on the initial site survey. There is a well-defined berm crest and a well-developed small dune system in the back beach area and some rip rap near the stair of the concession building. Large sand bars were located 30 and 60 feet offshore running parallel to the entire beach. Sand bars could act to retain algae.

- Length of beach: 1,850 feet
- Average width of beach: 162 feet

Potential Pollution Sources. There was evidence of gulls but no animals were seen during the initial site assessment. No litter was observed. A paved stairwell and cobble stoned walkway are situated on a bluff above the beach, which likely drain to the beach proper. Behind the concession area is a large paved parking lot. There is little infiltration between the parking lot and cobble pathways to the beach, which allows sheet flow to run directly to the beach. There is also a tributary (Molash Creek) which flows into Lake Michigan to the south of Point Beach State Park.

Photo 46: Looking south over Point Beach Concession at Point Beach State Forest.

Photo 47: Looking from the concession building down onto the beach.

Photo 48: Looking up from the beach at the concession building.

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 four times a week from 2010 to 2012 at Point Beach Concession. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There were no stormwater outfalls identified; however, a nearby tributary (Molash Creek) was sampled three times per week. Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 53: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Point Beach Concession Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	17	35	49%	307
2004	14	25	56%	496.8
2005	4	20	20%	320.5
2006	14	26	54%	667.6
2007	9	32	28%	282.5
2008	6	31	19%	144.6
2009	0	25	0%	43.7
2010	7	54	13%	173.6
2011	8	53	15%	228.9
2012	5	55	9%	147.9
Totals	**84**	**356**	**24%**	**281.3**

Table 54: Summary of total *E. coli* samples collected over the duration of the study at Point Beach Concession.

Summary of *E. coli* Samples Collected (2010-2012) Point Beach Concession					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	50	0	0	0	50
2011	38	136	81	51	306
2012	55	304	89	51	499
Total	143	440	170	102	855

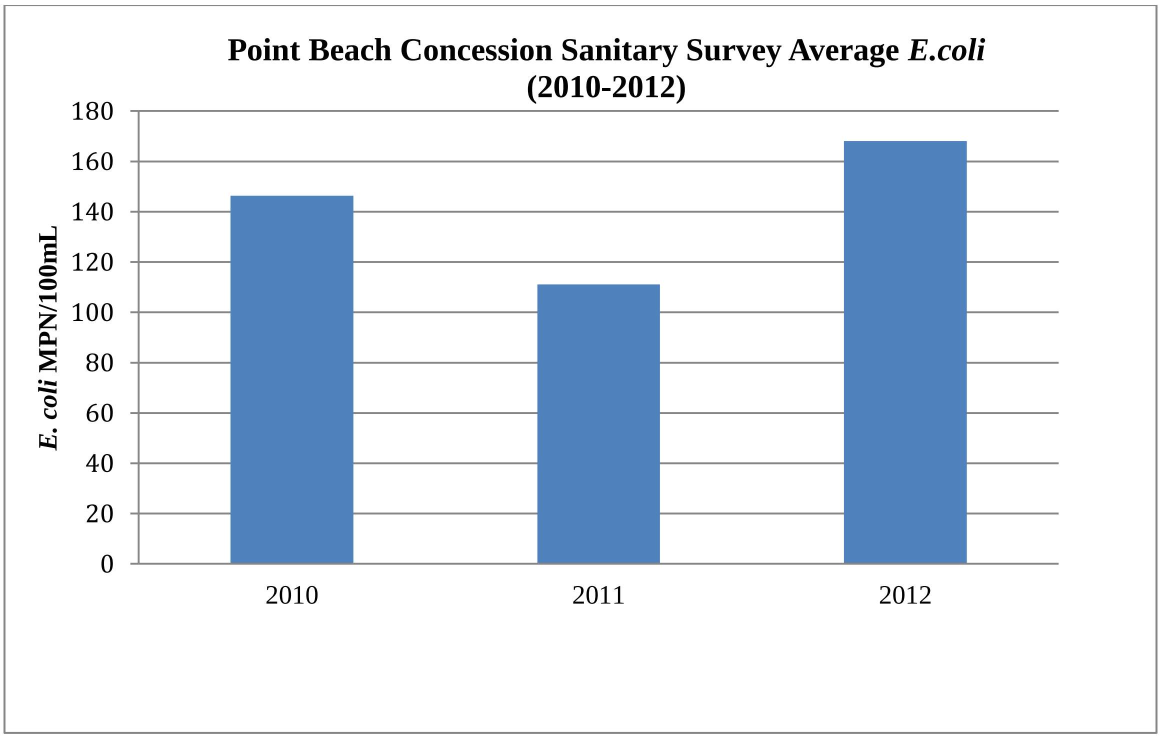


Figure 14: Average *E. coli* (MPN/100mL) at Concession Beach at Point Beach State Park in Two Rivers, Wisconsin, from 2010-2012.

Table 55: Mean Seasonal Results 2010-2012

Point Beach Concession Mean Results– 2010-2012						
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Molash Creek *E. coli* (MPN/100mL)
132.9	21.2	18.5	6.2	2	7.4	518.0
n= 143	n= 18	n= 151	n= 138	n= 153	n= 153	n= 88

Table 56: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Point Beach Concession	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0058	0.0126	0.1847
Wind Speed (mph)	0.0005	0.0470	0.0553
Water Temperature (°C)	0.0005	0.0113	0.0389
Air Temperature (°C)	0.0000	0.0213	0.0033
Turbidity (NTU)	0.1995	0.1624	0.1758
Wave Height (ft)	0.0640	0.3891	0.2298
Within 24hr Rain (cm)	0.0355	0.0003	0.0490
Algae (1-3 scale)	x	0.1181	0.0144
Gulls (#)	0.0312	x	x
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	0.0036	x	0.0000
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.0409	0.1256	0.0490
Longshore Current Direction (°)	x	x	x
Tributaries/Outfalls *E. coli* Molash Creek	x	0.0211	0.3145

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Point Beach Concession has been monitored routinely through the BEACH Act since 2003 and was on the impaired waters (EPA 303d) list from 2004 to 2012. The historical water quality (Table 53) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). The average *E. coli* concentration since 2003 exceeds the advisory standard of 235 MPN/100mL. A total of 855 samples were collected at Neshotah Beach from 2010 to 2012 through the GLRI project (2010 n=50, 2011 n=306, 2012 n=499) as shown in Table 54. The mean *E. coli* from each year between 2010 and 2012 was well below the 235 MPN/100mL exceedance level (Figure 14). The overall mean *E. coli* for Molash Creek from 2010 to 2012 was 518.0 MPN/100mL which may indicate Molash Creek as a possible source of pollution for Point Beach Concession (Table 55).

There were few potential pollution sources identified in the initial site assessment including gull populations and sheet flow runoff from the above concession cobble walkway, stairs, and parking lot. Following three years of data collection, statistical linear regression was conducted between physical/chemical/biological parameters and *E. coli* concentrations at the center of beach at 24”. Parameters with the highest R^2 value at Point Beach Concession included wave height, turbidity, longshore current speed, and Molash Creek (Table 56). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

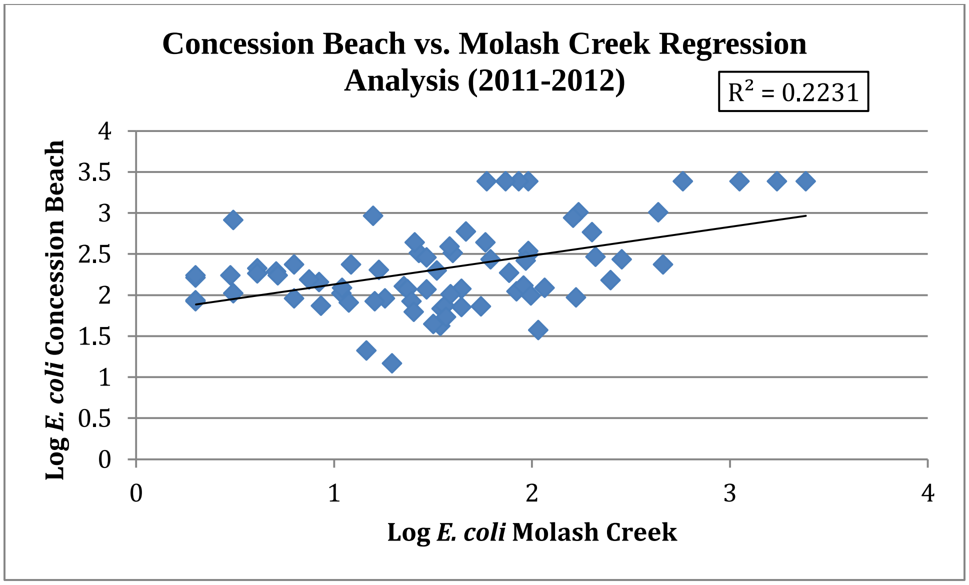


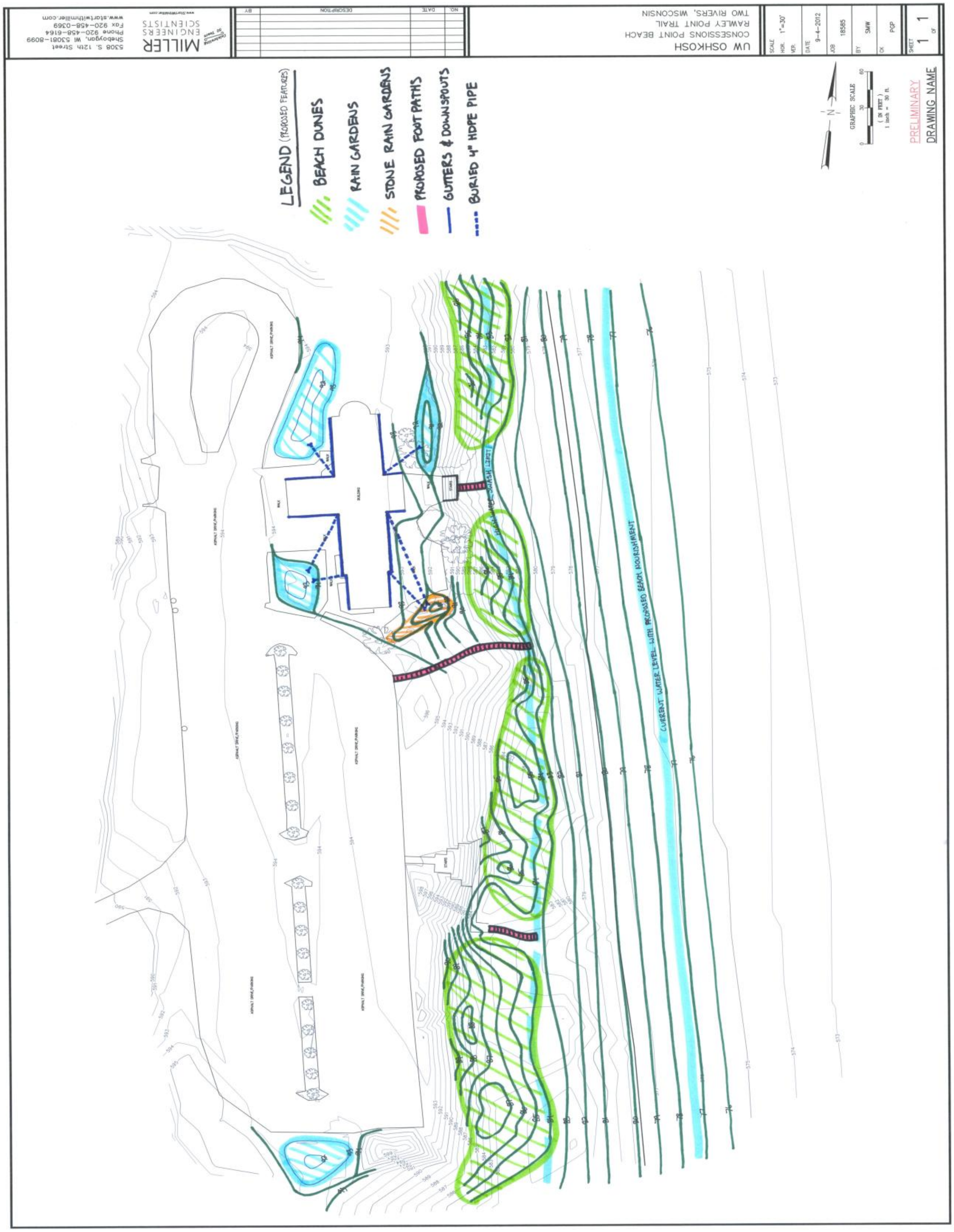
Figure 15: Linear Regression between *E. coli* concentrations from Molash Creek and Point Beach Concession (Center 24") from 2011-2012.

Molash Creek results show the highest R2 value of 0.2231 from two years of data collection (Figure 15). This suggests that Molash Creek is a source of contamination at Point Beach Concession.

RECOMMENDATIONS AND FUTURE WORK

Point Beach Concession was recommended for a conceptual redesign plan in the GLRI FY10 funding. The design plan integrates rain gardens near the concession building to infiltrate stormwater from the roof, stone rain gardens to infiltrate runoff before hitting the beach, and beach dunes to further mitigate dirty stormwater before entering the nearshore water. A public meeting was held in Two Rivers to discuss the preliminary redesign plan with the local community. It is now the responsibility of the community to move forward with final redesign plans and actual mitigation. UW Oshkosh will assist the community (if desired) to investigate funding sources to allow for full or partial implantation of the aforementioned redesign plans. Once the beach is fully reconstructed, sampling should be conducted in the years following to evaluate if the mitigation was effective.

CONCEPTUAL REDESIGN PLAN *(Following page)*



LEGEND (PROPOSED FEATURES)
BEACH DUNES
RAIN GARDENS
STONE RAIN GARDENS
PROPOSED FOOT PATHS
GUTTERS & DOWNSPOUTS
BURIED 4" HDPE PIPE
CURRENT WATER LEVEL WITH PROPOSED BEACH NOURISHMENT
UW OSHKOSH
CONSESSIONS POINT BEACH
RAWLEY POINT TRAIL
TWO RIVERS, WISCONSIN
MILLER
ENGINEERS
SCIENTISTS
5308 S. 12th Street
Sheboygan, WI 53081-8099
Phone 920-458-6164
Fax 920-458-0369
www.startwithmiller.com
GRAPHIC SCALE
PRELIMINARY
DRAWING NAME

Site: Red Arrow Beach – Manitowoc, Wisconsin

INITIAL SITE ASSESSMENT

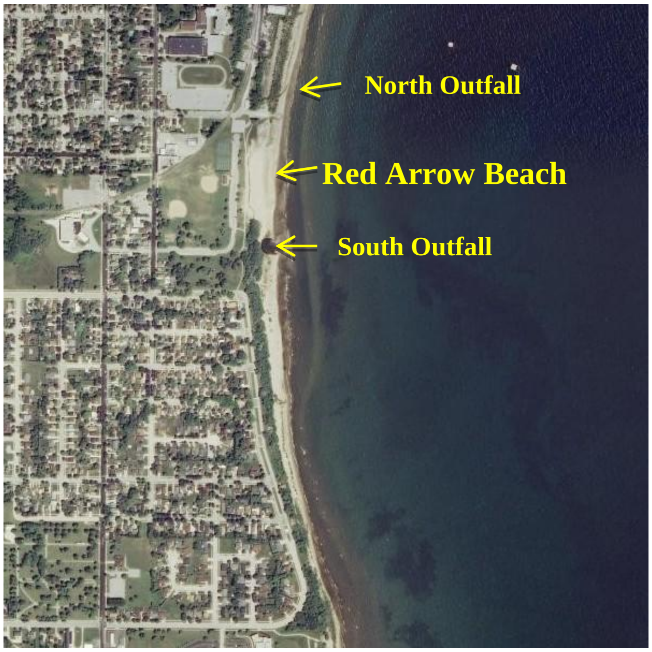


Photo 49: Aerial photo of Red Arrow Beach and two outfalls located on the north and south end of the beach.

Preliminary Site Assessment:
Red Arrow Beach is located in a very large municipal park. The lakefront is handicapped accessible and there is a beach walkway, boardwalk, and boat launch (north end).

Surrounding Area. Surrounding area is formed of parkland and industrial sites, including a railroad. The beach is bounded to the south by a large stormwater outfall pond and to the north by groins. About seven acres of the lakefront to the south of the beach has been set aside as a conservancy area. There are some concrete structures several hundred feet offshore, about mid-beach.

Physical Attributes. The main beach area is low and flat with "dense" sand and little vegetation (Photo 50). The swash zone is comprised of fine sand (Mean Grain Size=0.008878 in.). Submerged sediments are also comprised of fine sand. The beach is located at the base of a bluff. This is a very wide beach with minimal change in elevation at the southern end. The mid-beach area appears to be continually wet as there was bright green, vegetative matter present during the initial site investigation (Photo 52).

- Length of beach: 1,222 feet
- Average width of beach: 135.3 feet

Potential Pollution Sources. There were hundreds of gulls seen on the day the survey was conducted (Photo 51). There was accumulation of *Cladophora* on the beach face. Low amounts of litter were observed. A 6 to 8 foot stormwater outfall constantly discharges to the south of the beach. The discharge is pooled on the beach and forms a very productive pond (Photo 52). Municipal infrastructure of lesser size discharges from the industrial area to the north. There is potential for direct runoff from the boat launch. The beach is very urbanized.

Photo 50: Looking northeast over Red Arrow Beach in Manitowoc, Wisconsin.

Photo 51: Looking south along the low, flat beach at a copious amount of gulls.

Photo 52: Stormwater discharge “pond” at the south end of Red Arrow Beach.

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 four times a week from 2010 to 2012 at Red Arrow Park Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There were two stormwater outfalls identified; however, only one outfall (Outfall S) flowed in both dry and wet weather. Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 57: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Red Arrow Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	18	35	51%	323.4
2004	10	23	43%	281.7
2005	4	19	21%	173.2
2006	14	26	54%	721.6
2007	12	33	36%	473.9
2008	13	36	36%	462.1
2009	4	27	15%	133.2
2010	23	58	40%	577.4
2011	17	58	29%	416.3
2012	14	60	23%	322.1
Totals	**129**	**375**	**34%**	**388.5**

Table 58: Summary of total *E. coli* samples collected over the duration of the study at Red Arrow Park Beach.

Summary of *E. coli* Samples Collected (2010-2012) Red Arrow Park Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	53	0	0	0	53
2011	38	144	144	42	368
2012	60	302	58	81	501
Total	151	446	202	123	922

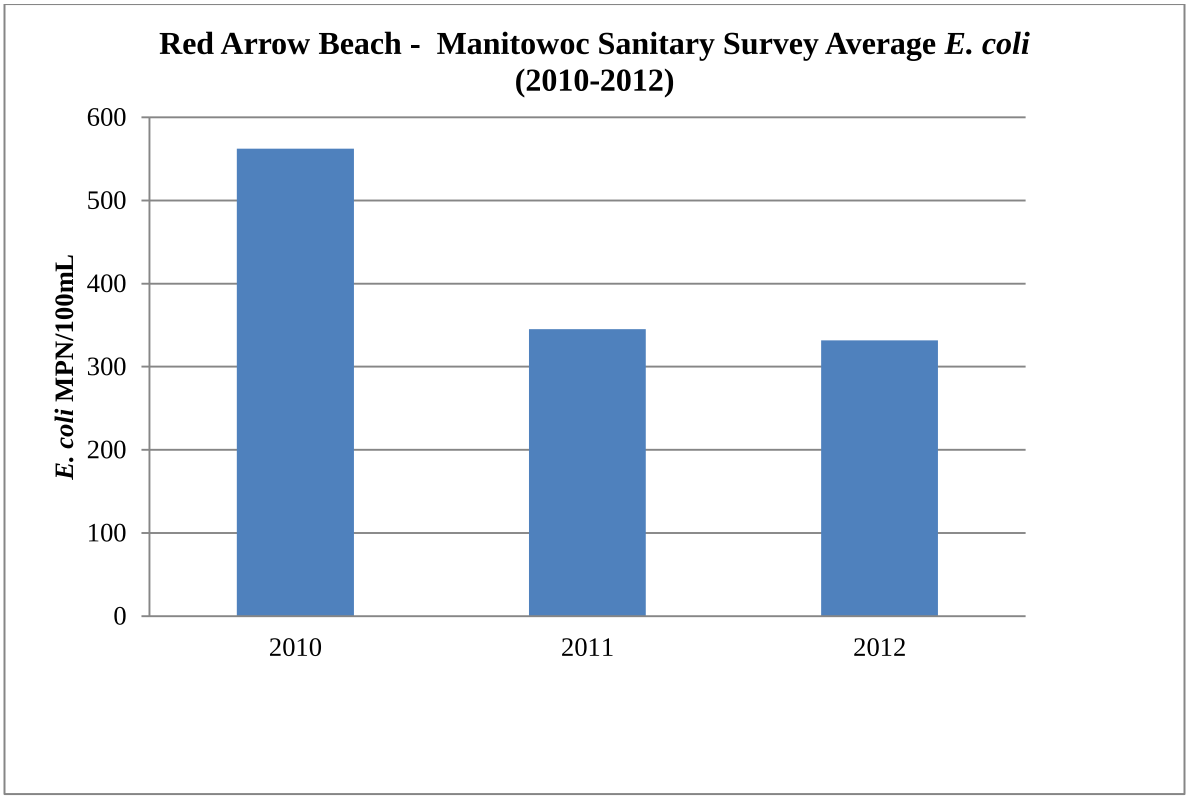


Figure 16: Average *E. coli* (MPN/100mL) at Red Arrow Beach in Manitowoc, Wisconsin, from 2010-2012.

Table 59: Mean Seasonal Results 2010-2012

Red Arrow Beach Mean Results–2010 - 2012						
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Outfall S *E. coli* (MPN/100mL)
416.8	11.4	18.6	7.7	89.5	2.4	463.6
n= 151	n= 24	n= 160	n= 150	n= 160	n= 160	n=55

Table 60: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Red Arrow Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0038	0.0248	0.0068
Wind Speed (mph)	0.0900	0.0087	0.0418
Water Temperature (°C)	0.0212	0.0119	0.0163
Air Temperature (°C)	0.0663	0.0332	0.0038
Turbidity (NTU)	0.1260	0.0319	0.2754
Wave Height (ft)	0.0085	0.1178	0.1252
Within 24hr Rain (cm)	0.0127	0.1260	0.1330
Algae (1-3 scale)	x	0.0082	0.0870
Gulls (#)	0.0008	0.0294	0.0738
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	x	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.1308	0.0006	0.1547
Longshore Current Direction (°)	x	x	x
Tributaries/Outfalls *E. coli* Outfall S	2010-2012: 0.2670 (n=55)		

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Red Arrow Beach has been monitored routinely through the BEACH Act since 2003 and has been the on the impaired waters (EPA 303d) list since 1998. The historical water quality (Table 57) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). The average *E. coli* concentration since 2003 exceeds the advisory standard of 235 MPN/100mL. A total of 922 samples were collected at Red Arrow Beach from 2010-2012 through the GLRI project (2010 n=53, 2011 n=368, 2012 n=501) as shown in Table 58. The mean *E. coli* from each year in 2010 to 2012 exceeded the 235 MPN/100mL exceedance level (Figure 16). The overall mean *E. coli* for the south outfall from 2010 to 2012 was 463.6 MPN/100mL, which may indicate the south outfall as a possible source of pollution for Red Arrow Beach (Table 59).

The potential pollution sources identified in the initial site assessment were gulls and other avian populations, stormwater infrastructure on the south end of the beach, and sheet flow runoff from the adjacent parking lot above the bluff. Following three years of data collection, statistical linear regression was conducted between physical/chemical/biological parameters and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Red Arrow Beach included turbidity, wave height, longshore current speed, and the south outfall (Table 60). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

Statistical linear regression was done between each beach transect and the south stormwater outfall. The south transect, which is closest to the outfall, had the highest correlation with *E. coli* from the outfall (R^2=0.267). The correlations at the center (R^2=0.1695) and north (R^2=0.1691) transects decreased as samples were taken further away from the outfall. These data suggest that the stormwater outfall at Red Arrow Park is a significant contributor to high *E. coli* concentrations at the beach, especially at the southern region of the beach.

Additional statistical analyses (Minitab16) were also conducted to evaluate average *E. coli* concentrations at three transects at Red Arrow Beach in order to assess the impact of stormwater pipe on the south end on *E. coli* concentrations. The difference between *E. coli* concentrations at the north, center, and south transects were not significant (ANOVA $p=0.982$ where $p<0.05$). These results may be due to homogenous mixing of the stormwater due to wave action or that *E. coli* is significantly high extending the entire beach.

RECOMMENDATIONS AND FUTURE WORK

Red Arrow Beach was not recommended for a redesign plan in the GLRI FY10 funding. However, through additional GLRI funding (UW Oshkosh) in 2012, and with assistance from the Bay-Lake Regional Planning Commission in 2011, a preliminary design plan was developed to mitigate the aforementioned pollution sources. The design plan addresses sheet flow runoff from the parking lot above the bluff, beach nourishment, dune grass planting, and stormwater mitigation. A meeting was held with the City of Manitowoc Parks and Public Works Departments where the preliminary design plan was approved and a plan for mitigation at Red Arrow Park Beach was put in place. The final design plans were presented in February of 2013 and construction should begin later in the spring. Sampling should be conducted in the years following beach reconstruction to evaluate if the mitigation was effective. UW Oshkosh has applied for funding through the UW Sea Grant for the above purpose, but has not been notified if funding will be awarded at this time. If funding is not awarded, UW Oshkosh will aid the local community (if desired) in applying for alternative funding to evaluate the completed mitigation project.

Site: Thompson's West End Park Beach – Washburn, Wisconsin

INITIAL SITE ASSESSMENT

Photo 53: Aerial photo of Thompson's West End Park Beach in Washburn, Wisconsin.

Preliminary Site Assessment:
Thompson's West End Park Beach is primarily used for swimming, boating, and other recreational activities in the adjacent park and campground.

Surrounding Area. There is a campground directly west of the beach and a jetty extending into the water to the south. There is also a boat launch bordering the east side of the beach with several open docks.

Physical Attributes. The foreshore area is comprised of medium sand with some cobbles mixed in (Mean Grain Size=0.0190). Submerged sediments are formed of moderate-sized sand with some visible pebbles or cobbles. Low amounts of algae and macrophytes were observed. There is a large amount of organic material resembling small wood chips residing on the swashzone and highwater regions of the beach. There is a poor-to-moderately-developed berm crest and little-to-no elevation from the paved parking lot to the shoreline. The jetty extending out at the south end of the beach appears to limit continuous water movement and flow, allowing for a tarred substance to reside at the beach proper.

- Length of beach: 774 feet
- Average width of beach: 32.3 feet

Potential Pollution Sources. There are several potential pollution sources near to the beach. The most noticeable pollution source is the stormwater drain directly east of Thompson's Beach. This stormwater drain includes overflow from an artesian well, possible campground dump station waste, stormwater from the City of Washburn, and stormwater from impervious surfaces including the adjacent parking lot. This parking lot does not have any naturalized boundary to defer stormwater from sheeting into the nearshore water during high rain events. Other potential pollution sources include the boat launch east of the beach, recreational activities at the adjacent campground, the fluctuation of geese present on the beach proper, Thompson's Creek located southeast of the beach, and the extending jetty and boat docks restricting water flow to and from the beach area. Finally, wood chips and other organic material wash into the swashzone area of the beach daily and are not currently removed on a regular basis.

Photo 54: Looking southwest at the full length of the beach.

Photo 55: Looking south at the beach and parking lot of the adjacent park.

Photo 56: Stormwater outfall (Pipe 1) at the east end of the beach (potential pollution source).

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 four times a week from 2010 to 2012 at Thompson's West End Park Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There were two stormwater outfalls (Pipe 1 and Pipe 2) identified and sampled at the beach. The tributary Thompson's Creek was also sampled. Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 61: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Thompson's West End Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	0	17	0%	31.5
2004	1	14	7%	97.7
2005	2	16	13%	193.2
2006	7	21	33%	375.4
2007	8	44	18%	227.6
2008	3	27	11%	151.0
2009	0	16	0%	20.5
2010	9	53	17%	198.0
2011	8	56	14%	154.7
2012	4	55	7%	88.3
Totals	**42**	**319**	**13%**	**153.8**

Table 62: Summary of total *E. coli* samples collected over the duration of the study at Thompson's West End Park Beach.

Summary of *E. coli* Samples Collected (2010-2012) Thompson's West End Park Beach					
Year	Routine Monitoring (Center 24")	Spatial Samples	Sand Samples	Investigative Samples (Tributaries, outfalls, etc.)	Total *E. coli* Samples per Year
2010	23	182	124	2	331
2011	48	144	135	221	548
2012	55	0	0	108	163
Total	126	326	259	331	1,042

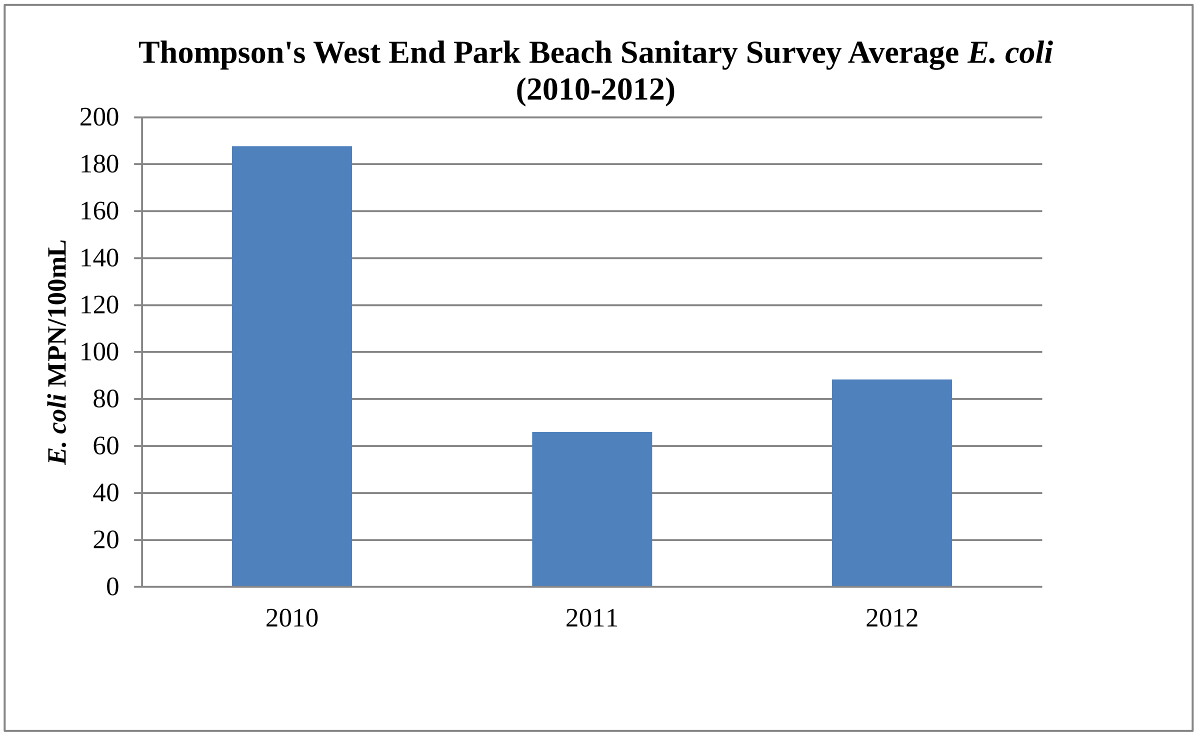


Figure 17: Average *E. coli* (MPN/100mL) at Thompson's West End Beach in Washburn, Wisconsin, from 2010-2012.

Table 63: Mean Seasonal Results 2010-2012

Thompson's West End Beach Mean Results–Summer 2010 - 2012								
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Creek *E. coli* (MPN/100mL)	Pipe 1 *E. coli* (MPN/100mL)	Pipe 2 *E. coli* (MPN/100mL)
136	60.9	18.9	3.2	1.2	1.1	310.4	182.2	135.8
n= 127	n= 29	n=146	n= 124	n= 144	n= 145	n= 45	n= 70	n= 66

Table 64: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Thompson's West End	R^2 Value		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0820	0.0023	0.0114
Wind Speed (mph)	0.0104	0.0036	0.0481
Water Temperature (°C)	0.0883	0.0034	0.0000
Air Temperature (°C)	0.0000	0.0000	0.0078
Turbidity (NTU)	0.1716	0.1776	0.3289
Wave Height (ft)	0.1669	0.0844	0.1171
Within 24hr Rain (cm)	0.0555	0.1410	0.2475
Algae (1-3 scale)	x	0.0030	0.0087
Gulls (#)	x	x	x
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	x	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.0031	0.0160	0.0210
Longshore Current Direction (°)	0.1149	0.0038	X
Tributaries/Outfalls *E. coli* Creek	x	0.1919	X
Tributaries/Outfalls *E. coli* Pipe 1	x	0.3146	0.3481
Tributaries/Outfalls *E. coli* Pipe 2	x	0.4238	0.4925
Tributaries/Outfalls *E. coli* Pipe 3	x	0.7170	X
Tributaries/Outfalls *E. coli* Waterfall 1	x	0.2296	X
Tributaries/Outfalls *E. coli* Waterfall 2	x	0.3184	X
Tributaries/Outfalls *E. coli* Pipe 1 Ditch	x	0.2423	X
Tributaries/Outfalls *E. coli* Stop Sign	x	0.1848	x
Tributaries/Outfalls *E. coli* Upstream from Pipe 2	x	0.0919	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Thompson's West End Beach was listed on the impaired waters (EPA 303d) list from 2008 to 2012. The historical water quality (Table 61) shows a peak in *E. coli* in 2006 where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). A total of 1,042 samples were collected at Thompson's West End Park Beach from 2010 to 2012 through the GLRI project (2010 n=331, 2011 n=548, 2012 n=163) as shown in Table 62. The mean *E. coli* from each year from 2010 to 2012 was well below the 235 MPN/100mL exceedance level (Figure 17). The overall mean *E. coli* for Thompson's Creek from 2010 to 2012 was 310.4 MPN/100mL, which may indicate Thompson's Creek is a possible source of pollution for Thompson's West End Park Beach (Table 63).

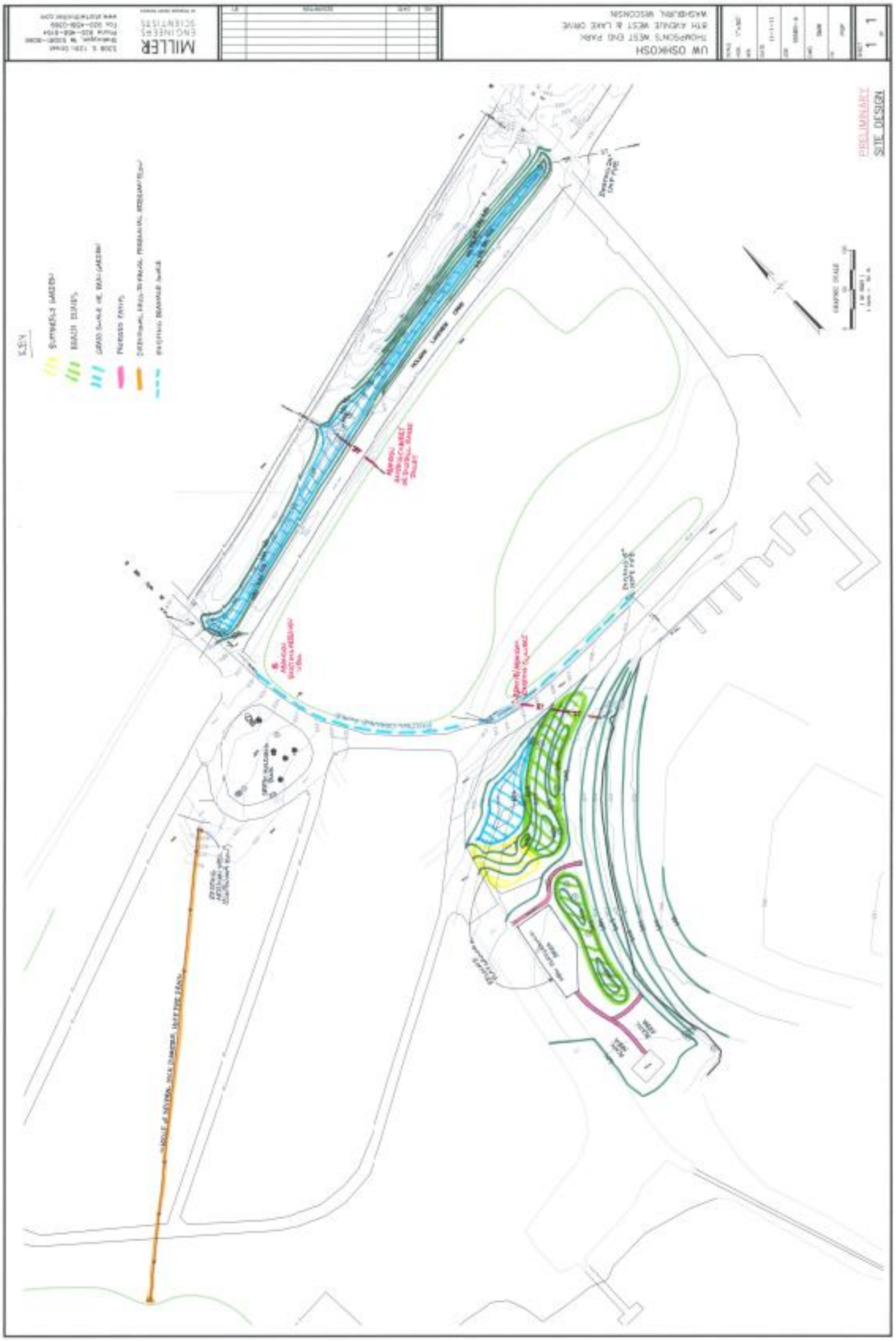
There were several potential pollution sources identified, including stormwater from an artesian well, possible campground dump station waste, stormwater from impervious surfaces including the adjacent parking lot, and stormwater from a large area of the City of Washburn. Additional sources include woody debris on the beach and various recreational activities from the park and campground.

Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Thompson's West End Beach include turbidity, wave height, rain, and tributary/stormwater input (Table 64). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations. Investigative sampling in 2011 revealed that the most significant pollution source was stormwater input. The City of Washburn is located on a hill and approximately half of the city's stormwater is channeled directly to Thompson's West End Beach.

RECOMMENDATIONS AND FUTURE WORK

Thompson's West End Beach was recommended for a conceptual redesign plan in the GLRI FY10 funding. Through additional GLRI funding (UW Oshkosh) in 2012, and with assistance from the Bay-Lake Regional Planning Commission in 2011, a preliminary redesign plan was developed and funding was awarded to mitigate the aforementioned pollution sources. The design plan addresses stormwater mitigation at both stormwater drains, abandoning the artesian well, beach nourishment, placement of sand dunes, moving the play area, and rain gardens that border the roadways and parking lot. A meeting was held with City of Washburn officials where the preliminary design plan was approved and a plan for mitigation at Thompson's West End was put into place. The final design plans will be presented in the spring of 2013, and construction should begin at the latest in the spring of 2014. Sampling should be conducted in the years following beach reconstruction to evaluate if the mitigation was effective. UW Oshkosh has applied for funding through the UW Sea Grant for this purpose, but has not been notified if funding will be awarded at this time.

CONCEPTUAL REDESIGN PLAN *(Following page)*



UW OSHKOSH
MILLER
PRELIMINARY
SITE DESIGN

Site: Van Ess Road Beach – Sheboygan, Wisconsin

INITIAL SITE ASSESSMENT

Photo 57: Aerial photo of Van Ess Road Beach in Sheboygan, Wisconsin.

Preliminary Site Assessment:
Van Ess Road Beach is a rural beach located in southern Sheboygan County.

Surrounding Area. Van Ess Road Beach is embayed by private property on the north and south end of the beach. On the northern end of the beach, there is also a small tributary. The nearby area is mostly residential with privately owned beach. There is a small public access area, but the beach is mainly used by local residents.

Physical Attributes. The foreshore area is comprised of medium sand (Mean Grain Size = 0.012496 in). Submerged sediments are formed primarily of fine sand. The beach is naturalized with a significant slope, dune grass in the upshore region of the beach, and a substantial swashzone.

- Length of beach: 774 feet
- Average width of beach: 32.3 feet

Potential Pollution Sources. Potential sources of pollution are few, but include gull fecal material deposited on the beach and in the nearshore water, and potential contamination from the northern tributary.

Photo 58: Looking north at a kayak waiting to be launched at Van Ess Road Beach, Sheboygan, Wisconsin.

Photo 59: Looking south at Van Ess Road Beach where private property begins.

Photo 60: Looking west at the northern tributary that inputs potential contamination to Van Ess Road Beach.

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 three times a week from 2010 to 2011 and once a week in 2012 at Van Ess Road Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There was one tributary identified and sampled north of the beach. Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 65: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Van Ess Road Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2005	2	11	18%	100.9
2006	7	19	37%	422.9
2008	0	14	0%	36.0
2010	1	13	8%	49.0
2011	0	31	0%	24.8
2012	2	13	15%	212.8
Totals	**12**	**101**	**12%**	**141.0**

Table 66: Summary of total *E. coli* samples collected over the duration of the study at Van Ess Road Beach.

Summary of *E. coli* Samples Collected (2010-2012) Van Ess Road Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	13	109	27	19	168
2011	30	136	32	9	207
2012	13	0	0	27	40
Total	56	245	59	55	415

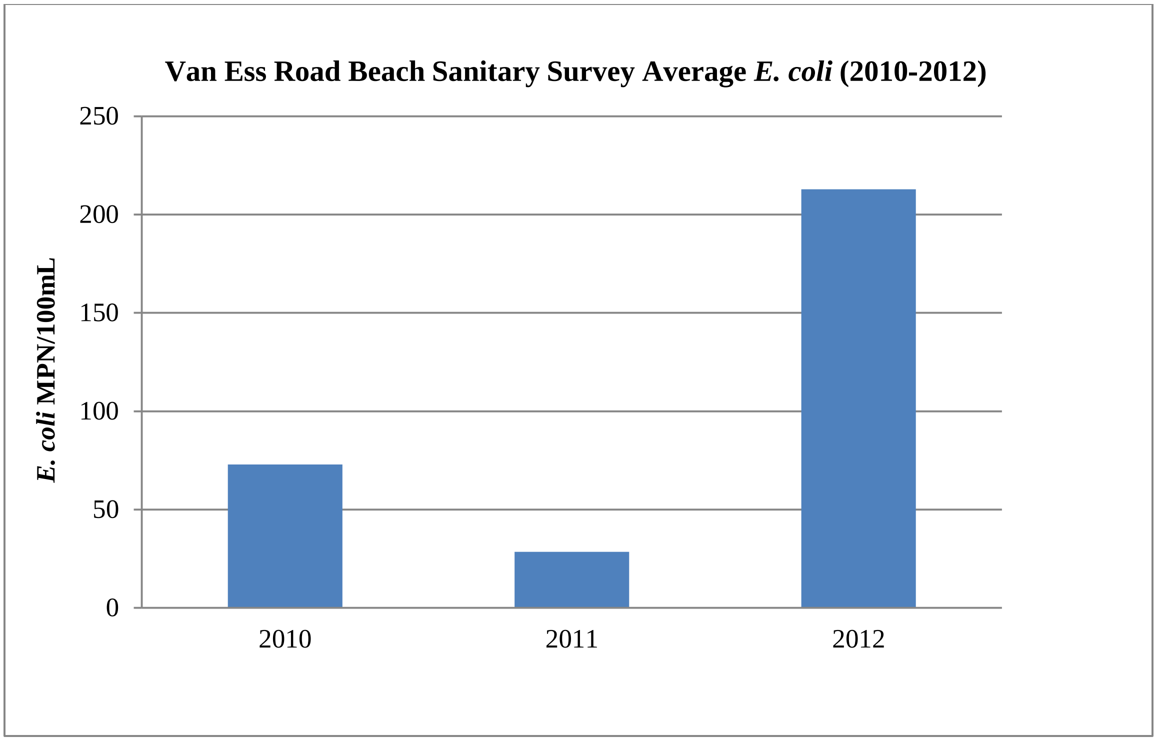


Figure 18: Average *E. coli* (MPN/100mL) at Van Ess Road Beach in Sheboygan, Wisconsin, from 2010-2012.

Table 67: Mean Seasonal Results 2010-2012

Van Ess Road Beach Mean Results–2010 - 2012						
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Tributary N *E. coli* (MPN/100mL)
74.5	0.6	17.3	4.6	9.8	1.3	381.0
n= 56	n= 18	n= 70	n= 59	n= 70	n= 71	n= 28

Table 68: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Van Ess Road Beach	R^2 Value		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0004	0.1723	0.1982
Wind Speed (mph)	0.1190	0.0274	0.3353
Water Temperature (°C)	0.2278	0.0000	0.1200
Air Temperature (°C)	0.2800	0.0933	0.0305
Turbidity (NTU)	0.0033	0.0528	0.0003
Wave Height (ft)	0.1919	0.0757	0.7690
Within 24hr Rain (cm)	0.1073	0.0467	0.0031
Algae (1-3 scale)	x	0.0135	0.0261
Gulls (#)	0.0001	X	x

Geese (#)	x	X	x
Other Avian (#)	x	X	x
Bathers at Beach (#)	0.0181	X	x
Bathers In Water (#)	x	X	x
Longshore Current Speed (cm/sec)	0.5294	0.0064	0.4919
Longshore Current Direction (°)	0.1885	0.0430	0.2243
Tributaries/Outfalls *E. coli* Tributary N	2010-2010: 0.2833 (n=16)		

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Van Ess Road Beach has been monitored routinely through the BEACH Act since 2005 and was previously on the impaired waters (EPA 303d) list from 2008 to 2011. Historical water quality (Table 65) shows 2006 as the only year where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). A total of 415 samples were collected at Van Ess Road Beach from 2010-2012 through the GLRI project (2010 n=168, 2011 n=207, 2012 n=40) as shown in Table 66. The mean *E. coli* from each year between 2010 and 2012 was below the 235 MPN/100mL exceedance level (Figure 18). The overall mean *E. coli* from 2010 to 2012 for the northern tributary was 381.0 MPN/100mL. This may indicate the tributary as a possible source of pollution for Van Ess Road Beach (Table 67).

There were few potential pollution sources identified in the initial site assessment, including gull populations and tributary input to the north of the beach. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Van Ess Road Beach included water temp, wave height, longshore current speed and direction, and tributary input (Table 68). While these correlations alone are all below an R^2 of 0.4, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

RECOMMENDATIONS AND FUTURE WORK

Van Ess Road Beach was not chosen to receive preliminary redesign plans due to little stormwater or tributary influence and low *E. coli* levels in the nearshore waters. This beach exhibits a naturalized upshore area with healthy dune grass, limited invasive species, and nourished medium-grained sand. Future recommendations for this beach include low priority monitoring (once a week), observing for significant increases in *E. coli* concentrations, and reevaluation if an increase in *E. coli* is found.

Site: Warm Waters Beach – Manitowoc, Wisconsin

INITIAL SITE ASSESSMENT

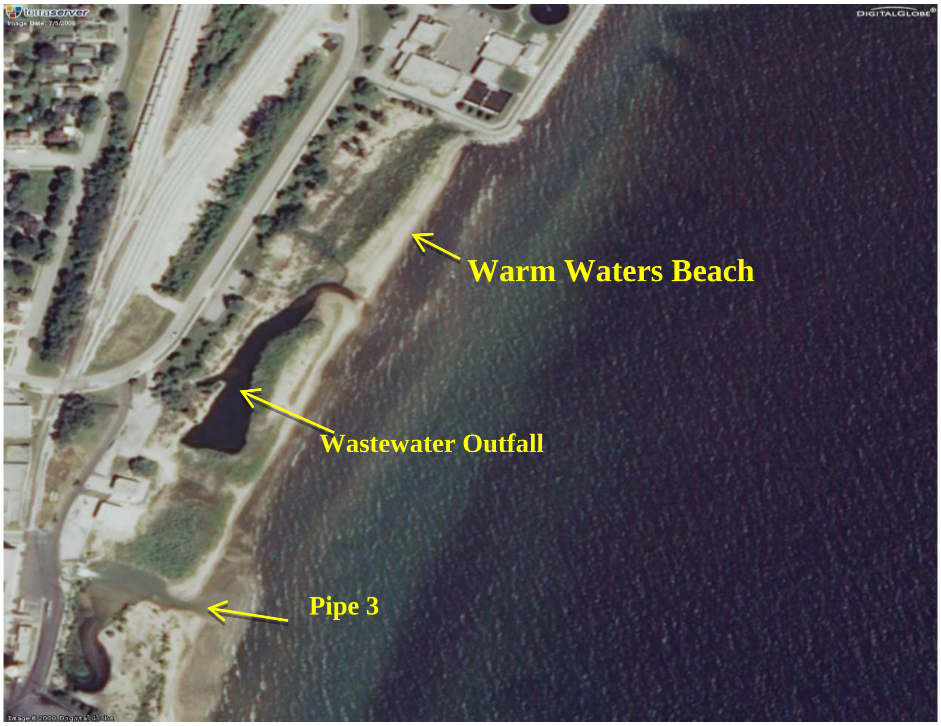


Photo 61: Aerial photo of Warm Waters Beach in Manitowoc, Wisconsin.

Preliminary Site Assessment:

Warm Waters Beach is located on the south side of the City of Manitowoc. Over the years, the swimming beach has moved from being located directly across from the coal power plant to north of the power plant nearer to the wastewater treatment plant.

Surrounding Area. The surrounding area consists of extensive grassy vegetation, a large stormwater drain, and discharge pipe from the adjacent power plant. The wastewater treatment plant is located directly north of the beach. The remaining area is residential housing.

Physical Attributes. The beach proper consists of fine-grained sand (Mean Grain Size=0.00877) with vast amounts of zebra/quagga mussel shells near the storm surge high water mark. The beach is bordered by grassy vegetation extending approximately 150 feet to the road.

- Length of beach: 1,542 feet
- Average width of beach: 62.5 feet

Potential Pollution Sources. There was evidence of gulls and dogs at the beach. There was an abundance of pooled water from a large stormwater drain at the south end of the beach. In addition, warm water is discharged from the coal power plant at the southernmost end of the beach. The wastewater treatment plant is also bordering the northernmost end of the beach and may contribute to poor water quality.

Photo 62: Looking north across Warm Waters Beach in Manitowoc, Wisconsin.

Photo 63: Stormwater discharge and coal power plant. Picture taken from beach proper looking onshore.

Photo 64: Coal power plant discharge on south end of Warm Waters Beach.

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 at Warm Waters Beach three times a week from 2010 to 2011, and once a week in 2012. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There were two tributaries identified and sampled; Warm Waters Outfall at the center of the beach, and Pipe 3 south of the beach. Sand samples were also collected up to three times a week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 69: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Warm Waters Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	7	31	23%	157.9
2004	5	17	29%	210.6
2010	6	15	40%	567.7
2011	7	32	22%	290.9
2012	1	39	3%	141.9
Totals	**26**	**134**	**19%**	**273.8**

Table 70: Summary of total *E. coli* samples collected over the duration of the study at Warm Waters Beach.

Summary of *E. coli* Samples Collected (2010-2012) Warm Waters Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	15	120	100	0	235
2011	29	133	72	51	285
2012	39	0	0	0	39
Total	83	253	172	51	559

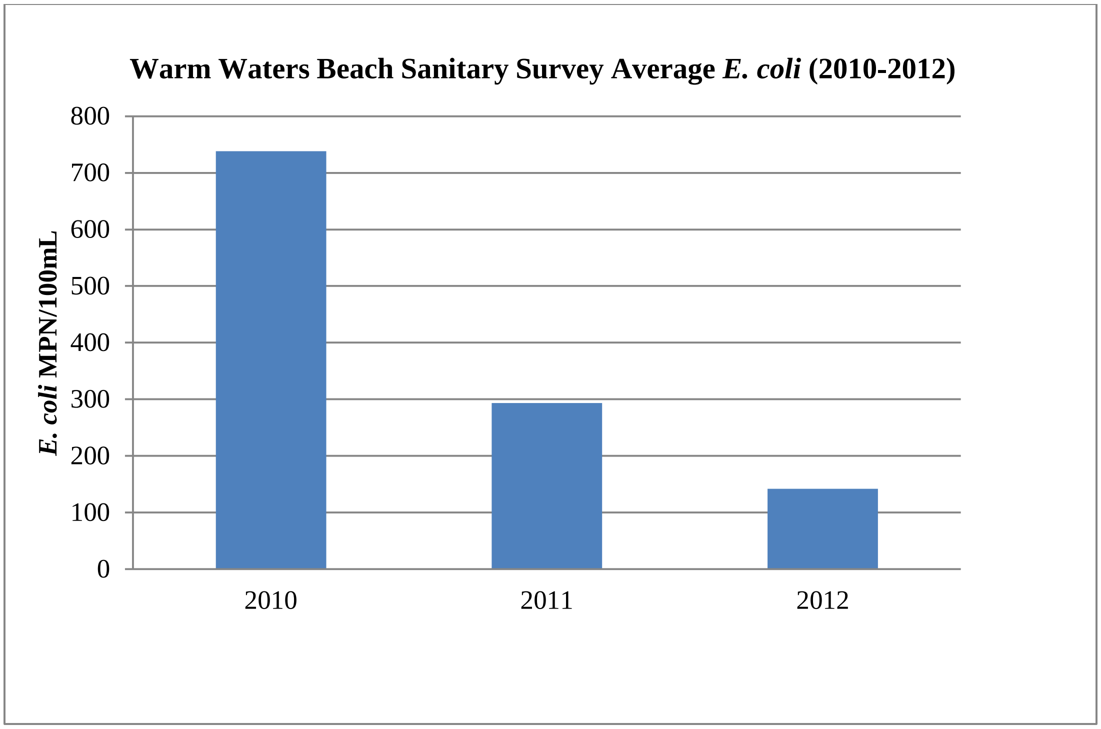


Figure 19: Average *E. coli* (MPN/100mL) at Warm Water Beach in Manitowoc, Wisconsin, from 2010-2012.

Table 71: Mean Seasonal Results 2010-2012

Warm Waters Beach Mean Results – 2010-2012							
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Pipe 3 *E. coli* (MPN/100mL)	WW Outfall *E. coli* (MPN/100mL)
276.3	42.1	18.9	7.6	33.3	3.7	79.9	802.2
n= 83	n= 17	n= 113	n= 108	n= 113	n= 113	n= 32	n= 11

Table 72: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

Warm Water Beach	R^2 Value		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.2517	0.1400	0.0355
Wind Speed (mph)	0.0252	0.0058	0.0911
Water Temperature (°C)	0.0903	0.0415	0.0000
Air Temperature (°C)	0.0132	0.0427	0.0341
Turbidity (NTU)	0.2335	0.3109	0.2345
Wave Height (ft)	0.4013	0.1553	0.2646
Within 24hr Rain (cm)	0.0633	0.0544	0.1052
Algae (1-3 scale)	x	0.0123	0.1632
Gulls (#)	x	0.1099	0.0382

Geese (#)	x	x	0.0167
Other Avian (#)	x	x	0.0472
Bathers at Beach (#)	x	0.1201	0.0000
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.0035	0.0123	0.2159
Longshore Current Direction (°)	x	0.0521	x
Tributaries/Outfalls *E. coli* Pipe 3	x	0.0169	x
Tributaries/Outfalls Wastewater Outfall	x	0.2675	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Warm Waters Beach has been intermittently monitored through the BEACH Act since 2003, and has been on the impaired waters (EPA 303d) list since 2006. The historical water quality (Table 69) shows 2006 as the only year where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). A total of 559 samples were collected at Warm Waters Beach from 2010 to 2012 through the GLRI project (2010 n=235, 2011 n=285, 2012 n=39) as shown in Table 70. The mean *E. coli* from 2010 to 2012 exceeded the 235 MPN/100mL exceedance level (Figure 19). The overall mean *E. coli* for the wastewater outfall from 2010 to 2012 was 802.2 MPN/100mL, which may indicate that it is a possible source of pollution for Warm Waters Beach (Table 71).

There potential pollution sources identified in the initial site assessment included gull populations, pet (dog) feces, municipal infrastructure and stormwater input. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Warm Waters Beach included wind direction, turbidity, wave height, and outfall contribution (Table 72). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

RECOMMENDATIONS AND FUTURE WORK

Warm Waters Beach was not chosen to receive preliminary redesign plans due to low beach usage and little community interest. With GLRI funding awarded later in 2011, UW Oshkosh was able to award funding to Warm Waters Beach for a preliminary and final remediation plan. It was recommended that this beach be redesigned as a naturalized area and not for human full body contact recreational usage. This beach could be re-utilized as a dog beach or alternative recreational use like kayaking or boating. Future recommendations for this beach include low priority monitoring (once a week), observing for significant increases in *E. coli* concentrations, and reevaluating if an increase in *E. coli* is found. If funding becomes available for mitigation, this previously recreational beach could become a newly naturalized area to improve shoreline quality and aesthetics.

Site: Wisconsin Point Beach 2 – Superior, Wisconsin

INITIAL SITE ASSESSMENT

Photo 65: Aerial photo of Wisconsin Point Beach 2 in Superior, WI.

Preliminary Site Assessment

Wisconsin Point Beach 2 is located east of the City of Superior on a small peninsula.

Surrounding Area. Wisconsin Point Beach 2 is located in between four other Wisconsin Point beaches, which extend approximately three miles total. There is a small outfall located immediately east of the public access which only flows in high rain periods. There is also a large ponded wetland on the western end of the beach which appears to overflow onto the beach and nearshore water during high rain events. Dutchman Creek flows into Lake Superior approximately one mile east of Wisconsin Point 2.

Physical Attributes. The foreshore area is comprised of course sand with some pebbles (Mean Grain Size = 0.0336 in), and the swashzone region consists of silt and fine sand. Submerged sediments are formed of fine sand with no visible pebbles or cobbles. The beach is in a naturalized state; steep, with a narrow swash zone. Wave action impacts the entire width up the start of the vegetation in the back beach area; area could become submerged if the lake level rise occurs.

- Length of beach: 1,968 feet
- Average width of beach: 63.3 feet

Potential Pollution Sources. Wisconsin Point Beach 2 is heavily impacted by rain. During high rain events, Dutchman Creek flows near Wisconsin Point 3 Beach, and may possibly contribute to high *E. coli* concentrations at Wisconsin Point 2 Beach. Other tributaries (on the east and west ends of beach) may also potentially contribute pollution to the nearshore water. The gravel area on top of the bluff in the public access area contributes sheet flow. There was also evidence that gulls loaf at the beach, although none were seen on the day of the assessment. Birds can deposit fecal material on the beach and nearshore water. This fecal material contains *E. coli* and other fecal pathogens which can be harmful to the public.

Photo 66: Looking west on Wisconsin Point Beach 2 at naturalized dunes and stormwater surge.

Photo 67: Small outfall east of the public access; only flows during high rain events.

Photo 68: Photo of ponded wetland area west of Wisconsin Point Beach 2.

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 three times a week from 2010 to 2012 at Wisconsin Point Beach 2. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There was one tributary identified at the east end of the beach (Outfall 1). Sand samples were also collected up to three times per week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 73: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

Wisconsin Point Beach 2 Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	3	20	15%	144.3
2004	1	15	7%	226.24
2005	8	27	30%	199.2
2006	9	25	36%	235
2007	6	20	30%	270.5
2008	13	25	52%	312
2009	3	15	20%	127.5
2010	15	30	50%	445.5
2011	21	43	49%	427.6
2012	21	35	60%	589.37
Totals	**100**	**255**	**39%**	**297.7**

Table 74: Summary of total *E. coli* samples collected over the duration of the study at Wisconsin Point Beach 2.

Summary of *E. coli* Samples Collected (2010-2012) Wisconsin Point Beach 2					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	4	32	36	0	72
2011	35	128	126	3	292
2012	35	0	0	1	36
Total	74	160	162	4	400

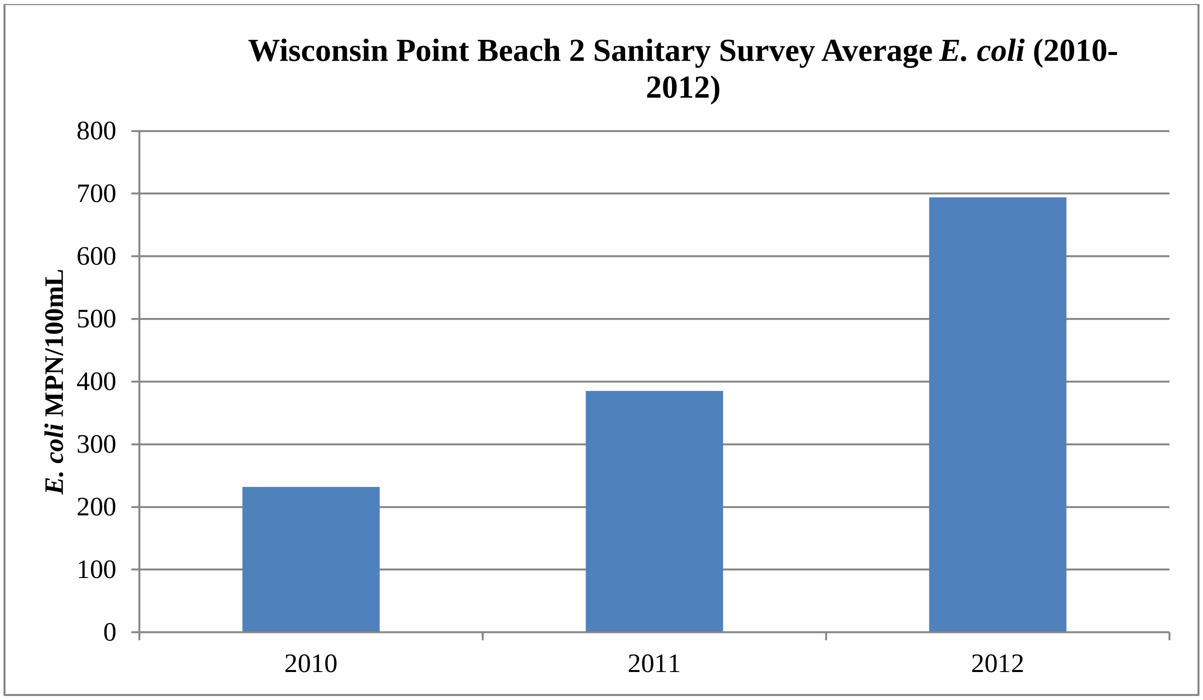


Figure 20: Average *E. coli* (MPN/100mL) at Wisconsin Point Beach 2 in Superior, WI from 2010-2012.

Table 75: Mean Seasonal Results 2010-2012

Wisconsin Point Beach 2 Mean Results– 2010-2012						
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Outfall *E. coli* (MPN/100mL)
503.1	405.8	18.7	43.9	170.1	00.59	68.9
n= 74	n= 15	n= 79	n= 57	n= 68	n= 67	n= 3

Table 76: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

WI Point Beach 2	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.4468	0.1640	0.0789
Wind Speed (mph)	0.1116	0.0101	0.0417
Water Temperature (°C)	0.7330	0.0000	0.0030
Air Temperature (°C)	0.4854	0.0065	0.0106
Turbidity (NTU)	x	0.1005	0.2519
Wave Height (ft)	0.0018	0.1000	0.1522
Within 24hr Rain (cm)	0.1098	0.0200	0.0000
Algae (1-3 scale)	x	x	x
Gulls (#)	0.3030	0.0019	0.0478
Geese (#)	x	x	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	0.0550	x	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	0.6564	0.0191	0.2207
Longshore Current Direction (°)	x	0.1136	x
Tributaries/Outfalls *E. coli* Outfall 1	x	x	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

Wisconsin Point Beach 2 has been monitored routinely through the BEACH Act since 2003, and has been on the impaired waters (EPA 303d) list since 2008. The historical water quality (Table 73) shows multiple years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). The average *E. coli* concentration since 2003 exceeds the advisory standard of 235 MPN/100mL. A total of 400 samples were collected at Wisconsin Point Beach 2 from 2010 to 2012 through the GLRI project (2010 n=72, 2011 n=292, 2012 n=36) as shown in Table 74. The mean *E. coli* from 2011 to 2012 was above the 235 MPN/100mL exceedance level (Figure 20). The overall mean *E. coli* for the outfall from 2010 to 2012 was only 68.9 MPN/100mL, making it unlikely to be a possible source of pollution for Wisconsin Point Beach 2 (Table 75).

The potential pollution sources identified in the initial site assessment included gulls, stormwater influence from tributaries, and sheet flow runoff down the bluff adjacent to the beach. Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at Wisconsin Point Beach 2 include wind direction, water and air temperature, turbidity, wave height, and longshore current direction (Table 76). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

Additional statistical analyses (Minitab16) were also conducted to evaluate average *E. coli* concentrations at three transects at Wisconsin Point Beach 2 in order to assess the impact of stormwater in nearshore water on *E. coli* concentrations. The difference between *E. coli* concentrations at left, center, and right of the beach were not significant (ANOVA $p=0.847$ where $p<0.05$). These results may be due to homogenous mixing of the stormwater due to wave action, current speed and direction.

RECOMMENDATIONS AND FUTURE WORK

Wisconsin Point Beach 2 was not recommended for a redesign plan in the GLRI FY10 funding. It is already a naturalized beach; however, some mitigation could be done to reduce stormwater runoff from the bluff above the beach. Additional investigation should occur outside of the typical nearshore pollution sources. A municipal landfill is near Wisconsin Point Beach 2 and could be a potential pollution contributor. If the community is interested in developing reengineering plans at Wisconsin Point Beach 2, UW Oshkosh is willing to assist the community in applying for alternative funding sources. Until then, this beach should continue to be monitored to inform and protect public health.

Site: YMCA Beach - Manitowoc, Wisconsin

INITIAL SITE ASSESSMENT

Photo 69: Aerial photo of YMCA Beach in Manitowoc, Wisconsin.

Preliminary Site Assessment:
YMCA Beach is located in the urban region of Manitowoc, Wisconsin. This beach is not only used for swimming, but a number of other recreational activities throughout the summer, including triathlons and dragon boat races.

Surrounding Area. Surrounding area is primarily made up of impervious surfaces and hard infrastructure such as parking lots, a pier, a marina, and boulders in place for bluff stabilization. There is very little vegetation between the adjacent parking lot and beach proper.

Physical Attributes. The foreshore sand is composed primarily of course sand (Mean Grain Size= 0.0236 in). YMCA beach has little-to-no elevation. It also shows some indication of sand starvation, partially due to sheet flow runoff from the YMCA parking lot.

- Length of beach: 377 feet
- Average width of beach: 36.4 feet

Potential Pollution Sources. There are a few potential sources of pollution at YMCA beach, including sheet flow from stormwater runoff off the adjacent parking lots (Photo 71). There are no barriers (vegetative or infrastructure) between the parking lot and upshore of the beach. A moderate amount of litter was observed at the beach along with other wooded debris. There is also an outfall located in the adjacent pier which runs underneath the marina. The pier itself restricts water movement and circulation, which could allow algae and other debris to become stagnant at YMCA Beach. In addition, gulls were evident on the day of the assessment due to large amounts of gull fecal material on the beach and in the swashzone. These fecal inputs can cause potential disease in recreational swimmers.

Photo 70: Looking South at YMCA Beach in Manitowoc, Wisconsin.

Photo 71: Stormwater pipe draining parking lot runoff onto YMCA Beach.

Photo 72: Looking east from entrance of YMCA Beach at Outfall 1.

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 three times a week from 2010 to 2012 at YMCA Beach. 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 longshore current and speed. Water quality was measured by collecting water samples at various transects (north, center, south) and depths (12 inches, 24 inches, 48 inches) and analyzing them for total coliforms, *Escherichia coli* (*E. coli*), and turbidity. In addition to spatial sampling, samples were collected at all identified outfalls and tributaries each time a RSS was conducted. There was one tributary identified, and one outfall adjacent to the beach in the breakwall that was identified and sampled (Outfall 1). Sand samples were also collected up to three times a week biweekly at multiple transects (upshore, swashzone, and 24 inch depth). Sand samples were analyzed for total coliforms and *E. coli* per gram of sand.

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 (2010-2012). 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.

RESULT SUMMARY

Table 77: Historical Water Quality (2003-2012): Routine Monitoring for BEACH Act

YMCA Beach Historical Data Number of Samples Exceeding Water Quality Standards				
Year	**Number of Exceedances**	**Total Samples**	**Percent Exceedances**	**Average *E. coli* (MPN/100 mL)**
2003	20	29	69%	567.9
2004	11	24	46%	377.5
2005	7	19	37%	315.8
2006	22	26	85%	1285.8
2007	22	40	55%	832.5
2010				
2011	16	38	42%	461.2
2012	14	40	35%	465.2
Totals	**112**	**216**	**52%**	**615.1**

Table 78: Summary of total *E. coli* samples collected over the duration of the study at YMCA Beach.

Summary of *E. coli* Samples Collected (2010-2012) YMCA Beach					
Year	**Routine Monitoring (Center 24")**	**Spatial Samples**	**Sand Samples**	**Investigative Samples (Tributaries, outfalls, etc.)**	**Total *E. coli* Samples per Year**
2010	16	128	122	0	266
2011	30	143	89	48	310
2012	44	0	18	51	113
Total	90	271	229	99	689

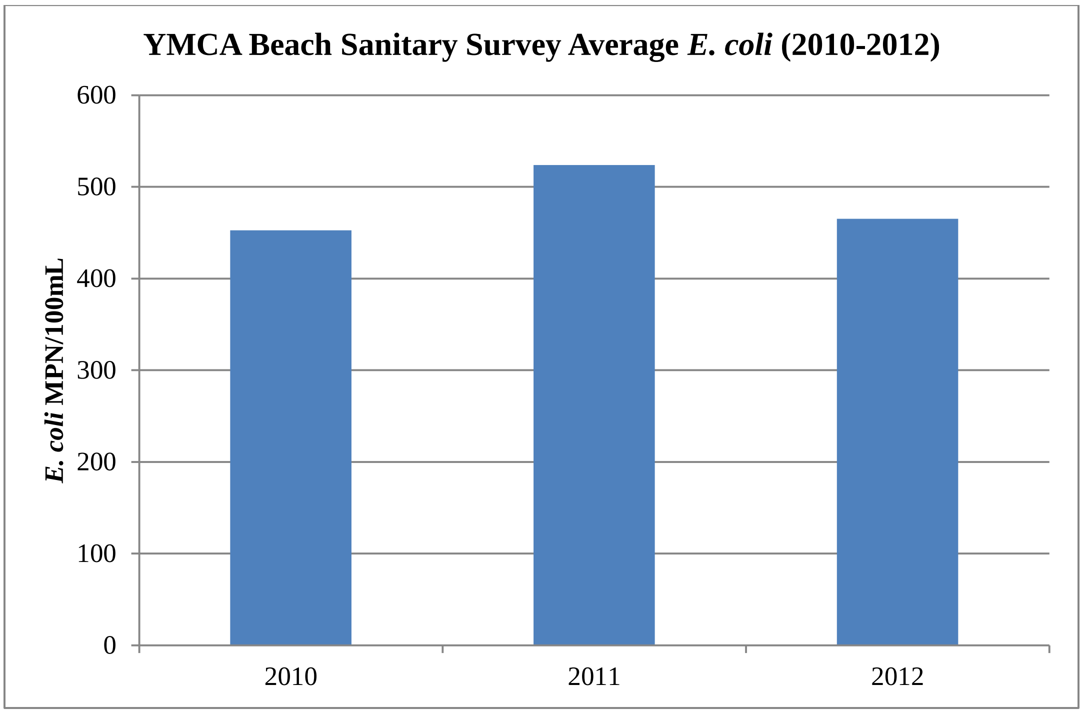


Figure 21: Average *E. coli* (MPN/100mL) at YMCA Beach in Manitowoc, Wisconsin, from 2010-2012.

Table 79: Mean Seasonal Results 2010-2012

YMCA Beach Mean Results– 2010-2012						
E. coli Center 24" (MPN/100 mL)	*E. coli* Sand (MPN/g)	Water Temp (°C)	Turbidity (NTU)	Avian (# gulls)	Bathers (# people)	Outfall 1 *E. coli* (MPN/100mL)
485.8	124.9	19.6	7.6	7.4	0.35	297.5
n= 89	n= 24	n=130	n= 129	n= 131	n= 131	n= 32

Table 80: Potential sources of contamination based on linear regression between biological, physical, or chemical parameters and log *E. coli* concentrations.

YMCA Beach	**R^2 Value**		
Physical/Chemical/Biological Parameter vs. Center *E. coli*	**2010**	**2011**	**2012**
Wind Direction (°)	0.0082	0.0545	0.0982
Wind Speed (mph)	0.2489	0.0576	0.0308
Water Temperature (°C)	0.0253	0.1010	0.0622
Air Temperature (°C)	0.1274	0.1250	0.0310
Turbidity (NTU)	0.0060	0.0734	0.0001
Wave Height (ft)	0.0034	0.1033	0.0077
Within 24hr Rain (cm)	0.0082	0.0525	0.0982
Algae (1-3 scale)	x	x	0.1173
Gulls (#)	0.4494	0.0228	0.0014
Geese (#)	x	0.0086	x
Other Avian (#)	x	x	x
Bathers at Beach (#)	x	x	x
Bathers In Water (#)	x	x	x
Longshore Current Speed (cm/sec)	x	x	x
Longshore Current Direction (°)	x	x	0.0334
Tributaries/Outfalls *E. coli* Outfall 1	x	0.1312	x

*x indicates insufficient data collected for statistical analysis.

CONCLUSIONS

YMCA Beach has been on the impaired waters (EPA 303d) list since 2004. The historical water quality (Table 77) shows several years where the average *E. coli* concentration exceeded water quality standards (235 MPN/100mL). YMCA Beach has been closed 52% of the beach days after the beach started being monitored in 2003. A total of 689 samples were collected at YMCA Beach from 2010 to 2012 through the GLRI project (2010 n=266, 2011 n=310, 2012 n=113) as shown in Table 78. The mean yearly *E. coli* from 2010 to 2012 was above the 235 MPN/100mL exceedance level (Figure 21). The overall mean *E. coli* for Outfall 1 from 2010 to 2012 was 297.5 MPN/100mL, which also exceeded water quality standards (Table 79).

The potential pollution sources identified during the initial site assessment include stormwater from a pipe in the adjacent pier, and storm water from impervious surfaces such as the adjacent parking lot. Additional sources include woody debris on the beach and various recreational activities such as kayaking, boating, and other marina related activities.

Following three years of data collection, statistical linear regression was conducted between physical, chemical, and biological parameters, and *E. coli* concentrations at the center of beach at 24 inches. Parameters with the highest R^2 value at YMCA Beach include wind speed, wave height, gull populations, and tributary/stormwater input (Table 80). While these factors alone do not attribute to all *E. coli* variation, when they are combined, they contribute to a significant amount of the variability in *E. coli* concentrations.

YMCA Beach is utilized for several recreational activities in the summer months including dragon boat races, kayaking, boating, swimming, and triathlons. With this beach exceeding water quality standards over 50% of beach days, it was imperative that these sources were identified and a redesign plan developed to protect public health.

RECOMMENDATIONS AND FUTURE WORK

YMCA Beach was recommended for a conceptual redesign plan in the GLRI FY10 funding. In addition, through further GLRI funding (UW Oshkosh) awarded in 2011, a preliminary and final redesign plan will be developed to mitigate the aforementioned pollution sources. The design plan addresses stormwater mitigation, beach nourishment, placement of sand dunes, vegetation to deter gull and geese, and rain gardens that border the roadways and parking lot. Since there is such extensive municipal infrastructure and the nearby Manitowoc River input, this beach may be better characterized as a recreational beach for non-full human body contact. Rather, a beach for other recreational activities like kayaking, boating, etc… which already existed at this beach would better protect public health. A meeting will be held with the City of Manitowoc officials to approve preliminary design plans in order to develop bid-ready final redesign plans for YMCA Beach. The final design plans will be presented in the summer of 2013. Future recommendations for this beach include high priority monitoring (four times a week), observing for significant increases in *E. coli* concentrations, and reevaluation if an increase is found. If funding would become available for mitigation, this beach would serve as a recreational destination for the local community and tourists.

CONCEPTUAL REDESIGN PLAN *(Following page)*


UW OSHKOSH
YMCA BEACH
MARITIME DRIVE
MANITOWOC, WISCONSIN
MILLER
ENGINEERS
SCIENTISTS
LEGEND
BEACH DUNES
INFILTRATION TRENCH
PROPOSED FOOT PATHS
OPTIONAL
OPTIONAL
PRELIMINARY
CONCEPT

LESSONS LEARNED

<u>Project Success</u>

Overall, this project was successful in accomplishing all objectives. Throughout the project there were several milestones and lessons learned which are described below.

<u>*Step One:*</u> *Each beach listed on the Wisconsin 303d list, or proposed for listing will be visited. The U.S. EPA Sanitary Survey Protocols will be used to assess each of the selected locations in terms of potential microbial contamination sources. This includes all potential contamination sources adjacent to the beach itself as well as locations inland that may not initially appear to be significant contributors to beach contamination at first glance.*

- All 20 sites were visited prior to the start of the project. In all cases, beaches were physically measured and potential pollution sources were identified. An annual sanitary survey was conducted at the initial site assessment and annually from there on after. In most cases all potential sources were readily identified. However, even though rain event sampling was conducted, an additional site assessment could have been conducted during a period of high water flow following a storm event prior to sampling. This would have identified stormwater sources that were not evident in dry weather.

<u>*Step Two:*</u> *A comprehensive assessment of each beach will be conducted using all available GIS and GPS information. Each location identified in Step One and associated potential contamination sources will be ground-truthed so that each site can be accurately placed in GIS inventories.*

- Aerial photos were achieved through a GIS database (TerraServer) to investigate sources of contamination at a watershed scale. These photos allowed for identification of tributaries and other sources (waste water treatment plants, retention basins, and various connecting tributaries) for a more comprehensive evaluation of pollution sources. In some cases, GIS data identified potential sources where the initial site assessments did not.

- GPS coordinates for each beach is available through the WDNR website.

<u>*Step Three:*</u> *Microbial contamination sources will be identified via preliminary bacterial testing and through Steps One and Two. Following the identification of possible sources at each location, samples for microbial source tracking (MST) may be collected at each beach included in the study. This will be in addition to any regularly beach monitoring data collected in accordance with the BEACH Act. This effort will yield samples to begin characterization pathogen sources in this phase of the project and will allow for a quantifiable measure of the significance of each source on the overall beach water quality. Other measures such as bather counts, microbial enumerations in adjacent watersheds, evaluation of outfalls in proximity to the beach, wind speed and direction, algae, avian counts, water clarity, etc. will also be collected at each sampling event in accordance with the US EPA sanitary survey tool.*

- Following the initial identification of potential pollution sources, a sample plan was developed uniquely for each beach to address each source. Routine sanitary surveys (RSS) were conducted at minimum of one time per week through the duration of the summer beach season. In years one and two of the study a comprehensive sample plan was used (RSS, spatial water and sand samples, and some investigative samples) to develop a substantial baseline database for each beach. In year three of the study, a more direct approach was used to investigate potential point and non-point sources at each beach. This modified sample plan in year three focused on sample collection from stormwater inputs, sample collection following rain events (>0.5 inches), and additional microbial source tracking techniques.

- Some improvements that could have been made could have been additional microbial source tracking at previously identified contamination sources to determine the fecal source. This could still be investigated if additional funding becomes available.

- Additional projects related to watershed studies could identify non-point sources in a larger geographic area that are not only on the Great Lakes coastline.

<u>*Step Four:*</u> *Data collected during the project will be recorded daily and placed on-line for easy dissemination in a similar manner to data recorded during BEACH Act monitoring. Data entry of routine sanitary survey data will also facilitate predictive modeling efforts under way and proposed by the WI DNR (Adam Mednick, project lead). Additionally, daily beach sanitary survey data from this project may be leveraged by a Madison, WI USGS team (Steve Corsi, project lead) to inform a broad USGS project dealing with pathogens in beach water. Routine reports will be provided to all partner communities and interested parties. Final project reports with all data collected will be provided to any interested group.*

- All data recorded via the RSS and internal Excel database. In addition, all RSS data was entered into the Wisconsin Beach Health (http://www.wibeaches.us/apex/f?p=BEACH:HOME:510822631072176) and Wisconsin GLRI (https://greatlakesbeaches.usgs.gov/input_forms/login.jsp) online databases. This database in conjunction with the Wisconsin GLRI database is publically available upon request.

- To access the data submitted to the Wisconsin GLRI database click on the below link and enter the following username and password:
    - https://greatlakesbeaches.usgs.gov/input_forms/login.jsp
    - USGS administers this website and is in progress developing a username and password for USEPA to access the database.
    - A username and password will be given to USEPA once USGS has provided UW Oshkosh with one.

- All RSS data that was collected was shared with the WDNR and USGS for the development of pre-emptive models to predict water quality. These models were developed and shared with the local communities.
- An improvement that could be made is to have the GLRI data entered in Wisconsin be automatically updated to the USEPA Beach Guard database. If funding would become available this would be of great value to the entire Great Lakes basin.

<u>Step Five:</u> *Beach water movement (current) and depth profiles of each location will be evaluated as part of this project. Additionally, the beach substrate will be characterized at each location in terms of its chemical and physical composition.*

- Current speed and direction in addition to other physical/chemical data was recorded at each beach when RSS were conducted. Beach sands were collected from the swashzone at each beach annually and analyzed for Mean Grain Size to determine the porosity potential of the sand.

- An improvement that could be made is to collect beach sand from different transects at the beach to determine Mean Grain Size at various points at the beach. A more detailed analysis of sand could be conducted to determine other physical, chemical, and biological attributes.

<u>Step Six:</u> *It is anticipated that during the aforementioned sampling and microbial source identification work that the potential sources of microbial contamination will be both identified and quantified in terms of their overall contribution to beach water contamination. Once the sources are identified, a plan to mitigate the microbial input from each source will be developed in conjunction with community partners at the proposed study sites. While, this project does not have the resources to implement these mitigation plans at all identified sources of microbial contamination it would have the funds to develop conceptual engineering plans for eight selected communities. These plans would have preliminary cost estimates and all general information needed for remediation of the beach location. Once these conceptual engineering plans are received by the communities the local unit of government can gather additional public input and then easily obtain construction ready engineering plans as the next step that are tailored to the specific needs of the community. However, it is anticipated that some mitigation may require little, if any, cost and can be implemented at the local level. At a minimum, affected communities will have a plan to act upon at the local level when resources and interest allow. Should additional funds become available in the future, this project will lay the foundation for remedial plans at all beaches listed as impaired in Wisconsin.*

- A total of eight beaches (four in the northern region) were chosen to receive conceptual redesign plans because there were readily identifiable sources that could be mitigated (Maslowski Beach in Ashland, WI; Point Beach Concession in Two Rivers, WI; Thompson’s West End in Washburn, WI; YMCA Beach in Manitowoc, WI). Each redesign plan addresses the aforementioned pollution sources identified using the USEPA RSS tool.

- All of these plans were presented to the local communities and a number of public meetings. If funding should become available these plans could be further developed into bid ready plans for implementation of mitigation.
- Some obstacles did arise when plans were presented to the communities at public meetings regarding implementation of dunes, dune grasses, and other vegetation on the beach. This was expected with concerns regarding visualization of the beach, decrease in area of the beach front, and misconception of necessity of usage of dunes and vegetation in beach mitigation.

    - These concerns are repetitive and numerous for local community members and local officials. In order to address these concerns further education and information should be presented to the communities to inform them of healthy beaches and proper mitigation strategies to protect public health from potential pollution sources at their beaches.

    - Future studies will be conducted by UW Oshkosh to assess beach mitigations already completed in the state of Wisconsin. These studies will not only include evaluation of water quality, but also a survey of beach usage and in turn the economic benefits of newly mitigated beaches and their positive effect on the local community. It is thought that this information will be an additional education piece that the local communities can use to be better informed of the positive aspects of proper beach mitigation in the future.

Step Seven: *The use of data collected as part of this study may be used as a tool to establish preemptive beach closures when conditions warrant. Based on results from other studies the impact of rain on the microbial water quality may warrant pre-emptive beach closures in some situations. This should be easily identifiable as a result of data collected during this project. The data obtained from this study would also be available to others (e.g. WI DNR) for the development or validation of forecasting and predictive models.*

- All RSS data that was collected was shared with the WDNR and USGS for the development of pre-emptive models to predict water quality. These models were developed and shared with the local communities.

- Especially with the recent budgetary spending cuts, the models that were developed using the RSS collected are of great value to the local communities where funding is no longer available. These predictive models allow for an attempt at continuing to protect the beach goers from poor water quality.

Key Personnel

The University of Wisconsin Oshkosh administered and managed the GLRI grant throughout the duration of the study. Satellite labs through UW Oshkosh conducted the sanitary surveys and other data collection and entry. Each satellite lab (Manitowoc, Door County, and Lake Superior) worked through UW Oshkosh to conduct the appropriate samples plans for each beach. USGS and WDNR worked with UW Oshkosh and its satellite labs to ensure the proper data was collected for use in their predictive modeling research. The local communities aided in public meetings and were close partners when discussing results of the RSS and progress of the select mitigation plan development. All reports and updates were written by UW Oshkosh staff and distributed to all associated partners.

- Although not directly involved in our project, we collaborated with Bay-Lake Regional Planning Commission in order to leverage funds (since some beaches were part of both projects) to ensure efficiency and fiscal responsibility when collecting data.

Future Projects

The Beach Sanitary Survey project for GLRI FY10 was the initial piece in the building blocks for the stepwise process in the beach mitigation. This project established baseline RSS data for 20 beaches in Northern Wisconsin and identified pollution sources. This project also compliments an additional GLRI grant administered to Bay-Lake Regional Planning Commission to evaluate additional beaches in Northern Wisconsin using RSS to evaluate beaches and identify potential pollution sources (*GLRI FY11 Beach Sanitary Survey Project for Northeast Wisconsin*). This baseline data was then used as a stepping stone for future successful GLRI applications regarding the development of preliminary and final redesign plans (*GLRI FY11 Implementation of Mitigation Strategies at Sanitary Survey Evaluated Beaches in Wisconsin*) and implementation of those redesign plans (*GLRI FY12 GLRI Implementation of Beach Redesigns to Make Northern and Southern Wisconsin Beaches Safer*). It is the intent that once the select beaches are mitigated that future funding should include projects aimed at assessment of the beach mitigation by conducted RSS.

Some locations have watershed level input that was not investigated because this was outside of the scope of this project. However, to accurately identify non-point sources and some of these beaches research should be conducted upstream of tributaries that are potential pollution sources to surrounding coastal beaches.

Budget Breakdown

Estimated and budget expenditures were closely aligned and all funds were spent, but there was no need for additional funds. Exact budget numbers are being reported on the US EPA budget forms per EPAs request.

Attribution - USEPA GLRI

Attribution was given to the USEPA GLRI granting agency throughout the study period. The USEPA GLRI logo was present on all signage at the beach, presentations, and reporting documents.

Appendix A: Quality Assurance Project Plan

Comprehensive Sanitary Survey Project for High Risk Wisconsin Beaches – Northern WI (Lake Superior and Northern Lake Michigan)

GL-00E00587-0

January 01, 2010 to December 31, 2012

Date Created: November 01, 2012
Date Approved: December 29, 2010

University of Wisconsin – Oshkosh
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Quality Assurance Project Plan
Comprehensive Sanitary Survey Project for High Risk Wisconsin Beaches – Northern WI (Lake Superior and Northern Lake Michigan)

Prepared by: Gregory Kleinheinz]

Dr. Greg Kleinheinz, Project Manager
University of Wisconsin-Oshkosh, Department of Biology and Microbiology

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Brian Langolf Quality Assurance Manager (or equivalent) (who is independent from the entities collecting and/or using the data).

Brian Langolf, Laboratory Manager
University of Wisconsin-Oshkosh, Department of Biology and Microbiology

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City of Racine Public Health Department

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EXECUTIVE SUMMARY

Wisconsin recreational waters are vital to our individual well-being and our local and state economies. Lake Michigan and Lake Superior have afforded the state of Wisconsin valuable natural resources for aquatic recreational activities. It is important to provide safe and healthy aquatic recreational activities to the public for both social and economic reasons.

This is a Quality Assurance Project Plan for the Beach Sanitary Surveys for Wisconsin's Great Lakes. Water quality standards staff, along with UW-Oshkosh staff and local health departments, has developed a procedure to conduct sanitary surveys on public beaches on Lake Michigan and Lake Superior coastlines based on the Sanitary Survey form and procedures developed during pilot testing by the U.S. EPA. This program supports beach sanitary surveys on impaired beaches within all of Wisconsin's coastal counties. Sanitary surveys may help identify sources of microbial pollution which may help with control of these sources and result in improved water quality. The goal of this project is to accurately characterize beaches with impaired water quality (as defined by Wisconsin's 303d list) on Lake Michigan and Superior in terms of the source of microbial pollution entering the beach area. This project will provide a basis for each of the communities participating in this study to begin to develop recommendations on addressing the causes of microbial contamination at their beaches.

A. PROGRAM ORGANIZATION

The Beach Sanitary Surveys will be supported by partners in all local municipalities where the selected beaches are housed.

Greg Kleinheinz and Julie Kinzelman will serve as the Supervisors responsible for oversight and evaluation activities to ensure project implementation.

The Quality Assurance Manager in the Aquatic Research Lab Manager Brian Langolf.

Contact Information:
Brian Langolf
Aquatic Research and Biosolids Laboratory Manager
University of Wisconsin Oshkosh
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Oshkosh, WI 54901

The Beach Program Coordinator [Gregory Kleinheinz] is responsible for contractual agreements for funding, data evaluation, organizing meetings and assisting with report writing. He is responsible for ensuring that technical and scheduling objectives as specified in the QAPP are achieved successfully and for maintaining the official, approved QA Project Plan. He assures that the project proceeds in compliance with grant requirements.

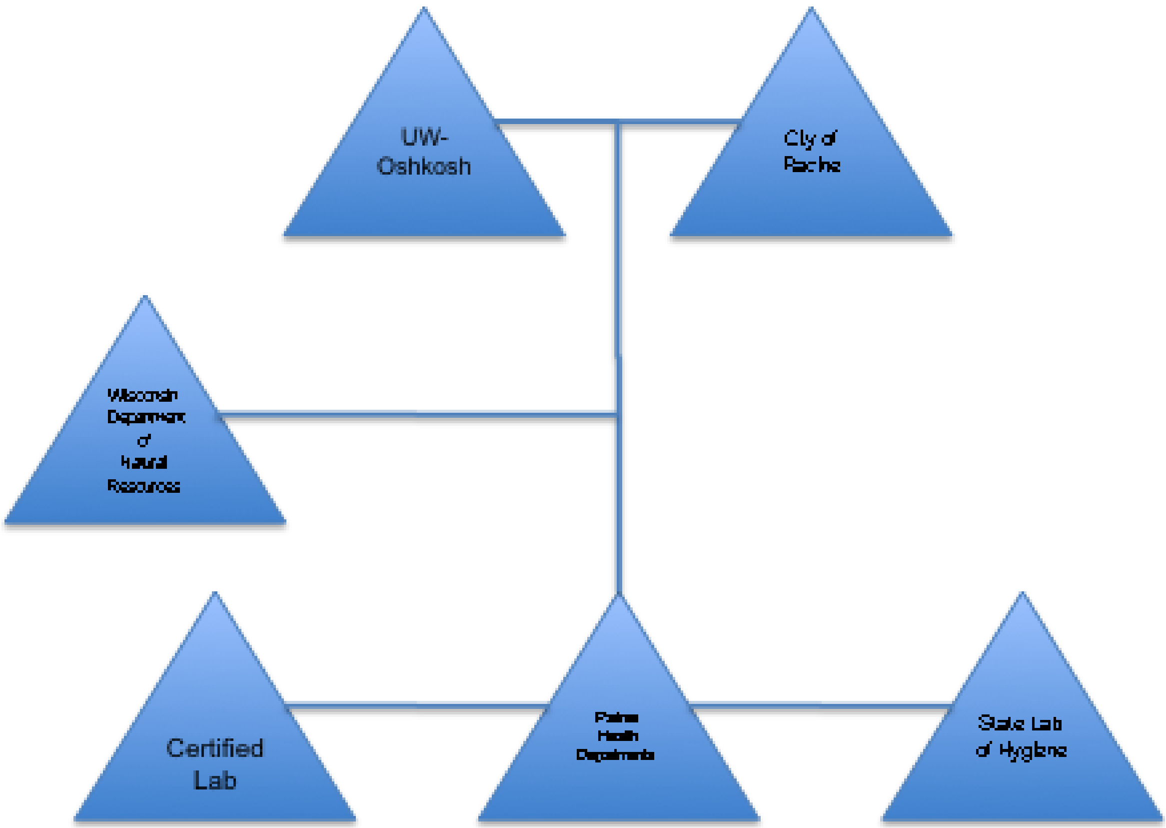
The "Participating Members" are representatives of local and state public health departments located along the Great Lakes. The City of Racine and UW-Oshkosh will be contracted to work within the counties with beaches chosen for sanitary surveys to be completed.

The labs are required to conduct testing based on current best practices, and have agreed to deliver results within 24 to 48 hours after sample submission.

Table 1 – Lab Analysis and Beaches Monitored

Labs To Analyze Samples
Racine Health Department
Kenosha County Health Department
UW-Oshkosh Environmental Microbiology Lab at UW-Extension Manitowoc
UW-Lab at Crossroads at Big Creek (UW-Oshkosh)
UW-Lab at Northland College (UW-Oshkosh)

Organizational Chart



Principal Data Users

- Wisconsin Department of Natural Resources
- Local Health Departments
- Beach Managers
- Bureau of Parks
- Administrator, USEPA
- Local Health Department Laboratories

1. Problem Definition & Background

In October 2000, Congress passed the Beaches Environmental Assessment and Coastal Health Act (BEACH Act) designed to reduce the risk of disease to users of the nation's coastal recreation waters including the Great Lakes. Wisconsin was one of the first states to implement a statewide BEACH Act Program to monitor beaches for microbial pollution and notify the public of risk associated with water quality. The program was developed to address health risks to beach users by the Wisconsin DNR, the BEACH Workgroup, and state and local health officials. The Lake Michigan and Lake Superior shorelines are lined with 192 public beaches. These beaches are visited by thousands of people each year and beach water is subject to contamination from sources such as storm sewers, wastewater treatment discharges, combined sewer overflows, agricultural runoff, wildlife wastes and adverse weather. This contaminated water is a potential cause of gastrointestinal illness and other diseases. While the BEACH Act provides funds to monitor microbial contamination at 127 monitoring sites in Wisconsin, the Program has not had additional funds to investigate the sources of microbial contamination. Sanitary surveys will be conducted at beaches with impaired water quality (as defined by Wisconsin's 303d list) in Wisconsin, to investigate the possible sources of microbial contamination and begin the process of planning for mitigation of these microbial contamination sources.

2. Project/Task Descriptions

The overall objective of this project is to investigate sources of microbial contamination by conducting sanitary surveys of beaches with impaired water quality (as defined by Wisconsin's 303d list) on Lake Superior and Lake Michigan.

Other program objectives include:
a) Beach Assessment and Identifying Possible Sources of Contamination
b) Sampling Design, Methods Assessment and Procedures
c) Monitoring Report Submission
d) Begin Development of Beach Forecasting Models
e) Develop complete redesigns of eight beaches using data gathered from this project and develop complete engineering plans for the local municipality.

3. Overall Project/Task Descriptions

Program Objective (a) – Beach Assessment and Identifying Possible Sources of Contamination

To determine potential microbial pollution sources, the U.S. EPA Annual Sanitary Survey Pilot Protocol will be used to assess beaches with impaired water quality (as defined by Wisconsin's 303d list) along Lake Superior and Lake Michigan.

Table 2: List of 303d Impaired Waters Beaches included in the study (Northern and Southern).

Impaired Water Report: Waterbody Type: GREAT LAKES BEACH TMDL: Y			North				
Stream Name	Local Waterbody Name	Start Mile	End Mile	Pollutant	Impairment	Counties	**Number**
Lake Michigan	Van Ess Road Beach	0	0.49	E. coli	Recreational Restrictions - Pathogens	Sheboygan	1
Lake Michigan	KK Road Beach	0	0.56	E. coli	Recreational Restrictions - Pathogens	Sheboygan	2
Lake Michigan	Amsterdam Beach	0	0.33	E. coli	Recreational Restrictions - Pathogens	Sheboygan	3
Lake Michigan	Warm Water Beach (L. Michigan)	0	0.78	E. coli	Recreational Restrictions - Pathogens	Manitowoc	4
Lake Michigan	Fischer Park Beaches	0	0.85	E. coli	Recreational Restrictions - Pathogens	Manitowoc	5
Lake Michigan	Hika Park Bay Beach	0	0.2	E. coli	Recreational Restrictions - Pathogens	Manitowoc	6
Lake Michigan	Red Arrow Park Beach	0	0.42	E. coli	Recreational Restrictions - Pathogens	Manitowoc	7
Lake Michigan	Ymca Beach	0	0.21	E. coli	Recreational Restrictions - Pathogens	Manitowoc	8
Lake Michigan	Memorial Drive Wayside Beach	0	3.24	E. coli	Recreational Restrictions - Pathogens	Manitowoc	9
Lake Michigan	Neshota Park Beach	0	0.68	E. coli	Recreational Restrictions - Pathogens	Manitowoc	10
Lake Michigan	Point Beach State Park Beach	0	1.51	E. coli	Recreational Restrictions - Pathogens	Manitowoc	11
Lake Michigan	Crescent (L. Michigan)	0	0.68	E. coli	Recreational Restrictions - Pathogens	Kewaunee	12
Lake Michigan	Kohler Andrae (L. Michigan)	0	3.71	E. coli	Recreational Restrictions - Pathogens	Sheboygan	13
Lake Michigan	City Of Kewaunee Beach (L. Michigan)	0	1.14	E. coli	Recreational Restrictions - Pathogens	Kewaunee	14
Lake Michigan	Sinissippi Lake Beach - Neider Park Landing	0	0.4	E. coli	Recreational Restrictions - Pathogens	Dodge	15
Lake Superior	Wisconsin Point Beach #2	0	0.48	E. coli	Recreational Restrictions - Pathogens	Douglas	16
Lake Superior	Barker's Island Inner Beach	0	0.4	E. coli	Recreational Restrictions - Pathogens	Douglas	17
Lake Superior	Maslowski Beach (L. Superior)	0	0.87	E. coli	Recreational Restrictions - Pathogens	Ashland	18
Lake Superior	Thompson West End Park Beach	0	0.68	E. coli	Recreational Restrictions - Pathogens	Bayfield	19
Lake Winnebago	Menomonie Park Beach						20
			South				
Lake Michigan	South Shore Beach	0	0.65	E. coli	Recreational Restrictions - Pathogens	Milwaukee	1
Lake Michigan	Bradford Beach	0	0.64	E. coli	Recreational Restrictions - Pathogens	Milwaukee	2
Lake Michigan	Southport Park Beach	0	0.07	E. coli	Recreational Restrictions - Pathogens	Kenosha	3
Lake Michigan	Mckinley Beach	0	0.59	E. coli	Recreational Restrictions - Pathogens	Milwaukee	4
Lake Michigan	Grant Park (L. Michigan)	0	0.7	E. coli	Recreational Restrictions - Pathogens	Milwaukee	5
Lake Michigan	Pennoyer Park Beach (L. Michigan)	0	0.74	E. coli	Recreational Restrictions - Pathogens	Kenosha	6
Lake Michigan	Alford Park Beach	0	0.23	E. coli	Recreational Restrictions - Pathogens	Kenosha	7
Lake Michigan	Eichelman Beach (L. Michigan)	0	0.58	E. coli	Recreational Restrictions - Pathogens	Kenosha	8
Lake Michigan	Simmons Island Beach (L. Michigan)	0	0.45	E. coli	Recreational Restrictions - Pathogens	Kenosha	9
Racine #1 New	Wind Point Lighthouse Beach (L. Michigan)	0		Unknown	Unknown	Racine	10
Racine #2 New	Shoop Park Beach (L. Michigan)	0		Unknown	Unknown	Racine	11
Racine #3 New	Parkway Beach (L. Michigan)	0		Unknown	Unknown	Racine	12
Racine #4 New	Michigan Boulevard Beach (L. Michigan)	0		Unknown	Unknown	Racine	13
Racine #5 New	Meyers Park Beach (L. Michigan)	0		Unknown	Unknown	Racine	14
Racine #6 New	Bayview Park Beach (L. Michigan)	0		E. coli	Recreational Restrictions - Pathogens	Milwaukee	15
Racine Inland	Olbrich Park Beach (Lake Monona)	0		E. coli	Recreational Restrictions - Pathogens	Dane	16

These beaches have been selected for the sanitary survey based on geographic location, frequent advisories and closures over the past four beach sampling seasons, and recent reconstruction. A comprehensive assessment of each beach will be conducted. Both the routine On-Site Surveys and Annual Comprehensive Survey will be performed at each beach. The routine On-site Survey, to be completed at the time of sample collection, can be found at: http://www.epa.gov/waterscience/beaches/sanitarysurvey/pdf/survey-routine.pdf. The Annual Sanitary Survey, a comprehensive survey to be performed annually for a beach, can be found at http://www.epa.gov/waterscience/beaches/sanitarysurvey/pdf/survey-annual.pdf.

The routine on-site sanitary survey will be conducted when water sampling occurs at each of the beaches. Approximately 100-200 samples will be taken at each beach inclusive of identified probable sources of microbial contamination (storm water outfalls, river mouths, runoff from nearby parking lots, etc.). This project will be in addition to samples collected for Wisconsin's BEACH Monitoring and Notification Program. This effort will yield >10,000 samples to characterize pathogen sources in this phase of the project, and allow for a quantifiable measure of the significance of each source on the overall beach water quality. At each sampling location there will be several various sampling sites identified and monitored. Water samples will be taken at the center of the beach at 24" along with spatial sampling at the left, center, and right of the beach and at 12", 24", and 48" in depth. Water samples will also be taken at any known outfalls in near proximity to the beach. Sand samples will be taken at each location at 24" in depth, the swashzone, and upshore at the left, center, and right of the beach. The sample locations hold true for all sample sites where sanitary surveys are administered.

In addition to water samples, beach water movement (currents) and depth profiles at each location will be evaluated as part of this project. The beach substrate will be characterized at each location in terms of its chemical and physical composition.

Program Objective (b) - Sampling Design, Methods Assessment & Procedures

To assure consistency in collecting samples for analysis, the following procedures will be used:

- Specific sites will be designated as potential contamination sources. Samples will be collected exclusively at these sites for the duration of the sampling period.

- Sample bottles will be prepared and provided by the laboratories charged with conducting bacteria analyses.

See Appendix A for Wisconsin's Beach Monitoring Sampling Protocol, which will be used for water quality sampling for the sanitary surveys.

The data will be verified through a systematic process to determine if the data has been collected in accordance with specifications resulting in compliance with established standards and the QAPP, e.g. precision, accuracy, consistency, and completeness. The department will assess whether the data quality objectives of this project have been met. Once the data have been confirmed to meet the standards, they will be systematically examined to determine their technical usability with respect to the planned objectives. The data will be assessed to determine whether they are of the right type, quality, and quantity to support the intended use.

Program Objective (c) - Monitoring Report Submission

Monitoring data will be updated daily, in a timely manner, for viewing by the public, EPA, and other agencies in a similar fashion as currently employed using the Beach Health Website. A final report will be completed for the project identifying outcomes and possible mitigation strategies.

Program Objective (d) - Begin Development of Beach Forecasting Models

Beach sanitary survey data and monitoring data will be organized, entered on-line daily, and evaluated to begin development of, or refine existing, forecasting models during the summers of 2010 and 2011, at beaches in Racine, Milwaukee, and Door County, WI. In conjunction with the WDNR, this effort will be used to test the predictive abilities of the US EPA's public domain nowcast model building software, Virtual Beach. This software allows the user to manipulate and choose variables that will be included in the predictive model, and thus create individualized predictive models specific to local beaches. The readily available routine, daily survey information (rainfall, wave height, wind speed and direction, cloud cover, bird counts, *Cladophora* prevalence, water turbidity, etc.) will be used for these beaches a minimum of five days per week and may extend over weekends, to ensure that the model can be used to forecast *E. coli* concentrations that will occur when maximum bather activity is expected, in each of two swimming seasons. The sanitary survey data along with the monitoring data may be plugged into the Virtual Beach software and *E. coli* concentrations in beach water will either be nowcast (0-12 hours post data collection) or forecast (24-48 hours post data collection). Actual *E. coli* concentrations and the predicted values will be compared to determine the predictive ability of each model. Currently, Door County and South Milwaukee issue pre-emptive beach closures, based on "significant" rainfall events occurring in the county. When the actual *E. coli* concentrations were examined on days when pre-emptive closures were instituted in 2006, this "predictive model system" proved to be correct in only about 20% of cases. The Virtual Beach model has been shown to be significantly better than this at the test beach (Huntington Beach, Ohio). This is an opportunity to test Virtual Beach software in settings both similar to and unlike the relatively urban Huntington Beach.

<u>Program Objective (e) - Develop complete redesigns of eight beaches using data gathered from this project and develop complete engineering plans for the local municipality.</u>

Once all the data has been collected it will be used to develop engineering plans for eight beaches. These plans will include draft designs to be reviewed with the appropriate beach managers and municipal personnel, as well as public meetings (at the discretion of the local municipality), in preparation of final engineered plans to mitigate the discovered sources of fecal pollution at the beach. The final plans will be construction ready documents.

4. Schedule

Data collection for this project will run concurrently with Wisconsin's BEACH Act Monitoring and Notification Program. Wisconsin's beach season for public coastal beaches is approximately 15 weeks in length (Memorial Day Weekend through Labor Day Weekend). Sample collection may, and laboratory analysis will, continue after the beach season. A final report will be available by the end of calendar year in 2010, 2011, and 2012.

The estimated schedule for completing beach sanitary survey activities per calendar year are as follows with each year following a similar schedule:

Date of Activity	Project Activities
March & April 2010	Meet with county collaborators
May 2010	Research sites and their unique characteristics. Identify any resources available such and county or state data that may be available. Conduct a site visit to each of the test sites prior to the start of the beach season. Begin preliminary sampling at sites in late May 2010. Meet with collaborators as needed to discuss results and gather input from each community involved in the project.
June 2010	Complete Sanitary Survey of each site using the forms and procedures developed during the EPA pilot program. Identify possible sources of contamination at each location. Start beach

	season sampling prior to Memorial Day. Meet with collaborators as needed to discuss results and gather input from each community involved in the project.
June, July, August 2010	Continue sampling and assess potential sources using methodologies described above. Conclude sampling on approximately Labor Day. Meet with collaborators as needed to discuss results and gather input from each community involved in the project. Genetic information for *E. coli* will be available in the late summer, identifying sources of microbial pollution.
September 2010	Conclude sampling and any laboratory work that is in progress. Meet with collaborators as needed to discuss results and gather input from each community involved in the project.
October 2010	Conduct data analysis and conclude any work that remains from the summer sampling season. Meet with collaborators as needed to discuss results and gather input from each community involved in the project.
December, November 2010 and months leading up to next beach sampling season	Complete and submit interim progress or Final Report to the USEPA and/or other appropriate agencies. Hold local community meetings in all locations that are interested. Answer questions of the public and allow public comment on the results of the project. Discuss redesigns in 2012.

5. Personnel, Special Equipment or Supplies

Personnel: BEACH Act Coordinator will serve as a liaison between the U.S. EPA and the local public health departments. This person is responsible for contractual agreements for funding, data evaluation, organizing meetings and report writing. No special equipment will need to be ordered for the beach sanitary surveys project.

6. Special Training Requirements or Certifications

State Registered Sanitarians, Public Health Officials and Interns under supervision of Sanitarians and/or City Parks personnel will be trained in filling out the Sanitary Survey form developed for this project.

Student interns and other staff and faculty members will conduct the sanitary survey data throughout the summer months. All samplers will be trained in a 12 week training course offered in the spring prior to summer sampling. If individuals are unable to attend the training course, special individual training will be administered with the same criteria as the training course. On-sight training will take place during the training course along with the initial set up of the laboratory at the various remote locations. A GLRI Lab Manual will be administered to all interns either during the training course or prior to beginning of employment in order to unify all procedures and protocols between sampler collectors. Proficiency testing will then be administered prior to summer employment to ensure collectors have been accurately trained and able to interpret data correctly. Faculty or staff members will also make random visits to remote laboratories to observe samplers periodically throughout the summer.

In addition, samples will be collected by State Registered Sanitarians, Public Health Officials, and Interns under the direction of Sanitarians and/or City Parks personnel trained on proper field sampling technique. Sample analyses will be performed by certified laboratory personnel, trained and experienced in current laboratory procedures for bacteria analysis. Laboratories certified by the Wisconsin Department of Agriculture Trade and Consumer Protection will perform all testing. Sample result evaluation and analysis, notification of results to project participants and the public, as well as any accompanying recommendations, are under the direct supervision of the Project Coordinator. Training is ongoing and documented.

7. Documentation and Records

Contractors for the Beach Sanitary Surveys, will follow the approved QAPP for the WI Beach Program as well as all elements found in this QAPP. Records generated during the project include:

- Documentation regarding agreements, contracts, and expectations.
- An annual comprehensive report to be prepared for submission to the Water Division Administrator, the Director of the Bureau of Watershed Management and the USEPA Administrator.

Storage, access to, and final disposition of all records are subject to the requirements of the State of Wisconsin.

a) Field Records

The Great Lakes Beaches Routine On-Site Survey and the Annual Sanitary Survey Form will be completed by field staff. All field information will be recorded on individual sanitary forms for each beach (Appendix B). If possible, EPA suggests printing Routine On-Site Sanitary Survey forms on waterproof paper. It is suggested also, that forms are filled out in pencil to avoid losing data that has been recorded. All possible sources of contamination will be geo-located and mapped. Hard copies of each file and other relevant field data, including notebooks, maps, drawings, photographs, and communication records will be stored by the health departments collecting the data. At the end of the project, all sanitary survey forms and files will be stored at the WDNR central office.

b) Laboratory Records

Laboratory data forms are to be completed initially by the sample collector at the time the sample is collected; followed by the laboratory sample receipt person and analyst when the sample is received, tested, and results are determined. The laboratory data form allows collection of information including, but not limited to, the name of beach, body of water, sampling point, date/time of collection, water and weather conditions, as well as name of laboratory, dates and times of testing, and final results. The laboratory data form serves as a Chain-of-Custody record for each sample collected and analyzed. The laboratory maintains control of other relevant laboratory records including logs, bench sheets, and raw analytical and QA/QC data. Data collected will be stored and available at www.wibeaches.us.

c) Standard Operating Procedures

A Sampling Protocol Requirements Page has been created to accompany all local health department grants (See Appendix A). Participants in the sanitary survey are required to comply with sampling requirements in order to receive contractual funding.

d) Constructing an Annual Survey Report

The Annual Survey Report Outline is a standard format for compiling a report to assess a beach and the surrounding watershed for potential sources of microbial contamination that impact the water quality of a beach (Draft Great Lakes Beach Sanitary Survey Guidance, Appendix B). This report format will allow for consistency among Great Lakes beach managers for sharing beach pollution source information on beaches.

B. DATA QUALITY OBJECTIVES

1. The Decision

a) Determine possible sources of microbial contamination through sanitary surveys.

2. Inputs to the Decisions

Sanitary surveys will be conducted on selected beaches located on Lake Superior and Lake Michigan. The annual survey includes:

a) Basic Information (Beach Name, Town City, Name of Waterbody)
b) Land Use Description in Watershed (Current Land Use, Erosion Measurements, Bounding Structures, Beach Materials, Comments/Observations)
c) Conditions (Beach Dimensions, Slope, Water Level)
d) Sampling Location
e) Bather Load
f) Beach Cleaning/Grooming Techniques
g) Sampling (Invasives, Algal Blooms, Wildlife and Domesticated Animals, Samples Collected, Water Quality)
h) Modeling
i) Advisories/Closures
j) Potential Pollutant Sources
k) Description of Sanitary Facilities
l) Description of Other Beach Facilities

The routine on-site sanitary survey will include the following parameters:

a) General Beach Conditions (Air Temperature, Rainfall, Weather Conditions)
b) Water Quality (Water Temperature, Odor, Turbidity, Algae)

c) Bather Load (# and Recreational Activities)
d) Potential Pollution Sources (Discharges, Floatables, Debris/Litter, Algae, Wildlife and Domesticated Animals)

3. Study Boundaries

Beach sanitary surveys, water sampling evaluations and assessments are to be conducted on twenty selected public coastal beaches located along Lake Michigan and Lake Superior.

4. Action Levels

a) Samples with E. coli levels exceeding 235 MPN or CFU/100 mL at potential microbial contamination sources will be used to indicate whether the source is contributing to beach advisories and closures.
b) Sanitary surveys will provide information to help facilitate mitigation plans for cleaning up microbial contamination sources at these beaches.

At each beach location a total of nine samples will be taken for special sampling at 3 days/week for the duration of the summer months. Regular beach monitoring ranges from 1X/week to 4X/week depending on the priority of the beach. Water samples will be taken at the left, center, and right of the beach at 12”, 24”, and 48” inches for spatial sampling 3X/week biweekly. Sand samples will be taken at the left, center, and right of the beach at 24” water depth, the swashzone, and upshore 3X/week biweekly. Samples from known outfalls and streams will be taken 3X/week. Locations of sample sites in streams will be determined after if elevated levels of *E. coli* concentrations are observed. If exceedances of 235 MPN of *E. coli* are reached in the above data, correlations will be evaluated by determining the R2 values between *E. coli* concentrations and the indicated physical/chemical parameter or location at the particular beach. These correlations will further indicate potential sources of *E. coli* contamination. Other statistics may also be used including t-tests and ANOVA for additional support for contamination sources.

C. MEASUREMENT/DATA ACQUISITION

1. Process Design

<u>Objective (a) – Beach Assessment and Identifying Possible Sources of Contamination</u>

a) Beach Sanitary Surveys - Each beach will be evaluated using the US EPA Draft Sanitary Survey Form. The Annual Survey form will be filled out by an intern in the beginning of the beach season with input from local partner agencies. While collecting beach water quality samples, and samples at potential sources of contamination, the On-Site Routine Sanitary Survey Form from EPA will be used.

The sanitary survey forms will include all parameters mentioned above in the Data Quality Objective Inputs (B2).

Environmental Conditions - The following WEB sites, in addition to local weather stations, can be used to view real-time and historical weather conditions, wind speed & direction, water temperature and wave height:

- http://www.aos.wisc.edu/~sco/
- http://www.coastwatch.msu.edu/twomichigans.html
- http://www.ndbc.noaa.gov\station_page.phtml?station=45007

b) Geo-locational data - All potential contamination sources at each of the beaches will be identified and located via the use of GPS and GIS technologies. All available Digital OrthoPhotos and Digital Raster Graphics will be viewed to see if outfalls are outlined clearly and can be digitized on screen using ArcView 3.2. Coordinates will be collected using a Trimble ProXR GPS unit or equivalent GPS unit. The Trimble ProXR GPS unit collects locational data in the Wisconsin Transverse Mercator (WTM) format with sub-meter accuracy. The data will be stored in the datalogger and downloaded into the computer using the Pathfinder software. Once a beach polygon layer has been created, it will be used to create a second layer by converting the polygons to polylines. The line layer will be edited so that a single line represents the length/location of each outfall. Attributes such as beach name and measured length will be tied to each line feature. A map of each beach participating will be developed indicating the adjacent coastal recreation waters, points of access by the public, length of beach, as well as any known potential sources of microbial pollution.

Quality Control

Geo-locational data: The TSC1 datalogger acts as the controlling software by communicating with the GPS receiver to set specific GPS parameters required for optimal accuracy. Data validity is determined by the number of satellites. If there are too few satellites, a warning tone sounds to identify the data. The same validity checks are built into the Pathfinder software. Any data collected by too few satellites was identified and eliminated through this software.

<u>Objective (b) - Assessment procedures to identify sources of microbial contamination</u>

Assessment Procedures for Identifying Short-term Increases

Frequent, regular sampling is required to identify short-term increases in pathogens and increases due to weather events. Beach monitoring efforts at potential sources of microbial contamination may help pinpoint when microbial contamination is occurring due to weather events. Existing monitoring data along with new data will be evaluated. The additional information collected during sanitary surveys can be used along with the monitoring data to aid in identifying short-term pathogen increases and increases due to storm events.

The usefulness of the data on beach conditions, beach uses, and environmental conditions that drive beach process must be evaluated to find significant or logical relationships of the driving mechanisms. Hopefully, parameter relationships will become apparent from the statistical analysis of the data. This information may be used for predictive modeling in the future. This circular process of valid sampling, statistical analysis and modeling beach conditions will hopefully improve our understanding of pathogen exposure at beaches and lead to a predictive model(s) that forewarns of impending health hazards.

Collaboration and Exchange of Information

The challenge at hand demands a collective effort and through this effort a collective solution. The sanitary survey effort will include communicating and sharing of information with universities, colleges, US EPA, USGS, other states, regional planning groups, counties, cities and other municipalities and interest groups. This will be done through individual contact, conferences and special meetings and/or site visits.

Final Report

This study will include a final report and the attendance of special meetings and conferences by the principal investigators to share the results of the beach sanitary survey project. The final report will include results of the sanitary surveys, a statistical analysis of water quality samples collected at the beaches, as well as any additional suggestions on monitoring for hazards and minimizing microbial contamination to the beaches.

2. Sampling Method Requirements

All sampling is required to follow these general rules:

a. Samples will be collected in containers approved by the Wisconsin Department of Agriculture Trade and Consumer Protection (WDATCP) laboratory certification program.

b. Extreme care needs to be taken to avoid contaminating the sample and sample container.
   - Do not remove bottle covering and closure until just prior to obtaining each sample.
   - Do not touch the inside of the sample container.
   - Do not rinse the sample container.
   - Do not put caps on the ground while sampling.
   - Do not transport the samples with other environmental samples.

c. Adhering to sample preservation and holding time limits is critical to the production of valid data.
   - Samples should be labeled, iced or refrigerated at 1 - 4 degrees C immediately after collection and during transit to the lab. Samples will be immediately placed on wet ice and placed in a cooler for transport to the laboratory.
   - Care should be taken to ensure that sample bottles are not totally immersed in water from melted ice during transit or storage.

- Samples should arrive in the laboratory no later than 24 hours after collection. Whenever possible samples should arrive at the lab on the day of collection, preferably before 2 p.m.

d. The sampler will complete the laboratory data form noting time, date, and location of sample collection.

e. Samples will be analyzed on the day of collection whenever possible and holding times may not exceed 24 hours.

3. Sample Handling and Custody Requirements

The laboratory data form will serve as a Chain-of-Custody record for each sample collected and analyzed. In keeping with laboratory requirements (Standard Methods), all samples must be sealed, chilled, and transported from the sample point to the laboratory for analysis within twenty-four hours after sampling. Sample collectors will have exclusive custody of any sample from the time of collection until the sample is deposited with the laboratory. The laboratory will assume custody of each sample it receives and is responsible for forwarding all sample analysis results to the Project Manager within twenty-four hours to forty-eight hours of receiving the sample.

4. Analytical Requirements

All analyses shall be performed in laboratories certified by the Wisconsin Department of Agriculture and Consumer Protection for microbiological analysis of *E. coli* in water. Table 1 lists all the current EPA approved analytical methods or microbiological analysis of *E. coli*.

Table 3 - EPA Approved Analytical Methods

Indicator	***Type of Analyses Performed***	***Method Number***
E. coli	❑ Membrane Filter Fecal Coliform Test (MFFCC) with Nutrient Agar	Standard Methods 9222(D) and Standard Methods 9222(G)
	❑ Membrane Filter (MF)	Standard Methods 9213(B)
	❑ MPN - Enzyme Substrate Test - Colilert™	Standard Methods 9223(B)

5. Quality Control Requirements

A number of quality control checks are required to ensure the quality of the generated data. All laboratory staff will adhere to current and generally accepted practices for safe handling, testing of samples, and chain of custody measures.

(a) Precision

Precision is a measure of the degree to which two or more measurements are in agreement. Field precision is estimated through the collection and measurement of two samples at the same sampling site at approximately 10 percent of the sites. The precision of laboratory analyses is estimated by analyzing two or more aliquots of the same water sample. This data quality indicator is obtained from two duplicate samples by calculating the relative percent difference (RPD) as follows:

$$RPD = \frac{|C1 - C2|}{(C1 - C2)/2} \times 100$$

Where C1 is the first of the two values and C2 is the second value. Because of the heterogeneity of populations of bacteria in surface waters, an RPD of less than or equal to 50 percent between field duplicates for microbiological analyses might be considered acceptable. When multiple replicates are analyzed, precision of the test will be expressed in terms of standard deviation and the ability to detect the target organism. Analysts should be able to duplicate bacterial colony counts on the same membrane within 5 percent and the counts of other analysts within 10 percent; otherwise, procedures should be reviewed and corrective action implemented.

(b) Accuracy

Accuracy is determined through the use of field blanks and through the adherence to all sampling handling and holding times. Because accuracy is the measurement of the degree of agreement between and observed value and an accepted reference value or a true value, and the true values of environmental physiochemical and biological characteristic cannot be known, accuracy is assessed by the use of a surrogate. To estimate the densities of bacteria, use of samples prepared from known quantities of freeze-dried and cultured bacteria as a surrogate can result in 97.9 percent recovery of the bacteria from water samples. Based on the mTEC medium, bias was determined to be 2 percent of the true value. This information is helpful in establishing the most appropriate methods to be followed.

(c) Representativeness

In the sample design, care is taken to determine if the area of sample collection is typical and representative of each area of concern.

6. Data Management

Wisconsin DNR contracts with the USGS to maintain a database capable of storing all pertinent information about each participating beach. The data is stored in an accessible form usable to the local decision-makers. A system of quality control checks is performed to assure that all data is accurately entered into any data storage system. All data are analyzed statistically immediately upon completion of tests so that beach advisory decisions can be made quickly. Additionally, all beach data are reported electronically in an acceptable form for reporting to USEPA. Appropriate user instructions and system documentation have been developed and made available to all staff using the database system.

D. ASSESSMENT/OVERSIGHT

The effectiveness of the monitoring program will be assessed at regular intervals through the use of technical systems audits, performance evaluations, and audits of data quality to verify that sampling and analysis are performed in accordance with the established QC procedures and that all operational aspects of the program are acceptable. This Project will identify specific assessment methods and procedures for project documentation as well as collection, preservation, and storage of water samples. The laboratory is responsible for the compliance regarding the analytical aspects of the Project.

The QA program will include procedures for identifying and defining a problem, assigning responsibility for investigating the problem, determining the cause of the problem, assigning responsibility for implementing corrective action, and assigning responsibility for determining the effectiveness of the corrective action and verifying that the corrective action has eliminated the problems.

E. RECONCILIATION WITH DATA OBJECTIVES

Sample records, chain of custody records, and sample tracking records will be reviewed to verify that all the samples collected were analyzed so the data set will be complete. Data entries and analyses will also be verified. The input of large quantities of historical data will be spot checked to detect potential data entry errors. Calculations will be reviewed by rechecking the computations, reviewing the assumptions used and checking the input data against the original sources to be sure transcription errors have not occurred.

Once the data have been confirmed to meet standards, a report that provides an assessment of the usability of the data, a summary of sample results, and a summary of QC and QA results will be prepared. The report will discuss any discrepancies between the Data Quality Objectives (DQOs) and the data collected and any effects such discrepancies might have on the ability to meet the DQOs.

SAMPLING PROTOCOL

Sampling Protocol for *E. coli* at Wisconsin's Beaches

To assure consistency in collecting samples for analysis, the following procedures will be used:

1) Specific sites will be designated for collecting samples during the bathing season. Samples will be collected exclusively at these sites for the duration of the sampling period.

2) Sample bottles will be prepared and provided by the laboratories charged with conducting bacteria analyses.

General Rules of Sampling

- Take extreme care to avoid contaminating the sample and sample container.
- Do not remove bottle covering and closure until just prior to obtaining each sample.
- Do not touch the inside of the sample container.
- Do not rinse the sample container.
- Do not put caps on the ground while sampling.
- Do not transport the samples with other environmental samples.
- Adhering to sample preservation and holding time limits is critical to the production of valid data.
- Samples should be labeled, iced or refrigerated at 1 - 4 degrees C immediately after collection and during transit to the lab.
- Care should be taken to ensure that sample bottles are not totally immersed in water during transit or storage.
- Samples should arrive in the lab no later than 24 hours after collection. Whenever possible samples should arrive at the lab on the day of collection, preferably before 2 p.m.
- The sampler will complete the laboratory data form noting time, date, and location of sample collection, current weather conditions (including wind direction and velocity), water temperature, clarity, wave height and any abnormal water conditions.

Sampling Method

(1) Carefully move to the first sampling location. Water should be approximately knee deep (24 – 30 inches). While wading slowly in the water, try to avoid kicking up bottom sediment at the sampling site.

(2) Open a sampling bottle and grasp it at the base with one hand and plunge the bottle mouth downward into the water to avoid introducing surface scum.

(3) The sampling depth should approximately 6 to 12 inches below the surface of the water.

(4) Position the mouth of the bottle into the current away from your hand. If the water body is static, an artificial current can be created by moving the bottle horizontally with the direction of the bottle pointed away from you.

(5) Tip the bottle slightly upward to allow air to exit and the bottle to fill.

(6)Make sure the bottle is completely filled before removing it from the water.

(7) Remove the bottle from the water body and pour out a small portion to allow an air space of 2 cm for proper mixing of the sample before analyses.
(8) Tightly close the cap and label the bottle.
(9) Store sample in a cooler filled with ice or suitable cold packs immediately.

Analytical Methods

All sample analyses shall be conducted by State certified labs using one of the following EPA approved methods:

Most probable number (MPN) tests for *E. coli*:

- LTB EC-MUG (Standard Methods 9221B.1/9221F)
- ONPG-MUG (Standard Methods 9223B, AOAC 991.15, Colilert, Colilert-18, and Autoanalysis Colilert)

Membrane filter tests for *E. coli*:

- MEndo, LES-Endo, or mFC followed by transfer to NA-MUG media (Standard Methods 9222B/9222G or 9222D/9222G)
- MI Agar, M-ColiBlue24 Broth

APPENDIX B- FORMS FOR SANITARY SURVEYS

Please see the following attached:
- Annual Sanitary Survey Document
- On-Site Routine Sanitary Survey Document

Annual Sanitary Survey

1. BASIC INFORMATION

Name of Beach:	Date(s) of Survey:
Beach ID:	Name of Waterbody:
Town/City/County/State:	Number of Routine Surveys Used:
Sampling Station(s)/ID:	Name(s) of Surveyor(s):
STORET Organizational ID:	Surveyor Affiliation:

2. DESCRIPTION OF LAND USE IN WATERSHED

Current Land Use in Watershed

Type	Residential	Industrial	Commercial	Agricultural	Other (specify):
Percentage					

Development	Describe
% undeveloped	
% developed	

How was land use measured:

Waterbody Uses: ☐ Boating ☐ Fishing ☐ Surfing ☐ Windsurfing ☐ Diving ☐ Other (specify)

Are maps of the beach area attached? ☐ yes ☐ no Are maps of the watershed attached? ☐ yes ☐ no

List maps and their sources:

Does the detailed map include locations of:

Sample Points	☐ yes	☐ no	(explain):
Hydrometric Network	☐ yes	☐ no	(explain):
Pollutant Sources	☐ yes	☐ no	(explain):
Boat Traffic	☐ yes	☐ no	(explain):
Marinas	☐ yes	☐ no	(explain):
Boat dockage	☐ yes	☐ no	(explain):
Fishing	☐ yes	☐ no	(explain):
Bathing/Swimming	☐ yes	☐ no	(explain):
Bounding Structures:			
Jetty	☐ yes	☐ no	(explain):
Groin	☐ yes	☐ no	(explain):
Seawall	☐ yes	☐ no	(explain):
Other	☐ yes	☐ no	(explain):
Sanitary Facilities	☐ yes	☐ no	(explain):
Restaurants/Bars	☐ yes	☐ no	(explain):
Playground	☐ yes	☐ no	(explain):
Parking Lot(s)	☐ yes	☐ no	(explain):
Other	☐ yes	☐ no	(explain):

Erosion/Accretion Measurements

High Watermark Location Identification	Fixed Object Description (e.g., tree, building)	Distance from Fixed Object to High Watermark	Feet or Meters?	Distance between High Watermark Locations	Feet or Meters?
A				A↔B:	
B				B↔C:	
C				C↔D:	
D (optional)				D↔E:	
E (optional)					

How were distances measured? ☐ Measuring tape ☐ By Pacing ☐ Using a Map ☐ Estimated ☐ Other (specify)

Bounding Structures

Bounding Structure	Number	Description or Comment
Jetty		
Groin		
Seawall		
Natural formation		
Other (specify):		
Other (specify):		

Beach Materials/Sediments:

☐ Sandy ☐ Mucky ☐ Rocky ☐ Other:

Or, Beach Materials/Sediments Lab Analysis (attach diagram or photographs of plot locations)

Name of Lab Used:	
Date of Sample Collection:	

Plot ID	Mean Grain Size Diameter	Uniformity Coefficient	Description of Plot Location:
Average			

Describe the results and conclusion of the sediment analysis and potential effects of the sediment distribution at this beach:

Photographs Taken in the Beach Area or Surrounding Watershed

Image Number	Date/Time	File Name	Description of Photograph (Include Pictures of High Watermark Locations and Corresponding Fixed Objects)

Habitat around beach:

☐ Dunes ☐ Wetlands ☐ River/stream ☐ Forest ☐ Park ☐ Protected Habitat or Reserve

☐ Other:

3. WEATHER CONDITIONS

Examine the weather data collected over the prior beach season(s) along with bacteria sampling results.
Do the bacteria concentrations at this beach appear to correlate with any of the following?

Rainfall	☐ yes	☐ no	(explain):
Air Temperature	☐ yes	☐ no	(explain):
Water Temperature	☐ yes	☐ no	(explain):
Cloud Cover	☐ yes	☐ no	(explain):
Wind Speed	☐ yes	☐ no	(explain):
Wind Direction	☐ yes	☐ no	(explain):
Other Weather	☐ yes	☐ no	(explain):

Have any statistical analyses been done to calculate the degree of correlation? ☐ yes ☐ no

Describe any analyses done, and any trends or correlations found (add lines if needed to describe in detail):

Average air temperature during beach season: ° C	Average water temperature during beach season: ° C
Average wind speed and direction during beach season (e.g., E or 90° at 15 mph):	
Typical weather conditions: ☐ Sunny ☐ Mostly Sunny ☐ Partly Cloudy ☐ Mostly Cloudy ☐ Overcast ☐ Rainy	
Rainfall total for the beach season (in):	Average rainfall for all beach seasons (in):
Number of significant rain events:	What constitutes "significant?" (e.g., 1 inch or more rain)

Additional Comments/Observations:

4. PHYSICAL BEACH CONDITIONS

Beach length or dimensions (indicate Z1, Z2, and Z3 on a map)

Length (m):	Width (average, in m):	
Width Z1 (m):	Width Z2 (m):	Width Z3 (m):
Local water level variation: feet inches	Hydrographic influences (e.g., seiches):	

Characterize any longshore or nearshore currents and their potential effects based on bacteria sampling results

Approximate beach slope at swim area: %

Description and date of last beach rehabilitation (example: new sand, nourishment, dredging, etc., physical structures will be described in Sections 12 and 13):

Comments/Observations:

5. BATHER LOAD (# OF BEACH USERS)

Is bather load measured? ☐ yes ☐ no

If yes, describe how beachgoer numbers are calculated (i.e., turnstile, counting at noon, photographs):

3

Beach Use

Beachgoer Category	Number of People Per Day Using the Beach					
	Peak Use for the Season (Daily Use)	Seasonal Average (Daily Use)	Holiday Average (Daily Use)	Weekend Average (Daily Use)	Weekday Average (Daily Use)	Off-Season Average if applicable (Daily Use)
Total beach users						
People in the water						
People on beach but not swimming						
People boating						
People fishing						
People surfing						
People windsurfing						
People diving						
People clamming						
Other (specify):						
Frequency of measurements (e.g., biweekly, weekly, monthly)						

Examine bather load data along with sampling results for the past beach season(s). Look at each sampling point. Does bather load appear to correlate with bacteria concentrations at any of these sampling points? Has a statistical analysis been done? Describe:

Comments/Observations:

6. BEACH CLEANING

Beach cleaning frequency during season:

Description of cleanup activities

	Leveling of Sand	Trimming or Removing Vegetation	Removing Debris	Removing Trash	Construction and Maintenance of a Temporary Pathway Directly to Open Water	Other (specify):
Check activities that were done						
Equipment used (if applicable)						

How often is beach debris/litter found on the beach? ☐ Never ☐ Sometimes ☐ Frequently ☐ Very frequently

Known sources of debris:

Types of debris/litter found (animal waste is addressed in Section 8): ☐ Tar ☐ Oil/Grease ☐ Trash ☐ Plastic

☐ Medical waste ☐ Other (describe):

Comments/Observations:

7. INFORMATION ON SAMPLING LOCATION

Description of Sample Points

Sample Point Name/ID	Location	Description	Sample Frequency	Time of Day of Sample Collection

Description of hydrometric network [note that this is a network of monitoring stations that collect data such as rainfall and stream flow]

Comments/Observations:

8. WATER QUALITY SAMPLING

Name of laboratory: ____________ Distance to laboratory: ________ miles

Is there a sampling and analysis plan? ☐ yes ☐ no Is it adequate? ☐ yes ☐ no (explain):

Are the sampling staff properly trained on sampling techniques, equipment maintenance, and calibration procedures? ☐ yes ☐ no

Biological Survey Results:

Were invasive/nonnative species present? ☐ yes ☐ no (describe): ____________ ____________

Have algae blooms been observed during the beach season? (If so, specify duration and algae species) ____________

Percent of beach season where algae was present in significant amounts in the nearshore water: ☐ None ☐ Low (1–20%) ☐ Moderate (21–50%) ☐ High (> 50%)

Percent of beach season where algae was present in significant amounts on the beach: ☐ None ☐ Low (1–20%) ☐ Moderate (21–50%) ☐ High (> 50%)

List any infectious snails that were found: ____________

List any dangerous aquatic organisms that were found: ____________

Presence of Wildlife and Domestic Animals

Type	Degree of Presence (Low, Mod, High)	Does the Presence Appear to Correlate with Bacteria Results? (Yes, No, Don't Know)	Describe Further (include whether fecal droppings are seen and are a problem)
Geese			
Gulls			
Dogs			
Other (specify):			
Other (specify):			
Other (specify):			

Bacteria Samples Collected

Do you test for *Escherichia coli*? ☐ yes ☐ no Analytical Method Used: ______
Do you test for *Enterococcus*? ☐ yes ☐ no Analytical Method Used: ______
Do you test for fecal coliform? ☐ yes ☐ no Analytical Method Used: ______
List any additional bacteria tested and associated analytical methods: ______
Do you composite any bacteria samples? ☐ yes ☐ no If yes, explain: ______

How do this past season's bacteria results compare to that of previous years'? ______

Do the bacteria results correlate to other parameters, such as water quality, weather, flow, bather load, algae, or wildlife? ☐ yes ☐ no Describe in detail analyses that were performed on the data (add additional lines as needed).

Water Quality (check all that are measured regularly)

Temperature	pH	Rainfall	Turbidity	Conductivity	Other

How does the water quality data compare to data from previous years? ______

Do any data correlate with bacteria sample results? ☐ yes ☐ no If yes, explain: ______

Were there any unusual results, such as extremely high or low values detected, or unusual trends? ☐ yes ☐ no If yes, explain what was found and any potential causes: ______

Are water quality annual trend data attached? ☐ yes ☐ no

Comments/Observations:

9. MODELING

Are models being used to predict the exceedance of bacteria standards? ☐ yes ☐ no
If yes, list types of models being used and a brief description of the models:

6

Comments/Observations:

10. ADVISORIES/CLOSINGS

List any advisories and closings that occurred, whether bacteria levels were high, and any possible reasons for advisory or closing or high bacteria level, such as stormwater runoff, sewage spill, or wildlife on the beach.

Advisory or Closing (specify one)	Start and End Dates	Length of Advisory or Closing (Days)	Did Bacteria Concentrations Exceed GM or SSM Criteria?	Reason for Advisory or Closing or Possible Contributing Factors

Total number of closings issued: ________ Total number of days under an advisory: ________

Total number of advisories issued: ________ Total number of days beach was closed: ________

Comments/Observations:

11. POTENTIAL POLLUTANT SOURCES

Type of Source	Level of Concern (H, M, L, or NA)	Latitude*	Longitude*	Describe how this source might contribute to beach pollution and frequency of contribution
Wastewater discharges				
Sewage overflows				
Septic systems				
Subsurface sewage disposal				
Stormwater outfalls				
Natural outfalls				
CAFOs or AFOs				
Wildlife				
Agriculture runoff				
Urban runoff, industrial waste				
Marinas, harbors				
Mooring boats				
Domestic animals				
Unsewered areas				

Type of Source	Level of Concern (H, M, L, or NA)	Latitude*	Longitude*	Describe how this source might contribute to beach pollution and frequency of contribution
Erosion-prone areas				
Landfills, open dumps				
Groundwater seepage				
Bathhouse leakage				
Drains and pipes nearby				
Stream or wetland drainage				
Vacant areas				
Other (specify):				
Other (specify):				
Other (specify):				

*If latitude and longitude are unknown, show the location on the detailed map and describe in the Comments/Observations section below.

Have potential pollutant sources identified above been included on the detailed map? ☐ yes ☐ no (explain):

Are there any discharge reports available for dischargers in the watershed? ☐ yes ☐ no If yes, attach report or pertinent sections and summarize here:

Have any sources been remediated, or have steps been taken to remediate sources? ☐ yes ☐ no (explain):

Comments/Observations:

12. DESCRIPTION OF SANITARY FACILITIES

Bathhouses: Total number of bathhouses at the beach:

Number or ID	Location	Condition (Good, Fair, or Poor)	Distance from Beach (feet)	Frequency of Cleaning (Daily, Weekly, Monthly)

Describe further. Include number of toilets, showers, sinks, etc., and whether these facilities are adequate to support beach use.

Litterbins: Total number of litterbins at the beach:

Number or ID	Location	Condition (Good, Fair, or Poor)	Distance from Beach (feet)	Frequency of Emptying (Daily, Weekly, Monthly)

Describe further. Include whether number and location of litterbins is adequate to support beach use.

How were distances from the bathhouses or litterbins to the beach measured? ☐ Measuring tape ☐ By pacing

☐ Using a map ☐ Estimated ☐ Other (specify)

13. DESCRIPTION OF OTHER FACILITIES

List facilities in the beach area, such as restaurants, bars, playgrounds, parking lots, and dog parks.

Facility Name/Type	Location	Condition (Good, Fair, or Poor)	Distance from Beach (feet)	How might this facility contribute to water quality problems?

Comments/Observations:

How were distances from the other facilities to the beach measured? ☐ Measuring tape ☐ By pacing

☐ Using a map ☐ Estimated ☐ Other (specify)

GREAT LAKES BEACHES ROUTINE ON-SITE SANITARY SURVEY

Name of Beach:	Date and Time of Survey:
Beach ID:	Surveyor Name(s):
Sampling Station(s)/ID:	Surveyor Affiliation:
STORET Organizational ID:	

PART I – GENERAL BEACH CONDITIONS

Air Temperature: ________ °C or °F | Wind: Speed (mph) ____________
Direction (e.g., E or 90°) ____________ (From which direction the wind is coming)

Rainfall: ☐ <24 hours ☐ <48 hours ☐ <72 ☐ >72 hours since last rain event and ______ inches **or** ______ cm rainfall measured

Rain Intensity: ☐ Misting ☐ Light Rain ☐ Steady Rain ☐ Heavy Rain ☐ Other

Weather Conditions:

Sky Condition	☐ Sunny	☐ Mostly Sunny	☐ Partly Sunny	☐ Mostly Cloudy	☐ Cloudy
Amount of cloud coverage	No Clouds	1/8 to 2/8	3/8 to 1/2	5/8 to 7/8	Total Coverage

Wave Intensity: ☐ Calm ☐ Normal ☐ Rough Wave Height: ________ ft ☐ Estimated or ☐ Actual

Longshore current speed and direction (cm/sec, S or 180°):

Comments/Observations

PART II – WATER QUALITY

Bacteria Samples Collected (list samples collected from beach water and potential pollution sources, if applicable—see Part IV)

Sample Point	Sample #	Parameter (*E. coli*, enterococci, etc.)	Comments:

Water Temperature: ________ °C or °F Change in Color? ☐ yes ☐ no If yes, describe ____________

Odor: ☐ None ☐ Septic ☐ Algae ☐ Sulfur ☐ Other ____________

Turbidity: ☐ Clear ☐ Slightly Turbid ☐ Turbid ☐ Opaque or NTU:

Comments/Observations

PART III – BATHER LOAD

Total number of people in the water: ____________ Total number of people out of the water: ____________

Total number of people at the beach: ____________

List of Activities Seen (optional):

Type of Activity				
Number of People				

Comments/Observations

PART IV – POTENTIAL POLLUTION SOURCES

Sources of Discharge:

Type	River(s)	Pond(s)	Wetland(s)	Outfall(s)	Other (specify):
Name(s) of Source(s)					
Amount (H, M, L)					
Flow Rate (M/sec)					
Volume					
Characteristics					

Did you collect any bacteria samples from the sources listed in the table above? ☐ yes ☐ no

If "Yes", did you list the samples in the table in Part II, Water Quality? ☐ yes ☐ no

Floatables present: ☐ yes ☐ no Please circle the following floatables if found:

Type	Street litter	Food-related litter	Medical items	Sewage-related	Building materials	Fishing related	Household waste	Other:
Example	Cigarette filters	Food packing, beverage containers	Syringes	Condoms, tampons	Pieces of wood, siding	Fishing line, nets, lures	Household trash, plastic bags	

Amount of Beach Debris/Litter on Beach: ☐ None ☐ Low (1-20%) ☐ Moderate (21-50%) ☐ High (>50%)

Type of Debris/Litter Found (please circle)

Type	Street litter	Food-related litter	Medical items	Sewage-related	Building materials	Fishing related	Household waste	Tar	Oil/ Grease	Other:
Example	Cigarette filters	Food packing, beverage containers	Syringes	Condoms, tampons	Pieces of wood, siding	Fishing line, nets, lures	Household trash, plastic bags	Tar balls	Oil slick	

Amount of Algae in Nearshore Water: ☐ None ☐ Low (1-20%) ☐ Moderate (21-50%) ☐ High (>50%)

Amount of Algae on Beach: ☐ None ☐ Low (1-20%) ☐ Moderate (21-50%) ☐ High (>50%)

Circle the types of algae found

Type	Periphyton	Globular	Free floating	Other
Description	Attached to rocks, stringy	Blobs of floating materials	No obvious mass of materials	Please describe

Circle the color of algae found

Light green	Bright green	Dark green	Yellow	Brown	Other

Presence of Wildlife and Domestic Animals

Type	Geese	Gulls	Dogs	Other (specify)
Number				

List the number of each species of bird found dead on the beach

Type	Common loons	Herring gulls	Ring-billed gulls	Double crested cormorants	Long-tailed ducks	White-winged scoter	Horned grebes	Red-necked grebes	Other
Number found dead									

Number of dead fish found on the beach: ____________

Comments/Observations (continue on back if necessary):