19 PUBLIC BEACH MONITORING

BACKGROUND

The Minneapolis Park and Recreation Board (MPRB) has ten beaches located on five lakes (Figure 19A). Prior to 2003, the City of Minneapolis Environmental Health Department monitored the beaches for fecal coliform bacteria. In 2003, the MPRB monitored the beaches for fecal coliform and *E. coli*. In 2004 through 2006, as recommended by the US Environmental Protection Agency (US EPA), the MPRB Environmental Operations staff monitored the beaches just for *Escherichia coli* (*E. coli*). In 2004 and 2005, the US EPA guidelines for *E. coli* required that a single sample should not exceed 235 organisms per 100 mL of water and that the geometric mean of not less than 5 samples, equally spaced over a 30-day period, should not exceed 126 organisms per 100 mL of water (US EPA, 1986). However, in 2006, the guideline of 1,260 organisms per 100 mL of water in a single sample was followed, which the Minnesota Pollution Control Agency (MPCA) is currently promulgating into rule.

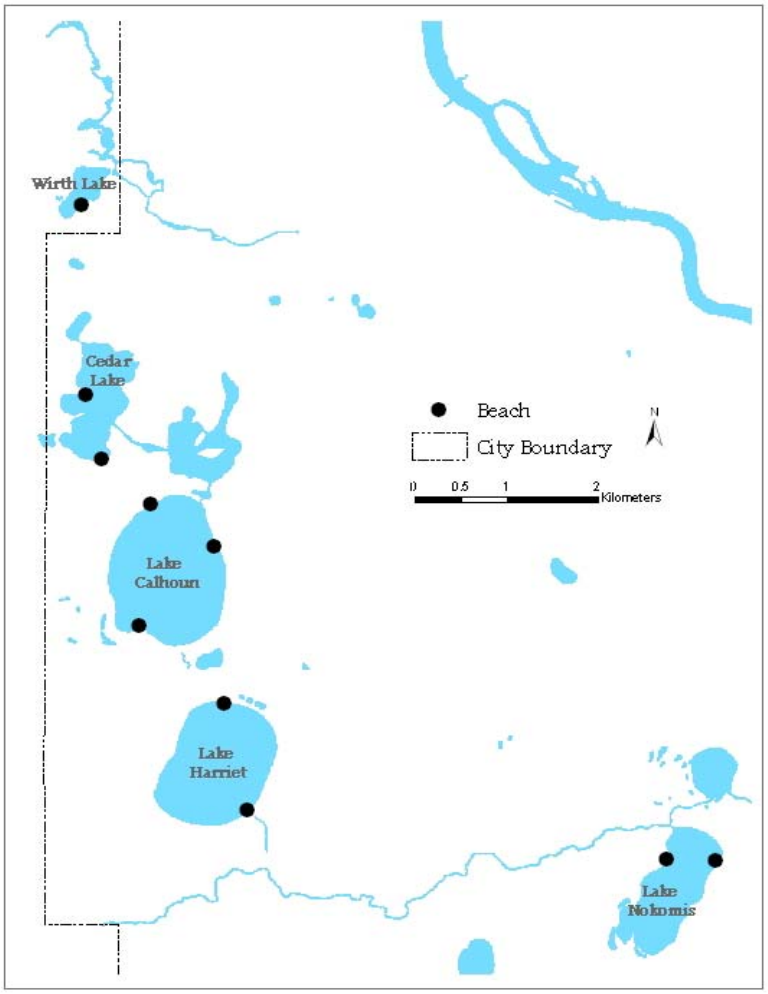

Figure19A. Map of monitored MPRB public beaches in 2006.

A great diversity of pathogenic microorganisms exist therefore testing for the array of microbes would be time consuming and expensive. Due to the difficulty, an indicator organism*, E. coli* is used for monitoring and regulation. The bacteria *E. coli* represents the measure of fecal contamination in recreational waters (US EPA, 2005). Since indicator organisms do not cause illness under normal conditions, they are useful to determine if a health risk is present in the lake water. Bacteria can enter the aquatic environment from agricultural and stormwater runoff, direct discharge of waste from mammals and birds, and from untreated human sewage. Elevated bacteria levels generally occur in aquatic environments after rain events when bacteria from various sources (see below) are washed into the lakes. Elevated bacteria levels in MPRB lakes usually return to normal levels within 24 to 48 hours of a rain event.

Potential sources of *E. coli* in lake water:

- Foreshore beach sand
- Leaking diapers, bather defecation
- Polluted stormwater runoff
- Sewage spills near the beach
- Sewer line break discharges
- Stream inflows
- Wild and domestic animal waste (such as geese, gulls, raccoons, dogs, etc.)

Conventional wisdom, backed by much research, has been that *E. coli* does not survive well outside of its host environment, the digestive systems of warm-blooded animals. Half-lives of approximately 1 day in water, 1.5 days in sediment and 3 days in soil are typical of *E. coli* (Winfield and Groisman, 2003).

However, new findings indicate that *E. coli* may survive and grow outside of its host environment. Research shows that algae can be a potential source of *E. coli*. Whitman et al. (2003) found that Cladophora (green algae) mats in Lake Michigan are capable of supporting *E. coli* in significant numbers. Bacteria from the dried mats grew upon rehydration even after 6 months.

Evidence has also pointed to another source, beach sand. Whitman and Nevers (2003) have shown that *E. coli* can sustain itself in wet beach sand that serves as a non-point source of bacterial contamination. Another study by Byappanahalli et al. (2003) found *E. coli* to be ubiquitous and persistent in a midwestern stream. *E. coli* was common in stream banks and wetted sediments, acting as a source of contamination to the stream. Genthner et al. (2005) found that after tidal events, the swash zone (area of beach where waves continuously wash up on the sand) harbored higher densities of microorganisms and indicator bacteria, which is partially attributable to entrapment. It was also proven that biological (e.g. nutrients and protection from predation) and physical (e.g. particulate matter, periodic wetting and drying, and protection from solar irradiation) factors enhance bacteria survival while providing a growth-promoting environmental niche. In a study closer to home, Ishii et al. (2005) found significant populations of viable, naturalized *E. coli* in northern temperate soils in three Lake Superior watersheds.

METHODS

In 2006, samples were collected from ten MPRB beaches every Monday and Wednesday during the beach season (6/12/06 through 8/13/06). The beaches monitored included the following:

- Calhoun 32nd Street
- Calhoun Main (North)
- Calhoun Thomas (South)
- Cedar Main (South)
- Cedar Point
- Harriet Main
- Harriet Southeast
- Nokomis 50th Street (East)
- Nokomis Main
- Wirth Main

Two samples were taken from each beach, in knee deep water (1.8 feet), roughly six to twelve inches below the surface. The samples were then transported, in an ice water bath, to the City of Minneapolis Public Health Lab. The City of Minneapolis Public Health Lab conducted the US EPA Method 1603 Membrane Filtration analysis on the samples. Two field duplicates were also collected every sampling day from the beaches in a rotating schedule. Water and air temperature were measured using a digital thermometer. Limited water quality parameters including dissolved oxygen, percent dissolved oxygen, pH, and specific conductivity were collected, throughout the beach season when staffing permitted, using a Hydrolab Minisonde 4a Multiprobe. Rain data was collected at the MPRB South Side Service Center using a tipping bucket rain gage.

In addition to the ten public beaches listed above, one other site was monitored at Lake Hiawatha. Hiawatha Beach was closed permanently in 2004 due to budget constraints and consistently elevated bacteria levels. Samples have continued to be collected at the site of the beach since 2004.

Other parameters collected in the field when samples were taken included:

- Air temperature
- Current weather
- LAURI parameters of beach (For additional information on the LAURI see Section 1)
- Number of beach users not in the water broken down by adults, children, and children in diapers
- Number of geese, ducks, and gulls on the beach
- Number of swimmers in the water broken down by adults, children, and children in diapers
- Water quality parameters (when permitted)
- Water temperature
- Comments (anything unusual, visible fecal material)

Additional data compiled in the office were:

- Amount of previous day's rainfall
- Average daily wind speed and direction
- Duration of rain event
- Hours since last rain event

- Intensity of rain event
- Lake level
- Previous day's beach attendance (provided by MPRB lifeguard counts)

RESULTS & DISCUSSION

Specific lake and beach results are discussed in each of the lake sections. Data from 2003 through 2006 were compiled and analyzed using Microsoft Excel's Pearson Correlations, to determine if relationships existed between *E. coli* sampling results and collected parameters (Table 19A).

Table 19A. Summary of statistical correlations between *E. coli* sampling results and other variables potentially affecting bacterial numbers at eleven MPRB monitored beach locations from 2003 – 2006.

Variables	*E. coli* (r)
Air Temperature	-0.03
Animals	-0.047
Birds	0.013
Dissolved Oxygen	-0.272
Lake Elevation	-0.043
Non-Swimmers	-0.047
Percent Dissolved Oxygen	-0.368
pH	-0.405
Rain Amount From Previous 24 Hours	0.318
Rainfall Intensity	0.143
Specific Conductivity	-0.253
Swimmers	-0.059
Water Temperature	-0.095
Wind Direction	0.034
Wind Speed	-0.024

Correlations were generally not significant between *E. coli* and other variables. *E. coli* did moderately correlate positively with rain amount (r=0.318). *E. coli* also moderately correlated negatively with dissolved oxygen (r= -0.272), percent dissolved oxygen (r= -0.368), and pH (r= -0.405). Correlations between variables by specific beach were sometimes stronger and these are listed in each lake section.

Table 19B shows the basic statistical analysis of *E. coli* (organisms per 100 mL of water) in the beach water sampled during the 2006 beach season. All the beaches had extremely low season long geometric means, five of which are in the single digits. The single sample limit of 1,260 *E. coli* per 100 mL of water was exceeded only once at Lake Hiawatha, which is not a public beach, and never at the ten public beaches.

Table 19B. Minimum, maximum, median, and geometric mean *E. coli* values for the eleven beaches monitored by the MPRB in 2006.

	Calhoun 32nd	Calhoun Main	Calhoun Thomas	Cedar Main	Cedar Point	Harriet Main	Harriet SE	Hiawatha	Nokomis 50th	Nokomis Main	Wirth
Minimum Value	2	2	2	2	2	2	2	15	2	2	2
Maximum Value	450	650	200	380	98	42	152	2300	66	94	17
Median Value	12	10	12	10	3	3	10	70	3	7	2
Geometric Mean	19	11	11	14	7	5	10	104	6	8	3
Standard Deviation	108	133	56	82	22	10	36	527	15	21	4
Samples Taken (N)	41	41	41	41	42	41	41	41	41	42	41

In general, rain is likely the single most influential cause of elevated *E. coli* levels in the Minneapolis Park System. Rain washes the bacteria off of hard surfaces and sends it through the storm sewer system to the lakes. In 2006, rain events did not elevate bacteria to levels which closed beaches. However, several beach closures did occur during the 2005 season. Rainfall amounts in 2006 were actually higher than 2005 (Table 19C). Therefore, the main reason for fewer closures may be attributed to the difference in pattern and timing of the rainfall.

Table 19C. Dates and rainfall totals of precipitation amounts that exceeded 0.10 inches at the MPRB South Side Service Center rain gauge during the 2005 and 2006 beach seasons.

Date	Rain (inches)		Date	Rain (inches)
6/13/2005	0.57		6/16/06	1.95
6/14/2005	0.10		6/17/06	0.11
6/15/2005	0.12		6/24/06	0.22
6/20/2005	0.99		6/25/06	0.28
6/27/2005	1.10		7/13/06	0.21
6/29/2005	0.36		7/16/06	0.41
7/3/2005	0.33		7/19/06	0.56
7/20/2005	0.26		7/24/06	1.73
7/23/2005	0.60		8/1/06	1.23
7/25/2005	1.78		8/2/06	2.65
8/4/2005	0.38		8/6/06	0.17
8/8/2005	0.11		8/10/06	0.49
8/9/2005	0.49		8/13/06	0.50
8/11/2005	0.11			
Total 2005	**7.30**		**Total 2006**	**10.51**

It is difficult to assess the quality of water the same day of sample collection as it requires a minimum of 24 hours to grow *E. coli* colonies in the lab (US EPA, 2005). This can result in unnecessary beach closures and/or exposure to poor water quality. A study by Ha Kim and Grant (2004) found that the public is misnotified about current water quality status and beaches are misposted up to 40% of the time. An example of this at MPRB occurred in August of 2005 when on August 1 a sample was taken and found to have exceeded the limit. The beach was closed around noon the next day when results were received, and was resampled. The results from that sample came back on August 3 and were below the limit. Therefore, the beach was open on August 1 when it should have been closed and closed unneccessarily on August 2 when it should have been open. The 24-hour delay caused posting errors on 2 days.

MPRB Environmental Operations staff seek out the latest *E. coli* and beach pathogen research, as well as technology for a rapid *E. coli* test to eliminate unnecessary closures. Staff also participate in a Metro-wide Beach Regulators group to enhance consistency among the different organizations operating beaches in the Metro.

In the US EPA Environmental Health Perspective (2005), the number of illnesses attributable to recreational water exposures was increasing. A study by Rangel, et al. (2005) found that between 1982 and 2002 a total of 326 *E. coli* O157:H7 outbreaks occurred nationwide. Of those, the highest number of outbreaks occurred in Minnesota (43). Recreational water was determined to be the source of transmission of 21 (6%) of the total 326 outbreaks. This information exemplifies a need for faster and more efficient bacteria monitoring technology.

Communicating the results of beach monitoring with the public is a very important aspect of the process and also offers an opportunity for water and public health education. A bilingual Beach Information Telephone Line (612.313.7713) was recorded in English and Spanish, and was updated daily on whether or not there were any beach closures due to bacteria testing. Results from testing were also put on the MPRB website the day results were received (http://www.minneapolisparks.org/default.asp?PageID=503). A phone and email tree was utilized to quickly notify staff and elected officials of beach closures and reopenings. The communication efforts were very successful and offered the public many opportunities to obtain information regarding beach water quality and closures.