Evaluating the Efficacy of a Storm Sewer Outfall Re-engineered for the Reduction of Bacterial Contamination to Surface Water

J. L. Kinzelman[1, 2], R. J. Van Swol[1,3], K. R. Pond[2], G. Rees[2], and R. C. Bagley[1]
[1]City of Racine Health Department, Racine, WI, [2] Univ. of Surrey, Guildford, UNITED KINGDOM, [3]Univ. of Wisconsin, Milwaukee, WI.

***Contact information*:**
Julie Kinzelman
730 Washington Avenue, Racine, WI 53403
PH: (262) 636-9501
FAX: (262) 636-9576
jkinzelman@cityofracine.org

INTRODUCTION

Racine, Wisconsin, located on the southwestern shore of Lake Michigan, experiences frequent recreational water quality advisories. A previous sanitary survey in conjunction with laboratory testing indicated that a storm sewer outfall was a significant point source contributor of bacterial contamination to the adjacent surface water. This storm sewer outfall was re-engineered in 2000. Engineering controls included: 1) the relocation of the outfall on an embankment, 2) the installation of a Vortechs System® (Vortechnics, Inc., Scarborough, ME), and 3) the placement of a series of nine natural sand bottom infiltration/evaporation beds. During rainfall events the first flush of storm water (1-2 cm) is diverted through the Vortechs System®, designed for the removal of solid wastes, contaminated sediments, and oils, and then channeled to the infiltration/evaporation beds that provide surface runoff retention [Figure 1]. This system has a finite capacity and any rainfall in excess of 0.25 in. flows concurrently through the outfall proper [Figure 2], partially bypassing the Vortechs System® and directly entering Lake Michigan. Initially estimated to reduce the influx of bacteria by 10 - 20%, the goal of this study was to determine whether or not the re-designed outfall was effective in reducing bacterial contamination.

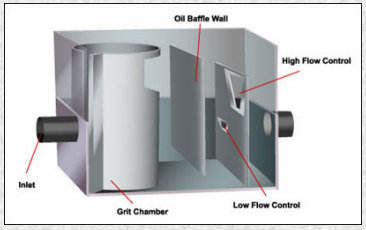

Figure 1 - The Vortechs System is an USEPA award-winning device designed to efficiently remove contaminated sediments, floating oil and debris from surface runoff (storm water).

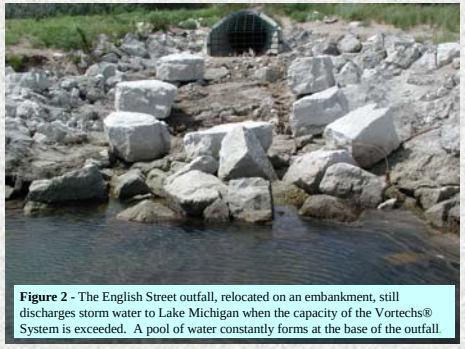

Figure 2 - The English Street outfall, relocated on an embankment, still discharges storm water to Lake Michigan when the capacity of the Vortechs® System is exceeded. A pool of water constantly forms at the base of the outfall.

MATERIALS & METHODS

For a period of 15 weeks during the summer of 2003 (May 27 - Sept. 5) , once weekly samples were collected from pools of standing water at the termini of the original outfall [Figure 3] and the infiltration/evaporation beds [Figure 4] in order to determine if the re-designed portion of this storm sewer system was more effective at filtering storm water than the original design. Samples were collected from the middle of each pool in Whirl-Pak bags (Nasco, Ft. Atkinson, WI) and returned to the laboratory on ice packs. Samples were analyzed within one hour of sample collection. The concentration of *Escherichia coli* was determined using a bacterial enzymatic substrate method (Colilert-18®, IDEXX Laboratories, Inc., Westbrook, ME) and reported as most probable number (MPN) per 100 ml. Weekly groundwater and three rainfall event samples were also collected and analyzed in the same manner.

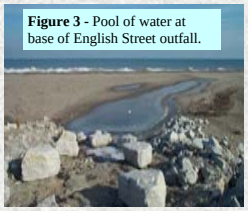

Figure 3 - Pool of water at base of English Street outfall.

Figure 4- Pool of water at the base of infiltration/evaporation beds.

Figure 5 - Infiltration bed pool became stagnant on 6-26-03.

E. coli Densities During Rain Events - Vortechs System [First Flush] vs. English Outfall

Date	I/E East Discharge MPN/100 ml	I/E West Discharge MPN/100 ml	EO Discharge	Dilution	PPT (in.)
6/26/2003	23820	46110	Not Flowing	1:100	0.01
7/3/2003	16100	Not Collected	22800	1:1000	0.32
8/1/2003	201400	Not Collected	63100	1:100	0.15

Table 1 - Comparison of *E. coli* concentrations in samples collected from the Vortechs® System and English Street outfall proper during three rainfall events during the summer of 2003 [I/E = discharge from Vortechs System to infiltration/evaporation beds, EO = English outfall overflow discharge].

Date	OFP	IBP	Temp. (OFP/IBP)	PPT-24hrs	Dilution
5/5/2003	1203	161	Not Taken	0	1:10
5/29/2003	218	74	63/59	0.35	1:10
6/5/2003	120	318	58/59	0	1:10
6/12/2003	145	84	60/60	0	1:10
6/19/2003	410	98	68/68	0.14	1:10
6/26/2003	12996	24192	74/73	Trace	1:10
7/2/2003	488	631	82/78	0	1:10
7/10/2003	630	300	68/72	0.03	1:100
7/17/2003	243	259	69/79	0	1:10
7/24/2003	85	85	Not Taken	0	1:10
7/31/2003	52	1	71/81	0	1:10
8/7/2003	521	1	72/83	0	1:10
8/14/2003	455	10	83/81	0	1:10
8/21/2003	504	31	78/84	0	1:10
8/28/2003	880	41	Not Taken	0	1:10
9/2/2003	921	250	72/68	0	1:1
MEAN	**458**	**156**	Without 6/26/03		

Table 2 - Comparison of *E. coli* densities in MPN/100 ml isolated from the pools of standing water at the bases of the English Street outfall and infiltr./evap.beds [OFP=pool at base of English St. outfall, IBP = pool at base of terminal infiltr./evap. bed] (Temperature in °F, precipitation for previous 24 hours in inches). The infiltration/evaporation bed became stagnated on 6-26-03 making sample collection difficult and, therefore, these results were excluded from the statistical analysis [Figure 5].

RESULTS

Rainfall event samples indicated that the system was functioning as proposed. The concentration of *E. coli* was at least threefold higher in the storm water exiting to the infiltration/evaporation beds when measured within 30 minutes of initial rainfall on two of three events [Table 1]. *E. coli* was not detected in groundwater samples ruling these samples out as potential sources of contamination at this site.

The concentration of *E. coli* collected weekly from the terminus of the infiltration/evaporation beds was significantly less than that collected from the terminus of the outfall proper (p=0.029) [Table 2]. Of note, during the course of this study it was observed that when an exchange occurred between the outfall pool and Lake Michigan surface water quality was adversely impacted. This exchange occurred during rainfall events (previously noted during a 1999 pluming study performed by EarthTech) but also due to wave action [Figure 6] and changing lake levels indicating that this site may be source of pollution in wet as well as dry weather. Conversely, at the terminus of the infiltration/evaporation beds, Lake Michigan surface water quality appeared to be most impacted when the capacity of these beds were exceeded [Figure 7].

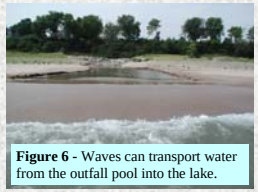

Figure 6 - Waves can transport water from the outfall pool into the lake.

Figure 7 - Infiltration/evaporation beds filled to capacity.

DISCUSSION

The remediation of this site is ongoing. This initial assessment revealed that the engineering practices currently in place are providing some relief with regards to the reducing the influx of *E. coli* to Lake Michigan. It may be that vegetation, planted for aesthetic value, can act as an effective filter for the removal of microorganisms and that similar remediation steps at the site of the original outfall terminus may reduce the potential for bacterial contamination. Additional spacial distribution studies are planned for the next two years as the environment surrounding bathing beaches must be continually assessed for sources of bacterial contamination in order to significantly reduce recreational water quality advisories.

ACKNOWLEDGEMENTS

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