Remediation of Storm Water Entering Lake Michigan through the Installation of Native Wetland Plants

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ABSTRACT

In Racine, a storm sewer outfall emptying directly into Lake Michigan was engineered to re-direct the first-flush, dirtiest, storm water to a series of vegetated infiltration/evaporation beds leaving the original outlet as the overflow site. Research conducted in 2003 demonstrated that these beds had significantly less (~66%) bacteria exiting them compared to the overflow outlet although they frequently accepted large volumes of storm water containing concentrations of *Escherichia coli* in excess of 200,000 most probable number (MPN) per 100 ml of sample. It was felt that the vegetation, placed in the beds for aesthetic purposes, also served as an effective means of reducing the bacterial content of the storm water. Therefore, installing native wetland plants at the overflow site, where none currently existed, might serve to further reduce the amount of bacteria available for transport to Lake Michigan. The unknown variable was whether or not the overflow site could be successfully vegetated since it was prone to extreme flash floods, not contained in a basin and in appearance resembled a stream (with erosional and depositional banks) rather than a wetland area. In May 2004, several species of natives rushes (*Scirpus validus, Scirpus americanus, Juncus effusus*), sedges (*Carex aquatilis, Carex stricta*) and grasses (*Spartina pectinata*) were planted at this site according to the provided instructions or using one of three experimental anchoring techniques (burlap weighted with washed stream bank stone, burlap weighted with 4"-8" fieldstones, and garden staples). The sedges, grasses and the *J. effusus* were planted along the perimeter while the other species of rushes were planted directly in the pool of water at the base of the outlet. The success of the wetland plants was monitored weekly using the following: per cent survival, average number of shoots, and average height. Other parameters measured included precipitation, standing water depth, pH, turbidity, temperature, total phosphorous, total nitrogen and concentration of *E. coli*. Precipitation for the months of May and June were 13.55 and 5.91 inches respectively, May representing a record amount. The *S. pectinata* was of poor quality and did not survive. All of the *S. americanus* and 50% of the *S. validus* was planted using burlap weighted with washed stream bank stone; all were washed out during the rain events. The other 50% of the *S. validus* were planted using burlap weighted with fieldstones; 17% remain and have increased in height by 300%. Only one of the rushes that was planted according to the provided instructions remains (2%, *J. effusus*). Of the sedges (both planted using garden staples), 36% of *C. stricta* and 100% of the *C. aquatilis* survived. In fact, the *C. aquatilis* increased 34% from 50 to 67 plants. The results of this study indicate that certain varieties of wetland plants can survive and thrive in this environment even during periods of excessive rainfall (when anchored sufficiently to allow the root systems to develop). Continuous monitoring of *E. coli* levels at this site will be necessary to determine the ultimate impact this remediation will have on Lake Michigan surface water quality.

Figure 1 – Vegetated infiltration and evaporation beds installed in Racine accept and retain first flush storm water.

Figure 2 – Initial installation of native plants at the English Street storm sewer overflow site took place on May 14, 2004 (Dr. Stephen Pedley, Univ. of Surrey, UK pictured).

INTRODUCTION

Recreational water quality advisories have increased in recent years, in part due to more frequent monitoring and in part due to an actual increase in the amount of bacterial contamination. Direct sources of contamination, such as sewage, and indirect sources, such as urban run-off, impact coastal areas as they become more populated and natural habitat is removed. Without intervention the environmental health of our nation's waterways will suffer. The value of wetland areas, as a natural buffer, has been noted. Wetlands have been used for water purification throughout the world for several decades (Verhoeven and Mueleman, 1999). Pollution from domestic and agricultural wastewater has been treated by both constructed (reed beds) and natural wetland areas (Kern and Idler, 1999, Tanner et al., 1999, US EPA 2000, Sundaravadivel and Vigneswaren, 2001). In recent years sustainable development communities have become more popular. For example, Coffee Creek, Chesterton, IN, fully embraces best management practices using a combination of vegetated swales, porous pavement and waste water treatment cells (Steve Coffee, personal communication). In Racine, the re-engineering of a storm water outlet on the shores of Lake Michigan has reduced the number of rainfall associated poor water quality advisories. This system provides bioretention through a series of infiltration basins vegetated with a combination of woody and herbaceous plants to remove pollutants from storm water (Figure 1). Although the advantages of this system are clearly visible, it does have a finite capacity which may be exceeded during the course of the swimming season. The purpose of this study was to determine if native plants could thrive in the overflow outlet that is subjected to flash flooding and is not contained in a basin. Successful installation of a wetland area at this site would increase the efficacy of current remediation efforts.

Figure 3 – Sedges grew most successfully when the plug was surrounded by burlap and then anchored in the sand with garden staples.

Figure 4 – Rushes had the best survival rate when the plug was surrounded by burlap and the plants were placed in front of or behind large (4 to 8-inch) field stones (position was dependent on the predominant flow pattern during rain events).

Figure 5 – A combination of sedges and rushes were planted in areas where the pool of water was of intermediate depth (6-10 inches).

MATERIAL & METHODS

In May 2004, several species of natives rushes (*Scirpus validus, Scirpus americanus, Juncus effusus*), sedges (*Carex aquatilis, Carex stricta*) and grasses (*Spartina pectinata*) were planted at this site according to the provided instructions (J & J Tranzplant Aquatic Nursery, Wild Rose, WI) or using one of three experimental anchoring techniques (Figure 2). All plants were supplied as plugs with the exception of the *J.* effusus, which was a bare root. The sedges, grasses and the *J. effusus* were generally planted along the perimeter while the other species of rushes were planted in the center of the pool of water at the base of the outlet. J & J Tranzplant recommended planting sedges and rushes in one foot of water and, therefore, sedges and rushes were commingled as depth permitted (Figure 5). The three experimental anchoring techniques consisted of:

- Burlap weighted with 2-inch washed stream bank stone [rushes] (Figure 2, forefront)
- Burlap anchored with garden staples [sedges] (Figure 3)
- Burlap weighted with 4"-8" field stone [rushes] (Figure 4)

All species of plants were planted so that at least 33% of the green, leafy part of the plant extended above the surface of the water. The growth rate of the wetland plants was monitored weekly, visually inspecting and recording the average number of shoots and average height (inches) in a field notebook. Field personnel also noted the per cent survival and kept a digital record of the study site (Figures 6, 7, 8). Chemical and other constituents were analyzed in order to determine the suitability of the area to promote vegetative growth. The parameters measured included precipitation (inches), standing water depth (cm), pH, turbidity (NTU), temperature (°F), total phosphorous (mg/L), total nitrogen (TKN) (mg/L), chlorophyll *a* (mcg/L) and concentration of *E. coli* (MPN/100 mL). The pH, turbidity, temperature and bacterial counts were performed weekly. Due to cost constraints the total phosphorous, chlorophyll *a* and TKN were only analyzed for three consecutive weeks (August 14 – 24, 2004). Tests performed weekly were conducted on site at the Racine Health Department Laboratory; all other analyses were performed at the Wisconsin State Lab of Hygiene, Madison, WI. The concentration of *E. coli* was monitored in order to determine a baseline amount by which future levels could be compared. All analyses for *E. coli* were performed using Colilert-18/Quanti-Tray 2000 according to the product insert (IDEXX Laboratories, Westbrook, ME).

Suggested Monitoring Protocol for English Street Site

ANALYTE	MINIMUM	MAXIMUM
pH	6.02	7.64
Turbidity (NTU)	1.65	6.25
Temperature (º F)	64	84
Total Phosphorus (mg/L)	0.011	0.037
Total Nitrogen (mg/L)	0.22	0.64
Chlorophyll *a* (mcg/L)	1.79	9.62

Table 1 – Select results of various water quality indicators monitored during the study period (bacteriological results not shown) [provided by Drs. Joy Marburger and Dan Mason, professional wetland scientists]

Wetland Plant Survival Rate - 2004

PLANT TYPE	# PLANTED	# SURVIVING	% SURVIVAL
Scirpus validus Soft stem bulrush	100	17	17
S. americanus 3-square bulrush	50	0	0
Carex aquatilis Water sedge	50	50 (+ 17 new)	134
C. stricta Upright sedge	50	18	36
Juncus effusus Soft rush	50	1	2
Spartina pectinata Prairie cord grass	50	0	0

Table 2 – Quantity and species of non-invasive plant species initially planted at the study site in May 2004 and per cent surviving as of September 2004.

Figure 6 – Appearance of transect (June 2004).

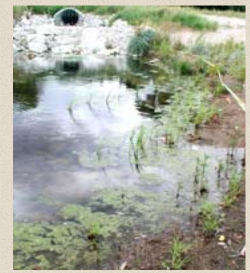

Figure 7 – Appearance of transect (July 2004).

RESULTS

Precipitation for the months of May and June were 13.55 and 5.91 inches respectively, May representing a record amount (data not shown). The turbidity of the water was relatively low (Table 1). The pH and concentration of nutrients were not excessive indicating that this pool of water was not eutrophic during the period of time which it was monitored (Table 1). Therefore, sufficient light penetration should occur to allow for photosynthesis. The amount of chlorophyll *a* did not appear to be indicative of a sufficient biomass (chlorophyll *a* x 67) to interfere with plant growth (Table 1). The *S. pectinata* was of poor quality and did not survive. All of the *S. americanus* and 50% of the *S. validus* was planted using burlap weighted with washed stream bank stone; all were washed out during the rain events. The other 50% of the *S. validus* were planted using burlap weighted with fieldstones; 17% remain and have increased in height by 300% (Figure 8B). Only one of the rushes that was planted according to the provided instructions remains (2%, *J. effusus*). Of the sedges (both planted using garden staples), 36% of *C. stricta* and 100% of the *C. aquatilis* survived. In fact, the *C. aquatilis* increased 34% from 50 to 67 plants (Table 2).

Figure 8 (A, B, C) – Appearance of transects (August/September 2004). [A-sedges, B-rushes, C-both]

DISCUSSION

The results of this study indicate that certain varieties of wetland plants can survive and thrive in a nutrient rich, high-flow environment even during periods of excessive rainfall (when anchored sufficiently to allow the root systems to develop). Currently available information, as a result of restoration projects here and elsewhere, can offer useful insights into the potential use of wetland areas to remediate storm water which is in direct contact with coastal waters. Stakeholders should carefully consider project objectives and the link between these objectives and expected performance. The success of this study can not be determined in a single year and the per cent survival of the original plants does not reflect wetland function and can, therefore, not be used to measure the performance of this system. Continuous monitoring of *E. coli* levels at this site will be necessary to determine what ultimate impact this remediation will have on Lake Michigan surface water quality in Racine, WI.

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