Article 120

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Performance of a Proprietary Stormwater Treatment Device: The Stormceptor®

The Stormceptor® is a popular proprietary storm water treatment device that has been widely applied across the U.S. and Canada in recent years. Its primary application is on small, highly impervious sites. A schematic of the device is shown in Figure 1. The device is popular because it is relatively easy to design, can be easily installed in a wide variety of applications, and can be installed in small sites without sacrificing land area. The typical device incorporates a circular holding tank that receives runoff from a flow diversion structure. Storms that exceed the capacity of the off-line device are diverted to the downstream drainage network. Unlike other stormwater practices, the Stormceptor® is designed and sized primarily on the *rate* of stormflow rather than its *volume*. Consequently, the Stormceptor® provides treatment within a much smaller area than is possible with most other stormwater practices.

A much anticipated monitoring study was recently completed by Steve Greb (Wisconsin DNR) and Robert Waschbusch (USGS) that provides the most comprehensive and independent performance evaluation of Stormceptor to date. They installed a Stormceptor® unit as a retrofit at the Badger Road public works maintenance yard in Madison, Wisconsin in mid-1996. The maintenance yard was about 4.3 acres in area and almost completely impervious. The yard was used for refueling, maintenance and parking of heavy vehicles, and also for storage of road salt, sand, yard wastes, and other materials.

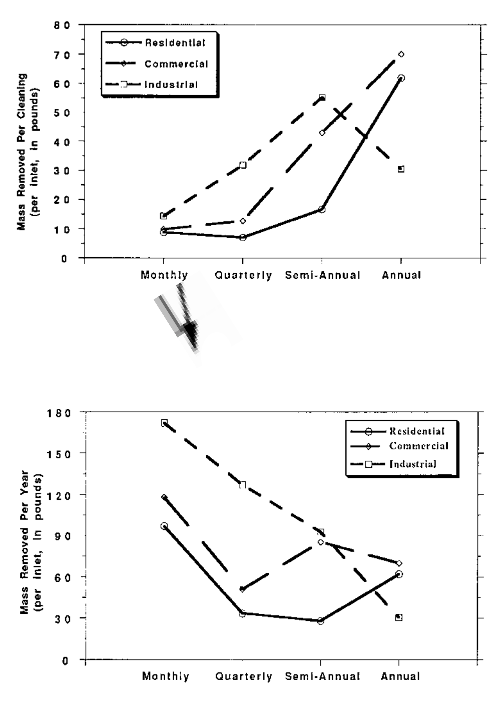


Figure 1: Schematic of Stormcepter® Unit with Sampling Locations

Maintenance yards often rank among the "dirtiest" pollutant source areas in the urban landscape, and the Badger Road yard was no exception. The median total suspended solid (TSS) concentration was reported to be 251 mg/l, which slightly higher than the Wisconsin commercial street median concentrations of 232 mg/l (Bannerman *et al*., 1996). The median chloride and total dissolved solids (TDS) runoff concentrations were 560 and 3,860 mg/l respectively, suggesting that stockpiled salt and other organic materials at the yard were a key pollutant source area.

The Stormceptor® unit selected for the retrofit at the Madison yard was the STC 6000 model with a sediment storage capacity of 610 ft^3. According to Stormceptor®'s sizing guidance, this unit has a sediment storage capacity of 142 ft^3/ac and is projected to have a suspended solids removal rate of approximately 75% (Stormceptor®, 1997).

Greb and his colleagues had to develop sophisticated monitoring techniques to measure the performance of such a small treatment unit. They installed flow-integrated storm samplers at the inflow and outflow locations of the Stormceptor® treatment tank, as well as at the bypass weir (see Figure 1 for locations). This sampling arrangement was needed to determine how much runoff volume bypassed the unit and was therefore not treated. If the bypass volume is high, then the treatment efficiency for the device would need to be adjusted downward. Although 24% of monitored storm events experienced some flow bypass around the Stormceptor® treatment tank, the team computed that only 10% of the total runoff volume during the study actually bypassed the device during the sampling period.

Flow was measured directly using a flow meter which was connected to a data-logger to initiate sampling during storm events. One composite sample was collected at the inflow and outlet for each storm event containing between five and 40 subsamples that was used to compute event-mean concentrations for the various pollutant constituents.

The sampling team evaluated the performance of the Stormceptor® during 45 precipitation events over a nine-month period that ranged in size from .02 inches to 1.31 inches. The monitoring study extended from August, 1996 to May, 1997 and included snowmelt events. During 15 storm events, the team evaluated 37 different pollutants, including a variety of solids, nutrients, metals, and polycyclic aromatic hydrocarbons (PAHs). For the remaining 30 storms, the team measured only three parameters: total suspended solids, total dissolved solids, and total phosphorus.

So how well did the Madison Stormceptor® work? Generally, the observed removal rates were lower than the manufacturer's expectations. The computed removal rates for the Madison unit are provided in Table 1. The Stormceptor® performed about as well as conventional catch basin inlets (Pitt, 1998) and certainly better than the traditional oil/grit separator. Note that the removal rates in Table 1 indicate both the actual removal efficiency of the tank, and an overall efficiency that accounts for untreated bypass flow. For example, the TSS removal rates drops from 25 to 21% when stormflow bypass is considered. The team conducted a particle size analysis and found less than 5% of the trapped sediment in the tank was of the silt or clay sized particle size. Nearly all of the trapped sediment were larger sand sized particles.

Closer examination of Table 1 indicates that Stormceptor® had a low to moderate ability to remove particulate pollutants (e.g., solids, PAH and metals), but virtually no ability to remove soluble pollutants (with the exception of dissolved phosphorus). This is not surprising since the device relies on particulate settling for pollutant removal. Total PAHs had among the highest overall removal rate at 37% . Although oil and grease were not directly monitored, the team found that about 120 gallons of oily material had accumulated in the tank during the nine-month study. The sizeable volume of oily material was likely generated from diesel fuel from a nearby refueling station.

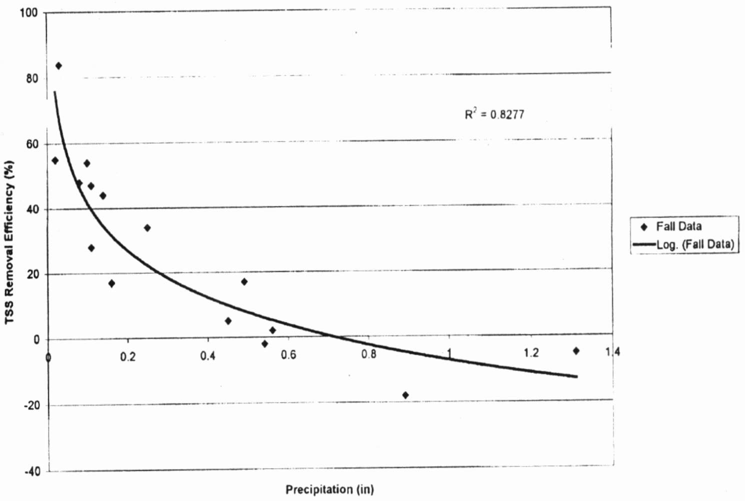
Another key finding of the Madison study was that Stormceptor®'s ability to remove suspended solids was dependent on the depth of rainfall in each storm event (see Figure 2). The Stormceptor® achieved fairly high rates of TSS removal (40 to 80%) when rainfall depths were less than 0.2 inches, but removal rates dropped sharply as rainfall depths increased. Winter storm events were excluded from Figure 2(a) because imported stockpiled snow at the yard contributed snowmelt that could not be related to specific measured rainfall depths.

Several factors could have affected the overall performance of the Madison Stormceptor®. First, the sampling effort included storm events during the late winter and spring of 1997. Cold temperatures and the high salinity of the water could have degraded particle settling conditions within the Stormceptor® tank during these events. Pitt (1998) found that winter settling velocities were about half of the settling velocity expected during the summer months for the same-sized

Table 1: Reported Pollutant Removal Efficiencies for the Stormceptor® From Madison, Wisconsin, Dept. of Public Works Maintenance Yard (Sreb *et al.*, 1998)

	Tank Efficiency			Overall Efficiency Including Bypass		
Pollutant	**Total load in**	**Total load out**	**Removal efficiency (%)**	**Total upstream load**	**Total downstream load**	**Overall removal efficiency (%)**
TSS (kg)	1,257	943	25	1,506	1,192	21
TDS (kg)	29,743	36,022	-21	30,051	36,330	-21
TP (kg)	1.43	1.16	19	1.60	1.33	17
Dissolved P (kg)	0.39	0.31	21	0.49	0.40	17
Total Lead (kg)	0.104	0.075	28	0.120	0.096	24
Total Zinc (kg)	0.590	0.465	21	0.728	0.603	17
Total PAH (kg)	0.058	0.036	37	0.066	0.045	32
Cl (kg)	6,066	7,685	-27	6,147	8,036	-25
NO_2 +NO_3 (kg)	0.270	0.254	6	0.297	0.281	5

(a) TSS Removal Efficiency for Storms Not Influenced by Snowmelt or Snow Storage



(b) TSS Removal for All Storms

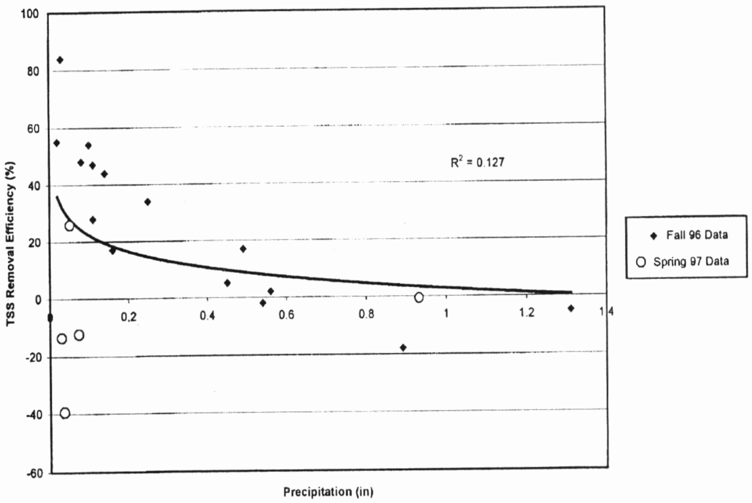


Figure 2: TSS Removal as a Function of Rainfall Depth as a Function of (a) Storms Not Influenced by Snowmelt and (b) All Storm Events

particles. Further, snowmelt from stockpiled snow at the yard increased the inflow to the unit in the winter and spring. By contrast, summer and fall storm events were not influenced by high chloride levels but experienced the greatest rainfall intensity and, consequently, the most storm bypasses.

Second, the sampling methods for measuring TSS could have slightly underestimated the actual removal since it did not fully measure the transport of sand. Sample intakes were located above the bottom of the inflow pipe and therefore could have failed to sample larger sand sized particles moving along the bottom of the pipe. The sampling team was able to calculate the missing bedload by measuring the amount of sediment actually trapped in the tank at the end of the study. They estimated that the unsampled bedload was about 8% of the total sediment load, and the maximum solids removal efficiency would increase to about 29 to 33% if the bedload was included.

Stormceptor Field Tested in Edmonton, Alberta, Canada

A second and more limited independent evaluation of Stormceptor® was performed by the City of Edmonton, Alberta, Canada (Labatiuk, 1997). The City monitored nine storms at a 9.9 acre commercial shopping center. The monitoring protocol required that three consecutive dry days occur before the storm sampler was triggered, in an effort to test the capability of Stormceptor to remove pollutants from "first flush" storms. Table 2 illustrates the pollutant removal rates for several pollutants, based on an analysis of four storm events during the second year of monitoring. Mean TSS removal was about 50%.

During the first year of monitoring, equipment difficulties and improper installation of some plumbing severely limited the validity of the sampling results. The results for the first year included five storms with a mean TSS removal rate of 6.9% and a standard deviation of 11.1%, but these results should be viewed with some skepticism given the monitoring difficulties and the fact that the Edmonton unit may have been undersized. Given the limited number of storms and the lack of on-site rainfall data, it was not possible to determine how pollutant removal rates were related to rainfall depths at the Edmonton site.

Conclusions

While the Madison monitoring effort was certainly comprehensive, more questions need to be answered to fully assess Stormceptor® technology. For example, how well would the Stormceptor® work in a more typical urban installation? Clearly, the Madison maintenance yard was a stormwater hotspot, and the salt and snow storage at the yard may have influenced the performance evaluation. For example, the settling characteristics at the Madison site may have been unusual due to extremely high levels of chlorides in the runoff. Second, the Madison tank may have been too deep. A shallower tank would allow particles to reach the bottom of the settling chamber faster, possibly increasing solid removal.

Interestingly, the Edmonton unit, with a smaller storage capacity, a shallower tank, and larger drainage area, out performed the Madison unit, at least for the limited number of events sampled. This may have been due to the shallow depth of the Edmonton tank, or simply a reflection of the small sample size of the Edmonton study. Clearly, more monitoring data are needed, since the Stormceptor® has been tested in a few locations and a relative handful of storms events. Additional Stormceptor® performance tests are currently underway in Colorado, Texas, and the Pacific Northwest that will expand our understanding of its performance. Based on what is known now, it is not clear whether the Stormceptor® has sufficient sediment and pollutant removal capability to serve as a "stand alone" stormwater management practice in most development situations.

Another perspective on the Madison Stormceptor® can be obtained by comparing its performance to that of the multi-chamber treatment train (MCTT) developed by Robert Pitt. One of the MCTT units also served a maintenance yard in Wisconsin, and sediment removal rates from between 83 to 98% were reported . Removal of other pollutants was on the order of 65 to 95%. The MCTT retains a much larger runoff volume per unit area than the Stormceptor®, and employed advanced techniques for inlet screens, sedimentation and filtration. By way of comparison, the MCTT had about 30 times more runoff storage volume per unit drainage area than the Stormceptor® yet also costs about 20 to 30 times as much as a Stormceptor®.

This initial round of Stormceptor® monitoring indicates that it can be reasonably effective at trapping sand, oil and grease if regular tank clean out occurs. This suggests that it may be useful for pre-treatment for other stormwater practices, particularly those that can easily clog with sediment, and at ultra urban hotspot situations where space is at a premium and designers must go underground.

—RAC

Table 2: Summary of Results of 1996 Stormcepter® Monitoring at Edmonton, Alberta, Canada Westmount Shopping Center (Labatiuk *et al.*, 1997)

Pollutant	Removal efficiency (%) *	Standard deviation (%)
Total suspended solids	51.5	20.5
Oil and grease	43.2	24.1
Total organic carbon	31.4	5.0
Lead	51.2	17.9
Zinc	39.1	7.9
Copper	21.5	7.5

* Mean of four storm events monitored in 1996

References

Bannerman, R., A. Legg, and S. Greb. 1996. *Quality of Wisconsin Stormwater, 1989-94*. U.S. Geological Survey. Open-File Report 96-458. Madison, WI.

Greb, S., S. Corsi, and R. Waschbusch. 1998. *Evaluation of Stormceptor® and Multi-Chamber Treatment Train as Urban Retrofit Strategies*. Presented at Retrofit Opportunities for Water Resource Protection in Urban Environments, A National Conference. The Westin Hotel. Chicago, Il. February 10-12, 1998.

Labatiuk, C., V. Nataly, and V. Bhardwaj. 1997. "Field Evaluation of a Pollution Abatement Device for Stormwater Quality Improvement." *Proceedings of the 1997 CSCE-ASCE Environmental Engineering Conference*. July 22-26, Edmonton, Alberta.

Pitt, R. 1998. *Personal Communication*. Professor, Department of Civil and Environmental Engineering. University of Alabama at Birmingham. Birmingham, Alabama.

Stormceptor Canada, Inc. 1997. *Stormceptor® - Technical Manual*. Etobicoke, Ontario, Canada.

USEPA. 1983. *Results of the Nationwide Urban Runoff Program. Vol. 1. Final Report*. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.