Urban Pollutant Loads and General BMP Cost Analysis

Introduction

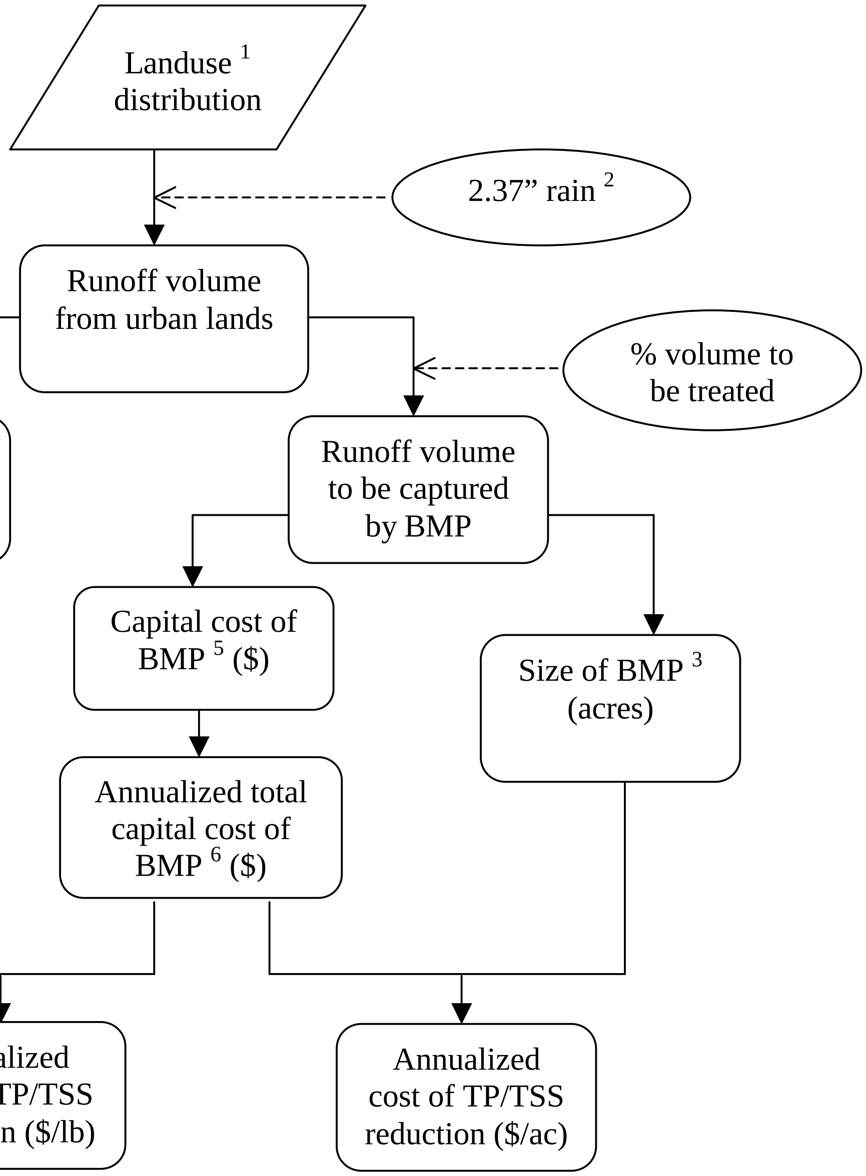
It is critical to reduce stormwater pollutant loadings from urban lands in order to restore water quality in streams and tributary rivers draining urban subwatersheds.

On the regulatory side, USEPA's NPDES Phase II Stormwater Program has put numerous urban communities in the watershed under regulatory obligation to develop stormwater pollution control and monitoring programs. As a result of the regulation and the high pollutant loadings from urban lands, it is necessary for the watershed management planning process to incude an examination of the magnitude of stormwater pollutant loadings and associated costs of abating such pollution at the source.

This effort is based on the empirical model used for estimating NPS pollutant loadings from storm sewer drainage units. This effort aimed at 1) exploring the pollutant removal potential of urban stormwater best management practices (BMPs); and 2) determining the costs associated with these BMPs.

Methods

The overall analysis procedure is represented in the flow chart shown in Figure 1. The 1997 land cover data for the Kalamazoo River Watershed was produced from Landsat 7 satellite data for previous TMDL-related efforts. The NPS model groups various land cover classes into five major categories: water and wetland, forest and open space, agricultural land, residential area (low intensity development), and commercial/industrial/transportation uses (high intensity development). Pollutant loading estimations were based on these five categories, and the combination of the latter two categories was considered urban and targeted for stormwater treatment.



[1] 1997 data.
[2] Equivalent to a one-hour 100-year or a 24-hour 2-year rain event for the Kalamazoo River Watershed.
[3] Based on an average depth of 5 feet.
[4] Load reduction efficiency of BMPs based on the Michigan Trading Rules.
[5] Cost based on Rouge River Watershed management plans.
[6] 30-year annualization with a 5% discount rate.

Figure 1. Flow Chart of Urban Storm Water BMP Cost Calculations

Two widely used urban stormwater BMPs, wet retention ponds and dry detention ponds, were chosen to evaluate pollution reduction opportunties and their cost-effectiveness in removing TP and TSS from urban stormwater runoff. These BMPs were selected because of their general applicability and the readily available information on their pollutant load reduction efficiencies (MI-ORR, 2002) and construction costs (Rouge River National Wet Weather).

The holding capacity or volume of a storm water retention or detention pond is a function of the rainfall depth of the storm event that the pond is designed to treat. As a generally accepted rule, pond volume is designed to fully capture minimally the first inch of the rainfall in a storm event, because runoff from this first inch is believed to carry most of the pollutants from the watershed. To achieve a higher and more consistent pollutant removal, however, ponds with larger holding capacities are necessary. In this study, a 2.37-inch rain depth representing a 24-hour 2-year or 1-hour 100-year storm event in the St. Joseph River Watershed (Huff, 1992) was chosen to ensure the TP and TSS removal efficiencies quoted in the Michigan Water Quality Trading Rule (MI-ORR, 2002) (listed in Table 2).

The runoff and pond volume associated with the 2.75-inch rainfall was calculated using the NPS loading model (K&A, 2003) based on the percent of the urban area to be treated by the storm water facilities. Costs of construction and maintenance were derived from literature values, which were based on pond volume and area (Table 1).

Table 1. Costs of storm water ponds.

	Construction [1]	**Design & permits** [1]	**Maintenance** [2]
Wet retention pond	$0.50 – 1.00/cubic feet	30% construction	$4,152/acre/year
Dry detention pond	$0.40 – 0.80/cubic feet	30% construction	$4,152/acre/year [3]

[1] Source: Rouge River National Wet Weather Demonstration Project, 2001; Median values were used in calculations in this study.
[2] Source: Pitt, 2002; average pond depth of 5 feet assumed; adjusted to 2000 dollar value based on $1,500/acre/year in 1978 dollars with Consumer Price Index from Bureau of Labor Statistics of the U.S. Department of Labor (http://data.bls.gov/cgi-bin/surveymost?bls).
[3] Assumed to be the same as wet retention ponds.

	TP	**TSS**
Wet retention pond	90%	90%
Dry detention pond	30%	50%

Table 2: Treatment efficiencies of storm water ponds.

Load reduction efficiencies achieved by the treatment ponds were obtained from the Michigan Water Quality Trading Rule (MI-ORR, 2002) and are shown in Table 2. The total load reductions for a treated urban area were then calculated by multiplying the total annual loads from the treated area by the load reduction efficiencies in Table 2.

References:

Huff, F. A. and J. R. Angel. 1992. *Rainfall Frequency Atlas of the Midwest.* Illinois State Water Survey, Champaign, Bulletin 71.

Pitt, R. 2002. The Design and Use of Detention Facilities for Storm Water Management Using DETPOND. http://unix.eng.ua.edu/~rpitt/SLAMMDETPOND/WinDetpond/WinDETPOND%20user%20guide%20and%20documentation.pdf.

State of Michigan Office of Regulatory Reform (MI-ORR). 2002. Part 30 - Water Quality Trading Rules. http://www.state.mi.us/orr/emi/arcrules.asp?type=Numeric&id=1999&subID=1999-036+EQ&subCat=Admincode.

Rouge River National Wet Weather Demonstration Project. 2001. *Appendix A of the Common Appendix for Rouge Subwatershed Management Plans Submitted in Fulfillment of the MDEQ Stormwater General Permit.* http://www.rougeriver.com/pdfs/stormwater/TR37/Appendix_A.pdf.

Table 7-1. Arcadia Creek Pond Load Reductions and Costs *(Task 1.1.2)*

Stretch	Wet pond 30-year cost including O&M ($)	Dry pond 30-year cost including O&M ($)	Wet pond TSS load reduction with 50% area treated (tons/yr)	Dry pond TSS load reduction with 50% area treated (tons/yr)	Wet pond TP load reduction with 50% area treated (lbs/yr)	Wet pond 30-year cost per pound TP including O&M ($/lb/yr)	Dry pond TP load reduction with 50% area treated (lbs/yr)	Dry pond 30-year cost per pound TP including O&M ($/lb/yr)	Pond volume with 50% area treated (cf)	Area (5-ft depth) (acres)
1	*									
2	36,430	30,828	18.3	10.1	120.3	303	40.1	769	441,645	2.0
3	11,745	9,939	6.0	3.3	40.1	293	13.4	744	142,388	0.7
4	*									
5	4,758	4,026	2.1	1.2	13.5	353	4.5	897	57,678	0.3
6	10,665	9,025	5.5	3.0	33.7	317	11.2	804	129,291	0.6
7	3,735	3,161	1.7	1.0	11.1	336	3.7	853	45,283	0.2
8	1,985	1,680	1.0	0.6	5.9	339	2.0	862	24,069	0.1
9	3,954	3,346	1.9	1.0	10.6	372	3.5	944	47,931	0.2
10	22,086	18,689	11.2	6.2	71.9	307	24.0	780	267,744	1.2
11+12	933	789	0.4	0.2	2.9	322	1.0	817	11,310	0.1
13	35,096	29,699	17.0	9.4	109.0	322	36.3	817	425,470	2.0
14	16,095	13,620	7.1	4.0	51.6	312	17.2	791	195,117	0.9
15	9,257	7,834	4.4	2.4	27.2	341	9.1	866	112,226	0.5
16	50,780	42,971	20.8	11.6	162.8	312	54.3	792	615,610	2.8
Totals	**207,520**	**175,608**	**97**	**54**	**660**	**4,229**	**220**	**10,736**	**2,515,762**	**12**

*no storm sewers

Table 7-2. Axtell Creek Pond Load Reductions and Costs *(Task 1.1.2)*

Stretch	Wet pond 30-year cost including O&M ($)	Dry pond 30-year cost including O&M ($)	Wet pond TSS load reduction with 50% area treated (tons/yr)	Dry pond TSS load reduction with 50% area treated (tons/yr)	Wet pond TP load reduction with 50% area treated (lbs/yr)	Wet pond 30-year per pound TP cost including O&M ($/lb/yr)	Dry pond TP load reduction with 50% area treated (lbs/yr)	Dry pond 30-year per pound TP cost including O&M ($/lb/yr)	Pond volume with 50% area treated (cf)	Area (5-ft depth) (acres)
1	1,422	1,204	0.59	0.33	4.4	325	1.5	825	17242.6	0.1
2	11,379	9,629	5.47	3.04	31.9	357	10.6	905	137948.8	0.6
3	3,311	2,802	1.45	0.81	9.9	334	3.3	847	40135.1	0.2
4	3,447	2,917	1.52	0.85	10.0	344	3.3	873	41786.2	0.2
5	35,500	30,041	15.19	8.44	106.1	335	35.4	850	430364.3	2.0
6	7,342	6,213	3.11	1.73	23.9	307	8.0	781	89011.5	0.4
Totals	**62,401**	**52,805**	**27**	**15.19**	**186.2**	**334**	**62.1**	**847**	**756488.5**	**3.5**

Table 7-3. Portage Creek Pond Load Reductions and Costs *(Task 1.1.2)*

Stretch	Wet pond 30-year cost including O&M ($)	Dry pond 30-year cost including O&M ($)	Wet pond TSS load reduction with 50% area treated (tons/yr)	Dry pond TSS load reduction with 50% area treated (tons/yr)	Wet pond TP load reduction with 50% area treated (lbs/yr)	Wet pond 30-year per pound TP cost including O&M ($/lb/yr)	Dry pond TP load reduction with 50% area treated (lbs/yr)	Dry pond 30-year per pound TP cost including O&M ($/lb/yr)	Pond volume with 50% area treated (cf)	Area (5-ft depth) (acres)
10	27,247	23,057	12.2	6.8	83.7	325	27.9	826	330,312	1.5
11	63,126	53,418	29.0	16.1	181.9	347	60.6	881	765,272	3.5
12	58,033	49,109	25.9	14.4	175.4	331	58.5	840	703,539	3.2
13	17,489	14,800	7.4	4.1	52.1	336	17.4	852	212,020	1.0
14	15,063	12,747	6.6	3.6	47.7	316	15.9	802	182,610	0.8
15	5,166	4,372	2.2	1.2	16.4	314	5.5	797	62,628	0.3
16	*									
17	62,621	52,991	25.5	14.2	198.7	315	66.2	800	759,152	3.5
18	32,363	27,386	13.4	7.4	104.9	309	35.0	783	392,338	1.8
Totals	**281,108**	**237,879**	**122**	**67.9**	**860.9**	**324**	**287**	**823**	**3,407,873**	**15.6**

*no storm sewers

Table 7-4. West Fork Pond Load Reductions and Costs *(Task 1.1.2)*

Stretch	Wet pond 30-year cost including O&M ($)	Dry pond 30-year cost including O&M ($)	Wet pond TSS load reduction with 50% area treated (tons/yr)	Dry pond TSS load reduction with 50% area treated (tons/yr)	Wet pond TP load reduction with 50% area treated (lbs/yr)	Wet pond 30-year per pound TP cost including O&M ($/lb/yr)	Dry pond TP load reduction with 50% area treated (lbs/yr)	Dry pond 30-year per pound TP cost including O&M ($/lb/yr)	Pond volume with 50% area treated (cf)	Area (5-ft depth) (acres)
3	9,558	8,088	4.4	2.4	25.5	375	8.5	952	115,870	0.5
5	1,294	1,095	0.6	0.3	3.2	405	1.1	1028	15,682	0.1
8	11,534	9,760	5.1	2.8	35.3	327	11.8	830	139,828	0.6
Totals	**$22,385**	**$18,943**	**10.1**	**5.62**	**64.0**	**369**	**21.3**	**936**	**271,379**	**1.2**

Note: Storm sewered areas were mapped in three sections of the watershed within the City of Kalamazoo.
Storm sewered areas at the mouth of the creek were grouped with Portage Creek Stretch 10