9.0 POLLUTANT LOADINGS FOR MUNICIPAL STORM OUTFALLS AND REMOVAL BY ASSOCIATED BMPs

Annual stormwater loadings from municipal outfalls in Frederick County were calculated using the Simple Method (Schueler 1987) for each pollutant of interest. The Simple Method computes stormwater pollutant loading as a function of annual rainfall (P), percent imperviousness (I), area (A), pollutant concentration (C), and conversion factors. In addition, it employs a correction factor (P_j) to account for the fraction of storms that produce runoff. Values for the equation variables were taken from published literature and laboratory data. Analytical results from Part 2 outfall sampling, completed in 1999, were incorporated into the Simple Method formula to enhance estimates of pollutant loads for each of the identified municipal storm outfalls. Results of pollutant loading calculations for each outfall have been submitted on the accompanying CD. Calculation factors for outfall pollutant loading estimates and reductions by associated structural BMPs were derived in the following manner:

- The annual rainfall volume (P) for Frederick County was determined to be the average of historic yearly rainfall data (1961-1990) taken from the NOAA annual summary for the Emmitsburg 2 SE site.

- The value for the correction factor, P_j, was taken from Schueler (1987). For all calculations, P_j was assumed to be 0.9.

Schueler (1987; Section 1.2.2) provides a range of values for percent imperviousness for each specific land use. The median number from each range was calculated and used in the Simple Method calculation. For mixed land uses, the ranges for the individual land uses were combined, and the median value was used.

BMP pollutant removal efficiency values were taken from Schueler (1987), Schueler (1997a), Schueler (1997b) and Winer (2000). In cases of combined BMP use, removal efficiencies were added together. In cases where the sum was greater than one hundred percent, ninety-nine percent was used (Table 9-1). Note that in a few cases, removal efficiencies are negative values, indicating that these BMPs result in a release of some constituents. Winer (2000) explains that in the case of dissolved phosphorus, organic or sediment bound forms of the nutrient are transformed within certain structural BMPs and flushed out during subsequent storm events. Presumably similar processes occur for TSS, TP and Cu within oil/grit separators as indicated in the table.

Concentration values are given as flow-weighted event mean concentrations (EMCs) calculated from stormwater sampling in the County. Grab samples were collected from three storms at five different sites. From the flow values measured at each grab sample time, the total storm volume was calculated. A volume-weighted average was used to determine the mean concentration for each pollutant from all 15 storm events. The EMC of each pollutant for a particular storm (Table 9-2) was multiplied by the total volume of water for that storm to find the total mass of pollutant. The flow-weighted EMC for a given pollutant was determined to be the total mass of the pollutant for the 15 storms, divided by total storm volume. See Table 9-2 for the concentrations used.

Table 9-1. Percent removal of pollutants by stormwater management structure type

	Total Suspended Solis (TSS)	Total Phosphorus (TP)	Total Nitrogen (TN)	Chemical Oxygen Demand (COD)	Biological Oxygen Demand (BOD)	Cadmium (Cd)	Copper (Cu)	Lead (Pb)	Zinc (Zn)	Total Kjeldahl Nitrogen (TKN)	Total Dissolved Solids (TDS)	Dissolved Phosphorus
Infiltration Trench (IT)	87	**100**	**42**	66	66	ND	34	71	80	ND	ND	**100**
Wet Pond (WP)	**79**	**49**	**32**	45	45	24	**58**	73	**65**	ND	ND	**62**
Dry Pond (DP)	**3**	**19**	**5**	-1	-1	54	**10**	43	**5**	ND	ND	**0**
Extended Wet Detention Pond (EDSW)	**80**	**55**	**35**	27	27	24	**44**	73	**69**	ND	ND	**67**
Extended Dry Detention Pond (EDSD)	**61**	**20**	**31**	25	25	54	**26**	43	**26**	ND	ND	**-11**
Infiltration Basin (IB) [a]	80	55	55	80	80	75	75	75	75	ND	ND	ND
Oil/Grit Separator (OGS) [b]	**-8**	**-41**	15	ND	ND	ND	**-11**	10	**17**	21	ND	**40**
Shallow Marsh (SM)	**83**	**43**	**26**	21	21	69	**33**	63	**42**	ND	ND	**29**
Swale (SW)	**81**	**34**	**84**	67	67	42	**51**	67	**71**	ND	ND	**38**
Sand Filter (SF)	**86**	**59**	**38**	67	67	ND	**49**	ND	**88**	ND	ND	**3**

All bold information from:
Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Prepared by Center for Watershed Protection for USEPA Office of Science and Technology.
Other (non-bold) information from:
Schueler, T. R. Technical Note 95. Comparative Pollutant Removal Capability of Urban BMPs: A Reanalysis. Watershed Protection Techniques. Vol. 2, No. 4. June 1997 except as noted below:
[a] Schueler, T. R. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs. Department of Environmental Programs Metropolitan Washington Council of Governments. July, 1987 Washington Metropolitan Water Resources Planning Board.
[b] Schueler, T. R. Technical Note 101. Performance of Oil-Grit Separators in Removing Pollutants at Small Sites. Watershed Protection Techniques. Vol. 2, No. 4. June 1997.
ND = No data available.

Table 9-2. Event mean concentrations (EMC) for each parameter used for estimating pollutant loads (Schueler 1987)

Parameter	Concentration (mg/L)
BOD5	4.34
COD	13.65
TDS	94.40
Cd	0.0004
Cu	0.0095
Pb	0.0046
TKN	1.03
TSS	15.21
Diss. Phos	0.09
TP	0.13
TN	1.80
Zn	0.0644

Load=$[(P)(P_j)(R_v)/12]*(C)(A)(2.72)$
P=annual precipitation (inches)=43.8 C=concentration in mg/L
P_j=fraction of events that produce runoff=0.9
$R_v=0.05+0.009(I)$ 2.72=conversion to pounds
I= % imperviousness in drainage:
Residential=30%, Commercial=70%, Industrial=70%, Institutional=50%

The table also indicates that TSS, TP, and Cu are being released from oil/grit separators during storms; the source of the released material is probably from parking lot maintenance (Schueler 1997a).

Area values were supplied by the County's SWM facility database (current as of January 6, 2006), which provides both a total drainage area and a managed drainage area for each site. To calculate annual loading in the absence of any BMPs, the total drainage area value was used; these are summarized by BMP type in Appendix D (Table D-1). The managed annual loading was found from the sum of the following two individual loading values. The first was calculated using the area managed by the BMPs, multiplied by the removal efficiency. The second loading value was calculated with an area equal to total area minus the managed area. These values were then summed to provide a loading estimate with the BMPs in place; a summary listing of these results is provided by BMP type in Appendix D (Table D-2). The difference between loadings with and without BMPs provides an estimate of pollutant removals by these BMPs (Appendix D, Table D-3); a percentage removal by BMP type, and pollutant, is presented in Appendix D (Table D-4) and Figure 9-1. Similar estimates can be made on a per-acre basis (Appendix D, Tables D-5 and D-6).

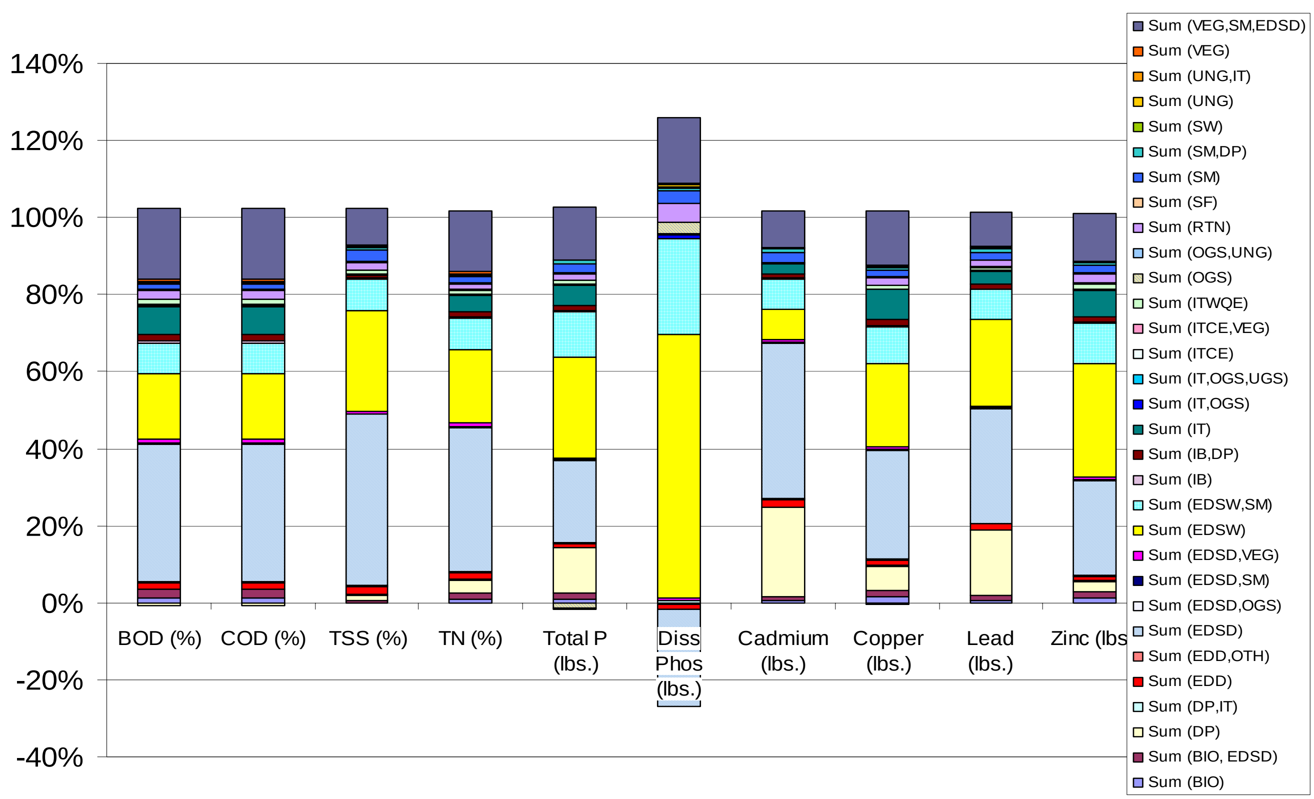

Figure 9-1. Percent pollutant removal by BMP type for Frederick County outfalls based on the Simple Method

Results show that on a total removal basis, that Extended Wet and Dry Detention Ponds remove the most pollutants because of their dominance in total drainage area covered (52.7%; Figure 9-1). Extended Dry Detention Ponds are the most efficient at removing pollutants, removing an average of 27.2% of all pollutants considered. Extended Dry Detention Ponds removed the most TSS, total nitrogen, cadmium, copper, lead and reduced BOD and COD. Extended Wet Detention Ponds were second in overall removal rates, averaging 25.5% of all pollutants considered. Extended Wet Detention Ponds were most efficient at removing dissolved and total phosphorus and zinc. Overall, these results are a function of area covered by BMP and its removal efficiency. On a per acre basis, removal percentages are much more uniform. Combined Infiltration Basins with dry ponds removed the greatest percentage of cadmium and copper, and were most effective at reducing BOD, while combined infiltration trenches and dry ponds removed the greatest percentage of total phosphorus. Oil/Grit Separator combined with an underground device was most effective at reducing TKN. Vegetative filters removed the most total nitrogen and vegetative filters combined with complete exfiltration were most effective at reducing COD. Dissolved phosphorus and zinc were removed equally well by three different combinations of infiltration trenches; infiltration trench with dry pond, infiltration trench with oil/grit separator, and infiltration trench, oil/grit separator and underground structure. TSS was removed equally by vegetative filters, retention, infiltration basin with dry pond, and three combinations of infiltration trenches. The three combinations were infiltration trench with a dry pond, infiltration trench and oil/grit separator, and infiltration trench with both an oil/grit separator and an underground structure. Dry pond combined with either infiltration trench or infiltration basin removed lead equally well.

An overall summary of pollutant removals at outfalls in Frederick County, by associated management practices, is listed in Table 9-3. These results show that 40% of total suspended solids are removed by these facilities, with only 27% to 24% of total phosphorus and nitrogen being removed, respectively, and about 20% each of BOD and COD is being removed. Removal of metals ranged from 27% to 42%.

Table 9-3. Summary of percent pollutant removal by stormwater BMPs

		Total Area, ac	Drainage Area, ac	BOD (lbs.)	COD (lbs.)	TSS (lbs.)	TN (lbs.)	Total Phos (lbs.)	Diss Phos (lbs.)	Cadmium (lbs.)	Copper (lbs.)	Lead (lbs.)	Zinc (lbs.)
Total Loadings	All ponds	11,728		194,519	611,795	681,714	80,676	5,827	4,034	18	426	206	2,886
Net Loadings			8,834	39,562	124,469	271,484	19,337	1,581	511	7	113	87	880
Percent Removal				20%	20%	40%	24%	27%	13%	39%	27%	42%	31%