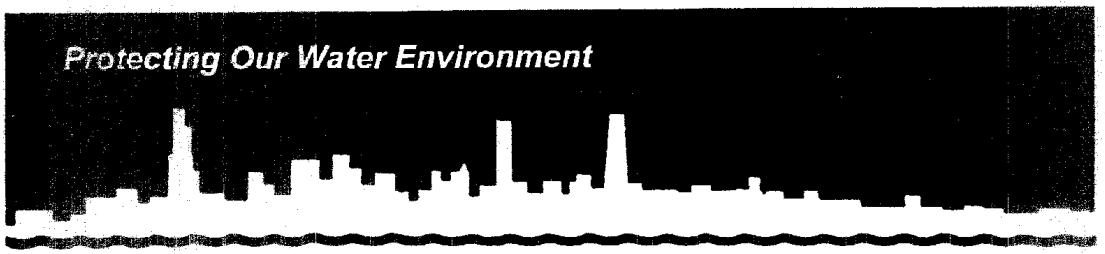

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CHARACTERISTICS OF STORMWATER RUNOFF SAMPLED AT TWO STORM SEWERS IN EVANSTON AND CRESTWOOD, ILLINOIS

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CHARACTERISTICS OF STORMWATER RUNOFF SAMPLED AT TWO STORM SEWERS IN EVANSTON AND CRESTWOOD, ILLINOIS

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DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

INTRODUCTION

Stormwater runoff in urban areas carries pollutants from atmospheric dust, street dirt, sidewalks, lawns, etc. and directly discharges them into surface waters through storm sewers. It is the principal source of non-point source pollution in urban areas. In order to collect data on pollutant loadings due to stormwater runoff to the Chicago Waterway System (CWS), the Research and Development (R&D) Department developed a storm sewer sampling program, and collected stormwater samples from the runoff of two storm sewer systems during several storm events between August 2002 and May 2003.

A minimum storm sewer diameter of 48 inches was used in the selection of storm sewers to provide larger drainage areas for sampling. Twelve storm sewers along the deep-draft portions of the Calumet-Sag Channel and the Little Calumet River as well as two additional storm sewers along the North Shore Channel were identified and inspected for feasibility of sampling. In order for a storm sewer to be suitable for sampling, it had to be readily accessible and meet safety standards such as not being located in the middle of a major street or on a steep slope. Of the total of fourteen storm sewers evaluated, only two were found suitable for sampling using an automatic sampler. The selected storm sewers were in

Evanston (at Cleveland Avenue) and Crestwood (at Central Avenue). Figures 1 and 2 show the sampling locations and approximate drainage areas for the selected Evanston and Crestwood storm sewers, respectively. The storm sewer under Cleveland Avenue in Evanston is a storm relief sewer with a diameter of 60 inches. This storm sewer accepts stormwater runoff from a drainage area of approximately 300 acres, which is also served by combined sewers for sanitary wastewater. The eastern portion of the drainage area is a residential area with mostly single family homes and a few multifamily buildings. The western portion of the drainage area is a commercial and light industrial area with extensive paved parking lots located close to the outfall of the storm sewer. Stormwater runoff through this storm sewer is discharged into the North Shore Channel of the CWS.

The storm sewer under Central Avenue in Crestwood is 54 inches in diameter. This storm sewer accepts stormwater runoff from a separate sewered area of approximately 160 acres that is mostly residential. Most of the area is served by storm sewers, but some of the area is served by storm ditches along 127th Street and some streets south of 127th Street, as shown in Figure 2. The residential area consists mostly of single family homes with approximately one-quarter of the area in multifamily buildings. The stormwater runoff through the

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FIGURE 1

STORM SEWER SAMPLING LOCATION AND APPROXIMATE DRAINAGE AREA
LOCATED IN EVANSTON, ILLINOIS

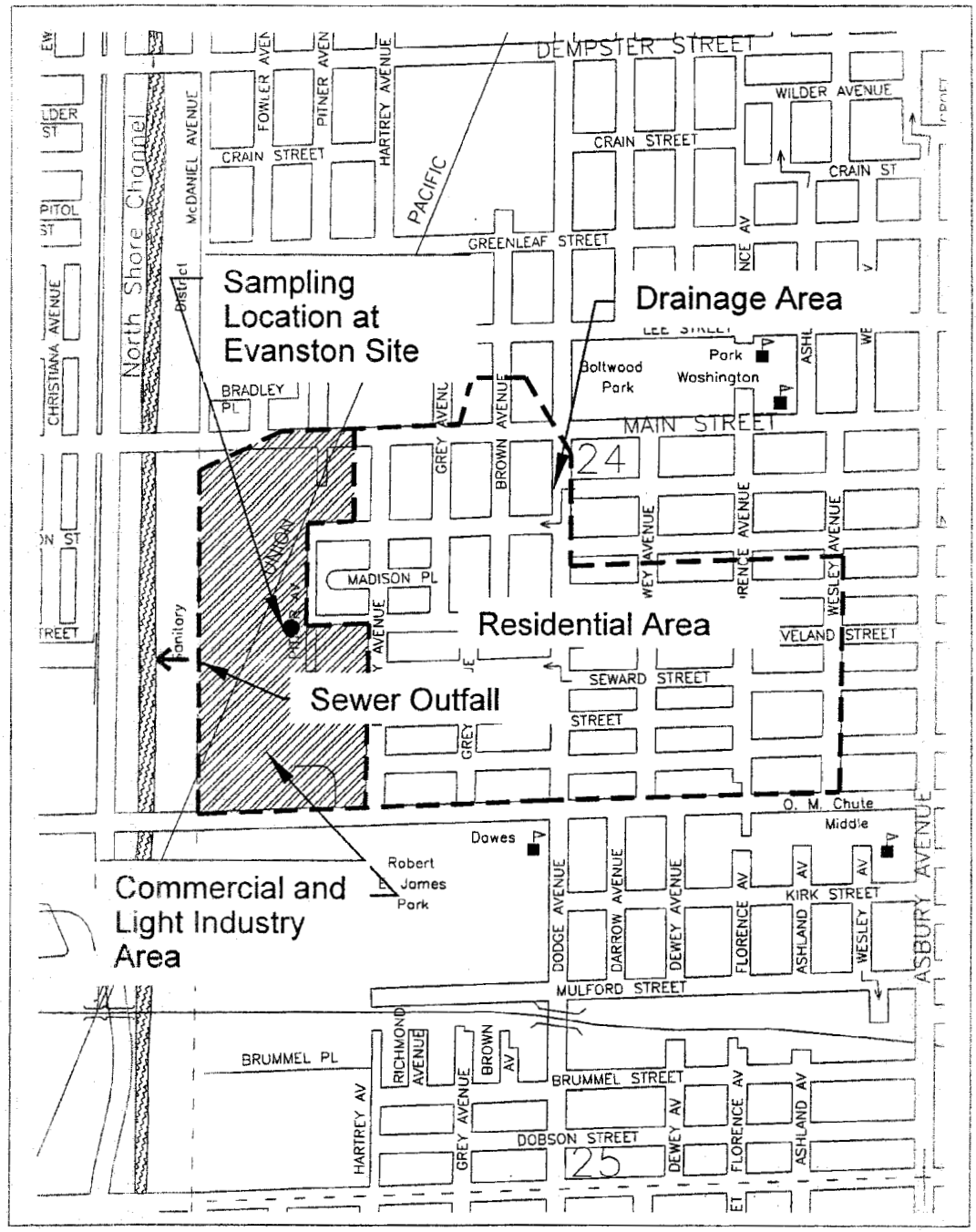

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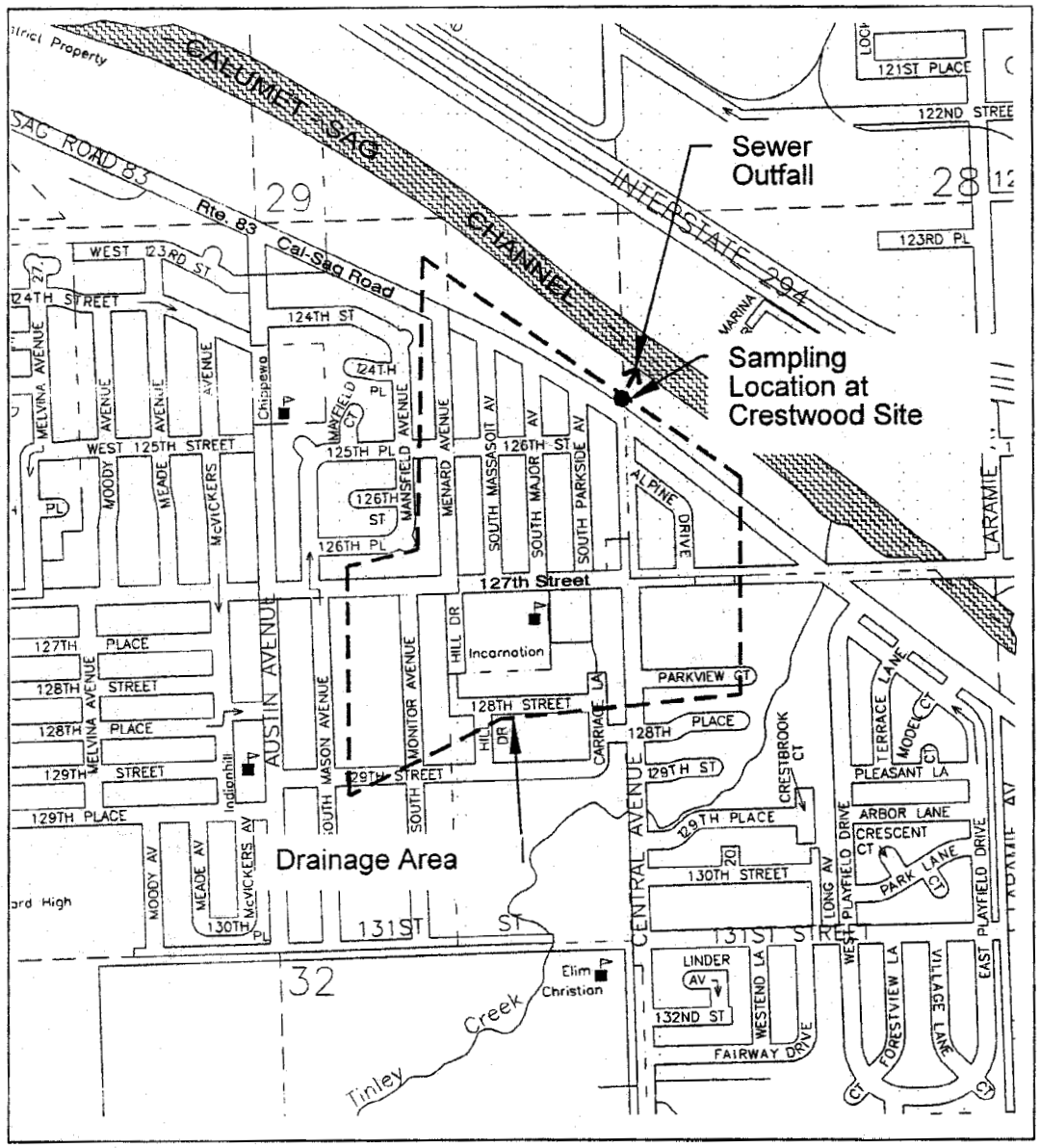
FIGURE 2

STORM SEWER SAMPLING LOCATION AND APPROXIMATE DRAINAGE AREA
LOCATED IN CRESTWOOD, ILLINOIS



54-inch storm sewer is discharged into the Calumet-Sag Channel of the CWS.

The storm sewer sampling protocol takes place in three phases. Phase I covers a time period from the onset of a storm event to 2 hours, and grab samples are collected every 15 minutes. Phase II covers from 2 to 6 hours after the onset of the event, and grab samples are collected every 30 minutes. Phase III covers from 6 hours to 12 hours after the onset, and grab samples are collected every 60 minutes. Sampling is terminated after 12 hours from the onset.

All samples were collected by an automatic sampler at each site, and the sampler discrete tray was packed with ice for sample preservation until the completion of each phase. The samples collected within each phase were delivered to the laboratory for sample login and analysis, immediately after the completion of a sampling phase.

This report presents the description of storm sewer sampling program, methods of data analysis, and results of the study.

OBJECTIVES

The objectives of this study are:

1. To examine the chemical characteristics of stormwater runoff sampled at the two storm sewers.
2. To compare the chemical characteristics of stormwater runoff from the two storm sewers.
3. To examine relationship between stormwater constituents and storm characteristics.
4. To find the correlation between stormwater constituents and storm variables.

METHODS

Stormwater Sample Collection

Two storm sewers were selected for collecting stormwater runoff samples. Multiple grab samples were collected at three predetermined time intervals in each storm event sampled. The sampling time intervals were designed such that samples were taken every 15 minutes in the first 2 hours, every 30 minutes in the next 4 hours, and every 60 minutes in the last 6 hours. Sampling was terminated either upon the cessation of stormwater runoff or after 12 hours had elapsed following the onset of sampling, whichever came first. Samples were taken by automatic samplers, and the discrete trays of samplers were ice packed for sample preservation. All samples, except for the first grab sample for DO measurement, were delivered to the laboratory for analyses.

Sample Analyses

Each sample was analyzed for 12 constituents. These constituents include BOD_5, carbonaceous BOD_5 ($CBOD_5$), total suspended solids (TSS), volatile suspended solids (VSS), nitrite nitrogen (NO_2), nitrite and nitrate nitrogen ($NO_2 + NO_3$), ammonia nitrogen (NH_3), Total Kjeldahl Nitrogen (TKN), total phosphorus (TP), conductivity, alkalinity (Alk), and chloride (CL). The District's laboratories are IEPA-accredited under

the National Environmental Laboratory Accreditation Program. All the analytical methods followed for analyzing the samples for these stormwater constituents were either USEPA-approved methods or Standard Methods (1, 2).

Data Analysis

The concentration values of each constituent for the samples collected in each storm event were pooled together for statistical analysis. The number of concentration values available for calculation, minimum (Min), maximum (Max), median, mean values, standard deviation (Std Dev), and coefficient of variation (CV) for each event were calculated in spreadsheets for both sampling sites. In this report, rather than individual nitrogen species, total nitrogen (TN), which is the sum of nitrite and nitrate nitrogen and TKN, was generally used for the data analysis.

Event mean concentrations (EMCs) were calculated using two different methods. One was an arithmetic average method, and the other a time-weighted average method. In the time-weighted average method, time intervals were used as time weights in the calculation, and a backward time interval, which was the time interval between a previous sample and the current sample, was adopted. A 15-minute time interval was assigned to the first sample regardless of when the sample was

taken. If a concentration value was missing, the time interval for this sample with a missing value was discarded, and the sum of sampling time for the event was reduced accordingly in the calculation of a time-weighted EMC.

Comparison between EMCs calculated with two different methods for a stormwater constituent for any sampling event was conducted in this study using the statistical approach developed in a previous study (3). The main objective of such comparison is to examine whether the corresponding EMCs calculated with two different methods is significantly different at a 10 percent level of significance (α=0.1). EMCs are an important parameter for this study, as the loading of a stormwater constituent from a storm runoff may be estimated using the product of its EMC and runoff volume. After the statistical analysis, one method used for calculating EMCs will be selected, and the EMCs computed with this method will be employed for further data analysis.

For the Evanston storm sewer, the nearest District rain gauge station is located at the North Side WRP, which is only about one mile southwest of the sampling location. For the Crestwood storm sewer, the nearest District rain gauge station is located at Hazelcrest - 175th Street, Homewood, Illinois, which is about eight miles southeast of the sampling location. This distance makes correlation of rainfall and constituent

concentrations of limited usefulness for the Crestwood storm sewer. Hourly rainfall data were provided for both gauge stations from October 1, 2002 to May 31, 2003, while only daily cumulative rainfall in inches was obtainable from August 1 to September 30, 2002.

Storm variables, such as rainfall, duration, intensity and the days since last rain with certain amount of rainfall, were used in a study on stormwater runoff volume, loads and pollutant concentrations (4). The values of these storm variables for the storm events sampled in this study could be derived from the rainfall data provided, and the amount of rainfall that signified a previous rain as the last rain was assumed to be 0.1 inch. Hence, these storm variables were used in this study to examine possible relationships between pollutant concentrations in stormwater runoff and storm characteristics.

Potential relationship between EMCs of four major stormwater pollutants, i.e. BOD_5, TSS, TN and TP, and storm characteristics was studied using multiple linear regression analysis. The analysis was conducted manually in order to eliminate redundant storm variables typically at P-value > 0.1. However, at least one storm variable was kept during the analysis regardless of P values. The main objective was to

find the most influential storm variable(s), rather than to develop regression equations for prediction.

The correlation between each stormwater constituent monitored and each storm variable was described by Pearson correlation coefficient (PCC). PCC has values ranging from -1.0 to +1.0. A PCC value close to either -1.0 or +1.0 for a pair of variables means that these two variables are highly correlated, whereas a PCC values close to zero from both negative and positive sides means no correlation between the two variables. If one variable increases linearly with an increase in another variable, PCC value for these two variables will be close to +1.0, and if one variable decreases linearly with an increase in another variable, PCC value for these two variables will be close to -1.0. A PCC value between a stormwater constituent and a storm variable was computed using the values of EMCs of this constituent and the values of the storm variable obtained for the corresponding storm events sampled.

RESULTS AND DISCUSSION

Seven storm events were sampled at each of the two storm sewers from August 2002 to May 2003 with most in the spring of 2003. At the sampling location for the Evanston storm sewer, two storm events were sampled in the fall of 2002, one in the early fall and the other in the late fall, and five storm events in the spring of 2003, ranging from early to middle spring. A summary of storm events sampled and related storm information for this site is presented in Table 1. At the sampling location for the Crestwood storm sewer, two storm events in the summer of 2002, one in the middle and the other in late summer, one storm event in early fall of 2002, and four storm events in the middle spring of 2003 were sampled. A summary of storm events sampled and related storm information for the Crestwood storm sewer is presented in Table 2.

Multiple samples were collected in each storm event monitored. The number of samples taken in each event ranged from 10 to 23 and 16 to 23 for Evanston and Crestwood sampling locations, respectively. The concentration values of stormwater constituents for the samples collected in all events are given in Appendix Tables AI-1 and AI-2 with some statistical calculations included. The concentrations of the stormwater constituents analyzed varied from sample to sample and event to

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TABLE 1

SUMMARY OF SAMPLING EVENTS AND RELATED STORM INFORMATION
FOR THE STORM SEWER AT CLEVELAND AVENUE IN EVANSTON, ILLINOIS

Sampling Date	Sampling Time (military time)	Number of Samples Collected	Rainfall				Days Since Last Rain* (day)
			Amount (inch)	Duration (military time)	Intensity (inch/h)	Intensity Range (inch/h)	
10/04/02	0935 - 1220	10	0.80	0900 - 1500	0.13	0.003 - 0.36	2.1
12/18/02	0615 - 1800	23	1.07	2300 - 2000**	0.051	0.003 - 0.18	15.0
03/28/03	0950 - 2135	22	0.31	0800 - 1800	0.031	0.003 - 0.10	3.1
04/30/03	0600 - 1745	22	0.79***	0500 - 1800	0.061	0.002 - 0.21	22.5
05/04-05/03	2030 - 0815	23	1.16	2000 - 0200	0.19	0.006 - 0.36	3.2
05/09/03	0015 - 1200	22	1.06	0000 - 0500	0.21	0.025 - 0.52	3.9
05/10-11/03	2320 - 1105	22	0.73	2300 - 0200	0.24	0.002 - 0.70	1.8

Note: The storm data used in this table was obtained from a District rain gauge station, which is located at North Side WRP at 3500 W. Howard St., Skokie, Illinois.

*The last rain should have at least a cumulative amount of 0.1 inches of rainfall.

**Rain started on the previous day.

***This is the cumulative amount till 1800 hour on 04/30/02. Rain continued after sampling stopped, but the remainder quantity was not included here.

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TABLE 2

SUMMA SUMMARY OF SAMPLING EVENTS AND RELATED STORM INFORMATION
FOR THE STORM SEWER AT CENTRAL AVENUE IN CRESTWOOD, ILLINOIS

Sampling Date	Sampling Time (military time)	Number of Samples Collected	Rainfall				Days Since Last Rain* (day)
			Amount (inch)	Duration (military time)	Intensity (inch/h)	Intensity Range (inch/h)	
08/22/02**	0620 - 1420	19	1.81	0400 - 1300	0.20	0.01 - 0.44	3.0
09/20/02**	0955 - 2155	23	0.41	0800 - 1500	0.059	0.00 - 0.14	0.4
10/04/02	0930 - 2030	22	1.02	0900 - 1500	0.17	0.01 - 0.51	2.1
05/01/03	0015 - 0715	18	0.77	2300 - 0600***	0.11	0.003 - 0.26	0.5
05/04-05/03	2100 - 0915	23	0.75	1900 - 0300	0.094	0.003 - 0.23	3.5
05/09/03	0100 - 1200	22	0.94	2300 - 0500***	0.16	0.002 - 0.33	3.8
05/20/03	0030 - 0600	16	0.58	0000 - 0600	0.096	0.005 - 0.30	5.1

Note: The storm data used in this table was obtained from a District rain gauge station, which is called Hazelcrest located at 175th St. at Palmer, Homewood, Illinois.

*The last rain should have at least a cumulative amount of 0.1 inches of rainfall.

**Rainfall data, except for amount, were from the rain gauge station at Calumet WRP.

***Rain started on the previous day.

event. For example, for the seven events monitored at the Evanston storm sewer, concentrations of individual samples varied from 5 to 71 mg/L for BOD_5, 5 to 2144 mg/L for TSS, 0.94 to 11.5 mg/L for TN, and 0.0 to 3.23 mg/L for TP. Among four of the major pollutants monitored, i.e. BOD_5, TSS, TN and TP, TSS had the largest variation in concentrations of individual samples, and TP had the second largest variation. A similar phenomenon was also observed for the Crestwood storm sewer with respect to concentration variation of individual samples.

Event mean concentrations of stormwater constituents were calculated for each event at both storm sewer sites, using arithmetic and time-weighted average methods, and the results of the calculations are presented in Tables 3 and 4 for Evanston and Crestwood, respectively. It is noted in Table 3 that the mean values of seven EMCs of all constituents calculated with the arithmetic average method are slightly higher than the corresponding ones with the time-weighted average method for the Evanston storm sewer. However, from Table 4, it is noted that, for the Crestwood storm sewer, the mean values of seven EMCs computed with the arithmetic average method are higher than the corresponding ones with the time-weighted average method for some constituents, such as BOD_5, $CBOD_5$, TSS, VSS, NH_3-N, TKN and TP, but lower for the others, such as

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TABLE 3

EVENT MEAN CONCENTRATIONS OF STORMWATER CONSTITUENTS ANALYZED FOR THE STORM SEWER AT CLEVELAND AVENUE IN EVANSTON, ILLINOIS

Event Date	Event Mean Concentrations (EMCs) (mg/L)											
	BOD_5	$CBOD_5$	TSS	VSS	NO_2+NO_3	NH_3	TKN	TN[1]	TP	Cond.[2]	Alk.[3]	Cl[4]
----------With Arithmetic Average Method----------												
10/04/02	12.5	8.8	136	31	0.36	0.86	3.02	3.38	0.49	389	82	66
12/18/02	20.0	14.2	117	38	0.58	1.02	2.63	3.21	0.54	2420	119	637
03/28/03	19.8	15.6	157	46	0.92	1.22	3.70	4.61	0.53	2032	128	697
04/30/03	31.5	24.8	131	39	0.80	1.01	3.23	4.03	0.58	1160	118	338
05/04-05/03	9.4	7.9	49	13	0.63	0.38	1.24	1.87	0.14	480	71	106
05/09/03	11.9	9.5	86	27	0.76	0.46	1.70	2.47	0.26	508	77	104
05/10-11/03	13.2	8.5	317	55	0.60	0.38	2.43	3.03	0.53	501	83	93
Mean	16.9	12.8	142	36	0.66	0.76	2.57	3.23	0.44	1070	97	292
Min	9.4	7.9	49	13	0.36	0.38	1.24	1.87	0.14	389	71	66
Max	31.5	24.8	317	55	0.92	1.22	3.70	4.61	0.58	2420	128	697
Std Dev	7.6	6.1	85	14	0.18	0.35	0.86	0.92	0.17	837	24	273
CV (%)	44.9	47.9	60.0	38.0	27.1	45.5	33.6	28.4	38.5	78.3	24.5	93.5

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TABLE 3 (Continued)

EVENT MEAN CONCENTRATIONS OF STORMWATER CONSTITUENTS ANALYZED FOR THE STORM SEWER AT CLEVELAND AVENUE IN EVANSTON, ILLINOIS

Event Date	Event Mean Concentrations (EMCs) (mg/L)											
	BOD$_5$	CBOD$_5$	TSS	VSS	NO_2+NO_3	NH_3	TKN	TN[1]	TP	Cond.[2]	Alk[3]	Cl[4]
With Time-Weighted Average Method												
10/04/02	12.1	8.7	123	29	0.36	0.80	2.88	3.23	0.46	371	78	63
12/18/02	19.0	13.6	124	41	0.52	0.91	2.39	2.90	0.51	2084	102	524
03/28/03	16.1	13.2	111	35	0.85	1.03	3.14	3.99	0.43	1848	114	624
04/30/03	29.7	24.1	133	38	0.76	0.98	3.05	3.81	0.57	1089	106	305
05/04-05/03	8.1	6.9	35	10	0.62	0.36	1.05	1.67	0.13	404	61	84
05/09/03	11.1	9.2	82	25	0.69	0.41	1.50	2.19	0.27	450	69	92
05/10-11/03	10.1	6.9	180	35	0.67	0.34	1.79	2.46	0.37	609	92	120
Mean	15.2	11.8	113	30	0.64	0.69	2.26	2.89	0.39	979	89	259
Min	8.1	6.9	35	10	0.36	0.34	1.05	1.67	0.13	371	61	63
Max	29.7	24.1	180	41	0.85	1.03	3.14	3.99	0.57	2084	114	624
Std Dev	7.4	6.1	45	10	0.16	0.31	0.82	0.85	0.15	719	20	232
CV (%)	48.6	51.5	40.1	34.5	25.4	44.9	36.5	29.4	38.2	73.5	22.4	89.5

Note: All nitrogen related species are noted as nitrogen (N). All units are mg/L, except for conductivity, which has unit of µmhos/cm.

[1]TN stands for total nitrogen, which is the sum of NO_2 + NO_3 and TKN.

[2]Cond stands for conductivity.

[3]Alk stands for alkalinity.

[4]Cl stands for chloride.

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TABLE 4

EVENT MEAN CONCENTRATIONS OF STORMWATER CONSTITUENTS ANALYZED
FOR THE STORM SEWER AT CENTRAL AVENUE IN CRESTWOOD, ILLINOIS

Event Date	Event Mean Concentrations (EMCs) (mg/L)											
	BOD_5	$CBOD_5$	TSS	VSS	$NO_2 + NO_3$	NH_3	TKN	TN[1]	TP	Cond.[2]	Alk[3]	Cl[4]
With Arithmetic Average Method												
08/22/02	7.3	5.4	38	5	0.82	0.32	1.68	2.50	0.81	215	42	34
09/20/02	4.4	1.5	33	9	0.59	0.08	0.98	1.57	0.23	156	44	18
10/04/02	7.8	6.1	56	14	0.79	0.07	1.12	1.91	0.70	170	38	20
05/01/03	10.3	7.8	109	23	1.13	0.62	2.00	3.13	0.33	458	46	112
05/04-05/03	9.2	7.9	127	22	1.34	0.37	1.88	3.22	0.28	530	66	130
05/09/03	9.5	7.5	334	39	1.70	0.50	2.48	4.18	0.46	484	89	93
05/20/03	20.0	15.4	288	40	0.96	0.43	3.23	4.19	0.61	444	87	95
Mean	9.8	7.4	141	22	1.05	0.34	1.91	2.96	0.49	351	59	72
Min	4.4	1.5	33	5	0.59	0.07	0.98	1.57	0.23	156	38	18
Max	20.0	15.4	334	40	1.70	0.62	3.23	4.19	0.81	530	89	130
Std Dev	4.9	4.2	122	14	0.38	0.21	0.78	1.03	0.22	163	22	47
CV (%)	50.0	56.8	86.9	63.7	35.8	60.7	4 0.7	34.7	45.7	46.4	37.0	64.9

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4 (Continued)

EVENT MEAN CONCENTRATIONS OF STORMWATER CONSTITUENTS ANALYZED
FOR THE STORM SEWER AT CENTRAL AVENUE IN CRESTWOOD, ILLINOIS

Event Date	Event Mean Concentrations (EMCs) (mg/L)											
	BOD_5	$CBOD_5$	TSS	VSS	$NO_2 + NO_3$	NH_3	TKN	TN[1]	TP	Cond.[2]	Alk[3]	Cl[4]
----------With Time-Weighted Average Method----------												
08/22/02	6.8	5.1	34	6	0.77	0.29	1.63	2.39	0.89	228	45	34
09/20/02	3.9	1.3	21	6	0.60	0.06	0.85	1.45	0.29	174	49	19
10/04/02	6.5	4.9	59	12	0.84	0.05	1.12	1.97	0.72	178	41	21
05/01/03	8.7	6.7	96	20	1.11	0.58	1.78	2.90	0.30	471	48	116
05/04-05/03	8.7	7.3	86	15	1.79	0.38	1.85	3.64	0.24	632	82	151
05/09/03	9.2	7.1	206	27	2.32	0.46	2.24	4.56	0.37	613	110	118
05/20/03	18.8	14.7	219	30	0.98	0.41	3.06	4.04	0.54	474	86	104
Mean	8.9	6.7	103	17	1.20	0.32	1.79	2.99	0.48	396	66	80
Min	3.9	1.3	21	6	0.60	0.05	0.85	1.45	0.24	174	41	19
Max	18.8	14.7	219	30	2.32	0.58	3.06	4.56	0.89	632	110	151
Std Dev	4.7	4.1	79	10	0.62	0.20	0.73	1.14	0.25	200	27	54
CV (%)	52.9	60.6	77.1	58.0	51.9	63.0	40.7	38.0	51.8	50.5	40.3	67.4

Note: All nitrogen related species are noted as nitrogen (N). All units are mg/L, except for conductivity, which has unit of µmhos/cm.
[1]TN stands for total nitrogen, which is the sum of $NO_2 + NO_3$ and TKN.
[2]Cond stands for conductivity.
[3]Alk stands for alkalinity.
[4]Cl stands for chloride.

NO_2 + NO_3, TN, conductivity, alkalinity and chloride. Although the mean values of seven EMCs of each stormwater constituent calculated using two different methods were slightly different for both storm sewers, statistical analysis of comparing the two means revealed that there was no statistically significant difference between the correspondent means of all constituents at the 90 percent confidence level. Hence, EMCs obtained with arithmetic average methods are used in further analysis.

For both storm sewers, EMCs of all stormwater constituents varied from event to event. For example, EMCs of BOD_5, TSS, TN and TP varied from 9.4 to 31.5 mg/L, 49 to 317 mg/L, 1.87 to 4.61 mg/L, and 0.14 to 0.58 mg/L, respectively, for the Evanston storm sewer, and from 4.4 to 20.0 mg/L, 33 to 334 mg/L, 1.57 to 4.19 mg/L, and 0.23 to 0.81 mg/L, respectively, for the Crestwood storm sewer. For the Evanston storm sewer, EMCs of chloride had the largest variation with a tenfold difference between the lowest and highest EMCs, while alkalinity had the least variation with the difference between the lowest and highest being less than twofold. EMCs for other stormwater constituents, except for TSS and conductivity, generally varied within a factor of 4.2. For the Crestwood storm sewer, EMCs of TSS, $CBOD_5$, and NH_3-N had the largest variation with a tenfold difference between the lowest and highest EMCs, while alkalinity and TN had the least variation with the difference

between the lowest and highest being less than threefold. The EMCs for the other seven stormwater constituents varied by factors between 3 and 10.

The degree of variation of EMCs of the corresponding stormwater constituents at the two storm sewer sites appeared to be similar, even though the ranges of EMCs might be different. Statistical analysis was conducted to compare the means of six major stormwater constituents between the two storm sewer sites, and the results are presented in Table 5. The mean values of BOD_5 and conductivity at the Evanston storm sewer were statistically higher than those at the Crestwood storm sewer (P-value < 0.1), while the mean values of other four constituents between the two storm sewers were not significantly different (P-value > 0.1). The higher conductivity values at the Evanston site were likely due to the seasonal effect.

At the Evanston storm sewer, two events that had very high EMCs of conductivity were sampled in the late fall of 2002 and early spring of 2003, during which period salt might be applied to streets, while no events in the same period were sampled at the Crestwood storm sewer. However, higher BOD_5 values at the Evanston storm sewer might not be attributed solely to seasonal effects. Storm sewer area specific

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TABLE 5

COMPARISON OF MAJOR STORMWATER CONSTITUENTS MONITORED AT TWO STORM SEWERS IN EVANSTON AND CRESTWOOD, ILLINOIS

Parameters	Major Stormwater Constituents Monitored					
	BOD_5	TSS	TKN	TN	TP	Conductivity
Mean at Evanston	16.90	142	2.57	3.23	0.440	1070
Standard Deviation at Evanston	7.59	85	0.86	0.92	0.169	837
Mean at Crestwood	9.80	141	1.91	2.96	0.489	351
Standard Deviation at Crestwood	4.89	122	0.78	1.03	0.224	163
Significance Probability (P value)	0.037	0.985	0.135	0.603	0.639	0.000
Different at 10% significance level (alpha = 0.1)	Yes	No	No	No	No	Yes

Note: Means and standard deviations have unit of mg/L, except for conductivity, which has unit of µmhos/cm.

characteristics, i.e. the frequency of street sweeping, may also have played a role in contributing BOD_5 to stormwater runoff. However, no attempt was made to correlate constituent concentration with storm sewer area characteristics.

Whether EMCs of four major stormwater pollutants, i.e. BOD_5, TSS, TN and TP, were related to storm characteristics was examined in this study. Figures 3 and 4 present EMCs of BOD_5, TSS, TN and TP versus rainfall (in inches) for all seven events sampled for the Evanston storm sewer. It appears that EMCs of TSS, TN, and TP generally decreased as rainfall increased at this location. However, this general trend was not observed for the Crestwood storm sewer. Figures 5 and 6 present EMCs of BOD_5, TSS, TN and TP versus rainfall (in inches) for all seven events sampled for the Crestwood storm sewer. No general trends could be observed, except that EMCs of TP appeared to increase with an increase in rainfall at this location.

The difference of EMCs of four major stormwater pollutants related to storm variables between the two sites was also examined using multiple linear regression. Table 6 presents the results of multiple linear regression analysis on EMCs of four major stormwater pollutants and storm variables for both storm sewers. It is noted that rainfall amount was the most important variable in multiple linear regression equations

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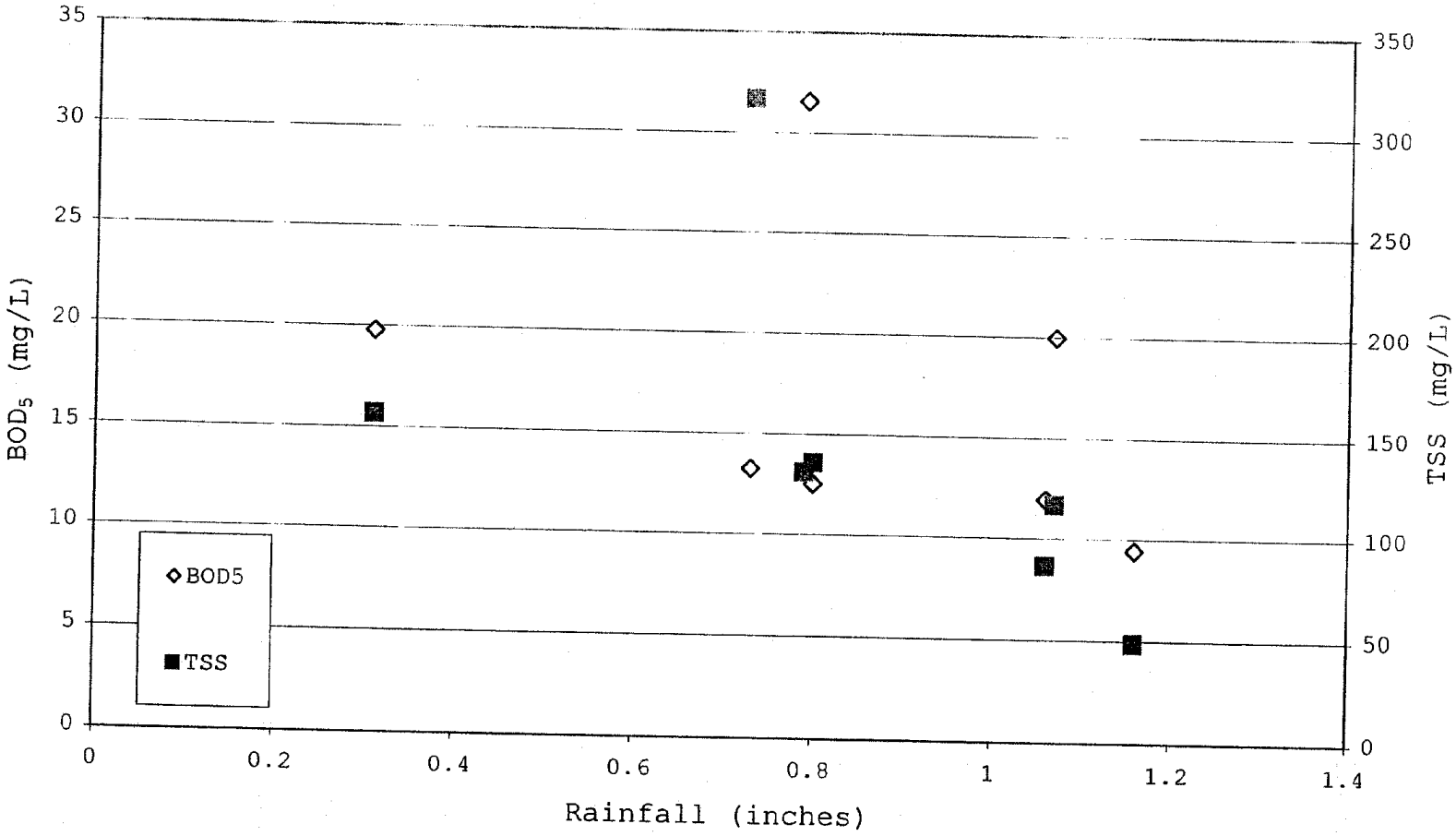
FIGURE 3

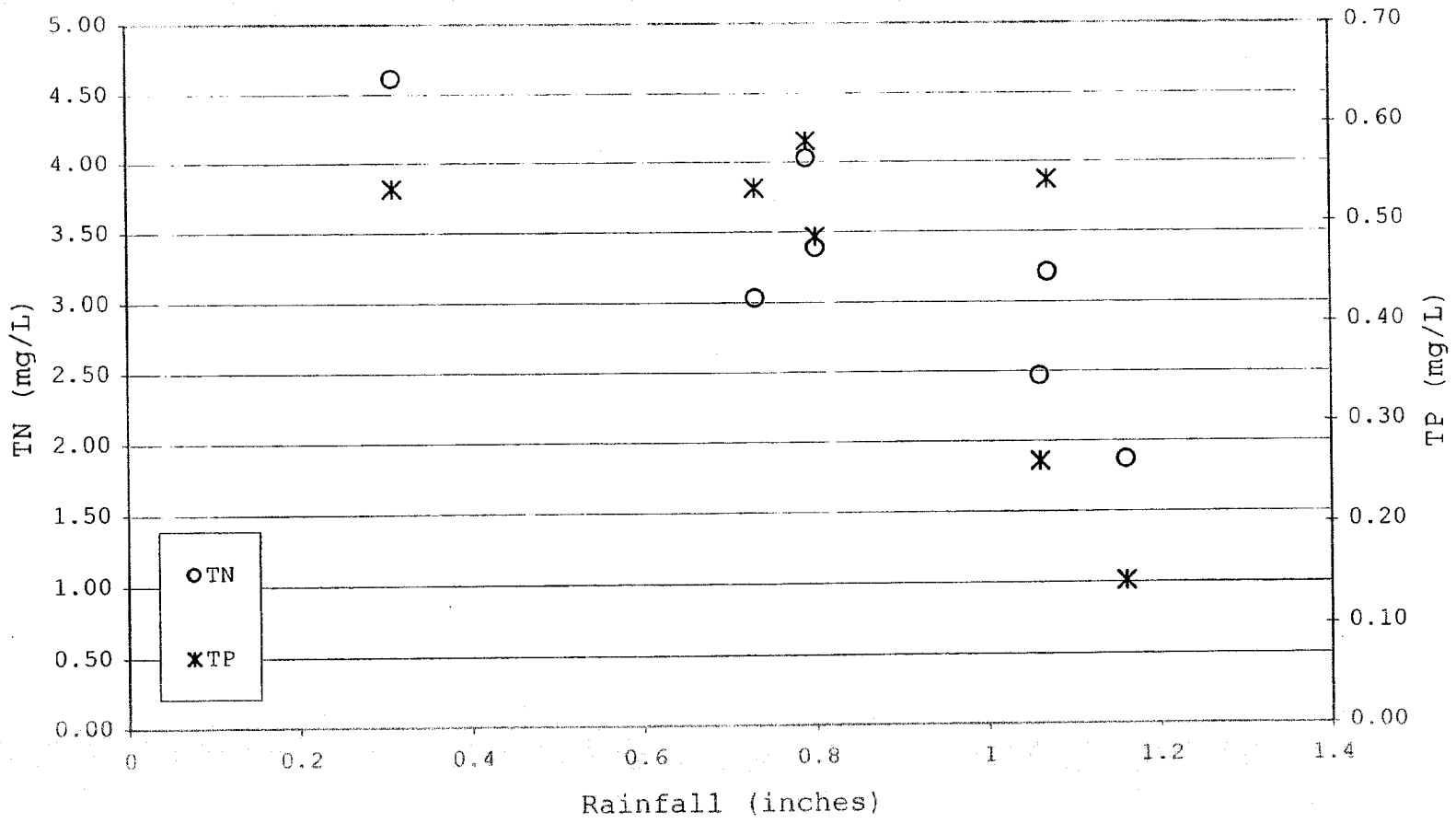
EMCs OF BOD_5 AND TSS VERSUS RAINFALL FOR THE STORM SEWER LOCATED IN EVANSTON, ILLINOIS



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 4

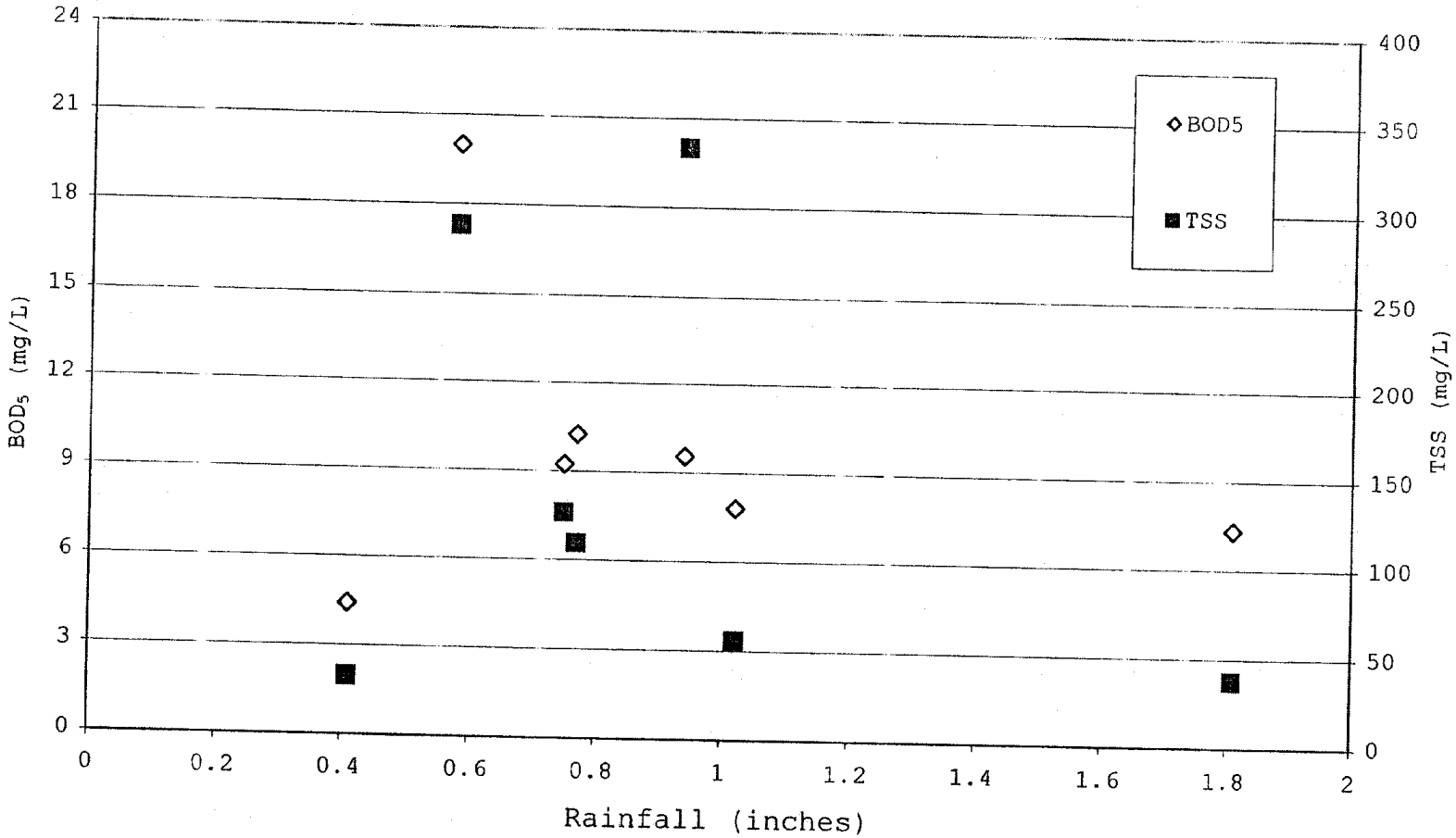
EMCs OF TN AND TP VERSUS RAINFALL FOR THE STORM SEWER LOCATED IN EVANSTON, ILLINOIS



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 5

EMCs OF BOD_5 AND TSS VERSUS RAINFALL FOR THE STORM SEWER LOCATED IN CRESTWOOD, ILLINOIS



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 6

EMCs OF TN AND TP VERSUS RAINFALL FOR THE STORM SEWER LOCATED IN CRESTWOOD, ILLINOIS

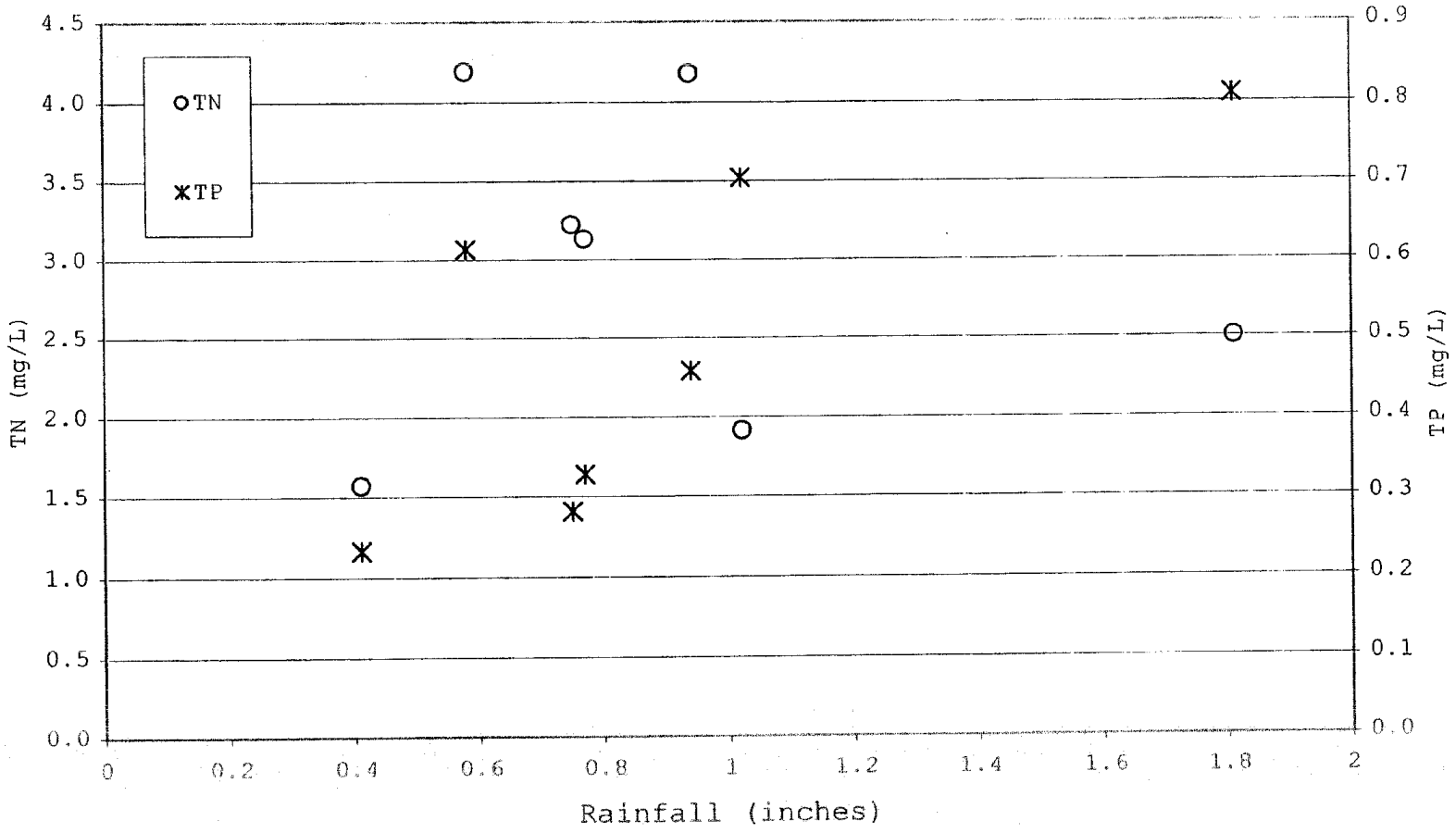


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TABLE 6

SUMMARY OF MULTIPLE LINEAR REGRESSION ANALYSIS BETWEEN EMCS OF FOUR MAJOR STORMWATER POLLUTANTS VERSUS STORM VARIABLES

Constituent	Intercept	Coefficients for Storm Variables				R^2	Adjusted R^2	Note
		Rainfall (inch)	Duration (day)	Intensity (inch/h)	LAST* (day)			
For Evanston Site								
BOD_5	20.9	-12.4	-	-	0.889	0.99	0.99	
TSS	252	-218	-	562	-	0.51	0.26	**
TN	5.54	-2.73	-	-	-	0.74	0.69	
TP	0.745	-0.361	-	-	-	0.38	0.26	**
For Crestwood Site								
BOD_5	4.64	-	-	-	1.96	0.49	0.38	***
TSS	-	-	-	-	52.3	0.49	0.32	
TN	1.83	-	-	-	0.43	0.53	0.44	
TP	0.157	0.371	-	-	-	0.56	0.47	***

Note: All regression equations have form: EMC = Constant + C_i Storm $Variable_i$ + ... + C_n Storm $Variable_n$.

*LAST stands for days since last rain event that had a cumulative rainfall > 0.1 inch.

**Zero is within the 90 percent confidence intervals for the coefficients (C_i) of storm variables in these regression equations (P-value > 0.1).

***Zero is within the 90 percent confidence intervals for the intercepts in these regression equations.

that may be used to predict EMCs for the Evanston storm sewer. However, the multiple linear regression equations for TSS and TP for this site may not be used for prediction of EMCs because of very low R square values. Conversely, rainfall amount, except for TP, was not an important variable in multiple linear regression equations for the Crestwood storm sewer, while the days since last rain event appeared to be important. The multiple linear regression equations derived for the Crestwood storm sewer cannot be used for prediction of EMCs because of low R square values. For both locations, the number of days since last rain event that had a cumulative rainfall larger than 0.1 inch had significant influence on EMCs of BOD_5.

The correlation of each stormwater constituent with each storm variables was further studied using Pearson correlation coefficient (PCC). Table 7 presents the Pearson correlation coefficients for stormwater constituents and storm variables for both storm sewers. At the Evanston site, it appeared that EMCs of most constituents had a tendency to moderately decrease with an increase in rainfall and intensity, and increase with an increase in duration and the days since last rain, except that solids (TSS and VSS) did not follow this general trend. Noticeably, EMCs of BOD_5 was highly positively

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TABLE 7

PEARSON CORRELATION COEFFICIENTS BETWEEN STORMWATER CONSTITUENTS AND STORM VARIABLES FOR BOTH STORM SEWER SAMPLING SITES

Storm Variable	Pearson Correlation Coefficient											
	BOD_5	$CBOD_5$	TSS	VSS	$NO_2 + NO_3$	NH_3	TKN	TN	TP	CONDCT[1]	Alk[2]	Cl[3]
For Evanston Site												
Rainfall	-0.34	-0.32	-0.50	-0.69	-0.42	-0.57	-0.83	-0.86	-0.62	-0.29	-0.56	-0.44
Duration	0.62	0.59	-0.27	0.08	0.12	0.69	0.35	0.36	0.45	0.87	0.75	0.78
Intensity	-0.72	-0.73	0.24	-0.18	-0.32	-0.97	-0.75	-0.76	-0.52	-0.83	-0.91	-0.86
LAST[4]	0.88	0.87	-0.19	0.08	0.23	0.48	0.30	0.33	0.44	0.46	0.59	0.40
For Crestwood Site												
Rainfall	-0.23	-0.16	-0.26	-0.40	-0.01	0.01	-0.12	-0.10	0.75	-0.26	-0.30	-0.27
Duration	-0.40	-0.35	-0.56	-0.64	-0.17	0.01	-0.30	-0.29	0.08	-0.12	-0.42	-0.03
Intensity	-0.14	-0.06	-0.03	-0.17	0.15	0.01	-0.04	0.02	0.53	-0.22	-0.15	-0.28
LAST[4]	0.70	0.74	0.70	0.62	0.43	0.25	0.75	0.73	0.43	0.47	0.78	0.37

[1]Cond. stands for conductivity.
[2]Alk stands for alkalinity.
[3]Cl stands for chloride.
[4]LAST stands for days since last rain event.

correlated with the days since last rain, while EMCs of TSS were highly negatively correlated with rainfall, and EMCs of TN and TP were highly negatively correlated with rainfall and intensity at this location.

For the Crestwood storm sewer, the general trend observed at the Evanston site was not observed. Correlation between EMCs of most stormwater constituents and rainfall, duration and intensity was poor. However, EMCs of most stormwater constituents appeared to increase with in increase in the days since last rain. The difference in the influence of storm variables on EMCs of stormwater constituents between the two locations might be partially due to the difference in the storm sewer system and drainage area characteristics. Poor correlation for the Crestwood storm sewer may also be due to the distance of the rain gauge from the drainage area.

CONCLUSIONS

The following conclusions may be drawn from this study:

1. Concentrations of individual grab samples of storm runoff collected at the selected Evanston and Crestwood storm sewers varied widely with TSS having the largest variation among the four major pollutants of BOD_5, TSS, TN and TP. No unique pattern of concentration profiles within a storm event was observed for any stormwater constituent for either storm sewer.
2. EMCs of 12 stormwater constituents among seven storm events sampled for both storm sewers varied within a factor of 10 between the lowest and highest. At the Evanston storm sewer, EMCs of chloride has the largest variation with a factor of 10, likely due to seasonal effects, and alkalinity had the least with a factor of 2. At the Crestwood storm sewer, EMCs of TSS, $CBOD_5$ and NH_3-N had the largest variation with a factor of 10, and TN and alkalinity had the least with a factor of less than 3. Seasonal effects were unable to be determined at the Crestwood storm

sewer due to the limitation of the data collected.

3. Although both storm runoff drainage areas sampled in this study are mainly urban residential areas, differences in the drainage areas and the storm sewer collection systems existed. Comparing the means of seven EMCs of six major stormwater constituents between the two storm sewers, no statistically significant difference in TSS, TKN, TN and TP between the two storm sewers was found at a 90 percent confidence level (P-value > 0.1), despite the differences in characteristics of the two storm sewers. However, the means of 7 EMCs of BOD_5 and conductivity were statistically higher at the Evanston storm sewer than those at the Crestwood storm sewer (P-value < 0.1). The higher BOD_5 values at the Evanston storm sewer were likely due to the characteristics of the drainage areas and storm sewer collection system, while higher conductivity was likely due to seasonal effects.

4. The relationships between stormwater constituents and storm variables at the two storm sewers were different. Such difference was possibly

due to the difference in the characteristics of the drainage areas and storm sewer collection systems. However, data are limited for developing predictable relationships.

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APPENDIX

DATA OF STORMWATER RUNOFF SAMPLES COLLECTED FROM STORM SEWERS AT CLEVELAND AVENUE IN EVANSTON, ILLINOIS, AND CENTRAL AVENUE IN CRESTWOOD, ILLINOIS, RESPECTIVELY

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CLEVELAND AVENUE STORM SEWER IN EVANSTON, ILLINOIS (ALL CONCENTRATIONS IN mg/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
10/4/02	0935	9	7	0.032	0.30	0.33	0.63	2.52	2.85	0.43	113	23	493	97	78
10/4/02	0950	7	5	0.022	0.39	0.41	0.23	1.11	1.52	0.15	113	23	96	22	10
10/4/02	1005	10	7	0.033	0.34	0.37	0.34	2.92	3.29	0.55	245	49	360	77	54
10/4/02	1020	20	14	0.037	0.49	0.53	0.41	3.41	3.94	0.57	199	52	200	53	24
10/4/02	1035	17	12	0.051	0.37	0.42	2.16	4.41	4.83	0.56	182	42	449	99	79
10/4/02	1050	13	10	0.046	0.28	0.32	1.37	4.13	4.45	0.64	139	35	546	110	98
10/4/02	1105	14	9	0.039	0.28	0.32	1.26	3.84	4.16	0.65	129	34	578	116	106
10/4/02	1120	15	8	0.037	0.27	0.30	1.23	3.54	3.84	0.60	114	18	598	122	114
10/4/02	1150	9	7	0.029	0.30	0.33	0.68	2.48	2.81	0.35	70	18	364	76	63
10/4/02	1220	11	9	0.030	0.29	0.32	0.29	1.84	2.16	0.35	53	18	202	45	31
Number		10	10	10	10	10	10	10	10	10	10	10	10	10	10
Min		7	5	0.022	0.27	0.30	0.23	1.11	1.52	0.15	53	18	96	22	9.8
Max		20	14	0.051	0.49	0.53	2.16	4.41	4.83	0.65	245	52	598	122	114
Median		12.0	8.5	0.035	0.30	0.33	0.66	3.17	3.57	0.56	122	29	407	87	70.8
Mean		12.5	8.8	0.036	0.33	0.36	0.86	3.02	3.38	0.49	136	31	389	82	66
Std Dev		4.1	2.7	0.008	0.07	0.07	0.63	1.05	1.05	0.16	59	13	175	33	36
CV (%)		32.5	30.2	23.7	21.3	19.3	72.8	34.6	31.1	33.2	43.1	42.0	45.1	40.6	54.5

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CLEVELAND AVENUE STORM SEWER IN EVANSTON, ILLINOIS (ALL CONCENTRATIONS IN MG/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
12/18/02	0615	22	15	0.081	0.64	0.72	1.42	3.33	4.05	0.61	84	32	3190	180	979
12/18/02	0630	23	17	0.09	0.64	0.73	1.47	3.46	4.19	0.66	108	40	3290	166	989
12/18/02	0645	22	17	0.096	0.66	0.76	1.38	2.96	3.72	0.62	102	10	3370	149	1073
12/18/02	0700	23	17	0.097	0.67	0.77	1.44	3.33	4.10	0.62	78	30	3320	168	1025
12/18/02	0715	21	15	0.098	0.59	0.69	1.55	3.35	4.04	0.72	66	32	3410	171	985
12/18/02	0730	21	15	0.101	0.56	0.66	1.56	3.34	4.00	0.61	74	24	3500	180	829
12/18/02	0745	19	13	0.096	0.58	0.68	1.48	3.38	4.06	0.59	74	30	3360	168	770
12/18/02	0800	18	13	0.091	0.54	0.64	1.21	2.85	3.49	0.53	60	26	3080	142	813
12/18/02	0830	18	13	0.088	0.53	0.61	0.96	2.5	3.11	0.44	66	24	2860	125	675
12/18/02	0900	17	13	0.082	0.59	0.67	0.57	1.62	2.29	0.33	52	30	1979	92	494
12/18/02	0930	26	13	0.09	0.61	0.70	0.76	2.26	2.96	0.42	120	26	2210	113	552
12/18/02	1000	18	14	0.101	0.60	0.70	0.86	2.57	3.27	0.48	80	26	2480	132	661
12/18/02	1030	19	14	0.104	0.65	0.75	0.82	1.65	2.40	0.50	122	20	2490	115	622
12/18/02	1100	14	10	0.041	0.30	0.34	0.14	1.47	1.81	0.29	136	20	314	27	77
12/18/02	1130	27	18	0.081	0.40	0.48	0.79	3.27	3.75	0.79	284	100	2190	87	605
12/18/02	1200	30	19	0.088	0.42	0.50	0.78	3.95	4.45	0.89	328	96	2160	82	550
12/18/02	1300	22	17	0.077	0.34	0.41	1.43	3.25	3.66	0.68	152	58	2900	118	615
12/18/02	1400	18	13	0.062	0.34	0.40	1.09	1.99	2.39	0.48	108	40	2040	92	499
12/18/02	1500	12	9	0.058	0.34	0.40	0.45	1.15	1.55	0.23	54	20	838	49	199
12/18/02	1600	20	15	0.074	0.35	0.43	0.75	2.2	2.63	0.57	174	80	1432	84	330
12/18/02	1700	13	10	0.062	0.34	0.40	0.58	1.91	2.31	0.41	124	38	1060	71	231
12/18/02	1800	16	12	0.055	0.30	0.36	0.95	1.99	2.35	0.45	118	24	1763	98	430
Number		22	22	22	22	22	22	22	22	22	22	22	22	22	22
Min		12	9	0.041	0.30	0.34	0.14	1.15	1.55	0.23	52	10	314	27	77
Max		30	19	0.104	0.67	0.77	1.56	3.95	4.45	0.89	328	100	3500	180	1073
Median		19.5	14.0	0.088	0.55	0.65	0.96	2.71	3.38	0.55	105	30	2485	117	618
Mean		20.0	14.2	0.082	0.50	0.58	1.02	2.63	3.21	0.54	117	38	2420	119	637
Std Dev		4.4	2.6	0.017	0.14	0.15	0.41	0.79	0.87	0.16	70	24	917	44	281
CV (%)		22.1	18.7	20.9	27.2	25.9	39.9	30.1	27.0	29.6	59.8	64.8	37.9	36.8	44.1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CLEVELAND AVENUE STORM SEWER IN EVANSTON, ILLINOIS (ALL CONCENTRATIONS IN MG/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
3/28/03	0950	40	29	0.069	0.76	0.83	1.10	4.43	5.26	0.58	323	94	926	82	269
3/28/03	1005	71	47	0.096	0.71	0.80	2.24	9.58	10.38	2.08	891	194	1394	173	504
3/28/03	1020	35	31	0.086	0.85	0.94	2.40	7.27	8.21	1.13	362	108	2960	199	1047
3/28/03	1035	21	17	0.098	0.94	1.04	1.97	6.20	7.24	0.93	228	64	3620	199	1271
3/28/03	1050	17	12	0.105	0.80	0.91	2.03	4.71	5.62	0.74	178	56	3630	200	1302
3/28/03	1105	17	14	0.112	0.94	1.05	1.61	3.87	4.92	0.59	158	46	3060	199	1139
3/28/03	1120	17	14	0.110	0.96	1.07	1.37	3.17	4.24	0.54	140	38	2920	160	987
3/28/03	1135	16	12	0.114	0.99	1.11	1.32	3.95	5.06	0.48	119	35	2640	151	911
3/28/03	1205	16	15	0.112	1.02	1.13	1.25	3.09	4.22	0.41	76	28	2580	144	836
3/28/03	1235	15	12	0.113	1.15	1.26	1.14	2.70	3.96	0.33	60	26	2290	139	777
3/28/03	1305	16	13	0.112	1.13	1.24	1.12	2.97	4.21	0.31	54	32	2170	129	730
3/28/03	1335	16	15	0.112	1.10	1.21	1.10	3.14	4.35	0.26	60	20	1763	110	615
3/28/03	1405	16	13	0.104	1.08	1.18	1.01	2.91	4.09	0.25	64	30	1288	86	449
3/28/03	1435	16	14	0.077	0.68	0.76	0.65	2.27	3.02	0.19	63	26	794	59	271
3/28/03	1505	20	13	0.129	0.77	0.90	0.82	2.42	3.32	0.42	146	32	1294	100	458
3/28/03	1535	17	13	0.111	0.66	0.77	0.71	2.93	3.70	0.37	116	36	1135	88	423
3/28/03	1635	10	11	0.090	0.56	0.65	0.63	2.24	2.89	0.31	74	26	1218	79	418
3/28/03	1735	13	10	0.092	0.53	0.62	0.67	2.48	3.10	0.34	80	20	1481	85	458
3/28/03	1835	11	11	0.101	0.60	0.70	0.80	3.07	3.77	0.42	93	35	1657	99	541
3/28/03	1935	11	10	0.091	0.62	0.72	0.90	2.74	3.46	0.38	62	22	1891	109	631
3/28/03	2035	12	9	0.089	0.60	0.68	0.97	2.65	3.33	0.36	55	22	2100	109	637
3/28/03	2135	12	9	0.084	0.57	0.65	0.93	2.54	3.19	0.33	46	20	1883	116	663
Number		22	22	22	22	22	22	22	22	22	22	22	22	22	22
Min		10	9	0.069	0.53	0.62	0.63	2.24	2.89	0.19	46	20	794	59	269
Max		71	47	0.129	1.15	1.26	2.4	9.58	10.38	2.08	891	194	3630	200	1302
Median		16.0	13.0	0.103	0.79	0.90	1.10	3.02	4.15	0.40	86.5	32	1887	113	634
Mean		19.8	15.6	0.100	0.82	0.92	1.22	3.70	4.61	0.53	157	46	2032	128	697
Std Dev		13.5	8.9	0.014	0.21	0.21	0.52	1.83	1.85	0.41	185	40	840	44	304
CV (%)		68.2	57.0	14.4	25.1	23.3	43.0	49.4	40.1	77.2	118.1	87.9	41.4	34.8	43.6

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CLEVELAND AVENUE STORM SEWER IN EVANSTON, ILLINOIS (ALL CONCENTRATIONS IN MG/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
4/30/03	0600	61	43	0.181	1.08	1.26	2.03	5.38	6.64	0.54	137	51	2030	155	745
4/30/03	0615	39	31	0.141	0.67	0.81	1.97	4.08	4.89	0.50	76	29	1850	241	641
4/30/03	0630	32	25	0.099	1.02	1.12	0.99	3.88	5.00	0.50	150	56	915	76	228
4/30/03	0645	17	13	0.055	0.61	0.66	0.45	2.34	3.00	0.37	141	47	256	29	57
4/30/03	0700	30	21	0.094	0.65	0.75	0.71	3.22	3.97	0.63	255	64	701	99	184
4/30/03	0715	54	34	0.082	0.75	0.83	1.39	5.72	6.55	1.22	271	79	1206	123	344
4/30/03	0730	34	28	0.083	0.74	0.82	1.28	3.59	4.41	0.66	123	35	1883	227	548
4/30/03	0745	29	24	0.069	0.79	0.86	1.25	3.43	4.29	0.66	93	25	1880	238	608
4/30/03	0815	24	20	0.070	0.82	0.89	0.56	2.58	3.47	0.51	57	19	1182	120	347
4/30/03	0845	23	18	0.072	0.79	0.86	0.58	2.34	3.20	0.41	93	28	914	94	271
4/30/03	0915	22	16	0.074	0.56	0.63	0.55	2.22	2.85	0.45	123	30	563	61	146
4/30/03	0945	30	24	0.073	0.66	0.73	0.72	2.68	3.42	0.53	101	33	1328	123	370
4/30/03	1015	34	27	0.082	0.64	0.72	0.91	2.82	3.54	0.57	94	30	1080	101	309
4/30/03	1045	33	27	0.079	0.62	0.70	0.88	2.97	3.67	0.56	88	29	1190	107	337
4/30/03	1115	33	28	0.084	0.65	0.74	0.88	3.26	4.00	0.83	71	25	1298	120	373
4/30/03	1145	33	26	0.084	0.64	0.72	0.90	2.87	3.59	0.53	70	22	1270	117	362
4/30/03	1245	27	27	0.079	0.57	0.65	1.05	2.45	3.10	0.45	39	14	1480	127	398
4/30/03	1345	28	26	0.079	0.57	0.65	1.08	2.57	3.22	0.44	39	17	1421	129	403
4/30/03	1445	26	24	0.102	0.61	0.71	0.88	2.57	3.28	0.36	132	40	799	65	205
4/30/03	1545	24	16	0.117	0.70	0.82	0.91	3.50	4.32	0.73	329	71	373	63	81
4/30/03	1645	29	22	0.109	0.70	0.81	1.03	3.33	4.14	0.70	265	64	725	70	170
4/30/03	1745	32	26	0.090	0.67	0.76	1.26	3.34	4.10	0.65	135	43	1174	100	312
Number		22	22	22	22	22	22	22	22	22	22	22	22	22	22
Min		17	13	0.055	0.56	0.63	0.45	2.22	2.85	0.36	39	14	256	29	57
Max		61	43	0.181	1.08	1.26	2.03	5.72	6.64	1.22	329	79	2030	241	745
Median		30.0	25.5	0.083	0.66	0.75	0.91	3.10	3.82	0.54	112	32	1186	112	341
Mean		31.5	24.8	0.091	0.70	0.80	1.01	3.23	4.03	0.58	131	39	1160	118	338
Std Dev		9.8	6.5	0.027	0.13	0.15	0.41	0.91	1.01	0.19	79	18	486	56	177
CV (%)		31.1	26.1	30.2	18.9	18.8	40.2	28.2	25.2	32.0	60.6	47.6	41.9	47.6	52.2

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CLEVELAND AVENUE STORM SEWER IN EVANSTON, ILLINOIS (ALL CONCENTRATIONS IN MG/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH$_3$-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
5/4/03	2030	13	11	0.038	1.12	1.16	0.50	2.01	3.17	0.10	35	12	1289	192	332
5/4/03	2045	11	9	0.032	1.03	1.06	0.52	2.11	3.17	0.10	30	12	1217	190	322
5/4/03	2100	26	23	0.018	0.92	0.93	0.86	2.91	3.84	0.14	50	22	782	83	189
5/4/03	2115	11	9	0.012	0.43	0.44	0.43	1.51	1.95	0.06	51	14	222	31	46
5/4/03	2130	11	8	0.030	0.69	0.72	0.48	2.09	2.81	0.24	87	20	655	105	144
5/4/03	2145	11	8	0.023	0.54	0.57	0.35	1.81	2.38	0.34	113	29	546	84	117
5/4/03	2200	11	8	0.024	0.60	0.63	0.23	1.30	1.93	0.22	88	28	811	129	181
5/4/03	2215	10	9	0.021	0.58	0.60	0.27	1.30	1.90	0.18	190	35	600	82	120
5/4/03	2245	9	7	0.021	0.51	0.53	0.28	0.97	1.50	0.12	36	15	431	57	91
5/4/03	2315	8	7	0.017	0.47	0.49	0.21	0.61	1.10	0.21	54	17	392	55	82
5/4/03	2345	8	7	0.015	0.31	0.33	0.22	1.44	1.77	0.19	46	15	233	36	47
5/5/03	0015	8	7	0.017	0.37	0.39	0.26	0.99	1.38	0.17	39	11	320	42	66
5/5/03	0045	12	10	0.017	0.39	0.40	0.47	1.08	1.48	0.15	92	19	267	34	52
5/5/03	0115	7	6	0.015	0.41	0.42	0.46	0.83	1.25	0.11	44	10	195	31	38
5/5/03	0145	6	5	0.015	0.42	0.44	0.48	0.50	0.94	0.06	15	6	200	30	37
5/5/03	0215	5	5	0.016	0.44	0.45	0.39	0.55	1.01	0.00	10	4	195	31	39
5/5/03	0315	5	5	0.017	0.46	0.47	0.40	0.51	0.98	0.06	5	1	213	32	40
5/5/03	0415	8	6	0.022	0.51	0.53	0.35	0.90	1.43	0.12	21	4	302	43	55
5/5/03	0515	8	7	0.021	0.63	0.65	0.31	1.17	1.82	0.13	14	4	375	54	70
5/5/03	0615	7	6	0.019	0.71	0.73	0.44	1.15	1.88	0.14	18	7	341	57	65
5/5/03	0715	6	5	0.023	0.92	0.95	0.30	0.80	1.75	0.14	14	2	434	73	83
5/5/03	0815	6	5	0.025	0.89	0.92	0.20	0.77	1.69	0.13	18	6	540	88	111
Number		22	22	22	22	22	22	22	22	22	22	22	22	22	22
Min		5	5	0.012	0.31	0.33	0.2	0.5	0.94	0	5	1	195	30	37
Max		26	23	0.038	1.12	1.16	0.86	2.91	3.84	0.34	190	35	1289	192	332
Median		8.0	7.0	0.020	0.53	0.55	0.37	1.12	1.76	0.135	37.5	12	384	56	76
Mean		9.4	7.9	0.021	0.61	0.63	0.38	1.24	1.87	0.14	49	13	480	71	106
Std Dev		4.4	3.8	0.006	0.23	0.24	0.15	0.62	0.77	0.07	43	9	311	47	84
CV (%)		46.6	48.3	29.9	38.2	37.7	38.9	50.1	41.4	51.3	89.1	69.7	64.9	66.9	79.6

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CLEVELAND AVENUE STORM SEWER IN EVANSTON, ILLINOIS (ALL CONCENTRATIONS IN MG/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
5/9/03	0015	22	17	0.010	1.86	1.87	1.28	2.61	4.48	0.15	37	21	699	78	153
5/9/03	0030	17	14	0.008	1.35	1.36	1.10	2.48	3.84	0.16	39	16	582	90	123
5/9/03	0045	13	11	0.010	0.96	0.97	0.65	2.15	3.12	0.16	66	33	523	73	94
5/9/03	0100	16	12	0.014	0.84	0.86	0.42	2.14	3.00	0.27	118	32	618	96	136
5/9/03	0115	23	10	0.015	0.80	0.82	0.35	2.02	2.84	0.29	160	40	624	92	122
5/9/03	0130	12	11	0.016	0.88	0.90	0.26	1.51	2.41	0.25	72	24	1202	193	276
5/9/03	0145	10	9	0.011	0.81	0.83	0.28	1.28	2.11	0.24	70	22	801	109	157
5/9/03	0200	10	8	0.010	0.62	0.63	0.36	1.59	2.22	0.24	142	45	414	60	78
5/9/03	0230	11	9	0.013	0.55	0.56	0.33	2.01	2.57	0.38	144	55	515	72	108
5/9/03	0300	9	9	0.012	0.41	0.42	0.30	1.69	2.11	0.30	116	38	412	60	87
5/9/03	0330	8	7	0.012	0.43	0.44	0.25	1.27	1.71	0.19	69	22	382	45	74
5/9/03	0400	10	9	0.022	0.61	0.63	0.54	3.19	3.82	0.42	119	27	237	56	34
5/9/03	0430	8	6	0.023	0.63	0.66	0.53	1.94	2.60	0.31	92	22	221	49	31
5/9/03	0500	9	7	0.022	0.63	0.65	0.53	1.67	2.32	0.28	79	19	296	51	52
5/9/03	0530	9	7	0.016	0.66	0.67	0.58	1.51	2.18	0.21	57	16	348	50	71
5/9/03	0600	8	7	0.018	0.64	0.65	0.56	1.98	2.63	0.23	64	16	384	55	74
5/9/03	0700	10	9	0.018	0.55	0.57	0.33	0.89	1.46	0.22	N/A	N/A	N/A	N/A	N/A
5/9/03	0800	11	9	0.020	0.59	0.61	0.31	1.04	1.65	0.13	N/A	N/A	N/A	N/A	N/A
5/9/03	0900	11	9	0.019	0.59	0.60	0.33	1.05	1.65	0.14	26	12	386	N/A	N/A
5/9/03	1000	12	10	0.019	0.67	0.69	0.32	1.13	1.82	0.19	N/A	N/A	N/A	N/A	N/A
5/9/03	1100	12	10	0.021	0.67	0.70	0.30	1.25	1.95	0.76	N/A	N/A	N/A	N/A	N/A
5/9/03	1200	11	10	0.025	0.70	0.73	0.31	1.10	1.83	0.20	N/A	N/A	N/A	N/A	N/A
Number		22	22	22	22	22	22	22	22	22	17	17	17	16	16
Min		8	6	0.008	0.41	0.42	0.25	0.89	1.46	0.13	26	12	221	45	31
Max		23	17	0.025	1.86	1.87	1.28	3.19	4.48	0.76	160	55	1202	193	276
Median		11.0	9.0	0.016	0.65	0.66	0.34	1.63	2.27	0.235	72	22	414	66	91
Mean		11.9	9.5	0.016	0.75	0.76	0.46	1.70	2.47	0.26	86	27	508	77	104
Std Dev		4.1	2.5	0.005	0.32	0.32	0.26	0.59	0.79	0.13	40	12	240	37	60
CV (%)		34.7	26.0	30.7	42.5	41.3	56.9	34.4	32.0	51.6	46.4	43.6	47.3	47.5	57.2

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CLEVELAND AVENUE STORM SEWER IN EVANSTON, ILLINOIS (ALL CONCENTRATIONS IN MG/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
5/10/03	2320	19	10	0.027	0.42	0.45	0.15	2.24	2.69	0.50	385	74	464	71	95
5/10/03	2335	44	21	0.023	0.21	0.23	0.32	11.26	11.49	3.23	2144	373	297	71	39
5/10/03	2350	26	11	0.016	0.20	0.21	0.19	5.79	6.00	1.31	758	174	142	35	16
5/11/03	0005	14	10	0.018	0.21	0.23	0.20	3.90	4.13	0.81	1174	130	175	38	25
5/11/03	0020	12	8	0.017	0.24	0.26	0.24	2.40	2.66	0.56	449	60	200	36	42
5/11/03	0035	10	7	0.019	0.26	0.28	0.17	1.80	2.08	0.39	308	55	203	29	38
5/11/03	0050	19	12	0.234	0.57	0.81	0.87	2.72	3.53	0.53	273	38	511	114	70
5/11/03	0105	19	12	0.272	0.72	0.99	1.11	2.94	3.93	0.51	211	32	604	128	75
5/11/03	0135	17	16	0.265	0.70	0.96	1.07	2.92	3.88	0.45	227	27	580	131	78
5/11/03	0205	13	10	0.263	0.69	0.96	1.04	2.61	3.57	0.45	169	24	579	146	86
5/11/03	0235	16	11	0.235	0.65	0.89	0.96	2.51	3.40	0.39	210	24	569	125	81
5/11/03	0305	8	6	0.023	0.37	0.39	0.18	0.89	1.28	0.23	85	17	467	62	118
5/11/03	0335	10	7	0.010	0.43	0.44	0.19	1.59	2.03	0.33	103	28	347	50	65
5/11/03	0405	13	7	0.025	0.39	0.41	0.17	1.29	1.70	0.31	91	23	290	45	54
5/11/03	0435	10	7	0.025	0.44	0.47	0.16	1.39	1.86	0.33	103	27	333	50	63
5/11/03	0505	8	6	0.024	0.52	0.55	0.15	1.37	1.92	0.31	69	19	374	56	76
5/11/03	0605	6	5	0.025	0.60	0.63	0.18	1.16	1.79	0.24	39	19	501	75	107
5/11/03	0705	5	4	0.025	0.68	0.70	0.17	0.94	1.64	0.18	34	10	695	86	137
5/11/03	0805	6	5	0.028	0.72	0.75	0.22	1.02	1.77	0.23	42	17	849	100	180
5/11/03	0905	5	4	0.029	0.76	0.79	0.24	0.89	1.68	0.16	33	14	877	113	183
5/11/03	1005	6	4	0.028	0.81	0.84	0.22	0.91	1.75	0.15	28	13	946	132	205
5/11/03	1105	5	3	0.029	0.88	0.91	0.22	1.01	1.92	0.14	35	20	1021	140	214
Number		22	22	22	22	22	22	22	22	22	22	22	22	22	22
Min		5	3	0.010	0.20	0.21	0.15	0.89	1.28	0.14	28	10	142	29	16
Max		44	21	0.272	0.88	0.99	1.11	11.26	11.49	3.23	2144	373	1021	146	214
Median		11.0	7.0	0.025	0.55	0.59	0.21	1.70	2.05	0.36	136	26	484	73	77
Mean		13.2	8.5	0.075	0.52	0.60	0.38	2.43	3.03	0.53	317	55	501	83	93
Std Dev		8.9	4.3	0.099	0.21	0.27	0.35	2.31	2.22	0.66	492	82	255	39	57
CV (%)		67.6	51.2	131.8	41.1	45.4	92.1	94.7	73.1	122.9	155.2	147.2	50.9	47.2	61.8

*Cond. stands for conductivity, Alk for alkalinity, and Cl for chloride.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CENTRAL AVENUE STORM SEWER IN CRESTWOOD, ILLINOIS (ALL CONCENTRATIONS IN mg/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
8/22/02	0620	9	7	0.057	0.88	0.94	0.43	2.35	3.29	0.24	75	7	164	31	29
8/22/02	0635	9	6	0.058	0.96	1.02	0.42	2.14	3.16	0.23	58	5	174	36	32
8/22/02	0650	8	7	0.064	1.04	1.10	0.34	2.00	3.10	0.25	43	1	201	43	40
8/22/02	0705	N/A	6	0.068	0.98	1.05	0.31	1.41	2.46	0.22	42	3	200	42	39
8/22/02	0720	11	7	0.068	0.95	1.02	0.34	1.59	2.61	0.24	39	2	203	41	43
8/22/02	0735	8	7	0.067	0.85	0.92	0.29	1.55	2.47	0.28	28	1	204	37	41
8/22/02	0750	6	4	0.064	0.79	0.85	0.26	1.22	2.07	0.14	21	2	197	37	34
8/22/02	0805	6	4	0.064	0.78	0.84	0.26	1.49	2.33	0.15	21	3	191	38	36
8/22/02	0820	7	N/A	0.067	0.78	0.85	0.22	0.99	1.84	0.10	22	1	197	39	35
8/22/02	0850	6	4	0.068	0.56	0.63	0.26	1.74	2.37	0.49	90	11	135	29	18
8/22/02	0920	6	4	0.086	0.72	0.80	0.22	1.24	2.04	0.53	43	3	200	41	32
8/22/02	0950	9	6	0.066	0.69	0.75	0.77	2.71	3.46	3.64	27	11	290	41	34
8/22/02	1020	8	5	0.098	0.78	0.87	0.31	1.88	2.75	1.30	55	7	281	51	47
8/22/02	1050	10	7	0.064	0.58	0.64	0.50	2.05	2.69	5.78	27	11	332	45	30
8/22/02	1120	7	5	0.062	0.70	0.76	0.27	1.61	2.37	0.48	17	4	192	41	30
8/22/02	1150	5	4	0.061	0.59	0.65	0.23	1.46	2.11	0.62	18	1	193	43	28
8/22/02	1220	9	6	0.065	0.65	0.71	0.43	2.09	2.80	0.40	67	9	179	38	25
8/22/02	1320	3	4	0.036	0.55	0.59	0.09	1.22	1.81	0.13	14	8	282	64	40
8/22/02	1420	5	4	0.048	0.63	0.67	0.05	1.14	1.81	0.16	9	3	263	60	40
Number		18	18	19	19	19	19	19	19	19	19	19	19	19	19
Min		3	4	0.036	0.55	0.59	0.05	0.99	1.81	0.10	9	1	135	29	18
Max		11	7	0.098	1.04	1.10	0.77	2.71	3.46	5.78	90	11	332	64	47
Median		7.5	5.5	0.064	0.78	0.84	0.29	1.59	2.46	0.25	28	3	200	41	34
Mean		7.3	5.4	0.065	0.76	0.82	0.32	1.68	2.50	0.81	38	5	215	42	34
Std Dev		2.0	1.3	0.013	0.15	0.15	0.16	0.46	0.50	1.45	22	4	50	9	7
CV (%)		27.7	23.9	19.4	19.9	18.7	49.4	27.2	20.1	178.7	59.7	74.6	23.4	20.4	20.1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CENTRAL AVENUE STORM SEWER IN CRESTWOOD, ILLINOIS (ALL CONCENTRATIONS IN mg/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
9/20/02	0955	10	N/A	0.016	0.32	0.33	0.09	1.67	2.00	0.21	79	22	82	15	10
9/20/02	1010	9	N/A	0.041	0.30	0.34	0.14	1.40	1.75	0.18	85	20	141	30	21
9/20/02	1025	6	4	0.022	0.42	0.45	0.12	1.27	1.72	0.13	48	13	83	21	7
9/20/02	1040	5	3	0.035	0.48	0.51	0.14	1.14	1.65	0.13	71	15	98	23	12
9/20/02	1055	4	3	0.032	0.46	0.50	0.12	1.29	1.79	0.14	37	7	74	21	7
9/20/02	1110	4	3	0.028	0.42	0.45	0.11	0.46	0.91	0.03	44	8	74	21	6
9/20/02	1125	5	3	0.048	0.55	0.59	0.13	1.35	1.94	0.09	49	10	151	44	17
9/20/02	1140	N/A	N/A	0.087	0.88	0.96	0.18	1.68	2.64	0.29	111	17	203	59	27
9/20/02	1155	6	4	0.055	0.82	0.87	0.15	1.61	2.48	0.24	83	14	169	46	20
9/20/02	1225	3	0	0.036	0.59	0.63	0.06	0.71	1.34	0.13	13	7	175	51	19
9/20/02	1255	3	0	0.036	0.60	0.63	0.06	0.76	1.39	0.17	9	5	172	50	19
9/20/02	1325	3	0	0.036	0.60	0.64	0.06	0.82	1.46	0.15	8	7	175	50	19
9/20/02	1355	3	0	0.037	0.60	0.64	0.07	0.95	1.59	0.13	10	7	174	48	19
9/20/02	1425	4	0	0.033	0.59	0.62	0.05	0.96	1.58	0.25	13	9	151	44	17
9/20/02	1455	3	0	0.037	0.60	0.63	0.07	0.75	1.38	0.15	10	6	176	49	19
9/20/02	1525	4	0	0.038	0.61	0.65	0.06	0.72	1.37	0.18	16	8	149	42	16
9/20/02	1555	3	0	0.037	0.60	0.64	0.06	0.66	1.30	0.16	10	8	169	49	19
9/20/02	1655	4	0	0.035	0.61	0.64	0.05	0.71	1.35	0.66	20	8	N/A	53	20
9/20/02	1755	3	3	0.030	0.60	0.63	0.04	0.74	1.37	0.40	11	1	183	55	21
9/20/02	1855	3	0	0.030	0.61	0.64	0.04	0.75	1.39	0.42	10	2	201	57	22
9/20/02	1955	5	3	0.026	0.55	0.58	0.03	0.77	1.35	0.50	13	3	206	58	22
9/20/02	2055	4	2	0.031	0.52	0.55	0.03	0.68	1.23	0.38	7	1	204	54	23
9/20/02	2155	3	2	0.029	0.53	0.56	0.03	0.58	1.14	0.23	4	1	221	61	24
Number		22	20	23	23	23	23	23	23	23	23	23	22	23	23
Min		3	0	0.016	0.30	0.33	0.03	0.46	0.91	0.03	4	1	74	15	6
Max		10	4	0.087	0.88	0.96	0.18	1.68	2.64	0.66	111	22	221	61	27
Median		4	1	0.035	0.59	0.63	0.06	0.77	1.39	0.18	13	8	171	49	19
Mean		4	2	0.036	0.56	0.59	0.08	0.98	1.57	0.23	33	9	156	44	18
Std Dev		2	2	0.014	0.13	0.14	0.04	0.37	0.40	0.15	32	6	46	14	5
CV (%)		43.5	107.1	37.5	23.1	23.4	54.0	37.9	25.6	63.7	96.5	67.5	29.3	32.6	31.1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CENTRAL AVENUE STORM SEWER IN CRESTWOOD, ILLINOIS (ALL CONCENTRATIONS IN mg/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
10/4/02	0930	13	11	0.069	0.68	0.75	0.14	1.53	2.28	0.30	85	28	158	32	23
10/4/02	0945	10	8	0.072	0.59	0.66	0.14	1.46	2.12	0.23	93	34	201	43	31
10/4/02	1000	9	8	0.078	0.55	0.63	0.15	1.18	1.81	0.22	70	28	193	42	26
10/4/02	1015	9	8	0.064	0.57	0.63	0.11	1.01	1.64	0.17	46	18	172	40	23
10/4/02	1030	9	6	0.055	0.55	0.60	0.10	0.91	1.51	0.13	27	10	174	37	22
10/4/02	1045	8	7	0.051	0.62	0.67	0.09	0.97	1.64	0.14	18	9	168	40	22
10/4/02	1100	8	7	0.040	0.68	0.72	0.07	0.98	1.70	0.22	10	7	148	35	18
10/4/02	1115	8	6	0.044	0.65	0.70	0.06	0.49	1.19	0.12	14	8	147	36	17
10/4/02	1130	8	5	0.043	0.64	0.68	0.05	0.51	1.19	0.12	9	7	152	38	17
10/4/02	1200	7	N/A	0.047	0.75	0.80	0.08	1.14	1.94	0.59	124	21	102	27	10
10/4/02	1230	9	N/A	0.037	0.73	0.77	0.07	2.13	2.90	1.51	177	31	177	34	20
10/4/02	1300	10	N/A	0.018	0.50	0.52	0.05	1.52	2.04	1.36	107	22	119	24	12
10/4/02	1330	9	7	0.041	0.89	0.93	0.04	1.21	2.14	1.74	28	12	167	34	17
10/4/02	1400	10	N/A	0.039	0.89	0.93	0.03	1.13	2.06	1.73	30	9	168	34	17
10/4/02	1430	10	8	0.040	0.90	0.94	0.05	1.23	2.17	1.83	44	14	167	33	17
10/4/02	1500	10	8	0.040	0.89	0.93	0.03	1.08	2.01	1.82	37	11	165	33	16
10/4/02	1530	10	8	0.040	0.89	0.93	0.04	1.10	2.03	1.77	24	8	166	33	17
10/4/02	1630	3	3	0.037	0.89	0.93	0.03	0.86	1.79	0.19	26	7	177	42	21
10/4/02	1730	3	2	0.036	0.91	0.94	0.04	0.93	1.87	0.30	52	8	193	49	24
10/4/02	1830	0	2	0.036	0.92	0.96	0.04	1.09	2.05	0.29	161	11	201	52	25
10/4/02	1930	4	3	0.028	0.88	0.91	0.02	1.31	2.22	0.38	28	5	214	52	25
10/4/02	2030	5	3	0.024	0.86	0.89	0.00	0.93	1.82	0.33	16	4	223	56	26
Number		22	18	22	22	22	22	22	22	22	22	22	22	22	22
Min		0	2	0.018	0.50	0.52	0.00	0.49	1.19	0.12	9	4	102	24	10
Max		13	11	0.078	0.92	0.96	0.15	2.13	2.90	1.83	177	34	223	56	31
Median		9	7	0.040	0.74	0.78	0.05	1.10	1.97	0.30	34	11	168	37	21
Mean		8	6	0.045	0.75	0.79	0.07	1.12	1.91	0.70	56	14	170	38	20
Std Dev		3	3	0.015	0.15	0.14	0.04	0.35	0.37	0.70	49	9	28	8	5
CV (%)		38.8	42.0	34.0	19.7	17.7	63.5	30.9	19.3	98.9	87.6	64.1	16.5	21.1	25.2

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CENTRAL AVENUE STORM SEWER IN CRESTWOOD, ILLINOIS (ALL CONCENTRATIONS IN mg/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
5/1/03	0015	16	11	0.143	1.00	1.15	0.69	2.94	4.09	0.45	154	44	307	31	78
5/1/03	0030	13	12	0.079	1.16	1.24	0.75	2.15	3.39	0.27	92	37	173	23	33
5/1/03	0045	10	9	0.129	1.01	1.14	0.72	2.06	3.20	0.26	63	19	280	38	62
5/1/03	0100	15	9	0.300	1.16	1.46	0.68	3.06	4.52	0.51	202	40	706	61	165
5/1/03	0115	N/A	N/A	0.163	1.20	1.37	0.69	3.49	4.86	0.63	260	40	658	59	181
5/1/03	0130	11	9	0.119	1.07	1.19	0.63	2.50	3.69	0.40	153	31	633	47	159
5/1/03	0145	11	9	0.117	1.14	1.26	0.72	2.34	3.60	0.35	87	21	583	48	152
5/1/03	0200	11	9	0.117	1.11	1.23	0.82	2.24	3.47	0.34	94	20	490	44	124
5/1/03	0215	11	9	0.102	1.02	1.13	0.53	2.22	3.35	0.28	121	24	416	40	103
5/1/03	0245	7	5	0.097	0.87	0.97	0.52	1.49	2.46	0.27	58	12	374	39	91
5/1/03	0315	N/A	N/A	0.099	0.72	0.82	0.40	1.55	2.37	0.29	103	22	319	34	74
5/1/03	0345	N/A	9	0.138	0.86	1.00	0.83	1.76	2.76	0.39	169	26	373	49	84
5/1/03	0415	N/A	N/A	0.121	0.79	0.91	0.95	1.44	2.35	0.31	109	20	337	44	76
5/1/03	0445	N/A	N/A	0.154	0.77	0.92	0.58	1.49	2.41	0.29	76	14	399	48	96
5/1/03	0515	9	4	0.185	0.86	1.05	0.50	1.38	2.43	0.23	66	13	524	49	116
5/1/03	0545	5	4	0.208	0.95	1.16	0.38	1.15	2.31	0.20	50	9	576	56	144
5/1/03	0615	N/A	N/A	0.142	0.79	0.93	0.44	1.52	2.45	0.26	82	18	404	45	98
5/1/03	0715	4	3	0.247	1.16	1.41	0.37	1.29	2.70	0.17	30	7	700	65	184
Number		12	13	18	18	18	18	18	18	18	18	18	18	18	18
Min		4	3	0.079	0.72	0.82	0.37	1.15	2.31	0.17	30	7	173	23	33
Max		16	12	0.300	1.20	1.46	0.95	3.49	4.86	0.63	260	44	706	65	184
Median		11	9	0.134	1.01	1.14	0.66	1.91	2.98	0.29	93	21	410	46	101
Mean		10	8	0.148	0.98	1.13	0.62	2.00	3.13	0.33	109	23	458	46	112
Std Dev		4	3	0.056	0.16	0.18	0.17	0.67	0.79	0.11	59	11	157	11	44
CV (%)		35.3	36.4	38.1	16.2	16.1	27.0	33.5	25.3	34.8	53.5	48.0	34.2	23.4	38.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CENTRAL AVENUE STORM SEWER IN CRESTWOOD, ILLINOIS (ALL CONCENTRATIONS IN mg/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
5/4/03	2100	18	14	0.140	1.03	1.17	0.22	2.07	3.24	0.23	123	45	688	52	212
5/4/03	2115	12	21	0.231	0.66	0.89	0.38	1.99	2.88	0.22	134	36	366	20	27
5/4/03	2130	8	6	0.067	0.47	0.54	0.34	1.17	1.71	0.15	106	22	140	27	99
5/4/03	2145	6	5	0.190	0.48	0.67	0.32	0.99	1.66	0.11	66	17	249	22	59
5/4/03	2200	10	7	0.173	0.78	0.96	0.33	2.10	3.06	0.31	201	35	797	69	236
5/4/03	2215	11	8	0.104	0.65	0.75	0.36	2.45	3.21	0.48	312	45	540	62	155
5/4/03	2230	12	10	0.077	0.54	0.62	0.35	2.16	2.78	0.46	366	53	379	45	95
5/4/03	2245	11	8	0.077	0.60	0.68	0.37	2.05	2.73	0.41	257	35	335	44	83
5/4/03	2300	9	7	0.110	0.55	0.66	0.37	2.00	2.66	0.42	322	38	362	48	87
5/4/03	2330	10	7	0.133	0.88	1.02	0.45	1.86	2.88	0.36	88	18	394	59	98
5/5/03	0000	8	6	0.148	1.07	1.21	0.41	1.74	2.95	0.29	60	17	N/A	63	99
5/5/03	0030	7	5	0.164	1.20	1.37	0.40	1.73	3.10	0.25	60	15	678	70	117
5/5/03	0100	8	6	0.151	1.04	1.19	0.36	2.26	3.45	0.25	85	15	461	63	108
5/5/03	0130	9	N/A	0.099	0.48	0.58	0.37	1.80	2.38	0.40	160	29	241	41	64
5/5/03	0200	8	N/A	0.147	0.51	0.65	0.49	1.93	2.58	0.47	200	34	310	52	70
5/5/03	0230	8	N/A	0.133	0.58	0.71	0.40	1.66	2.37	0.38	109	18	298	48	68
5/5/03	0300	N/A	N/A	0.126	0.70	0.82	0.43	2.66	3.48	0.45	109	18	329	47	68
5/5/03	0415	11	7	0.149	1.71	1.86	0.45	1.48	3.34	0.22	42	8	694	89	165
5/5/03	0515	10	8	0.165	2.16	2.32	0.35	1.93	4.25	0.13	28	3	749	114	183
5/5/03	0615	7	6	0.211	2.22	2.43	0.38	1.96	4.39	0.17	19	1	822	105	195
5/5/03	0715	6	6	0.245	2.65	2.89	0.36	1.84	4.73	0.13	28	3	883	114	210
5/5/03	0815	7	8	0.272	3.14	3.41	0.35	1.89	5.30	0.09	18	4	950	136	244
5/5/03	0915	7	6	0.305	3.23	3.53	0.30	1.53	5.06	0.08	24	3	991	131	243
Number		22	19	23	23	23	23	23	23	23	23	23	22	23	23
Min		6	5	0.067	0.47	0.54	0.22	0.99	1.66	0.08	18	1	140	20	27
Max		18	21	0.305	3.23	3.53	0.49	2.66	5.30	0.48	366	53	991	136	244
Median		9	7	0.148	0.78	0.96	0.37	1.93	3.06	0.25	106	18	428	59	99
Mean		9	8	0.157	1.19	1.34	0.37	1.88	3.22	0.28	127	22	530	66	130
Std Dev		3	4	0.062	0.88	0.93	0.06	0.37	0.96	0.13	104	15	257	33	67
CV (%)		29.1	47.4	39.5	74.1	69.2	15.0	19.6	29.8	47.8	81.7	69.3	48.5	50.4	51.9

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CENTRAL AVENUE STORM SEWER IN CRESTWOOD, ILLINOIS (ALL CONCENTRATIONS IN mg/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
5/9/03	0100	15	11	0.115	1.02	1.13	0.57	3.10	4.23	0.45	365	69	394	41	97
5/9/03	0115	12	10	0.039	0.72	0.76	0.52	3.40	4.16	0.67	619	71	205	39	28
5/9/03	0130	7	5	0.031	0.54	0.57	0.46	1.12	1.69	0.16	112	17	117	22	20
5/9/03	0200	10	9	0.024	0.76	0.79	0.56	2.86	3.65	0.53	506	58	343	53	73
5/9/03	0145	14	11	0.058	1.02	1.08	0.50	4.76	5.84	1.08	1293	112	566	154	117
5/9/03	0215	11	10	0.023	0.80	0.83	0.56	2.26	3.09	0.57	538	56	403	57	86
5/9/03	0230	9	7	0.027	0.73	0.76	0.49	2.35	3.11	0.76	802	73	340	67	69
5/9/03	0245	7	5	0.018	0.51	0.53	0.39	2.28	2.81	0.60	632	57	200	46	30
5/9/03	0300	9	6	0.021	0.65	0.67	0.43	3.23	3.90	0.86	1108	92	268	84	45
5/9/03	0330	8	6	0.055	0.64	0.69	0.75	2.61	3.30	0.57	246	34	222	46	40
5/9/03	0400	9	7	0.048	0.76	0.81	0.62	2.56	3.37	0.46	206	38	252	45	41
5/9/03	0430	9	8	0.036	0.99	1.03	0.73	2.64	3.67	0.51	180	30	287	58	56
5/9/03	0500	9	7	0.059	1.05	1.11	0.71	2.42	3.53	0.38	122	20	304	61	57
5/9/03	0530	9	7	0.078	1.45	1.53	0.67	1.87	3.40	0.35	93	18	405	80	77
5/9/03	0600	9	7	0.113	1.79	1.90	0.53	2.61	4.51	0.29	79	20	501	92	96
5/9/03	0630	10	8	0.126	2.14	2.27	0.45	2.71	4.98	0.34	71	19	587	116	127
5/9/03	0700	10	8	0.137	2.34	2.47	0.52	3.26	5.73	0.50	90	22	677	132	157
5/9/03	0800	7	6	0.205	2.78	2.98	0.36	1.99	4.97	0.27	85	11	835	N/A	N/A
5/9/03	0900	8	7	0.244	3.10	3.34	0.34	1.76	5.11	0.21	76	19	897	156	167
5/9/03	1000	8	6	0.274	3.50	3.78	0.28	1.55	5.33	0.18	36	11	886	174	183
5/9/03	1100	8	7	0.310	3.78	4.09	0.32	1.81	5.90	0.19	46	9	936	167	188
5/9/03	1200	12	6	0.339	3.90	4.23	0.25	1.40	5.63	0.14	36	7	1021	170	208
Number		22	22	22	22	22	22	22	22	22	22	22	22	21	21
Min		7	5	0.018	0.51	0.53	0.25	1.12	1.69	0.14	36	7	117	22	20
Max		15	11	0.339	3.90	4.23	0.75	4.76	5.90	1.08	1293	112	1021	174	208
Median		9	7	0.059	1.02	1.09	0.51	2.49	4.03	0.46	151	26	398	67	77
Mean		10	7	0.108	1.59	1.70	0.50	2.48	4.18	0.46	334	39	484	89	93
Std Dev		2	2	0.101	1.14	1.24	0.14	0.80	1.14	0.24	363	30	276	50	58
CV (%)		22.3	23.7	93.6	71.6	72.9	28.5	32.3	27.3	53.0	108.7	75.7	57.0	56.9	61.9

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

SAMPLING AND ANALYTICAL DATA OF STORMWATER RUNOFF SAMPLES COLLECTED AT CENTRAL AVENUE STORM SEWER IN CRESTWOOD, ILLINOIS (ALL CONCENTRATIONS IN mg/L UNLESS OTHERWISE NOTED)

Date	Time Collected (military time)	BOD_5	$CBOD_5$	NO_2-N	NO_3-N	NO_2+NO_3-N	NH_3-N	TKN	TN	TP	TSS	VSS	Cond.* µmhos/cm	Alk*	Cl*
5/20/03	0030	33	22	0.000	0.58	0.58	0.09	2.84	3.42	0.60	320	79	175	37	37
5/20/03	0045	12	10	0.178	0.31	0.49	0.12	2.09	2.58	0.47	221	40	99	27	13
5/20/03	0100	16	10	0.138	1.20	1.34	0.16	3.74	5.08	0.79	558	63	572	79	113
5/20/03	0115	31	27	0.130	1.17	1.30	0.83	5.63	6.93	1.73	1534	168	584	333	126
5/20/03	0130	28	22	0.185	1.10	1.29	0.78	5.54	6.83	1.06	741	105	436	93	83
5/20/03	0145	21	15	0.041	0.78	0.82	0.64	4.15	4.97	0.73	272	44	371	67	71
5/20/03	0200	24	19	0.036	0.72	0.76	0.61	3.46	4.22	0.63	191	35	328	56	71
5/20/03	0215	20	17	0.036	0.75	0.78	0.53	3.16	3.94	0.55	163	32	357	55	70
5/20/03	0230	22	15	0.043	0.76	0.81	0.50	2.37	3.18	0.54	176	30	373	56	72
5/20/03	0300	20	15	0.043	0.83	0.87	0.47	2.78	3.65	0.49	97	7	400	60	78
5/20/03	0330	19	15	0.049	0.83	0.88	0.46	2.96	3.84	0.43	88	7	393	65	88
5/20/03	0400	16	19	0.067	0.82	0.89	0.40	3.08	3.97	0.44	73	3	426	72	95
5/20/03	0430	22	12	0.106	0.84	0.94	0.36	2.97	3.91	0.40	83	16	486	85	110
5/20/03	0500	14	11	0.072	0.93	1.00	0.32	2.83	3.83	0.38	18	1	564	86	117
5/20/03	0530	12	9	0.151	1.02	1.17	0.31	2.14	3.31	0.26	37	7	713	100	170
5/20/03	0600	10	9	0.219	1.18	1.40	0.27	1.97	3.37	0.31	39	2	820	118	213
Number		16	16	16	16	16	16	16	16	16	16	16	16	16	16
Min		10	9	0.000	0.31	0.49	0.09	1.97	2.58	0.26	18	1	99	27	13
Max		33	27	0.219	1.20	1.40	0.83	5.63	6.93	1.73	1534	168	820	333	213
Median		20	15	0.070	0.83	0.89	0.43	2.97	3.88	0.52	170	31	413	70	85
Mean		20	15	0.093	0.86	0.96	0.43	3.23	4.19	0.61	288	40	444	87	95
Std Dev		7	5	0.066	0.23	0.27	0.22	1.09	1.22	0.36	386	45	181	70	48
CV (%)		33.6	34.4	70.2	27.1	28.2	51.1	33.7	29.1	58.3	134.0	113.9	40.9	80.2	50.2

*Cond. stands for conductivity, Alk for alkalinity, and Cl for chloride.