Data and Methods of a 1999–2000 Street Sweeping Study on an Urban Freeway in Milwaukee County, Wisconsin

Prepared in cooperation with Wisconsin Department of Transportation

Open-File Report 03–93

U.S. Department of the Interior
U.S. Geological Survey

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By Robert J. Waschbusch

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Middleton, Wisconsin: 2003

U.S. Department of the Interior
U.S. Geological Survey

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Conversion Factors and Other Abbreviations

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
acre (A)	0.4047	hectare (ha)
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
liter (L)	0.2642	gallon
cubic foot (ft^3)	7.4805	gallon
acre-foot (acre-ft)	328,851	gallon
cubic foot per second-day	646,000	gallon
	Mass	
pound (lb)	0.0005	ton
gm (g)	1,000	milligram (mg)
gm (g)	0.00220	pound
	Flow	
cubic feet per second (ft^3/s)	448.8	gallons per minute

Other Abbreviations:

cfs	cubic feet per second
in/hr	inches per hour
in/yr	inches per year
mg/L	milligrams per liter
mg/g	milligrams per gram

Data and Methods of a 1999–2000 Street Sweeping Study on an Urban Freeway in Milwaukee County, Wisconsin

By Robert J. Waschbusch

Abstract

The Wisconsin Department of Transportation is required to control the quality of runoff from roadways under their control as part of the National Pollution Discharge Elimination System. One way to control roadway runoff is to use street sweeping to remove pollutants before they are entrained in runoff. This may be a good option because land is often unavailable or prohibitively expensive and structural best-management practices can also be expensive. This study collected stormwater runoff samples and dirt samples from the roadway surface from a section of Interstate Highway 894 near Milwaukee, Wisconsin during periods when a street sweeping program was and was not in effect. These data may be useful in evaluating street sweeping as a stormwater best management practice but this study did not perform this evaluation. Data collection methods, concentrations of sediment and other constituents in stormwater runoff, and street dirt masses are presented in this report. Replicate and comparison sample results indicate that when evaluating the effectiveness of best-management practices on highway runoff, suspended sediment results should be used rather than suspended solids, presumably because the particle sizes in highway runoff is large compared to those found in other types of stormwater runoff.

Introduction

The Wisconsin Department of Transportation (WDOT) is required to control the quality of runoff from roadways under their control as part of the National Pollution Discharge Elimination System (NPDES). One way to control roadway runoff is to use street sweeping to remove pollutants before they are entrained in runoff. This may be a good option because land is often unavailable or prohibitively expensive and structural Best Management Practices (BMPs) can also be expensive. If street sweeping were an effective method at reducing pollutants in runoff, WDOT may only need to obtain improved sweepers, increase the sweeping frequency or both. This study used a paired-basin design (Clausen and Spooner, 1993) to collect data to help evaluate effectiveness of an improved street sweeping program at reducing dirt and pollutants in runoff from an urban highway street surface.

The study area was a section of Interstate 894, west of Milwaukee, one of the busiest stretches of roadway in Wisconsin, where a test basin had the street-sweeping program implemented and a control basin did not. The two basins were located between National Avenue and Oklahoma Avenue with a 1,100-ft. long buffer section between them. The purpose of the buffer section was to allow vehicles entering each study basin to travel over pavement that had been either swept or not swept so that the dirt the vehicle “pulled” into the basin would be comparable to either swept or unswept conditions (fig. 1).

The average daily traffic count (ADT) during the study period was 64,900 in the eastbound direction and 69,000 in the westbound direction for a combined ADT of 133,900 in both basins. There are no entrance or exit ramps between the two basins and the concrete pavement, which was last resurfaced in the mid-1990s, was in good condition for pavement of this age. The concrete shoulders were installed in the late 1970s.

The test basin, which was between Oklahoma Avenue and Dakota Street, had a drainage area of 4.56 acres that was comprised of 4.31 acres of highway surface and 0.25 acres of grassy area (fig. 2). Of the highway surface 1.56, 2.67, and 0.08 were the shoulder, the driving lanes and the median, respectively.

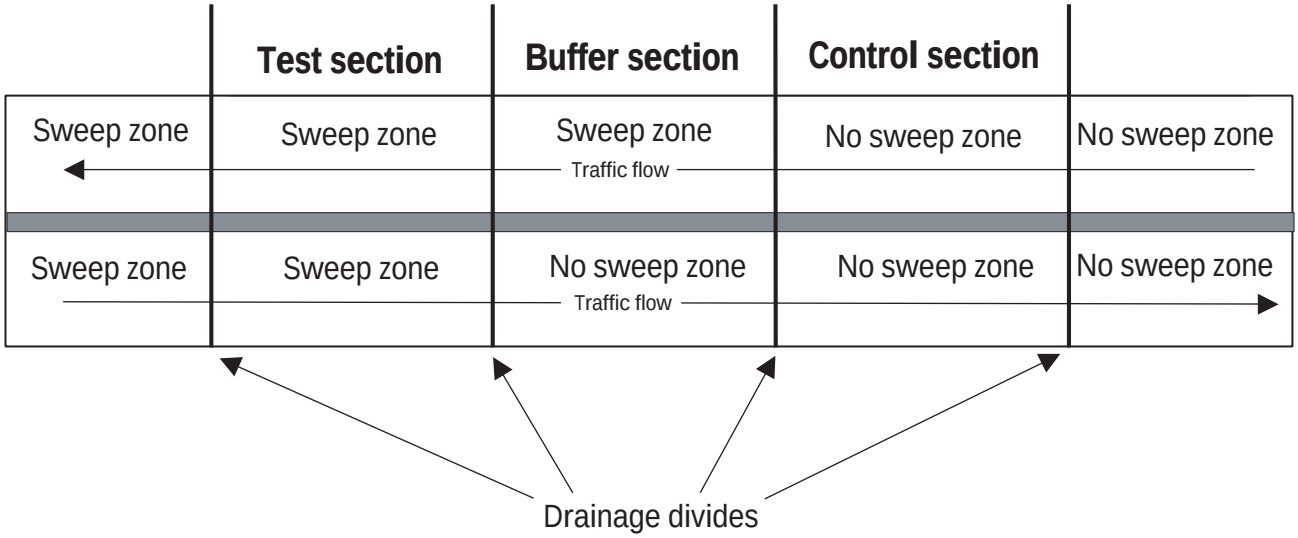

Figure 1. Diagram of study area.

The control basin, which was between National Avenue and Cleveland Avenue, had a drainage area of 5.51 acres that was comprised of 3.46 acres of highway surface and 2.05 acres of grassy area (fig. 2). Of the highway surfaces, 1.45, 1.95, and 0.06 were the shoulder, the driving lanes, and the median, respectively. The medians were not paved in either basin.

A Schwarze Industries Enviro Whirl EV2 street sweeper which combines mechanical sweeping with a vacuum was selected for the study. Because the street sweeper moved slowly, only the highway shoulders were swept. The outside shoulder was always swept with the Enviro Whirl sweeper; the inside shoulder was swept alternately with either this sweeper or with the mechanical non-vacuum type sweepers that Milwaukee County currently uses. The result of this sweeping protocol was that 34 percent of the test basin area was swept every week, with the Enviro Whirl sweeping 19.5 percent every week, and an additional 14.6 percent every other week.

Acknowledgments

The author thanks the City of Osceola, Wis., for use of the Enviro Whirl sweeper, Schwarze Industries for Enviro Whirl operation and maintenance training, Keith Ponath and the Milwaukee County Department of Public Works staff for operating the Enviro Whirl sweeper for the duration of the study, Mike Cape and Pat Klaggis of the Wisconsin Department of Transportation for their help with street dirt and runoff sample collection, Roger Bannerman of the Wisconsin Department of Natural Resources, and Roger Sutherland of Pacific Water Resources for their advice on the study design. Special thanks to the Wisconsin Department of Transportation for funding and support of this study.

Methods

Street Dirt Collection and Processing

Samples of street dirt were collected from the outside shoulders with a 6-in. wide wand attached to a 9-gal. wet-dry vacuum. During each sample collection, the wand was pulled from the curb to the edge of the traffic lane 24 times in each basin—12 times on the northbound shoulder and 12 times on the southbound shoulder; this method was based on the technique described by Pitt (1979) and Bannerman (1983). The street dirt samples were weighed, dried at 105°C and then reweighed. The samples were then sent to the University of Wisconsin Department of Geology Quaternary Laboratory in Madison, Wis., for sieving into 6.37–2.0 mm, 2.0–1.0 mm, 1–0.5 mm, 0.50–0.25 mm, 0.25–0.125 mm, 0.125–0.0625 mm, and <0.0625 mm size fractions. Two samples of the dirt collected by the Enviro Whirl street sweeper were also brought to the Wisconsin State Laboratory of Hygiene for Toxicity Characteristic Leachate Procedure (TCLP) analysis.

Vehicle Counts

Continuous-recording-traffic counters recorded 15-minute vehicle counts in both traffic directions at Cleveland Ave. (fig. 2). These data were summarized for runoff and sampling periods in appendix table A13.

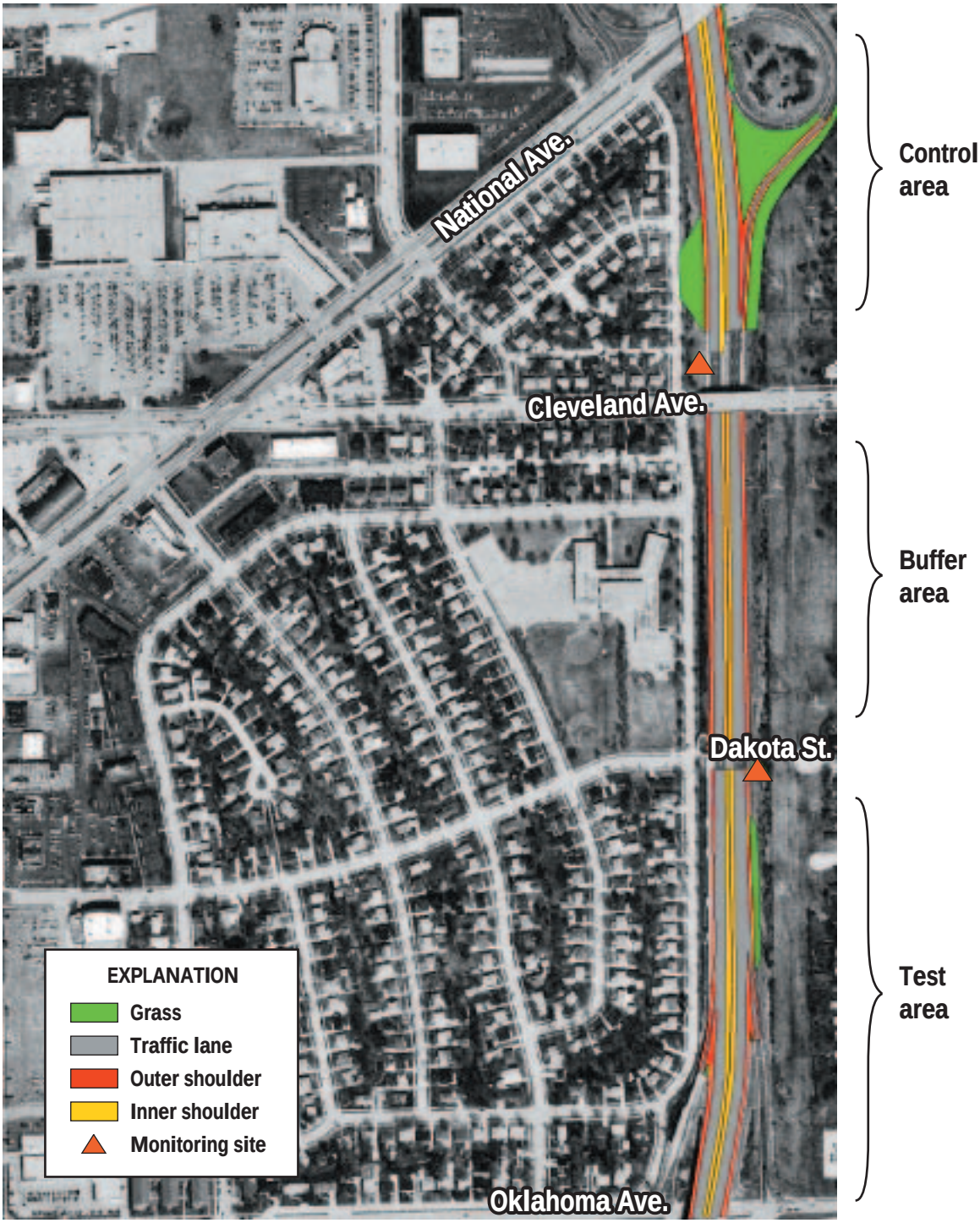

Figure 2. Study area with a GIS overlay detailing the test, control, and buffer areas.

Precipitation

Continuous-precipitation data was collected with a tipping-bucket-rain gage. A Campbell Scientific CR10 datalogger was used to record rainfall data. The rain gages used were not designed to measure snowfall so precipitation values from March 10–14, 1999 and December 14, 1999 to April 11, 2000 are probably inaccurate. On occasions when both study rain gages were not working, data was used from the Mitchell International Airport National Weather Service station, which is about 8 miles southeast of the study area. These periods are indicated in tables A5 and A6.

The precipitation data were compiled and various statistical summaries computed, which include total precipitation, maximum 15- and 30-minute intensities, antecedent dry time and erosivity index (Wischmeier and Smith, 1978) (tables A5 and A6).

Flow

Area-velocity-flow meters were the primary method used to measure runoff flow in the pipes that drained the study basins. A probe was mounted at the bottom of the pipes to measure water level and velocity. The probes at both sites measured velocity by using Doppler-type technology. Water level was measured at the control site by use of a bubbler-type probe and at the test site with the use of a submerged pressure transducer-type probe. In addition to area-velocity probes, an independent bubbler-stage sensor was installed in the pipes as a back up and for verification of the water-level measurement.

In early July 2000, the flow meter at the test site quit operating and did not resume operation. To calculate the flow for this period (July 2000 to September 2000), the stages from the independent bubbler sensor were used. During periods of high flow, the stages from the bubbler displayed significant drawdown (that is, the stage readings were lower than they should have been due to high velocities). Consequently, when drawdown appeared to be a problem, the stages from the control site were used to estimate the stages at the test site.

During the study period, the data showed that the two sites were giving significantly different flow rates for the same events. The mean percentage of rainfall that was measured as runoff from the test site was 62 percent and from the control site was only 28 percent (see results section). One explanation for this difference is that the drainage area of the test site was only 5 percent grass and 93 percent paved while the control site drainage area was 37 percent grass and 62 percent paved. In addition, some of the runoff discrepancy may be due to the different type of flowmeters employed. A submerged pressure transducer was used to determine stage in the pipe at the test site whereas the control site used a bubbler-type transducer. However, because the runoff volume used to trigger sub-samples was set independently at each site, the difference in measured flow rates was accounted for in the sampling and the discrepancy in measured runoff values did not affect the flow-composite sampling.

Several steps were taken to achieve the most accurate flow estimate possible. Velocity data from the Doppler probes frequently showed periods where data were unreliable, whereas the stage data appeared reliable for most periods. Therefore, stage-discharge relationships were determined because they eliminated the need to use unreliable velocity data. The stage-discharge relationships were developed by eliminating periods where the velocity data were questionable and fitting a best-fit curve through a scatter plot of the remaining stage versus discharge data. To make the ratings more accurate, at the end of the study, an independent flow meter with a different velocity-measurement technology (electromagnetic) was installed at the test site to collect data from a few events. These data were limited, but confirmed the rating at several points. Because the rating agreed with the limited data available, the rating seemed reasonable. Once the stage-discharge relationships were finalized, event discharges were computed and are presented in results tables.

Runoff Sampling

Flow composite water-quality samples were collected with refrigerated automatic-point samplers and analyzed for the constituents listed in table 1. These samples were initiated by the station datalogger based on flow rates. Samples were collected in a manner that resulted in flow-composite samples. Flow-composite sampling yields a single sample, which when analyzed, results in a single event mean concentration (EMC), which represents the concentration of the entire runoff event.

Only suspended solids, suspended sediment, total copper, and total zinc were analyzed for every event. The remaining constituents were analyzed for about one-quarter of the events.

Table 1. Constituents analyzed in samples of runoff, Interstate 894, Milwaukee County, Wisconsin

[$NO_2 + NO_3$, nitrate + nitrite; USGS – ISL, U.S. Geological Survey - Iowa Sediment Laboratory; WSLH, Wisconsin State Laboratory of Hygiene; EPA (1979); and SM, Standard Methods, American Public Health Association and others, 1989; Guy (1969)]

Constituent	Laboratory	Method or reference
Chemical oxygen demand	WSLH	EPA 410.4
Ammonia-nitrogen	WSLH	SM4500H
$NO_2 + NO_3$	WSLH	SM4500F
Total phosphorus	WSLH	SM4500PB
Dissolved phosphorus	WSLH	SM4500PF
Suspended solids	WSLH	SM2540D
Total dissolved solids	WSLH	SM2540C
Chloride	WSLH	SM4500CL
Total recoverable copper	WSLH	EPA 200.9
Dissolved copper	WSLH	SM3113B
Total recoverable zinc	WSLH	EPA 200.9
Dissolved zinc	WSLH	SM3113B
Suspended sediment	USGS - ISL	Guy (1969)
Particle-size analyses		
Sand-silt split	USGS - ISL	Guy (1969)
Visual accumulation tube	USGS - ISL	Guy (1969)
Sedigraph	USGS - ISL	Guy (1969)

Construction Effects on the Data

In May of 1999, construction began in the freeway right-of-ways in the study area. Most of the construction was in the buffer section but it did reach into the test and control sections. As a result, there was additional dirt on the road surfaces until the vegetation was reestablished (fig. 3). The constituent concentrations from this period, events 5, 6, and 7 (tables A7 and A8), appeared unusually high so data from these events were not included in the statistical summary calculations.

Freeway Median Runoff

Near the end of the project an attempt was made to gather information to assess the effects of the area between the center Jersey barriers. A 1-ft-long piece of 8-in.-diameter plastic pipe was cut in half lengthwise and installed at a median inlet to act as a trough where an automatic water-quality sampler with 24 discrete sample collection bottles was also installed to collect runoff samples. A tarp was mounted 6 inches above the inlet grate to prevent rain from falling directly onto the trough. The sampler was interfaced with the datalogger so that a sample was triggered at both the station and median samplers concurrently. The median samples were analyzed for total suspended solids and the amount of water in the various sample bottles was noted. The amount of water in the sample bottles was used to try to estimate the timing and volume of runoff from the median.

Quality Assurance/Quality Control

Quality assurance/quality control samples were collected from the automatic water-quality samplers and processed identically to event samples, as detailed in Corsi and others, 1995. Four blank samples were collected from each site during the monitoring period. Each blank sample was analyzed for the same constituents as the runoff samples (table 1). The blank samples were used to evaluate the integrity of the runoff samples, to identify whether sample contamination existed, and if so, to identify possible sources of sample contamination. In addition to blank samples, several replicate analyses were performed. Results from these blank and replicate analyses can be found in appendix tables A10–A12.

The rain gages were also calibrated four times during the study by slowly dripping a known volume of water through the gages using a rain-gage calibrator, and comparing the volume recorded to the actual volume. The rain gages were then adjusted to record the correct volume.

At the end of the sample-collection period, the quality of the individual event sample collections were assessed based on event coverage, missed samples, autosampler performance, and other similar factors. After this assessment, results from samples 22, 34, 41, 42, and 47 were eliminated from the statistical summary calculations because the quality of the sampling may have been poor.

Results

Street Dirt

Data from the street dirt vacuuming and sieving are presented in appendix tables A1 and A2. Table A3 shows particle-size data from dirt collected by the Enviro Whirl. Changes in dirt mass on the street surfaces before and after sweeping are plotted in figures 4 and 5. At the test site the mass of dirt on the street decreased by 25 percent on average (n=9). At the control site the mass of dirt on the street on the

Figure 3. Example of dirt and gravel from utility construction on highway shoulder.

same collection dates as the test site (but no street sweeping) increased 160 percent on average (n=9).

Results from the Toxicity Characteristic Leachate Procedure (TCLP) analysis of the street dirt collected by the Enviro Whirl are in appendix table A4.

Precipitation and Runoff Data for Sampled Events

Precipitation and runoff data for sampled events are listed in tables 2 and 3.

Precipitation Data for Unsampled Events

Precipitation data for the entire study period including unsampled events are listed in appendix tables A5 and A6.

Concentrations and Particle-Size Data

Constituent concentrations and particle-size data in runoff are in appendix tables A7–A9. Summary statistics for runoff concentrations at the test and control sites for the sweeping and non-sweeping periods are presented in table 4.

Suspended Solids Versus Suspended Sediment

After viewing the data (fig. 6) and consulting the report by Gray and others (2000) it was determined that analysis of this study data should use suspended sediment (S. Sed.) rather than suspended solids (TSS). These two parameters are similar in that they measure the mass of particles in water, however the laboratory analysis methods are different. It appears that the suspended solids analysis does not work well for samples with large particles, which results in concentrations that are biased low. The difference in the analysis methods may be particularly important when viewing roadway-runoff data because of the prevalence of larger-sized particles, which appear to accentuate the differences in results between the two constituents.

Sediment Replicate Results

Thirty-two replicate sediment analyses were performed during this study. The average difference between these replicates was 46 percent with a standard deviation of 50 percent (appendix table A10). Two possible explanations for this variability are: (1) that the churn splitter used to subsample the whole-water sample into separate bottles for

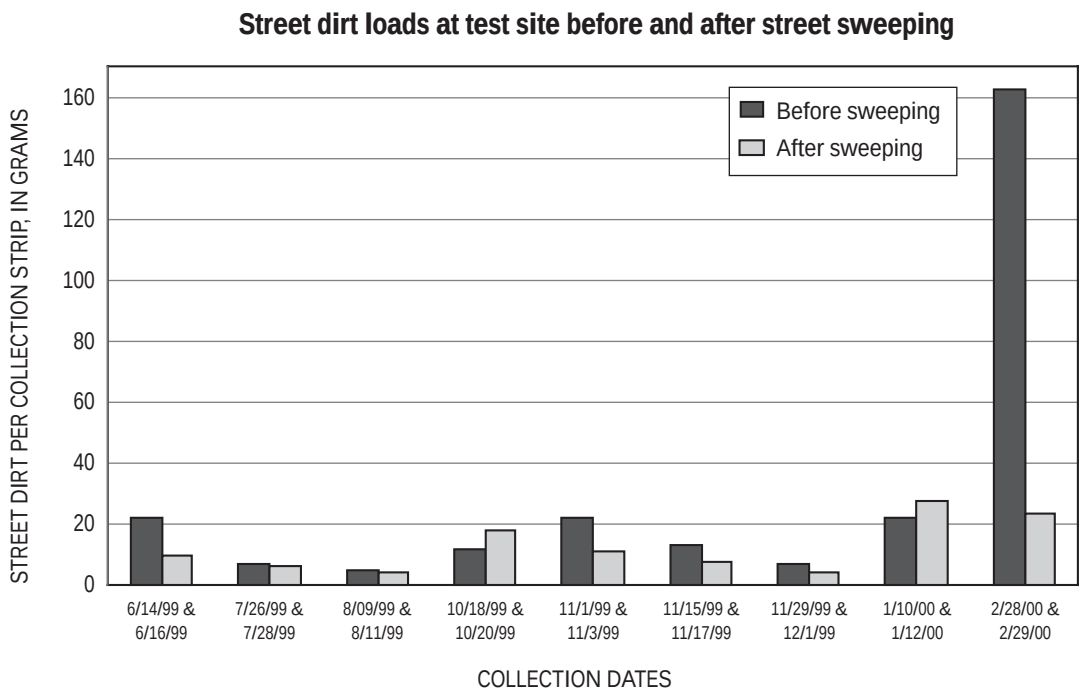

Figure 4. Street dirt loads at test site before and after street sweeping.

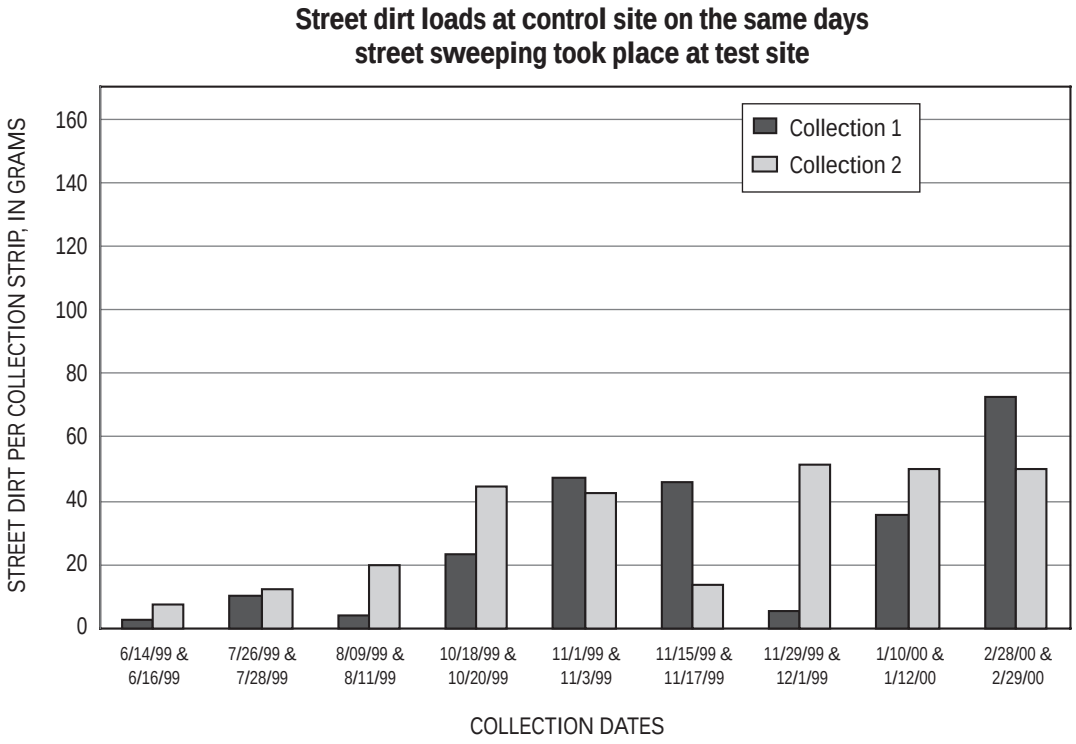

Figure 5. Street dirt loads at control site on the same days street sweeping took place at test site.

Table 2. Summaries of event runoff from test site, Interstate 894, Milwaukee County, Wisconsin

[in., inches; ft^3, cubic feet; ft^3/s, cubic feet per second]

Event number	Date	Total precipitation (in.)	Runoff volume during storm (ft^3)	Peak runoff during storm (ft^3/s)	Runoff volume during sampling (ft^3)	Peak runoff during sampling (cfs)	Percent runoff	Percent sampled
1	03/11/99	snowmelt	743	0.021	743	0.021	--	100
2	04/11/99	.26	734	.253	734	.253	17	100
3	04/16/99	.26	1,270	.059	1,253	.059	30	99
4	04/21/99	.95	3,871	1.092	3,836	1.092	25	99
5	05/21/99	.17	2,004	1.092	1,452	1.092	71	72
6	05/23/99	.50	4,830	5.944	3,715	5.944	58	77
7	06/10/99	1.17	11,448	8.782	11,189	8.782	59	98
8	06/16/99	.16	1,901	.846	1,685	.846	72	89
9	06/23/99	.15	1,279	.846	985	.846	52	77
10	06/28/99	.83	5,201	5.432	4,847	5.432	38	93
11	07/06/99	.09	518	.846	458	.846	35	88
12	07/09/99	2.45	28,140	15.526	26,196	15.526	69	93
13	07/16/99	1.26	17,038	2.286	16,623	2.286	82	98
14	07/21/99	1.85	16,537	12.282	16,088	12.282	54	97
15	07/31/99	.31	3,050	2.909	2,523	2.909	59	83
16	08/07/99	.32	2,946	1.395	2,756	1.395	56	94
17	08/10/99	.22	2,056	3.972	1,961	3.972	56	95
18	08/18/99	.55	7,309	1.092	6,869	1.092	80	94
19	08/23/99	.24	2,411	2.286	2,281	2.286	61	95
20	09/19/99	.50	4,821	8.537	4,562	8.537	58	95
21	09/27/99	.13	1,356	.618	1,192	.618	63	88
22	09/27/99	2.36	20,624	2.198	19,051	2.198	53	92
23	10/03/99	.57	7,448	1.092	7,214	1.092	79	97
24	10/16/99	.29	4,242	.846	4,035	.846	88	95
25	11/10/99	.49	5,003	3.229	4,864	3.229	62	97
26	11/23/99	.21	3,361	1.595	3,007	1.595	97	89
27	11/23/99	.12	924	.846	665	.846	47	72
28	12/14/99	snowmelt	1,452	.149	1,287	.149	--	89
29	01/03/00	snowmelt	6,299	.105	5,495	.105	--	87
30	02/18/00	snowmelt	9,469	.086	9,314	.086	--	98
31	02/21/00	snowmelt	3,335	.105	3,257	.105	--	98
32	02/24/00	snowmelt	5,581	.846	5,357	.846	--	96
33	04/07/00	snowmelt	10,040	1.595	10,040	1.595	--	100
34	05/09/00	1.13	9,167	1.699	5,538	1.699	49	60
35	05/17/00	1.70	7,914	3.744	7,370	3.744	28	93
36	06/01/00	.38	5,383	5.944	5,244	5.944	86	97
37	06/04/00	.46	8,389	2.103	8,389	2.103	110	100
38	06/14/00	.36	2,843	7.577	2,808	7.577	48	99
39	06/20/00	.21	2,497	3.858	2,281	3.858	72	91
40	07/28/00	1.74	13,997	4.427	13,789	4.427	49	99
41	08/05/00	2.61	29,212	4.785	10,765	4.785	68	37
42	08/17/00	2.17	26,473	3.435	3,612	2.802	74	14
43	08/17/00	.06	622	.069	622	.069	63	100
44	08/26/00	.84	5,556	12.157	5,521	12.157	40	99
45	09/07/00	.21	2,886	2.286	2,376	2.286	83	82
46	09/10/00	.48	5,910	4.006	5,841	4.006	74	99
47	09/14/00	.86	15,180	1.894	9,435	1.806	107	62
48	09/19/00	.42	6,134	.846	5,918	.846	88	96
OKM-11	09/22/00	.89	--	--	--	--	--	--
						mean	62	
						standard deviation	21	

Table 3. Summaries of event runoff from control site, Interstate 894, Milwaukee County, Wisconsin

[in., inches; ft^3, cubic feet; ft^3/s, cubic feet per second]

Event number	Date	Total precipitation (in.)	Runoff volume during storm (ft^3)	Peak runoff during storm (ft^3/s)	Runoff volume during sampling (ft^3)	Peak runoff during sampling (cfs)	Percent runoff	Percent sampled
1	03/11/99	snowmelt	1,638	0.0334	1,552	0.0334	--	95
2	04/11/99	.26	1,486	.827	1,339	.827	29	90
3	04/16/99	.22	804	.1002	648	.1002	18	81
4	04/21/99	.89	5,625	1.436	5,417	1.436	32	96
5	05/21/99	.15	467	.1986	337	.1986	16	72
6	05/23/99	.20	2,316	3.17	2,316	3.17	58	100
7	06/10/99	1.07	5,219	3.56	4,899	3.56	24	94
8	06/16/99	.13	467	.2502	302	.2502	18	65
9	06/23/99	.14	510	.573	423	.573	18	83
10	06/28/99	.75	4,380	4.134	4,173	4.134	29	95
11	07/06/99	.10	372	1.0148	130	.7254	19	35
12	07/09/99	2.14	13,116	5.61	11,241	5.61	31	86
13	07/16/99	1.09	6,618	1.862	6,342	1.862	30	96
14	07/21/99	1.51	9,245	6.35	8,044	6.35	31	87
15	07/31/99	.28	1,555	1.862	1,339	1.862	28	86
16	08/07/99	.32	1,901	1.686	1,719	1.686	30	90
17	08/10/99	.22	1,236	2.576	1,115	2.576	28	90
18	08/18/99	.58	4,044	1.95	3,923	1.95	35	97
19	08/23/99	.20	890	.573	544	.1986	22	61
20	09/19/99	.58	3,750	5.25	3,542	5.25	32	94
21	09/27/99	.13	804	.2502	622	.2502	31	77
22	09/27/99	2.16	17,366	2.46	15,587	2.46	40	90
23	10/03/99	.54	2,091	.3408	1,909	.3408	19	91
24	10/16/99	.30	1,331	.7762	1,227	.7762	22	92
25	11/10/99	.50	3,110	3.69	2,791	3.69	31	90
26	11/23/99	.22	769	.57	752	.57	17	98
27	11/23/99	.12	458	.6746	320	.6746	19	70
28	12/14/99	snowmelt	717	.0746	458	.0746	--	64
29	01/03/00	snowmelt	2,100	.0874	1,970	.0874	--	94
30	02/18/00	snowmelt	959	.0282	708	.023	--	74
31	02/21/00	snowmelt	916	.0386	829	.0386	--	91
32	02/24/00	snowmelt	1,814	.4114	1,650	.4114	--	91
33	04/07/00	snowmelt	2,125	.1344	2,074	.1344	--	98
34	05/09/00	.80	4,380	.6746	2,765	.6746	27	63
35	05/17/00	1.70	5,504	3.17	5,426	3.17	16	99
36	06/01/00	.38	5,115	2.358	4,571	2.358	67	89
37	06/04/00	.46	3,300	.5326	3,205	.5326	36	97
38	06/14/00	.33	1,521	2.576	916	2.358	23	60
39	06/20/00	.24	1,313	2.576	1,011	2.576	27	77
40	07/28/00	1.74	9,046	2.808	8,104	2.808	26	90
41	08/05/00	2.61	18,559	3.56	2,350	3.56	36	13
42	08/17/00	2.17	14,403	2.154	2,039	1.95	33	14
43	08/17/00	.07	389	.07	389	.07	28	100
44	08/26/00	.84	3,067	4.134	2,730	4.134	18	89
45	09/07/00	.27	1,175	1.686	942	1.598	22	80
46	09/10/00	.48	2,704	2.692	2,385	2.692	28	88
47	09/14/00	.84	5,115	2.256	2,609	.5326	30	51
48	09/19/00	.47	1,754	.1344	1,477	.1344	19	84
						mean	28	
						standard deviation	10	

Table 4. Summary statistics for runoff concentrations at the test and control sites during sweeping and non-sweeping periods

[when two concentrations were available due to replicate sampling, the average was used; events 5, 6 & 7 eliminated due to construction activities; events 34, 41, 42 & 47 eliminated due to poor sampling; n, number of sample results used to compute statistics; mg/L, milligrams per liter; µg/L, micrograms per liter; Dis., Dissolved; COD, Chemical Oxygen Demand; TSS, Total Suspended Residue; S. Sed., Total Suspended Sediment; NH_3, ammonia; org. N, organic nitrogen; NO_2 + NO_3, nitrate + nitrite; Ca, Calcium; Mg, magnesium; Cl, chloride; Cu, copper; Zn, zinc; P, phosphorus; Cd, cadmium; Pb, lead]

	Test site summary statistics											
	Non-sweeping periods						Sweeping periods					
Constituent	n	Mean	Median	Geomean	Standard deviation	Coefficient of variation	n	Mean	Median	Geomean	Standard deviation	Coefficient of variation
COD (mg/L)	5	49.2	50.0	47.8	13.4	0.27	5	158.1	97.0	120.7	153.4	0.97
Total Solids (mg/L)	2	923.0	923.0	658.3	-	-	5	2,551.4	3,090.0	1,436.7	2,162.1	.85
TSS (mg/L)	19	196.8	95.0	117.4	272.8	1.39	22	259.8	211.0	204.7	185.7	.71
S. Sed (mg/L)	16	564.7	228.0	284.8	782.3	1.39	22	669.1	358.0	366.6	838.7	1.25
Diss. NH_3 (mg/L)	5	.5	.4	.4	.3	.60	5	.7	.6	.6	.3	.50
Total NH_3 + org. N (mg/L)	5	1.3	1.1	1.2	.5	.41	5	1.6	1.5	1.5	.5	.32
Diss. NO_2+NO_3 (mg/L)	5	.8	.4	.6	.8	.95	5	.7	.7	.7	.1	.16
Total P (mg/L)	5	.2	.2	.2	.1	.41	5	.3	.3	.2	.3	.85
Diss. Ortho-P (mg/L)	5	.0	.0	.0	.0	1.10	5	.1	.1	.0	.0	.72
Total Ca (mg/L)	5	106.6	39.0	52.4	164.3	1.54	5	78.6	44.0	61.8	63.1	.80
Total Mg (mg/L)	5	50.0	12.0	21.3	83.9	1.68	5	23.6	16.0	17.9	22.5	.95
Diss. Cl (mg/L)	11	438.5	39.5	68.8	1,002.6	2.29	8	2,013.9	860.0	272.1	3,332.8	1.65
Diss. Cu (mg/L)	5	9.6	7.3	8.6	5.9	.62	5	119.4	17.0	46.1	175.2	1.47
Diss Zn (µg/L)	5	24.6	21.0	22.3	13.2	.54	5	411.4	64.0	115.8	633.1	1.54
Total Zn (µg/L)	19	319.8	230.0	253.3	263.3	.82	22	415.5	345.0	367.0	270.3	.65
Total Cd (µg/L)	5	1.0	.6	.8	.7	.74	5	2.4	1.6	1.6	2.5	1.04
Total Pb (µg/L)	5	68.6	35.0	45.5	79.9	1.17	5	77.9	38.0	50.0	96.6	1.24
Total Cu (µg/L)	19	69.5	61.0	60.1	43.0	0.62	22	88.4	70.0	74.3	78.4	.89
Total Hardness (µg/L)	5	469.4	170.0	222.3	744.7	1.59	5	292.0	180.0	229.8	243.2	.83

Table 4. Summary statistics for runoff concentrations at the test and control sites during sweeping and non-sweeping periods—Continued

[when two concentrations were available due to replicate sampling, the average was used; events 5, 6 & 7 eliminated due to construction activities; events 34, 41, 42 & 47 eliminated due to poor sampling; n, number of sample results used to compute statistics; mg/L, milligrams per liter; µg/L, micrograms per liter; Dis., Dissolved; COD, Chemical Oxygen Demand; TSS, Total Suspended Residue; S. Sed., Total Suspended Sediment; NH_3, ammonia; org. N, organic nitrogen; $NO_2 + NO_3$, nitrate + nitrite; Ca, Calcium; Mg, magnesium; Cl, chloride; Cu, copper; Zn, zinc; P, phosphorus; Cd, cadmium; Pb, lead]

	Control site summary statistics											
	Non-sweeping periods						Sweeping periods					
Constituent	n	Mean	Median	Geomean	Standard deviation	Coefficient of variation	n	Mean	Median	Geomean	Standard deviation	Coefficient of variation
COD (mg/L)	5	49.0	45.0	48.3	9.62	0.20	5	148.9	110.0	119.9	125.76	0.84
Total Solids (mg/L)	5	346.0	152.0	220.7	444.25	1.28	5	2,474.2	3,270.0	1,625.0	1,790.07	.72
TSS (mg/L)	18	107.8	91.0	85.3	69.21	.64	22	193.3	135.0	163.9	146.35	.76
S. Sed (mg/L)	18	190.1	104.5	114.4	242.94	1.28	22	362.8	248.8	232.8	376.04	1.04
Diss. NH_3 (mg/L)	5	.5	.5	.5	.14	.28	5	.6	.8	.3	.44	.76
Total NH_3 + org. N (mg/L)	5	1.3	1.2	1.2	.34	.27	5	1.5	1.9	1.4	.67	.44
Diss. NO_2+NO_3 (mg/L)	5	.7	.5	.6	.57	.77	5	.8	.8	.8	.22	.27
Total P (mg/L)	5	.1	.1	.1	.04	.32	5	.3	.2	.3	.22	.72
Diss. Ortho-P (mg/L)	5	.0	.0	.0	.01	.37	5	.0	.0	.0	.01	.82
Total Ca (mg/L)	5	31.2	29.0	25.9	22.52	.72	5	79.5	49.0	66.5	53.96	.68
Total Mg (mg/L)	5	13.3	13.0	11.1	9.08	.68	5	24.7	21.0	20.8	16.67	.68
Diss. Cl (mg/L)	12	511.9	36.3	56.9	1476.43	2.88	9	2,086.0	56.4	247.0	4,188.05	2.01
Diss. Cu (mg/L)	5	9.9	8.0	9.2	4.61	.47	5	151.2	22.0	49.0	263.54	1.74
Diss Zn (µg/L)	5	25.4	21.0	24.4	8.44	.33	5	398.1	110.0	155.7	624.13	1.57
Total Zn (µg/L)	18	212.6	185.0	186.6	116.72	.55	22	367.3	285.0	310.2	285.24	.78
Total Cd (µg/L)	6	28.8	.5	1.4	69.18	2.40	5	2.4	2.0	1.8	2.16	.91
Total Pb (µg/L)	5	25.6	26.0	25.2	5.13	.20	5	80.4	42.0	54.3	90.40	1.12
Total Cu (µg/L)	18	56.8	56.0	50.5	30.20	.53	22	103.7	79.5	81.9	118.53	1.14
Total Hardness (µg/L)	6	118.0	97.0	93.6	92.73	.79	5	298.0	210.0	251.8	202.16	.68

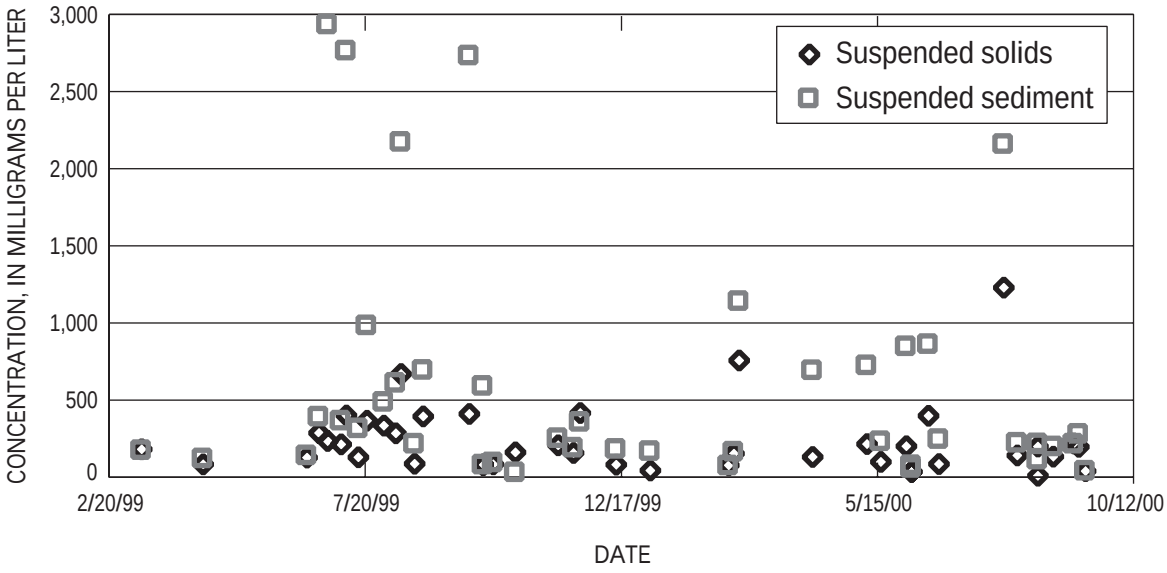

Figure 6. Suspended solids versus suspended sediment at the test site.

various analyses was not mixing the sediment sufficiently, and (2) variability in the laboratory analyses. The USGS has done a series of tests on the churn splitter and found that it performs well as long as the suspended-sediment concentration and particle-size distribution in the water is within certain ranges (Horowitz and others, 1997). Specifically, the suspended-sediment concentration must be less than 1,000 mg/L and the particle sizes must be less than 250 mm. Many of the samples from this study had particle sizes that exceeded the recommended particle size for the churn splitter and a few had suspended-sediment concentrations over 1,000 mg/L. These factors probably contributed to the problem, however, there were several samples where the particle size and concentration were within the churn splitters acceptable range yet the replicate results were poor. These results seem to indicate that there may have been problems in the lab analysis as well. Complete QA/QC results are found in appendix tables A10–A12. The large variability seen in the replicates will make detecting changes in runoff concentrations due to the sweeping program very difficult to detect.

Vehicle Counts

Vehicle-count data varies between the test and control sites only because of runoff and sampling times. The vehicle count data set was the same for both sites, but the summation periods differed according to runoff and sampling periods in each basin. As expected for data derived in this manner, the numbers of vehicles traveling on the freeway during the runoff and sampling events were similar between the sites, but occasionally vehicle numbers differed greatly possibly due to construction activities. Vehicle-count data are in appendix table A13.

Freeway Median Contribution

The highway median comprised 1.8 percent of the drainage area in the test basin and 1.0 percent in the control basin. The concentration results and the amount water collected in the sample bottles are listed in appendix tables A14 and A15.

Summary

The data collected in this study can be used to evaluate if the improved street sweeping program improves runoff quality enough to justify the additional effort and cost. Several factors need to be considered when the data from this study is used for this purpose.

The particle-size data from the control and test sites indicate that the highway runoff has larger particles than those typically seen at other USGS sites. These larger particle sizes probably contributed to the high replicate variability observed. High replicate variability makes detecting reductions in suspended-sediment concentrations very difficult.

Samples were collected for this study while utility construction occurred in the grassy right-of-way areas in the study area. Construction began on May 1, 1999, and runoff concentration and street dirt data collected from that date until about June 10, 1999 appeared high and were not included in the statistical summary (table 4) but are included in the appendix.

The small size and mostly impervious area of the study area made collection of acceptable runoff samples difficult due to the rapid response of the hydrograph to rainfall. This factor further reduced the number of data points available for analysis. During data compilation for this report, the adequacy of individual event samples was evaluated. This evaluation resulted in the concentration results from several events being excluded from the statistical summary (table 4). These events are noted in table 4 and the results are listed in the appendix.

The highway medians were not treated in any way, contained several inches of dirt, and had several inlets to the storm drainage system. The suspended solids concentrations in runoff from the highway medians were quite high (tables A13 and A14) indicating that the medians could have had a disproportionately large impact on the concentrations seen at the study sites.

Because of the slow speed of the Enviro Whirl sweeper, only the shoulders and not the traffic lanes could be swept. In addition, it was necessary to use a truck and trailer to get the sweeper to the inside shoulder of the freeway safely. This operation was cumbersome, thus the inside shoulder was swept with the Enviro Whirl only every other week. On alternate weeks, the inner shoulder was swept with the mechanical sweepers used currently by Milwaukee County. The result of this is that every other week only about half of the potentially treatable street surface was swept by the Enviro Whirl.

At the end of the study there were some questions regarding the condition of the Enviro Whirl sweeper. Apparently some brushes were installed incorrectly and some of the filters were not working properly. At a meeting of the participating parties, it was decided that most likely these problems occurred after the conclusion of the study. From direct observations of the sweeper performance, it did not seem to be performing as well as expected. Dirt piles and debris were noted on surfaces immediately after the sweeper had passed over them. Whether this performance was to be expected or was poor due to the pavement condition, dirt type, dirt location, sweeper problems or some other reason(s) is undetermined.

Because of the issues of high variability in replicate samples of suspended solids, limited data, highway median contribution, limited area swept, and possible sweeper problems, showing the benefit of the sweeping program in improving water quality running off the highway may prove difficult.

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APPENDIXES A1–A15

Table A1. Street dirt collected by vacuum sampling at the test site, Interstate 894, Milwaukee County, Wisconsin

[mm, millimeter; shaded areas indicate the sweeping period; --, no data; The mass of dirt collected per single pull of the vacuum wand from the edge of the shoulder nearest the traffic lane to the curb.]

Date	Street dirt per collection swipe (grams)	Percentage street dirt in size fractions by mass							
		>6.37 (mm)	6.37–2.0 (mm)	2.0–1.0 (mm)	1.0–0.5 (mm)	0.5–0.25 (mm)	0.25–0.125 (mm)	0.125–0.0625 (mm)	<0.0625 (mm)
04/01/99	50.52	5.34	12.17	10.98	16.33	26.14	20.04	4.92	4.08
04/13/99	27.71	7.5	14.75	9.37	14.85	23.49	18.14	5.98	5.92
04/21/99	14.67	12.74	22.64	11.68	12.96	18.09	15.35	3.96	2.57
04/29/99	18.33	3.58	29.67	13.55	17.3	20.42	11.09	3.28	1.12
06/14/99	22.00	7.80	13.20	11.95	17.64	24.61	18.27	4.97	1.56
06/16/99	9.42	11.86	21.25	10.27	13.65	21.76	14.96	4.48	1.77
06/30/99	8.42	14.31	16.28	10.11	14.22	21.58	16.57	5.34	1.59
07/26/99	7.21	26.9	23.06	11.00	12.65	14.44	8.79	2.49	0.67
07/28/99	6.38	39.27	16.91	7.68	8.79	12.3	9.51	3.93	1.6
08/09/99	4.96	13.75	19.81	13.49	16.61	19.8	10.29	3.89	2.36
08/11/99	3.88	24.52	20.34	10.43	11.14	14.6	11.26	5.2	2.51
08/25/99	10.71	12.96	14.92	9.51	18.74	24.11	12.5	4.14	3.12
09/01/99	9.71	17.37	15.22	9.5	15.09	21.91	14	4.79	2.11
09/10/99	16.75	14.28	19.23	13.05	16.4	20.14	12.05	3.34	1.5
09/13/99	9.71	28.4	14.94	11.39	14.52	16.29	9.85	3.08	1.53
09/20/99	3.92	20.12	16.49	12.14	14.05	18.53	14.53	3.58	.56
09/29/99	17.88	15.09	14.25	12.09	17.96	23.09	12.79	3.23	1.5
10/18/99	11.63	19.4	17.65	13.29	17.38	17.79	9.46	3.15	1.88
10/20/99	17.67	15.84	18.92	13.93	16.88	18.43	10.33	3.34	2.33
11/01/99	21.79	20.64	17.81	10.8	15.07	18.94	9.61	3.49	3.64
11/03/99	11.00	23.88	16.30	9.13	13.98	18.85	11.18	4.03	2.66
11/15/99	12.92	11.38	15.88	14.87	19.00	22.29	10.97	3.37	2.25
11/17/99	7.38	15.02	18.10	12.99	16.50	20.53	11.23	3.86	1.77
11/29/99	6.54	12.78	19.30	16.76	19.62	18.66	9.08	2.68	1.12
12/01/99	4.29	12.87	16.29	10.30	13.11	18.69	13.31	6.20	9.22
12/27/99	13.88	13.16	26.42	21.01	16.11	14.48	6.08	1.68	1.05
01/10/00	22.21	12.78	21.80	18.71	23.98	19.03	2.93	.31	.46
01/12/00	27.71	5.50	8.67	11.75	19.07	29.45	15.16	6.48	3.92
01/24/00[1]	8.21	--	--	--	--	--	--	--	--
01/31/00[1]	62.21	--	--	--	--	--	--	--	--
02/01/00	7.58	13.39	20.55	11.35	10.70	18.69	13.97	6.77	4.59
02/28/00	162.58	1.96	7.69	9.06	27.83	32.38	14.21	4.89	1.99
02/29/00	23.63	7.46	12.54	10.52	17.35	23.54	16.37	8.81	3.42
03/13/00	14.42	9.80	16.31	12.52	18.19	22.89	11.80	5.29	3.20
03/27/00	25.58	10.20	11.78	10.26	19.35	27.78	13.58	4.30	2.75
04/03/00	27.08	9.04	14.09	9.72	15.55	25.44	14.88	6.42	4.87

Table A1. Street dirt collected by vacuum sampling at the test site, Interstate 894, Milwaukee County, Wisconsin—Continued

[mm, millimeter; shaded areas indicate the sweeping period; --, no data; The mass of dirt collected per single pull of the vacuum wand from the edge of the shoulder nearest the traffic lane to the curb.]

Date	Street dirt per collection swipe (grams)	Percentage street dirt in size fractions by mass							
		>6.37 (mm)	6.37–2.0 (mm)	2.0–1.0 (mm)	1.0–0.5 (mm)	0.5–0.25 (mm)	0.25–0.125 (mm)	0.125–.0625 (mm)	<0.0625 (mm)
04/14/00	43.96	11.33	21.22	14.87	16.32	18.25	11.15	4.01	2.84
04/18/00	62.54	8.58	14.12	13.79	20.24	23.86	12.49	4.48	2.43
04/24/00	37.13	7.73	10.50	12.38	21.42	28.41	13.91	3.52	2.13
05/05/00	111.92	6.20	10.44	10.69	18.88	28.78	17.85	4.34	2.83
05/15/00	7.58	17.03	13.31	7.38	15.06	25.46	15.34	4.50	1.92
06/07/00	293.38	5.71	10.42	10.61	22.46	31.06	14.98	3.09	1.67
06/14/00	8.17	16.21	13.49	10.49	16.21	22.00	14.20	5.30	2.09
06/21/00	8.96	35.94	11.79	11.42	11.64	14.87	9.98	3.08	1.29
06/30/00	22.38	15.39	14.62	13.51	17.68	21.27	12.10	3.39	2.03
07/07/00	8.42	20.52	18.14	10.47	17.63	20.31	9.55	2.47	.91
07/10/00	4.33	31.55	15.44	9.49	12.89	16.00	10.56	3.06	1.01
07/21/00	13.67	25.94	21.31	10.68	13.57	16.43	8.78	2.43	.86
07/26/00	17.17	16.97	20.20	14.07	16.53	16.68	10.43	3.48	1.65
08/04/00	54.63	11.64	10.79	10.20	19.48	27.94	14.15	3.51	2.28
08/07/00	17.25	19.24	14.21	9.37	14.64	22.59	12.69	5.11	2.16
08/14/00	12.92	26.30	18.47	10.28	15.58	16.88	9.10	2.51	.87
08/21/00	31.33	27.74	18.36	11.37	13.17	16.51	9.29	2.70	.87
08/29/00	4.00	9.52	16.53	13.18	17.67	20.38	14.68	5.65	2.39
09/05/00	6.42	26.22	18.27	10.49	13.46	17.25	10.26	3.15	.90
09/12/00	5.08	9.47	9.85	8.84	22.78	32.79	12.81	2.92	.54
09/18/00	8.29	25.06	19.11	8.35	12.38	16.83	12.39	4.56	1.32
09/25/00	4.92	23.01	15.22	9.00	14.57	19.65	13.03	4.50	1.03

[1]Not sieved due to caking while drying.

Table A2. Street dirt collected by vacuum sampling at the control site, Interstate 894, Milwaukee County, Wisconsin

[mm, millimeter; The mass of dirt collected per single pull of the vacuum wand from the edge of the shoulder nearest the traffic lane to the curb]

Date	Street dirt per collection swipe (grams)	Percentage by mass in size fractions							
		>6.37 (mm)	6.37–2.0 (mm)	2.0–1.0 (mm)	1.0–0.5 (mm)	0.5–0.25 (mm)	0.25–0.125 (mm)	0.125–0.0625 (mm)	<0.0625 (mm)
04/01/99	31.21	11.4	23.18	14.66	15.26	16.95	11.38	3.75	3.42
04/13/99	23.36	9.26	34.69	17.28	12.95	11.37	7.33	3.91	3.2
04/21/99	113.29	4.83	24.47	20.78	21.77	16.96	7.57	2.04	1.58
04/29/99	17.14	13.24	33.74	15.1	12.42	11.59	7.66	3.88	2.36
06/14/99	2.90	25.80	21.67	9.91	9.47	12.38	11.91	6.31	2.54
06/16/99	7.36	24.39	31.65	10.56	7.81	8.94	7.31	5.1	4.25
06/30/99	10.29	15.61	39.19	15.13	9.5	9.9	6.48	3	1.19
07/26/99	10.14	14.36	25.67	12.25	16.07	19.1	8.53	2.98	1.05
07/28/99	12.29	42.22	21.42	8.04	8.54	10.29	5.38	2.64	1.46
08/09/99	4.36	14.86	34.85	14.55	10.37	10.26	6.28	4.52	4.31
08/11/99	19.79	24.01	28.56	14.49	13.67	12.86	4.12	1.43	0.85
08/25/99	10.00	28.55	27.76	12.76	10.58	10.6	5.64	2.5	1.61
09/01/99	10.29	23.35	31.04	11.76	10.68	12.08	6.45	2.77	1.87
09/10/99	29.50	16.76	27.59	14.96	14.19	14.54	6.28	2.88	2.8
09/13/99	7.29	32.83	20.43	13.67	10.14	11.11	6.72	3.29	1.83
09/20/99	3.64	24.66	16.99	13.31	11.64	12.72	11.17	6.1	3.41
09/29/99	5.29	32.41	16.92	8.8	7.43	13.16	13.08	6.17	2.04
10/18/99	23.36	22.7	30.8	18.56	11.51	9.03	4.8	1.72	.89
10/20/99	44.50	15.74	32.21	14.83	12.93	14.18	6.43	2.43	1.24
11/01/99	47.07	16.44	29.15	16.55	14.94	12.62	6.37	2.2	1.74
11/03/99	42.71	19.65	27.69	16.02	13.87	12.96	6.12	2.35	1.33
11/15/99	46.00	10.27	24.69	15.36	15.34	18.04	9.06	4.15	3.09
11/17/99	13.93	23.39	22.88	15.52	14.45	12.35	6.76	3.04	1.62
11/29/99	5.21	18.61	35.60	13.93	10.66	9.91	5.93	3.45	1.92
12/01/99	51.21	11.87	23.79	17.43	17.60	16.87	7.48	3.19	1.75
12/27/99	44.86	12.08	27.96	19.49	16.77	13.49	6.28	2.38	1.55
01/05/00	17.57	20.56	22.20	17.14	16.25	14.20	5.16	2.16	2.32
01/10/00	35.50	12.39	28.74	17.81	19.81	16.48	3.66	.53	.56
01/12/00	49.79	8.05	20.72	14.51	17.13	22.37	10.75	4.07	2.39
01/24/00[1]	13.93	--	--	--	--	--	--	--	--
01/31/00[1]	69.57	--	--	--	--	--	--	--	--
02/01/00	7.71	5.51	24.30	14.14	14.95	23.77	12.39	3.04	1.91
02/28/00	72.86	8.34	14.89	14.47	17.80	18.65	11.25	7.94	6.67
02/29/00	49.71	10.76	20.28	14.79	16.49	16.87	9.43	5.96	5.42
03/13/00	17.71	9.89	25.56	17.98	14.90	13.22	8.17	6.11	4.17
03/27/00	7.86	18.78	20.27	14.04	13.65	13.90	9.34	5.82	4.20

Table A2. Street dirt collected by vacuum sampling at the control site, Interstate 894, Milwaukee County, Wisconsin—Continued

[mm, millimeter; The mass of dirt collected per single pull of the vacuum wand from the edge of the shoulder nearest the traffic lane to the curb]

		Percentage by mass in size fractions							
	Street dirt per collection swipe (grams)	>6.37 (mm)	6.37–2.0 (mm)	2.0–1.0 (mm)	1.0–0.5 (mm)	0.5–0.25 (mm)	0.25–0.125 (mm)	0.125–.0625 (mm)	<0.0625 (mm)
04/03/00	25.71	16.68	23.51	14.15	13.83	13.85	8.46	5.07	4.43
04/14/00	42.50	12.49	26.94	15.62	15.02	15.67	7.44	3.61	3.22
04/18/00	39.36	15.58	25.47	17.41	18.05	13.62	6.13	2.16	1.57
04/24/00	25.07	15.26	24.50	14.29	14.43	16.56	8.40	3.89	2.67
05/05/00	42.79	15.45	22.15	14.59	14.31	15.06	11.20	4.37	2.89
05/15/00	7.00	11.65	19.78	17.49	17.71	12.16	8.68	5.28	7.25
06/07/00	10.29	43.49	15.49	8.71	8.40	9.78	7.30	4.35	2.47
06/14/00	5.29	39.52	19.88	7.59	7.11	8.94	7.91	5.13	3.90
06/21/00	11.00	26.75	22.49	15.80	13.31	11.14	5.92	2.98	1.62
06/30/00	14.29	32.31	25.91	13.68	10.72	8.63	4.72	2.24	1.79
07/07/00	8.64	48.00	22.10	9.47	7.37	7.34	3.51	1.46	.77
07/10/00	4.00	25.67	24.96	12.29	9.28	11.99	9.80	4.40	1.61
07/21/00	22.14	27.56	27.95	15.30	12.26	9.39	4.70	1.87	.98
07/26/00	29.79	14.98	37.22	14.20	11.26	11.79	6.45	2.69	1.42
08/04/00	7.21	45.93	20.65	8.73	6.70	5.87	4.69	3.77	3.66
08/07/00	3.36	30.30	15.89	9.70	10.30	12.60	10.63	6.72	3.87
08/14/00	12.29	16.85	32.44	17.73	12.78	11.28	5.35	2.30	1.27
08/21/00	10.29	33.87	23.16	12.28	10.33	9.5	6.43	3.03	1.38
08/29/00	23.29	8.48	26.63	17.4	17.47	18.07	8.19	2.65	1.1
09/05/00	5.86	25.61	20.46	11.57	12.88	13.95	9.35	4.28	1.89
09/12/00	2.57	17.75	30.91	8.44	9.64	13.87	12.53	5.64	1.22
09/18/00	10.00	43.36	23.19	10.58	10.72	4.64	4.7	1.92	.88
09/25/00	8.00	18.22	26.71	12.84	11.47	13.27	10.46	5.19	1.83

[1]Not sieved due to caking while drying.

Table A3. Particle-size distribution of street dirt collected by Enviro Whirl, Interstate 894, Milwaukee County, Wisconsin

[mm, millimeter]

	Percentage by mass in size fractions							
Collection date	**>6.37 (mm)**	**6.37–2.0 (mm)**	**2.0–1.0 (mm)**	**1.0–0.5 (mm)**	**0.5–0.25 (mm)**	**0.25–0.125 (mm)**	**0.125–.0625 (mm)**	**<0.0625 (mm)**
8/18/99	9.76	10.47	6.42	14.02	29.70	15.07	5.47	9.09

Table A4. Results of Toxicity Characteristic Leachate Procedure (TCLP) analysis on dirt collected by Enviro Whirl street sweeper, Interstate 894, Milwaukee County, Wisconsin

[mg/L, milligram per liter; Cd, cadmium; Ba, barium; As, arsenic; Cr, chromium; Pb, lead; Hg, mercury; Se, selenium; Ag, silver]

Collection date	Total As (mg/L)	Total Ba (mg/L)	Total Cd (mg/L)	Total Cr (mg/L)	Total Pb (mg/L)	Total Hg (mg/L)	Total Se (mg/L)	Total Ag (mg/L)
8/18/99	nd	0.62	0.02	nd	0.09	nd	nd	<1.0
3/31/00	nd	.30	nd	nd	nd	nd	nd	<1.0

Table A5. Control site precipitation data, Interstate 894, Milwaukee County, Wisconsin

[in, inch; in/hr, inch per hour; h, hours; min, minute; --, no data; shaded areas mean at least some snow melt so precipitation data may not be valid]

Monitored event number	Start date & time	End date & time	Total rainfall (in.)	Max. 15-min. intensity (in/hr)	Max. 30-min. intensity (in/hr)	Erosivity Index (hundreds of ft-lbs/acre/in/hr)	Antecedent dry time (h)	Comments
1	03/10/99 10:11	03/10/99 19:50	0.63	1.33	0.67	3.3	--	
1	03/11/99 02:16	03/11/99 18:09	.25	.26	.2	.3	--	
1	03/14/99 18:04	03/15/99 11:30	.79	1.61	.82	5.2	--	
	04/03/99 14:35	04/03/99 16:04	.07	.13	.08	0	--	
	04/04/99 04:04	04/04/99 08:20	.15	.13	.11	.1	--	
	04/06/99 01:59	04/06/99 02:20	.07	.22	.14	.1	--	
	04/08/99 20:01	04/09/99 12:00	2.18	.39	.35	5.1	--	
2	04/11/99 06:48	04/11/99 14:13	.26	.36	.26	.4	42.80	
3	04/15/99 23:51	04/16/99 07:44	.22	.13	.1	.1	105.63	
	04/20/99 16:25	04/20/99 18:58	.05	.08	.05	0	--	[1]
4	04/21/99 21:43	04/22/99 09:45	.89	.4	.28	2.1	26.75	
	05/05/99 08:36	05/05/99 10:07	.06	.12	.08	0	--	
	05/06/99 00:09	05/07/99 00:01	.80	.69	.42	2.2	--	
	05/11/99 23:04	05/12/99 11:10	.83	.38	.34	1.9	--	
	05/15/99 20:44	05/15/99 22:25	.05	.04	.05	0	--	
	05/16/99 18:25	05/17/99 02:50	.96	1.56	1.06	8.7	--	
	05/17/99 16:27	05/17/99 16:35	.21	.84	.42	.9	--	
	05/18/99 07:24	05/18/99 12:53	.20	.14	.11	.1	--	
5	05/21/99 17:56	05/21/99 21:48	.15	.19	.15	.1	77.05	
6	05/23/99 09:09	05/23/99 13:59	.20	.48	.3	.5	35.35	
	05/31/99 14:17	05/31/99 15:12	.13	.49	.25	.3	--	
	06/01/99 20:42	06/02/99 00:43	.77	1.12	.77	4.6	--	
	06/04/99 13:20	06/04/99 13:39	.05	.16	.1	0	--	[1]
	06/06/99 17:06	06/07/99 04:03	.40	.53	.28	.8	--	
7	06/10/99 14:04	06/10/99 21:56	1.07	1.6	.98	9.2	82.02	
	06/11/99 19:31	06/11/99 22:03	.29	.32	.25	.5	--	
	06/12/99 21:41	06/13/99 13:01	2.75	2.04	1.44	31	--	
8	06/16/99 17:15	06/16/99 18:41	.13	.2	.16	.1	76.23	
9	06/23/99 17:58	06/23/99 20:03	.14	.24	.12	.1	167.28	
10	06/28/99 16:19	06/28/99 19:02	.75	1.96	1.09	7.6	116.27	
11	07/06/99 00:33	07/06/99 00:54	.10	.39	.2	.2	173.52	
12	07/09/99 00:10	07/09/99 02:01	2.14	2.92	2.54	54.36	71.27	
13	07/16/99 22:53	07/17/99 14:49	1.09	.72	.5	3.8	188.87	
	07/18/99 15:12	07/18/99 16:56	.08	.12	.09	0	--	

Table A5. Control site precipitation data, Interstate 894, Milwaukee County, Wisconsin—Continued

[in, inch; in/hr, inch per hour; h, hours; min, minute; --, no data; shaded areas mean at least some snow melt so precipitation data may not be valid]

Monitored event number	Start date & time	End date & time	Total rainfall (in.)	Max. 15-min. intensity (in/hr)	Max. 30-min. intensity (in/hr)	Erosivity Index (hundreds of ft-lbs/acre/in/hr)	Antecedent dry time (h)	Comments
	07/19/99 01:14	07/19/99 08:45	0.34	0.33	0.27	0.6	--	
14	07/21/99 00:02	07/21/99 10:06	1.51	2.8	1.68	24.2	39.28	
	07/23/99 16:23	07/23/99 17:48	.08	.16	.11	0	--	
	07/26/99 06:09	07/26/99 08:44	.07	.13	.07	0	--	
15	07/31/99 04:27	07/31/99 07:07	.28	.46	.29	.6	115.72	
16	08/07/99 08:51	08/07/99 11:21	.32	.4	.32	.7	169.73	
17	08/10/99 01:40	08/10/99 02:12	.22	.76	.42	.8	62.32	
	08/12/99 08:09	08/12/99 09:56	.08	.11	.08	0	--	
18	08/18/99 21:27	08/19/99 04:08	.58	.48	.36	1.3	155.52	
19	08/23/99 14:34	08/23/99 20:52	.20	.24	.14	.241	106.43	
	09/12/99 00:00	09/12/99 00:00	.22	--	--	--	--	2
20	09/19/99 16:55	09/19/99 22:42	.58	2.02	1.02	5.6	184.92	
21	09/27/99 01:18	09/27/99 06:10	.13	.12	.08	.088	170.60	
22	09/27/99 12:14	09/28/990 2:51	2.16	.48	.48	8.774	6.07	
	10/02/99 01:28	10/02/99 05:18	.04	.04	.02	0	--	
23	10/03/99 11:05	10/03/99 20:21	.54	.24	.18	.819	29.78	
24	10/16/99 02:33	10/16/99 10:21	.30	.28	.2	.4	294.20	
25	11/10/99 17:29	11/10/99 19:52	.50	.92	.53	2	607.13	
	11/19/99 06:48	11/19/99 07:16	.04	.11	.08	0	--	
26	11/23/99 03:01	11/23/99 12:51	.22	.32	.2	.371	91.75	
27	11/23/99 16:56	11/23/99 17:18	.12	.4	--	--	4.08	
	12/03/99 09:15	12/03/99 14:40	.16	.15	.09	.1	--	
	12/04/99 18:37	12/05/99 09:37	.64	.18	.15	.5	--	
	12/09/99 15:38	12/09/99 19:59	.15	.09	.07	0	--	
28	12/14/99 15:37	12/15/99 11:51	.24	.09	.06	.1	115.63	
	12/19/99 23:57	12/20/99 02:54	.06	.04	.05	0	--	
	01/02/00 02:42	01/02/00 05:11	.10	.2	.14	.1	--	
29	01/03/00 12:40	01/03/00 14:56	.04	.04	.02	0	--	1
	01/06/00 10:49	01/06/00 15:33	.28	.14	.12	.2	--	
	01/08/00 10:39	01/08/00 13:48	.12	.09	.07	0	--	
	01/09/00 21:07	01/10/00 08:28	.13	.04	.05	0	--	
	01/15/00 10:48	01/15/00 14:17	.06	.08	.06	0	--	
	01/30/00 00:00	--	--	--	--	--	--	
	02/03/00 13:18	02/03/00 16:29	.06	.04	.04	0	--	
	02/50/00 12:45	02/05/00 14:44	.05	.04	.05	0	--	
	02/13/00 12:50	02/13/00 15:34	.06	.09	.06	0	--	1

Table A5. Control site precipitation data, Interstate 894, Milwaukee County, Wisconsin—Continued

[in, inch; in/hr, inch per hour; h, hours; min, minute; --, no data; shaded areas mean at least some snow melt so precipitation data may not be valid]

Monitored event number	Start date & time	End date & time	Total rainfall (in.)	Max. 15-min. intensity (in/hr)	Max. 30-min. intensity (in/hr)	Erosivity Index (hundreds of ft-lbs/acre/in/hr)	Antecedent dry time (h)	Comments
	02/14/00 10:21	02/14/00 16:28	0.20	0.1	0.08	0.1	--	1
	02/15/00 11:46	02/15/00 18:36	0.19	0.09	0.07	0.1	--	1
	02/17/00 19:57	02/18/00 03:49	.65	.53	.36	1.7	--	1
30	02/19/00 12:02	02/19/00 17:24	.05	.04	.04	0	--	1
	02/20/00 10:34	02/20/00 21:22	.24	.1	.07	.1	--	1
31	02/21/00 08:14	02/21/00 18:46	.09	.1	.08	0	--	1
32	02/24/00 04:17	02/24/00 09:29	.35	.19	.17	.3	--	1
	03/01/00 02:25	03/01/00 06:24	.05	.08	.04	0	--	
	03/08/00 19:00	03/08/00 22:43	.09	.1	.06	0	--	
	03/09/00 06:07	03/09/00 09:22	.07	.12	.07	0	--	1
	03/20/00 05:42	03/21/00 04:56	1.76	5.72	2.96	42	--	
	03/24/00 11:56	03/24/00 13:32	.16	.28	.15	.2	--	
	03/28/00 15:13	03/28/00 16:54	.06	.12	.08	0	--	
33	04/07/00 07:53	04/07/00 17:40	.27	.15	.12	.1	--	
	040/8/00 08:49	04/08/00 15:20	.33	.13	.1	.2	--	
	04/11/00 05:08	04/11/00 10:22	.11	.04	.05	0	--	
	04/19/00 02:41	04/20/00 09:41	1.55	.88	.55	6.1	--	
	04/20/00 17:41	04/21/00 05:22	.25	.13	.1	.1	--	
	04/23/00 03:19	04/23/00 07:21	.26	.26	.19	.3	--	
	04/29/00 00:38	04/29/00 01:52	.05	.08	.06	0	--	1
	05/01/00 03:41	05/01/00 08:46	.10	.1	.07	0	--	
	05/08/00 09:31	05/08/00 09:38	.05	.2	.1	0	--	
	05/08/00 19:59	05/09/00 00:28	.19	.64	.32	.5	--	
34	05/09/00 10:44	05/09/00 17:58	.80	.28	.22	1.1	10.27	
	05/11/00 10:17	05/11/00 14:30	.05	.12	.06	0	--	1
	05/12/00 00:36	05/12/00 01:35	.71	1.76	1.38	9.4	--	
	05/16/00 02:36	05/16/00 08:48	.06	.04	.05	0	--	
35	05/17/00 17:26	--	1.70	--	--	--	32.63	2
	05/18/00 11:09	--	1.53	--	--	--	--	2
	05/27/00 02:37	05/28/00 13:58	.91	.4	.29	1.5	--	
	05/29/00 09:49	05/30/00 10:31	.80	.64	.36	1.8	--	
	05/31/00 06:32	05/31/00 15:06	.52	.42	.36	1.3	--	
36	06/01/00 19:48	06/01/00 22:07	.38	1.11	.62	2.1	28.70	
37	06/04/00 13:13	06/05/00 06:09	.46	.26	.23	.6	63.10	
	06/11/00 01:16	06/11/00 04:35	.06	.11	.08	0	--	
	06/12/00 07:31	06/13/00 01:58	.93	.35	.3	1.7	--	

Table A5. Control site precipitation data, Interstate 894, Milwaukee County, Wisconsin—Continued

[in, inch; in/hr, inch per hour; h, hours; min, minute; --, no data; shaded areas mean at least some snow melt so precipitation data may not be valid]

Monitored event number	Start date & time	End date & time	Total rainfall (in.)	Max. 15-min. intensity (in/hr)	Max. 30-min. intensity (in/hr)	Erosivity Index (hundreds of ft-lbs/acre/in/hr)	Antecedent dry time (h)	Comments
	06/13/00 18:58	06/13/00 20:32	.09	.22	.13	.1	--	
38	06/14/00 16:14	06/14/00 16:31	.33	1.28	.66	2.2	19.70	
39	06/20/00 07:28	06/20/00 10:21	.24	.76	.4	.8	134.95	
	06/23/00 21:59	06/23/00 22:14	.05	.2	.1	0	--	
	06/28/00 10:34	06/28/00 14:37	.20	.2	.13	.1	--	
	07/02/00 18:06	07/03/00 03:58	4.40	4.56	3	108.4	--	
	07/08/00 08:15	07/08/00 09:21	.49	1.16	.85	3.6	--	
	07/10/00 05:47	07/10/00 08:27	.35	.38	.32	.7	--	
	07/14/00 01:17	07/14/00 01:47	.12	.37	.24	.2	--	
	07/14/00 17:30	07/14/00 17:36	.04	.16	.08	0	--	
	07/20/00 17:39	07/20/00 19:14	.05	.17	.09	0	--	[1]
	07/25/00 12:14	07/25/00 12:35	2.02	6.97	4.04	54	--	
	07/27/00 04:34	07/27/00 05:20	.89	2.45	1.32	11.7	--	
40	07/28/00 12:19	07/28/00 13:55	1.74	2.2	1.7	28.79	30.98	
	07/29/00 01:28	07/29/00 4:59	.35	1.24	.66	2.1	--	
	07/31/00 00:02	07/31/00 20:31	.32	.31	.26	.4	--	
	08/02/00 14:11	08/02/00 14:36	.11	.29	.22	.2	--	
41	08/05/00 13:26	08/05/00 21:30	2.61	2.08	1.42	32.9	70.83	
	08/13/00 11:52	08/13/00 12:18	.05	.14	.1	0	--	
42	08/17/00 03:59	08/17/00 10:39	2.17	1.4	1.12	20.1	87.68	
43	08/17/00 20:50	08/17/00 23:52	.07	.09	.06	0	10.18	
	08/22/00 16:53	08/22/00 19:52	.14	.17	.12	.1	--	
44	08/26/00 09:58	08/26/00 11:00	.84	2.84	1.59	13.3	86.10	
	09/02/00 05:46	09/02/00 11:06	.59	1.38	.72	3.7	--	
	09/03/00 07:38	09/03/00 10:16	.28	.54	.29	.6	--	
45	09/07/00 23:24	09/08/00 06:01	.27	.4	.21	.4	109.13	
46	09/10/00 07:57	09/10/00 09:02	.48	1.12	.8	3.5	49.93	
	09/11/00 10:37	09/12/00 04:12	2.67	1.72	1.5	34.5	--	
47	09/14/00 01:28	09/14/00 08:17	.84	.73	.46	2.7	45.27	
48	09/19/00 20:21	09/20/00 13:45	.47	.16	.1	.2	132.07	
	09/22/00 10:50	09/23/00 02:32	2.29	2.04	1.38	29.36	45.08	

Explanations from the Comments column:

[1]Data from test site.
[2]Data from Michell International Airport.

Table A6. Test site precipitation data, Interstate 894, Milwaukee County, Wisconsin

[in, inch; in/hr, inch per hour; h, hour; min, minute, shaded areas mean at least some snow melt so precipitation data may not be valid]

Monitored event number	Start date & time	End date & time	Total rainfall (in.)	Max. 15-min. intensity (in/hr)	Max. 30-min. intensity (in/hr)	Erosivity Index (hundreds of ft-lbs/acre/ in/hr)	Antecedent dry time (h)	Comments
1	03/10/99 08:53	03/10/99 16:55	0.45	0.15	0.12	0.3	--	
1	03/11/99 09:44	03/11/99 14:27	.14	.08	.06	0	--	
	03/31/99 11:25	03/31/99 12:21	1.87	2.36	2.24	42.5	--	
	04/06/99 01:59	04/06/99 02:19	.07	.24	.14	.1	--	
	04/08/99 20:02	04/09/99 12:13	2.42	.41	.36	5.9	--	
2	04/11/99 06:51	04/11/99 14:22	.26	.37	.25	.4	42.633	
3	04/15/99 22:23	04/16/99 07:26	.26	.13	.11	.1	104.017	
	04/20/99 16:25	04/20/99 18:58	.05	.08	.05	0	--	
4	04/21/99 21:43	04/22/99 09:20	.95	.44	.32	2.561	26.75	
	04/22/99 14:18	04/22/99 15:57	.19	.28	.26	.416	--	
	04/22/99 19:29	04/22/99 23:56	.46	.4	.34	1.318	--	
	05/05/99 08:37	05/05/99 09:49	.06	.12	.08	0	--	
	05/05/99 23:47	05/07/99 00:01	.85	.69	.42	2.3	--	
	50/11/99 22:58	05/12/99 11:09	.89	.42	.36	2.2	--	
	05/13/99 06:02	05/13/99 06:22	.04	.14	.08	0	--	
	05/15/99 20:43	05/15/99 22:52	.05	.04	.05	0	--	
	05/16/99 18:26	05/17/99 02:47	1.02	1.44	.95	8.4	--	
	05/17/99 12:59	05/17/99 16:36	.26	1	.5	1.2	--	
	05/18/99 07:29	05/18/99 12:51	.30	.24	.14	.2	--	
5	05/21/99 17:56	05/21/99 21:47	.17	.22	.18	.2	77.083	
6	05/23/99 09:09	05/23/99 14:09	.50	1.32	.66	3	35.367	
	05/31/99 14:18	05/31/99 15:12	.15	.57	.29	.4	--	
	06/01/99 20:43	06/02/99 00:26	.87	1.32	.88	6.1	--	
	06/04/99 13:20	06/04/99 13:39	.05	.16	.1	0	--	
	06/06/99 17:09	06/07/99 04:24	.54	.6	.36	1.5	--	
7	06/10/99 14:01	06/10/99 22:01	1.17	1.68	1.04	10.6	81.617	
	06/11/99 19:31	06/11/99 22:48	.31	.35	.27	.6	--	
	06/12/99 21:34	06/13/99 13:07	3.29	2.52	1.78	47.6	--	
8	06/16/99 17:16	06/16/99 18:28	.16	.26	.22	.2	76.15	
9	06/23/99 18:00	06/23/99 20:03	.15	.28	.14	.1	167.533	
10	06/28/99 16:41	06/28/99 19:02	.83	2.14	1.2	9.4	116.633	
11	07/06/99 00:34	07/06/99 00:38	.09	.36	.18	.2	173.533	
12	070/9/99 00:10	07/09/99 02:01	2.45	3.08	2.7	63.003	71.533	
13	07/16/99 22:52	07/17/99 15:16	1.26	.68	.56	5	188.85	

Table A6. Test site precipitation data, Interstate 894, Milwaukee County, Wisconsin—Continued

[in, inch; in/hr, inch per hour; h, hour; min, minute, shaded areas mean at least some snow melt so precipitation data may not be valid]

Monitored event number	Start date & time	End date & time	Total rainfall (in.)	Max. 15-min. intensity (in/hr)	Max. 30-min. intensity (in/hr)	Erosivity Index (hundreds of ft-lbs/acre/in/hr)	Antecedent dry time (h)	Comments
	07/18/99 15:11	07/18/99 17:00	0.09	0.13	0.09	0	--	
	07/19/99 01:12	07/19/99 08:46	.40	.32	.28	.7	--	
14	07/20/99 23:31	07/21/99 09:43	1.85	3.24	1.93	34.6	38.75	
	07/23/99 16:29	07/23/99 17:51	.08	.18	.12	.1	--	
	07/26/99 06:07	07/26/99 09:02	.08	.12	.07	0	--	
15	07/31/99 04:28	07/31/99 07:12	.31	.5	.33	.7	115.433	
16	08/07/99 08:51	08/07/99 11:21	.32	.4	.32	.7	169.65	1
17	08/10/99 01:40	08/10/99 02:12	.22	.76	.42	.8	62.317	1
	08/12/99 08:02	08/12/99 09:51	.08	.11	.08	0	--	
18	08/18/99 20:36	08/19/99 03:54	.55	.37	.29	1	154.75	
19	08/23/99 14:27	08/23/99 20:37	.24	.4	.2	.427	106.55	
	09/12/99 00:00		.22	--	--	--	--	2
20	09/19/99 17:00	09/19/99 22:50	.50	1.74	.88	4.1	185	
21	09/27/99 01:58	09/27/99 06:14	.13	.12	.08	.088	171.133	
22	09/27/99 09:23	09/28/99 02:49	2.36	.56	.48	9.592	3.15	
	10/02/99 01:18	10/02/99 06:27	.05	.04	.02	0	--	
23	10/03/99 11:16	10/03/99 20:24	.57	.28	.2	.965	28.817	
24	10/16/99 02:33	10/16/99 10:38	.29	.21	.18	.3	294.15	
25	11/10/99 17:29	11/10/99 20:00	.49	.85	.48	1.8	606.85	
	11/19/99 06:49	11/19/99 07:19	.04	.1	.08	0	--	
26	11/23/99 03:00	11/23/99 12:50	.21	.32	.18	.318	91.683	
27	11/23/99 16:52	11/23/99 17:26	.12	.36	.22	.227	4.033	
	12/03/99 09:15	12/03/99 14:40	.15	.14	.09	.1	--	
	12/04/99 19:09	12/05/99 09:56	.63	.18	.14	.5	--	
	12/09/99 15:46	12/09/99 19:11	.13	.09	.07	0	--	
28	12/14/99 15:00	12/15/99 20:02	.28	.1	.07	.1	115.817	
	12/19/99 23:05	12/20/99 04:53	.06	.04	.05	0	--	
	01/02/00 02:13	01/02/00 03:29	.09	.18	.14	.1	--	
29	01/03/00 12:40	01/03/00 14:56	.04	.04	.02	0	--	
	01/06/00 11:00	01/06/00 15:45	.34	.17	.15	.3	--	
	01/09/00 21:26	01/10/00 08:26	.12	.04	.05	0	--	
	01/15/00 10:48	01/15/00 14:17	.06	.08	.06	0	--	1
	01/30/00 00:00	--	.21	--	--	--	--	2
	02/13/00 12:50	02/13/00 15:34	.06	.09	.06	0	--	
	02/14/00 10:21	02/14/00 16:28	.20	.1	.08	.1	--	
	02/15/00 11:46	02/15/00 18:36	.19	.09	.07	.1	--	

Table A6. Test site precipitation data, Interstate 894, Milwaukee County, Wisconsin—Continued

[in, inch; in/hr, inch per hour; h, hour; min, minute, shaded areas mean at least some snow melt so precipitation data may not be valid]

Monitored event number	Start date & time	End date & time	Total rainfall (in.)	Max. 15-min. intensity (in/hr)	Max. 30-min. intensity (in/hr)	Erosivity Index (hundreds of ft-lbs/acre/in/hr)	Antecedent dry time (h)	Comments
	02/17/00 19:57	02/18/00 03:49	0.65	0.53	0.36	1.7	--	1
30	02/19/00 12:48	02/19/00 15:45	.05	.04	.04	0	--	
	02/20/00 10:30	02/20/00 16:40	.24	.1	.07	.1	--	
31	02/21/00 09:41	02/21/00 12:03	.09	.1	.08	0	--	
32	02/24/00 04:17	02/24/00 09:33	.35	.19	.17	.3	--	
	03/01/00 02:25	03/01/00 06:24	.05	.08	.04	0	--	1
	03/08/00 17:48	03/08/00 19:49	.22	.52	.3	.5	--	
	03/09/00 06:07	03/09/00 09:22	.07	.12	.07	0	--	
	03/19/00 06:56	03/21/00 04:56	.78	.17	.11	.4	--	
	03/24/00 11:56	03/24/00 13:32	.17	.28	.15	.2	--	
	03/28/00 15:15	03/28/00 17:01	.08	.14	.1	0	--	
33	04/07/00 07:52	04/07/00 17:13	.27	.16	.12	.1	--	
	04/08/00 11:05	04/08/00 17:02	.71	.43	.26	1.2	--	
	04/11/00 6:05	04/11/00 13:28	.12	.04	.05	0	--	
	04/16/00 21:36	04/16/00 23:38	.04	.08	.05	0	--	
	04/19/00 02:41	04/20/00 09:41	1.55	.88	.55	6.1	--	1
	04/20/00 17:41	04/21/00 05:22	.25	.13	.1	.1	--	1
	04/23/00 03:15	04/23/00 06:43	.29	.3	.21	.4	--	
	04/29/00 00:38	04/29/00 01:52	.05	.08	.06	0	--	
	05/01/00 3:38	05/01/00 08:43	.11	.1	.08	0	--	
	05/08/00 16:51	05/09/00 01:33	.28	.92	.46	1	--	2
34	05/09/00 10:50	05/09/00 18:00	1.13	.43	.3	2.3	9.283	
	05/11/00 10:17	05/11/00 14:30	.05	.12	.06	0	--	
	05/12/00 00:36	05/12/00 01:35	.71	1.76	1.38	9.4	--	1
	05/16/00 04:15	05/16/00 08:51	.09	.1	.07	0	--	
35	05/17/00 14:22	--	1.70	--	--	--	29.517	2
	05/18/00 11:09	--	1.53	--	--	--	--	2
	05/27/00 02:37	05/28/00 13:58	.91	.4	.29	1.5	--	1
	05/29/00 09:49	05/30/00 10:31	.80	.64	.36	1.8	--	1
	05/31/00 06:32	05/31/00 15:06	.52	.42	.36	1.3	--	1
36	06/01/00 19:48	06/01/00 22:07	.38	1.11	.62	2.1	28.7	1
37	06/04/00 13:05	06/05/00 06:09	.46	.26	.23	.6	62.967	1
	06/11/00 01:16	06/11/00 01:59	.05	.11	.08	0	--	
	06/12/00 05:23	06/13/00 02:47	.96	.34	.31	1.7	--	
	06/13/00 18:59	06/13/00 22:22	.09	.2	.11	.1	--	
38	06/14/00 16:16	06/14/00 16:27	.36	1.44	.72	2.7	17.9	

Table A6. Test site precipitation data, Interstate 894, Milwaukee County, Wisconsin—Continued

[in, inch; in/hr, inch per hour; h, hour; min, minute, shaded areas mean at least some snow melt so precipitation data may not be valid]

Monitored event number	Start date & time	End date & time	Total rainfall (in.)	Max. 15-min. intensity (in/hr)	Max. 30-min. intensity (in/hr)	Erosivity Index (hundreds of ft-lbs/acre/ in/hr)	Antecedent dry time (h)	Comments
39	06/20/00 07:27	06/20/00 09:13	0.21	0.64	0.34	0.635	135	
	06/23/00 21:59	06/23/00 22:33	.07	.25	.14	.1	--	
	06/28/00 10:34	06/28/00 14:37	.20	.2	.13	.1	--	[1]
	07/02/00 18:06	07/03/00 03:58	4.40	4.56	3	108.4	--	[1]
	07/08/00 08:15	07/08/00 08:44	.31	1.04	.62	1.7	--	
	07/10/00 05:45	07/10/00 08:20	.34	.36	.3	.7	--	
	07/14/00 01:17	07/14/00 01:50	.15	.46	.29	.3	--	
	07/14/00 17:30	07/14/00 17:36	.04	.16	.08	0	--	[1]
	07/20/00 17:39	07/20/00 19:14	.05	.17	.09	0	--	
	07/25/00 11:12	07/25/00 11:58	2.02	3.51	2.8	53.5	--	
	07/27/00 04:34	07/27/00 05:20	.89	2.45	1.32	11.7	--	[1]
40	07/28/00 12:19	07/28/00 13:55	1.74	2.2	1.7	28.786	30.983	[1]
	07/29/00 01:28	07/29/00 04:50	.24	.76	.38	.8	--	
	07/31/00 00:03	07/31/00 21:05	.38	.32	.26	.5	--	
	08/02/00 14:13	08/02/00 14:37	.11	.31	.22	.2	--	
41	08/05/00 13:30	08/05/00 21:30	2.61	2.08	1.42	32.9	70.883	[1]
	08/13/00 12:00	08/13/00 12:34	.04	.12	.08	0	--	
42	08/17/00 04:02	08/17/00 10:39	2.17	1.4	1.12	20.1	87.467	[1]
43	08/17/00 21:03	08/18/00 05:39	.06	.04	.04	0	10.4	
	08/22/00 16:59	08/22/00 19:49	.11	.16	.09	.1	--	
44	08/26/00 10:04	08/26/00 11:00	.84	2.84	1.59	13.3	86.25	[1]
	09/02/00 05:46	09/02/00 11:06	.59	1.38	.72	3.7	--	[1]
	09/03/00 07:38	09/03/00 10:16	.28	.54	.29	.6	--	[1]
45	09/07/00 23:25	09/08/00 05:57	.21	.32	.2	.3	109.15	
46	09/10/00 07:57	09/10/00 09:02	.48	1.12	.8	3.5	50	[1]
	09/11/00 10:38	09/12/00 04:12	2.67	1.72	1.5	34.5	--	[1]
47	09/14/00 01:28	09/14/00 08:14	.86	.76	.48	2.9	45.267	
48	09/19/00 20:25	09/20/00 13:45	.42	.16	.1	.2	132.183	
OKM-11	09/22/00 10:59	09/22/00 19:27	.89	.36	.36	2.707	45.233	

Explanations from the Comments column:

[1]Data from test site.
[2]Data from Michell International Airport.

Table A7. Runoff concentrations from test site, Interstate 894, Milwaukee, Wisconsin

[mg/L, milligrams per liter; µg/L, micrograms per liter; rep., replicate sample; Diss., dissolved; COD, chemical oxygen demand; TSS, total suspended solids; S. Sed., suspended sediment; NH_3, ammonia; org. N, organic nitrogen; NO_2 + NO_3, nitrate + Nitrite; P, phosphorus; Ca, calcium; Mg, magnesium; Cl, chloride; Cu, copper; Zn, zinc; Cd, cadmium; Pb, lead; --, no data; shaded areas are sweeping period data]

Event	Date	COD (mg/L)	Total solids (mg/L)	TSS (mg/L)	S. Sed (mg/L)	Diss. NH_3 (mg/L)	Total NH_3 + org. N (mg/L)	Diss. NO_2+ NO_3 (mg/L)	Total P (mg/L)	Diss. Ortho-P (mg/L)	Total Ca (mg/L)	Total Mg (mg/L)	Diss. Cl (mg/L)	Diss. Cu (µg/L)	Diss. Zn (µg/L)	Total Zn (µg/L)	Total Cd (µg/L)	Total Pb (µg/L)	Total Cu (µg/L)	Total hardness (mg/L)
1	03/11/99	--	--	182	171	--	--	--	--	--	--	--	3,370	--	--	488	--	--	120	--
2	04/11/99	70	1,570	88		0.923	1.87	2.16	0.105	0.023	47	12	791	20	47	200	1.2	29	61	170
3	04/16/99	--	--	84	117	--	--	--	--	--	--	--	417	--	--	240	--	--	69	--
4	04/21/99	--	--	61		--	--	--	--	--	--	--	--	--	--	170	--	--	64	--
5[1]	05/21/99	--	--	180		--	--	--	--	--	--	--	138	--	--	320	--	--	88	--
6[1]	05/23/99	--	--	352	2,330	--	--	--	--	--	--	--	65.1	--	--	290	--	--	100	--
7[1]	06/10/99	74	--	689	3,090	.481	1.79	1.03	.249	.013	510	270	40.9	12	28	710	3.3	130	1,700	2,400
8	06/16/99	--	--	127	137	--	--	--	--	--	--	--	--	--	--	290	--	--	58	--
9	06/23/99	--	--	286	388	--	--	--	--	--	--	--	--	--	--	570	--	--	120	--
10	06/28/99	--	--	236	2,930	--	--	--	--	--	--	--	17.5	--	--	350	--	--	68	--
11	07/06/99	--	--	214	362	--	--	--	--	--	--	--	--	--	--	460	--	--	110	--
12	07/09/99	--	--	230	2,760	--	--	--	--	--	--	--	--	--	--	260	--	--	72	--
rep.		--	--	569		--	--	--	--	--	--	--	--	--	--	950	--	--	140	--
13	07/16/99	61	208	159	312	.311	1.55	.66	.138	.12	27	10	29.3	14	43	200	.64	20	50	110
rep.		70	350	98		.312	1.05	.649	.126	.12	27	9.4	29.5	14	39	150	.5	21	41	110
14	07/21/99	--	--	367	981	--	--	--	--	--	--	--	--	--	--	330	--	--	77	--
15	07/31/99	78	354	335	485	.407	1.54	.629	.256	.064	44	16	30	17	12	310	.81	35	71	180
16	08/07/99	--	--	284	607	--	--	--	--	--	--	--	24.5	--	--	530	--	--	69	--
17	08/10/99	--	--	670	2,170	--	--	--	--	--	--	--	--	--	--	480	--	--	45	--
18	08/18/99	--	--	87	214	--	--	--	--	--	--	--	--	--	--	150	--	--	34	--
19	08/23/99	--	--	394	691	--	--	--	--	--	--	--	--	--	--	370	--	--	72	--
20	09/19/99	--	--	410	2,730	--	--	--	--	--	--	--	--	--	--	590	--	--	170	--
21	09/27/99	--	--	84	78	--	--	--	--	--	--	--	39.5	--	--	190	--	--	53	--
22	09/27/99	39	276	77	588	.26	.71	.309	.15	.019	39	17	15.8	5.8	15	170	.55	35	48	170
23	10/03/99	--	--	83	91	--	--	--	--	--	--	--	31.8	--	--	160	--	--	31	--
24	10/16/99	--	--	162	27	--	--	--	--	--	--	--	--	--	--	270	--	--	56	--
25	11/10/99	--	--	208	250	--	--	--	--	--	--	--	--	--	--	310	--	--	60	--
26	11/19/99	--	--	158	200	--	--	--	--	--	--	--	--	--	--	290	--	--	71	--
rep.	11/19/99	--	--	--	174	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
27	11/23/99	--	--	416	351	--	--	--	--	--	--	--	--	--	--	370	--	--	100	--
rep.	11/23/99	--	--	--	357		--	--	--	--	--	--	--	--	--	--	--	--	--	--
28	12/14/99	--	--	82	243	--	--	--	--	--	--	--	--	--	--	240	--	--	62	--

Table A7. Runoff concentrations from test site, Interstate 894, Milwaukee, Wisconsin—Continued

[mg/L, milligrams per liter; µg/L, micrograms per liter; rep., replicate sample; Diss., dissolved; COD, chemical oxygen demand; TSS, total suspended solids; S. Sed., suspended sediment; NH_3, ammonia; org. N, organic nitrogen; NO_2 + NO_3, nitrate + Nitrite; P, phosphorus; Ca, calcium; Mg, magnesium; Cl, chloride; Cu, copper; Zn, zinc; Cd, cadmium; Pb, lead; --, no data; shaded areas are sweeping period data]

Event	Date	COD (mg/L)	Total solids (mg/L)	TSS (mg/L)	S. Sed (mg/L)	Diss. NH_3 (mg/L)	Total NH_3 + org. N (mg/L)	Diss. NO_2+ NO_3 (mg/L)	Total P (mg/L)	Diss. Ortho-P (mg/L)	Total Ca (mg/L)	Total Mg (mg/L)	Diss. Cl (mg/L)	Diss. Cu (µg/L)	Diss Zn (µg/L)	Total Zn (µg/L)	Total Cd (µg/L)	Total Pb (µg/L)	Total Cu (µg/L)	Total hardness (mg/L)
rep.	12/14/99	--	--	--	117		--	--	--	--	--	--	--	--	--	--	--	--	--	--
29	01/03/00	--	--	43	166	--	--	--	--	--	--	--	9,840	--	--	280	--	--	47	--
30	02/18/00	--	--	78	71	--	--	--	--	--	--	--	--	--	--	480	--	--	49	--
31	02/21/00	120	5,104	154	162	.852	.98	.659	.335	.091	100	20	2,730	130	440	440	2.3	46	130	330
rep.	02/21/00	--	--	152	162	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
32	02/24/00	430	3,930	756	1,138	.623	1.77	.91	.763	.027	180	63	1,690	420	1500	1,500	6.7	250	420	700
rep.	02/24/00	--	--	--	552		--	--	--	--	--	--	--	--	--	--	--	--	--	--
33	04/07/00	97	3,090	113	690.4	1.12	2.33	.793	.092	.01	42	9.4	1,750	16	64	340	1.6	38	74	140
rep.	04/07/00	--	--	150	193	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
34	05/09/00	--	--	185	989	--	--	--	--	--	--	--	--	--	--	380	--	--	140	--
rep.	05/09/00	--	--	244	722.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
35	05/17/00	--	--	99	229	--	--	--	--	--	--	--	49.8	--	--	230	--	--	61	--
rep.	05/17/00	--	--	--	387		--	--	--	--	--	--	--	--	--	--	--	--	--	--
36	06/01/00	--	--	201	1,070	--	--	--	--	--	--	--	--	--	--	520	--	--	85	--
rep.		--	--	--	621.7		--	--	--	--	--	--	--	--	--	--	--	--	--	--
37	06/04/00	--	--	36	74.1	--	--	--	--	--	--	--	--	--	--	80	--	--	25	--
rep.		--	--	--	37.1		--	--	--	--	--	--	--	--	--	--	--	--	--	--
38	06/14/00	--	--	398	8,58.0	--	--	--	--	--	--	--	--	--	--	550	--	--	58	--
39	06/20/00	--	--	86	2,42.9	--	--	--	--	--	--	--	--	--	--	280	--	--	68	--
40	07/28/00	36	870	1,230	21,55.3	.249	1.08	.408	.281	.006	400	200	7.2	6.1	15	1,200	2.2	210	180	1,800
41	08/05/00	--	--	141	209.0	--	--	--	--	--	--	--	--	--	--	200	--	--	84	--
rep.		--	--	--	230.2		--	--	--	--	--	--	--	--	--	--	--	--	--	--
42	08/17/00	--	--	200	216	--	--	--	--	--	--	--	--	--	--	320	--	--	71	--
43	08/17/00	--	--	95	169	--	--	--	--	--	--	--	--	--	--	99	--	--	30	--
rep.		--	--	--	51.0		--	--	--	--	--	--	--	--	--	--	--	--	--	--
44	08/26/00	51	236	134	203.7	.67	1.71	.794	.266	.114	27	12	19	8.9	25	200	.55	51	39	120
rep.	08/26/00	--	--	65	187	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
45	09/07/00	--	--	245	192	--	--	--	--	--	--	--	66.6	--	--	340	--	--	68	--
rep.	09/07/00	--	--	193	234	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
46	09/10/00	50	204	115	2,42.2	.359	.9	.415	.152	.034	20	9	16.3	7.3	21	140	.48	18	40	87
rep.	09/10/00	--	--	280	310	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
47	09/14/00	--	--	40	34.7	--	--	--	--	--	--	--	--	--	--	130	--	--	26	--
rep.		--	--	--	42		--	--	--	--	--	--	--	--	--	--	--	--	--	--
48	09/19/00	--	--	95		--	--	--	--	--	--	--	--	--	--	230	--	--	50	--

[1]Construction on right of way may have influenced the concentrations on these samples

Table A8. Runoff concentrations from control site, Interstate 894, Milwaukee County, Wisconsin

[mg/L, milligrams per liter; µg/L, micrograms per liter; rep., replicate sample; Diss., dissolved; COD, chemical oxygen demand; TSS, total suspended solids; S. Sed., suspended sediment; NH_3, ammonia; org. N, organic nitrogen; NO_2 + NO_3, nitrate + Nitrite; P, phosphorus; Ca, calcium; Mg, magnesium; Cl, chloride; Cu, copper; Zn, zinc; Cd, cadmium; Pb, lead; --, no data]

Event	Date	COD (mg/L)	Total solids (mg/L)	TSS (mg/L)	S. Sed (mg/L)	Diss. NH_3 (mg/L)	Total NH_3 + org. N (mg/L)	Diss. NO_2+ NO_3 (mg/L)	Total P (mg/L)	Diss. Ortho-P (mg/L)	Total Ca (mg/L)	Total Mg (mg/L)	Diss. Cl (mg/L)	Diss. Cu (µg/L)	Diss. Zn (µg/L)	Total Zn (µg/L)	Total Cd (µg/L)	Total Pb (µg/L)	Total Cu (µg/L)	Total hardness (mg/L)
1	03/11/99	--	--	50	69	--	--	--	--	--	--	--	5,180	--	--	254.1	--	--	49	--
2	04/11/99	64	1,140	104	--	0.627	1.4	1.72	0.113	0.022	69	28	466	18	39	180	0.75	30	54	290
3	04/16/99	--	--	86	122	--	--	--	--	--	--	--	256	--	--	200	--	--	61	--
4	04/21/99	--	--	284	--	--	--	--	--	--	--	--	--	--	--	480	--	--	150	--
5[1]	05/21/99	--	--	224	--	--	--	--	--	--	--	--	117	--	--	290	--	--	80	--
6[1]	05/23/99	--	--	277	1,130	--	--	--	--	--	--	--	45.5	--	--	420	--	--	170	--
7[1]	06/10/99	140	2,580	613	866	.346	1.31	.9	.259	.011	450	240	23.2	13	31	390	1.8	110	160	2,100
8	06/16/99	--	--	108	114	--	--	--	--	--	--	--	--	--	--	220	--	--	66	--
9	06/23/99	--	--	130	158	--	--	--	--	--	--	--	--	--	--	280	--	--	82	--
10	06/28/99	--	--	447	711	--	--	--	--	--	--	--	32.8	--	--	500	--	--	140	--
11	07/06/99	--	--	280	361	--	--	--	--	--	--	--	--	--	--	520	--	--	140	--
12	07/09/99	--	--	232	968	--	--	--	--	--	--	--	--	--	--	230	--	--	66	--
rep.		--	--	145	--	--	--	--	--	--	--	--	--	--	--	210	--	--	77	--
13	07/16/99	60	232	106	377	.206	1.01	.582	.144	.009	33	13	23.6	14	34	170	.56	19	39	140
rep.		61	246	131	--	.206	.33	.565	.15	.01	34	14	23.5	14	33	150	.64	19	41	140
14	07/21/99	--	--	218	487	--	--	--	--	--	--	--	--	--	--	180	--	--	66	--
15	07/31/99	120	934	256	346	.026	1.87	.825	.321	.004	49	21	56.4	22	57	550	2	60	88	210
16	08/07/99	--	--	236	1,670	--	--	--	--	--	--	--	30	--	--	340	--	--	88	--
17	08/10/99	--	--	130	189	--	--	--	--	--	--	--	--	--	--	180	--	--	41	--
18	08/18/99	--	--	145	353	--	--	--	--	--	--	--	--	--	--	140	--	--	35	--
19	08/23/99	--	--	87	106	--	--	--	--	--	--	--	--	--	--	200	--	--	53	--
20	09/19/99	--	--	204	1,080	--	--	--	--	--	--	--	--	--	--	270	--	--	68	--
21	09/27/99	--	--	89	95	--	--	--	--	--	--	--	48.6	--	--	220	--	--	69	--
22	09/27/99	53	152	91	306	.327	.88	.299	.102	.019	30	14	15.1	7.0	21	140	.46	26	36	130
23	10/03/99	--	--	33	32	--	--	--	--	--	--	--	37.8	--	--	110	--	--	24	--
24	10/16/99	--	--	124	12	--	--	--	--	--	--	--	31.1	--	--	240	--	--	93	--
25	11/10/99	--	--	180	231	--	--	--	--	--	--	--	--	--	--	320	--	--	73	--
rep.		--	--	--	425	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
26	11/19/99	--	--	140	109	--	--	--	--	--	--	--	--	--	--	270	--	--	81	--
rep.		--	--	--	162	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
27	11/23/99	--	--	184	186	--	--	--	--	--	--	--	--	--	--	310	--	--	78	--
rep.		--	--	--	181	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table A8. Runoff concentrations from control site, Interstate 894, Milwaukee County, Wisconsin—Continued

[mg/L, milligrams per liter; µg/L, micrograms per liter; rep., replicate sample; Diss., dissolved; COD, chemical oxygen demand; TSS, total suspended solids; S. Sed., suspended sediment; NH_3, ammonia; org. N, organic nitrogen; NO_2 + NO_3, nitrate + Nitrite; P, phosphorus; Ca, calcium; Mg, magnesium; Cl, chloride; Cu, copper; Zn, zinc; Cd, cadmium; Pb, lead; --, no data]

Event	Date	COD (mg/L)	Total solids (mg/L)	TSS (mg/L)	S. Sed (mg/L)	Diss. NH_3 (mg/L)	Total NH_3 + org. N (mg/L)	Diss. NO_2+ NO_3 (mg/L)	Total P (mg/L)	Diss. Ortho-P (mg/L)	Total Ca (mg/L)	Total Mg (mg/L)	Diss. Cl (mg/L)	Diss. Cu (µg/L)	Diss Zn (µg/L)	Total Zn (µg/L)	Total Cd (µg/L)	Total Pb (µg/L)	Total Cu (µg/L)	Total hardness (mg/L)
28	12/14/99	--	--	124	179	--	--	--	--	--	--	--	--	--	--	250	--	--	65	--
rep.		--	--	--	106	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
29	01/03/00	--	--	128	180	--	--	--	--	--	--	--	13,000	--	--	580	--	--	120	--
30	02/18/00	--	--	89	59	--	--	--	--	--	--	--	--	--	--	470	--	--	77	--
rep.		--	--	--	84	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
31	02/21/00	84	3,530	90	91	.798	.93	.758	.173	.027	110	27	1860	82	290	290	1.2	42	82	370
rep.	--	--	--	84	94	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
32	02/24/00	370	4,398	734	689	.806	1.95	1.17	.678	.011	160	52	1970	620	1,500	1,500	6.1	240	620	620
33	04/07/00	110	3,270	112	450	1.07	2.15	.741	.199	.005	45	9.8	1770	18	110	360	2	41	81	150
rep.		--	--	126	167	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
34	05/09/00	--	--	108	152	--	--	--	--	--	--	--	--	--	--	240	--	--	69	--
rep.		--	--	124	97	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
35	05/17/00	--	--	89	348	--	--	--	--	--	--	--	36.7	--	--	180	--	--	73	--
rep.		--	--	--	246	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
36	06/01/00	--	--	102	165	--	--	--	--	--	--	--	--	--	--	170	--	--	59	--
rep.		--	--	--	215	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
37	06/04/00	--	--	26	32	--	--	--	--	--	--	--	--	--	--	79	--	--	25	--
rep.		--	--	--	29	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
38	06/14/00	--	--	213	330.3	--	--	--	--	--	--	--	--	--	--	500	--	--	58	--
39	06/20/00	--	--	139	200.8	--	--	--	--	--	--	--	--	--	--	250	--	--	65	--
40	07/28/00	41	176	134	325	.481	1.19	.457	.13	.03	15	6.3	9.4	7.4	21	180	.58	31	46	64
rep.		--	--	--	122.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
41	08/05/00	--	--	99	258.5	--	--	--	--	--	--	--	--	--	--	180	--	--	66	--
42	08/17/00	--	--	87	80	--	--	--	--	--	--	--	--	--	--	210	--	--	63	--
43	08/17/00	--	--	11	48	--	--	--	--	--	--	--	--	--	--	63	--	--	20	--
rep.		--	--	--	135.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
44	08/26/00	42	132	62	73.3	.597	1.8	.703	.13	.047	13	5.3	15.2	8.9	28	120	.49	19	36	55
rep.		--	--	120	68	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
45	09/07/00	--	--	--	114	--	--	--	--	--	--	--	35.8	--	--		--	--		--
46	09/10/00	45	130	69	88.8	.359	1.15	.501	.213	.039	29	13	11.5	8	18	190	.45	22	37	130
rep.		--	--	73	92	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
47	09/14/00	--	--	55	62.7	--	--	--	--	--	--	--	--	--	--	110	--	--	26	--
rep.		--	--	--	48	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
48	09/19/00	--	--	66	--	--	--	--	--	--	--	--	--	--	--	170	--	--	39	--

[1]Construction on right of way may have influenced the concentrations on these samples

Table A9. Runoff particle size analysis results at the test and control sites, Interstate 894, Milwaukee County, Wisconsin

[%, percent; mm, millimeter; --, no data; Because of new instrumentation at the lab, the shaded data shows the particle size distribution only within the 0.031 mm to 0.001 mm size fractions]

		Test site															
		Sand/fine break		Sieve analysis (% less than)			Visual accumulation tube analysis (% less than)					Sedigraph analysis (% less than)					
Sample ID	Date	% sand	% fine	8 (mm)	4 (mm)	2 (mm)	1 (mm)	0.5 (mm)	0.25 (mm)	0.125 (mm)	0.062 (mm)	0.031 (mm)	0.016 (mm)	0.008 (mm)	0.004 (mm)	0.002 (mm)	0.001 (mm)
OK-1	03/14/99	0	100								100	98.13	91.88	76.88	62.5	45.63	----
OK-3	04/16/99	17.78	82.22	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-8	06/16/99	26.75	73.25	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-9	06/23/99	32.48	67.52	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-10	06/28/99	93.1	6.9	100	97.2	90.5	70	56.2	20.2	8.4	6.9	--	--	--	--	--	--
OK-11	07/06/99	49.07	50.93	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-12	07/09/99	97.04	2.96	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-13	07/16/99	82	18			100	85.1	72.2	44.7	33.5	18	--	--	--	--	--	--
OK-14	07/21/99	91.92	8.08	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-15	07/31/99	73.4	26.6				100	93.4	67.7	42.7	26.6	--	--	--	--	--	--
OK-16	08/07/99	73.3	26.7			100	94.4	80.8	55.8	38.2	26.7	--	--	--	--	--	--
OK-17	08/10/99	92.6	7.4		100	94.6	78.1	63.9	31.4	13.1	7.4	--	--	--	--	--	--
OK-18	08/18/99	75.5	24.5			100	93	82	55.2	39.8	24.5	--	--	--	--	--	--
OK-19	08/23/99	78.13	21.87	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-20	09/19/99	91.67	8.33	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-21	09/27/99	19.97	80.03	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-22	09/27/99	89.8	10.2			100	91.1	72.5	25.5	12.6	10.2	--	--	--	--	--	--
OK-23	10/03/99	40.9	59.1			100	80.5	76.2	69.8	66.1	59.1	--	--	--	--	--	--
OK-24	10/16/99	> 35	< 65				100	75	65	35	--	93.3	79.7	62.9	40.8	19.1	13
OK-25	11/10/99	59.3	40.7			100	87	77.3	66.6	55.5	40.7	--	--	--	--	--	--
OK-26	11/19/99	64	36			100	80.8	80.3	74.8	71.2	64	95.3	88.8	78.4	54.4	43.2	33.5
OK-27	11/23/99	37.7	62.3			100	91.6	83.6	72.9	62.6	62.3	--	--	--	--	--	--
OK-28	12/14/99	13.5	86.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-31	02/21/00	4.7	95.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-32	02/24/00	10.1	89.9									84.88	74.63	60.87	46.94	32.73	27.42
OK-33	04/07/00	19.4	80.6			100	92.9	89.5	84.7	82	80.6	--	--	--	--	--	--

Table A9. Runoff particle size analysis results at the test and control sites, Interstate 894, Milwaukee County, Wisconsin—Continued

[%, percent; mm, millimeter; --, no data; Because of new instrumentation at the lab, the shaded data shows the particle size distribution only within the 0.031 mm to 0.001 mm size fractions]

Sample ID	Date	Sand/fine break		Sieve analysis (% less than)			Visual accumulation tube analysis (% less than)					Sedigraph analysis (% less than)					
		% sand	% fine	8 (mm)	4 (mm)	2 (mm)	1 (mm)	0.5 (mm)	0.25 (mm)	0.125 (mm)	0.062 (mm)	0.031 (mm)	0.016 (mm)	0.008 (mm)	0.004 (mm)	0.002 (mm)	0.001 (mm)
Test site—continued																	
OK-34	05/09/00	84.2	15.8			100	52.5	40.8	24.6	17	15.8	14.96	14.19	10.78	8.47	4.09	2.38
OK-35	50/17/00	67.8	32.2			100	62	53.1	40.3	32.8	32.2	--	--	--	--	--	--
OK-36	06/01/00	87.6	12.4			100	81.7	65.1	28.3	14.5	12.4	--	--	--	--	--	--
OK-37	06/04/00	19.9	80.1				100	90.2	82.1	80.1	80.1	--	--	--	--	--	--
OK-41	08/05/00	56.2	43.8				100	90.4	64.9	54.5	43.8	--	--	--	--	--	--
OK-42	08/17/00	34.8	65.2			100	89	78.3	72.3	69.9	65.2	--	--	--	--	--	--
OK-43	08/17/00	1.8	98.2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OK-44	08/26/00	46.8	53.2			100	91.5	80	60.8	57	53.2	--	--	--	--	--	--
OK-45	09/07/00	36.7	63.3			100	92	83.4	69	66.1	63.3	--	--	--	--	--	--
OK-46	09/10/00	66	34			100	88.4	71.5	53.6	38.9	34	--	--	--	--	--	--
OK-47	09/14/00	4.2	95.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Control site																	
NT-1	03/14/99	0	100									100	90	70	57.14	38.57	--
NT-3	04/16/99	35.69	64.31	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-8	06/16/99	18.52	81.48	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-9	06/23/99	13.1	86.9	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-10	06/28/99	82.1	17.9		100	78.2	78.2	65.4	36.3	21.3	17.9	--	--	--	--	--	--
NT-11	07/06/99	58.81	41.19	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-12	07/09/99	91.6	8.4	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-13	07/16/99	84.1	15.9			100	68.1	54.6	33.6	25.4	15.9	--	--	--	--	--	--
NT-14	07/21/99	83.56	16.45	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-15	07/31/99	63.3	36.7			100	90.6	89.8	71.9	53.8	36.7	--	--	--	--	--	--
NT-16	08/07/99	91.8	8.2	100	97.9	83	48.8	30.5	17.5	11.8	8.2	--	--	--	--	--	--
NT-17	08/10/99	62.5	37.5			100	91.9	85.9	60.3	48.4	37.5	--	--	--	--	--	--
NT-18	08/18/99	86.8	13.2			100	64.9	55.7	33.6	24.6	13.2	--	--	--	--	--	--
NT-19	08/23/99	27.4	72.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-20	09/19/99	88.55	11.45	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-21	09/27/99	23.94	76.06	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table A9. Runoff particle size analysis results at the test and control sites, Interstate 894, Milwaukee County, Wisconsin—Continued

[%, percent; mm, millimeter; --, no data; Because of new instrumentation at the lab, the shaded data shows the particle size distribution only within the 0.031 mm to 0.001 mm size fractions]

Control site—continued																	
		Sand/fine break		Sieve analysis (% less than)			Visual accumulation tube analysis (% less than)					Sedigraph analysis (% less than)					
Sample ID	Date	% sand	% fine	8 (mm)	4 (mm)	2 (mm)	1 (mm)	0.5 (mm)	0.25 (mm)	0.125 (mm)	0.062 (mm)	0.031 (mm)	0.016 (mm)	0.008 (mm)	0.004 (mm)	0.002 (mm)	0.001 (mm)
NT-22	09/27/99	83.5	16.5			100	68.5	49.3	25.9	21.2	16.5	--	--	--	--	--	--
NT-23	10/03/99	3.3	96.7					100	99.4	97.7	96.7	--	--	--	--	--	--
NT-24	10/16/99	> 31.2	< 68.8				100	90	50	31.2	--	98	84.1	78.6	48.8	33.9	24.3
NT-25	11/10/99	47.2	52.8			100	74.5	70	61.4	58.1	52.8	97.3	81.2	60.9	37.6	20.8	13.7
NT-26	11/19/99	9	91				100	99.8	96	93.6	91	92.2	88.3	77.2	57.4	32.3	24.1
NT-27	11/23/99	20	80			100	86.8	86.8	83.4	80.1	80	--	--	--	--	--	--
NT-28	12/14/99	2.4	97.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-30	02/18/00	0.72	99.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-31	02/21/00	1.2	98.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-33	04/07/00	2.9	97.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-34	05/09/00	31.5	68.5				100	97.7	77.5	72.6	68.5	--	--	--	--	--	--
NT-35	05/17/00	56.7	43.3			100	62.9	54.2	48.8	45.5	43.3	--	--	--	--	--	--
NT-36	06/01/00	49.5	50.5			100	80.6	70.1	53.8	50.8	50.5	--	--	--	--	--	--
NT-37	06/04/00	24.4	75.6	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-40	07/28/00	73.2	26.8			100	72.9	56.9	40.9	34.6	26.8	--	--	--	--	--	--
NT-42	08/17/00	16.3	83.7	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-43	08/17/00	1.2	98.8	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-44	08/26/00	38.9	61.1	--	--	--	--	--	--	--	--	--	--	--	--	--	--
NT-45	09/07/00	32.5	67.5			100	87.1	83.9	74	70.6	67.5	--	--	--	--	--	--
NT-46	09/10/00	41.6	58.4			100	86.5	75.3	64.1	58.7	58.4	--	--	--	--	--	--
NT-47	09/14/00	16.5	83.5	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Table A10. Replicate suspended sediment analysis results at the test and control sites, Interstate 894, Milwaukee County, Wisconsin

[mg/L, milligram per liter; %, percent; Percent difference is calculated as: 100*{absolute value [(replicate 1 concentration - replicate 2 concentration) / replicate concentration]}]

Replicate analysis results									
Test site					Control site				
Sample ID	Date	Suspended sediment (mg/L)	Suspended sediment - replicate (mg/L)	% Difference	Sample ID	Date	Suspended sediment (mg/L)	Suspended sediment - replicate (mg/L)	% Difference
OK-26	11/19/99	200	174.0	15	NT-25	11/10/99	231	424.9	46
OK-27	11/23/99	351	356	1	NT-26	11/19/99	109	162.4	33
OK-28	12/14/99	242.6	117	107	NT-27	11/23/99	186	181	3
OK-31	02/21/00	162	161.8	0	NT-28	12/14/99	178.8	106	69
OK-32	02/24/00	552	1,137.5	51	NT-30	02/18/00	59	83.7	30
OK-33	04/07/00	193	690.4	72	NT-31	02/21/00	91	93.7	3
OK-34	05/09/00	989	722.4	37	NT-33	04/07/00	167	450.2	63
OK-35	05/17/00	387	229.2	69	NT-34	05/09/00	152	97.1	57
OK-36	06/01/00	1,070	621.7	72	NT-35	05/17/00	246	348.1	29
OK-37	06/04/00	74	37.1	99	NT-36	06/01/00	165	215.3	23
OK-41	08/05/00	209	230.2	9	NT-37	06/04/00	32	28.5	12
OK-43	08/17/00	169	51.0	231	NT-40	07/28/00	325	122.3	166
OK-44	08/26/00	203.7	187	9	NT-43	08/17/00	48	135.5	65
OK-45	09/07/00	192.0	234.0	18	NT-44	08/26/00	73.3	68	8
OK-46	09/10/00	242.2	310.0	22	NT-46	09/10/00	88.8	92	3
OK-47	09/14/00	34.7	42	17	NT-47	09/14/00	62.7	48	31
			mean	52				mean	40
			standard deviation	59				standard deviation	41
			Combined sites mean	46					
			Combined sites standard deviation	50					

Table A11. Replicate suspended solids analysis results at the test and control sites, Interstate 894, Milwaukee County, Wisconsin

[mg/L, milligram per liter; %, percent; Percent difference is calculated as: 100*{absolute value [(replicate 1 concentration - replicate 2 concentration)/replicate 1 concentration]}]

Replicate analysis results									
Test site					Control site				
Sample ID	Date	Suspended solids (mg/L)	Suspended solids - replicate (mg/L)	% Difference	Sample ID	Date	Suspended solids (mg/L)	Suspended solids - replicate (mg/L)	% Difference
OK-12	07/09/99	230	569	147	NT-12	07/09/99	232	145	38
OK-13	07/16/99	159	98	38	NT-13	07/16/99	106	131	24
OK-31	02/21/00	154	152	1	NT-31	02/21/00	90	84	7
OK-33	04/07/00	113	150	33	NT-33	04/07/00	112	126	13
OK-34	05/09/00	185	244	32	NT-34	05/09/00	108	124	15
OK-44	08/26/00	134	65	51	NT-44	08/26/00	62	120	94
OK-45	09/07/00	245	193	21	NT-46	09/10/00	69	73	6
OK-46	09/10/00	115	280	143					
			mean	58				mean	28
			standard deviation	56				standard deviation	31
			Combined sites mean	44					
			Combined sites standard deviation	47					

Table A12. Blank sample analysis results at the test and control sites, Interstate 894, Milwaukee County, Wisconsin

[nd, not detected; --, not analyzed for; mg/L, milligram per liter; µg/L, microgram per liter; Diss., dissolved; COD, chemical oxygen demand; TSS, total suspended residue; NH_3, ammonia; N, nitrogen; NO_2 + NO_3, nitrate + nitrite; P, phosphorus; Ca, calcium; Mg, magnesium; Cl, chloride; Cu, copper; Zn, zinc; Cd, cadmium; Pb, lead; Shaded data indicates an unacceptably high concentration]

Sample ID	Date	Type of sample	COD (mg/L)	Total solids (mg/L)	TSS (mg/L)	Diss. NH_3 (mg/L)	Total NH_3 + organic N (mg/L)	Diss. NO_2+NO_3 (mg/L)	Total P (mg/L)	Diss. Ortho-P (mg/L)	Total Ca (mg/L)	Total Mg (mg/L)	Diss. Cl (mg/L)	Diss. Cu (µg/L)	Diss Zn (µg/L)	Total Zn (µg/L)	Total Cd (µg/L)	Total Pb (µg/L)	Total Cu (µg/L)	Total hardness (mg/L)
Test site																				
QOK-12	6/03/99	splitter blank	nd	nd	nd	nd	nd	nd	nd	--	0.06	0.06	0.2	--	--	nd	0.04	nd	nd	0.4
QOK-13	6/03/99	filter blank	--	--	--	--	--	--	--	0.002	--	--	--	nd	nd	--	--	--	--	--
QOK-23	9/30/99	splitter blank	nd	nd	nd	nd	nd	0.01	nd	--	.06	nd	.5	--	--	nd	nd	nd	nd	.3
QOK-24	9/30/99	filter blank	--	--	--	--	--	--	--	nd	--	--	--	1.4	nd	--	--	--	--	--
QOK-33	4/13/00	splitter blank	nd	nd	nd	nd	nd	nd	nd	--	.05	nd	.8	--	--	nd	.05	nd	nd	.2
QOK-34	4/13/00	filter blank	--	--	--	--	--	--	--	nd	--	--	--	nd	nd	--	--	--	--	--
QOK43	9/21/00	splitter blank	nd	nd	nd	nd	nd	nd	0.009	--	.02	nd	nd	--	--	nd	nd	nd	nd	nd
QOK-44	9/21/00	filter blank	--	--	--	--	--	--	--	nd	--	--	--	nd	nd	--	--	--	--	--
	lowest environmental concentration		36	204	9.5	.249	.71	.309	.092	.006	20	9	7.2	5.8	12	80	.48	18	25	87
Control site																				
QNT-12	6/03/99	splitter blank	nd	nd	nd	nd	nd	nd	nd	--	0.06	nd	nd	--	--	nd	nd	nd	nd	0.2
QNT-13	6/03/99	filter blank	--	--	--	--	--	--	--	.003	--	--	--	nd	nd	----	--	--	--	--
QNT-23	9/30/99	splitter blank	nd	nd	nd	nd	nd	.003	nd	--	.04	nd	nd	--	--	nd	nd	nd	nd	nd
QNT-24	9/30/99	filter blank	--	--	--	--	--	--	--	nd	--	--	--	nd	nd	--	--	--	--	--
QNT-31	4/13/00	before blank	nd	nd	nd	nd	nd	nd	.002	--	nd	nd	nd	--	--	nd	nd	.9	1	nd
QNT-32	4/13/00	ISCO blank	nd	nd	nd	nd	nd	nd	.003	--	.16	.03	4.8	--	--	nd	nd	nd	nd	.5
QNT-33	4/13/00	splitter blank	nd	16	6	nd	nd	.017	.006	--	.71	.31	5.1	--	--	220	.05	3.2	1	3.1
QNT-34	4/13/00	filter blank	--	--	--	--	--	--	--	nd	--	--	--	nd	nd	--	--	--	--	--
QNT-35	4/13/00	after blank	nd	nd	nd	.016	nd	nd	.003	--	.16	nd	nd	--	--	nd	nd	1.1	nd	nd
QNT-43	9/21/00	splitter blank	nd	10	nd	nd	nd	nd	.012	--	.04	nd	nd	--	--	nd	nd	nd	1	nd
QNT-44	9/21/00	filter blank	--	--	--	--	--	--	--	nd	--	--	--	nd	nd	--	--	--	--	--
	lowest environmental concentration		41	130	11	.026	.33	.299	.102	.004	13	5.3	9.4	7	18	63	.45	19	20	55

Table A13. Vehicle count data in test and control basins, Interstate 894, Milwaukee County, Wisconsin

[--, no data; shaded areas indicate the data is mostly or completely estimated from weekly averages]

Event number	Test site		Control site	
	Vehicle count during runoff period	Vehicle count during sampling period	Vehicle count during runoff period	Vehicle count during sampling period
1	285,387	285,387	491,416	474,611
2	47,191	40,918	47,191	44,668
3	30,850	26,521	26,259	14,345
4	54,398	39,183	52,816	40,010
5	29,442	23,936	28,907	6,515
6	37,198	32,884	35,478	35,478
7	57,902	55,016	56,500	53,128
8	14,476	11,370	15,962	6,151
9	16,760	13,970	16,760	13,281
10	23,114	19,514	25,259	20,201
11	1,237	902	981	362
12	2,489	1,926	2,558	1,695
13	76,666	74,706	74,706	63,548
14	3,098	3,098	16,313	1,182
15	4,833	2,037	4,144	1,884
16	23,906	19,437	26,105	20,562
17	886	726	1,030	513
18	11,972	10,915	13,029	10,056
19	17,733	14,498	18,548	12,270
20	22,498	22,498	32,540	29,383
21	11,461	4,188	11,461	4,188
22	74,218	73,442	74,218	71,654
23	65,490	61,450	66,752	57,503
24	32,882	28,696	12,982	10,213
25	20,601	19,321	27,827	18,046
26	536,462	528,412	542,800	526,419
27	9,151	4,337	17,060	10,365
28	37,265	34,594	39,992	19,966
29	--	--	--	--
30	--	--	--	--
31	80,579	79,730	81,639	74,577
32	45,597	38,697	35,366	27,771
33	75,957	75,957	75,957	74,820
34	36,059	19,272	37,735	20,987
35	33,792	33,792	27,280	23,980
36	16,503	15,339	54,507	46,223
37	72,739	62,947	34,081	34,081
38	5,863	3,795	8,844	1,902
39	14,051	8,160	12,573	6,400
40	20,299	13,732	21,485	9,601
41	43,098	15,560	50,909	4,183
42	49,121	1,644	50,891	3,038
43	11,708	3,486	12,905	12,905
44	13,287	8,969	8,969	6,981
45	16,358	7,674	12,143	7,674
46	8,435	4,575	8,435	3,531
47	40,382	14,946	38,799	18,345
48	91,782	80,664	86,899	70,860

Table A14. Suspended solids concentrations found in runoff samples collected from the freeway median, Interstate 894, Milwaukee County, Wisconsin

[mg/L, milligram per liter; TSS, total suspended solids; --, no data]

Test site median					
Field ID	**Collection start date and time**	**Collection end date and time**	**Event number**	**Sub-sample numbers**	**TSS (mg/L)**
OKM-1	07/27/00 04:41	07/27/00 04:44	--	1–3	1,480
OKM-2	07/27/00 04:45	07/27/00 04:49	--	4–6	998
OKM-3	07/28/00 12:29	07/28/00 12:32	40	1–2	4,232
OKM-4	07/28/00 12:44	--	40	3	7,270
OKM-5	07/28/00 12:46	07/28/00 12:48	40	4–5	1,060
OKM-6	08/17/00 04:19	08/17/00 07:34	42	1, 5, 6, 23	678
OKM-7	08/26/00 10:09	08/26/00 10:17	44	1–2	1,580
OKM-8	09/10/00 08:04	09/10/00 08:15	46	1–3	1,730
OKM-9	09/14/00 01:48	--	47	1	515
OKM-10	09/14/00 01:57	--	47	2	5,140
OKM-11	09/22/00 12:57	09/22/00 14:00	--	12–20, 24	207

Table A15. Test site freeway median runoff information, Interstate 894, Milwaukee County, Wisconsin

[--, no data]

Test site median				
Field ID	**Event number**	**Sub-samples composited**	**Sub-sample number**	**Percent full**
OKM-1	--	1–3	1	100
			2	100
			3	100
OKM-2	--	4–6	4	80
			5	67
			6	20
			7	0
OKM-3	40	1–2	1	80
			2	50
OKM-4	40	3	3	80
OKM-5	40	4–5	4	50
			5	30
			6–8	0
OKM-6	42	1, 5, 6, 23	1	100
			5	30
			6	15
			23	98
			2–4, 7–22, 24	0
OKM-7	44	1–2	1	100
			2	100
			3–8	0
OKM-8	46	1–3	1	100
			2	100
			3	3
			4–13	0
OKM-9	47	1	1	100
OKM-10	47	2	2	50
			3–10	0
OKM-11	--	12–20, 24	12	10
			13	20
			14	20
			15	35
			16	25
			17	15
			18	17
			19	20
			20	17
			24	22
			1–11, 21–23	0

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