CHARACTERIZATION OF THE RAIN STORMS OF MAY 2004

This article provides some perspective on the magnitude of the May 2004 rains by:

- Characterizing them relative to regional rainfall frequency analyses set forth in Table 1 that have either been described in SEWRPC Technical Report No. 40 (TR No. 40), *Rainfall Frequency in the Southeastern Wisconsin Region*, 2000, or recently prepared by Camp, Dresser & McKee Inc. under contract to the Milwaukee Metropolitan Sewerage District (MMSD).

- Describing the relationship between the rainfalls and the resultant flooding,

- Comparing the recent storm with severe storms which have occurred in the Region in the past, and

- Providing a context in which to evaluate the drainage and flooding impacts resulting from the rains.

GENERAL DESCRIPTION OF STORMWATER DRAINAGE AND FLOODING PROBLEMS

In order to better understand the causes of damages due to stormwater and flooding in general, it is helpful to characterize the problems as: 1) drainage problems related to stormwater runoff moving toward rivers, streams, and other low-lying areas; and 2) flooding problems relating to the direct overflow of streams. These are interrelated, both dealing with the problem of managing unwanted surface water. In addition, each of the two types of problems can have similar effects, including sewer surcharging; backup or bypassing; flooding of basements and first floors of structures; and flooding of streets and yards.

Stormwater Drainage Problems

From upstream to downstream within a drainage basin, a stormwater drainage system may include any or all of the following components: infiltration of runoff on pervious surfaces and in devices designed for infiltration; diffuse flow

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Table 1

RAINFALL DEPTHS FOR THE SOUTHEASTERN WISCONSIN REGION[a]

	Recurrence Interval, Percent Annual Probability, and Depths (inches)					
Storm Duration	2 Years,[a] 50 Percent	5 Years,[a] 20 Percent	10 Years,[a] 10 Percent	25 Years, 4 Percent	50 Years 2 Percent	100 Years, 1 Percent
24 Hours	2.57	3.14	3.62	4.41	5.11	5.88
72 Hours	3.29	3.94	4.40	5.09	5.63	6.17
5 Days	3.87	4.66	5.18	5.93	6.49	7.03
10 Days	4.90	5.78	6.34	7.13	7.70	8.22
15 Days	5.68	6.63	7.25	8.12	8.76	9.34
20 Days	6.61	7.56	8.11	8.82	9.30	9.71
25 Days	7.37	8.38	8.91	9.60	10.05	10.42

[a]*The rainfall frequency data for 24-hour and 72-hour periods are based on SEWRPC Technical Report No. 40. The data for 5-, 10-, 15-, 20-, and 25-day periods were developed by Camp, Dresser & McKee, Inc. (CDM) under contract to MMSD. The CDM/MMSD data include consideration of Milwaukee rainfall records from 1940 through May 2004. The SEWRPC Technical Report No. 40 data are based on Milwaukee records from 1940 through 1998.*

[b]*Factors presented in U.S. Weather Bureau TP-40 were applied to the annual series depths with recurrence intervals of two, five, and 10 years, converting those depths to the partial duration series amounts set forth in this table. The annual series depths were adjusted as follows:*

Two-year: multiplied by 1.136; five-year: multiplied by 1.042; and 10-year multiplied by 1.010.

Source: Rodgers and Potter and SEWRPC.

over pervious and impervious surfaces; collection of diffuse flow in open swales or street gutters; conveyance of the collected runoff in roadside ditches, storm sewers, or in the full street cross-section; temporary storage of runoff in depressions and detention basins; and, ultimately, discharge of the runoff to a receiving stream. If inadequate infiltration, collection, conveyance, or storage facilities are encountered as the runoff travels through the drainage system, localized ponding or overflow, or both, may result when storm sewers surcharge, roadside ditches overflow, or the hydraulic capacity of the full street cross-section is exceeded. Such ponding or overflow may result in inflow into sanitary sewers, sanitary and combined sewer surcharging, and backups into basements. In extreme cases, overland flooding of basements or even the first floors of low-lying structures may result.

Inflow of stormwater into sanitary sewers may result when runoff ponds over sanitary sewer manholes, or when basements flood from overland flow or sump pump failure and then drain into basement floor drains. Increased infiltration of clear water into sanitary sewers may also occur as a result of saturation of the ground adjacent to sanitary sewers and sewer laterals. When such conditions occur, a combination of stormwater and sewage may back up into the basements of structures, flowing out of floor drains and plumbing fixtures which are connected to the sanitary or combined sewers. In some cases, public sanitary sewer system bypassing to the surface waters or drainageways may have to be initiated to avoid basement backup problems.

Flooding Problems

Flooding problems are generally confined to corridors along the streams and water-courses. These problems manifest themselves when rainfall, snowmelt, or rainfall-snowmelt combinations cause streamflows to exceed the hydraulic capacities of the stream channels, and the waters overtop the stream banks and flow onto the adjacent floodplains. The floodplains may consist of open space, or may be occupied by flood-damage-prone streets and structures. When the streams overflow onto streets, this contributes to the inflow and infiltration of clear water into sanitary sewers and the resulting backups into basements. Also, direct overland flooding of building basements and first floors may occur when stream stages exceed flood levels.

Stormwater Drainage and Flood Control System Design Criteria

Insight into the nature of the May 2004 rainfalls and resulting flooding events can be gained through consideration of the hydrologic and hydraulic criteria generally used in the design of stormwater drainage systems, and the criteria generally used to determine the regulatory floodplain of a stream and to design flood control measures to alleviate flood problems. Urban stormwater drainage systems consist of two parts: a minor subsystem and a major subsystem. The minor stormwater drainage subsystem normally operates frequently and is intended to minimize the inconvenience attendant to runoff from relatively minor rainfall events. That system is generally designed to accommodate the runoff resulting from storms with annual probabilities of occurrence of 10 percent or greater. The minor stormwater drainage system includes infiltration facilities, street curbs and gutters, roadside swales, culverts, storm sewers, and stormwater detention and retention facilities.

When the capacity of the minor subsystem is exceeded, the additional runoff is conveyed in the major subsystem, which consists of the entire street cross-section and inter-connected drainage swales, open channels, and certain stormwater storage facilities. The major system is generally designed to accommodate the runoff from storms having annual probabilities of occurrence up to 1 percent.[1] These design storm frequencies for the minor and major stormwater drainage systems have been used over time in facility design by numerous municipalities and public works agencies. They were selected to provide a cost-effective level of protection for buildings and public facilities.

The regulatory floodplain of a stream, as determined for the purposes of zoning, Federal flood insurance, and design of flood control facilities, is based on the peak rate of discharge of a 1 percent annual probability flood.

As characterized below, there were certain areas of the Region that experienced relatively infrequent rainfalls and resultant floods during May 2004. However, in much of the Region, the probabilities of the rainfalls and the resultant floods were in the range commonly adopted for the stormwater and floodland management design purposes.

DESCRIPTION OF THE STORMS

As seen from Table 2 (see pages 12 and 13), in the first 24 days of May, rainfall totals throughout the Region ranged from about 5.5 to 11 inches.[2] This period of rain differed from past significant rain storms that produced drainage and flooding problems in that the storms were generally less intense and they occurred over a longer time period.

A straightforward means of evaluating the significance of the rainfalls, separate from the resulting flood flows, is to examine the probability of occurrence of those rains. This analysis was made for the 47 locations in the Region listed in Table 2 and located on

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[1]A 1 percent probability event is also referred to as a 100-year recurrence interval event and a 10 percent event is referred to as a 10-year recurrence interval event. This reflects the concept that, over a very long period of time, events of those magnitudes would average one occurrence for every 100 or 10 years, respectively

[2]The time period from May 6 through May 24 was analyzed because the rains that occurred during that period contributed to the stormwater drainage and riverine flooding problems that occurred in the Region. From May 1 through May 5, rainfalls throughout the Region were generally negligible.

Maps 1 through 3. The rain gauges included in Table 2 represent the best available sites for which reliable rain data were immediately available. Those gauges are operated by the Milwaukee Metropolitan Sewerage District (MMSD), the National Weather Service (NWS) or its cooperators, the U.S. Geological Survey, the City of Brookfield, the City of Mequon, and the Salem Utility District.[3,4]

The frequency of occurrence of a given rainfall occurring over a given time period can best be expressed as a probability that such a rainfall could happen in a given year. The higher the percent probability of occurrence, the more likely that a given event is to occur. For example, an event with a 1 percent probability of occurrence is much less likely to occur than an event with a 50 percent probability of occurrence.[5] As indicated in Table 2, the peak 24-hour rain periods all generally had a probability of occurrence of 50 percent or greater, indicating they were relatively common events. Because such events are unremarkable, it was decided to examine the longer-term rainfalls which were the distinguishing features of the May storms. In evaluating the relationship between rainfall and riverine flooding, rainfall periods of three, five, and 10 days were evaluated, and some consideration was also given to 15-day rainfall periods.

Maps 1, 2, and 3 show three-day (May 21 through 23), five-day (May 20 to 24), and 10-day (May 14 to 23) precipitation amounts measured at 47 locations in, or near, the Region. These time periods were chosen because they represent the largest rainfall periods for the greatest number of gauges. The maps also show isohyetal lines of equal precipitation depth as inferred from the measured rainfall amounts. Figures 1 through 5 present a set of graphs which compare measured maximum three-day, five-day, and 10-day rainfall amounts, respectively, with rainfall frequency data set forth in Table 1 based on analysis of rainfall data collected at the National Weather Service station at Milwaukee. Watershed areas are shown on the map and the graphs are presented by watershed to facilitate comparison of the probabilities of rainfall with those of the resulting flood flows.

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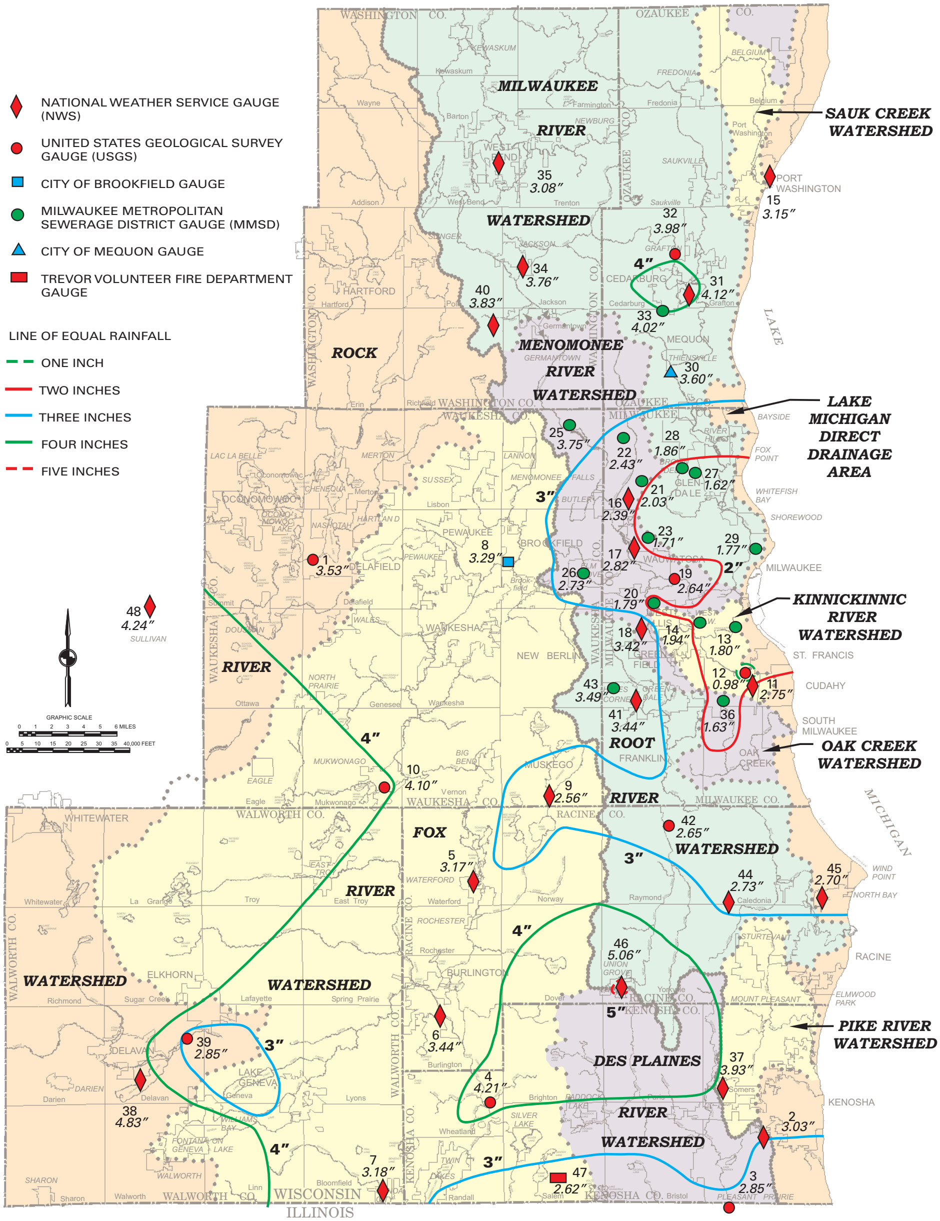
[3] *Data from 23 additional gauges were reviewed, but those gauges were eliminated from the analysis because of significant periods of missing data.*

[4] *The rainfall data assembled for this analysis are considered to be provisional by the recording agencies and may be subject to revision.*

[5] *A 50 percent probability event is also referred to as a two-year event.*

Map 1

RAINFALL PATTERN OVER SOUTHEASTERN WISCONSIN: 3-DAY PERIOD FROM MAY 21-23, 2004

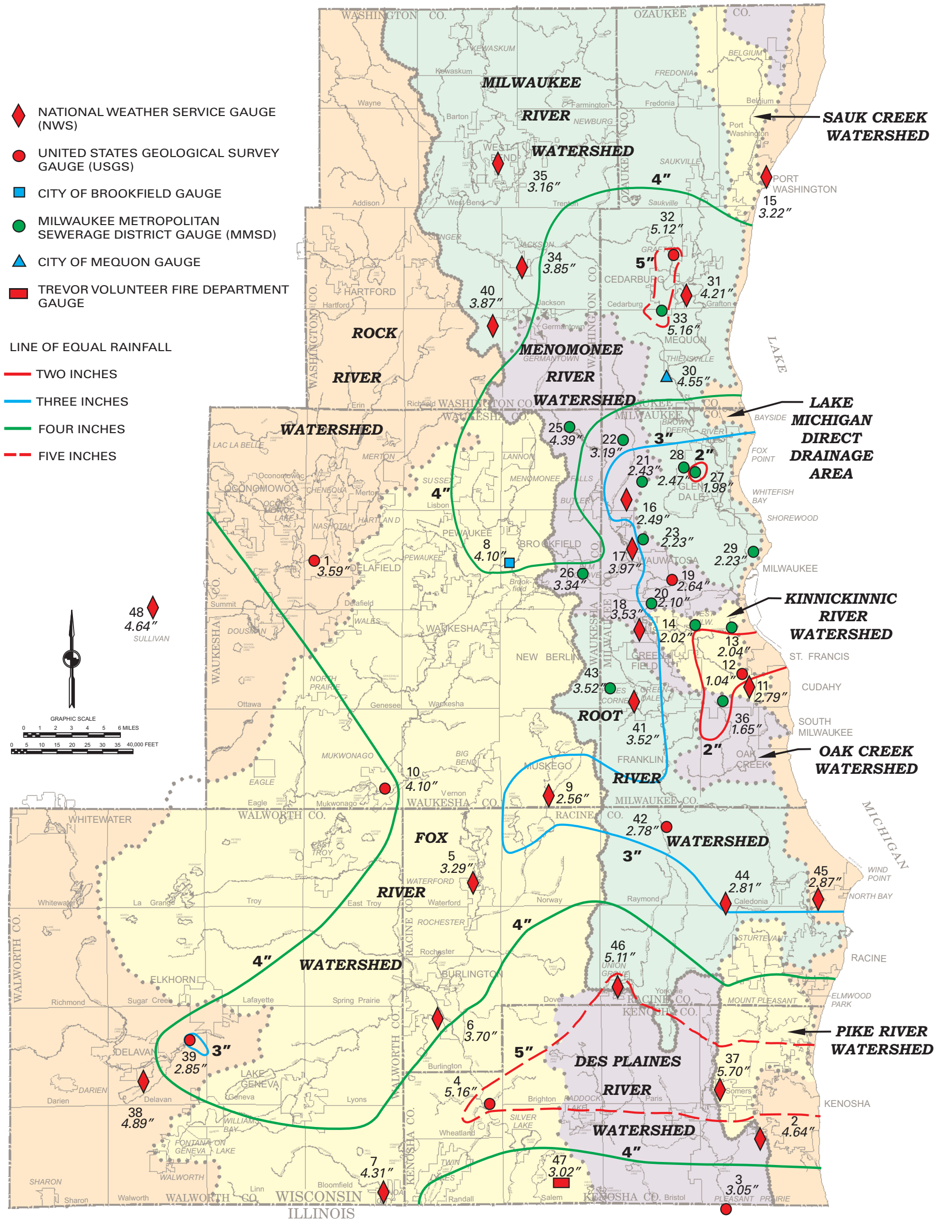


NOTE: Rainfall depths at each gauge are based on provisional data that is subject to revision. The locations of isohyetal lines are most accurate in those areas where rainfall gauges are concentrated.

Source: SEWRPC.

Map 2

RAINFALL PATTERN OVER SOUTHEASTERN WISCONSIN: 5-DAY PERIOD FROM MAY 20-24, 2004

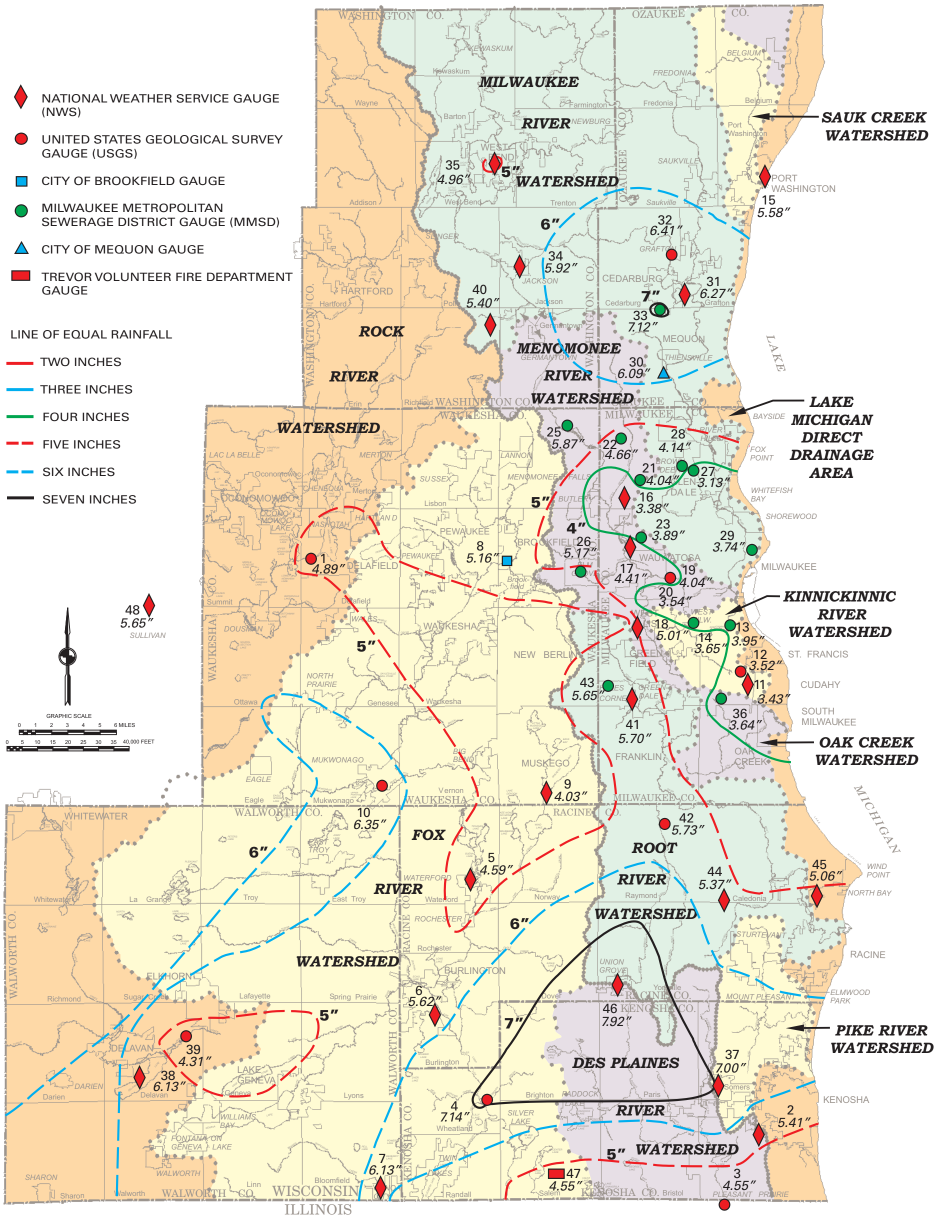


NOTE: Rainfall depths at each gauge are based on provisional data that is subject to revision. The locations of isohyetal lines are most accurate in those areas where rainfall gauges are concentrated.

Source: SEWRPC.

Map 3

RAINFALL PATTERN OVER SOUTHEASTERN WISCONSIN: 10-DAY PERIOD FROM MAY 14-23, 2004



NOTE: Rainfall depths at each gauge are based on provisional data that is subject to revision. The locations of isohyetal lines are most accurate in those areas where rainfall gauges are concentrated.

Source: SEWRPC.

The most extreme point rainfalls were generally measured in the Des Plaines, Fox, Menomonee, Milwaukee, and Rock River watersheds and at gauges very near the boundaries between the Des Plaines and Root River watersheds and the Des Plaines and Pike River watersheds. The following summaries by watershed are based on data set forth in Table 2 and Figures 1 through 5.

Des Plaines River Watershed

In, or near, the Des Plaines River watershed, the annual probabilities of occurrence of the most-intense three-day point rainfalls were in the range of 2 to 10 percent; however, at one location the annual probability was greater than 50 percent. The annual probabilities of occurrence of the most-intense five-day rains were in the range of 4 to 20 percent; however, once again, at one location the annual probability was greater than 50 percent. The annual probabilities of occurrence of the most-intense 10-day rains were in the range from less than 1 percent to 10 percent; however, at one location the annual probability was greater than 50 percent.

Fox River Watershed

In the Fox River watershed, the annual probabilities of occurrence of the most intense three-day point rains was 4 percent; however, at some locations the annual probability was greater than 50 percent. The annual probabilities of occurrence of the most intense five-day rains were in the range of 10 to 20 percent; however, once again, at some locations the annual probability was greater than 50 percent. The annual probabilities of occurrence of the most intense 10-day rains were in the range of 4 percent to 10 percent; but, at two locations the annual probability was greater than 50 percent.

Menomonee River Watershed

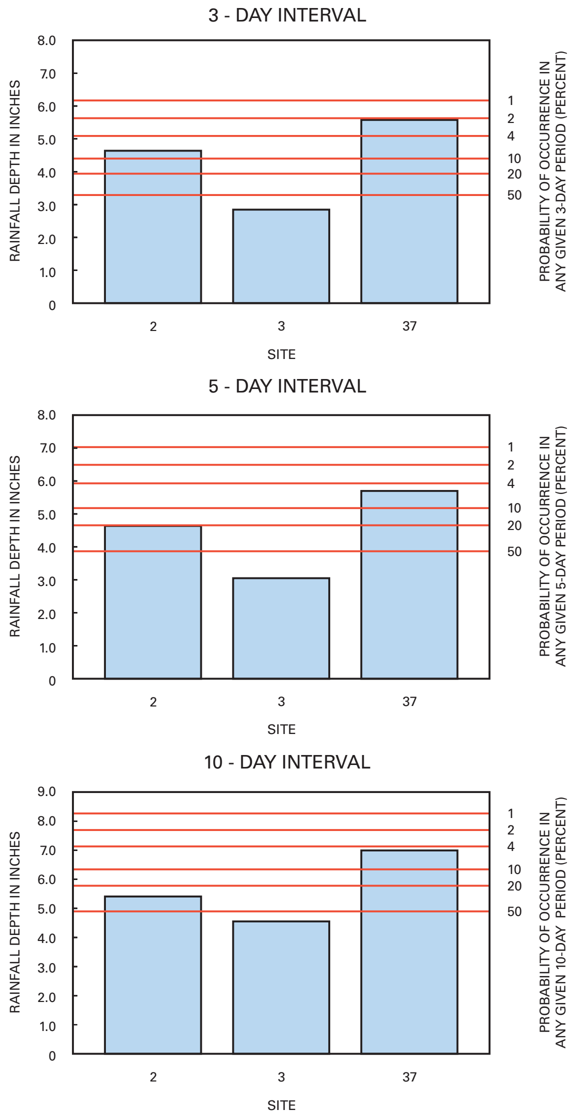
In the Menomonee River watershed, the annual probabilities of the three-day rains were 20 percent or greater and the probabilities of the five- and 10-day rains were 10 percent or greater.

Milwaukee River Watershed

In the Milwaukee River watershed, the annual probabilities of the three- and five-day rains were 10 percent or more. The annual probabilities of the most intense 10-day rains were in the range from 4 to 20 percent; however, at one location the annual probability was greater than 50 percent.

Figure 1

RAINFALL FREQUENCIES IN THE DES PLAINES RIVER WATERSHED MAXIMUM 3-, 5- AND 10-DAY RAINFALLS IN MARCH 2004



SITE LOCATION

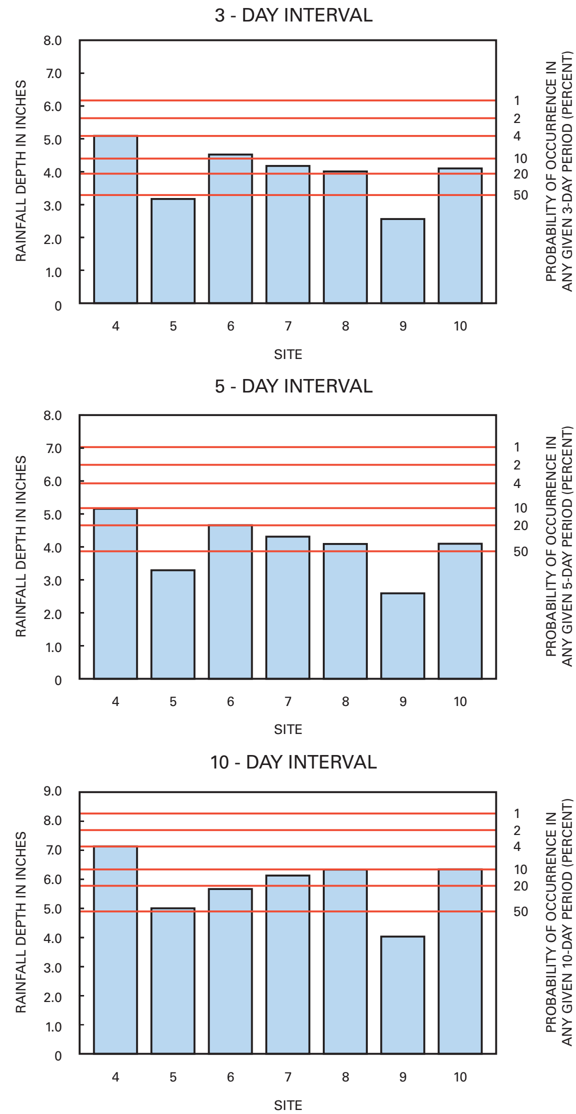
2 KENOSHA - 4 SW
3 DES PLAINES RIVER AT RUSSELL, ILLINOIS
37 KENOSHA - AIRPORT

NOTE: PROVISIONAL DATA SUBJECT TO REVISION BY RECORDING AGENCIES.

Source: National Weather Service NWS, U.S Geological Survey (USGS), and SEWRPC.

Figure 2

RAINFALL FREQUENCIES IN THE FOX RIVER WATERSHED MAXIMUM 3-, 5- AND 10-DAY RAINFALLS IN MARCH 2004



SITE LOCATION

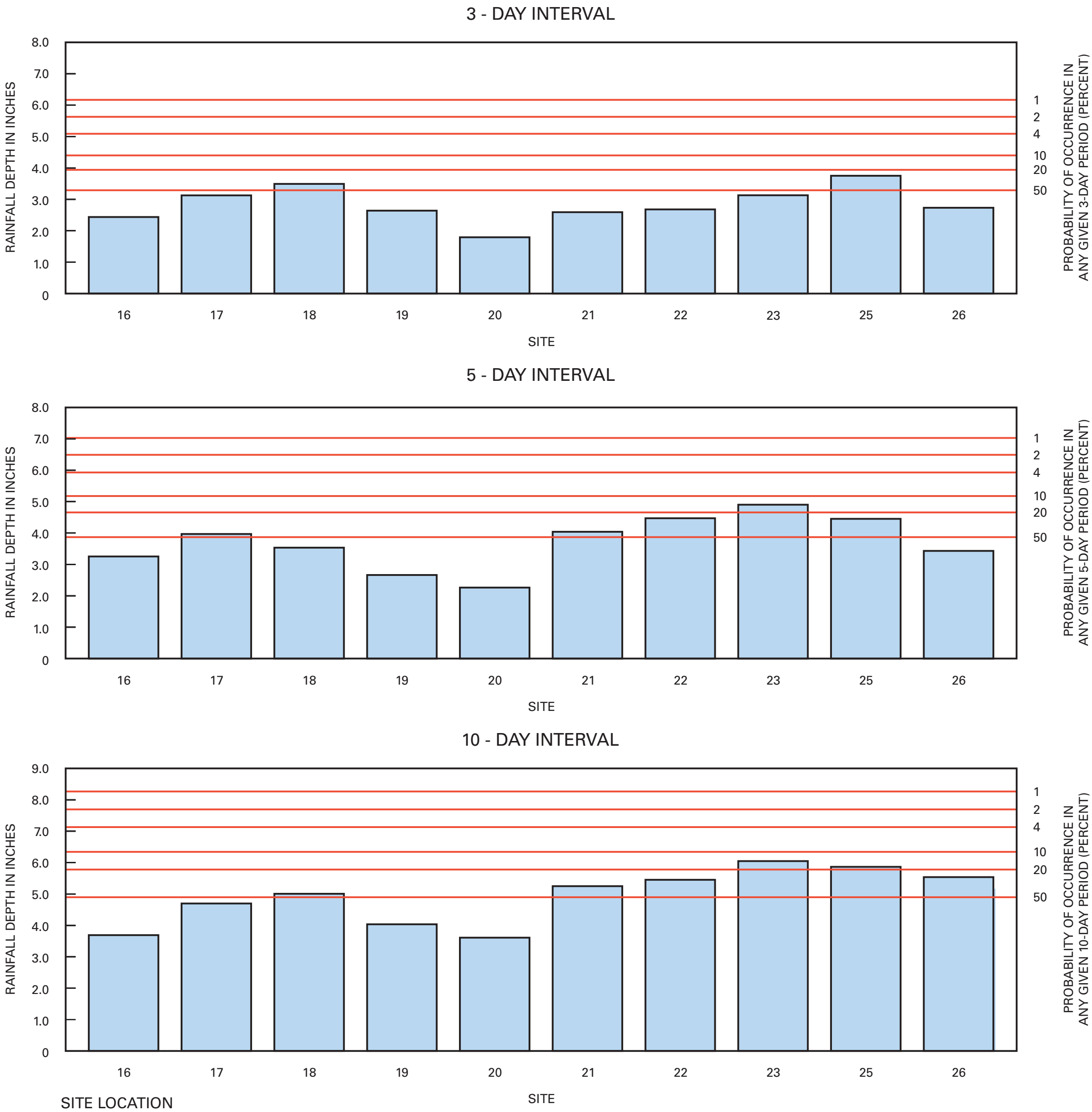
4 NEW MUNSTER - FOX RIVER
5 WATERFORD - 1 NW
6 BURLINGTON - WWTP
7 GENOA CITY
8 CITY OF BROOKFIELD WWTP
9 MUSKEGO 4S - BIG MUSKEGO LAKE
10 MUKWONAGO RIVER AT MUKWONAGO

NOTE: PROVISIONAL DATA SUBJECT TO REVISION BY RECORDING AGENCIES.

Source: City of Brookfield, NWS, USGS, and SEWRPC.

Figure 3

RAINFALL FREQUENCIES IN THE MENOMONEE RIVER WATERSHED MAXIMUM 3-, 5- AND 10-DAY RAINFALLS IN MARCH 2004



SITE LOCATION

16 MILWAUKEE - TIMMERMAN
17 MILWAUKEE - MT. MARY COLLEGE
18 WEST ALLIS
20 300 S. 84TH STREET
21 8414 W. FLORIST AVENUE
22 8463 N. GRANVILLE ROAD
25 MENOMONEE FALLS - W. 152 N. 8634 MARGARET ROAD
26 ELM GROVE - 13600 W. JUNEAU BOULEVARD

NOTE: PROVISIONAL DATA SUBJECT TO REVISION BY RECORDING AGENCIES.

Source: Milwaukee Metropolitan Sewerage District (MMSD), NWS, USGS, and SEWRPC.

Table 2

MAXIMUM 24-HR, THREE-, FIVE-, AND 10-DAY RAINS FROM MAY 1 THROUGH MAY 24, 2004[a]

WATERSHED	COUNTY	LOCATION/NWS, USGS, OR MMSD DESIGNATION	TYPE OF GAUGE	GAUGE NUMBER ON MAPS 1 THROUGH 3 AND FIGURES 1 THROUGH 5[b]	TOTAL 5/1 THROUGH 5/24/2004 (INCHES)	MAXIMUM 24-HOUR TOTAL[c] (INCHES)	MAXIMUM THREE-DAY TOTAL[c,d] (INCHES)	MAXIMUM FIVE-DAY TOTAL[c,d] (INCHES)	MAXIMUM 10-DAY TOTAL[c,d] (INCHES)	OBSERVED 24-HOUR PROBABILITY OF OCCURRENCE	OBSERVED THREE-DAY PROBABILITY OF OCCURRENCE	OBSERVED FIVE-DAY PROBABILITY OF OCCURRENCE	OBSERVED 10-DAY PROBABILITY OF OCCURRENCE
BARK	WAUKESHA	NAGAWICKA LAKE AT DELAFIELD	U.S. GEOLOGICAL SURVEY	1	8.01	1.43	3.53	3.59	4.89	>50%	20%	>50%	50%
DES PLAINES	KENOSHA	KENOSHA-4 SW	NATIONAL WEATHER SERVICE COOPERATOR	2	8.47	2.44	4.64	4.64	5.41	>50%	4 to 10%	20%	20 to 50%
DES PLAINES	LAKE COUNTY, IL	DES PLAINES RIVER AT RUSSELL, IL	U.S. GEOLOGICAL SURVEY	3	6.89	1.58	2.85	3.05	4.55	>50%	>50%	>50%	>50%
PIKE/DES PLAINES	KENOSHA	KENOSHA-AIRPT - LAT 42,35,43; LONG 87,55,39	NATIONAL WEATHER SERVICE COOPERATOR	37	10.02	2.5	5.58	5.7	7	>50%	2%	4 to 10%	4 to 10%
FOX	KENOSHA	NEW MUNSTER-FOX RIV.*	NATIONAL WEATHER SERVICE COOPERATOR	4	9.04	2.66	5.09	5.16	7.14	50%	4%	10%	4%
FOX	KENOSHA	TREVOR	VOLUNTEER FIRE DEPARTMENT	47	6.04	2.13	2.62	3.02	4.68	>50%	>50%	>50%	>50%
FOX	RACINE	WATERFORD-1 NW	NATIONAL WEATHER SERVICE COOPERATOR	5	9.05	2.44	3.17	3.29	5	>50%	>50%	>50%	20 to 50 %
FOX	RACINE	BURLINGTON-WWTP	NATIONAL WEATHER SERVICE COOPERATOR	6	10.37	2.88	4.52	4.66	5.67	20 to 50%	4 to 10%	20%	20 to 50 %
FOX	WALWORTH	GENOA CITY	NATIONAL WEATHER SERVICE COOPERATOR	7	7.83	2.53	4.18	4.31	6.13	50%	10 to 20%	20 to 50%	10 to 20%
FOX	WAUKESHA	C/BRKFLD WWTP - 21225 ENTERPRISE AVE.	CITY OF BROOKFIELD	8	9.59	2.49	4.01	4.10	6.33	>50%	10 to 20%	20 to 50%	10%
FOX	WAUKESHA	MUSKEGO 4S-B. MUS. LK*	NATIONAL WEATHER SERVICE COOPERATOR	9	6.64	1.56	2.56	2.59	4.03	>50%	>50%	>50%	>50%
FOX	WAUKESHA	MUKWONAGO R AT MUKWONAGO	U.S. GEOLOGICAL SURVEY	10	9.93	1.85	4.10	4.10	6.35	>50%	10 to 20%	20% to 50%	10%
KINNICKINNIC	MILWAUKEE	MILWAUKEE-MITCHELL FLD	NATIONAL WEATHER SERVICE	11	7.04	1.54	2.75	2.79	3.43	>50%	>50%	>50%	>50%
KINNICKINNIC	MILWAUKEE	WILSON PARK CR AT GMIA OUTFALL #7	U.S. GEOLOGICAL SURVEY	12	5.53	1.69	2.58	2.94	3.68	>50%	>50%	>50%	>50%
KINNICKINNIC	MILWAUKEE	MILWAUKEE - 245 W. LINCOLN (Gauge No. 1203)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	13	6.33	1.36	2.21	2.92	4.01	>50%	>50%	>50%	>50%
KINNICKINNIC	MILWAUKEE	MILWAUKEE - 3715 W. LINCOLN AVE. (Gauge No. 1208)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	14	6.04	1.11	2.17	2.87	3.93	>50%	>50%	>50%	>50%
LAKE MICHIGAN	OZAUKEE	PT. WASHINGTON-WWTP	NATIONAL WEATHER SERVICE COOPERATOR	15	9.89	1.75	3.15	4.28	5.58	>50%	>50%	20 to 50%	20 to 50 %
MENOMONEE	MILWAUKEE	MILWAUKEE-TIMMERMAN	NATIONAL WEATHER SERVICE COOPERATOR	16	6.83	2.14	2.44	3.25	3.69	>50%	>50%	>50%	>50%
MENOMONEE	MILWAUKEE	MILWAUKEE-MT MARY COLL	NATIONAL WEATHER SERVICE COOPERATOR	17	8.54	2.1	3.13	3.97	4.7	>50%	>50%	20 to 50%	>50%
MENOMONEE	MILWAUKEE	WEST ALLIS	NATIONAL WEATHER SERVICE COOPERATOR	18	8.18	2.36	3.49	3.53	5.01	>50%	20 to 50%	>50%	20 to 50 %
MENOMONEE	MILWAUKEE	MENOMONEE R AT WAUWATOSA	U.S. GEOLOGICAL SURVEY	19	6.70	1.29	2.64	2.64	4.04	>50%	>50%	>50%	>50%
MENOMONEE	MILWAUKEE	WEST ALLIS - 300 S. 84TH ST. (Gauge No. 1204)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	20	5.45	1.09	1.79	2.26	3.60	>50%	50%	>50%	>50%
MENOMONEE	MILWAUKEE	MILWAUKEE - 8414 W. FLORIST AVE. (Gauge No. 1207)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	21	8.08	1.80	2.59	4.04	5.25	>50%	>50%	20 to 50%	20 to 50%
MENOMONEE	MILWAUKEE	BROWN DEER - 8463 N. GRANVILLE RD. (Gauge No. 1209)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	22	8.76	1.78	2.68	4.47	5.45	>50%	>50%	20 to 50%	20 to 50%
MENOMONEE	MILWAUKEE	MILWAUKEE - 8800 W. LISBON AVE. (Gauge No. 1210)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	23	8.60	1.77	3.13	4.90	6.05	>50%	>50%	10 to 20%	10 to 20%
MENOMONEE	WAUKESHA	MENOMONEE FALLS - W.152 N.8634 MARGARET RD. (Gauge No. 1218)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	25	10.02	2.09	3.75	4.45	5.87	>50%	20 to 50%	20 to 50%	10 to 20%
MENOMONEE	WAUKESHA	ELM GROVE - 13600 W. JUNEAU BLVD. (Gauge No. 1219)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	26	7.98	1.28	2.82	3.43	5.54	>50%	>50%	>50%	20 to 50%
MILWAUKEE	MILWAUKEE	MILWAUKEE - 5335 N. TEUTONIA (Gauge No. 1202)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	27	6.82	1.39	2.15	3.49	4.51	>50%	>50%	>50%	>50%
MILWAUKEE	MILWAUKEE	MILWAUKEE - 6945 N. 41ST ST. (Gauge No. 1205)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	28	8.21	2.14	2.77	4.29	5.33	>50%	>50%	20 to 50%	20 to 50%
MILWAUKEE	MILWAUKEE	MILWAUKEE - 2647 N. BARTLETT AVE. (Gauge No. 1212)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	29	7.96	1.56	2.82	4.38	5.38	>50%	>50%	20 to 50%	20 to 50%
MILWAUKEE	OZAUKEE	MEQUON CITY HALL - 11333 N. CEDARBURG RD.	CITY OF MEQUON	30	9.71	1.42	3.60	4.55	6.09	>50%	20 to 50%	20 to 50 %	10 to 20%
MILWAUKEE	OZAUKEE	CEDARBURG-LAKEFIELD	NATIONAL WEATHER SERVICE COOPERATOR	31	10.05	2.65	4.12	4.37	6.27	50%	10 to 20%	20 to 50%	10 to 20%
MILWAUKEE	OZAUKEE	CEDAR CR NEAR CEDARBURG	U.S. GEOLOGICAL SURVEY	32	10.67	2.12	3.98	5.12	6.41	>50%	20%	10 to 20%	4 to 10%
MILWAUKEE	OZAUKEE	CEDARBURG - -700 W. PIONEER RD. (Gauge No. 1214)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	33	10.91	1.52	4.02	5.16	7.12	>50%	20%	10%	4%
MILWAUKEE	WASHINGTON	JACKSON	NATIONAL WEATHER SERVICE COOPERATOR	34	8.89	2.25	3.76	5.14	5.92	>50%	20 to 50%	10%	10 to 20%
MILWAUKEE	WASHINGTON	WEST BEND-2 SW-HAM	NATIONAL WEATHER SERVICE COOPERATOR	35	8.43	2.06	3.08	4.26	4.96	>50%	>50%	20 to 50%	20 to 50%
OAK CREEK	MILWAUKEE	MILWAUKEE - 6074 S. 13TH ST. (Gauge No. 1213)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	36	5.55	1.42	2.29	2.55	3.89	>50%	>50%	>50%	>50%
ROCK	WALWORTH	DELAVAN-HAM	NATIONAL WEATHER SERVICE COOPERATOR	38	9.94	2.64	4.83	4.89	6.13	50%	4 to 10%	10 to 20%	10 to 20%
ROCK	WALWORTH	JACKSON CR AT MOUND RD NR ELKHORN	U.S. GEOLOGICAL SURVEY	39	7.14	1.70	2.85	2.85	4.31	>50%	>50%	>50%	>50%
ROCK	WASHINGTON	RICHFIELD	NATIONAL WEATHER SERVICE COOPERATOR	40	8.86	2.38	3.83	4.24	5.4	>50%	20 to 50%	20 to 50%	20 to 50%
ROCK	JEFFERSON	SULLIVAN	NATIONAL WEATHER SERVICE	48	8.42	3.13	4.24	4.64	5.65	20%	10 to 20%	20%	20 to 50%
ROOT	MILWAUKEE	HALES CORNERS-WHITNALL	NATIONAL WEATHER SERVICE COOPERATOR	41	8.61	2.2	3.44	3.52	5.70	>50%	20 to 50%	>50%	20 to 50%
ROOT	MILWAUKEE	ROOT RIVER CANAL NR. FRANKLIN	U.S. GEOLOGICAL SURVEY	42	8.76	1.84	3.27	3.39	5.73	>50%	50%	>50%	20 to 50%
ROOT	MILWAUKEE	HALES CORNERS - 5635 S. NEW BERLIN RD. (Gauge No. 1220)	MILWAUKEE METROPOLITAN SEWERAGE DISTRICT	43	7.82	1.70	3.49	3.52	5.80	>50%	20 to 50%	>50%	20%
ROOT	RACINE	FRANKSVILLE	NATIONAL WEATHER SERVICE COOPERATOR	44	8.92	1.7	2.97	2.97	5.37	>50%	>50%	>50%	20 to 50%
ROOT	RACINE	RACINE-AIRPORT	NATIONAL WEATHER SERVICE COOPERATOR	45	8.35	2.17	2.79	3.08	5.06	>50%	>50%	>50%	20 to 50%
ROOT/DES PLAINES	RACINE	UNION GROVE	NATIONAL WEATHER SERVICE COOPERATOR	46	11.18[e]	2.87	5.06[f]	5.11[f]	8.26[g]	20 to 50%	4%[f]	10%[f]	1%[g]

[a] *Based on provisional data that is subject to revision.*

[b] *Gauge No. 24 is omitted.*

[c] *For comparison purposes, the 1 percent probability rainfall depths for 24 hours, three days, five days, and 10 days are 5.88, 6.17, 7.03, and 8.22 inches, respectively.*

[d] *These rainfall depths reflect the greatest three-, five-, and 10-day periods at each gauge. In some instances they differ from the three-, five-, and 10-year depths set forth on Maps 1 through 3 because the depths on those maps all correspond to the same time periods, which resulted in the largest rain totals for the greatest number of gauges.*

[e] *The May 12, 19, and 20, 2004, rainfall depths at the Union Grove gauge were not recorded. Thus, the May 1st through 24th total is understated by an unknown amount. Nearby gauges recorded from 0.7 to 1.2 inches on May 12th, 0.0 inch on May 19th, and 0.1 to 1.7 inches on May 20th.*

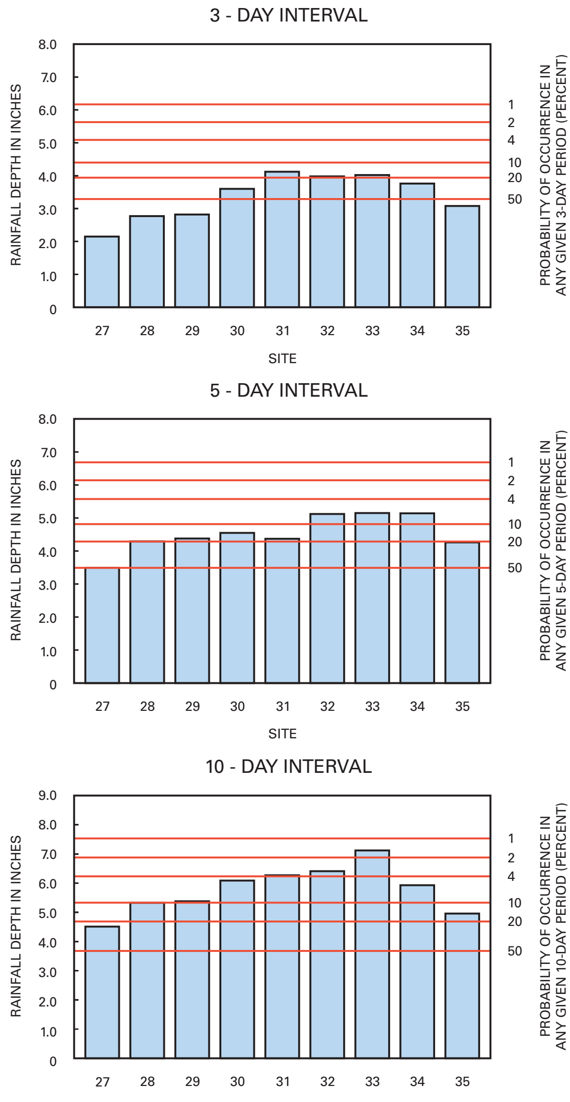
[f] *Approximate. May be affected by missing May 20th rainfall depth.*

[g] *Approximate. May be affected by missing May 19th and 20th rainfall depths*

Source: Cities of Brookfield and Mequon, MMSD, Salem Utility District, National Weather Service, U.S. Geological Survey, and SEWRPC.

Figure 4

RAINFALL FREQUENCIES IN THE MILWAUKEE RIVER WATERSHED MAXIMUM 3-, 5- AND 10-DAY RAINFALLS IN MARCH 2004



SITE LOCATION

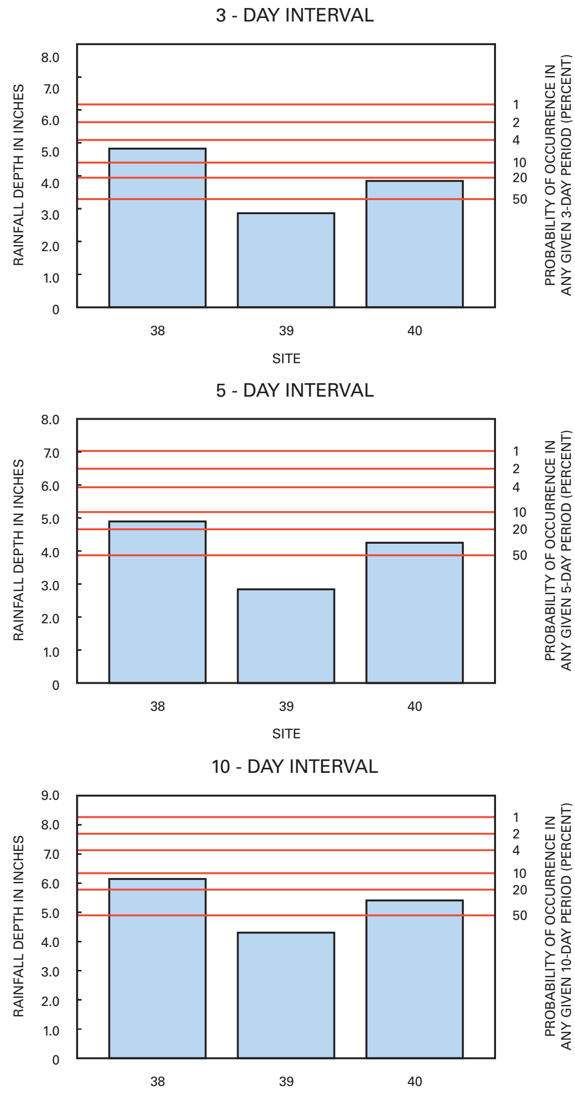
27 5335 N. TEUTONIA AVENUE
28 6945 N. 41ST STREET
29 2647 N. BARTLETT AVENUE
30 MEQUON CITY HALL
31 CEDARBURG - LAKEFIELD
32 CEDAR CREEK NEAR CEDARBURG
33 700 W. PIONEER ROAD AT CEDARBURG
34 JACKSON
35 WEST BEND - 2 SW - HAM

NOTE: PROVISIONAL DATA SUBJECT TO REVISION BY RECORDING AGENCIES.

Source: City of Mequon, NWS, USGS, and SEWRPC.

Figure 5

RAINFALL FREQUENCIES IN THE ROCK RIVER WATERSHED MAXIMUM 3-, 5- AND 10-DAY RAINFALLS IN MARCH 2004



SITE LOCATION

38 DELAVAN - HAM
39 JACKSON CREEK AT MOUND ROAD NEAR ELKHORN
40 RICHFIELD

NOTE: PROVISIONAL DATA SUBJECT TO REVISION BY RECORDING AGENCIES.

Source: NWS, USGS, and SEWRPC.

Rock River Watershed

In the Rock River watershed, the annual probabilities of occurrence of the most intense three-, five- and 10-day rains were in the range of 4 to 10 percent, 10 to 20 percent, and 10 to 20 percent, respectively. However, for each storm duration, at one location the annual probability was greater than 50 percent.

Root River Watershed

With the exception of the gauge at Union Grove, the rainfalls recorded in this watershed had probabilities of 20 percent or greater. More extreme rainfalls were recorded at Union Grove, where the three-, five-, and 10-day probabilities were 4 percent, 10 percent, and 1 percent, respectively.[6]

RELATIONSHIPS BETWEEN THE RAINFALLS AND THE RESULTANT FLOODING

The variability in both depths and extent of rainfall over each watershed for given time periods are two reasons why the probability of occurrence of the rainfalls do not always match the probability of occurrence of streamflows. Another factor which can create a disconnect between the probability of a rainfall event and the probability of the resulting streamflow is the influence of soil moisture conditions at the time of the rainfall. Thus, a low-probability rainfall (large depth for a given time period) occurring after an extended period of little or no rain may actually produce a lower flood peak than a higher-probability rainfall occurring on ground saturated due to previous rains. The runoff-producing effects of rainfall on saturated ground are most prominent in areas with significant amounts of pervious open lands. Also, the storm duration that is critical for producing peak flows is related to watershed characteristics such as the size of the tributary area, the watershed shape, soils, types of land cover, and the nature of the stream system.

These situations can be analyzed by applying continuous simulation hydrologic models such as those used by the Regional Planning Commission for about 30 years and, more recently, by the Milwaukee Metropolitan Sewerage District. Continuous simulation hydrologic models are calibrated to flow data measured at stream gauges and they enable

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[6] *The rainfall values on which the Union Grove probability estimates were made may be somewhat low because rainfall data were not collected on May 19 and 20, during the most intense three-, five-, and 10-day periods.*

computation of a continuous streamflow record over a period of many years, specifically accounting for many processes that influence the infiltration and runoff of precipitation. In this manner, soil moisture conditions are continuously accounted for and the potentials for less runoff from rain occurring after a dry period or more runoff for rain occurring after a wet period can be directly accounted for. The annual peak flows at numerous ungauged locations in a watershed can be estimated using continuous simulation modeling and statistical methods can be used to determine flood flow probabilities. In contrast, a single event, rather than continuous simulation, model assumes a rainfall of a given frequency produces a flood flow of the same frequency. Because of the simplifications inherent in that approach and the need to assume an antecedent moisture condition, single event models are not as well suited to adequately representing the true outcomes of the complex rainfall-runoff process as are continuous simulation models.

Table 3 sets forth streamflow information collected at gauges maintained throughout the Region and environs by the U.S. Geological Survey (USGS) in cooperation with the Regional Planning Commission and other local cooperators, including the Milwaukee Metropolitan Sewerage District, the City of Racine, the Racine Water and Wastewater Utilities, the Kenosha Water Utility, Waukesha County, the Wisconsin Department of Natural Resources, and the Illinois Department of Transportation. Gauge locations are shown on Map 4.

Des Plaines River Watershed

This watershed experienced extreme flood conditions in May 2004. The flood peak recorded on the Des Plaines River at the USGS streamflow gauge at Russell, Illinois, just south of the Wisconsin-Illinois state line significantly exceeded both the previous flood of record and the 1 percent probability flood. Examination of Map 3 indicates that the most extreme 10-day rainfall that is estimated to have occurred in the watershed had a probability of about 1 percent, although at the Russell gauge the rainfall probability was greater than 50 percent. The 15-day rainfall at Union Grove had an estimated probability of less than 0.2 percent. Because of the predominance of less frequent rains, in this case, there was a relatively direct correlation between the rainfall probability and the resulting flood probability.

Fox River Watershed

The Fox River did not experience peak flood flows as rare as those on the Des Plaines River. The recorded peaks were less than the floods of record and had probabilities of occurrence of 10 to 20 percent. Map 3 indicates that the average 10-day rainfall over

Table 3

SUMMARY OF PEAK FLOOD FLOWS IN THE SOUTHEASTERN WISCONSIN REGION: MAY 2004

USGS GAUGE NUMBER	GAUGE NAME	APPROXIMATE PERIOD OF RECORD OF GAUGE (YEARS)	PEAK RECORDED FLOW OVER PERIOD OF RECORD OF GAUGE PRIOR TO MAY 2004 (CFS)	DATE OF FLOOD OF RECORD	PEAK RECORDED FLOW IN MAY 2004[a] (CFS)	DATE OF PEAK MAY 2004 FLOW	ESTIMATED PROBABILITY OF PEAK MAY 2004 FLOW OCCURRING IN ANY YEAR[b] (PERCENT)
05426250	BARK RIVER NEAR ROME	15	476	4/20/1993	405[c]	5/23/2004	10
05527800	DES PLAINES RIVER AT RUSSELL, IL	44	2,130	6/14/2000	3,300[c]	5/24/2004	<1[d]
05543830	FOX RIVER AT WAUKESHA	41	2,260	4/22/1973	1,462	5/24/2004	10 TO 20
05545750	FOX RIVER NEAR NEW MUNSTER	65	7,520	3/31/1960	4,718	5/24/2004	10 TO 20
04087159	KINNICKINNIC RIVER AT S. 11TH ST, MILWAUKEE	22	10,600	8/6/1986	1,739	5/14/2004	>50
04087030	MENOMONEE RIVER AT MENOMONEE FALLS	28	1,500	6/21/1997	1,160	5/23/2004	4 TO 10
04087120	MENOMONEE RIVER AT WAUWATOSA	43	13,500	4/21/1973 AND 6/21/1997	5,112	5/22/2004	20 TO 50
04086600	MILWAUKEE RIVER NEAR CEDARBURG	23	5,500	6/18/1996	5,798	5/23/2004	2 TO 4
04087000	MILWAUKEE RIVER AT MILWAUKEE	90	16,500	6/21/1997	7,148	5/24/2004	10 TO 20
04086500	CEDAR CREEK NEAR CEDARBURG	66	3,600	3/30/1960	2,150[c]	5/24/2004	10 TO 20
04087204	OAK CREEK AT SOUTH MILWAUKEE	41	1,140	8/6/1986	611	5/23/2004	50
04087257	PIKE RIVER NEAR RACINE	33	1,580	6/12/2000	1,650	5/23/2004	1 TO 2
04087220	ROOT RIVER NEAR FRANKLIN	41	3,700	4/21/1973	1,360	5/23/2004	20 TO 50
04087240	ROOT RIVER AT RACINE	41	4,500	3/5/1974	2,914	5/24/2004	10 TO 20
04087233	ROOT RIVER CANAL NEAR FRANKLIN (AT RAYMOND)	41	1,440	3/4/1974	2,624	5/23/2004	<1

[a] *Provisional data that is subject to revision by the U.S. Geological Survey.*

[b] *Except for the Des Plaines River at Russell, Illinois, flood frequencies based on USGS analyses of gauged data through the year 2000 as set forth in Flood Frequency Characteristics of Wisconsin Streams, Water Resources Investigations Report 03-4250, 2003.*

[c] *Measured by USGS.*

[d] *Based on continuous simulation of 55 years of stream flow record using the calibrated U.S. Environmental Protection Agency HSPF model developed by the Regional Planning Commission staff under the watershed study described in SEWRPC Planning Report No. 44,* A Comprehensive Plan for the Des Plaines River Watershed, *June 2003.*

Source: U.S. Geological Survey and SEWRPC.

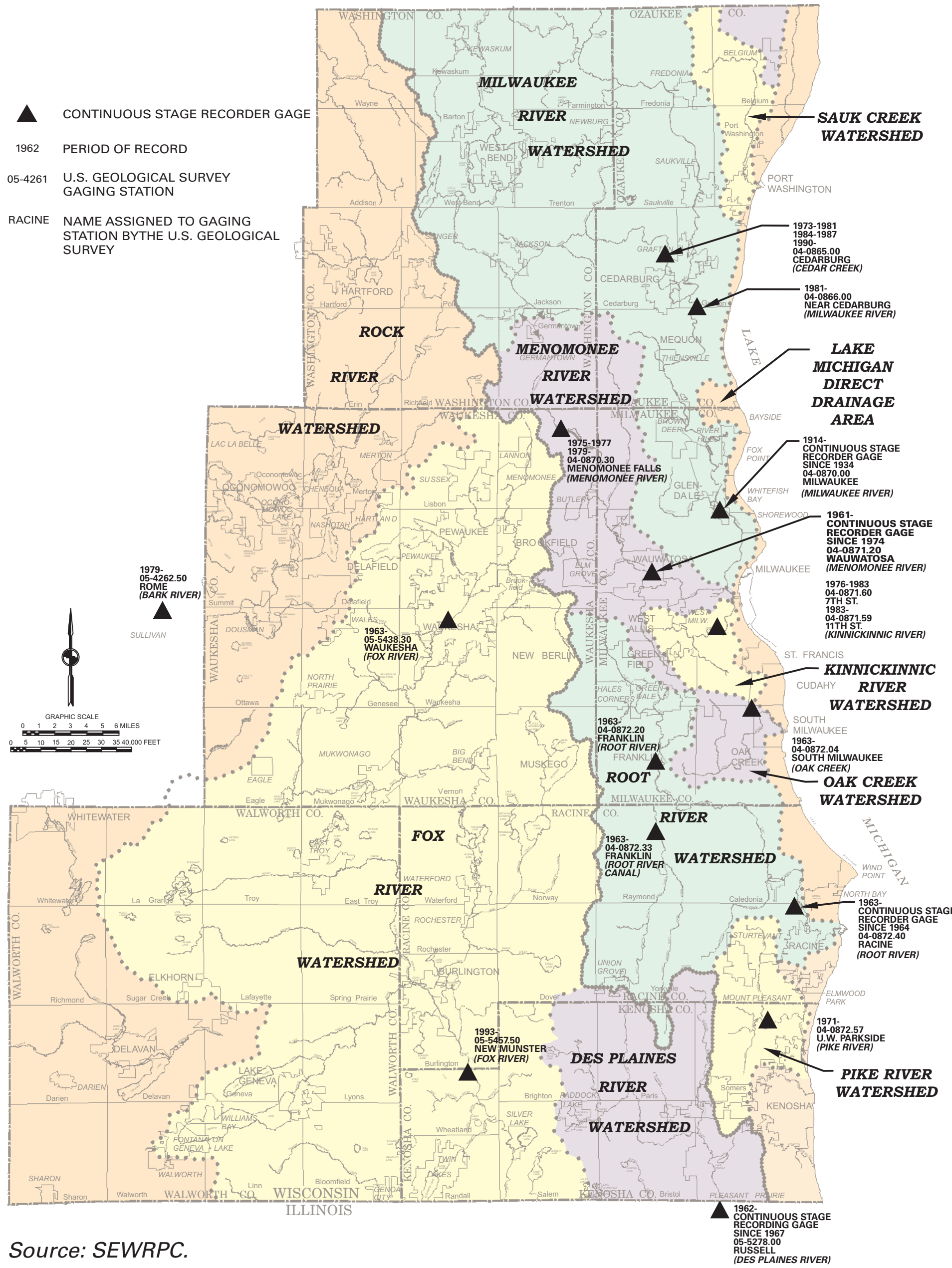
the watershed had a probability of about 20 to 50 percent, which is somewhat higher than the probability of the recorded peak flows. Although a small portion of the watershed experienced 10-day rainfalls with probabilities less than 10 percent, and the 15-day rainfall probability at the New Munster gauge is estimated to be about 2 percent, the effects of such localized heavier rains tend to be damped out in such a large watershed with significant floodwater storage.

Menomonee River Watershed

Five- and 10-day rainfall probabilities varied widely over the watershed. A flood peak with an estimated probability of 4 to 10 percent occurred at the USGS gauge on the Menomonee River in the Village of Menomonee Falls in the upper portion of the

Map 4

LOCATION OF SELECTED U.S. GEOLOGICAL SURVEY STREAM-GAGING STATIONS



Source: SEWRPC.

watershed. That flood probability is less than the estimated 20 percent probabilities of the average three-, five-, and 10-day rainfalls over the upper portion of the watershed that is tributary to the gauge site. It is possible that the lower probability flood peak resulted from significant rains that fell on saturated ground late in the 10-day period.

At the Menomonee River streamflow gauge in the City of Wauwatosa in the lower part of the watershed, the peak flow had an estimated probability of occurrence of 20 to 50 percent. That peak has a somewhat lower probability of occurrence than the average 10-day rainfall for the watershed, which is estimated to be about 50 percent, and a lower probability than the average three-day rainfall over the watershed, which has an estimated probability of greater than 50 percent. However, the estimated average five-day rainfall probability of 20 to 50 percent coincides with the rainfall probability, indicating that the five-day rain was more critical for determining peak flows in the lower portion of the watershed than were the three- or 10-day amounts.

Milwaukee River Watershed

Maps 1 through 3 and Table 2 indicate that the heaviest rains in this watershed were centered in southern Ozaukee County where 10-day rains with probabilities as low as 4 percent occurred and the 15-day rain probability was estimated to be in the range from 0.2 to 0.5 percent. The peak flood flow on the main stem of the Milwaukee River at Cedarburg in southern Ozaukee County had a probability of 2 to 4 percent, which falls between the most intense 10- and 15-day rainfall probabilities, and the peak at Milwaukee had a probability of 10 to 20 percent.

Over the Cedar Creek subwatershed, the probabilities of occurrence of the estimated average three- and five-day rains were in the range from 20 to 50 percent and the estimated average 10-day rain probability was in the 10 to 20 percent range. Also, the probabilities of the maximum five- and 10-day point rainfalls measured in the downstream portion of the subwatershed near the City of Cedarburg were in the 4 to 20 percent range. The peak flood flow measured on Cedar Creek at Cedarburg was in the range of 10 to 20 percent, which correlates with the average 10-day rainfall probabilities. In Cedarburg, the 15-day rainfall probability was estimated to be 0.2 to 0.5 percent, indicating that this localized, longer-duration rainfall may not have been as critical for producing the flood peak as were the shorter-duration rains.

Rock River Watershed

In the Rock River watershed, the gauge in, or near, the Region with the most significant tributary area is located on the Bark River near Rome in Jefferson County. As set forth in Table 3, a peak flood flow with a probability of about 10 percent occurred at that gauge. Although, there was not a great amount of rainfall data available for that subwatershed, Maps 1 through 3 indicate probabilities of about 20 to 50 percent for the estimated average three-, five-, and 10-day rainfalls. It is possible that the lower probability of the flood peak relative to the rainfalls is a result of increased runoff due to rainfall on saturated ground.

Root River Watershed

While Table 3 indicates that the peak flood flows on the Root River main stem were not especially rare, the flood of record occurred on the Root River Canal in the Town of Raymond. That flood peak has an estimated probability smaller than 1 percent.

The probabilities of the average three-, five-, and 10-day rainfalls over the Root River Canal subwatershed, which are estimated to be 20 to 50 percent, less than 50 percent, and 4 to 10 percent, respectively, are considerably less than the flood probability. However, the point 10-day rainfall at Union Grove was less frequent with a probability of about 1 percent. Closer examination of the rainfall record indicates that the large flood resulted from large rains that occurred late in the maximum 10-day rain period when significant amounts of rain fell on the saturated ground of the largely rural subwatershed.

COMPARISON OF THE MAY 2004 RAINS WITH OTHER SEVERE STORMS WHICH HAVE OCCURRED IN THE REGION

Many of the large floods which have occurred in the Region in the past 80 years have resulted from snowmelt or a combination of snowmelt and rainfall. Thus, the rainfalls which contributed to the occurrence of those floods were not necessarily rare, although the combinations of rainfall, snowmelt, and ground-frost conditions concerned were rare.

Extreme rainfall-only events which occurred in the Region include the following:

- The event of August 3 through August 6, 1924, when 9.3 inches of rain were recorded at the City of West Bend in Washington County. Four-day rainfall totals from that storm ranged from 9.3 inches at West Bend to 5.0 inches in central Milwaukee County. The rainfall measured at West Bend had a probability of occurring in any given year of less than 0.2 percent, while that measured at Milwaukee had a probability of 10 percent. The overall storm produced a flood of 15,100 cubic feet per second (cfs) on the Milwaukee River at Milwaukee. That flood had a probability of about 1 percent, and caused great damage.

- The event of August 6, 1986, when 6.84 inches of rain fell in 24 hours at General Mitchell International Airport in the City of Milwaukee. The most intense precipitation from that storm occurred within a band oriented from northwest to southeast across Milwaukee County. Another intense band of rain with a similar orientation occurred in western Kenosha and Racine Counties. The rainfall at General Mitchell International Airport had a probability of about 0.2 percent and the resultant flood peak of 10,600 cfs on the Kinnickinnic River at S. 11th Street in Milwaukee is estimated to have had a probability of less than 0.2 percent. The attendant flood also caused great damage throughout the area of heavy rain.

- The event of June 16 through June 18, 1996, when a three-day total of 13.52 inches of rain fell at the City of Port Washington in Ozaukee County. The most intense rainfall period occurred on June 18, when 9.87 inches of rain fell in 24 hours. The 24- and 72-hour rainfalls had probabilities of less than 0.2 percent. Considerable damage occurred in Port Washington.

- The event of June 20 and 21, 1997, when intense thunderstorms generally occurred over about a 10-hour period, beginning shortly before midnight on June 20. The most intense rainfall was centered in northern Milwaukee County and covered a 13-mile-wide, 18-mile-long band which included the extreme southern portion of Ozaukee County, southeastern Washington County, and northeastern Waukesha County. Within that band, six or more inches of rain fell in a 26-hour period on June 20 and 21. The greatest reported 26-hour rainfall was 9.79 inches in the Village of Brown Deer. That rainfall has a probability of occurrence of less than 0.2 percent.

  Total rainfall amounts of from 1.5 to 2.0 inches were reported across the Region in a 24-hour period on June 15 and 16. Those rains resulted in high-soil-moisture conditions when the intense rainfalls of June 20 and 21 occurred. Thus, the ability of the soil to absorb rainfall was reduced and the amount of runoff was increased during the heavy storms.

  June 21, 1997, flood probabilities were estimated at about 1 percent on Underwood Creek at the City of Wauwatosa; about 0.5 to 1 percent on the Menomonee River at Wauwatosa; and about 0.5 percent on the Milwaukee River at the City of Milwaukee. The floods on Underwood Creek, the Menomonee River, and the Milwaukee River were the largest recorded in the 23, 36, and 83 years, respectively, that the streamflow gages involved had been in operation as of 1997.

The floods resulting from this storm caused considerable flooding in northern Milwaukee County and northeastern Waukesha County.

- The storm of August 6, 1998, when the most intense rainfall covered a five-mile-wide, 16-mile-long band which included northern Milwaukee County and northeastern Waukesha County. Within that band, five or more inches of rain fell. Recording gauge records indicate that the rain generally occurred over a 19- to 20-hour period, with the heaviest rainfalls falling within about a seven- to 10-hour period. The greatest reported 24-hour rainfall was 11.75 inches in the City of Brookfield. A 24-hour total of 8.00 inches was reported in the Village of Brown Deer. The Brookfield rainfall had an estimated probability of less than 0.2 percent, and the Brown Deer rainfall had a probability of 0.2 percent.

  The floods resulting from this storm caused considerable flooding in northern Milwaukee County and northeastern Waukesha County.

As noted above, the May 2004 storms differed from these storms in that the 2004 storms occurred over longer time periods with the probability of occurrence of the rainfalls at a given location generally decreasing with storm duration. That is, the 10-day and longer rainfalls generally were more rare occurrences than the three-day rainfalls. The concluding section of this newsletter evaluates the longer duration 15-, 20-, and 25-day rainfall amounts that occurred in May 2004.

FIFTEEN- THROUGH 25-DAY RAINFALL FREQUENCIES IN MAY 2004

The preceding assessment of the May 2004 rain storms was focused on those storms which contributed to the flood peaks that occurred on rivers and streams in the Southeastern Wisconsin Region. As shown in Table 3, with the exception of the Kinnickinnic River, those flood peaks occurred between May 22 and May 24. The rainfall in the first 24 days of the month occurred in the 19-day period from May 6 through May 24. Thus, the rainfall probabilities for durations of 15 days and less were of interest as the events that produced the flood peaks. However, because the MMSD deep tunnel system continued to store sewage and runoff for periods beyond ten days and because elevated flood stages continued on some streams well beyond the time of occurrence of the flood peaks, MMSD hired Camp, Dresser & McKee Inc. (CDM) to

Table 4

MAXIMUM 10, 15-, 20-, AND 25-DAY RAINS: MAY 2004

County	Watershed	Type of Gauge	Location	Gauge Number on Maps 1 through 3	Maximum 10-Day Total	Maximum 15-Day Total	Maximum 20-Day Total	Maximum 25-Day Total	10-Day Probability of Occurrence	15-Day Probability of Occurrence	20-Day Probability of Occurrence	25-Day Probability of Occurrence
Walworth	Rock	NWS Cooperator	Delavan-Ham	38	6.13	9.19	9.94	12.34	10 to 20%	1 to 2%	0.5 to 1%	<0.2%
Kenosha	Fox	NWS Cooperator	New Munster-Fox River	4	7.14	8.74	9.54	10.90	4%	2%	1 to 2%	0.2 to 0.5%
Kenosha	Pike/ Des Plaines	NWS Cooperator	Kenosha-Airport	37	7.00	9.63	10.03	11.54	4 to 10%	0.5 to 1%	0.5%	<0.2%
Racine	Root/ Des Plaines	NWS Cooperator	Union Grove-WWTP	46	7.92	10.94	11.08	12.00	1 to 2%	<0.2%	<0.2%	<0.2%
Milwaukee	Menomonee	MMSD	8800 W. Lisbon Avenue (MMSD No. 1210)	23	6.05	8.03	8.72	10.06	10 to 20%	4 to 10%	4 to 10%	2%
Ozaukee	Milwaukee	MMSD	700 W. Pioneer Road Cedarburg (MMSD No.. 1214)	33	7.12	10.08	10.98	12.64	4%	0.2 to 0.5%	<0.2%	<0.2%
Milwaukee	Milwaukee	S.M.A.R.T. Weather Net	Bayside Middle School	- -	5.88	8.68	9.56	10.86	10 to 20%	2 to 4%	1 to 2%	0.2 to 0.5%

[a]*Based on provisional data that is subject to revision.*

Source: SEWRPC.

analyze the probabilities of the rainfall amounts for durations of 15, 20, and 25 days.[7] Those greater volume events were pertinent to the issues of deep tunnel storage and sustained elevated groundwater levels that contribute to infiltration to sanitary and combined sewers.

The Regional Planning Commission staff used the MMSD data to characterize longer duration rainfall probabilities at selected rain gauges throughout the Region. The longer duration rainfall information is presented in Table 4, which shows that as the storm duration increased, the probability of the total rainfall decreased significantly. Thus, while not all flood peaks that occurred on streams in the Region, and the 10-day and shorter rains that predominantly influenced them, were particularly rare, the long-term 15- through 25-day rainfall amounts were exceptional.

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[7]*As a part of that analysis, CDM also updated some of the rainfall depth-duration-frequency data developed under SEWRPC Technical Record No. 40. The data were updated by analyzing additional Milwaukee rainfall records from 1999 through May of 2004 and developing probabilities of occurrence for five- and 10-day rainfalls.*

This entire Newsletter is dedicated to characterizing the persistent rains that occurred in the Southeastern Wisconsin Region in May of 2004.

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