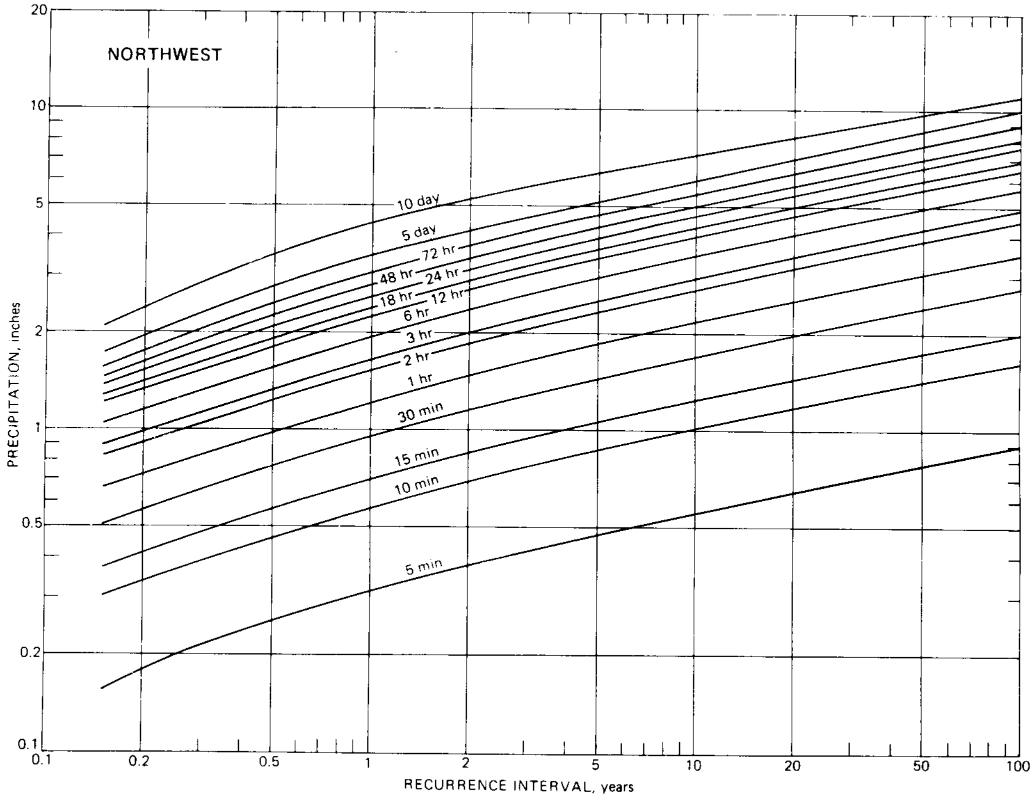


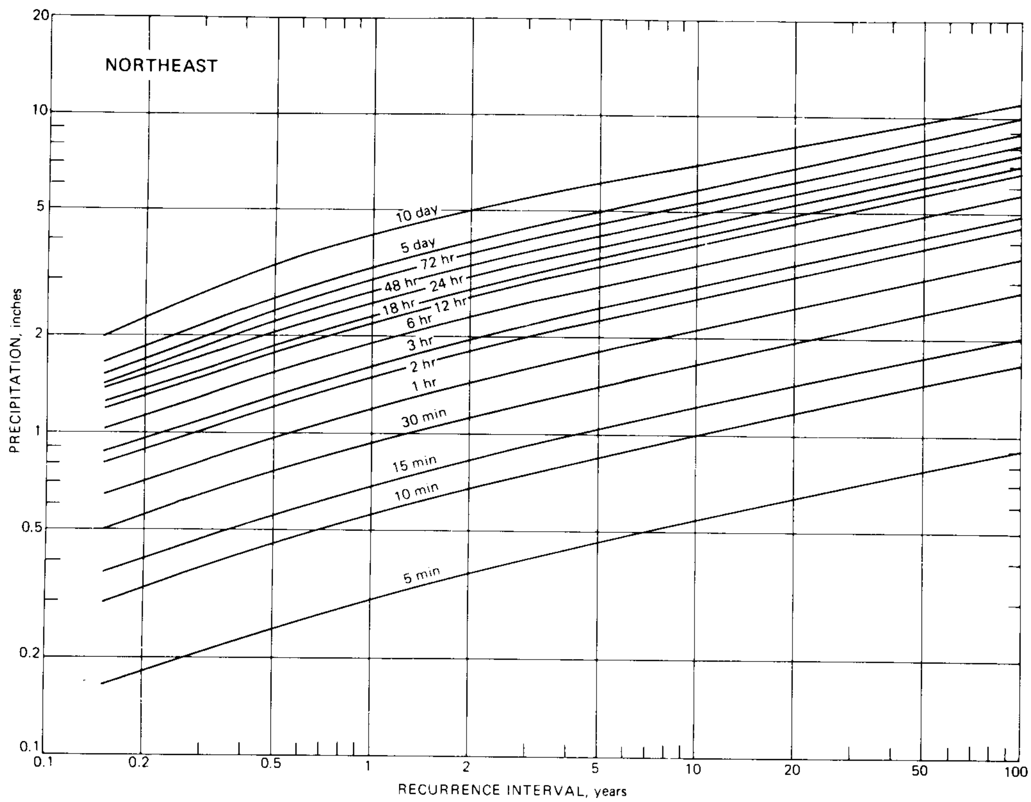
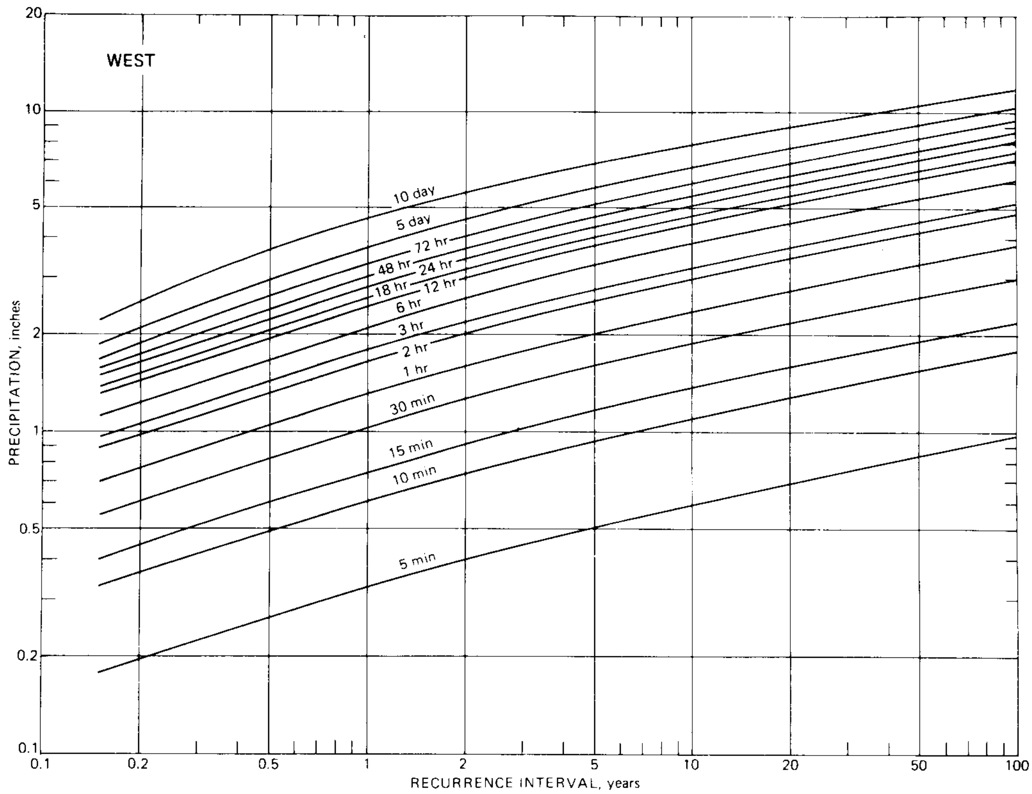


Figure 9. Frequency distributions of rainfall for ten Illinois climatic sections for storm periods of 5 minutes to 10 days and recurrence intervals of 2 months to 100 years



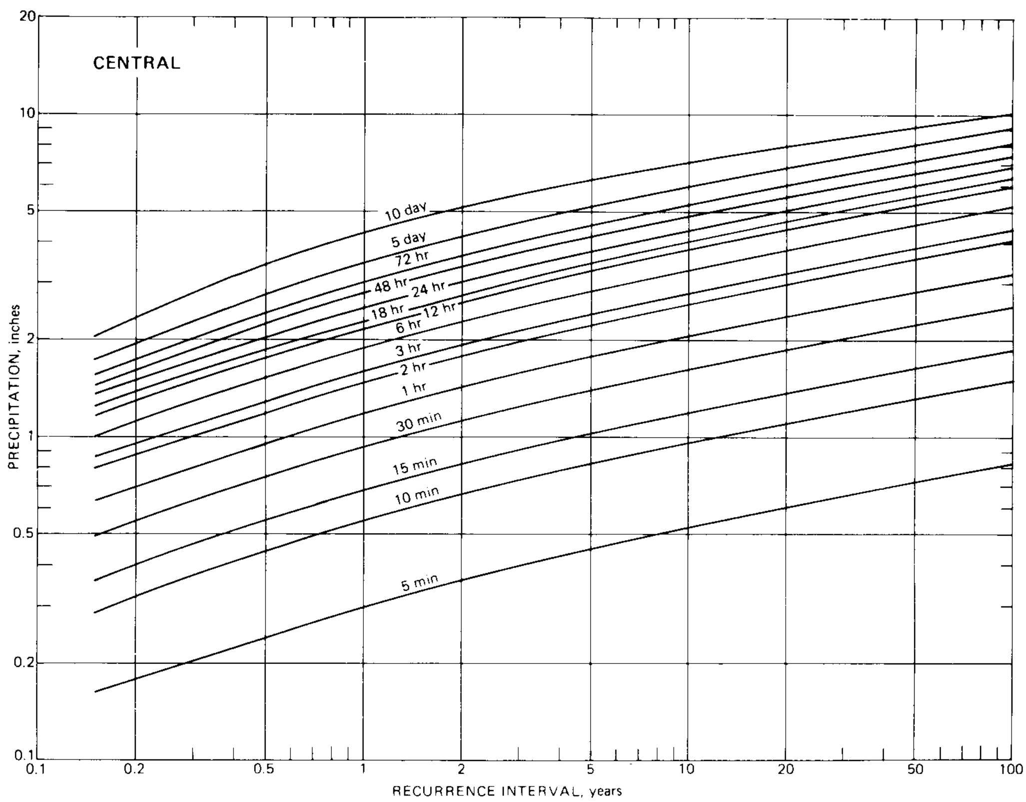
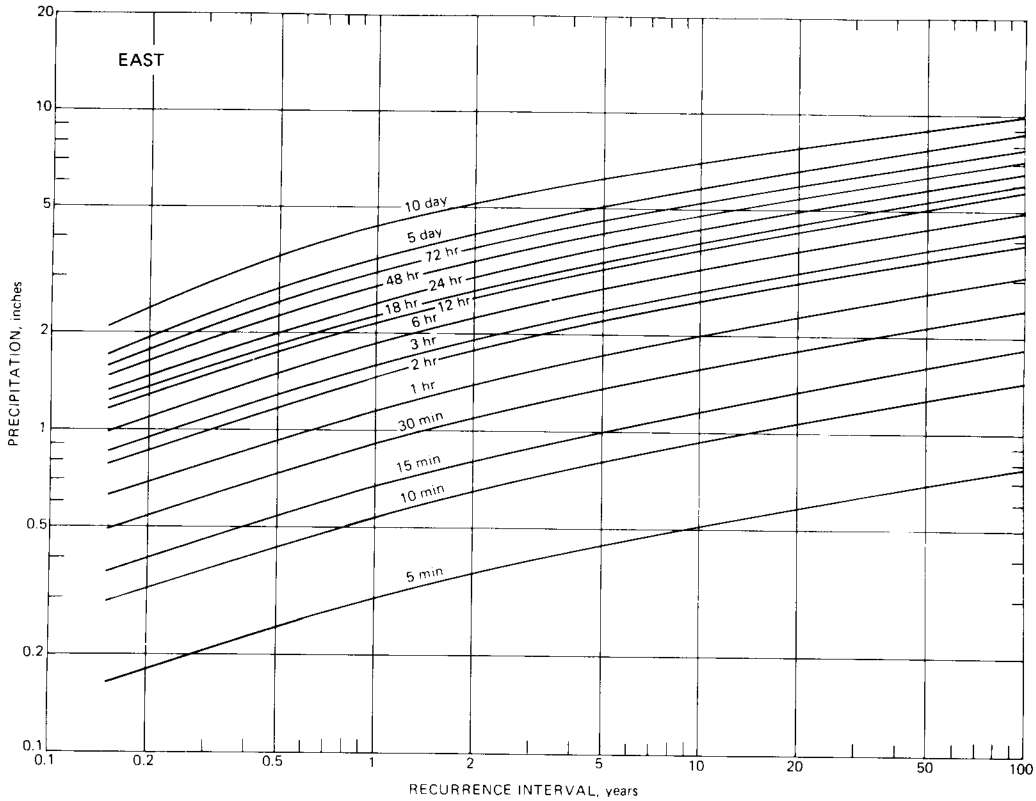


Figure 9. Continued



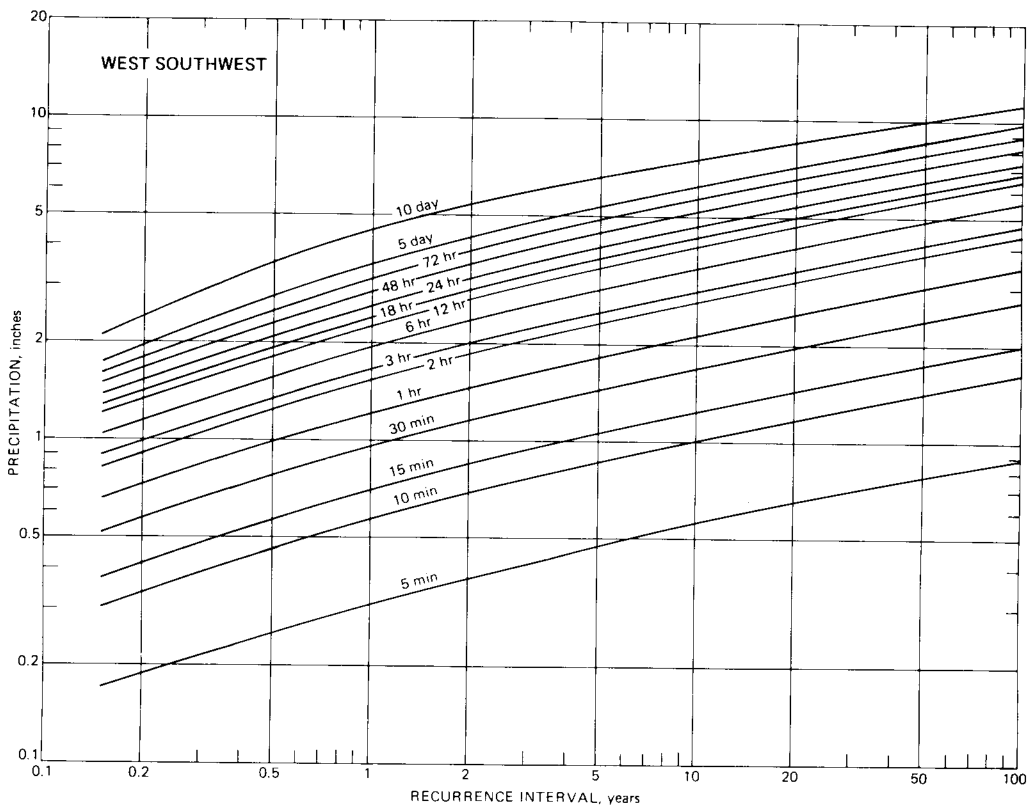
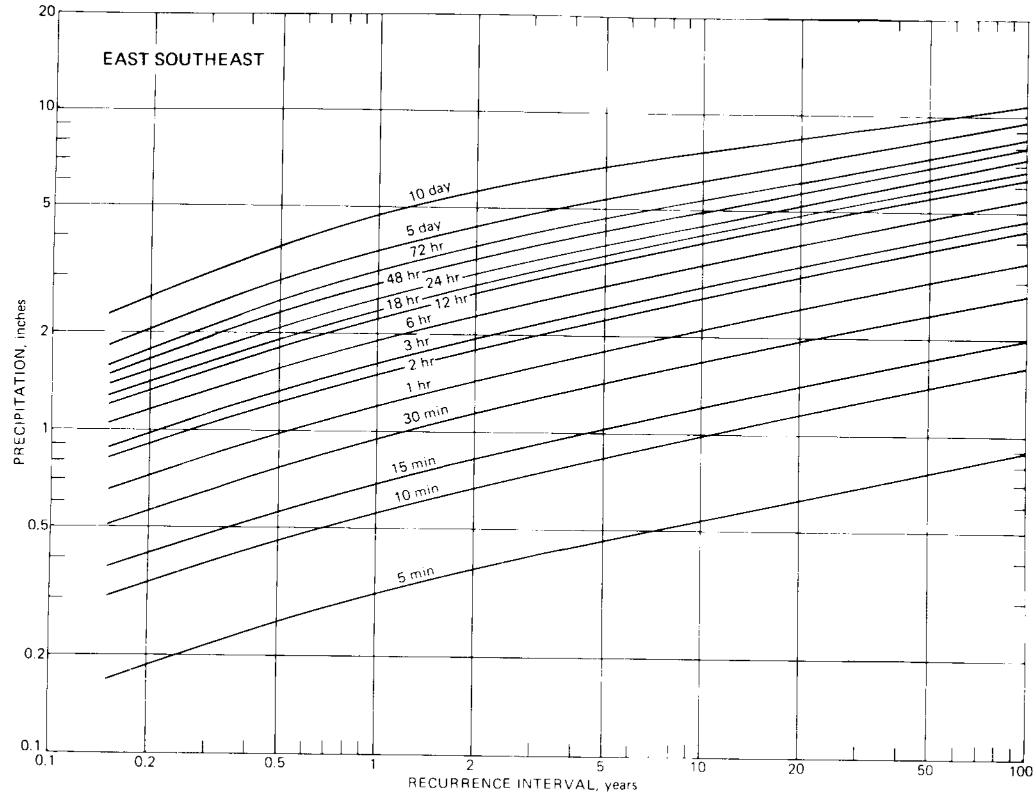


Figure 9. Continued



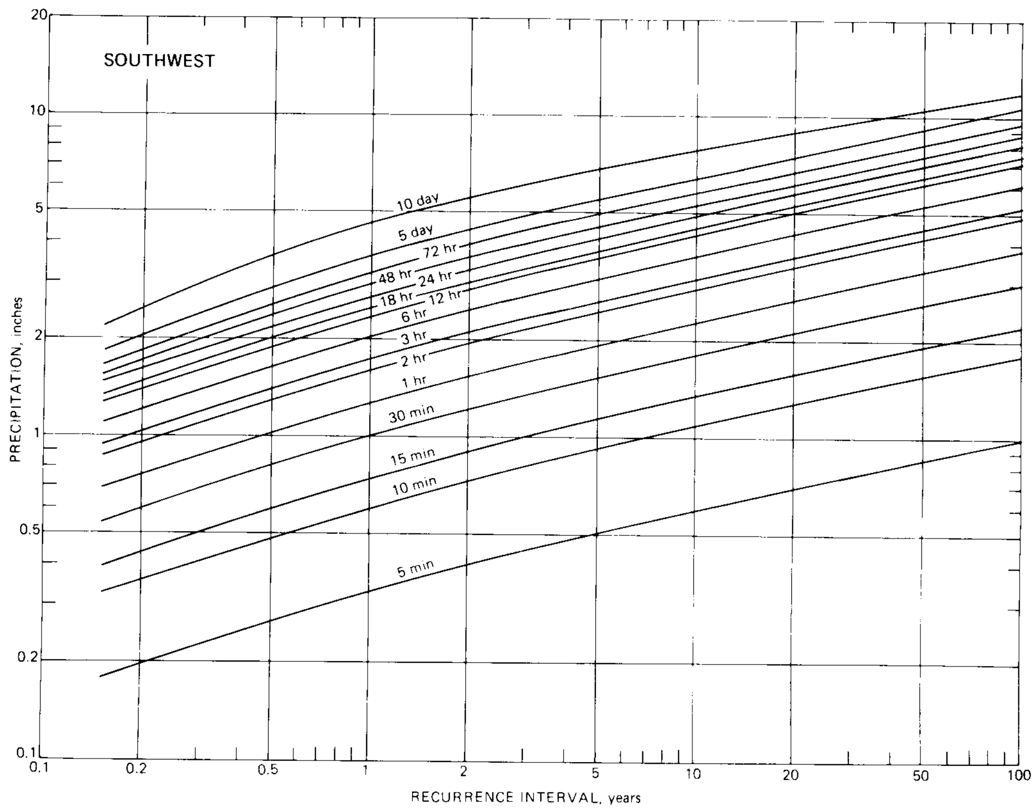
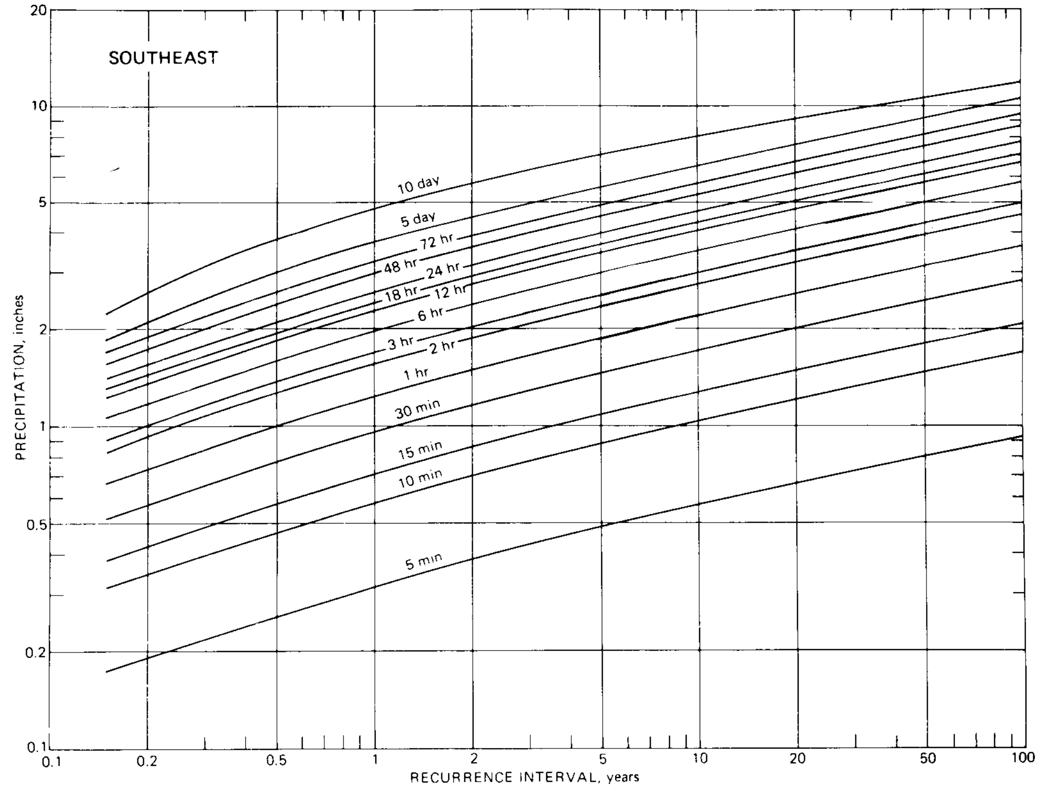


Figure 9. Continued



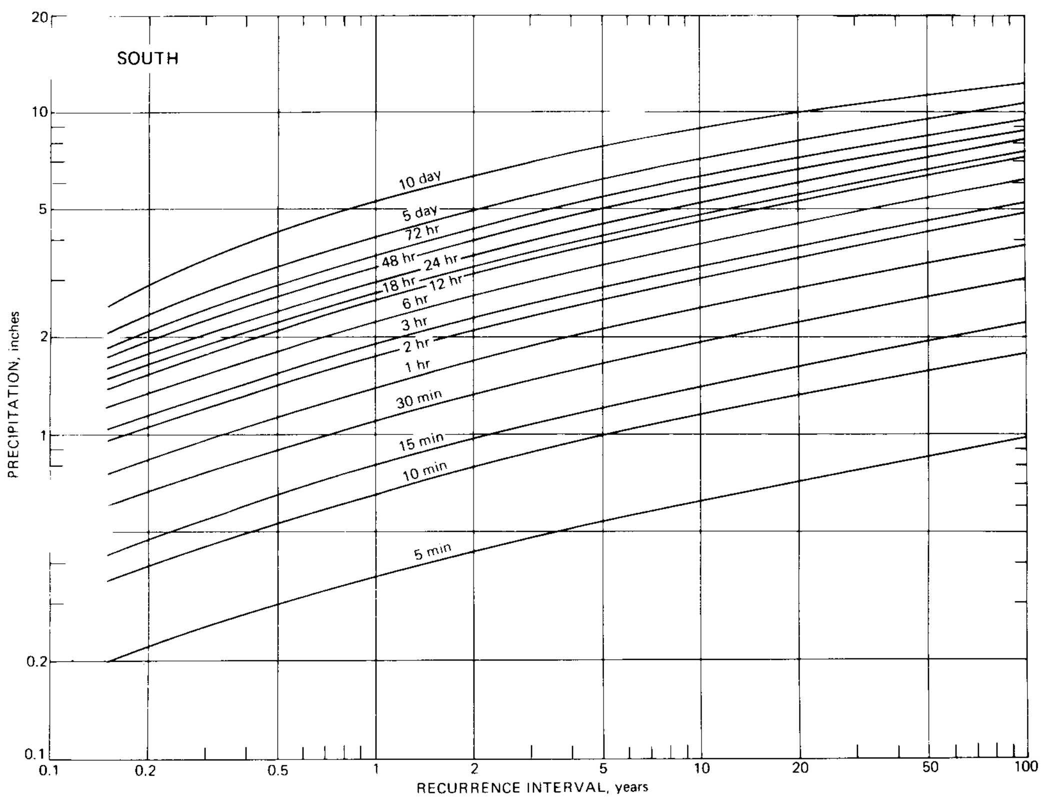


Figure 9. Concluded

Table 13. Sectional Frequency Distributions for Storm Periods of 5 Minutes to 10 Days and Recurrence Intervals of 2 Months to 100 Years

Storm codes

1 – 10 days
2 – 5 days
3 – 72 hours
4 – 48 hours
5 – 24 hours
6 – 18 hours
7 – 12 hours
8 – 6 hours
9 – 3 hours
10 – 2 hours
11 – 1 hour
12 – 30 minutes
13 – 15 minutes
14 – 10 minutes
15 – 5 minutes

Sectional (zone) codes

1 – Northwest
2 – Northeast
3 – West
4 – Central
5 – East
6 – West Southwest
7 – East Southeast
8 – Southwest
9 – Southeast
10 – South

		Rainfall (inches) for given recurrence interval											
Storm code	*Zone code*	*2-month*	*3-month*	*4-month*	*6-month*	*9-month*	*1-year*	*2-year*	*5-year*	*10-year*	*25-year*	*50-year*	*100-year*
1	1	2.14	2.60	2.97	3.50	4.02	4.37	5.23	6.30	7.14	8.39	9.64	11.09
1	2	2.02	2.48	2.80	3.30	3.79	4.12	4.95	6.04	6.89	8.18	9.38	11.14
1	3	2.27	2.78	3.13	3.68	4.23	4.60	5.60	6.91	7.89	9.24	10.36	11.90
1	4	2.10	2.58	2.92	3.43	3.93	4.29	5.12	6.27	7.10	8.19	9.10	10.18
1	5	2.13	2.62	2.96	3.48	4.00	4.35	5.15	6.21	6.97	8.04	8.90	9.92
1	6	2.16	2.65	2.99	3.52	4.05	4.40	5.35	6.62	7.45	8.66	9.79	11.26
1	7	2.30	2.80	3.16	3.70	4.27	4.64	5.58	6.80	7.61	8.66	9.70	10.87
1	8	2.22	2.74	3.09	3.63	4.18	4.54	5.54	6.80	7.80	9.20	10.44	11.81
1	9	2.30	2.88	3.23	3.80	4.33	4.75	5.74	7.09	8.07	9.54	10.68	11.79
1	10	2.55	3.15	3.58	4.21	4.84	5.26	6.36	7.81	8.90	10.34	11.36	12.50
2	1	1.76	2.12	2.38	2.76	3.17	3.45	4.13	5.10	5.91	7.21	8.36	9.97
2	2	1.66	1.98	2.24	2.60	2.99	3.25	3.93	4.91	5.70	6.93	8.04	9.96
2	3	1.92	2.30	2.56	2.97	3.41	3.71	4.57	5.80	6.65	7.90	8.95	10.50
2	4	1.77	2.12	2.37	2.78	3.20	3.48	4.17	5.11	5.84	6.96	7.98	9.21
2	5	1.75	2.10	2.37	2.75	3.15	3.42	4.12	4.96	5.67	6.76	7.65	8.78
2	6	1.77	2.13	2.39	2.78	3.19	3.47	4.19	5.32	6.20	7.44	8.53	9.93
2	7	1.85	2.22	2.50	2.90	3.31	3.63	4.34	5.33	6.11	7.28	8.37	9.65
2	8	1.85	2.21	2.49	2.90	3.31	3.62	4.40	5.46	6.34	7.68	8.88	10.68
2	9	1.90	2.29	2.59	3.00	3.45	3.75	4.48	5.57	6.50	7.91	9.16	10.57
2	10	2.09	2.52	2.83	3.29	3.77	4.10	4.99	6.20	7.21	8.45	9.45	10.82
3	1	1.58	1.90	2.11	2.45	2.82	3.06	3.73	4.67	5.42	6.59	7.64	8.87
3	2	1.53	1.83	2.02	2.34	2.70	2.93	3.55	4.44	5.18	6.32	7.41	8.78
3	3	1.72	2.05	2.28	2.64	3.02	3.30	4.08	5.11	5.87	6.97	7.95	9.48
3	4	1.59	1.91	2.12	2.44	2.80	3.05	3.70	4.55	5.26	6.15	7.25	8.16
3	5	1.61	1.93	2.16	2.48	2.85	3.10	3.71	4.57	5.20	6.17	6.97	7.83
3	6	1.63	1.95	2.16	2.50	2.88	3.13	3.81	4.85	5.68	6.84	7.76	8.92
3	7	1.62	1.90	2.15	2.50	2.87	3.12	3.73	4.64	5.32	6.39	7.35	8.54
3	8	1.67	1.97	2.20	2.54	2.93	3.22	3.94	4.92	5.74	6.97	8.12	9.55
3	9	1.73	2.02	2.25	2.62	3.00	3.27	3.92	4.92	5.75	7.05	8.23	9.40
3	10	1.88	2.25	2.49	2.87	3.30	3.59	4.36	5.48	6.34	7.53	8.54	9.52
4	1	1.47	1.74	1.93	2.24	2.58	2.80	3.42	4.28	4.96	6.07	7.02	8.07
4	2	1.44	1.70	1.90	2.18	2.49	2.70	3.30	4.09	4.81	5.88	6.84	8.16
4	3	1.61	1.88	2.09	2.42	2.76	3.01	3.68	4.56	5.50	6.45	7.56	8.80
4	4	1.48	1.76	1.95	2.25	2.58	2.81	3.38	4.19	4.86	5.78	6.62	7.51
4	5	1.51	1.77	1.95	2.26	2.57	2.82	3.40	4.16	4.77	5.66	6.40	7.16
4	6	1.52	1.81	2.00	2.30	2.64	2.87	3.49	4.45	5.21	6.28	7.12	8.19
4	7	1.52	1.78	1.98	2.30	2.64	2.87	3.42	4.26	4.88	5.84	6.75	8.00
4	8	1.57	1.85	2.06	2.38	2.75	2.97	3.59	4.52	5.26	6.43	7.36	8.81
4	9	1.59	1.87	2.07	2.40	2.76	3.00	3.60	4.52	5.28	6.48	7.58	8.62
4	10	1.75	2.08	2.31	2.65	3.02	3.30	4.00	5.03	5.80	6.93	7.86	8.79
5	1	1.40	1.64	1.80	2.08	2.36	2.57	3.11	3.95	4.63	5.60	6.53	7.36
5	2	1.38	1.61	1.76	2.03	2.31	2.51	3.04	3.80	4.47	5.51	6.46	7.58
5	3	1.53	1.77	1.95	2.24	2.56	2.79	3.45	4.29	4.93	6.07	7.04	8.20
5	4	1.39	1.63	1.80	2.04	2.32	2.52	3.02	3.76	4.45	5.32	6.08	6.92
5	5	1.36	1.58	1.75	2.00	2.27	2.47	3.01	3.71	4.26	5.04	5.87	6.61
5	6	1.42	1.66	1.84	2.10	2.38	2.59	3.11	3.93	4.65	5.57	6.46	7.45
5	7	1.40	1.63	1.78	2.07	2.35	2.55	3.03	3.80	4.44	5.37	6.23	7.41
5	8	1.49	1.73	1.90	2.20	2.48	2.71	3.28	4.13	4.76	6.02	7.07	8.21
5	9	1.44	1.68	1.85	2.12	2.41	2.62	3.16	4.00	4.62	5.79	6.71	7.73
5	10	1.63	1.91	2.10	2.41	2.74	2.97	3.62	4.51	5.21	6.23	7.11	8.27

Continued on next page

Table 13. Continued

Storm code	Zone code	Rainfall (inches) for given recurrence interval											
		2-month	3-month	4-month	6-month	9-month	1-year	2-year	5-year	10-year	25-year	50-year	100-year
6	1	1.30	1.52	1.66	1.92	2.18	2.37	2.86	3.63	4.26	5.15	6.01	6.92
6	2	1.26	1.47	1.61	1.86	2.12	2.30	2.79	3.50	4.11	5.06	5.95	6.97
6	3	1.41	1.64	1.80	2.07	2.36	2.57	3.18	3.95	4.53	5.59	6.47	7.55
6	4	1.27	1.51	1.66	1.88	2.12	2.28	2.75	3.46	4.09	4.90	5.59	6.37
6	5	1.25	1.47	1.62	1.84	2.09	2.27	2.77	3.41	3.92	4.63	5.37	6.08
6	6	1.31	1.53	1.68	1.93	2.19	2.38	2.86	3.61	4.28	5.12	5.95	6.85
6	7	1.29	1.50	1.64	1.90	2.16	2.35	2.79	3.49	4.08	4.94	5.73	6.81
6	8	1.35	1.59	1.74	2.00	2.29	2.49	3.02	3.80	4.38	5.54	6.51	7.55
6	9	1.33	1.55	1.71	1.95	2.22	2.41	2.91	3.68	4.25	5.33	6.17	7.11
6	10	1.51	1.77	1.95	2.22	2.52	2.74	3.33	4.15	4.79	5.74	6.54	7.61
7	1	1.23	1.43	1.57	1.81	2.06	2.24	2.71	3.43	4.03	4.88	5.66	6.51
7	2	1.20	1.40	1.53	1.77	2.01	2.18	2.64	3.31	3.89	4.79	5.62	6.59
7	3	1.34	1.56	1.70	1.94	2.22	2.43	2.98	3.73	4.29	5.28	6.13	7.14
7	4	1.19	1.40	1.53	1.77	2.01	2.17	2.62	3.27	3.87	4.63	5.29	6.02
7	5	1.18	1.38	1.53	1.74	1.98	2.15	2.62	3.23	3.71	4.38	5.08	5.75
7	6	1.24	1.44	1.57	1.82	2.07	2.25	2.71	3.39	3.97	4.84	5.62	6.48
7	7	1.21	1.42	1.55	1.80	2.04	2.22	2.63	3.30	3.86	4.67	5.42	6.45
7	8	1.28	1.50	1.64	1.88	2.15	2.35	2.86	3.60	4.14	5.24	6.15	7.14
7	9	1.25	1.46	1.60	1.85	2.10	2.28	2.75	3.48	4.02	5.04	5.84	6.72
7	10	1.42	1.66	1.83	2.10	2.38	2.59	3.15	3.93	4.53	5.42	6.19	7.20
8	1	1.06	1.24	1.37	1.56	1.77	1.93	2.33	2.96	3.48	4.20	4.90	5.69
8	2	1.03	1.21	1.32	1.52	1.74	1.88	2.28	2.85	3.35	4.13	4.85	5.68
8	3	1.15	1.34	1.47	1.67	1.91	2.10	2.58	3.22	3.70	4.55	5.28	6.15
8	4	1.03	1.21	1.34	1.53	1.74	1.89	2.26	2.82	3.33	3.99	4.56	5.19
8	5	1.00	1.18	1.32	1.49	1.70	1.85	2.26	2.78	3.20	3.78	4.38	4.96
8	6	1.07	1.24	1.37	1.57	1.78	1.94	2.33	2.95	3.48	4.18	4.85	5.59
8	7	1.06	1.23	1.37	1.55	1.74	1.87	2.27	2.85	3.33	4.03	4.67	5.56
8	8	1.12	1.30	1.44	1.64	1.87	2.03	2.45	3.10	3.57	4.52	5.30	6.16
8	9	1.08	1.27	1.41	1.60	1.81	1.97	2.37	3.00	3.47	4.34	5.03	5.80
8	10	1.23	1.44	1.58	1.71	2.05	2.23	2.73	3.39	3.91	4.68	5.31	6.21
9	1	0.91	1.06	1.16	1.33	1.52	1.65	1.99	2.53	2.97	3.59	4.18	4.90
9	2	0.88	1.02	1.13	1.30	1.47	1.60	1.94	2.43	2.86	3.53	4.14	4.85
9	3	0.98	1.15	1.26	1.44	1.65	1.79	2.21	2.75	3.15	3.89	4.51	5.25
9	4	0.89	1.03	1.13	1.30	1.47	1.61	1.93	2.41	2.85	3.41	3.89	4.43
9	5	0.87	1.02	1.12	1.28	1.46	1.58	1.93	2.37	2.73	3.22	3.74	4.23
9	6	0.91	1.07	1.18	1.34	1.52	1.66	1.99	2.51	2.98	3.56	4.14	4.77
9	7	0.89	1.05	1.15	1.32	1.50	1.63	1.94	2.43	2.84	3.44	3.99	4.74
9	8	0.95	1.12	1.22	1.40	1.59	1.73	2.10	2.63	3.08	3.86	4.52	5.25
9	9	0.92	1.08	1.21	1.37	1.55	1.68	2.02	2.56	2.96	3.71	4.29	4.95
9	10	1.06	1.23	1.35	1.54	1.75	1.90	2.32	2.89	3.33	3.99	4.55	5.29
10	1	0.84	0.97	1.06	1.23	1.40	1.52	1.83	2.33	2.74	3.31	3.86	4.47
10	2	0.81	0.95	1.05	1.20	1.36	1.48	1.79	2.24	2.64	3.25	3.82	4.47
10	3	0.91	1.06	1.17	1.32	1.50	1.65	2.02	2.53	2.91	3.58	4.15	4.84
10	4	0.82	0.95	1.04	1.19	1.37	1.48	1.78	2.22	2.62	3.14	3.59	4.08
10	5	0.79	0.93	1.03	1.17	1.34	1.46	1.78	2.19	2.52	2.97	3.44	3.90
10	6	0.84	0.98	1.08	1.24	1.41	1.53	1.84	2.32	2.74	3.28	3.81	4.39
10	7	0.83	0.97	1.07	1.22	1.38	1.50	1.79	2.24	2.62	3.17	3.67	4.39
10	8	0.88	1.02	1.13	1.28	1.47	1.60	1.94	2.44	2.87	3.55	4.20	4.84
10	9	0.85	1.00	1.12	1.26	1.43	1.55	1.85	2.36	2.72	3.41	3.96	4.56
10	10	0.97	1.13	1.25	1.43	1.62	1.76	2.14	2.66	3.07	3.68	4.20	4.88
11	1	0.67	0.78	0.86	0.98	1.11	1.21	1.46	1.86	2.18	2.63	3.07	3.51
11	2	0.65	0.76	0.84	0.96	1.09	1.18	1.43	1.79	2.10	2.59	3.04	3.56
11	3	0.72	0.84	0.92	1.06	1.21	1.31	1.60	2.02	2.32	2.86	3.31	3.85
11	4	0.65	0.76	0.83	0.95	1.09	1.18	1.42	1.77	2.09	2.50	2.86	3.25
11	5	0.64	0.74	0.81	0.93	1.07	1.16	1.41	1.74	2.00	2.39	2.74	3.11
11	6	0.67	0.79	0.87	0.99	1.12	1.21	1.46	1.85	2.19	2.62	3.04	3.50
11	7	0.66	0.77	0.85	0.97	1.10	1.20	1.42	1.78	2.09	2.52	2.93	3.48
11	8	0.70	0.81	0.89	1.02	1.15	1.26	1.54	1.93	2.27	2.84	3.32	3.86
11	9	0.68	0.79	0.88	1.00	1.13	1.23	1.49	1.88	2.20	2.72	3.15	3.63
11	10	0.77	0.90	0.99	1.13	1.29	1.40	1.70	2.12	2.45	2.93	3.34	3.89
12	1	0.52	0.61	0.68	0.77	0.87	0.95	1.15	1.46	1.71	2.07	2.42	2.77
12	2	0.51	0.60	0.65	0.75	0.86	0.93	1.12	1.41	1.65	2.04	2.39	2.80
12	3	0.57	0.66	0.73	0.83	0.95	1.03	1.27	1.59	1.82	2.25	2.61	3.03
12	4	0.52	0.60	0.66	0.75	0.86	0.93	1.12	1.39	1.64	1.97	2.25	2.56
12	5	0.50	0.58	0.64	0.74	0.84	0.91	1.11	1.37	1.57	1.87	2.16	2.45
12	6	0.53	0.61	0.68	0.78	0.88	0.96	1.15	1.46	1.72	2.06	2.39	2.75
12	7	0.52	0.60	0.66	0.76	0.86	0.93	1.12	1.41	1.64	1.99	2.31	2.74
12	8	0.55	0.64	0.71	0.81	0.92	1.00	1.22	1.53	1.78	2.25	2.62	3.03
12	9	0.53	0.62	0.68	0.78	0.89	0.97	1.17	1.47	1.73	2.14	2.48	2.86
12	10	0.61	0.70	0.77	0.89	1.01	1.10	1.34	1.66	1.93	2.31	2.63	3.06

Table 13. Concluded

Storm code	Zone code	2-month	3-month	4-month	6-month	9-month	1-year	2-year	5-year	10-year	25-year	50-year	100-year
		Rainfall (inches) for given recurrence interval											
13	1	0.38	0.45	0.50	0.57	0.64	0.70	0.84	1.07	1.25	1.51	1.76	1.99
13	2	0.37	0.44	0.48	0.55	0.63	0.68	0.82	1.03	1.21	1.49	1.75	2.05
13	3	0.41	0.48	0.53	0.61	0.69	0.75	0.91	1.16	1.33	1.64	1.90	2.21
13	4	0.37	0.44	0.49	0.56	0.63	0.68	0.81	1.02	1.20	1.44	1.64	1.87
13	5	0.37	0.43	0.47	0.54	0.62	0.67	0.81	1.00	1.14	1.37	1.60	1.85
13	6	0.38	0.45	0.49	0.57	0.64	0.70	0.84	1.06	1.26	1.52	1.75	2.01
13	7	0.38	0.44	0.49	0.56	0.63	0.69	0.82	1.03	1.20	1.45	1.68	2.00
13	8	0.40	0.47	0.52	0.59	0.67	0.73	0.89	1.12	1.29	1.63	1.91	2.22
13	9	0.39	0.46	0.50	0.58	0.65	0.71	0.85	1.08	1.25	1.56	1.81	2.09
13	10	0.43	0.51	0.56	0.65	0.74	0.80	0.98	1.22	1.41	1.68	1.92	2.23
14	1	0.31	0.36	0.40	0.46	0.52	0.57	0.68	0.87	1.02	1.23	1.44	1.62
14	2	0.30	0.35	0.39	0.45	0.51	0.55	0.67	0.84	0.98	1.21	1.42	1.67
14	3	0.34	0.39	0.43	0.49	0.56	0.61	0.74	0.94	1.08	1.33	1.55	1.81
14	4	0.30	0.35	0.39	0.45	0.50	0.55	0.66	0.83	0.98	1.17	1.34	1.52
14	5	0.30	0.35	0.38	0.43	0.49	0.54	0.66	0.81	0.94	1.12	1.28	1.46
14	6	0.31	0.36	0.40	0.46	0.52	0.57	0.68	0.87	1.02	1.22	1.42	1.64
14	7	0.31	0.36	0.40	0.45	0.51	0.56	0.66	0.83	0.98	1.18	1.37	1.63
14	8	0.33	0.38	0.42	0.49	0.55	0.60	0.72	0.91	1.05	1.32	1.55	1.81
14	9	0.32	0.37	0.41	0.47	0.53	0.58	0.70	0.88	1.02	1.27	1.48	1.70
14	10	0.36	0.42	0.46	0.53	0.60	0.65	0.80	0.99	1.14	1.37	1.56	1.82
15	1	0.17	0.20	0.22	0.25	0.29	0.31	0.37	0.47	0.56	0.67	0.78	0.89
15	2	0.17	0.19	0.21	0.24	0.28	0.30	0.36	0.46	0.54	0.66	0.78	0.91
15	3	0.18	0.21	0.23	0.26	0.30	0.33	0.40	0.51	0.59	0.73	0.84	0.98
15	4	0.17	0.19	0.21	0.24	0.28	0.30	0.36	0.45	0.53	0.64	0.73	0.83
15	5	0.17	0.19	0.21	0.24	0.28	0.30	0.36	0.44	0.51	0.61	0.70	0.79
15	6	0.17	0.20	0.22	0.25	0.29	0.31	0.37	0.47	0.56	0.67	0.78	0.89
15	7	0.17	0.20	0.22	0.25	0.29	0.31	0.36	0.46	0.54	0.64	0.75	0.89
15	8	0.18	0.21	0.23	0.26	0.30	0.33	0.40	0.50	0.58	0.72	0.85	0.99
15	9	0.18	0.20	0.22	0.26	0.29	0.32	0.38	0.48	0.55	0.69	0.81	0.93
15	10	0.20	0.23	0.25	0.29	0.33	0.36	0.43	0.54	0.62	0.75	0.85	0.99

Note: For Madison County, increase the southwest sectional values by 15% to adjust for the St. Louis urban effect.

Table 14. Variations in the Frequency Distributions of 24-Hour Rainfall between Selected Stations

	Recurrence interval				
	5 yrs	*10 yrs*	*25 yrs*	*50 yrs*	*100 yrs*
	Joliet versus Chicago, NE section, 22 mi. apart				
Joliet (in.)	4.08	4.85	6.04	7.17	8.47
Chicago Midway (in.)	3.81	4.49	5.56	6.47	7.50
Diff. (%)	7	8	9	11	13
	Danville versus Urbana, E section, 33 mi. apart				
Danville (in.)	4.01	4.61	5.40	5.95	6.75
Urbana (in.)	3.70	4.20	4.85	5.45	6.10
Diff. (%)	8	10	11	9	11
	Belleville versus Greenville, SW section, 33 mi. apart				
Belleville (in.)	4.30	5.08	6.54	7.74	9.20
Greenville (in.)	3.99	4.62	5.76	6.81	7.90
Diff. (%)	8	10	14	14	16

inch storm in 4 hours about 5 miles southeast of Urbana (July 1979); and a 5-inch storm in 3 hours just 3 miles west of Champaign (May 1959).

In contrast, the maximum daily rainfall recorded at Urbana in the 1901-1983 period was 4.50 inches in May 1921. However, Danville, located about 33 miles east of Urbana (figure 7), has experienced several more severe storms that are reflected in its higher rainfall frequency values compared with those of Urbana (table 14).

Using the averaging approach and allowing all stations equal weight in determining the sectional relationships reduces the subjectivity that usually abounds out of necessity in studies of the frequency distributions of extreme rainfall events. The area1 approach also permits computation of the dispersion (variability) to be expected among points in a particular climatic section over a given sampling period. This dispersion or variability is realistic; it occurs because of the large temporal and spatial variability in extreme rain events, which usually are of small area1 extent. This variability should be considered in applications of heavy storm events because obviously it will continue to occur in the future.

Another benefit of the area1 approach is that it tends to provide more reliable estimates of typical 5-year or longer recurrences in areas with similar precipitation climates. In the case of the 83-year record in the present Illinois study, there are 41 independent 2-year events at a precipitation station. However, this reduces to 16, 8, 4, and 2 independent samples for recurrences of 5, 10, 20, and 40 years, respectively. Thus, rainfall amounts for the longer recurrence intervals are subject to more sampling error, and beyond 20- to 25-year frequencies they become quite questionable. However, when several stations are combined to obtain the longer recurrence-interval values, rainfall amounts are established more reliably. For example, the nine stations in the northwestern climatic section provided 36 independent measurements for the 20-year event and 18 values for the 40-year event.

As has been discussed in the Urbana example, relatively large differences can occur between the frequency distributions of stations located a few miles apart in a relatively homogeneous region of precipitation climate. As indicated earlier, these differences occur even with records of relatively long length, such as the 83 years used in the present study. However, unless a significant climatic trend is in operation, area1 average relations are more likely to remain nearly constant with time if enough stations are included to obtain a reliable measure of the mean and the dispersion about the mean. We believe this has been accomplished in the present study and that the area1 method of establishing frequency relations is preferable to fitting isohyets to point data.

Point Frequency Distributions

Appendix A provides frequency distributions for each of the 61 stations used in the present Illinois study. As with the area1 distributions, they include rain periods ranging from 5 minutes to 10 days and recurrence intervals of 2 months to 100 years. These are provided for the benefit of the user who may need specific information for a particular location, or who wishes to construct a detailed isohyetal pattern for a specific region that is not covered adequately by the sectional curves or selected isohyetal maps presented in this report. It is stressed, however, that the point frequency distributions should be used with caution and should be compared with other nearby point relationships before the results are considered authentic. The reasons for this caution were discussed in the presentation of the area1 relationships.

Selected Iso hyetal Maps

As mentioned previously, certain isohyetal maps are included in this report to satisfy hydrologic needs for some applications in which isohyetal presentations are considered preferable to our recommended use of sectional frequency curves. These maps are shown in figures 10 through 17, and show spatial distributions for rain periods ranging from 1 to 72 hours. For each rain period, which may include a total or partial storm, maps for recurrence intervals of 2 to 100 years are presented.

The isohyetal maps do not extend into northeastern Illinois. This is because the six-county area in the cutoff region has been the subject of a special study (Huff and Vogel, 1976) that employed additional data from a raingage network in the Chicago urban area, plus data from other stations not used in the present 61-station study because of their record lengths. An updating of this six-county study is discussed in Section 4 of this report.

Pattern Features

As noted in the comparison of two 40-year periods (Section 1), the isohyetal patterns show certain characteristics that are generally consistent for various rain periods and recurrence intervals. These include a major high in extreme southern Illinois, which lies in a region of maximum thunderstorm frequency in the state (Changnon, 1957). Topographic influences from the Shawnee Hills may also affect the rainfall distribution (Huff, Changnon, and Jones, 1975).

A second major high in the heavy rainfall distributions occurs in the extreme western part of the state, which also lies in a region of relatively frequent thunderstorm occurrences in which most of the severe rain events breed. A low in the rainfall pattern extends along or in the vicinity of the Illinois River valley from northeastern to southwestern Illinois. A high extends northeastward from the vicinity of St. Louis to the Joliet-Kankakee region in northeastern Illinois and is nearly parallel to the Illinois River low. A low is also present in the extreme northeastern part of the state in the Waukegan-Marengo area. Another weak low is evident in east central Illinois and in some cases extends into southeastern Illinois.

The details of the statewide frequency distributions listed above are apparent only because of the existence and judicious use of the 83-year record from the many cooperative weather stations operated largely by the National Weather Service.

The Waukegan low may be related to the influence of Lake Michigan in dissipating or reducing the intensity of warm-season storms moving into the lake. However, Marengo, which is also in the northeastern low, is too far west of Lake Michigan to be significantly affected by it. This low is apparently related to climatic variations, possibly intensified by lake effects in the Waukegan area.

*Map **Analysis***

The maps in figures 10 through 17 were constructed by plotting rainfall amounts from each of the station frequency curves for the storm period and recurrence interval being analyzed. A total of 48 maps are included to cover the various storm periods and recurrence intervals. As discussed previously, sampling variability between nearby stations can cause substantial differences in frequency values. As a result, a considerable amount of subjectivity was involved in preparing the isohyetal patterns. Efforts were made to obtain a realistic, relatively smooth, isohyetal pattern from consideration of both plotted data and meteorological-climatological factors. In doing so, values at some stations were arbitrarily lowered and others increased to avoid sharp, unrealistic rainfall gradients between nearby stations.

The resulting maps in figures 10 through 17 reflect findings from the 1901-1983 data sample adjusted for climatic trend. Variations from these distribution patterns may occur in the future. However, in general, the comparison of the two 40-year periods, 1901-1940 and 1941-1980 (Section 1) indicates that most features of the patterns have persisted throughout the 83-year period.

Comparison between Values in Table 13 and Those in Technical Paper 40

The mean sectional frequency distributions summarized in table 13 were compared with those in U.S. Weather Bureau Technical Paper 40 (Hershfield, 1961), which has had widespread use throughout the United States. In general, the values in table 13 are very similar to those in Technical Paper 40 for recurrence intervals of 10 years and less. For longer recurrence intervals, table 13 shows larger values than Technical Paper 40, and the differences become larger with increasing recurrence interval.

Table 15 (see page 50) illustrates the differences between the two sets of frequency values for 24-hour maximum rainfall amounts at selected observational stations in Illinois. The Water Survey values are those for the climatic sections in which the stations are located. The values for Technical Paper 40 were interpolated from isohyetal maps for 24-hour rainfall.

The differences are most pronounced in the northeastern section (figure 7), where the climatic trend study (Section 1 of this report) showed the maximum increase in the frequency distributions of heavy rainstorms in the 1941-1980 period. Technical Paper 40, published in 1961, did not include some of the extremely heavy rain events that occurred in recent years, several of which affected the Chicago-Aurora-Joliet-Kankakee area. Note the Chicago values in table 15 that reflect these occurrences.

We believe that our method of fully using data from the cooperative observer network and employing the area1 analysis technique (sectional mean frequency distributions) provides a better estimate of the more extreme rainfall events (25-year to 100-year recurrences) than the technique used in Technical Paper 40, which placed major emphasis on first-order station data and isohyetal analysis of these data.

Six-County Frequency Relations

As mentioned previously, data from a 1976 study of the frequency distribution of heavy rainfall in the Chicago urban area and in the surrounding six-county area (**Huff and** Vogel, 1976) were updated. Basically, this was done by relating frequency relations derived from 1901-1983 data (present study) and from 1949-1974 data used in the 1976 study. This was done for five long-term stations, including the official first-order stations of the National Weather Service. The specific methodology used and the updated relations are presented for the urban area and the six-county area in Section 4.

Table 15. Increases/Decreases in New 24-Hour Maximum Rainfall Values in Illinois from Those in U.S. Weather Bureau Technical Paper 40 (Hershfield, 1961)

	Differences (in inches and percentages) for given recurrence intervals											
	2 yrs		5 yrs		10 yrs		25 yrs		50 yrs		100 yrs	
	in.	%	in.	%	in.	%	in.	%	in.	%	in.	%
Chicago	0.1	3	0.3	8	0.5	11	0.9	16	1.3	20	1.9	25
Moline	0.0	0	0.0	0	0.1	0	0.4	7	0.7	11	1.1	15
Peoria	-0.1	3	-0.2	6	0.0	0	0.1	2	0.3	5	0.5	7
Springfield	0.1	3	-0.2	6	0.1	2	0.3	5	0.6	9	0.9	12
Quincy	0.2	6	0.1	2	0.2	4	0.6	10	0.8	11	1.3	16
Urbana	0.0	0	-0.2	7	-0.1	2	-0.1	2	0.2	3	0.4	6
St. Louis	0.3	9	-0.3	8	-0.1	2	0.4	7	0.8	11	1.3	16
Cairo	0.0	Q	0.1	2	0.1	2	0.4	6	0.6	11	1.3	16
Mean		3		5		3		7		10		14
Median		3		6		2		6		11		15

4. URBAN EFFECTS ON FREQUENCY DISTRIBUTIONS

In view of the results of the substantial past Water Survey research on the effects of urban environments on the incidence and magnitudes of heavy rainstorms, it was considered necessary to assess and incorporate (if feasible) urban effects on the frequency distributions of heavy rainfall in Illinois. Two major urban areas are of sufficient size to cause local effects: the Chicago urban area, and a region lying east and northeast of the St. Louis metropolitan area. Other urban areas within or adjacent to the state are not considered large enough to affect the heavy rainfall distributions significantly.

Several earlier studies revealed evidence of local shifts of heavy rain events in the Chicago area. Detweiller and Changnon (1976) found an upward trend in the Chicago (and St. Louis) maximum annual daily rain values; Changnon (1980a) found that increased urban flooding in Chicago was related to local increases in heavy rain events; and Changnon (1980b) showed how storms were enhanced in urban areas. Huff and Changnon (1973) demonstrated that both Chicago and St. Louis have experienced sizable local increases in summer thunderstorms and rain days.

Huff and Changnon (1987) revealed that urban-related increases in heavy rains occurred in the St. Louis area during 1971-1975, when intensive field studies (METROMEX Project, Changnon et al., 1977) were carried out in that region. Thus, considerable evidence exists, in both cities and their environs, of localized increases in heavy rain events on the order of 10 to 25% in both incidence and magnitude.

The Chicago Effect

Huff and Vogel (1976) made a detailed study of the heavy rainfall distribution within the Chicago urban area and the surrounding six-county area, using an urban network of 16 recording raingages on an area of approximately 430 square miles during the 1949-1974 period (figure 18). These gages were operated by the Metropolitan Sanitary District of Greater Chicago, the city of Chicago, and the National Weather Service. Frequency distributions of point rainfall were derived for storm rainfall periods of 5 minutes to 72 hours and for recurrence intervals of 6 months to 50 years.

Results of this study indicated a central urban high in the isohyetal patterns for a given storm duration and recurrence interval. This high appeared to consist of two centers, one over the north central portion of the urban area and the other over the extreme southern part. The pattern is illustrated in figure 19 for 12-hour to 72-hour storm periods and a recurrence interval of 5 years.

However, even more pronounced highs in the heavy rainfall distributions were indicated 1) in the Aurora region, about 23 miles west of the western boundary of the urban area; and 2) at Joliet, about 13 miles